Application Note

AM62L Power Consumption Summary

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ABSTRACT

This application note discusses the power consumption for common benchmarks and system application usage scenarios for the AM62Lx Sitara™ processors. The metrics contained in this document serve to provide users with a better understanding of AM62Lx active power and low power metrics: making it easier to determine a suitable configuration to meet a given power budget.

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1 Active Power Consumption Summary

Categories	Test Name	A53 Core Speed	LPDDR4 Data Rate	AM62L Power (mW)
Core	Dhrystone	1 Core @ 833MHz	1600 MT/s	344.53
		1 Core @ 1250MHz	1600 MT/s	373.96
		2 Cores @ 833MHz	1600 MT/s	395.84
		2 Cores @ 1250MHz	1600 MT/s	450.78
	Whetstone	1 Core @ 1250MHz	1600 MT/s	352.85
		2 Cores @ 1250MHz	1600 MT/s	414.22
	Stress-ng	1 Core @ 1250MHz	1600 MT/s	407.35
		2 Cores @ 1250MHz	1600 MT/s	473.57
	CoreMark®-Pro	1 Core @ 1250MHz	1600 MT/s	430.16
		2 Cores @ 1250MHz	1600 MT/s	466.26
Memory & Data Storage	Stream	1 Core @ 1250MHz	800 MT/s	411.03
		2 Cores @ 1250MHz	800 MT/s	457.04
		1 Core @ 1250MHz	1600 MT/s	500.15
		2 Cores @ 1250MHz	1600 MT/s	537.98
	Memtester	1 Core @ 1250MHz	800 MT/s	423.58
		2 Cores @ 1250MHz	1600 MT/s	505.36
	eMMC Read	2 Cores @ 1250MHz	1600 MT/s	436.77
	eMMC Write	2 Cores @ 1250MHz	1600 MT/s	476.33
Networking & Cryptography	OpenSSL	1 Core @ 1250MHz	1600 MT/s	429.32
		2 Cores @ 1250MHz	1600 MT/s	458.05
	Ethernet Throughput	2 Cores @ 1250MHz	1600 MT/s	401.92
Application Demos	LVGL Demo	1250MHz	1600 MT/s	578.85
	Audio Playback Demo	1250MHz	1600 MT/s	376.31

2 Low Power Consumption Summary

For the most up-to-date power consumption data for AM62L's Low Power Modes, refer to the Linux SDK Kernel Performance Guide.

Categories	Low Power State	Variable Parameter	AM62L Power (mW)
Low Power Modes	DeepSleep	DeepSleep	10.97
	RTC-Only + DDR	RTC-Only + DDR	2.51
	RTC-Only	RTC-Only	Linux SDK 12.x

3 Introduction

The objective of this application note is to showcase the power consumption of the AM62L device under different scenarios including benchmarks and example use cases. For more information about the AM62L Performance Benchmarks, see the AM62L Benchmark Application Note.

3.1 Testing Conditions and Parameters

- Software
  - Linux SDK Version 11.1
- Hardware
  - AM62L Starter Kit Evaluation Module (TMDS62LEVM)
- Testing Environment
  - Ambient Room Temperature
  - Nominal Process
- Peripherals Used
  - USB-C Power Supply
  - Micro-USB for Serial Connection
  - HDMI/Speaker/Ethernet Depending on the Test Case

Note

The power and die temperature measurements were collected using the TMDS62LEVM evaluation module. This EVM is not optimized for thermal performance. The intend of the EVM design is to demonstrate the SoC features and capabilities. To accomplish this goal, most of the SoC pins are used which makes it difficult to implement layout best practices that improve heat dissipation. There are many variables that affect the junction-to-ambient thermal resistance of a system. These include the PCB size, number of VIAS, grounding techniques, number of layers, enclosures/heat sinks among others. In a real application where some of the pins in the package might be unused (and external devices that are included in the EVM are not needed), it is recommended to create more efficient grounding connections to reduce die junction temperature. For example: connecting all the ground pins under the SoC to a common ground plane on the same layer and adding as many VIAS as possible to the PCB ground layer. The following document describes some of the best practices and rules of thumb when it comes to thermal dissipation in PCB design: https://www.ti.com/lit/an/spradb7/spradb7.pdf . For the most accurate thermal representation of a system, import the device thermal model as well as the board properties into a thermal simulation program.

