AN12574

Power Consumption and Measurement of i.MX RT1010

Rev. 1 — 27 February 2020 Application Note

Contents

1 Introduction

This document discusses about the power consumption of i.MX RT1010. It includes the following content:

- i.MX RT1010 overview
- Run mode definition and configuration
- Low-power mode definition and configuration
- How to measure power consumption based on MIMXRT1010 EVK board
- Power consumption under different power modes

The development environment in this application note is IAR Embedded Workbench. The hardware environment is MIMXRT1010 EVK board (Rev C).

2 i.MX RT1010 chip overview

The i.MX RT1010 is a Cortex-M7 based chip. It operates at speed up to 500 MHz to provide high CPU performance and best real-time response.

- Cortex-M7 based processor which can operate at speed up to 500 MHz.
- 128 KB on-chip RAM which can be flexibly configured as a TCM or general-purpose on-chip RAM.
- Advanced power management module with DCDC and LDO to reduce the complexity of external power supply and simplifies power sequencing.
- Rich memory interfaces, including SPI NOR flash and a single/dual-channel quad SPI flash with XIP.
- Various interfaces for connecting peripherals, such as Bluetooth™ and GPS.
- Audio features, including the SPDIF and I2S audio interfaces.
- Rich set of peripheral modules, such as SPI, I2C, Flex-Timers, ADC, and other.
- Target at Industrial HMI, Motor Control, and Home Appliance areas.

3 Low-power overview

3.1 Power supply

Table 1 shows the power supply rails of i.MX RT1010.

Table 1. External power supply rails

Power Rail	Description
DCDC_IN	Power for DCDC
SOC_IN	Power for SOC
VDD_HIGH_IN	Power for Analog
VDD_SNVS_IN	Power for SNVS and RTC
USB_OTG1_VBUS	Power for USB VBUS
VDDA_ADC_3P3	Power for 12-bit ADC
NVCC_GPIO	IO power for GPIO in GPIO bank

3.2 Run mode

3.2.1 Run mode definition

Table 2. Run mode definition

Run mode	Definition
Overdrive run	• CPU runs at 500 MHz, overdrive voltage to 1.275 V • Bus frequency at 125 MHz • All the peripherals are enabled and runs at target frequency • All PLLs are enabled
Full-speed run	• CPU runs at 396 MHz, full loading, lower voltage to 1.15 V • Bus frequency at 132 MHz • All the peripherals are enabled and run at target frequency • All PLLs are enabled
Low-speed run	• CPU runs at 132 MHz, lower voltage to 1.15 V • Internal bus frequency at 33 MHz • All PLL and PFDs are disabled except SYSPLL, SYSPLLPFD2, and SYSPLLPFD3 • 20 % peripherals are active, others are in low-power mode
Low-power run	• CPU runs at 24 MHz, lower voltage to 0.95 V • Internal bus frequency at 12 MHz • All PLLs are powered down, OSC24M powered down, RCOSC24 enabled • High-speed peripherals are power down

In general, Run mode can be divided in four modes as shown in above table. The Low-speed run mode uses the bus clock of Full-speed run mode as core clock, and Low-power run mode uses 24 MHz internal OSC as core clock source.

