

# i.MX 7DS Power Consumption Measurement

## 1. Introduction

This application note helps you to design power management systems. It illustrates the current drain measurements of the i.MX 7DS Applications Processors taken on the NXP SABRE SD Platform through several use cases. You may choose the appropriate power supply domains for the i.MX 7DS chips and become familiar with the expected chip power in various scenarios.

Because the data presented in this application note is based on empirical measurements taken on a small sample size, the presented results are not guaranteed.

## Contents

- 1. Introduction..... 1
- 2. Overview of i.MX 7DS Voltage Supplies ..... 2
- 3. Internal Power Measurement of the i.MX 7DS Processor.. 5
  - 3.1. VDDA\_IP8 power ..... 5
  - 3.2. DDR I/O power ..... 5
  - 3.3. Voltage levels and DVFS usage in the measurement process 6
  - 3.4. Temperature measurements ..... 7
  - 3.5. Hardware and software used ..... 7
  - 3.6. Board setup used for the power measurements ..... 8
  - 3.7. Measuring points on the SABRE platform..... 8
- 4. Use Cases and Measurement Results ..... 8
  - 4.1. Low-power mode use cases ..... 8
  - 4.2. Use case two: system idle, M4 idle mode ..... 9
  - 4.3. Use case three: Audio\_Playback, M4 idle..... 10
  - 4.4. Dhrystone benchmark ..... 11
  - 4.5. SNVS ..... 12
- 5. Reducing Power Consumption..... 13
  - 5.1. Steps to be performed before entering the Suspend (Deep-Sleep) mode ..... 15
  - 5.2. Steps to be performed after exiting the Suspend mode 15
- 6. Use Case Configuration and Usage Guidelines..... 16
  - 6.1. Deep-Sleep mode ..... 16
  - 6.2. System Idle mode ..... 16
  - 6.3. Dhrystone on Cortex-A7 (1 GHz) ..... 18
  - 6.4. Heavy Loading use case..... 20
  - 6.5. SNVS ..... 23
  - 6.6. Important commands..... 23
- 7. Revision History ..... 23



## 2. Overview of i.MX 7DS Voltage Supplies

The i.MX 7DS processors have several power supply domains (voltage supply rails) and several internal power domains. The following figure shows the connectivity of these supply rails and the distribution of the internal power domains.

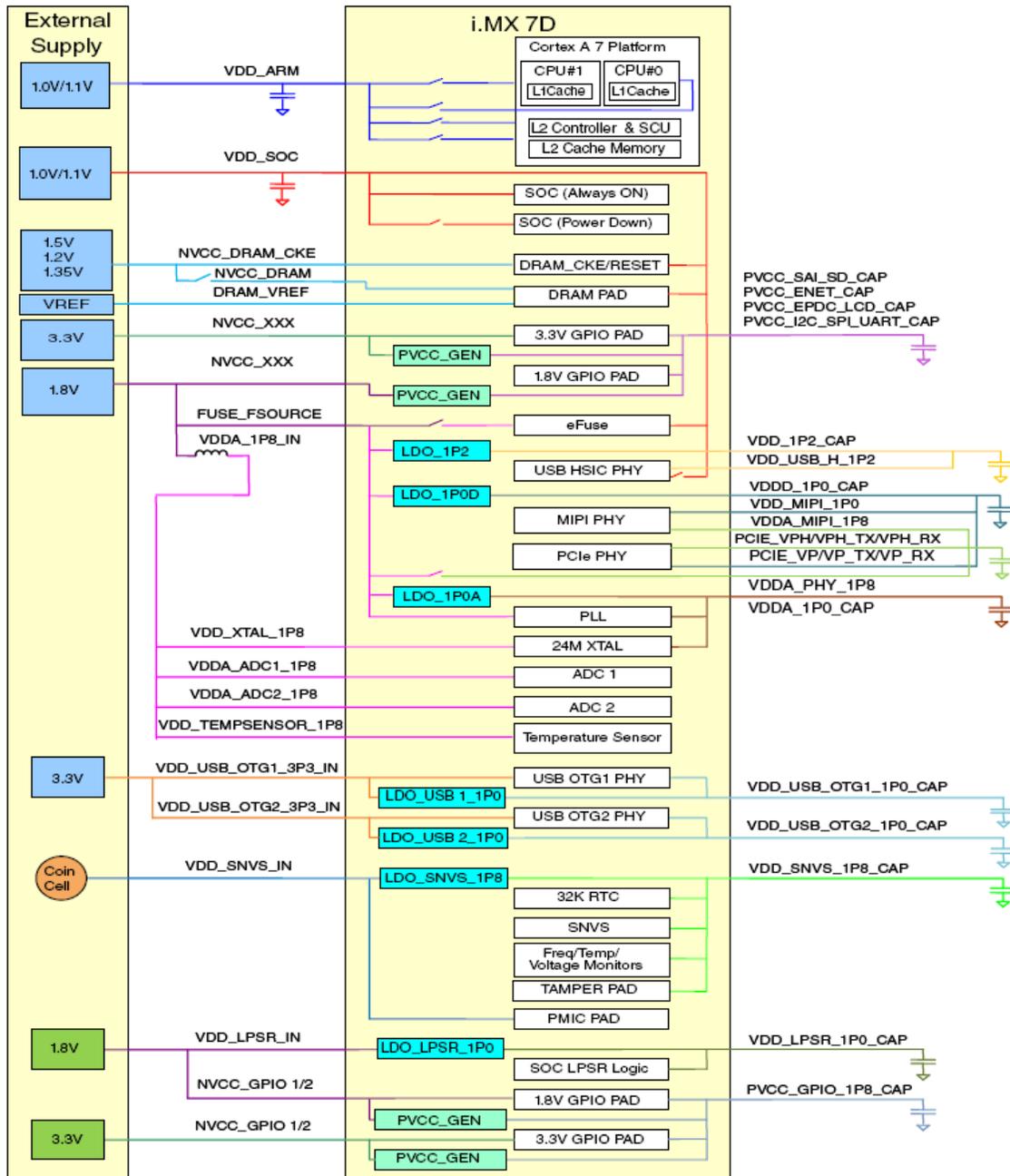


Figure 1. i.MX7DS power rails

**NOTE**

See the *i.MX 7DS datasheet for consumer products* (document [IMX7DCEC](#)) for the recommended operating conditions of each supply rail and for a detailed description of the groups of pins that are powered by each I/O voltage supply.

