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EFM[®]32

... the world's most energy friendly microcontrollers

EFM32WG360 DATASHEET

F256/F128/F64

- **ARM Cortex-M4 CPU platform**
 - High Performance 32-bit processor @ up to 48 MHz
 - DSP instruction support and floating-point unit
 - Memory Protection Unit
- **Flexible Energy Management System**
 - 20 nA @ 3 V Shutoff Mode
 - 0.4 µA @ 3 V Shutoff Mode with RTC
 - 0.65 µA @ 3 V Stop Mode, including Power-on Reset, Brown-out Detector, RAM and CPU retention
 - 0.95 µA @ 3 V Deep Sleep Mode, including RTC with 32.768 kHz oscillator, Power-on Reset, Brown-out Detector, RAM and CPU retention
 - 63 µA/MHz @ 3 V Sleep Mode
 - 225 µA/MHz @ 3 V Run Mode, with code executed from flash
- **256/128/64 KB Flash**
- **32 KB RAM**
- **65 General Purpose I/O pins**
 - Configurable push-pull, open-drain, pull-up/down, input filter, drive strength
 - Configurable peripheral I/O locations
 - 16 asynchronous external interrupts
 - Output state retention and wake-up from Shutoff Mode
- **12 Channel DMA Controller**
- **12 Channel Peripheral Reflex System (PRS) for autonomous inter-peripheral signaling**
- **Hardware AES with 128/256-bit keys in 54/75 cycles**
- **Timers/Counters**
 - 4× 16-bit Timer/Counter
 - 4×3 Compare/Capture/PWM channels
 - Dead-Time Insertion on TIMER0
 - 16-bit Low Energy Timer
 - 1× 24-bit Real-Time Counter and 1× 32-bit Real-Time Counter
 - 3× 16/8-bit Pulse Counter
 - Watchdog Timer with dedicated RC oscillator @ 50 nA
- **Backup Power Domain**
 - RTC and retention registers in a separate power domain, available in all energy modes
 - Operation from backup battery when main power drains out
- **Communication interfaces**
 - 3× Universal Synchronous/Asynchronous Receiver/Transmitter
 - UART/SPI/SmartCard (ISO 7816)/IrDA/I2S
 - 2× Universal Asynchronous Receiver/Transmitter
 - 2× Low Energy UART
 - Autonomous operation with DMA in Deep Sleep Mode
 - 2× I²C Interface with SMBus support
 - Address recognition in Stop Mode
 - Universal Serial Bus (USB) with Host & OTG support
 - Fully USB 2.0 compliant
 - On-chip PHY and embedded 5V to 3.3V regulator
- **Ultra low power precision analog peripherals**
 - 12-bit 1 Msamples/s Analog to Digital Converter
 - 8 single ended channels/4 differential channels
 - On-chip temperature sensor
 - 12-bit 500 ksamples/s Digital to Analog Converter
 - 2× Analog Comparator
 - Capacitive sensing with up to 16 inputs
 - 3× Operational Amplifier
 - 6.1 MHz GBW, Rail-to-rail, Programmable Gain
 - Supply Voltage Comparator
- **Low Energy Sensor Interface (LESENSE)**
 - Autonomous sensor monitoring in Deep Sleep Mode
 - Wide range of sensors supported, including LC sensors and capacitive buttons
- **Ultra efficient Power-on Reset and Brown-Out Detector**
- **Debug Interface**
 - 2-pin Serial Wire Debug interface
 - 1-pin Serial Wire Viewer
 - Embedded Trace Module v3.5 (ETM)
- **Pre-Programmed USB/UART Bootloader**
- **Temperature range -40 to 85 °C**
- **Single power supply 1.98 to 3.8 V**
- **CSP81 package**

32-bit ARM Cortex-M0+, Cortex-M3 and Cortex-M4 microcontrollers for:

- Energy, gas, water and smart metering
- Health and fitness applications
- Smart accessories
- Alarm and security systems
- Industrial and home automation



1 Ordering Information

Table 1.1 (p. 2) shows the available EFM32WG360 devices.

Table 1.1. Ordering Information

Ordering Code	Flash (kB)	RAM (kB)	Max Speed (MHz)	Supply Voltage (V)	Temperature (°C)	Package
EFM32WG360F64G-A-CSP81	64	32	48	1.98 - 3.8	-40 - 85	CSP81
EFM32WG360F128G-A-CSP81	128	32	48	1.98 - 3.8	-40 - 85	CSP81
EFM32WG360F256G-A-CSP81	256	32	48	1.98 - 3.8	-40 - 85	CSP81

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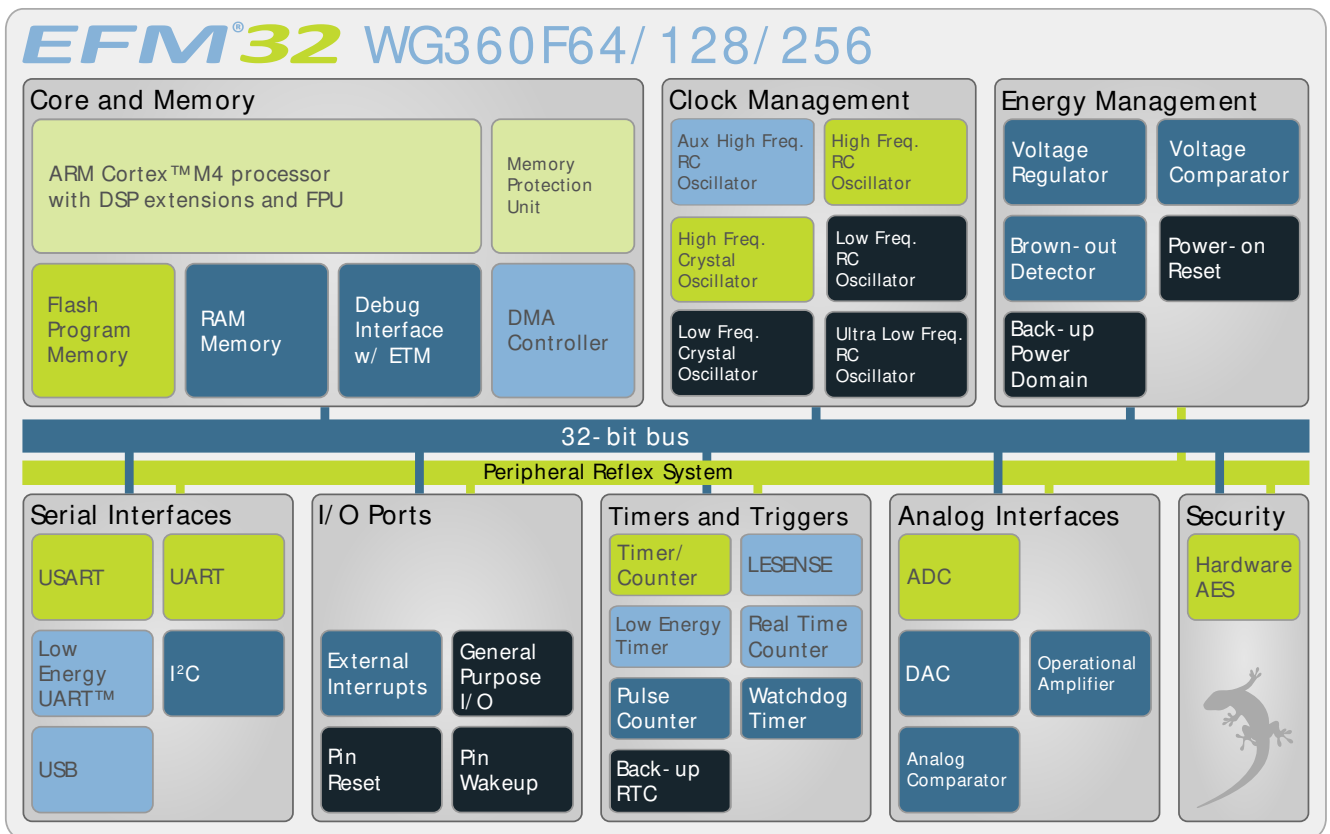
2 System Summary

2.1 System Introduction

The EFM32 MCUs are the world's most energy friendly microcontrollers. With a unique combination of the powerful 32-bit ARM Cortex-M4, with DSP instruction support and floating-point unit, innovative low energy techniques, short wake-up time from energy saving modes, and a wide selection of peripherals, the EFM32WG microcontroller is well suited for any battery operated application as well as other systems requiring high performance and low-energy consumption. This section gives a short introduction to each of the modules in general terms and also shows a summary of the configuration for the EFM32WG360 devices. For a complete feature set and in-depth information on the modules, the reader is referred to the *EFM32WG Reference Manual*.

A block diagram of the EFM32WG360 is shown in Figure 2.1 (p. 3) .

Figure 2.1. Block Diagram



2.1.1 ARM Cortex-M4 Core

The ARM Cortex-M4 includes a 32-bit RISC processor, with DSP instruction support and floating-point unit, which can achieve as much as 1.25 Dhrystone MIPS/MHz. A Memory Protection Unit with support for up to 8 memory segments is included, as well as a Wake-up Interrupt Controller handling interrupts triggered while the CPU is asleep. The EFM32 implementation of the Cortex-M4 is described in detail in *ARM Cortex-M4 Devices Generic User Guide*.

2.1.2 Debug Interface (DBG)

This device includes hardware debug support through a 2-pin serial-wire debug interface and an Embedded Trace Module (ETM) for data/instruction tracing. In addition there is also a 1-wire Serial Wire Viewer pin which can be used to output profiling information, data trace and software-generated messages.

2.1.3 Memory System Controller (MSC)

The Memory System Controller (MSC) is the program memory unit of the EFM32WG microcontroller. The flash memory is readable and writable from both the Cortex-M4 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.

2.1.4 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.

2.1.5 Reset Management Unit (RMU)

The RMU is responsible for handling the reset functionality of the EFM32WG.

