Revision history—90002258

<table>
<thead>
<tr>
<th>Revision</th>
<th>Date</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>May 2019</td>
<td>Added information for Clean shutdown and securing the connection between and XBee and Remote Manager.</td>
</tr>
<tr>
<td>K</td>
<td>July 2019</td>
<td>Added socket information. Additional edits.</td>
</tr>
<tr>
<td>L</td>
<td>September 2019</td>
<td>Added firmware update information. Added PPP information.</td>
</tr>
<tr>
<td>M</td>
<td>February 2020</td>
<td>Reorganized device and cellular firmware update information.</td>
</tr>
</tbody>
</table>

Trademarks and copyright

Digi, Digi International, and the Digi logo are trademarks or registered trademarks in the United States and other countries worldwide. All other trademarks mentioned in this document are the property of their respective owners.

© 2020 Digi International Inc. All rights reserved.

Disclaimers

Information in this document is subject to change without notice and does not represent a commitment on the part of Digi International. Digi provides this document “as is,” without warranty of any kind, expressed or implied, including, but not limited to, the implied warranties of fitness or merchantability for a particular purpose. Digi may make improvements and/or changes in this manual or in the product(s) and/or the program(s) described in this manual at any time.

Warranty

To view product warranty information, go to the following website:

www.digi.com/howtobuy/terms

Customer support

Gather support information: Before contacting Digi technical support for help, gather the following information:

- ✔ Product name and model
- ✔ Product serial number(s)
- ✔ Firmware version
- ✔ Operating system/browser (if applicable)
- ✔ Logs (from time of reported issue)
✔ Trace (if possible)
✔ Description of issue
✔ Steps to reproduce

Contact Digi technical support: Digi offers multiple technical support plans and service packages. Contact us at +1 952.912.3444 or visit us at www.digi.com/support.

Feedback

To provide feedback on this document, email your comments to

technical@digi.com

Include the document title and part number (Digi XBee® 3 Cellular LTE-M/NB-IoT Global Smart Modem User Guide, 90002258 I) in the subject line of your email.
Contents

Digi XBee® 3 Cellular LTE-M/NB-IoT Global Smart Modem User Guide

Applicable firmware and hardware .......................................................... 16
SIM cards .................................................................................................. 16
NB-IoT network ......................................................................................... 16

Get started with the XBee Smart Modem

Identify the kit contents ........................................................................... 18
Determine cellular service and acquire a SIM card ............................... 19
  US customers .......................................................................................... 19
  European customers ................................................................................ 19
  Cellular service ....................................................................................... 19
Connect the hardware ............................................................................... 20
Install and upgrade XCTU ....................................................................... 21
  Add a device to XCTU ........................................................................... 21
Update the device and cellular firmware using XCTU ......................... 22
Configure your module for cellular connectivity .................................. 22
  US customers .......................................................................................... 22
  European customers ................................................................................ 22
Check for cellular registration and connection ....................................... 23

XBee connection examples

Connect to the Echo server .................................................................... 26
Connect to the ELIZA server ................................................................... 28
Connect to the Daytime server ................................................................. 30
Perform a (GET) HTTP request ............................................................... 32
Connect to a TCP/IP address .................................................................. 33
Debugging ................................................................................................. 34
Software libraries .................................................................................... 34

Get started with MicroPython

About MicroPython .................................................................................... 36
  Why use MicroPython ............................................................................ 36
MicroPython on the XBee Smart Modem ............................................... 36
Use XCTU to enter the MicroPython environment .................................. 36
Use the MicroPython Terminal in XCTU ............................................... 37
  Troubleshooting ...................................................................................... 37
Get started with BLE

On XBee 3 Cellular firmware ending in x15 or newer ........................................... 43
On XBee 3 Cellular firmware ending in x14 or older ............................................ 43
Enable BLE on an XBee device ............................................................................. 44
Enable BLE and configure the BLE password using XCTU ................................. 44
Get the Digi XBee Mobile phone application ......................................................... 45
Connect with BLE and configure your XBee device ............................................. 45
BLE reference ........................................................................................................ 46
  BLE advertising behavior and services .............................................................. 46
  Device Information Service ................................................................................ 46
  XBee API BLE Service ..................................................................................... 46
  API Request characteristic .............................................................................. 47
  API Response characteristic ............................................................................ 47

Get started with Digi Remote Manager

Create a Remote Manager account and add devices ............................................. 48
  Create a Remote Manager account ................................................................. 49
  Add an XBee Smart Modem to Remote Manager ........................................... 49
  Verify the connection between a device and Remote Manager ..................... 50
Configure Remote Manager features by scheduling tasks .................................... 50
  Overview: Create a schedule for a set of tasks .............................................. 51
  Examples ........................................................................................................... 51
  Example: Read settings and state using Remote Manager ............................. 51
  Example: Configure a device from Remote Manager using XML .................. 52
  Example: Schedule a task to update the device firmware using Remote Manager 53
  Example: Update MicroPython from Remote Manager using XML ............... 54
Manage data in Remote Manager ........................................................................ 58
  Review device status information from Remote Manager ............................ 58
  Manage secure files in Remote Manager ......................................................... 59
Remote Manager reference .................................................................................... 60
  Enable SM/UDP .............................................................................................. 60
  TCP connection ............................................................................................. 60
  Disconnect ....................................................................................................... 62
  Configure XBee settings within Remote Manager ......................................... 62

Examples: IOT protocols with transparent mode

Get started with CoAP ............................................................................................ 66
  CoAP terms ....................................................................................................... 66
  CoAP quick start example ............................................................................... 66
  Configure the device ......................................................................................... 67
  Example: manually perform a CoAP request ................................................. 67
  Example: use Python to generate a CoAP message ....................................... 68
Get started with MQTT ................................................................. 70
Example: MQTT connect .......................................................... 70
Send a connect packet .............................................................. 72
Example: send messages (publish) with MQTT ........................... 73
Example: receive messages (subscribe) with MQTT .................. 74
Use MQTT over the XBee Cellular Modem with a PC .................. 75

Update the firmware

Create a plan for device and cellular component firmware updates .................................................. 80
Update the device and the cellular firmware using XCTU ................................................................. 81
  Update the device and cellular firmware using XCTU and USB Direct access .................................. 81
Update the device firmware ......................................................... 83
  Update the firmware from the Devices page in Remote Manager ....................................................... 83
  Update the firmware using web services in Remote Manager ............................................................ 84
  Use a host processor to update the modem firmware for XBee 3 devices over UART prior to *10 .... 86
  Use a host processor to update the device firmware for XBee 3 devices over UART after *10 ........... 88
Update the cellular firmware ....................................................... 90
  Update an XBee module cellular component using FOTA ................................................................. 90
  Update an XBee module cellular component using API mode .......................................................... 92
  Update the cellular module from a PC using the EasyFlash Firmware Update ................................. 95

Technical specifications

Interface and hardware specifications ........................................ 97
  Cellular RF characteristics .................................................... 97
  Bluetooth RF characteristics ................................................ 97
  Cellular networking specifications ........................................ 97
  Power requirements ........................................................... 98
  Power consumption .......................................................... 99
  Electrical specifications ....................................................... 100
  Regulatory approvals .......................................................... 101

Hardware

  Mechanical drawings .......................................................... 103
  Pin signals ........................................................................ 103
    Pin connection recommendations ...................................... 104
  RSSI PWM ......................................................................... 105
  SIM card .......................................................................... 105
  Associate LED functionality ................................................. 105
  Development boards .......................................................... 107
    XBIB-U-DEV reference ..................................................... 107
    XBIB-CU-TH reference .................................................... 109
    XBIB-C-GPS reference ..................................................... 112
    Interface with the XBIB-C-GPS module ............................... 113

Antenna recommendations

  Antenna placement ............................................................. 115
Design recommendations

- Cellular component firmware updates ........................................... 117
- Power supply considerations ...................................................... 117
- Minimum connection diagram ..................................................... 117
- Heat considerations and testing .................................................. 118
- Custom configuration: Create a new factory default ...................... 118
  - Set a custom configuration .................................................. 119
  - Clear all custom configurations on a device ......................... 119
- Clean shutdown ........................................................................... 119
  - SD (Shutdown) command .................................................... 119
  - Sleep feature ........................................................................ 120
  - Airplane mode ...................................................................... 120

Cellular connection process

- Connecting .................................................................................. 122
  - Cellular network .................................................................... 122
  - Data network connection ....................................................... 122
  - Data communication with remote servers (TCP/UDP) .............. 122
- Disconnecting ............................................................................ 123

Modes

- Select an operating mode .......................................................... 125
- Transparent operating mode ....................................................... 126
- API operating mode ................................................................... 126
- Command mode ........................................................................ 126
  - Enter Command mode ........................................................ 126
  - Troubleshooting .................................................................... 127
  - Send AT commands .............................................................. 127
  - Response to AT commands ................................................... 127
  - Apply command changes ....................................................... 128
  - Make command changes permanent .................................... 128
  - Exit Command mode ............................................................. 128
- MicroPython mode ...................................................................... 128
- USB direct mode ....................................................................... 129
  - Configure the data pins ........................................................ 129
  - Enable USB direct mode ....................................................... 129
- Bypass operating mode (DEPRECATED) ...................................... 132
  - Enter Bypass operating mode ............................................... 133
  - Leave Bypass operating mode .............................................. 133
  - Restore cellular settings to default in Bypass operating mode .. 133

Sleep modes

- About sleep modes ................................................................. 135
- Normal mode .......................................................................... 135
- Pin sleep mode ......................................................................... 135
- Cyclic sleep mode ..................................................................... 135
- Cyclic sleep with pin wake up mode ....................................... 135
- SPI mode and sleep pin functionality ......................................... 135
### Power saving features and design recommendations

<table>
<thead>
<tr>
<th>Feature</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airplane mode</td>
<td>138</td>
</tr>
<tr>
<td>Power Saving Mode (PSM)</td>
<td>138</td>
</tr>
<tr>
<td>PSM behavior</td>
<td>138</td>
</tr>
<tr>
<td>Low voltage shutdown</td>
<td>138</td>
</tr>
<tr>
<td>Deep Sleep mode</td>
<td>140</td>
</tr>
</tbody>
</table>

### Serial communication

<table>
<thead>
<tr>
<th>Feature</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serial interface</td>
<td>142</td>
</tr>
<tr>
<td>Serial data</td>
<td>142</td>
</tr>
<tr>
<td>UART data flow</td>
<td>142</td>
</tr>
<tr>
<td>Serial buffers</td>
<td>143</td>
</tr>
<tr>
<td>CTS flow control</td>
<td>143</td>
</tr>
<tr>
<td>RTS flow control</td>
<td>143</td>
</tr>
<tr>
<td>Enable UART or SPI ports</td>
<td>143</td>
</tr>
<tr>
<td>I2C</td>
<td>144</td>
</tr>
</tbody>
</table>

### SPI operation

<table>
<thead>
<tr>
<th>Feature</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPI communications</td>
<td>146</td>
</tr>
<tr>
<td>Full duplex operation</td>
<td>147</td>
</tr>
<tr>
<td>Low power operation</td>
<td>148</td>
</tr>
<tr>
<td>Select the SPI port</td>
<td>148</td>
</tr>
<tr>
<td>Force UART operation</td>
<td>149</td>
</tr>
<tr>
<td>Data format</td>
<td>149</td>
</tr>
</tbody>
</table>

### File system

<table>
<thead>
<tr>
<th>Feature</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overview of the file system</td>
<td>151</td>
</tr>
<tr>
<td>Directory structure</td>
<td>151</td>
</tr>
<tr>
<td>Paths</td>
<td>151</td>
</tr>
<tr>
<td>Secure files</td>
<td>151</td>
</tr>
<tr>
<td>XCTU interface</td>
<td>152</td>
</tr>
<tr>
<td>Encrypt files</td>
<td>152</td>
</tr>
</tbody>
</table>

### Socket behavior

<table>
<thead>
<tr>
<th>Feature</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supported sockets</td>
<td>154</td>
</tr>
<tr>
<td>Best practices when using sockets</td>
<td>154</td>
</tr>
<tr>
<td>Sockets and Remote Manager</td>
<td>154</td>
</tr>
<tr>
<td>Sockets and API mode</td>
<td>154</td>
</tr>
<tr>
<td>Socket timeouts</td>
<td>154</td>
</tr>
<tr>
<td>Socket limits in API mode</td>
<td>155</td>
</tr>
<tr>
<td>Enable incoming TCP sockets in API mode</td>
<td>155</td>
</tr>
<tr>
<td>API mode behavior for outgoing TCP and TLS connections</td>
<td>155</td>
</tr>
<tr>
<td>API mode behavior for outgoing UDP data</td>
<td>156</td>
</tr>
<tr>
<td>API mode behavior for incoming TCP connections</td>
<td>156</td>
</tr>
</tbody>
</table>
API mode behavior for incoming UDP data ........................................... 157
Transparent mode behavior for outgoing TCP and TLS connections ............. 157
Transparent mode behavior for outgoing UDP data .................................... 158
Transparent mode behavior for incoming TCP connections ......................... 158
Transparent mode behavior for incoming UDP connections ......................... 158

Extended Socket frames

Examples ........................................................................................................ 159
Available Extended Socket frames ............................................................... 160
Extended Socket example: Single HTTP Connection ...................................... 160
  Send a Socket Create frame ................................................................. 160
  Receive a Socket Create response ......................................................... 161
  Send Socket Connect ............................................................................. 161
  Receive a Socket Connect Response ....................................................... 161
  Receive a Socket Status ......................................................................... 162
  Send HTTP Request using Socket Send frame ......................................... 162
  Receive TX Status ................................................................................ 163
  Receive one or more Receive Data frames ............................................. 163
  Receive Socket Status indicating closed connection ................................ 164
Extended Socket example: UDP ................................................................. 164
  Send a Socket Create frame ................................................................. 164
  Receive a Socket Create response ......................................................... 165
  Bind local source address ..................................................................... 165
  Receive Bind/Listen Response ............................................................... 165
  Send to Digi echo server ...................................................................... 166
  Receive TX Status ................................................................................ 166
  Receive echoed data ............................................................................. 166
  Send to Digi time server ..................................................................... 167
  Receive TX Status ................................................................................ 167
  Receive daytime value ........................................................................... 167
  Close the socket ................................................................................ 168
  Receive close response ........................................................................ 168
Extended Socket example: TCP Listener ...................................................... 169
  Send a Socket Create frame ................................................................. 169
  Receive a Socket Create response ......................................................... 169
  Designate the socket as a listener ......................................................... 169
  Receive a Socket Bind/Listen Response .................................................. 170
  Making a connection to the listener socket ............................................. 170
  Receiving Data from the new socket ..................................................... 171
  Receive a Socket Status indicating closed connection ............................ 171

Transport Layer Security (TLS)

Specifying TLS keys and certificates ........................................................ 174
Transparent mode and TLS ....................................................................... 175
API mode and TLS .................................................................................... 175
Key formats ............................................................................................... 175
Certificate formats .................................................................................... 175
Certificate limitations ................................................................................. 175
Cipher suites ............................................................................................. 176
Server Name Indication (SNI) ................................................................... 176
Secure the connection between an XBee and Remote Manager with server authentication ................................................................. 176
  Step 1: Get the certificate ..................................................................... 177
Step 2: Configure device ................................................................. 177
Step 3: Verify that authentication is being performed ................................ 177

AT commands

Special commands ................................................................. 180
  AC (Apply Changes) ............................................................... 180
  FR (Force Reset) ................................................................. 180
  RE (Restore Defaults) ............................................................ 180
  SD (Shutdown) ................................................................. 181
  WR (Write) ................................................................. 181

Cellular commands ................................................................. 182
  PH (Phone Number) ............................................................... 182
  S# (ICCID) ................................................................. 182
  IM (IMEI) ................................................................. 182
  II (Subscriber identity) .......................................................... 182
  MN (Operator) ................................................................. 182
  MV (Modem Firmware Version) .................................................. 183
  DB (Cellular Signal Strength) .................................................... 183
  DT (Cellular Network Time) ..................................................... 183
  AN (Access Point Name) .......................................................... 184
  CP (Carrier Profile) ............................................................... 184
  BM (Bandmask) (LTE-M) .......................................................... 185
  BN (Bandmask) (NB-IoT) .......................................................... 185
  AM (Airplane Mode) ............................................................... 186
  N# (Preferred Network Technology) .............................................. 186
  SQ (Reference Signal Received Quality) ........................................ 186
  SW (Reference Signal Received POWER) ........................................ 187
  PN (SIM PIN) ................................................................. 187
  PK (SIM PUK) ................................................................. 187
  CU (Cellular user name) .......................................................... 188
  CW (Cellular password) .......................................................... 188

Network commands ................................................................. 189
  IP (IP Protocol) ................................................................. 189
  TL (TLS Protocol Version) ......................................................... 189
  $0 (TLS Profile 0) ................................................................. 190
  $1 (TLS Profile 1) ................................................................. 190
  $2 (TLS Profile 2) ................................................................. 190
  TM (IP Client Connection Timeout) ............................................. 191
  TS (IP Server Connection Timeout) .............................................. 191
  DO (Device Options) .............................................................. 191
  DX (Requested eDRX cycle length) ............................................. 192
  D? (Network-provided eDRX cycle length) ..................................... 193

Addressing commands ............................................................. 194
  SH (Serial Number High) .......................................................... 194
  SL (Serial Number Low) .......................................................... 194
  MY (Module IP Address) ........................................................ 194
  P# (Destination Phone Number) ................................................. 194
  N1 (DNS Address) ............................................................... 195
  N2 (DNS Address) ............................................................... 195
  DL (Destination Address) ......................................................... 195
  OD (Operating Destination Address) ........................................... 195
  DE (Destination port) ............................................................ 196
  C0 (Source Port) ................................................................. 196
  LA (Lookup IP Address of FQDN) .............................................. 196
Serial interfacing commands ................................................................. 197
  BD (Baud Rate) .................................................................................. 197
  NB (Parity) ......................................................................................... 197
  SB (Stop Bits) .................................................................................... 198
  RO (Packetization Timeout) ............................................................... 198
  TD (Text Delimiter) ........................................................................... 198
  FT (Flow Control Threshold) ............................................................ 198
  AP (API Enable) .................................................................................. 199
  IB (Cellular Component Baud Rate) .................................................. 199
I/O settings commands ............................................................................ 201
  D0 (DIO0/AD0) ................................................................................... 201
  D1 (DIO1/AD1) ................................................................................... 201
  D2 (DIO2/AD2) ................................................................................... 202
  D3 (DIO3/AD3) ................................................................................... 202
  D4 (DIO4) ........................................................................................... 202
  D5 (DIO5/ASSOCIATED_INDICATOR) ............................................. 203
  D6 (DIO6/RTS) ................................................................................... 203
  D7 (DIO7/CTS) ................................................................................... 203
  D8 (DIO8/SLEEP_REQUEST) ............................................................ 204
  D9 (DIO9/ON_SLEEP) ......................................................................... 204
  P0 (DIO10/PWM0 Configuration) ..................................................... 205
  P1 (DIO11/PWM1 Configuration) ..................................................... 205
  P2 (DIO12 Configuration) ................................................................. 206
  P3 (DIO13/DOUT) .............................................................................. 206
  P4 (DIO14/DIN) ................................................................................ 207
  PD (Pull Direction) ............................................................................ 207
  PR (Pull-up/down Resistor Enable) .................................................. 207
  M0 (PWM0 Duty Cycle) ..................................................................... 208
  M1 command ..................................................................................... 209
I/O sampling commands ............................................................................ 210
  TP (Temperature) ............................................................................. 210
  IS (Force Sample) ............................................................................. 210
Sleep commands ...................................................................................... 212
  SM (Sleep Mode) .............................................................................. 212
  SP (Sleep Period) .............................................................................. 212
  ST (Wake Time) ................................................................................. 212
  PA (Requested Active Timer) ............................................................ 213
  PU (Requested Tracking Area Update Timer) .................................... 213
Command mode options ........................................................................... 214
  CC (Command Sequence Character) ................................................. 214
  CT (Command Mode Timeout) ........................................................... 214
  CN (Exit Command mode) ............................................................... 214
  GT (Guard Times) ............................................................................... 214
MicroPython commands ........................................................................... 216
  PS (Python Startup) ........................................................................... 216
  PY (MicroPython Command) ............................................................ 216
Firmware version/information commands .............................................. 218
  VR (Firmware Version) ..................................................................... 218
  VL (Verbose Firmware Version) ....................................................... 218
  HV (Hardware Version) .................................................................... 218
  HS (Hardware Series) ....................................................................... 218
  CK (Configuration CRC) .................................................................. 218
  AI (Association Indication) .............................................................. 219
  FI (FTP OTA Update Indication) ...................................................... 219
  FO (FTP OTA command) .................................................................... 220
Diagnostic interface commands ................................................................. 222
  DI (Remote Manager Indicator) ............................................................ 222
  CI (Protocol/Connection Indication) ....................................................... 222
  AS (Active scan for network environment data) ....................................... 224
Execution commands .............................................................................. 226
  NR (Network Reset) .............................................................................. 226
  !R (Modem Reset) ................................................................................ 226
File system commands ............................................................................ 227
  Error responses .................................................................................... 227
  ATFS (File System) .............................................................................. 227
  ATFS PWD ............................................................................................ 227
  ATFS CD directory ................................................................................ 227
  ATFS MD directory ................................................................................ 227
  ATFS LS [directory] ................................................................................ 227
  ATFS PUT filename ................................................................................ 228
  ATFS XPUT filename ............................................................................ 228
  ATFS HASH filename ............................................................................ 228
  ATFS GET filename ................................................................................ 228
  ATFS MV source_path dest_path ............................................................ 228
  ATFS RM file_or_directory .................................................................. 228
  ATFS INFO .......................................................................................... 228
  ATFS FORMAT confirm ....................................................................... 229
BLE commands ........................................................................................ 230
  BI (Bluetooth Identifier) ........................................................................ 230
  BL (Bluetooth MAC address) .................................................................. 230
  BT (Bluetooth enable) ........................................................................... 230
  $S (SRP Salt) ........................................................................................ 230
  $V, $W, $X, $Y (SRP password verifier) .................................................. 231
Remote Manager commands ..................................................................... 232
  DF (Remote Manager Status Check Interval) ......................................... 232
  EQ (Remote Manager FQDN) .................................................................. 232
  K1 (Remote Manager Server Send Keepalive) ....................................... 232
  K2 (Remote Manager Device Send Keepalive) ........................................ 232
  MO (Remote Manager Options) ............................................................. 233
  $D (Remote Manager certificate) ............................................................ 233
  RI (Remote Manager Service ID) ........................................................... 233
  DP (Remote Manager Phone Number) .................................................... 234
  HF (Health Metrics Reporting Frequency) .............................................. 234
  HM (Health Metrics) ............................................................................ 234
System commands .................................................................................... 235
  KL (Device Location) ............................................................................ 235
  KP (Device Description) ........................................................................ 235
  KC (Contact Information) ...................................................................... 235
Socket commands ..................................................................................... 236
  SI (Socket Info) .................................................................................... 236
Power measurement commands .............................................................. 237
  %V command ....................................................................................... 237
  %L (Low voltage shutdown base threshold) ........................................ 237
  %M (Low voltage shutdown reset offset) .............................................. 238

Operate in API mode

  API mode overview ............................................................................... 240
  Use the AP command to set the operation mode ..................................... 240
  API frame format .................................................................................. 240
API operation (AP parameter = 1) ............................................................. 240
API operation with escaped characters (AP parameter = 2) ......................... 241

API frames

AT Command - 0x08 .......................................................... 245
AT Command: Queue Parameter Value - 0x09 ............................... 246
Transmit (TX) SMS - 0x1F ............................................. 247
Transmit (TX) Request: IPv4 - 0x20 ................................. 248
Tx Request with TLS Profile - 0x23 ................................ 250
AT Command Response - 0x88 ........................................ 252
Transmit (TX) Status - 0x89 .................................. 253
Modem Status - 0x8A .............................................. 255
Receive (RX) Packet: SMS - 0x9F .................................. 256
Receive (RX) Packet: IPv4 - 0xB0 ................................ 257
User Data Relay - 0x2D ........................................ 258
Example use cases ....................................................... 258
User Data Relay Output - 0xAD .................................. 260
BLE Unlock API - 0x2C ........................................ 261
Example sequence to perform AT Command XBee API frames over BLE .... 263
BLE Unlock Response - 0xAC ........................................ 265
Socket Create - 0x40 ................................................ 266
Socket Create Response - 0xC0 ..................................... 267
Socket Option Request - 0x41 .......................................... 268
Socket Option Response - 0xC1 ....................................... 269
Socket Connect - 0x42 ............................................. 270
Socket Connect Response - 0xC2 ..................................... 271
Socket Close - 0x43 .................................................. 272
Socket Close Response - 0xC3 ....................................... 273
Socket Send (Transmit) - 0x44 ......................................... 274
Socket SendTo (Transmit Explicit Data): IPv4 - 0x45 ............... 275
Socket Bind/Listen - 0x46 ............................................... 276
Socket Listen Response - 0xC6 ...................................... 277
Socket New IPv4 Client - 0xCC ................................... 278
Socket Receive - 0xCD ............................................. 279
Socket Receive From: IPv4 - 0xCE .................................. 280
Socket Status - 0xCF ............................................. 281

Troubleshooting

Cannot find the serial port for the device ........................................ 283
Condition .......................................................... 283
Solution ............................................................. 283
Other possible issues ......................................................... 284
Enable Virtual COM port (VCP) on the driver ................................ 284
Correct a macOS Java error .................................................. 285
Condition .......................................................... 285
Solution ............................................................. 285
Unresponsive cellular component in Bypass mode ......................... 286
Condition .......................................................... 286
Solution ............................................................. 286
Syntax error at line 1 ...................................................... 286
Solution ............................................................. 286
Error Failed to send SMS .................................................. 286
### Network connection issues
- Condition ......................................................... 287
- Solution ......................................................... 287

### Brownout issue
- Voltage brownout ........................................... 287
- Power-on discontinuities .................................... 287
- How to distinguish revision B parts ....................... 287

### Hardware flow control in Bypass mode
- Solution ......................................................... 288

### Baud rate in Bypass mode
- Solution ......................................................... 288

### Socket leaks
- Condition ......................................................... 288
- Solution ......................................................... 288

### Regulatory information

**United States (FCC)** .................................................. 291
- OEM labeling requirements ................................... 291
- FCC notices ....................................................... 291
- FCC-approved antennas ...................................... 292
- RF exposure ...................................................... 292
- FCC publication 996369 related information .......... 293

**Innovation, Science and Economic Development Canada (ISED)** ........................................... 294
- Labeling requirements ........................................ 294
- RF Exposure ....................................................... 294

**CE mark (Europe)** .................................................. 295
The XBee Smart Modem provides OEMs with a simple way to integrate low-power cellular connectivity into their devices. Features include:

- FCC certified and carrier end-device certified
- Excellent coverage and building penetration
- Manage and configure with XCTU and Digi Remote Manager®
- Available with Digi provided SIM cards and data plans
- Digital I/O support
- Analog input support
- API and Transparent mode
- Command mode
- Bypass to the raw cellular modem
- SMS: Some carriers do not support SMS on LTE-M and/or NB-IoT. Check with your carrier for details.
- TCP/UDP (up to six sockets)
- TLS (up to six sockets)
- Incoming connections
- MicroPython
  - On-module programmability to add local intelligence
  - Many examples in the Digi MicroPython Programming Guide
  - AT commands for managing run-time behavior
- Low power modes
- LTE power save mode (PSM)
- Deep sleep mode
- Pin sleep support
- Cyclic sleep support
- Airplane mode support
- Digi TrustFence secure boot
- Multi-network capability (Verizon, AT&T)
Applicable firmware and hardware

This manual supports the following firmware:

- 114xx and above

Note This manual uses the placeholder value "xx" in the firmware versions listed above, as the manual documents the released features as of the time of its writing. Digi International periodically releases new firmware containing bug fixes and new features. As new firmware is released and distributor stock is refreshed, the new firmware will gradually become available without the need to update. However, no guarantees can be made that a specific version of the firmware will be populated on any given XBee as delivered. If a specific revision is desired, it is the user’s responsibility to ensure that version is loaded onto all XBees purchased.

Note You must upgrade your device to the latest firmware for all features to be available. See Update the firmware.

It supports the following hardware:

- XB3-C-A2-UT-xxx

SIM cards

The XBee Smart Modem requires a 4FF (Nano) size SIM card. The SIM interface supports both 1.8 V and 3 V SIM types.

NB-IoT network

NB-IoT network is supported by XBee 3 Cellular. Note the following:

- NB-IoT does not support roaming. You cannot roam between networks.
- For NB-IoT, TCP support is dependent on the network. Contact your network provider for details.
- For NB-IoT, SMS support is dependent on the network. Contact your network provider for details.
- Digi Remote Manager® requires TCP and will not work with NB-IoT unless the network supports TCP.
- The SIM card in the device determines whether the device supports NB-IoT, LTE-M, or both.
Get started with the XBee Smart Modem

This section describes how to connect the hardware in the XBee, and provides some examples you can use to communicate with the device.
You should perform all of the steps below in the order shown.

1. Identify the kit contents
2. Determine cellular service and acquire a SIM card
3. Connect the hardware
4. Install and upgrade XCTU
5. Use one of the following methods to verify your cellular connection:
   - Connect to the Echo server
   - Connect to the ELIZA server
   - Connect to the Daytime server

Optional steps
You can review the information in these steps for more XBee connection examples and examples of how to use MicroPython.

1. Review additional connection examples to help you learn how to use the device. See XBee connection examples.
2. Review introductory MicroPython examples. You can use MicroPython to enhance the intelligence of the XBee to enable you to do edge-computing by adding business logic in MicroPython, rather than using external components.
   - Example: hello world
   - Example: turn on an LED
Identify the kit contents

The Developer's kit includes the following:

One XBIB-U-DEV board

One 12 V power supply

One cellular antenna with U.FL connector

One Bluetooth Low Energy (BLE) antenna

One USB cable

One XBee Smart Modem

Note The XBee Smart Modem comes attached to the board in ESD wrap.

One SIM card

Note NB-IoT kits (Digi product number XK3-C-N1-UT-E) do not include a SIM card. Contact your NB-IoT mobile carrier provider to obtain a SIM card and service. See Determine cellular service and acquire a SIM card.
Determine cellular service and acquire a SIM card

You need cellular service to use your XBee. Depending on the device that you purchased, your kit may not include a SIM card.

**Note** If your kit came with a SIM card, you can skip this section. If you are interested in purchasing a Cellular Bundled Service plan from Digi, see Cellular service.

If your kit does not include a SIM card, the following sections below explain how to purchase a SIM card in the US and Europe.

**US customers**

In the US, Digi XBee® 3 Cellular LTE-M/NB-IoT works with AT&T, Verizon, and T-Mobile. You must purchase a SIM card before you can connect the hardware. Contact Digi Sales at www.digi.com/contactus for information about obtaining a SIM card and activating cellular service. After you have purchased your SIM card, you must get the APN from the carrier. You will need this information when you get service. See Configure your module for cellular connectivity.

**European customers**

If you are using the LTE-M/NB-IoT European kit, you must purchase a SIM card before you can connect the hardware. Contact your mobile carrier provider to obtain a SIM card and service.

- Vodafone: www.vodafone.com
- Deutsche Telekom: www.telekom.com/en

After you have purchased your SIM card, you can get the APN (if needed by your carrier), network bands, and supported channels from the carrier. You will need this information when configuring the device from the SIM card and service you have selected. See Configure your module for cellular connectivity.

**Cellular service**

Digi now offers Cellular Bundled Service plans. This service includes pre-configured cellular data options that are ideal for IoT applications, bundled together with Digi Remote Manager for customers who want to remotely monitor and manage their devices.

**Note** The Digi Cellular Bundled Service plan is not offered for NB-IoT. Contact Digi for more information about Digi Cellular Bundled Service.

To learn more, or obtain the plan that is right for your needs, contact us:

- By phone: 1-877-890-4014 (USA/toll free) or +1-952-912-3456 (International). Select the Wireless Plan Support or Activation option in the menu.
- By email: Data.Plan.QuoteDesk@digi.com.

The XBee Cellular kit includes six months of free cellular service. Six months of free cellular service assumes a rate of 5 MB/month. If you exceed a limit of 30 MB during the six month period your SIM will be deactivated.

**Note** The NB-IoT kit does not include free cellular service. Note that carriers put limits on your data service. Exceeding the allotted usage may result in automatic suspension or termination of service.
Connect the hardware

1. The XBee Smart Modem should already be plugged into the development board. For more information about development boards, see Development boards.
2. If a SIM card is included with the kit, the card is inserted into the XBee. If a SIM card is not included, install the SIM card into the XBee before attaching the XBee device to the board.

   Note Some kits do not include a SIM card. Contact your mobile carrier provider to obtain a SIM card and service. See Determine cellular service and acquire a SIM card.

   WARNING! Never insert or remove the SIM card while the device is powered!

3. Attach the XBee device to the board.
4. Connect the antennas.
   a. Connect the cellular antenna.
   b. Connect the BLE antenna if you are using BLE functionality. If you are not, you do not have to connect the BLE antenna.
**Note** Align the U.FL connectors carefully, then firmly press straight down to seat the connector. You should hear a snap when the antenna attaches correctly. U.FL is fragile and is not designed for multiple insertions, so exercise caution when connecting or removing the antennas. We recommend using a U.FL removal tool.

5. Plug the 12 V power supply to the power jack on the development board. The LED indicator blinks when the board is powered.

6. Connect the USB cable from a PC to the USB port on the development board. The computer searches for a driver, which can take a few minutes to install. If you have trouble downloading the USB driver, see Other possible issues.

## Install and upgrade XCTU

XBeesConfiguration and Test Utility (XCTU) is a multi-platform program developed by Digi that enables users to interact with Digi radio frequency (RF) devices through a graphical interface. The application includes built-in tools that make it easy to set up, configure, and test Digi RF devices.

XCTU does not work directly over an SPI interface.

You can use XCTU to update the device firmware, and if needed, XCTU will attempt to update your cellular firmware. Firmware is the program code stored in the device's persistent memory that provides the control program for the device.

For instructions on downloading and using XCTU, see the [XCTU User Guide](#).

**Note** If you are on a macOS computer and encounter problems installing XCTU, see [Correct a macOS Java error](#).

### Step 1: Install and upgrade XCTU

You can use XCTU to update the device firmware.

1. To use XCTU, you may need to install FTDI Virtual COM port (VCP) drivers onto your computer. Click [here](#) to download the drivers for your operating system.

2. Upgrade XCTU to the latest version. This step is required.

### Step 2: Add a device to XCTU

You must add a device to XCTU before you can update the device's firmware or configure the device from XCTU.

## Add a device to XCTU

These instructions show you how to add the XBee to XCTU.

If XCTU does not find your serial port, see [Cannot find the serial port for the device](#) and [Enable Virtual COM port (VCP) on the driver](#).

1. Launch XCTU

**Note** XCTU's **Update the radio module firmware** dialog box may open and will not allow you to continue until you click **Update** or **Cancel** on the dialog.
2. Click Help > Check for XCTU Updates to ensure you are using the latest version of XCTU.
3. Click the Discover radio modules button in the upper left side of the XCTU screen.
4. In the Discover radio devices dialog, select the serial ports where you want to look for XBee modules, and click Next.
5. In the Set port parameters window, maintain the default values and click Finish.
6. As XCTU locates radio modules, they appear in the Discovering radio modules dialog box.
7. Select the device(s) you want to add and click Add selected devices.

If your module could not be found, XCTU displays the Could not find any radio module dialog providing possible reasons why the module could not be added.

Update the device and cellular firmware using XCTU

You should use XCTU to update the device firmware on your XBee 3 to the most recent version. This ensures that you can take advantage of all the latest fixes and features. XCTU will update the device firmware, and if needed, XCTU will attempt to update your cellular firmware. Upgrading the cellular component firmware requires USB Direct.

Update the device and cellular firmware using XCTU and USB Direct access.

Configure your module for cellular connectivity

Note LTE-M is configured by default. You can skip this section if you are using LTE-M.

If you are using an NB-IoT kit, you must configure the device to use NB-IoT.

**US customers**

Note Some carriers require an APN. If the carrier does not require an APN, you should not change the APN from the default

1. Click the Configuration working modes button.
2. Select an XBee module from the Radio Modules list.
3. Set the APN using the AN command. You should get the APN from your carrier when you purchased your SIM card. See Determine cellular service and acquire a SIM card.
4. To set the APN, in the AN field, type the APN value from your carrier and click the Write button.

**European customers**

Note Some carriers require an APN. If the carrier does not require an APN, you should not change the APN from the default

1. Click the Configuration working modes button.
2. Select an XBee module from the Radio Modules list.
3. Set the APN using the AN command. You should get the APN from your carrier when you purchased your SIM card. See Determine cellular service and acquire a SIM card.

   To set the APN, in the **AN** field, type the APN value from your carrier and click the **Write** button.

4. Set the N# parameter to 3. In the **N#** field, select **NB-IoT Only [3]** and click the **Write** button.

5. Enable the bands. The bands are specified as a bit mask given as a hexadecimal value.

   To enable bands 8 and 20, in the **BN** field, enter **80080** and click the **Write** button.

6. To set the **CP**, in the **CP** field, select **No Profile (1)** and click the **Write** button.

7. Reset the module with either the **reset button** or issue the **FR command**.

8. Wait for a connection. You may wait for up to 5-6 minutes.

   - **If you have a connection**: This process is complete. The LED on the development board blinks when the XBee is registered to the cellular network. See Check for cellular registration and connection.
   - **If you do not have a connection**: If the LED remains solid, registration has not occurred properly.
     a. Repeat steps 1-5 to make sure you have correctly configured NB-IoT.
     b. If you still do not have a connection, contact your carrier to confirm that the carrier has correctly configured the service.
        i. If the carrier makes a change to the service, reset the module and wait 5-6 minutes.
        ii. If the carrier does not make a change to the service, then contact Digi support.

---

**Check for cellular registration and connection**

In the following examples, proper cellular network registration and address assignment must occur successfully. The LED on the development board blinks when the XBee is registered to the cellular network; see **Associate LED functionality**. If the LED remains solid, registration has not occurred properly.

Registration typically takes 5 - 6 minutes the first time a device is connected to the network.

**Note** Make sure you are in an area with adequate cellular network reception or the XBee will not make the connection.

**Note** Check the antenna connections if the device has trouble connecting to the network.

In addition to the LED confirmation, you can check the AT commands below in XCTU to check the registration and connection.

To view these commands:

1. You must have previously added at least one device. See **Add a device to XCTU**.
2. Open XCTU.
3. Click the **Configuration working mode** button.
4. Select a device from the **Radio Modules** list. XCTU displays the current firmware settings for that device.

**Note** To search for an AT command in XCTU, use the search box 🔍.

The relevant commands are:

- **AI (Association Indication)** reads **0** when the device successfully registers to the cellular network. If it reads **23** it is connecting to the Internet; **22** means it is registering to the cellular network.
- **MY (Module IP Address)** should display a valid IP address. If it reads **0.0.0.0**, it has not registered yet.

**Note** To read a command's value, click the **Read** button 🔄 next to the command.
XBee connection examples

The following examples provide some additional scenarios you can try to get familiar with the XBee. These examples are focused on inter-operating with a host processor to drive the XBee.
If you are interested in using the intelligence built into the XBee, see Get started with MicroPython.

Note Some carriers restrict your internet access. If access is restricted, running some of these examples may not be possible. Check with your carrier provider to determine whether internet access is restricted.

Connect to the Echo server  .................................................................26
Connect to the ELIZA server .................................................................28
Connect to the Daytime server ...............................................................30
Perform a (GET) HTTP request .............................................................32
Connect to a TCP/IP address .................................................................33
Debugging .........................................................................................34
Software libraries .............................................................................34
Connect to the Echo server

This server echoes back the messages you type. You may use TCP or UDP, depending on the protocols supported by your network carrier.

**Note** For help with debugging, see Debugging.

The following table explains the AT commands that you use in this example.

<table>
<thead>
<tr>
<th>At command</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>IP (IP Protocol)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>TCP:</td>
<td>Set the expected transmission mode to TCP communications.</td>
</tr>
<tr>
<td>0</td>
<td>UDP:</td>
<td>Set the expected transmission mode to UDP communications.</td>
</tr>
<tr>
<td><strong>TD (Text Delimiter)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D (0x0D)</td>
<td>The text delimiter to be used for Transparent mode, as an ASCII hex code.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>No information is sent until this character is entered, unless the</td>
<td></td>
</tr>
<tr>
<td></td>
<td>maximum number of characters has been reached. Set to 0 to disable</td>
<td></td>
</tr>
<tr>
<td></td>
<td>text delimiter checking. Set to D for a carriage return.</td>
<td></td>
</tr>
<tr>
<td><strong>DL (Destination Address)</strong></td>
<td>52.43.121.77</td>
<td>The target IP address of the echo server.</td>
</tr>
<tr>
<td><strong>DE (Destination Port)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0x2329</td>
<td>TCP:</td>
<td>The target port number of the TCP echo server. This port in decimal is 9001.</td>
</tr>
<tr>
<td>0x2711</td>
<td>UDP:</td>
<td>The target port number of the UDP echo server. This port in decimal is 10001.</td>
</tr>
</tbody>
</table>

To communicate with the Echo server:

1. Ensure that the device is set up correctly with the SIM card installed and the antennas connected as described in Connect the hardware.
2. Open XCTU and Add a device to XCTU.
3. Click the Configuration working mode button.
4. Select a device from the Radio Modules list. XCTU displays the current firmware settings for that device.
5. To switch to TCP communication, in the IP field, select 1 and click the Write button.
6. To enable the XBee to recognize carriage return as a message delimiter, in the TD field, type D and click the Write button.
7. To enter the destination address of the echo server, in the DL field, type 52.43.121.77 and click the Write button.
8. To enter the destination IP port number, in the DE field, type 2329 and click the Write button.

**Note** XCTU does not follow the standard hexadecimal numbering convention. The leading 0x is not needed in XCTU.
9. Click the **Consoles working mode** button on the toolbar to open a serial console to the device. For instructions on using the Console, see the AT console topic in the **XCTU User Guide**.

10. Click the **Open** button to open a serial connection to the device.
11. Click in the left pane of the **Console log**, then type in the Console to talk to the echo server. The following screenshot provides an example of this chat.
**Connect to the ELIZA server**

You can use the XBee to chat with the ELIZA Therapist Bot. ELIZA is an artificial intelligence (AI) bot that emulates a therapist and can perform simple conversations.

**Note** For help with debugging, see Debugging.

The following table explains the AT commands that you use in this example.

<table>
<thead>
<tr>
<th>At command</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>IP (IP Protocol)</td>
<td>1</td>
<td>Set the expected transmission mode to TCP communications.</td>
</tr>
<tr>
<td>DL (Destination Address)</td>
<td>52.43.121.77</td>
<td>The target IP address of the ELIZA server.</td>
</tr>
<tr>
<td>DE (Destination Port)</td>
<td>0x2328</td>
<td>The target port number of the ELIZA server.</td>
</tr>
</tbody>
</table>

**Note** Some carriers may require whitelisted IP addresses. If this IP is not whitelisted by your carrier you will not be able to run this example.

To communicate with the ELIZA Therapist Bot:

1. Ensure that the device is set up correctly with the SIM card installed and the antennas connected as described in Connect the hardware.
2. Open XCTU and Add a device to XCTU.
3. Click the **Configuration working mode** button.
4. Select a device from the **Radio Modules** list. XCTU displays the current firmware settings for that device.
5. To switch to TCP communication, in the **IP** field, select 1 and click the **Write** button.
6. To enter the destination address of the ELIZA Therapist Bot, in the **DL** field, type **52.43.121.77** and click the **Write** button.
7. To enter the destination IP port number, in the **DE** field, type **2328** and click the **Write** button.
8. Click the **Consoles working mode** button on the toolbar to open a serial console to the device. For instructions on using the Console, see the **AT console** topic in the XCTU User Guide.
9. Click the **Open** button to open a serial connection to the device.
10. Click in the left pane of the **Console log**, then type in the Console to talk to the ELIZA Therapist Bot. The following screenshot provides an example of this chat with the user’s text in blue.
Hello. How are you feeling today?
Wonderful. How do you feel when you say that?
Like a million dollars. I see. And what does that tell you?
That I don’t need a therapist. How does that make you feel?
Connect to the Daytime server

The Daytime server reports the current Coordinated Universal Time (UTC) value responding to any user input.

**Note** For help with debugging, see Debugging.

The following table explains the AT commands that you use in this example.

<table>
<thead>
<tr>
<th>At command</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>IP (IP Protocol)</strong></td>
<td>1</td>
<td>Set the expected transmission mode to TCP communications.</td>
</tr>
<tr>
<td><strong>DL (Destination Address)</strong></td>
<td>52.43.121.77</td>
<td>The target IP of the Daytime server.</td>
</tr>
<tr>
<td><strong>DE (Destination Port)</strong></td>
<td>0x232A</td>
<td>The target port number of the Daytime server.</td>
</tr>
<tr>
<td><strong>TD (Text Delimiter)</strong></td>
<td>0</td>
<td>The text delimiter to be used for Transparent mode, as an ASCII hex code. No information is sent until this character is entered, unless the maximum number of characters has been reached. Set to zero to disable text delimiter checking.</td>
</tr>
</tbody>
</table>

To communicate with the Daytime server:

1. Ensure that the device is set up correctly with the SIM card installed and the antennas connected as described in Connect the hardware.
2. Open XCTU and Add a device to XCTU.
3. Click the **Configuration working mode** button.
4. Select a device from the **Radio Modules** list. XCTU displays the current firmware settings for that device.
5. To switch to TCP communication, in the **IP** field, select 1 and click the **Write** button.
6. To enter the destination address of the daytime server, in the **DL** field, type **52.43.121.77** and click the **Write** button.
7. To enter the destination IP port number, in the **DE** field, type **232A** and click the **Write** button.
8. To disable text delimiter checking, in the **TD** field, type **0** and click the **Write** button.
9. Click the **Consoles working mode** button on the toolbar to open a serial console to the device. For instructions on using the Console, see the **AT console** topic in the **XCTU User Guide**.
10. Click the **Open** button to open a serial connection to the device.
11. Click in the left pane of the **Console log**, then type in the Console to query the Daytime server. The following screenshot provides an example of this chat.
Perform a (GET) HTTP request

You can use the XBee to perform a GET Hypertext Transfer Protocol (HTTP) request using XCTU. HTTP is an application-layer protocol that runs over TCP. This example uses httpbin.org as the target website that responds to the HTTP request.

Note For help with debugging, see Debugging.

To perform a GET request:

1. Ensure that the device is set up correctly with the SIM card installed and the antennas connected as described in Connect the hardware.
2. Open XCTU and Add a device to XCTU.
3. Click the Configuration working mode button.
4. Select a device from the Radio Modules list. XCTU displays the current firmware settings for that device.
5. To enter the destination address of the target website, in the DL field, type httpbin.org and click the Write button.
6. To enter the HTTP request port number, in the DE field, type 50 and click the Write button. Hexadecimal 50 is 80 in decimal.
7. To switch to TCP communication, in the IP field, select 1 and click the Write button.
8. To move into Transparent mode, in the AP field, select 0 and click the Write button.
9. Wait for the AI (Association Indication) value to change to 0 (Connected to the Internet).
10. Click the Consoles working mode button on the toolbar.
11. From the AT console, click the Add new packet button in the Send packets dialog. The Add new packet dialog appears.
12. Enter the name of the data packet.
13. Type the following data in the ASCII input tab:
   
   ```
   GET /ip HTTP/1.1
   Host: httpbin.org
   ```
   
14. Click the HEX input tab and add 0A (zero A) after each OD (zero D), and add an additional OD 0A at the end of the message body. For example, copy and paste the following text into the HEX input tab:
   
   ```
   47 45 54 20 2F 69 70 20 48 54 54 50 2F 31 2E 31 0D 0A 48 6F 73 74 3A 20 68 74 74 70 62 69 6E 2E 6F 72 67 0D 0A 0D 0A
   ```
   
   Note The HTTP protocol requires an empty line (a line with nothing preceding the CRLF) to terminate the request.
15. Click Add packet.
16. Click the Open button.
17. Click **Send selected packet**.
18. A GET HTTP response from httpbin.org appears in the Console log.

## Connect to a TCP/IP address

The XBee Smart Modem can send and receive TCP messages while in Transparent mode; see [Transparent operating mode](#).

**Note** You can use this example as a template for sending and receiving data to or from any TCP/IP server.

**Note** For help with debugging, see [Debugging](#).

The following table explains the AT commands that you use in this example.

<table>
<thead>
<tr>
<th>Command</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>IP</strong> (IP Protocol)</td>
<td>1</td>
<td>Set the expected transmission mode to TCP communication.</td>
</tr>
<tr>
<td><strong>DL</strong> (Destination IP Address)</td>
<td>&lt;Target IP address&gt;</td>
<td>The target IP address that you send and receive from. For example, a data logging server’s IP address that you want to send measurements to.</td>
</tr>
<tr>
<td><strong>DE</strong> (Destination Port)</td>
<td>&lt;Target port number&gt;</td>
<td>The target port number that the device sends the transmission to. This is represented as a hexadecimal value.</td>
</tr>
</tbody>
</table>

To connect to a TCP/IP address:

1. Ensure that the device is set up correctly with the SIM card installed and the antennas connected as described in [Connect the hardware](#).
2. Open XCTU and [Add a device to XCTU](#).
3. Click the **Configuration working mode** button.
4. Select a device from the [Radio Modules](#) list. XCTU displays the current firmware settings for that device.
5. In the **IP** field, select 1 and click the **Write** button 🔄.
6. In the **DL** field, type the `<target IP address>` and click the **Write** button. The target IP address is the IP address that you send and receive from.
7. In the **DE** field, type the `<target port number>`, converted to hexadecimal, and click the **Write** button.
8. Exit Command mode.

After exiting Command mode, any UART data sent to the device is sent to the destination IP address and port number after the **RO (Packetization Timeout)** occurs.
Debugging

If you experience problems with the settings in the examples, you can load the default settings in XCTU.

**Note** If you load the default settings, you will need to reapply any configuration settings that you have previously made.

1. On the Configuration toolbar, click the **Default** button 🔄 to load the default values established by the firmware, and click **Yes** to confirm.
2. Factory settings are loaded but not written to the device. To write them, click the **Write** button 🖋 on the toolbar.

Software libraries

One way to communicate with the XBee device is by using a software library. The libraries available for use with the XBee Smart Modem include:

- XBee Java library
- XBee Python library

The XBee Java Library is a Java API. The package includes the XBee library, its source code and a collection of samples that help you develop Java applications to communicate with your XBee devices.

The XBee Python Library is a Python API that dramatically reduces the time to market of XBee projects developed in Python and facilitates the development of these types of applications, making it an easy process.
Get started with MicroPython

This section provides an overview and simple examples of how to use MicroPython with the XBee Smart Modem. You can use MicroPython to enhance the intelligence of the XBee to enable you to do edge-computing by adding business logic in MicroPython, rather than using external components.

