Application Note

AM62x Power Consumption

Anshu Madwesh and Colin Callaghan

ABSTRACT

This application note discusses the power consumption for common benchmarks and system application usage scenarios for the AM62x Sitara™ processors. The metrics contained in this document serve to provide users with a better understanding of AM62x active power and low power metrics: making it easier to determine a suitable configuration to meet a given power budget.

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Trademarks

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1 Active Power Consumption Summary

Categories	Test Name / Mode	Variable Parameters	0.75V Core Voltage LDDR4
Core	Dhrystone	1 Core 1000MHz	675.55mW
		4 Cores 1000MHz	856.07mW
	Whetstone	1 Core 1000MHz	660.28mW
		4 Cores 1000MHz	807.53mW
	Stress-ng	1 Core 1000MHz	666.81mW
		4 Cores 1000Mhz	844.45mW
Memory	Stream	1 Core 1000MHz	790.55mW
		4 Cores 1000MHz	943.04mW
Networking / Cryptography	OpenSSL	1 Core 1000MHz	696.35 mW
		4 Cores 1000MHz	914.74mW
Graphics	glmark2	1000MHz	1011.40mW
High Activity Concurrency Tests	4-Core Dhrystone + glmark2	1000MHz	1006.01mW
	4-Core Stress-ng + glmark2	1000MHz	999.38mW
	4-Core Stream + glmark2	1000MHz	1078.18mW
Application Demos	Human Machine Interface Demo	1000MHz	818.55mW
	Driver Monitoring System Demo	1000MHz	681.11mW

2 Low Power Consumption Summary

Categories	Test Mode	Variable Parameters	0.75V Core Voltage LDDR4
Low Power Modes	OS Idle	1000MHz	343.59mW
		1250MHz	349.60mW
	Deep Sleep	Deep Sleep	14.62mW
	MCU Only	MCU Only	54.91mW

For more information about the Low Power Mode power measurements, review this section.

3 Introduction

The objective of this application note is to showcase the power consumption of the AM62x device under different scenarios including benchmarks and example use cases. For more information about the AM62x Performance Benchmarks, see the AM62x Benchmark.

3.1 Testing Conditions and Parameters

- Software: Linux SDK Version 9.0 using the Default Image
- Testing Environment
  - Ambient Room Temperature
  - Nominal Process
- Peripherals Used
  - USB-C Power Supply
  - Micro-USB for Serial Connection to Terminals
  - HDMI/Ethernet/USB Camera/USB Mouse depending on test case

3.2 Starter Kit EVM Information

Starter Kit EVM	Core Supply Voltage Rail	DDR4/LPDDR4	VDDR_CORE Rail Measured	Test Operating Speed of A53 Cores
SK-AM62B	0.75V	DDR4	Yes, but only measured with Multi-Meter	1GHz
SK-AM62B-P1	0.85V	DDR4	No	1.4GHz
SK-AM62-LP	0.75V	LPDDR4	Yes	1GHz
	0.85V			1.25GHz

This table contains information about the different boards being used in these measurements.

3.3 Starter Kit EVM Power Rails

There are six SoC Power rails on the AM62x Starter Kits:

Power Supply	Description
VDD_CORE	The power supply for the SoC ARM cores, the CORE_USB and the CORE_CSI supplies.
VDDR_CORE	This powers the internal SRAM memory banks of the SoC.
VDD_DDR	This rail includes both the SoC DDR4 IO, as well as the power source for the external DRAM part; **power consumption on this rail includes consumption from a non-AM62x part.**
SOC_DVDD1V8	The 1v8 digital IO rail; this rail powers the OSPI, both MMC0 and 2, and some of the general VDDSHV0 rails
SOC_DVDD3V3	The 3v3 digital IO rail; this rail powers the RGMII, GPMC, MCU general, USB IO, and some of the general VDDSHV0 rails
VDDA_1V8	The SoC analog supply. This rail powers the oscillators, PLLs , and the MCU, USB, CSIRx, and OLDI 1v8 supplies.

For more information about the VDD power supply rails see the AM62x Starter Kit User's Guide.

4 Power Measurement Data

This section will discuss the different 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 AM62x 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.

4.1.1 OS Idle

OS Idle is the state where the device is powered on, but not running any functions.

4.1.1.1 OS Idle Setup

The only setup is the changing of the A53 Core speeds. For more information, see Section A.2 How to Change the A53 Core Speed.

4.1.1.2 OS Idle Data

This set of data is an optimized version of OS Idle. This data was optimized by disabling unused peripherals and their respective clocks.

4.1.1.2.1 OS Idle at 200MHz

		0.85V VDD_CORE DDR4	0.75V VDD_CORE DDR4	0.85V VDD_CORE LPDDR4	0.75V VDD_CORE LPDDR4
EVM VDD Rail	Rail Voltage	Power (mW)	Power (mW)	Power (mW)	Power (mW)
VDD_CORE	0.75V/0.85V	239.20	168.95	194.75	150.04
VDDR_CORE	0.85V	N/A	N/A	2.15	2.39
VDD_LPDDR4/ VDD_DDR4	1.1V/1.2V	74.05	75.55	58.39	58.21
SoC_DVDD1V8	1.8V and 3.3V	16.69	17.16	49.15	49.31
SoC_DVDD3V3					
VDDA_CORE	1.8V	53.6	53.91	56.14	56.32
	Total Power	**383.54**	**315.58**	**360.58**	**316.26**

4.1.1.2.2 OS Idle at 400MHz

		0.85V VDD_CORE DDR4	0.75V VDD_CORE DDR4	0.85V VDD_CORE LPDDR4	0.75V VDD_CORE LPDDR4
EVM VDD Rail	Rail Voltage	Power (mW)	Power (mW)	Power (mW)	Power (mW)
VDD_CORE	0.75V/0.85V	248.80	175.67	204.31	157.19
VDDR_CORE	0.85V	N/A	N/A	2.19	2.44
VDD_LPDDR4/ VDD_DDR4	1.1V/1.2V	74.14	75.65	58.37	58.25
SoC_DVDD1V8	1.8V and 3.3V	16.76	17.30	49.24	49.37
SoC_DVDD3V3					
VDDA_CORE	1.8V	53.6	54.01	56.21	56.37
	Total Power	**393.31**	**322.64**	**370.32**	**323.61**

