

EZR32HG Wireless MCUs

EZR32HG320 Data Sheet



EZR32HG320 Wireless MCU family with ARM Cortex-M0+ CPU, USB, and sub-GHz Radio

The EZR32HG Wireless MCUs are the latest in Silicon Labs family of wireless MCUs delivering a high performance, low-energy wireless solution integrated into a small form factor package. By combining a high performance sub-GHz RF transceiver with an energy efficient 32-bit MCU, the EZR32HG family provides designers the ultimate in flexibility with a family of pin-compatible devices that scale with 64/32 kB of flash and support Silicon Labs EZRadio or EZRadioPRO transceivers. The ultra-low power operating modes and fast wake-up times of the Silicon Labs energy friendly 32-bit MCUs, combined with the low transmit and receive power consumption of the sub-GHz radio, result in a solution optimized for battery powered applications.

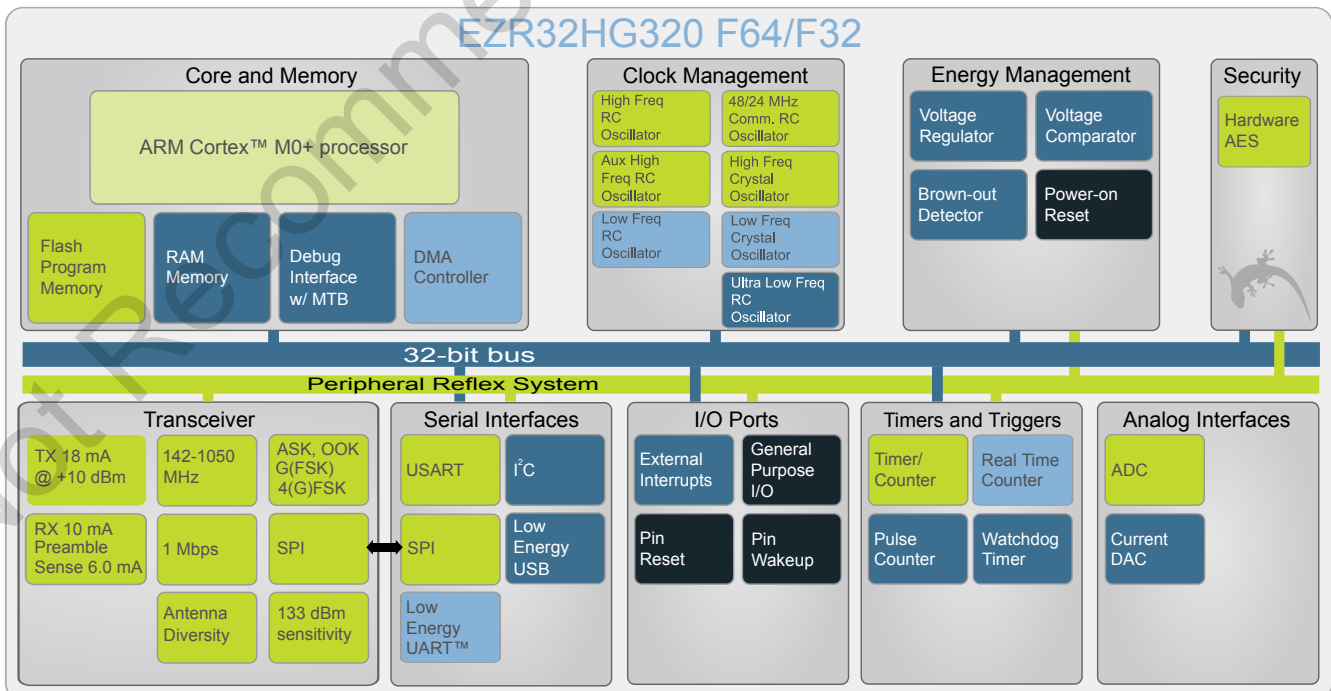
32-Bit ARM Cortex wireless MCUs applications include the following:

- Energy, gas, water and smart metering
- Health and fitness applications
- Consumer electronics
- Alarm and security systems
- Building and home automation

KEY FEATURES

- Silicon Labs' energy efficient 32-bit Wireless MCUs
- Based on ARM Cortex M0 CPU core with 64 kB of flash and 8 kB RAM
- Best-in-class RF performance with EZradio and EZRadioPro transceivers
- Ultra-low power wireless MCU
 - Low transmit and receive currents
 - Ultra-low power standby and sleep modes
 - Fast wake-up time
- Rich set of peripherals including 12-bit ADC and IDAC, multiple communication interfaces (USB, UART, SPI, I2C), multiple GPIO and timers
- AES Accelerator with 128-bit keys

EZR32HG320 F64/F32



1. Feature List

The HG highlighted features are listed below.

MCU Features

- ARM Cortex-M0+ CPU platform
 - Up to 25 MHz
 - 64/32 kB Flash w/8 kB RAM
 - Hardware AES with 128-bit keys
- Flexible Energy Management System
 - 20 nA @ 3 V Shutoff Mode
 - 0.6 μ A @ 3 V Stop Mode
 - 127 μ A/MHz @ 3 V Run Mode
- Timers/Counters
 - 3 \times Timer/Counter
 - 3 \times 3 Compare/Capture/PWM channels
 - Real-Time Counter
 - 16/8-bit Pulse Counter
 - Watchdog Timer
- Communication interfaces
 - 1 \times USART (UART/SPI)
 - 1 \times Low Energy UART
 - 1 \times I2C Interface with SMBus support
 - Universal Serial Bus (USB)
- Ultra low power precision analog peripherals
 - 12-bit 1 Msamples/s ADC
 - On-chip temperature sensor
 - Current Digital to Analog Converter
- Up to 25 General Purpose I/O pins

RF Features

- Frequency Range
 - 142-1050 MHz
- Modulation
 - (G)FSK, 4(G)FSK, (G)MSK, OOK
- Receive sensitivity up to -133 dBm
- Up to +20 dBm max output power
- Low active power consumption
 - 10/13 mA RX
 - 18 mA TX at +10 dBm
 - 6 mA @ 1.2 kbps (Preamble Sense)
- Data rate = 100 bps to 1 Mbps
- Excellent selectivity performance
 - 69 dB adjacent channel
 - 79 dB blocking at 1 MHz
- Antenna diversity and T/R switch control
- Highly configurable packet handler
- TX and RX 64 byte FIFOs
- Automatic frequency control (AFC)
- Automatic gain control (AGC)
- IEEE 802.15.4g compliant

System Features

- Power-on Reset and Brown-Out Detector
- Debug Interface
- Temperature range -40 to 85 $^{\circ}$ C
- Single power supply 1.98 to 3.8 V
- QFN48 package

2. Ordering Information

The table below shows the available EZR32HG320 devices.

Table 2.1. Ordering Information

| Ordering | Radio | Flash (kB) | RAM (kB) | Power Amplifier (dBm) | Max Sensitivity (dBm) | Supply Voltage (V) | Package | Radio Chip Revision |
|-----------------------------------|-------------|------------|----------|-----------------------|-----------------------|--------------------|---------|---------------------|
| EZR32HG320FxxR55G-C0 ¹ | EZRadio | 32-64 | 8 | +13 | -116 | 1.98 - 3.8 | QFN48 | C |
| EZR32HG320FxxR60G-C0 ¹ | EZRadio-Pro | 32-64 | 8 | +13 | -126 | 1.98 - 3.8 | QFN48 | C |
| EZR32HG320FxxR61G-C0 ¹ | EZRadio-Pro | 32-64 | 8 | +16 | -126 | 1.98 - 3.8 | QFN48 | C |
| EZR32HG320FxxR63G-C0 ¹ | EZRadio-Pro | 32-64 | 8 | +20 | -126 | 1.98 - 3.8 | QFN48 | C |
| EZR32HG320FxxR67G-C0 ¹ | EZRadio-Pro | 32-64 | 8 | +13 | -133 | 1.98 - 3.8 | QFN48 | C |
| EZR32HG320FxxR68G-C0 ² | EZRadio-Pro | 32-64 | 8 | +20 | -133 | 1.98 - 3.8 | QFN48 | C |
| EZR32HG320FxxR69G-C0 ¹ | EZRadio-Pro | 32-64 | 8 | +13 & 20 | -133 | 1.98 - 3.8 | QFN48 | C |

Note:

1. End of Life.
2. Not Recommended for New Designs.

Table 2.2. Flash Sizes

| Example Part Number | Flash Size |
|---------------------|------------|
| EZR32HG320F32R55G | 32 kB |
| EZR32HG320F64R55G | 64 kB |

Note: Add an "(R)" at the end of the device part number to denote tape and reel option.

Visit www.silabs.com for information on global distributors and representatives.

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Not Recommended for New Designs

3. System Overview

3.1 Introduction

The EZR32HG320 Wireless MCUs are the latest in the Silicon Labs family of wireless MCUs delivering a high-performance, low-energy wireless solution integrated into a small form factor package. By combining a high performance sub-GHz RF transceiver with an energy efficient 32-bit ARM Cortex-M0+, the EZR32HG family provides designers with the ultimate in flexibility with a family of pin-compatible parts that scale from 32 to 64 kB of flash and support Silicon Labs EZRadio or EZRadioPRO transceivers. The ultra-low power operating modes and fast wake-up times combined with the low transmit and receive power consumption of the sub-GHz radio result in a solution optimized for low power and battery powered applications. For a complete feature set and in-depth information on the modules, refer to the [EZR32HG Reference Manual](#).

The EZR32HG320 block diagram is shown below.

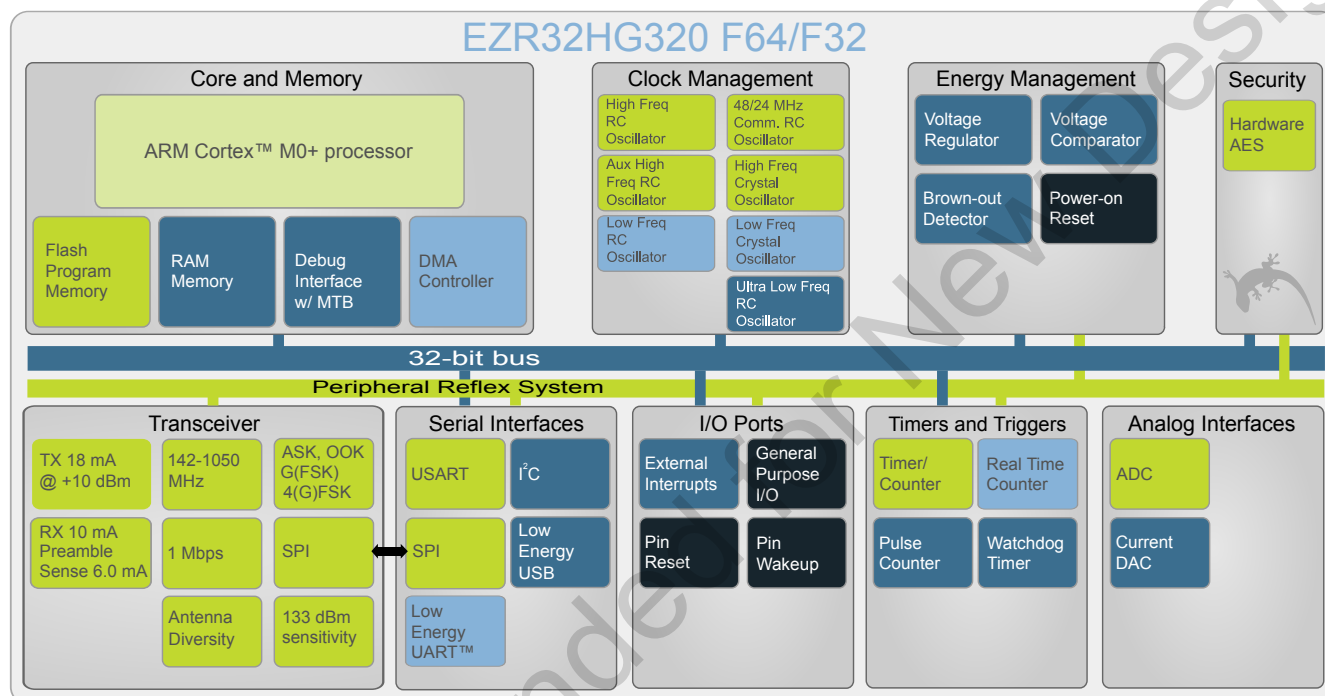


Figure 3.1. Block Diagram

3.1.1 ARM Cortex-M0+ Core

The ARM Cortex-M0+ includes a 32-bit RISC processor which can achieve as much as 0.9 Dhrystone MIPS/MHz. A Wake-up Interrupt Controller handling interrupts triggered while the CPU is asleep is included as well. The EZR32 implementation of the Cortex-M0+ is described in detail in *ARM Cortex-M0+ Devices Generic User Guide*.

3.1.2 Debugging Interface (DBG)

These devices include hardware debug support through a 2-pin serial-wire debug interface.

3.1.3 Memory System Controller (MSC)

The Memory System Controller (MSC) is the program memory unit of the EZR32HG microcontroller. The flash memory is readable and writable from both the Cortex-M0+ and DMA. The flash memory is divided into two blocks: the main block and the information block. Program code is normally written to the main block. Additionally, the information block is available for special user data and flash lock bits. There is also a read-only page in the information block containing system and device calibration data. Read and write operations are supported in the energy modes EM0 and EM1.

3.1.4 Direct Memory Access Controller (DMA)

The Direct Memory Access (DMA) controller performs memory operations independently of the CPU. This has the benefit of reducing the energy consumption and the workload of the CPU, and enables the system to stay in low energy modes when moving, for instance, data from the USART to RAM or from the External Bus Interface to a PWM-generating timer. The DMA controller uses the PL230 μ DMA controller licensed from ARM.

3.1.5 Reset Management Unit (RMU)

The Reset Management Unit (RMU) is responsible for handling the reset functionality of the EZR32HG.

3.1.6 Energy Management Unit (EMU)

The Energy Management Unit (EMU) manages all the low energy modes (EM) in EZR32HG microcontrollers. Each energy mode manages if the CPU and the various peripherals are available. The EMU can also be used to turn off the power to unused SRAM blocks.

3.1.7 Clock Management Unit (CMU)

The Clock Management Unit (CMU) is responsible for controlling the oscillators and clocks on-board the EZR32HG. The CMU provides the capability to turn on and off the clock on an individual basis to all peripheral modules in addition to enable/disable and configure the available oscillators. The high degree of flexibility enables software to minimize energy consumption in any specific application by not wasting power on peripherals and oscillators that are inactive.

3.1.8 Watchdog (WDOG)

The purpose of the watchdog timer is to generate a reset in case of a system failure, to increase application reliability. The failure may, for example, be caused by an external event, such as an ESD pulse, or by a software failure.

3.1.9 Peripheral Reflex System (PRS)

The Peripheral Reflex System (PRS) system is a network which lets the different peripheral module communicate directly with each other without involving the CPU. Peripheral modules which send out Reflex signals are called producers. The PRS routes these reflex signals to consumer peripherals which apply actions depending on the data received. The format for the Reflex signals is not given, but edge triggers and other functionality can be applied by the PRS.

3.1.10 Universal Serial Bus Controller (USB)

The USB is a full-speed USB 2.0 compliant device controller. The device supports both fullspeed (12 MBit/s) and low speed (1.5 MBit/s) operation. The USB also supports a Low Energy Mode that can be used to lower the current consumption up to 90% by shutting off the clock to the USB Core and possibly suspending the USHFRCO. The USB device includes an internal dedicated Descriptor-Based Scatter/Gather DMA and supports up to 3 OUT endpoints and 3 IN endpoints, in addition to endpoint 0.

3.1.11 Inter-Integrated Circuit Interface (I²C)

The I²C module provides an interface between the MCU and a serial I²C-bus. It is capable of acting as both a master and a slave, and supports multi-master buses. Both standard-mode, fast-mode and fast-mode plus speeds are supported, allowing transmission rates all the way from 10 kbit/s up to 1 Mbit/s. Slave arbitration and timeouts are also provided to allow implementation of an SMBus compliant system. The interface provided to software by the I²C module allows both fine-grained control of the transmission process and close to automatic transfers. Automatic recognition of slave addresses is provided in all energy modes.

3.1.12 Universal Synchronous/Asynchronous Receiver/Transmitter (USART)

The Universal Synchronous Asynchronous serial Receiver and Transmitter (USART) is a very flexible serial I/O module. It supports full duplex asynchronous UART communication as well as RS-485, SPI, MicroWire and 3-wire. It can also interface with ISO7816 Smart-Cards, IrDA and I2S devices.

3.1.13 Pre-Programmed USB/UART Bootloader

The bootloader presented in application note *AN0042* is pre-programmed in the device at the factory. The bootloader enables users to program the EZR32 through a UART or a USB CDC class virtual UART without the need for a debugger. The autobaud feature, interface, and commands are described further in the application note.

3.1.14 Low Energy Universal Asynchronous Receiver/Transmitter (LEUART)

The unique Low Energy Universal Asynchronous Receiver/Transmitter (LEUART™), the Low Energy UART, is a UART that allows two-way UART communication on a strict power budget. Only a 32.768 kHz clock is needed to allow UART communication up to 9600 baud/s. The LEUART includes all necessary hardware support to make asynchronous serial communication possible with minimum of software intervention and energy consumption.

3.1.15 Timer/Counter (TIMER)

The 16-bit general purpose Timer has 3 compare/capture channels for input capture and compare/Pulse-Width Modulation (PWM) output. TIMER0 also includes a Dead-Time Insertion module suitable for motor control applications.

3.1.16 Real Time Counter (RTC)

The Real Time Counter (RTC) contains a 24-bit counter and is clocked either by a 32.768 kHz crystal oscillator, or a 32.768 kHz RC oscillator. In addition to energy modes EM0 and EM1, the RTC is also available in EM2. This makes it ideal for keeping track of time since the RTC is enabled in EM2 where most of the device is powered down.

3.1.17 Pulse Counter (PCNT)

The Pulse Counter (PCNT) can be used for counting pulses on a single input or to decode quadrature encoded inputs. It runs off either the internal LFACLK or the PCNTn_S0IN pin as external clock source. The module may operate in energy mode EM0 - EM3.

3.1.18 Voltage Comparator (VCMP)

The Voltage Supply Comparator (VCMP) is used to monitor the supply voltage from software. An interrupt can be generated when the supply falls below or rises above a programmable threshold. Response time and thereby also the current consumption can be configured by altering the current supply to the comparator.

3.1.19 Analog to Digital Converter (ADC)

The Analog to Digital Converter (ADC) is a Successive Approximation Register (SAR) architecture, with a resolution of up to 12 bits at up to one million samples per second. The integrated input mux can select inputs from 4 external pins and 6 internal signals.

3.1.20 Current Digital to Analog Converter (IDAC)

The current digital to analog converter (IDAC) can source or sink a configurable constant current, which can be output on, or sinked from pin or ADC. The current is configurable with several ranges of various step sizes.

3.1.21 Advanced Encryption Standard Accelerator (AES)

The Advanced Encryption Standard Accelerator (AES) performs AES encryption and decryption with 128-bit keys. Encrypting or decrypting one 128-bit data block takes 52 HFCORECLK cycles with 128-bit keys and 75 HFCORECLK cycles with 256-bit keys. The AES module is an AHB slave which enables efficient access to the data and key registers. All write accesses to the AES module must be 32-bit operations (i.e., 8- or 16-bit operations are not supported).

3.1.22 General Purpose Input/Output (GPIO)

In the EZR32HG320, there are 25 General Purpose Input/Output (GPIO) pins, which are divided into ports with up to 16 pins each. These pins can individually be configured as either an output or input. More advanced configurations like open-drain, filtering and drive strength can also be configured individually for the pins. The GPIO pins can also be overridden by peripheral pin connections, like Timer PWM outputs or USART communication, which can be routed to several locations on the device. The GPIO supports up to 16 asynchronous external pin interrupts, which enables interrupts from any pin on the device. Also, the input value of a pin can be routed through the Peripheral Reflex System to other peripherals.

3.1.23 EZRadio® and EZRadioPro® Transceivers

The EZR32HG family of devices is built using high-performance, low-current EZRadio and EZRadioPro RF transceivers covering the sub-GHz frequency bands from 142 to 1050 MHz. These devices offer outstanding sensitivity of up to -133 dBm (using EZRadioPro) while achieving extremely low active and standby current consumption. The EZR32HG devices using the EZRadioPro transceiver offer frequency coverage in all major bands and include optimal phase noise, blocking, and selectivity performance for narrow band and licensed band applications, such as FCC Part 90 and 169 MHz wireless Mbus. The 69 dB adjacent channel selectivity with 12.5 kHz channel spacing ensures robust receive operation in harsh RF conditions, which is particularly important for narrow band operation. The active mode TX current consumption of 18 mA at +10 dBm and RX current of 10 mA coupled with extremely low standby current and fast wake times is optimized for extended battery life in the most demanding applications. The EZR32HG devices can achieve up to +27 dBm output power with built-in ramping control of a low-cost external FET. The devices can meet worldwide regulatory standards: FCC, ETSI, and ARIB. All devices using the EZRadioPRO transceiver are designed to be compliant with 802.15.4g and WMBus smart metering standards. The devices are highly flexible and can be programmed and configured via Simplicity Studio, available at www.silabs.com.

Communications between the radio and MCU are done over USART and IRQ, which requires the pins to be configured in the following way:

Table 3.1. Radio MCU Communication Configuration

| EZR32HG MCU | RF | EZR32HG Function Assignment |
|-------------|---------------|---|
| PA2 | SDN | GPIO Output |
| PC0 | \bar{n} SEL | US1_CS #5 |
| PC1 | SDI | US1_MOSI #5 |
| PC2 | SDO | US1_MISO #5 |
| PC3 | SCLK | US1_CLK #5 |
| PC4 | \bar{n} IRQ | GPIO_EM4WU6 (GPIO Input with IRQ enabled) |

3.1.23.1 EZRadio and EZRadioPRO Transceivers GPIO Configuration

The EZRadio and EZRadioPRO Transceivers have 4 General Purpose Digital I/O pins. These GPIOs may be configured to perform various radio-specific functions, including Clock Output, FIFO Status, POR, Wake-up Timer, TRSW, AntDiversity control, etc.

3.2 Configuration Summary

The features of the EZR32HG320 are a subset of the feature set described in the *EZR32HG Reference Manual*. The table below describes device specific implementation of the features.

Table 3.2. Configuration Summary

| Module | Configuration | Pin Connections |
|------------|---|---|
| Cortex-M0+ | Full configuration | NA |
| DBG | Full configuration | DBG_SWCLK, DBG_SWDIO |
| MSC | Full configuration | NA |
| DMA | Full configuration | NA |
| RMU | Full configuration | NA |
| EMU | Full configuration | NA |
| CMU | Full configuration | CMU_CLK0, CMU_CLK1 |
| WDOG | Full configuration | NA |
| PRS | Full configuration | NA |
| USB | Full configuration | USB_VBUS, USB_VREGI, USB_VREGO, USB_DM, USB_DMPU, USB_DP |
| I2C0 | Full configuration | I2C0_SDA, I2C0_SCL |
| UART0 | Full configuration with IrDA and I2S | US0_TX, US0_RX, US0_CLK, US0_CS |
| LEUART0 | Full configuration | LEU0_TX, LEU0_RX |
| USARTRF1 | Reduced configuration | USRF1_RX, USRF1_TX |
| TIMER0 | Full configuration with DTI | TIM0_CC[2:0], TIM0_CDTI[2:0] |
| TIMER1 | Full configuration | TIM1_CC[2:0] |
| TIMER2 | Full configuration | TIM2_CC[2:0] |
| RTC | Full configuration | NA |
| PCNT0 | Full configuration, 16-bit count register | PCNT0_S[1:0] |
| VCMP | Full configuration | NA |
| ADC0 | Full configuration | ADC0_CH[7, 6, 5, 4, 1, 0] |
| IDAC0 | Full configuration | IDAC0_OUT |
| AES | Full configuration | NA |
| GPIO | 25 pins | Available pins are shown in 5.4 GPIO Pin-out Overview |

3.3 Memory Map

The EZR32HG320 memory map is shown below with RAM and flash sizes for the largest memory configuration.

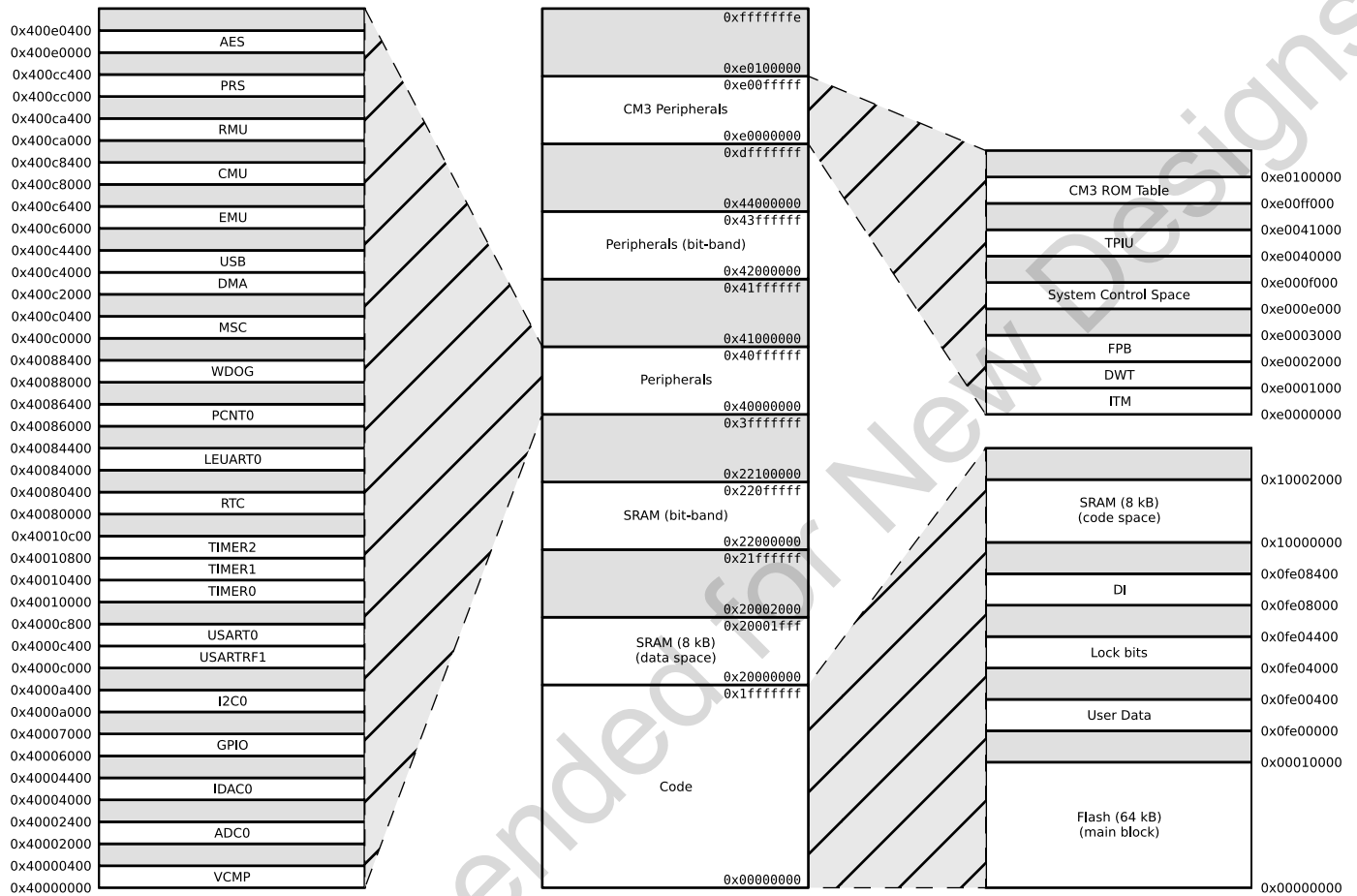


Figure 3.2. EZR32HG320 Memory Map with Largest RAM and Flash Sizes

4. Electrical Specifications

4.1 Test Conditions

4.1.1 Typical Values

The typical data are based on $T_{AMB} = 25^{\circ}\text{C}$ and $V_{DD} = 3.0\text{ V}$, as defined in [Table 4.3 General Operating Conditions on page 14](#), by simulation and/or technology characterisation unless otherwise specified.

4.1.2 Minimum and Maximum Values

The minimum and maximum values represent the worst conditions of ambient temperature, supply voltage and frequencies, as defined in [Table 4.3 General Operating Conditions on page 14](#), by simulation and/or technology characterisation unless otherwise specified.

4.2 Absolute Maximum Ratings

The absolute maximum ratings are stress ratings, and functional operation under such conditions are not guaranteed. Stress beyond the limits specified in the table below may affect the device reliability or cause permanent damage to the device. Functional operating conditions are given in [Table 4.3 General Operating Conditions on page 14](#).

Table 4.1. Absolute Maximum Ratings

| Parameter | Symbol | Test Condition | Min | Typ | Max | Unit |
|--|-------------|-------------------------------------|------|-----|------------------|--------------------|
| Storage temperature range | T_{STG} | | -55 | — | 150 ¹ | $^{\circ}\text{C}$ |
| Maximum soldering temperature | T_S | Latest IPC/JEDEC J-STD-020 Standard | — | — | 260 | $^{\circ}\text{C}$ |
| External main supply voltage | V_{DDMAX} | | 0 | — | 3.8 | V |
| Voltage on any I/O pin | V_{IOPIN} | | -0.3 | — | $V_{DD}+0.3$ | V |
| Note: 1. Based on programmed devices tested for 10000 hours at 150 $^{\circ}\text{C}$. Storage temperature affects retention of pre-programmed calibration values stored in flash. Refer to the Flash section in the Electrical Characteristics for information on flash data retention for different temperatures. | | | | | | |

4.3 Thermal Characteristics

Table 4.2. Thermal Conditions

| Parameter | Symbol | Test Condition | Min | Typ | Max | Unit |
|---|-----------|------------------------------|-----|-----|-------------------|------|
| Ambient temperature range | T_{AMB} | | -40 | — | 85 | °C |
| Junction temperature value | T_J | | — | — | 105 ¹ | °C |
| Thermal impedance junction to ambient | TI_{JA} | +13/+16 dBm on 2-layer board | — | — | 61.8 | °C/W |
| | | +20 dBm on 4-layer board | — | — | 20.7 ² | °C/W |
| Storage temperature range | T_{STG} | | -55 | — | 150 | °C |
| Note: 1. Values are based on simulations run on 2-layer and 4-layer PCBs at 0m/s airflow. 2. Based on programmed devices tested for 10000 hours at 150 °C. Storage temperature affects retention of preprogrammed calibration values stored in flash. Refer to the Flash section in the Electrical Characteristics for information on flash data retention for different temperatures. | | | | | | |

4.4 General Operating Conditions

Table 4.3. General Operating Conditions

| Parameter | Symbol | Min | Typ | Max | Unit |
|------------------------------|------------|------|-----|------|------|
| Ambient temperature range | T_{AMB} | -40 | — | 85 | °C |
| Operating supply voltage | V_{DDOP} | 1.98 | — | 3.8 | V |
| Internal APB clock frequency | f_{APB} | — | — | 4825 | MHz |
| Internal AHB clock frequency | f_{AHB} | — | — | 4825 | MHz |