2.1.6 Energy Management Unit (EMU)

The Energy Management Unit (EMU) manage all the low energy modes (EM) in EFM32WG 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.

2.1.7 Clock Management Unit (CMU)

The Clock Management Unit (CMU) is responsible for controlling the oscillators and clocks on-board the EFM32WG. 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.

2.1.8 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 e.g. be caused by an external event, such as an ESD pulse, or by a software failure.

2.1.9 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.

2.1.10 Universal Serial Bus Controller (USB)

The USB is a full-speed USB 2.0 compliant OTG host/device controller. The USB can be used in Device, On-the-go (OTG) Dual Role Device or Host-only configuration. In OTG mode the USB supports both Host Negotiation Protocol (HNP) and Session Request Protocol (SRP). The device supports both full-speed (12MBit/s) and low speed (1.5MBit/s) operation. The USB device includes an internal dedicated Descriptor-Based Scatter/Gather DMA and supports up to 6 OUT endpoints and 6 IN endpoints, in addition to endpoint 0. The on-chip PHY includes all OTG features, except for the voltage booster for supplying 5V to VBUS when operating as host.

2.1.11 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.

2.1.12 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 SmartCards, IrDA and I2S devices.

2.1.13 Pre-Programmed USB/UART Bootloader

The bootloader presented in application note AN0042 is pre-programmed in the device at factory. The bootloader enables users to program the EFM32 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.

2.1.14 Universal Asynchronous Receiver/Transmitter (UART)

The Universal Asynchronous serial Receiver and Transmitter (UART) is a very flexible serial I/O module. It supports full- and half-duplex asynchronous UART communication.

2.1.15 Low Energy Universal Asynchronous Receiver/Transmitter (LEUART)

The unique 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.

2.1.16 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.

2.1.17 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.

2.1.18 Backup Real Time Counter (BURTC)

The Backup Real Time Counter (BURTC) contains a 32-bit counter and is clocked either by a 32.768 kHz crystal oscillator, a 32.768 kHz RC oscillator or a 1 kHz ULFRACO. The BURTC is available in all Energy Modes and it can also run in backup mode, making it operational even if the main power should drain out.

2.1.19 Low Energy Timer (LETIMER)

The unique LETIMER[™], the Low Energy Timer, is a 16-bit timer that is available in energy mode EM2 in addition to EM1 and EM0. Because of this, it can be used for timing and output generation when most of the device is powered down, allowing simple tasks to be performed while the power consumption of the system is kept at an absolute minimum. The LETIMER can be used to output a variety of waveforms with minimal software intervention. It is also connected to the Real Time Counter (RTC), and can be configured to start counting on compare matches from the RTC.

2.1.20 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.

2.1.21 Analog Comparator (ACMP)

The Analog Comparator is used to compare the voltage of two analog inputs, with a digital output indicating which input voltage is higher. Inputs can either be one of the selectable internal references or from external pins. Response time and thereby also the current consumption can be configured by altering the current supply to the comparator.

2.1.22 Voltage Comparator (VCMP)

The Voltage Supply Comparator 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.

2.1.23 Analog to Digital Converter (ADC)

The 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 8 external pins and 6 internal signals.

2.1.24 Digital to Analog Converter (DAC)

The Digital to Analog Converter (DAC) can convert a digital value to an analog output voltage. The DAC is fully differential rail-to-rail, with 12-bit resolution. It has two single ended output buffers which can be combined into one differential output. The DAC may be used for a number of different applications such as sensor interfaces or sound output.

2.1.25 Operational Amplifier (OPAMP)

The EFM32WG360 features 3 Operational Amplifiers. The Operational Amplifier is a versatile general purpose amplifier with rail-to-rail differential input and rail-to-rail single ended output. The input can be set to pin, DAC or OPAMP, whereas the output can be pin, OPAMP or ADC. The current is programmable and the OPAMP has various internal configurations such as unity gain, programmable gain using internal resistors etc.

2.1.26 Low Energy Sensor Interface (LESENSE)

The Low Energy Sensor Interface (LESENSE[™]), is a highly configurable sensor interface with support for up to 16 individually configurable sensors. By controlling the analog comparators and DAC, LESENSE is capable of supporting a wide range of sensors and measurement schemes, and can for instance measure LC sensors, resistive sensors and capacitive sensors. LESENSE also includes a programmable FSM which enables simple processing of measurement results without CPU intervention. LESENSE is

available in energy mode EM2, in addition to EM0 and EM1, making it ideal for sensor monitoring in applications with a strict energy budget.

2.1.27 Backup Power Domain

The backup power domain is a separate power domain containing a Backup Real Time Counter, BURTC, and a set of retention registers, available in all energy modes. This power domain can be configured to automatically change power source to a backup battery when the main power drains out. The backup power domain enables the EFM32WG360 to keep track of time and retain data, even if the main power source should drain out.

2.1.28 Advanced Encryption Standard Accelerator (AES)

The AES accelerator performs AES encryption and decryption with 128-bit or 256-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.

2.1.29 General Purpose Input/Output (GPIO)

In the EFM32WG360, there are 65 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.

2.2 Configuration Summary

The features of the EFM32WG360 is a subset of the feature set described in the EFM32WG Reference Manual. Table 2.1 (p. 7) describes device specific implementation of the features.

Table 2.1. Configuration Summary

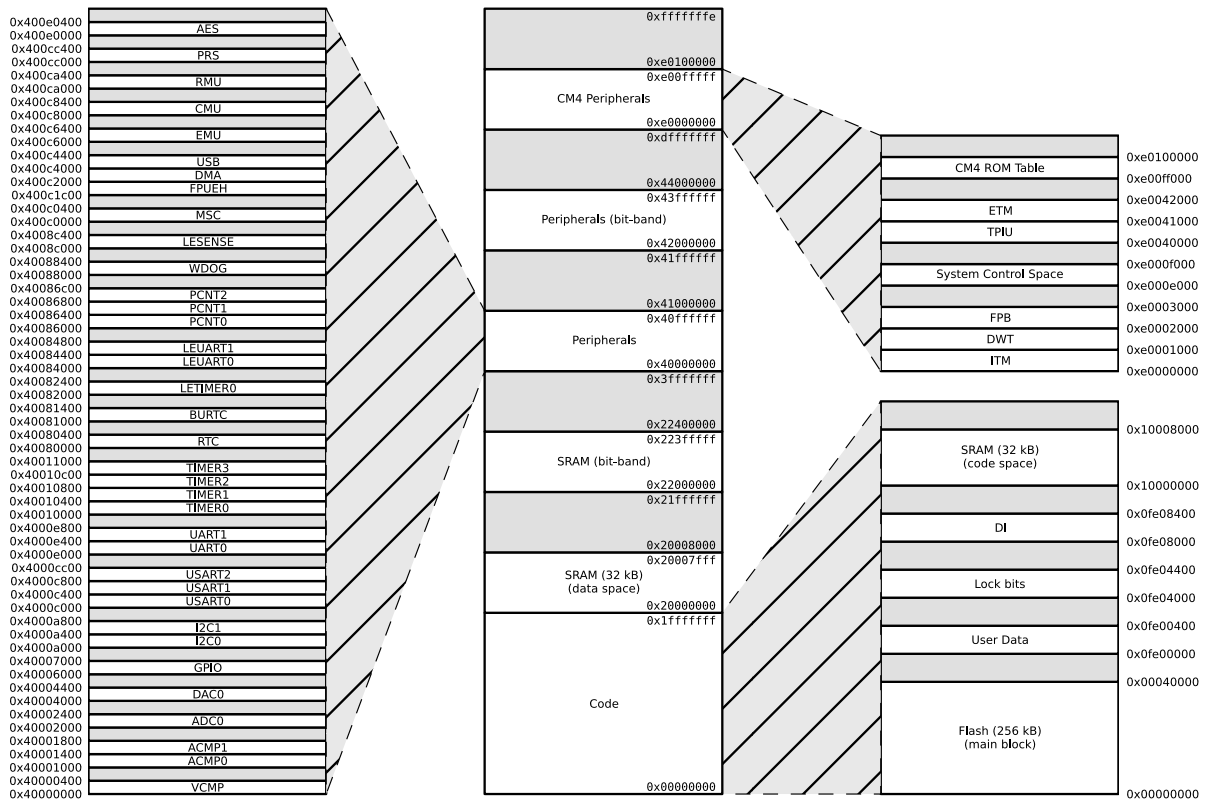
Module	Configuration	Pin Connections
Cortex-M4	Full configuration	NA
DBG	Full configuration	DBG_SWCLK, DBG_SWDIO, DBG_SWO
MSC	Full configuration	NA
DMA	Full configuration	NA
RMU	Full configuration	NA
EMU	Full configuration	NA
CMU	Full configuration	CMU_OUT0, CMU_OUT1
WDOG	Full configuration	NA
PRS	Full configuration	NA
USB	Full configuration	USB_VBUS, USB_VBUSEN, USB_VREGI, USB_VREGO, USB_DM, USB_DMPU, USB_DP, USB_ID

Module	Configuration	Pin Connections
I2C0	Full configuration	I2C0_SDA, I2C0_SCL
I2C1	Full configuration	I2C1_SDA, I2C1_SCL
USART0	Full configuration with IrDA	US0_TX, US0_RX, US0_CLK, US0_CS
USART1	Full configuration with I2S	US1_TX, US1_RX, US1_CLK, US1_CS
USART2	Full configuration with I2S	US2_TX, US2_RX, US2_CLK, US2_CS
UART0	Full configuration	U0_TX, U0_RX
UART1	Full configuration	U1_TX, U1_RX
LEUART0	Full configuration	LEU0_TX, LEU0_RX
LEUART1	Full configuration	LEU1_TX, LEU1_RX
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]
TIMER3	Full configuration	TIM3_CC[2:0]
RTC	Full configuration	NA
BURTC	Full configuration	NA
LETIMER0	Full configuration	LET0_O[1:0]
PCNT0	Full configuration, 16-bit count register	PCNT0_S[1:0]
PCNT1	Full configuration, 8-bit count register	PCNT1_S[1:0]
PCNT2	Full configuration, 8-bit count register	PCNT2_S[1:0]
ACMP0	Full configuration	ACMP0_CH[7:0], ACMP0_O
ACMP1	Full configuration	ACMP1_CH[7:0], ACMP1_O
VCMP	Full configuration	NA
ADC0	Full configuration	ADC0_CH[7:0]
DAC0	Full configuration	DAC0_OUT[1:0], DAC0_OUTxALT
OPAMP	Full configuration	Outputs: OPAMP_OUTx, OPAMP_OUTxALT, Inputs: OPAMP_Px, OPAMP_Nx
AES	Full configuration	NA
GPIO	65 pins	Available pins are shown in Table 4.3 (p. 62)

2.3 Memory Map

The *EFM32WG360* memory map is shown in Figure 2.2 (p. 9), with RAM and Flash sizes for the largest memory configuration.