3.2 Starter Kit EVM Information

- EVM Used: TMDS62LEVM
  - 0.75V Core Supply Voltage
  - LPDDR4 DRAM at 1600MT/s unless stated otherwise
  - Both A53 Core Operating at 1.25GHz unless stated otherwise

3.2.1 Starter Kit EVM Power Rails

Power Supply	Description
VDD_CORE	The power supply for the SoC ARM® cores.
VDD_LPDDR4	This rail includes both the SoC LPDDR4 IO, as well as the power source for the external DRAM part.
VDD_RTC	The power supply for the internal Real Time Clock module.
VDD_RTC_1V8	The power supply for the internal Real Time Clock's 1v8 I/Os.
VDDA_1V8	The SoC analog supply. This rail powers the oscillators, PLLs, USB, DSI and ADC supplies.
SOC_DVDD_1V8	The 1v8 digital I/O rail; this rail powers the OSPI, both MMC0 and 2, and some of the general VDDS0/1 rails.
SOC_DVDD_3V3	The 3v3 digital I/O rail; this rail powers the RGMII, GPMC, USB I/O, and some of the general VDDSHV0/1 rails.

4 Power Measurement Data

This sections will discuss the different data measurements for different low power modes, benchmarks, and use cases.

4.1 Low Power Modes

Low-power modes are device states where minimum components are turned on and the device is waiting for an interrupt to wake up back to normal operation. The goal of low-power modes are to minimize power consumption and improve energy efficiency when the device is standing idle. For more details of the various low-power modes, wake up sources, and sleep sequencing, see the *Power Modes* section of the AM62L Technical Reference Manual. Note that not all the features described in the device-specific Technical Reference Manual have been implemented into the Software Development Kit.

For the most up-to-date power consumption data for AM62L's Low Power Modes, refer to the Linux SDK Kernel Performance Guide.

4.1.1 DeepSleep

Follow the ARM Trusted Firmware side changes to ensure that the correct Low Power Mode is selected.

Then, the command to enter DeepSleep is:

```
root@am62lxx-evm:~# echo mem > /sys/power/state
```

Refer to the AM62L Linux SDK Power Managment section for the latest instructions.

Rail Name	**Rail Voltage**	**Power (mW)**
VDD_CORE	0.75V	5.20
SOC_DVDD_1V8	1.8V	2.01
SOC_DVDD_3V3	3.3V	2.12
VDDA_1V8	1.8V	0.59
VDD_LPDDR4	1.1V	1.02
VDD_RTC	0.75V	0.02
VDD_RTC_1V8	1.8V	0.02
Total Power		10.97

4.1.2 RTC Only Plus DDR

Follow the ARM Trusted Firmware side changes to ensure that the correct Low Power Mode is selected.

Then, the command to enter RTC Only Plus DDR mode is

```
root@am62lxx-evm:~# echo mem > /sys/power/state
```

Refer to the AM62L Linux SDK Power Managment section for the latest instructions.

Rail Name	Rail Voltage	Power (mW)
VDD_CORE	0.75V	0.00
SOC_DVDD_1V8	1.8V	1.33
SOC_DVDD_3V3	3.3V	1.13
VDDA_1V8	1.8V	0.00
VDD_LPDDR4	1.1V	0.00
VDD_RTC	0.75V	0.02
VDD_RTC_1V8	1.8V	0.05
Total Power		2.51

4.1.3 RTC Only

RTC Only Low Power Mode will be added in a future Linux SDK release. This low power mode will keep only the internal RTC module on to maintain calendar time and wake up the SoC after a user-defined period of time.

This application note will be updated when RTC Only is supported in the Linux SDK.

4.2 Core

This section will focus on benchmarks centered on the Cortex® A53 Cores

4.2.1 Dhrystone

N-Core indicates how many instances of Dhrystone are being ran concurrently. Each instance is ran on one A53 core.