4.5 Current Consumption

Table 4.4. Current Consumption

| Symbol | Parameter | Condition | Min | Typ | Max | Unit |
|---|---|--|-----|--------------------------|-----|--------------------------|
| I_{EMO} | EMO current. No prescaling. Running prime number calculation code from Flash. | 24 MHz HFXO, all peripheral clocks disabled, $V_{DD} = 3.0\text{ V}$, $T_{AMB} = 25^{\circ}\text{C}$ | — | 148 | 158 | $\mu\text{A}/\text{MHz}$ |
| | | 24 MHz HFXO, all peripheral clocks disabled, $V_{DD} = 3.0\text{ V}$, $T_{AMB} = 85^{\circ}\text{C}$ | — | 153 | 163 | $\mu\text{A}/\text{MHz}$ |
| | | 24 MHz USHFRCO, all peripheral clocks disabled, $V_{DD} = 3.0\text{ V}$, $T_{AMB} = 25^{\circ}\text{C}$ | — | 161 | 172 | $\mu\text{A}/\text{MHz}$ |
| | | 24 MHz USHFRCO, all peripheral clocks disabled, $V_{DD} = 3.0\text{ V}$, $T_{AMB} = 85^{\circ}\text{C}$ | — | 163 | 174 | $\mu\text{A}/\text{MHz}$ |
| | | 24 MHz HFRCO, all peripheral clocks disabled, $V_{DD} = 3.0\text{ V}$, $T_{AMB} = 25^{\circ}\text{C}$ | — | 127 | 137 | $\mu\text{A}/\text{MHz}$ |
| | | 24 MHz HFRCO, all peripheral clocks disabled, $V_{DD} = 3.0\text{ V}$, $T_{AMB} = 85^{\circ}\text{C}$ | — | 129 | 139 | $\mu\text{A}/\text{MHz}$ |
| | | 21 MHz HFRCO, all peripheral clocks disabled, $V_{DD} = 3.0\text{ V}$, $T_{AMB} = 25^{\circ}\text{C}$ | — | 131 | 140 | $\mu\text{A}/\text{MHz}$ |
| | | 21 MHz HFRCO, all peripheral clocks disabled, $V_{DD} = 3.0\text{ V}$, $T_{AMB} = 85^{\circ}\text{C}$ | — | 134 | 143 | $\mu\text{A}/\text{MHz}$ |
| | | 14 MHz HFRCO, all peripheral clocks disabled, $V_{DD} = 3.0\text{ V}$, $T_{AMB} = 25^{\circ}\text{C}$ | — | 134 | 143 | $\mu\text{A}/\text{MHz}$ |
| | | 14 MHz HFRCO, all peripheral clocks disabled, $V_{DD} = 3.0\text{ V}$, $T_{AMB} = 85^{\circ}\text{C}$ | — | 137 | 145 | $\mu\text{A}/\text{MHz}$ |
| | | 11 MHz HFRCO, all peripheral clocks disabled, $V_{DD} = 3.0\text{ V}$, $T_{AMB} = 25^{\circ}\text{C}$ | — | 136 | 144 | $\mu\text{A}/\text{MHz}$ |
| | | 11 MHz HFRCO, all peripheral clocks disabled, $V_{DD} = 3.0\text{ V}$, $T_{AMB} = 85^{\circ}\text{C}$ | — | 139 | 148 | $\mu\text{A}/\text{MHz}$ |
| | | 6.6 MHz HFRCO, all peripheral clocks disabled, $V_{DD} = 3.0\text{ V}$, $T_{AMB} = 25^{\circ}\text{C}$ | — | 142 | 150 | $\mu\text{A}/\text{MHz}$ |
| | | 6.6 MHz HFRCO, all peripheral clocks disabled, $V_{DD} = 3.0\text{ V}$, $T_{AMB} = 85^{\circ}\text{C}$ | — | 146 | 154 | $\mu\text{A}/\text{MHz}$ |
| | | 1.2 MHz HFRCO, all peripheral clocks disabled, $V_{DD} = 3.0\text{ V}$, $T_{AMB} = 25^{\circ}\text{C}$ | — | 184 | 196 | $\mu\text{A}/\text{MHz}$ |
| 1.2 MHz HFRCO, all peripheral clocks disabled, $V_{DD} = 3.0\text{ V}$, $T_{AMB} = 85^{\circ}\text{C}$ | — | 194 | 208 | $\mu\text{A}/\text{MHz}$ | | |

| Symbol | Parameter | Condition | Min | Typ | Max | Unit |
|---|-------------|--|-----|--------|-------|--------|
| I _{EM1} | EM1 current | 24 MHz HFXO, all peripheral clocks disabled, V _{DD} = 3.0 V, T _{AMB} = 25°C | — | 64 | 68 | µA/MHz |
| | | 24 MHz HFXO, all peripheral clocks disabled, V _{DD} = 3.0 V, T _{AMB} = 85°C | — | 67 | 71 | µA/MHz |
| | | 24 MHz USHFRCO, all peripheral clocks disabled, V _{DD} = 3.0 V, T _{AMB} = 25°C | — | 85 | 91 | µA/MHz |
| | | 24 MHz USHFRCO, all peripheral clocks disabled, V _{DD} = 3.0 V, T _{AMB} = 85°C | — | 86 | 92 | µA/MHz |
| | | 24 MHz HFRCO, all peripheral clocks disabled, V _{DD} = 3.0 V, T _{AMB} = 25°C | — | 51 | 55 | µA/MHz |
| | | 24 MHz HFRCO, all peripheral clocks disabled, V _{DD} = 3.0 V, T _{AMB} = 85°C | — | 52 | 56 | µA/MHz |
| | | 21 MHz HFRCO, all peripheral clocks disabled, V _{DD} = 3.0 V, T _{AMB} = 25°C | — | 53 | 57 | µA/MHz |
| | | 21 MHz HFRCO, all peripheral clocks disabled, V _{DD} = 3.0 V, T _{AMB} = 85°C | — | 54 | 58 | µA/MHz |
| | | 14 MHz HFRCO, all peripheral clocks disabled, V _{DD} = 3.0 V, T _{AMB} = 25°C | — | 56 | 59 | µA/MHz |
| | | 14 MHz HFRCO, all peripheral clocks disabled, V _{DD} = 3.0 V, T _{AMB} = 85°C | — | 57 | 61 | µA/MHz |
| | | 11 MHz HFRCO, all peripheral clocks disabled, V _{DD} = 3.0 V, T _{AMB} = 25°C | — | 58 | 61 | µA/MHz |
| | | 11 MHz HFRCO, all peripheral clocks disabled, V _{DD} = 3.0 V, T _{AMB} = 85°C | — | 59 | 63 | µA/MHz |
| | | 6.6 MHz HFRCO, all peripheral clocks disabled, V _{DD} = 3.0 V, T _{AMB} = 25°C | — | 64 | 68 | µA/MHz |
| | | 6.6 MHz HFRCO, all peripheral clocks disabled, V _{DD} = 3.0 V, T _{AMB} = 85°C | — | 67 | 71 | µA/MHz |
| | | 1.2 MHz HFRCO, all peripheral clocks disabled, V _{DD} = 3.0 V, T _{AMB} = 25°C | — | 106 | 114 | µA/MHz |
| 1.2 MHz HFRCO, all peripheral clocks disabled, V _{DD} = 3.0 V, T _{AMB} = 85°C | — | 114 | 126 | µA/MHz | | |
| I _{EM2} | EM2 current | EM2 current with RTC prescaled to 1 Hz, 32.768 kHz LFRCO, V _{DD} = 3.0 V, T _{AMB} = 25°C | — | 0.9 | 1.35 | µA |
| | | EM2 current with RTC prescaled to 1 Hz, 32.768 kHz LFRCO, V _{DD} = 3.0 V, T _{AMB} = 85°C | — | 1.6 | 3.50 | µA |
| I _{EM3} | EM3 current | EM3 current (ULFRCO enabled, LFRCO/LFXO disabled), V _{DD} = 3.0 V, T _{AMB} = 25°C | — | 0.6 | 0.90 | µA |
| | | EM3 current (ULFRCO enabled, LFRCO/LFXO disabled), V _{DD} = 3.0 V, T _{AMB} = 85°C | — | 1.2 | 2.65 | µA |
| I _{EM4} | EM4 current | V _{DD} = 3.0 V, T _{AMB} = 25°C | — | 0.02 | 0.035 | µA |
| | | V _{DD} = 3.0 V, T _{AMB} = 85°C | — | 0.18 | 0.480 | µA |

4.5.1 EM0 Current Consumption

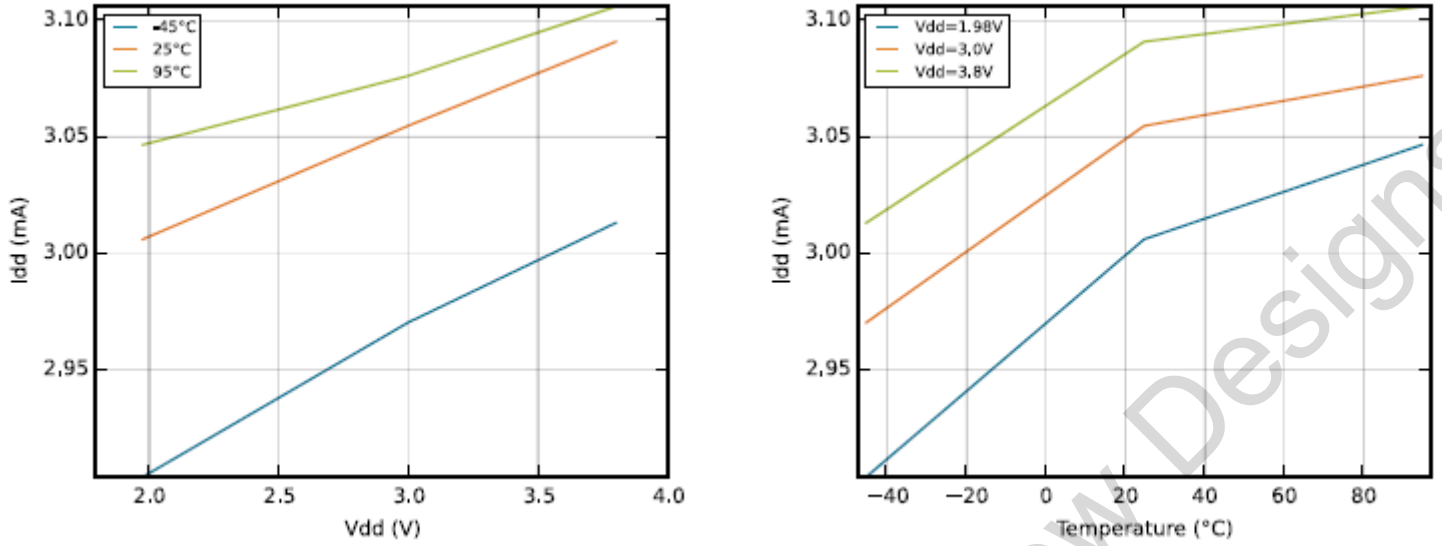


Figure 4.1. EM0 Current Consumption while Executing Prime Number Calculation Code from Flash with HFRCO Running at 24 MHz

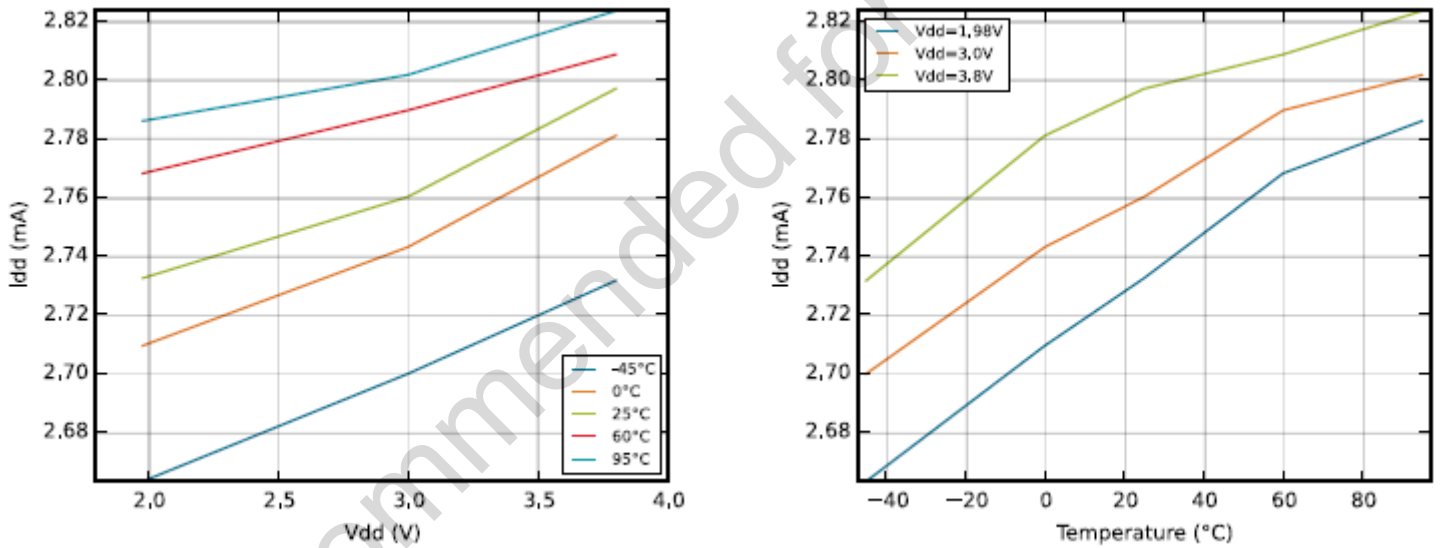


Figure 4.2. EM0 Current Consumption while Executing Prime Number Calculation Code from Flash with HFRCO Running at 21 MHz

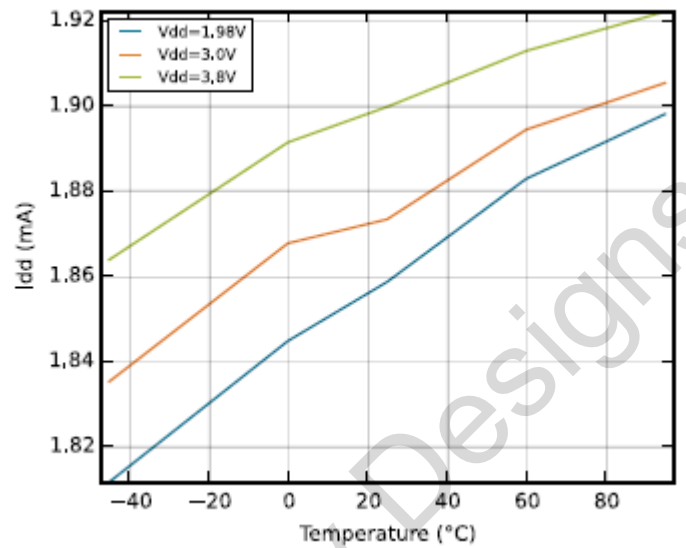
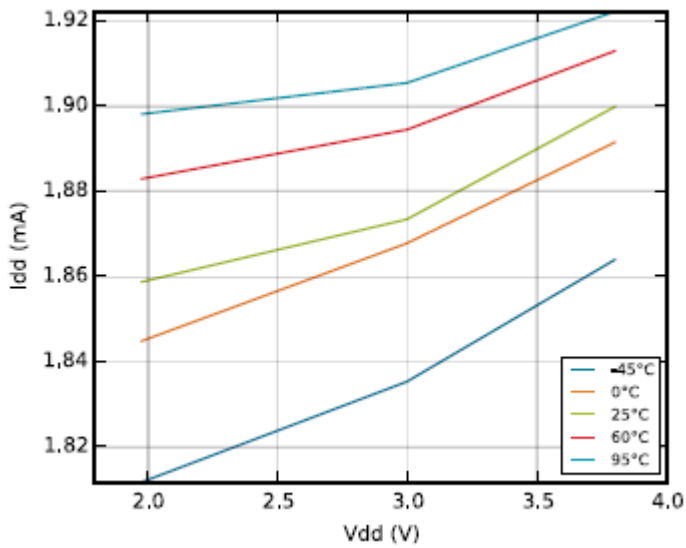


Figure 4.3. EM0 Current Consumption while Executing Prime Number Calculation Code from Flash with HFRCO Running at 14 MHz

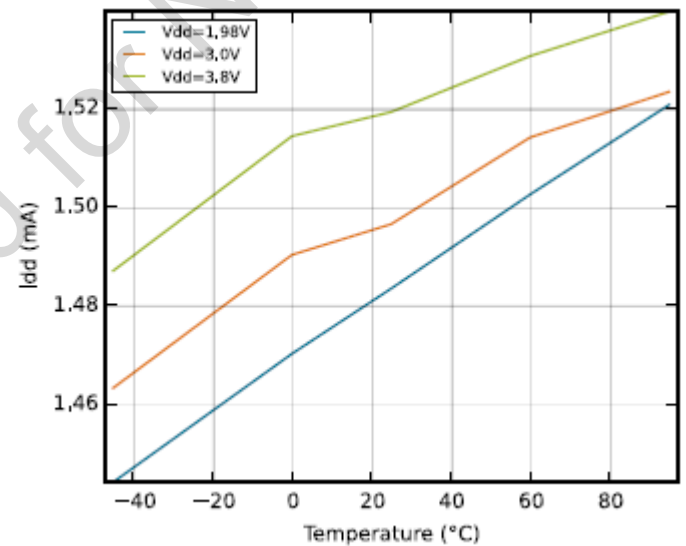
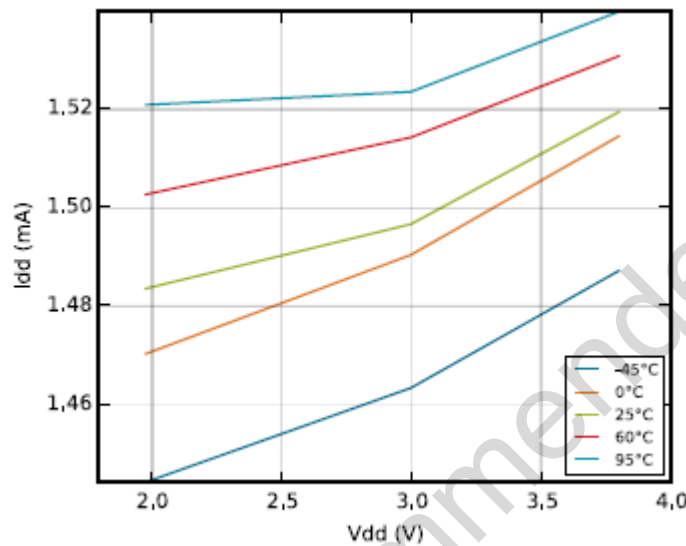


Figure 4.4. EM0 Current Consumption while Executing Prime Number Calculation Code from Flash with HFRCO Running at 11 MHz

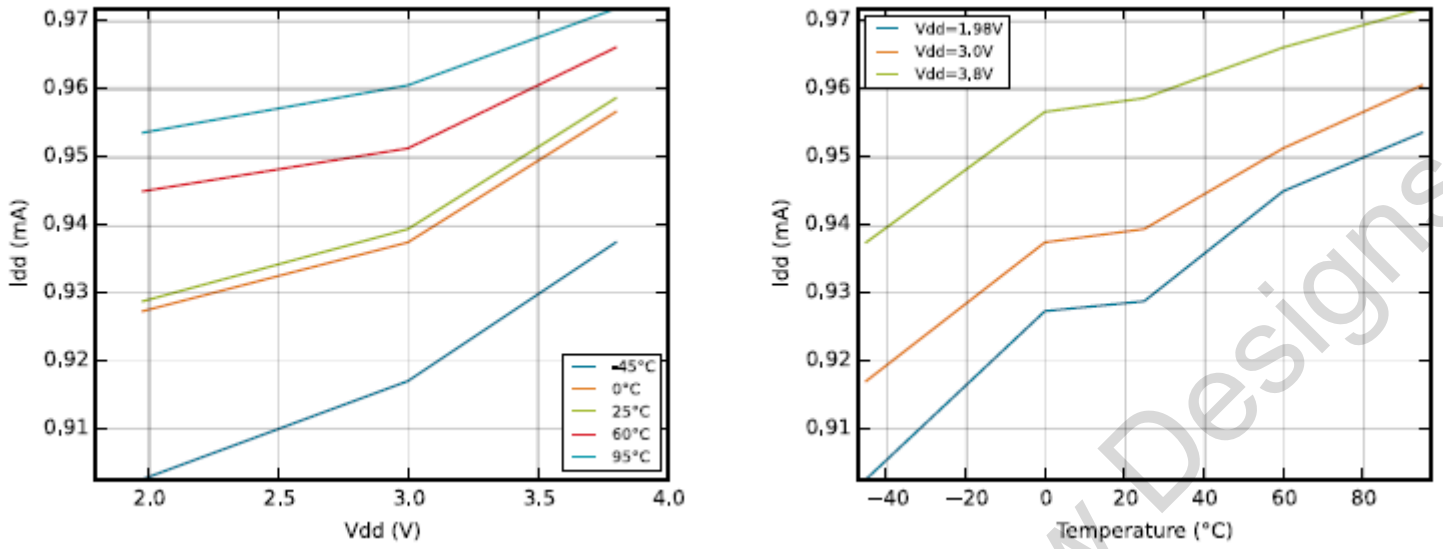


Figure 4.5. EM0 Current Consumption while Executing Prime Number Calculation Code from Flash with HFRCO Running at 6.6 MHz

Not Recommended for New Designs

4.5.2 EM1 Current Consumption

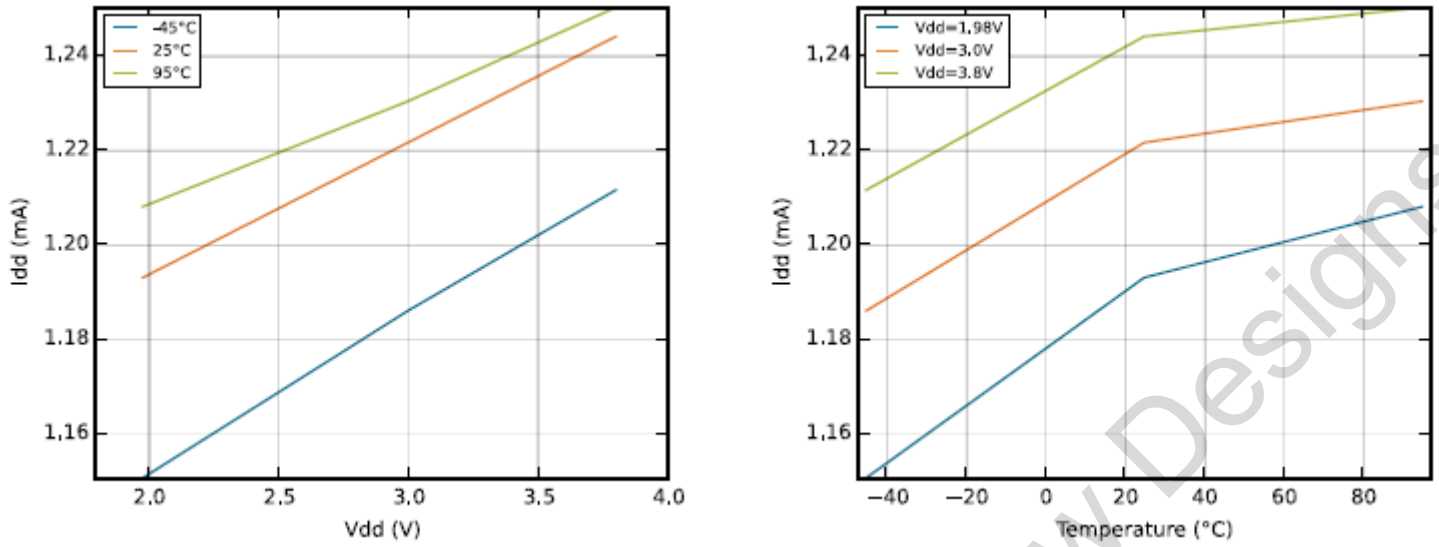


Figure 4.6. EM1 Current Consumption with all Peripheral Clocks Disabled and HFRCO Running at 24 MHz

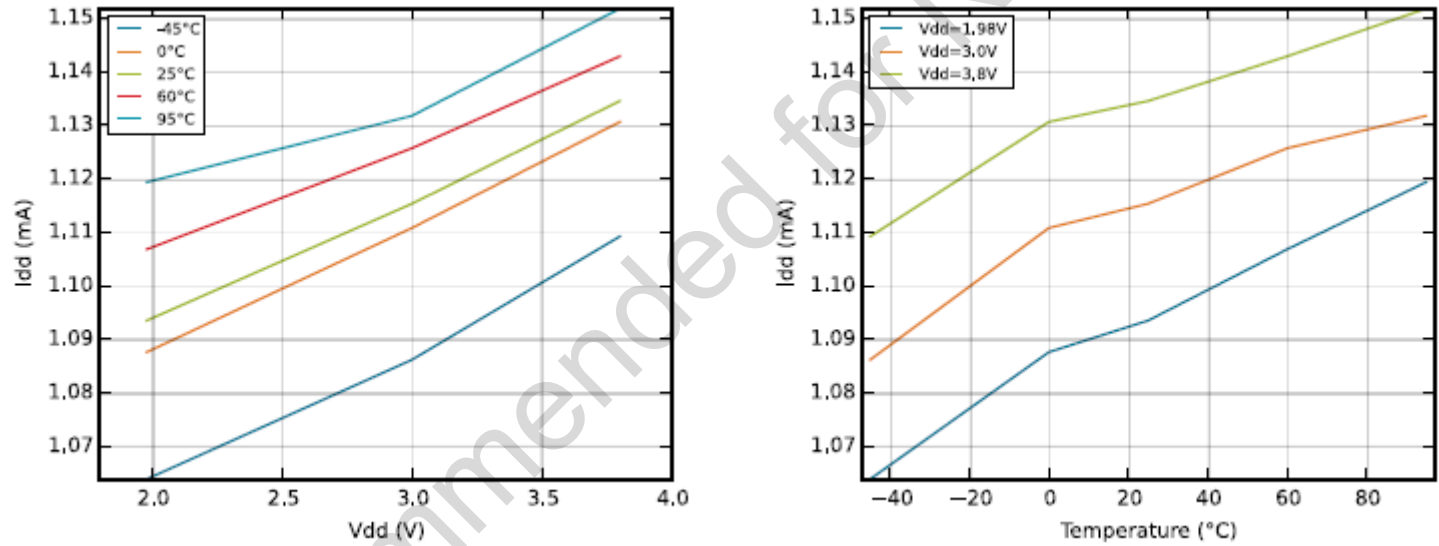


Figure 4.7. EM1 Current Consumption with all Peripheral Clocks Disabled and HFRCO Running at 21 MHz

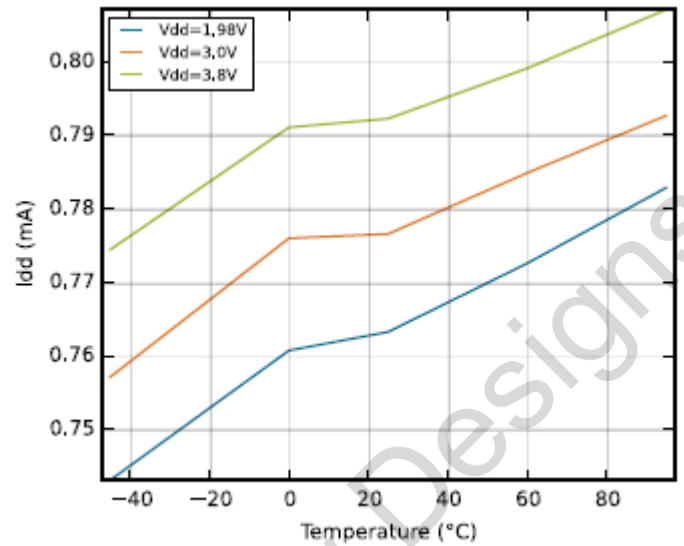
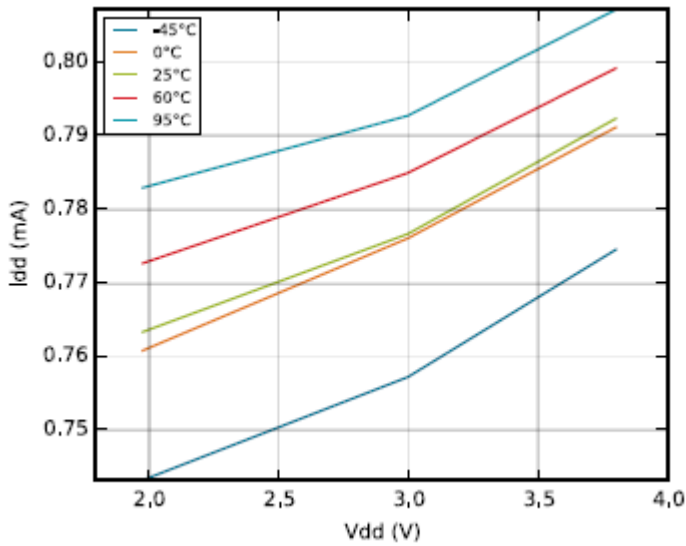


Figure 4.8. EM1 Current Consumption with all Peripheral Clocks Disabled and HFRCO Running at 14 MHz

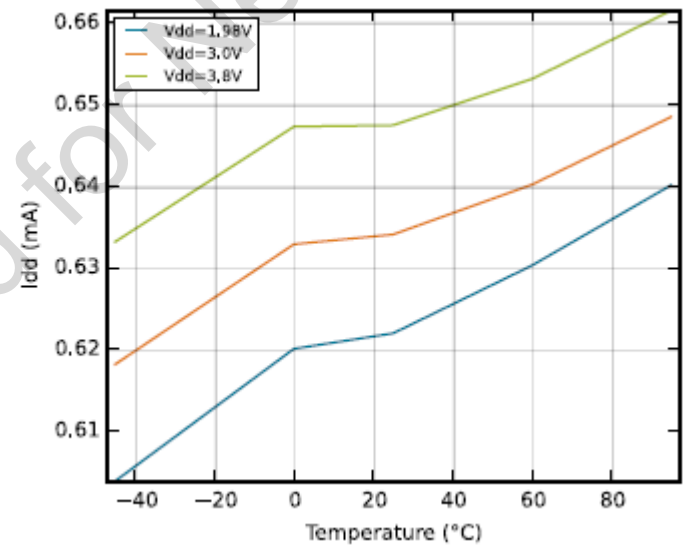
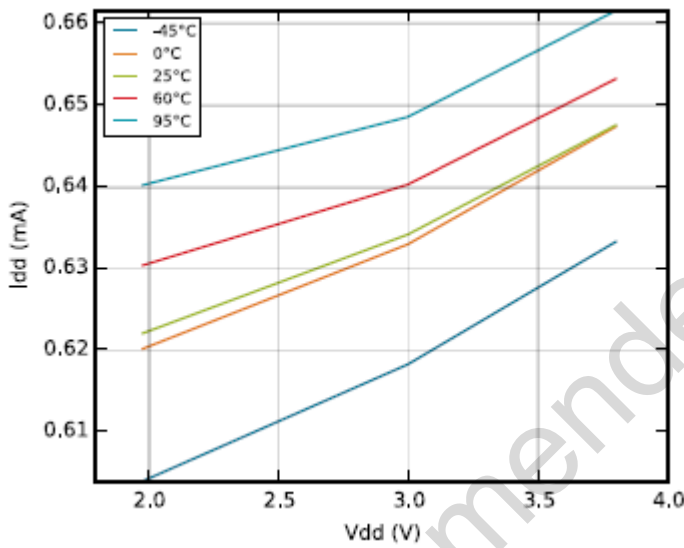


Figure 4.9. EM1 Current Consumption with all Peripheral Clocks Disabled and HFRCO Running at 11 MHz

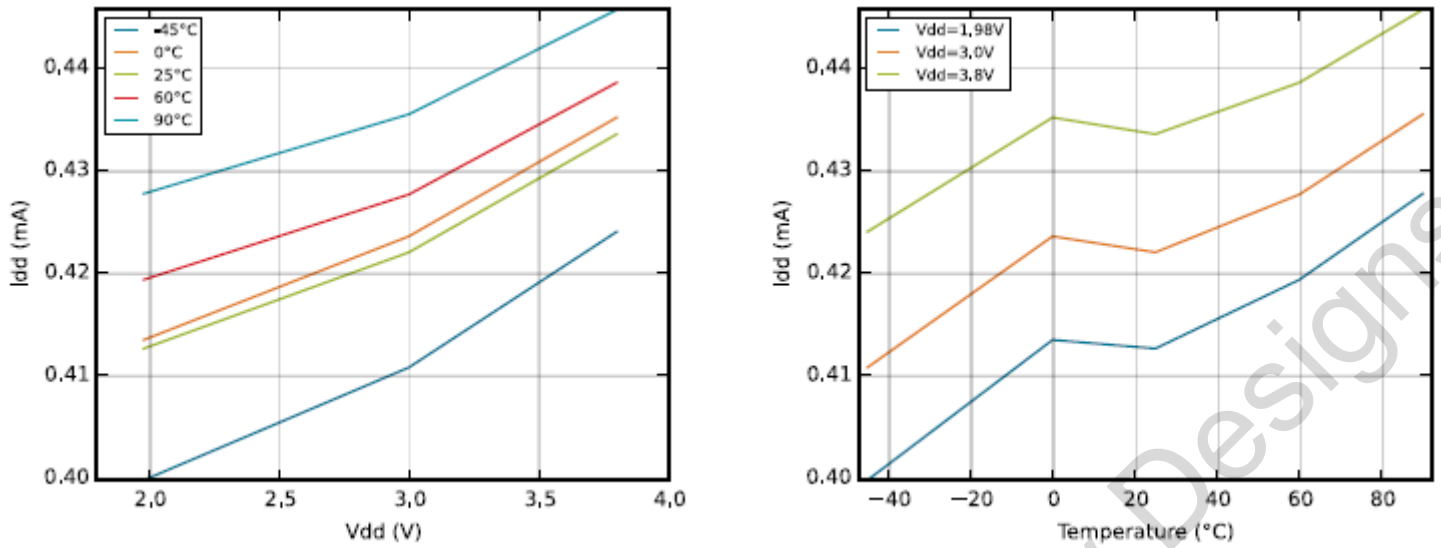


Figure 4.10. EM1 Current Consumption with all Peripheral Clocks Disabled and HFRCO Running at 6.6 MHz

4.5.3 EM2 Current Consumption

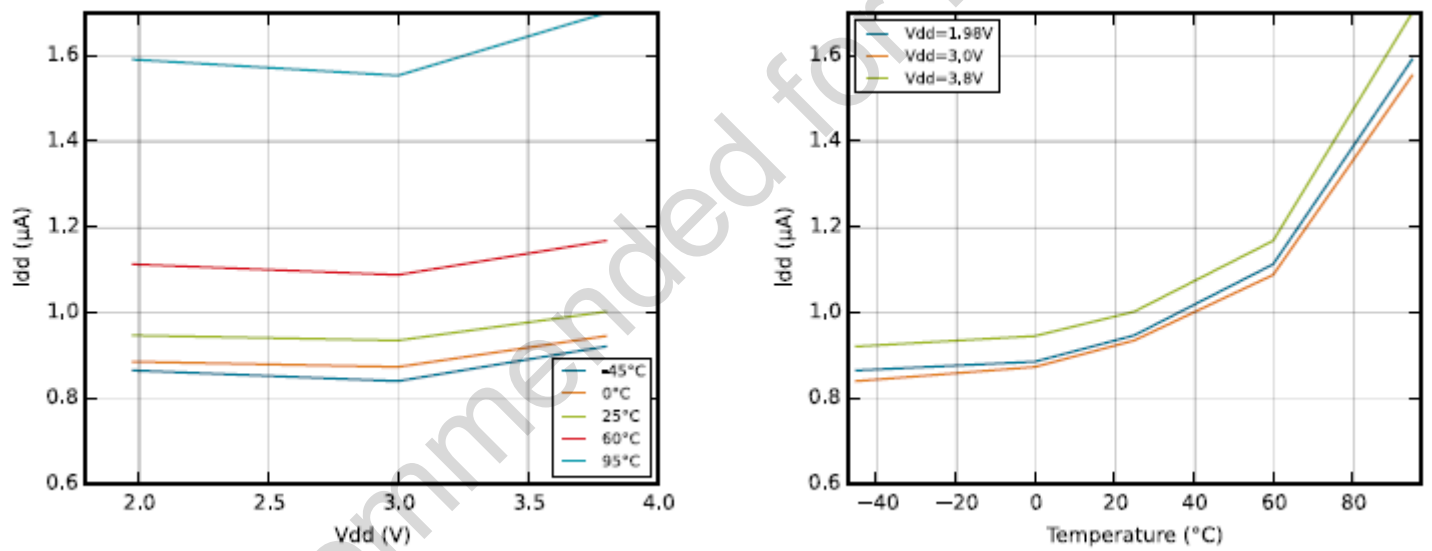


Figure 4.11. EM2 Current Consumption, RTC Prescaled to 1 kHz, 32.768 kHz LFRCO

4.5.4 EM3 Current Consumption

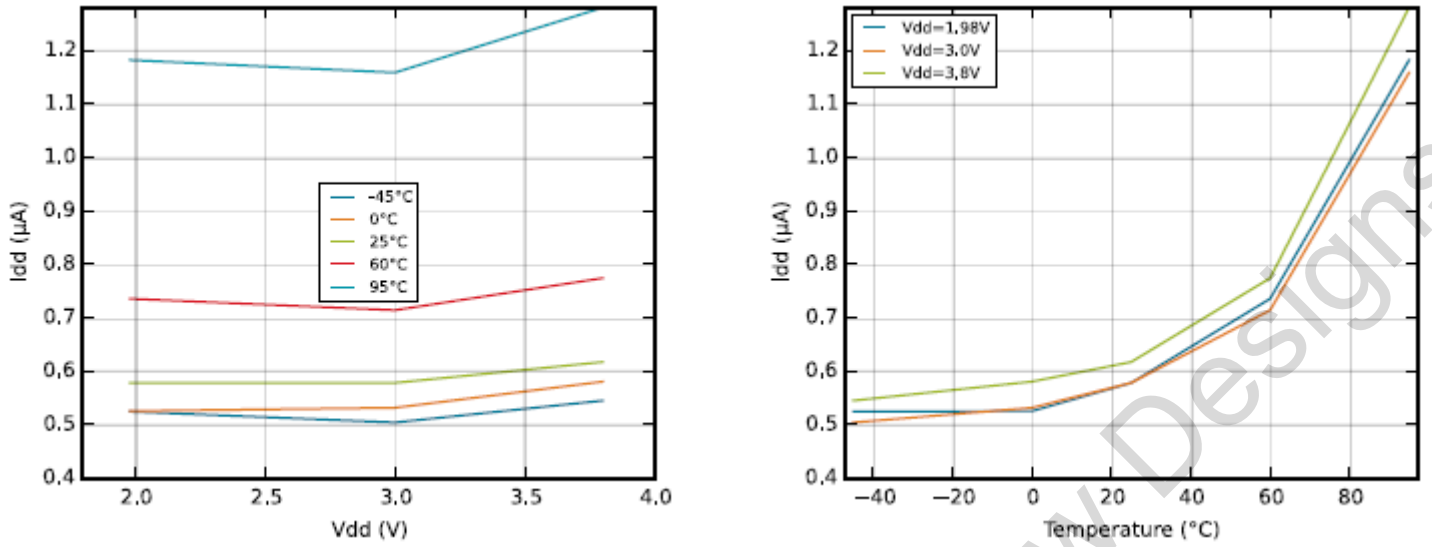


Figure 4.12. EM3 Current Consumption

4.5.5 EM4 Current Consumption

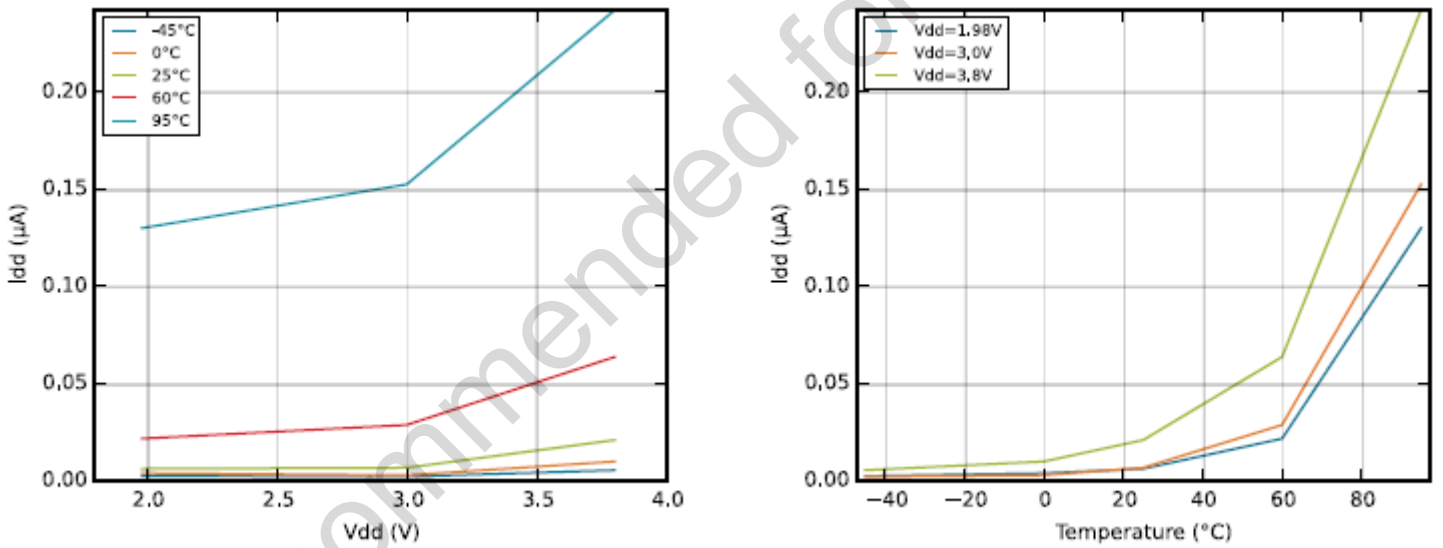


Figure 4.13. EM4 Current Consumption

4.6 Transitions between Energy Modes

The transition times are measured from the trigger to the first clock edge in the CPU.