Figure 2.2. EFM32WG360 Memory Map with largest RAM and Flash sizes



3 Electrical Characteristics

3.1 Test Conditions

3.1.1 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 3.2 (p. 10), by simulation and/or technology characterisation unless otherwise specified.

3.1.2 Minimum and Maximum Values

The minimum and maximum values represent the worst conditions of ambient temperature, supply voltage and frequencies, as defined in Table 3.2 (p. 10), by simulation and/or technology characterisation unless otherwise specified.

3.2 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 Table 3.1 (p. 10) may affect the device reliability or cause permanent damage to the device. Functional operating conditions are given in Table 3.2 (p. 10).

Table 3.1. Absolute Maximum Ratings

Symbol	Parameter	Condition	Min	Typ	Max	Unit
T_{STG}	Storage temperature range		-40		150 ¹	$^{\circ}\text{C}$
T_S	Maximum soldering temperature	Latest IPC/JEDEC J-STD-020 Standard			260	$^{\circ}\text{C}$
V_{DDMAX}	External main supply voltage		0		3.8	V
V_{IOPIN}	Voltage on any I/O pin		-0.3		$V_{DD}+0.3$	V

¹Based on programmed devices tested for 10000 hours at 150°C . Storage temperature affects retention of preprogrammed calibration values stored in flash. Please refer to the Flash section in the Electrical Characteristics for information on flash data retention for different temperatures.

3.3 General Operating Conditions

3.3.1 General Operating Conditions

Table 3.2. General Operating Conditions

Symbol	Parameter	Min	Typ	Max	Unit
T_{AMB}	Ambient temperature range	-40		85	$^{\circ}\text{C}$
V_{DDOP}	Operating supply voltage	1.98		3.8	V
f_{APB}	Internal APB clock frequency			48	MHz
f_{AHB}	Internal AHB clock frequency			48	MHz

3.3.2 Environmental

WLCSP devices can be handled and soldered using industry standard surface mount assembly techniques. However, because WLCSP devices are essentially a piece of silicon and are not encapsulated

in plastic, they are susceptible to mechanical damage and may be sensitive to light. When WLCSPs must be used in an environment exposed to light, it may be necessary to cover the top and sides with an opaque material.

3.4 Current Consumption

Table 3.3. Current Consumption

Symbol	Parameter	Condition	Min	Typ	Max	Unit
I _{EM0}	EM0 current. No prescaling. Running prime number calculation code from Flash. (Production test condition = 14 MHz)	48 MHz HFXO, all peripheral clocks disabled, V _{DD} = 3.0 V, T _{AMB} =25°C		225	236	μA/MHz
		48 MHz HFXO, all peripheral clocks disabled, V _{DD} = 3.0 V, T _{AMB} =85°C		225		μA/MHz
		28 MHz HFRCO, all peripheral clocks disabled, V _{DD} = 3.0 V, T _{AMB} =25°C		226	238	μA/MHz
		28 MHz HFRCO, all peripheral clocks disabled, V _{DD} = 3.0 V, T _{AMB} =85°C		227		μA/MHz
		21 MHz HFRCO, all peripheral clocks disabled, V _{DD} = 3.0 V, T _{AMB} =25°C		228	240	μA/MHz
		21 MHz HFRCO, all peripheral clocks disabled, V _{DD} = 3.0 V, T _{AMB} =85°C		229		μA/MHz
		14 MHz HFRCO, all peripheral clocks disabled, V _{DD} = 3.0 V, T _{AMB} =25°C		230	243	μA/MHz
		14 MHz HFRCO, all peripheral clocks disabled, V _{DD} = 3.0 V, T _{AMB} =85°C		231		μA/MHz
		11 MHz HFRCO, all peripheral clocks disabled, V _{DD} = 3.0 V, T _{AMB} =25°C		232	245	μA/MHz
		11 MHz HFRCO, all peripheral clocks disabled, V _{DD} = 3.0 V, T _{AMB} =85°C		233		μA/MHz
		6.6 MHz HFRCO, all peripheral clocks disabled, V _{DD} = 3.0 V, T _{AMB} =25°C		238	250	μA/MHz
		6.6 MHz HFRCO, all peripheral clocks disabled, V _{DD} = 3.0 V, T _{AMB} =85°C		238		μA/MHz
		1.2 MHz HFRCO, all peripheral clocks disabled, V _{DD} = 3.0 V, T _{AMB} =25°C		271	286	μA/MHz
		1.2 MHz HFRCO, all peripheral clocks disabled, V _{DD} = 3.0 V, T _{AMB} =85°C		275		μA/MHz
I _{EM1}	EM1 current (Production test condition = 14 MHz)	48 MHz HFXO, all peripheral clocks disabled, V _{DD} = 3.0 V, T _{AMB} =25°C		63	75	μA/MHz

Symbol	Parameter	Condition	Min	Typ	Max	Unit
		48 MHz HF XO, all peripheral clocks disabled, V _{DD} = 3.0 V, T _{AMB} =85°C		65	76	µA/ MHz
		28 MHz HFRCO, all peripheral clocks disabled, V _{DD} = 3.0 V, T _{AMB} =25°C		64	75	µA/ MHz
		28 MHz HFRCO, all peripheral clocks disabled, V _{DD} = 3.0 V, T _{AMB} =85°C		65	77	µA/ MHz
		21 MHz HFRCO, all peripheral clocks disabled, V _{DD} = 3.0 V, T _{AMB} =25°C		65	76	µA/ MHz
		21 MHz HFRCO, all peripheral clocks disabled, V _{DD} = 3.0 V, T _{AMB} =85°C		66	78	µA/ MHz
		14 MHz HFRCO, all peripheral clocks disabled, V _{DD} = 3.0 V, T _{AMB} =25°C		67	79	µA/ MHz
		14 MHz HFRCO, all peripheral clocks disabled, V _{DD} = 3.0 V, T _{AMB} =85°C		68	82	µA/ MHz
		11 MHz HFRCO, all peripheral clocks disabled, V _{DD} = 3.0 V, T _{AMB} =25°C		68	81	µA/ MHz
		11 MHz HFRCO, all peripheral clocks disabled, V _{DD} = 3.0 V, T _{AMB} =85°C		70	83	µA/ MHz
		6.6 MHz HFRCO, all peripheral clocks disabled, V _{DD} = 3.0 V, T _{AMB} =25°C		74	87	µA/ MHz
		6.6 MHz HFRCO, all peripheral clocks disabled, V _{DD} = 3.0 V, T _{AMB} =85°C		76	89	µA/ MHz
		1.2 MHz HFRCO. all peripheral clocks disabled, V _{DD} = 3.0 V, T _{AMB} =25°C		106	120	µA/ MHz
		1.2 MHz HFRCO. all peripheral clocks disabled, V _{DD} = 3.0 V, T _{AMB} =85°C		112	129	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		0.95 ¹	1.7 ¹	µA
		EM2 current with RTC prescaled to 1 Hz, 32.768 kHz LFRCO, V _{DD} = 3.0 V, T _{AMB} =85°C		3.0 ¹	4.0 ¹	µA
I _{EM3}	EM3 current	V _{DD} = 3.0 V, T _{AMB} =25°C		0.65	1.3	µA
		V _{DD} = 3.0 V, T _{AMB} =85°C		2.65	4.0	µA
I _{EM4}	EM4 current	V _{DD} = 3.0 V, T _{AMB} =25°C		0.02	0.055	µA
		V _{DD} = 3.0 V, T _{AMB} =85°C		0.44	0.9	µA

¹Using backup RTC.

3.4.1 EM1 Current Consumption

Figure 3.1. EM1 Current consumption with all peripheral clocks disabled and HFXO running at 48 MHz

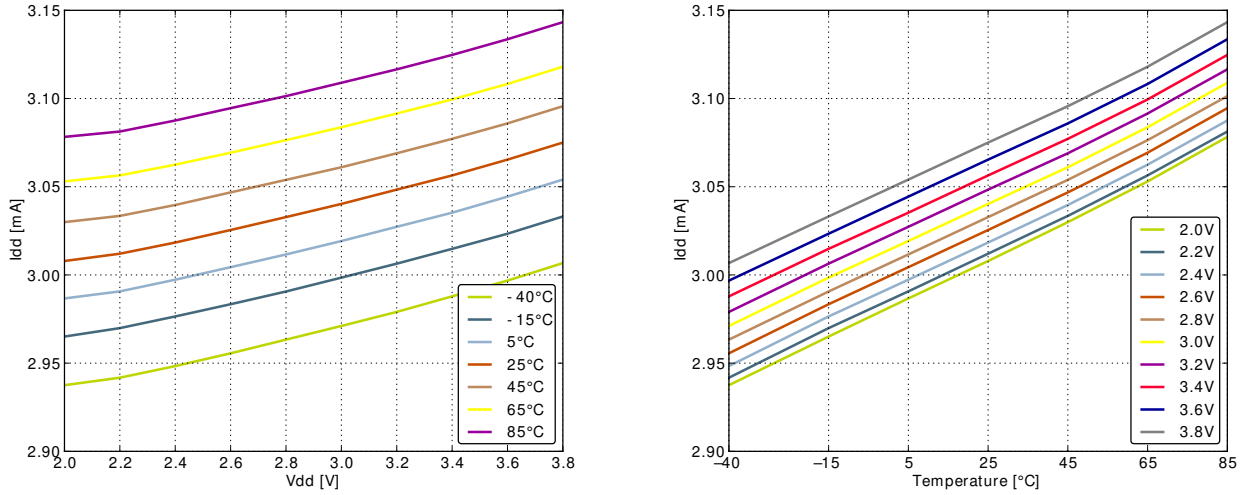


Figure 3.2. EM1 Current consumption with all peripheral clocks disabled and HFRCO running at 28 MHz

