



# ConnectCore® 8M Mini Performance and Power Benchmarking Report

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## Application Note

## Revision history—90002465

| Revision | Date        | Description      |
|----------|-------------|------------------|
| A        | August 2021 | Initial release. |

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# Contents

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## Introduction

## Power architecture

|                              |   |
|------------------------------|---|
| Primary input supplies ..... | 6 |
| VSYS and VSYS2 .....         | 6 |
| VCC_MCA .....                | 7 |
| PMIC output supplies .....   | 7 |

## Measurement conditions

|                                  |    |
|----------------------------------|----|
| Hardware used .....              | 8  |
| Software used .....              | 8  |
| Digi Embedded Yocto .....        | 8  |
| MCA firmware .....               | 8  |
| Benchmark packages .....         | 8  |
| Host requirements .....          | 9  |
| General conditions .....         | 9  |
| Location and environment .....   | 9  |
| Instrumentation .....            | 10 |
| SOM power measurements .....     | 10 |
| How to calculate SOM power ..... | 10 |
| Console cable .....              | 10 |
| Measure points .....             | 10 |
| Formula .....                    | 11 |

## Use cases

|                       |    |
|-----------------------|----|
| Low-power modes ..... | 12 |
| Power-off .....       | 12 |
| Suspend to RAM .....  | 12 |
| System idle .....     | 13 |
| Active modes .....    | 13 |

## Performance tests

|                |    |
|----------------|----|
| CPU .....      | 14 |
| CoreMark ..... | 14 |
| Memory .....   | 14 |

|  |    |
|--|----|
| perf-bench .....                           | 14 |
| eMMC .....                                 | 15 |
| IOzone3 .....                              | 15 |
| USB .....                                  | 15 |
| IOzone3 .....                              | 15 |
| Ethernet .....                             | 16 |
| Environment conditions .....               | 16 |
| iPerf3 .....                               | 16 |
| FTP .....                                  | 17 |
| Wi-Fi .....                                | 18 |
| Environment conditions .....               | 18 |
| iPerf3 .....                               | 18 |
| Setup .....                                | 18 |
| FTP .....                                  | 19 |
| GPU .....                                  | 20 |
| Environment conditions .....               | 20 |
| Glmark2 .....                              | 20 |
| VPU .....                                  | 20 |
| Environment conditions .....               | 20 |
| Gstreamer video playback (decoding) .....  | 21 |
| Gstreamer video recording (encoding) ..... | 21 |
| Audio .....                                | 22 |
| Environment conditions .....               | 22 |
| Audio playback .....                       | 22 |
| Audio recording .....                      | 22 |

## Additional information

## Introduction

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This document characterizes power consumption and performance for the ConnectCore 8M Mini SOM. It includes detailed measurements representing a variety of use cases and includes performance tests for key interfaces, including CPU, memory, Wi-Fi, and video and audio playback.

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**Note** This information is provided as a reference on the capabilities of the ConnectCore 8M Mini platform. You may see different figures due to software or other factors.