3.2.2 Run mode configuration

Table 3. Run mode configuration

	Overdrive run	Full-speed run	Low- speed run	Low-power run
CPU Core	500 MHz	396 MHz	132 Mhz	24 MHz
L1 Cache	ON	ON	ON	ON
IPG CLK	125 MHz	132 MHz	33 MHz	12 MHz
PER CLK	62.5 MHz	66 MHz	33 MHz	12 MHz
FlexRAM	ON	ON	ON	ON
SOC Voltage	1.275 V	1.15 V	1.15 V	0.95 V
Analog LDO	ON	ON	ON	In weak-mode
24MHz XTAL OSC	ON	ON	ON	OFF
24MHz RC OSC	OFF	OFF	OFF	ON
SYS PLL	ON	ON	ON	Power Down
SYS PFD0	ON	ON	Power Down	Power Down
SYS PFD1	ON	ON	Power Down	Power Down
SYS PFD2	ON	ON	ON	Power Down
SYS PFD3	ON	ON	ON	Power Down
USB1 PLL	ON	ON	Power Down	Power Down
USB1 PFD0	ON	ON	Power Down	Power Down
USB1 PFD1	ON	ON	Power Down	Power Down
USB1 PFD2	ON	ON	Power Down	Power Down
USB1 PFD3	ON	ON	Power Down	Power Down
Audio PLL	ON	ON	Power Down	Power Down
ENET PLL	ON	ON	Power Down	Power Down
Module Clock	ON	ON	On as needed	Peripheral clock off
RTC32K	ON	ON	ON	ON

3.3 Low-power mode

3.3.1 Low-power mode definition

Table 4. Low-power mode definition

Low-power mode	Definition
System idle	• CPU can automatically enter this mode when no thread running • All the peripherals can remain active • CPU only enters WFI mode, it has its state retained so the interrupt response can be very short
Low-power idle	• Much lower power than System idle mode, with longer exit time • All PLLs are shut off, analog modules running in low-power mode • All high-speed peripherals are power gated, low-speed peripherals can remain running at low frequency
Suspend	• The most power-saving mode with longest exit time • All PLLs are shut off, XTAL are off, all clocks are shut off except 32K clock • All high-speed peripherals are power gated, low-speed peripherals are clock gated
SNVS	• All SOC digital logic, analog modules are shut off only except SNVS domain • 32 kHz RTC is alive • VDD_HIGH_IN and VDD_DCDC_IN can be powered off

3.3.2 Low-power mode configuration

Table 5. Low-power mode configuration

	System idle	Low- power idle	Suspend	SNVS
CCM LPM Mode	WAIT	WAIT	STOP	-
CPU Core	WFI	WFI	Power Down	OFF
L1 Cache	ON	ON	Power Down	OFF
FlexRAM	ON	ON	ON	OFF
SOC Voltage	1.15 V	0.95 V	0.925 V	OFF
SYS PLL	ON	Power Down	Power Down	OFF
SYS PFD0	Power Down	Power Down	Power Down	OFF
SYS PFD1	Power Down	Power Down	Power Down	OFF
SYS PFD2	ON	Power Down	Power Down	OFF

Table continues on the next page...

Table 5. Low-power mode configuration (continued)

SYS PFD3	ON	Power Down	Power Down	OFF
USB1 PLL	Power Down	Power Down	Power Down	OFF
USB1 PFD0	Power Down	Power Down	Power Down	OFF
USB1 PFD1	Power Down	Power Down	Power Down	OFF
USB1 PFD2	Power Down	Power Down	Power Down	OFF
USB1 PFD3	Power Down	Power Down	Power Down	OFF
Audio PLL	Power Down	Power Down	Power Down	OFF
ENET PLL	Power Down	Power Down	Power Down	OFF
24MHz XTAL OSC	ON	OFF	OFF	OFF
24MHz RC OSC	OFF	ON	OFF	OFF
LDO2P5	ON	OFF	OFF	OFF
LDO1P1	ON	OFF	OFF	OFF
WEAK2P5	OFF	ON	OFF	OFF
WEAK1P1	OFF	ON	OFF	OFF
Bandgap	ON	OFF	OFF	OFF
Low Power Bandgap	ON	ON	ON	OFF
AHB clock	33 MHz	12 MHz	OFF	OFF
IPG clock	33 MHz	12 MHz	OFF	OFF
PER clock	33 MHz	12 MHz	OFF	OFF
Module Clocks	ON as needed	ON as needed	OFF	OFF
RTC32K	ON	ON	ON	ON

3.3.3 Wake-up source

Table 6. Wake-up source

	System-idle	Low- power idle	Suspend	SNVS
GPIO wake-up	YES	YES	YES	NO
RTC wake-up	YES	YES	YES	YES
USB remote wake-up	YES	YES	YES	NO
Other peripheral wake-up sources	YES	YES	YES	NO

NOTE

Irrespective of whether the system is in System-idle, Low-power idle or Suspend modes, the wake-up interrupt should be enabled in GPC module, or the wake-up fails.