The Linux Commands to run Dhrystone:

1-Core Dhrystone

```
root@am62lxx-evm:~# dhrystone 400000000
```

2-Core Dhrystone

```
root@am62lxx-evm:~# taskset 0x1 dhrystone 400000000 &
root@am62lxx-evm:~# taskset 0x2 dhrystone 400000000 &
```

		1-Core at 833MHz	1-Core at 1250MHz	2-Core at 833MHz	2-Core at 1250MHz
Rail Name	**Rail Voltage**	**Power (mW)**			
VDD_CORE	0.75V	260.58	290.06	312.17	367.12
SOC_DVDD_1V8	1.8V	4.57	4.58	4.53	4.56
SOC_DVDD_3V3	3.3V	2.68	2.67	2.67	2.67
VDDA_1V8	1.8V	20.81	20.79	20.81	20.81
VDD_LPDDR4	1.1V	55.85	55.82	55.60	55.57
VDD_RTC	0.75V	0.02	0.02	0.03	0.02
VDD_RTC_1V8	1.8V	0.02	0.02	0.02	0.02
Total Power		344.53	373.96	395.84	450.78
Die Temp (°C)		43°C	43°C	43°C	43°C

4.2.2 Whetstone

N-Core indicates how many instances of Whetstone are being ran concurrently. Each instance is ran on one A53 core.

Linux Commands to run Whetstone:

1-Core Whetstone

```
root@am62lxx-evm:~# whetstone 3600000
```

2-Core Whetstone

```
root@am62lxx-evm:~# taskset 0x1 whetstone 3600000 &
root@am62lxx-evm:~# tastset 0x2 whetstone 3600000 &
```

		1-Core at 1250MHz	2-Core at 1250MHz
Rail Name	Rail Voltage	Power (mW)	
VDD_CORE	0.75V	269.22	330.57
SOC_DVDD_1V8	1.8V	4.58	4.56
SOC_DVDD_3V3	3.3V	2.65	2.68
VDDA_1V8	1.8V	20.78	20.80
VDD_LPDDR4	1.1V	55.59	55.57
VDD_RTC	0.75V	0.02	0.02
VDD_RTC_1V8	1.8V	0.02	0.02
Total Power		352.85	414.22
Die Temp (°C)		41°C	43°C

4.2.3 Stress-ng

N-Core indicates how many threads of Stress-ng are being ran concurrently. Each thread is ran on one A53 core.

Linux Commands to run Stress-ng follow this format:

```
root@am62lxx-evm:~# stress-ng --cpu <# of Cores> -t <time in minutes>m
```

		1-Core at 1250MHz	2-Core at 1250MHz
Rail Name	Rail Voltage	Power (mW)	
VDD_CORE	0.75V	314.82	382.06
SOC_DVDD_1V8	1.8V	4.97	5.18
SOC_DVDD_3V3	3.3V	2.14	2.14
VDDA_1V8	1.8V	20.83	20.83
VDD_LPDDR4	1.1V	64.53	63.31
VDD_RTC	0.75V	0.03	0.03
VDD_RTC_1V8	1.8V	0.01	0.01
Total Power		407.35	473.57
Die Temp (°C)		41°C	42°C

4.2.4 CoreMark®-Pro

This benchmark test is not included in the Core SDK.

First, clone the repository, then build

```
root@am62lxx-evm:~# git clone https://github.com/eembc/coremark-pro.git
root@am62lxx-evm:~# cd coremark-pro/
root@am62lxx-evm:~/coremark-pro# make TARGET=linux64 build-all
```

Run the benchmark where N is the number of cores utilized:

```
root@am62lxx-evm:~/coremark-pro# make TARGET=linux64 certify-all XCMD='-cN'
```

For more information, refer to the AM62L Benchmarks Application Note.

		1-Core at 1250MHz	2-Core at 1250MHz
Rail Name	Rail Voltage	Power (mW)	
VDD_CORE	0.75V	295.31	318.09
SOC_DVDD_1V8	1.8V	7.52	8.36
SOC_DVDD_3V3	3.3V	2.66	2.68
VDDA_1V8	1.8V	20.68	20.83
VDD_LPDDR4	1.1V	103.95	116.26
VDD_RTC	0.75V	0.03	0.03
VDD_RTC_1V8	1.8V	0.02	0.02
Total Power		430.16	466.26
Die Temp (°C)		43°C	43°C

4.3 Memory and Data Storage

This section will focus on stressing the DDR4/LPDDR4 as well as reading & writing from eMMC.

