EFM32®

... the world's most energy friendly microcontrollers

EFM32TG825 DATASHEET

F32/F16/F8

- **ARM Cortex-M3 CPU platform**
  - High Performance 32-bit processor @ up to 32 MHz
  - Wake-up Interrupt Controller
- **Flexible Energy Management System**
  - 20 nA @ 3 V Shutoff Mode
  - 0.6 µA @ 3 V Stop Mode, including Power-on Reset, Brown-out Detector, RAM and CPU retention
  - 1.0 µA @ 3 V Deep Sleep Mode, including RTC with 32.768 kHz oscillator, Power-on Reset, Brown-out Detector, RAM and CPU retention
  - 51 µA/MHz @ 3 V Sleep Mode
  - 150 µA/MHz @ 3 V Run Mode, with code executed from flash
- **32/16/8 KB Flash**
- **4/4/2 KB RAM**
- **37 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
- **8 Channel DMA Controller**
- **8 Channel Peripheral Reflex System (PRS) for autonomous inter-peripheral signaling**
- **Hardware AES with 128/256-bit keys in 54/75 cycles**
- **Timers/Counters**
  - 2× 16-bit Timer/Counter
    - 2×3 Compare/Capture/PWM channels
  - 16-bit Low Energy Timer
  - 1× 24-bit Real-Time Counter
  - 1× 16-bit Pulse Counter
  - Watchdog Timer with dedicated RC oscillator @ 50 nA
- **Integrated LCD Controller for up to 8×11 segments**
  - Voltage boost, adjustable contrast and autonomous animation
- **Communication interfaces**
  - 2× Universal Synchronous/Asynchronous Receiver/Transmitter
    - UART/SPI/SmartCard (ISO 7816)/IrDA/I2S
    - Triple buffered full/half-duplex operation
  - Low Energy UART
    - Autonomous operation with DMA in Deep Sleep Mode
  - I^2C Interface with SMBus support
    - Address recognition in Stop Mode
- **Ultra low power precision analog peripherals**
  - 12-bit 1 Msamples/s Analog to Digital Converter
    - 4 single ended channels/2 differential channels
    - On-chip temperature sensor
  - 12-bit 500 ksamples/s Digital to Analog Converter
  - 2× Analog Comparator
    - Capacitive sensing with up to 4 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**
- **2-pin Serial Wire Debug interface**
  - 1-pin Serial Wire Viewer
- **Pre-Programmed UART Bootloader**
- **Temperature range -40 to 85 ºC**
- **Single power supply 1.98 to 3.8 V**
- **BGA48 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

ARM ZERO TINY GECKO LEOPARD GIANT WONDER

SILICON LABS

1 Ordering Information

Table 1.1 (p. 2) shows the available EFM32TG825 devices.

Table 1.1. Ordering Information

Ordering Code	Flash (kB)	RAM (kB)	Max Speed (MHz)	Supply Voltage (V)	Temperature (ºC)	Package
EFM32TG825F8-BGA48	8	2	32 MHz	1.98 - 3.8	-40 - 85	BGA48
EFM32TG825F16-BGA48	16	4	32 MHz	1.98 - 3.8	-40 - 85	BGA48
EFM32TG825F32-BGA48	32	4	32 MHz	1.98 - 3.8	-40 - 85	BGA48

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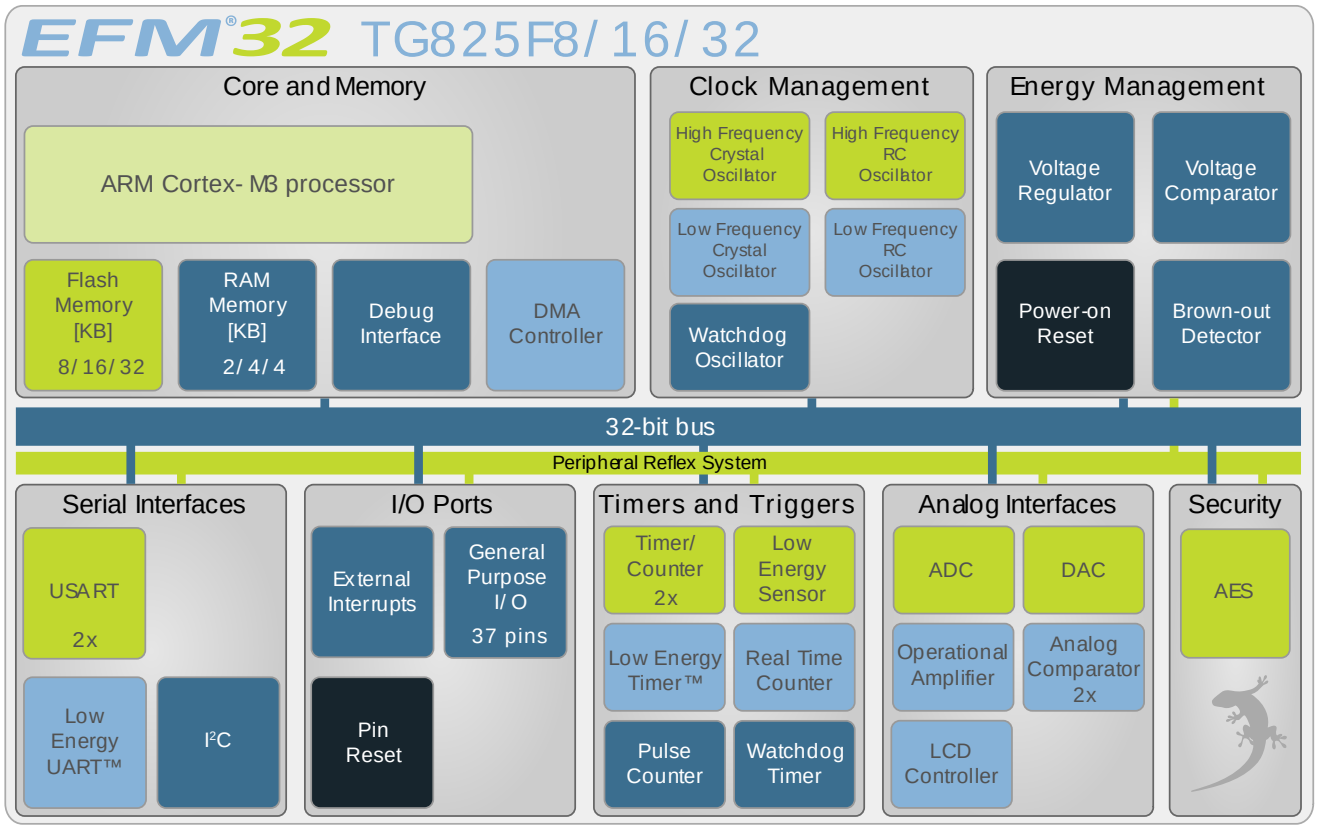
2 System Summary

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-M3, innovative low energy techniques, short wake-up time from energy saving modes, and a wide selection of peripherals, the EFM32TG 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 EFM32TG825 devices. For a complete feature set and in-depth information on the modules, the reader is referred to the *EFM32TG Reference Manual*.

A block diagram of the EFM32TG825 is shown in Figure 2.1 (p. 3) .

Figure 2.1. Block Diagram



2.1.1 ARM Cortex-M3 Core

The ARM Cortex-M3 includes a 32-bit RISC processor which can achieve as much as 1.25 Dhrystone MIPS/MHz. A Wake-up Interrupt Controller handling interrupts triggered while the CPU is asleep is included as well. The EFM32 implementation of the Cortex-M3 is described in detail in *EFM32 Cortex-M3 Reference Manual*.

2.1.2 Debug Interface (DBG)

This device includes hardware debug support through a 2-pin serial-wire debug interface. 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 EFM32TG microcontroller. The flash memory is readable and writable from both the Cortex-M3 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 µDMA controller licensed from ARM.

2.1.5 Reset Management Unit (RMU)

The RMU is responsible for handling the reset functionality of the EFM32TG.

2.1.6 Energy Management Unit (EMU)

The Energy Management Unit (EMU) manage all the low energy modes (EM) in EFM32TG 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 EFM32TG. 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 Inter-Integrated Circuit Interface (I2C)

The I^2C module provides an interface between the MCU and a serial I^2C-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 I^2C 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.

2.1.11 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.

2.1.12 Pre-Programmed UART Bootloader

The bootloader presented in application note AN0003 is pre-programmed in the device at factory. Auto-baud and destructive write are supported. The autobaud feature, interface and commands are described further in the application note.

2.1.13 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.

2.1.14 Timer/Counter (TIMER)

The 16-bit general purpose Timer has 3 compare/capture channels for input capture and compare/Pulse-Width Modulation (PWM) output.

2.1.15 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.

2.1.16 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.

2.1.17 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.

2.1.18 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.

2.1.19 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.

2.1.20 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 4 external pins and 6 internal signals.

2.1.21 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 one single ended output buffer connected to channel 0. The DAC may be used for a number of different applications such as sensor interfaces or sound output.

2.1.22 Operational Amplifier (OPAMP)

The EFM32TG825 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.

2.1.23 Low Energy Sensor Interface (LESENSE)

The Low Energy Sensor Interface (LESENSE™), is a highly configurable sensor interface with support for up to 4 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.

2.1.24 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.

2.1.25 General Purpose Input/Output (GPIO)

In the EFM32TG825, there are 37 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.

2.1.26 Liquid Crystal Display Driver (LCD)

The LCD driver is capable of driving a segmented LCD display with up to 8x11 segments. A voltage boost function enables it to provide the LCD display with higher voltage than the supply voltage for the device. In addition, an animation feature can run custom animations on the LCD display without any CPU intervention. The LCD driver can also remain active even in Energy Mode 2 and provides a Frame Counter interrupt that can wake-up the device on a regular basis for updating data.

2.2 Configuration Summary

The features of the EFM32TG825 is a subset of the feature set described in the EFM32TG Reference Manual. Table 2.1 (p. 7) describes device specific implementation of the features.