4 How to measure power consumption on MIMXRT1010 EVK

4.1 MIMXRT1010-EVK (REV C) board overview

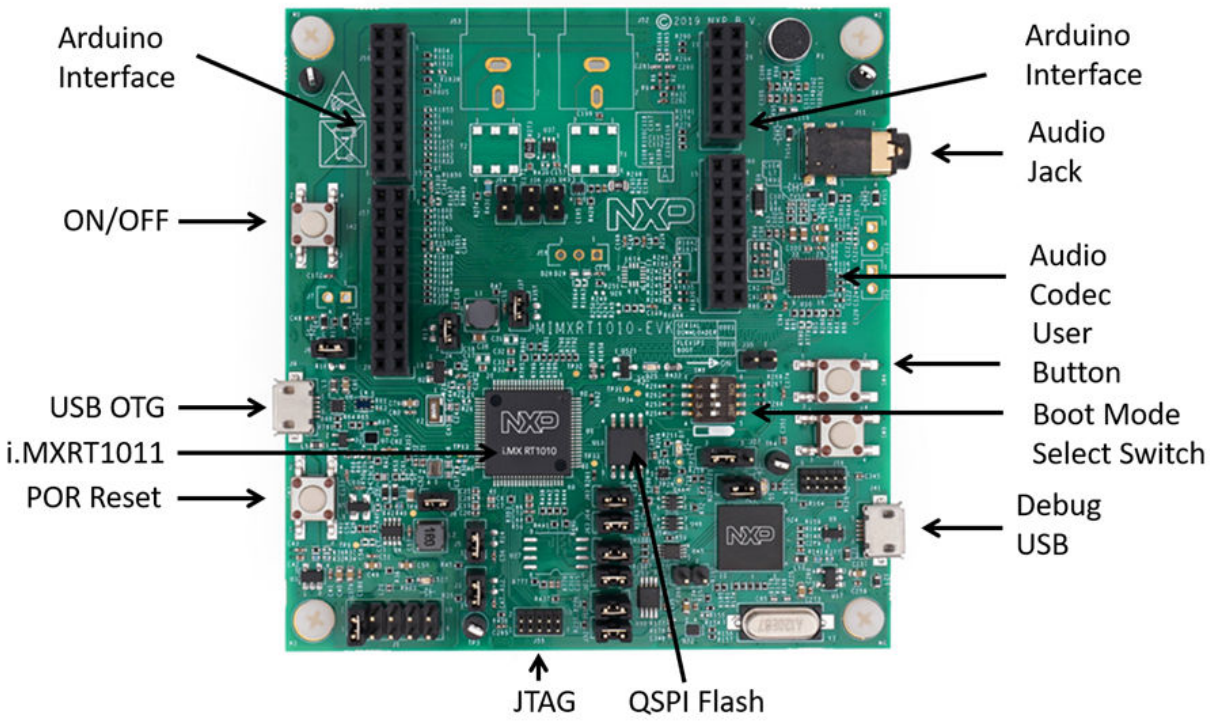

Figure 1. Overview of the MIMXRT1010 EVK Board (Front side)

4.2 Current measurements on EVK

For this application note, measure the current value of DCDC_IN(J37), VDD_HIGH_IN (J5) and VDD_SNVS_IN (J6).