Table 4.5. Energy Modes Transitions

| Parameter | Symbol | Min | Typ | Max | Unit |
|---------------------------------|------------|-----|-----|-----|------------------|
| Transition time from EM1 to EM0 | t_{EM10} | — | 0 | — | HFCORECLK cycles |
| Transition time from EM2 to EM0 | t_{EM20} | — | 2 | — | μs |
| Transition time from EM3 to EM0 | t_{EM30} | — | 2 | — | μs |
| Transition time from EM4 to EM0 | t_{EM40} | — | 163 | — | μs |

4.7 Power Management

The EZR32HG requires the AVDD_x, VDD_DREG, RFVDD_x and IOVDD_x pins to be connected together (with optional filter) at the PCB level. For practical schematic recommendations, see the application note, [AN0002.0: EFM32 and EZR32 Wireless MCU Series 0 Hardware Design Considerations](#).

Table 4.6. Power Management

| Symbol | Parameter | Condition | Min | Typ | Max | Unit |
|------------------|---|---|------|------|------|---------------|
| $V_{BODextthr-}$ | BOD threshold on falling external supply voltage | EM0 | 1.74 | — | 1.96 | V |
| | | EM2 | 1.71 | 1.86 | 1.98 | V |
| $V_{BODextthr+}$ | BOD threshold on rising external supply voltage | | — | 1.85 | — | V |
| t_{RESET} | Delay from reset is released until program execution starts | Applies to Power-on Reset, Brown-out Reset and pin reset. | | — | 163 | μs |
| $C_{DECOUPLE}$ | Voltage regulator decoupling capacitor. | X5R capacitor recommended. Apply between DECOUPLE pin and GROUND | | — | 1 | μF |
| C_{USB_VREGO} | USB voltage regulator out decoupling capacitor. | X5R capacitor recommended. Apply between USB_VREGO pin and GROUND | | — | 1 | μF |
| C_{USB_VREGI} | USB voltage regulator in decoupling capacitor. | X5R capacitor recommended. Apply between USB_VREGI pin and GROUND | | — | 4.7 | μF |

4.8 Flash

Table 4.7. Flash

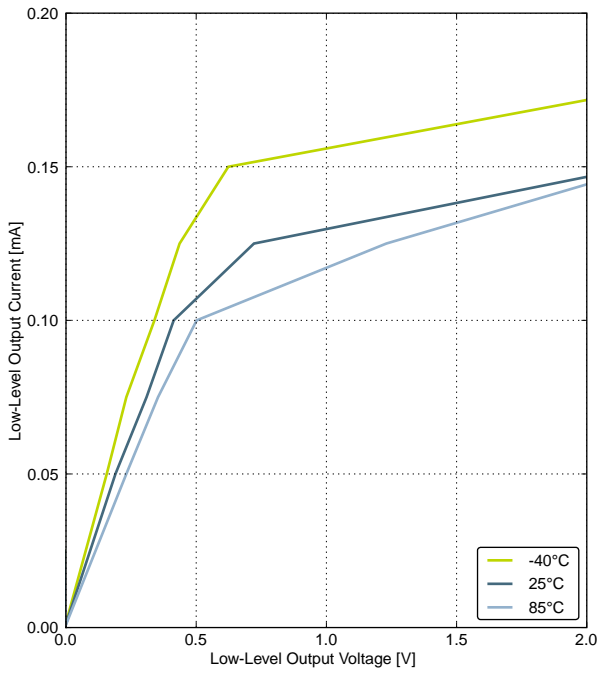
| Parameter | Symbol | Test Condition | Min | Typ | Max | Unit |
|---|---------------|---------------------------|-------|------|----------------|---------------|
| Flash erase cycles before failure | EC_{FLASH} | | 20000 | — | — | cycles |
| Flash data retention | RET_{FLASH} | $T_{AMB} < 150\text{ °C}$ | 10000 | — | — | h |
| | | $T_{AMB} < 85\text{ °C}$ | 10 | — | — | years |
| | | $T_{AMB} < 70\text{ °C}$ | 20 | — | — | years |
| Word (32-bit) programming time | t_{W_PROG} | | 20 | — | — | μs |
| Page erase time | t_{PERASE} | | 20 | 20.4 | 20.8 | ms |
| Device erase time | t_{DERASE} | | 40 | 40.8 | 41.6 | ms |
| Erase current | I_{ERASE} | | — | — | 7 ¹ | mA |
| Write current | I_{WRITE} | | — | — | 7 ¹ | mA |
| Supply voltage during flash erase and write | V_{FLASH} | | 1.98 | — | 3.8 | V |
| Note: | | | | | | |
| 1. Measured at 25 °C. | | | | | | |

4.9 General Purpose Input Output

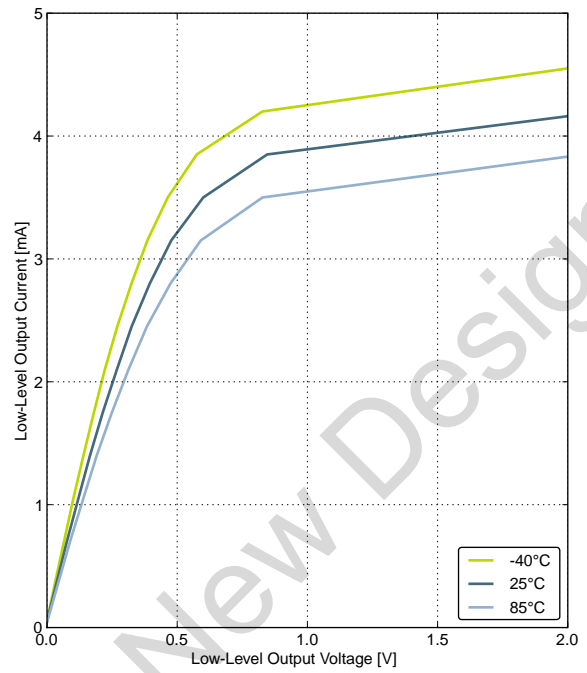
Table 4.8. GPIO

| Parameter | Symbol | Test Condition | Min | Typ | Max | Unit |
|--|------------|---|---------------|---------------|---------------|------|
| Input low voltage | V_{IOIL} | | — | — | $0.30 V_{DD}$ | V |
| Input high voltage | V_{IOIH} | | $0.70 V_{DD}$ | — | — | V |
| Output high voltage (Production test condition = 3.0 V, DRIVE-MODE = STANDARD) | V_{IOOH} | Sourcing 0.1 mA, $V_{DD} = 1.98$ V, GPIO_Px_CTRL DRIVEMODE = LOWEST | — | $0.80 V_{DD}$ | — | V |
| | | Sourcing 0.1 mA, $V_{DD} = 3.0$ V, GPIO_Px_CTRL DRIVEMODE = LOWEST | — | $0.90 V_{DD}$ | — | V |
| | | Sourcing 1 mA, $V_{DD} = 1.98$ V, GPIO_Px_CTRL DRIVEMODE = LOW | — | $0.85 V_{DD}$ | — | V |
| | | Sourcing 1 mA, $V_{DD} = 3.0$ V, GPIO_Px_CTRL DRIVEMODE = LOW | — | $0.90 V_{DD}$ | — | V |
| | | Sourcing 6 mA, $V_{DD} = 1.98$ V, GPIO_Px_CTRL DRIVEMODE = STANDARD | $0.75 V_{DD}$ | — | — | V |
| | | Sourcing 6 mA, $V_{DD} = 3.0$ V, GPIO_Px_CTRL DRIVEMODE = STANDARD | $0.85 V_{DD}$ | — | — | V |
| | | Sourcing 20 mA, $V_{DD} = 1.98$ V, GPIO_Px_CTRL DRIVEMODE = HIGH | $0.60 V_{DD}$ | — | — | V |
| | | Sourcing 20 mA, $V_{DD} = 3.0$ V, GPIO_Px_CTRL DRIVEMODE = HIGH | $0.80 V_{DD}$ | — | — | V |

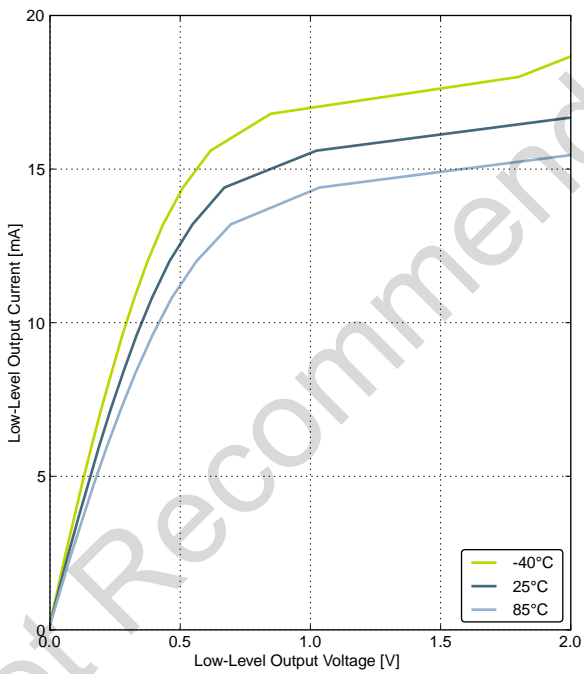
| Parameter | Symbol | Test Condition | Min | Typ | Max | Unit |
|---|----------------|---|---------------|---------------|---------------|------------|
| Output low voltage (Production test condition = 3.0 V, DRIVE-MODE = STANDARD) | V_{IOOL} | Sinking 0.1 mA, $V_{DD} = 1.98$ V, GPIO_Px_CTRL DRIVEMODE = LOWEST | — | $0.20 V_{DD}$ | — | V |
| | | Sinking 0.1 mA, $V_{DD} = 3.0$ V, GPIO_Px_CTRL DRIVEMODE = LOWEST | — | $0.10 V_{DD}$ | — | V |
| | | Sinking 1 mA, $V_{DD} = 1.98$ V, GPIO_Px_CTRL DRIVEMODE = LOW | — | $0.10 V_{DD}$ | — | V |
| | | Sinking 1 mA, $V_{DD} = 3.0$ V, GPIO_Px_CTRL DRIVEMODE = LOW | — | $0.05 V_{DD}$ | — | V |
| | | Sinking 6 mA, $V_{DD} = 1.98$ V, GPIO_Px_CTRL DRIVEMODE = STANDARD | — | — | $0.30 V_{DD}$ | V |
| | | Sinking 6 mA, $V_{DD} = 3.0$ V, GPIO_Px_CTRL DRIVEMODE = STANDARD | — | — | $0.20 V_{DD}$ | V |
| | | Sinking 20 mA, $V_{DD} = 1.98$ V, GPIO_Px_CTRL DRIVEMODE = HIGH | — | — | $0.35 V_{DD}$ | V |
| | | Sinking 20 mA, $V_{DD} = 3.0$ V, GPIO_Px_CTRL DRIVEMODE = HIGH | — | — | $0.25 V_{DD}$ | V |
| Input leakage current | I_{IOLEAK} | High Impedance IO connected to GROUND or Vdd | — | ± 0.1 | ± 40 | nA |
| I/O pin pull-up resistor | R_{PU} | | — | 40 | — | k Ω |
| I/O pin pull-down resistor | R_{PD} | | — | 40 | — | k Ω |
| Internal ESD series resistor | R_{IOESD} | | — | 200 | — | Ω |
| Pulse width of pulses to be removed by the glitch suppression filter | $t_{IOGLITCH}$ | | 10 | — | 50 | ns |
| Output fall time | t_{IOF} | GPIO_Px_CTRL DRIVEMODE = LOWEST and load capacitance $C_L = 12.5$ -25 pF. | $20+0.1 C_L$ | — | 250 | ns |
| | | GPIO_Px_CTRL DRIVEMODE = LOW and load capacitance $C_L = 350$ -600 pF | $20+0.1 C_L$ | — | 250 | ns |
| I/O pin hysteresis ($V_{IOTHR+} - V_{IOTHR-}$) | V_{IOHYST} | $V_{DD} = 1.98 - 3.8$ V | $0.10 V_{DD}$ | — | — | V |



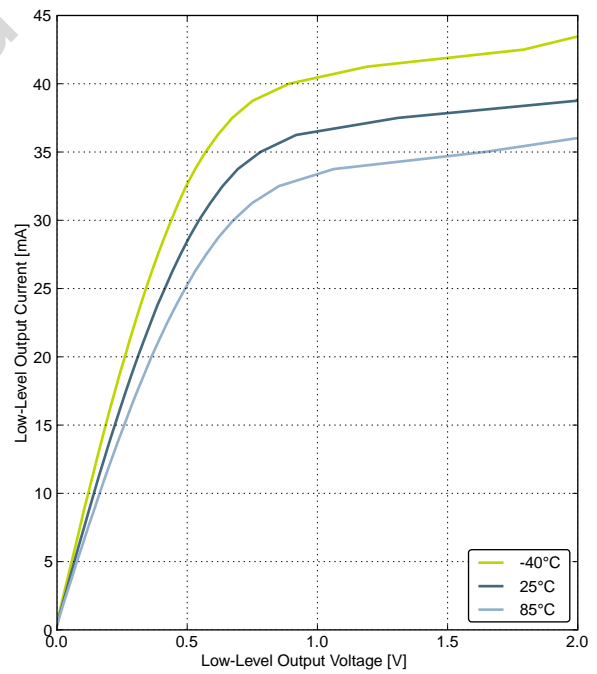
GPIO_Px_CTRL DRIVEMODE = LOWEST



GPIO_Px_CTRL DRIVEMODE = LOW

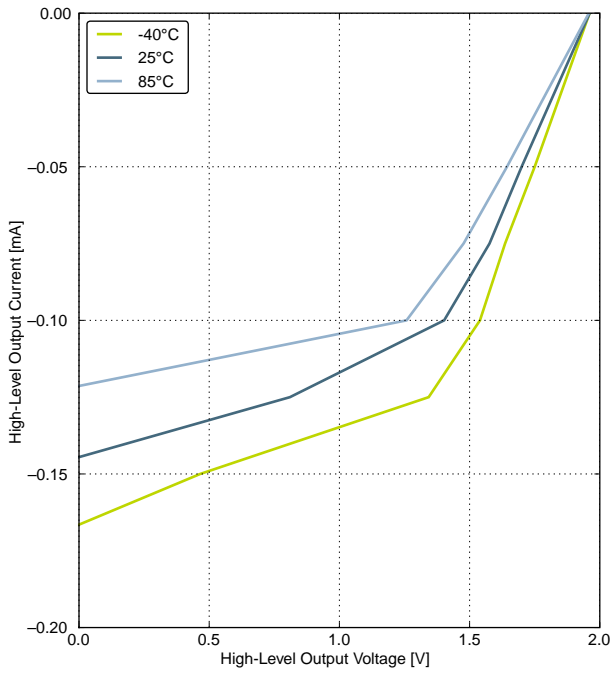


GPIO_Px_CTRL DRIVEMODE = STANDARD

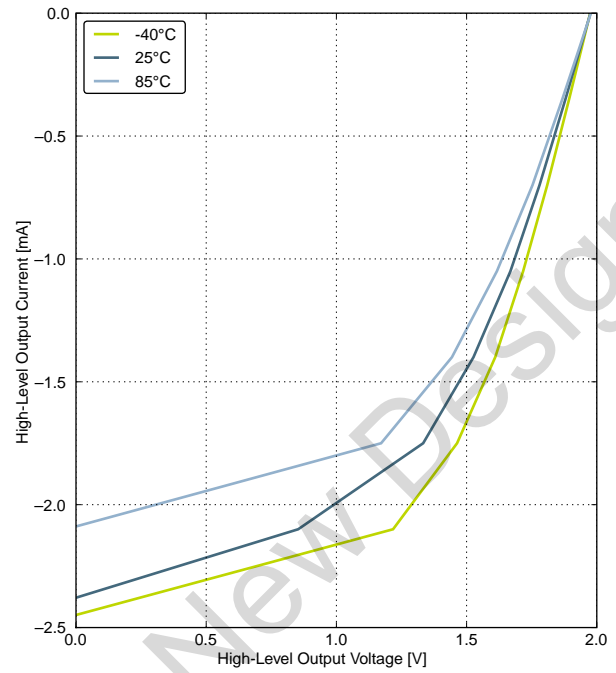


GPIO_Px_CTRL DRIVEMODE = High

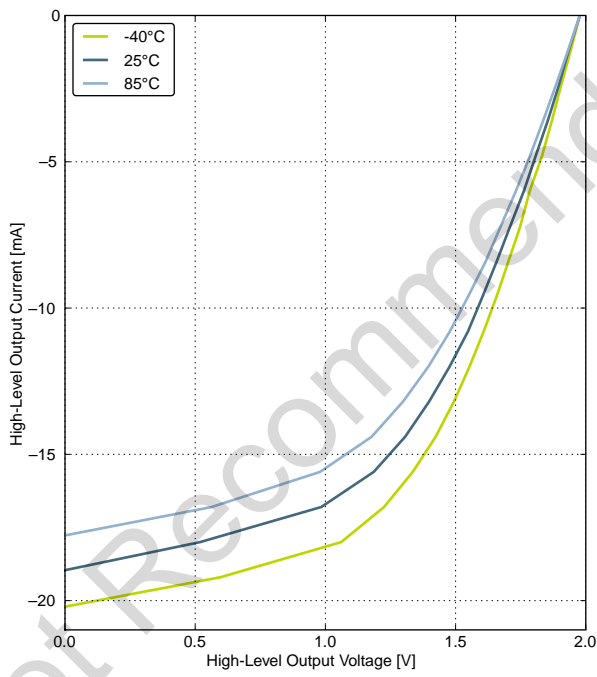
Figure 4.14. Typical Low-Level Output Current, 2 V Supply Voltage



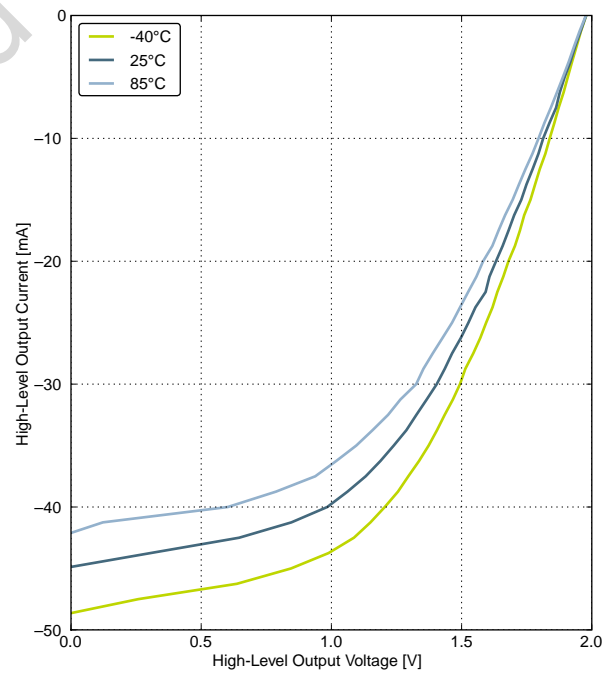
GPIO_Px_CTRL DRIVEMODE = LOWEST



GPIO_Px_CTRL DRIVEMODE = LOW

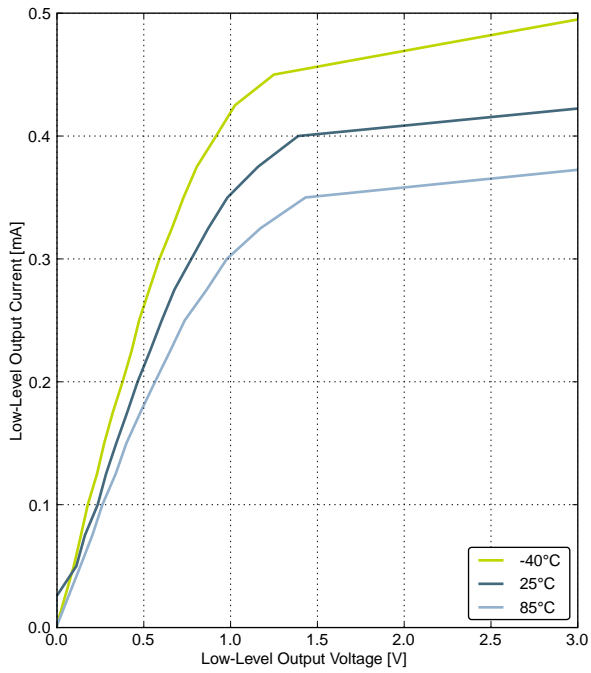


GPIO_Px_CTRL DRIVEMODE = STANDARD

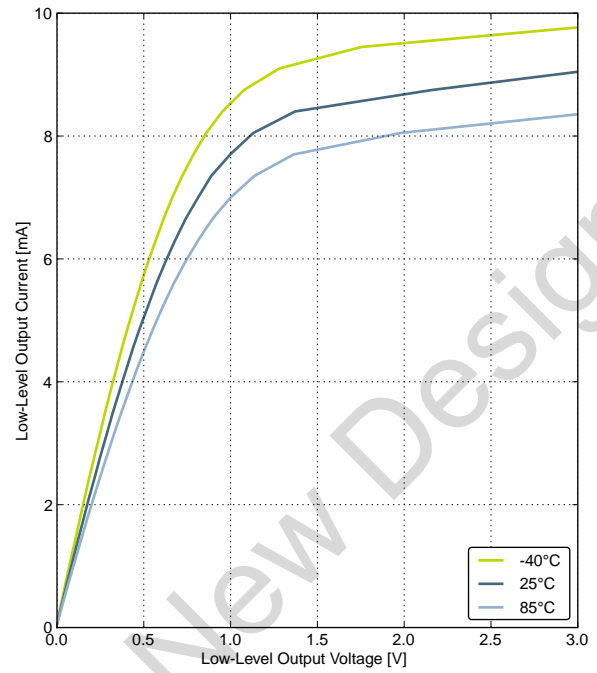


GPIO_Px_CTRL DRIVEMODE = High

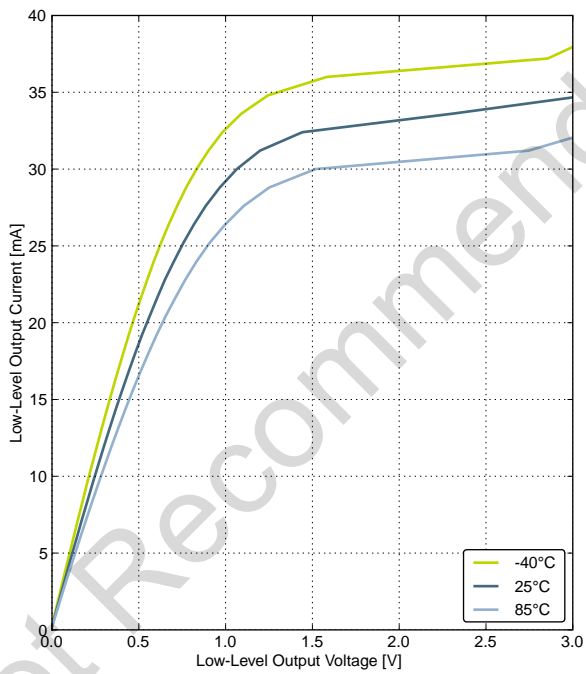
Figure 4.15. Typical High-Level Output Current, 2 V Supply Voltage



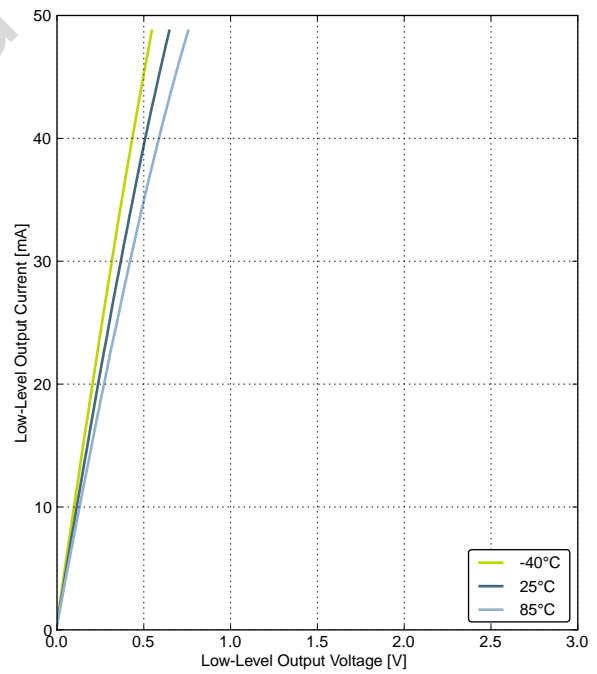
GPIO_Px_CTRL DRIVEMODE = LOWEST



GPIO_Px_CTRL DRIVEMODE = LOW

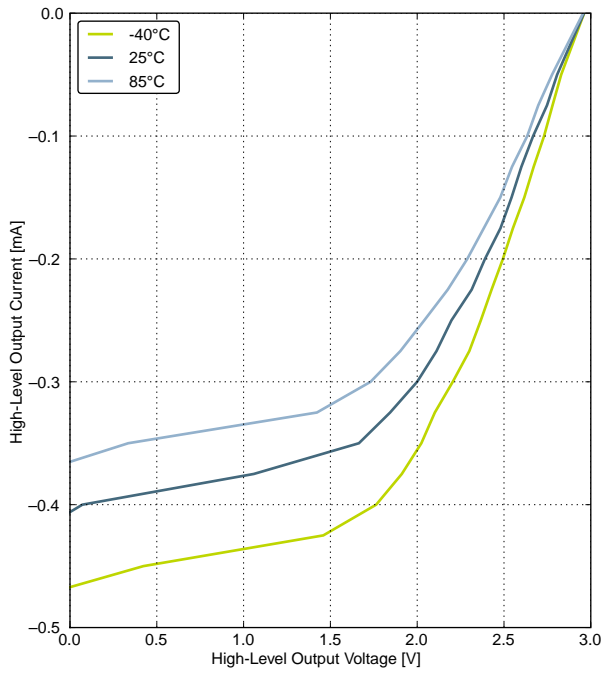


GPIO_Px_CTRL DRIVEMODE = STANDARD

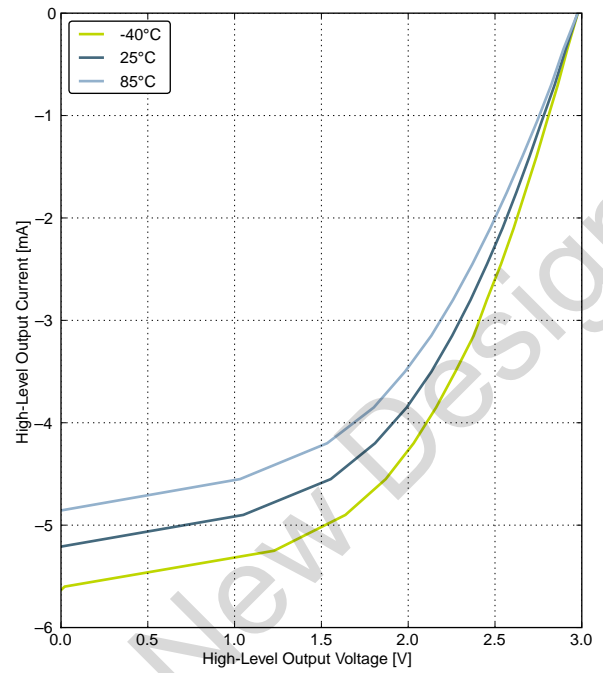


GPIO_Px_CTRL DRIVEMODE = High

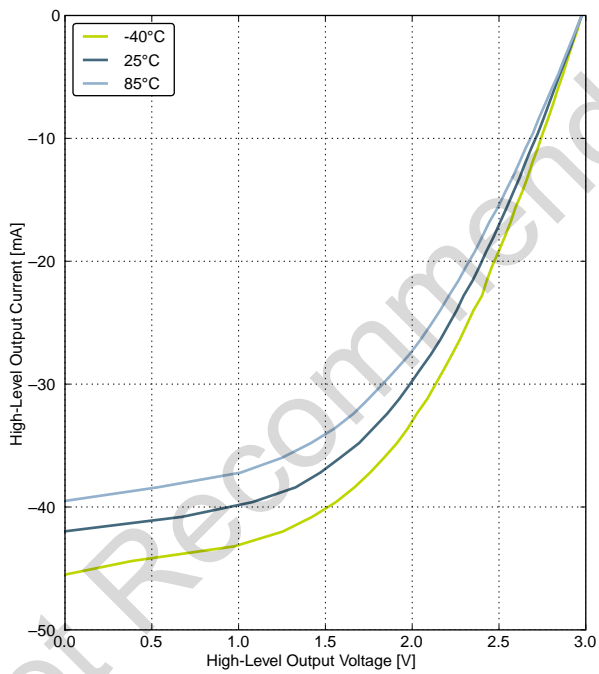
Figure 4.16. Typical Low-Level Output Current, 3 V Supply Voltage