For more details regarding the i.MX 7DS power rails, see the “Power Management Unit (PMU)” chapter in the *i.MX 7DS Applications Processor Reference Manual* (document [IMX7DRM](#)).

The diagram below is a snippet from the IMX7D SABRE Board schematic showing power distribution.

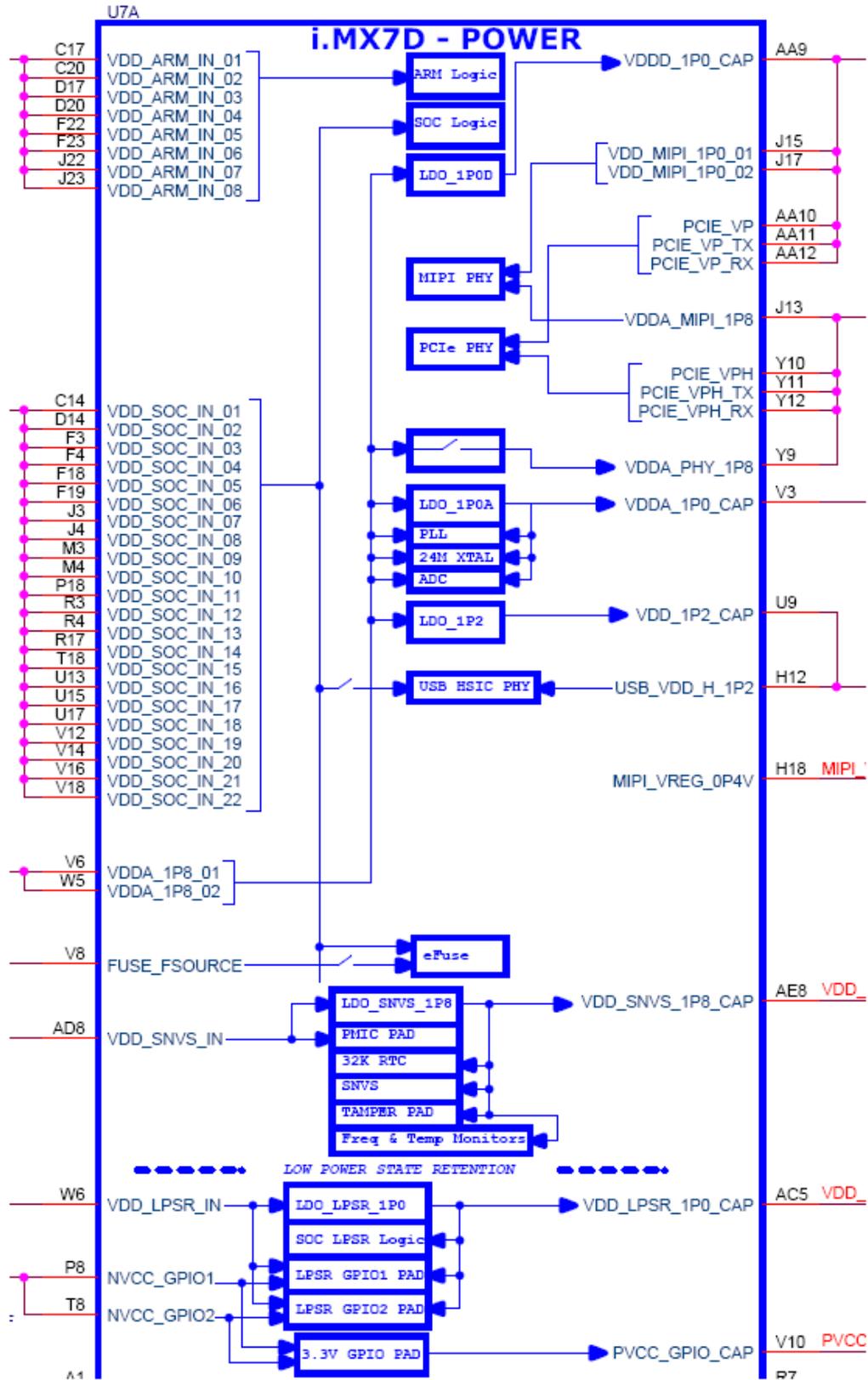


Figure 2. IMX7D power schematic

### 3. Internal Power Measurement of the i.MX 7DS Processor

Several use cases (described in [Section 6, “Use Case Configuration and Usage Guidelines”](#)) are run on the SABRE platform (Revision D). The measurements are taken mainly for the following power supply domains:

- VDD\_ARM: ARM® Cortex®-A7 core supply.
- VDD\_SOC: platform’s supply.

These supply domains consume the majority of the processor’s internal power. For relevant use cases, the power of additional supply domains is added. However, the power of these supply domains does not depend on specific use cases, but on whether or not these modules are used. The power consumption of the SNVS is comparatively negligible (except for the Deep-Sleep mode).

The NVCC\_\* power consumption depends primarily on the board-level configuration and the components. Therefore, it is not included in the i.MX7DS internal power analysis.

The power consumption for these supplies (in different use cases) is provided in [Table 2](#) through to **Error! Reference source not found.**

#### NOTE

Unless stated otherwise, all measurements were taken on a typical process silicon, at a room temperature (approximately 25 °C).

#### 3.1. VDDA\_1P8 power

The VDD\_1P8 voltage domain is generated from the PMIC. This domain powers the following circuits:

- On-chip LDOs (LDO\_1P0D, LDO\_1P0A, LDO\_1P2).
- PHY power supplies (MIPI, PCIe, USB HSIC).
- Analog part of the PLLs.

#### 3.2. DDR I/O power

The DDR I/O is supplied from the NVCC\_DRAM which provides the power for the DDR I/O pads. The target voltage for this supply depends on the DDR interface used. The target voltages for the different DDR interfaces are as follows:

- 1.5 V for DDR3
- 1.35 V for DDR3L
- 1.2 V for LPDDR2/3

The power consumption for the NVCC\_DRAM supply is affected by various factors, including the following:

- The amount of activity on the DDR interface.
- On-Die Termination (ODT): enabled/disabled, termination value, which is used for the DDR controller and the DDR memories.
- The board termination for the DDR control and the address bus.