4.3.1 Stream

The Linux command to run these tests follow this format:

```
root@am62lxx-evm:~# stream -P <# of Cores/# of Threads> -N <# of Iterations>
```

For lower amount of cores being used, increase the number of iterations so there is enough time for measurements.

1-Core Stream

```
root@am62lxx-evm:~# stream -P 1 -N 500
```

2-Core Stream

```
root@am62lxx-evm:~# stream -P 2 -N 200
```

LPDDR4 Data Rate		800MT/s		1600MT/s	
A53 Core Speed		1-Core at 1250MHz	2-Core at 1250MHz	1-Core at 1250MHz	2-Core at 1250MHz
Rail Name	Rail Voltage	Power (mW)			
VDD_CORE	0.75V	248.29	290.18	316.38	366.23
SOC_DVDD_1V8	1.8V	6.93	7.97	8.60	9.90
SOC_DVDD_3V3	3.3V	2.67	2.68	2.69	2.65
VDDA_1V8	1.8V	20.80	20.82	20.82	20.78
VDD_LPDDR4	1.1V	132.29	135.35	151.62	138.38
VDD_RTC	0.75V	0.02	0.03	0.03	0.02
VDD_RTC_1V8	1.8V	0.02	0.02	0.02	0.02
Total Power		411.03	457.04	500.15	537.98
Die Temp (°C)		43°C	43°C	44°C	45°C

4.3.2 Memtester

The Linux command to run these tests follow this format:

```
root@am62lxx-evm:~# memtester 1G 1
```

Which allocates 1 Gigabyte of memory space to test and will execute for one loop.

LPDDR4 Data Rate		800MT/s	1600MT/s
A53 Core Speed		2-Cores at 1250MHz	
Rail Name	Rail Voltage	Power (mW)	
VDD_CORE	0.75V	258.14	328.34
SOC_DVDD_1V8	1.8V	6.35	8.41
SOC_DVDD_3V3	3.3V	2.67	2.69
VDDA_1V8	1.8V	20.80	20.84
VDD_LPDDR4	1.1V	135.58	145.03
VDD_RTC	0.75V	0.02	0.03
VDD_RTC_1V8	1.8V	0.02	0.02
Total Power		423.58	505.36
Die Temp (°C)		43°C	45°C

4.3.3 eMMC Read & Write

For this test, the AM62L EVM's on-board eMMC device is being written and read from.

To execute the write sequence:

```
root@am62lxx-evm:~# dd if=/dev/urandom of=<eMMC block device> bs=1M status=progress count=10000
```

To execute the read sequence:

```
root@am62lxx-evm:~# dd if=<eMMC block device> of=/dev/null bs=1M status=progress
```

eMMC Operation		Read	Write
A53 Core Speed		2-Cores at 1250MHz	
Rail Name	Rail Voltage	Power (mW)	
VDD_CORE	0.75V	270.12	310.20
SOC_DVDD_1V8	1.8V	27.31	37.40
SOC_DVDD_3V3	3.3V	2.67	2.68
VDDA_1V8	1.8V	20.80	20.82
VDD_LPDDR4	1.1V	115.81	105.17
VDD_RTC	0.75V	0.02	0.03
VDD_RTC_1V8	1.8V	0.02	0.02
Total Power		436.77	476.33
Die Temp (°C)		43°C	45°C

4.4 Networking & Cryptography

This section focuses on networking with Ethernet and cryptography

4.4.1 OpenSSL

This is a networking and cryptographic based benchmark. An Ethernet Cable connected to EVM is needed for this test.

The Linux command to run these tests follow this format:

```
root@am62lxx-evm:~# openssl speed -multi <# of Cores/# of Threads>
```

		1-Core at 1250MHz	2-Core at 1250MHz
Rail Name	Rail Voltage	Power (mW)	
VDD_CORE	0.75V	336.71	365.46
SOC_DVDD_1V8	1.8V	11.59	11.58
SOC_DVDD_3V3	3.3V	2.32	2.32
VDDA_1V8	1.8V	20.88	20.91
VDD_LPDDR4	1.1V	57.78	57.73
VDD_RTC	0.75V	0.03	0.04
VDD_RTC_1V8	1.8V	0.01	0.01
Total Power		429.32	458.05
Die Temp (°C)		45°C	47°C

4.4.2 Ethernet Throughput

This test will send data through the Ethernet port. An Ethernet Cable connected to EVM is needed for this test.