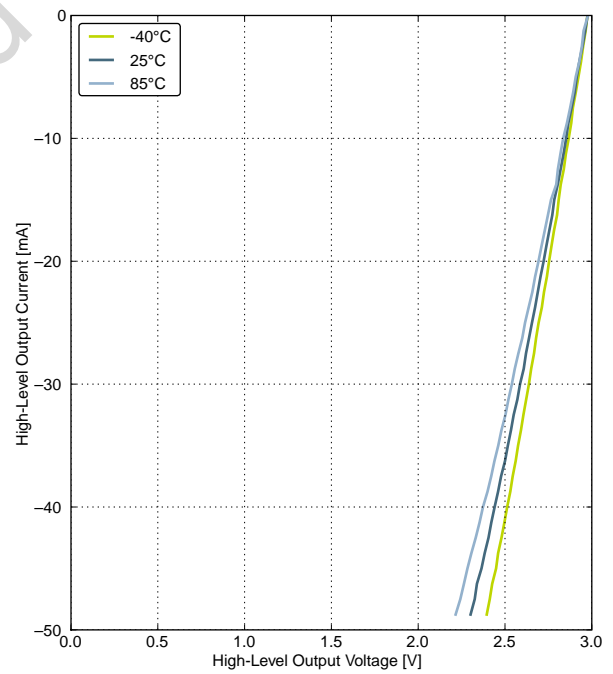
GPIO_Px_CTRL DRIVEMODE = LOWEST



GPIO_Px_CTRL DRIVEMODE = LOW

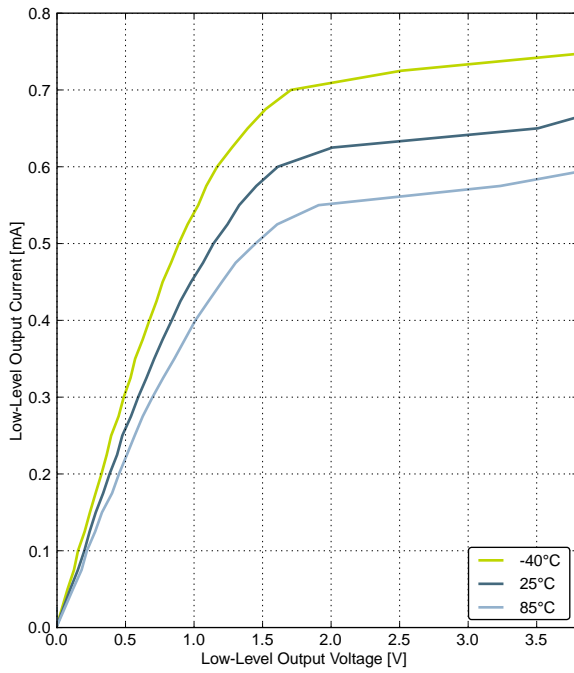


GPIO_Px_CTRL DRIVEMODE = STANDARD

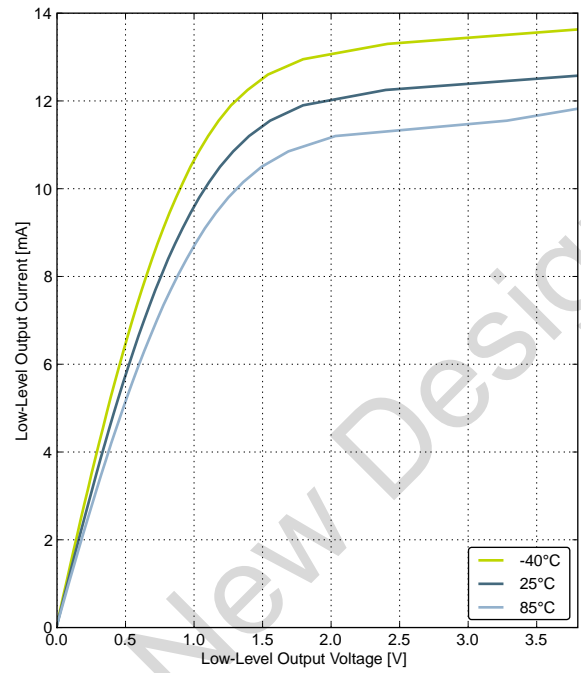


GPIO_Px_CTRL DRIVEMODE = High

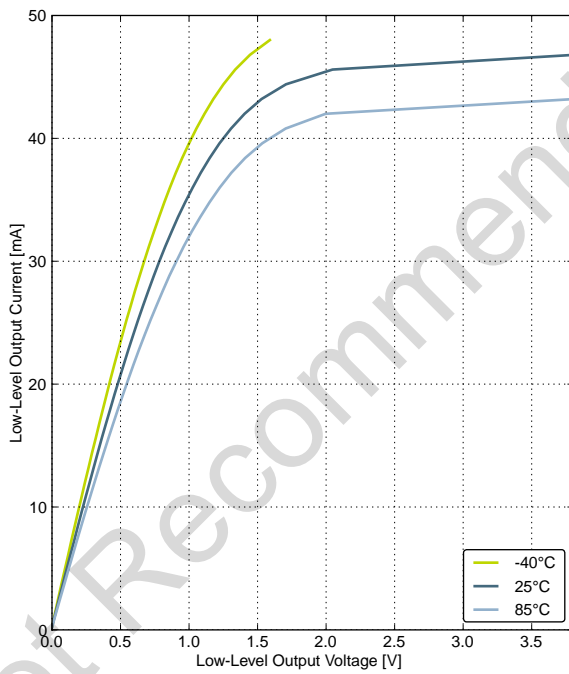
Figure 4.17. Typical High-Level Output Current, 3 V Supply Voltage



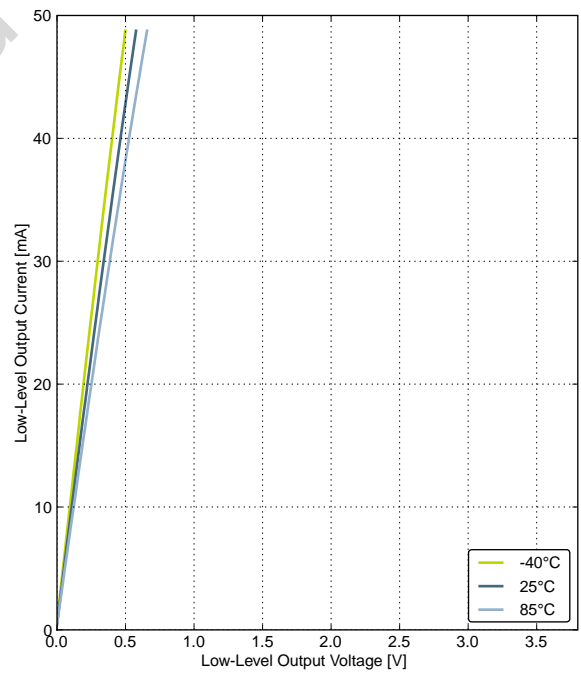
GPIO_Px_CTRL DRIVEMODE = LOWEST



GPIO_Px_CTRL DRIVEMODE = LOW

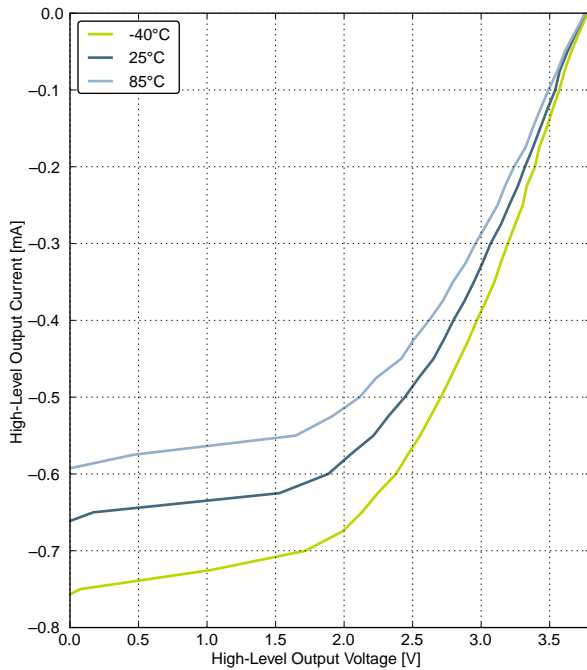


GPIO_Px_CTRL DRIVEMODE = STANDARD

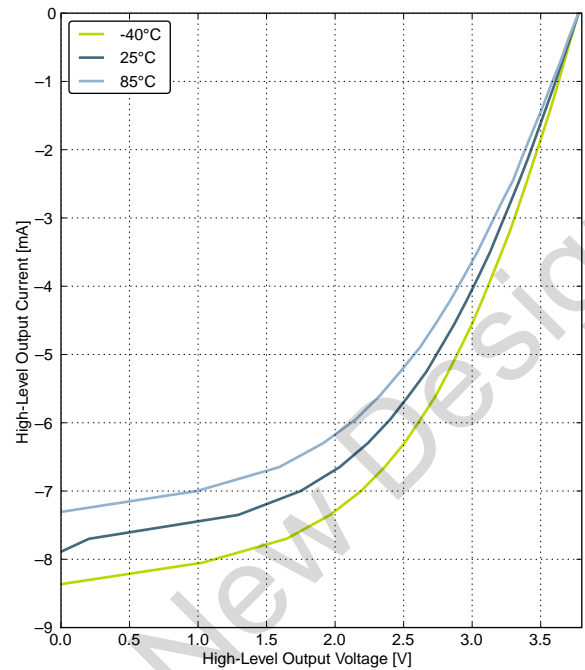


GPIO_Px_CTRL DRIVEMODE = High

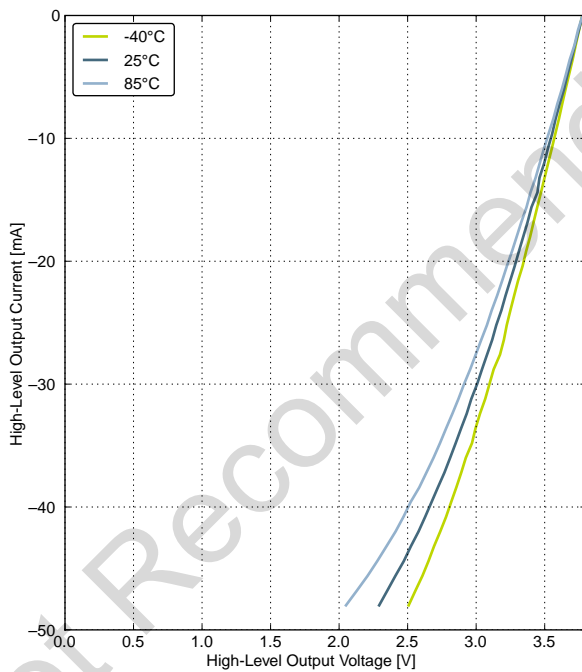
Figure 4.18. Typical Low-Level Output Current, 3.8 V Supply Voltage



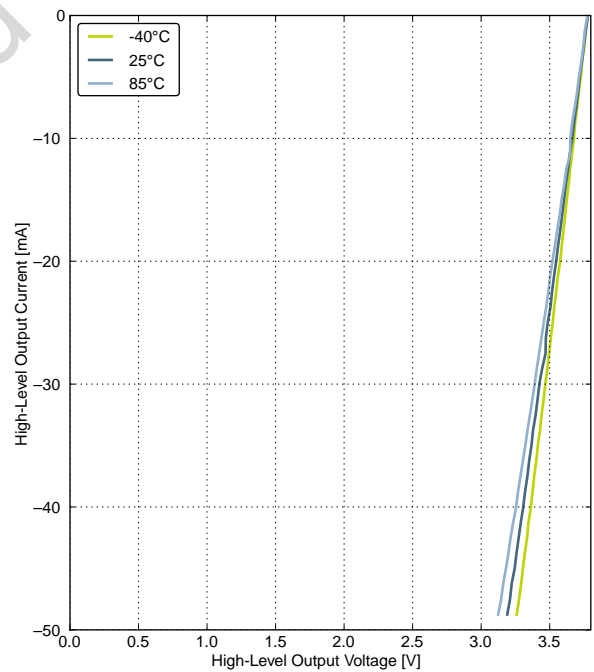
GPIO_Px_CTRL DRIVEMODE = LOWEST



GPIO_Px_CTRL DRIVEMODE = LOW



GPIO_Px_CTRL DRIVEMODE = STANDARD



GPIO_Px_CTRL DRIVEMODE = High

Figure 4.19. Typical High-Level Output Current, 3.8 V Supply Voltage

4.10 Oscillators

4.10.1 LFXO

Table 4.9. LFXO

| Parameter | Symbol | Test Condition | Min | Typ | Max | Unit |
|---|--------------|---|-----------------|--------|------|------------|
| Supported nominal crystal frequency | f_{LFXO} | | 31.3 | 32.768 | 34.3 | kHz |
| Supported crystal equivalent series resistance (ESR) | ESR_{LFXO} | | — | 30 | 120 | k Ω |
| Supported crystal external load range | C_{LFXOL} | | X ¹⁵ | — | 25 | pF |
| Duty cycle | DC_{LFXO} | | 48 | 50 | 53.5 | % |
| Current consumption for core and buffer after startup | I_{LFXO} | ESR=30 k Ω , C_L =10 pF, LFXO-BOOST in CMU_CTRL is 1 | — | 190 | — | nA |
| Start-up time | t_{LFXO} | ESR=30 k Ω , C_L =10 pF, 40% - 60% duty cycle has been reached, LFXOBOOST in CMU_CTRL is 1 | — | 1100 | — | ms |

Note:

1. See Minimum Load Capacitance (C_{LFXOL}) Requirement For Safe Crystal Startup in energyAware Designer in Simplicity Studio.

For safe startup of a given crystal, the Configurator tool in Simplicity Studio contains a tool to help users configure both load capacitance and software settings for using the LFXO. For details regarding the crystal configuration, refer to application note, [AN0016.0: EFM32 Oscillator Design Considerations](#).

4.10.2 HFXO

Table 4.10. HFXO

| Parameter | Symbol | Test Condition | Min | Typ | Max | Unit |
|--|----------------------------|--|-----|-----|------|---------------|
| Supported frequency, any mode | f_{HFXO} | | 4 | — | 25 | MHz |
| Supported crystal equivalent series resistance (ESR) | ESR_{HFXO} | Crystal frequency 25 MHz | — | 30 | 100 | Ω |
| | | Crystal frequency 4 MHz | — | 400 | 1500 | Ω |
| The transconductance of the HFXO input transistor at crystal startup | g_{mHFXO} | HFXOBOOST in CMU_CTRL equals 0b11 | 20 | — | — | ms |
| Supported crystal external load range | C_{HFXOL} | | 5 | — | 25 | pF |
| Current consumption for HFXO after startup | I_{HFXO} | 4 MHz: ESR=400 Ohm, $C_L=20$ pF, HFXOBOOST in CMU_CTRL equals 0b11 | — | 85 | — | μA |
| | | 25 MHz: ESR=30 Ohm, $C_L=10$ pF, HFXOBOOST in CMU_CTRL equals 0b11 | — | 165 | — | μA |
| Startup time | t_{HFXO} | 25 MHz: ESR=30 Ohm, $C_L=10$ pF, HFXOBOOST in CMU_CTRL equals 0b11 | — | 785 | — | μs |

4.10.3 LFRCO

Table 4.11. LFRCO

| Parameter | Symbol | Test Condition | Min | Typ | Max | Unit |
|--|----------------------------|----------------|------|--------|------|---------|
| Oscillation frequency, $V_{DD}=3.0$ V, $T_{AMB}=25$ °C | f_{LFRCO} | | 31.3 | 32.768 | 34.3 | kHz |
| Startup time not including software calibration | t_{LFRCO} | | — | 150 | — | μ s |
| Current consumption | I_{LFRCO} | | — | 361 | 492 | nA |
| Frequency step for LSB change in TUNING value | TUNE-STEP _{LFRCO} | | — | 202 | — | Hz |

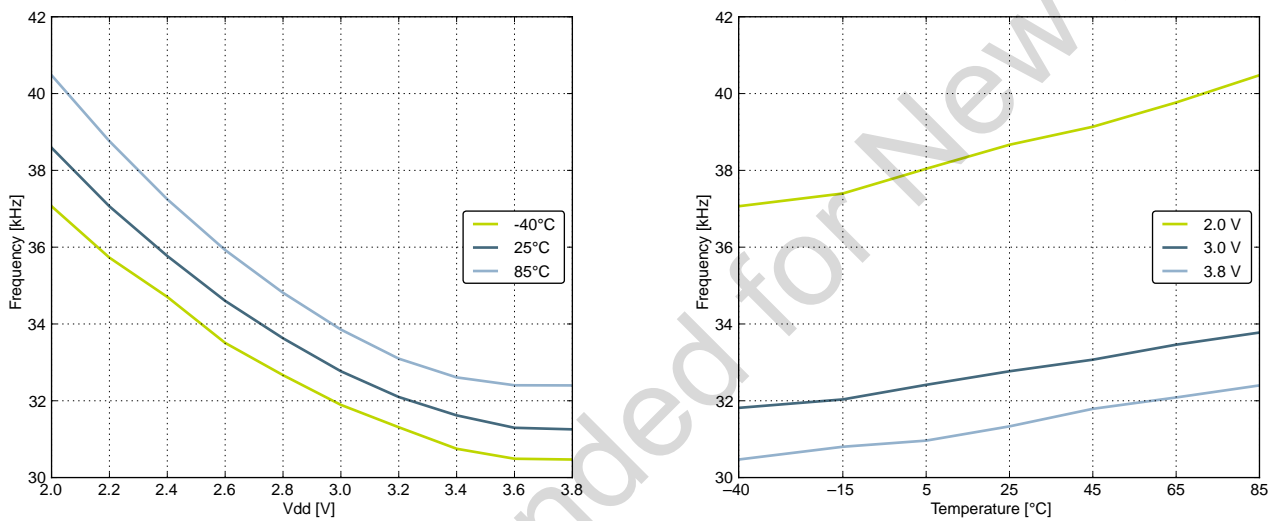


Figure 4.20. Calibrated LFRCO Frequency vs Temperature and Supply Voltage

4.10.4 HFRCO

Table 4.12. HFRCO

| Symbol | Parameter | Condition | Min | Typ | Max | Unit |
|------------------------------|---|--------------------------------------|-------|-------------------|-------|---------------|
| f_{HFRCO} | Oscillation frequency, $V_{\text{DD}} = 3.0 \text{ V}$, $T_{\text{AMB}} = 25^\circ\text{C}$ | 24 MHz frequency band | 23.28 | 24.0 | 24.72 | MHz |
| | | 21 MHz frequency band | 20.37 | 21.0 | 21.63 | MHz |
| | | 14 MHz frequency band | 13.58 | 14.0 | 14.42 | MHz |
| | | 11 MHz frequency band | 10.67 | 11.0 | 11.33 | MHz |
| | | 7 MHz frequency band | 6.40 | 6.60 | 6.80 | MHz |
| | | 1 MHz frequency band | 1.15 | 1.20 | 1.25 | MHz |
| $t_{\text{HFRCO_settling}}$ | Settling time after start-up | $f_{\text{HFRCO}} = 14 \text{ MHz}$ | — | 0.6 | — | Cycles |
| I_{HFRCO} | Current consumption | $f_{\text{HFRCO}} = 24 \text{ MHz}$ | — | 158 | 184 | μA |
| | | $f_{\text{HFRCO}} = 21 \text{ MHz}$ | — | 143 | 175 | μA |
| | | $f_{\text{HFRCO}} = 14 \text{ MHz}$ | — | 113 | 140 | μA |
| | | $f_{\text{HFRCO}} = 11 \text{ MHz}$ | — | 101 | 125 | μA |
| | | $f_{\text{HFRCO}} = 6.6 \text{ MHz}$ | — | 84 | 105 | μA |
| | | $f_{\text{HFRCO}} = 1.2 \text{ MHz}$ | — | 27 | 40 | μA |
| TUNE-STEP $_{\text{HFRCO}}$ | Frequency step for LSB change in TUNING value | 24 MHz frequency band | — | 66.8 ¹ | — | kHz |
| | | 21 MHz frequency band | — | 52.8 ¹ | — | kHz |
| | | 14 MHz frequency band | — | 36.9 ¹ | — | kHz |
| | | 11 MHz frequency band | — | 30.1 ¹ | — | kHz |
| | | 7 MHz frequency band | — | 18.0 ¹ | — | kHz |
| | | 1 MHz frequency band | — | 3.4 | — | kHz |

Note:

- The TUNING field in the CMU_HFRCOCTRL register may be used to adjust the HFRCO frequency. There is enough adjustment range to ensure that the frequency bands above 7 MHz will always have some overlap across supply voltage and temperature. By using a stable frequency reference such as the LFXO or HFXO, a firmware calibration routine can vary the TUNING bits and the frequency band to maintain the HFRCO frequency at any arbitrary value between 7 MHz and 21 MHz across operating conditions.

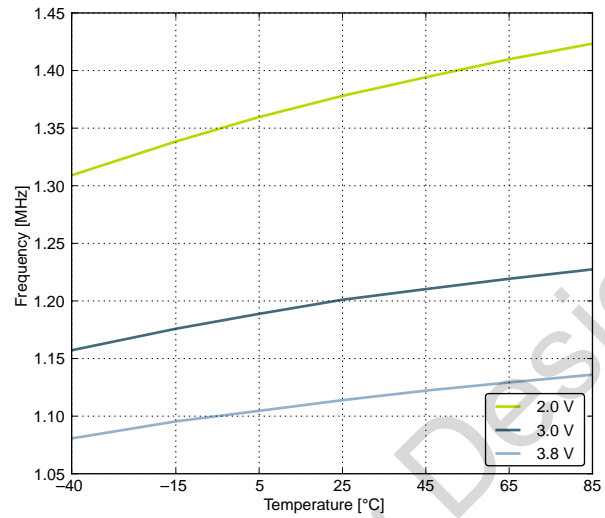
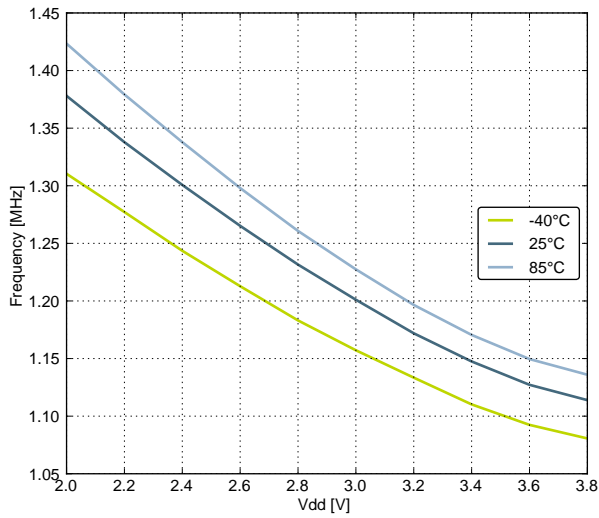


Figure 4.21. Calibrated HFRCO 1 MHz Band Frequency vs Supply Voltage and Temperature

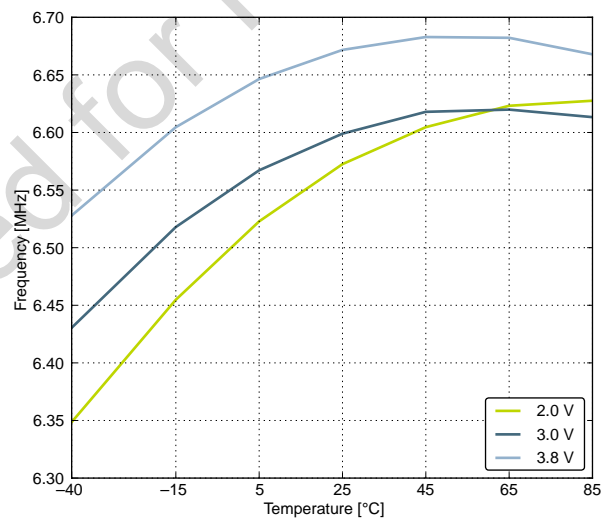
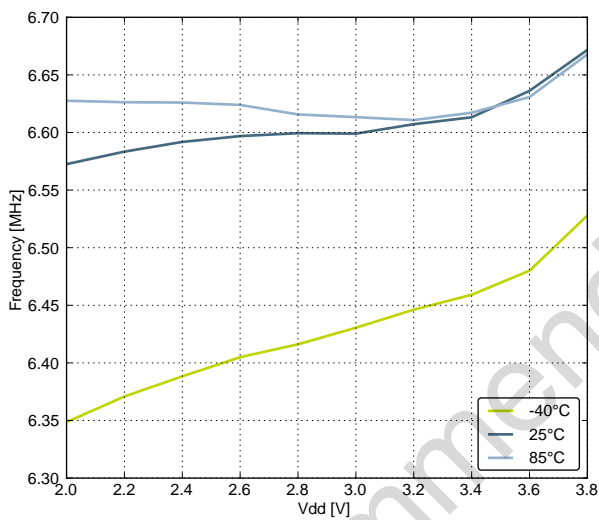


Figure 4.22. Calibrated HFRCO 7 MHz Band Frequency vs Supply Voltage and Temperature

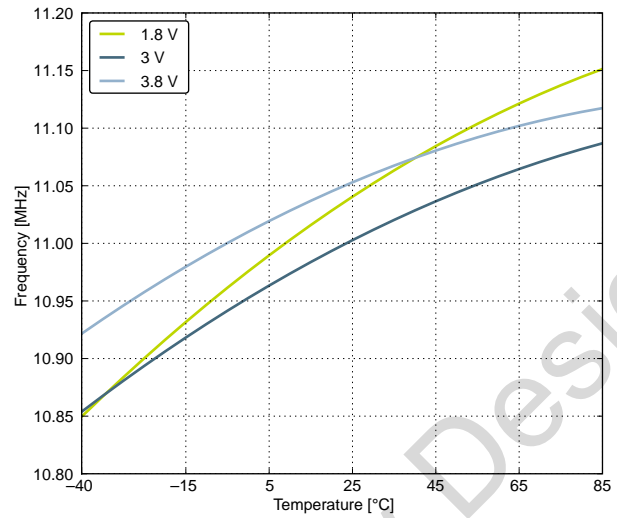
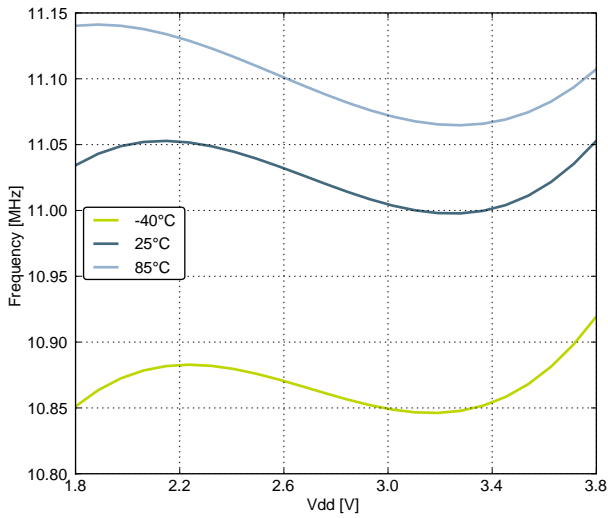


Figure 4.23. Calibrated HFRCO 11 MHz Band Frequency vs Supply Voltage and Temperature

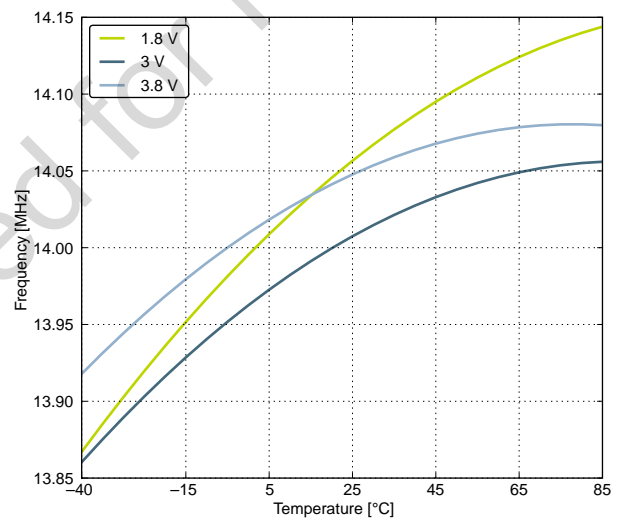
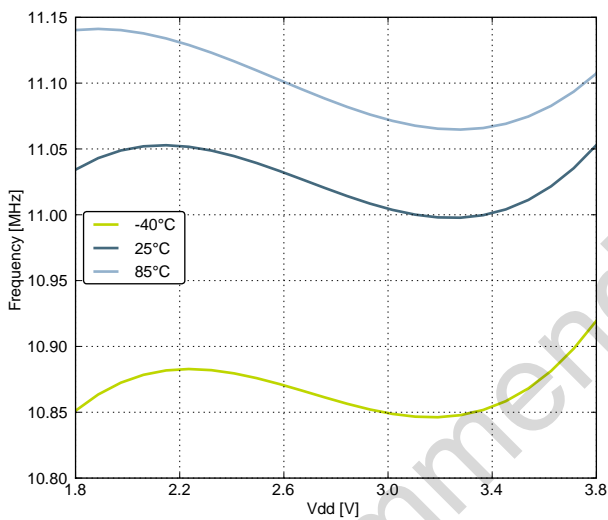


Figure 4.24. Calibrated HFRCO 14 MHz Band Frequency vs Supply Voltage and Temperature

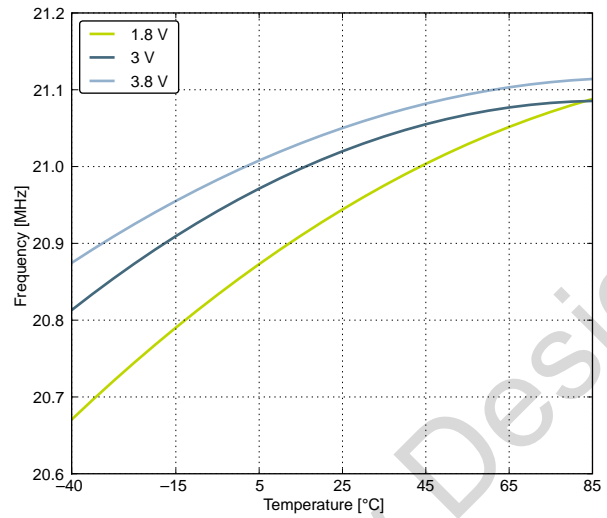
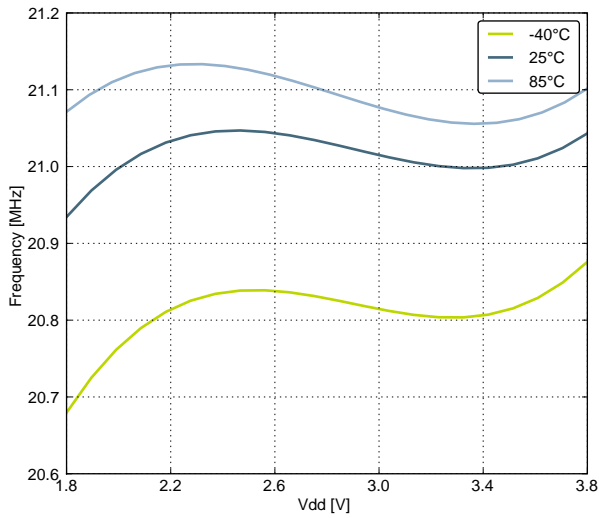


Figure 4.25. Calibrated HFRCO 21 MHz Band Frequency vs Supply Voltage and Temperature

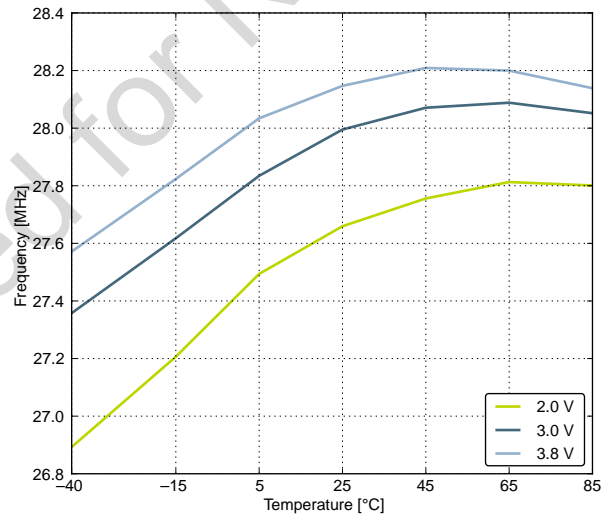
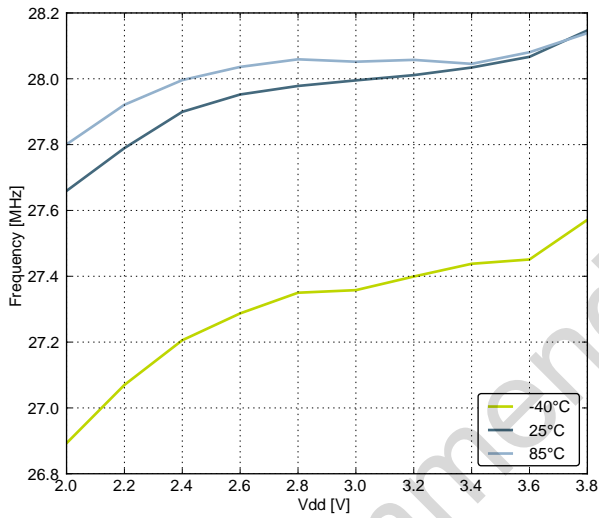


Figure 4.26. Calibrated HFRCO 28 MHz Band Frequency vs Supply Voltage and Temperature

4.10.5 AUXHFRCO

Table 4.13. AUXHFRCO

| Symbol | Parameter | Condition | Min | Typ | Max | Unit |
|--|--|--|-------|------|-------|--------|
| f_{AUXHFRCO} | Oscillation frequency, $V_{\text{DD}} = 3.0 \text{ V}$, $T_{\text{AMB}} = 25^\circ\text{C}$ | 21 MHz frequency band | 20.37 | 21.0 | 21.63 | MHz |
| | | 14 MHz frequency band | 13.58 | 14.0 | 14.42 | MHz |
| | | 11 MHz frequency band | 10.67 | 11.0 | 11.33 | MHz |
| | | 7 MHz frequency band | 6.40 | 6.60 | 6.80 | MHz |
| | | 1 MHz frequency band | 1.15 | 1.20 | 1.25 | MHz |
| $t_{\text{AUXHFRCO_set-}}\text{-tling}$ | Settling time after start-up | $f_{\text{AUXHFRCO}} = 14 \text{ MHz}$ | — | 0.6 | — | Cycles |
| TUNE-STEP _{AUXHFRCO} | Frequency step for LSB change in TUNING value | 21 MHz frequency band | — | 52.8 | — | kHz |
| | | 14 MHz frequency band | — | 36.9 | — | kHz |
| | | 11 MHz frequency band | — | 30.1 | — | kHz |
| | | 7 MHz frequency band | — | 18.0 | — | kHz |
| | | 1 MHz frequency band | — | 3.4 | — | kHz |