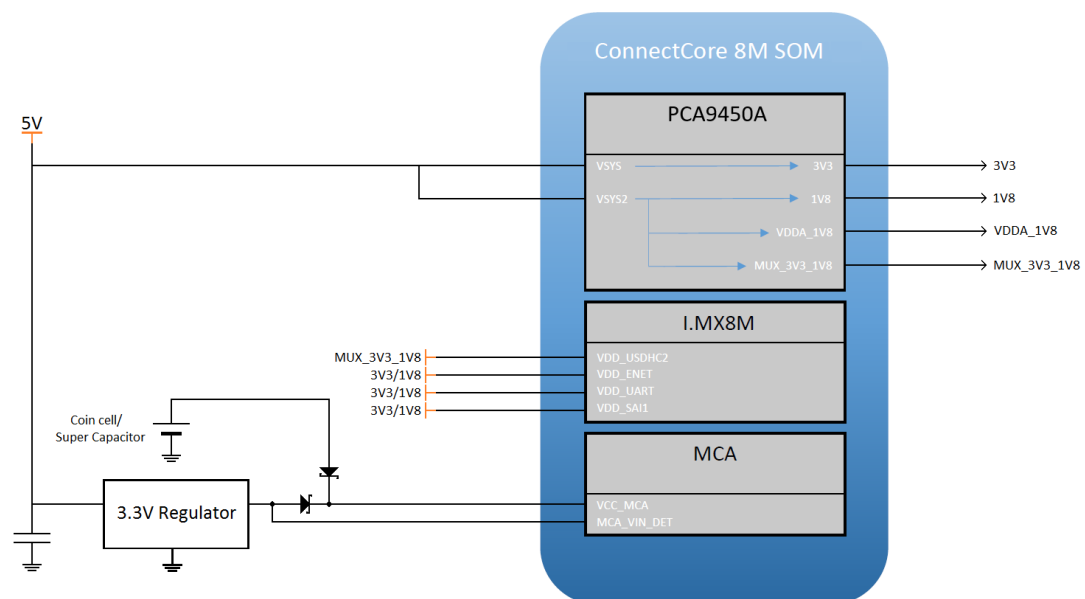
---

## Power architecture

The following diagram represents the full power architecture distribution of the ConnectCore 8M Mini module with its three main components:

- The PCA9450 PMIC
- The iMX8M SOC
- The Micro Controller Assist (MCA)

The following diagram shows a typical application:



## Primary input supplies

The ConnectCore 8M Mini requires three primary power supply inputs:

- VSYS
- VSYS2
- VCC\_MCA

### VSYS and VSYS2

VSYS and VSYS2 are the input power supplies to the on-module NXP PCA9450A Power Management IC (PMIC), as well as to most of its regulators.

Some PMIC regulators are internally dedicated to powering the module, while others power external circuitry.

## VCC\_MCA

VCC\_MCA is the input power supply of the on-module Digi Microcontroller Assist (MCA).

## PMIC output supplies

The PMIC generates many power rails. Most are used internally in the SOM and some are also used externally:

| PMIC power rails | Comments                        | Used internally | Used externally |
|------------------|---------------------------------|-----------------|-----------------|
| 1V8              | General purpose 1.8V power rail | Yes             | Yes             |
| 3V3              | General purpose 3.3V power rail | Yes             | Yes             |
| VDDA_1V8         |                                 | Yes             | No              |
| MUX_3V3/1V8      |                                 | Yes             | No              |

## Measurement conditions

---

**Note** The power consumption and performance figures described in this document were measured using Yocto Linux. Performance figures on systems running Android may differ.

---

## Hardware used

The following hardware was used for the measurements:

- ConnectCore 8M Mini SOM
  - Variant 0x03: ConnectCore 8M Mini Industrial Quad 1.6GHz, 8GB eMMC, 2GB LPDDR4, -40/+85C, Wireless, Bluetooth
  - PN: 55002095-03
- ConnectCore 8M Mini DVK
  - Hardware version: 30016232-02

## Software used

### Digi Embedded Yocto

The software used on the devices is the pre-built installer binary image for Digi Embedded Yocto 3.0-r4.1 release, available on the [Digi support site](#) (md5sum: 951fe72339c750c93b59b783221cafe1).

To install the firmware, visit the [documentation portal for your platform](#) and follow the Get Started documentation.

After installing the firmware you can run **sysinfo** to verify the component versions:

| Component | Version                      |
|-----------|------------------------------|
| U-Boot    | dub-2020.04-r3.1+g749d90196c |
| Firmware  | dey-3.0-r4-20210308172617    |
| Kernel    | 5.4.84-dey+g6f752f9e395c     |

### MCA firmware

The firmware version used on the SOM during the tests is 1.01.

See the [documentation](#) for information on programming the MCA firmware.

### Benchmark packages

A few additional packages with benchmark tools have been built and must be installed on the device after programming the firmware. Download these tools from the [Digi FTP server](#).



| Package   | Description  |
|-----------|--|
| coreutils | A set of system commands with more extended options than the ones in Busybox |
| coremark  | CPU benchmark application (executable binary).                               |
| glmark2   | GPU benchmark application.   |
| iozone3   | File system benchmark application.   |
| iperf3    | Network interfaces benchmark application.                                    |

Copy pre-built binary **coremark** directly to **/usr/sbin** on the target and give the application execution permissions.

---

```
~# chmod 755 /usr/sbin/coremark
```

---

To install RPM packages on the device, transfer the files to the target and then run for each package:

---

```
~# rpm -i <filename.rpm>
```

---

## Host requirements

For the network tests your host system needs to have the **iperf3** tool. To install it:

---

```
~$ sudo apt-get install iperf3
```

---

## General conditions

### Location and environment

The power consumption and benchmark tests have been carried out at room temperature of 22°C, 30% humidity.

The target sits on a table with no enclosure.