- The configuration of the DDR pads (such as the drive strength).
- The board layout.
- The load of the DDR memory devices.

#### NOTE

Due to the factors specified in the previous paragraph, the measurements provided in the following tables vary from one system to another. The provided data is for guidance only and should not be treated as a specification.

The measured current on the SABRE Platform also includes the current of the on-board DDR3L memory devices. This board (on which the measurements were taken) includes two DDR3L devices, with a total capacity of 1024 MB. The SABRE Platform does not require board-level resistor terminations. This further reduces the DDR I/O power usage.

### 3.2.1. ODT settings

The ODT is a feature of the DDR3/DDR3L SDRAM that allows the DRAM to turn the termination resistance for each DQ, DQS, DQS#, and DM signal on or off. The ODT feature is designed to improve the signal integrity of the memory channel by allowing the DRAM controller to independently turn the termination resistance for any (or all) DRAM devices on or off.

The use of weaker ODT settings can greatly reduce the power of the DDR I/O. The required ODT settings are system-dependent and may vary among different board designs. These settings must be carefully selected for the power optimization while ensuring that the JEDEC requirements for the DDR parameters are still met. The default settings that are used in the Linux BSP release may need to be modified by the system designers to fit for different systems.

## 3.3. Voltage levels and DVFS usage in the measurement process

The voltage levels of all the supplies (except for the VDD\_ARM) are set to the typical voltage levels, as defined in the *i.MX 7DS datasheet for consumer products* (document [IMX7DCEC](#)).

The VDD\_ARM supplies require a special explanation. To save power, the VDD\_ARM voltage is changed using DVFS (Dynamic Voltage and Frequency Scaling) during the run time of the use cases. The voltage levels of these supplies can be changed to standby voltage levels in low-power modes.

### 3.3.1. VDD\_ARM voltage levels

The target voltage levels for the VDD\_ARM can vary according to the DVFS set-point used, which is selected by the DVFS (also named CPUFREQ) driver. There are several factors that contribute to the set-point decisions, with the CPU load being the most important. The other factors are CPU latency requirements, thermal restrictions, and peripheral I/O performance requirements. The voltage and frequency set-points used for the measurements are provided in [Table 1](#).

**NOTE**

See the operating ranges table in the *i.MX 7DS datasheet for consumer products* (document [IMX7DCEC](#)) for the official operating points.

Most of the measurements are performed using these voltage levels, and the power data that appears in this document is according to these values. If the measurement is done at different voltage levels, the power consumption scales with the voltage change. In real applications, when the DVFS is applied, the software (in conjunction with the hardware) automatically adjusts the voltage and frequency values based on the use case requirements.

The voltage used for the power calculation is the average voltage between those set-points. It depends on the amount of time spent at each set-point.

**3.3.2. VDD\_SOC voltage levels**

See the operating ranges table in the i.MX 7DS datasheet for the official operating points.

**Table 1. VDDARM voltage levels (for reference only)**

ARM frequency	VDD_ARM
Below 800 MHz	1.0 V
800 MHz – 1 GHz	1.1 V

**3.4. Temperature measurements**

In some of the use cases, the die temperature is measured. The temperature measurements were taken using the on-chip thermal sensor on a thermally calibrated part. While measuring the temperature, it is recommended to wait until the temperature stabilizes.

**NOTE**

The measured temperatures are for reference only and vary on different systems due to the differences in board, enclosure, and heat spreading techniques. When using the same board type, the measured temperature may vary due to factors such as the environment, silicon variations, and measurement errors.

**3.5. Hardware and software used**

The software versions used for the measurements are as follows:

- Yocto rootfs, Linux Kernel version: L4.1.15.2.0\_GA.
- The board used for the measurements is the i.MX7D SABRE platform.
- The measurements were performed using the Agilent 34401A 6½ Digital Multimeter.

### 3.6. Board setup used for the power measurements

The power measurements are taken using the default voltages of the supplies. The default input voltages are as follows:

- VDD\_ARM at the appropriate values based on the frequency.
- VDD\_SOC at 0.975 V.
- NVCC\_DRAM at 1.35 V.

### 3.7. Measuring points on the SABRE platform

The power data is obtained by measuring the average voltage drop over the measurement points and dividing it by the resistor value to determine the average current. The tolerance of the 0.02  $\Omega$  resistors on the SABRE board is 1 %. The measuring points for the various supply domains are as follows:

- VDD\_ARM: The A7 ARM complex current is measured on R20. For the low-power measurements, the resistance value is 0.02  $\Omega$ .
- VDD\_SOC: The chip domain current is measured on R24 and the recommended resistance value for this measurement is 0.02  $\Omega$ .
- VDD\_1P8: The VDD\_1P8 domain current is measured on R326 and the recommended resistance value for this measurement is 0.02  $\Omega$ .
- DDR3L I/O plus memories: The current in this domain includes the NVCC\_DRAM current and the overall current of the on-board DDR3L memory devices. The current in this domain is measured on R23 and the recommended resistance value for this measurement is 0.02  $\Omega$ .

## 4. Use Cases and Measurement Results

The main use cases and subtypes, which form the benchmarks for the i.MX 7DS internal power measurements on the SABRE platform, are described in the following sections.

### 4.1. Low-power mode use cases

The use-case scenarios that have been tested are:

- System Idle.
- Deep Sleep Mode (DSM).
- Audio Playback.
- A7 Dhrystone.
- A7 Dhrystone with the M4 running Coremark.

### 4.1.1. Use case 1: Deep-Sleep Mode (DSM)

This mode is called either “Dormant mode” or “Suspend-To-RAM” in the Linux BSP. This is the lowest possible power state where the external supplies are still on.

The use case is as follows:

- The ARM platform is power-gated.
- The L1 Cache periphery is power-gated.
- The M4 is idle.
- The SoC is in the LDO mode and the ARM LDO is power-gated automatically.
- All PLL (Phase-Locked Loop) and CCM (Clock Controller Module) generated clocks are off.
- The CKIL (32 kHz) input is on.
- All of the modules are disabled.
- All analog PHYs are powered down.
- The external high-frequency crystal and the on-chip oscillator are powered down (by asserting the SBYOS bit in the CCM).
- The VDD\_SOC is reduced to 0.925 V. In this mode, no current flow is caused by external resistive loads.