4.1.1.2.3 OS Idle at 600MHz

		0.85V VDD_CORE DDR4	0.75V VDD_CORE DDR4	0.85V VDD_CORE LPDDR4	0.75V VDD_CORE LPDDR4
EVM VDD Rail	Rail Voltage	Power (mW)	Power (mW)	Power (mW)	Power (mW)
VDD_CORE	0.75V/0.85V	258.72	183.53	213.62	163.93
VDDR_CORE	0.85V	N/A	N/A	2.24	2.45
VDD_LPDDR4/ VDD_DDR4	1.1V/1.2V	74.21	75.77	58.42	58.24
SoC_DVDD1V8	1.8V and 3.3V	16.87	17.29	49.25	49.41
SoC_DVDD3V3					
VDDA_CORE	1.8V	52.55	53.10	55.37	55.46
	Total Power	**402.36**	**329.69**	**378.89**	**329.49**

4.1.1.2.4 OS Idle at 800MHz

		0.85V VDD_CORE DDR4	0.75V VDD_CORE DDR4	0.85V VDD_CORE LPDDR4	0.75V VDD_CORE LPDDR4
EVM VDD Rail	Rail Voltage	Power (mW)	Power (mW)	Power (mW)	Power (mW)
VDD_CORE	0.75V/0.85V	268.67	190.75	222.95	171.01
VDDR_CORE	0.85V	N/A	N/A	2.27	2.49
VDD_LPDDR4/ VDD_DDR4	1. V/1.2V	74.28	75.78	58.42	58.20
SoC_DVDD1V8	1.8V and 3.3V	16.86	17.43	49.33	49.33
SoC_DVDD3V3					
VDDA_CORE	1.8V	53.63	54.06	56.27	56.44
	Total Power	**413.44**	**338.02**	**370.32**	**337.48**

4.1.1.2.5 OS Idle at 1000MHz

		0.85V VDD_CORE DDR4	0.75V VDD_CORE DDR4	0.85V VDD_CORE LPDDR4	0.75V VDD_CORE LPDDR4
EVM VDD Rail	Rail Voltage	Power (mW)	Power (mW)	Power (mW)	Power (mW)
VDD_CORE	0.75V/0.85V	277.79	197.71	231.96	178.01
VDDR_CORE	0.85V	N/A	N/A	2.29	2.48
VDD_LPDDR4/ VDD_DDR4	1.1V/1.2V	74.33	76.07	58.45	58.31
SoC_DVDD1V8	1.8V and 3.3V	16.78	17.36	49.31	49.33
SoC_DVDD3V3					
VDDA_CORE	1.8V	52.59	53.11	55.37	55.47
	Total Power	**393.31**	**344.25**	**397.39**	**343.59**

4.1.1.2.6 OS Idle at 1250MHz

		0.85V VDD_CORE DDR4	0.75V VDD_CORE DDR4	0.85V VDD_CORE LPDDR4	0.75V VDD_CORE LPDDR4
EVM VDD Rail	Rail Voltage	Power (mW)	Power (mW)	Power (mW)	Power (mW)
VDD_CORE	0.75 V/0.85 V	290.07	206.73	243.58	186.18
VDDR_CORE	0.85 V	N/A	N/A	2.34	2.50
VDD_LPDDR4/ VDD_DDR4	1.1 V/1.2 V	74.39	75.76	58.55	58.23
SoC_DVDD1V8	1.8 V & 3.3 V	16.84	17.41	49.35	49.37
SoC_DVDD3V3					
VDDA_CORE	1.8 V	50.48	51.04	53.28	53.33
	Total Power	**431.78**	**350.95**	**407.10**	**349.60**

4.1.1.2.7 OS Idle at 1400MHz

		0.85V VDD_CORE DDR4
EVM VDD Rail	Rail Voltage	Power (mW)
VDD_CORE	0.75V/0.85V	298.93
VDDR_CORE	0.85V	N/A
VDD_LPDDR4/VDD_DDR4	1.1V/1.2V	75.37
SoC_DVDD1V8	1.8V and 3.3V	16.76
SoC_DVDD3V3		
VDDA_CORE	1.8V	51.77
	Total Power	**442.84**

4.1.2 Deep Sleep

Deep Sleep (Suspend-to-RAM) is a low power mode designed for battery power applications. In Deep Sleep, its assumed that DDR4/LPDDR4 is in Self-Refresh Mode. The device's state is stored in DDR4/LPDDR4 when the device is powered off. Deep Sleep requires a wake-up source to move the device back into normal operation.

4.1.2.1 Deep Sleep Setup

All tests were run at 60 seconds for ample time to measure. The wake-up source used is the Real Time Clock.

```
root@am62xx-evm:~# rtcwake -s <# of seconds asleep> -m mem
```

4.1.2.2 Deep Sleep Data

This data was optimized to reduce current leakage.

		0.85V VDD_CORE DDR4	0.75V VDD_CORE DDR4	0.75V VDD_COR LPDDR4
EVM VDD Rail	Rail Voltage	Power (mW)	Power (mW)	Power (mW)
VDD_CORE	0.75V/0.85V	7.65	4.19	5.48
VDDR_CORE	0.85V	N/A	0.93	0.68
VDD_LPDDR4/ VDD_DDR4	1.1V/1.2V	9.61	12.09	1.10
SoC_DVDD1V8	1.8V	2.98	7.20	2.70
SoC_DVDD3V3	3.3V	2.31	4.68	2.68
VDDA_CORE	1.8V	1.89	3.24	1.98
	Total Power	**24.44**	**32.51**	**14.62**

For more information about the Low Power Mode power measurements, review this section.

4.1.3 MCU Only

MCU Only is another low power mode. Unlike Deep Sleep, the MCU Core is powered on which allows for it to run an application while the rest of the SoC is powered off.

4.1.3.1 MCU Only Setup

MCU Only needs a wake-up source so the device tree overlay is needed.