## Instrumentation

The following instruments were used during the tests:

| Qty | Instrument             | Model                   | Details |
|-----|------------------------|-------------------------|---------|
| 1   | Regulated power supply | RIGOL DP832             | 5V / 3A |
| 1   | Multimeter             | FLUKE 8846A 6-1/2 Digit |         |
| 3   | Multimeter             | FLUKE 289 True RMS      |         |

## SOM power measurements

### How to calculate SOM power

As depicted in the [Power architecture](#) diagram, current flows **into** the SOM through VSYS, VSYS2, and VCC\_MCA.

The power provided by the SOM to the carrier board peripherals through the 1V8\_EXT and 3V3\_EXT power rails is application-specific and has been subtracted from the total input power to estimate the power consumed solely by the SOM.

### Console cable

The FTDI chip of the USB console cable introduces undesired voltage feedback to the CPU through the data lines. It must be disconnected to get accurate power measurements.

### Measure points

The ConnectCore 8M Mini DVK has several 0-ohm resistors for the purpose of power consumption calculations. Some headers (not populated by default) are added to make measurements easier to perform:

- Remove R28 and populate J6. Connect an ammeter to measure the current flowing **in** through VSYS and VSYS2. Measure the voltage at this point too (~5V) to calculate the power more accurately.
- Remove R31 and populate J7. Connect an ammeter to measure the current flowing **out** through 3V3\_EXT. Measure the voltage at this point too (~3.3V) to calculate the power more accurately.
- Remove R32 and populate J8. Connect an ammeter to measure the current flowing **out** through 1V8\_EXT. Measure the voltage at this point too (~1.8V) to calculate the power more accurately.
- Remove R13 and populate J3. Connect an ammeter to measure the current flowing **in** through VCC\_MCA. Measure the voltage at this point too (~3.3V) to calculate the power more accurately.

| Power | Measuring point | Power rail   | Voltage | Direction with respect to SOM |
|-------|-----------------|--------------|---------|-------------------------------|
| P1    | R1              | VSYS + VSYS2 | 5V      | In                            |

| Power | Measuring point | Power rail | Voltage | Direction with respect to SOM |
|-------|-----------------|------------|---------|-------------------------------|
| P2    | R2              | EXT_3V3    | 3.3V    | Out                           |
| P3    | R3              | EXT_1V8    | 1.8V    | Out                           |
| P4    | R31             | VCC_MCA    | 3.3V    | In                            |

## Formula

SOM power can be estimated as  $P1 - P2 - P3 + P4$ .

This is the closest estimation you can measure on the ConnectCore 8M Mini SBC Pro. Note that part of EXT\_1V8 power rail is routed back to the SOM to power some additional domains of the SOC (VDD\_ENET0 and VDD\_ESAI\_SPDIF).

## Use cases

---

Digi measured power consumption of the ConnectCore 8M Mini SOM in the following use cases:

- Low-power modes
  - Power-off
  - Suspend to RAM
  - System idle
- Active modes (I/O, video, audio, camera, network interfaces)

---

**Note** This chapter presents the power measurements for the low-power modes.

The next section, containing the performance benchmarks for different tests, presents the power measurements for the active modes beside each benchmark score.

---

## Low-power modes

### Power-off

To enter power-off mode, press the ON/OFF button of the carrier board for more than two seconds, or run:

---

```
~# poweroff
```

---

In this mode only the MCA is powered, which maintains the MCA RTC and other low-power functionality of the MCA such as wake-up interrupts (ADC, tamper, keypad, etc.).

| SOM variant | SOM power |
|-------------|-----------|
| Quad        | 1 mW      |

### Suspend to RAM

To enter standby mode, press the ON/OFF button of the carrier board once, or run:

---

```
~# standby
```

---

In this mode, the system suspends to RAM and operation can be resumed without doing a new boot cycle. RAM memory is in self-refresh mode.

| SOM variant | SOM power |
|-------------|-----------|
| Quad        | 25.85 mW  |

## System idle

In this use case, the system is running Digi Embedded Yocto graphical image with standard daemons and a graphical desktop.

| SOM variant | SOM power |
|-------------|-----------|
| Quad        | 970 mW    |

## Active modes

The [Performance tests](#) section, containing the performance benchmarks for different tests, presents the power measurements for active modes beside each benchmark score.

## Performance tests

---

### CPU

#### CoreMark

CoreMark is a benchmark tool specifically designed to test the functionality of a processor core. The test produces a single-number score in iterations per second.