The following table shows the measurement results when this use case is applied on the i.MX 7DS processor.

**Table 2. Deep-Sleep Mode (DSM), M4 idle measurement results**

Supply domain	Voltage (V)	L4.1.15_1.2.0 GA	
		P (mW)	I (mA)
VDD_ARM	0.974	0.242	0.248
VDD_SOC	0.974	1.365	1.401
VDD_1P8	1.8	0.092	0.51
Total power (without DDR3L I/O + memories)	—	1.699	—
DDR3L I/O + memories3	1.35	26.720	19.792
Total power	—	28.419	—

For additional details about this use case and settings, see [Section 6, “Use Case Configuration and Usage Guidelines”](#).

### 4.2. Use case two: system idle, M4 idle mode

The use case is as follows:

- The ARM A7 is power-gated if the kernel is in the lowest level of idle.
- The M4 is idle.
- The ANATOP goes into the low-power mode if the lowest level of idle is entered and all PLLs are off.

- The operating system is on.

The following table shows the measurement results when this use case is applied on the i.MX 7D processor.

**Table 3. System idle mode measurement results**

Supply domain	L4.1.15_1.2.0 GA		
	Voltage (V)	P (mW)	I (mA)
VDD_ARM	0.974	0.196	0.201
VDD_SOC	0.974	21.265	21.822
VDD_1P8	1.8	0.283	0.158
Total power (without DDR3L I/O + memories)	—	21.744	—
DDR3L I/O + memories	1.35	30.210	22.383
Total power	—	51.954	—

For additional details on this use case and settings, see [Section 6, “Use Case Configuration and Usage Guidelines”](#).

### 4.3. Use case three: Audio\_Playback, M4 idle

The use case is as follows:

- The DDR clock is 100 MHz.
- The AXI clock is 24 MHz.
- The AHB clock is 24 MHz.
- The IPG clock is 12 MHz.

**Table 4. Audio playback mode measurement results**

Supply domain	L4.1.15_1.2.0 GA		
	Voltage (V)	P (mW)	I (mA)
VDD_ARM	0.974	14.203	14.585
VDD_SOC	0.974	66.005	67.662
VDD_1P8	1.8	18.687	10.420
Total power (without DDR3L I/O + memories)	—	98.895	—
DDR3L I/O + memories	1.35	71.390	52.893
Total power	—	170.285	—

## 4.4. Dhrystone benchmark

Dhrystone is a synthetic benchmark used to measure the integer computational performance of processors and compilers. The small size of the Dhrystone benchmark enables it to fit into the L1 cache and minimizes accesses to the L2 cache and DDR.

### 4.4.1. Use case 1: Dhrystone benchmark on Cortex-A7 (1 GHz), M4 idle

In this use case, the Dhrystone test is performed by both Cortex-A7 cores. Both Cortex-A7 cores run the test in a loop at a frequency of 996 MHz.

- The DDR clock is 1066 MHz.
- The AXI clock is 332 MHz.
- The AHB clock is 135 MHz.
- The IPG clock is 67.5 MHz.

The following table shows the measurement results when this use case is applied on the i.MX 7DS processor.

**Table 5. Dhrystone benchmark measurement results on Cortex-A7 (996 MHz)**

Supply domain	L4.1.15_1.2.0 GA		
	Voltage (V)	P (mW)	I (mA)
VDD_ARM	1.079	241.675	224.046
VDD_SOC	0.974	55.485	56.881
VDD_1P8	1.8	15.325	8.544
Total power (without DDR3L I/O + memories)	—	312.485	—
DDR3L I/O + memories	1.35	40.257	29.825
Total power	—	352.742	—

### 4.4.2. Use case 2: Dhrystone benchmark on Cortex-A7 (1 GHz), M4 Coremark

In this use case, the Dhrystone test is performed on both Cortex-A7 cores and the M4 is running the Coremark benchmark. This use case has all cores running at maximum frequencies.

- The DDR clock is 1066 MHz.
- The AXI clock is 332 MHz.
- The AHB clock is 135 MHz.
- The IPG clock is 67.5 MHz.
- The M4 clock is 240 MHz.

**Table 6. Dhrystone benchmark on Cortex-A7 and Coremark benchmark on M4 (240 MHz)**

Supply domain	L4.1.15_1.2.0_GA		
	Voltage (V)	P (mW)	I (mA)
VDD_ARM	1.079	244.027	226.222
VDD_SOC	0.978	191.343	195.555
VDD_1P8	1.8	16.091	8.970
Total power (without DDR3L I/O + memories)	—	312.485	—
DDR3L I/O + memories	1.35	71.703	53.124
Total power	—	352.742	—

## 4.5. SNVS

In this mode, most of the power rails on the boards are off, except for the VDD\_SNVS domain. VDD\_SNVS is kept on to ensure that the RTC and the other logic in the SNVS domain remain powered on. Tamper use cases should be considered for VDD\_SNVS power reduction. Measurements under different tamper cases are presented here for reference.

### NOTE

1. Tamper0~8 are used for detection, while Tamper9 is used for NVCC\_DRAM power switch for LPSR by default. In this measurement Tamper9 was fused to tamper detection function (=> fuse prog -y 1 3 0x80000000), which reduced the consumption significantly. But PIN9 could not be GPIO any longer once fused.
2. Besides, R280 was removed to exclude consumption of PWRON PIN on the PMIC.

**Table 7. SNVS mode measurement results**

L4.14.98_2.0.0_GA				
Supply domain	Use case of TAMPER0~9	Voltage(V)	P(μW)	I(μA)
VDD_SNVS (System total power)	All pins are unused	2.997	12.719	4.244
	All pins for passive tamper (active high)	2.997	11.688	3.900
	All pins for passive tamper (active low)	2.997	72.854	24.309
	5 pairs for active tamper	2.997	44.089	14.711
	4 pairs for active tamper; one pin for passive (active high) tamper; one pin for passive (active low) tamper.	2.997	40.483	13.508

The recommended circuits for tamper detection for different use cases are showed in the Figure 3. Since the Mesh traces connected to tamper pins are usually very long, these pins could be very sensitive to the environment noises. To improve the system EMC immunity, RC filters should be placed closely to the tamper inputs on the PCB.