To add the device tree overlay, follow these steps:

```
HOST$ cd <SDK installation directory>/board-support/ti-linux-kernel/
HOST$ make CROSS_COMPILE=aarch64-none-linux-gnu- ARCH=arm64 dtbs
HOST$ sudo cp arch/arm64/boot/dts/ti/k3-am62x-sk-mcu-gpio-wakeup.dtbo <path-to-sdk>/root/
boot/dtb/ti/
```

In boot/uEnv.txt, the device tree overlay needs to be added so it will be recognized.

```
name_overlays=ti/k3-am62x-sk-mcu-gpio-wakeup.dtso
```

Now the device tree overlay is added, this is how to enter MCU Only mode:

```
root@am62xx-evm:~# echo enabled > /sys/bus/platform/devices/5000000.m4fss/power/wakeup
root@am62xx-evm:~# echo mem > /sys/power/state
```

Based on the device tree overlay, the wake-up source will be MCU_GPIO0_16.

4.1.3.2 MCU Only Data

This data was optimized to reduce current leakage and slow down the MCU Clock.

		0.85V VDD_CORE DDR4	0.75V VDD_CORE DDR4	0.75V VDD_CORE LPDDR4
EVM VDD Rail	Rail Voltage	Power (mW)	Power (mW)	Power (mW)
VDD_CORE	0.75V/0.85V	39.56	27.00	27.23
VDDR_CORE	0.85V	N/A	1.61	1.62
VDD_LPDDR4/ VDD_DDR4	1.1V/1.2V	8.39	8.14	0.77
SoC_DVDD1V8	1.8V	3.60	4.51	2.34
SoC_DVDD3V3	3.3V	3.67	3.34	11.62
VDDA_CORE	1.8V	10.27	10.99	11.34
	Total Power	**65.50**	**55.59**	**54.91**

For more information about the Low Power Mode power measurements, review this section.

4.2 Core Benchmarks

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

4.2.1 Dhrystone

4.2.1.1 Dhrystone Setup

The commands to run Dhrystone are stated below.

1-Core Dhrystone

```
root@am62xx-evm:~# dhrystone 400000000
```

2-Core Dhrystone

```
root@am62xx-evm:~# taskset 0x1 dhrystone 400000000 &
root@am62xx-evm:~# tastset 0x2 dhrystone 400000000 &
```

4-Core Dhrystone

```
root@am62xx-evm:~# taskset 0x1 dhrystone 400000000 &
root@am62xx-evm:~# tastset 0x2 dhrystone 400000000 &
root@am62xx-evm:~# taskset 0x4 dhrystone 400000000 &
root@am62xx-evm:~# taskset 0x8 dhrystone 400000000 &
```

4.2.1.2 Dhrystone Data

4.2.1.2.1 1-Core Dhrystone Data

		0.85V VDD_CORE DDR4	0.75V VDD_CORE DDR4	0.85V VDD_CORE LPDDR4	0.75V VDD_CORE LPDDR4
EVM VDD Rail	Rail Voltage	Power (mW)	Power (mW)	Power (mW)	Power (mW)
VDD_CORE	0.75V/0.85V	710.95	488.40	616.97	451.32
VDDR_CORE	0.85V	N/A	N/A	3.94	3.96
VDD_LPDDR4/ VDD_DDR4	1.1V/1.2V	74.99	76.22	58.59	58.94
SoC_DVDD1V8	1.8V and 3.3V	70.22	72.69	104.85	105.40
SoC_DVDD3V3					
VDDA_CORE	1.8V	52.30	53.61	53.72	55.93
	Total Power	**908.45**	**690.92**	**838.07**	**675.55**

4.2.1.2.2 2-Core Dhrystone Data

		0.85V VDD_CORE DDR4	0.75V VDD_CORE DDR4	0.85V VDD_CORE LPDDR4	0.75V VDD_CORE LPDDR4
EVM VDD Rail	Rail Voltage	Power (mW)	Power (mW)	Power (mW)	Power (mW)
VDD_CORE	0.75V/0.85V	824.35	550.85	713.95	510.73
VDDR_CORE	0.85V	N/A	N/A	5.26	5.04
VDD_LPDDR4/ VDD_DDR4	1.1V/1.2V	74.44	76.56	58.53	58.36
SoC_DVDD1V8	1.8V and 3.3V	69.88	72.66	104.73	105.03
SoC_DVDD3V3					
VDDA_CORE	1.8V	52.37	53.71	53.87	55.97
	Total Power	**1021.04**	**753.78**	**936.35**	**735.13**

4.2.1.2.3 4-Core Dhrystone Data

		0.85V VDD_CORE DDR4	0.75V VDD_CORE DDR4	0.85V VDD_CORE LPDDR4	0.75V VDD_CORE LPDDR4
EVM VDD Rail	Rail Voltage	Power (mW)	Power (mW)	Power (mW)	Power (mW)
VDD_CORE	0.75V/0.85V	1044.26	669.79	902.80	629.13
VDDR_CORE	0.85V	N/A	N/A	7.82	7.39
VDD_LPDDR4/ VDD_DDR4	1.1V/1.2V	74.53	76.81	58.58	58.57
SoC_DVDD1V8	1.8V and 3.3V	69.85	72.46	104.60	105.01
SoC_DVDD3V3					
VDDA_CORE	1.8V	52.50	53.66	53.84	55.97
	Total Power	**1241.14**	**872.72**	**1127.64**	**856.07**

4.2.2 Whetstone

4.2.2.1 Whetstone Setup

The commands to run Whetstone are stated below.

1-Core Whetstone

```
root@am62xx-evm:~# whetstone 3600000
```

2-Core Whetstone

```
root@am62xx-evm:~# taskset 0x1 whetstone 3600000 &
root@am62xx-evm:~# tastset 0x2 whetstone 3600000 &
```

4-Core Whetstone

```
root@am62xx-evm:~# taskset 0x1 whetstone 3600000 &
root@am62xx-evm:~# tastset 0x2 whetstone 3600000 &
root@am62xx-evm:~# taskset 0x4 whetstone 3600000 &
root@am62xx-evm:~# taskset 0x8 whetstone 3600000 &
```

4.2.2.2 Whetstone Data

4.2.2.2.1 1-Core Whetstone Data

		0.85V VDD_CORE DDR4	0.75V VDD_CORE DDR4	0.85V VDD_CORE LPDDR4	0.75V VDD_CORE LPDDR4
EVM VDD Rail	Rail Voltage	Power (mW)	Power (mW)	Power (mW)	Power (mW)
VDD_CORE	0.75V/0.85V	690.92	476.47	603.61	437.22
VDDR_CORE	0.85V	N/A	N/A	3.39	3.27
VDD_LPDDR4/ VDD_DDR4	1.1V/1.2V	74.35	76.16	58.88	58.43
SoC_DVDD1V8	1.8V and 3.3V	70.40	72.64	104.86	105.47
SoC_DVDD3V3					
VDDA_CORE	1.8V	52.29	53.62	53.79	55.90
	Total Power	**887.96**	**678.89**	**824.54**	**660.28**