Table 2.1. Configuration Summary

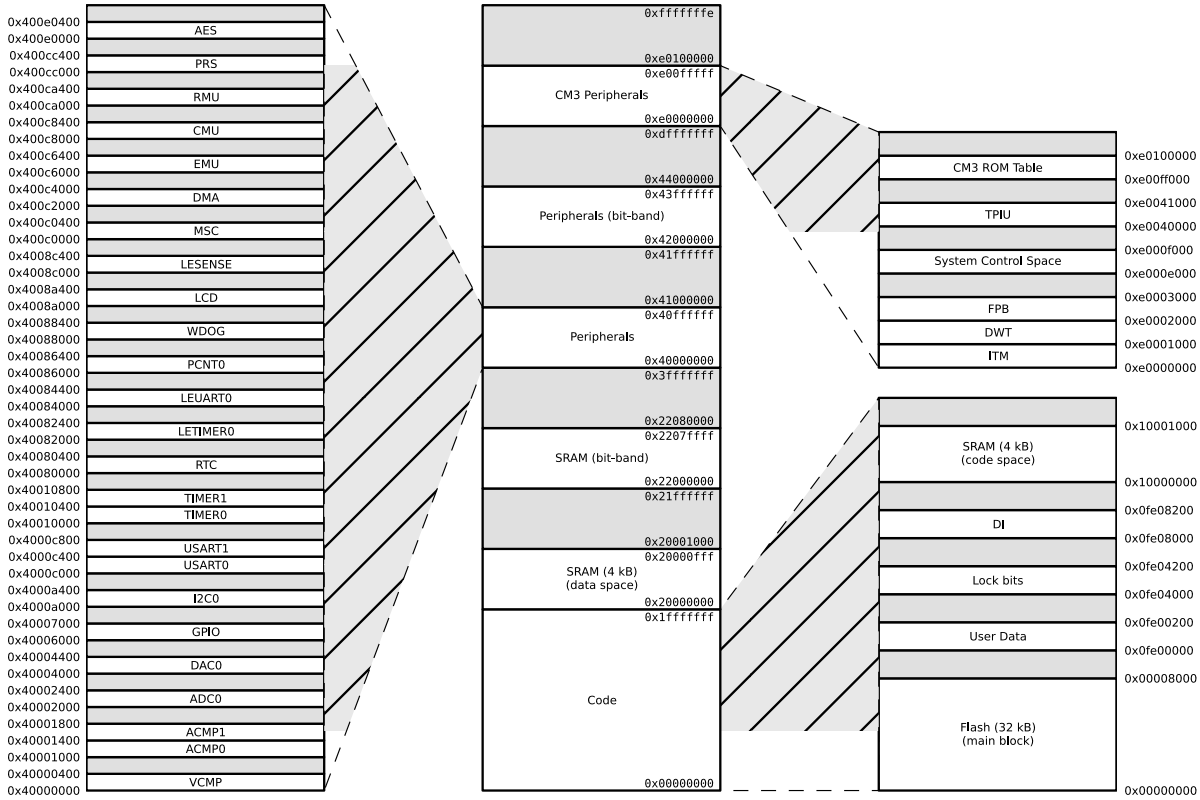
Module	Configuration	Pin Connections
Cortex-M3	Full configuration	NA
DBG	Full configuration	DBG_SWCLK, DBG_SWDIO, DBG_SWO
MSC	Full configuration	NA
DMA	Full configuration	NA
RMU	Full configuration	NA
EMU	Full configuration	NA
CMU	Full configuration	CMU_OUT0, CMU_OUT1
WDOG	Full configuration	NA
PRS	Full configuration	NA
I2C0	Full configuration	I2C0_SDA, I2C0_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
LEUART0	Full configuration	LEU0_TX, LEU0_RX
TIMER0	Full configuration	TIM0_CC[2:0]
TIMER1	Full configuration	TIM1_CC[2:0]
RTC	Full configuration	NA
LETIMER0	Full configuration	LET0_O[1:0]
PCNT0	Full configuration, 16-bit count register	PCNT0_S[1:0]
ACMP0	Full configuration	ACMP0_CH[4], ACMP0_O
ACMP1	Full configuration	ACMP1_CH[7:5], ACMP1_O
VCMP	Full configuration	NA
ADC0	Full configuration	ADC0_CH[7:4]
DAC0	Full configuration	DAC0_OUT[0], DAC0_OUTxALT
OPAMP		
AES	Full configuration	NA
GPIO	37 pins	Available pins are shown in Table 4.3 (p. 53)

Module	Configuration	Pin Connections
LCD	Full configuration	LCD_SEG[10:0], LCD_COM[7:0], LCD_BCAP_P, LCD_BCAP_N, LCD_BEXT

2.3 Memory Map

The *EFM32TG825* memory map is shown in Figure 2.2 (p. 8), with RAM and Flash sizes for the largest memory configuration.

Figure 2.2. EFM32TG825 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°C and V_{DD}=3.0 V, as defined in Table 3.2 (p. 9), 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. 9), 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. 9) may affect the device reliability or cause permanent damage to the device. Functional operating conditions are given in Table 3.2 (p. 9) .

Table 3.1. Absolute Maximum Ratings

Symbol	Parameter	Condition	Min	Typ	Max	Unit
T_{STG}	Storage temperature range		-40		150[1]	°C
T_S	Maximum soldering temperature	Latest IPC/JEDEC J-STD-020 Standard			260	°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

[1]Based 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	°C
V_{DDOP}	Operating supply voltage	1.98		3.8	V
f_{APB}	Internal APB clock frequency			32	MHz
f_{AHB}	Internal AHB clock frequency			32	MHz

3.3.2 Environmental

Table 3.3. Environmental

Symbol	Parameter	Condition	Min	Typ	Max	Unit
V_{ESDHBM}	ESD (Human Body Model HBM)	T_{AMB}=25°C			1500	V
V_{ESDCDM}	ESD (Charged Device Model, CDM)	T_{AMB}=25°C			750	V

Latch-up sensitivity passed: ±100 mA/1.5 × V_{SUPPLY}(max) according to JEDEC JESD 78 method Class II, 85°C.

3.4 Current Consumption

Table 3.4. 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)	32 MHz HFXO, all peripheral clocks disabled, V_{DD}= 3.0 V		157		µA/ MHz
		28 MHz HFRCO, all peripheral clocks disabled, V_{DD}= 3.0 V		150	195	µA/ MHz
		21 MHz HFRCO, all peripheral clocks disabled, V_{DD}= 3.0 V		153	199	µA/ MHz
		14 MHz HFRCO, all peripheral clocks disabled, V_{DD}= 3.0 V		155	202	µA/ MHz
		11 MHz HFRCO, all peripheral clocks disabled, V_{DD}= 3.0 V		157	204	µA/ MHz
		6.6 MHz HFRCO, all peripheral clocks disabled, V_{DD}= 3.0 V		162	210	µA/ MHz
		1.2 MHz HFRCO, all peripheral clocks disabled, V_{DD}= 3.0 V		210		µA/ MHz
I_{EM1}	EM1 current (Production test condition = 14 MHz)	32 MHz HFXO, all peripheral clocks disabled, V_{DD}= 3.0 V		53		µA/ MHz
		28 MHz HFRCO, all peripheral clocks disabled, V_{DD}= 3.0 V		51	66	µA/ MHz
		21 MHz HFRCO, all peripheral clocks disabled, V_{DD}= 3.0 V		55	71	µA/ MHz
		14 MHz HFRCO, all peripheral clocks disabled, V_{DD}= 3.0 V		56	73	µA/ MHz
		11 MHz HFRCO, all peripheral clocks disabled, V_{DD}= 3.0 V		58	75	µA/ MHz
		6.6 MHz HFRCO, all peripheral clocks disabled, V_{DD}= 3.0 V		63	82	µA/ MHz
		1.2 MHz HFRCO. all peripheral clocks disabled, V_{DD}= 3.0 V		140		µA/ MHz
I_{EM2}	EM2 current	EM2 current with RTC at 1 Hz, RTC prescaled to 1kHz, 32.768 kHz LFRCO, V_{DD}= 3.0 V, T_{AMB}=25°C		1		µA
		EM2 current with RTC at 1 Hz, RTC prescaled to 1kHz, 32.768 kHz LFRCO, V_{DD}= 3.0 V, T_{AMB}=85°C		2.4	5	µA
I_{EM3}	EM3 current	V_{DD}= 3.0 V, T_{AMB}=25°C		0.59		µA
		V_{DD}= 3.0 V, T_{AMB}=85°C		2	4.5	µA
I_{EM4}	EM4 current	V_{DD}= 3.0 V, T_{AMB}=25°C		0.02		µA
		V_{DD}= 3.0 V, T_{AMB}=85°C		0.25	0.7	µA

Figure 3.1. EM2 current consumption. RTC prescaled to 1kHz, 32.768 kHz LFRCO.

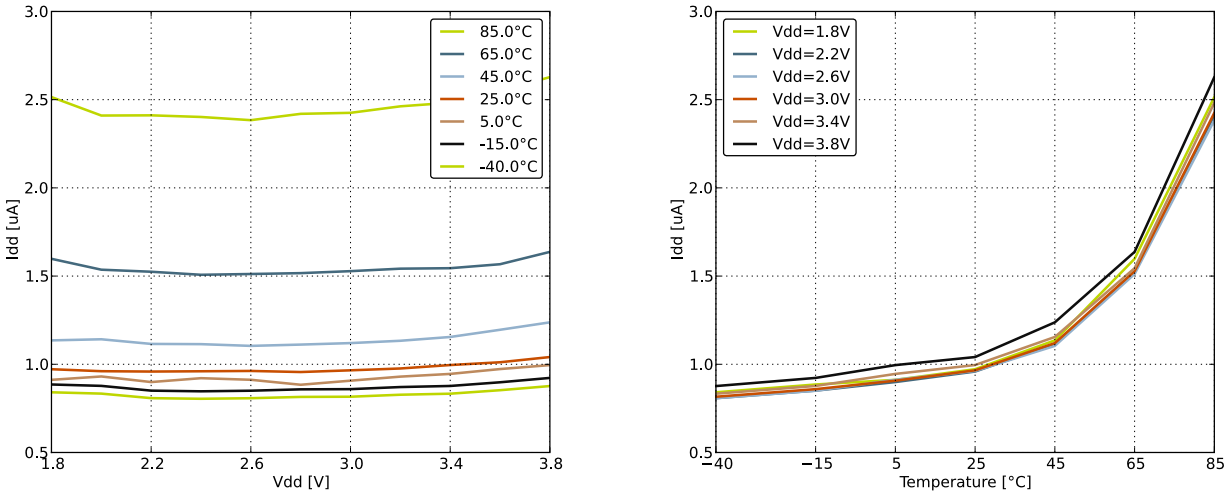


Figure 3.2. EM3 current consumption.