4.10.6 USHFRCO

Table 4.14. USHFRCO

| Symbol | Parameter | Condition | Min | Typ | Max | Unit |
|-----------------------|----------------------------|---|-------|--------|-------|------|
| f_{USHFRCO} | Oscillation frequency | No Clock Recovery, Full Temperature and Supply Range, 48 MHz band | 47.10 | 48.00 | 48.90 | MHz |
| | | No Clock Recovery, Full Temperature and Supply Range, 24 MHz band | 23.73 | 24.00 | 24.32 | MHz |
| | | No Clock Recovery, 25°C, 3.3V, 48 MHz band | 47.50 | 48.00 | 48.50 | MHz |
| | | No Clock Recovery, 25°C, 3.3V, 24 MHz band | 23.86 | 24.00 | 24.16 | MHz |
| | | USB Active with Clock Recovery, Full Temperature and Supply Range | 47.88 | 48.00 | 48.12 | MHz |
| TC _{USHFRCO} | Temperature coefficient | 3.3V | — | 0.0175 | — | %/°C |
| VC _{USHFRCO} | Supply voltage coefficient | 25°C | — | 0.0045 | — | %/V |
| I _{USHFRCO} | Current consumption | $f_{\text{USHFRCO}} = 48 \text{ MHz}$ | 1.21 | 1.36 | 1.48 | mA |
| | | $f_{\text{USHFRCO}} = 24 \text{ MHz}$ | 0.81 | 0.92 | 1.02 | mA |

4.10.7 ULFRCO

Table 4.15. ULFRCO

| Parameter | Symbol | Test Condition | Min | Typ | Max | Unit |
|----------------------------|---------------|----------------|-----|-------|------|------|
| Oscillation frequency | f_{ULFRCO} | 25 °C, 3 V | 0.7 | | 1.75 | kHz |
| Temperature coefficient | TC_{ULFRCO} | | – | 0.05 | – | %/°C |
| Supply voltage coefficient | VC_{ULFRCO} | | – | -18.2 | – | %/V |

Not Recommended for New Designs

4.11 Analog Digital Converter (ADC)

Table 4.16. ADC

| Symbol | Parameter | Condition | Min | Typ | Max | Unit |
|---------------------------|--|---|----------------------|------------------|-----------------------|------|
| V _{ADCIN} | Input voltage range | Single-ended | 0 | — | V _{REF} | V |
| | | Differential | -V _{REF} /2 | — | V _{REF} /2 | V |
| V _{ADCREFIN} | Input range of external reference voltage, single-ended and differential | | 1.25 | — | V _{DD} | V |
| V _{ADCREFIN_CH7} | Input range of external negative reference voltage on channel 7 | See V _{ADCREFIN} | 0 | — | V _{DD} - 1.1 | V |
| V _{ADCREFIN_CH6} | Input range of external positive reference voltage on channel 6 | See V _{ADCREFIN} | 0.625 | — | V _{DD} | V |
| V _{ADCCMIN} | Common mode input range | | 0 | — | V _{DD} | V |
| I _{ADCIN} | Input current | 2 pF sampling capacitors | — | <100 | — | nA |
| CMRR _{ADC} | Analog input common mode rejection ratio | | — | 65 | — | dB |
| I _{ADC} | Average active current | 1 Msamples/s, 12 bit, external reference, ADC_CLK = 13 MHz, BIASPROG = 0xF4B | — | 735 ¹ | — | μA |
| | | 1 Msamples/s, 12 bit, internal 1.25V reference, ADC_CLK = 13 MHz, BIASPROG = 0xF4B | — | 760 ¹ | — | μA |
| | | 500 Ksamples/s, 12 bit, external reference, ADC_CLK = 7 MHz, BIASPROG = 0x747 | — | 346 ¹ | — | μA |
| | | 500 Ksamples/s, 12 bit, internal 1.25V reference, ADC_CLK = 7 MHz, BIASPROG = 0x747 | — | 354 ¹ | — | μA |
| | | 10 kSamples/s, 12 bit, internal 1.25 V reference, WARMUP = 00b, ADC_CLK = 7 MHz, BIASPROG = 0x747 | — | 52 ¹ | — | μA |
| | | 10 kSamples/s, 12 bit, internal 1.25 V reference, WARMUP = 01b, ADC_CLK = 7 MHz, BIASPROG = 0x747 | — | 50 ¹ | — | μA |
| | | 10 kSamples/s, 12 bit, internal 1.25 V reference, WARMUP = 10b, ADC_CLK = 7 MHz, BIASPROG = 0x747 | — | 54 ¹ | — | μA |
| I _{ADCREF} | Current Consumption of internal voltage reference | Internal voltage reference | — | 65 | — | μA |
| C _{ADCIN} | Input capacitance | | — | 2 | — | pF |

| Symbol | Parameter | Condition | Min | Typ | Max | Unit |
|-------------------|--|----------------------|-----|-----|-----|---------------|
| R_{ADCIN} | Input ON resistance | | 300 | — | 800 | Ω |
| $R_{ADCFILT}$ | Input RC filter resistance | | — | 10 | — | k Ω |
| $C_{ADCFILT}$ | Input RC filter/decoupling capacitance | | — | 250 | — | fF |
| $I_{ADCBIASIN}$ | Input bias current | $VSS < V_{IN} < VDD$ | -40 | — | 40 | nA |
| $I_{ADCOFFSETIN}$ | Input offset current | $VSS < V_{IN} < VDD$ | -40 | — | 40 | nA |
| f_{ADCCLK} | ADC Clock Frequency | BIASPROG=0x747 | — | — | 7 | MHz |
| | | BIASPROG=0xF4B | — | — | 13 | MHz |
| $t_{ADCCONV}$ | Conversion time | 6-bit | 7 | — | — | ADCCLK Cycles |
| | | 8-bit | 11 | — | — | ADCCLK Cycles |
| | | 12-bit | 13 | — | — | ADCCLK Cycles |
| t_{ADCACQ} | Acquisition time | Programmable | 1 | — | 256 | ADCCLK Cycles |
| $t_{ADCACQVDD3}$ | Required acquisition time for VDD/3 reference | | 2 | — | — | μ s |
| $t_{ADCSTART}$ | Startup time of reference generator and ADC core | NORMAL mode | — | 5 | — | μ s |
| | | KEEPADCWARM mode | — | 1 | — | μ s |

| Symbol | Parameter | Condition | Min | Typ | Max | Unit |
|--------------------|-----------------------------|---|-----|-----|-----|------|
| SNR _{ADC} | Signal-to-Noise Ratio (SNR) | 1 MSamples/s, 12 bit, single-ended, internal 1.25 V reference, ADC_CLK = 13 MHz, BIASPROG = 0xF4B | — | 59 | — | dB |
| | | 1 MSamples/s, 12 bit, single-ended, internal 2.5 V reference, ADC_CLK = 13 MHz, BIASPROG = 0xF4B | — | 63 | — | dB |
| | | 1 MSamples/s, 12 bit, single-ended, V _{DD} reference, ADC_CLK = 13 MHz, BIASPROG = 0xF4B | — | 67 | — | dB |
| | | 1 MSamples/s, 12 bit, differential, internal 1.25 V reference, ADC_CLK = 13 MHz, BIASPROG = 0xF4B | — | 63 | — | dB |
| | | 1 MSamples/s, 12 bit, differential, internal 2.5 V reference, ADC_CLK = 13 MHz, BIASPROG = 0xF4B | — | 66 | — | dB |
| | | 1 MSamples/s, 12 bit, differential, 5 V reference, ADC_CLK = 13 MHz, BIASPROG = 0xF4B | — | 66 | — | dB |
| | | 1 MSamples/s, 12 bit, differential, V _{DD} reference, ADC_CLK = 13 MHz, BIASPROG = 0xF4B | 63 | 69 | — | dB |
| | | 1 MSamples/s, 12 bit, differential, 2xV _{DD} reference, ADC_CLK = 13 MHz, BIASPROG = 0xF4B | — | 70 | — | dB |
| | | 200 kSamples/s, 12 bit, single-ended, internal 1.25 V reference, ADC_CLK = 7 MHz, BIASPROG = 0x747 | — | 62 | — | dB |
| | | 200 kSamples/s, 12 bit, single-ended, internal 2.5 V reference, ADC_CLK = 7 MHz, BIASPROG = 0x747 | — | 63 | — | dB |
| | | 200 kSamples/s, 12 bit, single-ended, V _{DD} reference, ADC_CLK = 7 MHz, BIASPROG = 0x747 | — | 67 | — | dB |
| | | 200 kSamples/s, 12 bit, differential, internal 1.25 V reference, ADC_CLK = 7 MHz, BIASPROG = 0x747 | — | 63 | — | dB |
| | | 200 kSamples/s, 12 bit, differential, internal 2.5 V reference, ADC_CLK = 7 MHz, BIASPROG = 0x747 | — | 66 | — | dB |
| | | 200 kSamples/s, 12 bit, differential, 5 V reference, ADC_CLK = 7 MHz, BIASPROG = 0x747 | — | 66 | — | dB |

| Symbol | Parameter | Condition | Min | Typ | Max | Unit |
|--------------------|-----------------------------|--|-----|-----|-----|------|
| SNR _{ADC} | Signal-to-Noise Ratio (SNR) | 200 kSamples/s, 12 bit, differential, V _{DD} reference, ADC_CLK = 7 MHz, BIASPROG = 0x747 | 63 | 69 | — | dB |
| | | 200 kSamples/s, 12 bit, differential, 2xV _{DD} reference, ADC_CLK = 7 MHz, BIASPROG = 0x747 | — | 70 | — | dB |

Not Recommended for New Designs

| Symbol | Parameter | Condition | Min | Typ | Max | Unit |
|----------------------|--|---|-----|-----|-----|------|
| SINAD _{ADC} | Signal-to-Noise And Distortion Ratio (SINAD) | 1 MSamples/s, 12 bit, single-ended, internal 1.25 V reference, ADC_CLK = 13 MHz, BIASPROG = 0xF4B | — | 58 | — | dB |
| | | 1 MSamples/s, 12 bit, single-ended, internal 2.5 V reference, ADC_CLK = 13 MHz, BIASPROG = 0xF4B | — | 62 | — | dB |
| | | 1 MSamples/s, 12 bit, single-ended, V _{DD} reference, ADC_CLK = 13 MHz, BIASPROG = 0xF4B | — | 66 | — | dB |
| | | 1 MSamples/s, 12 bit, differential, internal 1.25 V reference, ADC_CLK = 13 MHz, BIASPROG = 0xF4B | — | 63 | — | dB |
| | | 1 MSamples/s, 12 bit, differential, internal 2.5 V reference, ADC_CLK = 13 MHz, BIASPROG = 0xF4B | — | 66 | — | dB |
| | | 1 MSamples/s, 12 bit, differential, 5 V reference, ADC_CLK = 13 MHz, BIASPROG = 0xF4B | — | 66 | — | dB |
| | | 1 MSamples/s, 12 bit, differential, V _{DD} reference, ADC_CLK = 13 MHz, BIASPROG = 0xF4B | 62 | 68 | — | dB |
| | | 1 MSamples/s, 12 bit, differential, 2xV _{DD} reference, ADC_CLK = 13 MHz, BIASPROG = 0xF4B | — | 68 | — | dB |
| | | 200 kSamples/s, 12 bit, single-ended, internal 1.25 V reference, ADC_CLK = 7 MHz, BIASPROG = 0x747 | — | 61 | — | dB |
| | | 200 kSamples/s, 12 bit, single-ended, internal 2.5 V reference, ADC_CLK = 7 MHz, BIASPROG = 0x747 | — | 62 | — | dB |
| | | 200 kSamples/s, 12 bit, single-ended, V _{DD} reference, ADC_CLK = 7 MHz, BIASPROG = 0x747 | — | 66 | — | dB |
| | | 200 kSamples/s, 12 bit, differential, internal 1.25 V reference, ADC_CLK = 7 MHz, BIASPROG = 0x747 | — | 63 | — | dB |
| | | 200 kSamples/s, 12 bit, differential, internal 2.5 V reference, ADC_CLK = 7 MHz, BIASPROG = 0x747 | — | 66 | — | dB |
| | | 200 kSamples/s, 12 bit, differential, 5V reference, ADC_CLK = 7 MHz, BIASPROG = 0x747 | — | 66 | — | dB |

| Symbol | Parameter | Condition | Min | Typ | Max | Unit |
|----------------------|--|--|-----|-----|-----|------|
| SINAD _{ADC} | Signal-to-Noise And Distortion Ratio (SINAD) | 200 kSamples/s, 12 bit, differential, V _{DD} reference, ADC_CLK = 7 MHz, BIASPROG = 0x747 | 62 | 68 | — | dB |
| | | 200 kSamples/s, 12 bit, differential, 2xV _{DD} reference, ADC_CLK = 7 MHz, BIASPROG = 0x747 | — | 69 | — | dB |

Not Recommended for New Designs

| Symbol | Parameter | Condition | Min | Typ | Max | Unit |
|---------------------|------------------------------------|---|-----|-----|-----|------|
| SFDR _{ADC} | Spurious-Free Dynamic Range (SFDR) | 1 MSamples/s, 12 bit, single-ended, internal 1.25 V reference, ADC_CLK = 13 MHz, BIASPROG = 0xF4B | — | 75 | — | dBc |
| | | 1 MSamples/s, 12 bit, single-ended, internal 2.5 V reference, ADC_CLK = 13 MHz, BIASPROG = 0xF4B | — | 76 | — | dBc |
| | | 1 MSamples/s, 12 bit, single-ended, V _{DD} reference, ADC_CLK = 13 MHz, BIASPROG = 0xF4B | — | 76 | — | dBc |
| | | 1 MSamples/s, 12 bit, differential, internal 1.25 V reference, ADC_CLK = 13 MHz, BIASPROG = 0xF4B | — | 78 | — | dBc |
| | | 1 MSamples/s, 12 bit, differential, internal 2.5 V reference, ADC_CLK = 13 MHz, BIASPROG = 0xF4B | — | 77 | — | dBc |
| | | 1 MSamples/s, 12 bit, differential, V _{DD} reference, ADC_CLK = 13 MHz, BIASPROG = 0xF4B | — | 76 | — | dBc |
| | | 1 MSamples/s, 12 bit, differential, 2xV _{DD} reference, ADC_CLK = 13 MHz, BIASPROG = 0xF4B | 68 | 79 | — | dBc |
| | | 1 MSamples/s, 12 bit, differential, 5 V reference, ADC_CLK = 13 MHz, BIASPROG = 0xF4B | — | 79 | — | dBc |
| | | 200 kSamples/s, 12 bit, single-ended, internal 1.25 V reference, ADC_CLK = 7 MHz, BIASPROG = 0x747 | — | 75 | — | dBc |
| | | 200 kSamples/s, 12 bit, single-ended, internal 2.5 V reference, ADC_CLK = 7 MHz, BIASPROG = 0x747 | — | 75 | — | dBc |
| | | 200 kSamples/s, 12 bit, single-ended, V _{DD} reference, ADC_CLK = 7 MHz, BIASPROG = 0x747 | — | 76 | — | dBc |
| | | 200 kSamples/s, 12 bit, differential, internal 1.25 V reference, ADC_CLK = 7 MHz, BIASPROG = 0x747 | — | 79 | — | dBc |
| | | 200 kSamples/s, 12 bit, differential, internal 2.5 V reference, ADC_CLK = 7 MHz, BIASPROG = 0x747 | — | 79 | — | dBc |
| | | 200 kSamples/s, 12 bit, differential, 5 V reference, ADC_CLK = 7 MHz, BIASPROG = 0x747 | — | 78 | — | dBc |

| Symbol | Parameter | Condition | Min | Typ | Max | Unit |
|-------------------------|--|--|-------|-------------------|--------------------|--------------|
| SFDR _{ADC} | Spurious-Free Dynamic Range (SFDR) | 200 kSamples/s, 12 bit, differential, V _{DD} reference, ADC_CLK = 7 MHz, BIASPROG = 0x747 | 68 | 79 | — | dBc |
| | | 200 kSamples/s, 12 bit, differential, 2xV _{DD} reference, ADC_CLK = 7 MHz, BIASPROG = 0x747 | — | 79 | — | dBc |
| V _{ADCOFFSET} | Offset voltage | After calibration, single-ended | — | 0.3 | — | mV |
| | | After calibration, differential | -4 | 0.3 | 4 | mV |
| TGRAD _{ADCTH} | Thermometer output gradient | | — | -1.92 | — | mV/°C |
| | | | — | -6.3 | — | ADC Codes/°C |
| DNL _{ADC} | Differential non-linearity (DNL) | V _{DD} = 3.0 V, external 2.5V reference | -1 | ±0.7 | 4 | LSB |
| INL _{ADC} | Integral non-linearity (INL), End point method | V _{DD} = 3.0 V, external 2.5V reference | — | ±1.6 | ±3 | LSB |
| MC _{ADC} | Missing codes | V _{DD} = 3.0 V, external 2.5 V reference | — | — | 3 | LSB |
| GAIN _{ED} | Gain error drift | 1.25 V reference | — | 0.01 ² | 0.033 ³ | %/°C |
| | | 2.5 V reference | — | 0.01 ² | 0.03 ³ | %/°C |
| OFFSET _{ED} | Offset error drift | 1.25 V reference | — | 0.00 ² | 0.06 ³ | LSB/°C |
| | | 2.5 V reference | — | 0.00 ² | 0.04 ³ | LSB/°C |
| V _{REF} | VREF voltage | 1.25 V reference | 1.2 | 1.25 | 1.3 | V |
| | | 2.5 V reference | 2.4 | 2.5 | 2.6 | V |
| V _{REF_VDRIFT} | VREF voltage drift | 1.25 V reference | -12.4 | 2.9 | 18.2 | mV/V |
| | | 2.5 V reference, V _{DD} > 2.5 V | -24.6 | 5.7 | 35.2 | mV/V |
| V _{REF_TDRIFT} | VREF temperature drift | 1.25 V reference | -132 | 272 | 677 | μV/°C |
| | | 2.5 V reference | -231 | 545 | 1271 | μV/°C |
| I _{VREF} | VREF current consumption | 1.25 V reference | — | 67 | 114 | μA |
| | | 2.5 V reference | — | 55 | 82 | μA |
| V _{REF_MATCH} | ADC and DAC VREF matching | 1.25 V reference | — | 99.85 | — | % |
| | | 2.5 V reference | — | 100.01 | — | % |

Note:

1. Includes required contribution from the voltage reference.
2. Typical numbers given by $\text{abs}(\text{Mean}) / (85 - 25)$.
3. Max number given by $(\text{abs}(\text{Mean}) + 3 \times \text{stddev}) / (85 - 25)$.

The integral non-linearity (INL) and differential non-linearity (DNL) parameters are explained in the following figures.

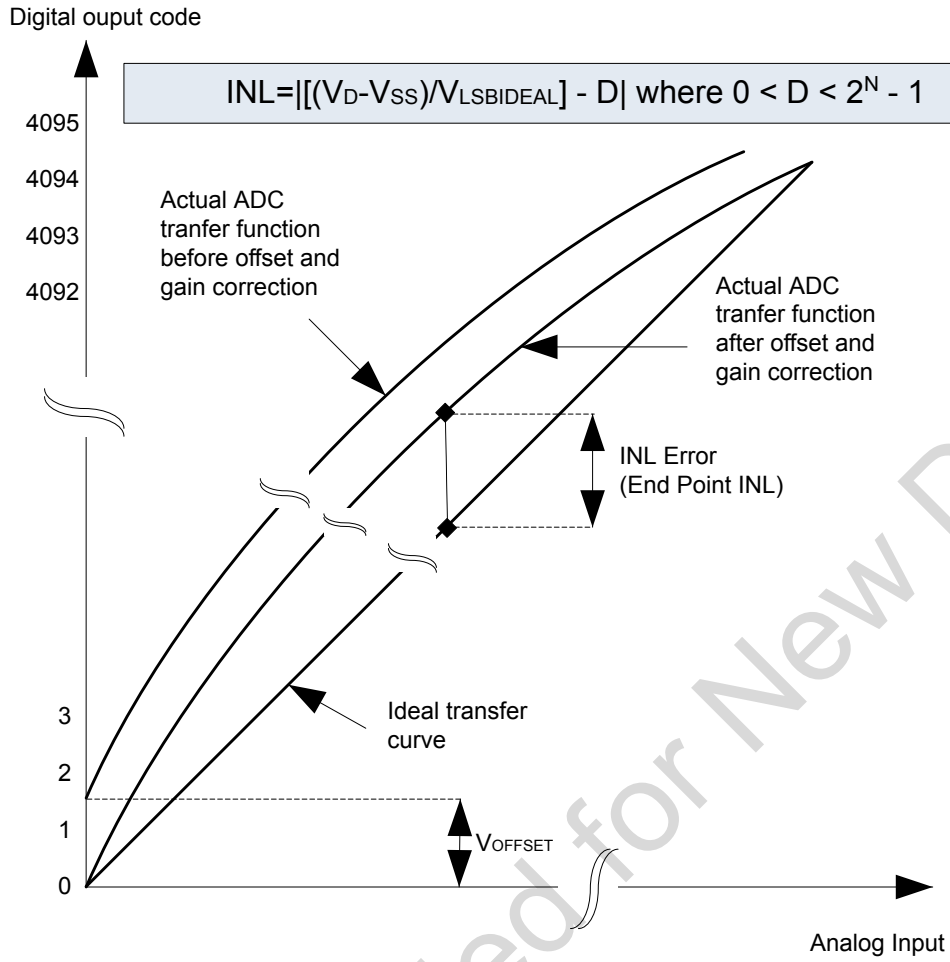


Figure 4.27. Integral Non-Linearity (INL)

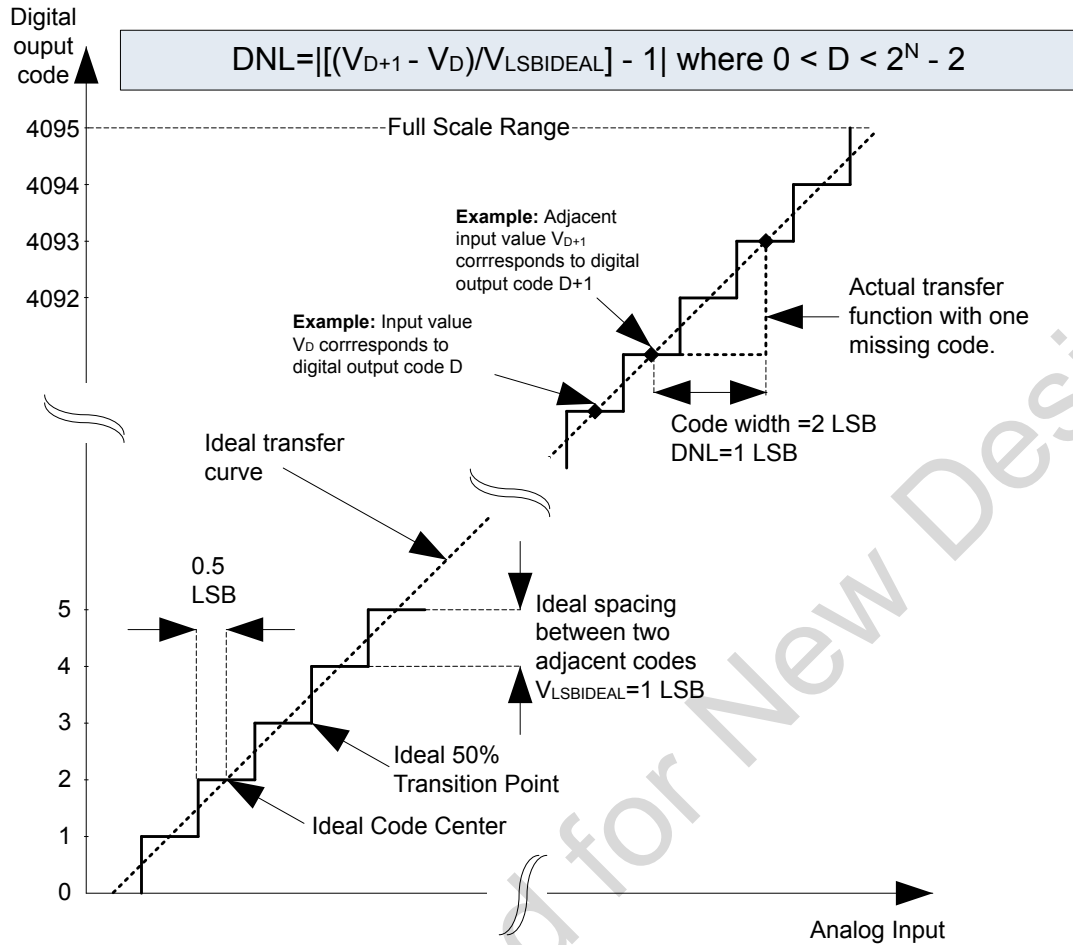
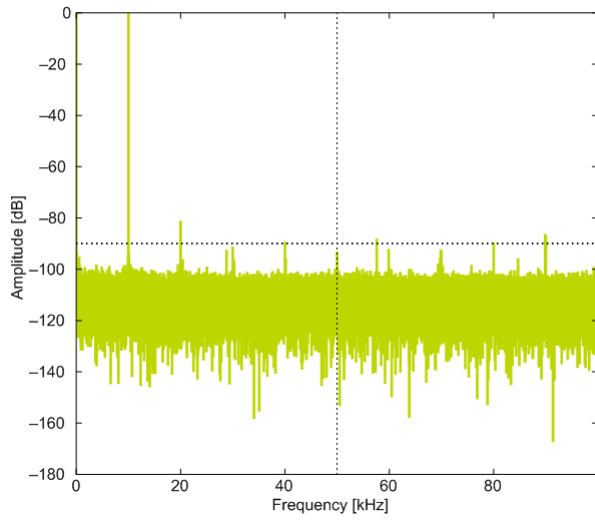
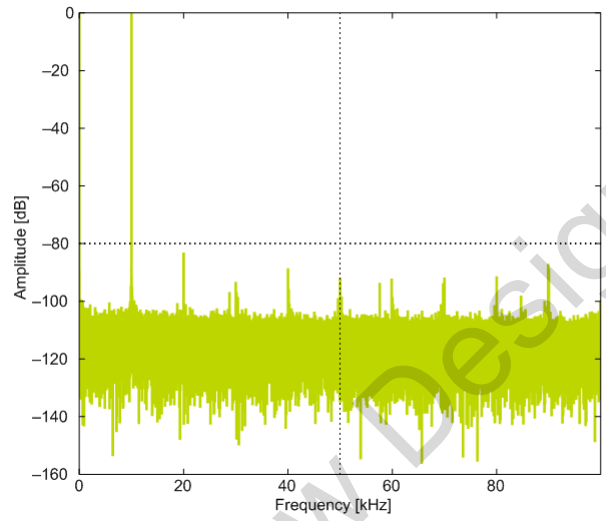


Figure 4.28. Differential Non-Linearity (DNL)

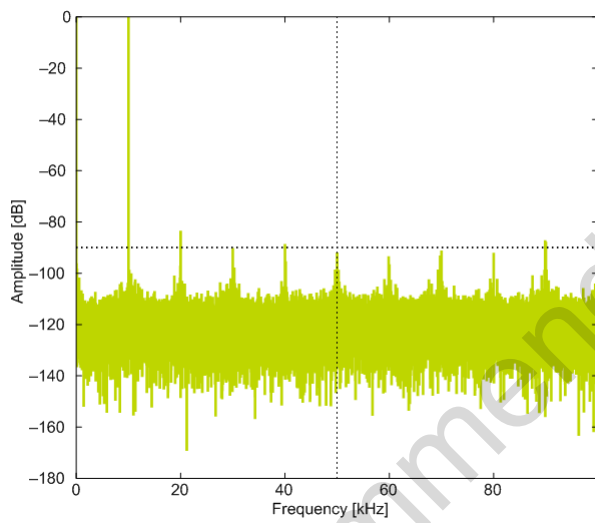
4.11.1 Typical Performance



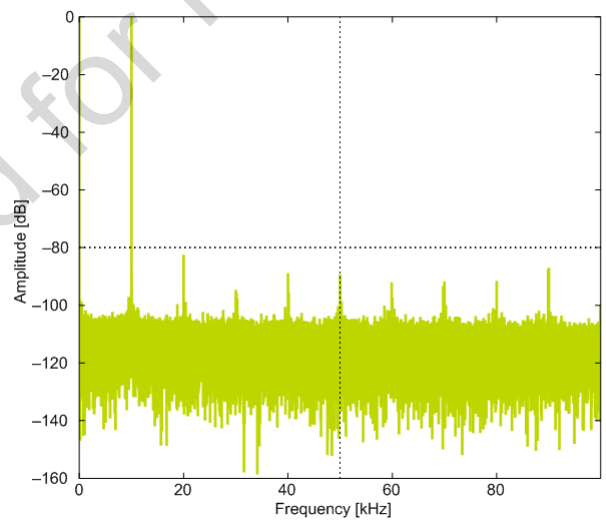
1.25 V Reference



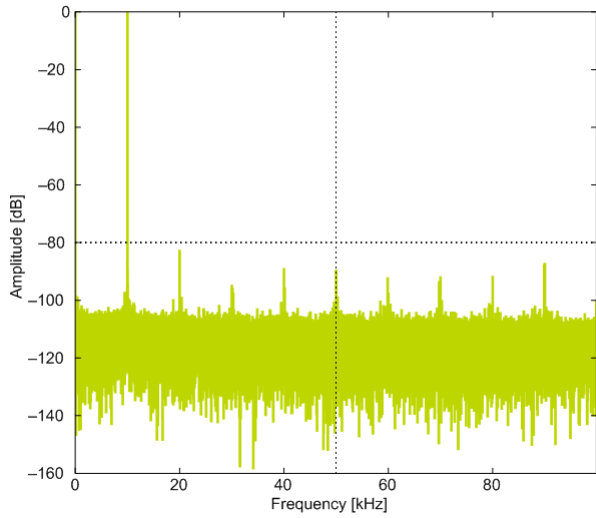
2.5 V Reference



2XVDDVSS Reference

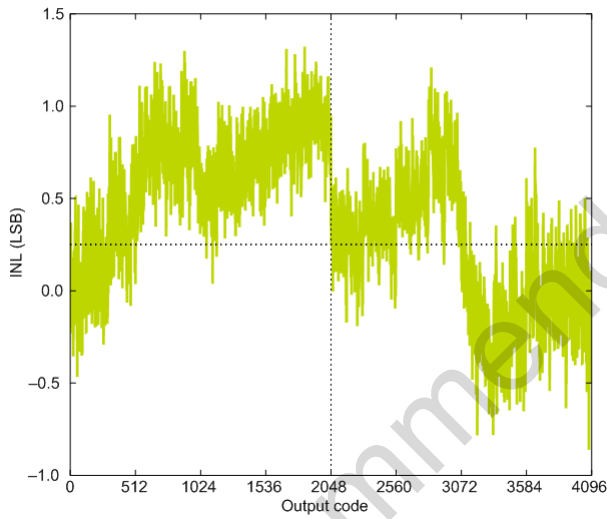


5VDIFF Reference

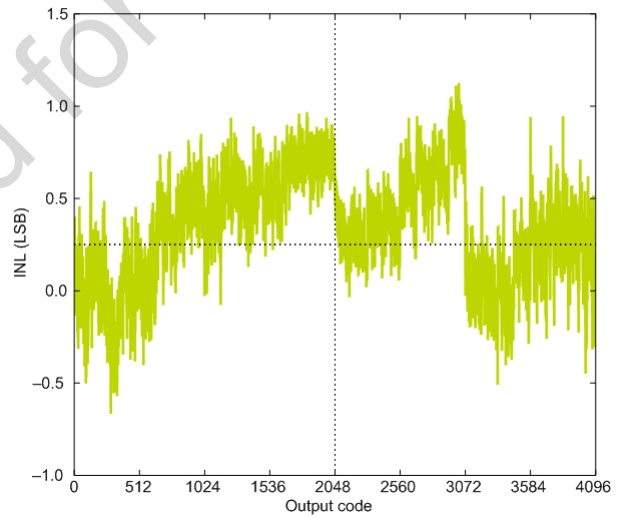


V_{DD} Reference

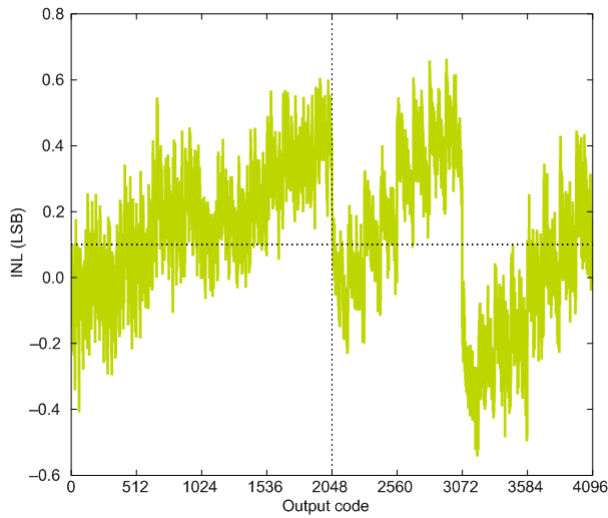
Figure 4.29. ADC Frequency Spectrum, V_{DD} = 3 V, Temp = 25 °C