4.2.2.2.2 2-Core Whetstone Data

		0.85V VDD_CORE DDR4	0.75V VDD_CORE DDR4	0.85V VDD_CORE LPDDR4	0.75V VDD_CORE LPDDR4
EVM VDD Rail	Rail Voltage	Power (mW)	Power (mW)	Power (mW)	Power (mW)
VDD_CORE	0.75V/0.85V	788.21	525.66	683.47	486.35
VDDR_CORE	0.85V	N/A	N/A	4.01	3.74
VDD_LPDDR4/ VDD_DDR4	1.1V/1.2V	74.40	76.32	58.58	58.30
SoC_DVDD1V8	1.8V and 3.3V	69.91	72.68	104.78	105.41
SoC_DVDD3V3					
VDDA_CORE	1.8V	52.34	53.68	53.76	55.91
	Total Power	**984.86**	**728.34**	**904.61**	**709.71**

4.2.2.2.3 4-Core Whetstone Data

		0.85V VDD_CORE DDR4	0.75V VDD_CORE DDR4	0.85V VDD_CORE LPDDR4	0.75V VDD_CORE LPDDR4
EVM VDD Rail	Rail Voltage	Power (mW)	Power (mW)	Power (mW)	Power (mW)
VDD_CORE	0.75V/0.85V	956.26	621.24	848.26	583.27
VDDR_CORE	0.85V	N/A	N/A	5.51	4.97
VDD_LPDDR4/ VDD_DDR4	1.1V/1.2V	74.20	76.31	58.63	58.33
SoC_DVDD1V8	1.8V and 3.3V	70.01	72.36	104.64	105.00
SoC_DVDD3V3					
VDDA_CORE	1.8V	52.36	53.68	53.82	55.97
	Total Power	**1152.84**	**823.58**	**1070.87**	**807.53**

4.2.3 Stress-ng

4.2.3.1 Stress-ng Setup

The Linux command to run these tests follow this format:

```
root@am62xx-evm:~# stress-ng --cpu <# of Cores> -t <time in minutes>m
```

1-Core Stress-ng

```
root@am62xx-evm:~# stress-ng --cpu 1 -t 1m
```

2-Core Stress-ng

```
root@am62xx-evm:~# stress-ng --cpu 2 -t 1m
```

4-Core Stress-ng

```
root@am62xx-evm:~# stress-ng --cpu 4 -t 1m
```

4.2.3.2 Stress-ng Data

4.2.3.2.1 1-Core Stress-ng Data

		0.85V VDD_CORE DDR4	0.75V VDD_CORE DDR4	0.85V VDD_CORE LPDDR4	0.75V VDD_CORE LPDDR4
EVM VDD Rail	Rail Voltage	Power (mW)	Power (mW)	Power (mW)	Power (mW)
VDD_CORE	0.75V/0.85V	698.26	482.93	607.95	442.88
VDDR_CORE	0.85V	N/A	N/A	3.49	3.40
VDD_LPDDR4/ VDD_DDR4	1.1V/1.2V	75.23	76.83	59.68	58.96
SoC_DVDD1V8	1.8V and 3.3V	70.65	72.45	104.98	105.79
SoC_DVDD3V3					
VDDA_CORE	1.8V	52.23	53.60	53.81	55.77
	Total Power	**896.37**	**685.81**	**829.91**	**666.81**

4.2.3.2.2 2-Core Stress-ng Data

		0.85V VDD_CORE DDR4	0.75V VDD_CORE DDR4	0.85V VDD_CORE LPDDR4	0.75V VDD_CORE LPDDR4
EVM VDD Rail	Rail Voltage	Power (mW)	Power (mW)	Power (mW)	Power (mW)
VDD_CORE	0.75V/0.85V	799.82	537.13	695.60	497.66
VDDR_CORE	0.85V	N/A	N/A	4.53	4.27
VDD_LPDDR4/ VDD_DDR4	1.1 V/1.2 V	78.79	80.11	65.22	64.21
SoC_DVDD1V8	1.8V and 3.3V	70.01	72.49	105.08	105.60
SoC_DVDD3V3					
VDDA_CORE	1.8V	52.31	53.64	53.80	55.89
	Total Power	**1000.94**	**743.37**	**924.22**	**727.62**

4.2.3.2.3 4-Core Stress-ng Data

		0.85V VDD_CORE DDR4	0.75V VDD_CORE DDR4	0.85V VDD_CORE LPDDR4	0.75V VDD_CORE LPDDR4
EVM VDD Rail	Rail Voltage	Power (mW)	Power (mW)	Power (mW)	Power (mW)
VDD_CORE	0.75V/0.85V	988.76	642.69	860.18	600.48
VDDR_CORE	0.85V	N/A	N/A	6.35	5.80
VDD_LPDDR4/ VDD_DDR4	1.1V/1.2V	95.91	95.90	78.75	76.44
SoC_DVDD1V8	1.8V and 3.3V	69.82	71.97	105.68	105.88
SoC_DVDD3V3					
VDDA_CORE	1.8V	52.47	53.61	53.81	55.85
	Total Power	**1206.96**	**864.17**	**924.22**	**844.45**

4.3 Memory Benchmark

This section will focus on stressing the DDR4/LPDDR4.

