ConnectCore® 8M Mini Performance and Power

Benchmarking Report

Application Note

Revision history—90002465

Revision	Date	Description
A	August 2021	Initial release.

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Contents

Additional information

Introduction

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.

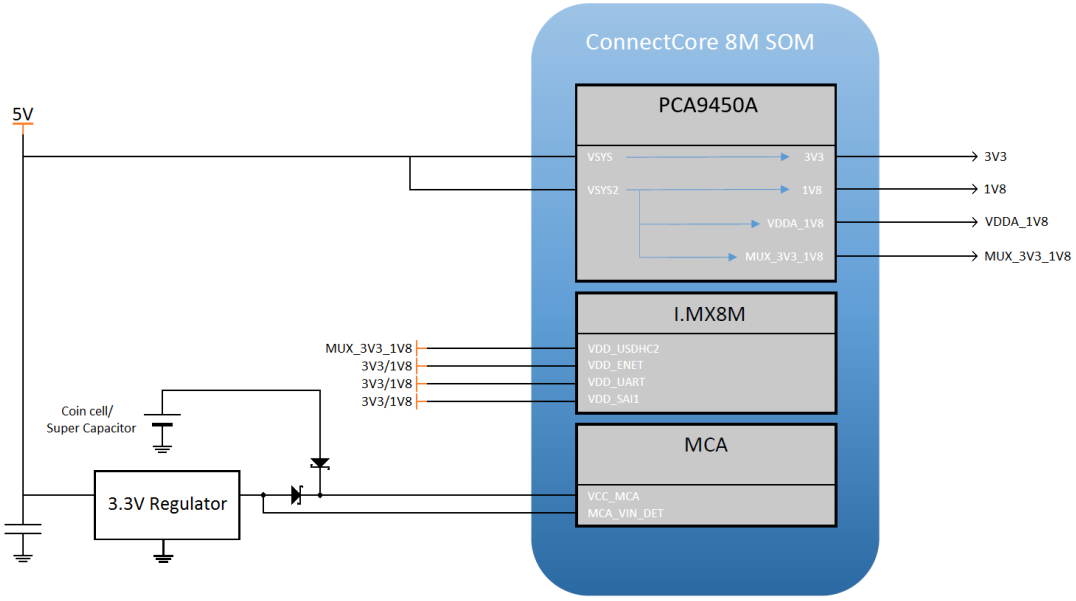
Note This information is provided as a reference on the capabilities of the ConnectCore 8M Mini platform. You may see different figures due to software or other factors.

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 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 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	**25012**	iter./s	2601 mW	55 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 2GB LPDDR4 1.1V 32 bits 1600 MHz	memset	8772	MB/s	2511 mW	50 ºC

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>
~# 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	SOM temp
IOzone3	Quad	Transcend Information, Inc. JetFlash 16 GB 2.0	Read	15	MB/s	1657 mW	48 ºC

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 ºC
			10/100	95/94	Mbits/sec	1485 mW	47 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)	107	MB/s	1619 mW	48 ºC
			PUT (host to target)	27	MB/s	1905 mW	48 ºC
		10/100	GET (target to host)	11	MB/s	1357 mW	46 ºC
			PUT (host to target)	10	MB/s	1342 mW	46 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)	29/28	Mbits/sec	2216 mW	50 ºC
			5 GHz (802.11ac)	103/103	Mbits/sec	2340 mW	50 ºC
	Soft-AP	Quad	2.4 GHz (802.11b/g/n)	55/53	Mbits/sec	1682 mW	48 ºC
			5 GHz (802.11ac)	87/86	Mbits/sec	1899 mW	49 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)	3.3	MB/s	2266 mW	50 ºC
				PUT (host to target)	6.15	MB/s	1736 mW	50 ºC

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 ºC
					1280x720 (HD)	24	fps	1772 mW	52 ºC

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 ºC
			1280x720 (HD)	22	fps	1534 mW	46 ºC

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 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	1394 mW	46 ºC
		WAV 22050 Hz, 16 bit, stereo	1392 mW	46 ºC

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.