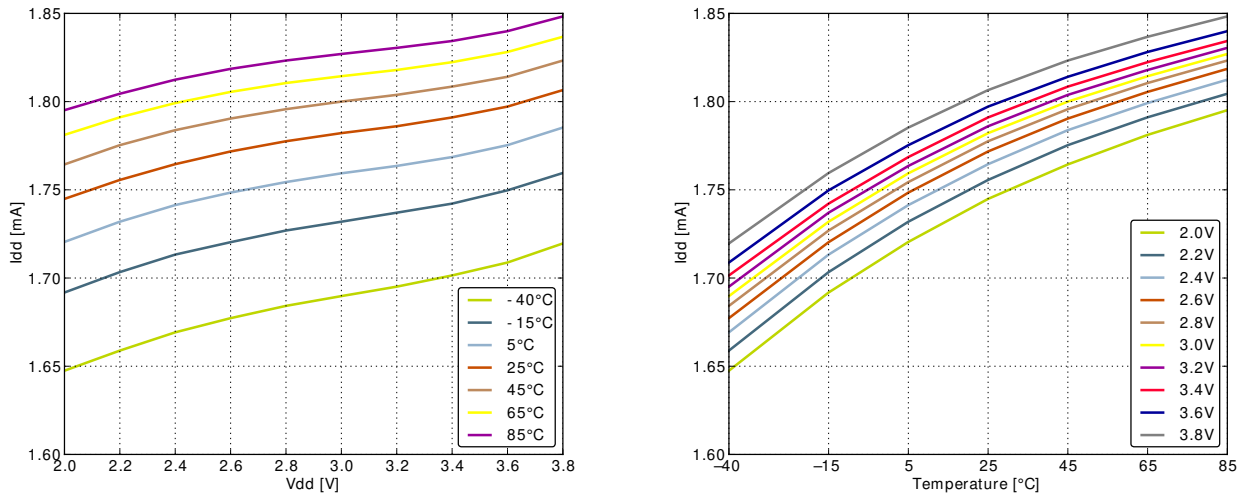


Figure 3.3. EM1 Current consumption with all peripheral clocks disabled and HFRCO running at 21 MHz

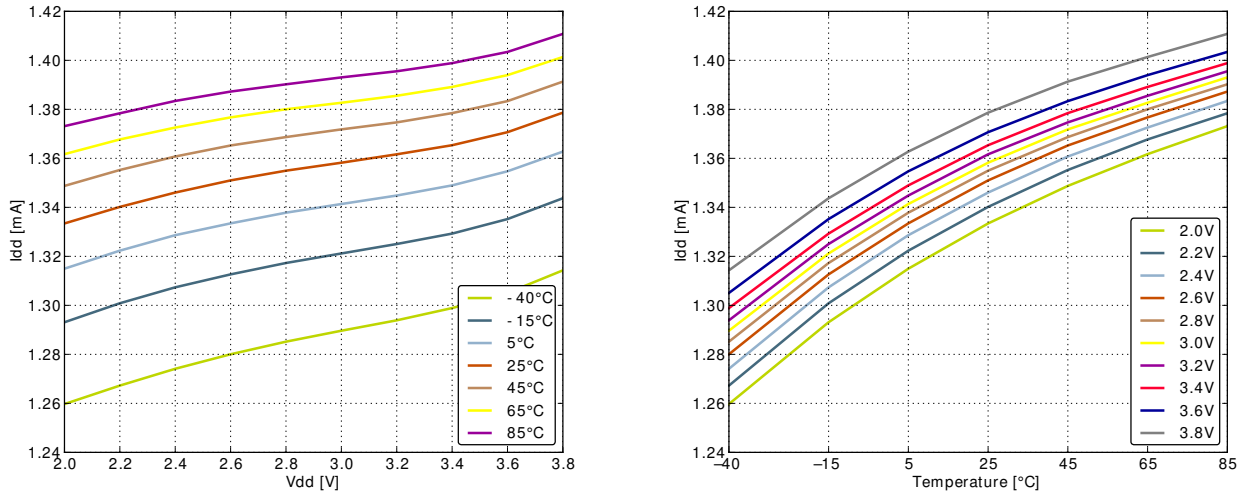


Figure 3.4. EM1 Current consumption with all peripheral clocks disabled and HFRCO running at 14 MHz

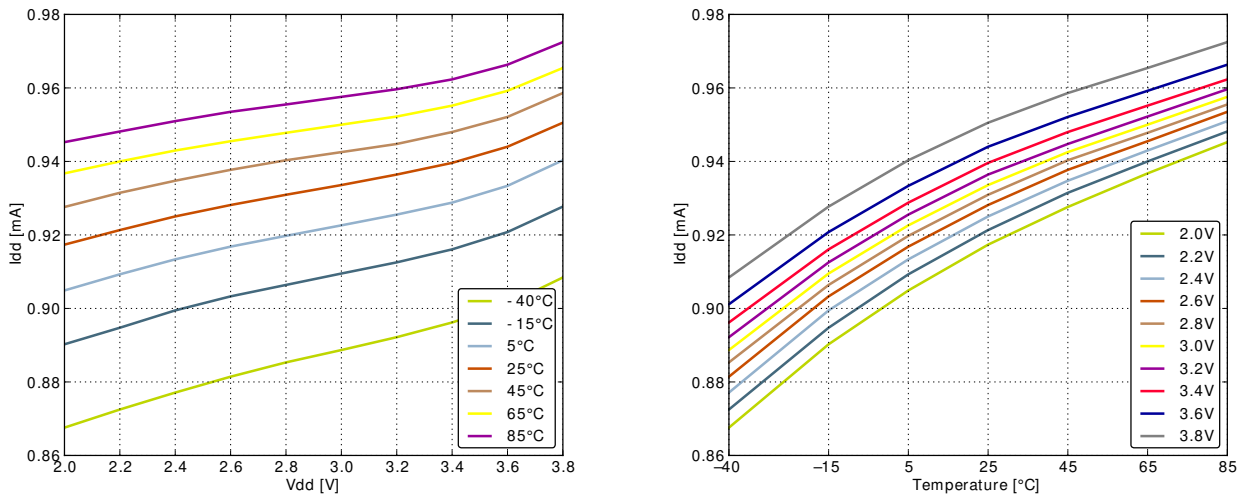


Figure 3.5. EM1 Current consumption with all peripheral clocks disabled and HFRCO running at 11 MHz

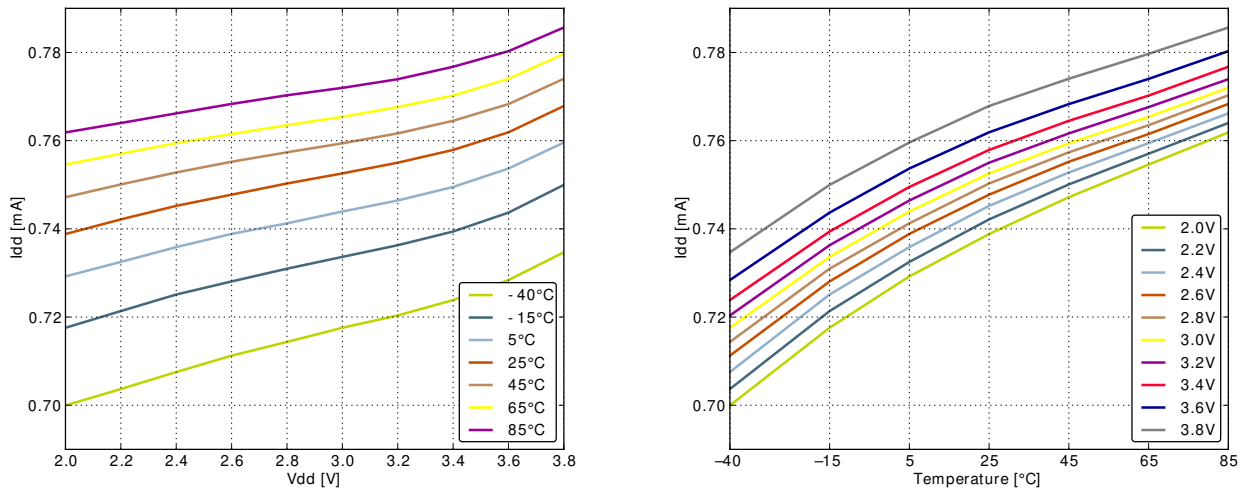


Figure 3.6. EM1 Current consumption with all peripheral clocks disabled and HFRCO running at 6.6 MHz