4.3.1 Stream

4.3.1.1 Stream Setup

The Linux command to run these tests follow this format:

```
root@am62xx-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@am62xx-evm:~# stream -P 1 -N 500
```

2-Core Stream

```
root@am62xx-evm:~# stream -P 2 -N 200
```

4-Core Stream

```
root@am62xx-evm:~# stream -P 4 -N 10
```

4.3.1.2 Stream Data

4.3.1.2.1 1-Core Stream Data

		0.85V VDD_CORE DDR4	0.75V VDD_CORE DDR4	0.85V VDD_CORE LPDDR4	0.75V VDD_CORE LPDDR4
EVM VDD Rail	Rail Voltage	Power (mW)	Power (mW)	Power (mW)	Power (mW)
VDD_CORE	0.75V/0.85V	744.25	523.26	647.18	475.53
VDDR_CORE	0.85V	N/A	N/A	3.44	3.75
VDD_LPDDR4/ VDD_DDR4	1.1V/1.2V	286.63	294.34	153.13	148.45
SoC_DVDD1V8	1.8V and 3.3V	69.71	71.63	106.67	106.88
SoC_DVDD3V3					
VDDA_CORE	1.8V	52.39	53.51	53.82	55.94
	Total Power	**1152.97**	**942.74**	**964.23**	**790.55**

4.3.1.2.2 2-Core Stream Data

		0.85V VDD_CORE DDR4	0.75V VDD_CORE DDR4	0.85V VDD_CORE LPDDR4	0.75V VDD_CORE LPDDR4
EVM VDD Rail	Rail Voltage	Power (mW)	Power (mW)	Power (mW)	Power (mW)
VDD_CORE	0.75V/0.85V	829.21	578.60	722.57	529.89
VDDR_CORE	0.85V	N/A	N/A	3.81	4.16
VDD_LPDDR4/ VDD_DDR4	1.1V/1.2V	330.92	336.84	146.78	146.34
SoC_DVDD1V8	1.8V and 3.3V	69.73	72.04	107.28	107.46
SoC_DVDD3V3					
VDDA_CORE	1.8 V	52.48	53.74	53.86	55.98
	Total Power	**1282.34**	**1041.23**	**1034.29**	**843.84**

4.3.1.2.3 4-Core Stream Data

		0.85V VDD_CORE DDR4	0.75V VDD_CORE DDR4	0.85V VDD_CORE LPDDR4	0.75V VDD_CORE LPDDR4
EVM VDD Rail	Rail Voltage	Power (mW)	Power (mW)	Power (mW)	Power (mW)
VDD_CORE	0.75 V/0.85 V	930.17	634.58	811.17	595.74
VDDR_CORE	0.85 V	N/A	N/A	4.76	4.75
VDD_LPDDR4/ VDD_DDR4	1.1 V/1.2 V	346.92	352.81	155.98	178.10
SoC_DVDD1V8	1.8 V & 3.3 V	69.77	72.13	109.01	108.51
SoC_DVDD3V3					
VDDA_CORE	1.8 V	52.45	53.72	53.82	55.94
	Total Power	**1399.31**	**1113.25**	**1134.74**	**943.04**

4.4 Networking/Cryptography Benchmark

This section focuses on networking with Ethernet and cryptography.

4.4.1 OpenSSL

4.4.1.1 OpenSSL Setup

An Ethernet connection is needed.

The Linux command to run these tests follow this format:

```
root@am62xx-evm:~# openssl speed -multi <# of Cores/# of Threads>
```

1-Core OpenSSL

```
root@am62xx-evm:~# openssl speed -multi 1
```

2-Core OpenSSL

```
root@am62xx-evm:~# openssl speed -multi 2
```

4-Core OpenSSL

```
root@am62xx-evm:~# openssl speed -multi 4
```

4.4.1.2 OpenSSL Data

4.4.1.2.1 1-Core OpenSSL Data

		0.85V VDD_CORE DDR4	0.75V VDD_CORE DDR4	0.85V VDD_CORE LPDDR4	0.75V VDD_CORE LPDDR4
EVM VDD Rail	Rail Voltage	Power (mW)	Power (mW)	Power (mW)	Power (mW)
VDD_CORE	0.75V/0.85V	726.15	497.63	626.18	454.75
VDDR_CORE	0.85V	N/A	N/A	3.77	3.72
VDD_LPDDR4/ VDD_DDR4	1.1V/1.2V	74.53	83.04	58.75	58.39
SoC_DVDD1V8	1.8 and 3.3V	86.75	89.42	123.45	123.59
SoC_DVDD3V3					
VDDA_CORE	1.8V	52.47	53.61	53.82	55.90
	Total Power	**939.91**	**723.70**	**865.97**	**696.35**

4.4.1.2.2 2-Core OpenSSL Data

		0.85V VDD_CORE DDR4	0.75V VDD_CORE DDR4	0.85V VDD_CORE LPDDR4	0.75V VDD_CORE LPDDR4
EVM VDD Rail	Rail Voltage	Power (mW)	Power (mW)	Power (mW)	Power (mW)
VDD_CORE	0.75V/0.85V	842.52	557.54	723.03	518.38
VDDR_CORE	0.85V	N/A	N/A	4.95	4.94
VDD_LPDDR4/ VDD_DDR4	1.1V/1.2V	74.66	82.84	58.57	58.38
SoC_DVDD1V8	1.8V and 3.3V	86.73	89.12	123.54	123.62
SoC_DVDD3V3					
VDDA_CORE	1.8 V	52.53	53.67	53.84	55.95
	Total Power	**1056.44**	**783.17**	**963.93**	**761.27**

4.4.1.2.3 4-Core OpenSSL Data

		0.85V VDD_CORE DDR4	0.75V VDD_CORE DDR4	0.85V VDD_CORE LPDDR4	0.75V VDD_CORE LPDDR4
EVM VDD Rail	Rail Voltage	Power (mW)	Power (mW)	Power (mW)	Power (mW)
VDD_CORE	0.75V/0.85V	1073.38	695.09	936.19	669.13
VDDR_CORE	0.85V	N/A	N/A	7.48	7.36
VDD_LPDDR4/ VDD_DDR4	1.1V/1.2V	75.14	86.58	59.22	58.44
SoC_DVDD1V8	1.8V and 3.3V	86.81	88.76	123.65	123.85
SoC_DVDD3V3					
VDDA_CORE	1.8 V	52.74	53.72	53.86	55.96
	Total Power	**1288.07**	**924.15**	**1180.40**	**914.74**

4.5 Graphics Example Use Case

This section will discuss running a graphics example.

4.5.1 glmark2

This graphics use case shows the power consumed in a standard graphics display from glmark2.

4.5.1.1 glmark2 Setup

This setup requires an HDMI connection to a monitor.

