ConnectCore® 8M Nano Performance and Power

Benchmarking Report

Application Note

Revision history—90002449

Revision	Date	Description
A	February 2021	Initial release.

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Additional information

Introduction

This document characterizes power consumption and performance for the ConnectCore 8M Nano 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.

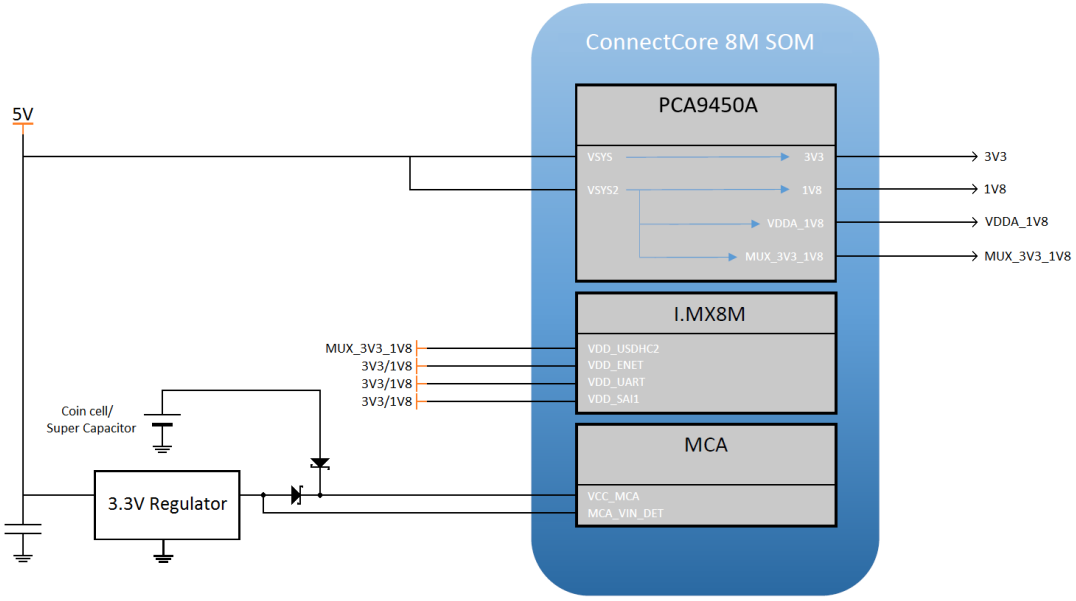
Note This information is provided as a reference on the capabilities of the ConnectCore 8M Nano platform. You may see different figures due to software or other factors.

Power architecture

The following diagram represents the full power architecture distribution of the ConnectCore 8M Nano 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 Nano 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 Nano SOM
  - Variant 0x02: Industrial Quad 1.4GHz, 8GB eMMC, 1GB LPDDR4, -40/+85C, Wireless, Bluetooth
  - PN: 55002070-01 1P
- ConnectCore 8M Nano 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-r2.4 release, available on the Digi support site (md5sum: 90d156525f1732505b7df3ebbcecba4c).

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-r1.3+gb84d3443cc
Firmware	dey-3.0-r2-20201023151245
Kernel	5.4.64-dey+g8086dc5f8e29

MCA firmware

The firmware version used on the SOM during the tests is 1.0.

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 22ºC, 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_EX 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 Nano 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 Nano 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 Nano 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	325 uW

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 enters a low-power state where the CPU is halted and the content of the RAM is maintained (self-refresh mode). The state of the PMIC power rails is configurable (on/off/voltage) through the device tree. For this measurement, Digi used the default configuration, which disables the 3V3_EXT power domain when the SOM is suspended to RAM. In this state, the device can wake up from multiple wake-up sources (MCA and CPU peripherals).

SOM variant	SOM power
Quad	29 mW

System idle

All power domains are active and the operating system will perform CPU frequency and voltage scaling according to the CPU load.

SOM variant	SOM power
Quad	1140 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	**21832**	iter./s	2200 mW	49 ºC

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 1GB LPDDR4 1.1V 16 bits 1600 MHz	memset	3155	MB/s	1844 mW	47 ºC

Test	SOM variant	LPDDR4 in SOM	Operation	Score	Metric	SOM power	SOM temp
			memcpy	1306	MB/s	1694 mW	47 °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	1491 mW	44 °C
				Write	20	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>
~# 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	SOM Variant	Media model	Operation	Score	Metric	SOM power
IOzone3	Quad	Transcend Information, Inc. JetFlash 16 GB 2.0	Read	14	MB/s	1319 mW
			Write	11	MB/s	
	Quad	USB3.0 to SATA: Samsung v-nan SSD 860 PRO	Read	28	MB/s	1413 mW
			Write	29	MB/s	

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	937	Mbits/sec	1358 mW	45 ºC
			10/100	95	Mbits/sec	1238 mW	43 ºC

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)	112	MB/s	1792 mW	46 ºC
			PUT (host to target)	23	MB/s	1522 mW	45 ºC
		10/100	GET (target to host)	11	MB/s	1382 mW	43 ºC
			PUT (host to target)	11	MB/s	1332 mW	43 ºC

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)	36	Mbits/sec	2041 mW	42 ºC
			5 GHz (802.11ac)	80.5	Mbits/sec	1791 mW	42 ºC
	Soft-AP	Quad	2.4 GHz (802.11b/g/n)	41	Mbits/sec	1475 mW	42 ºC
			5 GHz (802.11ac)	71.3	Mbits/sec	1750 mW	42 ºC

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)	3.6	MB/s	2266 mW	43 ºC
				PUT (host to target)	5.42	MB/s	1666 mW	43 ºC

Test	Mode	SOM variant	Band	Operation	Score	Metric	SOM power	SOM temp
			5 GHz (802.11ac)	GET (target to host)	8.81	MB/s	2041 mW	42 °C
				PUT (host to target)	9.72	MB/s	1766 mW	42 °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	204	Glmark2 score	2041 mW	51 °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	AVI Mpeg4	AC3 surround	1920x1080 (Full-HD)	24	fps	1802 mW	48 °C
					1280x720 (HD)	24	fps	1462 mW	
			MOV H264	AAC surround	1920x1080 (Full-HD)	24	fps	2700 mW	54 °C
					1280x720 (HD)	24	fps	2202 mW	50 °C
** Tested with dey-3.0-r3.2 firmware*									

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	1169 mW	42 ° C
		MP3 128Kbps, 16 bit, stereo	1184 mW	42 ºC

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	1169 mW	42 ºC
		WAV 22050 Hz, 16 bit, stereo	1195 mW	42 ºC

Additional information

See the ConnectCore 8M Nano documentation portal for additional information, including hardware reference manuals, comprehensive software documentation, links to design documents, and hardware compatibility reports.