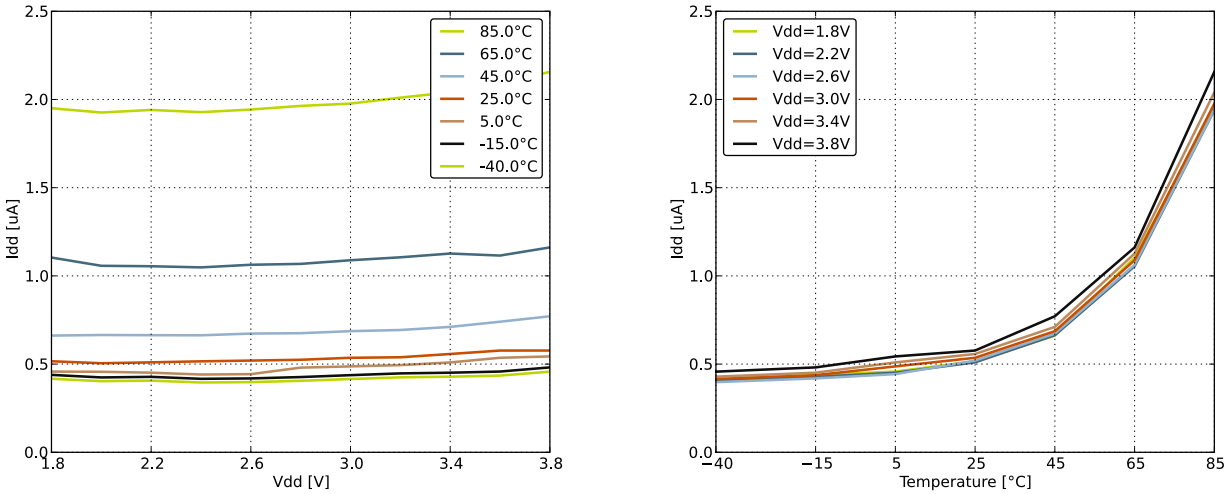
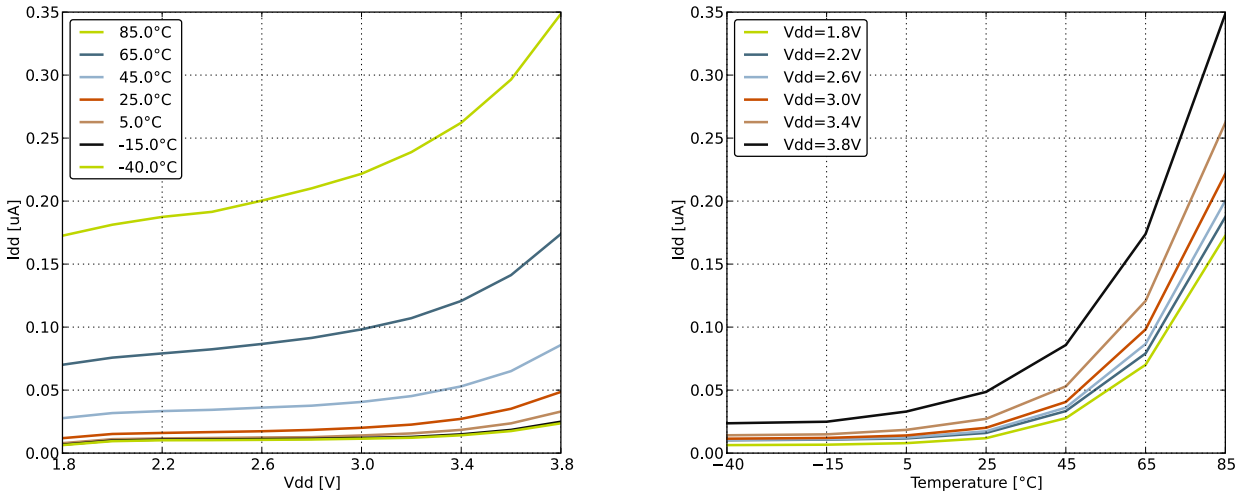


Figure 3.3. EM4 current consumption.



3.5 Transition between Energy Modes

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

Table 3.5. 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		µs
t_{EM30}	Transition time from EM3 to EM0		2		µs
t_{EM40}	Transition time from EM4 to EM0		163		µs

3.6 Power Management

The EFM32TG 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 3.6. 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		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

3.7 Flash

Table 3.7. 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_{P_ERASE}	Page erase time		20	20.4	20.8	ms
t_{D_ERASE}	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

[1]Measured at 25°C

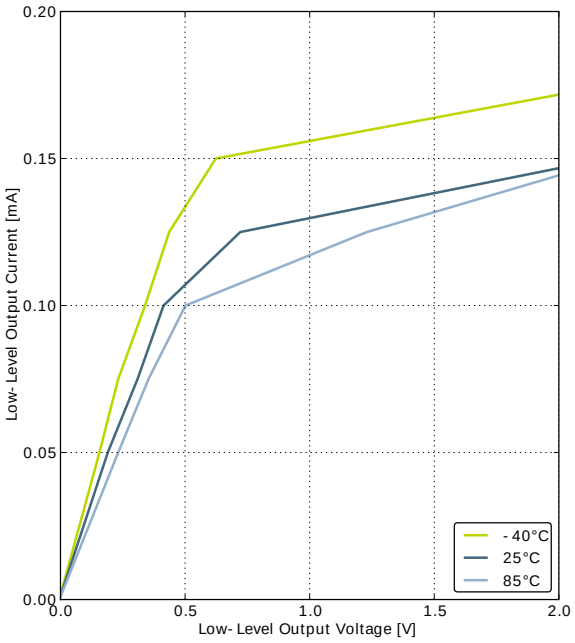
3.8 General Purpose Input Output

Table 3.8. GPIO

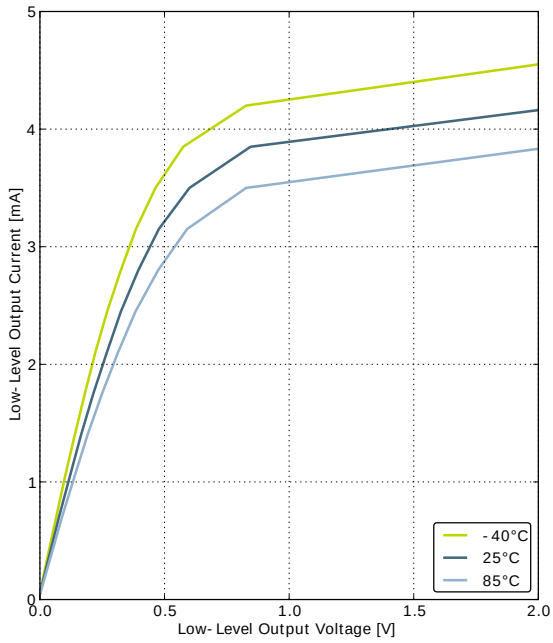
Symbol	Parameter	Condition	Min	Typ	Max	Unit
V_{IOIL}	Input low voltage				$0.30V_{DD}$	V
V_{IOIH}	Input high voltage		$0.70V_{DD}$			V
V_{IOOH}	Output high voltage (Production test condition = 3.0V, DRIVEMODE = STANDARD)	Sourcing 0.1 mA, V_{DD}=1.98 V, GPIO_Px_CTRL DRIVEMODE = LOWEST		$0.80V_{DD}$		V
		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			0.20V_{DD}	V
I_{IOLEAK}	Input leakage current	High Impedance IO connected to GROUND or Vdd		±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	0.1V_{DD}			V

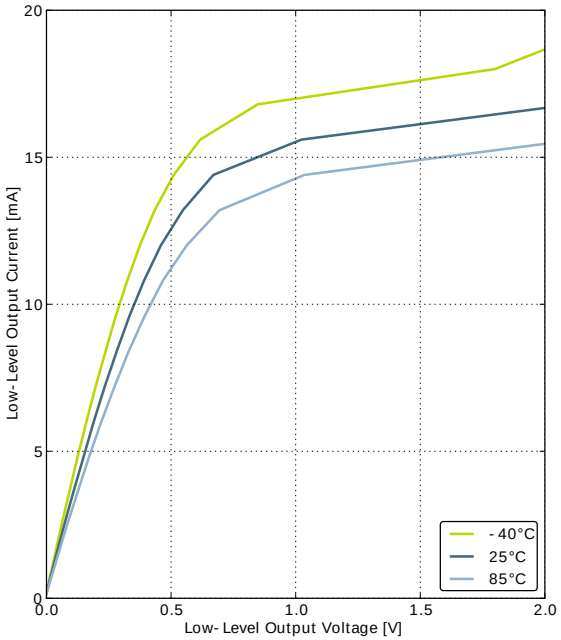
Figure 3.4. Typical Low-Level Output Current, 2V Supply Voltage