To simplify the process, this is a simple bash script to infinite run the Jellyfish example.

```
#!/bin/sh

for i in $(seq 3); do
   glmark2-es2-wayland -b jellyfish --run-forever > /dev/null &
done

wait
```

Then the script needs to be copied onto the SD Card.

```
HOST$ sudo cp <GPU Script> /media/<USER>/root/home/root
```

```
root@am62xx-evm:~# systemctrl stop ti-apps-launcher
root@am62xx-evm:~# systemctrl disable ti-apps-launcher
root@am62xx-evm:~# systemctrl start weston
root@am62xx-evm:~# ./<GPU Script>.sh
```

To exit the bash script, send an interrupt into the terminal with CTRL + C.

4.5.1.2 glmark2 Data

		0.85V VDD_CORE DDR4	0.75V VDD_CORE DDR4	0.85V VDD_CORE LPDDR4	0.75V VDD_CORE LPDDR4
EVM VDD Rail	Rail Voltage	Power (mW)	Power (mW)	Power (mW)	Power (mW)
VDD_CORE	0.75V/0.85V	992.91	651.67	856.64	648.95
VDDR_CORE	0.85V	N/A	N/A	6.55	6.52
VDD_LPDDR4/ VDD_DDR4	1.1V/1.2V	174.82	168.66	125.13	123.84
SoC_DVDD1V8	1.8V and 3.3V	185.33	133.06	172.36	176.58
SoC_DVDD3V3					
VDDA_CORE	1.8V	54.65	55.67	55.58	55.50
	Total Power	**1353.07**	**1009.06**	**1216.27**	**1011.40**

4.6 High Activity Concurrency Tests

4.6.1 4-Core Dhrystone + glmark2

This high activity use case combines the Core stess from Dhrystone with the Graphics use from glmark2.

4.6.1.1 4-Core Dhrystone + glmark2 Setup

This setup requires connecting a HDMI cable for a monitor and an Ethernet cable.

```
root@am62xx-evm:~# ifconfig
root@am62xx-evm:~# systemctrl stop ti-apps-launcher
root@am62xx-evm:~# systemctrl disable ti-apps-launcher
root@am62xx-evm:~# systemctrl start weston
root@am62xx-evm:~# ./GPU_test.sh
```

In another terminal, ssh into the Starter Kit EVM. Use the inet for the Ethernet port used from the output of ifconfig.

```
HOST$: ssh root@<ip-addr>
root@am62xx-evm:~# taskset 0x1 dhrystone 400000000 &
root@am62xx-evm:~# tastset 0x2 dhrystone 400000000 &
root@am62xx-evm:~# taskset 0x4 dhrystone 400000000 &
root@am62xx-evm:~# taskset 0x8 dhrystone 400000000 &
```

To exit the command, send an interrupt with CTRL + C on each terminal.

4.6.1.2 4-Core Dhrystone + glmark2 Data

		0.85V VDD_CORE DDR4	0.75V VDD_CORE DDR4	0.85V VDD_CORE LPDDR4	0.75V VDD_CORE LPDDR4
EVM VDD Rail	Rail Voltage	Power (mW)	Power (mW)	Power (mW)	Power (mW)
VDD_CORE	0.75V/0.85V	1063.19	683.58	925.97	647.24
VDDR_CORE	0.85V	N/A	N/A	8.02	7.32
VDD_LPDDR4/ VDD_DDR4	1.1V/1.2V	152.70	144.29	110.07	105.36
SoC_DVDD1V8	1.8V and 3.3V	146.55	161.45	189.20	188.28
SoC_DVDD3V3					
VDDA_CORE	1.8V	54.78	55.63	55.69	57.80
	Total Power	**1417.22**	**1044.95**	**1288.94**	**1006.01**

4.6.2 4-Core Stress-ng + glmark2

This high activity use case combines the general (mostly Core) stress of Stress-ng with the Graphics use case of glmark2.

4.6.2.1 4-Core Stress-ng + glmark2 Setup

This setup requires connecting a HDMI cable for a monitor and an Ethernet cable.

```
root@am62xx-evm:~# ifconfig
root@am62xx-evm:~# systemctrl stop ti-apps-launcher
root@am62xx-evm:~# systemctrl disable ti-apps-launcher
root@am62xx-evm:~# systemctrl start weston
root@am62xx-evm:~# ./GPU_test.sh
```

In another terminal, ssh into the SKEVM. Use the inet from the output of ipconfig.

```
HOST$: ssh root@<ip-addr>
root@am62xx-evm:~# stress-ng --cpu 4 -t 3m
```

To exit the command, send an interrupt with CTRL + C on each terminal.

4.6.2.2 4-Core Stress-ng + glmark2 Data

		0.85V VDD_CORE DDR4	0.75V VDD_CORE DDR4	0.85V VDD_CORE LPDDR4	0.75V VDD_CORE LPDDR4
EVM VDD Rail	Rail Voltage	Power (mW)	Power (mW)	Power (mW)	Power (mW)
VDD_CORE	0.75V/0.85V	1025.59	662.99	897.06	628.93
VDDR_CORE	0.85V	N/A	N/A	7.05	6.53
VDD_LPDDR4/ VDD_DDR4	1.1V/1.2V	168.43	159.00	122.81	116.63
SoC_DVDD1V8	1.8 and 3.3V	147.25	162.87	190.44	189.40
SoC_DVDD3V3					
VDDA_CORE	1.8V	54.76	55.64	55.66	57.89
	Total Power	**1396.03**	**1040.50**	**1273.02**	**999.38**

4.6.3 4-Core Stream + glmark2

This high activity use case combines the DDR4 stress from Stream along with the Graphics use case from glmark2.

4.6.3.1 4-Core Stream + glmark2 Setup

This setup requires connecting a HDMI cable for a monitor and an Ethernet cable.

```
root@am62xx-evm:~# ifconfig
root@am62xx-evm:~# systemctrl stop ti-apps-launcher
root@am62xx-evm:~# systemctrl disable ti-apps-launcher
root@am62xx-evm:~# systemctrl start weston
root@am62xx-evm:~# ./GPU_test.sh
```

In another terminal, ssh into the SKEVM. Use the inet from the output of ifconfig.

```
HOST$: ssh root@<ip-addr>
root@am62xx-evm:~# stream -P 4 -N 10
```

To exit the command, send an interrupt with CTRL + C on each terminal.