About software(register) configurations please refer to Chapter 9 in the *Security Reference Manual for i.MX7Dual and 7Solo Applications Processors*, or DOC-342423 on the NXP community (<https://community.nxp.com/docs/DOC-342423>).

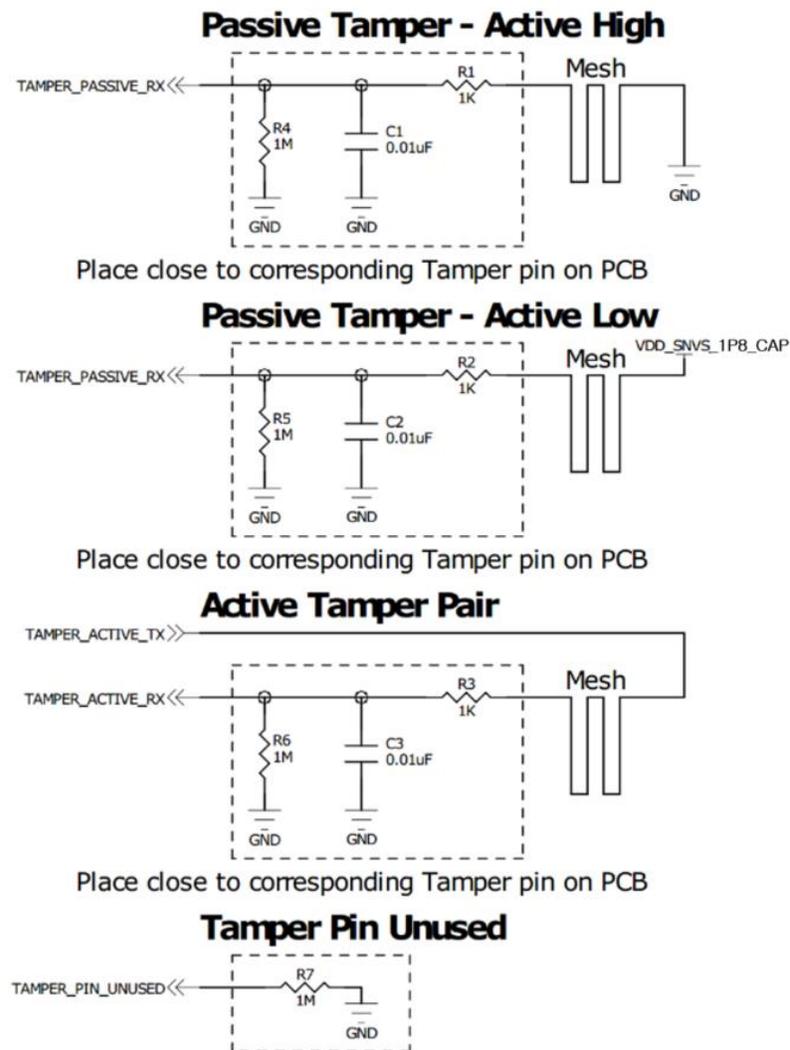


Figure 3. Circuits for Tamper detection

## 5. Reducing Power Consumption

The overall system power consumption depends on both the software optimization and how the system hardware is implemented. Below is a list of suggestions that may help to reduce the system power. Some

of these are already implemented in the Linux BSP. Further optimizations can be done on the individual customer's system.

- Apply the clock gating whenever the clocks or modules are not used by configuring the CCGR registers in the Clock Controller Module (CCM).
- Reduce the number of operating PLLs: applicable mainly in the Audio\_Playback or Idle modes.
- Core DVFS and system bus scaling: applying the DVFS for ARM and scaling the frequencies of the AXI, AHB, and IPG bus clocks can significantly reduce the power consumption of the VDD\_ARM and VDD\_SOC domains. However, due to the reduced operation frequency, the accesses to the DDR take longer, which increases the power consumption of the DDR I/O and memories. This trade-off must be taken into account for each mode to quantify the overall effect on the system power.
- Put the i.MX 7DS into the low-power modes (WAIT, STOP) whenever possible. See the “Clock Controller Module (CCM)” chapter in the *i.MX 7DS Applications Processor Reference Manual* (document [IMX7DRM](#)) for details.
- DDR interface optimization:
  - Employ careful board routing of the DDR memories, maintaining the PCB trace lengths as short as possible.
  - Use as reduced an ODT (On-Die Termination) setting as possible. The termination used greatly influences the power consumption of the DDR interface pins.
  - Use a proper output driver impedance for the DDR interface pins that provide good impedance matching. Select the lowest possible drive strength that provides the required performance to reduce the current flowing through the DDR I/O pins.
  - Choose the on-board resistors so that the least amount of current is wasted; for example, when selecting the impedance matching resistors between CLK and CLK\_B (when using DDR3L memories).
  - In the lower-performance use cases, switching to the DLL Off mode greatly reduces the DDR frequency. This disables or reduces the termination, and reduces the drive strength. Thus, the power consumption of the DDR interface pins can be reduced significantly.
  - Float the i.MX 7DS DDR interface pins (set to high Z) when the DDR memory is in the Self-Refresh mode, and keep DDR\_SDCKE0 and DDR\_SDCKE1 at a low value. If DDR\_SDCKE0 and DDR\_SDCKE1 are kept at a low value using external pull-down resistors, make sure that there is no on-board termination on these pins during this mode.
  - If possible (depending on the system stability), configure the DDR input pins to the CMOS mode instead of the Differential mode. This can be done by clearing the DDR\_INPUT bit in the corresponding registers in the IOMUXC. This setting is mostly recommended when operating at low frequencies, such as in the DLL Off mode.
  - The use of the LV DDR3L memory devices (operating at a low I/O voltage) can further reduce the I/O power by 20 %.
  - The use of the DDR memory offerings in the latest process technology can significantly reduce the power consumption of the DDR devices and the DDR I/O.

The various steps involved in floating the i.MX 7DS DDR interface pins are shown below.

**NOTE**

All the programming steps below are performed when the code is running from the internal RAM rather than the DDR memory. The code is non-cacheable.