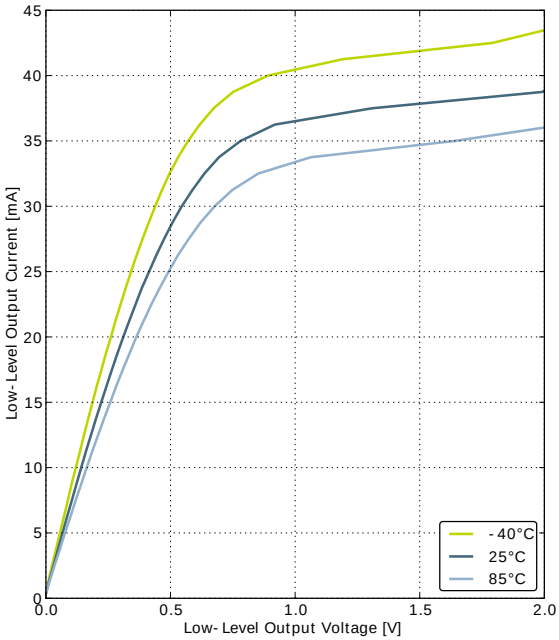
GPIO_Px_CTRL DRIVEMODE = LOWEST



GPIO_Px_CTRL DRIVEMODE = LOW

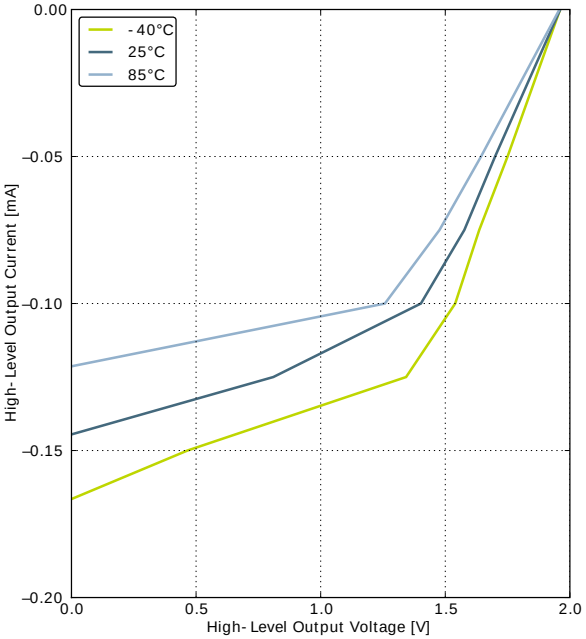


GPIO_Px_CTRL DRIVEMODE = STANDARD

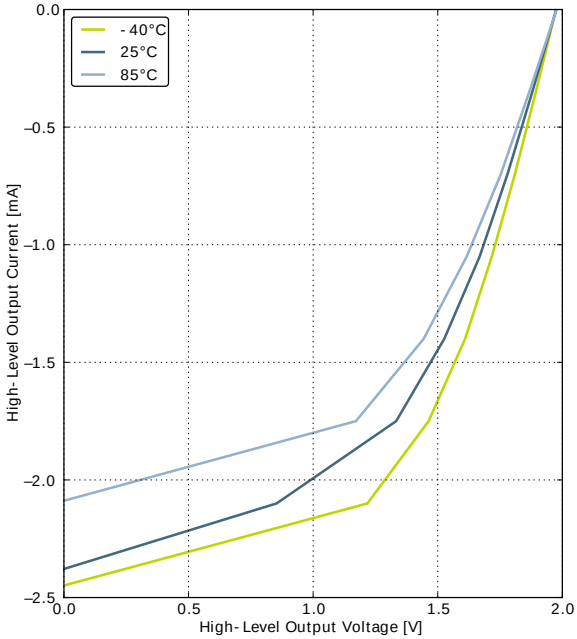


GPIO_Px_CTRL DRIVEMODE = HIGH

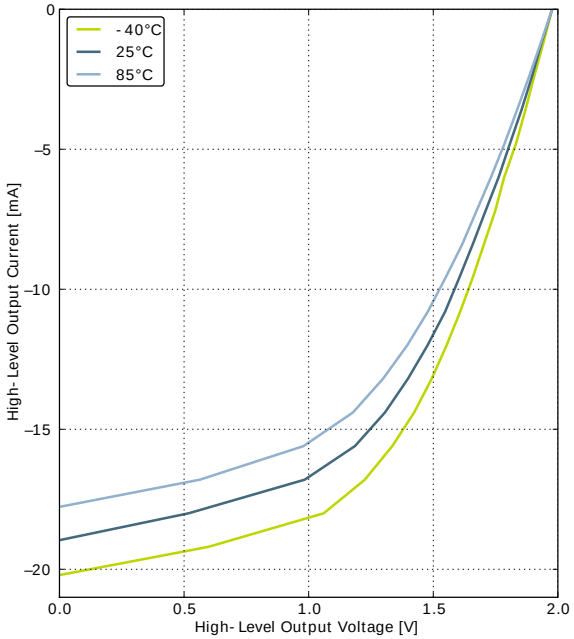
Figure 3.5. Typical High-Level Output Current, 2V Supply Voltage



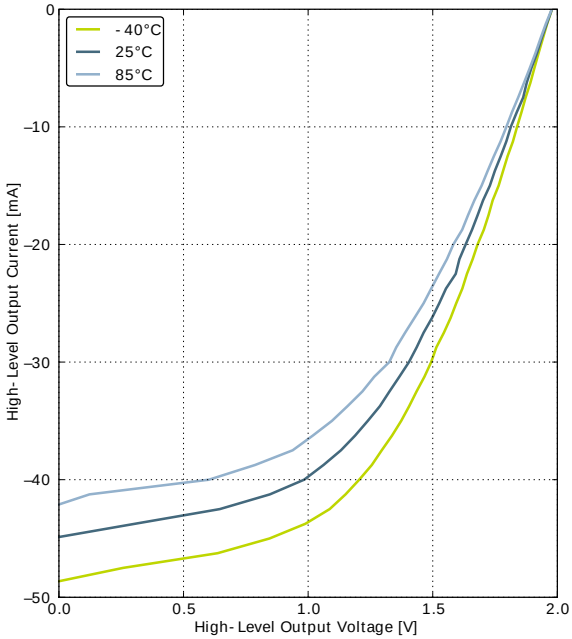
GPIO_Px_CTRL DRIVEMODE = LOWEST



GPIO_Px_CTRL DRIVEMODE = LOW

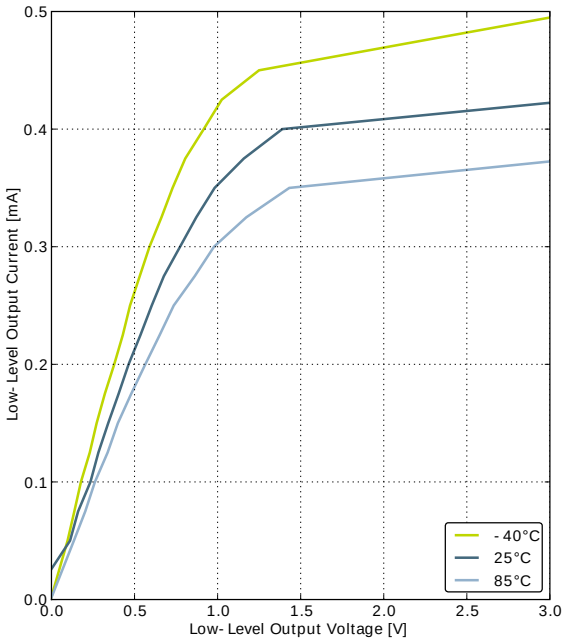


GPIO_Px_CTRL DRIVEMODE = STANDARD

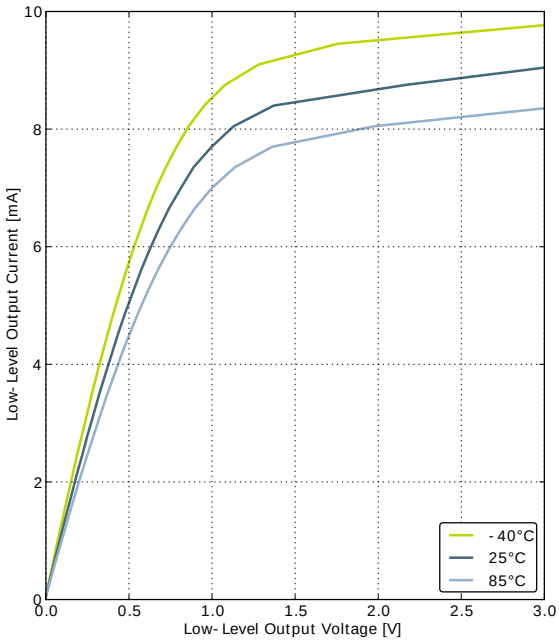


GPIO_Px_CTRL DRIVEMODE = HIGH

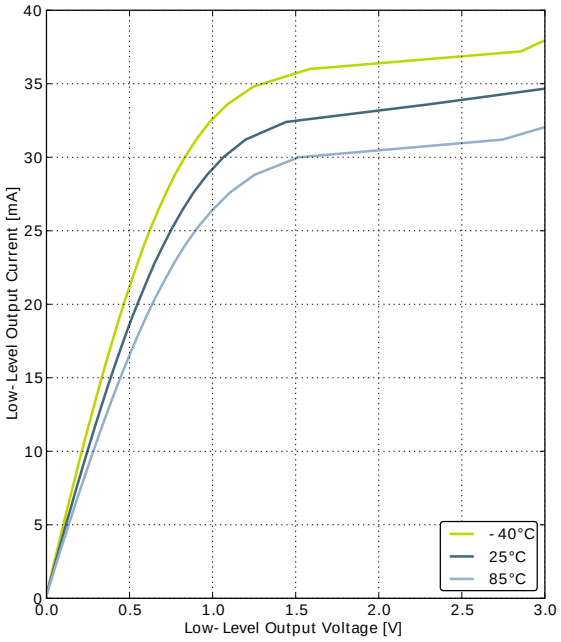
Figure 3.6. Typical Low-Level Output Current, 3V Supply Voltage