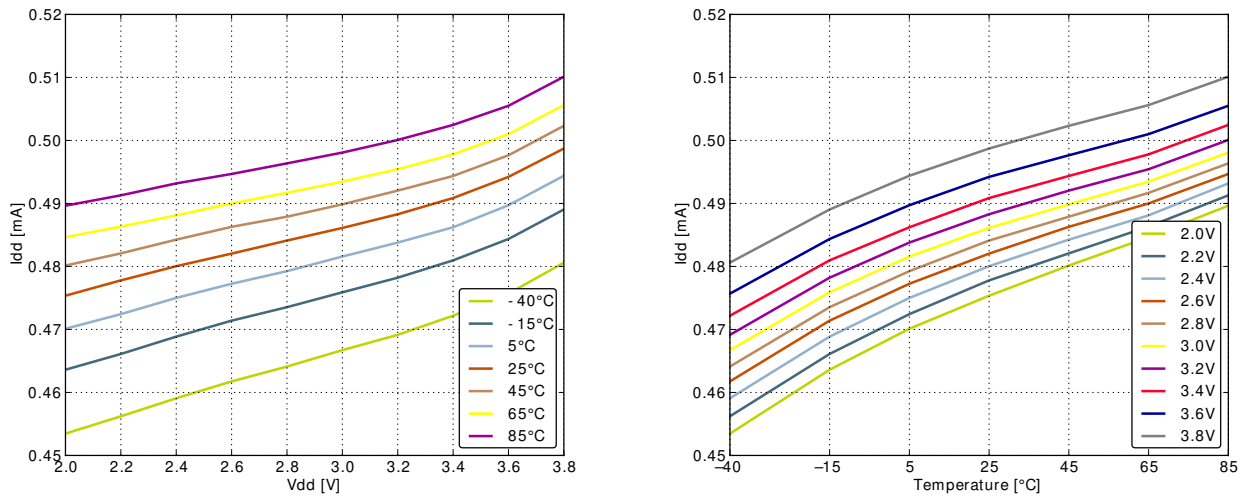
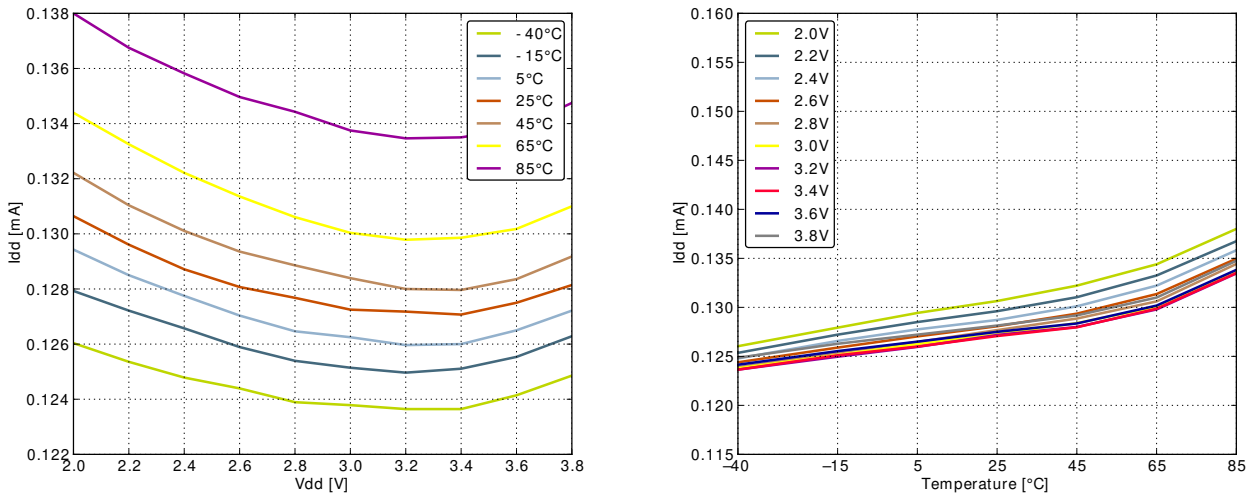
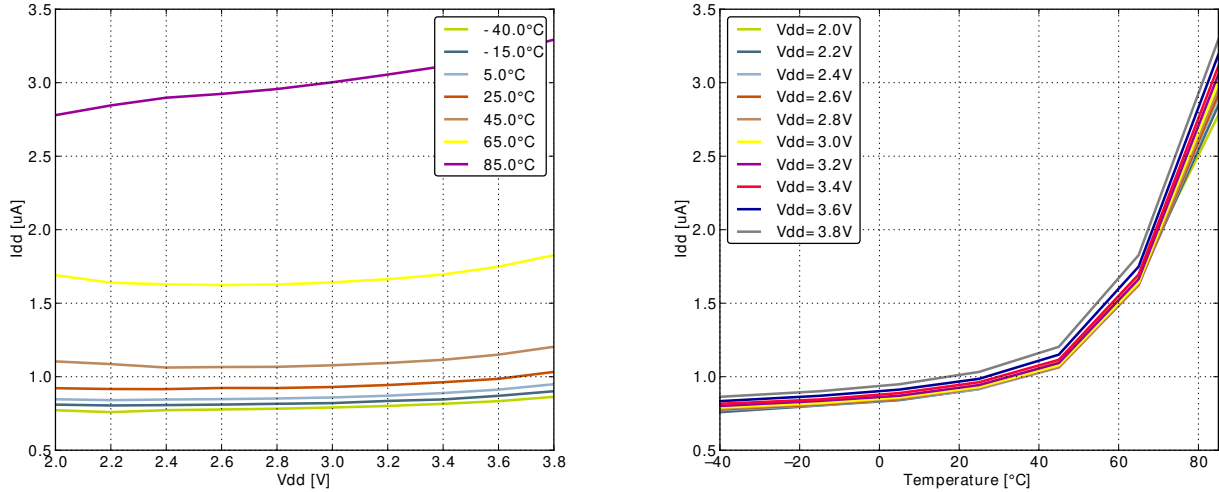


Figure 3.7. EM1 Current consumption with all peripheral clocks disabled and HFRCO running at 1.2 MHz



3.4.2 EM2 Current Consumption

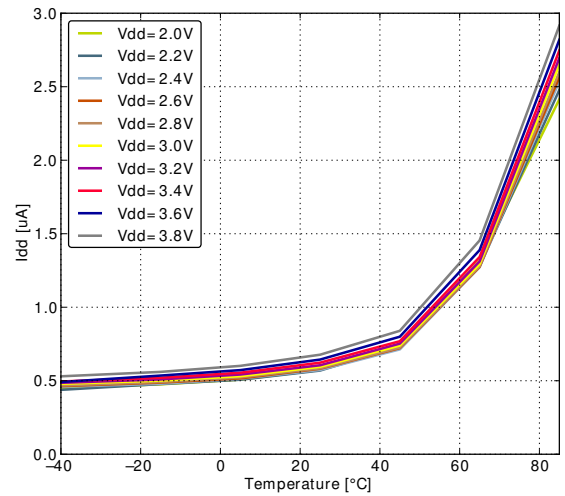
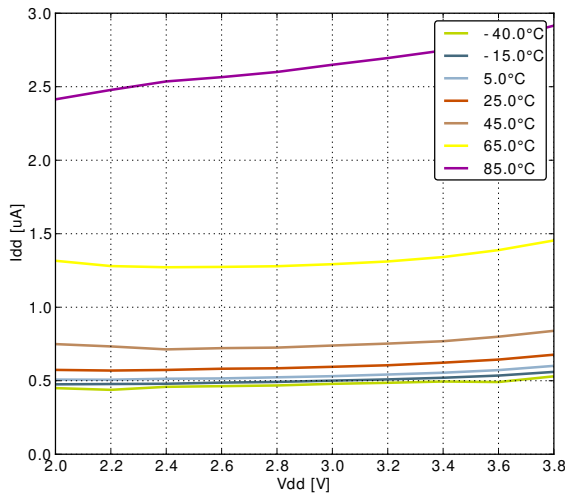
Figure 3.8. EM2 current consumption. RTC¹ prescaled to 1kHz, 32.768 kHz LFRCO.



¹Using backup RTC.

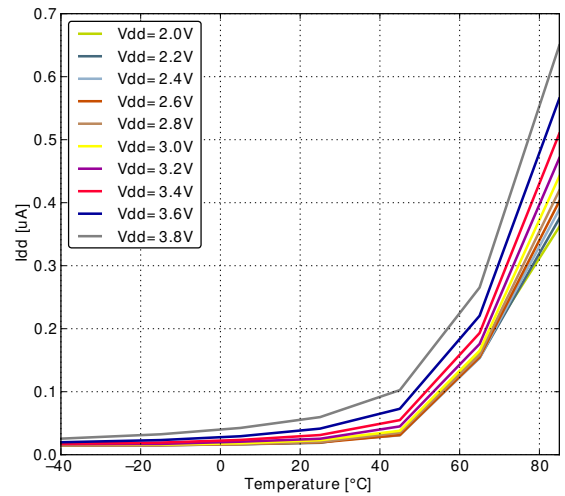
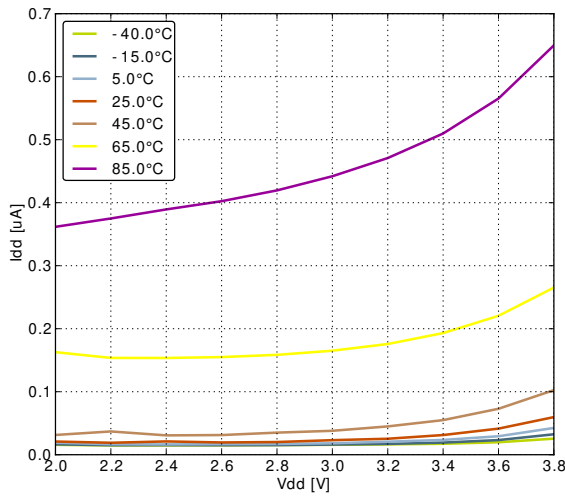
3.4.3 EM3 Current Consumption

Figure 3.9. EM3 current consumption.



3.4.4 EM4 Current Consumption

Figure 3.10. EM4 current consumption.



3.5 Transition between Energy Modes

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

Table 3.4. Energy Modes Transitions

Symbol	Parameter	Min	Typ	Max	Unit
t_{EM10}	Transition time from EM1 to EM0		0		HF-CORE-CLK cycles
t_{EM20}	Transition time from EM2 to EM0		2		μ s
t_{EM30}	Transition time from EM3 to EM0		2		μ s
t_{EM40}	Transition time from EM4 to EM0		163		μ s

3.6 Power Management

The EFM32WG requires the AVDD_x, VDD_DREG and IOVDD_x pins to be connected together (with optional filter) at the PCB level. For practical schematic recommendations, please see the application note, "AN0002 EFM32 Hardware Design Considerations".