Note For in-depth information and more complex code examples, refer to the Digi MicroPython Programming Guide.

About MicroPython ................................................................. 36
MicroPython on the XBee Smart Modem ................................................................. 36
Use XCTU to enter the MicroPython environment .................................................. 36
Use the MicroPython Terminal in XCTU ................................................................. 37
Example: hello world ......................................................................................... 37
Example: turn on an LED ..................................................................................... 37
Example: debug the secondary UART ................................................................. 38
Exit MicroPython mode .......................................................................................... 39
Other terminal programs ...................................................................................... 39
Use picocom in Linux ............................................................................................. 41
About MicroPython

MicroPython is an open-source programming language based on Python 3, with much of the same syntax and functionality, but modified to fit on small devices with limited hardware resources, such as microcontrollers, or in this case, a cellular modem.

Why use MicroPython

MicroPython enables on-board intelligence for simple sensor or actuator applications using digital and analog I/O. MicroPython can help manage battery life. Cryptic readings can be transformed into useful data, excess transmissions can be intelligently filtered out, modern sensors and actuators can be employed directly, and logic can glue inputs and outputs together in an intelligent way.

For more information about MicroPython, see www.micropython.org.
For more information about Python, see www.python.org.

MicroPython on the XBee Smart Modem

The XBee Smart Modem has MicroPython running on the device itself. You can access a MicroPython prompt from the XBee Smart Modem when you install it in an appropriate development board (XBDB or XBIB), and connect it to a computer via a USB cable.

Note MicroPython does not work with SPI.

The examples in this guide assume:

- You have XCTU on your computer. See Install and upgrade XCTU.
- You have a terminal program installed on your computer. We recommend using the Use the MicroPython Terminal in XCTU. This requires XCTU 6.3.7 or higher.
- You have an XBee Smart Modem installed in an appropriate development board, such as an XBIB-U-DEV.

Note Most examples in this guide require the XBIB-U-DEV board.

- The XBee Smart Modem is connected to the computer via a USB cable and XCTU recognizes it.
- The board is powered by an appropriate power supply, 12 VDC and at least 1.1 A.

Use XCTU to enter the MicroPython environment

To use the XBee Smart Modem in the MicroPython environment:

1. Use XCTU to add the device(s); see Install and upgrade XCTU and Add a device to XCTU.
2. The XBee Smart Modem appears as a box in the Radio Modules information panel. Each module displays identifying information about itself.
3. Click this box to select the device and load its current settings.
4. Set the device’s baud rate to 115200 b/s, in the BD field select 115200 [7] or higher and click the Write button . We recommend using flow control to avoid data loss, especially when pasting large amounts of code/text.
5. Put the XBee Smart Modem into MicroPython mode, in the AP field select MicroPython REPL [4] and click the Write button .
Get started with MicroPython

6. Note what COM port(s) the XBee Smart Modem is using, because you will need this information when you use terminal communication. The Radio Modules information panel lists the COM port in use.

Use the MicroPython Terminal in XCTU

You can use the MicroPython Terminal to communicate with the XBee Smart Modem when it is in MicroPython mode. This requires XCTU 6.3.7 or higher. To enter MicroPython mode, follow the steps in Use XCTU to enter the MicroPython environment. To use the MicroPython Terminal:

1. Click the Tools drop-down menu and select MicroPython Terminal. The terminal opens.
2. Click Open. If you have not already added devices to XCTU:
   a. In the Select the Serial/USB port area, click the COM port that the device uses.
   b. Verify that the baud rate and other settings are correct.
3. Click OK. The Open icon changes to Close , indicating that the device is properly connected.
4. Press Ctrl+B to get the MicroPython version banner and prompt.

You can now type or paste MicroPython commands at the >>> prompt.

Troubleshooting

If you receive No such port: 'Port is already in use by other applications.' in the MicroPython Terminal close any other console sessions open inside XCTU and close any other serial terminal programs connected to the device, then retry the MicroPython connection in XCTU.

If the device seems unresponsive, try pressing Ctrl+C to end any running programs.

You can use the +++ escape sequence and look for an OK for confirmation that you have the correct baud rate.

Example: hello world

Before you begin, you must have previously added a device in XCTU. See Add a device to XCTU.

1. At the MicroPython >>> prompt, type the Python command: print("Hello, World!")
2. Press Enter to execute the command. The terminal echos back Hello, World!.

Example: turn on an LED

1. Note the DS4 LED on the XBIB board. The following image highlights it in a red box. The LED is normally off.

---

1See Other terminal programs if you do not use the MicroPython Terminal in XCTU.
2. At the MicroPython >>> prompt, type the commands below, pressing Enter after each one. After entering the last line of code, the LED illuminates. Anything after a # symbol is a comment, and you do not need to type it.

Note You can easily copy and paste code from the online version of this guide. Use caution with the PDF version, as it may not maintain essential indentations.

```python
import machine
from machine import Pin
led = Pin("D4", Pin.OUT, value=0)  # Makes a pin object set to output 0.
# One might expect 0 to mean OFF and 1 to mean ON, and this is normally the case.
# But the LED we are turning on and off is setup as what is known as "active low".
# This means setting the pin to 0 allows current to flow through the LED and then through the pin, to ground.

3. To turn it off, type the following and press Enter:

```python
led.value(1)
```

You have successfully controlled an LED on the board using basic I/O.

**Example: debug the secondary UART**

This sample code is handy for debugging the secondary UART. It simply relays data between the primary and secondary UARTs.
from machine import UART
import sys, time

def uart_init():
    u = UART(1)
    u.write('Testing from XBe\n')
    return u

def uart_relay(u):
    while True:
        uart_data = u.read(-1)
        if uart_data:
            sys.stdout.buffer.write(uart_data)
        stdin_data = sys.stdin.buffer.read(-1)
        if stdin_data:
            u.write(stdin_data)
        time.sleep_ms(5)

    u = uart_init()
    uart_relay(u)

You only need to call \texttt{uart\_init()} once.
\textbf{Call \texttt{uart\_relay()} to pass data between the UARTs.}
\textbf{Send \texttt{Ctrl-C} to exit relay mode.}
\textbf{When done, call \texttt{u.close()} to close the secondary UART.}

\section*{Exit MicroPython mode}

To exit MicroPython mode:

1. In the XCTU MicroPython Terminal, click the green \texttt{Close} button.
2. Click \texttt{Close} at the bottom of the terminal to exit the terminal.
3. In XCTU's Configuration working mode, change \texttt{AP API Enable} to another mode and click the \texttt{Write} button. We recommend changing to Transparent mode [0], as most of the examples use this mode.

\section*{Other terminal programs}

If you do not use the MicroPython Terminal in XCTU, you can use other terminal programs to communicate with the XBee Smart Modem. If you use Microsoft Windows, follow the instructions for Tera Term, if you use Linux, follow the instructions for picocom. To download these programs:

- Tera Term for Windows; see https://ttssh2.osdn.jp/index.html.en.
Tera Term for Windows

With the XBee Smart Modem in MicroPython mode (AP = 4), you can access the MicroPython prompt using a terminal.

1. Open Tera Term. The Tera Term: New connection window appears.
2. Click the Serial radio button to select a serial connection.
3. From the Port: drop-down menu, select the COM port that the XBee Smart Modem is connected to.
4. Click OK. The COMxx - Tera Term VT terminal window appears and Tera Term attempts to connect to the device at a baud rate of 9600 b/s. The terminal will not allow communication with the device since the baud rate setting is incorrect. You must change this rate as it was previously set to 115200 b/s.
5. Click Setup and Serial Port. The Tera Term: Serial port setup window appears.

![Tera Term: Serial port setup window](image)

6. In the Tera Term: Serial port setup window, set the parameters to the following values:
   - **Port**: Shows the port that the XBee Smart Modem is connected on.
   - **Baud rate**: 115200
   - **Data**: 8 bit
   - **Parity**: none
   - **Stop**: 1 bit
   - **Flow control**: hardware
   - **Transmit delay**: N/A

7. Click OK to apply the changes to the serial port settings. The settings should go into effect right away.

8. To verify that local echo is not enabled and that extra line-feeds are not enabled:
   a. In Tera Term, click Setup and select Terminal.
   b. In the New-line area of the Tera Term: Serial port setup window, click the Receive drop-down menu and select CR if it does not already show that value.
   c. Make sure the Local echo box is not checked.

9. Click OK.
10. Press Ctrl+B to get the MicroPython version banner and prompt.
Now you can type MicroPython commands at the >>> prompt.

**Use picocom in Linux**

With the XBee Smart Modem in MicroPython mode \((AP = 4)\), you can access the MicroPython prompt using a terminal.

**Note** The user must have read and write permission for the serial port the XBee Smart Modem is connected to in order to communicate with the device.

1. Open a terminal in Linux and type `picocom -b 115200 /dev/ttyUSB0`. This assumes you have no other USB-to-serial devices attached to the system.
2. Press `Ctrl+B` to get the MicroPython version banner and prompt. You can also press `Enter` to bring up the prompt.

If you do have other USB-to-serial devices attached:

1. Before attaching the XBee Smart Modem, check the directory `/dev/` for any devices named `ttyUSBx`, where `x` is a number. An easy way to list these is to type: `ls /dev/ttyUSB*`. This produces a list of any device with a name that starts with `ttyUSB`.
2. Take note of the devices present with that name, and then connect the XBee Smart Modem.
3. Check the directory again and you should see one additional device, which is the XBee Smart Modem.
4. In this case, replace `/dev/ttyUSB0` at the top with `/dev/ttyUSB<number>`, where `<number>` is the new number that appeared.
5. It should connect and show Terminal ready.
Now you can type MicroPython commands at the `>>>` prompt.
Get started with BLE

BLE (Bluetooth® Low Energy) is an RF protocol that enables you to connect your XBee (server) device to another (client) device. If your device is updated to the most recent firmware, BLE enables you to connect your XBee (client) to another (server) device. The latest Digi XBee products include a dual-mode radio that allows the device to communicate through the BLE interface and the RF/Cellular network at the same time.

The XBee acts as a BLE GATT server and allows client devices, such as a cellphone or a third-party BLE device such as the Nordic nRF and SiLabs BGM, to configure the XBee or transfer data with the User Data Relay frame using the XBee API BLE Service.

The XBee does not support modifying the XBee’s GATT database. This means that the XBee cannot be configured to appear as something else, such as a temperature sensor.

On XBee 3 Cellular firmware ending in x15 or newer

The XBee supports the following BLE features:

- GATT server supporting the XBee API BLE Service and the standard Device Information Service. Note that support for these features was added in firmware ending in x10.
- Configurable BLE device name in advertisements using the ATBI command.
- Configurable BLE advertisement payload, such as beacons, using MicroPython.
- GAP (Generic Access Profile) discovery (scanning for advertisements or beacons) using MicroPython.
- GATT client support in MicroPython.
  - Connect to another BLE device (such as a sensor) using GAP.
  - Discover services, characteristics, and descriptors on the remote device’s GATT server.
  - Read and write characteristic and descriptor values. For example, read a temperature sensor.
  - Configure notifications or indications on characteristic values.

For more information, see the Digi MicroPython Programming Guide.

On XBee 3 Cellular firmware ending in x14 or older

The XBee supports the following BLE features:

- GATT server supporting the XBee API BLE Service and the standard Device Information Service.

The XBee is a GATT server only, which can be used to configure the XBee or transfer data with the User Data Relay Frame.
The XBee does not support the following:

- Scanning for advertisements or beacons.
- Connecting to another BLE device, such as a sensor or another XBee.

**Enable BLE on an XBee device**

This process explains how to enable BLE on your XBee 3 device and verify the connection.

1. Set up your XBee device, and make sure to connect the BLE antenna to the device. See Get started with the XBee Smart Modem.
2. Enable BLE and configure the BLE password using XCTU.
3. Get the Digi XBee Mobile phone application.
4. Connect with BLE and configure your XBee device.

**Note** The BLE protocol is disabled on the XBee device by default. You can create a custom factory default configuration that ensures BLE is always enabled. See Custom configuration: Create a new factory default.

**Enable BLE and configure the BLE password using XCTU**

Some of the latest XBee 3 modules support Bluetooth Low Energy (BLE) as an extra interface for configuration. If you want to use this feature, you have to enable BLE. You must also enable security by setting a BLE password on the XBee device in order to connect, configure, or send data over BLE. The BLE password is configured using XCTU. Make sure you have installed or updated XCTU to version 6.4.2. or later. Earlier versions of XCTU do not include the BLE configuration features. See Download and install XCTU for installation instructions.

Before you begin, you should determine the password you want to use for BLE on the XBee device and store it in a secure place. Digi recommends a secure password of at least 8 characters and a random combination of letters, numbers, and special characters. Digi also recommends using a security management tool such as LastPass or Keepass for generating and storing passwords for many devices.

**Note** When you enter the BLE password in XCTU, the salt and verifier values are calculated as you set your password. For more information on how these values are used in the authentication process, see BLE Unlock API - 0x2C.

1. Launch XCTU
2. Switch to Configuration working mode
3. Select a BLE compatible radio module from the device list.
4. In the Bluetooth Options section, select **Enabled [1]** from the **BT Bluetooth Enable** command drop-down.
5. Click the **Write setting** button. The **Bluetooth authentication not set** dialog appears.

   **Note** If BLE has been previously configured, the **Bluetooth authentication not set** dialog does not appear. If this happens, click **Configure** in the Bluetooth Options section to display the **Configure Bluetooth Authentication** dialog.

6. Click **Configure** in the dialog. The **Configure Bluetooth Authentication** dialog appears.

7. In the **Password** field, type the password for the device. As you type, the **Salt** and **Verifier** fields are automatically calculated and populated in the dialog as shown above. Make a note of the password, as this password is used when you connect to this XBee device via BLE using the Digi XBee Mobile app.

8. Click **OK** to save the configuration.

---

**Get the Digi XBee Mobile phone application**

To see the nearby devices that have BLE enabled, you must get the free Digi XBee Mobile application from the iOS App Store or Google Play and downloaded to your phone.

1. On your phone, go to the App store.
2. Search for **Digi XBee Mobile**.
3. Download and install the application.

The Digi XBee Mobile application is compatible with the following operating systems and versions:

- Android 5.0 or higher
- iOS 11 or higher

---

**Connect with BLE and configure your XBee device**

You can use the Digi XBee Mobile application to verify that BLE is enabled on your XBee device.
1. Get the Digi XBee Mobile phone application.
2. Open the Digi XBee Mobile application. The **Find XBee devices** screen appears and the app automatically begins scanning for devices. All nearby devices with BLE enabled are displayed in a list.
3. Scroll through the list to find your XBee device. The first time you open the app on a phone and scan for devices, the device list contains only the name of the device and the BLE signal strength. No identifying information for the device displays. After you have authenticated the device, the device information is cached on the phone. The next time the app on this phone connects to the XBee device, the IMEI for the device displays in the app device list.

   **Note** The IMEI is derived from the SH and SL values.

4. Tap the XBee device name in the list. A password dialog appears.
5. Enter the password you previously configured for the device in XCTU.
6. Tap **OK**. The **Device Information** screen displays. You can now scroll through the settings for the XBee device and change the device's configuration as needed.

**BLE reference**

**BLE advertising behavior and services**

When the Bluetooth radio is enabled, periodic BLE advertisements are transmitted. The advertisement data includes the product name. When an XBee device connects to the Bluetooth radio, the BLE services are listed:

- Device Information Service
- XBee API BLE Service

**Device Information Service**

The standard Device Information Service is used. The Manufacturer, Model, and Firmware Revision characters are provided inside the service.

**XBee API BLE Service**

You can configure the XBee through the BLE interface using API frame requests and responses. The API frame format through Bluetooth is equivalent to setting AP=1 and transmitting the frames over the UART or SPI interface. API frames can be executed over Bluetooth regardless of the AP setting.

The BLE interface allows these frames:

- **BLE Unlock API** - 0x2C
- **BLE Unlock Response** - 0xAC
- **AT Command** - 0x08

This API reference assumes that you are familiar with Bluetooth and GATT services. The specifications for Bluetooth are an open standard and can be found at the following links:
The XBee API GATT Service contains two characteristics: the API Request characteristic and the API Response characteristic. The UUIDs for the service and its characteristics are listed in the table below.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>UUID</th>
</tr>
</thead>
<tbody>
<tr>
<td>API Service UUID</td>
<td>53da53b9-0447-425a-b9ea-9837505eb59a</td>
</tr>
<tr>
<td>API Request Characteristic UUID</td>
<td>7dddca00-3e05-4651-9254-44074792c590</td>
</tr>
<tr>
<td>API Response Characteristic UUID</td>
<td>f9279ee9-2cd0-410c-81cc-adf11e4e5aea</td>
</tr>
</tbody>
</table>

**API Request characteristic**

**UUID:** 7dddca00-3e05-4651-9254-44074792c590  
**Permissions:** Writeable

XBee API frames are broken into chunks and transmitted sequentially to the request characteristic using write operations. Valid frames will then be processed and the result will be returned through indications on the response characteristic.

API frames do not need to be written completely in a single write operation to the request characteristic. In fact, Bluetooth limits the size of a written value to 3 bytes smaller than the configured MTU (Maximum Transmission Unit), which defaults to 23, meaning that by default, you can only write 20 bytes at a time.

After connecting, you must send a valid Bluetooth Unlock API Frame in order to authenticate the connection. If the Bluetooth Unlock API Frame has not been executed, all other API frames will be silently ignored and not processed.

**API Response characteristic**

**UUID:** f9279ee9-2cd0-410c-81cc-adf11e4e5aea  
**Permissions:** Readable, Indicate

Responses to API requests made to the request characteristic will be returned through the response characteristics. This characteristic cannot be read directly.

Response data will be presented through indications on this characteristic. Indications are acknowledged and re-transmitted at the BLE link layer and application layer and provides a robust transport for this data.
Get started with Digi Remote Manager

Digi Remote Manager® is a cloud-based device and data management platform that you can use to configure and update a device, and view and manage device data.

Note Digi Remote Manager requires TCP and will not work with NB-IoT, unless the carrier supports TCP.

The sections below describe how to create a Remote Manager account, upgrading your device, configure your device, and manage data in Remote Manager.

1. Create a Remote Manager account and add devices
2. To ensure that all Remote Manager features are available, you should upgrade your device to the latest firmware. See Update the firmware from the Devices page in Remote Manager or Update the firmware using web services in Remote Manager.
3. Configure your device in Remote Manager
To be able to configure your device in Remote Manager, the device must be connected to Remote Manager. You can connect to and configure your device in Remote Manager using one of the following methods:
   ○ Scheduled connection: In this method, you create a list of tasks that you want to perform on the device, and then start the operation. This is the recommended method, and is the best choice for low data usage. See Configure Remote Manager features by scheduling tasks.
   ○ Always connected: This method can be used for initial configuration, or when you are not concerned with low data usage. See Configure XBee settings within Remote Manager.
4. Secure the connection between an XBee and Remote Manager with server authentication.
5. Manage data in Remote Manager
6. Remote Manager reference

Create a Remote Manager account and add devices
To be able to use Remote Manager, you must create a Remote Manager account and add your XBee devices to the device list. You should also verify that the device is enabled to connect to Remote Manager.
1. Create a Remote Manager account.
2. Add an XBee Smart Modem to Remote Manager.
3. Verify the connection between a device and Remote Manager

Create a Remote Manager account

Digi Remote Manager is an on-demand service with no infrastructure requirements. Remote devices and enterprise business applications connect to Remote Manager through standards-based web services. This section describes how to configure and manage an XBee using Remote Manager. For detailed information on using Remote Manager, refer to the Remote Manager User Guide, available via the Documentation tab in Remote Manager.

**Note** Digi Remote Manager requires TCP and will not work with NB-IoT, unless the carrier supports TCP.

Before you can manage an XBee with Remote Manager, you must create a Remote Manager account. To create a Remote Manager account:

2. Click **30 DAY FREE TRIAL/LOGIN**.
3. Follow the online instructions to complete account registration. You can upgrade your Developer account to a paid account at any time.

When you are ready to deploy multiple XBee Smart Modems in the field, upgrade your account to access additional Remote Manager features.

Add an XBee Smart Modem to Remote Manager

Each XBee Smart Modem must be added to the Remote Manager account inventory list. Before adding an XBee to your Remote Manager account inventory, you need to determine the International Mobile Equipment Identity (IMEI) number for the device. Use XCTU to view the IMEI number by querying the **IM parameter**.

**Note** Digi Remote Manager requires TCP and will not work with NB-IoT, unless the carrier supports TCP.

To add an XBee to your Remote Manager account inventory, follow these steps:

1. Log into Remote Manager.
2. Click **Device Management > Devices**.
3. Click **Add Devices**. The **Add Devices** dialog appears.
4. Select **IMEI #**, and type or paste the IMEI number of the XBee you want to add. The **IM (IMEI)** command provides this number.
5. Click **Add** to add the device. The XBee is added to your inventory.
6. Click **OK** to close the **Add Devices** dialog and return to the **Devices** view.

### Verify the connection between a device and Remote Manager

By default, the XBee is configured to enable communication with Remote Manager. The communication between XBee and Remote Manager is achieved using periodic UDP operations. You should verify the default settings to ensure that communication will work as desired.

1. **Launch XCTU**
2. Verify that the **MO command** is set to **6**, which is the default.
3. Configure the frequency of polling for Remote Manager activity using the **DF command**. The default is 1440 minutes (24 hours).
4. Enable the **SM/UDP** feature in Remote Manager for each device. See **Enable SM/UDP**.

### Configure Remote Manager features by scheduling tasks

Remote Manager provides tools to perform common management and maintenance tasks on your XBee device. A Remote Manager task is a sequence of commands that can be performed on one or more XBee Cellular devices. Tasks can then be assigned to a schedule. When a scheduled task is run it becomes an active operation and can be monitored for status and completion.

**Note** You must upgrade your device to the latest firmware for all features to be available. See **Update the firmware**.

Some typical examples of useful things that can be done with scheduled tasks include:

- Change configuration
- Update your MicroPython application and libraries to add features and capabilities
- Update your security certificates
- Perform a data service device request
- Send an SMS message to your device

Scheduled tasks can be created and performed through the following methods:
Remote Manager Schedules user interface.
Remote Manager API Explorer user interface
Programming web service calls

Note For any of these methods to work properly, you must have SM/UDP enabled. See Enable SM/UDP.

Overview: Create a schedule for a set of tasks
When using the most current firmware version, the XBee Cellular devices are designed to poll Remote Manager once per day over the SM/UDP protocol to check for any active operations. In order to perform a set of tasks, the device needs to be told to connect to Remote Manager, perform the sequence of tasks, and then told to disconnect.

The following provides a template of how to create a schedule for an XBee to connect, perform a set of tasks and then disconnect:

1. Make sure that SM/UDP is enabled. See Enable SM/UDP.
2. Log into Remote Manager.
3. Click Device Management > Schedules.

Note The Steps to schedule a task wizard may display. Click the x in the upper left corner to close the wizard. See Schedule walk-through feature in the Digi Remote Manager® User Guide for more information.

5. In the Description field, enter a name for the schedule, such "Read Settings."
6. Add the following tasks:
   a. Click SM/UDP > SM/UDP Request Connect. A task is added to the dialog.
   b. Add other tasks as needed. For examples, refer to the Examples section.
   c. Click Device > Disconnect. A task is added to the dialog.
7. Click Schedule in the lower right corner of the dialog to schedule the tasks to run. The schedule screen displays.

Note You can also click Save as to save this schedule for future use.

8. Select the device(s) on which you want to run this schedule. You can add more than one device.
9. Click Run Now.

Examples
The examples in the following sections assume you are using the Digi Remote Manager Schedule wizard. However, you should be aware that operations can be created and performed programmatically via web service calls or via the API explorer. The XML web service calls provide more options than are available in the GUI dashboard for some tasks.

Example: Read settings and state using Remote Manager
In order to configure devices you need to know the structure of the XML for your XBee's settings. The easiest way to obtain this is to perform a query_setting RCI request against your device.
Get started with Digi Remote Manager

Configure Remote Manager features by scheduling tasks

**Note** You must upgrade your device to the latest firmware for all features to be available. See Update the firmware.

**Note** To obtain the state of the device, you can perform the same operations in the example below, but replace `query_setting` with `query_state`.

1. Log into Remote Manager.
2. Click Device Management > Schedules.
3. Click New Schedule. The New Schedule page displays.
   
   **Note** The Steps to schedule a task wizard may display. Click the x in the upper left corner to close the wizard. See Schedule walk-through feature in the Digi Remote Manager® User Guide for more information.

4. In the Description field, enter a name for the schedule, such "Read Settings."
5. Add the following tasks:
   a. Click SM/UDP > SM/UPD Request Connect. A task is added to the dialog.
   b. Click Device > RCI Command. A task is added to the dialog.
      
      Change the RCI command to the following:

      ```
      <rci_request>
      <query_setting/>
      </rci_request>
      ```

   c. Click Device > Disconnect. A task is added to the dialog.
6. Click Schedule in the lower right corner of the dialog to schedule the tasks to run. The schedule screen displays.
   
   **Note** You can also click Save as to save this schedule for future use.

7. Select the device(s) on which you want to run this schedule. You can add more than one device.
8. Click Run Now.

After your operation completes you can click Response to view the XML for all of the settings that your XBee reports. This XML structure has the same settings that you will use in the set_setting command to configure your XBee as shown in this example: Example: Configure a device from Remote Manager using XML.

**Example: Configure a device from Remote Manager using XML**

You can configure each XBee device from Remote Manager, using XML. The devices must be in the Remote Manager inventory device list and be active.

**Note** You must upgrade your device to the latest firmware for all features to be available. See Update the firmware.
Note Digi Remote Manager requires TCP and will not work with NB-IoT, unless the carrier supports TCP.

In this configuration example, you are changing the device to poll four times a day instead of just once. In this case, you should change the DF parameter to 360 minutes.

1. Log into Remote Manager.
2. Click Device Management > Schedules.
3. Click New Schedule. The New Schedule page displays.

Note The Steps to schedule a task wizard may display. Click the x in the upper left corner to close the wizard. See Schedule walk-through feature in the Digi Remote Manager® User Guide for more information.

4. In the Description field, enter a name for the schedule, such as "Configure Reporting Frequency."
5. Add the following tasks:
   a. Click SM/UDP > SM/UPD Request Connect. A task is added to the dialog.
   b. Click Device > RCI Command. A task is added to the dialog.
      Change the RCI command to the following:

      `<rci_request>
       <set_setting>
       <remote_manager>
       <DF>360</DF>
       </remote_manager>
       </set_setting>
       </rci_request>`

   c. Click Device > Disconnect. A task is added to the dialog.
6. Click Schedule in the lower right corner of the dialog to schedule the tasks to run. The schedule screen displays.

Note You can also click Save as to save this schedule for future use.

7. Select the device(s) on which you want to run this schedule. You can add more than one device.
8. Click Run Now.

Example: Schedule a task to update the device firmware using Remote Manager

You can use a scheduled task to update the XBee Cellular firmware. Since the device is configured by default to poll Remote Manager once a day, you need to be able to set up a scheduled task to update the device’s firmware to take advantage of new features and fixes. To update the firmware to a new version you will need to obtain the .gbl file for the new firmware from our support site. This file is one of the files in the .zip (for example, XBXC-31011.zip) archive that you can download for the product.
Note You must upgrade your device to the latest firmware for all features to be available. See Update the firmware.

Note Digi Remote Manager requires TCP and will not work with NB-IoT, unless the carrier supports TCP.

To upgrade using a scheduled task perform the following steps:

1. Download the updated firmware file for your device from Digi's support site.
   a. Go to the Digi XBee 3 Cellular LTE-M support page.
   b. Scroll down to the Firmware Updates section.
   c. Locate and click Digi XBee 3 Cellular LTE-M/NB-IoT Gating Firmware to download the zip file. If you have already upgraded past the gating firmware, click XBee Cellular LTE-M/NB-IoT Firmware to download the zip file.
   d. Unzip the file. The file contains either a .ebin or a .gbl file.
2. Log into Remote Manager.
3. Make sure that you have enabled SM/UDP. See Enable SM/UDP.
4. Click Device Management > Schedules.
5. Click New Schedule. The New Schedule page displays.
   Note The Steps to schedule a task wizard may display. Click the x in the upper left corner to close the wizard. See Schedule walk-through feature in the Digi Remote Manager® User Guide for more information.
6. In the Description field, enter a name for the schedule, such as "Update XBee Firmware."
7. Add the following tasks:
   a. Click SM/UDP > SM/UDP Request Connect. A task is added to the dialog.
   b. Click Device > Gateway Firmware Update.
   c. Click Browse and select the .gbl file (for example, XBXC-11411.gbl) for the new firmware to update.
   d. Click Device > Disconnect. A task is added to the dialog.
8. Click Schedule in the lower right corner of the dialog to schedule the tasks to run. The schedule screen displays.
   Note You can also click Save as to save this schedule for future use.
9. Select the device(s) on which you want to run this schedule. You can add more than one device.
10. Click Run Now.

Example: Update MicroPython from Remote Manager using XML
You can use the API Explorer in Remote Manager to create a schedule that enables you to update the MicroPython application. In this example, you want to add FTP client capability to the MicroPython application. You will need to add the library uftp.py and then update the main.py application.
This example is done following these steps: upload the MicroPython files to Remote Manager, create an XML file with the tasks that you want to perform, upload the XML file, and then schedule an operation to upload the files onto your device.

**Note** You must upgrade your device to the latest firmware for all features to be available. See Update the firmware.

**Note** Digi Remote Manager requires TCP and will not work with NB-IoT, unless the carrier supports TCP.

**Step 1: Upload the MicroPython files**

1. Log into Remote Manager.
2. Click **Data Services > Data Files**.
   a. Click **New Folder**. The **New Folder** dialog displays.
   b. In the **Folder name** field, enter a descriptive name, such as "MicroPython."
   c. Click **Create**. The new file is added to the list of files.
   d. Find the "MicroPython" folder in the folder list.
   e. Click **Upload Files**. The **Upload Files** dialog displays.
   f. Browse for the **main.py** file. Check with your system administrator for the location of the application file.
   g. Click **OK**.
   a. Find the "MicroPython" folder in the folder list.
   b. Click **Upload Files**. The **Upload Files** dialog displays.
   c. Browse for the **uftp.py** file. The library **uftp.py** file is found on the GitHub repository: https://github.com/digidotcom/xbee-micropython
   d. Click **OK**.

**Step 2: Create an XML file with the tasks that you want to perform**

This XML file will contain a list of commands for the operation that you will schedule in **Step 3**.

**Note** The RCI commands to set_settings in the task may fail to execute because of disconnects after changing the value for MO.

1. Open the editor of your choice.
2. Create a new file named **updatemicropython.xml**.
3. Copy the XML below and paste it into the new file.
4. Save the file.

```xml
<task>
  <description>Update MicroPython</description>
  <command>
    <name>SM/UDP Request Connect</name>
    <event>
      <on_error>
```
<end_task/>
</on_error>
</event>
<sci>
  <send_message reply="none" >
  <sm_udp>
    <request_connect/>
  </sm_udp>
  </send_message>
</sci>
</command>
</command>
<html>
<title>Digi XBee® 3 Cellular LTE-M/NB-IoT Global Smart Modem User Guide</title>
</html>
Get started with Digi Remote Manager

Configure Remote Manager features by scheduling tasks

```xml
<task>
  <command>
    <name>Upload Files</name>
    <event>
      <on_error>
        <continue/>
      </on_error>
    </event>
    <sci>
      <file_system allowOffline="true" >
        <commands>
          <put_file path="/flash/lib/uftp.py">
            <file>~/MicroPython/uftp.py</file>
          </put_file>
        </commands>
      </file_system>
    </sci>
  </command>
  <command>
    <name>RCI Command</name>
    <event>
      <on_error>
        <continue/>
      </on_error>
    </event>
    <sci>
      <send_message cache="false" allowOffline="true">
        <!-- Enable Python Auto-start -->
        <rci_request>
          <set_setting>
            <micropython>
              <PS>1</PS>
            </micropython>
            <remote_manager>
              <MO>6</MO>
            </remote_manager>
          </set_setting>
        </rci_request>
      </send_message>
    </sci>
  </command>
  <command>
    <!-- Reboot to start the program -->
  </command>
</task>
```
Step 3: Upload the XML to Remote Manager

In this step you will upload the file you just created (updatedmicropython.xml) to Remote Manager.

1. Log into Remote Manager.
2. Click Data Services > Data Files.
3. Upload the XML file you just created: updatedmicropython.xml
   a. Find the "~/my_tasks" folder in the folder list.
   b. Click Upload Files. The Upload Files dialog displays.
   c. Browse for the updatedmicropython.xml file.
   d. Click OK.

Step 4: Schedule an operation to upload the files

1. Log into Remote Manager.
2. Click Documentation > API Explorer.
3. Click SCI Targets. The Select devices to be used in examples dialog appears.
   a. From the Add Targets list box, search for the IMEI (device ID) of the device that you want to update.
   b. Click Add. The device is added to the device list.
   c. Click OK.
4. Click the Examples drop-down list button.
5. Click Scheduled Operation > Create immediate running schedule.
6. Update the XML to refer to the updatedmicropython.xml file you created previously.

```xml
<!-- Runs immediately -->
<Schedule on="IMMEDIATE">
  <targets>
    <device id="00010000-00000000-03588320-70372440"/>
  </targets>

  <task path="~/my_tasks/updatedmicropython.xml"/>
</Schedule>
```

7. Click Send to schedule the task.

Manage data in Remote Manager

You can view and manage XBee data in Remote Manager.

You can also update your device firmware from Remote Manager. See Update the device firmware.

Review device status information from Remote Manager

You can view address, BLE, cellular, firmware, and I/O sampling status information for a XBee device in Remote Manager. The device must be in the Remote Manager inventory device list and be active.
Digi Remote Manager requires TCP and will not work with NB-IoT, unless the carrier supports TCP.

1. Set up a persistent connection to connect the device to Remote Manager using one of the following methods:
   - **Remote Manager:** A persistent connection can be set up in Remote Manager. This option should be used when you have many deployed devices and no local access. See Restore persistent connection to a remote XBee.
   - **XCTU:** This option allows immediate access, and should be used when you have local access, such as when using a development kit or in a lab environment.

2. Log into Remote Manager.
3. Click **Device Management > Devices**.
4. Select the device that you want to configure.
5. Click **Properties** in the toolbar. As an alternative, click **Properties > Edit Device Configuration**. The configuration **Home** page appears.
6. Click **Status** in the toolbar to display the status sub-menus.
7. Click on the status group that has information you want to display. The status information is related to AT commands. For information about each AT command in the categories, click on the appropriate link below.
   - **Addressing**
   - **Bluetooth**
   - **Cellular**
   - **Firmware Version/Information**
   - **I/O**
8. Click **Home** to return to the configuration **Home** page.
9. When all changes are complete, disconnect the device from Remote Manager.

**Manage secure files in Remote Manager**

You can interact with files on the XBee device from Remote Manager, using either the **SCI (Server command interface)** or in the **File Management** view.

You can securely upload files by appending a hash sign (#) to the end of the file name. After the upload, the hash sign (#) is not retained as part of the file name. For example, you could upload a file named `my-cert.crt` appended with a hash sign (#): `my-cert.crt#`. After the upload is complete, the file is named `my-cert.crt`.

**Note** Uploading secure files in Remote Manager has the same result as doing an **ATFS XPUT** locally. See **Secure files** for more information.

**SCI (Server command interface)**

You can use the **SCI (Server command interface)** `file_system` command to securely upload a file. For more information, see the `file_system` section in the **Digi Remote Manager Programming Guide**.

**File Management view**

You can upload and manage files in the Remote Manager **File Management** view.
1. Prepare the file that you want to upload.
   a. Find the file on your hard drive.
   b. Rename the file and append a hash sign (#) to the end of the file name.
2. Set up a persistent connection to connect the device to Remote Manager using one of the following methods:
   - **Remote Manager**: A persistent connection can be set up in Remote Manager. This option should be used when you have many deployed devices and no local access. See Restore persistent connection to a remote XBee.
   - **XCTU**: This option allows immediate access, and should be used when you have local access, such as when using a development kit or in a lab environment. See DO (Device Options) and MO (Remote Manager Options). Both must be enabled.
3. Log into Remote Manager.
4. Click **Device Management > Devices**.
5. Select the device that you want to configure.
6. Click **Properties** in the toolbar. As an alternative, double-click on the device name. The **Properties** page appears.
7. Click **File Management**. The **File Management** view appears.
8. Click the upload icon. The **Upload File** dialog appears.
   a. Click **Browse** to browse for the file you want to upload. The selected file displays in the **File** field. Make sure that the file name is appended by a hash sign (#).
   b. Click **OK**. The uploaded file displays in the **File Management** view. Note that the file name is no longer appended by a hash sign (#).
9. When all changes are complete, disconnect the device from Remote Manager.

**Remote Manager reference**

**Enable SM/UDP**
You can use the SM/UDP feature to leverage the very small data footprint of Remote Manager SM protocol over UDP.

1. Log into Remote Manager.
2. Click **Device Management > Devices**.
3. Select the device that you want to configure.
4. Click **More > SM/UDP > Configure**. The **SM/UDP** dialog appears.
5. Verify that the **Battery Operated Mode** is not selected.
   - This mode is not supported with Remote Manager and if enabled, the connectivity between XBee and Remote Manager may not work as expected.
6. Select **SM/UDP Service Enabled** to enable SM/UDP.
7. Click **Save**.

**TCP connection**
The TCP connection between an XBee and Remote Manager is dependent on the device’s firmware version. Options are to query Remote Manager once a day or to maintain a persistent TCP connection.
To determine which connection method is being used, refer to the version listed below.

<table>
<thead>
<tr>
<th>Module</th>
<th>Upgrade firmware version</th>
</tr>
</thead>
<tbody>
<tr>
<td>XBee 3 LTE-M</td>
<td>11411</td>
</tr>
</tbody>
</table>

- **At or above the listed version:** If your firmware version is at or above the listed version, your device queries Remote Manager only once a day. The device connects to Remote Manager, queries Remote Manager for updates and then receives updates. When the update is complete, the device disconnects from Remote Manager.
  
  If you upgrade to the new firmware version, it is recommended that you keep the polling frequency low to reduce data usage. In order to upgrade firmware in the future, refer to Example: Schedule a task to update the device firmware using Remote Manager.

  **Note** If you wish to restore the persistent connection behavior that was the default in prior firmware versions, see Restore persistent connection to a remote XBee.

- **Below the listed version:** If your firmware version is below the listed version, a persistent TCP connection is used by default. The device is continually connected to Remote Manager using TCP.

*Restore persistent connection to a remote XBee*

The default connectivity to Remote Manager in the most recent firmware polls once a day using SM/UDP, which means that your XBee will always appear in a disconnected state and will use significantly less data.

If needed, you can restore the default connectivity to use the former behavior, where the device is continually connected using TCP. To do this, you will need to set bit 0 of the MO setting. The suggested value for MO is 7 to connect securely over TLS, or you can use 1 for no security, which is the legacy value.

You can make the change using one of the following methods:

- **Local access:** If you have local access to the device you can use XCTU to change the MO setting back to the former default value.

- **Remote access:** If you only have remote access to your XBee you can change the device to maintain a persistent connection to Remote Manager. To do this you can set up a scheduled operation in Remote Manger for your device, as shown below.

  To set up a scheduled operation to maintain a persistent connection:

  1. Log into Remote Manager.
  2. Make sure that you have enabled SM/UDP. See Enable SM/UDP.
  3. Click **Device Management > Schedules**.
  4. Click **New Schedule**. The **New Schedule** page displays.

    **Note** The **Steps to schedule a task** wizard may display. Click the x in the upper left corner to close the wizard. See Schedule walk-through feature in the Digi Remote Manager® User Guide for more information.

  5. In the **Description** field, enter a name for the schedule, such as "Restore Persistent."
6. Add the following tasks:
   a. Click SM/UDP > SM/UDP Request Connect. A task is added to the dialog.
   b. Click Device > RCI Command. A task is added to the dialog.
      Change the RCI command to the following:
      
      `<rci_request>
        <set_setting>
          <remote_manager>
            <MO>7</MO>
          </remote_manager>
        </set_setting>
      </rci_request>`

7. Click Schedule in the lower right corner of the dialog to schedule the tasks to run. The schedule screen displays.
   
   **Note** You can also click Save as to save this schedule for future use. The XML for your task is saved in the `~\my_tasks` directory on Data Services > Data Files in Remote Manager.

8. Select the device(s) on which you want to run this schedule. You can add more than one device.

9. Click Run Now. Within the next 24 hours, which is the default polling period for querying Remote Manager, your device will connect and will remain connected, as specified by the change to the MO setting.


### Disconnect

The TCP connection remains open and periodic polling occurs until you manually disconnect the TCP connection. After you have disconnected the TCP connection, Remote Manager is no longer updated.

You can disconnect the TCP connection using either of the following methods:

- From the Devices page in Remote Manager: See Disconnect a device in the Digi Remote Manager® User Guide.
- Using web services in Remote Manager: See Request connect SM/UDP support in the Digi Remote Manager® Programming Guide.

### Configure XBee settings within Remote Manager

You can configure the device settings to use features with Remote Manager. For more information, see Example: Read settings and state using Remote Manager.

### Configure device settings in Remote Manager

You can configure each XBee device from Remote Manager. The devices must be in the Remote Manager inventory device list and be active.

**Note** Digi Remote Manager requires TCP and will not work with NB-IoT, unless the carrier supports TCP.
1. Set up a persistent connection to connect the device to Remote Manager using one of the following methods:
   - **Remote Manager**: A persistent connection can be set up in Remote Manager. This option should be used when you have many deployed devices and no local access. See Restore persistent connection to a remote XBee.
   - **XCTU**: This option allows immediate access, and should be used when you have local access, such as when using a development kit or in a lab environment. See DO (Device Options) and MO (Remote Manager Options). Both must be enabled.
2. Log into Remote Manager.
3. Click **Device Management > Devices**.
4. Select the device that you want to configure.
5. Click **Properties** in the toolbar. As an alternative, click **Properties > Edit Device Configuration**. The configuration **Home** page appears.
6. Click **Config** in the toolbar to display the settings sub-menus.
7. Click on the settings category that you want to configure. The settings in that category appear.
8. Make the desired configuration changes. See **AT commands** for information about each setting in the categories.
9. As you finish configuring in each setting category, click **Apply** to save the changes. If the changes are valid, Remote Manager writes them to non-volatile memory and applies them.
10. When all changes are complete, **disconnect the device** from Remote Manager.

**Configure Remote Manager keepalive interval**

*Note* Digi Remote Manager requires TCP and will not work with NB-IoT, unless the carrier supports TCP.

Managing the data usage and the keepalive interval is important if you have the MO (Remote Manager Options) command bit 0 set to 1 or if you have enabled the **Request connect feature** in Remote Manager.

Digi Remote Manager is enabled on the XBee by default and has a 60 second keepalive interval, which can result in excessive cellular data usage, depending on your plan. The **K1** and **K2** commands can be used to tune the keepalive interval. Your carrier will disconnect an inactive socket automatically if there is no activity, so you need to tune this value based on your carrier’s disconnect timeout.

You can further reduce your data usage by periodically duty cycling your Remote Manager connection, either from MicroPython or your host processor. For example, you could enable the Remote Manager connection for 2 hours a day and then disable the connection for 22 hours. Your host processor or MicroPython program would need to keep track of the time to ensure the time interval.

**Configure SMS messaging in Remote Manager**

You can configure a XBee device to use SMS functionality in Remote Manager. This feature uses a "request connect" operation and asks a device to make a full TCP connection to Remote Manager. For a device with SMS capability this can be significantly lower on latency and data cap consumption, as it does not involve polling.

Each device must be individually configured in Remote Manager to use this feature.

*Note* The SMS provision feature cannot be used. This feature is found by selecting a device and then choosing **More > SMS > Provision**. Attempts to enable this feature are ignored.
1. Set up a persistent connection to connect the device to Remote Manager using one of the following methods:
   - **Remote Manager**: A persistent connection can be set up in Remote Manager. This option should be used when you have many deployed devices and no local access. See Restore persistent connection to a remote XBee.
   - **XCTU**: This option allows immediate access, and should be used when you have local access, such as when using a development kit or in a lab environment. See DO (Device Options) and MO (Remote Manager Options). Both must be enabled.

2. Log in to Remote Manager.
3. Select the **Device Management** tab.
4. Select the device that you want to configure.
5. In the toolbar, select **More > SMS > Configure**. The SMS Configuration dialog appears.
6. Select the **SIM 1** option. This should be selected by default.
7. In the **Phone Number** field, enter the device’s SIM card phone number. You can use the **PH (Phone Number)** command to discover the device’s phone number.
8. Expand the **Advanced Options** section.
9. From the **Server Number for SIM 1** list box, select the appropriate option:
   - If the Remote Manager phone number is a domestic number, select a short code. The default is **32075-idgp**.
   - If the Remote Manager phone number is an international number, select a long code.

   **Note** The options in the **Server Number for SIM 1** list box are determined within Remote Manager, and are used to ensure an SMS connection between the device and Remote Manager. The option selected from the list box must match the Remote Manager phone number and service ID set for the device. The XBee examines received SMS messages and if the phone number matches and content contains the correct service ID it will be processed internally rather than being delivered as user data.

   By default, the device is configured with "32075" as the Remote Manager phone number and "idgp" as the Remote Manager service ID. If you need an alternate short (domestic) code or a long (international) code, you can re-configure the device using the **DP (Remote Manager Phone Number)** and **RI (Remote Manager Service ID)** commands.

10. Click **Save**.
11. When all changes are complete, disconnect the device from Remote Manager.
Examples: IOT protocols with transparent mode

The following examples provide some additional scenarios you can use to get familiar with the XBee. If you are interested in using the intelligence built into the XBee, see Get started with MicroPython.

Get started with CoAP ................................................................. 66
Get started with MQTT ............................................................. 70
Get started with CoAP

Constrained Application Protocol (CoAP) is based on UDP connection and consumes low power to deliver similar functionality to HTTP. This guide contains information about sending GET, POST, PUT and DELETE operations by using the Coap Protocol with XCTU and Python code working with the XBee Smart Modem and Coapthon library (Python 2.7 only).

The Internet Engineering Task Force describes CoAP as:

The protocol is designed for machine-to-machine (M2M) applications such as smart energy and building automation. CoAP provides a request/response interaction model between application endpoints, supports built-in discovery of services and resources, and includes key concepts of the Web such as URIs and Internet media types. CoAP is designed to easily interface with HTTP for integration with the Web while meeting specialized requirements such as multicast support, very low overhead, and simplicity for constrained environments (source).

CoAP terms

When describing CoAP, we use the following terms:

<table>
<thead>
<tr>
<th>Term</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method</td>
<td>COAP’s method action is similar to the HTTP method. This guide discusses the GET, POST, PUT and DELETE methods. With these methods, the XBee Smart Modem can transport data and requests.</td>
</tr>
<tr>
<td>URI</td>
<td>URI is a string of characters that identifies a resource served at the server.</td>
</tr>
<tr>
<td>Token</td>
<td>A token is an identifier of a message. The client uses the token to verify if the received message is the correct response to its query.</td>
</tr>
<tr>
<td>Payload</td>
<td>The message payload is associated with the POST and PUT methods. It specifies the data to be posted or put to the URI resource.</td>
</tr>
<tr>
<td>Message ID</td>
<td>The message ID is also an identifier of a message. The client matches the message ID between the response and query.</td>
</tr>
</tbody>
</table>

CoAP quick start example

The following diagram shows the message format for the CoAP protocol; see ISSN: 2070-1721 for details:

This is an example GET request:

```
44 01 C4 09 74 65 73 74 B7 65 78 61 6D 70 6C 65
```
The following table describes the fields in the GET request.

<table>
<thead>
<tr>
<th>Field</th>
<th>HEX</th>
<th>Bits</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ver</td>
<td>44</td>
<td>01</td>
<td>Version 01, which is mandatory here.</td>
</tr>
<tr>
<td>T</td>
<td>00</td>
<td></td>
<td>Type 0: confirmable.</td>
</tr>
<tr>
<td>TKL</td>
<td></td>
<td>0100</td>
<td>Token length: 4.</td>
</tr>
<tr>
<td>Code</td>
<td>01</td>
<td>00000001</td>
<td>Code: 0.01, which indicates the GET method.</td>
</tr>
<tr>
<td>Message ID</td>
<td>C4</td>
<td>09</td>
<td>Message ID. The response message will have the same ID. This can help out identification.</td>
</tr>
<tr>
<td>Token</td>
<td>74</td>
<td>65 73 74</td>
<td>4 Bytes equal to hex at left.</td>
</tr>
<tr>
<td>Option delta</td>
<td>B7</td>
<td>1011</td>
<td>Delta option: 11 indicates the option data is Uri-Path.</td>
</tr>
<tr>
<td>Option length</td>
<td></td>
<td>0111</td>
<td>Delta length: 7 indicates there are 7 bytes of data following as a part of this delta option.</td>
</tr>
<tr>
<td>Option value</td>
<td></td>
<td>65 78 61 6D 70 6C 65</td>
<td>Example.</td>
</tr>
</tbody>
</table>

### Configure the device

1. Ensure that the device is set up correctly with the SIM card installed and the antennas connected as described in [Connect the hardware](#).
2. Open XCTU and click the **Configuration working mode** button.
3. Add the XBee Smart Modem to XCTU; see [Add a device to XCTU](#).
4. Select a device from the **Radio Modules** list. XCTU displays the current firmware settings for that device.
5. To switch to UDP communication, in the IP field, select 0 and click the **Write** button.
6. To set the target IP address that the XBee Smart Modem will talk to, in the DL field type **52.43.121.77** and click the **Write** button. A CoAP server is publicly available at address 52.43.121.77.
7. To set the XBee Smart Modem to send data to port 5683 in decimal, in the DE field, type **1633** and click the **Write** button.
8. To move into Transparent mode, in the AP field, select 0 and click the **Write** button.
9. Wait for the **AI** (Association Indication) value to change to 0 (Connected to the Internet). You can click **Read** to get an update on the **AI** value.

### Example: manually perform a CoAP request

Follow the steps in [Configure the device](#) prior to this example. This example performs the CoAP GET request:
Examples: IOT protocols with transparent mode

- Method: GET
- URI: example
- Given message token: test

1. Click the **Consoles working mode** button on the toolbar to add a customized packet.

2. From the AT console, click the **Add new packet button** in the Send packets dialog. The **Add new packet** dialog appears.

3. Click the **HEX tab** and type the name of the data packet: **GET_EXAMPLE**.

4. Copy and paste the following text into the **HEX input tab**:
   44 01 C4 09 74 65 73 74 B7 65 78 61 6D 70 6C 65
   This is the CoAP protocol message decomposed by bytes to perform a GET request on an example URI with a token test.

5. Click **Add packet**.

6. Click the **Open** button.

7. Click **Send selected packet**. The message is sent to the public CoAP server configured in Configure the device. A response appears in the Console log. Blue text is the query, red text is the response.

   The payload is **Get to uri: example**, which specifies that this is a successful CoAP GET to URI end example, which was specified in the query.

   Click the **Close** button to terminate the serial connection.

**Example: use Python to generate a CoAP message**

This example illustrates how the CoAP protocol can perform GET/POST/PUT/DELETE requests similarly to the HTTP protocol and how to do this using the XBee Smart Modem. In this example, the XBee Smart Modem talks to a CoAP Digi Server. You can use this client code to provide an abstract wrapper to generate a CoAP message that commands the XBee Smart Modem to talk to the remote CoAP server.

**Note** It is crucial to configure the XBee Smart Modem settings. See Configure the device and follow the steps. You can target the IP address to a different CoAP public server.

1. Install Python 2.7. The Installation guide is located at: [python.org/downloads/](http://python.org/downloads/).
2. Download and install the CoAPthon library in the python environment from [pypi.python.org/pypi/CoAPthon](http://pypi.python.org/pypi/CoAPthon).
3. Download these two .txt files: Coap.txt and CoapParser.txt. After you download them, open the files in a text editor and save them as .py files.
4. In the folder that you place the Coap.py and CoapParser.py files, press **Shift + right-click** and then click **Open command window**.
5. At the command prompt, type **python Coap.py** and press **Enter** to run the program.
6. Type the USB port number that the XBee Smart Modem is connected to and press **Enter**. Only the port number is required, so if the port is COM19, type 19.
**Note** If you do not know the port number, open XCTU and look at the XBee Smart Modem in the Radio Modules list. This view provides the port number and baud rate, as in the figure below where the baud rate is 9600 b/s.

7. Type the baud rate and press **Enter**. You must match the device's current baud rate. XCTU provides the current baud rate in the BD Baud Rate field. In this example you would type 9600.

8. Press **Y** if you want an auto-generated example. Press **Enter** to build your own CoAP request.

9. If you press **Y** it generates a message with:
   - Method: POST
   - URI: example
   - payload: hello world
   - token: test

The send and receive message must match the same token and message id. Otherwise, the client re-attempts the connection by sending out the request.

In the following figure, the payload contains the server response to the query. It shows the results for when you press **Enter** rather than **Y**.