4.6.3.2 4-Core Stream + glmark2 Data

		0.85V VDD_CORE DDR4	0.75V VDD_CORE DDR4	0.85V VDD_CORE LPDDR4	0.75V VDD_CORE LPDDR4
EVM VDD Rail	Rail Voltage	Power (mW)	Power (mW)	Power (mW)	Power (mW)
VDD_CORE	0.75V/0.85V	1022.36	669.31	887.80	638.61
VDDR_CORE	0.85V	N/A	N/A	6.30	5.82
VDD_LPDDR4/ VDD_DDR4	1.1V/1.2V	320.26	336.64	175.53	184.73
SoC_DVDD1V8	1.8V and 3.3V	145.95	156.30	191.79	189.40
SoC_DVDD3V3					
VDDA_CORE	1.8V	54.83	55.69	55.70	57.80
	Total Power	**1543.40**	**1217.93**	**1317.12**	**1078.18**

4.7 Application Demos

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

4.7.1 HMI Demo

The HMI (Human Machine Interface) demo utilizes the TI-Apps-Launcher's Industrial HMI Demo of a motor controller interface.

4.7.1.1 HMI Demo Setup

The demo requires a monitor connection to display the demo and a USB mouse to interact with the interface. By default, the ti-apps-launcher will be open when using the default image. If not, use these commands:

```
root@am62xx-evm:~# systemctl start weston
root@am62xx-evm:~# systemctl start ti-apps-launcher
root@am62xx-evm:~# reboot
```

Once the ti-apps-launcher is open and running, use the USB mouse to select "Industrial HMI."

4.7.1.2 HMI Demo Data

		0.85V VDD_CORE DDR4	0.75V VDD_CORE DDR4	0.85V VDD_CORE LPDDR4	0.75V VDD_CORE LPDDR4
EVM VDD Rail	Rail Voltage	Power (mW)	Power (mW)	Power (mW)	Power (mW)
VDD_CORE	0.75V/0.85V	863.45	604.34	656.47	505.62
VDDR_CORE	0.85V	N/A	N/A	4.30	4.34
VDD_LPDDR4/ VDD_DDR4	1.1V/1.2V	262.23	263.47	99.68	98.91
SoC_DVDD1V8	1.8V and 3.3V	109.14	114.41	149.88	148.23
SoC_DVDD3V3					
VDDA_CORE	1.8V	59.95	61.21	61.10	61.46
	Total Power	**1294.76**	**1043.44**	**971.42**	**818.55**

4.7.2 DMS Demo

The DMS (Driving Monitor System) Demo is simple application that uses a USB Camera to capture video and displays the output on a monitor via HDMI. This is to mimic a common automotive application.

4.7.2.1 DMS Demo Setup

1. Determine the video number. Find the first video number (/dev/video#) connected to the USB Camera.

   ```
   root@am62xx-evm:~# v4l2-ctl --list-devices
   ```

2. Make sure weston is off.

   ```
   root@am62xx-evm:~# systemctl stop weston
   root@am62xx-evm:~# systemctl disable weston
   ```

3. Run the video stream with /dev/video# found before.

   ```
   root@am62xx-evm:~# gst-launch-1.0 v4l2src device="/dev/video#" ! video/x-raw, width=640,
   height=480 ! kmssink driver-name=tidss plane-id=<31>
   ```

4.7.2.2 DMS Demo Data

		0.85V VDD_CORE DDR4	0.75V VDD_CORE DDR4	0.85V VDD_CORE LPDDR4	0.75V VDD_CORE LPDDR4
EVM VDD Rail	Rail Voltage	Power (mW)	Power (mW)	Power (mW)	Power (mW)
VDD_CORE	0.75V/0.85V	640.95	464.94	559.59	418.51
VDDR_CORE	0.85V	N/A	N/A	2.75	3.13
VDD_LPDDR4/ VDD_DDR4	1.1V/1.2V	93.74	96.46	73.17	71.90
SoC_DVDD1V8	1.8V and 3.3V	81.98	84.65	118.02	120.18
SoC_DVDD3V3					
VDDA_CORE	1.8V	64.20	63.62	65.09	67.40
	Total Power	**880.86**	**709.67**	**818.62**	**681.11**

5 Limitations

5.1 Low Power Mode Measurement Discrepancy

Low Power Mode test results for Deep Sleep measurements demonstrated a range of results from 25-34mW. This is expected for several reasons: First, the VDD_DDR4 (and LPDDR4) rail sources power to both the AM62x SoC DDR IO rails, as well as the DDR IC power-supply rails. Per the table found in Starter Kit EVM Rails, there will be power consumed on the DDR rail by the DRAM IC. More information can be found about the expected power consumed by the Micron DDR IC in their device specific App Notes. Often the values needed to evaluate are 'IDD6N, Self Refresh Current', for LPDDR4 and DDR4 memory types.

An additional reason for varying power measurements in the Deep Sleep modes is due to the IO power supply rails are not yet optimized with internal Pull Ups and Pull Downs for Deep Sleep modes, for each AM62x variant board type. The default resistor configuration does not follow recommendations from the legacy Sitara AM335x Low Power Design Guide.

5.2 Measurement Methods

For Active Power measurements, the on-board INA Current Monitoring devices were used to measure the power consumed on each of the Starter Kit EVM Rails. There is one INA device per EVM rail which can be accessed via I2C. The INA measurements can be read from a python script.

The INAs may not be calibrated correctly or may not have the correct shunt resistor which creates a degree of inaccuracy in the measurements.

Starter Kit EVM	INA Used for Each EVM Rail
SK-AM62B	INA226
SK-AM62B-P1	INA231
SK-AM62-LP	

For Low Power Mode measurements, a high precision multi-meter was used to measure the voltage drop-off across each of the power rail resistors on the board.

5.3 Starter Kit EVM I/O Rails

Power measurements on the SoC_DVDD1V8 and SoC_DVDD3V3 rails were optimized for functionality, less for LPMs. Board to board variance involving Pull-Up, Pull-Down resistors coupled to peripheral components will reflect varying power measurements between AM62x board variants.