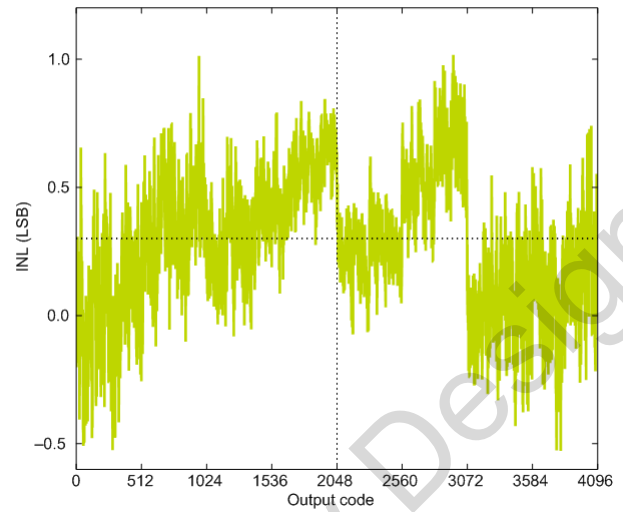
1.25 V Reference



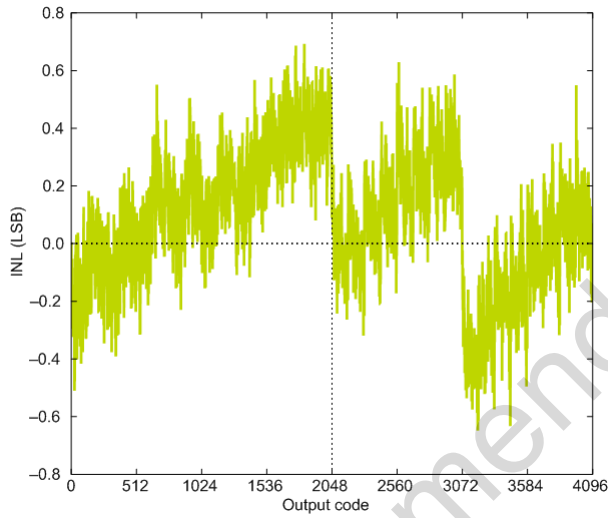
2.5 V Reference



2XVDDVSS Reference

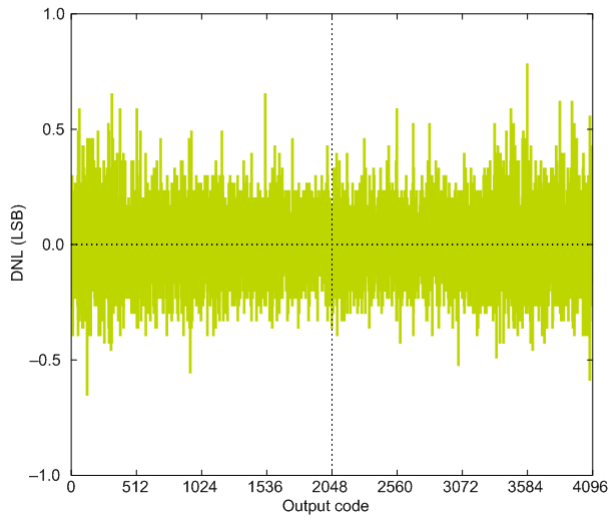


5VDIFF Reference

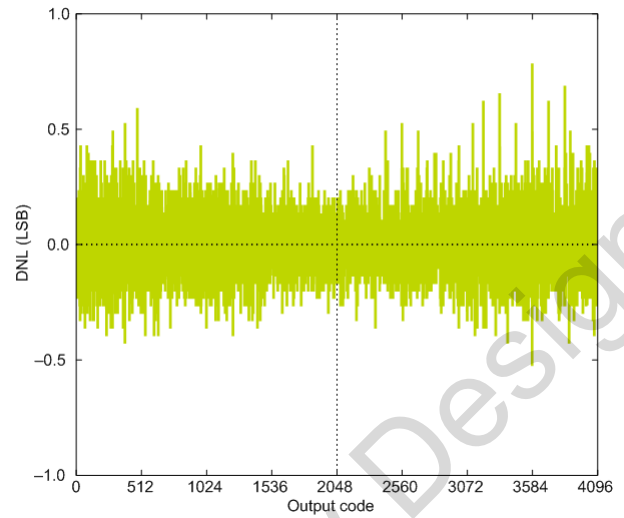


VDD Reference

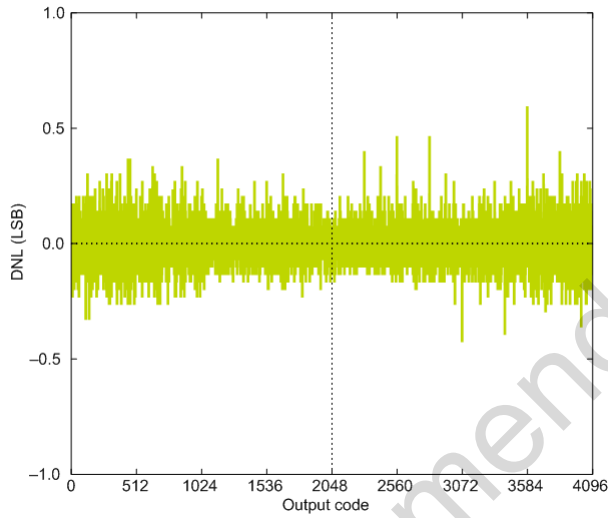
Figure 4.30. ADC Integral Linearity Error vs Code, $V_{DD} = 3\text{ V}$, Temp = 25 °C



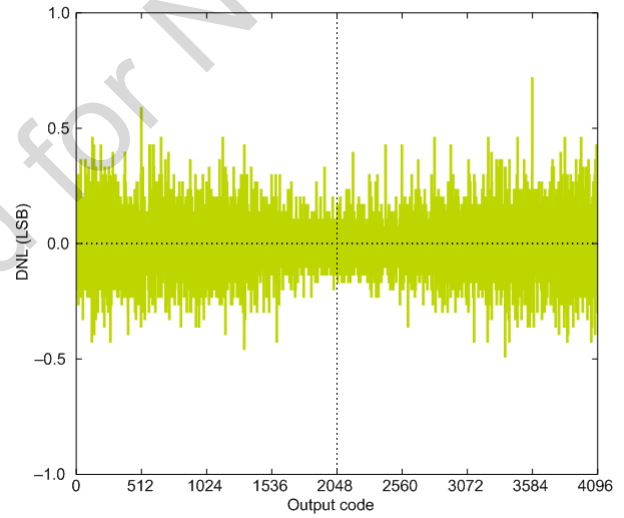
1.25 V Reference



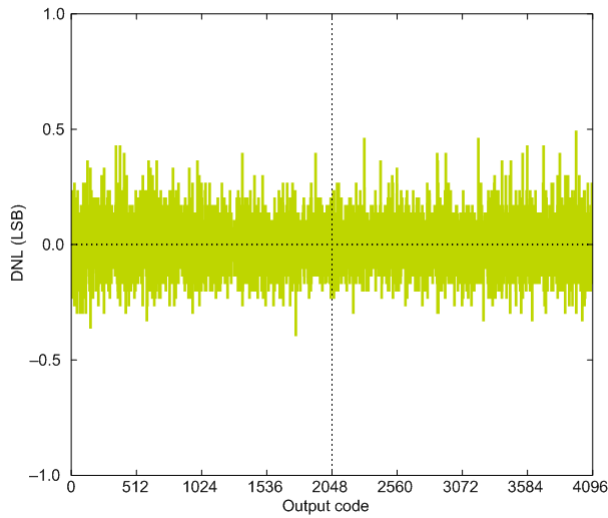
2.5 V Reference



2XVDDVSS Reference

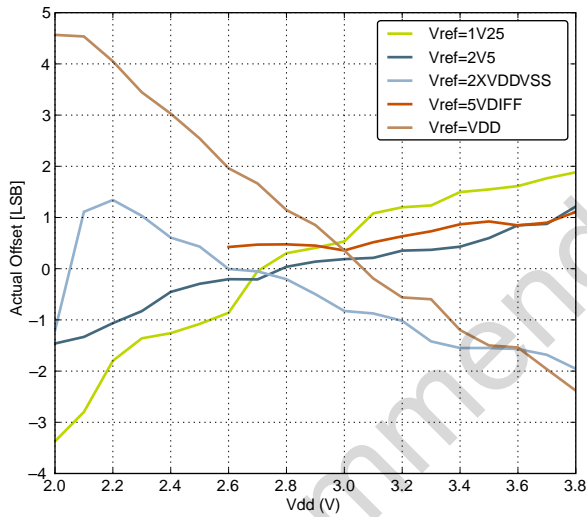


5VDIFF Reference

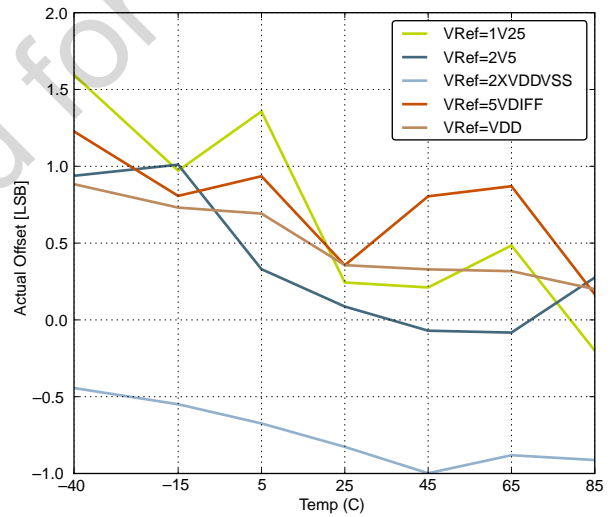


V_{DD} Reference

Figure 4.31. ADC Differential Linearity Error vs Code, V_{DD} = 3 V, Temp = 25 °C

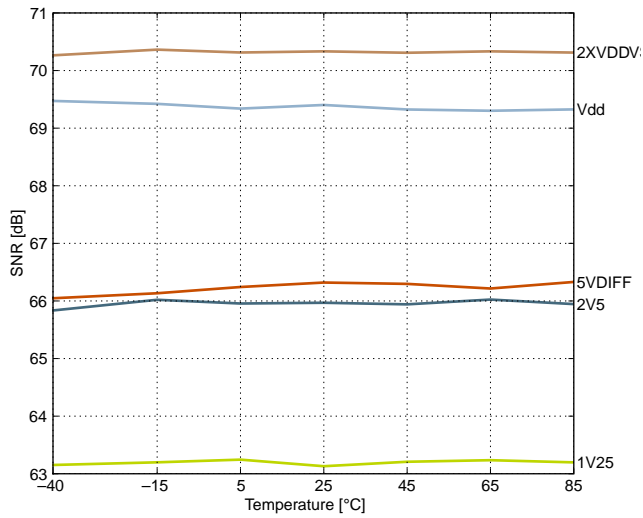


Offset vs Supply Voltage, Temp = 25 °C

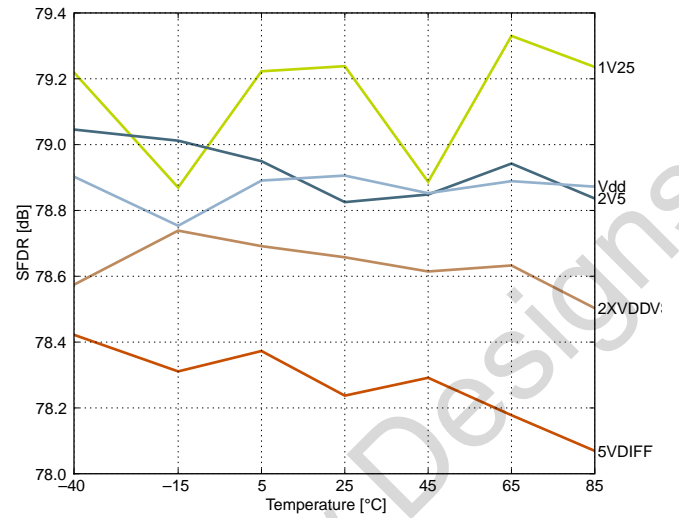


Offset vs Temperature, V_{DD} = 3 V

Figure 4.32. ADC Absolute Offset, Common Mode = V_{DD}/2



Signal to Noise Ratio (SNR)



Spurious-Free Dynamic Range (SFDR)

Figure 4.33. ADC Dynamic Performance vs Temperature for all ADC References, $V_{DD} = 3\text{ V}$

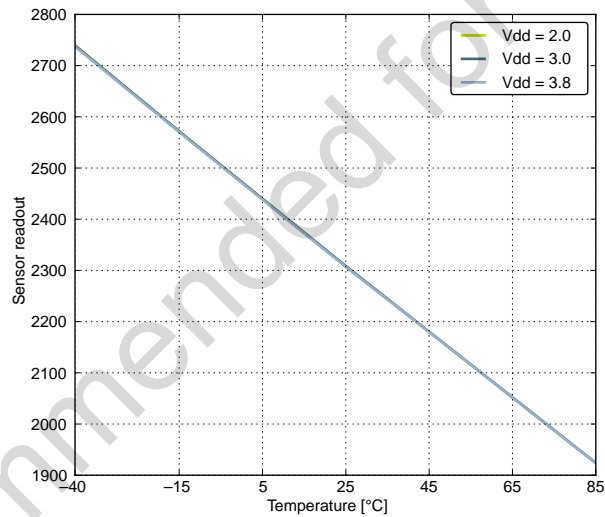


Figure 4.34. ADC Temperature Sensor Readout

4.12 Current Digital Analog Converter (IDAC)
Table 4.17. IDAC Range 0 Source

| Parameter | Symbol | Test Condition | Min | Typ | Max | Unit |
|---|--------------------|---|-----|------|-----|-------|
| Active current with STEPSEL=0x10 | I _{IDAC} | EM0, default settings | — | 13.0 | — | μA |
| | | Duty-cycled | — | 10 | — | nA |
| Nominal IDAC output current with STEPSEL=0x10 | I _{0x10} | | — | 0.85 | — | μA |
| Step size | I _{STEP} | | — | 0.05 | — | μA |
| Current drop at high impedance load | I _D | V _{IDAC_OUT} = V _{DD} - 100mV | — | 0.79 | — | % |
| Temperature coefficient | TC _{IDAC} | V _{DD} = 3.0V, STEPSEL=0x10 | — | 0.3 | — | nA/°C |
| Voltage coefficient | VC _{IDAC} | T = 25 °C, STEPSEL=0x10 | — | 11.7 | — | nA/V |

Table 4.18. IDAC Range 0 Sink

| Parameter | Symbol | Test Condition | Min | Typ | Max | Unit |
|---|--------------------|---------------------------------------|-----|------|-----|-------|
| Active current with STEPSEL=0x10 | I _{IDAC} | EM0, default settings | — | 15.1 | — | μA |
| Nominal IDAC output current with STEPSEL=0x10 | I _{0x10} | | — | 0.85 | — | μA |
| Step size | I _{STEP} | | — | 0.05 | — | μA |
| Current drop at high impedance load | I _D | V _{IDAC_OUT} = 200 mV | — | 0.30 | — | % |
| Temperature coefficient | TC _{IDAC} | V _{DD} = 3.0 V, STEPSEL=0x10 | — | 0.2 | — | nA/°C |
| Voltage coefficient | VC _{IDAC} | T = 25 °C, STEPSEL=0x10 | — | 12.5 | — | nA/V |

Table 4.19. IDAC Range 1 Source

| Parameter | Symbol | Test Condition | Min | Typ | Max | Unit |
|---|--------------------|---|-----|------|-----|-------|
| Active current with STEPSEL=0x10 | I _{IDAC} | EM0, default settings | — | 14.4 | — | μA |
| | | Duty-cycled | — | 10 | — | nA |
| Nominal IDAC output current with STEPSEL=0x10 | I _{0x10} | | — | 3.2 | — | μA |
| Step size | I _{STEP} | | — | 0.1 | — | μA |
| Current drop at high impedance load | I _D | V _{IDAC_OUT} = V _{DD} - 100mV | — | 0.75 | — | % |
| Temperature coefficient | TC _{IDAC} | V _{DD} = 3.0 V, STEPSEL=0x10 | — | 0.7 | — | nA/°C |
| Voltage coefficient | VC _{IDAC} | T = 25 °C, STEPSEL=0x10 | — | 38.4 | — | nA/V |

Table 4.20. IDAC Range 1 Sink

| Parameter | Symbol | Test Condition | Min | Typ | Max | Unit |
|---|-------------|--|-----|------|-----|----------------|
| Active current with STEPSEL=0x10 | I_{IDAC} | EM0, default settings | — | 19.4 | — | μA |
| Nominal IDAC output current with STEPSEL=0x10 | I_{0x10} | | — | 3.2 | — | μA |
| Step size | I_{STEP} | | — | 0.1 | — | μA |
| Current drop at high impedance load | I_D | $V_{IDAC_OUT} = 200\text{ mV}$ | — | 0.32 | — | % |
| Temperature coefficient | TC_{IDAC} | $V_{DD} = 3.0\text{ V}$, STEPSEL=0x10 | — | 0.7 | — | $nA/^{\circ}C$ |
| Voltage coefficient | VC_{IDAC} | $T = 25\text{ }^{\circ}C$, STEPSEL=0x10 | — | 40.9 | — | nA/V |

Table 4.21. IDAC Range 2 Source

| Parameter | Symbol | Test Condition | Min | Typ | Max | Unit |
|---|-------------|--|-----|------|-----|----------------|
| Active current with STEPSEL=0x10 | I_{IDAC} | EM0, default settings | — | 17.3 | — | μA |
| | | Duty-cycled | — | 10 | — | nA |
| Nominal IDAC output current with STEPSEL=0x10 | I_{0x10} | | — | 8.5 | — | μA |
| Step size | I_{STEP} | | — | 0.5 | — | μA |
| Current drop at high impedance load | I_D | $V_{IDAC_OUT} = V_{DD} - 100\text{mV}$ | — | 1.22 | — | % |
| Temperature coefficient | TC_{IDAC} | $V_{DD} = 3.0\text{ V}$, STEPSEL=0x10 | — | 2.8 | — | $nA/^{\circ}C$ |
| Voltage coefficient | VC_{IDAC} | $T = 25\text{ }^{\circ}C$, STEPSEL=0x10 | — | 96.6 | — | nA/V |

Table 4.22. IDAC Range 2 Sink

| Parameter | Symbol | Test Condition | Min | Typ | Max | Unit |
|---|-------------|--|-----|------|-----|----------------|
| Active current with STEPSEL=0x10 | I_{IDAC} | EM0, default settings | — | 29.3 | — | μA |
| Nominal IDAC output current with STEPSEL=0x10 | I_{0x10} | | — | 8.5 | — | μA |
| Step size | I_{STEP} | | — | 0.5 | — | μA |
| Current drop at high impedance load | I_D | $V_{IDAC_OUT} = 200\text{ mV}$ | — | 0.62 | — | % |
| Temperature coefficient | TC_{IDAC} | $V_{DD} = 3.0\text{ V}$, STEPSEL=0x10 | — | 2.8 | — | $nA/^{\circ}C$ |
| Voltage coefficient | VC_{IDAC} | $T = 25\text{ }^{\circ}C$, STEPSEL=0x10 | — | 94.4 | — | nA/V |

Table 4.23. IDAC Range 3 Source

| Parameter | Symbol | Test Condition | Min | Typ | Max | Unit |
|---|--------------------|--|-----|-------|-----|-------|
| Active current with STEPSEL=0x10 | I _{IDAC} | EM0, default settings | — | 18.7 | — | μA |
| | | Duty-cycled | — | 10 | — | nA |
| Nominal IDAC output current with STEPSEL=0x10 | I _{0x10} | | — | 33.9 | — | μA |
| Step size | I _{STEP} | | — | 2.0 | — | μA |
| Current drop at high impedance load | I _D | V _{IDAC_OUT} = V _{DD} - 100 mV | — | 3.54 | — | % |
| Temperature coefficient | TC _{IDAC} | V _{DD} = 3.0 V, STEPSEL=0x10 | — | 10.9 | — | nA/°C |
| Voltage coefficient | VC _{IDAC} | T = 25 °C, STEPSEL=0x10 | — | 159.5 | — | nA/V |

Table 4.24. IDAC Range 3 Sink

| Parameter | Symbol | Test Condition | Min | Typ | Max | Unit |
|---|--------------------|---------------------------------------|-----|-------|-----|-------|
| Active current with STEPSEL=0x10 | I _{IDAC} | EM0, default settings | — | 62.5 | — | μA |
| Nominal IDAC output current with STEPSEL=0x10 | I _{0x10} | | — | 34.1 | — | μA |
| Step size | I _{STEP} | | — | 2.0 | — | μA |
| Current drop at high impedance load | I _D | V _{IDAC_OUT} = 200 mV | — | 1.75 | — | % |
| Temperature coefficient | TC _{IDAC} | V _{DD} = 3.0 V, STEPSEL=0x10 | — | 10.9 | — | nA/°C |
| Voltage coefficient | VC _{IDAC} | T = 25 °C, STEPSEL=0x10 | — | 148.6 | — | nA/V |

Table 4.25. IDAC

| Parameter | Symbol | Min | Typ | Max | Unit |
|---|------------------------|-----|-----|-----|------|
| Start-up time, from enabled to output settled | t _{IDACSTART} | — | 40 | — | μs |

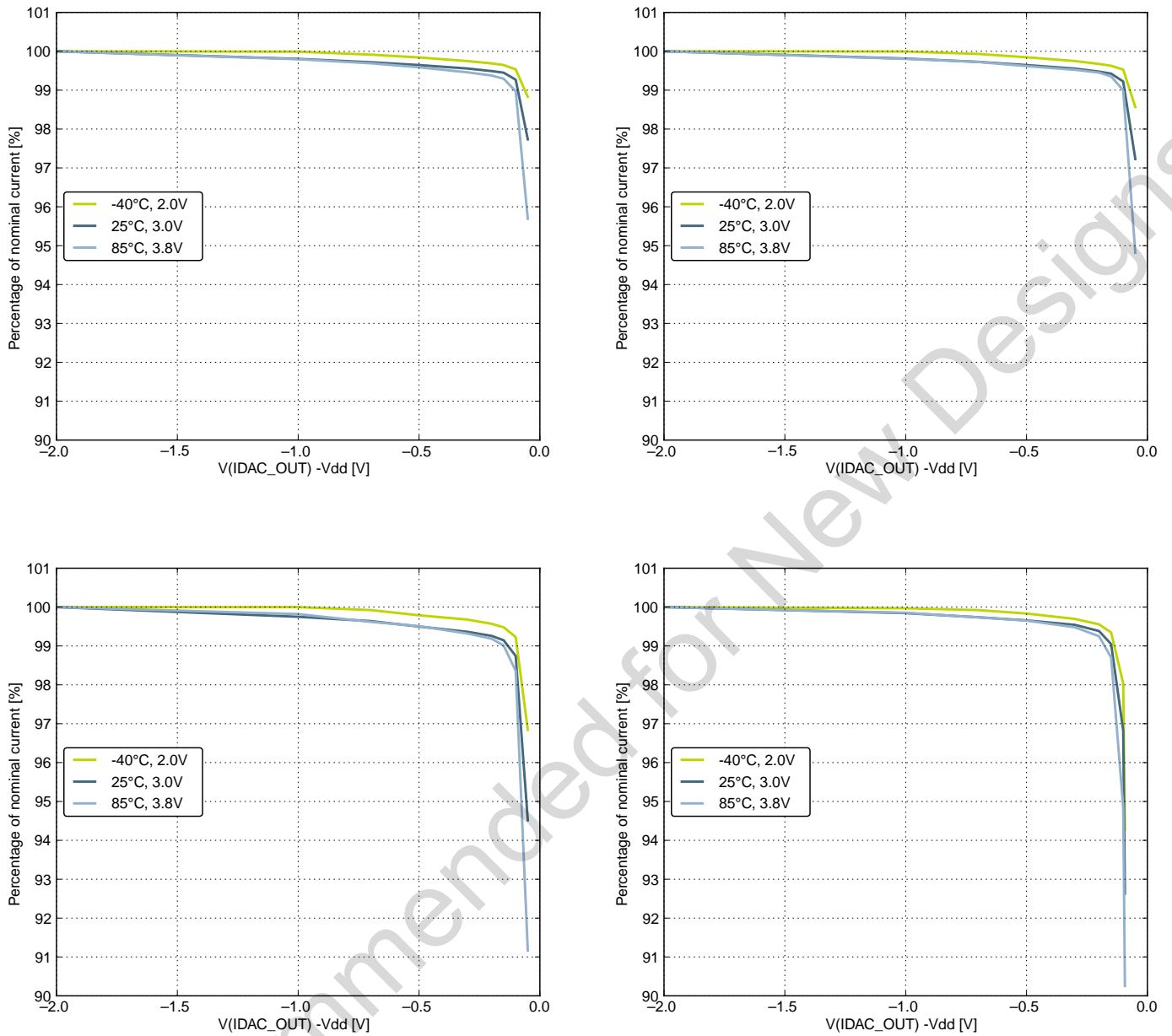


Figure 4.35. IDAC Source Current as a Function of Voltage on IDAC_OUT

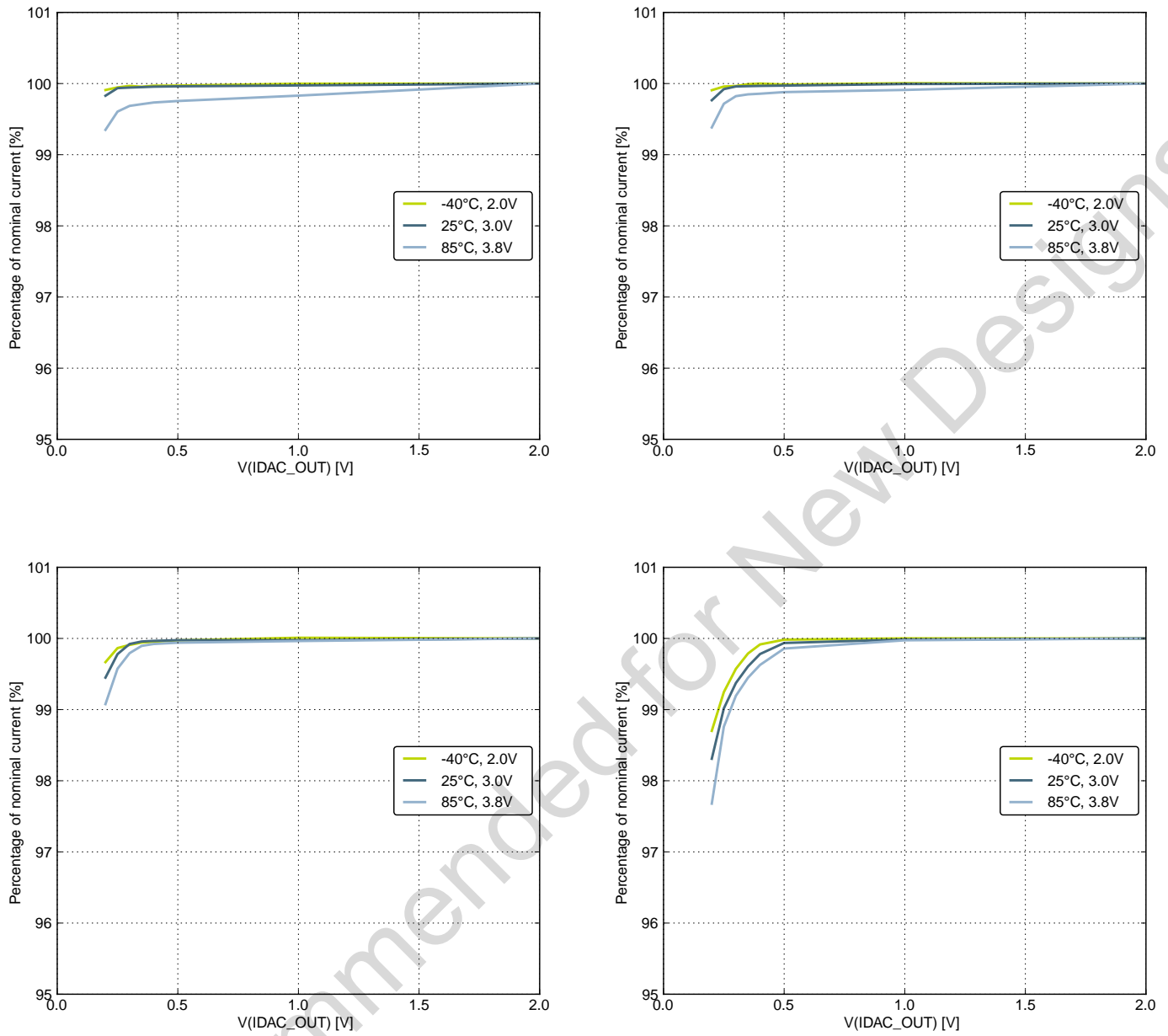


Figure 4.36. IDAC Sink Current as a Function of Voltage from IDAC_OUT

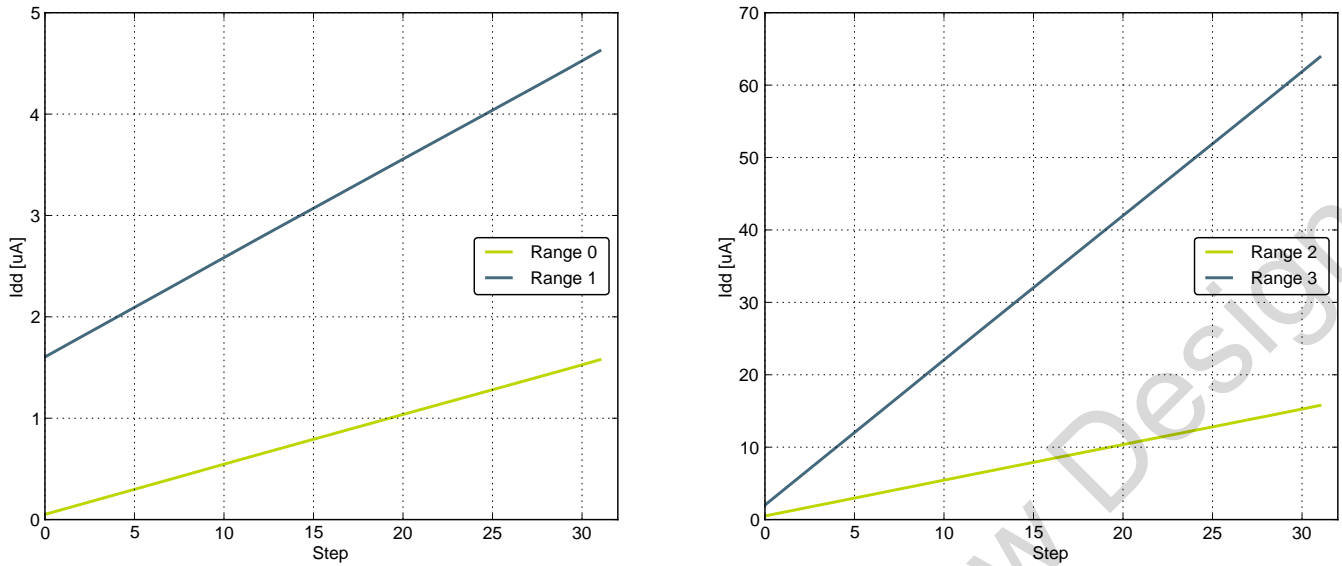


Figure 4.37. IDAC Linearity

4.13 Voltage Comparator (VCMP)

Table 4.26. VCMP

| Parameter | Symbol | Test Condition | Min | Typ | Max | Unit |
|----------------------------------|------------------|--|-----|----------|--------|---------|
| Input voltage range | V_{VCMPIN} | | — | V_{DD} | — | V |
| VCMP Common Mode voltage range | V_{VCMPCM} | | — | V_{DD} | — | V |
| Active current | I_{VCMP} | BIASPROG=0b0000 and HALF-BIAS=1 in VCMPn_CTRL register | — | 0.30.2 | 0.60.8 | μA |
| | | BIASPROG=0b1111 and HALF-BIAS=0 in VCMPn_CTRL register. LPREF=0. | — | 2222 | 3535 | μA |
| Startup time reference generator | $t_{VCMPREF}$ | NORMAL | — | 10 | — | μs |
| Offset voltage | $V_{VCMPOFFSET}$ | single-ended | — | 10 | — | mV |
| | | Differential | — | 10 | — | mV |
| VCMP hysteresis | $V_{VCMPHYS}$ | | — | 6117 | 210— | mV |
| Startup time | $t_{VCMPSTART}$ | | — | — | 10 | μs |

The V_{DD} trigger level can be configured by setting the TRIGLEVEL field of the VCMP_CTRL register in accordance with the following equation: $V_{DD} \text{ Trigger Level} = 1.667 V + 0.034 \times \text{TRIGLEVEL}$

4.14 I2C

Table 4.27. I2C Standard-Mode (Sm)

| Parameter | Symbol | Min | Typ | Max | Unit |
|--|--------------|-----|-----|----------------------|---------|
| SCL clock frequency | f_{SCL} | 0 | — | 100 ¹ | kHz |
| SCL clock low time | t_{LOW} | 4.7 | — | — | μ s |
| SCL clock high time | t_{HIGH} | 4.0 | — | — | μ s |
| SDA set-up time | $t_{SU,DAT}$ | 250 | — | — | ns |
| SDA hold time | $t_{HD,DAT}$ | 8 | — | 3450 ^{2, 3} | ns |
| Repeated START condition set-up time | $t_{SU,STA}$ | 4.7 | — | — | μ s |
| (Repeated) START condition hold time | $t_{HD,STA}$ | 4.0 | — | — | μ s |
| STOP condition set-up time | $t_{SU,STO}$ | 4.0 | — | — | μ s |
| Bus free time between a STOP and a START condition | t_{BUF} | 4.7 | — | — | μ s |

Note:

1. For the minimum HPPERCLK frequency required in Standard-mode, see the I2C chapter in the [EZR32HG Reference Manual](#).
2. The maximum SDA hold time ($t_{HD,DAT}$) needs to be met only when the device does not stretch the low time of SCL (t_{LOW}).
3. When transmitting data, this number is guaranteed only when $I2Cn_CLKDIV < ((3450 * 10^{-9} [s] * f_{HPPERCLK} [Hz]) - 4)$.

Table 4.28. I2C Fast-Mode (Fm)

| Parameter | Symbol | Min | Typ | Max | Unit |
|--|--------------|-----|-----|---------------------|---------|
| SCL clock frequency | f_{SCL} | 0 | — | 400 ¹ | kHz |
| SCL clock low time | t_{LOW} | 1.3 | — | — | μ s |
| SCL clock high time | t_{HIGH} | 0.6 | — | — | μ s |
| SDA set-up time | $t_{SU,DAT}$ | 100 | — | — | ns |
| SDA hold time | $t_{HD,DAT}$ | 8 | — | 900 ^{2, 3} | ns |
| Repeated START condition set-up time | $t_{SU,STA}$ | 0.6 | — | — | μ s |
| (Repeated) START condition hold time | $t_{HD,STA}$ | 0.6 | — | — | μ s |
| STOP condition set-up time | $t_{SU,STO}$ | 0.6 | — | — | μ s |
| Bus free time between a STOP and a START condition | t_{BUF} | 1.3 | — | — | μ s |

Note:

1. For the minimum HPPERCLK frequency required in Fast-mode, see the I2C chapter in the [EZR32HG Reference Manual](#).
2. The maximum SDA hold time ($t_{HD,DAT}$) needs to be met only when the device does not stretch the low time of SCL (t_{LOW}).
3. When transmitting data, this number is guaranteed only when $I2Cn_CLKDIV < ((900 * 10^{-9} [s] * f_{HPPERCLK} [Hz]) - 4)$.