Table 3.5. Power Management

Symbol	Parameter	Condition	Min	Typ	Max	Unit
V _{BODextthr-}	BOD threshold on falling external supply voltage		1.74		1.96	V
V _{BODextthr+}	BOD threshold on rising external supply voltage			1.85	1.98	V
V _{PORthr+}	Power-on Reset (POR) threshold on rising external supply voltage				1.98	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

3.7 Flash

Table 3.6. Flash

Symbol	Parameter	Condition	Min	Typ	Max	Unit
EC _{FLASH}	Flash erase cycles before failure		20000			cycles
RET _{FLASH}	Flash data retention	T _{AMB} <150°C	10000			h
		T _{AMB} <85°C	10			years
		T _{AMB} <70°C	20			years
t _{W_PROG}	Word (32-bit) programming time		20			µs
t _{PERASE}	Page erase time		20	20.4	20.8	ms
t _{DERASE}	Device erase time		40	40.8	41.6	ms
I _{ERASE}	Erase current				7 ¹	mA
I _{WRITE}	Write current				7 ¹	mA
V _{FLASH}	Supply voltage during flash erase and write		1.98		3.8	V

¹Measured at 25°C

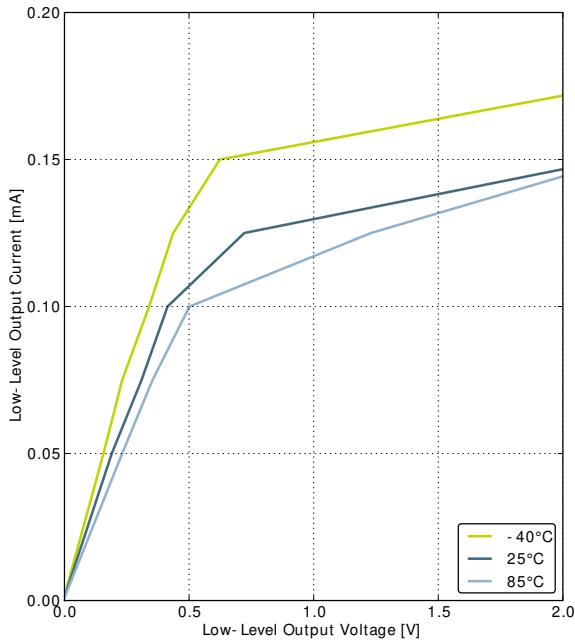
3.8 General Purpose Input Output

Table 3.7. GPIO

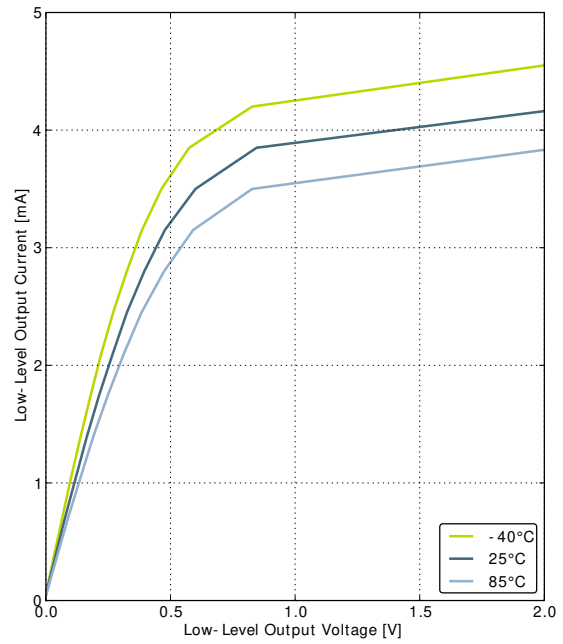
Symbol	Parameter	Condition	Min	Typ	Max	Unit
V _{IOIL}	Input low voltage				0.30V _{DD}	V
V _{IOIH}	Input high voltage		0.70V _{DD}			V
V _{IOOH}	Output high voltage (Production test condition = 3.0V, DRIVEMODE = STANDARD)	Sourcing 0.1 mA, V _{DD} =1.98 V, GPIO_Px_CTRL DRIVEMODE = LOWEST		0.80V _{DD}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

Symbol	Parameter	Condition	Min	Typ	Max	Unit
		Sourcing 20 mA, V _{DD} =3.0 V, GPIO_Px_CTRL DRIVEMODE = HIGH	0.80V _{DD}			V
V _{IOOL}	Output low voltage (Production test condition = 3.0V, DRIVEMODE = STANDARD)	Sinking 0.1 mA, V _{DD} =1.98 V, GPIO_Px_CTRL DRIVEMODE = LOWEST		0.20V _{DD}		V
		Sinking 0.1 mA, V _{DD} =3.0 V, GPIO_Px_CTRL DRIVEMODE = LOWEST		0.10V _{DD}		V
		Sinking 1 mA, V _{DD} =1.98 V, GPIO_Px_CTRL DRIVEMODE = LOW		0.10V _{DD}		V
		Sinking 1 mA, V _{DD} =3.0 V, GPIO_Px_CTRL DRIVEMODE = LOW		0.05V _{DD}		V
		Sinking 6 mA, V _{DD} =1.98 V, GPIO_Px_CTRL DRIVEMODE = STANDARD			0.30V _{DD}	V
		Sinking 6 mA, V _{DD} =3.0 V, GPIO_Px_CTRL DRIVEMODE = STANDARD			0.20V _{DD}	V
		Sinking 20 mA, V _{DD} =1.98 V, GPIO_Px_CTRL DRIVEMODE = HIGH			0.35V _{DD}	V
		Sinking 20 mA, V _{DD} =3.0 V, GPIO_Px_CTRL DRIVEMODE = HIGH			0.25V _{DD}	V
I _{IOLEAK}	Input leakage current	High Impedance IO connected to GROUND or V _{DD}		±0.1	±100	nA
R _{PU}	I/O pin pull-up resistor			40		kOhm
R _{PD}	I/O pin pull-down resistor			40		kOhm
R _{IOESD}	Internal ESD series resistor			200		Ohm
t _{IOGLITCH}	Pulse width of pulses to be removed by the glitch suppression filter		10		50	ns
t _{IOOF}	Output fall time	GPIO_Px_CTRL DRIVEMODE = LOWEST and load capacitance C _L =12.5-25pF.	20+0.1C _L		250	ns
		GPIO_Px_CTRL DRIVEMODE = LOW and load capacitance C _L =350-600pF	20+0.1C _L		250	ns
V _{IOHYST}	I/O pin hysteresis (V _{IOTHR+} - V _{IOTHR-})	V _{DD} = 1.98 - 3.8 V	0.10V _{DD}			V

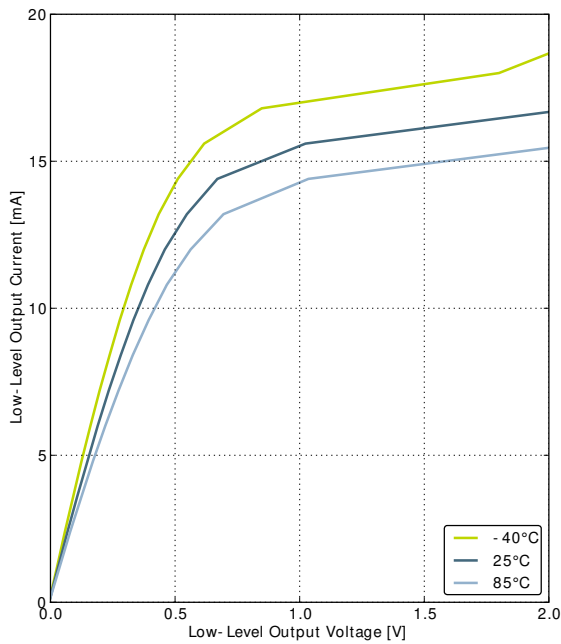
Figure 3.11. Typical Low-Level Output Current, 2V Supply Voltage