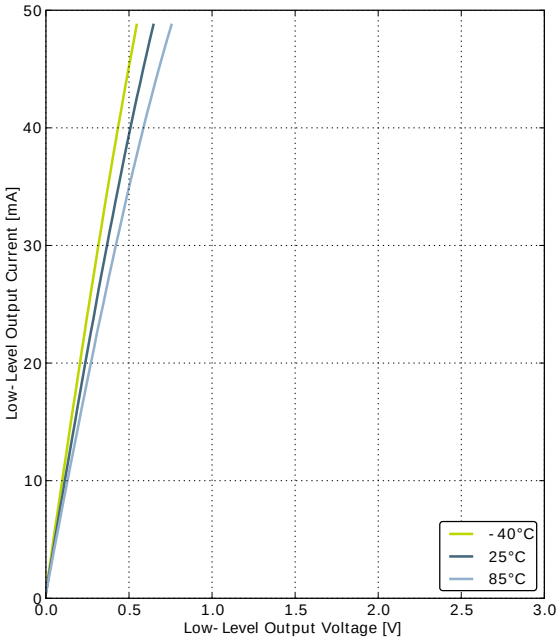
GPIO_Px_CTRL DRIVEMODE = LOWEST



GPIO_Px_CTRL DRIVEMODE = LOW

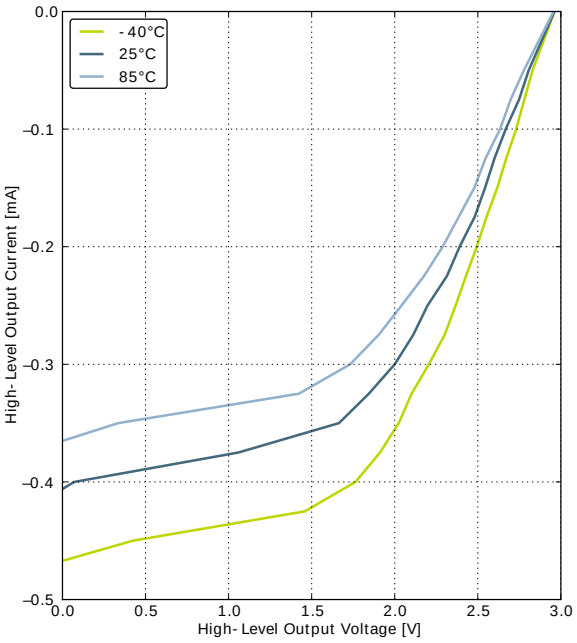


GPIO_Px_CTRL DRIVEMODE = STANDARD

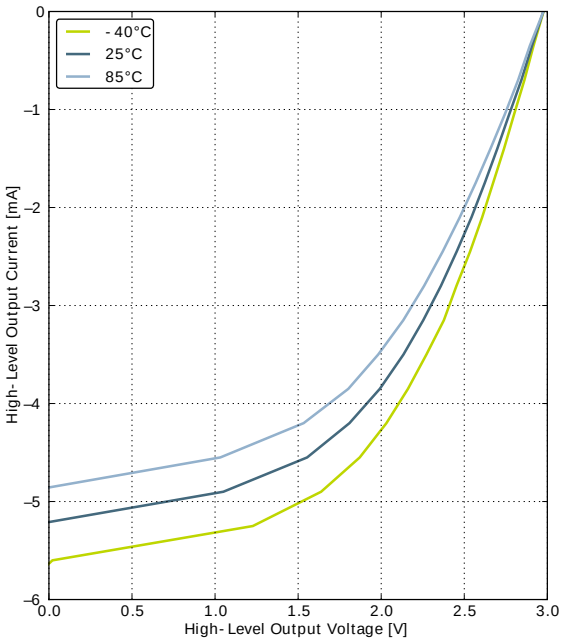


GPIO_Px_CTRL DRIVEMODE = HIGH

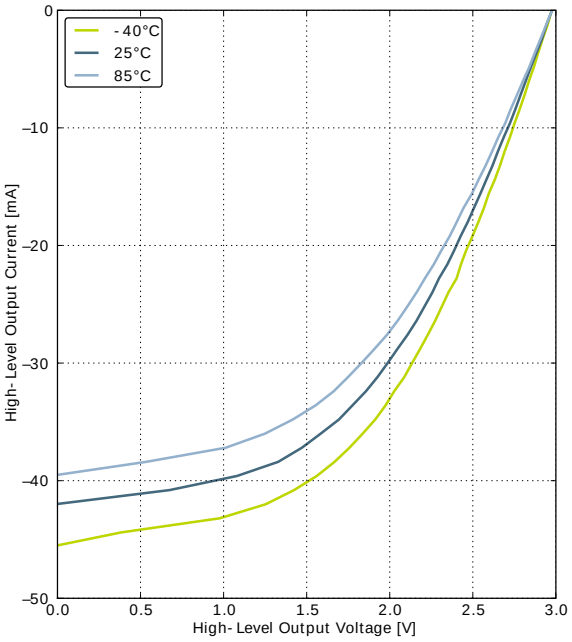
Figure 3.7. Typical High-Level Output Current, 3V Supply Voltage



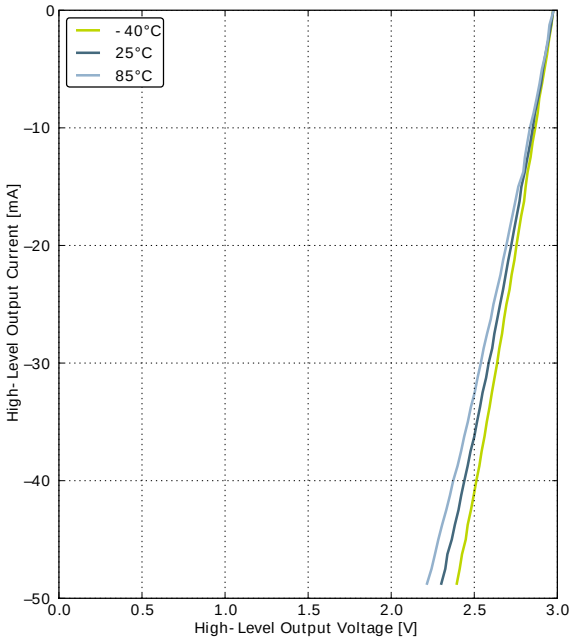
GPIO_Px_CTRL DRIVEMODE = LOWEST



GPIO_Px_CTRL DRIVEMODE = LOW

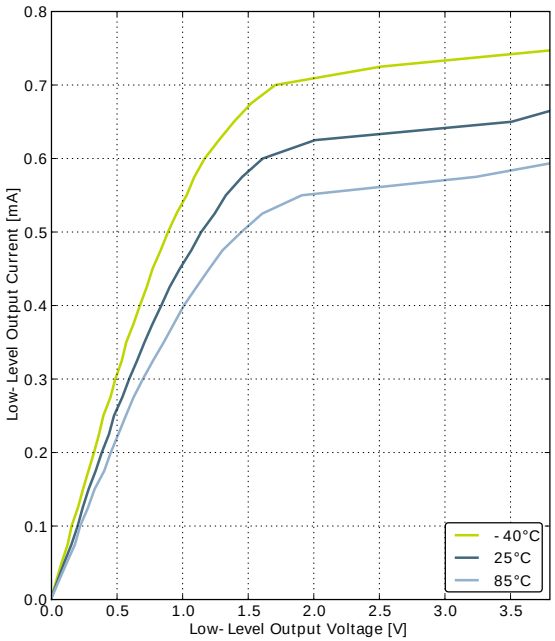


GPIO_Px_CTRL DRIVEMODE = STANDARD

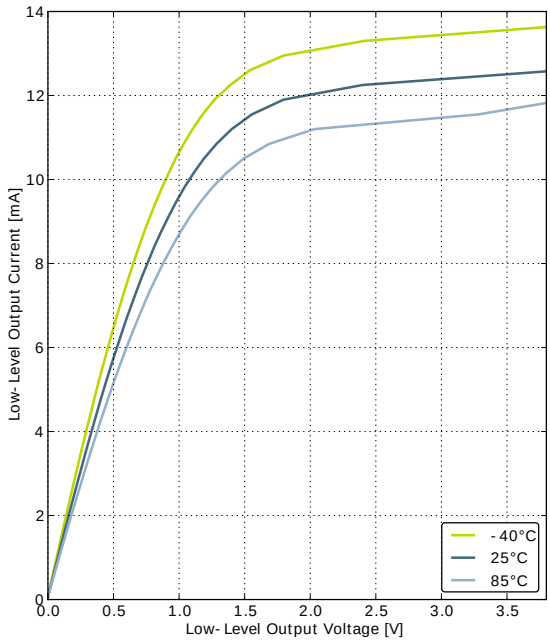


GPIO_Px_CTRL DRIVEMODE = HIGH

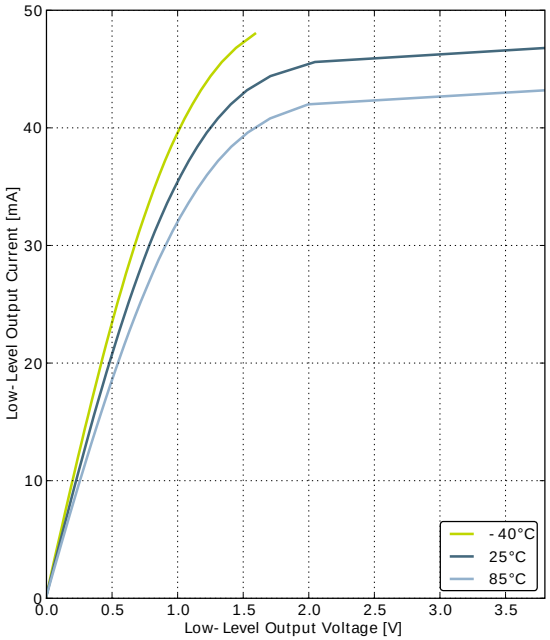
Figure 3.8. Typical Low-Level Output Current, 3.8V Supply Voltage



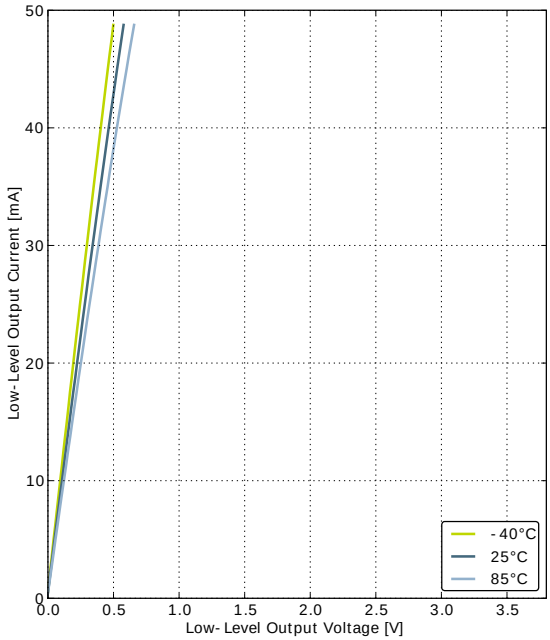
GPIO_Px_CTRL DRIVEMODE = LOWEST



GPIO_Px_CTRL DRIVEMODE = LOW

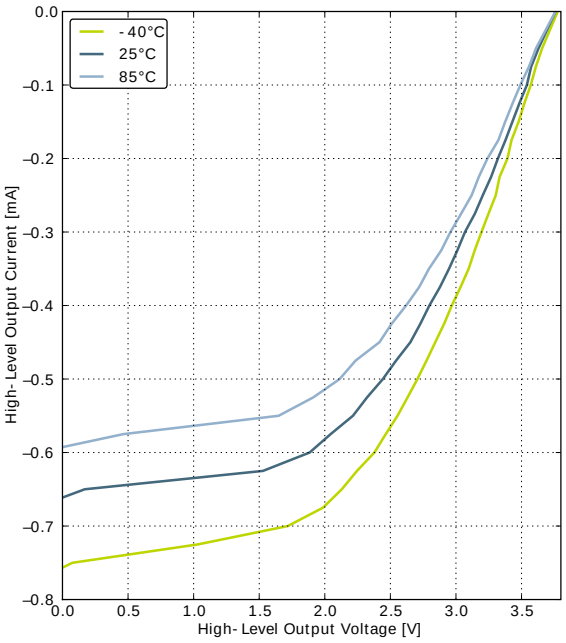


GPIO_Px_CTRL DRIVEMODE = STANDARD

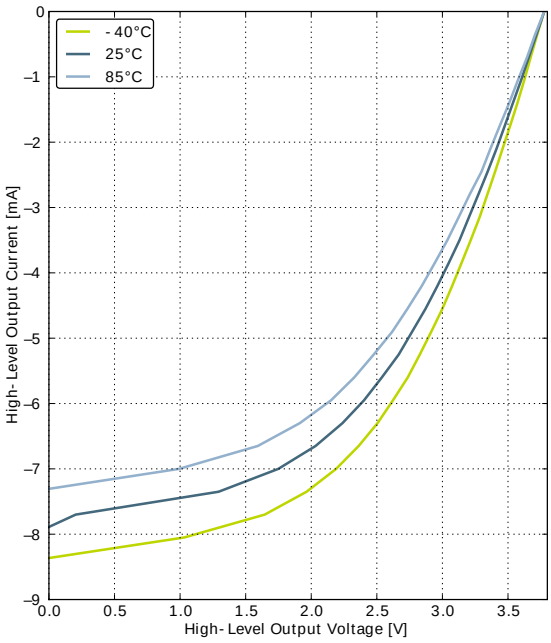


GPIO_Px_CTRL DRIVEMODE = HIGH

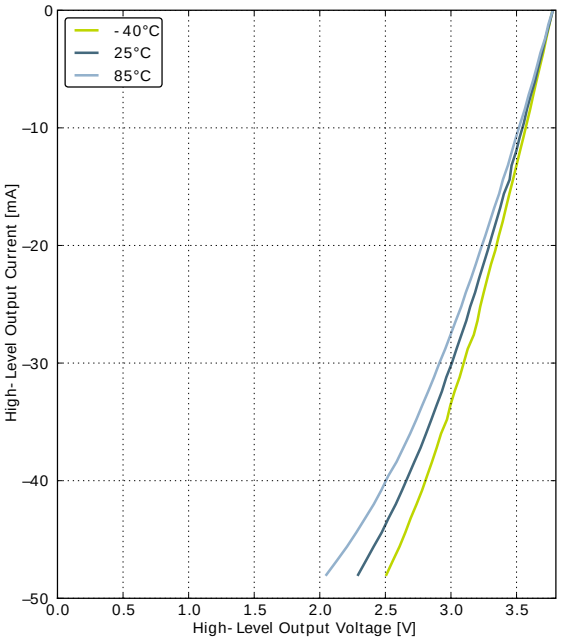
Figure 3.9. Typical High-Level Output Current, 3.8V Supply Voltage