#### Command

---

```
~# coremark
```

---

#### Results

| Test     | SOM variant | Score        | Metric  | SOM power | SOM temp |
|----------|-------------|--------------|---------|-----------|----------|
| CoreMark | Quad        | <b>25012</b> | iter./s | 2601 mW   | 55 °C    |

### Memory

#### perf-bench

**perf-bench** is a tool used to exercise and benchmark the RAM of the SOM.

#### Command: *memset*

---

```
~# perf bench -f simple mem memset -s 200MB
```

---

#### Command: *memcpy*

---

```
~# perf bench -f simple mem memcpy -s 200MB
```

---

#### Results

| Test       | SOM variant | LPDDR4 in SOM                            | Operation | Score | Metric | SOM power | SOM temp |
|------------|-------------|--|-----------|-------|--------|-----------|----------|
| perf-bench | Quad        | SMIC 2GB LPDDR4 1.1V 32 bits<br>1600 MHz | memset    | 8772  | MB/s   | 2511 mW   | 50 °C    |

| Test | SOM variant | LPDDR4 in SOM | Operation | Score | Metric | SOM power | SOM temp |
|------|-------------|---------------|-----------|-------|--------|-----------|----------|
|      |             |               | memcpy    | 1886  | MB/s   | 2838 mW   | 50 °C    |

## eMMC

### IOzone3

IOzone3 is a file system benchmark tool that generates and measures a variety of file operations. The following test measures the file system performance on eMMC (vfat) media.

```
~# cd <mount-point-of-test-media>
~# iozone -i 0 -i 1 -b /tmp/iozone.xls -r 128k -s 2G -l 1 -u 1
```

The test:

- Runs write/rewrite (-i 0)
- Runs read/reread (-i 1)
- Uses a record size of 128k (-r 128 k)
- Uses a file size of 2 GB (-s 2 G)
- Runs on a single core (-u 1)

### Results

| Test    | Media | SOM Variant | Media model          | Operation | Score | Metric | SOM power | SOM temp |
|---------|-------|-------------|----------------------|-----------|-------|--------|-----------|----------|
| IOzone3 | eMMC  | Quad        | SMIC 8GB eMMC BGA153 | Read      | 157   | MB/s   | 1652 mW   | 48 °C    |
|         |       |             |                      | Write     | 23    | MB/s   |           |          |

## USB

### IOzone3

IOzone3 is a file system benchmark tool that generates and measures a variety of file operations. The following test measures the file system performance on USB 2.0 (vfat).

**Command**


---

```
~# cd <mount-point-of-test-media>
~# iotzone -i 0 -i 1 -b /tmp/iotzone.xls -r 128k -s 2G -l 1 -u 1
```

---

The test:

- Runs write/rewrite (-i 0)
- Runs read/reread (-i 1)
- Uses a record size of 128k (-r 128 k)
- Uses a file size of 2 GB (-s 2 G)
- Runs on a single core (-u 1)

**Results**

| Test    | SOM Variant | Media model                                       | Operation | Score | Metric | SOM power  | SOM temp |
|---------|-------------|---|-----------|-------|--------|------------|----------|
| IOzone3 | Quad        | Transcend Information, Inc.<br>JetFlash 16 GB 2.0 | Read      | 15    | MB/s   | 1657<br>mW | 48 °C    |

## Ethernet

**Environment conditions**

- Ethernet cable: 3 m CAT6 patch cable
- Gigabit switch model: D-Link DGS-108
- 10/100 switch model: D-Link DES-1008D

**iPerf3**

iPerf3 is a tool for active measurements of the maximum achievable bandwidth on IP networks.

**Command (host)**


---

```
~# iperf3 -s
```

---

**Command (target)**


---

```
~# iperf3 -c <server ip>
```

---



## Results

| Test   | SOM variant | Interface | Network | Score send/receive | Metric    | SOM power | SOM temp |
|--------|-------------|-----------|---------|--------------------|-----------|-----------|----------|
| iPerf3 | Quad        | ETH1      | Gigabit | 939/937            | Mbits/sec | 1664 mW   | 47 °C    |
|        |             |           | 10/100  | 95/94              | Mbits/sec | 1485 mW   | 47 °C    |

## FTP

FTP is a protocol for file transfer over the network.