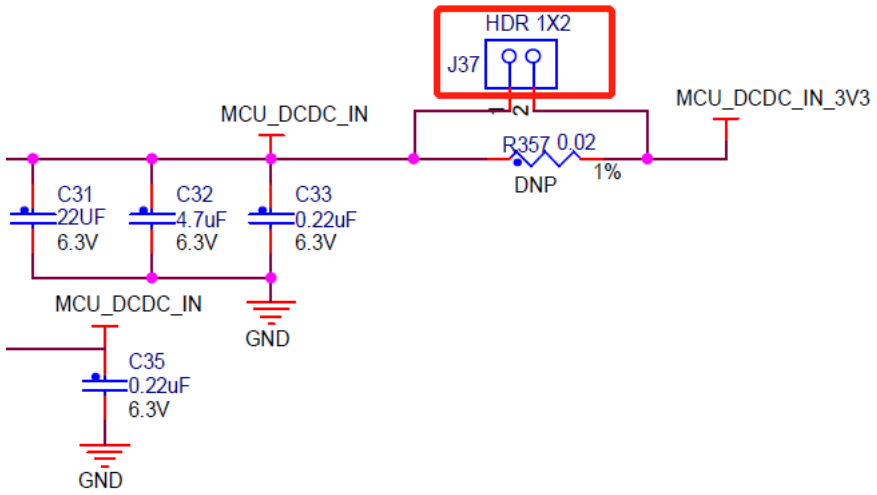

Figure 2. Test Points for DCDC_IN

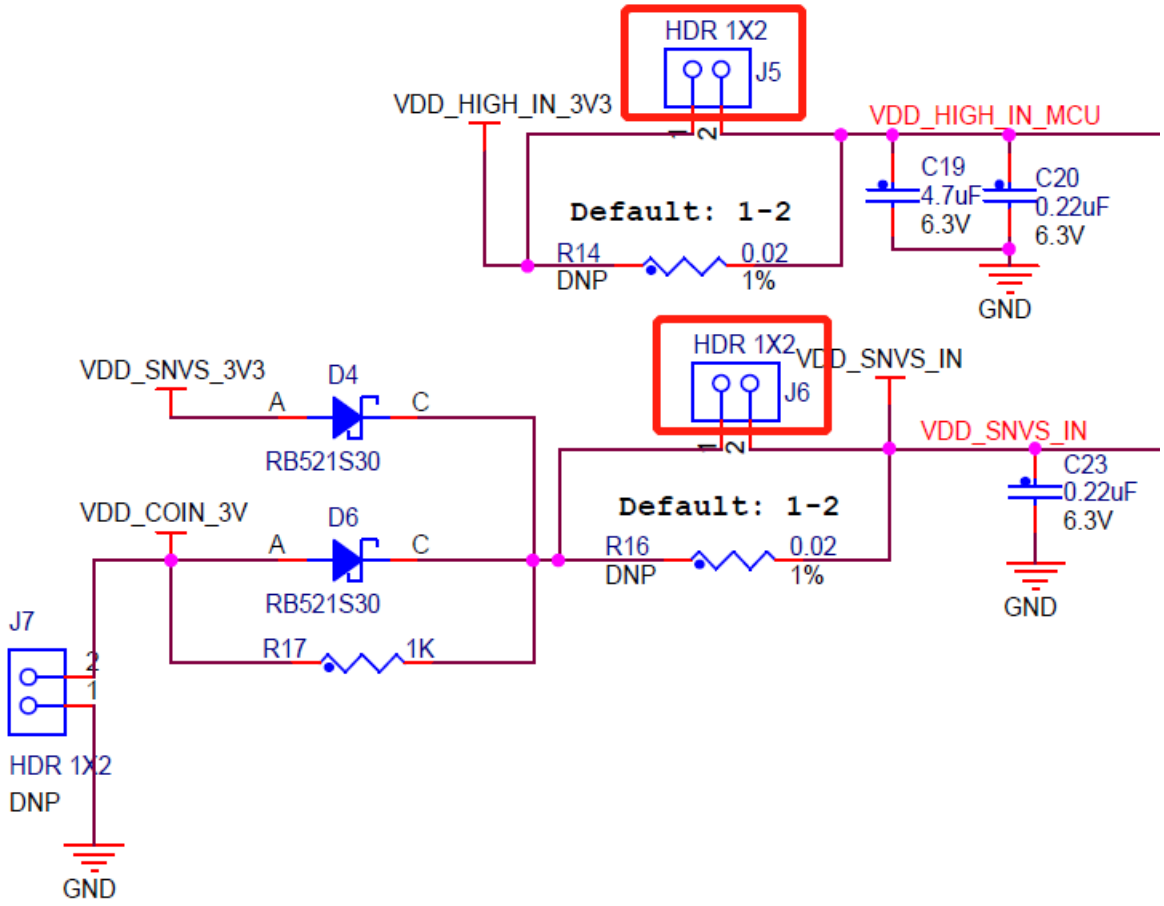

Figure 3. Test Points for VDD_HIGH_IN and VDD_SNVS_IN

4.3 Hardware rework for the EVK

R206 should be removed, leaving this resistor populated causes higher SNVS current than what is shown in this application note.

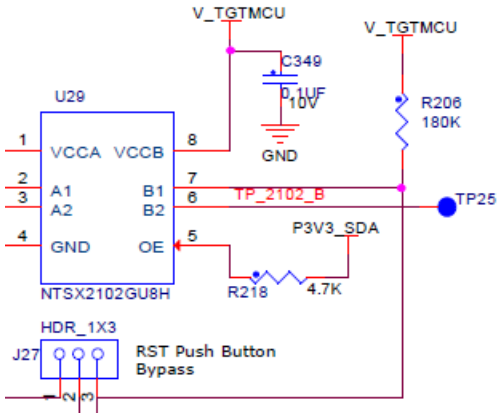

Figure 4. Removing resistor R206

4.4 Run IAR-based project demo example – Power mode switch

1. The project file is at: boards\evkbmimxrt1010\demo_apps\power_mode_switch_bm\iar\power_mode_switch_bm.eww.
2. Download the project.
3. Select the target power mode on the terminal.

5 Power consumption results

5.1 Run mode

The power consumption in Table 7 and Table 8 are measured with the power mode switch project.

Table 7. Run mode on RAM

RT1010-EVK		Overdrive (500 MHz)		Full Speed Run (396 MHz)		Low Speed Run (132 MHz)		Low Power Run (24 MHz)	