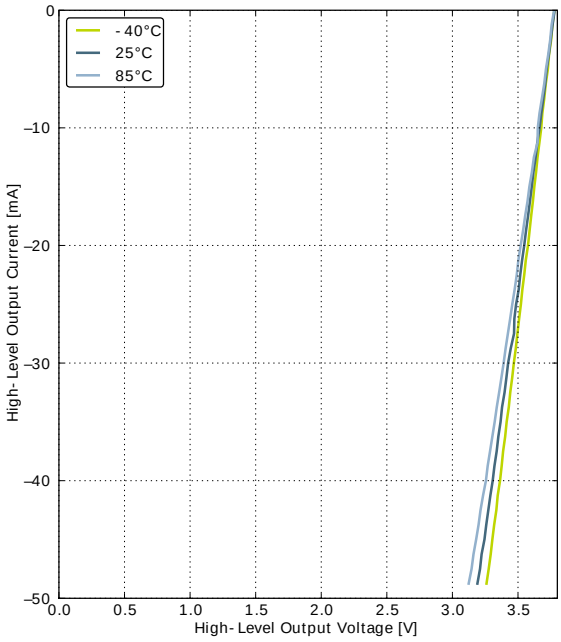
GPIO_Px_CTRL DRIVEMODE = LOWEST



GPIO_Px_CTRL DRIVEMODE = LOW



GPIO_Px_CTRL DRIVEMODE = STANDARD



GPIO_Px_CTRL DRIVEMODE = HIGH

3.9 Oscillators

3.9.1 LFXO

Table 3.9. LFXO

Symbol	Parameter	Condition	Min	Typ	Max	Unit
f_{LFXO}	Supported nominal crystal frequency			32.768		kHz
ESR_{LFXO}	Supported crystal equivalent series resistance (ESR)			30	120	kOhm
C_{LFXOL}	Supported crystal external load range		X[1]		25	pF
I_{LFXO}	Current consumption for core and buffer after startup.	ESR=30 kOhm, C_L=10 pF, LFXOBOOST in CMU_CTRL is 1		190		nA
t_{LFXO}	Start- up time.	ESR=30 kOhm, C_L=10 pF, 40% - 60% duty cycle has been reached, LFXOBOOST in CMU_CTRL is 1		400		ms

[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 energyAware Designer 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, the reader is referred to application note "AN0016 EFM32 Oscillator Design Consideration".

3.9.2 HFXO

Table 3.10. HFXO

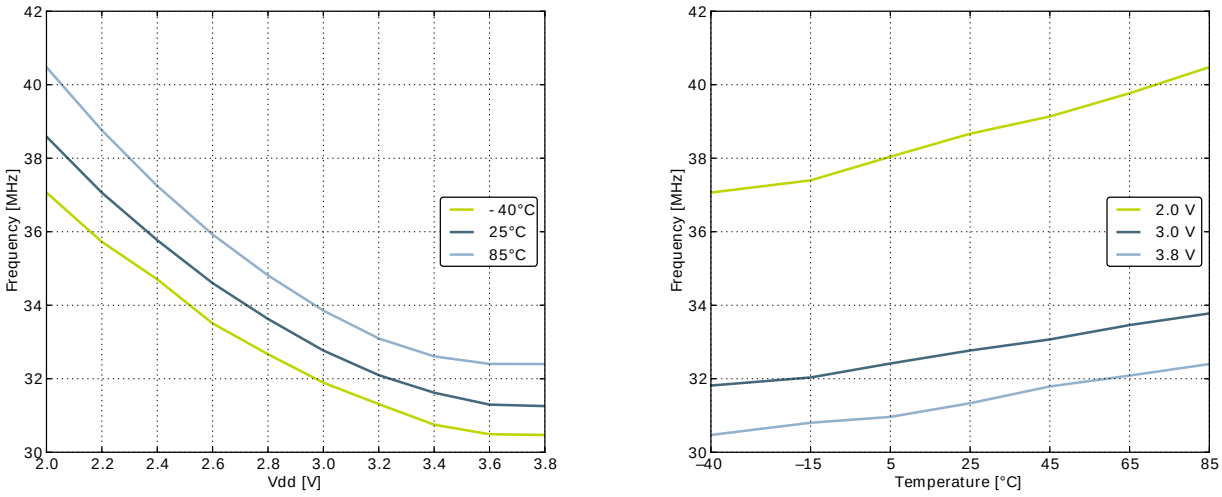
Symbol	Parameter	Condition	Min	Typ	Max	Unit
f_{HFXO}	Supported nominal crystal Frequency		4		32	MHz
ESR_{HFXO}	Supported crystal equivalent series resistance (ESR)	Crystal frequency 32 MHz		30	60	Ohm
		Crystal frequency 4 MHz		400	1500	Ohm
g_{mHFXO}	The transconductance of the HFXO input transistor at crystal startup	HFXOBOOST in CMU_CTRL equals 0b11	20			mS
C_{HFXOL}	Supported crystal external load range		5		25	pF
I_{HFXO}	Current consumption for HFXO after startup	4 MHz: ESR=400 Ohm, C_L=20 pF, HFXOBOOST in CMU_CTRL equals 0b11		85		µA
		32 MHz: ESR=30 Ohm, C_L=10 pF, HFXOBOOST in CMU_CTRL equals 0b11		165		µA
t_{HFXO}	Startup time	32 MHz: ESR=30 Ohm, C_L=10 pF, HFXOBOOST in CMU_CTRL equals 0b11		400		µs

3.9.3 LFRCO

Table 3.11. LFRCO

Symbol	Parameter	Condition	Min	Typ	Max	Unit
f_{LFRCO}	Oscillation frequency , V_{DD}= 3.0 V, T_{AMB}=25°C			32.768		kHz
t_{LFRCO}	Startup time not including software calibration			150		µs
I_{LFRCO}	Current consumption			190		nA
$TUNESTEP_{L-FRCO}$	Frequency step for LSB change in TUNING value			1.5		%

Figure 3.10. Calibrated LFRCO Frequency vs Temperature and Supply Voltage



3.9.4 HFRCO

Table 3.12. HFRCO

Symbol	Parameter	Condition	Min	Typ	Max	Unit
f_{HFRCO}	Oscillation frequency, V_{DD}= 3.0 V, T_{AMB}=25°C	28 MHz frequency band		28		MHz
		21 MHz frequency band		21		MHz
		14 MHz frequency band		14		MHz
		11 MHz frequency band		11		MHz
		7 MHz frequency band		6.6[1]		MHz
		1 MHz frequency band		1.2[2]		MHz
$t_{HFRCO_settling}$	Settling time after start-up	f_{HFRCO} = 14 MHz		0.6		Cycles
I_{HFRCO}	Current consumption (Production test condition = 14 MHz)	f_{HFRCO} = 28 MHz		106		µA
		f_{HFRCO} = 21 MHz		93		µA

Symbol	Parameter	Condition	Min	Typ	Max	Unit
		f_{HFRCO} = 14 MHz		77		µA
		f_{HFRCO} = 11 MHz		72		µA
		f_{HFRCO} = 6.6 MHz		63		µA
		f_{HFRCO} = 1.2 MHz		22		µA
DC_{HFRCO}	Duty cycle	f_{HFRCO} = 14 MHz	48.5	50	51	%
$TUNESTEP_{H-FRCO}$	Frequency step for LSB change in TUNING value			0.3[3]		%

[1]For devices with prod. rev. < 19, Typ = 7MHz and Min/Max values not applicable.

[2]For devices with prod. rev. < 19, Typ = 1MHz and Min/Max values not applicable.

[3]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 28 MHz across operating conditions.