```
C:users\jzhang\Desktop\example>python Coap.py
Please enter the serial port number for XBee: 18
Please enter the baudrate number of XBee: 9600
Do you want an auto-generated example <Press Y> or build your own <Press ENTER>:
Please enter the HTTP method (GET, POST, PUT, DELETE): PUT
Please enter the url end path: example
Please enter the payload content. And it cannot be empty: hello world
Please enter the token: digi

This is the send out message:
Source: (None, None)
Destination: None
Type: CONTENT
MB: 56645
Code: PUT
Token: digi
Uri-Path: example
Payload: hello world

This is the received message
Source: (None, None)
Destination: None
Type: ACK
MB: 56645
Code: CHANGED
Token: digi
Payload: Put hello world to uri: example
```
Get started with MQTT

MQ Telemetry Transport (MQTT) is a messaging protocol that is ideal for the Internet of Things (IoT) due to a light footprint and its use of the publish-subscribe model. In this model, a client connects to a broker, a server machine responsible for receiving all messages, filtering them, and then sending messages to the appropriate clients.

The first two MQTT examples do not involve the XBee Smart Modem. They demonstrate using the MQTT libraries because those libraries are required for Use MQTT over the XBee Cellular Modem with a PC.

The examples in this guide assume:

- Some knowledge of Python.
- An integrated development environment (IDE) such as PyCharm, IDLE or something similar.

The examples require:

- An XBee Smart Modem.
- A compatible development board, such as the XBIB-U.
- XCTU. See Install and upgrade XCTU.
- That you install Python on your computer. You can download Python from: https://www.python.org/downloads/.
- That you install the pyserial and paho-mqtt libraries to the Python environment. If you use Python 2, install these libraries from the command line with pip install pyserial and pip install paho-mqtt. If you use Python 3, use pip3 install pyserial and pip3 install paho-mqtt.
- The full MQTT library source code, which includes examples and tests, which is available in the paho-mqtt github repository at https://github.com/eclipse/paho.mqtt.python. To download this repository you must have Git installed.

Example: MQTT connect

This example provides insight into the structure of packets in MQTT as well as the interaction between the client and broker. MQTT uses different packets to accomplish tasks such as connecting, subscribing, and publishing. You can use XCTU to perform a basic example of sending a broker a connect packet and receiving the response from the server, without requiring any coding. This is a good way to see how the client interacts with the broker and what a packet looks like. The following table is an example connect packet:

<table>
<thead>
<tr>
<th>Description</th>
<th>Hex value</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONNECT packet fixed header</td>
<td></td>
</tr>
<tr>
<td>byte 1</td>
<td>Control packet type</td>
</tr>
<tr>
<td>byte 2</td>
<td>Remaining length</td>
</tr>
<tr>
<td>CONNECT packet variable header</td>
<td></td>
</tr>
<tr>
<td>Protocol name</td>
<td></td>
</tr>
</tbody>
</table>
The following table describes the fields in the packet:

<table>
<thead>
<tr>
<th>Field name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protocol Name</td>
<td>The connect packet starts with the protocol name, which is MQTT. The length of the protocol name (in bytes) is immediately before the name itself.</td>
</tr>
<tr>
<td>Protocol Level</td>
<td>Refers to the version of MQTT in use, in this case a value of 4 indicates MQTT version 3.1.1.</td>
</tr>
<tr>
<td>Connect Flags</td>
<td>Indicate certain aspects of the packet. For simplicity, this example only sets the Clean Session flag, which indicates to the client and broker to discard any previous session and start a new one.</td>
</tr>
<tr>
<td>Keep Alive</td>
<td>How often the client pings the broker to keep the connection alive; in this example it is set to 60 seconds.</td>
</tr>
</tbody>
</table>
Examples: IOT protocols with transparent mode

Get started with MQTT

<table>
<thead>
<tr>
<th>Field name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Client ID</td>
<td>The length of the ID (in bytes) precedes the ID itself. Each client connecting to a broker must have a unique client ID. In the example, the ID is DIGI. When using the Paho MQTT Python libraries, a random alphanumeric ID is generated if you do not specify an ID.</td>
</tr>
</tbody>
</table>

The following table provides the CONNECT flag bits from byte 8, the CONNECT flags byte.

<table>
<thead>
<tr>
<th>CONNECT Flag Bit(s)</th>
<th>Bit 7</th>
<th>Bit 6</th>
<th>Bit 5</th>
<th>Bit 4</th>
<th>Bit 3</th>
<th>Bit 2</th>
<th>Bit 1</th>
<th>Bit 0</th>
</tr>
</thead>
<tbody>
<tr>
<td>User name flag</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Password flag</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Will retain</td>
<td></td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Will QoS</td>
<td></td>
<td></td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Will flag</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Clean session</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Reserved</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
</tr>
</tbody>
</table>

Send a connect packet

Now that you know what a connect packet looks like, you can send a connect packet to a broker and view the response. Open XCTU and click the Configuration working mode button.

1. Ensure that the device is set up correctly with the SIM card installed and the antennas connected as described in Connect the hardware.

2. Open XCTU and click the Configuration working mode button.

3. Add the XBee Smart Modem to XCTU. See Add a device to XCTU.

4. Select a device from the Radio Modules list. XCTU displays the current firmware settings for that device.

5. In the AP field, set Transparent Mode to [0] if it is not already and click the Write button.

6. In the DL field, type the IP address or the fully qualified domain name of the broker you wish to use. This example uses test.mosquitto.org.

7. In the DE field, type 75B and set the port that the broker uses. This example uses 75B, because the default MQTT port is 1883 (0x75B).

8. Once you have entered the required values, click the Write button to write the changes to the XBee Smart Modem.

9. Click the Consoles working mode button on the toolbar to open a serial console to the device. For instructions on using the Console, see the AT console topic in the XCTU User Guide.

10. Click the Open button to open a serial connection to the device.

11. From the AT console, click the Add new packet button in the Send packets dialog. The Add new packet dialog appears.
12. Enter the name of the data packet. Name the packet `connect_frame` or something similar.

13. Click the HEX input tab and type the following (these values are the same values from the table in Example: MQTT connect):

   10 10 00 04 4D 51 54 54 04 02 00 3C 00 04 44 49 47 49

14. Click Add packet. The new packet appears in the Send packets list.

15. Click the packet in the Send packets list.

16. Click Send selected packet.

17. A CONNACK packet response from the broker appears in the Console log. This is a connection acknowledgment; a successful response should look like this:

   ![Console log screenshot]

You can verify the response from the broker as a CONNACK by comparing it to the structure of a CONNACK packet in the MQTT documentation, which is available at [http://docs.oasis-open.org/mqtt/mqtt/v3.1.1/os/mqtt-v3.1.1-os.html#_Toc398718081](http://docs.oasis-open.org/mqtt/mqtt/v3.1.1/os/mqtt-v3.1.1-os.html#_Toc398718081).

**Example: send messages (publish) with MQTT**

A basic Python example of a node publishing (sending) a message is:

```python
mqttc = mqtt.Client("digitest")  # Create instance of client with client ID "digitest"
mqttc.connect("m2m.eclipse.org", 1883)  # Connect to (broker, port, keepalive-time)
```
Examples: IOT protocols with transparent mode

```python
mqttc.loop_start()  # Start networking daemon
mqttc.publish("digitest/test1", "Hello, World!")  # Publish message to
"digitest /test1" topic
mqttc.loop_stop()  # Kill networking daemon
```

**Note** You can easily copy and paste code from the online version of this guide. Use caution with the PDF version, as it may not maintain essential indentations.

This example imports the MQTT library, allowing you to use the MQTT protocol via APIs in the library, such as the `connect()`, `subscribe()`, and `publish()` methods.

The second line creates an instance of the client, named `mqttc`. The client ID is the argument you passed in: `digitest` (this is optional).

In line 3, the client connects to a public broker, in this case `m2m.eclipse.org`, on port **1883** (the default MQTT port, or 8883 for MQTT over TLS). There are many publicly available brokers available, you can find a list of them here: https://github.com/mqtt/mqtt.github.io/wiki/brokers.

Line 4 starts the networking daemon with `client.loop_start()` to handle the background network/data tasks.

Finally, the client publishes its message **Hello, World!** to the broker under the topic `digitest/backlog/test1`. Any nodes (devices, phones, computers, even microcontrollers) subscribed to that same topic on the same broker receive the message.

Once no more messages need to be published, the last line stops the network daemon with `client.loop_stop()`.

**Example: receive messages (subscribe) with MQTT**

This example describes how a client would receive messages from within a specific topic on the broker:

```python
import paho.mqtt.client as mqtt

def on_connect(client, userdata, flags, rc):  # The callback for when the
    client connects to the broker
    print("Connected with result code {0}".format(str(rc)))  # Print result
        of connection attempt
    client.subscribe("digitest/test1")  # Subscribe to the topic
"digitest/test1", receive any messages published on it

def on_message(client, userdata, msg):  # The callback for when a PUBLISH
    message is received from the server.
      print("Message received-> " + msg.topic + " " + str(msg.payload))  # Print a received msg

client = mqtt.Client("digi_mqtt_test")  # Create instance of client with
client ID “digi_mqtt_test”
client.on_connect = on_connect  # Define callback function for successful
connection
client.on_message = on_message  # Define callback function for receipt of a
message
# client.connect("m2m.eclipse.org", 1883, 60)  # Connect to (broker, port,
keepalive-time)
client.connect('127.0.0.1', 17300)
```
client.loop_forever()  # Start networking daemon

**Note** You can easily copy and paste code from the online version of this guide. Use caution with the PDF version, as it may not maintain essential indentations.

The first line imports the library functions for MQTT.

The functions `on_connect` and `on_message` are callback functions which are automatically called by the client upon connection to the broker and upon receiving a message, respectively.

The `on_connect` function prints the result of the connection attempt, and performs the subscription. It is wise to do this in the callback function as it guarantees the attempt to subscribe happens only after the client is connected to the broker.

The `on_message` function prints the received message when it comes in, as well as the topic it was published under.

In the body of the code, we:

- Instantiate a client object with the client ID `digi_mqtt_test`.
- Define the callback functions to use upon connection and upon message receipt.
- Connect to an MQTT broker at `m2m.eclipse.org`, on port 1883 (the default MQTT port, or 8883 for MQTT over TLS) with a keepalive of 60 seconds (this is how often the client pings the broker to keep the connection alive).

The last line starts a network daemon that runs in the background and handles data transactions and messages, as well as keeping the socket open, until the script ends.

**Use MQTT over the XBee Cellular Modem with a PC**

To use this MQTT library over an XBee Smart Modem, you need a basic proxy that transfers a payload received via the MQTT client’s socket to the serial or COM port that the XBee Smart Modem is active on, as well as the reverse; transfer of a payload received on the XBee Smart Modem’s serial or COM port to the socket of the MQTT client. This is simplest with the XBee Smart Modem in Transparent mode, as it does not require code to parse or create API frames, and not using API frames means there is no need for them to be queued for processing.

1. To put the XBee Cellular Modem in Transparent mode, set AP to 0.
2. Set DL to the IP address of the broker you want to use.
3. Set DE to the port to use, the default is 1883 (0x75B). This sets the XBee Smart Modem to communicate directly with the broker, and can be performed in XCTU as described in Example: MQTT connect.
4. You can make the proxy with a dual-threaded Python script, a simple version follows:

```python
import threading
import serial
import socket

def setup():
    """
    This function sets up the variables needed, including the serial port, and it's speed/port settings, listening socket, and localhost adddress.
    """
```

---

*Examples: IOT protocols with transparent mode*  

*Get started with MQTT*
global clisock, cliaddr, svrsock, ser
# Change this to the COM port your XBee Cellular module is using. On
# Linux, this will be /dev/ttyUSB#
comport = 'COM44'
# This is the default serial communication speed of the XBee Cellular
# module
comspeed = 115200
buffer_size = 4096  # Default receive size in bytes
debug_on = 0  # Enables printing of debug messages
toval = None  # Timeout value for serial port below
# Serial port object for XBCell modem
ser = serial.Serial(comport,comspeed,timeout=toval)
# Listening socket (accepts incoming connection)
svrsock = socket.socket(socket.AF_INET,socket.SOCK_STREAM)
svrsock.setsockopt(socket.SOL_SOCKET,socket.SO_REUSEADDR, 1)
# These are first defined before thread creation
addrtuple = ('127.0.0.1', 17300)  # Address tuple for localhost
# Binds server socket to localhost (allows client program connection)
svrsock.bind(addrtuple)
svrsock.listen(1)  # Allow (1) connection

def ComReaderThread():
    """
    This thread listens on the defined serial port object ('ser') for data
    from the modem, and upon receipt, sends it out to the client over the
    client socket ('clisock').
    """
    global clisock
    while (1):
        resp = ser.read()  ## Read any available data from serial port
        print("Received {} bytes from modem.".format(len(resp)))

        clisock.sendall(resp)  # Send RXd data out on client socket
        print("Sent {} byte payload out socket to client.".format(len
        (resp)))

def SockReaderThread():
    """
    This thread listens to the MQTT client's socket and upon receiving a
    payload, it sends this data out on the defined serial port ('ser') to
    the
    modem for transmission.
    """
    global clisock
    while (1):
        data = clisock.recv(4096)  # RX data from client socket
        if (len(data) == 0):
            print("ERROR - socket has closed. Exiting socket reader
thread.")
            return 1  # Exit the thread to avoid a loop of 0-byte receptions
        else:
            print("Received {} bytes from client via socket.".format(len
        (data)))
print("Sending payload to modem...")
bytes_wr = ser.write(data)  # Write payload to modem via UART/serial

print("Wrote {} bytes to modem".format(bytes_wr))

def main():
    setup()  # Setup the serial port and socket
    global clisock, svrsock
    if (not clisock):  # Accept a connection on 'svrsock' to open 'clisock'
        print("Awaiting ACCEPT on server sock...")
        (clisock, cliaddr) = svrsock.accept()  # Accept an incoming connection
        print("Connection accepted on socket")
    # Make thread for ComReader
    comthread = threading.Thread(target=ComReaderThread)
    comthread.start()  # Start the thread
    # Make thread for SockReader
    sockthread = threading.Thread(target=SockReaderThread)
    sockthread.start()  # Start the thread

main()

Note This script is a general TCP-UART proxy, and can be used for other applications or scripts that use the TCP protocol. Its functionality is not limited to MQTT.

Note You can easily copy and paste code from the online version of this guide. Use caution with the PDF version, as it may not maintain essential indentations.

This proxy script waits for an incoming connection on localhost (127.0.0.1), on port 17300. After accepting a connection, and creating a socket for that connection (clisock), it creates two threads, one that reads the serial or COM port that the XBee Smart Modem is connected to, and one that reads the socket (clisock), that the MQTT client is connected to.

With:

- The proxy script running
- The MQTT client connected to the proxy script via localhost (127.0.0.1)
- The XBee Smart Modem connected to the machine via USB and properly powered
- AP, DL, and DE set correctly

the proxy acts as an intermediary between the MQTT client and the XBee Smart Modem, allowing the MQTT client to use the data connection provided by the device.

Think of the proxy script as a translator between the MQTT client and the XBee Smart Modem. The following figure shows the basic operation.

Proxy script

MQTT client

Socket data

Thread 2

UART/Serial data

Thread 1

XBee Cellular Modem
The thread that reads the serial port forwards any data received onward to the client socket, and the thread reading the client socket forwards any data received onward to the serial port. This is represented in the figure above.

The proxy script needs to be running before running an MQTT publish or subscribe script.

1. With the proxy script running, run the subscribe example from Example: receive messages (subscribe) with MQTT, but change the connect line from `client.connect("m2m.eclipse.org", 1883, 60)` to `client.connect("127.0.0.1", port=17300, keepalive=20)`. This connects the MQTT client to the proxy script, which in turn connects to a broker via the XBee Smart Modem’s internet connection.

2. Run the publish example from Example: send messages (publish) with MQTT in a third Python instance (while the publish script is running you will have three Python scripts running at the same time).

The publish script runs over your computer’s normal Internet connection, and does not use the XBee Smart Modem. You are able to see your published message appear in the subscribe script’s output once it is received from the broker via the XBee Smart Modem. If you watch the output of the proxy script during this process you can see the receptions and transmissions taking place.

The proxy script must be running before you run the subscribe and publish scripts. If you stop the subscribe script, the socket closes, and the proxy script shows an error. If you try to start the proxy script after starting the subscribe script, you may also see a socket error. To avoid these errors, it is best to start the scripts in the correct order: proxy, then subscribe, then publish.
Update the firmware

You should update your XBee to the latest firmware to take advantage of all the latest fixes and features. Refer to the topics below for information about the available update methods.

Digi strongly recommends that you devise a plan to update the firmware after initial deployment. For more information, see Create a plan for device and cellular component firmware updates.

Create a plan for device and cellular component firmware updates .......................................................... 80
Update the device and the cellular firmware using XCTU .................................................................................. 81
Update the device firmware .............................................................................................................................. 83
Update the cellular firmware .............................................................................................................................. 90
Create a plan for device and cellular component firmware updates

You should update your XBee to the latest firmware to take advantage of all the latest fixes and features. Changes to the cellular network, security issues, or software bugs may be identified which require firmware updates to resolve. In addition, Digi periodically releases new device firmware which includes new features and improves reliability and performance of existing features. You should evaluate and test the new releases and update your firmware to take advantage of the improvements and new features.

**Note** Digi will not accept responsibility for customers who have not planned to update their units. Please review the information provided below.

Please review the suggestions below:

- Always test device and any cellular component firmware updates before deploying these updates to units in the field.
- If updates will be performed using a PC, XCTU version 6.5.0 or later is able to perform complete firmware updates on all device cellular modems, including updating the cellular component firmware.
- If updates will be performed using a host processor, see Use a host processor to update the modem firmware for XBee 3 devices over UART prior to *10 or Use a host processor to update the device firmware for XBee 3 devices over UART after *10.
- If updates will be performed over-the-air (OTA):
  - If your XBee application is using API mode, monitor for Modem Status (0x8A) API frames with status codes 0x38 through 0x3A. These modem status frames inform the XBee's host application about ongoing and completed or failed firmware updates.
  - If your XBee application is using Transparent mode, test your application to determine whether it is tolerant to over-the-air firmware updates of the cellular component and XBee firmware. If your application cannot tolerate the network connection being non-functional for up to 30 minutes (for example, if the XBee will be reset in a shorter time than that), do not use over-the-air updates, and be aware that firmware updates to the XBee require user intervention.
    - If the XBee firmware is updated over-the-air using Digi Remote Manager: After the new firmware image has been downloaded and validated, the XBee modem reboots automatically to install the firmware. The XBee then resets into the new firmware once the update is complete, which may take up to 60 seconds.
    - If the cellular component firmware is being updated: After the cellular firmware update image has been downloaded, the XBee modem disconnects from the network and the cellular component will be updated. This update will take up to 30 minutes. After the update completes (or fails), the XBee will reconnect to the cellular network automatically.

**IMPORTANT**

Future cellular component updates may require the use of USB Direct access. Ensure your hardware design permits USB Direct functionality, either by designing in a USB port and options for enabling and disabling USB Direct, or by allowing the XBee 3 cellular modem to be removed from its socket and placed on a development board, such as the Digi XBIB-CU-TH.
Update the firmware

Use XCTU to update the device firmware, and if needed, XCTU will attempt to update your cellular firmware.

**Update the device and cellular firmware using XCTU and USB Direct access**

**Note** Before you begin, make sure you have XCTU installed and the device is added to the utility. See Install and upgrade XCTU.

**WARNING!** Version 1140F reorganizes the product's flash memory and upgrades the product to version 11410. You cannot downgrade to a version earlier than 11410 after installing 1140F/11410. You also need to use XCTU version 6.4.2 or later.

**Prerequisites**

- Windows PC
- Digi XCTU version 6.5.0 or newer. You should upgrade XCTU to the latest version.
- The device is added to XCTU. See Add a device to XCTU.
- Digi XBIB-CU-TH development board, or your own hardware which enables USB Direct access
- USB cable for USB Direct access is connected to the PC
- Cellular component USB drivers are installed

To update the device and cellular firmware:

1. Launch XCTU.
2. Click the **Configuration working modes** button.
3. From the **Radio Modules** list, select the device that you want to update.
4. Verify the following configuration. The cellular component firmware update may not work if any of these settings is enabled. Ensure the following:
   - Airplane mode is disabled: ATAM set to 0
   - Bypass mode is not is use: ATAP not 5
   - USB Direct Mode is disabled: ATP1 not 7
5. Click **Update firmware**. The **Update the radio module firmware** dialog appears and displays the available and compatible device firmware for the selected XBee module.
6. Select the product family of the XBee module, the function set, and the latest firmware version for the device.
7. Make sure you check the **Force the module to maintain its current configuration** to ensure you do not lose any changes to your configuration.

8. If desired, you can select the **Force the Cellular modem update** option. When selected, the cellular component is updated even if it is already on the newest firmware version. This step is optional.

9. Click **Update** to update the device firmware.

10. If the cellular component firmware requires an update or if you selected the **Force the Cellular modem update** option, a prompt displays.

11. Click **OK** to continue with the update process. XCTU performs the following:
   - XCTU applies and updates the device firmware.
   - If the cellular firmware is being updated, XCTU reconfigures the XBee for USB Direct access and updates the new cellular firmware on the device.
Update the device firmware

You should update the device firmware on your XBee to the latest version to take advantage of all the latest fixes and features. Security issues or software bugs may be identified which require firmware updates to resolve. In addition, Digi periodically releases new firmware which includes new features and improves reliability and performance of existing features.

- For information about updating the cellular firmware, see Update the cellular firmware.
- For information about using XCTU to update both the device firmware and, if needed, the cellular firmware, see Update the device and the cellular firmware using XCTU.

The table below lists update methods you can use and the instructions for each method.

<table>
<thead>
<tr>
<th>Method</th>
<th>Instructions</th>
</tr>
</thead>
<tbody>
<tr>
<td>FOTA (DRM)</td>
<td>- Update the firmware from the Devices page in Remote Manager&lt;br&gt;- Update the firmware using web services in Remote Manager&lt;br&gt;- Schedule a task to update the device firmware using Remote Manager</td>
</tr>
<tr>
<td>API</td>
<td>- Use a host processor to update the modem firmware for XBee 3 devices over UART prior to *10&lt;br&gt;- Use a host processor to update the modem firmware for XBee 3 devices over UART after *10</td>
</tr>
</tbody>
</table>

Update the firmware from the Devices page in Remote Manager

You can update the device firmware for one or multiple devices from the Devices page in Remote Manager.

Before you begin, verify the TCP connection method your device uses to connect to Remote Manager: query once a day or use a persistent TCP connection. See TCP connection.

**Note** Digi Remote Manager requires TCP and will not work with NB-IoT, unless the carrier supports TCP.

**WARNING!** The firmware version 1140F reorganizes the product’s flash memory and upgrades the product to version 11410. You cannot downgrade to a version earlier than 11410 after installing 1140F/11410.

To perform a firmware update:

1. Download the updated firmware file for your device from Digi's support site.
   a. Go to the Digi XBee 3 Cellular LTE-M support page.
   b. Scroll down to the Firmware Updates section.
c. Locate and click **DiXiBee 3 Cellular LTE-M/NB-IoT Gating Firmware** to download the zip file.

d. Unzip the file. The file contains either a .ebin or a .gbl file.

2. Set up a persistent connection to connect the device to Remote Manager. See **Restore persistent connection to a remote XBee**.

3. **Log into Remote Manager**.

4. In your Remote Manager account, click **Device Management > Devices**.

5. Select the first device you want to update. To select multiple devices (must be of the same type), press the Control key and select additional devices.

6. Click **More** in the **Devices** toolbar and select **More > Update > Update Firmware**. The **Update Firmware** dialog appears.

7. Click **Browse** to select the .ebin or .gbl file that you unzipped earlier.

8. Click **Update Firmware**. The updated devices automatically reboot when the updates are complete.

   **Note** The update is immediately rejected and an error is returned if the device is going into sleep mode or is being shut down. See **Clean shutdown**.

9. When all changes are complete, **disconnect the device** from Remote Manager.

### Update the firmware using web services in Remote Manager

Remote Manager supports both synchronous and asynchronous firmware update using web services. The following examples show how to perform an asynchronous firmware update. See the Remote Manager documentation for more details on firmware updates.

Before you begin, verify the TCP connection method your device uses to connect to Remote Manager: query once a day or use a persistent TCP connection. See **TCP connection**.

---

**WARNING!** The firmware version 1140F reorganizes the product's flash memory and upgrades the product to version 11410. You cannot downgrade to a version earlier than 11410 after installing 1140F/11410.

---

**Note** DiXi Remote Manager requires TCP and will not work with NB-IoT, unless the carrier supports TCP.

1. Download the updated firmware file for your device from DiXi's support site.
   a. Go to the **DiXiBee 3 Cellular LTE-M** support page.
   b. Scroll down to the **Firmware Updates** section.
   c. Locate and click **DiXiBee 3 Cellular LTE-M/NB-IoT Gating Firmware** to download the zip file.
   d. Unzip the file and locate the .gbl file in the unzipped directory.

2. Send an HTTP SCI request to Remote Manager with the contents of the downloaded .gbl file converted to base64 data. Refer to the following examples:

   Examples for .gbl:
Example: Update the XBeé .gbl firmware synchronously with Python 3.0

Example: Use the device's .gbl firmware image to update the XBeé firmware synchronously

Example: Update the XBeé .gbl firmware synchronously with Python 3.0

```python
import base64
import requests

# Location of firmware image
firmware_path = 'XBXC.gbl'

# Remote Manager device ID of the device being updated
device_id = '00010000-00000000-03526130-70153378'

# Remote Manager username and password
username = "my_Remote_manager_username"
password = "my_remote_manager_password"

url = 'https://remotemanager.digi.com/ws/sci'

# Get firmware image
fw_file = open(firmware_path, 'rb')
fw_data = fw_file.read()
fw_data = base64.encodebytes(fw_data).decode('utf-8')

# Form update firmware request
data = ""
<sci_request version="1.0">
  <update_firmware filename="firmware.gbl">
    <targets>
      <device id="{}"/>
    </targets>
    <data>{}</data>
  </update_firmware>
</sci_request>
"".format(device_id, fw_data)

# Post request
r = requests.post(url, auth=(username, password), data=data)
if (r.status_code != 200) or ("error" in r.content.decode('utf-8')):
    print("firmware update failed")
else:
    print("firmware update success")
```

Example: Use the device's .gbl firmware image to update the XBeé firmware synchronously

To update the XBeé firmware synchronously with Python 3.0, but using the device firmware image already uploaded to Remote Manager, upload the device's *.gbl firmware to Remote Manager:

1. Download the updated firmware file for your device from Digi's support site. This zip file contains the firmware image.
2. Unzip the file and locate the .gbl file inside the unzipped directory.
3. Log in to Remote Manager.
4. Click the Data Services tab.
5. Click **Data Files**.
6. Click **Upload Files**; browse and select the *.gbl firmware file to upload it.
7. Send an HTTP SCI request to Remote manager with the path of the .gbl file; see the example below.

```python
import base64
import requests

# Location of firmware image on Remote Manager
firmware_path = '~/XBXC.gbl'

# Remote Manager device ID of the device being updated
device_id = '00010000-00000000-03526130-70153378'

# Remote Manager username and password
username = "my_remote_manager_username"
password = "my_remote_manager_password"

url = 'https://remotemanager.digi.com/ws/sci'

# Form update_firmware request
data = '''
<sci_request version="1.0">
  <update_firmware filename="firmware.gbl">
    <targets>
      <device id="{}"/>
    </targets>
    <file>{}</file>
  </update_firmware>
</sci_request>'''.format(device_id, firmware_path)

# Post request
r = requests.post(url, auth=(username, password), data=data)
if (r.status_code != 200) or ("error" in r.content.decode('utf-8')):
    print("firmware update failed")
else:
    print("firmware update success")
```

### Use a host processor to update the modem firmware for XBee 3 devices over UART prior to *10

This process explains how to update the modem firmware for XBee 3 Cellular devices with a modem firmware version prior to *10 (11410 and 31010).

#### Update the modem firmware

1. Make sure you have the correct version of the modem firmware for your XBee device.
2. Enter programming (bootloader) mode. Use one of the following methods: AT commands or hardware signaling.
   - **AT commands**
     a. Send the %P command. The %P command must be sent an argument derived from the SL parameter of the module being updated. The argument is the value of SL added to the value 0xDB8A and then masked by performing a bitwise-AND with
0x3FFF.

i. Run ATSL to get the address value, which is in hex.

```
ATSL
123456
```

ii. Add bitwise-AND with 0x3FFF.

```
(0xDB8A + 0x123456) & 0x3FFF = 0xFE0
```

iii. Send the command AT%PFE0.

```
AT%PFE0
```

b. The **OK** string is returned.

c. After the command is sent, the radio module resets and automatically enters programming mode.

d. Send the **FR command** to reboot and enter into bootloader.

- **Invoke the bootloader with hardware signaling**
  a. De-Assert RTS (pin 16).
  b. Assert DTR (pin 9).
  c. Put DIN in a low state (break) (pin 3).
  d. Reset the module (pin 5).
  e. Release the break on DIN (pin 3) The module should now be in bootloader at 38400 baud.

3. Once the module is in programming (bootloader) mode, configure the local serial port to 38400/8/N/1.

4. Get the hardware version of the radio module from the bootloader.
   a. Send the V command. The response to that command has the following format:

<table>
<thead>
<tr>
<th>XXXXXYYYYZZAABBBCCCDDDDDDEEEEFGGGGGGGGGGGGGGGGGGGGGGGGGGGGGG</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>XXXX</strong>: The hardware version. See <strong>ATHV</strong>, little endian.</td>
<td></td>
</tr>
<tr>
<td><strong>YYYY</strong>: The hardware revision. See <strong>AT%R</strong>, little endian.</td>
<td></td>
</tr>
<tr>
<td><strong>ZZ</strong>: The hardware compatibility number. See <strong>AT%C</strong>.</td>
<td></td>
</tr>
<tr>
<td><strong>AA</strong>: Unused and should be 0.</td>
<td></td>
</tr>
<tr>
<td><strong>BBBB</strong>: The hardware series. See <strong>ATHS</strong>, little endian.</td>
<td></td>
</tr>
<tr>
<td><strong>CCCCCCCCCCCCCCCC</strong>: The serial number.</td>
<td></td>
</tr>
</tbody>
</table>

5. If possible, change the baud rate of the serial port to optimize the firmware update process. Send the X command to the bootloader.
- The bootloader answers with the maximum supported baud rate (in ASCII) and, just after that, the bootloader changes its baud rate to that value. Change your baud rate to match the max supported rate.
- If the bootloader does not answer to this command, remain at the current rate.

6. Send the I command (initialization command). This command erases the current firmware from the device.
7. Transfer the firmware to the device using the transfer protocol shown below.

**Transfer the firmware to the device**

1. You must split the file into 512 byte blocks.
2. Transfer each block using the following structure, with block index and CRC16 sent in little endian byte:
   
   ```
P [2 bytes for block index] [block data with page size length] [2 bytes for CRC16]
   ```

   **Note** CRC16 is calculated only with the bytes of the page to be sent, and is initialized with 0x0000. The polynomial used for the CRC16 is 0x8005.

3. After each block is transferred, wait for a response. Options are:
   - 0x55 - ACK: This is the expected answer.
   - 0x12: Checksum/CRC16 error.
   - 0x13: Flash write/verify error.

   **Note** If an error occurs, you may try to transfer each block up to three times.

4. Verify and write the firmware to flash.
   a. Send the C command (verify) to verify and write the firmware to the flash.
   b. Verify that the answer to this command is 0x55 (ACK). Any other result is an error.

5. Wait a couple of seconds for the firmware to be installed and start running.

**Use a host processor to update the device firmware for XBee 3 devices over UART after *10**

This process explains how to update the device firmware for XBee 3 Cellular devices over UART with a firmware version after *10.

**Update the modem firmware**

1. Make sure you have the correct version of the device firmware for your XBee device.
2. Enter programming (bootloader) mode.
   a. Send the %P command. The %P command must be sent an argument derived from the SL parameter of the device being updated. The argument is the value of SL added to the value 0xDB8A and then masked by performing a bitwise-AND with 0x3FFF. For example:
i. Run ATSL to get the address value, which is in hex.

```
ATSL
123456
```

ii. Add bitwise-AND with 0xFFFF.

```
(0xDB8A + 0x123456) & 0x3FFF = 0x0FE0
```

iii. Send the command AT%PFE0.

```
AT%PFE0
```

b. You will receive a response.

- If successful, OK is returned.
- If an error occurs, ERROR is returned.

c. After the command is sent, the radio module resets and automatically enters programming mode.

3. Once the device is in programming (bootloader) mode, configure the local serial port to 115200/8/N/1.

**Send a firmware image**

After invoking the bootloader, a menu is sent out the UART at 115200 baud.

**Note** If no menu is received after the switch to 115200, send the CR (Carriage Return) command to attempt to receive the prompt again.

To upload a firmware image through the UART interface:

1. Look for the bootloader prompt BL > to ensure the bootloader is active.
2. Send an ASCII 1 character to initiate a firmware update.
3. After sending a 1, the device waits for an XModem CRC upload of a .gbl image over the serial line at 115200 baud. Send the .gbl file to the device using standard XMODEM-CRC.
4. If the firmware image is successfully loaded, the bootloader outputs a “complete” string. Invoke the newly loaded firmware by sending a 2 to the device.

If the firmware image is not successfully loaded, the bootloader outputs an "aborted string". It returns to the main bootloader menu. Some causes for failure are:

- Over 1 minute passes after the command to send the firmware image and the first block of the image has not yet been sent.
- A power cycle or reset event occurs during the firmware load.
- A file error or a flash error occurs during the firmware load.
Update the cellular firmware

You should update the cellular firmware on your device to take advantage of all the latest fixes and features.

**Note** You should also create a plan to update the cellular component firmware on a regular basis, after initial deployment. Security issues or software bugs may be identified which require firmware updates to resolve.

- For information about updating the device firmware, see Update the device firmware.
- For information about using XCTU to update both the device firmware and, if needed, the cellular firmware, see Update the device and the cellular firmware using XCTU.

<table>
<thead>
<tr>
<th>Method</th>
<th>Instructions</th>
</tr>
</thead>
<tbody>
<tr>
<td>FOTA (DRM)</td>
<td>Update an XBee module cellular component using FOTA</td>
</tr>
<tr>
<td>API</td>
<td>Update an XBee module cellular component using API mode</td>
</tr>
<tr>
<td>USB</td>
<td>Update the cellular module from a PC using the EasyFlash Firmware Update</td>
</tr>
</tbody>
</table>

Update an XBee module cellular component using FOTA

You can update an XBee 3 Cellular LTE-M/NB-IoT module from A2.00 or A2.01 to L0.00.00.05.08.A.02.04 (maintenance release) using FOTA and the script described in this section.

**Prerequisites**

- You will need a list of the IMEI values for all XBee 3 Cellular LTE-M/NB-IoT modules to be updated.
- Each module must be running firmware 11413 or later. For update instructions, see Update to the latest firmware from XCTU.
- Each module must have an active, registered SIM card installed.
- Each module must be configured to be connected to Remote Manager and to reconnect when connection is lost. For instructions, see Restore persistent connection to a remote XBee.
- Each module must have visibility to an FTP server hosting the files.
- The machine that will be performing the update must have Python 3.6 or higher installed and the script must be run using Python 3.

**Note** If installing on Windows, ensure that the checkbox for "Add Python to PATH" is checked. If Python is not added to the PATH, you will need to manually specify the directory in which Python is installed in order to proceed.

- The script dependencies must be satisfied by running `pip install --user -r requirements.txt` in the directory containing the script. Creating and using a Python virtual environment with the `virtualenv` command is recommended as a best practice. If
using virtualenv, install the script dependencies using pip install -r requirements.txt once the environment is activated.

**Script usage**
The arguments and default values for the script are shown below. By default, Digi hosts the update files on a public FTP server and the script attempts to apply the appropriate update files based on intelligence built into the script. The optional arguments should only rarely need to be changed and generally only if the Digi FTP server is not accessible on a private APN, or by direction of Digi Technical Support.

```
usage: fota.py [-h] [--type {auto,es2,ip}] [--ftp_server FTP_SERVER]
              [--ftp_port FTP_PORT] [--ftp_user FTP_USER]
              [--ftp_password FTP_PASSWORD] [--ftp_basedir FTP_BASEDIR]

Performance Over The Air Firmware update (FOTA) on XBee Cellular LTE-M/NB-IoT

positional arguments:
  <IMEI>               IMEI of device on which to perform update.

optional arguments:
  -h, --help
  --type {auto,es2,ip}  Type of modules (default: auto)
  --ftp_server FTP_SERVER  FTP server (default: ftp1.digi.com)
  --ftp_port FTP_PORT  FTP port (default: 21)
  --ftp_user FTP_USER  FTP username (default: anonymous)
  --ftp_password FTP_PASSWORD  FTP password (default: fotadi.com)
  --ftp_basedir FTP_BASEDIR  FTP base directory (default: /support/ublox)
```

**Run the update script**
The IMEI values for the modules you want to update are entered as arguments when you run the script. See Script usage for information about the arguments.

1. Download the script.
   a. Go to the Digi XBee 3 Cellular LTE-M support page.
   b. Scroll down to the Firmware Updates section.
   c. Locate and click u-blox Module Over the Air Update Script to download the zip file: over-the-air.zip.
   d. Unzip the downloaded file.
2. Go to a command line and navigate to the directory containing the script.
3. Run `pip install --user -r requirements.txt` in the directory containing the script.

   **Note** If using virtualenv, run `pip install -r requirements.txt` instead.

4. Run the script. Type: `python fota.py <arguments>`
   where `<arguments>` includes the IMEIs and any optional parameters needed for the environment. For more information, see Script usage.
5. Press **Enter**. You will be prompted for your Remote Manager user name and password.
6. After you have entered the user name and password, the script connects to Remote Manager. For each device listed as an argument in the command line, the script performs the following items:
   - Verifies connectivity to Remote Manager and the module configuration.
   - Applies a sequence of updates to the module that are needed to perform the update.
   - Verifies the final cellular component version.
7. When complete, a CSV is generated and named using this format: `results-<timestamp>.csv`, where `<timestamp>` is the time of the run. The file lists each IMEI, whether the update for that IMEI was successful, and any error message if the update failed.
8. A successful update appears as:

   SUCCESS updating 352753090812345090861053

9. If the update was not successful, try the update again with this flag: `--type=ip`
10. If the update was still not successful, contact Digi Technical Support at tech.support@digi.com.

### Update an XBee module cellular component using API mode

You can update an XBee 3 Cellular LTE-M/NB-IoT module from A2.00 or A2.01 to L0.00.00.05.08,A.02.04 (maintenance release) using API mode and the script described in this section.

**Prerequisites**

- Each module must be inserted into a development board such as the Digi XBIB-CU-TH, powered on, and connected to the PC.
- Each module must be running firmware 11413 or later. For update instructions, see [Update to the latest firmware from XCTU](https://www.digi.com/support/xctu).  
- Each module must have an active, registered SIM card installed.
- Each module must be configured in the default operating mode:
  - **ATAM** set to 0 to disable airplane mode
  - **ATSM** set to 0 to disable sleep
  - **ATP0** set to 0 and **ATP1** set to 0 to disable direct USB.

  If any of these settings needed to be changed, issue **ATWR** to save changes.
- Each module must be configured to use unescaped API mode: **ATAP** set to 1.
- Each module must be configured to use the same baud rate on the UART interface (same **ATBD** value).
- The machine that will be performing the update must have Python 3.6 or higher installed and the script must be run using Python 3.

**Note** If installing on Windows, ensure that the checkbox for "Add Python to PATH" is checked. If Python is not added to the PATH, you will need to manually specify the directory in which Python is installed in order to proceed.

- The machine that will be performing the update must have visibility to an HTTP server hosting the files.
The script dependencies must be satisfied by running pip install --user -r requirements.txt in the directory containing the script. Creating and using a Python virtual environment with the virtualenv command is recommended as a best practice. If using virtualenv, install the script dependencies using pip install --user -r requirements.txt once the environment is activated.

**Script usage**

The arguments and default values for the script are shown below. By default, Digi hosts the update files on a public FTP server and the script attempts to apply the appropriate update files based on intelligence built into the script. The optional arguments should only rarely need to be changed and generally only if the Digi FTP server is not accessible on a private APN, or by direction of Digi Technical Support.

```
```

Update the u-blox SARA-R410M cellular module used by the Digi XBee 3 Cellular LTE-M/NB-IoT device to firmware version L0.00.05.08,A.02.04 (maintenance release) using a serial link to one or XBee 3 Cellular devices. Script version: 1.1.

optional arguments:
- `-h, --help` show this help message and exit

Serial port:
Arguments which control how the script interfaces with the XBee

- `<PORT>` COM port (or /dev/ttyUSBx device) for the XBee 3 Cellular device. Can be specified multiple times to update multiple devices.
- `--baud <BAUD>` Current baud rate of the XBee 3 Cellular device(s) (default: 9600)

Firmware update:
Arguments which control the firmware update process

- `--type {auto,es2,ip}` Type of modules (default: auto)
- `--remote BASE_URL` HTTP server base path where firmware files are located (default: http://ftp1.digi.com/support/ublox)
- `--local BASE_DIRECTORY` Local directory where update files are located (overrides --remote) (default: None)
- `-f FILE, --file FILE` Apply only this one file (default: None)

Other arguments:
- `-v, --verbose` Also emit log messages about communications with the XBee (default: False)

For additional help, see the XBee 3 Cellular LTE-M/NB-IoT user guide or contact Digi Technical Support at <tech.support@digi.com>.

**Example**

Examples of usage:
C: \Users\admin\over-the-wire>C: \Users\admin\AppData\Local\Programs\Python\Python37-32\python.exe update.py COM17
Run the update script

The serial port (COM port or /dev/ttyX device) values for the modules you want to update are entered as arguments when you run the script. See Script usage for information about the arguments.

1. Download the script.
   a. Go to the Digi XBee 3 Cellular LTE-M support page.
   b. Scroll down to the Firmware Updates section.
   c. Locate and click u-blox Over the Wire Update Script to download the zip file: over-the-wire.zip.
   d. Unzip the downloaded file.
2. Go to a command line.
3. Navigate to the directory containing the script.
4. Run pip install --user -r requirements.txt in the directory containing the script.

   Note If using virtualenv, run pip install -r requirements.txt instead.

5. Verify that you are in the same directory as the script.
6. Run the script. Type: python update.py <arguments>
   where <arguments> includes the serial port (COM# port or /dev/tty# device, where # is the port number) and any optional parameters needed for the environment. For more information, see Script usage.

   Windows example
   C:\Users\admin\over-the-wire>C:\Users\admin\AppData\Local\Programs\Python\Python37-32\python.exe update.py COM17

   Linux examples
   $ python update.py /dev/tty5
   $ python update.py COM10 --baud=115200
7. Press Enter to begin running the script. For a detailed description of how the update script works, see How the script works.
8. When complete, a digi-update.log text file is created, which contains a copy of the log messages emitted to the terminal while the script was running.
9. A successful update appears as:

```
2019-06-27 16:06:28,501 update.py: INFO: Update successful. New MV value: L0.00.00.05.08,A.02.04
2019-06-27 16:06:28,744 update.py: INFO: Updates complete. This script should automatically exit in a moment. If it does not exit, use Ctrl-C to stop the script.
```
Update the cellular module from a PC using the EasyFlash Firmware Update

A critical issue patch and a maintenance release to update the cellular modem firmware of the XBee 3 Cellular LTE-M module using EasyFlash and the XBIB-CU-TH development board are available. These updates apply to the XBee 3 Cellular device containing the following cellular modem:

u-blox SARA-R410M-02B

For instructions, see Digi XBee 3 Cellular LTE-M Cellular Module Patch and Maintenance Release via EasyFlash Firmware Update.
Technical specifications

Interface and hardware specifications ................................................................. 97
Cellular RF characteristics .................................................................................. 97
Bluetooth RF characteristics .............................................................................. 97
Cellular networking specifications ...................................................................... 97
Power requirements ............................................................................................. 98
Power consumption .............................................................................................. 99
Electrical specifications ....................................................................................... 100
Regulatory approvals ......................................................................................... 101
Interface and hardware specifications

The following table provides the interface and hardware specifications for the device.

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimensions</td>
<td>24.38 mm x 32.94 mm (0.960 x 1.297 in)</td>
</tr>
<tr>
<td>Weight</td>
<td>5 g (0.18 oz)</td>
</tr>
<tr>
<td>Operating temperature</td>
<td>-40 to +85 °C</td>
</tr>
<tr>
<td>Antenna connector</td>
<td>Cellular: U.FL</td>
</tr>
<tr>
<td></td>
<td>Bluetooth: U.FL</td>
</tr>
<tr>
<td>Digital I/O</td>
<td>13 I/O lines, I^2C</td>
</tr>
<tr>
<td>ADC</td>
<td>4 10-bit analog inputs</td>
</tr>
<tr>
<td>Analog input voltage range</td>
<td>0 - 2.5 V</td>
</tr>
<tr>
<td>Cellular chipset</td>
<td>u-blox SARA-R410M-028</td>
</tr>
<tr>
<td>Form factor</td>
<td>Digi XBee 20-pin through-hole</td>
</tr>
<tr>
<td>SIM size</td>
<td>4FF Nano</td>
</tr>
</tbody>
</table>

Cellular RF characteristics

The following table provides the RF characteristics for the device.

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmit power</td>
<td>Up to 23 dBm, Power Class 3</td>
</tr>
<tr>
<td>Receive sensitivity</td>
<td>-105 dBm</td>
</tr>
</tbody>
</table>

Bluetooth RF characteristics

The following table provides the Bluetooth RF characteristics for the device.

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmit power</td>
<td>Up to 8 dBm</td>
</tr>
<tr>
<td>Receive sensitivity, 1 Mb/s data rate</td>
<td>-92 dBm</td>
</tr>
<tr>
<td>Receive sensitivity, 2 Mb/s data rate</td>
<td>-88 dBm</td>
</tr>
<tr>
<td>Operating frequency band</td>
<td>ISM 2.4 - 2.4835 GHz</td>
</tr>
</tbody>
</table>

Cellular networking specifications

The following table provides the networking and carrier specifications for the device.
### Technical specifications

#### Carrier and technology
- AT&T and Verizon LTE-M
- T-Mobile NB-IoT in US
- Vodafone and Deutsche Telekom NB-IoT in Europe
- Compatible with other LTE-M carriers, see supported bands

#### Supported bands
**LTE FDD bands:**
- Band 12 (700 Mhz)
- Band 28 (700 MHz)
- Band 13 (700 MHz)
- Band 20 (800 MHz)
- Band 26 (850 MHz)
- Band 18 (850 MHz)
- Band 5 (850 MHz)
- Band 19 (850 MHz)
- Band 8 (900 MHz)
- Band 4 (1700 MHz)
- Band 3 (1800 Mhz)
- Band 2 (1900 MHz)
- Band 25 (1900 MHz)\(^1\)
- Band 1 (2100 MHz)

**LTE TDD bands:**
- Band 39 (1900 MHz)

#### Security
- Digi Trustfence™

#### Downlink/uplink speeds
**LTE M1**
- up to 300 kb/s DL
- up to 375 kb/s UL

**LTE NB1**
- up to 27.2 kb/s DL
- up to 62.5 kb/s UL

#### Duplex mode
- Half-duplex

#### Addressing options
- SMS and IP-based protocols may not be available. Check with your carrier’s specifications for LTE-M\NB-IoT.

---

### Power requirements

The following table provides the power requirements for the device.

---

\(^1\)Band 25 is only supported by products containing SARA-R410M-02B-01 and newer. Band 25 is for LTE CAT M1 only.
### Technical specifications

#### Power consumption

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply voltage</td>
<td>3.3 to 4.3 V</td>
</tr>
</tbody>
</table>

#### Power consumption

<table>
<thead>
<tr>
<th>Specification</th>
<th>State</th>
<th>Using serial interface, VCC = 3.3 V</th>
<th>Using USB direct mode, VCC = 3.3 V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak transmit current</td>
<td>Bluetooth disabled</td>
<td>550 mA</td>
<td>550 mA</td>
</tr>
<tr>
<td></td>
<td>Bluetooth enabled</td>
<td>610 mA</td>
<td>610 mA</td>
</tr>
<tr>
<td>Average connected mode current</td>
<td>TX/RX @ 23 dBm</td>
<td>205 mA</td>
<td>220 mA</td>
</tr>
<tr>
<td>Active mode current</td>
<td>Idle/connected, listening</td>
<td>20 mA</td>
<td>35 mA</td>
</tr>
<tr>
<td>Power save mode current</td>
<td></td>
<td>20 µA</td>
<td>Not supported</td>
</tr>
<tr>
<td>Deep sleep current</td>
<td></td>
<td>10 µA</td>
<td>10 µA (USB direct mode must be disabled during sleep)</td>
</tr>
</tbody>
</table>
## Electrical specifications

The following table provides the electrical specifications for the XBee Smart Modem.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Condition</th>
<th>Min</th>
<th>Typical</th>
<th>Max</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>VCCMAX</td>
<td>Maximum limits of VCC line</td>
<td>0</td>
<td></td>
<td>4.3</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>VDD_IO</td>
<td>Internal supply voltage for I/O</td>
<td>(VCC - 0.15 V) or 3.3 V, whichever is lower</td>
<td></td>
<td>VCC or 3.3 V, whichever is lower</td>
<td>3.3</td>
<td>V</td>
</tr>
<tr>
<td>VI</td>
<td>Other XBee pins</td>
<td>-0.3</td>
<td></td>
<td></td>
<td>VDD_IO + 0.3</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>Voltage on XBee pin 6 (5 V tolerant)</td>
<td>-0.3</td>
<td></td>
<td>5.25 or VDD_IO+2, whichever is lower(^1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VIL</td>
<td>Input low voltage</td>
<td></td>
<td></td>
<td>0.3*VDD_IO</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>VIH</td>
<td>Input high voltage</td>
<td>0.7*VDD_IO</td>
<td></td>
<td></td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>VOL</td>
<td>Voltage output low</td>
<td>Sinking 3 mA, VCC = 3.3 V</td>
<td></td>
<td>0.2*VDD_IO</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>VOH</td>
<td>Voltage output high</td>
<td>Sourcing 3 mA, VCC = 3.3 V</td>
<td></td>
<td>0.8*VDD_IO</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>I_IN</td>
<td>Input leakage current</td>
<td>High Z state I/O connected to Ground or VDD_IO</td>
<td></td>
<td>0.1</td>
<td>30</td>
<td>nA</td>
</tr>
<tr>
<td>RPU</td>
<td>Internal pull-up resistor</td>
<td>Enabled</td>
<td></td>
<td>40</td>
<td></td>
<td>kΩ</td>
</tr>
<tr>
<td>RPD</td>
<td>Internal pull-down resistor</td>
<td>Enabled</td>
<td></td>
<td>40</td>
<td></td>
<td>kΩ</td>
</tr>
</tbody>
</table>

\(^1\)Pin 6 is 5 V tolerant even when the XBee Smart Modem is not powered. We recommend only driving this pin with 3.3 V for compatibility with other XBee products.
## Regulatory approvals

The following table provides the regulatory and carrier approvals for the device.

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>XB3M1</td>
</tr>
<tr>
<td>United States</td>
<td>FCC ID: MCQ-XB3M1</td>
</tr>
<tr>
<td></td>
<td>FCC ID: XPY2AGQN4NNN</td>
</tr>
<tr>
<td>Innovation, Science and Economic Development Canada (ISED)</td>
<td>IC: 1846A-XB3M1</td>
</tr>
<tr>
<td></td>
<td>IC: 8595A-2AGQN4NNN</td>
</tr>
<tr>
<td>RoHS</td>
<td>Lead-free and RoHS compliant</td>
</tr>
<tr>
<td>AT&amp;T end-device certified</td>
<td>Complete</td>
</tr>
<tr>
<td>Verizon end-device certified</td>
<td>Complete</td>
</tr>
<tr>
<td>PTCRB</td>
<td>Complete</td>
</tr>
<tr>
<td>Bluetooth</td>
<td>Declaration ID: D042514</td>
</tr>
<tr>
<td></td>
<td>QDID: 121268</td>
</tr>
</tbody>
</table>
## Hardware

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanical drawings</td>
<td>103</td>
</tr>
<tr>
<td>Pin signals</td>
<td>103</td>
</tr>
<tr>
<td>RSSI PWM</td>
<td>105</td>
</tr>
<tr>
<td>SIM card</td>
<td>105</td>
</tr>
<tr>
<td>Associate LED functionality</td>
<td>105</td>
</tr>
<tr>
<td>Development boards</td>
<td>107</td>
</tr>
</tbody>
</table>
**Mechanical drawings**

The following figures show the mechanical drawings for the XBee Smart Modem. All dimensions are in inches.

![Mechanical drawings](image1)

**Pin signals**

The pin locations are:

```
1   20
2   19
3   18
4   17
5   16
6   15
7   14
8   13
9   12
10  11
```
The following table shows the pin assignments for the through-hole device. In the table, low-asserted signals have a horizontal line above signal name.

<table>
<thead>
<tr>
<th>Pin</th>
<th>Name</th>
<th>Direction</th>
<th>Default</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>VCC</td>
<td></td>
<td></td>
<td>Power supply</td>
</tr>
<tr>
<td>2</td>
<td>DOUT</td>
<td>Output</td>
<td>Output</td>
<td>UART Data Out</td>
</tr>
<tr>
<td>3</td>
<td>DIN / CONFIG</td>
<td>Input</td>
<td>Input</td>
<td>UART Data In</td>
</tr>
<tr>
<td>4</td>
<td>DIO12 / SPI_MISO</td>
<td>Either</td>
<td>Disabled</td>
<td>Digital I/O 12 or SPI Slave Output line¹</td>
</tr>
<tr>
<td>5</td>
<td>RESET</td>
<td>Input</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>PWM0 / RSSI / DIO10/USB_VBUS</td>
<td>Either</td>
<td>Output</td>
<td>PWM Output 0 / RX Signal Strength Indicator / Digital I/O 10</td>
</tr>
<tr>
<td>7</td>
<td>DIO11/USB D+</td>
<td>Either</td>
<td>Disabled</td>
<td>Digital I/O 11 or USB Direct D+ line</td>
</tr>
<tr>
<td>8</td>
<td>USB D-</td>
<td>Either</td>
<td>Disabled</td>
<td>USB Direct D- line</td>
</tr>
<tr>
<td>9</td>
<td>DTR / SLEEP_RQ / DIO8</td>
<td>Either</td>
<td>Disabled</td>
<td>Pin Sleep Control Line or Digital I/O 8</td>
</tr>
<tr>
<td>10</td>
<td>GND</td>
<td></td>
<td></td>
<td>Ground</td>
</tr>
<tr>
<td>11</td>
<td>DIO4 / SPI_MOSI</td>
<td>Either</td>
<td>Disabled</td>
<td>Digital I/O 4 or SPI Slave Input Line</td>
</tr>
<tr>
<td>12</td>
<td>CTS / DIO7</td>
<td>Either</td>
<td>Output</td>
<td>Output Clear-to-Send Flow Control or Digital I/O 7</td>
</tr>
<tr>
<td>13</td>
<td>ON / SLEEP / DIO9</td>
<td>Output</td>
<td>Output</td>
<td>Module Status Indicator or Digital I/O 9</td>
</tr>
<tr>
<td>14</td>
<td>VREF</td>
<td>-</td>
<td></td>
<td>Feature not supported on this device. Used on other XBee devices for analog voltage reference.</td>
</tr>
<tr>
<td>15</td>
<td>Associate / DIO5</td>
<td>Either</td>
<td>Output</td>
<td>Associated Indicator, Digital I/O 5</td>
</tr>
<tr>
<td>16</td>
<td>RTS / DIO6</td>
<td>Either</td>
<td>Disabled</td>
<td>Input Request-to-Send Flow Control, Digital I/O 6</td>
</tr>
<tr>
<td>17</td>
<td>AD3 / DIO3 / SPI_SS</td>
<td>Either</td>
<td>Disabled</td>
<td>Analog Input 3 or Digital I/O 3, SPI low enabled select line</td>
</tr>
<tr>
<td>18</td>
<td>AD2 / DIO2 / SPI_CLK</td>
<td>Either</td>
<td>Disabled</td>
<td>Analog Input 2 or Digital I/O 2, SPI Clock line</td>
</tr>
<tr>
<td>19</td>
<td>AD1 / DIO1 / SPI_ATTN</td>
<td>Either</td>
<td>Disabled</td>
<td>Analog Input 1 or Digital I/O 1, SPI Attention line output</td>
</tr>
<tr>
<td>20</td>
<td>AD0 / DIO0</td>
<td>Either</td>
<td>Input</td>
<td>Analog Input 0, Digital I/O 0</td>
</tr>
</tbody>
</table>

### Pin connection recommendations

To ensure compatibility with future updates, make USB D+ and D- (pin 7 and pin 8) available in your design.

---

1DIO12/SPI_MISO and DIO4/SPI_MOSI (pin 4 and pin 11) may optionally be configured as a secondary UART serial port using MicroPython. See the Digi MicroPython Programming Guide for details.
The recommended minimum pin connections are VCC, GND, DIN, DOUT, RTS, DTR and RESET. Firmware updates require access to these pins.

**RSSI PWM**

The XBee Smart Modem features an RSSI/PWM pin (pin 6) that, if enabled, adjusts the PWM output to indicate the signal strength of the cellular connection. Use P0 (DIO10/PWM0 Configuration) to enable the RSSI pulse width modulation (PWM) output on the pin. If P0 is set to 1, the RSSI/PWM pin outputs a PWM signal where the frequency is adjusted based on the received signal strength of the cellular connection.

The RSSI/PWM output is enabled continuously unlike other XBee products where the output is enabled for a short period of time after each received transmission. If running on the XBIB development board, DIO10 is connected to the RSSI LEDs, which may be interpreted as follows:

<table>
<thead>
<tr>
<th>PWM duty cycle</th>
<th>Number of LEDs turned on</th>
<th>Received signal strength (dBm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>79.39% or more</td>
<td>3</td>
<td>-83 dBm or higher</td>
</tr>
<tr>
<td>62.42% to 79.39%</td>
<td>2</td>
<td>-93 to -83 dBm</td>
</tr>
<tr>
<td>45.45% to 62.42%</td>
<td>1</td>
<td>-103 to -93 dBm</td>
</tr>
<tr>
<td>Less than 45.45%</td>
<td>0</td>
<td>Less than -103 dBm, or no cellular network connection</td>
</tr>
</tbody>
</table>

**SIM card**

The XBee Smart Modem uses a 4FF (Nano) size SIM card.

---

**CAUTION!** Never insert or remove SIM card while the power is on!

**Associate LED functionality**

The following table describes the Associate LED functionality. For the location of the Associate LED on the XBIB-U development board, see number 6 on the XBIB-U-DEV reference.

<table>
<thead>
<tr>
<th>LED status</th>
<th>Blink timing</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>On, solid</td>
<td></td>
<td>Not joined to a mobile network.</td>
</tr>
</tbody>
</table>
### Associate LED functionality

<table>
<thead>
<tr>
<th>LED status</th>
<th>Blink timing</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Double blink</td>
<td>½ second</td>
<td>The last TCP/UDP attempt failed. If the LED has this pattern, you may need to check DI (Remote Manager Indicator) or CI (Protocol/Connection Indication) for the cause of the error.</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Note</strong> This pattern applies only to the Transparent mode. Other transmission modes do not affect the Associate LED blink pattern.</td>
</tr>
<tr>
<td>Standard single blink</td>
<td>1 second</td>
<td>Normal operation.</td>
</tr>
</tbody>
</table>

The normal association LED signal alternates evenly between high and low as shown below:

```
[LED signal diagram]
```

Where the low signal means LED off and the high signal means LED on.

When **CI** is not **0** or **0xFF**, the Associate LED has a different blink pattern that looks like this:

```
[LED signal diagram]
```
Development boards

XBIB-U-DEV reference
This picture shows the XBee USB development board and the table that follows explains the callouts in the picture.
<table>
<thead>
<tr>
<th>Number</th>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Programming header</td>
<td>Header used to program XBee programmable devices.</td>
</tr>
<tr>
<td>2</td>
<td>Self power module</td>
<td>Advanced users only—voids the warranty. Depopulate R31 to power the device using V+ and GND from J2 and J5. You can connect sense lines to S+ and S- for sensing power supplies.</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>CAUTION:</strong> Voltage is not regulated. Applying the incorrect voltage can cause fire and serious injury.</td>
</tr>
<tr>
<td>3</td>
<td>Current testing</td>
<td>Depopulating R31 allows a current probe to be inserted across P6 terminals. The current though P6/R31 powers the device only. Other supporting circuitry is powered by a different trace.</td>
</tr>
<tr>
<td>4</td>
<td>Loopback jumper</td>
<td>Populating P8 with a loopback jumper causes serial transmissions both from the device and from the USB to loopback.</td>
</tr>
<tr>
<td>5</td>
<td>DC barrel plug: 6-20 V</td>
<td>Greater than 500 mA loads require a DC supply for correct operation. Plug in the external power supply prior to the USB connector to ensure that proper USB communications are not interrupted.</td>
</tr>
<tr>
<td>7</td>
<td>USB</td>
<td>Connects to your computer.</td>
</tr>
<tr>
<td>8</td>
<td>RSSI indicator</td>
<td>See RSSI PWM. On the XBIB-U, more lights are better.</td>
</tr>
<tr>
<td>9</td>
<td>User buttons</td>
<td>Connected to DIO lines for user implementation.</td>
</tr>
<tr>
<td>10</td>
<td>Reset button</td>
<td>Press the reset button to reset the device to the default configuration.</td>
</tr>
<tr>
<td>11</td>
<td>SPI power</td>
<td>Connect to the power board from 3.3 V.</td>
</tr>
<tr>
<td>12</td>
<td>SPI</td>
<td>Only used for surface-mount devices.</td>
</tr>
</tbody>
</table>
| 13     | Indicator LEDs                | DS5: ON/SLEEP  
DS2: DIO12, the LED illuminates when driven low.  
DS3: DIO11, the LED illuminates when driven low.  
DS4: DIO4, the LED illuminates when driven low.                                                                                                                                 |
| 14     | Through-hole XBee sockets    | Connects the Digi XBee 3® Cellular LTE-M/NB-IoT modem to the XBee USB development board.                                                                                                                     |
| 15     | 20-pin header                 | Maps to standard through-hole XBee pins. Male, Samtec header, part number: TSW-110-26-L-D. 2.54 mm / .100" pitch and row spacing.                                                                               |

1Powering the board with J2 and J5 without R31 removed can cause shorts if the USB or barrel plug power are connected. Applying too high a voltage destroys electronic circuitry in the device and other board components and/or can cause injury.
**XBIB-CU-TH reference**

This picture shows the XBee-CU-TH development board and the table that follows explains the callouts in the picture.

*Note* This module is sold separately.
## Secondary USB (USB MICRO B) and DIP Switch

Secondary USB Connector for direct programming of modules on some XBee units. Flip the Dip switches to the right for I2C access to the board; flip Dip switches to the left to disable I2C access to the board. The USB_P and USB_N lines are always connected to the XBee, regardless of Dip switch setting. USB communications will fail if switches are not in the left position or if XBEE is not configured to enable USB communications. See ATP1 command.

This USB port is not designed to power the module or the board. A USB-C cable or battery port is required to power the board. Cable can be connected at any time, with the XBee powered or unpowered.

**WARNING!** USB micro port should not be connected when used with XBees that do not support USB communications.

## Current Measure

Large switch controls whether current measure mode is active or inactive. When inactive, current can freely flow to the VCC pin of the XBee. When active, the VCC pin of the XBee is disconnected from the 3.3 V line on the development board. This allows current measurement to be conducted by attaching a current meter across the jumper P10.

**WARNING!** Battery current discharge rating must be enough to support 5 W or more.

**WARNING!** There is no circuit to prevent over discharge of battery. Battery must contain its own protection circuitry.

**WARNING!** Move UART switches to the left (OFF position) when using battery or external power or for the XBee and the USB-C connector is not powering the UART.

**Note** Power supply outputs 3.3V to XBee regardless of input voltage as long as current requirement can be met to achieve power consumption of devices.
<table>
<thead>
<tr>
<th>Number</th>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>USB-C Connector</td>
<td>Provides power and UART communications for the XBEE and development board.</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Note</strong> Requires USB 3.0 to supply 1 amp of required current. USB 2.0 ports that cannot supply at least 1 amp cannot be used.</td>
</tr>
</tbody>
</table>
| 5      | LED indicator         | Red: UART DOUT (modem sending serial/UART data to host)  
Green: UART DIN (modem receiving serial/UART data from host)  
White: ON/SLP/DIO9  
Blue: Connection Status/DIO5  
Yellow: RSSI/PWM0/DIO10  
Note Requires USB 3.0 to supply 1 amp of required current. USB 2.0 ports that cannot supply at least 1 amp cannot be used.                                                                                                                                                                                                 |
| 6      | User Buttons          | Comm DIO0 Button connects the Commissioning/DIO0 pin to GND when pressed.  
RESET button resets the XBee module when pressed.                                                                                                                                                                                                                                                                                           |
| 7      | Breakout Connector    | This 40 pin connects to various XBee pins as shown on the silkscreen on the bottom of the board.                                                                                                                                                                                                                                                |
| 8      | UART Dip Switch       | Push Dip switches to the right (OFF position) to disconnect USB-to-UART conversion chip from the XBee. This allows UART lines to be individually selected to connect through the breakout connector or the USB-C interface.                                                                                                                                                                      |
| 9      | Grove Connector       | This connector attaches I2C-enabled devices to the development board.  
Note that I2C needs to be available on the XBee in the board for this functionality to be used.  
Move both USB direct connect switches to the right (closed position) and disconnect the USB micro port for correct operation of the I2C to connector.  
Pin 1: I2C_CLK/XBee DIO1  
Pin2: I2C_SDA/XBee DIO11  
Pin3: VCC  
Pin4: GND  
Move both USB direct connect switches to the right (closed position) and disconnect the USB micro port for correct operation of the I2C sensor.                                                                                                                                                                                                                                                                 |
| 10     | Temp/Humidity Sensor  | This part is a Texas Instruments HDC1080 temperature and humidity sensor connected through I2C on XBee pins DIO1 and DIO11. Move both USB direct connect switches to the right (closed position) and disconnect the USB micro port for correct operation of the I2C sensor.                                                                                                                                 |
| 11     | XBee Socket           | This is the socket for the XBee (TH form factor).                                                                                                                                                                                                                                                                                            |
| 12     | XBee Test Point Pins  | Allows easy access to pins 1 to 20 of the XBee.                                                                                                                                                                                                                                                                                              |
**XBIB-C-GPS reference**

This picture shows the XBIB-C-GPS module and the table that follows explains the callouts in the picture.

*Note* This GPS module is sold separately and requires an XBIB-CU-TH development board.

*Note* You run a demo using MicroPython to parse UART to GPS communications. see Run the MicroPython GPS demo.
<table>
<thead>
<tr>
<th>Number</th>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>40-pin header</td>
<td>This header is used to connect the XBIB-C-GPS board to a compatible XBIB development board. Insert the XBIB-C-GPS module slowly with alternating pressure on the upper and lower parts of the connector. Do not bend pins during insertion or removal process.</td>
</tr>
<tr>
<td>2</td>
<td>GPS unit</td>
<td>Contains GPS module CAM-M8Q-0-10. Proper orientation is with the board laying flat, with the GPS module having a clear view of the sky.</td>
</tr>
</tbody>
</table>

### Interface with the XBIB-C-GPS module

The XBee Smart Modem can interface with the XBIB-C-GPS board through the 40-pin header. This header is designed to fit into XBIB-C development board. This allows the XBee Smart Modem in the XBIB-C board to communicate with the XBIB-C-GPS board—provided the XBee device has MicroPython capabilities (see this link to determine which devices have MicroPython capabilities). There are two ways to interface with the XBIB-C-GPS board: through the host board's Secondary UART or through the I2C compliant lines.

The following picture shows a typical setup:
I2C communication

There are two I2C lines connected to the host board through the 40-pin header, SCL and SDA. I2C communication is performed over an I2C-compliant Display Data Channel. The XBIB-C-GPS module operates in slave mode. The maximum frequency of the SCL line is 400 kHz. To access data through the I2C lines, the data must be queried by the connected XBee Smart Modem.

For more information about I2C Operation see the I2C section of the Digi Micro Python Programming Guide.

For more information on the operation of the XBIB-C-GPS board see the CAM-M8 datasheet. Other CAM-M8 documentation is located here.

UART communication

UART (RX and TX) are pins connected from the XBIB-C-GPS to the host board by the 40-pin header. By default, the UART on the XBIB-C-GPS board is active and sends GPS readings once every second. The baud rate of the UART is 9600 baud.

For more information about using Micro Python to communicate to the XBIB-C-GPS module, see Class UART.

Run the MicroPython GPS demo

The Digi MicroPython github repository contains a GPS demo program that parses the GPS NMEA data from the UART and prints them.

Note If you are unfamiliar with MicroPython on XBee, see Get started with MicroPython. For more detailed information, refer to the Digi MicroPython Programming Guide.

Step 1: Clone or download the XBee MicroPython repository

1. Navigate to: https://github.com/digidotcom/xbee-micropython/
2. You must either clone or download a zip file of the repository. You can use either method.
   - **Clone**: If you are familiar with Git, follow the standard Git process to clone the repository.
   - **Download**
     a. Click Download zip to download a zip file of the repository to the download folder of your choosing.
     b. Extract the repository to a location of your choosing on your hard drive.

Step 2: Edit the MicroPython file

1. Navigate to the location that you created in Step 1.
2. Navigate to: samples/gps_uart
3. Open the MicroPython file: main.py

Step 3: Run the program

1. Copy the file onto your device’s root filesystem directory.
2. Open XCTU and use the MicroPython Terminal to run the demo.
3. Type <CTRL>-R from the MicroPython prompt to run the code.
Antenna recommendations

Antenna placement

Antenna location is important for optimal performance. The following suggestions help you achieve optimal antenna performance. See Regulatory information for details on cellular and Bluetooth antennas that you may use with the XBee Smart Modem.

Keep the antenna(s) as far away from metal objects and other electronics (including the XBee Smart Modem) as possible. Metal objects near the antenna cause parasitic coupling and detuning, preventing the antenna from radiating efficiently. Metal objects between the transmitter and receiver can also block the radiation path or reduce the transmission distance. Some objects that are often overlooked are:

- Metal poles
- Metal studs or beams in structures
- Concrete (reinforced with metal rods)
- Metal enclosures
- Vehicles
- Elevators
- Ventilation ducts
- Batteries
- Tall electrolytic capacitors

Often, small antennas are desirable, but may come at the cost of reduced range and efficiency.

If you implement the Bluetooth interface, ensure that the Bluetooth and cellular antennas are at least 3 inches apart (6 inches recommended) to prevent cellular sensitivity from being degraded.
Design recommendations

Cellular component firmware updates ................................................................. 117
Power supply considerations .................................................................................. 117
Minimum connection diagram ............................................................................... 117
Heat considerations and testing ........................................................................... 118
Custom configuration: Create a new factory default .......................................... 118
Clean shutdown ...................................................................................................... 119
Cellular component firmware updates

Even if you do not plan to use the USB interface (Pin 7 and 8), we strongly recommend you provide a way to access the USB pins (Pin 7 and 8) to support direct firmware updates of the Cellular modem. You should keep Pins 7 and 8 routing as a 90 ohm diff pair for USB communications.

**CAUTION!** If you do not provide access to these USB pins, you may be unable to perform cellular component firmware updates.

One way to provide access to the USB interface is to connect the USB pins to a header or USB connector on the host design; see Run the MicroPython GPS demo for more information. At a minimum you should connect pins 7 and 8 to test points so they are easy to wire to a connector if necessary.

If you are using the USB pins for other purposes you must provide a way to disconnect those interfaces during USB operation, such as using zero ohm resistors.

Power supply considerations

**Note** XBee LTE-M parts with an early revision of the microcontroller unit (MCU) may experience an issue recovering from brownouts under rare conditions. See Brownout issue for details on how to avoid this issue.

When considering a power supply, use the following design practices.

1. Power supply ripple should be less than 75 mV peak to peak.
2. The power supply should be capable of providing a minimum of 750 mA at 3.3 V (2.5 W).
3. Place sufficient bulk capacitance on the XBee VCC pin to maintain voltage above the minimum specification during transmissions. Power consumption lists the peak current during transmitting.
4. Place smaller high frequency ceramic capacitors very close to the XBee Smart Modem VCC pin to decrease high frequency noise.
5. Use a wide power supply trace or power plane to ensure it can handle the peak current requirements with minimal voltage drop. The supply should be inside the supply voltage operating range at startup and should not be allowed to droop lower than 3.2 V during operation.

Minimum connection diagram

In high EMI noise environments, we recommend adding a 10 nF ceramic capacitor very close to pin 5.
Heat considerations and testing

The XBee Smart Modem may generate significant heat during sustained operation. In addition to heavy data transfer, other factors that can contribute to heating include ambient temperature, air flow around the device, and proximity to the nearest cellular tower (the XBee Smart Modem must transmit at a higher power level when communicating over long distances). Overheating can cause device malfunction and potential damage.

The XBee Smart Modem must not be operated in ambient temperatures exceeding 85 °C. Additionally, if you expect to operate the product above 70 °C, we recommend that you perform an analysis of your application to characterize the self-heating of the XBee device:

1. Set up the device in the typical operating scenario you plan to use it in.
2. Monitor the device temperature using TP (Temperature) until it reaches a steady state.
3. Convert the returned value from hex format to decimal.

If the reading is greater than 5 °C above the ambient temperature, we recommend either de-rating the maximum ambient temperature or implementing heat mitigating measures; for example, reduce transmission frequency and duration, enter sleep mode more frequently, or improve airflow. Addressing heat issues will help to ensure long term device reliability.

Custom configuration: Create a new factory default

You can create a custom configuration that is used as a new factory default. This feature is useful if you need, for example, to maintain certain settings for manufacturing or want to ensure a feature is always enabled. When you perform a factory reset on the device using the RE command, the custom configuration is set on the device rather than the original factory default settings.

For example, by default Bluetooth is disabled on devices. You can create a custom configuration in which Bluetooth is enabled by default. When you use the RE command to reset the device to the factory defaults, the Bluetooth configuration is set to the custom configuration (enabled) rather than the original factory default (disabled).
The custom configuration is stored in non-volatile memory. You can continue to create and save custom configurations until the device’s memory runs out of space. If there is no space left to save a configuration, XBee returns an error.

You can use the `IC` command to clear or overwrite a custom configuration at any time.

### Set a custom configuration

1. Open XCTU on the device.
2. Enter Command mode.
3. Perform the following process for each configuration that you want to set as a factory default.
   a. Issue an `AT%F` command. This command enables you to enter a custom configuration.
   b. Issue the custom configuration command. For example: `ATBT 1`. This command sets the default for Bluetooth to enabled.

### Clear all custom configurations on a device

After you have set configurations using the `AT%F` command, you can return all configurations to the original factory defaults.

1. Open XCTU on the device.
2. Enter Command mode.
3. Issue `ATIC`.

### Clean shutdown

**WARNING!** Improper shutdown of the modem may result in the underlying cellular module becoming irrecoverably unresponsive.

Digi strongly recommends performing a clean shutdown procedure on your XBee cellular devices before removing power from the devices. Performing a shutdown allows the module to unregister from the cellular network and safely store operating parameters. Failure to shutdown properly has the potential to result in delays resuming network operation and in some rare instances may result in an unrecoverable module failure.

You can use any of the following methods to perform a clean shutdown.

#### SD (Shutdown) command

You should use the `SD` command to safely shut down a device before removing power. This is the recommended method.

Issue the `SD` command. When the shut down process is complete, the device returns `OK`. After the device responds `OK`, you can safely remove power from the device.

The device will return `ERROR` if any of the following actions are in progress:

- Over-the-air update of the cellular component
- Local update of the cellular component
- Over-the-air update of the XBee firmware.

In addition, if the radio can't be fully shut down within two minutes, the device returns `ERROR`. 
You can verify the state of the device using the AI command. After you issue the SD command and a response has been returned (either OK or ERROR), issue the AI command. If the shutdown was successful, 2D is returned.

**Sleep feature**

The recommended approach is to use one of the available sleep configurations such as the Pin Sleep feature (SM=1) or sleeping through MicroPython (xbee.sleep_now()). When the module has gone to sleep and the SLEEP pin (pin 13) is low, power may safely be removed.

1. Initiate sleep: Assert SLEEP_RQ
2. Wait for sleep state to be entered: SLEEP pin (pin 13) low.
3. Power off the device.

**Airplane mode**

Change the XBee configuration to use Airplane mode (AM=1). This puts the XBee into a safe state for shutdown.

1. Set AM=1.
2. Apply configuration change.
3. Wait 30 seconds to allow time for shutdown to occur.
4. Power off the device.
Cellular connection process

Connecting ................................................................. 122
Data communication with remote servers (TCP/UDP) ......................... 122
Disconnecting ............................................................. 123
Connecting

In normal operations, the XBee Smart Modem automatically attempts both a cellular network connection and a data network connection on power-up. The sequence of these connections is as follows:

**Cellular network**

1. The device powers on.
2. It looks for cellular towers.
3. It chooses a candidate tower with the strongest signal.
4. It negotiates a connection.
5. It completes cellular registration.

**Data network connection**

1. The network enables the evolved packet system (EPS) bearer with an access point name (APN). See AN (Access Point Name) if you have APN issues.
2. The device negotiates a data connection with the access point.
3. The device receives its IP configuration and address.
4. The AI (Association Indication) command now returns a 0 and the sockets become available.

**Data communication with remote servers (TCP/UDP)**

Once the data network connection is established, communication with remote servers can be initiated in several ways.

*Note* For NB-IoT, TCP support is dependent on the network. Contact your network provider for details.

- Transparent mode data sent to the serial port (see TD (Text Delimiter) and RO (Packetization Timeout) for timing).
- API mode: Transmit (TX) Request: IPv4 - 0x20 received over the serial connection.
- Digi Remote Manager connectivity begins.

Data communication begins when:

1. A socket opens to the remote server.
2. Data is sent.

Data connectivity ends when:

1. The server closes the connection.
2. The **TM** timeout expires (see TM (IP Client Connection Timeout)).
3. The cellular network may also close the connection after a timeout set by the network operator.
Disconnecting

When the XBee Smart Modem is put into Airplane mode, deep sleep is requested, or ATSD (shutdown) command is executed:

1. Sockets are closed, cleanly if possible.
2. The cellular connection is shut down.
3. The cellular component is powered off.

Note We recommend entering Airplane mode before resetting or rebooting the device to allow the cellular module to detach from the network.
Modes

Select an operating mode ................................................................. 125
Transparent operating mode ......................................................... 126
API operating mode ...................................................................... 126
Command mode ............................................................................ 126
MicroPython mode ........................................................................ 128
USB direct mode .......................................................................... 129
Bypass operating mode (DEPRECATED) ........................................... 132
Select an operating mode

The XBee Smart Modem interfaces to a host device such as a microcontroller or computer through a logic-level asynchronous serial port. It uses a UART for serial communication with those devices.

The XBee Smart Modem supports three operating modes: Transparent operating mode, API operating mode, and Bypass operating mode. The default mode is Transparent operating mode. Use the AP (API Enable) command to select a different operating mode.

The following flowchart illustrates how the modes relate to each other.
Transparent operating mode

Devices operate in this mode by default. The device acts as a serial line replacement when it is in Transparent operating mode. The device queues all serial data it receives through the DIN pin for RF transmission. When a device receives RF data, it sends the data out through the DOUT pin. You can set the configuration parameters using Command mode.

The IP (IP Protocol) command setting controls how Transparent operating mode works for the XBee Smart Modem.

**Note** Transparent operation is not available when using SPI.

API operating mode

API operating mode is an alternative to Transparent operating mode. API mode is a frame-based protocol that allows you to direct data on a packet basis. The device communicates UART or SPI data in packets, also known as API frames. This mode allows for structured communications with computers and microcontrollers.

The advantages of API operating mode include:

- It is easier to send information to multiple destinations
- The host receives the source address for each received data frame
- You can change parameters without entering Command mode

Command mode

Command mode is a state in which the firmware interprets incoming characters as commands. It allows you to modify the device’s configuration using parameters you can set using AT commands. When you want to read or set any parameter of the XBee Smart Modem using this mode, you have to send an AT command. Every AT command starts with the letters AT followed by the two characters that identify the command and then by some optional configuration values.

The operating modes of the XBee Smart Modem are controlled by the AP (API Enable) setting, but Command mode is always available as a mode the device can enter while configured for any of the operating modes.

Command mode is available on the UART interface for all operating modes. You cannot use the SPI interface to enter Command mode.

Enter Command mode

To get a device to switch into Command mode, you must issue the following sequence: +++ within one second. There must be at least one second preceding and following the +++ sequence. Both the command character (CC) and the silence before and after the sequence (GT) are configurable. When the entrance criteria are met the device responds with OK on UART signifying that it has entered Command mode successfully and is ready to start processing AT commands.

If configured to operate in Transparent operating mode, when entering Command mode the XBee Smart Modem knows to stop sending data and start accepting commands locally.

**Note** Do not press Return or Enter after typing +++ because it interrupts the guard time silence and prevents you from entering Command mode.

When the device is in Command mode, it listens for user input and is able to receive AT commands on the UART. If CT time (default is 10 seconds) passes without any user input, the device drops out of
Modes

Command mode and returns to the previous operating mode. You can force the device to leave Command mode by sending **CN (Exit Command mode)**.

You can customize the command character, the guard times and the timeout in the device’s configuration settings. For more information, see **CC (Command Sequence Character)**, **CT (Command Mode Timeout)** and **GT (Guard Times)**.

**Troubleshooting**

Failure to enter Command mode is often due to baud rate mismatch. Ensure that the baud rate of the connection matches the baud rate of the device. By default, **BD (Baud Rate) = 3** (9600 b/s).

There are two alternative ways to enter Command mode:

- A serial break for six seconds enters Command mode. You can issue the "break" command from a serial console, it is often a button or menu item.
- Asserting DIN (serial break) upon power up or reset enters Command mode. XCTU guides you through a reset and automatically issues the break when needed.

Both of these methods temporarily set the device's baud rate to 9600 and return an **OK** on the UART to indicate that Command mode is active. When Command mode exits, the device returns to normal operation at the baud rate that **BD** is set to.

**Send AT commands**

Once the device enters Command mode, use the syntax in the following figure to send AT commands. Every AT command starts with the letters **AT**, which stands for "attention." The AT is followed by two characters that indicate which command is being issued, then by some optional configuration values. To read a parameter value stored in the device’s register, omit the parameter field.

```
“AT” + ASCII + Space (optional) + Parameter (optional, HEX) + Carriage return
```

**Example:** `AT NI 2 <CR>`

**Multiple AT commands**

You can send multiple AT commands at a time when they are separated by a comma in Command mode; for example, **ATNIMy XBee,AC<cr>**.

The preceding example changes the **NI (Node Identifier)** to **My XBee** and makes the setting active through **AC (Apply Changes)**.

**Parameter format**

Refer to the list of **AT commands** for the format of individual AT command parameters. Valid formats for hexadecimal values include with or without a leading 0x for example **FFFF** or **0xFFFF**.

**Response to AT commands**

When using AT commands to set parameters the XBee Smart Modem responds with **OK<cr>** if successful and **ERROR<cr>** if not.

For devices with a file system:
ATAP1<cr>
OK<cr>
When reading parameters, the device returns the current parameter value instead of an OK message.
ATAP<cr>
1<cr>

Apply command changes
Any changes you make to the configuration command registers using AT commands do not take effect until you apply the changes. For example, if you send the BD command to change the baud rate, the actual baud rate does not change until you apply the changes. To apply changes:

1. Send AC (Apply Changes).
2. Send WR (Write).
   or:
3. Exit Command mode.

Make command changes permanent
Send a WR (Write) command to save the changes. WR writes parameter values to non-volatile memory so that parameter modifications persist through subsequent resets.
Send as RE (Restore Defaults) to wipe settings saved using WR back to their factory defaults.

Note You still have to use WR to save the changes enacted with RE.

Exit Command mode

1. Send CN (Exit Command mode) followed by a carriage return.
   or:
2. If the device does not receive any valid AT commands within the time specified by CT (Command Mode Timeout), it returns to Transparent or API mode. The default Command mode timeout is 10 seconds.

For an example of programming the device using AT Commands and descriptions of each configurable parameter, see AT commands.

MicroPython mode

MicroPython mode (AP = 4) allows you to communicate with the XBee Smart Modem using the MicroPython programming language. You can use the MicroPython Terminal tool in XCTU to communicate with the MicroPython stack of the XBee Smart Modem through the serial interface.
MicroPython mode connects the primary serial port to the stdin/stdout interface on MicroPython, which is either the REPL or code launched at startup.
When code runs in MicroPython with AP set to a value other than 4, stdout goes to the bit bucket and there is no input to read on stdin.
USB direct mode

Note In order to use USB direct mode in Digi XBee development kits, you must use the XBIB-C-TH development board.

Note You should use this mode if you want to connect using PPP through the cellular modem while using a host operating system, such as embedded Linux.

This mode allows you to access the XBee Smart Modem's USB interface directly through XBee pins 7 and 8. VBUS functionality is optionally provided on XBee pin 6 if you wish to enable and disable USB mode based on an external source. While in USB mode the cellular modem is not able to communicate serially with the XBee MCU. All communication with the cellular modem must be performed by the user via the USB port.

Configure the data pins
Set P1 (DIO11/PWM1 Configuration) to 7 to configure pins 7 and 8 for USB direct mode.
If USB Direct is not enabled (P1 is not set to 7), then DO (Device Options) bit 2 and P0 being set to 6 have no effect on the USB VBUS state.

Enable USB direct mode
You can enable USB direct mode in two ways:

1. Enable via software: Set DO (Device Options) bit 2. Ensure that P0 (DIO10/PWM0 Configuration) is not set to 6 as that would override the DO setting.
2. Enable based on the state of VBUS (pin 6): Set P0 to 6. Apply a logic high signal to DIO10/PWM0 (pin 6) to enable USB or a logic low signal to disable USB.

Note Although pin 6 is 5 V tolerant on this device, it operates with the same 3.3 V logic as the other XBee device pins. For compatibility with other XBee devices we recommend driving the line with no more than 3.3 V. Moreover, driving the pin at 5 V will cause input leakage current to increase to 3.3 µA typical.

You must reset the device to enable or disable USB direct mode.
While in USB direct mode, AI (Association Indication) returns 0x2B.

Configure and use PPP with a Digi XBee 3 Cellular LTE-M/NB-IoT modem
Your XBee 3 Cellular device can communicate directly with the modem and can drop into PPP mode.

Prerequisites
- A working SIM card to get onto the LTE-M network.
- Knowledge of the APN for the given network and SIM.
- A Linux distribution with pppd/chat.

Step 1: Configure the device for PPP
USB direct is used to gain access to the underlying modem, which enables the use of PPP.
1. **Set up USB direct mode.**
2. Issue the **WR** command to save the settings.

Once USB direct is configured, an additional USB device should be attached to the Linux machine. In order to have a consistent device name on the Linux machine, you should set up a udev rule for the device, as described in the next step.

**Step 2: Set up the USB device for use with PPP**

A udev rule is needed to give the USB connection a constant name using a symlink.

1. Make sure that the modem is plugged in.
2. Place the following **ppp-setup.rules** file here: **/etc/udev/rules.d**

```bash
# Sara-R410 rule
SUBSYSTEM=="tty", ATTRS{bInterfaceNumber}="02", ENV{ID_VENDOR_ID}="05c6",
ENV{ID_MODEL_ID}="90b2", SYMLINK+="ppp_direct_usb"
```
3. You must run the two commands shown below to restart the udev daemon to apply the new rule.

```bash
sudo udevadm control --reload-rules
sudo udevadm trigger
```
4. Verify that the new device has been created: **/dev/ppp_direct_usb**. If was not, make sure the modem is plugged in and then repeat this process.

**Step 3: Configure PPPD**

PPPD by default looks in the **/etc/ppp/** directory for an options file and a chat script. The option file configures and specifies the chat script for PPPD. The chat script configures and dials the modem for the PPP connection.

1. Below is an example of an options file. This file must be in the **/etc/ppp/** directory.

```bash
## Show debug info
debg
## Modem serial port
/dev/ppp_direct_usb
## Baud-rate
921600
## Hardware flow control using rts/cts
crtscct
## For debugging purposes
ndetach
## Bring up the connection if it gets shutdown
persist
## Disable remote authentication
noauth
## Control character map
asyncmap 0
## Setup interface as default route
defaultroute
replacedefaultroute
```
## disable getting the local IP address from the host-name
noipdefault
## Accept new IP addresses from IPCP negotiations (default)
ipcp-accept-local
ipcp-accept-remote
## Lock the serial device
lock
## Let the remote designate the name-servers
usepeerdns
## Enable IPv6 and use provided address
+ipv6 ip6cp-use-ipaddr
## Connect script (chat script)
connect "/usr/sbin/chat -V -t 60 -f net-chat"

2. Place the chat script in the /etc/ppp/ directory. An example is shown below. The net-chat script is an automated script that both configures and dials the modem for the PPP connection. This script turns on hardware flow-control, sets the APN, sets the DSR line to ON, and dials the peer.

Note In the net-chat script below, you must replace <APN> with the correct APN for your network and SIM.

<table>
<thead>
<tr>
<th>ABORT 'ERROR'</th>
<th>ABORT 'BUSY'</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABORT 'NO CARRIER'</td>
<td>AT</td>
</tr>
<tr>
<td>OK AT+IFC=2,2</td>
<td>OK ATE0</td>
</tr>
<tr>
<td>OK AT+CGDCONT=1,&quot;IP&quot;,&quot;&lt;APN&gt;&quot;</td>
<td>OK AT&amp;S0</td>
</tr>
<tr>
<td>OK ATD<em>99</em>**1#</td>
<td>CONNECT</td>
</tr>
</tbody>
</table>

### Step 4: Run PPPD

PPPD is the program that brings up the PPP interface.

1. You should bring down any other network interfaces that may complicate routing.
2. Run PPPD to bring up the PPP interface.

```
sudo pppd
```

3. Various LCP, PAP and IPCP messages should be output. If the interface was brought up correctly `ifconfig` should list a PPP interface as `pppx` (where x is a number).
4. Ping a web server from the PPP interface.

```
ping www.digi.com
```

### Step 5: Low power use case

You may want to reduce power consumption by turning off the XBee modem. Follow this process to properly bring down the PPP connection and shut down the modem.
1. Terminate PPPD by sending a terminate signal: Ctrl+C
2. Issue the shutdown command to the modem over the USB connection.

   AT+CPWROFF

3. Wait for an **OK** response.
4. When received, remove power from the XBee.
5. Restart the PPP connection.
   a. Power on the XBee.
   b. Issue the following command:

   ```
   sudo pppd
   ```

**Note** Do not power cycle the modem too often as it can lead to network registration rejection. Cycling should not be performed more than a few times an hour. Check with your network carrier for the exact limits.

**Troubleshooting**

**Error after running sudo pppd**

```
+CME ERRORScript /usr/sbin/chat -V -t 60 -f net-chat finished (pid 5523), status = 0x4
Connect script failed
```

This indicates that the <APN> field was most likely not set correctly in the net-chat script.

**Error after running sudo pppd**

```plaintext
pppd: In file /etc/ppp/options: unrecognized option '/dev/ppp_direct_usb'
```

This indicates pppd could not open up the USB port to the modem. Make sure that the modem is plugged in and shows up under the `/dev/` directory as **ppp_direct_usb**.

**Error after running "ping www.digi.com"**