First, add the IP address:

```
root@am62lxx-evm:~# ip addr add <ip addr>/<mask> dev <ethernet device>
```

On the host machine, setup the iperf3 server:

```
HOST:~# ip addr add <different ip addr>/<mask> dev <ethernet device>
HOST:~# iperf3 -s
```

Finally, on the EVM, start the throughput test:

```
root@am62lxx-evm:~# iperf3 -c <host defined ip addr>
```

		2-Core at 1250MHz
Rail Name	Rail Voltage	Power (mW)
VDD_CORE	0.75V	275.63
SOC_DVDD_1V8	1.8V	17.74
SOC_DVDD_3V3	3.3V	2.66
VDDA_1V8	1.8V	20.82
VDD_LPDDR4	1.1V	85.03
VDD_RTC	0.75V	0.03
VDD_RTC_1V8	1.8V	0.02
Total Power		401.92
Die Temp (°C)		44°C

4.5 Application Demos

The objective of these tests to show the power consumption of different application use cases.

4.5.1 LVGL Demo

Follow the hardware prerequisites to ensure that the EVM is configured to run the demo. The demo requires a HDMI cable connected to a monitor to display the demo and a USB mouse to interact with the interface. The TI LVGL Demo will launch automatically when the device is fully booted with a SD card flashed with the 'tisdk-default-image'.

		2-Core at 1250MHz
Rail Name	**Rail Voltage**	**Power (mW)**
VDD_CORE	0.75V	300.09
SOC_DVDD_1V8	1.8V	12.44
SOC_DVDD_3V3	3.3V	126.23
VDDA_1V8	1.8V	46.22
VDD_LPDDR4	1.1V	93.80
VDD_RTC	0.75V	0.04
VDD_RTC_1V8	1.8V	0.01
Total Power		578.85
Die Temp (°C)		48°C

4.5.2 Audio Playback Demo

To run the audio playback demo, create a script that acts like the following.

```
#!/bin/sh
while [ 1 ]; do
    arecord -Dplughw:0,0 | aplay -Dplughw:0,0
done
```

And then you can run the script with the following command.

```
root@am62lxx-evm:~# ./<Audio Script>.sh
```

Use Ctrl + C to end the script execution.

		2-Core at 1250MHz
Rail Name	**Rail Voltage**	**Power (mW)**
VDD_CORE	0.75V	277.03
SOC_DVDD_1V8	1.8V	7.29
SOC_DVDD_3V3	3.3V	6.44
VDDA_1V8	1.8V	27.25
VDD_LPDDR4	1.1V	58.26
VDD_RTC	0.75V	0.03
VDD_RTC_1V8	1.8V	0.02
Total Power		376.31
Die Temp (°C)		40°C

5 References

1. AM62L Linux SDK Power Managment Documentation
2. AM62L Benchmarks
3. AM62L Linux SDK Latest Guide
4. AM62L Product Page
5. AM62L Data Sheet
6. AM62L Technical Reference Manual
7. AM62L EVM Page
8. AM62L EVM User's Guide

6 Appendix

6.1 How to Change LPDDR4 Data Rate

1. Go to dev.ti.com/sysconfig
2. Under 'Software Product', select 'DDR Configuration ... AM62Lx'
3. Under 'Device', select AM62L
4. Change the speed from 800MHz to 400MHz which is the DDR clock speed.
5. Follow the instructions in the SYSCONFIG Tool on implementing the change.
6. Re-build U-Boot after implementing the change for a new TF-A

6.2 How to Measure On-Die Temperature

AM62L has one on-die temperature sensor which is located in-between the A53 Compute Cluster and the DDR controller. The VTM (Voltage and Thermal Module) Linux Driver enables the use of a SYSFS entry to read the temperature sensor.

The on-die temperature sensor can be read from here:

```
root@am62lxx-evm:~# cat /sys/class/thermal/thermal_zone0/temp
```

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