### Command (target)

On the target side, allow access to user **root** (forbidden by default):

```
~# sed /root/d -i /etc/vsftpd.ftpusers
```

Generate a 1 GB file with random data.

```
~# dd bs=1M count=1024 if=/dev/urandom of=testfile && sync
```

### Command (host): GET

On the host side, connect to the target via FTP (user: root, pass: root) and get the file:

```
~$ ftp -p <target_ip_address>
ftp> get testfile
```

### Command (host): PUT

Send the file to the target

```
ftp> put testfile
```

## Results

| Test   | SOM variant | Network | Operation            | Score | Metric | SOM power | SOM temp |
|--------|-------------|---------|----------------------|-------|--------|-----------|----------|
| iPerf3 | Quad        | Gigabit | GET (target to host) | 107   | MB/s   | 1619 mW   | 48 °C    |
|        |             |         | PUT (host to target) | 27    | MB/s   | 1905 mW   | 48 °C    |
|        |             | 10/100  | GET (target to host) | 11    | MB/s   | 1357 mW   | 46 °C    |
|        |             |         | PUT (host to target) | 10    | MB/s   | 1342 mW   | 46 °C    |

## Wi-Fi

### Environment conditions

- Dual band antennas connected to both U.FL connectors
- Access point model: NETGEAR Nighthawk X6 R8000
- Distance from target to access point: 2 m (with no obstacles in between)

### iPerf3

iPerf3 is a tool for active measurements of the maximum achievable bandwidth on IP networks.

**Note** Wi-Fi performance is subject to many variables which are difficult or impossible to control, such as the electromagnetic radiation present in the place where the test is carried out, the channel used for the test, etc.

This test was not performed in an isolated chamber.

### Setup

To measure the performance of the wireless interface, Digi set up two scenarios: one with the target working in station mode (the target is connected to an access point), and other scenario as AP (the target is acting as an access point)

#### **Station**

The target is connected to an access point. The setup requires an auxiliary device (host) connected to the same network as the access point. Ideally, the auxiliary device is connected to the access point using a Cat6 cable.

#### **Soft-AP**

The target is acting like an access point. This setup requires an auxiliary device connected to the network created by the target. A mobile phone with the 5GHz band can be used with the [iperf3](#) application.

#### **Command (host)**

```
~# iperf3 -s
```

#### **Command (target)**

```
~# iperf3 -c <server ip>
```

## Results

| Test   | Mode    | SOM variant | Band                  | Score send /receive | Metric    | SOM power | SOM temp |
|--------|---------|-------------|-----------------------|---------------------|-----------|-----------|----------|
| iPerf3 | Station | Quad        | 2.4 GHz (802.11b/g/n) | 29/28               | Mbits/sec | 2216 mW   | 50 °C    |
|        |         |             | 5 GHz (802.11ac)      | 103/103             | Mbits/sec | 2340 mW   | 50 °C    |
|        | Soft-AP | Quad        | 2.4 GHz (802.11b/g/n) | 55/53               | Mbits/sec | 1682 mW   | 48 °C    |
|        |         |             | 5 GHz (802.11ac)      | 87/86               | Mbits/sec | 1899 mW   | 49 °C    |

## FTP

FTP is a protocol for file transfer over the network.

### Command (target)

On the target side, allow access to user **root** (forbidden by default):

```
~# sed /root/d -i /etc/vsftpd.ftpusers
```

Generate a 1 GB file with random data.

```
~# dd bs=1M count=1024 if=/dev/urandom of=testfile && sync
```

### Command (host): GET

On the host side, connect to the target via FTP (user: root, pass: root) and get the file:

```
~$ ftp -p <target_ip_address>
ftp> get testfile
```

### Command (host): PUT

Send the file to the target:

```
ftp> put testfile
```

## Results

| Test | Mode    | SOM variant | Band                  | Operation            | Score | Metric | SOM power | SOM temp |
|------|---------|-------------|-----------------------|----------------------|-------|--------|-----------|----------|
| FTP  | Station | Quad        | 2.4 GHz (802.11b/g/n) | GET (target to host) | 3.3   | MB/s   | 2266 mW   | 50 °C    |
|      |         |             |                       | PUT (host to target) | 6.15  | MB/s   | 1736 mW   | 50 °C    |

| Test | Mode | SOM variant | Band             | Operation            | Score | Metric | SOM power | SOM temp |
|------|------|-------------|------------------|----------------------|-------|--------|-----------|----------|
|      |      |             | 5 GHz (802.11ac) | GET (target to host) | 11.60 | MB/s   | 2471 mW   | 51 °C    |
|      |      |             |                  | PUT (host to target) | 10.16 | MB/s   | 2071 mW   | 51 °C    |

## GPU

### Environment conditions

- Full screen

### Glmark2

Glmark2 runs a series of tests, rendering different kinds of 2D and 3D graphics and animations on the screen and then measures the output performance in terms of frames per second (fps). It then averages out the fps across all the tests to calculate a score for the GPU.