```plaintext
ping: unknown host www.digi.com
```

The name server was not setup correctly for the PPP interface. Make sure there is a valid name server in `/etc/resolv.conf`.

**Bypass operating mode (DEPRECATED)**

![Warning Icon]

**WARNING!** Bypass mode is now deprecated and is not recommended for new designs. XBee 3 Cellular products support direct USB to access the cellular modem directly. See [USB direct mode](#) for details on how to configure your XBee to use direct USB.
CAUTION! Bypass operating mode is an alternative to Transparent and API modes for advanced users with special configuration needs. Changes made in this mode might change or disable the device and we do not recommended it for most users.

CAUTION! The lack of hardware flow control support in the cellular component may impact the reliability of Bypass mode. See Hardware flow control in Bypass mode for details.

In Bypass mode, the device acts as a serial line replacement to the cellular component. In this mode, the XBee Smart Modem exposes all control of the cellular component's AT port through the UART. If you use this mode, you must setup the cellular modem directly to establish connectivity. The modem does not automatically connect to the network.

Note The cellular component can become unresponsive in Bypass mode. See Unresponsive cellular component in Bypass mode for help in this situation.

When Bypass mode is active, most of the XBee Smart Modem's AT commands do not work. For example, IM (IMEI) may never return a value, and DB does not update. In this configuration, the firmware does not test communication with the cellular component (which it does by sending AT commands). This is useful in case you have reconfigured the cellular component in a way that makes it incompatible with the firmware. Bypass operating mode exists for users who wish to communicate directly with the cellular component settings and do not intend to use XBee Smart Modem software features such as API mode.

Command mode is available while in Bypass mode; see Enter Command mode for instructions.

Enter Bypass operating mode
To configure a device for Bypass operating mode:

1. Set the AP (API Enable) parameter value to 5.
2. Send WR (Write) to write the changes.
3. Send FR (Force Reset) to reboot the device.
4. After rebooting, enter Command mode and verify that Bypass operating mode is active by querying AI (Association Indication) and confirming that it returns a value of 0x2F.

It may take a moment for Bypass operating mode to become active.

Leave Bypass operating mode
To configure a device to leave Bypass operating mode:

1. Set AP (API Enable) to something other than 5.
2. Send WR (Write) to write the changes.
3. Send FR (Force Reset) to reboot the device.
4. After rebooting, enter Command mode and verify that Bypass operating mode is not active by querying AI (Association Indication) and confirming that it returns a value other than 0x2F.

Restore cellular settings to default in Bypass operating mode
Send AT&F1 to reset the cellular component to its factory profile.
Chapter 13: Sleep modes

About sleep modes
Normal mode
Pin sleep mode
Cyclic sleep mode
Cyclic sleep with pin wake up mode
SPI mode and sleep pin functionality
The sleep timer
MicroPython sleep behavior
About sleep modes

A number of low-power modes exist to enable devices to operate for extended periods of time on battery power. Use SM (Sleep Mode) to enable these sleep modes.

Normal mode

Set SM to 0 to enter Normal mode.

Normal mode is the default sleep mode. If a device is in this mode, it does not sleep and is always awake.

Devices in Normal mode are typically mains powered.

Pin sleep mode

Set SM to 1 to enter pin sleep mode.

Pin sleep allows the device to sleep and wake according to the state of the SLEEP_RQ pin (SLEEP_RQ).

When you assert SLEEP_RQ (high), the device finishes any transmit or receive operations, closes any active connection, and enters a low-power state.

When you de-assert SLEEP_RQ (low), the device wakes from pin sleep.

Cyclic sleep mode

Set SM to 4 to enter Cyclic sleep mode.

Cyclic sleep allows the device to sleep for a specific time and wake for a short time to poll.

If you use the D7 command to enable hardware flow control, the CTS pin asserts (low) when the device wakes and can receive serial data, and de-asserts (high) when the device sleeps.

Cyclic sleep with pin wake up mode

Set SM to 5 to enter Cyclic sleep with pin wake up mode.

This mode is a slight variation on Cyclic sleep mode (SM = 4) that allows you to wake a device prematurely by de-asserting the SLEEP_RQ pin (SLEEP_RQ).

In this mode, you can wake the device after the sleep period expires, or if a high-to-low transition occurs on the SLEEP_RQ pin.

SPI mode and sleep pin functionality

SLEEP_RQ/ DIO8 is configured as a peripheral by default and is used for pin sleep to wake the XBee Smart Modem and put it to sleep. This applies regardless of if the serial interface is UART or SPI.

However, if SLEEP_RQ is not configured as a peripheral and SPI_SSEL is configured as a peripheral, then pin sleep is controlled by SPI_SSEL rather than by SLEEP_RQ. Asserting SPI_SSEL by driving it low wakes the XBee Smart Modem, or keeps it awake. De-asserting SPI_SSEL by driving it high puts the device to sleep.

If neither pin is configured as a peripheral, then the device stays awake, being unable to sleep when SM (Sleep Mode) is 1.
Sleep modes

The sleep timer

<table>
<thead>
<tr>
<th>DIO8/SLEEP_RQ configured as peripheral (D8 = 1)?</th>
<th>DIO3/SPI_SSEL configured as peripheral (D3 = 1)?</th>
<th>Pin sleep controlled by...</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>Yes</td>
<td>DIO8/SLEEP_RQ</td>
</tr>
<tr>
<td>Yes</td>
<td>No</td>
<td>DIO8/SLEEP_RQ</td>
</tr>
<tr>
<td>No</td>
<td>Yes</td>
<td>DIO3/SPI_SSEL</td>
</tr>
<tr>
<td>No</td>
<td>No</td>
<td>Neither (pin sleep does not work)</td>
</tr>
</tbody>
</table>

Advantage of using SPI_SSEL to control sleep:

- One less physical pin connection is required to implement pin sleep. This makes DIO8/SLEEP_RQ available for another purpose.

Disadvantages of using SPI_SSEL to control sleep:

- The XBee Smart Modem is put to sleep whenever the SPI master negates SPI_SSEL, even if that was not the intent.
- The XBee Smart Modem begins entering sleep as soon as the control pin is asserted (brought high). Immediately de-asserting the control pin (bringing it low) only has the effect of preventing the microcontroller from entering low-power mode before waking up the device—all other sleep preparations (such as closing sockets) continue as in typical sleep operation. This can take several seconds, and this added time in the case of an unintended sleep request may not be acceptable.

The sleep timer

The sleep timer starts when the device wakes and resets on re-configuration. When the sleep timer expires the device returns to sleep.

MicroPython sleep behavior

When the XBee Smart Modem enters Deep Sleep mode, any MicroPython code currently executing is suspended until the device comes out of sleep. When the XBee Smart Modem comes out of sleep mode, MicroPython execution continues where it left off.

Upon entering deep sleep mode, the XBee Smart Modem closes any active UDP connections and turns off the cellular component. As a result, any sockets that were opened in MicroPython prior to sleep report as no longer being connected. This behavior appears the same as a typical socket disconnection event will:

- `socket.send` raises `OSError: ENOTCONN`
- `socket.sendto` raises `OSError: ENOTCONN`
- `socket.recv` returns the empty string, the traditional end-of-file return value
- `socket.recvfrom` returns an empty message, for example:
  (b"", (<address from connect()>, <port from connect()>) )

The underlying UDP socket resources have been released at this point.
# Power saving features and design recommendations

<table>
<thead>
<tr>
<th>Feature</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airplane mode</td>
<td>138</td>
</tr>
<tr>
<td>Power Saving Mode (PSM)</td>
<td>138</td>
</tr>
<tr>
<td>PSM behavior</td>
<td>138</td>
</tr>
<tr>
<td>Low voltage shutdown</td>
<td>138</td>
</tr>
<tr>
<td>Deep Sleep mode</td>
<td>140</td>
</tr>
</tbody>
</table>
Airplane mode

While not technically a sleep mode, Airplane mode is another way of saving power. When set, the cellular component of the XBee Smart Modem is fully turned off and no access to the cellular network is performed or possible. Use AM (Airplane Mode) to configure this mode.

Power Saving Mode (PSM)

To enable PSM, set DO (Device Options) bit 3.

Note For NB-IoT, TCP and SMS support is dependent on the network. Contact your network provider for details.

Note The cellular module comes out of the PSM low-power state whenever any network activity occurs, including Remote Manager activity. See Verify the connection between a device and Remote Manager.

When PSM is enabled, the cellular component spends most of its time in a low power state. In the low power state the XBee Smart Modem still has an IP address and is registered to the network, which allows for quick resumption of activity, but is not reachable so cannot receive IP or SMS traffic until it wakes up. This low power state is used even when taking advantage of XBee sleep features (such as Pin Sleep or Cyclic Sleep), rather than powering the cellular component off entirely to ensure readiness when exiting sleep.

The cellular component wakes to participate in maintaining the network state periodically based on timers negotiated with the cell tower. It is also triggered to wake up when the user performs any activity requiring network connectivity such as mobile-originated traffic like sending an SMS or UDP/TCP traffic. When it wakes up, it spends a short time awake so that it is reachable through the network at that time and then returns to the low power state.

PSM behavior

Commands exist to influence the PSM behavior when PSM is enabled (DO bit 3 is set).

Note For NB-IoT, TCP and SMS support is dependent on the network. Contact your network provider for details.

They are:

- PA (Requested Active Timer)
- PU (Requested Tracking Area Update Timer)

PA and PU are the values the XBee Smart Modem requests from the network. The network is free to assign values other than those which have been requested.

See the LTE-M Deployment Guide from GSMA for a description of what the PSM timers are and what functions they perform on the network.

Low voltage shutdown

The XBee Smart Modem can monitor the XBee VCC line in order to detect a failing power supply. Monitoring the VCC line can prevent possible memory corruption on both the cellular modem and the file system due to insufficient power. This feature is recommended for users who run the XBee off of a battery.
You must first enable this feature and then set a base threshold for the voltage on the XBee Vcc line. When the voltage falls below the base threshold, the XBee goes into a shutdown state. When in a shutdown state:

- The cellular modem will be shut down completely, halting any network activity.
- The file system will be shut down completely, disallowing any file system operations.

Once in this state, the XBee will resume normal functionality only after a reset. A reset is triggered if the voltage rises above an upper threshold set by a combination of values.

*Note* The XBee VCC voltage gets read periodically, once every two minutes. Consequently, it may take up to two minutes to change to or from a shutdown state.

**Enable and configure the low voltage shutdown feature**

1. Enable the feature by setting the DO command bit 4.
2. Set the base threshold for the voltage on the XBee VCC line using the %L command. When the voltage for the XBee VCC line goes below the base threshold, the XBee goes into a shut down state.
3. Set the reset offset for the XBee VCC line using the %M command. The XBee resets and resumes normal operation when the voltage reaches the base threshold set in the %L command, plus the value of the reset offset set in the %M command.

**Example**

The graph shown below demonstrates this feature. In this example, AT%L (Base Threshold) is set to 0xC1C (3100 mV) and AT%M (Reset Offset) is set to 0x64 (100 mV).

- After the XBee VCC voltage drops below the base threshold of 3100 mV (set by AT%L), the XBee goes into the shutdown state.
- When in the shutdown state, the XBee VCC voltage must rise 100 mV (set by AT%M) above the shutdown voltage (AT%L) to reset and then resume normal operation.
Deep Sleep mode

In Deep Sleep mode the cellular component is shut off and the XBee processor is put to sleep.

**Note** When the XBee Smart Modem enters deep sleep mode, any MicroPython code currently executing is suspended until the device comes out of sleep.
## Serial communication

<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serial interface</td>
<td>142</td>
</tr>
<tr>
<td>Serial data</td>
<td>142</td>
</tr>
<tr>
<td>UART data flow</td>
<td>142</td>
</tr>
<tr>
<td>Serial buffers</td>
<td>143</td>
</tr>
<tr>
<td>CTS flow control</td>
<td>143</td>
</tr>
<tr>
<td>RTS flow control</td>
<td>143</td>
</tr>
<tr>
<td>Enable UART or SPI ports</td>
<td>143</td>
</tr>
<tr>
<td>I2C</td>
<td>144</td>
</tr>
</tbody>
</table>
Serial interface

The XBee Smart Modem interfaces to a host device through a serial port. The device’s serial port can communicate:

- Through a logic and voltage compatible universal asynchronous receiver/transmitter (UART).
- Through a level translator to any serial device, for example, through an RS-232 or USB interface board.
- Through a serial peripheral interface (SPI) port.

Serial data

A device sends data to the XBee Smart Modem’s UART through pin 3 DIN as an asynchronous serial signal. When the device is not transmitting data, the signals should idle high.

For serial communication to occur, you must configure the UART of both devices (the microcontroller and the XBee Smart Modem) with compatible settings for the baud rate, parity, start bits, stop bits, and data bits.

Each data byte consists of a start bit (low), 8 data bits (least significant bit first) and a stop bit (high). The following diagram illustrates the serial bit pattern of data passing through the device. The diagram shows UART data packet 0x1F (decimal number 31) as transmitted through the device.

![Serial data pattern diagram]

You can configure the UART baud rate, parity, and stop bits settings on the device with the **BD**, **NB**, and **SB** commands respectively. For more information, see Serial interfacing commands.

In the rare case that a device has been configured with the UART disabled, you can recover the device to UART operation by holding DIN low at reset time. DIN forces a default configuration on the UART at 9600 baud and it brings the device up in Command mode on the UART port. You can then send the appropriate commands to the device to configure it for UART operation. If those parameters are written, the device comes up with the UART enabled on the next reset.

UART data flow

Devices that have a UART interface connect directly to the pins of the XBee Smart Modem as shown in the following figure. The figure shows system data flow in a UART-interfaced environment. Low-asserted signals have a horizontal line over the signal name.
Serial buffers

The XBee Smart Modem maintains internal buffers to collect serial and RF data that it receives. The serial receive buffer collects incoming serial characters and holds them until the device can process them. The serial transmit buffer collects the data it receives via the RF link until it transmits that data out the serial or SPI port.

**CTS flow control**

We strongly encourage you to use flow control with the XBee Smart Modem to prevent buffer overruns.

CTS flow control is enabled by default; you can disable it with D7 (DIO7/CTS). When the serial receive buffer fills with the number of bytes specified by FT (Flow Control Threshold), the device de-asserts CTS (sets it high) to signal the host device to stop sending serial data. The device re-asserts CTS when less than FT-32 bytes are in the UART receive buffer.

*Note* Serial flow control is not possible when using the SPI port.

**RTS flow control**

If you set D6 (DIO6/RTS) to enable RTS flow control, the device does not send data in the serial transmit buffer out the DOUT pin as long as RTS is de-asserted (set high). Do not de-assert RTS for long periods of time or the serial transmit buffer will fill.

**Enable UART or SPI ports**

To enable the UART port, configure DIN and DOUT (P3 and P4 parameters) as peripherals. To enable the SPI port, enable SPI_MISO, SPI_MOSI, SPI_SSEL, and SPI_CLK (P5 through P9) as peripherals. If you enable both ports then output goes to the UART until the first input on SPI.

When both the UART and SPI ports are enabled on power-up, all serial data goes out the UART. As soon as input occurs on either port, that port is selected as the active port and no input or output is allowed on the other port until the next device reset.

If you change the configuration so that only one port is configured, then that port is the only one enabled or used. If the parameters are written with only one port enabled, then the port that is not enabled is not used even temporarily after the next reset.
Serial communication

If both ports are disabled on reset, the device uses the UART in spite of the wrong configuration so that at least one serial port is operational.

I²C

For I²C see the Class I2C: two-wire serial protocol section in the MicroPython Programming Guide for details.
## SPI operation

<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPI communications</td>
<td>146</td>
</tr>
<tr>
<td>Full duplex operation</td>
<td>147</td>
</tr>
<tr>
<td>Low power operation</td>
<td>148</td>
</tr>
<tr>
<td>Select the SPI port</td>
<td>148</td>
</tr>
<tr>
<td>Force UART operation</td>
<td>149</td>
</tr>
<tr>
<td>Data format</td>
<td>149</td>
</tr>
</tbody>
</table>
SPI communications

The XBee Smart Modem supports SPI communications in slave mode. Slave mode receives the clock signal and data from the master and returns data to the master. The following table shows the signals that the SPI port uses on the device.

<table>
<thead>
<tr>
<th>Signal</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPI_MOSI</td>
<td>Inputs serial data from the master</td>
</tr>
<tr>
<td>SPI_MISO</td>
<td>Outputs serial data to the master</td>
</tr>
<tr>
<td>SPI_SCLK</td>
<td>Clocks data transfers on MOSI and MISO</td>
</tr>
<tr>
<td>SPI_SSEL</td>
<td>Enables serial communication with the slave</td>
</tr>
<tr>
<td>SPI_ATTN</td>
<td>Alerts the master that slave has data queued to send. The XBee Smart Modem asserts this pin as soon as data is available to send to the SPI master and it remains asserted until the SPI master has clocked out all available data.</td>
</tr>
</tbody>
</table>

In this mode:
- SPI clock rates up to 4.8 MHz are possible.
- Data is most significant bit (MSB) first; bit 7 is the first bit of a byte sent over the interface.
- Frame Format mode 0 is used. This means CPOL = 0 (idle clock is low) and CPHA = 0 (data is sampled on the clock’s leading edge).
- The SPI port only supports API Mode (AP = 1).

The following diagram shows the frame format mode 0 for SPI communications.

SPI mode is chip to chip communication. We do not supply a SPI communication option on the device development evaluation boards.
Full duplex operation

The specification for SPI includes the four signals SPI_MISO, SPI_MOSI, SPI_CLK, and SPI_SSEL. Using these four signals, the SPI master cannot know when the slave needs to send and the SPI slave cannot transmit unless enabled by the master. For this reason, the SPI_ATTN signal is available in the design. This allows the SPI slave to alert the SPI master that it has data to send. In turn, the SPI master is expected to assert SPI_SSEL and start SPI_CLK, unless these signals are already asserted and active respectively. This, in turn, allows the XBee Smart Modem SPI slave to send data to the master.

SPI data is latched by the master and slave using the SPI_CLK signal. When data is being transferred the MISO and MOSI signals change between each clock. If data is not available then these signals will not change and will be either 0 or 1. This results in receiving either a repetitive 0 or 0xFF. The means of determining whether or not received data is valid is by packetizing the data with API packets, without escaping. Valid data to and from the XBee Smart Modem is delimited by 0x7E, a length, the payload, and finally a checksum byte. Everything else in both directions should be ignored. The bytes received between frames will be either 0xff or 0x00. This allows the SPI master to scan for a 0x7E delimiter between frames.

SPI allows for valid data from the slave to begin before, at the same time, or after valid data begins from the master. When the master is sending data to the slave and the slave has valid data to send in the middle of receiving data from the master, it allows a true full duplex operation where data is valid in both directions for a period of time. During this time, the master and slave must simultaneously transmit valid data at the clock speed so that no invalid bytes appear within an API frame, causing the whole frame to be discarded.

An example follows to more fully illustrate the SPI interface during the time valid data is being sent in both directions. First, the master asserts SPI_SSEL and starts SPI_CLK to send a frame to the slave. Initially, the slave does not have valid data to send the master. However, while it is still receiving data from the master, it has its own data to send. Therefore, it asserts SPI_ATTN low. Seeing that SPI_SSEL is already asserted and that SPI_CLK is active, it immediately begins sending valid data, even while it is receiving valid data from the master. In this example, the master finishes its valid data before the slave does. The master will have two indications of valid data: The SPI_ATTN line is asserted and the API frame length is not yet expired. For both of these reasons, the master should keep SPI_SSEL asserted and should keep SPI_CLK toggling in order to receive the end of the frame from the slave, even though these signals were originally turned on by the master to send data. During the time that the SPI master is sending invalid data to the SPI slave, it is important no 0x7E is included in that invalid data because that would trigger the SPI slave to start receiving another valid frame.

The following figure illustrates the SPI interface while valid data is being sent in both directions.
Low power operation

Sleep modes generally work the same on SPI as they do on UART. However, due to the addition of SPI mode, there is an option of another sleep pin, as described below.

By default, Digi configures DIO8 (SLEEP_REQUEST) as a peripheral and during pin sleep it wakes the device and puts it to sleep. This applies to both the UART and SPI serial interfaces.

If SLEEP_REQUEST is not configured as a peripheral and SPI_SSEL is configured as a peripheral, then pin sleep is controlled by SPI_SSEL rather than by SLEEP_REQUEST. Asserting SPI_SSEL (pin 17) by driving it low either wakes the device or keeps it awake. Negating SPI_SSEL by driving it high puts the device to sleep.

Using SPI_SSEL to control sleep and to indicate that the SPI master has selected a particular slave device has the advantage of requiring one less physical pin connection to implement pin sleep on SPI. It has the disadvantage of putting the device to sleep whenever the SPI master negates SPI_SSEL (meaning time is lost waiting for the device to wake), even if that was not the intent.

If the user has full control of SPI_SSEL so that it can control pin sleep, whether or not data needs to be transmitted, then sharing the pin may be a good option in order to make the SLEEP_REQUEST pin available for another purpose.

If the device is one of multiple slaves on the SPI, then the device sleeps while the SPI master talks to the other slave, but this is acceptable in most cases.

If you do not configure either pin as a peripheral, then the device stays awake, being unable to sleep in SM1 mode.

Select the SPI port

To force SPI mode, hold DOUT/DIO13 pin 2 low while resetting the device until SPI_ATTN asserts. This causes the device to disable the UART and go straight into SPI communication mode. Once configuration is complete, the device queues a modem status frame to the SPI port, which causes the SPI_ATTN line to assert. The host can use this to determine that the SPI port is configured properly.

This method forces the configuration to provide full SPI support for the following parameters:

- **D1** (This parameter will only be changed if it is at a default of zero when the method is invoked.)
- **D2**
- **D3**
- **D4**
- **P2**

As long as the host does not issue a WR command, these configuration values revert to previous values after a power-on reset. If the host issues a WR command while in SPI mode, these same parameters are written to flash. After a reset, parameters that were forced and then written to flash become the mode of operation.

If the UART is disabled and the SPI is enabled in the written configuration, then the device comes up in SPI mode without forcing it by holding DOUT low. If both the UART and the SPI are enabled at the time of reset, then output goes to the UART until the host sends the first input. If that first input comes on the SPI port, then all subsequent output goes to the SPI port and the UART is disabled. If the first input comes on the UART, then all subsequent output goes to the UART and the SPI is disabled.

Once you select a serial port (UART or SPI), all subsequent output goes to that port, even if you apply a new configuration. The only way to switch the selected serial port is to reset the device. On surface-mount devices, forcing DOUT low at the time of reset has no effect. To use SPI mode on the SMT devices, assert the SPI_SSEL (pin 17) low after reset and before any UART data is input.
When the master asserts the slave select (SPI_SSEL) signal, SPI transmit data is driven to the output pin SPI_MISO, and SPI data is received from the input pin SPI_MOSI. The SPI_SSEL pin has to be asserted to enable the transmit serializer to drive data to the output signal SPI_MISO. A rising edge on SPI_SSEL causes the SPI_MISO line to be tri-stated such that another slave device can drive it, if so desired.

If the output buffer is empty, the SPI serializer transmits the last valid bit repeatedly, which may be either high or low. Otherwise, the device formats all output in API mode 1 format, as described in Operate in API mode. The attached host is expected to ignore all data that is not part of a formatted API frame.

**Force UART operation**

If you configure a device with only the SPI enabled and no SPI master is available to access the SPI slave port, you can recover the device to UART operation by holding DIN/CONFIG low at reset time. DIN/CONFIG forces a default configuration on the UART at 9600 baud and brings up the device in Command mode on the UART port. You can then send the appropriate commands to the device to configure it for UART operation. If you write those parameters, the device comes up with the UART enabled on the next reset.

**Data format**

SPI only operates in API mode 1. The XBee Smart Modem does not support Transparent mode or API mode 2 (which escapes control characters). This means that the AP configuration only applies to the UART, and the device ignores it while using SPI. The reason for this operation choice is that SPI is full duplex. If data flows in one direction, it flows in the other. Since it is not always possible to have valid data flowing in both directions at the same time, the receiver must have a way to parse out the valid data and to ignore the invalid data.

The XBee Smart Modem sends 0xFF when there is no data to send to the host.
File system

For detailed information about using MicroPython on the XBee Smart Modem refer to the *Digi MicroPython Programming Guide*.

Overview of the file system ................................................................. 151
XCTU interface ....................................................................................... 152
Encrypt files ............................................................................................ 152
Overview of the file system

XBee Smart Modem firmware versions ending in 0B (for example, 1130B, 100B, 3100B) and later include support for storing files on an internal 1 MB SPI flash.

CAUTION! You need to format the file system if upgrading a device that originally shipped with older firmware. You can use XCTU, AT commands or MicroPython for that initial format or to erase existing content at any time.

Note To use XCTU with file system, you need XCTU 6.4.0 or newer.

See ATFS FORMAT confirm and ensure that the format is complete.

Directory structure

The SPI flash appears in the file system as /flash, the only entry at the root level of the file system. It has a lib directory intended for MicroPython modules and a cert directory for files used for TLS sockets.

Paths

The XBee Smart Modem stores all of its files in the top-level directory /flash. On startup, the ATFS commands and MicroPython each use that as their current working directory. When specifying the path to a file or directory, it is interpreted as follows:

- Paths starting with a forward slash are "absolute" and must start with /flash to be valid.
- All other paths are relative to the current working directory.
- The directory .. refers to the parent directory, so an operation on ../filename.txt that takes place in the directory /flash/test accesses the file /flash/filename.txt.
- The directory . refers to the current directory, so the command ATFS ls . lists files in the current directory.
- Names are case-insensitive, so FILE.TXT, file.txt and FiLe.TxT all refer to the same file.
- File and directory names are limited to 64 characters, and can only contain letters, numbers, periods, dashes and underscores. A period at the end of the name is ignored.
- The full, absolute path to a file or directory is limited to 255 characters.

Secure files

The file system includes support for secure files with the following properties:

- Created via the ATFS XPUT command or in MicroPython using a mode of * with the open() method.
- Unable to download via the ATFS GET command or MicroPython's open() method.
- SHA256 hash of file contents available from ATFS HASH command (to compare with a local copy of a file).
- Encrypted on the SPI flash.
- MicroPython can execute code in secure files.
- Sockets can use secure files when creating TLS connections.
**XCTU interface**

XCTU releases starting with 6.4.0 include a **File System Manager** in the **Tools** menu. You can upload files to and download files from the device, in addition to renaming and deleting existing files and directories. See the **File System manager tool** section of the **XCTU User Guide** for details of its functionality.

**Encrypt files**

You can encrypt files on the file system. This provides two things:

1. Protection of the client private key for TLS authentication while it is stored on the XBee Smart Modem.
2. Protection for user's MicroPython applications.

Use **ATFS XPUT filename** to place encrypted files on the file system. The XPUT operation is otherwise identical to the PUT operation. Files placed in this way are indicated with a **pound sign (#)** following the filename. The XBee Smart Modem does not allow an encrypted file to be read by normal use so it:

1. Cannot be retrieved with the GET operation.
2. Cannot be opened and read in MicroPython applications.
3. Cannot be created by a MicroPython application.

When **ATFS HASH filename** is run with the filename of an encrypted file, it reports the SHA256 hash of the file contents. In this way you can validate that the correct file has been placed on the XBee Smart Modem.
Socket behavior

See Socket leaks for instances where a socket leaks when closing a connection while there is pending RX data.

Note For NB-IoT, TCP support is dependent on the network. Contact your network provider for details.

Supported sockets ................................................................. 154
Best practices when using sockets .................................................. 154
Socket timeouts ...................................................................... 154
Socket limits in API mode ......................................................... 155
Enable incoming TCP sockets in API mode .................................. 155
API mode behavior for outgoing TCP and TLS connections ............ 155
API mode behavior for outgoing UDP data .................................... 156
API mode behavior for incoming TCP connections ....................... 156
API mode behavior for incoming UDP data ................................... 157
Transparent mode behavior for outgoing TCP and TLS connections .. 157
Transparent mode behavior for outgoing UDP data ......................... 158
Transparent mode behavior for incoming TCP connections ............. 158
Transparent mode behavior for incoming UDP connections .......... 158
Supported sockets

The XBee Smart Modem supports the following number of sockets:

- 6 maximum: 4 TLS sockets maximum.\(^1\)

**Note** For NB-IoT, TCP support is dependent on the network. Contact your network provider for details.

Best practices when using sockets

**Sockets and Remote Manager**

If you use Remote Manager to remotely communicate with and configure your XBee Cellular device, you must leave at least two sockets available in the system: one UDP socket (for periodic low-data-usage check-ins), and one TCP/TLS socket (to be used when a full connection is needed).

If your application allocates so many sockets that Remote Manager functionality in the firmware cannot get the sockets that it requires, Remote Manager functionality will be prevented from working until sockets become available.

For example, each call to `socket.socket()` in MicroPython will allocate a socket, and this socket will remain allocated to MicroPython until the socket's close method is called, or the MicroPython REPL is restarted using Ctrl-D.

See Supported sockets for more information on the total number of sockets supported by the device.

**Sockets and API mode**

When using API mode to transmit TCP/TLS data to a remote destination (using the 0x20 or 0x23 API frames), sending a large amount of data as a single API frame is preferable to multiple smaller API frames. Using a single large API frame allows the XBee to transmit the data using fewer operations than transmitting multiple pieces of data in sequence, which improves overall throughput.

Additionally, one API frame consumes less dynamic memory in the system than multiple smaller API frames, which means there will be more memory available to process incoming IP data as well as subsequent API frames sent into the XBee Cellular device.

**Socket timeouts**

The XBee Smart Modem implicitly opens the socket any time there is data to be sent, and closes it according to the timeout settings. The TM (IP Client Connection Timeout) command controls the timeout settings.

**Note** For NB-IoT, TCP support is dependent on the network. Contact your network provider for details.

---

\(^1\) TCP socket is used for Remote Manager, so if you have Remote Manager enabled, subtract 1 socket from the values above.
Socket behavior

Socket limits in API mode

**Note** For NB-IoT, TCP support is dependent on the network. Contact your network provider for details.

In API mode there are a fixed number of sockets available; see Supported sockets. When a Transmit (TX) Request: IPv4 - 0x20 frame is sent to the XBee Smart Modem for a new destination, it creates a new socket. The exception to this is when using the UDP protocol with the C0 source port, which allows unlimited destinations on the socket created by C0 (Source Port). If no more sockets are available, the device sends back a Transmit (TX) Status - 0x89 frame with a Resource Error. The Resource Error resolves when an existing socket is closed. An existing socket may be closed when the socket times out (see TM (IP Client Connection Timeout) and TS (IP Server Connection Timeout)) or when the socket is closed via a TX request with the CLOSE flag set.

In API mode each socket has a maximum number of pending Transmit (TX) Requests allowed. When a Transmit (TX) Request: IPv4 - 0x20 frame is sent to the XBee Smart Modem for an existing destination, it sends that request using the socket for that destination. If the number of pending Transmit (TX) Requests would be exceeded for the socket, the device sends back a Transmit (TX) Status - 0x89 frame with a Resource Error indicating that the device is not able to send the request and should retry again later. The Resource Error resolves when a Transmit (TX) Request that is pending on the socket is transmitted; this is indicated by the Transmit (TX) Status frame for the request.

Enable incoming TCP sockets in API mode

In API mode, you can enable incoming connections to the XBee Smart Modem.

**Note** For NB-IoT, TCP support is dependent on the network. Contact your network provider for details.

1. To enable listening, set C0 (Source Port) to the value of the listening port.
2. To use TCP for client and server socket connections, set IP (IP Protocol) to 0x01.

The listener allows multiple clients (incoming connections), up to the limit of the maximum number of sockets on the system.

When the XBee Smart Modem receives RF data on the port defined by C0, you get a Receive (RX) Packet: IPv4 - 0xB0 with the incoming address and port.

If you want to communicate back to the incoming connection, use the Transmit (TX) Request: IPv4 - 0x20 and enter the received address and port as the destination address and port, along with the listening (C0) local source port.

API mode behavior for outgoing TCP and TLS connections

To initiate an outgoing TCP or TLS connection to a remote host, send a Transmit (TX) Request: IPv4 - 0x20 frame to the XBee Smart Modem's serial port specifying the destination address and destination port for the remote host; the data is optional and the source port is 0.

**Note** For NB-IoT, TCP support is dependent on the network. Contact your network provider for details.

If the connection is disconnected at any time, send a Transmit TX Request frame to trigger a new connection attempt.

To send data over this connection use the Transmit (TX) Request: IPv4 - 0x20.
The device sends a Transmit (TX) Status - 0x89 frame in reply to the Transmit TX Request indicating the status of the request. A status of 0 indicates the connection and/or data was successful, a value of 0x32 indicates a temporary Resource Error (see Socket limits in API mode), and other values indicates a failure.

Any data received on the connection is sent out the XBee Smart Modem's serial port as a Receive RX frame.

A connection is closed when:

- The remote end closes the connection.
- No data is sent or received for longer than the socket timeout set by TM (IP Client Connection Timeout).
- A Transmit TX Request is sent with the CLOSE flag set.

API mode behavior for outgoing UDP data

To send a UDP datagram to a remote host, send a Transmit (TX) Request: IPv4 - 0x20 frame to the XBee Smart Modem's serial port specifying the destination address and destination port of the remote host. If you use a source port of 0, the device creates a new socket for the purpose of sending to the remote host. The XBee Smart Modem supports a finite number of sockets, so if you need to send to many destinations:

1. The socket must be closed after use.

   or

2. You must use the socket specified by the C0 (Source Port) setting.

To use the socket specified by the C0 setting, in the Transmit TX request frame use a source port that matches the value configured for the C0 setting.

The device sends a Transmit (TX) Status - 0x89 frame in reply to the Transmit TX Request to indicate the status of the request. A status of 0 indicates the connection and/or data was successful, a value of 0x32 indicates a temporary Resource Error (see Socket limits in API mode), and other values indicates a failure.

Any data received on the UDP socket is sent out the XBee Smart Modem’s serial port as a Receive (RX) Packet: IPv4 - 0xB0 frame.

A UDP socket is closed when:

- No data has been sent or received for longer than the socket timeout set by TM (IP Client Connection Timeout).
- A transmit TX Request is sent with the CLOSE flag set.

API mode behavior for incoming TCP connections

For incoming connections and data in API mode, the XBee Smart Modem uses the C0 (Source Port) and IP (IP Protocol) settings to specify the listening port and protocol used. The XBee Smart Modem does not currently support the TLS protocol for incoming connections.

Note For NB-IoT, TCP support is dependent on the network. Contact your network provider for details.
When the **IP** setting is TCP the XBee Smart Modem allows multiple incoming TCP connections on the port specified by the **C0** setting. Any data received on the connection is sent out the XBee Smart Modem’s serial port as a **Receive (RX) Packet: IPv4 - 0xB0** frame.

To send data from the device over the connection, use the **Transmit (TX) Request: IPv4 - 0x20** frame with the corresponding address fields received from the Receive RX frame. In other words:

- Take the source address, source port, and destination port fields from the Receive (RX) frame and use those respectively as:
- The destination address, destination port, and source port fields for the Transmit (TX) Request frame.

A connection is closed when:

- The remote end closes the connection.
- No data has been sent or received for longer than the socket timeout set by **TS (IP Server Connection Timeout)**.
- A Transmit (TX) Request frame is sent with the **CLOSE** flag set.

### API mode behavior for incoming UDP data

When the **IP** (IP Protocol) setting is UDP, any data sent from a remote host to the XBee Smart Modem’s network port specified by the **C0 (Source Port)** setting is sent out the XBee Smart Modem’s serial port as a **Receive (RX) Packet: IPv4 - 0xB0** frame.

To send data from the XBee Smart Modem to the remote destination, use the **Transmit (TX) Request: IPv4 - 0x20** frame with the corresponding address fields received from the Receive RX frame. In other words take the source address, source port, and destination port fields from the Receive (RX) frame and use those respectively as the destination address, destination port, and source port fields for the Transmit (TX) Request frame.

### Transparent mode behavior for outgoing TCP and TLS connections

For Transparent mode, the **IP (IP Protocol)** setting specifies the protocol and the **DL (Destination Address)** and **DE (Destination port)** settings specify the destination address used for outgoing data (UDP) and outgoing connections (TCP and TLS).

**Note** For NB-IoT, TCP support is dependent on the network. Contact your network provider for details.

To initiate an outgoing TCP or TLS connection to a remote host, send data to the XBee Smart Modem’s serial port. If **C1 (Protocol/Connection Indication)** reports a value of **0**, then the connection was successfully established, otherwise the value of **C1** indicates why the connection attempt failed. Any data received over the connection is sent out the XBee Smart Modem’s serial port.

A connection is closed when:

- The remote end closes the connection.
- No data has been sent or received for longer than the socket timeout set by **TM (IP Client Connection Timeout)**.
- You make and apply a change to the **IP**, **DL**, or **DE**.
**Socket behavior**

**Transparent mode behavior for outgoing UDP data**

To send outgoing UDP data to a remote host, send data to the XBee Smart Modem’s serial port. If CI (Protocol/Connection Indication) reports a value of 0, the data was successfully sent; otherwise, the value of CI indicates why the data failed to be sent.

The RO (Packetization Timeout) setting provides some control in how the serial data gets packetized before being sent to the remote host. The first send opens up a UDP socket used to send and receive data. Any data received by this socket is sent out the XBee Smart Modem's serial port.

*Note* Set RO to FF for real time typing by humans. Also, see TD (Text Delimiter).

**Transparent mode behavior for incoming TCP connections**

The C0 (Source Port) and IP (IP Protocol) settings specify the listening port and protocol used for incoming connections (TCP) and incoming data (UDP) in Transparent mode. TLS is not currently supported for incoming connections.

*Note* For NB-IoT, TCP support is dependent on the network. Contact your network provider for details.

When the IP setting is TCP and there is no existing connection to or from the XBee Smart Modem, the device accepts one incoming connection. Any data received on the connection is sent out the XBee Smart Modem's serial port. Any data sent to the XBee Smart Modem's serial port is sent over the connection. If the connection is disconnected, it discards pending data.

**Transparent mode behavior for incoming UDP connections**

When the IP (IP Protocol) setting is UDP any data sent from a remote host to the XBee Smart Modem’s network port specified by C0 (Source Port) is sent out the XBee Smart Modem’s serial port. Any data sent to the XBee Smart Modem's serial port is sent to the network destination specified by the DL (Destination Address) and DE (Destination port) settings. If the DL and DE settings are unspecified or invalid, the XBee Smart Modem discards data sent to the serial port.
Extended Socket frames

The XBee Cellular product line includes a set of Extended Socket frames. You can use these frames in applications where the existing frames (Transmit Request (0x20), TLS Transmit (0x23) and Receive (0xB0)) limit the possibilities for an application.

You can use Extended Socket frames to do the following:

- Multiple simultaneous connections can be made to the same port on the same host. For example, you can overlap simultaneous HTTP requests.
- Immediate unsolicited notification of changes in socket status. This allows an application to react to a server-side socket closure rather than relying on an implicit connection to be re-established for continuing communication.
- A generalized mechanism for per-socket option selection. Currently used for TLS profile selection. Previously this required a unique frame, as options are added, this allows combinations of choices.
- Allow DNS look up during the connection process rather than a separate step.

In addition, for diagnostic purposes, you can use the Socket Info (SI) AT command to retrieve information regarding all open sockets currently active in the system. This can be queried during development or used by an application to confirm or refresh information during execution.

**Note** Sockets opened with the Extended Socket frames cannot be used with the legacy frames (Transmit Request (0x20), TLS Transmit (0x23) and Receive (0xB0)), nor vice versa.

For a list of the socket frames, see Available Extended Socket frames.

Examples

In the examples below the Frame IDs in all frames are set to 1 for simplicity. Socket IDs in all frames after the Socket Create are hard-coded to 0 as well. If you wish to use the example repeatedly the XBee should be rebooted between attempts.

We recommend the use of the XCTU frame generator for experimentation with frames during development. Paste the provided frame content directly into the Add API frame to list window in XCTU to follow along manually.

Extended Socket example: Single HTTP Connection
Extended Socket example: UDP
Extended Socket example: TCP Listener
### Available Extended Socket frames

**Note** For information about all frames, see API frames.

- Socket Create - 0x40
- Socket Option Request - 0x41
- Socket Connect - 0x42
- Socket Close - 0x43
- Socket Send (Transmit) - 0x44
- Socket SendTo (Transmit Explicit Data): IPv4 - 0x45
- Socket Bind/Listen - 0x46
- Socket Create Response - 0xC0
- Socket Option Response - 0xC1
- Socket Connect Response - 0xC2
- Socket Close Response - 0xC3
- Socket Listen Response - 0xC6
- Socket New IPv4 Client - 0xCC
- Socket Receive - 0xCD
- Socket Receive From: IPv4 - 0xCE
- Socket Status - 0xCF

### Extended Socket example: Single HTTP Connection

This example demonstrates a complete request with an HTTP server. It fetches a random fact about a number from a web services API offered by the website http://numbersapi.com.

**Note** Digi is not affiliated with numbersapi.com and the example is for education only.

### Send a Socket Create frame

**Note** To adapt this example for an HTTPS server, change Protocol below to 0x04 (TLS) and optionally use the Socket Option frame to specify a TLS profile.

<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame type</td>
<td>0x40 (Socket Create)</td>
</tr>
<tr>
<td>Frame ID</td>
<td>0x01</td>
</tr>
<tr>
<td>Protocol</td>
<td>0x01 (TCP)</td>
</tr>
</tbody>
</table>

Socket Create frame data:

```
7E 00 03 40 01 01 BD
```
Receive a Socket Create response

The XBee responds to the Socket Create request with a response. The response contains the socket ID assigned. In this example, the socket ID is 0.

<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame type</td>
<td>0xC0 (Socket Create Response)</td>
</tr>
<tr>
<td>Frame ID</td>
<td>0x01</td>
</tr>
<tr>
<td>Socket ID</td>
<td>0x00</td>
</tr>
<tr>
<td>Status</td>
<td>0x00 (Success)</td>
</tr>
</tbody>
</table>

Socket Create Response received from XBee:

7E 00 04 C0 01 00 00 3E

Send Socket Connect

This example uses the "string" destination address type to have the XBee perform DNS look-up during the connection process.

**Note** To adapt this example for TLS, use destination port 0x01 0xbb (decimal 443). Be aware that many HTTPS servers use SNI (Server Name Identification) which is not currently supported.

<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame type</td>
<td>0x42 (Socket Create Response)</td>
</tr>
<tr>
<td>Frame ID</td>
<td>0x01</td>
</tr>
<tr>
<td>Socket ID</td>
<td>0x00</td>
</tr>
<tr>
<td>Destination Port</td>
<td>0x00 0x50 (80 decimal, HTTP)</td>
</tr>
<tr>
<td>Destination Address Type</td>
<td>0x01 (String)</td>
</tr>
<tr>
<td>Destination Address</td>
<td>numbersapi.com</td>
</tr>
</tbody>
</table>

Socket Connect frame data:

7E 00 14 42 01 00 00 50 01 6E 75 6D 62 65 72 73 61 70 69 2E 63 6F 6D 6C 65

Receive a Socket Connect Response

The request to connect is immediately acknowledged with a response. However, it is not permitted to proceed transmitting data until the next stage, after a Socket Status frame has been received indicating success.
Extended Socket frames

Extended Socket example: Single HTTP Connection

### Field | Value
---|---
Frame type | 0xC2 (Socket Connect Response)
Frame ID | 0x01
Socket ID | 0x00
Status | 0x00 (Success)

Socket Connect Response received from XBee:

```
7E 00 04 C2 01 00 00 3C
```

#### Receive a Socket Status

The socket has been fully established when a Socket Status frame is received with the connected status after the socket has connected.

### Field | Value
---|---
Frame type | 0xCF (Socket Status)
Socket ID | 0x00
Status | 0x00 (Connected)

Socket Status received from XBee with connected status:

```
7E 00 03 CF 00 00 30
```

#### Send HTTP Request using Socket Send frame

The request uses the "Connection: close" header to have the server close the connection on request completion. This allows the example to demonstrate the Socket Status reporting of a close by the peer.

### Field | Value
---|---
Frame type | 0x44 (Socket Status)
Frame ID | 0x01
Socket ID | 0x00
Transmit Options | 0x00
Data | GET /random/trivia HTTP/1.1
Host: numbersapi.com
Connection: close

Socket Send frame data:
Extended Socket frames

Extended Socket example: Single HTTP Connection

<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame type</td>
<td>0x89 (TX Status)</td>
</tr>
<tr>
<td>Frame ID</td>
<td>0x01</td>
</tr>
<tr>
<td>Status</td>
<td>0x00 (Success)</td>
</tr>
</tbody>
</table>

TX Status received from XBee data:

7E 00 03 89 01 00 75

Receive one or more Receive Data frames

The server will respond with an interesting fact about a number. The following information is a sample response. Multiple frames may be needed to contain the full response content depending on size and network conditions.

<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame type</td>
<td>0xCD (Socket Receive)</td>
</tr>
<tr>
<td>Frame ID</td>
<td>0x00</td>
</tr>
<tr>
<td>Socket ID</td>
<td>0x00</td>
</tr>
<tr>
<td>Status</td>
<td>0x00</td>
</tr>
<tr>
<td>Payload</td>
<td>HTTP/1.1 200 OK</td>
</tr>
<tr>
<td></td>
<td>Server: nginx/1.4.6 (Ubuntu)</td>
</tr>
<tr>
<td></td>
<td>Date: Thu, 18 Jul 2019 16:13:47 GMT</td>
</tr>
<tr>
<td></td>
<td>Content-Type: text/plain; charset=&quot;UTF-8&quot;; charset=utf-8</td>
</tr>
<tr>
<td></td>
<td>Content-Length: 53</td>
</tr>
<tr>
<td></td>
<td>Connection: close</td>
</tr>
<tr>
<td></td>
<td>X-Powered-By: Express</td>
</tr>
<tr>
<td></td>
<td>Access-Control-Allow-Origin: *</td>
</tr>
<tr>
<td></td>
<td>Access-Control-Allow-Headers: X-Requested-With</td>
</tr>
<tr>
<td></td>
<td>X-Numbers-API-Number: 270</td>
</tr>
<tr>
<td></td>
<td>X-Numbers-API-Type: trivia</td>
</tr>
<tr>
<td></td>
<td>Pragma: no-cache</td>
</tr>
<tr>
<td></td>
<td>Cache-Control: no-cache</td>
</tr>
<tr>
<td></td>
<td>Expires: 0</td>
</tr>
</tbody>
</table>

270 is the average number of days in human pregnancy.
**Receive Socket Status indicating closed connection**

Finally, due to the "Connection" header in the request, the server should remotely close the connection.

<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame type</td>
<td>0xCF (TX Status)</td>
</tr>
<tr>
<td>Socket ID</td>
<td>0x00</td>
</tr>
<tr>
<td>Status</td>
<td>0x07 (Connection lost)</td>
</tr>
</tbody>
</table>

Example Socket Status received from XBee indicating connection lost:

```
7E 00 03 CF 00 07 29
```

When Socket Status indicating a connection close is received, the socket ID will have been deallocated by the XBee and no further operations are possible or necessary using that ID.

**Extended Socket example: UDP**

UDP is connection-less, so this example demonstrates that a Socket Connect frame is not required to begin communication and that multiple peers can be used with a single socket.

**Send a Socket Create frame**

<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame type</td>
<td>0x40 (Socket Create)</td>
</tr>
<tr>
<td>Frame ID</td>
<td>0x01</td>
</tr>
<tr>
<td>Protocol</td>
<td>0x00 (UDP)</td>
</tr>
</tbody>
</table>

UDP Socket Create frame data:
Extended Socket frames

Extended Socket frames

Receive a Socket Create response

<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame type</td>
<td>0xC0 (Socket Create Response)</td>
</tr>
<tr>
<td>Frame ID</td>
<td>0x01</td>
</tr>
<tr>
<td>Socket ID</td>
<td>0x00</td>
</tr>
<tr>
<td>Status</td>
<td>0x00 (Success)</td>
</tr>
</tbody>
</table>

Socket Create Response received from XBee:

7E 00 03 40 01 00 BE

Bind local source address

The bind/listen operation is necessary prior to transmit in order to assign a known source address to all data sent from this socket.

<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame type</td>
<td>0x46 (Socket Bind/Listen)</td>
</tr>
<tr>
<td>Frame ID</td>
<td>0x01</td>
</tr>
<tr>
<td>Socket ID</td>
<td>0x00</td>
</tr>
<tr>
<td>Source Port</td>
<td>0x12 0x34</td>
</tr>
</tbody>
</table>

Socket Bind/Listen frame data:

7E 00 05 46 01 00 12 34 72

Receive Bind/Listen Response

The XBee generates a response indicating the status of the request to bind the requested port.

<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame type</td>
<td>0xC6 (Socket Bind/Listen Response)</td>
</tr>
<tr>
<td>Frame ID</td>
<td>0x01</td>
</tr>
<tr>
<td>Socket ID</td>
<td>0x00</td>
</tr>
<tr>
<td>Status</td>
<td>0x00 (Success)</td>
</tr>
</tbody>
</table>

Socket Bind/Listen Response received from XBee:
Extended Socket frames

Extended Socket example: UDP

Send to Digi echo server
Digi hosts a server at 52.43.121.77 port 10001 which echos all UDP traffic sent to it.

<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame type</td>
<td>0x45 (Socket SendTo)</td>
</tr>
<tr>
<td>Frame ID</td>
<td>0x01</td>
</tr>
<tr>
<td>Socket ID</td>
<td>0x00</td>
</tr>
<tr>
<td>Destination Address</td>
<td>0x34 0x2B 0x79 0x4D (52.43.121.77)</td>
</tr>
<tr>
<td>Destination Port</td>
<td>0x27 0x11 (decimal 10001)</td>
</tr>
<tr>
<td>Transmit Options</td>
<td>0x00</td>
</tr>
<tr>
<td>Payload</td>
<td>echo this</td>
</tr>
</tbody>
</table>

Socket SendTo frame data:

7E 00 13 45 01 00 34 2B 79 4D 27 11 00 65 63 68 6F 20 74 68 69 73 E5

Receive TX Status
Extended sockets use the existing TX Status frame (0x89) to report acceptance of the data for transmit.

<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame type</td>
<td>0x89 (TX Status)</td>
</tr>
<tr>
<td>Frame ID</td>
<td>0x01</td>
</tr>
<tr>
<td>Status</td>
<td>0x00 (Success)</td>
</tr>
</tbody>
</table>

TX Status received from XBee:

7E 00 03 89 01 00 75

Receive echoed data
When the response from the server is sent back, the XBee provides it using a Socket Receive From frame.

<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame type</td>
<td>0xCE (Socket Receive From)</td>
</tr>
</tbody>
</table>
Extended Socket frames

Extended Socket example: UDP

Field | Value
--- | ---
Frame ID | 0x00
Socket ID | 0x00
Source address | 0x34 0x2B 0x79 0x4D (52.43.121.77)
Source Port | 0x27 0x11 (decimal 10001)
Status | 0x00 (Success)
Payload | echo this

Socket ReceiveFrom received from XBee, containing echoed data:

```
7E 00 13 CE 00 00 34 2B 79 4D 27 11 00 65 63 68 20 74 68 69 73 5D
```

**Send to Digi time server**

Digi hosts a server at 54.43.121.77 port 10002 which will reply with the time when it receives a packet.

Field | Value
--- | ---
Frame type | 0x45 (Socket SendTo)
Frame ID | 0x01
Socket ID | 0x00
Destination Address | 0x34 0x2B 0x79 0x4D (52.43.121.77)
Destination Port | 0x27 0x12 (decimal 10002)
Transmit Options | 0x00
Payload | 0x20 (ASCII space, any value should do)

Socket SendTo time server frame data:

```
7E 00 0B 45 01 00 34 2B 79 4D 27 12 00 20 3B
```

**Receive TX Status**

This is exactly the same as the previous transmission to the echo server on success.

**Receive daytime value**

When the response from the server is sent back, the XBee will provide it using a Socket Receive From frame.
Extended Socket example: UDP

<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame type</td>
<td>0xCE (Socket Receive From)</td>
</tr>
<tr>
<td>Frame ID</td>
<td>0x00</td>
</tr>
<tr>
<td>Socket ID</td>
<td>0x00</td>
</tr>
<tr>
<td>Source address</td>
<td>0x34 0x2B 0x79 0x4D (52.43.121.77)</td>
</tr>
<tr>
<td>Source Port</td>
<td>0x27 0x12 (decimal 10002)</td>
</tr>
<tr>
<td>Status</td>
<td>0x00 (Success)</td>
</tr>
<tr>
<td>Payload</td>
<td>&lt;current UTC time&gt;</td>
</tr>
</tbody>
</table>

Socket Receive From frame received from XBee containing time data:

```
7E 00 1E CE 00 00 34 2B 79 4D 00 32 30 31 39 2D 30 37 2D 31 38 20 31 38 3A
35 32 3A 34 33 0A 08
```

**Close the socket**

When the socket is no longer needed it should be closed to return resources to the system.

<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame type</td>
<td>0x43 (Socket Close)</td>
</tr>
<tr>
<td>Frame ID</td>
<td>0x01</td>
</tr>
<tr>
<td>Status</td>
<td>0x00</td>
</tr>
</tbody>
</table>

Socket Close frame data:

```
7E 00 03 43 01 00 BB
```

**Receive close response**

Finally, the XBee indicates the socket has been closed with a Socket Close Response frame.

<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame type</td>
<td>0xC3 (Socket CloseResponse)</td>
</tr>
<tr>
<td>Frame ID</td>
<td>0x01</td>
</tr>
<tr>
<td>Socket ID</td>
<td>0x00</td>
</tr>
<tr>
<td>Status</td>
<td>0x00 (Success)</td>
</tr>
</tbody>
</table>

Socket Close Response received from XBee:

```
7E 00 04 C3 01 00 00 3B
```
Extended Socket frames

Extended Socket example: TCP Listener

The following example demonstrates setting up a TCP listener on the XBee Cellular and interacting with incoming connections. It will open up a listener socket on a given port and then receive data from a client.

**Note** The module must either have a public IP or be on a private network in order to be accessible as a server (listener).

Send a Socket Create frame

**Note** The XBee Cellular does not support incoming TLS sockets.

<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame type</td>
<td>0x40 (Socket Create)</td>
</tr>
<tr>
<td>Frame ID</td>
<td>0x01</td>
</tr>
<tr>
<td>Protocol</td>
<td>0x01 (TCP)</td>
</tr>
</tbody>
</table>

Socket Create frame data:

7E 00 03 40 01 01 BD

Receive a Socket Create response

The response contains the socket ID assigned. This example assumes zero.

<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame type</td>
<td>0xC0 (Socket Create Response)</td>
</tr>
<tr>
<td>Frame ID</td>
<td>0x01</td>
</tr>
<tr>
<td>Socket ID</td>
<td>0x00</td>
</tr>
<tr>
<td>Status</td>
<td>0x00 (Success)</td>
</tr>
</tbody>
</table>

Socket Create Response received from XBee:

7E 00 04 C0 01 00 00 3E

Designate the socket as a listener

The Socket Bind/Listen Frame takes the socket ID from the socket create response and a source port that the socket will then listen on. In this example port 10001 is used.
Extended Socket frames

Extended Socket example: TCP Listener

<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame type</td>
<td>0x46 (Socket Listen)</td>
</tr>
<tr>
<td>Frame ID</td>
<td>0x01</td>
</tr>
<tr>
<td>Socket ID</td>
<td>0x00</td>
</tr>
<tr>
<td>Source Port</td>
<td>0x2711 (10001)</td>
</tr>
</tbody>
</table>

Socket Bind/Listen frame data:

```
7E 00 05 46 01 00 27 11 80
```

**Receive a Socket Bind/Listen Response**

The Socket Bind/Listen Response contains a Status. A Status of zero is a success and any other value is an error.

<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame type</td>
<td>0xC6 (Socket Listen)</td>
</tr>
<tr>
<td>Frame ID</td>
<td>0x01</td>
</tr>
<tr>
<td>Socket ID</td>
<td>0x00</td>
</tr>
<tr>
<td>Status</td>
<td>0x00 (Success)</td>
</tr>
</tbody>
</table>

Socket Bind/Listen frame received from XBee:

```
7E 00 04 C6 01 00 00 38
```

**Making a connection to the listener socket**

The IP of the XBee can be acquired through the MY at command.

```
ATMY 172.20.1.235
```

Using an external tool like netcat, a connection can be made to the given address.