Table 4.29. I2C Fast-mode Plus (Fm+)

| Parameter | Symbol | Min | Typ | Max | Unit |
|--|--------------|------|-----|-------------------|---------|
| SCL clock frequency | f_{SCL} | 0 | — | 1000 ¹ | kHz |
| SCL clock low time | t_{LOW} | 0.5 | — | — | μ s |
| SCL clock high time | t_{HIGH} | 0.26 | — | — | μ s |
| SDA set-up time | $t_{SU,DAT}$ | 50 | — | — | ns |
| SDA hold time | $t_{HD,DAT}$ | 8 | — | — | ns |
| Repeated START condition set-up time | $t_{SU,STA}$ | 0.26 | — | — | μ s |
| (Repeated) START condition hold time | $t_{HD,STA}$ | 0.26 | — | — | μ s |
| STOP condition set-up time | $t_{SU,STO}$ | 0.26 | — | — | μ s |
| Bus free time between a STOP and a START condition | t_{BUF} | 0.5 | — | — | μ s |

Note:

1. For the minimum HPPERCLK frequency required in Fast-mode Plus, see the I2C chapter in the [EZR32HG Reference Manual](#).

4.15 USB

The USB hardware in the EZR32HG320 passes all tests for USB 2.0 Full Speed certification. The test report will be distributed with application note *AN0046 - USB Hardware Design Guide* when ready.

Table 4.30. USB

| Symbol | Parameter | Condition | Min | Typ | Max | Unit |
|--------------|------------------------------|--|------|-------|-------|------|
| V_{USBOUT} | USB regulator output voltage | | 3.1 | 3.4 | 3.7 | V |
| I_{USBOUT} | USB regulator output current | BIASPROG=0, $T_{AMB}=25^{\circ}\text{C}$ | 55.7 | 79.4 | 104.1 | mA |
| | | BIASPROG=1, $T_{AMB}=25^{\circ}\text{C}$ | 66.0 | 95.9 | 126.4 | mA |
| | | BIASPROG=2, $T_{AMB}=25^{\circ}\text{C}$ | 94.6 | 146.5 | 188.1 | mA |
| | | BIASPROG=3, $T_{AMB}=25^{\circ}\text{C}$ | 80.4 | 128.3 | 176.0 | mA |

4.16 Radio

All minimum and maximum values are guaranteed across the recommended operating conditions of supply voltage and from -40 to $+85^{\circ}\text{C}$ unless otherwise stated. All typical values apply at $V_{DD} = 3.3\text{ V}$ and 25°C unless otherwise stated. The data was collected while running off the internal RC oscillator (HFRCO).

4.16.1 EZRadioPRO (R6x) DC Electrical Characteristics

Measured on direct-tie RF evaluation board.

Table 4.31. EZRadioPro DC Characteristics

| Parameter | Symbol | Test Condition | Min | Typ | Max | Unit |
|-----------------------------|-------------------------|---|-----|------|-------|---------------|
| Power Saving Modes | I_{shutdown} | RC Oscillator, Main Digital Regulator, and Low Power Digital Regulator OFF | — | 30 | 4000 | nA |
| | I_{standby} | Register values maintained and RC oscillator/WUT OFF | — | 40 | 9000 | nA |
| | I_{SleepRC} | RC Oscillator, Main Digital Regulator, and Low Power Digital Regulator OFF | — | 740 | 10000 | nA |
| | I_{SleepXO} | Sleep current using an external 32 kHz crystal | — | 1.7 | — | μA |
| | $I_{\text{Sensor-LBD}}$ | Low battery detector ON, register values maintained, and all other blocks OFF | — | 1 | — | μA |
| | I_{Ready} | Crystal Oscillator and Main Digital Regulator ON, all other blocks OFF | — | 1.8 | — | mA |
| Preamble Sense Mode Current | I_{psm} | Duty cycling during preamble search, 1.2 kbps, 4 byte preamble | — | 6 | — | mA |
| | | Fixed 1s wakeup interval, 50 kbps, 5 byte preamble | — | 10 | — | μA |
| TUNE Mode Current | I_{TuneRX} | RX Tune, High Performance Mode | — | 7.6 | — | mA |
| | I_{TuneTX} | TX Tune, High Performance Mode | — | 7.8 | — | mA |
| RX Mode Current | I_{RXH} | High Performance Mode, 915 MHz, 40 kbps | — | 13.7 | 22 | mA |
| | I_{RXL} | Low Power Mode, 915 MHz, 40 kbps | — | 11.1 | — | mA |
| TX Mode Current (R69) | I_{TX_+20} | +20 dBm output power, class-E match, 915 MHz, 3.3 V | — | 93 | 108 | mA |
| | I_{TX_+13} | +13 dBm output power, class-E match, 868/915 MHz, 3.3 V | — | 22 | — | mA |
| TX Mode Current (R63, R68) | I_{TX_+20} | +20 dBm output power, class-E match, 915 MHz, 3.3 V | — | 93 | 108 | mA |
| | | +20 dBm output power, square-wave match, 169 MHz, 3.3 V | — | 69 | 80 | mA |
| | I_{TX_+13} | +13 dBm output power, class-E match, 915 MHz, 3.3 V | — | 44.5 | 60 | mA |
| TX Mode Current (R60, R67) | I_{TX_+10} | +10 dBm output power, class-E match, 868/915 MHz, 3.3 V | — | 19.7 | — | mA |
| | I_{TX_+10} | +10 dBm output power, class-E match, 169 MHz, 3.3 V | — | 18 | — | mA |
| | I_{TX_+13} | +13 dBm output power, class-E match, 868/915 MHz, 3.3 V | — | 22 | — | mA |

| Parameter | Symbol | Test Condition | Min | Typ | Max | Unit |
|-----------------------|---------------|--|-----|------|-----|------|
| TX Mode Current (R61) | I_{TX_+16} | +16 dBm output power, class-E match, 868 MHz, 3.3 V | — | 43 | 55 | mA |
| | I_{TX_+13} | +13 dBm output power, switched-current match, 868 MHz, 3.3 V | — | 33.5 | 40 | mA |

4.16.2 EZRadioPRO (R6x) Synthesizer AC Electrical Characteristics

Table 4.32. EZRadioPro Synthesizer

| Parameter | Symbol | Test Condition | Min | Typ | Max | Unit |
|----------------------------------|----------------|---|-----|------|------|---------|
| Synthesizer Frequency Range | F_{SYN} | | 850 | — | 1050 | MHz |
| | | | 350 | — | 525 | MHz |
| | | | 284 | — | 350 | MHz |
| | | | 142 | — | 175 | MHz |
| Synthesizer Frequency Resolution | $F_{RES-1050}$ | 850–1050 MHz | — | 28.6 | — | Hz |
| | $F_{RES-525}$ | 420–525 MHz | — | 14.3 | — | Hz |
| | $F_{RES-420}$ | 350–420 MHz | — | 11.4 | — | Hz |
| | $F_{RES-350}$ | 283–350 MHz | — | 9.5 | — | Hz |
| | $F_{RES-175}$ | 142–175 MHz | — | 4.7 | — | Hz |
| Synthesizer Settling Time | t_{LOCK} | Measured from exiting Ready mode with XOSC running to any frequency. Including VCO Calibration. | — | 50 | — | μ s |
| Phase Noise | $L_{(fM)}$ | F = 10 kHz, 169 MHz, High Perf Mode | — | –117 | –108 | dBc/Hz |
| | | F = 100 kHz, 169 MHz, High Perf Mode | — | –120 | –115 | dBc/Hz |
| | | F = 1 MHz, 169 MHz, High Perf Mode | — | –138 | –135 | dBc/Hz |
| | | F = 10 MHz, 169 MHz, High Perf Mode | — | –148 | –143 | dBc/Hz |
| | | F = 10 kHz, 915 MHz, High Perf Mode | — | –102 | –94 | dBc/Hz |
| | | F = 100 kHz, 915 MHz, High Perf Mode | — | –105 | –97 | dBc/Hz |
| | | F = 1 MHz, 915 MHz, High Perf Mode | — | –125 | –122 | dBc/Hz |
| | | F = 10 MHz, 915 MHz, High Perf Mode | — | –138 | –135 | dBc/Hz |

4.16.3 EZRadioPRO (R6x) Receiver AC Electrical Characteristics

For PER tests, 48 preamble symbols, 4 byte sync word, 10 byte payload and CRC-32 was used.

Measured over 50000 bits using PN9 data sequence and data and clock on GPIOs. Sensitivity is expected to be better if reading data from packet handler FIFO especially at higher data rates.

Table 4.33. EZRadioPro Receiver AC Electrical Characteristics

| Parameter | Symbol | Test Condition | Min | Typ | Max | Unit |
|--|---------------|--|-----|--------|------|------|
| RX Frequency Range | F_{RX} | | 850 | — | 1050 | MHz |
| | | | 350 | — | 525 | MHz |
| | | | 284 | — | 350 | MHz |
| | | | 142 | — | 175 | MHz |
| RX Sensitivity 169 MHz (R68, R67)3 | $P_{RX_0.1}$ | (BER < 0.1%) (100 bps, GFSK, BT = 0.5, $f = \pm 100$ Hz) | — | -133 | — | dBm |
| RX Sensitivity 169 MHz (R60, R61, R63)3 | $P_{RX_0.5}$ | (BER < 0.1%) (500 bps, GFSK, BT = 0.5, $f = \pm 250$ Hz) | — | -129 | — | dBm |
| RX Sensitivity 169 MHz (R60, R61, R63, R67, R68)3 | P_{RX_40} | (BER < 0.1%) (40 kbps, GFSK, BT = 0.5, $f = \pm 20$ kHz) | — | -110.7 | -108 | dBm |
| | P_{RX_100} | (BER < 0.1%) (100 kbps, GFSK, BT = 0.5, $f = \pm 50$ kHz) | — | -106 | -104 | dBm |
| | P_{RX_125} | (BER < 0.1%) (500 kbps, GFSK, BT = 0.5, $f = \pm 250$ kHz) | — | -99 | -96 | dBm |
| | $P_{RX_9.6}$ | (PER 1%) (9.6 kbps, 4GFSK, BT = 0.5, $f = \pm 2.4$ kHz) | — | -110 | — | dBm |
| | P_{RX_1M} | (PER 1%) (1 Mbps, 4GFSK, BT = 0.5, inner deviation = 83.3 kHz) | — | -89 | — | dBm |
| | P_{RX_OOK} | (BER < 0.1%, 4.8 kbps, 350 kHz BW, OOK, PN15 data) | — | -110 | -107 | dBm |
| | | (BER < 0.1%, 40 kbps, 350 kHz BW, OOK, PN15 data) | — | -103 | -100 | dBm |
| | | (BER < 0.1%, 120 kbps, 350 kHz BW, OOK, PN15 data) | — | -97 | -93 | dBm |
| RX Sensitivity 915/868 MHz (R68, R67)3 | $P_{RX_0.1}$ | (BER < 0.1%) (100 bps, GFSK, BT = 0.5, $f = \pm 100$ Hz) | — | -132 | — | dBm |
| RX Sensitivity 915 MHz (R60, R61, R63, R69)3 | $P_{RX_0.5}$ | (BER < 0.1%) (500 bps, GFSK, BT = 0.5, $f = \pm 250$ Hz) | — | -127 | — | dBm |
| RX Sensitivity 868 MHz (R60, R61, R63, R69)3 | | (BER < 0.1%) (500 bps, GFSK, BT = 0.5, $f = \pm 250$ Hz) | — | -127 | — | dBm |
| RX Sensitivity 868 MHz (R60, R61, R63, R67, R68, R69)3 | P_{RX_40} | (BER < 0.1%) (40 kbps, GFSK, BT = 0.5, $f = \pm 20$ kHz) | — | -109.9 | — | dBm |
| RX Sensitivity 915 MHz (R60, R61, R63, R67, R68, R69)3 | | (BER < 0.1%) (40 kbps, GFSK, BT = 0.5, $f = \pm 20$ kHz) | — | -109.4 | — | dBm |

| Parameter | Symbol | Test Condition | Min | Typ | Max | Unit |
|--|---------------------|--|-----|--------|------|------|
| RX Sensitivity 915/868 MHz (R60, R61, R63, R67, R68, R69)3 | P _{RX_100} | (BER < 0.1%) (100 kbps, GFSK, BT = 0.5, f = ±50 kHz) | — | -104 | -102 | dBm |
| | P _{RX_125} | (BER < 0.1%) (500 kbps, GFSK, BT = 0.5, f = ±250 kHz) | — | -97 | -92 | dBm |
| | P _{RX_9.6} | (PER 1%) (9.6 kbps, 4GFSK, BT = 0.5, f = ±2.4 kHz) | — | -110.6 | — | dBm |
| | P _{RX_1M} | (PER 1%) (1 Mbps, 4GFSK, BT = 0.5, inner deviation = 83.3 kHz) | — | -88.7 | — | dBm |
| | P _{RX_OOK} | (BER < 0.1%, 4.8 kbps, 350 kHz BW, OOK, PN15 data) | — | -108 | -104 | dBm |
| | | (BER < 0.1%, 40 kbps, 350 kHz BW, OOK, PN15 data) | — | -101 | -97 | dBm |
| (BER < 0.1%, 120 kbps, 350 kHz BW, OOK, PN15 data) | | — | -96 | -91 | dBm | |
| RX Channel Bandwidth (R60, R61, R63) | BW | | 1.1 | — | 850 | kHz |
| RX Channel Bandwidth (R68, R67) | | | 0.2 | — | 850 | kHz |
| RSSI Resolution | RES _{RSSI} | Valid from -110 dBm to -90 dBm | — | ±0.5 | — | dB |
| ±1-Ch Offset Selectivity, 169 MHz | C/I _{1-CH} | Desired Ref Signal 3 dB above sensitivity, BER, <0.1%. Interferer is CW and desired is modulated with 2.4 kbps F = 1.2 kHz GFSK with BT = 0.5, RX channel BW = 4.8 kHz, channel spacing = 12.5 kHz | — | -69 | -59 | dB |
| ±1-Ch Offset Selectivity, 450 MHz | | | — | -60 | -50 | dB |
| ±1-Ch Offset Selectivity, 868 / 915 MHz | | | — | -52.5 | -45 | dB |
| Blocking 1 MHz Offset | 1M _{BLOCK} | Desired Ref Signal 3 dB above sensitivity, BER, <0.1%. Interferer is CW and desired is modulated with 2.4 kbps F = 1.2 kHz GFSK with BT = 0.5, RX channel BW = 4.8 kHz | — | -79 | -68 | dB |
| Blocking 8 MHz Offset | 8M _{BLOCK} | | — | -86 | -75 | dB |

| Parameter | Symbol | Test Condition | Min | Typ | Max | Unit |
|-----------------------------------|-------------------|--|-----|-----|-----|------|
| Image Rejection (IF = 468.75 kHz) | Im _{REJ} | No image rejection calibration. Rejection at the image frequency. RF = 460 MHz | 30 | 40 | — | dB |
| | | With image rejection calibration. Rejection at the image frequency. RF = 460 MHz | 40 | 55 | — | dB |
| | | No image rejection calibration. Rejection at the image frequency. RF = 915 MHz | 30 | 45 | — | dB |
| | | With image rejection calibration. Rejection at the image frequency. RF = 915 MHz | 40 | 52 | — | dB |
| | | No image rejection calibration. Rejection at the image frequency. RF = 169 MHz | 35 | 45 | — | dB |
| | | With image rejection calibration. Rejection at the image frequency. RF = 169 MHz | 45 | 60 | — | dB |

Note:

1. BER sensitivity measure using GPIO3 for data and GPIO1 for data clock. Use of other GPIO pins could result in degraded sensitivity.
2. When in HFXO mode sensitivity will degrade at multiples of HFXO crystal frequency. Values in data sheet do not include spurious channel values.

4.16.4 EZRadioPRO (R6x) Transmitter AC Electrical Characteristics

The maximum data rate is dependent on the XTAL frequency and is calculated as per the formula: Maximum Symbol Rate = $F_{xtal}/60$, where F_{xtal} is the XTAL frequency (typically 30 MHz).

Default API setting for modulation deviation resolution is double the typical value specified.

Output power is dependent on matching components and board layout.

Table 4.34. EZRadioPro Transmitter AC Electrical Characteristics

| Parameter | Symbol | Test Condition | Min | Typ | Max | Unit |
|----------------------------------|----------------|--|-----|------|-------|------|
| TX Frequency Range | F_{TX} | | 850 | — | 1050 | MHz |
| | | | 350 | — | 525 | MHz |
| | | | 284 | — | 350 | MHz |
| | | | 142 | — | 175 | MHz |
| (G)FSK Data Rate | DR_{FSK} | | 0.1 | — | 500 | kbps |
| 4(G)FSK Data Rate | DR_{4FSK} | | 0.2 | — | 1000 | kbps |
| OOK Data Rate | DR_{OOK} | | 0.1 | — | 120 | kbps |
| Modulation Deviation Range | f_{960} | 850–1050 MHz | — | 1.5 | — | MHz |
| | f_{525} | 420–525 MHz | — | 750 | — | kHz |
| | f_{420} | 350–420 MHz | — | 600 | — | kHz |
| | f_{350} | 283–350 MHz | — | 500 | — | kHz |
| | f_{175} | 142–175 MHz | — | 250 | — | kHz |
| Modulation Deviation Resolution | $F_{RES-1050}$ | 850–1050 MHz | — | 28.6 | — | Hz |
| | $F_{RES-525}$ | 420–525 MHz | — | 14.3 | — | Hz |
| | $F_{RES-420}$ | 350–420 MHz | — | 11.4 | — | Hz |
| | $F_{RES-350}$ | 283–350 MHz | — | 9.5 | — | Hz |
| | $F_{RES-175}$ | 142–175 MHz | — | 4.7 | — | Hz |
| Typical Output Power Range (R63) | P_{TX63} | Typical Output Power Range at 3.3 V with Class E mtch optimized for best PA efficiency | –20 | — | +20 | dBm |
| Typical Output Power Range (R61) | P_{TX61} | Typical Output Power Range at 3.3 V with Class E mtch optimized for best PA efficiency | –40 | — | +16 | dBm |
| Typical Output Power Range (R60) | P_{TX60} | Typical Output Power Range at 3.3 V with Class E mtch optimized for best PA efficiency | –20 | — | +12.5 | dBm |
| Typical Output Power Range (R68) | P_{TX68} | Typical Output Power Range at 3.3 V with Class E mtch optimized for best PA efficiency | –20 | — | +20 | dBm |
| Typical Output Power Range (R69) | P_{TX69} | Typical Output Power Range at 3.3 V with Class E mtch optimized for best PA efficiency | –20 | — | +20 | dBm |
| Typical Output Power Range (R67) | P_{TX67} | Typical Output Power Range at 3.3 V with Class E mtch optimized for best PA efficiency | –20 | — | +12.5 | dBm |

| Parameter | Symbol | Test Condition | Min | Typ | Max | Unit |
|--|--------------------------|--|------|------|------|------|
| Output Power Variation (R63, R68, R69) | | At 20 dBm PA power setting, 915 MHz, Class E match, 3.3 V, 25 °C | 19 | 20 | 21 | dBm |
| Output Power Variation (R60, R67) | | At 10 dBm PA power setting, 915 MHz, Class E match, 3.3 V, 25 °C | 9 | 10 | 11 | dBm |
| Output Power Variation (R63, R68) | | At 20 dBm PA power setting, 169 MHz, Square Wave match, 3.3 V, 25 °C | 18.5 | 20 | 21 | dBm |
| Output Power Variation (R60, R67) | | At 10 dBm PA power setting, 169 MHz, Square Wave match, 3.3 V, 25 °C | 9.5 | 10 | 10.5 | dBm |
| TX RF Output Steps | P _{RF_OUT} | Using switched current match within 6 dB of max power | — | 0.25 | 0.4 | dB |
| TX RF Output Level Variation vs. Temperature | P _{RF_TEMP} | −40 to +85 °C | — | 2.3 | 3 | dB |
| TX RF Output Level Variation vs. Frequency | P- RF _{FREQ} | Measured across 902–928 MHz | — | 0.6 | 1.7 | dB |
| Transmit Modulation Filtering | B×T | Gaussian Filtering Bandwidth Time Product | — | 0.5 | — | |

4.16.5 EZRadioPRO (R6x) Radio Auxillary Block Specifications

Microcontroller clock frequency tested in production at 1 MHz, 30 MHz, 32 MHz, and 32.768 kHz. Other frequencies tested by bench characterization.

XTAL Range tested in production using an external clock source (similar to using a TCXO).

Table 4.35. EZRadioPro Auxiliary Block Specifications

| Parameter | Symbol | Test Condition | Min | Typ | Max | Unit |
|--|-----------------------|---|-----|------|-----|------|
| XTAL Range | XTAL _{RANGE} | | 25 | — | 32 | MHz |
| 30 MHz XTAL Start-Up Time | t _{30M} | Using XTAL and board layout in reference design. Start-up time will vary with XTAL type and board layout. | — | 300 | — | µs |
| 30 MHz XTAL Cap Resolution | 30M _{RES} | | — | 70 | — | fF |
| 32 kHz XTAL Start-Up Time | t _{32K} | | — | 2 | — | sec |
| 32 kHz Accuracy using Internal RC Oscillator | 32KRC _{RES} | | — | 2500 | — | ppm |
| POR Reset Time | t _{POR} | | — | — | 6 | ms |

4.16.6 EZRadio (R55) DC Electrical Characteristics

Table 4.36. EZRadio DC Characteristics

| Parameter | Symbol | Test Condition | Min | Typ | Max | Unit |
|--------------------|------------------------|---|-----|------|-----|------|
| Power Saving Modes | I_{shutdown} | RC Oscillator, Main Digital Regulator, and Low Power Digital Regulator OFF | — | 30 | — | nA |
| | I_{standby} | Register values maintained | — | 40 | — | nA |
| | I_{Ready} | Crystal Oscillator and Main Digital Regulator ON, all other blocks OFF | — | 1.8 | — | mA |
| | $I_{\text{SPIActive}}$ | SPI active state | — | 1.5 | — | mA |
| TUNE Mode Current | I_{TuneRX} | RX Tune | — | 6.8 | — | mA |
| | I_{TuneTX} | TX Tune | — | 7.1 | — | mA |
| RX Mode Current | I_{RX} | Measured at 40 kbps, 20 kHz deviation, 315 MHz | — | 10.9 | — | mA |
| TX Mode Current | I_{TX} | +10 dBm output power, measured on direct tie RF evaluation board at 868 MHz | — | 19 | — | mA |
| | | +13 dBm output power, measured on direct tie RF evaluation board at 868 MHz | — | 24 | — | mA |

4.16.7 EZRadio (R55) Synthesizer AC Electrical Characteristics

Table 4.37. EZRadio Synthesizer

| Parameter | Symbol | Test Condition | Min | Typ | Max | Unit |
|----------------------------------|----------------------|----------------------|-----|-------|-----|--------|
| Synthesizer Frequency Range | F_{SYN} | | 284 | — | 350 | MHz |
| | | | 350 | — | 525 | MHz |
| | | | 850 | — | 960 | MHz |
| Synthesizer Frequency Resolution | $F_{\text{RES-960}}$ | 850-960 MHz | — | 114.4 | — | Hz |
| | $F_{\text{RES-525}}$ | 420-525 MHz | — | 57.2 | — | Hz |
| | $F_{\text{RES-350}}$ | 283-350 MHz | — | 38.1 | — | Hz |
| Phase Noise | $L_{\text{(fM)}}$ | F = 10 kHz, 915 MHz | — | 100 | — | dBc/Hz |
| | | F = 100 kHz, 915 MHz | — | 102.1 | — | dBc/Hz |
| | | F = 1 MHz, 915 MHz | — | 123.5 | — | dBc/Hz |
| | | F = 10 MHz, 915 MHz | — | 136.6 | — | dBc/Hz |

4.16.8 EZRadio (R55) Receiver AC Electrical Characteristics

Table 4.38. EZRadio Receiver AC Electrical Characteristics

| Parameter | Symbol | Test Condition | Min | Typ | Max | Unit |
|--------------------------|-----------------------|--|-----|--------|-----|------|
| RX Frequency Range | F _{RX} | | 284 | — | 350 | MHz |
| | | | 350 | — | 525 | MHz |
| | | | 850 | — | 960 | MHz |
| RX Sensitivity 915 MHz | P _{RX_2} | (BER < 0.1%) (2.4 kbps, GFSK, BT = 0.5, f = ±30 kHz, 114 kHz RX BW) | — | -115 | — | dBm |
| | P _{RX_40} | (BER < 0.1%) (40 kbps, GFSK, BT = 0.5, f = ±25 kHz, 114 kHz RX BW) | — | -107.6 | — | dBm |
| | P _{RX_128} | (BER < 0.1%) (128 kbps, GFSK, BT = 0.5, f = ±70 kHz, 305 kHz RX BW) | — | -102.4 | — | dBm |
| | P _{RX_OOK} | (BER < 0.1%, 1 kbps, 185 kHz Rx BW, OOK, PN15 data) | — | -113.5 | — | dBm |
| | | (BER < 0.1%, 40 kbps, 185 kHz BW, OOK, PN15 data) | — | -102.7 | — | dBm |
| RX Sensitivity 434 MHz | P _{RX_2} | (BER < 0.1%) (2.4 kbps, GFSK, BT = 0.5, DF = ±30 kHz, 114 kHz Rx BW) | — | -116 | — | dBm |
| | P _{RX_40} | (BER < 0.1%) (40 kbps, GFSK, BT = 0.5, DF = ±25 kHz, 114 kHz Rx BW) | — | -108 | — | dBm |
| | P _{RX_128} | (BER < 0.1%) (128 kbps, GFSK, BT = 0.5, DF = ±70 kHz, 305 kHz Rx BW) | — | -103 | — | dBm |
| | P _{RX_OOK} | (BER < 0.1%, 1 kbps, 185 kHz Rx BW, OOK, PN15 data) | — | -113 | — | dBm |
| | | (BER < 0.1%, 40 kbps, 185 kHz BW, OOK, PN15 data) | — | -102 | — | dBm |
| RX Channel Bandwidth | BW | | 40 | — | 850 | kHz |
| RSSI Resolution | RES _{RSSI} | Valid from -110 dBm to -90 dBm | — | ±0.5 | — | dB |
| ±1-Ch Offset Selectivity | C/I _{1-CH} | Desired Ref Signal 3 dB above sensitivity, BER, <0.1%. Interferer is CW and desired is modulated with 1.2 kbps F = 5.2 kHz GFSK with BT = 0.5, RX channel BW = 58 kHz, channel spacing = 100 kHz | — | -50 | — | dB |
| ±2-Ch Offset Selectivity | C/I _{2-CH} | | — | -56 | — | dB |
| Blocking 200 kHz–1 MHz | 200K _{BLOCK} | Desired Ref Signal 3 dB above sensitivity, BER, <0.1%. Interferer is CW and desired is modulated with 1.2 kbps F = 5.2 kHz GFSK with BT = 0.5, RX channel BW = 58 kHz | — | -56 | — | dB |
| Blocking 1 MHz Offset | 1M _{BLOCK} | | — | -71 | — | dB |
| Blocking 8 MHz Offset | 8M _{BLOCK} | | — | -71 | — | dB |

| Parameter | Symbol | Test Condition | Min | Typ | Max | Unit |
|-----------------|------------|---|-----|-----|-----|------|
| Image Rejection | Im_{REJ} | Rejection at the image frequency IF = 468 kHz | — | 40 | — | dB |

Note:

1. BER sensitivity measure using GPIO3 for data and GPIO1 for data clock. Use of other GPIO pins could result in degraded sensitivity.
2. When in HFXO mode sensitivity will degrade at multiples of HFXO crystal frequency. Values in data sheet do not include spurious channel values.

4.16.9 EZRadio (R55) Transmitter AC Electrical Characteristics

The maximum data rate is dependent on the XTAL frequency and is calculated as per the formula: Maximum Symbol Rate = $F_{xtal}/60$, where F_{xtal} is the XTAL frequency (typically 30 MHz).

Conducted measurements based on RF evaluation board. Output power and emissions specifications are dependent on transmit frequency, matching components, and board layout.

Table 4.39. EZRadio Transmitter AC Electrical Characteristics

| Parameter | Symbol | Test Condition | Min | Typ | Max | Unit |
|--|----------------|---|-----|-------|-----|------|
| TX Frequency Range | F_{TX} | | 284 | — | 350 | MHz |
| | | | 350 | — | 525 | MHz |
| | | | 850 | — | 960 | MHz |
| (G)FSK Data Rate | DR_{FSK} | | 1.0 | — | 500 | kbps |
| OOK Data Rate | DR_{OOK} | | 0.5 | — | 120 | kbps |
| Modulation Deviation Range | f_{960} | 850-960 MHz | — | — | 500 | kHz |
| | f_{525} | 350-525 MHz | — | — | 500 | kHz |
| | f_{350} | 284-350 MHz | — | — | 500 | kHz |
| Modulation Deviation Resolution | $F_{RES-960}$ | 850-960 MHz | — | 114.4 | — | Hz |
| | $F_{RES-525}$ | 420-525 MHz | — | 57.2 | — | Hz |
| | $F_{RES-420}$ | 350-420 MHz | — | 45.6 | — | Hz |
| | $F_{RES-350}$ | 284-350 MHz | — | 38.1 | — | Hz |
| Output Power Range | P_{TX} | Measured at 434 MHz, 3.3 V, Class E match | -20 | — | +13 | dBm |
| TX RF Output Steps | P_{RF_OUT} | Using switched current match within 6 dB of max power | — | 0.25 | — | dB |
| TX RF Output Level Variation vs. Temperature | P_{RF_TEMP} | -40 to +85 °C | — | 2.3 | — | dB |
| TX RF Output Level Variation vs. Frequency | P_{RF_FREQ} | Measured across 902-928 MHz | — | 0.6 | — | dB |
| Transmit Modulation Filtering | $B \times T$ | Gaussian Filtering Bandwidth Time Product | — | 0.5 | — | |

4.16.10 EZRadio (R55) Radio Auxiliary Block Specifications

XTAL Range tested in production using an external clock source (similar to using a TCXO).

Microcontroller clock frequency tested in production at 1 MHz, 30 MHz, 32 MHz, and 32.768 kHz. Other frequencies tested by bench characterization.

Table 4.40. EZRadio Auxilliary Block Specifications

| Parameter | Symbol | Test Condition | Min | Typ | Max | Unit |
|----------------------------|-----------------------|---|-----|-----|-----|------|
| XTAL Range | XTAL _{RANGE} | | 25 | | 32 | MHz |
| 30 MHz XTAL Start-Up Time | t _{30M} | Using XTAL and board layout in reference design. Start-up time will vary with XTAL type and board layout. | — | 300 | — | us |
| 30 MHz XTAL Cap Resolution | 30M _{RES} | | — | 70 | — | Ff |
| POR Reset Time | t _{POR} | | — | — | 6 | ms |

4.16.11 Radio Digital I/O Specification

6.7 ns is typical for GPIO0 rise time.

Assuming $V_{DD} = 3.3$ V, drive strength is specified at $V_{OH}(\min) = 2.64$ V and $V_{OL}(\max) = 0.66$ V at room temperature.

2.4 ns is typical for GPIO0 fall time.

Table 4.41. EZRadio/Pro Digital I/O Specification

| Parameter | Symbol | Test Condition | Min | Typ | Max | Unit |
|---|--------------|---|-------------------------|------|-------------------------|------|
| Rise Time | T_{RISE} | $0.1 \times V_{DD}$ to $0.9 \times V_{DD}$, $C_L = 10$ pF, $DRV[1:0] = LL$ | — | 2.3 | — | ns |
| Fall Time | T_{FALL} | $0.9 \times V_{DD}$ to $0.1 \times V_{DD}$, $C_L = 10$ pF, $DRV[1:0] = LL$ | — | 2 | — | ns |
| Input Capacitance | C_{IN} | | — | 2 | — | pF |
| Logic High Level Input Voltage | V_{IH} | | $V_{DD_RF} \times 0.7$ | — | — | V |
| Logic Low Level Input Voltage | V_{IL} | | — | — | $V_{DD_RF} \times 0.3$ | V |
| Input Current | I_{IN} | $0 < V_{IN} < V_{DD}$ | -1 | — | 1 | uA |
| Input Current If Pullup is Activated | I_{INP} | $V_{IL} = 0$ V | 1 | — | 4 | uA |
| Drive Strength for Output Low Level ³ | I_{OmaxLL} | $DRV[1:0] = LL$ | — | 6.66 | — | mA |
| | I_{OmaxLH} | $DRV[1:0] = LH$ | — | 5.03 | — | mA |
| | I_{OmaxHL} | $DRV[1:0] = HL$ | — | 3.16 | — | mA |
| | I_{OmaxHH} | $DRV[1:0] = HH$ | — | 1.13 | — | mA |
| Drive Strength for Output High Level ³ | I_{OmaxLL} | $DRV[1:0] = LL$ | — | 5.75 | — | mA |
| | I_{OmaxLH} | $DRV[1:0] = LH$ | — | 4.37 | — | mA |
| | I_{OmaxHL} | $DRV[1:0] = HL$ | — | 2.73 | — | mA |
| | I_{OmaxHH} | $DRV[1:0] = HH$ | — | 0.96 | — | mA |
| Drive Strength for Output High Level for GPIO3 | I_{OmaxLL} | $DRV[1:0] = LL$ | — | 2.53 | — | mA |
| | I_{OmaxLH} | $DRV[1:0] = LH$ | — | 2.21 | — | mA |
| | I_{OmaxHL} | $DRV[1:0] = HL$ | — | 1.7 | — | mA |
| | I_{OmaxHH} | $DRV[1:0] = HH$ | — | 0.80 | — | mA |
| Logic High Level Output Voltage | V_{OH} | $DRV[1:0] = HL$ | $V_{DD_RF} \times 0.8$ | — | — | V |
| Logic Low Level Output Voltage | V_{OL} | $DRV[1:0] = HL$ | — | — | $V_{DD_RF} \times 0.2$ | V |

4.17 Digital Peripherals

Table 4.42. Digital Peripherals

| Parameter | Symbol | Condition | Min | Typ | Max | Unit |
|----------------|---------------------|-------------------------------------|-----|------|-----|--------------------------|
| USART current | I_{USART} | USART idle current, clock enabled | — | 7.5 | — | $\mu\text{A}/\text{MHz}$ |
| LEUART current | I_{LEUART} | LEUART idle current, clock enabled | — | 150 | — | nA |
| I2C current | I_{I2C} | I2C idle current, clock enabled | — | 6.25 | — | $\mu\text{A}/\text{MHz}$ |
| TIMER current | I_{TIMER} | TIMER_0 idle current, clock enabled | — | 8.75 | — | $\mu\text{A}/\text{MHz}$ |
| PCNT current | I_{PCNT} | PCNT idle current, clock enabled | — | 100 | — | nA |
| RTC current | I_{RTC} | RTC idle current, clock enabled | — | 100 | — | nA |
| AES current | I_{AES} | AES idle current, clock enabled | — | 2.5 | — | $\mu\text{A}/\text{MHz}$ |
| GPIO current | I_{GPIO} | GPIO idle current, clock enabled | — | 5.31 | — | $\mu\text{A}/\text{MHz}$ |
| PRS current | I_{PRS} | PRS idle current | — | 2.81 | — | $\mu\text{A}/\text{MHz}$ |
| DMA current | I_{DMA} | Clock enable | — | 8.12 | — | $\mu\text{A}/\text{MHz}$ |

5. Pinout and Package

Note: Refer to the application note, [AN0002.0: EFM32 and EZR32 Wireless MCU Series 0 Hardware Design Considerations](#), for guidelines on designing Printed Circuit Boards (PCB's) for the EZR32HG320.