### Command

```
~# glmark2-es2-wayland --fullscreen
```

### Results

| Test    | Resolution | SOM variant | Interface | Score | Metric        | SOM power | SOM temp |
|---------|------------|-------------|-----------|-------|---------------|-----------|----------|
| Glmark2 | 1280x800   | Quad        | LVDS0     | 164   | Glmark2 score | 2110 mW   | 52 °C    |

## VPU

### Environment conditions

- Full screen
- Playback:
  - Video files (video codec, audio codec)
    - You can find videos with different resolutions and format here: <https://filesamples.com/categories/video>
- Recording:
  - MIPI camera model: [Pcam 5C Digilent](#)
  - Video codecs
    - MOV H264

## Gstreamer video playback (decoding)

This test plays videos with different codecs and measures the performance in frames per second (fps).

### Command

```
~# gplay-1.0 <video-file>
```

### Results

| Test                                | Display resolution | SOM variant | Video codec | Audio codec  | Video resolution    | Score | Metric | SOM power | SOM temp |
|-------------------------------------|--------------------|-------------|-------------|--------------|---------------------|-------|--------|-----------|----------|
| Gstreamer video playback (decoding) | 1280x800           | Quad        | MOV H264    | AC3 surround | 1920x1080 (Full-HD) | 24    | fps    | 1899 mW   | 54 °C    |
|                                     |                    |             |             |              | 1280x720 (HD)       | 24    | fps    | 1772 mW   | 52 °C    |

## Gstreamer video recording (encoding)

This test records videos from a camera and encodes them to a RAM-based file system. Score is represented as the average of the fps recorded in one minute.

### Command

```
~# gst-launch-1.0 v4l2src device=/dev/video1 ! video/x-raw,width=1920,height=1080 ! waylandsink
```

The command line considers the MIPI camera was detected as **/dev/video1**.

Parameters **width** and **height** are adjusted for each resolution.

### Results

| Test                                 | SOM variant | Video codec | Video resolution    | Score | Metric | SOM power | SOM temp |
|--------------------------------------|-------------|-------------|---------------------|-------|--------|-----------|----------|
| Gstreamer video recording (encoding) | Quad        | MOV H264    | 1920x1080 (Full-HD) | 14    | fps    | 1663 mW   | 46 °C    |
|                                      |             |             | 1280x720 (HD)       | 22    | fps    | 1534 mW   | 46 °C    |

## Audio

### Environment conditions

- Playback audio files
  - WAV 44100 Hz, 16 bit, stereo
  - MP3 128 Kbps, 16 bit, stereo
- Recording audio files
  - WAV 44100 Hz, 16 bit, stereo
  - WAV 22050 Hz, 16 bit, stereo

### Audio playback

This test plays audio files in different formats. The only score is the power consumption. You can find sample audio files here: <https://filesamples.com/categories/audio>.

#### Command

---

```
/* Wav files */
~# aplay <file>
/* MP3 files */
~# gst-launch-1.0 filesrc location=<file> ! id3demux ! queue ! beepdec !
alsasink
```

---

#### Results

| Test                      | SOM variant | Audio file                   | SOM power | SOM temp |
|---------------------------|-------------|------------------------------|-----------|----------|
| Audio playback (decoding) | Quad        | WAV 44100 Hz, 16 bit, stereo | 1520 mW   | 46 °C    |
|                           |             | MP3 128Kbps, 16 bit, stereo  | 1424 mW   | 46 °C    |

### Audio recording

This test records audio files in different formats. The only score is the power consumption.

#### Command

---

```
~# arecord -f cd sound.wav --duration 60
~# arecord -f S16_LE -c 2 -r22050 sound.wav --duration 60
```

---

#### Results

| Test                      | SOM variant | Audio file                   | SOM power | SOM temp |
|---------------------------|-------------|------------------------------|-----------|----------|
| Audio playback (decoding) | Quad        | WAV 44100 Hz, 16 bit, stereo | 1394 mW   | 46 °C    |
|                           |             | WAV 22050 Hz, 16 bit, stereo | 1392 mW   | 46 °C    |

## Additional information

---

See the [ConnectCore 8M Mini documentation portal](#) for additional information, including hardware reference manuals, comprehensive software documentation, links to design documents, and hardware compatibility reports.