```
nc -p 10001 172.20.1.235 10001
Hello XBee!
```

After the connection has been made, the XBee outputs a Socket New IPv4 Client frame indicating the presence of a new client connection. It contains the listener's socket ID and the new Client Socket ID along with the connection's remote address information.

<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame type</td>
<td>0xCC (Socket New IPv4 Client)</td>
</tr>
</tbody>
</table>
Extended Socket frames

Extended Socket example: TCP Listener

<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Socket ID</td>
<td>0x00</td>
</tr>
<tr>
<td>Client Socket ID</td>
<td>0x01</td>
</tr>
<tr>
<td>Remote Address</td>
<td>0x0A 0x0A 4A 9D</td>
</tr>
<tr>
<td>Remote Port</td>
<td>0x27 0x11</td>
</tr>
</tbody>
</table>

Socket New IPv4 Client frame:

7E 00 09 CC 00 01 0A 0A 4A 9D 27 11 FF

**Note** XBee Cellular Cat-1 variants require data to be sent before the connection is presented. Other variants present the connection as soon as it is made.

**Receiving Data from the new socket**

After the connection is established, data received from the new socket is contained in a Socket Receive frame just like any other TCP socket.

<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame type</td>
<td>0xCD (Socket Status)</td>
</tr>
<tr>
<td>Frame ID</td>
<td>0x01</td>
</tr>
<tr>
<td>Socket ID</td>
<td>0x01</td>
</tr>
<tr>
<td>Status</td>
<td>0x00</td>
</tr>
<tr>
<td>Payload</td>
<td>Hello XBee!</td>
</tr>
</tbody>
</table>

Receive Data indicating data from remote TCP peer:

7E 00 10 CD 00 01 00 48 65 6C 6F 20 58 42 65 21 0A 8E

**Receive a Socket Status indicating closed connection**

You may close the client socket remotely which elicits a Socket Status with a Status of 0x07.

<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame type</td>
<td>0xCF (Socket Status)</td>
</tr>
<tr>
<td>Socket ID</td>
<td>0x01</td>
</tr>
<tr>
<td>Status</td>
<td>0x07</td>
</tr>
</tbody>
</table>

Socket Status received from XBee indicating connection lost:

7E 00 03 CF 01 07 28
When a Socket Status indicating a connection close is received, the socket ID will have been de-allocated by the XBee and no further operations are possible or necessary using that ID.
Transport Layer Security (TLS)

For detailed information about using MicroPython on the XBee Smart Modem refer to the Digi MicroPython Programming Guide.

Note For NB-IoT, TCP support is dependent on the network. Contact your network provider for details.

Specifying TLS keys and certificates ................................................................. 174
Transparent mode and TLS ............................................................................. 175
API mode and TLS ......................................................................................... 175
Key formats ....................................................................................................... 175
Certificate formats .......................................................................................... 175
Certificate limitations ..................................................................................... 175
Cipher suites .................................................................................................... 176
Server Name Indication (SNI) ........................................................................ 176
Secure the connection between an XBee and Remote Manager with server authentication .. 176
Specifying TLS keys and certificates

**Note** For NB-IoT, TCP support is dependent on the network. Contact your network provider for details.

These AT commands, when used together, let you interact with TLS features: ATFS (File System), TL (TLS Protocol Version), IP (IP Protocol), $0 (TLS Profile 0), $1 (TLS Profile 1), and $2 (TLS Profile 2). The format of the $ commands is:

```
AT$<num>[<ca_cert>];[<client_cert>];[<client_key>]
```

Where:

- **num**: Profile index. Index zero is used for Transparent mode connections and TLS connections using Transmit (TX) Request: IPv4 - 0x20.
- **ca_cert**: (optional) Filename of a file in the **certs** directory. Indicates the certificate identifying a trusted root certificate authority (CA) to use in validating servers. If **ca_cert** is empty the server certificate will not be authenticated. This must be a single root CA certificate. The modules do not allow a non-self signed certificate to work, so intermediate CAs are not enough.

**Note** This module will only work with the originating end of chain Root CA, so you will need to use that one. For example, with Amazon web services ATS endpoints Digi recommends that you use the Starfield Services Root Certificate from [https://ssl-ccc.secureserver.net/repository/sf-class2-root.crt](https://ssl-ccc.secureserver.net/repository/sf-class2-root.crt). The intermediate "root CAs" from Amazon will not work. You will need the actual end of chain certificate.

- **client_cert**: (optional) Filename of a file in the **certs** directory. Indicates the certificate presented to servers when requested for client authentication. If **client_cert** is empty no certificate is presented to the server should it request one. This may result in mutual authentication failure.
- **client_key**: (optional) Filename of a file in the **certs** directory. Indicates the private key matching the public key contained in **client_cert**. This should be a secure file uploaded with ATFS XPUT filename. This should always be provided if **client_cert** is provided and match the certificate or client authentication will fail.

The default value is ":". This default value preserves the legacy behavior by allowing the creation of encrypted connections that are confidential but not authenticated.

To specify a key stored outside of **certs**, you can either use a relative path, for example ../*.server.pem or an absolute path starting with /flash, for example /flash/server.pem. Both examples refer to the same file.

It is not an error at configuration time to name a file that does not yet exist. An error is generated if an attempt to create a TLS connection is made with improper settings.

- Files specified should all be in PEM format, not DER.
- Upload private keys securely with ATFS XPUT filename.
- Certificates can be uploaded with ATFS PUT filename as they are not sensitive. It is not possible to use ATFS GET filename to GET them if they have been securely uploaded.

To authenticate a server not participating in a public key infrastructure (PKI) using CAs, the server must present a self-signed certificate. That certificate can be used in the **ca_cert** field to authenticate that single server.

There are effectively three levels of authentication provided depending on the parameters provided.
1. No authentication: None of the parameters are provided, this is the default value. With this configuration identity is not validated and a man in the middle (MITM) attack is possible.
2. Server authentication: Only ca_cert is provided. Only the servers identity is checked
3. Mutual authentication: All items are provided and both sides are assured of the identity of their peer

It is not possible to only have client authentication.

**Transparent mode and TLS**

Transparent mode connections made when IP (IP Protocol) = 4 (TLS) are made using the configuration specified by $0 (TLS Profile 0).

**Note** For NB-IoT, TCP support is dependent on the network. Contact your network provider for details.

**API mode and TLS**

On the Transmit (TX) Request: IPv4 - 0x20 frame, when you specify protocol 4 (TLS), the profile configuration specified by $0 (TLS Profile 0) is used to form the TLS connection. Tx Request with TLS Profile - 0x23 lets you choose the IP setting for the serial data.

**Note** For NB-IoT, TCP support is dependent on the network. Contact your network provider for details.

**Key formats**

The RSA PKCS#1 format is the only common format across XBee Cellular device variants. You can identify a PKCS#1 key file by the presence of **BEGIN RSA PRIVATE KEY** in the file header.

Digi’s implementation does not support encrypted keys, we use file system encryption to protect the keys at rest in the system.

**Note** For NB-IoT, TCP support is dependent on the network. Contact your network provider for details.

**Certificate formats**

For SARA-R410 cellular components used in the XBee 3 Cellular LTE-M Global Smart Modem, if the server certificate has a Common Name (CN) that is greater than 31 characters the SSL connection fails.

**Note** For NB-IoT, TCP support is dependent on the network. Contact your network provider for details.

**Certificate limitations**

The XBee Smart Modem only supports certificate files that contain a single certificate in them.
Note: For NB-IoT, TCP support is dependent on the network. Contact your network provider for details.

The implications of this are:

- For client certificate files (for example when client authentication is required):
  - Self-signed certificates will work.
  - Certificates signed by the root CA will work, because the root CA can be omitted per RFC 5246. The root certificate authority may be omitted from the chain, under the assumption that the remote end must already possess it in order to validate it in any case.
  - Certificate chains that include a intermediate CA are problematic. To work around this the client’s certificate chain has to be supplied to the server outside of the connection.
- For server certificate files (when server authentication is required) this is not a problem unless the client is expected to connect to multiple servers that are using different self signed certificates or are using certificate chains that are signed by different root CA certificates. To work around this you have to change the certificates before making the connection, or in the case of API mode specify a different authentication profile.

Cipher suites

Note: For NB-IoT, TCP support is dependent on the network. Contact your network provider for details.

The only documented shared suites between the XBee 3 Cellular LTE Cat 1 Smart Modem and the XBee 3 Cellular LTE-M Global Smart Modem are:

- TLS_RSA_WITH_AES_128_CBC_SHA
- TLS_RSA_WITH_AES_256_CBC_SHA

For the u-blox SARA-R410 and SARA-U201 cellular components:

- TLS_RSA_WITH_AES_128_CBC_SHA
- TLS_RSA_WITH_AES_128_CBC_SHA256
- TLS_RSA_WITH_AES_256_CBC_SHA
- TLS_RSA_WITH_AES_256_CBC_SHA256
- TLS_RSA_WITH_3DES_EDE_CBC_SHA

Server Name Indication (SNI)

We do not currently support SNI. Therefore servers which use SNI to present certificates based on client provided host data may be unable to establish the expected connections.

Secure the connection between an XBee and Remote Manager with server authentication

The XBee devices that have the *11 or later version of the firmware installed are by default able to secure the TLS connection to Digi Remote Manager. The default configuration provides confidentiality of the communication but is not able to authenticate the server without a certificate being provided.
If you have devices that have been upgraded in the field or manufactured prior to being pre-populated with the Remote Manager certificate, you should follow the procedure below to add the necessary certificate if server authentication is needed.

**Step 1: Get the certificate**

1. Navigate to the Firmware Updates section of the Digi XBee 3 Cellular LTE-M/NB-IoT support page.
2. Click Remote Manager TLS Public Certificate to download the certificate .zip file.
3. Unzip the .zip file.
4. Calculate the SHA-256 hash to verify that the file is correct. The correct file will have an SHA-256 hash of:
   
   33d91e18668b0d8a9ec59c5f9f312c53ca2884adaa62337839e5495c26d2d64c

**Step 2: Configure device**

You should confirm that the default settings are correct. You can use either Remote Manager or XCTU to verify these settings and place the certificate file in the correct location.

1. Verify the following settings:

<table>
<thead>
<tr>
<th>Setting</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>DO</td>
<td>Bit 0 (mask 0x1) must be set. This enables the use of Digi Remote Manager within the firmware.</td>
</tr>
<tr>
<td>MO</td>
<td>Bit 1 (mask 0x2) must be set. When this value is set the Remote Manager TCP connection will be secured with TLS.</td>
</tr>
<tr>
<td>$D</td>
<td>By default will contain the value /flash/cert/digi-remote-mgr.pem. This is the file system location where the firmware will look for the certificate to use.</td>
</tr>
</tbody>
</table>

2. Use XCTU or Remote Manager to place the downloaded and unzipped certificate file in the location specified in the $D command.

**Step 3: Verify that authentication is being performed**

The next TCP connection to Remote Manager should only succeed if the server can be authenticated using the provided certificate. You can confirm that the server has been authenticated.

1. Cause an active connection to Remote Manager. For example, you could set bit 0 for the MO command. Make sure that you do not clear bit 1.
2. After a short wait you should be able to see the device as connected in Remote Manager.
   a. Log in to Remote Manager.
   b. Click Device Management.
   c. Locate the device in the device list and verify that the connection icon in the left column is blue and the hover tool tip says "Connected".
3. When the device is connected to Remote Manager, the DI command can take on any of the three values shown below, based on the security level of the connection. Verify that the DI
Transport Layer Security (TLS) Secure the connection between an XBee and Remote Manager with server authentication

command is set to 6 to verify that the server was correctly authenticated.

- 0: Connected without TLS
- 5: Connected with TLS but without authentication
- 6: Connected with TLS and with authentication
AT commands

Special commands ................................................................. 180
Cellular commands ............................................................... 182
Network commands ............................................................... 189
Addressing commands .......................................................... 194
Serial interfacing commands .................................................. 197
I/O settings commands .......................................................... 201
I/O sampling commands ......................................................... 210
Sleep commands .................................................................... 212
Command mode options ......................................................... 214
MicroPython commands .......................................................... 216
Firmware version/information commands ................................. 218
Diagnostic interface commands .............................................. 222
Execution commands .............................................................. 226
File system commands ........................................................... 227
BLE commands ..................................................................... 230
Remote Manager commands ................................................... 232
System commands ................................................................... 235
Socket commands ................................................................... 236
Power measurement commands .............................................. 237
Special commands

The following commands are special commands.

AC (Apply Changes)
Immediately applies new settings without exiting Command mode.
Applying changes means that the device re-initializes based on changes made to its parameter values. Once changes are applied, the device immediately operates according to the new parameter values. This behavior is in contrast to issuing the WR (Write) command. The WR command saves parameter values to non-volatile memory, but the device still operates according to previously saved values until the device is rebooted or you issue the CN (Exit AT Command Mode) or AC commands.

Parameter range
N/A
Default
N/A

FR (Force Reset)
Resets the device. The device responds immediately with an OK and performs a reset 100 ms later. If you issue FR while the device is in Command Mode, the reset effectively exits Command mode.

Note Digi recommends shutting down the cellular component before resetting or rebooting the device to allow the cellular module to detach from the network. The cellular component can be shut down by issuing the SD command.

Parameter range
N/A
Default
N/A

RE (Restore Defaults)
Restore device parameters to factory defaults.
The RE command does not write restored values to non-volatile (persistent) memory. Issue the WR (Write) command after issuing the RE command to save restored parameter values to non-volatile memory.

Parameter range
N/A
Default
N/A
**SD (Shutdown)**

Shuts down the device. When the shut down process is complete, the device returns **OK**. After the device responds **OK**, you can safely remove power from the device.

If the radio can't be fully shut down within two minutes, the device returns **ERROR**.

You can verify the state of the device using the **AI command**. After you issue the **SD** command and a response has been returned (either **OK** or **ERROR**), issue the **AI** command. If the shutdown was successful, **2D** is returned.

**Parameter range**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Shuts down the device. When the shut down process is complete, the device returns <strong>OK</strong>.</td>
</tr>
<tr>
<td>1</td>
<td>Reboots the module when the shut down completes.</td>
</tr>
</tbody>
</table>

**Default**

N/A

**WR (Write)**

Writes parameter values to non-volatile memory so that parameter modifications persist through subsequent resets.

**Note** Once you issue a **WR** command, do not send any additional characters to the device until after you receive the **OK** response.

**Parameter range**

N/A

**Default**

N/A
**Cellular commands**

The following AT commands are cellular configuration and data commands.

**PH (Phone Number)**
Reads the SIM card phone number.

**Parameter range**
N/A

**Default**
Set by the cellular carrier via the SIM card

**S# (ICCID)**
Reads the Integrated Circuit Card Identifier (ICCID) of the inserted SIM.

**Parameter range**
N/A

**Default**
Set by the SIM card

**IM (IMEI)**
Reads the device’s International Mobile Equipment Identity (IMEI).

**Parameter range**
N/A

**Default**
Set in the factory

**II (Subscriber identity)**
Reads the IMSI (International Mobile Subscriber Identity) from the SIM inserted into the module.

**Parameter range**
N/A

**Default**
N/A

**MN (Operator)**
Reads the network operator on which the device is registered.

**Parameter range**
N/A
**MV (Modem Firmware Version)**
Read the firmware version string for cellular component communications. See the related VR (Firmware Version) command.

Parameter range
N/A

Default
Set in the currently loaded firmware

**DB (Cellular Signal Strength)**
Reads the absolute value of the current signal strength to the cell tower in dB. If DB is blank, the XBee Smart Modem has not received a signal strength from the cellular component.
DB only updates when the modem is registered with the cellular tower. It is updated periodically, and not when read.

Parameter range

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Returns the most recent, cached RSSI signal value received.</td>
</tr>
<tr>
<td>1</td>
<td>Returns a fresh, uncached RSSI signal value.</td>
</tr>
</tbody>
</table>

Returned values
0x71 - 0x33 (-113 dBm to -51 dBm) [read-only]

Default
N/A

**DT (Cellular Network Time)**
Reads the current network-provided local time of the XBee device, as reported by the cellular tower. If the time is not known, the response is empty. This value is synchronized with the network approximately once per hour.

**Note** The time is provided by the network. If the time is not what you expect, contact your network provider.

Parameter range
0 - 1

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>The response is the number of seconds since 2000-01-01 00:00:00, as a 32-bit number. This is the default.</td>
</tr>
<tr>
<td>1</td>
<td>The response is the current date and time in ISO 8601 format. For example, &quot;2018-12-25T22:00:05&quot;.</td>
</tr>
</tbody>
</table>
Note You can also send DT, which acts like DT=0.

Default
0

AN (Access Point Name)
Specifies the packet data network that the modem uses for Internet connectivity. This information is provided by your cellular network operator. After you set this value, applying changes with AC (Apply Changes) or CN (Exit Command mode) triggers a network reset. See Network connection issues if the XBee Smart Modem is not joining the network.

Parameter range
1 - 100 ASCII characters

Default
-

CP (Carrier Profile)
Configures the cellular component to select network operator settings (RF bands, packet data configuration) for various networks. The default setting of 0 (autodetect) increases the boot time.

The 1 (No Profile) setting should be used if the module is not able to join the network because the underlying cellular modem does not have a predefined profile that supports the inserted SIM card. The 1 (No Profile) setting does not use any predefined profiles, which forces the module to attempt to join an appropriate network based on the module's current configuration. Changes to the value only take effect on boot so a reboot or power cycle is required for any changes to become active.

Parameter range
0 - 3

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Autodetect from inserted ICCID (SIM) [default]</td>
</tr>
<tr>
<td>1</td>
<td>No Profile</td>
</tr>
<tr>
<td>2</td>
<td>AT&amp;T</td>
</tr>
<tr>
<td>3</td>
<td>Verizon</td>
</tr>
</tbody>
</table>

Note This value should only be used with Verizon home network SIM cards. Setting the value to 3 with other SIM cards may adversely affect network registration and activity.
BM (Bandmask) (LTE-M)

**Note** This command is for use with only LTE-M.

Configures the enabled 4G LTE bands for LTE-M when CP is set to 1 (No Profile). Changes to the value only take effect on boot so a reboot or power cycle is required for any changes to become active.

**Note** The actual set of enabled bands will be a subset of this bit field, depending on the limitations of the cellular component.

**WARNING!** If this value is configured incorrectly, the XBee module may be unable to locate a tower and join the network.

**Parameter range**

0 - 0xFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF (bit field)

Example: 0x080080 (bits 7 and 19) enable LTE Bands 8 and 20.

<table>
<thead>
<tr>
<th>Bit</th>
<th>LTE Band</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>...</td>
<td></td>
</tr>
<tr>
<td>127</td>
<td>128</td>
</tr>
</tbody>
</table>

**Default**

0xFFFFFFFFFFFFFFFF (bands 1-64 enabled)

BN (Bandmask) (NB-IoT)

**Note** This command is for use with only NB-IoT.

Configures the enabled 4G LTE bands for NB-IoT when the CP command is set to 1 (No Profile). If CP is not set to 1, the BN command will return an error. Changes to the value only take effect on boot so a reboot or power cycle is required for any changes to become active.

**Note** The actual set of enabled bands will be a subset of this bit field, depending on the limitations of the cellular component.

**WARNING!** If this value is configured incorrectly, the XBee module may be unable to locate a tower and join the network.

**Parameter range**

0 - 0xFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF (bit field)

Example: 0x080080 (bits 7 and 19) enable NB-IoT Bands 8 and 20.
AT commands

<table>
<thead>
<tr>
<th>Bit</th>
<th>LTE Band</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>...</td>
<td></td>
</tr>
<tr>
<td>127</td>
<td>128</td>
</tr>
</tbody>
</table>

**Default**

0xFFFFFFFFFFFFFFFF (bands 1-64 enabled)

**AM (Airplane Mode)**

When set, the cellular component of the XBee Smart Modem is fully turned off and no access to the cellular network is performed or possible.

**Parameter range**

0 - 1

0 = Normal operation
1 = Airplane mode

**Default**

0

**N# (Preferred Network Technology)**

---

**Note** This command applies only to XBee 3 Cellular LTE-M/NB-IoT.

Allows the XBee 3 Cellular LTE-M/NB-IoT module to select the preferred network technology. A reboot or power cycle is required for any parameter changes to become active.

**Range**

0 - 3

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>LTE-M with NB-IoT fallback.</td>
</tr>
<tr>
<td>1</td>
<td>NB-IoT with LTE-M fallback.</td>
</tr>
<tr>
<td>2</td>
<td>LTE-M only.</td>
</tr>
<tr>
<td>3</td>
<td>NB-IoT only.</td>
</tr>
</tbody>
</table>

**Default**

0

**SQ (Reference Signal Received Quality)**

Returns the Reference Signal Received Quality (RSRQ) value.

The value returned is in hex, and should be converted by the user with the following formula:
RSRQ = -(<hex_value> / 0xA)

Example: The value returned from the command is 82:
RSRQ = -(0x82 / 0xA) = -13.0 dB

Example: The value returned is A0:
RSRQ = -(0xA0 / 0xA) = -16.0 dB

If the value cannot be retrieved for some reason, such as the device is not on the network yet, an empty string with **OK** after it is returned.

**Parameter range**

N/A

**Default**

N/A

**SW (Reference Signal Received POWER)**

Returns the Reference Signal Received Power (RSRP) value.
The value returned is in hex, and should be converted by the user with the following formula:

\[ \text{RSRP} = -(\text{hex_value} / 0xA) \]

Example: The value returned from the command is 384:
RSRP = -(0x384 / 0xA) = -90.0 dBm

Example: The value returned is A0:
RSRQ = -(0xA0 / 0xA) = -16.0 dB

If the value cannot be retrieved for some reason, such as the device is not on the network yet, an empty string with **OK** after it is returned.

**Parameter range**

N/A

**Default**

N/A

**PN (SIM PIN)**

Specifies the PIN when using a SIM.
This command is write-only.

**Parameter range**

4 to 8 ASCII digits or space character.
A value of a single space character (ASCII 0x20) acts as an empty value.

**Default**

0x20: A single ASCII space character that indicates there is no PIN.

**PK (SIM PUK)**

Specifies the PUK for unlocking a SIM. This is needed only if the wrong PIN was used and the SIM is locked out.
This command is write-only.

**Parameter range**
- 8 ASCII digits or space character
- A value of a single space character (ASCII 0x20) acts as an empty value.

**Default**
- 0x20: A single ASCII space that indicates there is no PUK.

**CU (Cellular user name)**
Specifies the user name used when authenticating to the cellular network.
This command is write-only.

**Parameter range**
- 1 to 30 ASCII characters
- A value of a single space character (ASCII 0x20) acts as an empty value.

**Default**
- 0x20: A single ASCII space that indicates there is no cellular user name.

**CW (Cellular password)**
Specifies the password used when authenticating to the cellular network.
This command is write-only.

**Parameter range**
- 1 to 30 ASCII characters
- A value of a single space character (ASCII 0x20) acts as an empty value.

**Default**
- 0x20: A single ASCII space that indicates there is no cellular password.
Network commands

The following commands are network commands.

IP (IP Protocol)

Note For NB-IoT, TCP and SMS support is dependent on the network. Contact your network provider for details.

Sets or displays the IP protocol used for client and server socket connections in IP socket mode. For TLS, the ublox SARA-R4 series AT Commands Manual provides the list of supported cipher suites under the SSL/TLS security layer profile manager +USECPRF heading.

Parameter range
0 - 4

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x00</td>
<td>UDP</td>
</tr>
<tr>
<td>0x01</td>
<td>TCP</td>
</tr>
<tr>
<td>0x02</td>
<td>SMS (Transparent mode)</td>
</tr>
<tr>
<td>0x03</td>
<td>Reserved</td>
</tr>
<tr>
<td>0x04</td>
<td>TLS over TCP</td>
</tr>
</tbody>
</table>

Default
0x01

TL (TLS Protocol Version)

Sets the TLS protocol version used for the TLS socket. If you change the TL value, it does not affect any currently open sockets. The value only applies to subsequently opened sockets.

Note Due to known vulnerabilities in prior protocol versions, we strongly recommend that you use the latest TLS version whenever possible.

Note For NB-IoT, TCP support is dependent on the network. Contact your network provider for details.

Range

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x00</td>
<td>SSL v3</td>
</tr>
<tr>
<td>0x01</td>
<td>TLS v1.0</td>
</tr>
<tr>
<td>0x02</td>
<td>TLS v1.1</td>
</tr>
<tr>
<td>0x03</td>
<td>TLS v1.2</td>
</tr>
</tbody>
</table>
**Default**

0x03

**$0 (TLS Profile 0)**

Specifies the TLS certificate(s) to use in Transparent mode (when IP (IP Protocol) = 4) or API mode (Transmit (TX) Request: IPv4 - 0x20 or Tx Request with TLS Profile - 0x23 with profile set to 0).

**Note** For NB-IoT, TCP support is dependent on the network. Contact your network provider for details.

**Format**

```plaintext
server_cert;client_cert;client_key
```

**Parameter range**

From 1 through 127 ASCII characters.

**Default**

N/A

**$1 (TLS Profile 1)**

Specifies the TLS certificate(s) to use for Tx Request with TLS Profile - 0x23 transmissions with profile set to 1.

**Note** For NB-IoT, TCP support is dependent on the network. Contact your network provider for details.

**Format**

```plaintext
server_cert;client_cert;client_key
```

**Parameter range**

From 1 through 127 ASCII characters.

**Default**

N/A

**$2 (TLS Profile 2)**

Specifies the TLS certificate(s) to use for Tx Request with TLS Profile - 0x23 transmissions with profile set to 2.

**Note** For NB-IoT, TCP support is dependent on the network. Contact your network provider for details.

**Format**

```plaintext
server_cert;client_cert;client_key
```

**Parameter range**

From 1 through 127 ASCII characters.
Default
N/A

**TM (IP Client Connection Timeout)**
The IP client connection timeout. If there is no activity for this timeout then the connection is closed. If **TM** is 0, the connection is closed immediately after the device sends data.
If you change the **TM** value while in Transparent Mode, the current connection is immediately closed.
Upon the next transmission, the **TM** value applies to the newly created socket.
If you change the **TM** value while in API Mode, the value only applies to subsequently opened sockets.
**TM** does not apply to explicit sockets.

>Note For NB-IoT, TCP support is dependent on the network. Contact your network provider for details.

**Parameter range**
0 - 0xFFFF [x 100 ms]

**Default**
0xBB8 (5 minutes)

**TS (IP Server Connection Timeout)**
The IP server connection timeout. If no activity for this timeout then the connection is closed. When set to 0 the connection is closed immediately after data is sent.

>Note For NB-IoT, TCP support is dependent on the network. Contact your network provider for details.

**Parameter Range**
10 - 0xFFFF; (x 100 ms)

**Default**
0xBB8 (5 minutes)

**DO (Device Options)**
Enables and disables special features on the XBee Smart Modem.

>Note For NB-IoT, TCP support is dependent on the network. Contact your network provider for details.

**Bit 0 - Remote Manager support**
Controls whether Remote Manager is active.
If the XBee Smart Modem cannot establish a connection with Remote Manager, it waits 30 seconds before trying again. On each successive connection failure, the wait time doubles (60 seconds, 120, 240, and so on) up to a maximum of 1 hour. This time resets to 30 seconds once the connection to Remote Manager succeeds or if the device is reset.
Bit 2 - USB direct enable
Set bit 2 to enable USB direct mode. After setting, use WR (Write) to write all values to flash and use FR (Force Reset) to reset the device.

**Note** Setting P0 (DIO10/PWM0 Configuration) to 6 overrides setting DO bit 2.

Bit 3 - PSM
To enable PSM, set DO (Device Options) bit 3. See Power Saving Mode (PSM).

Bit 4 - Low Voltage Shutdown
Set bit 4 to enable the Low Voltage Shutdown feature. See Low voltage shutdown.

Bit 5 - Enable eDRX
Set bit 5 to request the eDRX feature from the network. The requested cycle length is defined by the DX command, and the network-provided cycle length can be read using D? command, once the device is registered on the network. When connected to the network, the AI command is set to 0.

**Range**
0-5

**Bitfield**

<table>
<thead>
<tr>
<th>Bit</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Enable Remote Manager</td>
</tr>
<tr>
<td>2</td>
<td>Enable USB Direct</td>
</tr>
<tr>
<td>3</td>
<td>Enable PSM</td>
</tr>
<tr>
<td>4</td>
<td>Enable the Low Voltage Shutdown feature</td>
</tr>
<tr>
<td>5</td>
<td>Enable eDRX</td>
</tr>
</tbody>
</table>

**Note** We strongly recommend that you clear bit 0 (Enable Remote Manager) if you set bit 3. If not, the connection that the device retains with Remote Manager causes the cellular component to spend very little time in low power, negating the value of selecting that feature.

**Default**
1 (Bit 0 enabled)

**DX (Requested eDRX cycle length)**
The eDRX cycle length (in milliseconds) that will be requested from the network if DO command bit 5 is set. For best power characteristics, you should set this to the maximum receive latency your application is designed to tolerate.

The actual value obtained is provided by the network and is generally less than the value requested. The specific legal values depend on network access technology and carrier policy. The maximum value, where data is retained by the network without loss, also depends on carrier policy and this value should be selected in light of guidance provided by your carrier.
Parameter range
N/A

Default
0xea60 (60 seconds)

D? (Network-provided eDRX cycle length)
The value currently being used as the eDRX cycle length (in milliseconds). If eDRX is not active, or registration with the network has not yet been achieved, an empty response is returned.

Parameter range
N/A

Default
N/A
Addressing commands

The following AT commands are addressing commands.

**SH (Serial Number High)**
The upper digits of the unique International Mobile Equipment Identity (IMEI) assigned to this device.

**Parameter range**
0 - 0xFFFFFFFF [read-only]

**Default**
N/A

**SL (Serial Number Low)**
The lower digits of the unique International Mobile Equipment Identity (IMEI) assigned to this device.

**Parameter range**
0 - 0xFFFFFFFF [read-only]

**Default**
N/A

**MY (Module IP Address)**
Reads the device’s IP address. This command is read-only because the IP address is assigned by the mobile network.

In API mode, the address is represented as the binary four byte big-endian numeric value representing the IPv4 address.

In Transparent or Command mode, the address is represented as a dotted-quad string notation.

**Parameter range**
0-15 IPv4 characters

**Default**
0.0.0.0

**P# (Destination Phone Number)**
Sets or displays the destination phone number used for SMS when IP (IP Protocol) = 2. Phone numbers must be fully numeric, using ASCII digits, for example: 8889991234.

**P#** allows international numbers with or without the + prefix. If you omit + and are dialing internationally, you need to include the proper International Dialing Prefix for your calling region, for example, 011 for the United States.

**Range**
5 - 20 ASCII digits including an optional + prefix

**Note** In device firmware versions ending in *10 or earlier, the range is 7-20 ASCII digits.
**Default**

N/A

**N1 (DNS Address)**
Displays the IPv4 address of the primary domain name server.

**Parameter Range**
Read-only

**Default**
0.0.0.0 (waiting on cellular connection)

**N2 (DNS Address)**
Displays the IPv4 address of the secondary domain name server.

**Parameter Range**
Read-only

**Default**
0.0.0.0 (waiting on cellular connection)

**DL (Destination Address)**
The destination IPv4 address or fully qualified domain name used by Transparent mode.

To set the destination address to an IP address, the value must be a dotted quad, for example `XXX.XXX.XXX.XXX`.

To set the destination address to a domain name, the value must be a legal Internet host name, for example `remotemanager.digi.com`

**Parameter range**
0 - 128 ASCII characters

**Default**
0.0.0.0
The destination IPv4 address or fully qualified domain name used by Transparent mode.

**OD (Operating Destination Address)**
Read the destination IPv4 address currently in use by Transparent mode. The value is `0.0.0.0` if no Transparent IP connection is active.

In API mode, the address is represented as the binary four byte big-endian numeric value representing the IPv4 address.

In Transparent or Command mode, the address is represented as a dotted-quad string notation.

**Parameter range**
-
Default
0.0.0.0

DE (Destination port)
Sets or displays the destination IP port number used in Transparent mode.
This command reads all input as hexadecimal. All values must be entered in hexadecimal with no
leading 0x. For example, the destination port 9001 has the hexadecimal value of 0x2329. The
command would be entered as ATDE 2329.

Parameter range
0x0 - 0xFFFF

Default
0x2616

C0 (Source Port)
The IP port used to listen for incoming connections (TCP/TLS) or incoming data (UDP) when using
Transparent mode or API mode with implicit sockets.
As long as a network connection is established to this port (for TCP) data received on the serial port is
transmitted on the established network connection.
IP (IP Protocol) sets the protocol used.
For more information on using incoming connections, see Socket behavior.

Parameter range
0 - 0xFFFF

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Disabled</td>
</tr>
<tr>
<td>Non-0</td>
<td>Enabled on that port</td>
</tr>
</tbody>
</table>

Default
0

LA (Lookup IP Address of FQDN)
Performs a DNS lookup of the given fully qualified domain name (FQDN) and outputs its IP address.
When you issue LA in API mode, the IP address is formatted in binary four byte big-endian numeric
value. In all other cases (for example, Command mode) the format is dotted decimal notation.

Range
Valid FQDN

Default
-
Serial interfacing commands

The following AT commands are serial interfacing commands.

**BD (Baud Rate)**

Sets or displays the serial interface baud rate for communication between the device's serial port and the host.

Modified interface baud rates do not take effect until the XBee Smart Modem exits Command mode or you issue AC (Apply Changes). The baud rate resets to default unless you save it with WR (Write) or by clicking the Write module settings button in XCTU.

**Parameter range**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x0</td>
<td>1200 b/s</td>
</tr>
<tr>
<td>0x1</td>
<td>2400 b/s</td>
</tr>
<tr>
<td>0x2</td>
<td>4800 b/s</td>
</tr>
<tr>
<td>0x3</td>
<td>9600 b/s</td>
</tr>
<tr>
<td>0x4</td>
<td>19200 b/s</td>
</tr>
<tr>
<td>0x5</td>
<td>38400 b/s</td>
</tr>
<tr>
<td>0x6</td>
<td>57600 b/s</td>
</tr>
<tr>
<td>0x7</td>
<td>115200 b/s</td>
</tr>
<tr>
<td>0x8</td>
<td>230400 b/s</td>
</tr>
</tbody>
</table>

**Default**

0x3 (9600 b/s)

**NB (Parity)**

Set or read the serial parity settings for UART communications.

**Parameter range**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x0</td>
<td>No parity</td>
</tr>
<tr>
<td>0x1</td>
<td>Even parity</td>
</tr>
<tr>
<td>0x2</td>
<td>Odd parity</td>
</tr>
</tbody>
</table>
AT commands

Serial interfacing commands

**Default**
0x00

**SB (Stop Bits)**
Sets or displays the number of stop bits for UART communications.

**Parameter range**
0 - 1

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>One stop bit</td>
</tr>
<tr>
<td>1</td>
<td>Two stop bits</td>
</tr>
</tbody>
</table>

**Default**
0

**RO (Packetization Timeout)**
Set or read the number of character times of inter-character silence required before transmission begins when operating in Transparent mode.
RF transmission also starts after the maximum packet size for the selected protocol is received in the UART receive buffer.
Set RO to 0 to transmit characters as they arrive instead of buffering them into one RF packet.

**Parameter range**
0 - 0xFF (x character times)

**Default**
3

**TD (Text Delimiter)**
The ASCII character used as a text delimiter for Transparent mode. When you select a character, information received over the serial port in Transparent mode is not transmitted until that character is received. To use a carriage return, set to 0x0D. Set to zero to disable text delimiter checking.

**Parameter range**
0 - 0xFF

**Default**
0x0

**FT (Flow Control Threshold)**
Set or display the flow control threshold.
The device de-asserts CTS when FT bytes are in the UART receive buffer.
**Parameter range**

0x9D - 0x82D

**Default**

0x681

**AP (API Enable)**

Enables the frame-based application programming interface (API) mode. The API mode setting. The device can format the RF packets it receives into API frames and send them out the UART. When API is enabled the UART data must be formatted as API frames because Transparent mode is disabled. See Modes for more information.

**Parameter range**

0x00 - 0x05

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x00</td>
<td>API disabled (operate in Transparent mode)</td>
</tr>
<tr>
<td>0x01</td>
<td>API enabled</td>
</tr>
<tr>
<td>0x02</td>
<td>API enabled (with escaped control characters)</td>
</tr>
<tr>
<td>0x03</td>
<td>N/A</td>
</tr>
<tr>
<td>0x04</td>
<td>MicroPython REPL</td>
</tr>
<tr>
<td>0x05</td>
<td>Bypass mode</td>
</tr>
</tbody>
</table>

**Default**

0

**IB (Cellular Component Baud Rate)**

*Note* Digi does not recommend using bypass mode. You should use USB Direct mode instead.

Sets the serial interface baud rate for communication between the XBee CPU and the cellular component when in bypass mode. You can set bypass mode by setting the AP command to 5. You must configure the cellular modem to use the same baud rate (AT+IPR) prior to changing this setting.

**Parameter range**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x0</td>
<td>1200 b/s</td>
</tr>
<tr>
<td>0x1</td>
<td>2400 b/s</td>
</tr>
<tr>
<td>0x2</td>
<td>4800 b/s</td>
</tr>
<tr>
<td>Parameter</td>
<td>Description</td>
</tr>
<tr>
<td>-----------</td>
<td>-------------</td>
</tr>
<tr>
<td>0x3</td>
<td>9600 b/s</td>
</tr>
<tr>
<td>0x4</td>
<td>19200 b/s</td>
</tr>
<tr>
<td>0x5</td>
<td>38400 b/s</td>
</tr>
<tr>
<td>0x6</td>
<td>57600 b/s</td>
</tr>
<tr>
<td>0x7</td>
<td>115200 b/s</td>
</tr>
<tr>
<td>0x8</td>
<td>230400 b/s</td>
</tr>
<tr>
<td>0x9</td>
<td>460800 b/s</td>
</tr>
<tr>
<td>0xA</td>
<td>921600 b/s</td>
</tr>
</tbody>
</table>

**Default**
- uBlox based modules: 0x9 (460800 baud)
- Telit based modules: 0x7 (115200 baud)
I/O settings commands

The following AT commands are I/O settings commands.

**D0 (DIO0/AD0)**
Sets or displays the DIO0/AD0 configuration (pin 20).

**Parameter range**
0, 2 - 5

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Disabled</td>
</tr>
<tr>
<td>1</td>
<td>N/A</td>
</tr>
<tr>
<td>2</td>
<td>Analog input</td>
</tr>
<tr>
<td>3</td>
<td>Digital input</td>
</tr>
<tr>
<td>4</td>
<td>Digital output, default low</td>
</tr>
<tr>
<td>5</td>
<td>Digital output, default high</td>
</tr>
</tbody>
</table>

Default
0

**D1 (DIO1/AD1)**
Sets or displays the DIO1/AD1 configuration (pin 19).

**Parameter range**
0 - 6

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Disabled</td>
</tr>
<tr>
<td>1</td>
<td>SPI_ATTN</td>
</tr>
<tr>
<td>2</td>
<td>ADC</td>
</tr>
<tr>
<td>3</td>
<td>Digital input</td>
</tr>
<tr>
<td>4</td>
<td>Digital output, low</td>
</tr>
<tr>
<td>5</td>
<td>Digital output, high</td>
</tr>
<tr>
<td>6</td>
<td>I2C SCL</td>
</tr>
</tbody>
</table>

Default
0
**D2 (DIO2/AD2)**
Sets or displays the DIO2/AD2 configuration (pin 18).

**Parameter range**
0 - 5

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Disabled</td>
</tr>
<tr>
<td>1</td>
<td>SPI_CLK</td>
</tr>
<tr>
<td>2</td>
<td>Analog input</td>
</tr>
<tr>
<td>3</td>
<td>Digital input</td>
</tr>
<tr>
<td>4</td>
<td>Digital output, default low</td>
</tr>
<tr>
<td>5</td>
<td>Digital output, default high</td>
</tr>
</tbody>
</table>

**Default**
0

**D3 (DIO3/AD3)**
Sets or displays the DIO3/AD3 configuration (pin 17).

**Parameter range**
0 - 5

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Disabled</td>
</tr>
<tr>
<td>1</td>
<td>SPI_SSEL</td>
</tr>
<tr>
<td>2</td>
<td>Analog input</td>
</tr>
<tr>
<td>3</td>
<td>Digital input</td>
</tr>
<tr>
<td>4</td>
<td>Digital output, default low</td>
</tr>
<tr>
<td>5</td>
<td>Digital output, default high</td>
</tr>
</tbody>
</table>

**Default**
0

**D4 (DIO4)**

**Parameter range**

**Default**
0
D5 (DIO5/ASSOCIATED_INDICATOR)
Sets or displays the DIO5/ASSOCIATED_INDICATOR configuration (pin 15).

Parameter range
0, 1, 3 - 5

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Disabled</td>
</tr>
<tr>
<td>1</td>
<td>Associated LED</td>
</tr>
<tr>
<td>2</td>
<td>N/A</td>
</tr>
<tr>
<td>3</td>
<td>Digital input</td>
</tr>
<tr>
<td>4</td>
<td>Digital output, default low</td>
</tr>
<tr>
<td>5</td>
<td>Digital output, default high</td>
</tr>
</tbody>
</table>

Default
1

D6 (DIO6/RTS)
Sets or displays the DIO6/RTS configuration (pin 16).

Parameter range
0, 1, 3 - 5

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Disabled</td>
</tr>
<tr>
<td>1</td>
<td>RTS flow control</td>
</tr>
<tr>
<td>2</td>
<td>N/A</td>
</tr>
<tr>
<td>3</td>
<td>Digital input</td>
</tr>
<tr>
<td>4</td>
<td>Digital output, default low</td>
</tr>
<tr>
<td>5</td>
<td>Digital output, default high</td>
</tr>
</tbody>
</table>

Default
0

D7 (DIO7/CTS)
Sets or displays the DIO7/CTS configuration (pin 12).

Parameter range
0, 1, 3 - 5
### AT commands

#### I/O settings commands

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Disabled</td>
</tr>
<tr>
<td>1</td>
<td>CTS flow control</td>
</tr>
<tr>
<td>2</td>
<td>N/A</td>
</tr>
<tr>
<td>3</td>
<td>Digital input</td>
</tr>
<tr>
<td>4</td>
<td>Digital output, default low</td>
</tr>
<tr>
<td>5</td>
<td>Digital output, default high</td>
</tr>
</tbody>
</table>

**Default**

0x1

**D8 (DIO8/SLEEP_REQUEST)**

Sets or displays the DIO8/DTR/SLP_RQ configuration (pin 9).

**Parameter range**

0, 1, 3 - 5

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Disabled</td>
</tr>
<tr>
<td>1</td>
<td>SLEEP_REQUEST input</td>
</tr>
<tr>
<td>3</td>
<td>Digital input</td>
</tr>
<tr>
<td>4</td>
<td>Digital output, default low</td>
</tr>
<tr>
<td>5</td>
<td>Digital output, default high</td>
</tr>
</tbody>
</table>

**Default**

1

**D9 (DIO9/ON_SLEEP)**

Sets or displays the DIO9/ON_SLEEP configuration (pin 13).

**Parameter range**

0, 1, 3 - 5

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Disabled</td>
</tr>
<tr>
<td>1</td>
<td>ON/SLEEP output</td>
</tr>
<tr>
<td>3</td>
<td>Digital input</td>
</tr>
</tbody>
</table>
### Parameter Description

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Digital output, default low</td>
</tr>
<tr>
<td>5</td>
<td>Digital output, default high</td>
</tr>
</tbody>
</table>

**Default**

1

### P0 (DIO10/PWM0 Configuration)

Sets or displays the PWM/DIO10 configuration (pin 6).

This command enables the option of translating incoming data to a PWM so that the output can be translated back into analog form.

**Parameter range**

0 - 6

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Disabled</td>
</tr>
<tr>
<td>1</td>
<td>RSSI PWM0 output</td>
</tr>
<tr>
<td>2</td>
<td>PWM0 output</td>
</tr>
<tr>
<td>3</td>
<td>Digital input</td>
</tr>
<tr>
<td>4</td>
<td>Digital output, low</td>
</tr>
<tr>
<td>5</td>
<td>Digital output, high</td>
</tr>
<tr>
<td>6</td>
<td>USB VBUS</td>
</tr>
</tbody>
</table>

**Default**

0

### P1 (DIO11/PWM1 Configuration)

Sets or displays the DIO11 configuration (pin 7).

**Parameter range**

0, 1, 3 - 7

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Disabled</td>
</tr>
<tr>
<td>1</td>
<td>Fan enable. Output is low when the XBee Smart Modem is sleeping, turning an attached fan off when the cellular component is in a power saving mode, and also during Airplane Mode</td>
</tr>
<tr>
<td>Parameter</td>
<td>Description</td>
</tr>
<tr>
<td>-----------</td>
<td>------------------------------</td>
</tr>
<tr>
<td>2</td>
<td>Enables PWM output</td>
</tr>
<tr>
<td>3</td>
<td>Digital input</td>
</tr>
<tr>
<td>4</td>
<td>Digital output, default low</td>
</tr>
<tr>
<td>5</td>
<td>Digital output, default high</td>
</tr>
<tr>
<td>6</td>
<td>I2C SDA</td>
</tr>
<tr>
<td>7</td>
<td>USB direct</td>
</tr>
</tbody>
</table>

**Default**

0

**P2 (DIO12 Configuration)**
Sets or displays the DIO12 configuration (pin 4).

**Parameter range**

0, 1, 3 - 5

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Disabled</td>
</tr>
<tr>
<td>1</td>
<td>SPI_MISO</td>
</tr>
<tr>
<td>2</td>
<td>N/A</td>
</tr>
<tr>
<td>3</td>
<td>Digital input</td>
</tr>
<tr>
<td>4</td>
<td>Digital output, default low</td>
</tr>
<tr>
<td>5</td>
<td>Digital output, default high</td>
</tr>
</tbody>
</table>

**Default**

0

**P3 (DIO13/DOUT)**
Sets or displays the DIO13/DOUT configuration (pin 17).

**Parameter range**

0, 1

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Disabled</td>
</tr>
<tr>
<td>1</td>
<td>UART DOUT enabled</td>
</tr>
</tbody>
</table>
**P4 (DIO14/DIN)**
Sets or displays the DIO14/DIN configuration (pin 3).

**Parameter range**

0 - 1

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Disabled</td>
</tr>
<tr>
<td>1</td>
<td>UART DIN enabled</td>
</tr>
</tbody>
</table>

**PD (Pull Direction)**
The resistor pull direction bit field (1 = pull-up, 0 = pull-down) for corresponding I/O lines that are set by PR (Pull-up/down Resistor Enable).
If the bit is not set in PR, the device uses PD.

**Note** Resistors are not applied to disabled lines.

See PR (Pull-up/down Resistor Enable) for bit mappings, which are the same.

**Parameter range**

0x0 - 0x7FFF

**PR (Pull-up/down Resistor Enable)**
Sets or displays the bit field that configures the internal resistor status for the digital input lines. Internal pull-up/down resistors are not available for digital output pins, analog input pins, or for disabled pins.
Use the PD command to specify whether the resistor is pull-up or pull-down.

- If you set a PR bit to 1, it enables the pull-up/down resistor.
- If you set a PR bit to 0, it specifies no internal pull-up/down resistor.

The following table defines the bit-field map for both the PR and PD commands.
### Bit I/O line Module pin

<table>
<thead>
<tr>
<th>Bit</th>
<th>I/O line</th>
<th>Module pin</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>DIO4</td>
<td>pin 11</td>
</tr>
<tr>
<td>1</td>
<td>DIO3/AD3</td>
<td>pin 17</td>
</tr>
<tr>
<td>2</td>
<td>DIO2/AD2</td>
<td>pin 18</td>
</tr>
<tr>
<td>3</td>
<td>DIO1/AD1</td>
<td>pin 19</td>
</tr>
<tr>
<td>4</td>
<td>DIO0/AD0</td>
<td>pin 20</td>
</tr>
<tr>
<td>5</td>
<td>DIO6/RTS</td>
<td>pin 16</td>
</tr>
<tr>
<td>6</td>
<td>DIO8/SLEEP_REQUEST</td>
<td>pin 9</td>
</tr>
<tr>
<td>7</td>
<td>DIO14/DIN</td>
<td>pin 3</td>
</tr>
<tr>
<td>8</td>
<td>DIO5/ASSOCIATE</td>
<td>pin 15</td>
</tr>
<tr>
<td>9</td>
<td>DIO9/On/SLEEP</td>
<td>pin 13</td>
</tr>
<tr>
<td>10</td>
<td>DIO12</td>
<td>pin 4</td>
</tr>
<tr>
<td>11</td>
<td>DIO10</td>
<td>pin 6</td>
</tr>
<tr>
<td>12</td>
<td>DIO11</td>
<td>pin 7</td>
</tr>
<tr>
<td>13</td>
<td>DIO7/CTS</td>
<td>pin 12</td>
</tr>
<tr>
<td>14</td>
<td>DIO13/DOUT</td>
<td>pin 17</td>
</tr>
</tbody>
</table>

**Parameter range**

0 - 0x7FFF (bit field)

**Default**

0x7FFF

### M0 (PWM0 Duty Cycle)

Sets the duty cycle of PWM0 (pin 6) for P0 = 2, where a value of 0x200 is a 50% duty cycle. Before setting the line as an output:

1. Enable PWM0 output (P0 (DIO10/PWM0 Configuration) = 2).
2. Apply the settings (use CN (Exit Command mode) or AC (Apply Changes)).

The PWM period is 42.62 $\mu$s and there are 0x03FF (1023 decimal) steps within this period. When M0 = 0 (0% PWM), 0x01FF (50% PWM), 0x03FF (100% PWM), and so forth.

**Parameter range**

0 - 0x3FF

**Default**

0
M1 command
Sets the duty cycle of PWM1 for P1 = 2, where a value of 0x200 is a 50% duty cycle.

Parameter range
0 - 0x3FF

Default
0
I/O sampling commands

The following AT commands configure I/O sampling parameters.

**TP (Temperature)**
Displays the temperature of the XBee Smart Modem in degrees Celsius. The temperature value is displayed in 8-bit two's complement format. For example, 0x1A = 26 °C, and 0xF6 = -10 °C.

**Parameter range**
0 - 0xFF which indicates degrees Celsius displayed in 8-bit two's complement format.

**Default**
N/A

**IS (Force Sample)**
When run, IS reports the values of all of the enabled digital and analog input lines. If no lines are enabled for digital or analog input, the command returns an error.

**Command mode**
In Command mode, the response value is a multi-line format, individual lines are delimited with carriage returns, and the entire response terminates with two carriage returns. Each line is a series of ASCII characters representing a single number in hexadecimal notation. The interpretation of the lines is:

- **Number of samples.** For legacy reasons this field always returns 1.
- **Digital channel mask.** A bit-mask of all I/O capable pins in the system. The bits set to 1 are configured for digital I/O and are included in the digital data value below. Pins D0 - D9 are bits 0 - 9, and P0 - P2 are bits 10 - 12.
- **Analog channel mask.** The bits set to 1 are configured for analog I/O and have individual readings following the digital data field.
- **Digital data.** The current digital value of all the pins set in the digital channel mask, only present if at least one bit is set in the digital channel mask.
- **Analog data.** Additional lines, one for each set pin in the analog channel mask. Each reading is a 10-bit ADC value for a 2.5 V voltage reference.

**API operating mode**
In API operating mode, IS immediately returns an OK response.

The API response is ordered identical to the Command mode response with the same fields present. Each field is a binary number of the size listed in the following table. Multi-byte fields are in big-endian byte order.

<table>
<thead>
<tr>
<th>Field</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of samples</td>
<td>1 byte</td>
</tr>
<tr>
<td>Digital channel mask</td>
<td>2 bytes</td>
</tr>
</tbody>
</table>
### Field | Size
--- | ---
Analog channel mask | 1 byte
Samples | 2 bytes each

**Parameter range**
- N/A

**Default**
- N/A
Sleep commands

The following AT commands are sleep commands.

SM (Sleep Mode)
Sets or displays the sleep mode of the device.
The sleep mode determines how the device enters and exits a power saving sleep.

Parameter range
0, 1, 4, 5

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Normal. In this mode the device never sleeps.</td>
</tr>
<tr>
<td>1</td>
<td>Pin Sleep. In this mode the device honors the SLEEP_RQ pin. Set D8 (DIO8/SLEEP_REQUEST) to the sleep request function: 1.</td>
</tr>
<tr>
<td>4</td>
<td>Cyclic Sleep. In this mode the device repeatedly sleeps for the value specified by SP and spends ST time awake.</td>
</tr>
<tr>
<td>5</td>
<td>Cyclic Sleep with Pin Wake. In this mode the device acts as in Cyclic Sleep but does not sleep if the SLEEP_RQ pin is inactive, allowing the device to be kept awake or woken by the connected system.</td>
</tr>
</tbody>
</table>

Default
0

SP (Sleep Period)
Sets or displays the time to spend asleep in cyclic sleep modes. In Cyclic sleep mode, the node sleeps with CTS disabled for the sleep time interval, then wakes for the wake time interval.

Parameter range
0x1 - 0x83D600 (x 10 ms)

Default
0x7530 (5 minutes)

ST (Wake Time)
Sets or displays the time to spend awake in cyclic sleep modes.

Parameter range
0x1 - 0x36EE80 (x 1 ms)

Default
0xEA60 (60 seconds)
PA (Requested Active Timer)
The requested Active Timer for PSM.

Note This is related to 3GPP timer T3324.

For NB-IoT, TCP support is dependent on the network. Contact your network provider for details.

Parameter range
0 - 0xFFFF (0 - 65535 [* 1 s])

Default
0xa (10 s)

PU (Requested Tracking Area Update Timer)
The requested Active Timer for PSM.

Note This is related to 3GPP timer T3412.

For NB-IoT, TCP support is dependent on the network. Contact your network provider for details.

Parameter range
0 - 0x35683200 (* 1 s)

Default
0x8ca00 (576000 s)
Command mode options

The following commands are Command mode option commands.

**CC (Command Sequence Character)**
The character value the device uses to enter Command mode.
The default value (0x2B) is the ASCII code for the plus (+) character. You must enter it three times within the guard time to enter Command mode. To enter Command mode, there is also a required period of silence before and after the command sequence characters of the Command mode sequence (GT + CC + GT). The period of silence prevents inadvertently entering Command mode.

**Parameter range**
0 - 0xFF

**Default**
0x2B (the ASCII plus character: +)

**CT (Command Mode Timeout)**
Sets or displays the Command mode timeout parameter. If a device does not receive any valid commands within this time period, it returns to Idle mode from Command mode.

**Parameter range**
2 - 0x1770 (x 100 ms)

**Default**
0x64 (10 seconds)

**CN (Exit Command mode)**
Immediately exits Command Mode and applies pending changes.

**Note** Whether Command mode is exited using the CN command or by CT timing out, changes are applied upon exit.

**Parameter range**
N/A

**Default**
N/A

**GT (Guard Times)**
Set the required period of silence before and after the command sequence characters of the Command mode sequence (GT + CC + GT). The period of silence prevents inadvertently entering Command mode.

**Parameter range**
0x2 - 0x6D3 (x 1 ms)
**Default**

0x3E8 (one second)
MicroPython commands

The following commands relate to using MicroPython on the XBee Smart Modem.

PS (Python Startup)
Sets whether or not the XBee Smart Modem runs the stored Python code at startup.

Range
0 - 1

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Do not run stored Python code at startup.</td>
</tr>
<tr>
<td>1</td>
<td>Run stored Python code at startup.</td>
</tr>
</tbody>
</table>

Default
0

PY (MicroPython Command)
Interact with the XBee Smart Modem using MicroPython. PY is a command with sub-commands. These sub-commands are arguments to PY.

PYB (Bundled Code Report)
You can store compiled code in flash using the os.bundle() function in the MicroPython REPL; refer to the Digi MicroPython Programming Guide. The PYB sub-command reports details of the bundled code. In Command mode, it returns two lines of text, for example:

```
bytecode: 619 bytes (hash=0x0900DBCE)
bundled: 2017-05-09T15:49:44
```

The messages are:

- **bytecode**: The size of bytecode stored in flash and its 32-bit hash. A size of 0 indicates that there is no stored code.
- **bundled**: A compilation timestamp. A timestamp of **2000-01-01T00:00:00** indicates that the clock was not set during compilation.

In API mode, **PYB** returns three 32-bit big-endian values:

- bytecode size
- bytecode hash
- timestamp as seconds since 2000-01-01T00:00:00

PYE (Erase Bundled Code)
**PYE** interrupts any running code, erases any bundled code and then does a soft-reboot on the MicroPython subsystem.

PYV (Version Report)
Report the MicroPython version.
**PY^ (Interrupt Program)**

Sends `KeyboardInterrupt` to MicroPython. This is useful if there is a runaway MicroPython program and you have filled the stdin buffer. You can enter Command mode (+++) and send `ATPY^` to interrupt the program.

**Default**

N/A
Firmware version/information commands

The following AT commands are firmware version/information commands.

**VR (Firmware Version)**
Reads the firmware version on a device.

**Parameter range**
0 - 0xFFFF [read-only]

**Default**
Set in firmware

**VL (Verbose Firmware Version)**
Shows detailed version information including the application build date and time.

**Parameter range**
N/A

**Default**
Set in firmware

**HV (Hardware Version)**
Read the device's hardware version. Use this command to distinguish between different hardware platforms. The upper byte returns a value that is unique to each device type. The lower byte indicates the hardware revision.

**Parameter range**
0 - 0xFFFF [read-only]

**Default**
Set in firmware

**HS (Hardware Series)**
Read the device's hardware series number.

**Parameter range**
N/A

**Default**
Set in the firmware

**CK (Configuration CRC)**
Displays the cyclic redundancy check (CRC) of the current AT command configuration settings.
Parameter range
0 - 0xFFFFFFF

Default
N/A

AI (Association Indication)
Reads the Association status code to monitor association progress. The following table provides the status codes and their meanings.

<table>
<thead>
<tr>
<th>Status code</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x00</td>
<td>Connected to the Internet.</td>
</tr>
<tr>
<td>0x22</td>
<td>Registering to cellular network.</td>
</tr>
<tr>
<td>0x23</td>
<td>Connecting to the Internet.</td>
</tr>
<tr>
<td>0x24</td>
<td>The cellular component is missing, corrupt, or otherwise in error. The cellular component requires a new firmware image.</td>
</tr>
<tr>
<td>0x25</td>
<td>Cellular network registration denied.</td>
</tr>
<tr>
<td>0x2A</td>
<td>Airplane mode.</td>
</tr>
<tr>
<td>0x2B</td>
<td>USB Direct active.</td>
</tr>
<tr>
<td>0x2C</td>
<td>Cellular component is in PSM.</td>
</tr>
<tr>
<td></td>
<td><strong>Note</strong> For NB-IoT, TCP support is dependent on the network. Contact your network provider for details.</td>
</tr>
<tr>
<td>0x2D</td>
<td>Modem shut down. See SD (Shutdown).</td>
</tr>
<tr>
<td>0x2E</td>
<td>Low voltage shut down.</td>
</tr>
<tr>
<td>0x2F</td>
<td>Bypass mode active.</td>
</tr>
<tr>
<td>0x30</td>
<td>An update is in process.</td>
</tr>
<tr>
<td>0xFF</td>
<td>Initializing.</td>
</tr>
</tbody>
</table>

Parameter range
0 - 0xFF [read-only]

Default
N/A

FI (FTP OTA Update Indication)
Reports the result of the previous FTP OTA operation.
### AT commands

#### Firmware version/information commands

<table>
<thead>
<tr>
<th>Status code</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x0</td>
<td>Last update succeeded.</td>
</tr>
<tr>
<td>0x1</td>
<td>Update file transfer failed.</td>
</tr>
<tr>
<td>0x2</td>
<td>Update image rejected by cellular component.</td>
</tr>
<tr>
<td>0x10</td>
<td>A problem processing the update request occurred.</td>
</tr>
<tr>
<td>0x11</td>
<td>Update was blocked by XBee sleep.</td>
</tr>
<tr>
<td>0x12</td>
<td>One or more update parameters were invalid.</td>
</tr>
<tr>
<td>0xFE</td>
<td>An update is currently in progress.</td>
</tr>
<tr>
<td>0xFF</td>
<td>No update status to report.</td>
</tr>
</tbody>
</table>

**Parameter range**

N/A

**Default**

N/A

**FO (FTP OTA command)**

The FO command allows for the initiation of a cellular component FTP OTA from an AT command interface.

The FO command has sub-commands that either set or read a parameter, initiate the FTP OTA (ATFOI) or clears the parameters (ATFOC).

The table below shows the FTP OTA parameters that can be set and their default values.

**Note** Any of the parameter commands in the table below will return ERROR if the entered parameter is invalid or if an FTP OTA has already been initiated.

<table>
<thead>
<tr>
<th>Command</th>
<th>Parameter</th>
<th>Default</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATFOS</td>
<td>Server</td>
<td>ftp1.digi.com</td>
</tr>
<tr>
<td>ATFOF</td>
<td>Filename</td>
<td></td>
</tr>
<tr>
<td>ATFOC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ATFOU</td>
<td>Username</td>
<td>anonymous</td>
</tr>
<tr>
<td>ATFOI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ATFOI</td>
<td>Directory</td>
<td>support/ublox</td>
</tr>
<tr>
<td>ATFOI</td>
<td>File</td>
<td></td>
</tr>
</tbody>
</table>

**ATFOI**

ATFOI initiates an FTP OTA with the set parameters. To check the status of an initiated FTP OTA, check ATFI to get the status of the last FTP OTA operation.

This can return ERROR immediately if there are invalid parameters set or another FTP OTA already in progress.
**ATFOC**
ATFOC clears all parameters back to their defaults as listed in the table above.

**Example usage**
**Setting a parameter**

```
ATFOSmymftp.server.com
OK
```

**Reading a parameter**

```
ATFOS
myftp.server.com
```

**Initiating FTO OTA**

```
ATFOI
OK
```
Diagnostic interface commands

The following AT commands are diagnostic interface commands.

**DI (Remote Manager Indicator)**
Displays the current Remote Manager status for the XBee.

*Note* Digi Remote Manager requires TCP and will not work with NB-IoT, unless the carrier supports TCP.

**Range**

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x00</td>
<td>Connected, but without TLS or authentication.</td>
</tr>
<tr>
<td>0x01</td>
<td>Before connection to the Internet.</td>
</tr>
<tr>
<td>0x02</td>
<td>Remote Manager connection in progress.</td>
</tr>
<tr>
<td>0x03</td>
<td>Disconnecting from Remote Manager.</td>
</tr>
<tr>
<td>0x04</td>
<td>Not configured for Remote Manager.</td>
</tr>
<tr>
<td>0x05</td>
<td>Connected over TLS.</td>
</tr>
<tr>
<td>0x06</td>
<td>Connected over TLS with authenticated server.</td>
</tr>
</tbody>
</table>

**Default**

N/A

**CI (Protocol/Connection Indication)**
Displays information regarding the last IP connection when using Transparent mode \(AP = 0\).
The following table provides the parameter's meaning when \(IP = 0\) for UDP connections.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x00</td>
<td>The socket is open.</td>
</tr>
<tr>
<td>0x01</td>
<td>Tried to send but could not.</td>
</tr>
<tr>
<td>0x02</td>
<td>Invalid parameters (bad IP/host).</td>
</tr>
<tr>
<td>0x03</td>
<td>TCP not supported on this cellular component.</td>
</tr>
</tbody>
</table>

*Note* For NB-IoT, TCP support is dependent on the network. Contact your network provider for details.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x10</td>
<td>Not registered to the cell network.</td>
</tr>
<tr>
<td>0x11</td>
<td>Cellular component not identified yet.</td>
</tr>
</tbody>
</table>
### AT commands

#### Diagnostic interface commands

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x12</td>
<td>DNS query lookup failure.</td>
</tr>
<tr>
<td>0x13</td>
<td>Socket leak</td>
</tr>
<tr>
<td>0x20</td>
<td>Bad handle.</td>
</tr>
<tr>
<td>0x21</td>
<td>User closed.</td>
</tr>
<tr>
<td>0x22</td>
<td>Unknown server - DNS lookup failed.</td>
</tr>
<tr>
<td>0x23</td>
<td>Connection lost.</td>
</tr>
<tr>
<td>0x24</td>
<td>Unknown.</td>
</tr>
<tr>
<td>0xFF</td>
<td>No known status.</td>
</tr>
</tbody>
</table>

The following table provides the parameter's meaning when **IP = 1 or 4** for TCP connections.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x00</td>
<td>The socket is open.</td>
</tr>
<tr>
<td>0x01</td>
<td>Tried to send but could not.</td>
</tr>
<tr>
<td>0x02</td>
<td>Invalid parameters (bad IP/host).</td>
</tr>
<tr>
<td>0x03</td>
<td>TCP not supported on this cellular component.</td>
</tr>
<tr>
<td>0x10</td>
<td>Not registered to the cell network.</td>
</tr>
<tr>
<td>0x11</td>
<td>Cellular component not identified yet.</td>
</tr>
<tr>
<td>0x12</td>
<td>DNS query lookup failure.</td>
</tr>
<tr>
<td>0x13</td>
<td>Socket leak</td>
</tr>
<tr>
<td>0x20</td>
<td>Bad handle.</td>
</tr>
<tr>
<td>0x21</td>
<td>User closed.</td>
</tr>
<tr>
<td>0x22</td>
<td>No network registration.</td>
</tr>
<tr>
<td>0x23</td>
<td>No internet connection.</td>
</tr>
<tr>
<td>0x24</td>
<td>No server - timed out on connection.</td>
</tr>
<tr>
<td>0x25</td>
<td>Unknown server - DNS lookup failed.</td>
</tr>
<tr>
<td>0x26</td>
<td>Connection refused.</td>
</tr>
<tr>
<td>0x27</td>
<td>Connection lost.</td>
</tr>
<tr>
<td>0x28</td>
<td>Unknown.</td>
</tr>
<tr>
<td>0xFF</td>
<td>No known status.</td>
</tr>
</tbody>
</table>

The following table provides the parameter's meaning when **IP = 2** for SMS connections.
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x00</td>
<td>SMS successfully sent.</td>
</tr>
<tr>
<td>0x01</td>
<td>SMS failed to send.</td>
</tr>
<tr>
<td>0x02</td>
<td>Invalid SMS parameters - check P# (Destination Phone Number).</td>
</tr>
<tr>
<td>0x03</td>
<td>SMS not supported.</td>
</tr>
<tr>
<td>0x10</td>
<td>No network registration.</td>
</tr>
<tr>
<td>0x11</td>
<td>Cellular component stack error.</td>
</tr>
<tr>
<td>0x12</td>
<td>A modem update is in-progress. Try again after its completion.</td>
</tr>
<tr>
<td>0xFF</td>
<td>No SMS state to report (no SMS messages have been sent).</td>
</tr>
</tbody>
</table>

**Parameter range**

0 - 0xFF (read-only)

**Default**

- 

**AS (Active scan for network environment data)**

Scans for mobile cells in the vicinity and returns information about the cells in the service area of the device. When you run the command, the cell module waits until all other communication is idle and then performs the scan.

The information that can be reported by this command varies based on the network technology of the module that you are using.

In both AT and API mode the command returns line-based records mapping key-value pairs. The record for the serving cell begins with the capital letter S, and keys for the fields are MCC, MNC, Area, CID, and Signal. Each line describes a particular cell and only those values determined during a single scan are reported.

**Example**

```
atas
S MCC:311 MNC:480 Area:48707
CID:48825632 Signal:-88
CID:48825612 Signal:-95
CID:48825603 Signal:-68
CID:48825601 Signal:-71
```
### Value | Description
--- | ---
0 or no value | Scans for mobile cells in the vicinity and returns information about the cells in the service area of the module. When you run the command, the cell module waits until all other communication is idle and then performs the scan.

**Parameter range**
- N/A

**Default**
- N/A
Execution commands

The location where most AT commands set or query register values, execution commands execute an action on the device. Execution commands are executed immediately and do not require changes to be applied.

NR (Network Reset)
NR resets the network layer parameters. The XBee Smart Modem tears down any TCP/UDP sockets and resets Internet connectivity.

The XBee Smart Modem responds immediately with an OK on the UART and then causes a network restart.

You can also send NR, which acts like NR = 0.

Parameter range
0

Default
N/A

!R (Modem Reset)
Forces the cellular component to reboot.

CAUTION! This command is for advanced users, and you should only use it if the cellular component becomes completely stuck while in Bypass mode. Normal users should never need to run this command. See the FR (Force Reset) command instead.

Range
N/A

Default
N/A
File system commands

To access the file system, Enter Command mode and use the following commands. All commands block the AT command processor until completed and only work from Command mode; they are not valid for API mode or MicroPython’s xbee.atcmd() method. Commands are case-insensitive as are file and directory names. Optional parameters are shown in square brackets ([ ]).

FS is a command with sub-commands. These sub-commands are arguments to FS.
For FS commands, you have to type AT before the command, for example ATFS PWD, ATFS LS and so forth.

Error responses

If a command succeeds it returns information such as the name of the current working directory or a list of files, or OK if there is no information to report. If it fails, you see a detailed error message instead of the typical ERROR response for a failing AT command. The response is a named error code and a textual description of the error.

Note The exact content of error messages may change in the future. All errors start with a capital E, followed by one or more uppercase letters and digits, a space, and an description of the error.
If writing your own AT command parsing code, you can determine if an FS command response is an error by checking if the first letter of the response is capital E.

ATFS (File System)

When sent without any parameters, FS prints a list of supported commands.

ATFS PWD

Prints the current working directory, which always starts with / and defaults to /flash at startup.

ATFS CD directory

Changes the current working directory to directory. Prints the current working directory or an error if unable to change to directory.

ATFS MD directory

Creates the directory directory. Prints OK if successful or an error if unable to create the requested directory.

ATFS LS [directory]

Lists files and directories in the specified directory. The directory parameter is optional and defaults to a period (.), which represents the current directory. The list ends with a blank line.
Entries start with zero or more spaces, followed by filesize or the string <DIR> for directories, then a single space character and the name of the entry. Directory names end with a forward slash (/) to differentiate them from files. Secure files end with a hash mark (#) and you cannot download them.

| <DIR> ./ |
| <DIR> ../ |
| <DIR> cert/ |
ATFS PUT filename

Starts a YMODEM receive on the XBee Smart Modem, storing the received file to filename and ignoring the filename that appears in block 0 of the YMODEM transfer. The XBee Smart Modem sends a prompt (Receiving file with YMODEM...) when it is ready to receive, at which point you should initiate a YMODEM send in your terminal emulator.

If the command is incorrect, the reply will be an error as described in Error responses.

ATFS XPUT filename

Similar to the PUT command, but stores the file securely on the XBee Smart Modem. See Secure files for details on what this means.

If the command is incorrect, the reply will be an error as described in Error responses.

ATFS HASH filename

Print a SHA-256 hash of a file to allow for verification against a local copy of the file.

- On Windows, you can generate a SHA-256 hash of a file with the command certutil -hashfile test.txt SHA256.
- On Mac and Linux use shasum -b -a 256 test.txt.

ATFS GET filename

Starts a YMODEM send of filename on the XBee device. When it is ready to send, the XBee Smart Modem sends a prompt: (Sending file with YMODEM...). When the prompt is sent, you should initiate a YMODEM receive in your terminal emulator.

If the command is incorrect, the reply will be an error as described in Error responses.

ATFS MV source_path dest_path

Moves or renames the selected file or directory source_path to the new name or location dest_path. This command fails with an error if source_path does not exist, or dest_path already exists.

Note Unlike a computer’s command prompt which moves a file into the dest_path if it is an existing directory, you must specify the full name for dest_path.

ATFS RM file_or_directory

Removes the file or empty directory specified by file_or_directory. This command fails with an error if file_or_directory does not exist, is not empty, refers to the current working directory or one of its parents.

ATFS INFO

Report on the size of the filesystem, showing bytes in use, available, marked bad and total. The report ends with a blank line, as with most multi-line AT command output. Example output:

```
ATFS INFO

<DIR> lib/
    32 test.txt
    1234 secure.bin#
```
ATFS FORMAT confirm
Reformats the file system, leaving it with a default directory structure. Pass the word confirm as the first parameter to confirm the format. The XBee Smart Modem responds with Formatting..., adds a period every second until the format is complete and ends the response with a carriage return.
BLE commands

The following AT commands are BLE commands.

BI (Bluetooth Identifier)
A human-friendly name for the device. This name appears in BLE advertisement messages. If set to the default (a single ASCII space character), the Bluetooth identifier displays as the device name, such as XBee 3 Cellular LTE-M/NB-IoT. If you are using XBee Mobile, adjustments to the filter options will be needed if this value is populated.

Parameter range
A string of case-sensitive ASCII printable characters from 1 to 22 bytes in length.

Default
0x20 (an ASCII space character)

BL (Bluetooth MAC address)
The BL command reports the EUI-48 Bluetooth device address (BLE MAC address). Due to standard XBee AT Command processing, leading zeroes are not included in the response when in command mode.

Parameter range
N/A

Default
N/A

BT (Bluetooth enable)
The BT command enables or disables the Bluetooth functionality.

Parameter range

<table>
<thead>
<tr>
<th>Bit</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Bluetooth functionality is disabled.</td>
</tr>
<tr>
<td>1</td>
<td>Bluetooth functionality is enabled.</td>
</tr>
</tbody>
</table>

Default
0

$S (SRP Salt)

Note You should only use this command if you have already configured a password on the XBee device and the salt corresponds to the password.

The SRP (Secure Remote Password) Salt is a 32-bit number used to create an encrypted password for the XBee device. The $S command is used in conjunction with the $V, $W, $X, and $Y verifiers.
Together, the command and the verifiers authenticate the client for the BLE API Service without storing the XBee password on the XBee device. The salt is configured in the $S$ command. In the $V$, $W$, $X$, and $Y$ verifiers, you specify the 128-byte verifier value, where each command represents 32 bytes of the total 128-byte verifier value.

**Note** XBee device does not allow for 0 to be valid salt. If the value is 0, SRP is disabled and you will not be able to authenticate using Bluetooth.

**Parameter range**

0 - FFFFFFFF

**Default**

0

$V$, $W$, $X$, $Y$ (SRP password verifier)

**Note** You should only use these commands if you have already configured a password on the XBee device and the salt verifier values correspond to the password.

The $V$, $W$, $X$, and $Y$ commands are used in conjunction with the $S$ command used to create an encrypted password for the XBee device. Together with the $S$ command, these commands authenticate the client for the BLE API Service without storing the XBee password on the XBee device. The salt is configured in the $S$ command. In the $V$, $W$, $X$, and $Y$ verifiers, you specify the 128-byte verifier value, where each command represents 32 bytes of the total 128-byte verifier value.

**Parameter range**

1 - 32 bytes (1-64 hexadecimal characters in command mode)

**Default**

0
Remote Manager commands

The following commands are used with Remote Manager.

DF (Remote Manager Status Check Interval)
Defines the number of minutes between polls for Remote Manager activity.

Parameter range
1 to 0x10E0

Default
1440

EQ (Remote Manager FQDN)
Sets or display the fully qualified domain name of the Remote Manager server.

Note For NB-IoT, TCP support is dependent on the network. Contact your network provider for details.

Range
From 0 through 63 ASCII characters.

Default
my.devicecloud.com

K1 (Remote Manager Server Send Keepalive)
Specify the Remote Manager Server Send Transmit Keepalive Interval value in seconds. The XBee device considers a Remote Manager connection to have failed after 3 missed keepalives.
This command works with the K2 command to limit data usage. See Configure Remote Manager keepalive interval.

Note Changing this value causes any currently active Remote Manager connections to be closed and recreated.

Parameter range
10 - 7200 (x 1 s)

Default
75

K2 (Remote Manager Device Send Keepalive)
Specify the Remote Manager Device Send Transmit Keepalive Interval value in seconds. The Remote Manager considers a connection to have failed after 3 missed keepalives.
This command works with the K1 command to limit data usage. See Configure Remote Manager keepalive interval.
Note Changing this value causes any currently active Remote Manager connections to be closed and recreated.

**Parameter range**
10 - 7200 (x 1 s)

**Default**
60

**MO (Remote Manager Options)**
Configures the connection to Remote Manager.

Note When bit 0 is set to 0, you should manage the Remote Manager keepalive interval, which may otherwise result in excessive data usage. See Configure Remote Manager keepalive interval.

**Parameter range**
0 - 7

<table>
<thead>
<tr>
<th>Bit</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Maintains a persistent TCP connection to Remote Manager.</td>
</tr>
<tr>
<td>1</td>
<td>TCP connection uses TLS. This is the default.</td>
</tr>
<tr>
<td>2</td>
<td>Reserved for future use.</td>
</tr>
</tbody>
</table>

**Default**
6 (Bits 1 and 2 are enabled by default.)

**$D (Remote Manager certificate)**
Defines the TLS Remote Manager certificate.

**Parameter range**
N/A

**Default**
/flash/cert/digi-remote-mgr.pem

**RI (Remote Manager Service ID)**
Sets the Remote Manager service ID for the XBee.
See Configure SMS messaging in Remote Manager for more information.

**Range**
-

**Default**
idgp
**DP (Remote Manager Phone Number)**

Sets the Remote Manager phone number for the XBee device. This code must match the phone number option in the **SMS Configuration** dialog.

See [Configure SMS messaging in Remote Manager](#) for more information.

**Range**

-

**Default**

32075

**HF (Health Metrics Reporting Frequency)**

Reports the time between attempts to upload metrics. The time is measured in minutes. Metrics which cannot be collected or reported at any particular time are skipped until the next attempt.

**Parameter range**

1 to 0xFFFF

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x3c</td>
<td>One hour.</td>
</tr>
</tbody>
</table>

**Default**

0x3c

**HM (Health Metrics)**

Sets the Health Metrics to report. This is a bit-mask of values. Each bit set in the mask represents a metric which is reported to Remote Manager.

**Parameter range**

N/A

<table>
<thead>
<tr>
<th>Bit</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Signal Strength. This is the same value as reported by the <a href="#">DB command</a> in dbM and will be reported to the &quot;metrics/signal_strength&quot; Data Stream in Remote Manager for the devices.</td>
</tr>
</tbody>
</table>

**Default**

0x0
**System commands**

The following commands are used to assign descriptors to the XBee Smart Modem, which distinguish the devices from each other in Remote Manager.

**KL (Device Location)**
Sets or displays a user-defined physical location for the XBee displayed in Remote Manager.

**Range**
Up to 20 ASCII characters

**Default**
One ASCII space character (0x20).

**KP (Device Description)**
Sets or displays a user-defined description for the XBee displayed in Remote Manager.

**Range**
Up to 20 ASCII characters

**Default**
One ASCII space character (0x20)

**KC (Contact Information)**
Sets or displays user-defined contact information for the XBee displayed in Remote Manager.

**Range**
Up to 20 ASCII characters

**Default**
One ASCII space character (0x20).
Socket commands

The following AT commands are socket commands.

**SI (Socket Info)**

Lists either information about a given socket or lists the socket IDs of all active (open) sockets on the modem in a human-readable format.

When the SI command is issued without a parameter, the XBee outputs a list of socket IDs in hex, separated by carriage returns (<CR>). After the last socket ID has been printed the list is terminated with an additional carriage return.

In both API and command mode the payload (output) will have the following format:

```
ID<CR>
ID<CR>
... 
ID<CR>
<CR>
```

In the list of socket IDs, an asterisk (*) displays after the socket ID for non-Extended API Sockets (which are sockets created implicitly when using IPv4 TX API frames). In the example below, the 0x00 socket is an IPv4 TX/RX socket, and the 0x01 and 0x02 sockets are both Extended API sockets. The socket IDs are displayed in ascending order, from smallest socket value to the largest.

```
0x00*
0x01
0x02
```

**Note** When sending AT commands for API frames it is standard to send the command as ASCII text and the parameters for that command as binary.

When the SI command is issued with a socket ID, specified in hex, the response is a list of information about the socket. The list is separated by carriage returns (<CR>) and terminated with an additional carriage return.

In both API and command mode the payload/output will have the following format:

```
ID<CR>
STATE<CR>
PROTOCOL<CR>
LOCAL_PORT<CR>
REMOTE_PORT<CR>
REMOTE_ADDRESS<CR>
<CR>
```

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ID</td>
<td>The socket ID.</td>
</tr>
</tbody>
</table>
### AT commands

#### Power measurement commands

The following commands enable you to access voltage readings and manage a value for minimum allowed operating voltage.

#### %V command

Measures the supply voltage of the XBee VCC pin for the device in mV units.

**Parameter range**

N/A

**Default**

N/A

#### %L (Low voltage shutdown base threshold)

Sets the voltage threshold in millivolts at which the XBee enters a shutdown state. You must enable this feature by setting the DO command bit 4. See Low voltage shutdown.

---

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>STATE</td>
<td>The state of the socket:</td>
</tr>
<tr>
<td></td>
<td>- ALLOCATED</td>
</tr>
<tr>
<td></td>
<td>- CONNECTING</td>
</tr>
<tr>
<td></td>
<td>- CONNECTED</td>
</tr>
<tr>
<td></td>
<td>- LISTENING</td>
</tr>
<tr>
<td></td>
<td>- BOUND</td>
</tr>
<tr>
<td></td>
<td>- CLOSING</td>
</tr>
<tr>
<td>PROTOCOL</td>
<td>The protocol of the socket:</td>
</tr>
<tr>
<td></td>
<td>- UDP</td>
</tr>
<tr>
<td></td>
<td>- TCP</td>
</tr>
<tr>
<td></td>
<td>- TLS</td>
</tr>
<tr>
<td>LOCAL_PORT</td>
<td>The local port of the socket. This is 0 unless the socket is explicitly bound to a port.</td>
</tr>
<tr>
<td>REMOTE_PORT</td>
<td>The remote port of the socket.</td>
</tr>
<tr>
<td>REMOTE_ADDRESS</td>
<td>The remote IPv4 address for the given socket. This is 0.0.0.0 for an unconnected socket.</td>
</tr>
</tbody>
</table>

**Parameter range**

0x00 - 0xFE

**Default**

-
Parameter range
0xA28 - 0xC80 mV

Default
0xBB8 mV

%M (Low voltage shutdown reset offset)
The voltage offset in millivolts above %L command (Low voltage shutdown base threshold) at which the XBee recovers from a shutdown state by resetting. You must enable this feature by setting the DO command bit 4. See Low voltage shutdown.

Parameter range
0x64 - 0x2BC mV

Default
0xC8 mV
Operate in API mode

API mode overview ................................................................. 240
Use the AP command to set the operation mode .......................... 240
API frame format ..................................................................... 240
API mode overview

As an alternative to Transparent operating mode, you can use API operating mode. API mode provides a structured interface where data is communicated through the serial interface in organized packets and in a determined order. This enables you to establish complex communication between devices without having to define your own protocol. The API specifies how commands, command responses and device status messages are sent and received from the device using the serial interface or the SPI interface.

We may add new frame types to future versions of firmware, so build the ability to filter out additional API frames with unknown frame types into your software interface.

Use the AP command to set the operation mode

Use AP (API Enable) to specify the operation mode:

<table>
<thead>
<tr>
<th>AP command setting</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AP = 0</td>
<td>Transparent operating mode, UART serial line replacement with API modes disabled. This is the default option.</td>
</tr>
<tr>
<td>AP = 1</td>
<td>API operation.</td>
</tr>
<tr>
<td>AP = 2</td>
<td>API operation with escaped characters (only possible on UART).</td>
</tr>
<tr>
<td>AP = 3</td>
<td>N/A</td>
</tr>
<tr>
<td>AP = 4</td>
<td>MicroPython REPL</td>
</tr>
<tr>
<td>AP = 5</td>
<td>Bypass mode. This mode is for direct communication with the underlying chip and is only for advanced users.</td>
</tr>
</tbody>
</table>

The API data frame structure differs depending on what mode you choose.

API frame format

An API frame consists of the following:

- Start delimiter
- Length
- Frame data
- Checksum

API operation (AP parameter = 1)

This is the recommended API mode for most applications. The following table shows the data frame structure when you enable this mode:
**Operate in API mode**

**API frame format**

<table>
<thead>
<tr>
<th>Frame fields</th>
<th>Byte</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start delimiter</td>
<td>1</td>
<td>0x7E</td>
</tr>
<tr>
<td>Length</td>
<td>2 - 3</td>
<td>Most Significant Byte, Least Significant Byte</td>
</tr>
<tr>
<td>Frame data</td>
<td>4 - number (n)</td>
<td>API-specific structure</td>
</tr>
<tr>
<td>Checksum</td>
<td>n + 1</td>
<td>1 byte</td>
</tr>
</tbody>
</table>

Any data received prior to the start delimiter is silently discarded. If the frame is not received correctly or if the checksum fails, the XBee replies with a radio status frame indicating the reason for the failure.

**API operation with escaped characters (AP parameter = 2)**

Setting API to 2 allows escaped control characters in the API frame. Due to its increased complexity, we only recommend this API mode in specific circumstances. API 2 may help improve reliability if the serial interface to the device is unstable or malformed frames are frequently being generated.

When operating in API 2, if an unescaped 0x7E byte is observed, it is treated as the start of a new API frame and all data received prior to this delimiter is silently discarded. For more information on using this API mode, see the Escaped Characters and API Mode 2 in the Digi Knowledge base.

API escaped operating mode works similarly to API mode. The only difference is that when working in API escaped mode, the software must escape any payload bytes that match API frame specific data, such as the start-of-frame byte (0x7E). The following table shows the structure of an API frame with escaped characters:

<table>
<thead>
<tr>
<th>Frame fields</th>
<th>Byte</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start delimiter</td>
<td>1</td>
<td>0x7E</td>
</tr>
<tr>
<td>Length</td>
<td>2 - 3</td>
<td>Most Significant Byte, Least Significant Byte</td>
</tr>
<tr>
<td>Frame data</td>
<td>4 - n</td>
<td>API-specific structure</td>
</tr>
<tr>
<td>Checksum</td>
<td>n + 1</td>
<td>1 byte</td>
</tr>
</tbody>
</table>

**Start delimiter field**

This field indicates the beginning of a frame. It is always 0x7E. This allows the device to easily detect a new incoming frame.

**Escaped characters in API frames**

If operating in API mode with escaped characters (AP parameter = 2), when sending or receiving a serial data frame, specific data values must be escaped (flagged) so they do not interfere with the data frame sequencing. To escape an interfering data byte, insert 0x7D and follow it with the byte to be escaped (XORed with 0x20).

The following data bytes need to be escaped:

- 0x7E: start delimiter
- 0x7D: escape character
To escape a character:

1. Insert 0x7D (escape character).
2. Append it with the byte you want to escape, XORed with 0x20.

In API mode with escaped characters, the length field does not include any escape characters in the frame and the firmware calculates the checksum with non-escaped data.

**Example: escape an API frame**

To express the following API non-escaped frame in API operating mode with escaped characters:

<table>
<thead>
<tr>
<th>Start delimiter</th>
<th>Length</th>
<th>Frame type</th>
<th>Frame Data</th>
<th>Checksum</th>
</tr>
</thead>
<tbody>
<tr>
<td>7E</td>
<td>00</td>
<td>0F</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>01 00 13 A2 00 AD 14 2E FF FE 02 4E 49 6D</td>
<td></td>
</tr>
</tbody>
</table>

You must escape the 0x13 byte:

1. Insert a 0x7D.
2. XOR byte 0x13 with 0x20: 13 ⊕ 20 = 33

The following figure shows the resulting frame. Note that the length and checksum are the same as the non-escaped frame.

<table>
<thead>
<tr>
<th>Start delimiter</th>
<th>Length</th>
<th>Frame type</th>
<th>Frame Data</th>
<th>Checksum</th>
</tr>
</thead>
<tbody>
<tr>
<td>7E</td>
<td>00</td>
<td>0F</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>01 00 7D 33 A2 00 40 AD 14 2E FF FE 02 4E 49 6D</td>
<td></td>
</tr>
</tbody>
</table>

The length field has a two-byte value that specifies the number of bytes in the frame data field. It does not include the checksum field.

**Length field**

The length field is a two-byte value that specifies the number of bytes contained in the frame data field. It does not include the checksum field.

**Frame data**

This field contains the information that a device receives or will transmit. The structure of frame data depends on the purpose of the API frame:

<table>
<thead>
<tr>
<th>Length</th>
<th>Frame data</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>9</td>
<td>...</td>
</tr>
<tr>
<td>n</td>
<td>n+1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>0x7E</th>
<th>MSB</th>
<th>LSB</th>
<th>Data</th>
<th></th>
</tr>
</thead>
</table>

- **Frame type** is the API frame type identifier. It determines the type of API frame and indicates how the Data field organizes the information.
- **Data** contains the data itself. This information and its order depend on the what type of frame that the Frame type field defines.
Multi-byte values are sent big-endian.

**Calculate and verify checksums**

To calculate the checksum of an API frame:

1. Add all bytes of the packet, except the start delimiter 0x7E and the length (the second and third bytes).
2. Keep only the lowest 8 bits from the result.
3. Subtract this quantity from 0xFF.

To verify the checksum of an API frame:

1. Add all bytes including the checksum; do not include the delimiter and length.
2. If the checksum is correct, the last two digits on the far right of the sum equal 0xFF.

**Example**

Consider the following sample data packet: **7E 00 0A 01 01 50 00 48 65 6C 6F** **B8**

<table>
<thead>
<tr>
<th>Byte(s)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>7E</td>
<td>Start delimiter</td>
</tr>
<tr>
<td>00 0A</td>
<td>Length bytes</td>
</tr>
<tr>
<td>01</td>
<td>API identifier</td>
</tr>
<tr>
<td>01</td>
<td>API frame ID</td>
</tr>
<tr>
<td>50 01</td>
<td>Destination address low</td>
</tr>
<tr>
<td>00</td>
<td>Option byte</td>
</tr>
<tr>
<td>48 65 6C 6C 6F</td>
<td>Data packet</td>
</tr>
<tr>
<td>B8</td>
<td>Checksum</td>
</tr>
</tbody>
</table>

To calculate the checksum you add all bytes of the packet, excluding the frame delimiter 7E and the length (the second and third bytes):

**7E 00 0A 01 01 50 00 48 65 6C 6F** **B8**

Add these hex bytes:

\[
01 + 01 + 50 + 01 + 00 + 48 + 65 + 6C + 6C + 6F = 247
\]

Now take the result of 0x247 and keep only the lowest 8 bits which in this example is 0xC4 (the two far right digits). Subtract 0x47 from 0xFF and you get 0x3B (0xFF - 0xC4 = 0x3B). 0x3B is the checksum for this data packet.

If an API data packet is composed with an incorrect checksum, the XBee Smart Modem will consider the packet invalid and will ignore the data.

To verify the checksum of an API packet add all bytes including the checksum (do not include the delimiter and length) and if correct, the last two far right digits of the sum will equal FF.

\[
01 + 01 + 50 + 01 + 00 + 48 + 65 + 6C + 6C + 6F + B8 = 2FF
\]
API frames

The following sections describe the API frames.

AT Command - 0x08 .......................................................... 245
AT Command: Queue Parameter Value - 0x09 .......................... 246
Transmit (TX) SMS - 0x1F ................................................. 247
Transmit (TX) Request: IPv4 - 0x20 .................................... 248
Tx Request with TLS Profile - 0x23 ...................................... 250
AT Command Response - 0x88 ........................................... 252
Transmit (TX) Status - 0x89 .............................................. 253
Modem Status - 0x8A ..................................................... 255
Receive (RX) Packet: SMS - 0x9F ..................................... 256
Receive (RX) Packet: IPv4 - 0xB0 ...................................... 257
User Data Relay - 0x2D ................................................... 258
User Data Relay Output - 0xAD .......................................... 260
BLE Unlock API - 0x2C ................................................... 261
BLE Unlock Response - 0xAC ............................................ 265
Socket Create - 0x40 ....................................................... 266
Socket Create Response - 0xC0 ......................................... 267
Socket Option Request - 0x41 ............................................ 268
Socket Option Response - 0xC1 .......................................... 269
Socket Connect - 0x42 ...................................................... 270
Socket Connect Response - 0xC2 ....................................... 271
Socket Close - 0x43 .......................................................... 272
Socket Close Response - 0xC3 ............................................ 273
Socket Send (Transmit) - 0x44 .......................................... 274
Socket SendTo (Transmit Explicit Data): IPv4 - 0x45 ................. 275
Socket Bind/Listen - 0x46 .................................................. 276
Socket Listen Response - 0xC6 ......................................... 277
Socket New IPv4 Client - 0xCC .......................................... 278
Socket Receive - 0xCD ...................................................... 279
Socket Receive From: IPv4 - 0xCE ..................................... 280
Socket Status - 0xCF ........................................................ 281
AT Command - 0x08

Description
Use this frame to query or set parameters on the local device. Changes this frame makes to device parameters take effect after executing the AT command.

Format
The following table provides the contents of the frame. For details on frame structure, see API frame format.

<table>
<thead>
<tr>
<th>Field name</th>
<th>Field value</th>
<th>Data type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame type</td>
<td>0x08</td>
<td>Byte</td>
<td></td>
</tr>
<tr>
<td>Frame ID</td>
<td></td>
<td>Byte</td>
<td>Identifies the data frame for the host to correlate with a subsequent ACK. If set to 0, the device does not send a response.</td>
</tr>
<tr>
<td>AT command</td>
<td></td>
<td>Byte</td>
<td>Command name: two ASCII characters that identify the AT command.</td>
</tr>
<tr>
<td>Parameter value</td>
<td></td>
<td>Byte</td>
<td>If present, indicates the requested parameter value to set the given register. If no characters are present, it queries the register.</td>
</tr>
</tbody>
</table>
AT Command: Queue Parameter Value - 0x09

Description
This frame allows you to query or set device parameters. In contrast to AT Command - 0x08, this frame queues new parameter values and does not apply them until you issue either:

- The AT Command (0x08) frame
- The AC command

When querying parameter values, the 0x09 frame behaves identically to the 0x08 frame. The device returns register queries immediately and not does not queue them. The response for this command is also an AT Command Response frame (0x88).

Format
The following table provides the contents of the frame. For details on frame structure, see API frame format.

<table>
<thead>
<tr>
<th>Field name</th>
<th>Field value</th>
<th>Data type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame type</td>
<td>0x09</td>
<td>Byte</td>
<td></td>
</tr>
<tr>
<td>Frame ID</td>
<td></td>
<td>Byte</td>
<td>Identifies the data frame for the host to correlate with a subsequent ACK. If set to 0, the device does not send a response.</td>
</tr>
<tr>
<td>AT command</td>
<td></td>
<td>Byte</td>
<td>Command name: two ASCII characters that identify the AT command.</td>
</tr>
<tr>
<td>Parameter value</td>
<td></td>
<td>Byte</td>
<td>If present, indicates the requested parameter value to set the given register. If no characters are present, it queries the register.</td>
</tr>
</tbody>
</table>
Transmit (TX) SMS - 0x1F

Description
Transmit an SMS message. The frame allows international numbers with or without the + prefix. If you omit + and are dialing internationally, you need to include the proper International Dialing Prefix for your calling region, for example, 011 for the United States.

Note For NB-IoT, SMS support is dependent on the network. Contact your network provider for details.

Format
The following table provides the contents of the frame. For details on frame structure, see API frame format.

<table>
<thead>
<tr>
<th>Field name</th>
<th>Field value</th>
<th>Data type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame type</td>
<td>0x1F</td>
<td>Byte</td>
<td>Reference identifier used to match status responses. 0 disables the TX Status frame.</td>
</tr>
<tr>
<td>Frame ID</td>
<td></td>
<td>Byte</td>
<td>Reserved for future use.</td>
</tr>
<tr>
<td>Options</td>
<td></td>
<td>Byte</td>
<td>Reserved for future use.</td>
</tr>
<tr>
<td>Phone number</td>
<td>20 byte string</td>
<td>String representation of phone number terminated with a null (0x0) byte. Use numbers and the + symbol only, no other symbols or letters.</td>
<td></td>
</tr>
<tr>
<td>Payload</td>
<td>Variable (160 characters maximum)</td>
<td>Data to send as the body of the SMS message.</td>
<td></td>
</tr>
</tbody>
</table>
Transmit (TX) Request: IPv4 - 0x20

Description
A TX Request message causes the device to transmit data in IPv4 format. A TX request frame for a new destination creates a network socket. After the network socket is established, data from the network that is received on the socket is sent out the device’s serial port in the form of a Receive (RX) Packet frame.

When you specify protocol 4 (TLS), the profile configuration specified by $0 (TLS Profile 0) is used to form the TLS connection.

*Note* For NB-IoT, TCP support is dependent on the network. Contact your network provider for details.

Format
The following table provides the contents of the frame. For details on frame structure, see API frame format.

<table>
<thead>
<tr>
<th>Field name</th>
<th>Field value</th>
<th>Data type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame type</td>
<td>0x20</td>
<td>Byte</td>
<td></td>
</tr>
<tr>
<td>Frame ID</td>
<td></td>
<td>Byte</td>
<td>Reference identifier used to match status responses. 0 disables the TX Status frame.</td>
</tr>
<tr>
<td>Destination address</td>
<td></td>
<td>32-bit big endian</td>
<td></td>
</tr>
<tr>
<td>Destination port</td>
<td></td>
<td>16-bit big endian</td>
<td></td>
</tr>
<tr>
<td>Source port</td>
<td></td>
<td>16-bit big endian</td>
<td>If the source port is 0, the device attempts to send the frame data using an existing open socket with a destination that matches the destination address and destination port fields of this frame. If there is no matching socket, then the device attempts to open a new socket. If the source port is non-zero, the device attempts to send the frame data using an existing open socket with a source and destination that matches the source port, destination address, and destination port fields of this frame. If there is no matching socket, the TX Status frame returns an error.</td>
</tr>
<tr>
<td>Protocol</td>
<td></td>
<td>Byte</td>
<td>0 = UDP 1 = TCP 4 = SSL/TLS</td>
</tr>
</tbody>
</table>

*Note* For NB-IoT, TCP support is dependent on the network. Contact your network provider for details.
<table>
<thead>
<tr>
<th>Field name</th>
<th>Field value</th>
<th>Data type</th>
<th>Description</th>
</tr>
</thead>
</table>
| Transmit options | Byte        | bitfield           | Bit fields are offset 0  
Bit field 0 - 7. Bits 0, and 2-7 are reserved, bit 1 is not. BIT 1 =  
1 - Terminate the TCP socket after transmission is complete  
0 - Leave the socket open. Closed by timeout, see TM (IP Client Connection Timeout).  
Ignore this bit for UDP packets.  
All other bits are reserved and should be 0. |
| Payload          | Variable    |                   | Data to be transferred to the destination, may be up to 1500 bytes.  
UDP is limited to 512 bytes. |
Tx Request with TLS Profile - 0x23

Description
The frame gives greater control to the application over the TLS settings used for a connection. A TX Request with TLS Profile frame implies the use of TLS and behaves similar to the TX Request (0x20) frame, with the protocol field replaced with a TLS Profile field to choose from the profiles configured with the $0, $1, and $2 configuration commands.

Note For NB-IoT, TCP support is dependent on the network. Contact your network provider for details.

Format
The following table provides the contents of the frame. For details on frame structure, see API frame format.

<table>
<thead>
<tr>
<th>Field name</th>
<th>Field value</th>
<th>Data type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame type</td>
<td>0x23</td>
<td>Byte</td>
<td>Reference identifier used to match status responses. 0 disables the TX Status frame.</td>
</tr>
<tr>
<td>Frame ID</td>
<td></td>
<td>Byte</td>
<td></td>
</tr>
<tr>
<td>Destination address</td>
<td></td>
<td>32-bit big endian</td>
<td></td>
</tr>
<tr>
<td>Destination port</td>
<td></td>
<td>16-bit big endian</td>
<td></td>
</tr>
<tr>
<td>Source port</td>
<td></td>
<td>16-bit big endian</td>
<td>If the source port is 0, the device attempts to send the frame data using an existing open socket with a destination that matches the destination address and destination port fields of this frame. If there is no matching socket, then the device attempts to open a new socket. If the source port is non-zero, the device attempts to send the frame data using an existing open socket with a source and destination that matches the source port, destination address, and destination port fields of this frame. If there is no matching socket, the TX Status frame returns an error.</td>
</tr>
<tr>
<td>TLS profile</td>
<td></td>
<td>Byte</td>
<td>Zero-indexed number that indicates the profile as specified by the corresponding $&lt;num&gt;$ command.</td>
</tr>
<tr>
<td>Field name</td>
<td>Field value</td>
<td>Data type</td>
<td>Description</td>
</tr>
<tr>
<td>------------------</td>
<td>-------------</td>
<td>-----------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| Transmit options | Byte bitfield|           | Bit fields are offset 0  
|                  |             |           | Bit field 0 - 7. Bits 0, and 2-7 are reserved, bit 1 is not.  
|                  |             |           | BIT 1 =  
|                  |             |           | 1 - Terminate the TCP socket after transmission is complete  
|                  |             |           | 0 - Leave the socket open. Closed by timeout, see TM (IP  
|                  |             |           | Client Connection Timeout).  
|                  |             |           | Ignore this bit for UDP packets.  
|                  |             |           | All other bits are reserved and should be 0.                                                                                               |
| Payload          | Variable    |           | Data to be transferred to the destination, may be up to 1500 bytes.                                                                       |
AT Command Response - 0x88

Description
A device sends this frame in response to an AT Command (0x08) frame. Some commands send back multiple frames.

Format
The following table provides the contents of the frame. For details on frame structure, see API frame format.

<table>
<thead>
<tr>
<th>Field name</th>
<th>Field value</th>
<th>Data type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame type</td>
<td>0x88</td>
<td>Byte</td>
<td></td>
</tr>
<tr>
<td>Frame ID</td>
<td></td>
<td>Byte</td>
<td>Identifies the data frame for the host to correlate with a subsequent ACK. If set to 0, the device does not send a response.</td>
</tr>
<tr>
<td>AT command</td>
<td></td>
<td>Byte</td>
<td>Command name: two ASCII characters that identify the AT command.</td>
</tr>
<tr>
<td>Status</td>
<td>##</td>
<td>Byte</td>
<td>0 = OK&lt;br&gt;1 = ERROR&lt;br&gt;2 = Invalid command&lt;br&gt;3 = Invalid parameter</td>
</tr>
<tr>
<td>Parameter value</td>
<td></td>
<td>Byte</td>
<td>Register data in binary format. If the register was set, then this field is not returned.</td>
</tr>
</tbody>
</table>
Transmit (TX) Status - 0x89

Description
Indicates the success or failure of a transmit operation.

Format
The following table provides the contents of the frame. For details on frame structure, see API frame format.

<table>
<thead>
<tr>
<th>Field name</th>
<th>Field value</th>
<th>Data type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame type</td>
<td>0x89</td>
<td>Byte</td>
<td></td>
</tr>
<tr>
<td>Frame ID</td>
<td></td>
<td>Byte</td>
<td>Refers to the frame ID specified in a previous transmit frame</td>
</tr>
<tr>
<td>Status</td>
<td></td>
<td>Byte</td>
<td>Status code (see the table below)</td>
</tr>
</tbody>
</table>

The following table shows the status codes.

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x0</td>
<td>Successful transmit</td>
</tr>
<tr>
<td>0x21</td>
<td>Failure to transmit to cell network</td>
</tr>
<tr>
<td>0x22</td>
<td>Not registered to cell network</td>
</tr>
<tr>
<td>0x2c</td>
<td>Invalid frame values (check the phone number)</td>
</tr>
<tr>
<td>0x31</td>
<td>Internal error</td>
</tr>
<tr>
<td>0x32</td>
<td>Resource error (retry operation later). See Socket limits in API mode for more information.</td>
</tr>
<tr>
<td>0x74</td>
<td>Message too long</td>
</tr>
<tr>
<td>0x76</td>
<td>Socket closed unexpectedly</td>
</tr>
<tr>
<td>0x78</td>
<td>Invalid UDP port</td>
</tr>
<tr>
<td>0x79</td>
<td>Invalid TCP port</td>
</tr>
<tr>
<td>0x7A</td>
<td>Invalid host address</td>
</tr>
<tr>
<td>0x7B</td>
<td>Invalid data mode</td>
</tr>
<tr>
<td>0x7C</td>
<td>Invalid interface. See User Data Relay - 0x2D.</td>
</tr>
<tr>
<td>0x7D</td>
<td>Interface not accepting frames. See User Data Relay - 0x2D.</td>
</tr>
<tr>
<td>Code</td>
<td>Description</td>
</tr>
<tr>
<td>-------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>0x7E</td>
<td>A modem update is in progress. Try again after the update is complete.</td>
</tr>
<tr>
<td>0x80</td>
<td>Connection refused</td>
</tr>
<tr>
<td>0x81</td>
<td>Socket connection lost</td>
</tr>
<tr>
<td>0x82</td>
<td>No server</td>
</tr>
<tr>
<td>0x83</td>
<td>Socket closed</td>
</tr>
<tr>
<td>0x84</td>
<td>Unknown server</td>
</tr>
<tr>
<td>0x85</td>
<td>Unknown error</td>
</tr>
<tr>
<td>0x86</td>
<td>Invalid TLS configuration (missing file, and so forth)</td>
</tr>
<tr>
<td>0x87</td>
<td>Socket not connected</td>
</tr>
<tr>
<td>0x88</td>
<td>Socket not bound</td>
</tr>
</tbody>
</table>
Modem Status - 0x8A

Description
Cellular component status messages are sent from the device in response to specific conditions.

Format
The following table provides the contents of the frame. For details on frame structure, see API frame format.

<table>
<thead>
<tr>
<th>Field name</th>
<th>Field value</th>
<th>Data type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame type</td>
<td>0x8A</td>
<td>Byte</td>
<td></td>
</tr>
<tr>
<td>Status</td>
<td>0x0</td>
<td>Byte</td>
<td>0 = Hardware reset or power up</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td></td>
<td>1 = Watchdog timer reset</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td></td>
<td>2 = Registered with cellular network</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td></td>
<td>3 = Unregistered with cellular network</td>
</tr>
<tr>
<td></td>
<td>0x0E</td>
<td></td>
<td>0x0E = Remote Manager connected</td>
</tr>
<tr>
<td></td>
<td>0x0F</td>
<td></td>
<td>0x0F = Remote Manager disconnected</td>
</tr>
<tr>
<td></td>
<td>0x32</td>
<td></td>
<td>0x32 = BLE Connect</td>
</tr>
<tr>
<td></td>
<td>0x33</td>
<td></td>
<td>0x33 = BLE Disconnect</td>
</tr>
<tr>
<td></td>
<td>0x34</td>
<td></td>
<td>0x34 = Bandmask configuration failed</td>
</tr>
<tr>
<td></td>
<td>0x35</td>
<td></td>
<td>0x35 = Cellular component update started</td>
</tr>
<tr>
<td></td>
<td>0x36</td>
<td></td>
<td>0x36 = Cellular component update failed</td>
</tr>
<tr>
<td></td>
<td>0x37</td>
<td></td>
<td>0x37 = Cellular component update completed</td>
</tr>
<tr>
<td></td>
<td>0x38</td>
<td></td>
<td>0x38 = XBee firmware update started</td>
</tr>
<tr>
<td></td>
<td>0x39</td>
<td></td>
<td>0x39 = XBee firmware update failed</td>
</tr>
<tr>
<td></td>
<td>0x3A</td>
<td></td>
<td>0x3A = XBee firmware update applying</td>
</tr>
</tbody>
</table>

Note The BLE Connect and BLE Disconnect events are reported over the UART/SPI interface in API mode when a valid Bluetooth connection has been made and API mode has been unlocked, and also when an unlocked connection disconnects.
Receive (RX) Packet: SMS - 0x9F

Description
This XBee Smart Modem uses this frame when it receives an SMS message.

Note For NB-IoT, SMS support is dependent on the network. Contact your network provider for details.

Format
The following table provides the contents of the frame. For details on frame structure, see API frame format.

<table>
<thead>
<tr>
<th>Field name</th>
<th>Field value</th>
<th>Data type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame Type</td>
<td>0x9F</td>
<td>Byte</td>
<td></td>
</tr>
<tr>
<td>Phone number</td>
<td>20 byte string</td>
<td>String representation of the phone number, padded out with null bytes (0x0).</td>
<td></td>
</tr>
<tr>
<td>Payload</td>
<td>Variable</td>
<td>Body of the received SMS message.</td>
<td></td>
</tr>
</tbody>
</table>
Receive (RX) Packet: IPv4 - 0xB0

Description
The XBee Smart Modem uses this frame when it receives RF data on a network socket that is created by a TX request frame or configuring C0 (Source Port).

Note For NB-IoT, TCP support is dependent on the network. Contact your network provider for details.

Format
The following table provides the contents of the frame. For details on frame structure, see API frame format.

<table>
<thead>
<tr>
<th>Frame data fields</th>
<th>Offset</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame type</td>
<td>3</td>
<td>0xB0</td>
</tr>
<tr>
<td>IPv4 32-bit source address</td>
<td>MSB 4</td>
<td>The address in the example below is for a source address of 192.168.0.104. 32-bit big endian.</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>16-bit destination port</td>
<td>MSB 8</td>
<td>The port that the packet was received on. 16-bit big endian.</td>
</tr>
<tr>
<td></td>
<td>LSB 9</td>
<td></td>
</tr>
<tr>
<td>16-bit source port</td>
<td>MSB 10</td>
<td>The port that the packet was sent from. 16-bit big endian.</td>
</tr>
<tr>
<td></td>
<td>LSB 11</td>
<td></td>
</tr>
<tr>
<td>Protocol</td>
<td>MSB 12</td>
<td>0 = UDP 1 = TCP 4 = SSL over TCP</td>
</tr>
<tr>
<td></td>
<td>LSB 13</td>
<td></td>
</tr>
<tr>
<td>Status</td>
<td>13</td>
<td>Reserved</td>
</tr>
<tr>
<td>Payload</td>
<td>14</td>
<td>Data received from the source. The maximum size is 1500 bytes.</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td></td>
</tr>
<tr>
<td></td>
<td>16</td>
<td></td>
</tr>
<tr>
<td></td>
<td>17</td>
<td></td>
</tr>
<tr>
<td></td>
<td>18</td>
<td></td>
</tr>
</tbody>
</table>
## User Data Relay - 0x2D

### Description

Allows for data to be sent to an interface with a designation of a target interface for the data to be output on. The frame can be sent or received from any of the following interfaces: MicroPython (internal interface), UART, and BLE. This frame is used in conjunction with User Data Relay Output - 0xAD.

You can send and receive User Data Relay Frames from MicroPython. See Send and receive User Data Relay frames in the MicroPython Programming Guide.

### Format

The following table provides the contents of the frame. For details on frame structure, see API frame format.

<table>
<thead>
<tr>
<th>Field name</th>
<th>Field value</th>
<th>Data type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame type</td>
<td>0x2D</td>
<td>Byte</td>
<td>Reference identifier used to match TX Status frames (type 0x89) sent for errors. A value of 0 disables the TX Status frame.</td>
</tr>
<tr>
<td>Frame ID</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Destination interface</td>
<td>Byte</td>
<td>0 = Serial port (SPI, or UART when in API mode)</td>
<td>1 = BLE</td>
</tr>
<tr>
<td>Data</td>
<td>Variable</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Error cases

The Frame ID is used to report error conditions in a method consistent with existing transmit frames. The error codes are mapped to statuses. The following conditions result in an error that is reported in a TX Status frame, referencing the frame ID from the 0x2d request.

- **Invalid interface** (0x7c): The user specified a destination interface that does not exist.
- **Interface not accepting frames** (0x7d): The destination interface is a valid interface, but is not in a state that can accept data. For example UART not in API mode, BLE does not have a GATT client connected, or buffer queues are full.

### Example use cases

These examples show you can use this frame.

- You can use the frame to send data to an external processor through the XBee UART/SPI via the BLE connection. Use a cellphone to send the frame with UART interface as a target. Data contained within the frame is sent out the UART contained within an Output Frame. The external processor then receives and acts on the frame.
- Use an external processor to output the frame over the UART with the BLE interface as a target. This outputs the data contained in the frame as the Output Frame over the active BLE connection via indication.
- An external processor outputs the Frame over the UART with the Micropython interface as a target. Micropython operates over the data and publishes the data to mqtt topic.
User Data Relay Output - 0xAD

Description

Allows for data to be received on an interface with a designation of the target interface for the data to be output on. The frame can be sent or received from any of the following interfaces: MicroPython (internal interface), UART, and BLE. This frame is used in conjunction with User Data Relay - 0x2D.

Format

The following table provides the contents of the frame. For details on frame structure, see API frame format.

<table>
<thead>
<tr>
<th>Field name</th>
<th>Field value</th>
<th>Data type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame type</td>
<td>0xAD</td>
<td>Byte</td>
<td></td>
</tr>
<tr>
<td>Source interface</td>
<td></td>
<td>Byte</td>
<td>0 = Serial port (SPI, or UART when in API mode)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1 = BLE</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2 = MicroPython</td>
</tr>
<tr>
<td>Data</td>
<td></td>
<td>Variable</td>
<td></td>
</tr>
</tbody>
</table>
BLE Unlock API - 0x2C

Description
The XBee Smart Modem uses this frame to authenticate a connection on the Bluetooth interface and unlock the processing of AT command frames. This frame is used in conjunction with the Response (0xAC) frame.

The unlock process is an implementation of the SRP (Secure Remote Password) algorithm using the RFC5054 1024-bit group and the SHA-256 hash algorithm. The SRP identifying user name, commonly referred to as I, is fixed to the value apiservice.

Upon completion, each side will have derived a shared session key which is used to communicate in an encrypted fashion with the peer. Additionally, a Modem Status - 0x8A with the status code 0x32 (Bluetooth Connected) is sent through the UART (if AP=1 or 2). When an unlocked connection is terminated, a Modem Status Frame with the status code 0x33 (Bluetooth Disconnected) is sent through the UART.

The following implementations are known to work with the BLE SRP implementation:

- [https://github.com/cncfanatics/SRP](https://github.com/cncfanatics/SRP)
  You will need to modify the hashing algorithm to SHA256 and the values of N and g to use the RFC5054 1024-bit group.
- [https://github.com/cocagne/csrp](https://github.com/cocagne/csrp)
- [https://github.com/cocagne/pysrp](https://github.com/cocagne/pysrp)

Format
The following table provides the contents of the frame. For details on frame structure, see API frame format.

<table>
<thead>
<tr>
<th>Frame data fields</th>
<th>Offset</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame type</td>
<td>3</td>
<td>0x2C = Request</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0xAC = Response</td>
</tr>
</tbody>
</table>
Frame data fields | Offset | Description
--- | --- | ---
Step | 4 | Indicates the phase of authentication and interpretation of payload data. See
1 = Client presents A value  
2 = Server presents B and salt  
3 = Client present M1 session key validation value  
4 = Server presents M2 session key validation value and two 12-byte nonces  
See the phase tables below for more information.

Step values greater than 0x80 indicate error conditions.

0x80 = Unable to offer B (cryptographic error with content, usually due to A mod N == 0)  
0x81 = Incorrect payload length  
0x82 = Bad proof of key  
0x83 = Resource allocation error  
0x84 = Request contained a step not in the correct sequence

Payload | 5 | Payload structure varies by Frame ID value. Descriptions are in the tables, below.

The tables below give more information about the phase of authentication and interpretation of payload data.

**Phase 1 (Client presents A)**

If the A value is zero, the server will terminate the connection.

<table>
<thead>
<tr>
<th>Frame data field</th>
<th>Offset in frame</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>5</td>
<td>128 bytes</td>
</tr>
</tbody>
</table>

**Phase 2 (Server presents B and salt)**

<table>
<thead>
<tr>
<th>Frame data field</th>
<th>Offset in frame</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>salt</td>
<td>5</td>
<td>4 bytes</td>
</tr>
<tr>
<td>B</td>
<td>9</td>
<td>128 bytes</td>
</tr>
</tbody>
</table>

**Phase 3 (Client presents M1)**

<table>
<thead>
<tr>
<th>Frame data field</th>
<th>Offset in frame</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1</td>
<td>5</td>
<td>Hash algorithm digest length (32 bytes for SHA256)</td>
</tr>
</tbody>
</table>
**Phase 4 (Server presents M2)**

<table>
<thead>
<tr>
<th>Frame data field</th>
<th>Offset in frame</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>M2</td>
<td>5</td>
<td>Hash algorithm digest length (32 bytes for SHA256)</td>
</tr>
<tr>
<td>TX nonce</td>
<td>37</td>
<td>12-byte (96-bit) random nonce, used as the constant prefix of the counter block for encryption/decryption of data transmitted to the API service by the client</td>
</tr>
<tr>
<td>RX nonce</td>
<td>49</td>
<td>12-byte (96-bit) random nonce, used as the constant prefix of the counter block for encryption/decryption of data received by the client from the API service</td>
</tr>
</tbody>
</table>

Upon completion of M2 verification, the session key has been determined to be correct and the API service is unlocked and will allow additional API frames to be used. Content from this point will be encrypted using AES-256-CTR with the following parameters:

- **Key**: The entire 32-byte session key.
- **Counter**: 128 bits total, prefixed with the appropriate nonce shared during authentication. Initial remaining counter value is 1.

The counter for data sent into the XBee API Service is prefixed with the TX nonce value (see the Phase 4 table, above), and the counter for data sent by the XBee to the client is prefixed with the RX nonce value.

**Example sequence to perform AT Command XBee API frames over BLE**

1. Discover the XBee 3 device through scanning for advertisements.
2. Create a connection to the GATT Server.
3. Optional, but recommended, request a larger MTU for the GATT connection.
4. Turn on indications for the API Response characteristic.
5. Perform unlock procedure using unlock frames. See BLE Unlock API - 0x2C.
6. Once unlocked, AT Command (0x8) frames may be sent and AT Command Response frames received.
   a. For each frame to send, form the API Frame, and encrypt through the stream cipher as described in the unlock procedure. See BLE Unlock API - 0x2C.
   b. Write the frame using one or more Write operations.
   c. When successful, the response arrives in one or more indications. If your stack does not do it for you, remember to acknowledge each indication as it is received. Note that you are
expected to process these indications and the response data is not available if you attempt to perform a read operation to the characteristic.

d. Decrypt the stream of content provided through the indications, using the stream cipher as described in the unlock procedure. See BLE Unlock API - 0x2C.
BLE Unlock Response - 0xAC

Description
The XBee Smart Modem uses the BLE Unlock API - 0x2C frame to authenticate a connection on the Bluetooth interface and unlock the processing of AT command frames. This frame is used in conjunction with the Response (0xAC) frame.
For details, see BLE Unlock API - 0x2C.
Socket Create - 0x40

Description
Use this frame to create a new socket with the following protocols: TCP, UDP, or TLS.

Format
The following table provides the contents of the frame. For details on frame structure, see API frame format.

<table>
<thead>
<tr>
<th>Field name</th>
<th>Field value</th>
<th>Data type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame type</td>
<td>0x40</td>
<td>Byte</td>
<td></td>
</tr>
<tr>
<td>Frame ID</td>
<td></td>
<td>Byte</td>
<td>Reference identifier used to match status responses. A response is required and will be sent regardless of the frame ID.</td>
</tr>
</tbody>
</table>
| Protocol    |             | Byte      | 0 = UDP  
1 = TCP  
4 = SSL over TCP |
Socket Create Response - 0xC0

Description
The device sends this frame in response to a Socket Create (0x40) frame. It contains a socket ID that should be used for future transactions with the socket and a status field. If the status field is non-zero, which indicates an error, the socket ID will be set to 0xFF and the socket will not be opened.

Format
The following table provides the contents of the frame. For details on frame structure, see API frame format.

<table>
<thead>
<tr>
<th>Field name</th>
<th>Field value</th>
<th>Data type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame type</td>
<td>0xC0</td>
<td>Byte</td>
<td></td>
</tr>
<tr>
<td>Frame ID</td>
<td></td>
<td>Byte</td>
<td>A reference identifier used to match status responses.</td>
</tr>
<tr>
<td>Socket ID</td>
<td></td>
<td>Byte</td>
<td>A unique socket ID to address the socket. This field is 0xFF if the value in the status field is non-zero.</td>
</tr>
<tr>
<td>Status</td>
<td></td>
<td>Byte</td>
<td>Status code. See table below.</td>
</tr>
</tbody>
</table>

The following table shows the status codes.

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x0</td>
<td>Successful open</td>
</tr>
<tr>
<td>0x22</td>
<td>Not registered to cell network</td>
</tr>
<tr>
<td>0x31</td>
<td>Internal error</td>
</tr>
<tr>
<td>0x32</td>
<td>Resource error: retry the operation later See Socket limits in API mode.</td>
</tr>
<tr>
<td>0x7B</td>
<td>Invalid protocol</td>
</tr>
<tr>
<td>0x7E</td>
<td>A modem update is in process. Try again after its completion.</td>
</tr>
</tbody>
</table>
Socket Option Request - 0x41

Description

Use this frame to modify the behavior of sockets to change their behavior to be different than the normal default behavior. If the Option Data field is zero-length the request acts as a query, and the Socket Option Response frame (0xC1) reports the current effective value.

Format

The following table provides the contents of the frame. For details on frame structure, see API frame format.

<table>
<thead>
<tr>
<th>Field name</th>
<th>Field value</th>
<th>Data type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame type</td>
<td>0x41</td>
<td>Byte</td>
<td></td>
</tr>
<tr>
<td>Frame ID</td>
<td></td>
<td>Byte</td>
<td>A reference identifier used to match status responses. Requests made with Frame ID 0 will not send a response.</td>
</tr>
<tr>
<td>Socket ID</td>
<td></td>
<td>Byte</td>
<td>The socket ID to modify.</td>
</tr>
<tr>
<td>Option ID</td>
<td></td>
<td>Byte</td>
<td>Identifier of the parameter to change.</td>
</tr>
<tr>
<td>Option Data</td>
<td></td>
<td>Variable</td>
<td>Variable length field based on option type. If zero length, the current effective value will be returned in the response frame.</td>
</tr>
</tbody>
</table>

Options

<table>
<thead>
<tr>
<th>Option ID</th>
<th>Option Name</th>
<th>Data Type</th>
<th>Default Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x00</td>
<td>TLS Profile</td>
<td>Byte</td>
<td>0x00</td>
<td>Determines the TLS profile to be used: $0 - $2. This is valid only for TLS sockets.</td>
</tr>
</tbody>
</table>
Socket Option Response - 0xC1

Description

Reports the status of requests made with the Socket Option Request (0x41) frame.

Format

The following table provides the contents of the frame. For details on frame structure, see API frame format.

<table>
<thead>
<tr>
<th>Field name</th>
<th>Field value</th>
<th>Data type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame type</td>
<td>0xC1</td>
<td>Byte</td>
<td></td>
</tr>
<tr>
<td>Frame ID</td>
<td></td>
<td>Byte</td>
<td>Identifier provided in request.</td>
</tr>
<tr>
<td>Socket ID</td>
<td></td>
<td>Byte</td>
<td>The socket ID for which modification was requested.</td>
</tr>
<tr>
<td>Option ID</td>
<td></td>
<td>Byte</td>
<td>Identifier of the parameter requested.</td>
</tr>
<tr>
<td>Status</td>
<td></td>
<td>Byte</td>
<td>0x00: Success 0x01: Invalid parameters 0x02: Failed to retrieve option value 0x20: Bad socket ID</td>
</tr>
<tr>
<td>Option Data</td>
<td></td>
<td>Variable</td>
<td>Current effective value of the option. This field is only present if the corresponding request was a query (empty value).</td>
</tr>
</tbody>
</table>
Socket Connect - 0x42

Description

Use this frame to connect a socket to the given address and port.

For a UDP socket, this filters out any received responses that are not from the specified remote address and port.

Two frames occur in response:

1. **Socket Connect Response frame**: Arrives immediately and confirms the request.
2. **Socket Status frame**: Indicates if the connection was successful.

Format

The following table provides the contents of the frame. For details on frame structure, see [API frame format](#).

<table>
<thead>
<tr>
<th>Field name</th>
<th>Field value</th>
<th>Data type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame type</td>
<td>0x42</td>
<td>Byte</td>
<td></td>
</tr>
<tr>
<td>Frame ID</td>
<td></td>
<td>Byte</td>
<td>A reference identifier used to match status responses. If set to 0, the device does not send a response.</td>
</tr>
<tr>
<td>Socket ID</td>
<td></td>
<td>Byte</td>
<td>ID of the socket to connect.</td>
</tr>
<tr>
<td>Destination port</td>
<td></td>
<td>16-bit big endian</td>
<td></td>
</tr>
<tr>
<td>Destination address type</td>
<td></td>
<td>Byte</td>
<td>0: Indicates the destination address field is a binary IPv4 address in network byte order. 1: Indicates the destination address field is a string containing either a dotted quad value or a domain name to be resolved.</td>
</tr>
<tr>
<td>Destination address</td>
<td></td>
<td>Variable</td>
<td></td>
</tr>
</tbody>
</table>
Socket Connect Response - 0xC2

Description
The device sends this frame in response to a Socket Connect (0x42) frame. The frame contains a status regarding the initiation of the connect.

Format
The following table provides the contents of the frame. For details on frame structure, see API frame format.

<table>
<thead>
<tr>
<th>Field name</th>
<th>Field value</th>
<th>Data type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame type</td>
<td>0xC2</td>
<td>Byte</td>
<td></td>
</tr>
<tr>
<td>Frame ID</td>
<td></td>
<td>Byte</td>
<td>A reference identifier used to match status responses.</td>
</tr>
<tr>
<td>Socket ID</td>
<td></td>
<td>Byte</td>
<td>ID of the socket that will be connected.</td>
</tr>
<tr>
<td>Status</td>
<td></td>
<td>Byte</td>
<td>Status code. See the table below.</td>
</tr>
</tbody>
</table>

The following table shows the status codes.

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x00</td>
<td>Successfully started the connection process</td>
</tr>
<tr>
<td>0x01</td>
<td>Invalid destination address type</td>
</tr>
<tr>
<td>0x02</td>
<td>Invalid parameter: address or port</td>
</tr>
<tr>
<td>0x03</td>
<td>Connection already in progress</td>
</tr>
<tr>
<td>0x04</td>
<td>Already connected</td>
</tr>
<tr>
<td>0x05</td>
<td>Unknown error</td>
</tr>
<tr>
<td>0x20</td>
<td>Invalid socket ID</td>
</tr>
</tbody>
</table>
Socket Close - 0x43

Description
Use this frame to close an Extended API socket with a specified Socket ID or to close all currently open Extended API sockets.

Format
The following table provides the contents of the frame. For details on frame structure, see API frame format.

<table>
<thead>
<tr>
<th>Field name</th>
<th>Field value</th>
<th>Data type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame type</td>
<td>0x43</td>
<td>Byte</td>
<td></td>
</tr>
<tr>
<td>Frame ID</td>
<td></td>
<td>Byte</td>
<td>A reference identifier used to match status responses. If set to 0, the device does not send a response.</td>
</tr>
</tbody>
</table>
| Socket ID  |             | Byte      | The following options can be used:  
- ID of the socket to be closed.  
- 0xFF: Close all Extended API sockets that are currently open. |
Socket Close Response - 0xC3

Description
The device sends this frame in response to a Socket Connect (0x43) frame. Since a close will always succeed for a socket that exists, the status can be only one of two values: Success or Bad socket ID.

Format
The following table provides the contents of the frame. For details on frame structure, see API frame format.

<table>
<thead>
<tr>
<th>Field name</th>
<th>Field value</th>
<th>Data type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame type</td>
<td>0xC3</td>
<td>Byte</td>
<td></td>
</tr>
<tr>
<td>Frame ID</td>
<td>Byte</td>
<td>A reference identifier used to match status responses.</td>
<td></td>
</tr>
<tr>
<td>Socket ID</td>
<td>Byte</td>
<td>ID of the socket that has been closed.</td>
<td></td>
</tr>
<tr>
<td>Status</td>
<td>Byte</td>
<td>0x00 = Success 0x20 = Bad socket ID</td>
<td></td>
</tr>
</tbody>
</table>
Socket Send (Transmit) - 0x44

Description
A Socket Send message causes the device to transmit data using the current connection. For a non-zero frame ID, this will elicit a Transmit (TX) Status - 0x89 frame.

This frame requires a successful Socket Connect - 0x42 frame first. For a socket that is not connected, the device responds with a Transmit (TX) Status - 0x89 frame with an error. To send data from a UDP socket that is not connect, use a Socket SendTo - 0x45 frame.

Format
The following table provides the contents of the frame. For details on frame structure, see API frame format.

<table>
<thead>
<tr>
<th>Field name</th>
<th>Field value</th>
<th>Data type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame type</td>
<td>0x44</td>
<td>Byte</td>
<td></td>
</tr>
<tr>
<td>Frame ID</td>
<td></td>
<td>Byte</td>
<td>A reference identifier used to match status responses. If set to 0, the Transmit (TX) Status - 0x89 frame is disabled.</td>
</tr>
<tr>
<td>Socket ID</td>
<td></td>
<td>Byte</td>
<td>ID of the socket to send on.</td>
</tr>
<tr>
<td>Transmit options</td>
<td></td>
<td>Byte bit-field</td>
<td>Reserved</td>
</tr>
<tr>
<td>Payload</td>
<td></td>
<td>Variable</td>
<td>Data to be transferred to the destination, up to 1500 bytes.</td>
</tr>
</tbody>
</table>
Socket SendTo (Transmit Explicit Data): IPv4 - 0x45

Description
A Socket SendTo (Transmit Explicit Data) message causes the device to transmit data using an IPv4 address and port. For a non-zero frame ID, this will elicit a Transmit (TX) Status - 0x89 frame. If this frame is used with a TCP, SSL, or a connected UDP socket, the address and port fields are ignored.

You must perform a Socket Bind/Listen - 0x46 frame for a UDP connection before you attempt a SendTo in order to assign a source port.

Format
The following table provides the contents of the frame. For details on frame structure, see API frame format.

<table>
<thead>
<tr>
<th>Field name</th>
<th>Field value</th>
<th>Data type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame type</td>
<td>0x45</td>
<td>Byte</td>
<td></td>
</tr>
<tr>
<td>Frame ID</td>
<td></td>
<td>Byte</td>
<td>A reference identifier used to match status responses. If set to 0, the Transmit (TX) Status - 0x89 frame is disabled.</td>
</tr>
<tr>
<td>Socket ID</td>
<td></td>
<td>Byte</td>
<td>ID of the socket to send on.</td>
</tr>
<tr>
<td>Destination address</td>
<td></td>
<td>32-bit big endian</td>
<td></td>
</tr>
<tr>
<td>Destination port</td>
<td></td>
<td>16-bit big endian</td>
<td></td>
</tr>
<tr>
<td>Transmit options</td>
<td></td>
<td>Byte bit-field</td>
<td>Reserved</td>
</tr>
<tr>
<td>Payload</td>
<td></td>
<td>Variable</td>
<td>Data to be transferred to the destination, up to 1500 bytes.</td>
</tr>
</tbody>
</table>
Socket Bind/Listen - 0x46

Description

Opens a listener socket that listens for incoming connections.

When there is an incoming connection on the listener socket, a Socket New IPv4 Client - 0xCC frame is sent, indicating the socket ID for the new connection along with the remote address information.

For a UDP socket, this frame binds the socket to a given port. A bound UDP socket can receive data with a Socket Receive From: IPv4 - 0xCE frame.

Format

The following table provides the contents of the frame. For details on frame structure, see API frame format.

<table>
<thead>
<tr>
<th>Field name</th>
<th>Field value</th>
<th>Data type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame type</td>
<td>0x46</td>
<td>Byte</td>
<td></td>
</tr>
<tr>
<td>Frame ID</td>
<td></td>
<td>Byte</td>
<td>A reference identifier used to match status responses. If set to 0, the device does not send a response.</td>
</tr>
<tr>
<td>Socket ID</td>
<td></td>
<td>Byte</td>
<td>The socket ID to listen on.</td>
</tr>
<tr>
<td>Source port</td>
<td></td>
<td>16-bit big endian</td>
<td>The port to listen on.</td>
</tr>
</tbody>
</table>
Socket Listen Response - 0xC6

Description
The device sends this frame in response to a Socket Bind/Listen (0x46) frame.

Format
The following table provides the contents of the frame. For details on frame structure, see API frame format.

<table>
<thead>
<tr>
<th>Field name</th>
<th>Field value</th>
<th>Data type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame type</td>
<td>0xC6</td>
<td>Byte</td>
<td></td>
</tr>
<tr>
<td>Frame ID</td>
<td></td>
<td>Byte</td>
<td>Resource identifier used to match status responses.</td>
</tr>
<tr>
<td>Socket ID</td>
<td></td>
<td>Byte</td>
<td>The socket ID of the socket that has started listening.</td>
</tr>
<tr>
<td>Status</td>
<td></td>
<td>Byte</td>
<td>Status code. See table below.</td>
</tr>
</tbody>
</table>

The following table shows the status codes.

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x00</td>
<td>Success</td>
</tr>
<tr>
<td>0x01</td>
<td>Invalid port</td>
</tr>
<tr>
<td>0x02</td>
<td>Error</td>
</tr>
<tr>
<td>0x03</td>
<td>Already bound or listening</td>
</tr>
<tr>
<td>0x20</td>
<td>Invalid socket ID</td>
</tr>
</tbody>
</table>
Socket New IPv4 Client - 0xCC

Description
The XBee Cellular modem generates this frame when an incoming connection is accepted on a listener socket.
This frame contains the original listener's socket ID and a new socket ID of the incoming connection, along with the connection's remote address information.

Format
The following table provides the contents of the frame. For details on frame structure, see API frame format.

<table>
<thead>
<tr>
<th>Field name</th>
<th>Field value</th>
<th>Data type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame type</td>
<td>0xCC</td>
<td>Byte</td>
<td></td>
</tr>
<tr>
<td>Socket ID</td>
<td></td>
<td>Byte</td>
<td>The socket ID of the listener socket.</td>
</tr>
<tr>
<td>Client Socket ID</td>
<td></td>
<td>Byte</td>
<td>The socket ID of the new connection.</td>
</tr>
<tr>
<td>Remote address</td>
<td></td>
<td>32-bit big endian</td>
<td></td>
</tr>
<tr>
<td>Remote port</td>
<td></td>
<td>16-bit big endian</td>
<td></td>
</tr>
</tbody>
</table>
Socket Receive - 0xCD

Description
The XBee Cellular modem uses this frame when it receives RF data on the specified socket.

Format
The following table provides the contents of the frame. For details on frame structure, see API frame format.

<table>
<thead>
<tr>
<th>Field name</th>
<th>Field value</th>
<th>Data type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame type</td>
<td>0xCD</td>
<td>Byte</td>
<td></td>
</tr>
<tr>
<td>Frame ID</td>
<td></td>
<td>Byte</td>
<td>(Optional) This field allows for solicited reads to be in the future.</td>
</tr>
<tr>
<td>Socket ID</td>
<td></td>
<td>Byte</td>
<td>ID of the socket that the data has been received on.</td>
</tr>
<tr>
<td>Status</td>
<td></td>
<td>Byte bit-field</td>
<td>Reserved</td>
</tr>
<tr>
<td>Payload</td>
<td></td>
<td>Variable</td>
<td>Data received from the destination. It may be up to 1500 bytes.</td>
</tr>
</tbody>
</table>
Socket Receive From: IPv4 - 0xCE

Description
The XBee cellular modem uses this frame when it receives RF data on the specified socket. This frame is sent only for UDP sockets that have not used a Socket Connect - 0x42 frame to connect, providing addressing information about the source.

Format
The following table provides the contents of the frame. For details on frame structure, see API frame format.

<table>
<thead>
<tr>
<th>Field name</th>
<th>Field value</th>
<th>Data type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame type</td>
<td>0xCE</td>
<td>Byte</td>
<td></td>
</tr>
<tr>
<td>Frame ID</td>
<td></td>
<td>Byte</td>
<td>Optional: This field allows for solicited reads to be in the future.</td>
</tr>
<tr>
<td>Socket ID</td>
<td></td>
<td>Byte</td>
<td>ID of the socket that the data has been received on.</td>
</tr>
<tr>
<td>Source address</td>
<td></td>
<td>32-bit big endian</td>
<td></td>
</tr>
<tr>
<td>Source port</td>
<td></td>
<td>16-bit big endian</td>
<td></td>
</tr>
<tr>
<td>Status</td>
<td></td>
<td>Byte bit-field</td>
<td>Reserved</td>
</tr>
<tr>
<td>Payload</td>
<td></td>
<td>Variable</td>
<td>Data to be transferred to the destination, up to 1500 bytes.</td>
</tr>
</tbody>
</table>
Socket Status - 0xCF

Description
This frame is sent out the device's serial port to indicate the state related to the socket.

Format
The following table provides the contents of the frame. For details on frame structure, see API frame format.

<table>
<thead>
<tr>
<th>Field name</th>
<th>Size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame type</td>
<td>1</td>
<td>Socket Status frame type (0xCF)</td>
</tr>
<tr>
<td>Socket ID</td>
<td>1</td>
<td>Socket ID for status reported</td>
</tr>
</tbody>
</table>
| Status     | 1    | 0x00 = Connected  
All values other than 0x00 = Connected are fatal and the Socket ID is closed and invalid after receipt.  
0x01 = Failed DNS lookup  
0x02 = Connection refused  
0x03 = Transport closed  
0x04 = Timed out  
0x05 = Internal error  
0x06 = Host unreachable  
0x07 = Connection lost  
0x08 = Unknown error  
0x09 = Unknown server  
0x0A = Resource error |
Troubleshooting

This section contains troubleshooting steps for the XBee Smart Modem.

Cannot find the serial port for the device .......................................................... 283
Correct a macOS Java error .................................................................................. 285
Unresponsive cellular component in Bypass mode ............................................... 286
Syntax error at line 1 ............................................................................................ 286
Error Failed to send SMS .................................................................................... 286
Network connection issues ................................................................................. 287
Brownout issue .................................................................................................... 287
Hardware flow control in Bypass mode ............................................................... 288
Baud rate in Bypass mode .................................................................................... 288
Socket leaks ......................................................................................................... 288
Cannot find the serial port for the device

Condition
In XCTU, the serial port that your device is connected to does not appear.

Solution
1. Click the Discover radio modules button.
2. Select all of the ports to be scanned.
3. Click Next and then Finish. A dialog notifies you of the devices discovered and their details.
4. Remove the development board from the USB port and view which port name no longer appears in the Discover radio devices list of ports. The port name that no longer appears is the correct port for the development board.
Troubleshooting

Cannot find the serial port for the device

Other possible issues

Other reasons that the XBee Smart Modem is not discoverable include:

1. If you accidentally have the loopback pins jumpered.
2. You may not have a driver installed. If you do not have a driver installed, the item will have an exclamation point icon next to it in the Windows Device Manager.
3. You may not be using an updated FTDI driver.
   a. Click here to download the drivers for your operating system.
   b. This may require you to reboot your computer.
   c. Disconnect the power and USB from the XBIB-U-DEV board and reconnect it.
4. If you have a driver installed and updated but still have issues, on Windows 10 you may have to enable VCP on the driver; see Enable Virtual COM port (VCP) on the driver.

Enable Virtual COM port (VCP) on the driver

On Windows 10 computers, if XCTU does not see the devices you have attached to a PC, you may need to enable VCP on the USB driver.

To enable VCP:

1. Click the Search button.
2. Type Device Manager to search for it.
3. Click Universal Serial Bus controllers.
4. If it displays more than one USB controller, unplug the XBee Smart Modem and plug it back in to make sure you choose the correct one.
5. Right-click the USB controller and select Properties; a dialog displays.
6. Select the Advanced tab.
7. Check Load VCP.
8. Click OK.
9. Unplug the board and plug it back in.
Correct a macOS Java error

When you use XCTU on macOS computer, you may encounter a Java error.

**Condition**
When opening XCTU for the first time on a macOS computer, you may see the following error:

![Error Message]

**Solution**

1. Click **More info** to open a browser window.
2. Click **Download** to get the file javaforosx.dmg.
3. Double-click on the downloaded javaforosx.dmg.
4. In the dialog, double-click the JavaForOSX.pkg and follow the instructions to install Java.
Unresponsive cellular component in Bypass mode

When in Bypass mode, the XBee Smart Modem does not automatically reset or reboot the cellular component if it becomes unresponsive.

Condition

In Bypass mode, the XBee Smart Modem does not respond to commands.

Solution

1. Query the AI (Association Indication) parameter to determine whether the cellular component is connected to the XBee Smart Modem software. If AI is 0x2F, Bypass mode should work. If not, look at the status codes in AI (Association Indication) for guidance.
2. Ensure that you set DO (Device Options) bit 3 to 0 before entering Bypass mode.
3. You can send the !R (Modem Reset) command to reset only the cellular component.

Syntax error at line 1

You may get a syntax error at line 1 error after pasting example MicroPython code and pressing Ctrl+D.

Solution

This commonly happens when you accidentally type a character at the beginning of line 1 before pasting the code.

Error Failed to send SMS

In MicroPython, you consistently get Error Failed to send SMS messages.

Note For NB-IoT, SMS support is dependent on the network. Contact your network provider for details.

Solution

Your device cannot connect to the cell network. The reason may be:

1. The antenna is improperly or loosely connected.
2. The device is at a location where cellular service cannot reach. If the device is connected to the network, the red LED blinks about twice in a second. If it is not connected it does not blink; see Associate LED functionality.
3. You SIM card is out of SMS text quota.
4. The device is not getting enough current, for example if power is being supplied only by USB to the XBIB development board, rather than using an additional external power supply.
Network connection issues

Condition
The XBee Smart Modem is not joining the network, AI (Association Indication) is cycling between 0xFF (Initializing), 0x22 (Registering to Cellular Network) and 0x25 (Cellular Network Registration Denied).

Solution
Some things to check are:
- The antennas are connected correctly to the device.
- The SIM card is seated properly in the device.
- APN is set correctly.
- If you had to change a modem parameter, check to make sure you have reset the module using the FR command or by pressing the reset button, especially if you have changed settings such as CP, N#, BM, or BN.

Note The default APN configured in the kit should allow the XBee Smart Modem to get on the network with the SIM included in the kit. However, you may program the APN explicitly to 10569.mcs if you are having difficulty registering with the network.

Brownout issue
The XBee 3 RF Module uses a Silicon Labs EFR32MG System on Chip (SoC). Silicon Labs has announced an intermittent restarting issue with EFR32MG revision B SoCs which can be caused by voltage brownout or supply dips during power-on. The information below is provided to help you avoid this condition.

Voltage brownout
This issue may occur if the supply powering the XBee VCC pin dips momentarily into the range of approximately 1.2 to 1.8 V. When the supply returns to normal levels the SoC may not restart properly and enter an unresponsive state. You must fully power cycle the XBee to recover from this state. The failure rate tends to increase with slower ramp down rates of the power supply; for more details see RMU_E203 — AVDD Ramp Issue. If you keep the power supply within the operational voltage range specified in Power requirements, the conditions to cause this failure are never met.

Power-on discontinuities
This issue is similar to the voltage brownout issue. The SoC may fail to start if, during power on, the supply powering the VCC pin experiences discontinuities in the voltage rise (in other words, dips) while the voltage is in the range of approximately 1.2 to 1.8 V. You must fully power cycle the XBee Smart Modem to recover from this state. The failure rate tends to increase with slower ramp up rates of the power supply; for more details see RMU_E203 — AVDD Ramp Issue. The issue can be avoided by ramping your power supply steadily to the normal operating range.

How to distinguish revision B parts
Si)[i]licon Labs has corrected these issues in revision C of their SoC. We are printing the SoC revision on the XBee label to make it easy to distinguish. The revision letter is located on the bottom right corner
Hardware flow control in Bypass mode

Support for hardware flow control in Bypass mode is available with version L0.0.00.00.05.08,A.02.04 of the SARA-R410M cellular component. Digi recommends that you update to at least firmware version L0.0.00.00.05.08,A.02.04 of the cellular component (using a serial port or from Remote Manager) and firmware version 11414 of the XBee Smart Modem.

Note Earlier versions of the SARA-R410M firmware did not support hardware flow control. The lack of hardware flow control may lead to data loss while in Bypass operating mode during periods of high UART traffic.

Baud rate in Bypass mode

If you change the AT+IPR setting of the cellular component away from its default you will lose communication with the cellular component while in Bypass mode.

In firmware version *14 and later, the IB (Cellular Component Baud Rate) command was added to control the baud rate to the cellular component. If you change the baud rate of the cellular component using the AT+IPR setting you will need to match it with the IB setting to maintain communication.

Note Digi does not recommend using bypass mode. You should use USB Direct mode instead.

Socket leaks

This applies to devices with the u-blox SARA-R410 cellular component used in the XBee 3 Cellular LTE-M Global Smart Modem.

Condition

There are instances where a socket leaks when closing a connection while there is pending RX data. This state is reported whenever the number of leaked sockets causes an inability to create a new connection.

For Transparent and API modes the XBee Smart Modem returns specific status responses to describe that you need to perform a hard reset to recover the leaked sockets. These statuses are:
<table>
<thead>
<tr>
<th>Mode</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transparent mode</td>
<td>CI (Protocol/Connection Indication) reports <strong>0x13</strong> Socket leak</td>
</tr>
<tr>
<td>API mode</td>
<td>Transmit (TX) Status - <strong>0x89</strong> status <strong>0x32</strong> Resource error (retry operation later)</td>
</tr>
<tr>
<td>MicroPython</td>
<td>When attempting to make a connection to a server you receive <strong>errno.ENFILE (7023)</strong></td>
</tr>
</tbody>
</table>

**Solution**

To recover the leaked sockets and make them available again in all modes, you should perform a reset of the cellular component (hard or soft).
Regulatory information

United States (FCC) ................................................................. 291
Innovation, Science and Economic Development Canada (ISED) ............................. 294
CE mark (Europe) ................................................................. 295
United States (FCC)

XBee Smart Modems comply with Part 15 of the FCC rules and regulations. Compliance with the labeling requirements, FCC notices and antenna usage guidelines is required.

To fulfill FCC Certification, the OEM must comply with the following regulations:

1. The system integrator must ensure that the text on the external label provided with this device is placed on the outside of the final product.
2. RF Modules may only be used with antennas that have been tested and approved for use with the modules.

OEM labeling requirements

**WARNING!** As an Original Equipment Manufacturer (OEM) you must ensure that FCC labeling requirements are met. You must include a clearly visible label on the outside of the final product enclosure that displays the following content:

**Required FCC Label for OEM products containing the XBee 3 Cellular LTE-M RF Module**

Contains FCC ID: MCQ-XB3M1
Contains FCC ID: XPY2AGQN4NNN

The enclosed device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (i.) this device may not cause harmful interference and (ii.) this device must accept any interference received, including interference that may cause undesired operation.

FCC notices

**IMPORTANT:** XBee modules have been certified by the FCC for use with other products without any further certification (as per FCC section 2.1091). Modifications not expressly approved by Digi could void the user’s authority to operate the equipment.

**IMPORTANT:** OEMs must test final product to comply with unintentional radiators (FCC section 15.107 & 15.109) before declaring compliance of their final product to Part 15 of the FCC Rules.

**IMPORTANT:** The RF module has been certified for remote and base radio applications. If the module will be used for portable applications, the device must undergo SAR testing.

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation.

If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures: Re-orient or relocate the receiving antenna, increase the separation between the equipment and receiver, connect equipment and receiver to outlets on different circuits, or consult the dealer or an experienced radio/TV technician for help.
FCC-approved antennas

The equipment can be installed using antennas and cables constructed with non-standard connectors (RPSMA, RPTNC, and so forth) An adapter cable may be necessary to attach the XBee connector to the antenna connector.

The modules are FCC approved for fixed base station and mobile applications for the channels indicated in the tables below. If the antenna is mounted at least 25 cm from nearby persons, the application is considered a mobile application.

The antennas below have been approved for use with this module. Digi does not carry all of these antenna variants. Contact Digi Sales for available antennas.

Bluetooth antennas

The following antennas are approved for use with the Bluetooth radio.

<table>
<thead>
<tr>
<th>Part number</th>
<th>Type (description)</th>
<th>Gain</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>31000020-02</td>
<td>Integral antenna</td>
<td>-2.5 dBi</td>
<td>Fixed/Mobile</td>
</tr>
<tr>
<td>29000095</td>
<td>Dipole (Half-wave articulated RPSMA - 4.5&quot;)</td>
<td>2.1 dBi</td>
<td>Fixed/Mobile</td>
</tr>
<tr>
<td>A24-HASM-450</td>
<td>Dipole (Half-wave articulated RPSMA-4.5&quot;)</td>
<td>2.1 dBi</td>
<td>Fixed/Mobile</td>
</tr>
<tr>
<td>A24-HABSM</td>
<td>Dipole (Articulated RPSMA)</td>
<td>2.1 dBi</td>
<td>Fixed</td>
</tr>
<tr>
<td>A24-HABUF-P5I</td>
<td>Dipole (Half-wave bulkhead mount U.FL w/ 5&quot; pigtail)</td>
<td>2.1 dBi</td>
<td>Fixed</td>
</tr>
<tr>
<td>A24-HASM-525</td>
<td>Dipole (Half-wave articulated RPSMA-5.25&quot;)</td>
<td>2.1 dBi</td>
<td>Fixed/Mobile</td>
</tr>
<tr>
<td>29000812</td>
<td>Flexible PCB, U.FL w/ 200mm pigtail</td>
<td>4.4 dBi</td>
<td>Fixed/Mobile</td>
</tr>
<tr>
<td>FXP74.07.0100A</td>
<td>Flexible PCB, U.FL w/ 100mm pigtail</td>
<td>4.0 dBi</td>
<td>Fixed/Mobile</td>
</tr>
</tbody>
</table>

Cellular antennas

The gain of the system antenna (i.e. the combined transmission line, connector, cable losses and radiating element gain) must not exceed the values below for mobile and fixed or mobile operating configurations:

- 3.67 dBi in 700 MHz, i.e. LTE FDD-12 band
- 4.10 dBi in 850 MHz, i.e. LTE FDD-5 band
- 6.74 dBi in 1700 MHz, i.e. LTE FDD-4 band
- 7.12 dBi in 1900 MHz, i.e. LTE FDD-2 band

RF exposure

If you are an integrating the XBee 3 RF Module into another product, you must include the following Caution statement in OEM product manuals to alert users of FCC RF exposure compliance:

**CAUTION!** To satisfy FCC RF exposure requirements for mobile transmitting devices, a separation distance of 25 cm or more should be maintained between the antenna of this device and persons during device operation. To ensure compliance, operations at closer than this distance are not recommended. The antenna used for this transmitter must not be co-located in conjunction with any other antenna or transmitter.
FCC publication 996369 related information
In publication 996369 section D03, the FCC requires information concerning a module to be presented by OEM manufacturers. This section assists in answering or fulfilling these requirements.

2.1 General
No requirements are associated with this section.

2.2 List of applicable FCC rules
This module conforms to FCC Parts 27(cellular).

2.3 Summarize the specific operational use conditions
Certain approved antennas require attenuation for operation. For the XBee Smart Modem, see FCC-approved antennas.
Host product user guides should include the antenna table if end customers are permitted to select antennas.

2.4 Limited module procedures
Not applicable.

2.5 Trace antenna designs
While it is possible to build a trace antenna into the host PCB, this requires at least a Class II permissive change to the FCC grant which includes significant extra testing and cost. If an embedded trace or chip antenna is desired contact a Digi sales representative for information on how to engage with a lab to get the modified FCC grant.

2.6 RF exposure considerations
For RF exposure considerations see RF exposure.
Host product manufacturers need to provide end-users a copy of the “RF Exposure” section of the manual: RF exposure.

2.7 Antennas
A list of approved antennas is provided for the XBee Smart Modem. See FCC-approved antennas.

2.8 Label and compliance information
Host product manufacturers need to follow the sticker guidelines outlined in OEM labeling requirements.

2.9 Information on test modes and additional testing requirements
Contact a sales representative for information on how to configure test modes for the XBee Smart Modem.

2.10 Additional testing, Part 15 Subpart B disclaimer
All final host products must be tested to be compliant to FCC Part 15 Subpart B standards. While the XBee Smart Modem was tested to be complaint to FCC unintentional radiator standards, FCC Part 15 Subpart B compliance testing is still required for the final host product. This testing is required for all
end products, and XBee Smart Modem Part 15 Subpart B compliance does not affirm the end product’s compliance.
See FCC notices.

Innovation, Science and Economic Development Canada (ISED)

Labeling requirements
Labeling requirements for Industry Canada are similar to those of the FCC. A clearly visible label on the outside of the final product enclosure must display the following text.
Contains IC: 1846A-XB3M1
Contains IC: 8595A-2AGQN4NNN
The integrator is responsible for its product to comply with IC ICES-003 & FCC Part 15, Sub. B - Unintentional Radiators. ICES-003 is the same as FCC Part 15 Sub. B and Industry Canada accepts FCC test report or CISPR 22 test report for compliance with ICES-003.
This device complies with Industry Canada licence-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.
Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

RF Exposure

CAUTION! This equipment is approved for mobile and base station transmitting devices only. Antenna(s) used for this transmitter must be installed to provide a separation distance of at least 25 cm from all persons and must not be co-located or operating in conjunction with any other antenna or transmitter.

ATTENTION! Cet équipement est approuvé pour la mobile et la station base dispositifs d'émission seulement. Antenne(s) utilisé pour cet émetteur doit être installé pour fournir une distance de séparation d'au moins 25 cm à partir de toutes les personnes et ne doit pas être situé ou fonctionner en conjonction avec tout autre antenne ou émetteur.

Transmitters with Detachable Antennas
This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in FCC-approved antennas with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.
Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés ci-dessous et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur.
Detachable Antenna

Under Industry Canada regulations, this radio transmitter may operate using only an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (EIRP) is not more than that necessary for successful communication.

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante.

CE mark (Europe)

The XBee is certified for use in several European countries. For information, visit www.digi.com/resources/certifications.

If the XBee is incorporated into a product, the manufacturer must ensure compliance of the final product with articles 3.1a and 3.1b of the RE Directive (Radio Equipment Directive). A Declaration of Conformity must be issued for each of these standards and kept on file as described in the RE Directive (Radio Equipment Directive).

Furthermore, the manufacturer must maintain a copy of the XBee user manual documentation and ensure the final product does not exceed the specified power ratings, antenna specifications, and/or installation requirements as specified in the user manual. If any of these specifications are exceeded in the final product, a submission must be made to a notified body for compliance testing to all required standards.

OEM labeling requirements
The CE marking must be affixed to a visible location on the OEM product.

CE labeling requirements

The CE mark shall consist of the initials “CE” taking the following form:
If the CE marking is reduced or enlarged, the proportions given in the above graduated drawing must be respected.

- The CE marking must have a height of at least 5mm except where this is not possible on account of the nature of the apparatus.

- The CE marking must be affixed visibly, legibly, and indelibly.