5.1 Pinout

The EZR32HG320 pinout is shown in below. Alternate locations are denoted by "#" followed by the location number (Multiple locations on the same pin are split with "/"). Alternate locations can be configured in the LOCATION bitfield in the *_ROUTE register in the module in question.

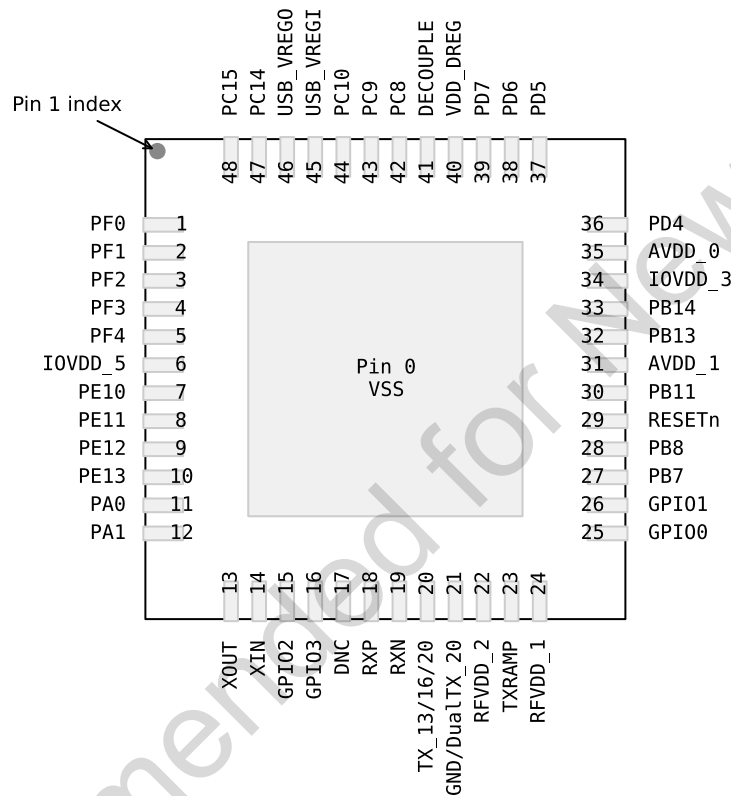


Figure 5.1. Pinout (top view, not to scale)

5.2 Pin Descriptions

Table 5.1. Device Pinout

| QFN48 Pin# and Name | | Pin Alternate Functionality / Description | | | |
|---------------------|---------------|---|---|---------------------------------------|--|
| Pin # | Pin Name | Analog | Timers | Communication | Other |
| 0 | VSS | Ground. | | | |
| 1 | PF0 | | TIM0_CC0 #5 | LEU0_TX #3 I2C0_SDA #5 | DBG_SWCLK #0 |
| 2 | PF1 | | TIM0_CC1 #5 | LEU0_RX #3 I2C0_SCL #5 | DBG_SWDIO #0 GPIO_EM4WU3 |
| 3 | PF2 | | TIM0_CC2 #5/6 TIM2_CC0 #3 | LEU0_TX #4 | CMU_CLK0 #3 PRS_CH0 #3 GPIO_EM4WU4 |
| 4 | PF3 | | TIM0_CDTI0 #5 | | PRS_CH0 #1 |
| 5 | PF4 | | TIM0_CDTI1 #5 | | PRS_CH1 #1 |
| 6 | IOVDD_5 | Digital IO power supply 5. | | | |
| 7 | PE10 | | TIM1_CC0 #1 | US0_TX #0 | PRS_CH2 #2 |
| 8 | PE11 | | TIM1_CC1 #1 | US0_RX #0 | PRS_CH3 #2 |
| 9 | PE12 | ADC0_CH0 | TIM1_CC2 #1 TIM2_CC1 #3 | US0_RX #3 US0_CLK #0/6 I2C0_SDA #6 | CMU_CLK1 #2 PRS_CH1 #3 |
| 10 | PE13 | ADC0_CH1 | TIM2_CC2 #3 | US0_TX #3 US0_CS #0/6 I2C0_SCL #6 | PRS_CH2 #3 GPIO_EM4WU5 |
| 11 | PA0 | | TIM0_CC1 #6 TIM0_CC0 #0/1/4 PCNT0_S0IN #4 | USB_DMPU #0 LEU0_RX #4 I2C0_SDA #0 | PRS_CH0 #0 PRS_CH3 #3 GPIO_EM4WU0 |
| 12 | PA1 | | TIM0_CC0 #6 TIM0_CC1 #0/1 | I2C0_SCL #0 | CMU_CLK1 #0 PRS_CH1 #0 |
| 13 | XOUT | EZRadio peripheral crystal oscillator output. Connect to an external 26/30 MHz crystal or leave floating if driving the XOUT pin with an external signal source. | | | |
| 14 | XIN | EZRadio peripheral crystal oscillator input. Connect to an external 26/30 MHz crystal or to an external clock source. If using an external clock source with no crystal, dc coupling with a nominal 0.8 VDC level is recommended with a minimum ac amplitude of 700 mVpp. Refer to AN417 for more details about using an external clock source. | | | |
| 15 | GPIO2 | General Purpose Digital I/O for the radio. May be configured to perform various EZRadio functions, including Clock Output, FIFO Status, POR, Wake-up Timer, TRSW, AntDiversity control, etc. | | | |
| 16 | GPIO3 | General Purpose Digital I/O for the radio. May be configured to perform various EZRadio functions, including Clock Output, FIFO Status, POR, Wake-up Timer, TRSW, AntDiversity control, etc. | | | |
| 17 | DNC | Do not connect. | | | |
| 18 | RXP | Differential RF Input Pin of the LNA. See application schematic for example matching network. | | | |
| 19 | RXN | Differential RF Input Pin of the LNA. See application schematic for example matching network. | | | |
| 20 | TX_13/16/20 | Transmit Output Pin. +13 dBm for EZR32HG320FXXR55, R60, R67 and R69, +16 dBm for EZR32HG320FXXR61, and +20 dBm for EZR32HG320FXXR63 and R68 variants. The PA output is an open-drain connection, so the L-C match must supply VDD (+3.3 VDC nominal) to this pin. | | | |
| 21 | GND/DualTX_20 | +20 dBm for EZR32HG320FXXR69 variant. | | | |

| QFN48 Pin# and Name | | Pin Alternate Functionality / Description | | | |
|---------------------|-----------|--|---|---------------------------------|------------------------|
| Pin # | Pin Name | Analog | Timers | Communication | Other |
| 22 | RFVDD_2 | +1.8 to +3.6 V Supply Voltage Input to Internal Regulators for the Radio. The recommended VDD supply voltage is +3.3 V. | | | |
| 23 | TXRAMP | Programmable Bias Output with Ramp Capability for External FET PA. | | | |
| 24 | RFVDD_1 | +1.8 to +3.6 V Supply Voltage Input to Internal Regulators for the Radio. The recommended VDD supply voltage is +3.3 V. | | | |
| 25 | GPIO0 | General Purpose Digital I/O for the radio. May be configured to perform various EZRadio functions, including Clock Output, FIFO Status, POR, Wake-up Timer, TRSW, AntDiversity control, etc. | | | |
| 26 | GPIO1 | General Purpose Digital I/O for the radio. May be configured to perform various EZRadio functions, including Clock Output, FIFO Status, POR, Wake-up Timer, TRSW, AntDiversity control, etc. | | | |
| 27 | PB7 | LFXTAL_P | TIM1_CC0 #3 | US0_TX #4 | |
| 28 | PB8 | LFXTAL_N | TIM1_CC1 #3 | US0_RX #4 | |
| 29 | RESETn | Reset input, active low. To apply an external reset source to this pin, it is required to only drive this pin low during reset, and let the internal pull-up ensure that reset is released. | | | |
| 30 | PB11 | IDAC0_OUT | TIM1_CC2 #3 PCNT0_S1IN #4 | | CMU_CLK1 #3 |
| 31 | AVDD_1 | Analog power supply 1. | | | |
| 32 | PB13 | HFXTAL_P | | US0_CLK #4/5 LEU0_TX #1 | |
| 33 | PB14 | HFXTAL_N | | US0_CS #4/5 LEU0_RX #1 | |
| 34 | IOVDD_3 | Digital IO power supply 3. | | | |
| 35 | AVDD_0 | Analog power supply 0. | | | |
| 36 | PD4 | ADC0_CH4 | | LEU0_TX #0 | |
| 37 | PD5 | ADC0_CH5 | | LEU0_RX #0 | |
| 38 | PD6 | ADC0_CH6 | TIM1_CC0 #4 PCNT0_S0IN #3 | USRF1_RX #2 I2C0_SDA #1 | BOOT_RX |
| 39 | PD7 | ADC0_CH7 | TIM1_CC1 #4 PCNT0_S1IN #3 | USRF1_TX #2 I2C0_SCL #1 | CMU_CLK0 #2 BOOT_TX |
| 40 | VDD_DREG | Power supply for on-chip voltage regulator. | | | |
| 41 | DECOUPLE | Decouple output for on-chip voltage regulator. An external capacitance of size C _{DECOUPLE} is required at this pin. | | | |
| 42 | PC8 | | TIM2_CC0 #2 | US0_CS #2 | |
| 43 | PC9 | | TIM2_CC1 #2 | US0_CLK #2 | GPIO_EM4WU2 |
| 44 | PC10 | | TIM2_CC2 #2 | US0_RX #2 | |
| 45 | USB_VREGI | | | | |
| 46 | USB_VREGO | | | | |
| 47 | PC14 | | TIM0_CDT11 #1/6 TIM1_CC1 #0 PCNT0_S1IN #0 | US0_CS #3 LEU0_TX #5 USB_DM | PRS_CH0 #2 |
| 48 | PC15 | | TIM0_CDT12 #1/6 TIM1_CC2 #0 | US0_CLK #3 LEU0_RX #5 USB_DP | PRS_CH1 #2 |

5.3 Alternate Functionality Pinout

A wide selection of alternate functionality is available for multiplexing to various pins. This is shown in the table. The table shows the name of the alternate functionality in the first column, followed by columns showing the possible LOCATION bitfield settings.

Note: Some functionality, such as analog interfaces, do not have alternate settings or a LOCATION bitfield. In these cases, the pinout is shown in the column corresponding to the LOCATION 0.

Table 5.2. Alternate Functionality Overview

| Alternate Functionality | LOCATION | | | | | | | Description |
|----------------------------|----------|---|------|------|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | |
| ADC0_CH0 | PE12 | | | | | | | Analog to digital converter ADC0, input channel number 0. |
| ADC0_CH1 | PE13 | | | | | | | Analog to digital converter ADC0, input channel number 1. |
| ADC0_CH4 | PD4 | | | | | | | Analog to digital converter ADC0, input channel number 4. |
| ADC0_CH5 | PD5 | | | | | | | Analog to digital converter ADC0, input channel number 5. |
| ADC0_CH6 | PD6 | | | | | | | Analog to digital converter ADC0, input channel number 6. |
| ADC0_CH7 | PD7 | | | | | | | Analog to digital converter ADC0, input channel number 7. |
| BOOT_RX | PD6 | | | | | | | Bootloader RX. |
| BOOT_TX | PD7 | | | | | | | Bootloader TX. |
| CMU_CLK0 | | | PD7 | PF2 | | | | Clock Management Unit, clock output number 0. |
| CMU_CLK1 | PA1 | | PE12 | PB11 | | | | Clock Management Unit, clock output number 1. |
| DBG_SWCLK | PF0 | | | | | | | Debug-interface Serial Wire clock input. Note that this function is enabled to pin out of reset, and has a built-in pull down. |
| DBG_SWDIO | PF1 | | | | | | | Debug-interface Serial Wire data input / output. Note that this function is enabled to pin out of reset, and has a built-in pull up. |
| GPIO_EM4WU 0 | PA0 | | | | | | | Pin can be used to wake the system up from EM4 |
| GPIO_EM4WU 2 | PC9 | | | | | | | Pin can be used to wake the system up from EM4 |
| GPIO_EM4WU 3 | PF1 | | | | | | | Pin can be used to wake the system up from EM4 |
| GPIO_EM4WU 4 | PF2 | | | | | | | Pin can be used to wake the system up from EM4 |
| GPIO_EM4WU 5 | PE13 | | | | | | | Pin can be used to wake the system up from EM4 |
| HFX TAL_N | PB14 | | | | | | | High Frequency Crystal negative pin. Also used as external optional clock input pin. |
| HFX TAL_P | PB13 | | | | | | | High Frequency Crystal positive pin. |

| Alternate | LOCATION | | | | | | | Description |
|------------|----------|------|------|------|------|------|------|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | |
| I2C0_SCL | PA1 | PD7 | | | | PF1 | PE13 | I2C0 Serial Clock Line input / output. |
| I2C0_SDA | PA0 | PD6 | | | | PF0 | PE12 | I2C0 Serial Data input / output. |
| IDAC0_OUT | PB11 | | | | | | | IDAC0 output. |
| LEU0_RX | PD5 | PB14 | | PF1 | PA0 | PC15 | | LEUART0 Receive input. |
| LEU0_TX | PD4 | PB13 | | PF0 | PF2 | PC14 | | LEUART0 Transmit output. Also used as receive input in half duplex communication. |
| LFXTAL_N | PB8 | | | | | | | Low Frequency Crystal (typically 32.768 kHz) negative pin. Also used as an optional external clock input pin. |
| LFXTAL_P | PB7 | | | | | | | Low Frequency Crystal (typically 32.768 kHz) positive pin. |
| PCNT0_S0IN | | | | PD6 | PA0 | | | Pulse Counter PCNT0 input number 0. |
| PCNT0_S1IN | PC14 | | | PD7 | PB11 | | | Pulse Counter PCNT0 input number 1. |
| PRS_CH0 | PA0 | PF3 | PC14 | PF2 | | | | Peripheral Reflex System PRS, channel 0. |
| PRS_CH1 | PA1 | PF4 | PC15 | PE12 | | | | Peripheral Reflex System PRS, channel 1. |
| PRS_CH2 | | | PE10 | PE13 | | | | Peripheral Reflex System PRS, channel 2. |
| PRS_CH3 | | | PE11 | PA0 | | | | Peripheral Reflex System PRS, channel 3. |
| TIM0_CC0 | PA0 | PA0 | | | PA0 | PF0 | PA1 | Timer 0 Capture Compare input / output channel 0. |
| TIM0_CC1 | PA1 | PA1 | | | | PF1 | PA0 | Timer 0 Capture Compare input / output channel 1. |
| TIM0_CC2 | | | | | | PF2 | PF2 | Timer 0 Capture Compare input / output channel 2. |
| TIM0_CDT10 | | | | | | PF3 | | Timer 0 Complimentary Deat Time Insertion channel 0. |
| TIM0_CDT11 | | PC14 | | | | PF4 | PC14 | Timer 0 Complimentary Deat Time Insertion channel 1. |
| TIM0_CDT12 | | PC15 | | | | | PC15 | Timer 0 Complimentary Deat Time Insertion channel 2. |
| TIM1_CC0 | | PE10 | | PB7 | PD6 | | | Timer 1 Capture Compare input / output channel 0. |
| TIM1_CC1 | PC14 | PE11 | | PB8 | PD7 | | | Timer 1 Capture Compare input / output channel 1. |
| TIM1_CC2 | PC15 | PE12 | | PB11 | | | | Timer 1 Capture Compare input / output channel 2. |
| TIM2_CC0 | | | PC8 | PF2 | | | | Timer 2 Capture Compare input / output channel 0. |
| TIM2_CC1 | | | PC9 | PE12 | | | | Timer 2 Capture Compare input / output channel 1. |
| TIM2_CC2 | | | PC10 | PE13 | | | | Timer 2 Capture Compare input / output channel 2. |
| US0_CLK | PE12 | | PC9 | PC15 | PB13 | PB13 | PE12 | USART0 clock input / output. |
| US0_CS | PE13 | | PC8 | PC14 | PB14 | PB14 | PE13 | USART0 chip select input / output. |

| Alternate | LOCATION | | | | | | | Description |
|-----------------------|-----------|---|------|------|-----|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | |
| US0_RX | PE11 | | PC10 | PE12 | PB8 | | | USART0 Asynchronous Receive. USART0 Synchronous mode Master Input / Slave Output (MISO). |
| US0_TX | PE10 | | | PE13 | PB7 | | | USART0 Asynchronous Transmit. Also used as receive input in half duplex communication. USART0 Synchronous mode Master Output / Slave Input (MOSI). |
| USB_DM | PC14 | | | | | | | USB D- pin. |
| USB_DMPU | PA0 | | | | | | | USB D- Pullup control. |
| USB_DP | PC15 | | | | | | | USB D+ pin. |
| USB_VREGI | USB_VREGI | | | | | | | USB Input to internal 3.3 V regulator |
| USB_VREGO | USB_VREGO | | | | | | | USB Decoupling for internal 3.3 V USB regulator and regulator output |
| USRF1_RX ¹ | | | PD6 | | | | | USARTRF1 Asynchronous Receive. USARTRF1 Synchronous mode Master Input / Slave Output (MISO). |
| USRF1_TX ¹ | | | PD7 | | | | | USARTRF1 Asynchronous Transmit. Also used as receive input in half duplex communication. USARTRF1 Synchronous mode Master Output / Slave Input (MOSI). |

Note:

1. The USART1 peripheral is shared between the radio and the external (asynchronous) communication and it is not possible to simultaneously use USART1 for external communication and communication with the radio. It is possible but not recommended to alternate between the two functions. If this is done certain precautions in timing and data must be taken. To use USART1 for communicating with the radio, see pins/location# in [Radio MCU Communication Configuration](#) table.

5.4 GPIO Pinout Overview

The specific GPIO pins available in EZR32HG320 are shown in the GPIO pinout table. Each GPIO port is organized as 16-bit ports indicated by letters A through F, and the individual pin on this port is indicated by a number from 15 down to 0.

Table 5.3. GPIO Pinout

| Port | Pin 15 | Pin 14 | Pin 13 | Pin 12 | Pin 11 | Pin 10 | Pin 9 | Pin 8 | Pin 7 | Pin 6 | Pin 5 | Pin 4 | Pin 3 | Pin 2 | Pin 1 | Pin 0 |
|--------|--------|--------|--------|--------|--------|--------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Port A | - | - | - | - | - | - | - | - | - | - | - | - | - | - | PA1 | PA0 |
| Port B | - | PB14 | PB13 | - | PB11 | - | - | PB8 | PB7 | - | - | - | - | - | - | - |
| Port C | PC15 | PC14 | - | - | - | PC10 | PC9 | PC8 | - | - | - | - | - | - | - | - |
| Port D | - | - | - | - | - | - | - | - | PD7 | PD6 | PD5 | PD4 | - | - | - | - |
| Port E | - | - | PE13 | PE12 | PE11 | PE10 | - | - | - | - | - | - | - | - | - | - |
| Port F | - | - | - | - | - | - | - | - | - | - | - | PF4 | PF3 | PF2 | PF1 | PF0 |

5.5 QFN48 Package

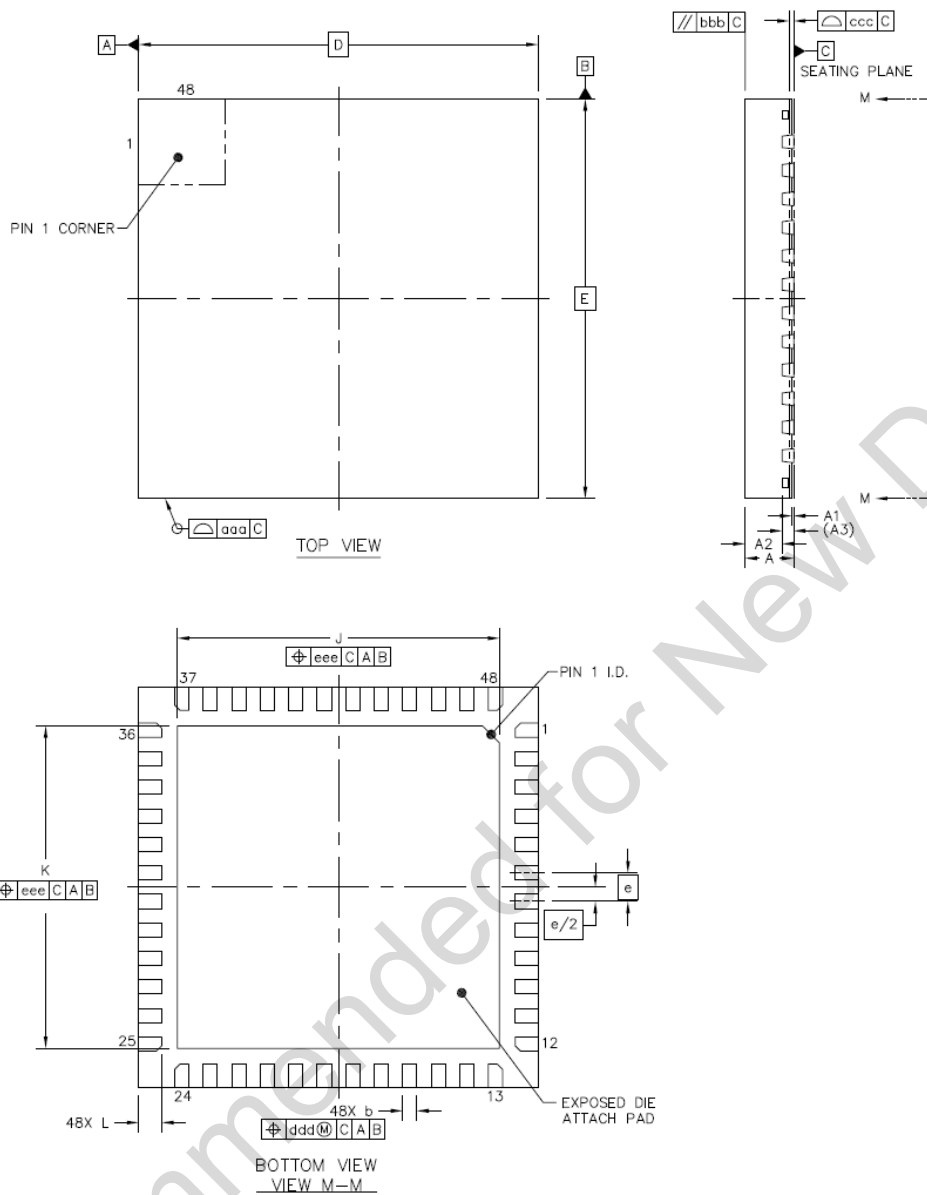


Figure 5.2. QFN48

Note:

1. All dimensions shown are in millimeters (mm) unless otherwise noted.
2. Dimensioning and Tolerancing per ANSI Y14.5M-1994.
3. This drawing conforms to the JEDEC Solid State Outline MO-220, Variation VKKD-4.
4. Recommended card reflow profile is per the JEDEC/IPC J-STD-020 specification for Small Body Components.

Table 5.4. QFN48 (Dimensions in mm)

| Dimension | MIN | NOM | MAX |
|-----------|-----------|-------|------|
| A | 0.80 | 0.85 | 0.90 |
| A1 | 0.00 | 0.035 | 0.05 |
| A2 | --- | 0.65 | 0.67 |
| A3 | 0.203 REF | | |
| b | 0.20 | 0.25 | 0.30 |
| D | 6.90 | 7.00 | 7.10 |
| E | 6.90 | 7.00 | 7.10 |
| J | 5.55 | 5.65 | 5.75 |
| K | 5.55 | 5.65 | 5.75 |
| e | 0.50 BSC | | |
| L | 0.35 | 0.40 | 0.45 |
| aaa | 0.10 | | |
| bbb | 0.10 | | |
| ccc | 0.08 | | |
| ddd | 0.10 | | |
| eee | 0.10 | | |

The QFN48 Package uses Matte Tin plated leadframe. All EZR32 packages are RoHS compliant and free of Bromine (Br) and Antimony (Sb).

For additional Quality and Environmental information, please see: <http://www.silabs.com/support/quality/pages/default.aspx>

6. PCB Layout and Soldering

6.1 Recommended PCB Layout

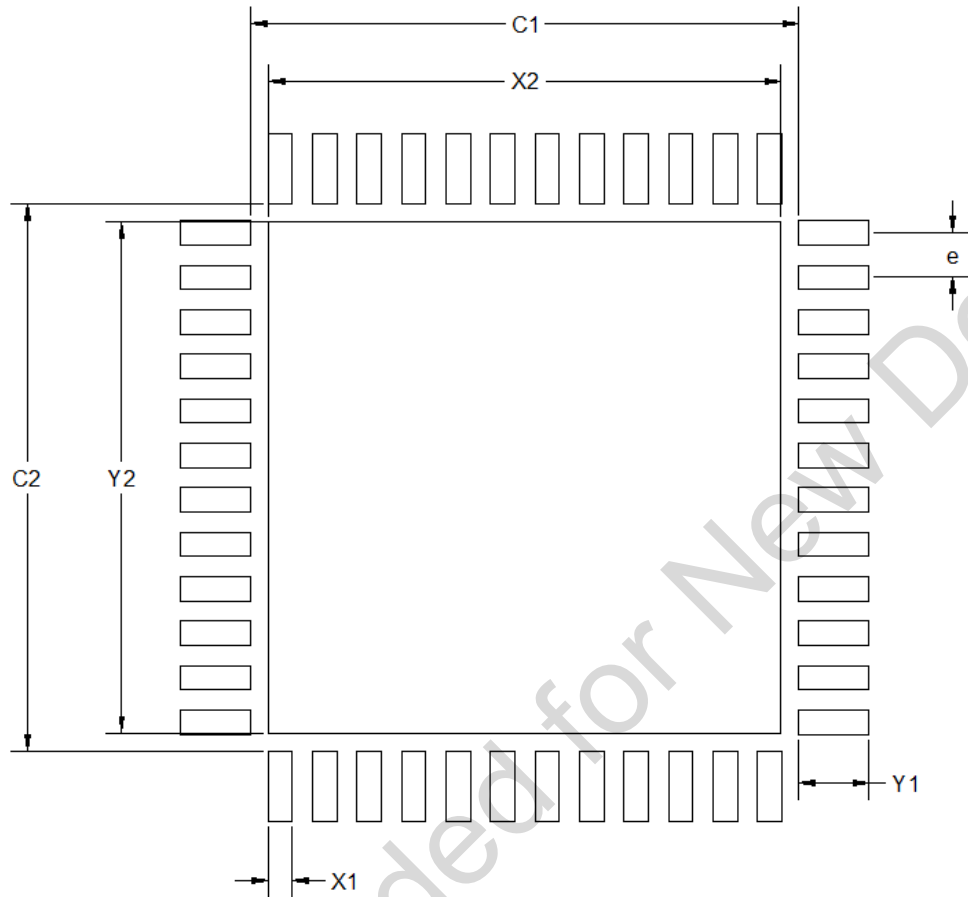


Figure 6.1. PCB Land Pattern

Table 6.1. PCB Land Pattern Dimensions (Dimensions in mm)

| Dimension | MIN | MAX |
|-----------|----------|------|
| C1 | 6.05 | 6.25 |
| C2 | 6.05 | 6.25 |
| e | 0.50 BSC | |
| X1 | 0.17 | 0.37 |
| X2 | 5.65 | 5.85 |
| Y1 | 0.69 | 0.89 |
| Y2 | 5.65 | 5.85 |

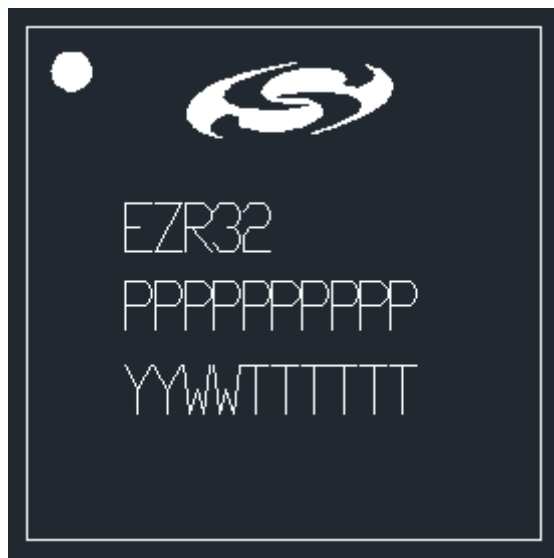
| Dimension | MIN | MAX |
|--|-----|-----|
| Note: | | |
| General | | |
| <ol style="list-style-type: none">1. All dimensions shown are in millimeters (mm) unless otherwise noted.2. This Land Pattern Design is based on the IPC-7351 guidelines. | | |
| Solder Mask Design | | |
| <ol style="list-style-type: none">1. All metal pads are to be non-solder mask defined (NSMD). Clearance between the solder mask and the metal pad is to be 60 μm minimum, all the way around the pad. | | |
| Stencil Design | | |
| <ol style="list-style-type: none">1. A stainless steel, laser-cut and electro-polished stencil with trapezoidal walls should be used to assure good solder paste release.2. The stencil thickness should be 0.125 mm (5 mils).3. The ratio of stencil aperture to land pad size should be 1:1 for all perimeter pads.4. A 4x4 array of 1.1 mm square openings on 1.3 mm pitch should be used for the center ground pad. | | |
| Card Assembly | | |
| <ol style="list-style-type: none">1. A No-Clean, Type-3 solder paste is recommended.2. The recommended card reflow profile is per the JEDEC/IPC J-STD-020 specification for Small Body Components. | | |

6.2 Soldering Information

The latest IPC/JEDEC J-STD-020 recommendations for Pb-Free reflow soldering should be followed.

7. Top Marking

The top marking is illustrated and explained below.



| | | |
|------------------------|---|--|
| Mark Method: | Laser | |
| Logo Size: | Top center | |
| Font Size: | 0.71 mm Left-Justified | |
| Line 1 Marking: | FFFFFFFF = Family Part Number (EZR32)EZR32 | Refer to the line marking instruction from assembly PO. |
| Line 2 Marking: | P1P2P3P4P5P6P7 = Part Number <ul style="list-style-type: none"> • P₁P₂: HG = Happy Gecko • P₃P₄P₅: 320 (USB) • P₆P₇: Flash Size <ul style="list-style-type: none"> • FD = 32 • FE = 64 | <ul style="list-style-type: none"> • P₈P₉: Radio <ul style="list-style-type: none"> • 55 = EZRadio +13 dBm, -116 sensitivity • 60 = EZRadioPRO +13 dBm, -129-126 sensitivity • 61 = EZRadioPRO +16 dBm, -129-126 sensitivity • 63 = EZRadioPRO +20 dBm, -129-126 sensitivity • 67 = EZRadioPRO +13 dBm, -133 sensitivity • 68 = EZRadioPRO +20 dBm, -133 sensitivity • 69 = EZRadioPRO +13 & 20 dBm, -133 sensitivity • P₁₀: Temperature Range <ul style="list-style-type: none"> • G = -40 — 85 °C |
| Line 3 Marking: | YY = Year | Assigned by the Assembly House. |
| | WW = Work Week | Corresponds to the year and work week of the mold date. |
| | TTTTTT = Mfg Code | Manufacturing Code from the Assembly Purchase Order from assembly PO. |
| Line 4 Marking: | Circle = 1.3 mm diameter; center justified | "e3" Pb-Free Symbol |
| | Gecko Logo; right justified | Gecko Logo height = 1.90 mm |

8. Revision History

Revision 1.4

March, 2024

- Updated [2. Ordering Information](#) to note NRND and EOL parts.

Revision 1.3

January, 2023

- Updated [2. Ordering Information](#) table with radio chip revision and noted NRND parts.

Revision 1.2

April, 2020

- In [4.11 Analog Digital Converter \(ADC\)](#):
 - Updated test conditions, updated specifications, and added footnote for average active current.
 - Added input bias current. • Added input offset current.
 - Updated ADC clock frequency.
 - Input ON resistance (R_{ADCIN}) changed from 1 M Ω minimum to 300 Ω minimum and 800 Ω maximum.
 - Updated SNR, SINAD and SFDR.
 - Updated offset voltage.
 - Updated missing codes specification (MC_{ADC}).
 - Added gain error drift and offset error drift.
 - Removed ADC internal voltage reference.
 - Added VREF output voltage, VREF voltage drift, VREF temperature drift, VREF current consumption, and ADC and DAC VREF matching.

Revision 1.1

August, 2019

- Updated [2. Ordering Information](#) for the release of revision C devices.
- Added footnote to USRF1_TX and USRF1_RX in [5.3 Alternate Functionality Pinout](#).
- Updated [6.1 Recommended PCB Layout](#) to fix typographical error.
- New formatting throughout

Revision 1.0

- Added R69 content.

Revision 0.4

- Removed content currently documented the RFI database:
 - Environmental Table from the Electrical Specifications chapter
 - Moisture Sensitivity Level in the Soldering Information section

Revision 0.3

- Updated Current Consumption table
- Updated Power Management table
- Revised text describing LFXO Oscillator: “energyAware Designer” to “Configurator tool”
- Updated HFXO oscillator table, fHXFO parameter changed: “Supported nominal crystal Frequency” to “Supported frequency, any mode”
- Updated LFRCO table
- Updated HFRCO table
- Updated AUXHFRCO table
- Updated USHFRCO table
- Updated ADC table
- Added USB electrical table

Revision 0.2

- Initial release

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