Power Rail	Voltage (V)	Current (mA)	Power (mW)	Current (mA)	Power (mW)	Current (mA)	Power (mW)	Current (mA)	Power (mW)
DCDC_IN	3.30	22.228	73.35	16.728	55.2	7.568	24.97	1.358	4.48
HIGH_IN	3.30	14.069	46.43	14.066	46.42	5.649	18.64	0.229	0.76
SNVS_IN	3.30	0.0355	0.12	0.0364	0.12	0.0214	0.071	0.0429	0.14

Table 8. Run mode XIP on Flash

RT1010-EVK		Overdrive (500 MHz)		Full Speed Run (396 MHz)		Low Speed Run (132 MHz)		Low Power Run (24 MHz)	
Power Rail	Voltage	Current	Power	Current	Power	Current	Power	Current	Power

Table continues on the next page...

Table 8. Run mode XIP on Flash (continued)

	(V)	(mA)	(mW)	(mA)	(mW)	(mA)	(mW)	(mA)	(mW)
DCDC_IN	3.30	21.825	72.02	16.379	54.05	7.764	25.62	1.377	4.54
HIGH_IN	3.30	14.067	46.42	14.071	46.43	5.65	18.65	0.23	0.76
SNVS_IN	3.30	0.0356	0.12	0.0366	0.12	0.0215	0.071	0.0429	0.14

The power consumption in Table 9 and Table 10 are measured with the coremark benchmark project.