Figure 3.11. Calibrated HFRCO 1 MHz Band Frequency vs Supply Voltage and Temperature

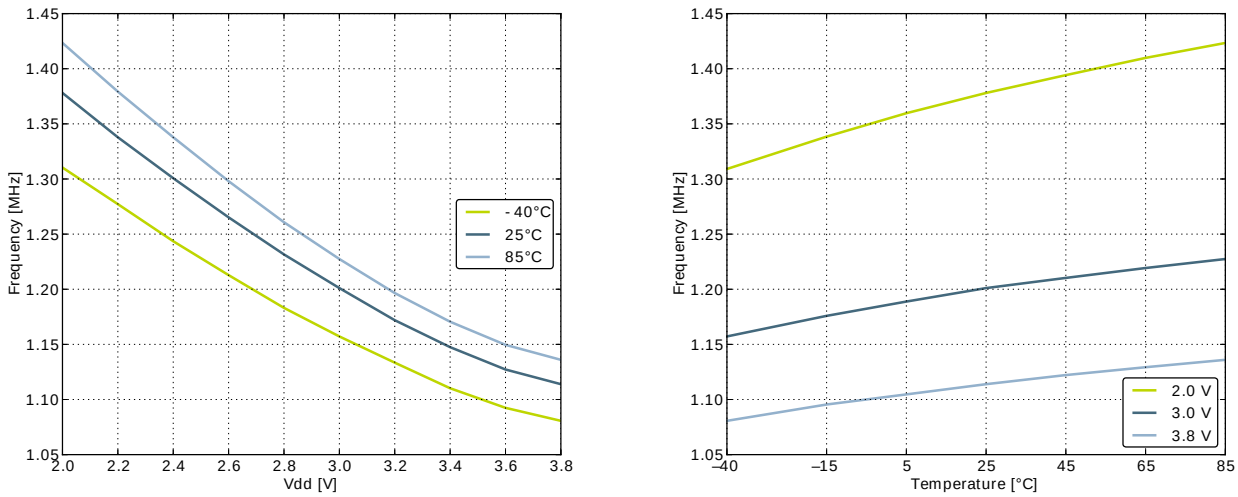


Figure 3.12. Calibrated HFRCO 7 MHz Band Frequency vs Supply Voltage and Temperature

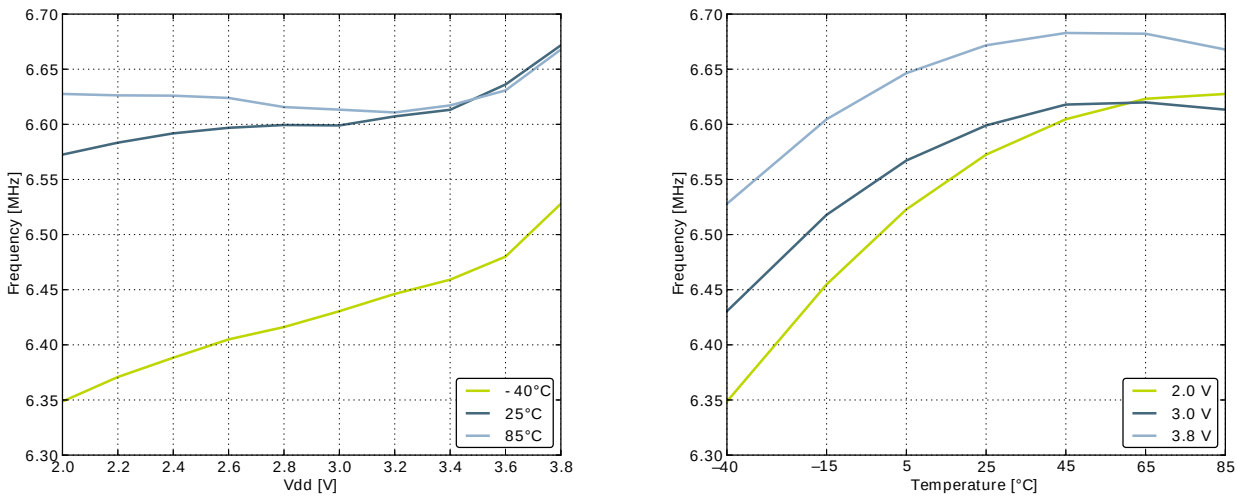


Figure 3.13. Calibrated HFRCO 11 MHz Band Frequency vs Supply Voltage and Temperature

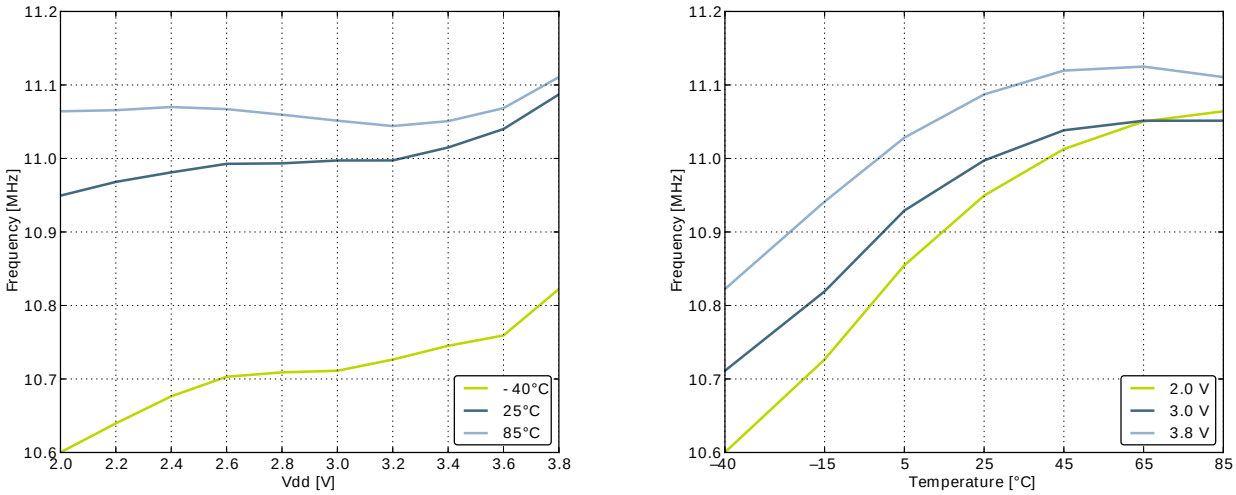


Figure 3.14. Calibrated HFRCO 14 MHz Band Frequency vs Supply Voltage and Temperature

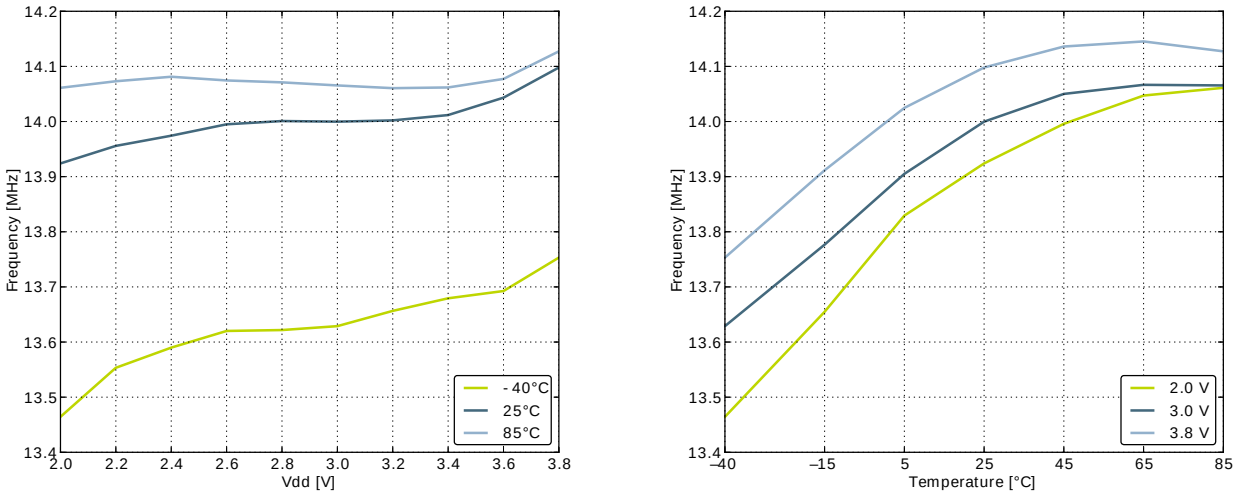


Figure 3.15. Calibrated HFRCO 21 MHz Band Frequency vs Supply Voltage and Temperature

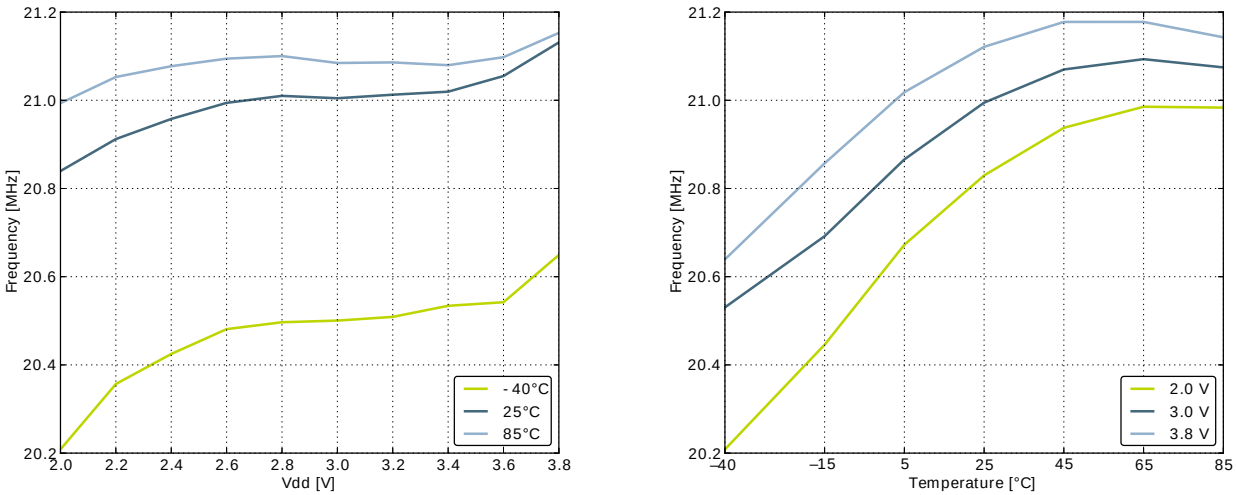
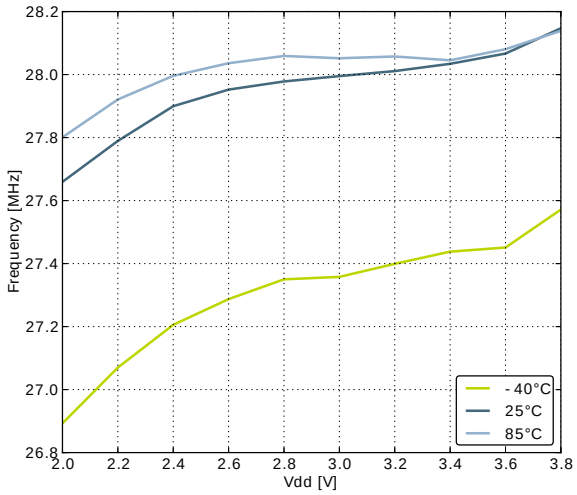
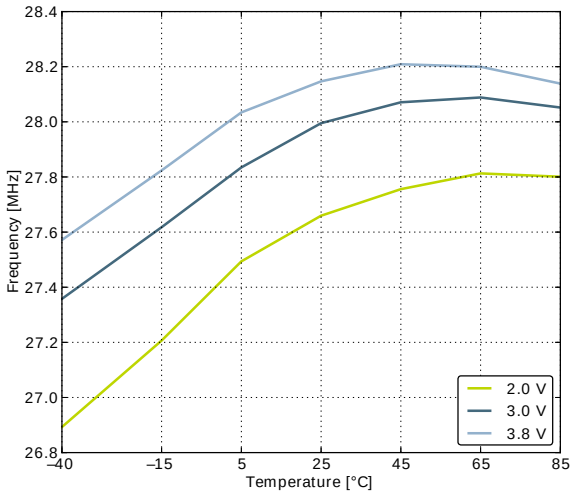