## 5.1. Steps to be performed before entering the Suspend (Deep-Sleep) mode

1. Read the power saving status in the MMDC in the MAPSR register (automatic power saving is enabled) to make sure that the DDR is in the Self-Refresh mode.
2. Do the following:
  - a) If there is no on-board termination for the DDR control and the address bus, set the DSE (drive strength selection, in IOMUXC) for all DDR IF I/O to 0 (High Z), except for CKE0 and CKE1.
  - b) If the DDR control and the address bus have on-board termination resistors connected to VTT, such as in the case where SODIMM is used:
    - Option 1: As per 2a, keep SDCKE0/1 active. This causes some extra current from the pins sharing the same DSE control in the IOMUXC\_SW\_PAD\_CTL\_GRP\_CTLDS register. The pins are DRAM\_CS0, DRAM\_CS1, DRAM\_SDBA2, DRAM\_SDCKE0, DRAM\_SDCKE1, and DRAM\_SDWE.
    - Option 2 (requires on-board pull-down resistors on the DRARM\_SDCKE0/1 pins):
      - Set the supply of the termination resistor to be floated (this can be done through the pins with the GPIO capability).
      - Set the DSE (drive strength selection, in IOMUXC) for all DDR IF I/O to 0 (High Z).
3. Enter the Suspend mode.

## 5.2. Steps to be performed after exiting the Suspend mode

1. Restore all the settings for the DDR I/O to the required values.
2. The system proceeds to the Run mode.

**NOTE**

If the system can ensure that there are no masters accessing the DDR, the following may be applied to the other scenarios besides the Deep-Sleep mode: The DDR pins can be floated in the same manner (even when the Suspend mode is not entered) and the DDR can be manually put into the Self-Refresh mode to save power. This happens when the CPU is not running or running from the internal RAM.

## 6. Use Case Configuration and Usage Guidelines

### 6.1. Deep-Sleep mode

In this use case, all clocks and PLLs are turned off, except for the 32 kHz clock which is used for the system wakeup.

1. Boot up the Linux image.
2. Run this command to put the system into the DSM mode:  

```
echo mem > /sys/power/state
```
3. Measure the power and record the result.

### 6.2. System Idle mode

#### 6.2.1. System Idle mode: clock configuration

The clock configuration in the following table is aligned with release L4.1.15.

**Table 8. System Idle mode clock configuration**

Clock name	Frequency (MHz)
AXI	24
AHB	3
CPU	0
MMDC CH0	1

#### 6.2.2. System Idle mode: PLL configuration

The PLL configuration in the following table is aligned with release L4.1.15.

**Table 9. System Idle mode PLL configuration**

Clock root	Source selected	Frequency (MHz)
ARM_A7_CLK	PLL_ARM_MAIN_CLK	792
ARM_M4_CLK	PLL_SYS_MAIN_240M_CLK	24
MAIN_AXI_CLK	OSC	24
DISP_AXI_CLK	PLL_SYS_PFD1	off
ENET_AXI_CLK	PLL_ENET_250M_CLK	off
NAND_USDHC_BUS_CLK	PLL_SYS_PFD2	270

**Table 9. System Idle mode PLL configuration**

Clock root	Source selected	Frequency (MHz)
AHB_CLK_ROOT	OSC	24
IPG_CLK	AHB_CLK_ROOT	12
DRAM_CLK	DRAM_ALT_CLK	24
DRAM_PHYM_ALT_CLK	OSC	24
DRAM_ALT_CLK	OSC	24
USB_HSIC_CLK	PLL_SYS_MAIN_CLK	off
PCIE_CTRL_CLK	PLL_ENET_250M_CLK	off
EPDC_PIXEL_CLK	PLL_SYS_MAIN_CLK	off
LCDIF_PIXEL_CLK	PLL_VIDEO_POST_DIV	off
MIPI_DSI_CLK	OSC	off
MIPI_CSI_CLK	PLL_SYS_PFD3	24
MPI_DPHY_REF_CLK	OSC	24
SAIx_CLK	OSC	off
ENETx_REF_CLK	PLL_ENET_125M_CLK	off
ENETx_TIME_CLK	PLL_ENET_100M_CLK	off
ENET_PHY_REF_CLK	PLL_ENET_25M_CLK	off
EIM_CLK	PLL_SYS_MAIN_120M_CLK	off
NAND_CLK	PLL_SYS_MAIN_CLK	off
QSPI_CLK	PLL_SYS_PFD4_CLK	off
USHDCx_CLK	PLL_SYS_PFD0_392M_CLK	off
CANx_CLK	OSC	off
I2Cx_CLK	OSC	off
UARTx_Clk	OSC	24
ECSPiX_CLK	PLL_SYS_MAIN_240M_CLK	off
PWMx_CLK	OSC	off
FLEXTIMERCx_CLK	OSC	off
SIMx_CLK	PLL_SYS_MAIN_120M_CLK	off
GPTx_CLK	OSC	24
TRACE_CLK	OSC	off
WDOG_CLK	OSC	24
CSI_MCLK_CLK	OSC	off
AUDIO_MCLK_CLK	PLL_AUDIO_POST_DIV	off

### 6.2.3. System Idle mode: system setup

Disconnect everything except for the SD.

1. Boot up the Linux image by entering “x11=false uart\_from\_osc” into the command line.
2. Run the following script to put the system into the “powersave” governor:

```
#!/bin/bash
echo 8 > /proc/sys/kernel/printk
ifconfig eth0 down ifconfig eth1 down
echo powersave > /sys/devices/system/cpu/cpu0/cpufreq/scaling_governor echo 1 >
/sys/class/graphics/fb0/blank
```

3. Measure the power and record the result.

## 6.3. Dhrystone on Cortex-A7 (1 GHz)

### 6.3.1. Dhrystone on Cortex-A7 (1 GHz): clock configuration

The clock configuration in the following table is aligned with release L4.1.15.

**Table 10. Dhrystone clock configuration**

Clock name	Frequency (MHz)
AXI	—
AHB	—
CPU	1 GHz
MMDC CH0	—

### 6.3.2. Dhrystone on Cortex-A7 (1 GHz): PLL configuration

The PLL configuration in the following table is aligned with release L4.1.15\_1.2.0 GA.