Table 9. Coremark on RAM

RT1010-EVK		Overdrive (500 MHz)		Full-Speed Run (396 MHz)		Low-Speed Run (132 MHz)		Low-Power Run (24 MHz)	
Power Rail	Voltage (V)	Current (mA)	Power (mW)	Current (mA)	Power (mW)	Current (mA)	Power (mW)	Current (mA)	Power (mW)
DCDC_IN	3.30	40.511	133.69	27.122	89.50	10.818	35.70	1.864	6.15
HIGH_IN	3.30	14.056	46.38	14.049	46.36	5.691	18.78	0.197	0.65
SNVS_IN	3.30	0.0327	0.11	0.0337	0.11	0.0196	0.065	0.0388	0.13

Table 10. CoreMark XIP on Flash

RT1010-EVK		Overdrive (500 MHz)		Full-Speed Run (396 MHz)		Low-Speed Run (132 MHz)		Low-Power Run (24 MHz)	
Power Rail	Voltage (V)	Current (mA)	Power (mW)	Current (mA)	Power (mW)	Current (mA)	Power (mW)	Current (mA)	Power (mW)
DCDC_IN	3.30	39.653	130.85	26.692	88.08	10.971	36.20	1.881	6.20
HIGH_IN	3.30	14.102	46.54	14.052	46.37	5.691	18.78	0.198	0.65
SNVS_IN	3.30	0.0311	0.10	0.0327	0.11	0.0195	0.064	0.0387	0.13

NOTE

Overdrive: CPU runs at 500 MHz, all peripheral enabled and running at target frequency.

Full Speed Run: CPU runs at 396 MHz, all peripheral enabled and running at target frequency.

Low Speed Run: CPU runs at 132 MHz, 20 % peripherals active.

Low Speed Run: CPU runs at 24 MHz, only low speed peripherals active, such as UART/I2C.

All power consumption values are typical silicon at 25 C.

5.2 Low-power mode

The power consumption in Table 11 and Table 12 are measured with the power mode switch project.

Table 11. Low Power mode on RAM

RT1010-EVK		System-Idle		Low-Power Idle		Suspend[1]		SNVS[2]	
Power Rail	Voltage (V)	Current (mA)	Power (mW)	Current (mA)	Power (mW)	Current (mA)	Power (mW)	Current (mA)	Power (mW)
DCDC_IN	3.30	1.972	6.51	0.738	2.44	0.095	0.31	/	/
HIGH_IN	3.30	5.691	18.78	0.200	0.66	0.016	0.053	/	/
SNVS_IN	3.30	0.0187	0.062	0.0387	0.13	0.0152	0.050	0.0114	0.038

Table 12. Low power mode XIP on Flash

RT1010-EVK		System-Idle		Low-Power Idle		Suspend[1]		SNVS[2]	
Power Rail	Voltage (V)	Current (mA)	Power (mW)	Current (mA)	Power (mW)	Current (mA)	Power (mW)	Current (mA)	Power (mW)
DCDC_IN	3.30	2.581	8.52	0.832	2.75	0.095	0.31	/	/
HIGH_IN	3.30	5.693	18.79	0.200	0.66	0.016	0.053	/	/
SNVS_IN	3.30	0.0188	0.062	0.0389	0.13	0.0155	0.051	0.0114	0.038

NOTE

1. **Suspend:** Suspend mode with RAM data in OCRAM/D-TCM (bank0).
2. **SNVS:** SNVS mode with RTC working.

NOTE

Discontinuous conduction mode (DCM) increases the efficiency of DCDC in case of low current loading and is always recommended.

To reduce power consumption, VDD_SNVS_IN is powered by VDD_HIGH_IN in all power modes except the SNVS mode.

All power consumption values are typical silicon at 25 C.

6 Conclusion

This document mainly describes how to measure power consumption on i.MX RT based on MIMXRT1010 EVK (Rev C). For more design details in designing a low-power application, see the application note How to use iMXRT Low Power Feature.

7 References

1. i.MX RT 1010 Reference Manual
2. ARM Cortex M7 Reference Manual
3. How to use iMXRT Low Power Feature

8 Revision history

Table 13. Revision history

Revision number	Date	Substantive changes
0	08/2019	Initial release
1	01/2020	Added Table 7 and Table 8. Few titles changed

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