6 References

1. Processor SDK Version 9.0: https://www.ti.com/tool/download/PROCESSOR-SDK-LINUX-AM62X/09.00.00.03
2. Processor SDK Version 9.0 Documentation: https://software-dl.ti.com/processor-sdk-linux/esd/AM62X/09_00_00_03/exports/docs/devices/AM62X/linux/Overview.html
3. AM625 Product Page: https://www.ti.com/product/AM625
4. SK-AM62B Starter Kit EVM
5. SK-AM62B-P1 Starter Kit EVM
6. SK-AM62-LP Starter Kit EVM: https://www.ti.com/tool/SK-AM62-LP
7. [E2E FAQ] How do I measure power and temperature on the AM62A and the AM62X?: https://e2e.ti.com/support/processors-group/processors/f/processors-forum/1273364/faq-sk-am62-how-do-i-measure-power-and-temperature-on-the-am62a-and-the-am62x
8. Texas Instruments: *AM62x Benchmarks*
9. Texas Instruments: *AM62x SK EVM User's Guide*
10. Texas Instruments: *AM335x Low Power Design Guide*
11. Texas Instruments: *AM62x Technical Reference Manual*

Appendix

A.1 Summary Table

Categories	Test Name / Mode	0.85V Core DDR4 1400MHz Power (mW)	0.75V Core DDR4 1000MHz Power (mW)	0.85V Core LDDR4 1250MHz Power (mW)	0.75V Core LDDR4 1000MHz Power (mW)
OS Idle	200MHz	383.54	315.58	360.58	316.26
	400MHz	393.31	322.64	370.32	323.61
	600MHz	402.36	329.69	378.89	329.49
	800MHz	413.44	338.02	389.24	337.48
	1000MHz	421.49	344.25	397.39	343.59
	1250MHz	431.78	350.95	407.10	349.60
	1400MHz	442.84	N/A	N/A	N/A
Low Power Modes	Deep Sleep	24.44	32.51	N/A	14.62
	MCU Only	65.50	55.59	N/A	54.91
Dhrystone	1 Core	908.45	690.92	838.07	675.55
	2 Cores	1021.04	753.78	936.35	735.13
	4 Cores	1241.14	872.72	1127.64	856.07
Whetstone	1 Core	887.96	678.89	824.54	660.28
	2 Cores	984.86	728.34	904.61	709.71
	4 Cores	1152.84	823.58	1070.87	807.53
Stress-ng	1 Core	896.37	685.81	829.91	666.81
	2 Cores	1000.94	743.37	924.22	727.62
	4 Cores	1206.96	856.35	1104.77	844.45
Stream	1 Core	1152.97	938.44	964.23	790.55
	2 Cores	1282.34	1041.23	1034.29	843.84
	4 Cores	1399.31	1113.25	1134.74	943.04
OpenSSL	1 Core	939.91	723.70	865.97	696.35
	2 Cores	1056.44	783.17	963.93	761.27
	4 Cores	1288.07	924.15	1180.40	914.74
Graphics	glmark2	1353.07	1009.06	1216.27	1011.40
High Activity Concurrency Tests	4-Core Dhrystone + glamark2	1417.22	1044.95	1288.94	1006.01
	4-Core Stress-ng + glmark2	1396.03	1040.50	1273.02	999.38
	4-Core Stream + glmark2	1543.40	1217.93	1317.12	1078.18
Application Demos	Human Machine Interface Demo	1294.76	1043.44	971.42	818.55
	Driver Monitoring System Demo	880.86	709.67	818.62	681.11

A.2 How to Change the A53 Core Speed

```
root@am62xx-evm:~# cd /sys/devices/system/cpu/cpufreq/policy0/
root@am62xx-evm:/sys/devices/system/cpu/cpufreq/policy0# ls -l
total 0
-r--r--r-- 1 root root 4096 Jan  1 00:00 affected_cpus
-r-------- 1 root root 4096 Jan  1 00:00 cpuinfo_cur_freq
-r--r--r-- 1 root root 4096 Jan  1 00:00 cpuinfo_max_freq
-r--r--r-- 1 root root 4096 Jan  1 00:00 cpuinfo_min_freq
-r--r--r-- 1 root root 4096 Jan  1 00:00 cpuinfo_transition_latency
-r--r--r-- 1 root root 4096 Jan  1 00:00 related_cpus
-r--r--r-- 1 root root 4096 Jan  1 00:00 scaling_available_frequencies
-r--r--r-- 1 root root 4096 Jan  1 00:00 scaling_available_governors
-r--r--r-- 1 root root 4096 Jan  1 00:00 scaling_cur_freq
-r--r--r-- 1 root root 4096 Jan  1 00:00 scaling_driver
-rw-r--r-- 1 root root 4096 Jan  1 00:04 scaling_governor
-rw-r--r-- 1 root root 4096 Jan  1 00:00 scaling_max_freq
-rw-r--r-- 1 root root 4096 Jan  1 00:00 scaling_min_freq
-rw-r--r-- 1 root root 4096 Jan  1 00:08 scaling_setspeed
drwxr-xr-x 2 root root    0 Jan  1 00:00 stats
root@am62xx-evm:/sys/devices/system/cpu/cpufreq/policy0# cat cpuinfo_cur_freq ###Current CPU
Frequency in kHz
1000000
root@am62xx-evm:/sys/devices/system/cpu/cpufreq/policy0# cat scaling_available_governors
###Available Governors
ondemand userspace performance schedutil
root@am62xx-evm:/sys/devices/system/cpu/cpufreq/policy0# cat scaling_governor ###Currently Governor
= schedutil
schedutil
root@am62xx-evm:/sys/devices/system/cpu/cpufreq/policy0# echo userspace > scaling_governor
###schedutil --> userspace
root@am62xx-evm:/sys/devices/system/cpu/cpufreq/policy0# cat scaling_governor
userspace
root@am62xx-evm:/sys/devices/system/cpu/cpufreq/policy0# cat scaling_available_frequencies
###Available CPU Speeds in khz
200000 400000 600000 800000 1000000 1250000 1400000
root@am62xx-evm:/sys/devices/system/cpu/cpufreq/policy0# echo 1000000 > scaling_setspeed ###Change
speed (in khz)
root@am62xx-evm:/sys/devices/system/cpu/cpufreq/policy0# cat cpuinfo_cur_freq
1000000
root@am62xx-evm:/sys/devices/system/cpu/cpufreq/policy0# k3conf --cpuinfo ###Verified that speed is
changed
```

The maximum operating speed for devices using 0.85V Core Voltage is 1400MHz & using 0.75V Core Voltage is 1250MHz.

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Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265