**Table 11. Dhrystone PLL configuration**

Clock root	Source selected	Frequency (MHz)
ARM_A7_CLK	PLL_ARM_MAIN_CLK	996
ARM_M4_CLK	PLL_SYS_MAIN_240M_CLK	off
MAIN_AXI_CLK	PLL_SYS_PFD1_332M_CLK	332
DISP_AXI_CLK	PLL_SYS_PFD1_332M_CLK	332
ENET_AXI_CLK	PLL_ENET_250M_CLK	250
NAND_USDHC_BUS_CLK	PLL_SYSY_PFD2_270M_CLK	270
AHB_CLK_ROOT	PLL_SYSY_PFD2_270M_CLK	135
IPG_CLK	AHB_ROOT_CLK	67.5
DRAM_CLK	PLL_DRAM_MAIN_CLK	533

Table 11. Dhrystone PLL configuration

Clock root	Source selected	Frequency (MHz)
DRAM_PHYM_ALT_CLK	PLL_DRAM_MAIN_CLK	1066
DRAM_ALT_CLK	OSC	24
USB_HSIC_CLK	PLL_SYS_MAIN_CLK	off
PCIE_CTRL_CLK	PLL_ENET_250M_CLK	off
EPDC_PIXEL_CLK	PLL_SYS_MAIN_CLK	off
LCDIF_PIXEL_CLK	PLL_VIDEO_POST_DIV	92
MIPI_DSI_CLK	OSC	off
MIPI_CSI_CLK	PLL_SYS_PFD3_CLK	240
MPI_DPHY_REF_CLK	OSC	24
SAIx_CLK	PLL_AUDIO_POST_DIV	36.8
ENETx_REF_CLK	PLL_ENET_125M_CLK	125
ENETx_TIME_CLK	PLL_ENET_100M_CLK	100
ENET_PHY_REF_CLK	PLL_ENET_25M_CLK	25
EIM_CLK	PLL_SYS_MAIN_120M_CLK	off
NAND_CLK	PLL_SYS_MAIN_CLK	off
QSPI_CLK	PLL_SYS_PFD4_CLK	off
USHDCx_CLK	PLL_SYS_PFD0_392M_CLK	392
CANx_CLK	OSC	off
I2Cx_CLK	OSC	24
QSPI_CLK	PLL_SYS_PFD4_CLK	off
USHDCx_CLK	—	—
CANx_CLK	—	—
I2Cx_CLK	—	—
UARTx_Clk	OSC	24
ECSPiX_CLK	PLL_SYS_MAIN_240M_CLK	off
PWMx_CLK	OSC	24
FLEXTIMERCx_CLK	OSC	off
SIMx_CLK	PLL_SYS_MAIN_120M_CLK	off
GPTx_CLK	OSC	24
TRACE_CLK	OSC	off
WDOG_CLK	OSC	off
CSI_MCLK_CLK	OSC	off
AUDIO_MCLK_CLK	PLL_AUDIO_POST_DIV	off

### 6.3.3. Dhrystone on Cortex-A7 (1 GHz ): system setup

- SD boot.
- Connect the LCD panel.

### 6.3.4. Dhrystone on Cortex-A7 (1 GHz ): steps

1. Boot up the Linux image and boot the board to the SD rootfs.
2. Run the following script to measure at 1 GHz.

```
#!/bin/sh
ifconfig eth0 down ifconfig eth1 down
echo 1 > /sys/class/graphics/fb0/blank;
echo userspace > /sys/devices/system/cpu/cpu0/cpufreq/scaling_governor; echo 996000
> /sys/devices/system/cpu/cpu0/cpufreq/scaling_setspeed;
```

3. Run dry2 and measure:

```
while true; do dry2; done
```
4. Measure the power and record the result.

## 6.4. Heavy Loading use case

A7 Dhrystone with M4 running Coremark.

### 6.4.1. Heavy Loading: clock configuration

The clock configuration in the following table is aligned with release L4.1.15\_1.2.0 GA.

**Table 12. Maximum power clock configuration**

Clock name	Frequency (MHz)
DDR clock	1066
AXI	332
AHB	135
IPG	67.5
A7 CPU's	996
M4	240
MMDC CH0	396

## 6.4.2. Heavy Loading: PLL configuration

The PLL configuration in the following table is aligned with release L4.1.15.

**Table 13. Maximum power PLL configuration**

Clock root	Source selected	Frequency (MHz)
ARM_A7_CLK	PLL_ARM_MAIN_CLK	996
ARM_M4_CLK	PLL_SYS_MAIN_240M_CLK	off
MAIN_AXI_CLK	PLL_SYS_PFD1_332M_CLK	332
DISP_AXI_CLK	PLL_SYS_PFD1_332M_CLK	off
ENET_AXI_CLK	PLL_ENET_250M_CLK	250
NAND_USDHC_BUS_CLK	PLL_SYSY_PFD2_270M_CLK	270
AHB_CLK_ROOT	PLL_SYSY_PFD2_270M_CLK	135
IPG_CLK	AHB_ROOT_CLK	67.5
DRAM_CLK	PLL_DRAM_MAIN_CLK	533
DRAM_PHYM_ALT_CLK	PLL_DRAM_MAIN_CLK	1066
DRAM_ALT_CLK	OSC	24
USB_HSIC_CLK	PLL_SYS_MAIN_CLK	off
PCIE_CTRL_CLK	PLL_ENET_250M_CLK	off
EPDC_PIXEL_CLK	PLL_SYS_MAIN_CLK	off
LCDIF_PIXEL_CLK	PLL_VIDEO_POST_DIV	92
MIPI_DSI_CLK	OSC	off
MIPI_CSI_CLK	PLL_SYS_PFD3_CLK	240
MPI_DPHY_REF_CLK	OSC	24
SAIx_CLK	PLL_AUDIO_POST_DIV	36.8
ENETx_REF_CLK	PLL_ENET_125M_CLK	125
ENETx_TIME_CLK	PLL_ENET_25M_CLK	100
ENET_PHY_REF_CLK	PLL_ENET_25M_CLK	25
EIM_CLK	PLL_SYS_MAIN_120M_CLK	off
NAND_CLK	PLL_SYS_MAIN_CLK	off
QSPI_CLK	PLL_SYS_PFD4_CLK	off
USHDCx_CLK	PLL_SYS_PFD0_392M_CLK	392
CANx_CLK	OSC	off
I2Cx_CLK	OSC	24
QSPI_CLK	—	—
USHDCx_CLK	—	—