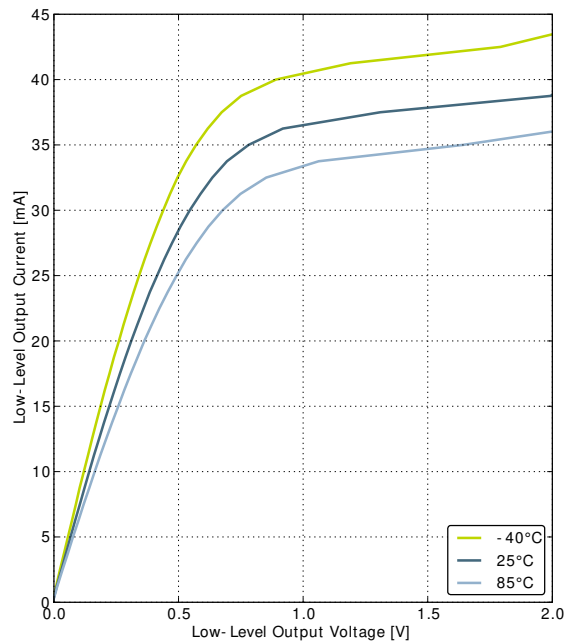
GPIO_Px_CTRL DRIVEMODE = LOWEST



GPIO_Px_CTRL DRIVEMODE = LOW

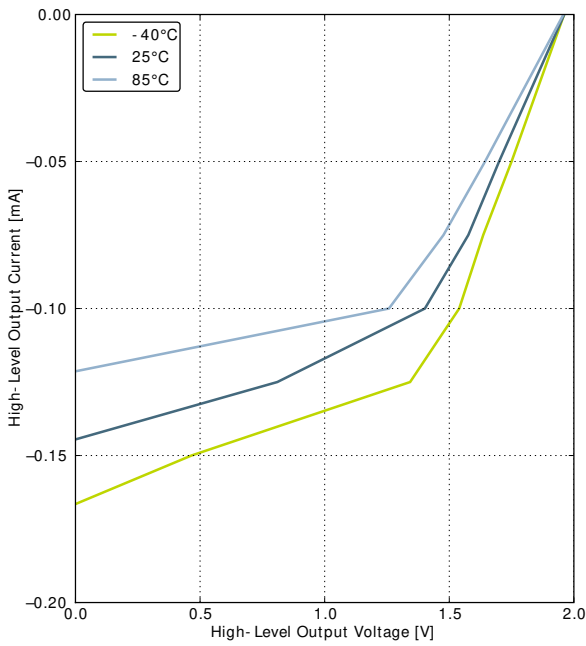


GPIO_Px_CTRL DRIVEMODE = STANDARD

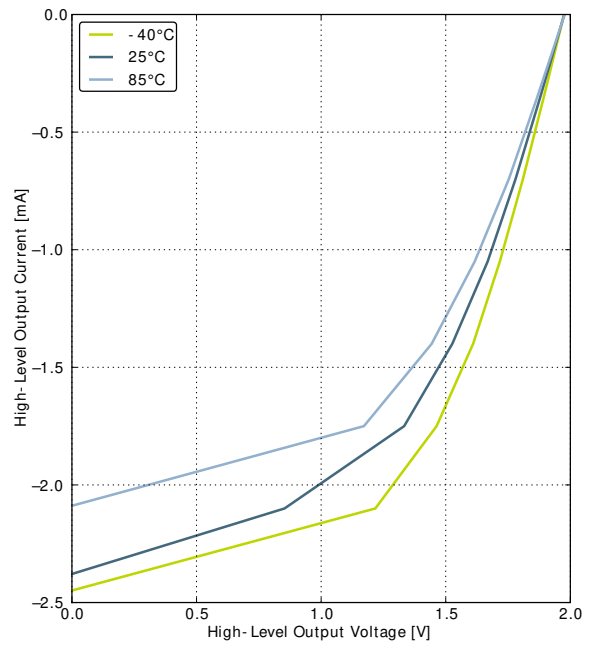


GPIO_Px_CTRL DRIVEMODE = HIGH

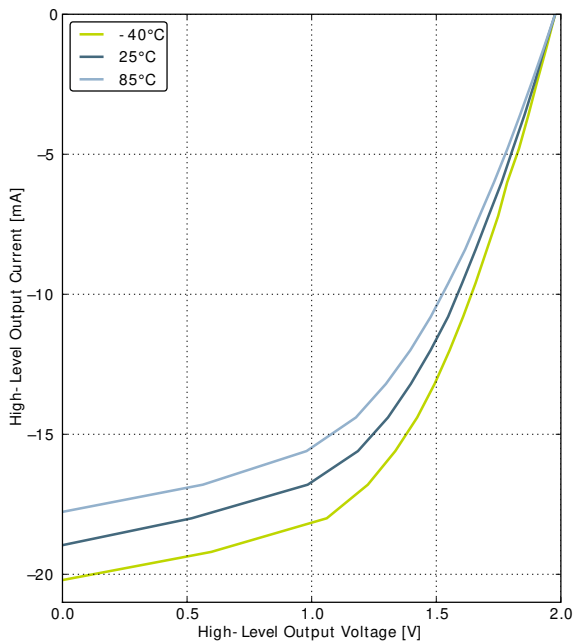
Figure 3.12. Typical High-Level Output Current, 2V Supply Voltage



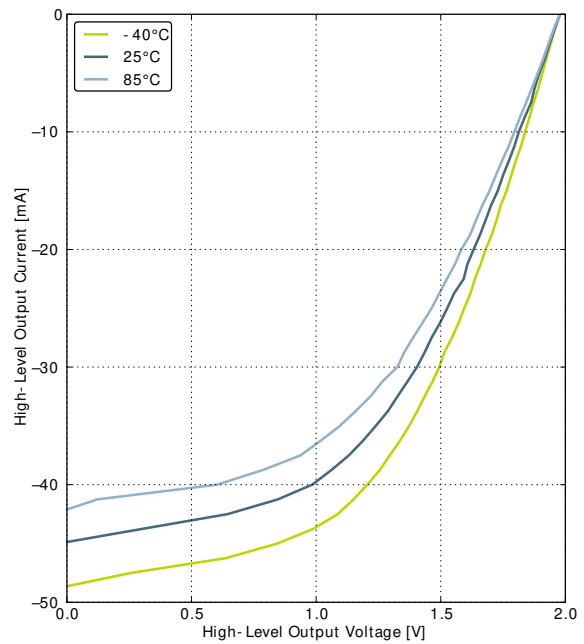
GPIO_Px_CTRL DRIVEMODE = LOWEST



GPIO_Px_CTRL DRIVEMODE = LOW

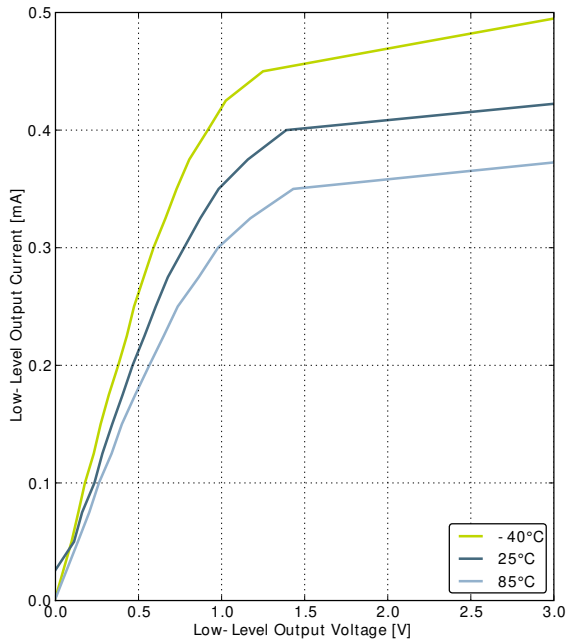


GPIO_Px_CTRL DRIVEMODE = STANDARD

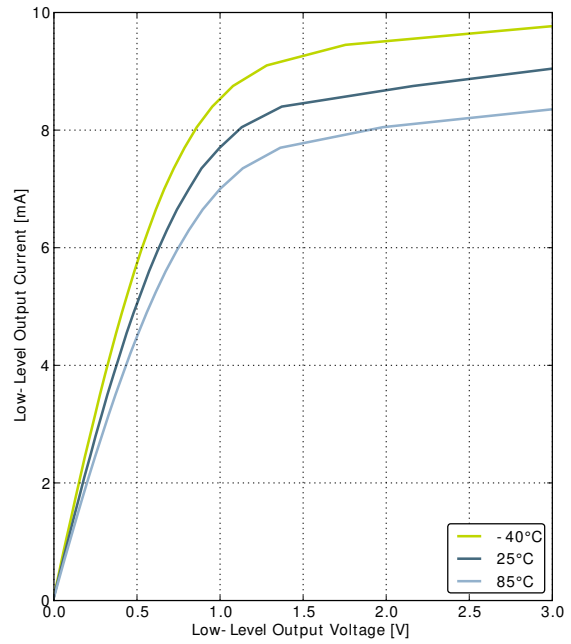


GPIO_Px_CTRL DRIVEMODE = HIGH

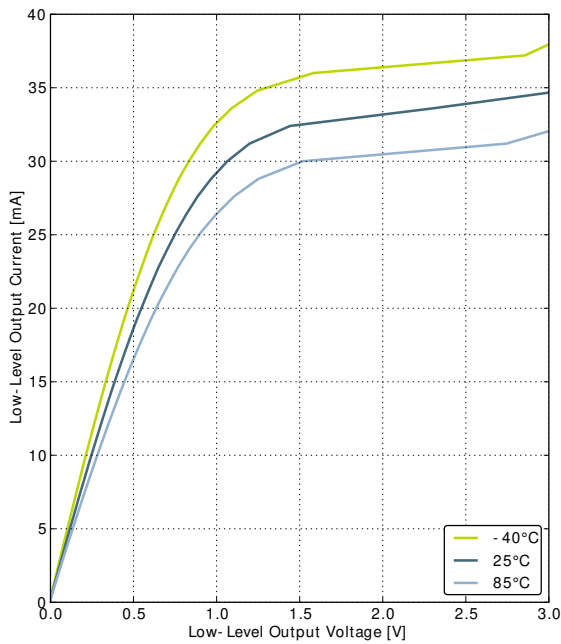
Figure 3.13. Typical Low-Level Output Current, 3V Supply Voltage