Table 13. Maximum power PLL configuration

Clock root	Source selected	Frequency (MHz)
CANx_CLK	—	—
I2Cx_CLK	—	—
UARTx_CLK	OSC	24
ECSPiX_CLK	PLL_SYS_MAIN_240M_CLK	off
PWMx_CLK	OSC	24
FLEXTIMERCx_CLK	OSC	off
SIMx_CLK	PLL_SYS_MAIN_120M_CLK	off
GPTx_CLK	OSC	24
TRACE_CLK	OSC	24
WDOG_CLK	OSC	24
CSI_MCLK_CLK	OSC	off
AUDIO_MCLK_CLK	PLL_AUDIO_POST_DIV	12.2

### 6.4.3. Heavy Loading: system setup

- SD boot to the U-boot.
- Load/Run the M4 code.
- Boot the Linux.

### 6.4.4. Heavy Loading: steps

1. Boot the U-boot.
2. Load/Run the M4 code.

```
Setenv m4image m4_coremark
Run m4boot
```

#### NOTE

The M4 Coremark code is used for testing and not available for distribution.

3. Boot up the Linux image and boot the board to the SD rootfs.
4. Run the following script to measure at 996 MHz:

```
#!/bin/sh
echo userspace > /sys/devices/system/cpu/cpu0/cpufreq/scaling_governor; echo 996000
> /sys/devices/system/cpu/cpu0/cpufreq/scaling_setspeed; echo 0 >
/sys/class/graphics/fb0/blank
```

5. Measure the power and record the result.

## 6.5. SNVS

### 6.5.1. SNVS: steps

1. Boot up the Linux image and boot the board to the SD rootfs.
2. Press and hold the power (on/off) key for about five seconds so that the board powers down.
3. Measure the power and record the result.

## 6.6. Important commands

In the U-boot console:

- `printenv`: displays the environment variables.
- `setenv`: updates the environment variables.
  - `setenv <name> <value> ...`
    - Sets the environment variable “name” to “value ...”.
  - `setenv <name>`
    - Deletes the environment variable “name”.
- `saveenv`: saves the updates to the environment variables.
- `bootargs`: passes to the kernel, which are called kernel command lines.

In the Linux OS console:

- `cat /proc/cmdline`: displays the command line.
- `cat /sys/devices/virtual/thermal/thermal_zone0/temp`: prints the temperature to the screen (the chip should be calibrated).
- `cat /sys/kernel/debug/clk/clk_summary`: prints all clks to the screen.

## 7. Revision History

The following table summarizes the changes made to this document since the initial release:

**Table 14. Revision history**

Revision number	Date	Substantive changes
0	11/2016	Initial release
1	05/2019	Table 7 , corrected

**How to Reach Us:**

**Home Page:**

[nxp.com](http://nxp.com)

**Web Support:**

[nxp.com/support](http://nxp.com/support)

Information in this document is provided solely to enable system and software implementers to use NXP products. There are no express or implied copyright licenses granted hereunder to design or fabricate any integrated circuits based on the information in this document. NXP reserves the right to make changes without further notice to any products herein.

NXP makes no warranty, representation, or guarantee regarding the suitability of its products for any particular purpose, nor does NXP assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation consequential or incidental damages. "Typical" parameters that may be provided in NXP data sheets and/or specifications can and do vary in different applications, and actual performance may vary over time. All operating parameters, including "typicals," must be validated for each customer application by customer's technical experts. NXP does not convey any license under its patent rights nor the rights of others. NXP sells products pursuant to standard terms and conditions of sale, which can be found at the following address: [nxp.com/SalesTermsandConditions](http://nxp.com/SalesTermsandConditions).

While NXP has implemented advanced security features, all products may be subject to unidentified vulnerabilities. Customers are responsible for the design and operation of their applications and products to reduce the effect of these vulnerabilities on customer's applications and products, and NXP accepts no liability for any vulnerability that is discovered. Customers should implement appropriate design and operating safeguards to minimize the risks associated with their applications and products.

NXP, the NXP logo, NXP SECURE CONNECTIONS FOR A SMARTER WORLD, COOLFLUX, EMBRACE, GREENCHIP, HITAG, I2C BUS, ICODE, JCOP, LIFE VIBES, MIFARE, MIFARE CLASSIC, MIFARE DESFire, MIFARE PLUS, MIFARE FLEX, MANTIS, MIFARE ULTRALIGHT, MIFARE4MOBILE, MIGLO, NTAG, ROADLINK, SMARTLX, SMARTMX, STARPLUG, TOPFET, TRENCHMOS, UCODE, Freescale, the Freescale logo, Altivec, C 5, CodeTEST, CodeWarrior, ColdFire, ColdFire+, C Ware, the Energy Efficient Solutions logo, Kinetis, Layerscape, MagniV, mobileGT, PEG, PowerQUICC, Processor Expert, QorIQ, QorIQ Qonverge, Ready Play, SafeAssure, the SafeAssure logo, StarCore, Symphony, VortiQa, Vybrid, Airfast, BeeKit, BeeStack, CoreNet, Flexis, MXC, Platform in a Package, QUICC Engine, SMARTMOS, Tower, TurboLink, and UMEMS are trademarks of NXP B.V. All other product or service names are the property of their respective owners. Arm, AMBA, Arm Powered, Artisan, Cortex, Jazelle, Keil, SecurCore, Thumb, TrustZone, and  $\mu$ Vision are registered trademarks of Arm Limited (or its subsidiaries) in the EU and/or elsewhere. Arm7, Arm9, Arm11, big.LITTLE, CoreLink, CoreSight, DesignStart, Mali, Mbed, NEON, POP, Sensinode, Socrates, ULINK and Versatile are trademarks of Arm Limited (or its subsidiaries) in the EU and/or elsewhere. All rights reserved. Oracle and Java are registered trademarks of Oracle and/or its affiliates. The Power Architecture and Power.org word marks and the Power and Power.org logos and related marks are trademarks and service marks licensed by Power.org.

© 2016-2019 NXP B.V.

Document Number: AN5383  
Rev. 1  
05/2019