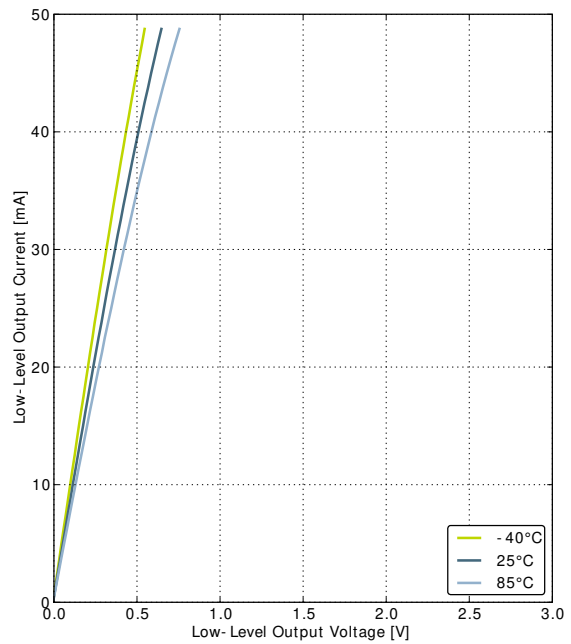
GPIO_Px_CTRL DRIVEMODE = LOWEST



GPIO_Px_CTRL DRIVEMODE = LOW

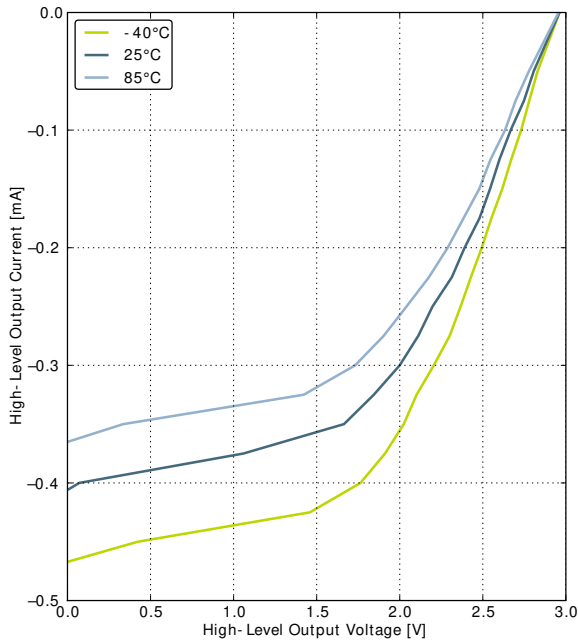


GPIO_Px_CTRL DRIVEMODE = STANDARD

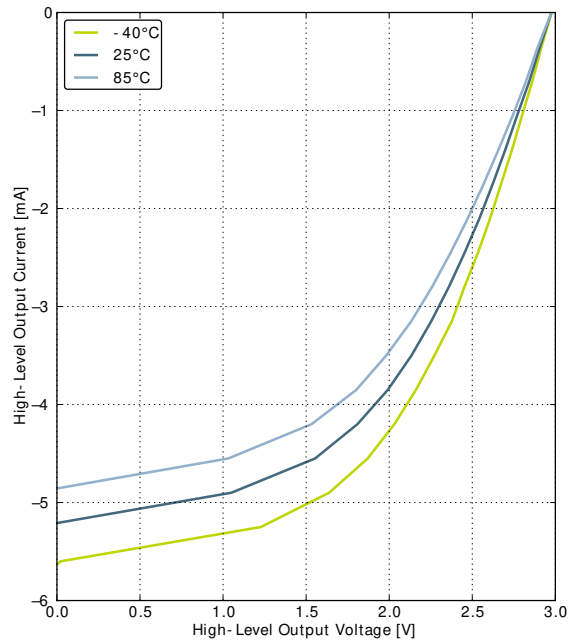


GPIO_Px_CTRL DRIVEMODE = HIGH

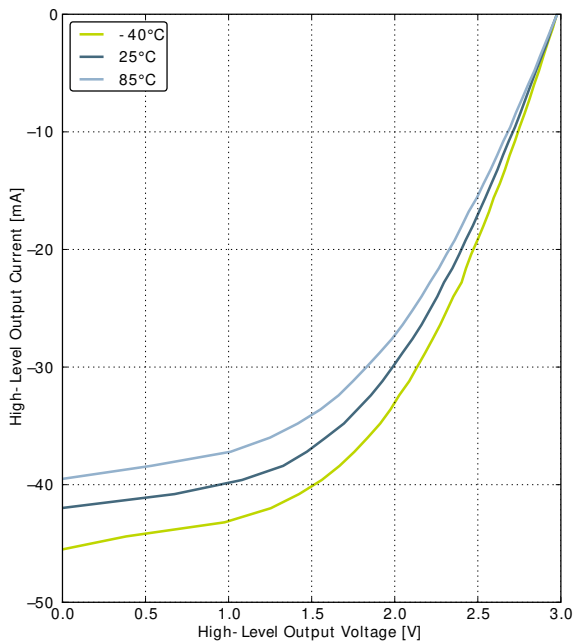
Figure 3.14. Typical High-Level Output Current, 3V Supply Voltage



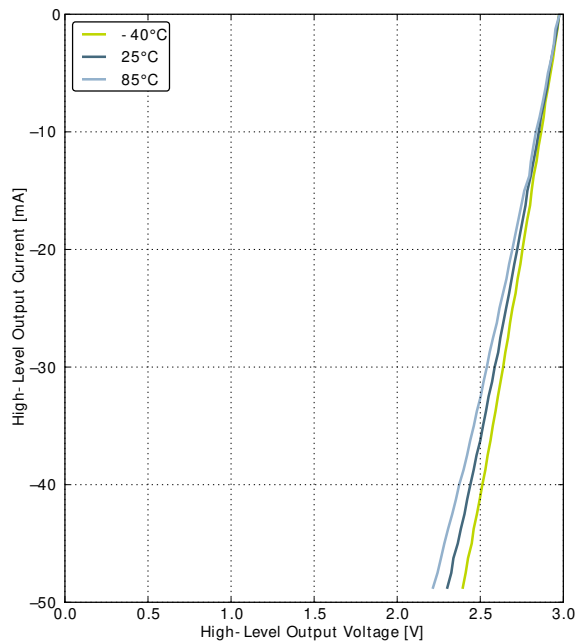
GPIO_Px_CTRL DRIVEMODE = LOWEST



GPIO_Px_CTRL DRIVEMODE = LOW

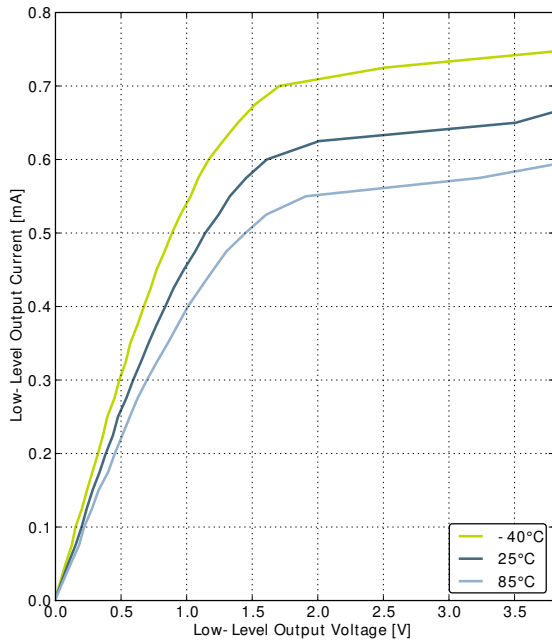


GPIO_Px_CTRL DRIVEMODE = STANDARD

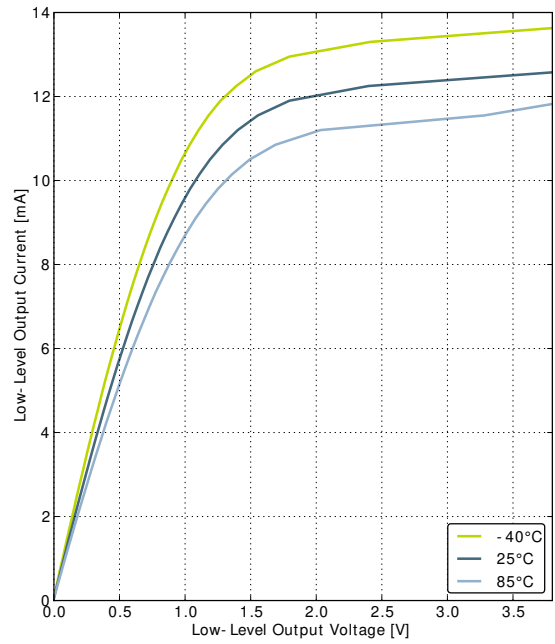


GPIO_Px_CTRL DRIVEMODE = HIGH

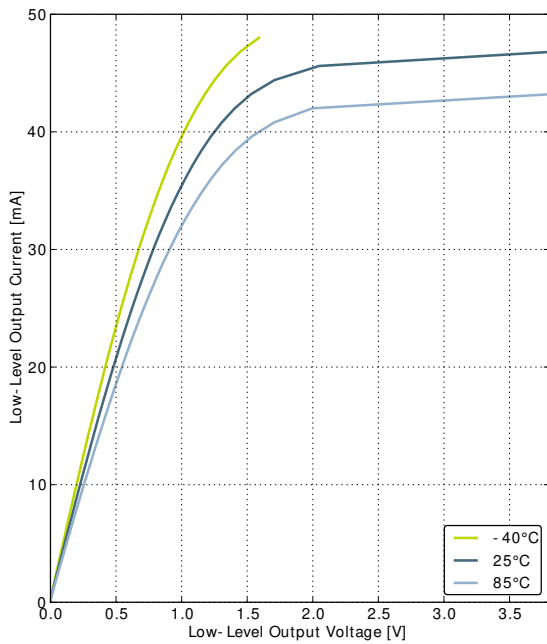
Figure 3.15. Typical Low-Level Output Current, 3.8V Supply Voltage



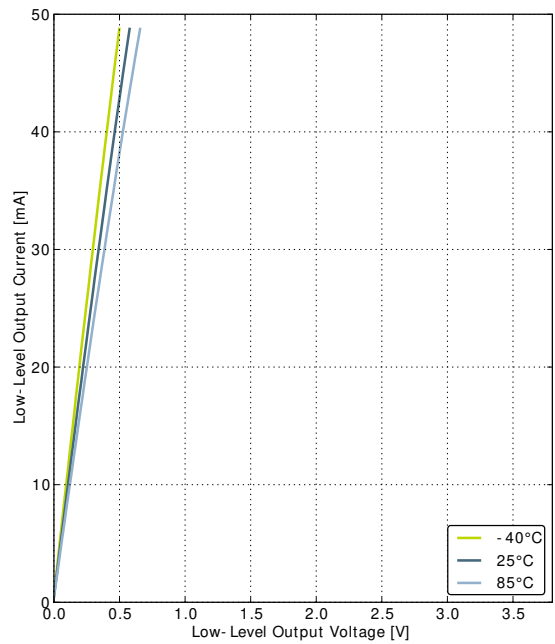
GPIO_Px_CTRL DRIVEMODE = LOWEST



GPIO_Px_CTRL DRIVEMODE = LOW



GPIO_Px_CTRL DRIVEMODE = STANDARD



GPIO_Px_CTRL DRIVEMODE = HIGH