Figure 3.16. Calibrated HFRCO 28 MHz Band Frequency vs Supply Voltage and Temperature





3.9.5 ULFRCO

Table 3.13. ULFRCO

Symbol	Parameter	Condition	Min	Typ	Max	Unit
f_{ULFRCO}	Oscillation frequency	25°C, 3V	0.70		1.75	kHz
TC_{ULFRCO}	Temperature coefficient			0.05		%/°C
VC_{ULFRCO}	Supply voltage coefficient			-18.2		%/V

3.10 Analog Digital Converter (ADC)

Table 3.14. 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	2pF sampling capacitors		<100		nA

Symbol	Parameter	Condition	Min	Typ	Max	Unit
$CMRR_{ADC}$	Analog input common mode rejection ratio			65		dB
I_{ADC}	Average active current	1 MSamples/s, 12 bit, external reference		351		µA
		10 kSamples/s 12 bit, internal 1.25 V reference, WARMUP-MODE in ADCn_CTRL set to 0b00		67		µA
		10 kSamples/s 12 bit, internal 1.25 V reference, WARMUP-MODE in ADCn_CTRL set to 0b01		63		µA
		10 kSamples/s 12 bit, internal 1.25 V reference, WARMUP-MODE in ADCn_CTRL set to 0b10		64		µA
I_{ADCREF}	Current consumption of internal voltage reference	Internal voltage reference		65		µA
C_{ADCIN}	Input capacitance			2		pF
R_{ADCIN}	Input ON resistance		1			MOhm
$R_{ADCFILT}$	Input RC filter resistance			10		kOhm
$C_{ADCFILT}$	Input RC filter/decoupling capacitance			250		fF
f_{ADCCLK}	ADC Clock Frequency				13	MHz
$t_{ADCCONV}$	Conversion time	6 bit	7			ADC-CLK Cycles
		8 bit	11			ADC-CLK Cycles
		12 bit	13			ADC-CLK Cycles
t_{ADCACQ}	Acquisition time	Programmable	1		256	ADC-CLK Cycles
$t_{ADCACQVDD3}$	Required acquisition time for VDD/3 reference		2			µs
$t_{ADCSTART}$	Startup time of reference generator and ADC core in NORMAL mode			5		µs
	Startup time of reference generator and ADC core in KEEPADCWARM mode			1		µs

Symbol	Parameter	Condition	Min	Typ	Max	Unit
SNR_{ADC}	Signal to Noise Ratio (SNR)	1 MSamples/s, 12 bit, single ended, internal 1.25V reference		59		dB
		1 MSamples/s, 12 bit, single ended, internal 2.5V reference		63		dB
		1 MSamples/s, 12 bit, single ended, V_{DD} reference		65		dB
		1 MSamples/s, 12 bit, differential, internal 1.25V reference		60		dB
		1 MSamples/s, 12 bit, differential, internal 2.5V reference		65		dB
		1 MSamples/s, 12 bit, differential, 5V reference		54		dB
		1 MSamples/s, 12 bit, differential, V_{DD} reference		67		dB
		1 MSamples/s, 12 bit, differential, $2xV_{DD}$ reference		69		dB
		200 kSamples/s, 12 bit, single ended, internal 1.25V reference		62		dB
		200 kSamples/s, 12 bit, single ended, internal 2.5V reference		63		dB
		200 kSamples/s, 12 bit, single ended, V_{DD} reference		67		dB
		200 kSamples/s, 12 bit, differential, internal 1.25V reference		63		dB
		200 kSamples/s, 12 bit, differential, internal 2.5V reference		66		dB
		200 kSamples/s, 12 bit, differential, 5V reference		66		dB
		200 kSamples/s, 12 bit, differential, V_{DD} reference		69		dB
		200 kSamples/s, 12 bit, differential, $2xV_{DD}$ reference		70		dB
$SINAD_{ADC}$	SIgnal-to-Noise And Distortion-ratio (SINAD)	1 MSamples/s, 12 bit, single ended, internal 1.25V reference		58		dB
		1 MSamples/s, 12 bit, single ended, internal 2.5V reference		62		dB
		1 MSamples/s, 12 bit, single ended, V_{DD} reference		64		dB
		1 MSamples/s, 12 bit, differential, internal 1.25V reference		60		dB
		1 MSamples/s, 12 bit, differential, internal 2.5V reference		64		dB
		1 MSamples/s, 12 bit, differential, 5V reference		54		dB
		1 MSamples/s, 12 bit, differential, V_{DD} reference		66		dB

Symbol	Parameter	Condition	Min	Typ	Max	Unit
		1 MSamples/s, 12 bit, differential, 2xV_{DD} reference		68		dB
		200 kSamples/s, 12 bit, single ended, internal 1.25V reference		61		dB
		200 kSamples/s, 12 bit, single ended, internal 2.5V reference		65		dB
		200 kSamples/s, 12 bit, single ended, V_{DD} reference		66		dB
		200 kSamples/s, 12 bit, differential, internal 1.25V reference		63		dB
		200 kSamples/s, 12 bit, differential, internal 2.5V reference		66		dB
		200 kSamples/s, 12 bit, differential, 5V reference		66		dB
		200 kSamples/s, 12 bit, differential, V_{DD} reference		68		dB
		200 kSamples/s, 12 bit, differential, 2xV_{DD} reference		69		dB
$SFDR_{ADC}$	Spurious-Free Dynamic Range (SFDR)	1 MSamples/s, 12 bit, single ended, internal 1.25V reference		64		dBc
		1 MSamples/s, 12 bit, single ended, internal 2.5V reference		76		dBc
		1 MSamples/s, 12 bit, single ended, V_{DD} reference		73		dBc
		1 MSamples/s, 12 bit, differential, internal 1.25V reference		66		dBc
		1 MSamples/s, 12 bit, differential, internal 2.5V reference		77		dBc
		1 MSamples/s, 12 bit, differential, V_{DD} reference		76		dBc
		1 MSamples/s, 12 bit, differential, 2xV_{DD} reference		75		dBc
		1 MSamples/s, 12 bit, differential, 5V reference		69		dBc
		200 kSamples/s, 12 bit, single ended, internal 1.25V reference		75		dBc
		200 kSamples/s, 12 bit, single ended, internal 2.5V reference		75		dBc
		200 kSamples/s, 12 bit, single ended, V_{DD} reference		76		dBc
		200 kSamples/s, 12 bit, differential, internal 1.25V reference		79		dBc
		200 kSamples/s, 12 bit, differential, internal 2.5V reference		79		dBc
		200 kSamples/s, 12 bit, differential, 5V reference		78		dBc

Symbol	Parameter	Condition	Min	Typ	Max	Unit
		200 kSamples/s, 12 bit, differential, V_{DD} reference		79		dBc
		200 kSamples/s, 12 bit, differential, 2xV_{DD} reference		79		dBc
$V_{ADCOFFSET}$	Offset voltage	After calibration, single ended		0.3		mV
		After calibration, differential		0.3		mV
$TGRAD_{ADCTH}$	Thermometer output gradient			-1.92		mV/°C
				-6.3		ADC Codes/°C
DNL_{ADC}	Differential non-linearity (DNL)			±0.7		LSB
INL_{ADC}	Integral non-linearity (INL), End point method			±1.2		LSB
MC_{ADC}	No missing codes		11.999[1]	12		bits
$GAIN_{ED}$	Gain error drift	1.25V reference		0.01[2]	0.033[3]	%/°C
		2.5V reference		0.01[2]	0.03[3]	%/°C
$OFFSET_{ED}$	Offset error drift	1.25V reference		0.2[2]	0.7[3]	LSB/°C
		2.5V reference		0.2[2]	0.62[3]	LSB/°C

[1]On the average every ADC will have one missing code, most likely to appear around 2048 ± n*512 where n can be a value in the set {-3, -2, -1, 1, 2, 3}. There will be no missing code around 2048, and in spite of the missing code the ADC will be monotonic at all times so that a response to a slowly increasing input will always be a slowly increasing output. Around the one code that is missing, the neighbour codes will look wider in the DNL plot. The spectra will show spurs on the level of -78dBc for a full scale input for chips that have the missing code issue.

[2]Typical numbers given by abs(Mean) / (85 - 25).

[3]Max number given by (abs(Mean) + 3x stddev) / (85 - 25).

The integral non-linearity (INL) and differential non-linearity parameters are explained in Figure 3.17 (p. 31) and Figure 3.18 (p. 31) , respectively.

Figure 3.17. Integral Non-Linearity (INL)

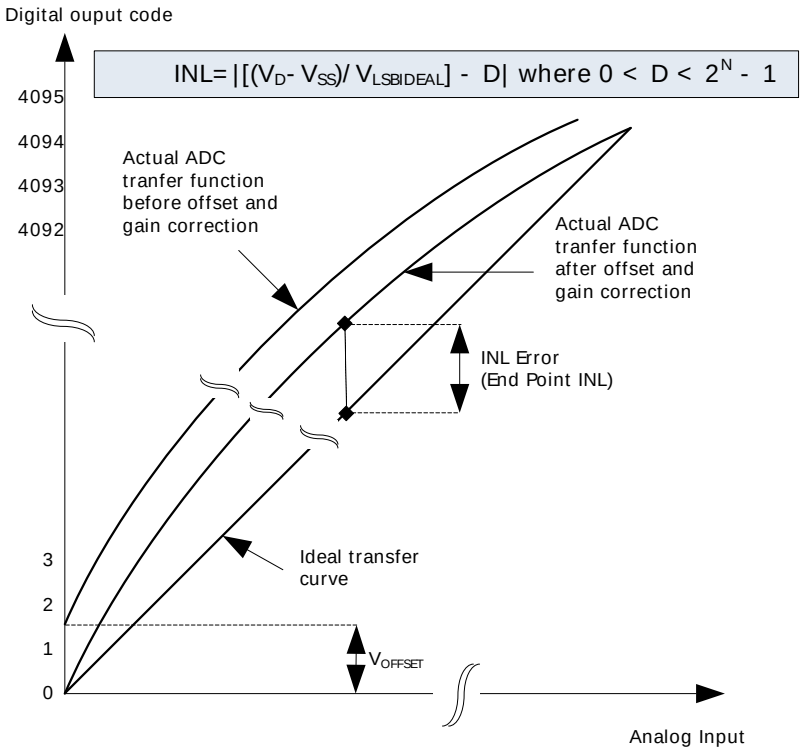
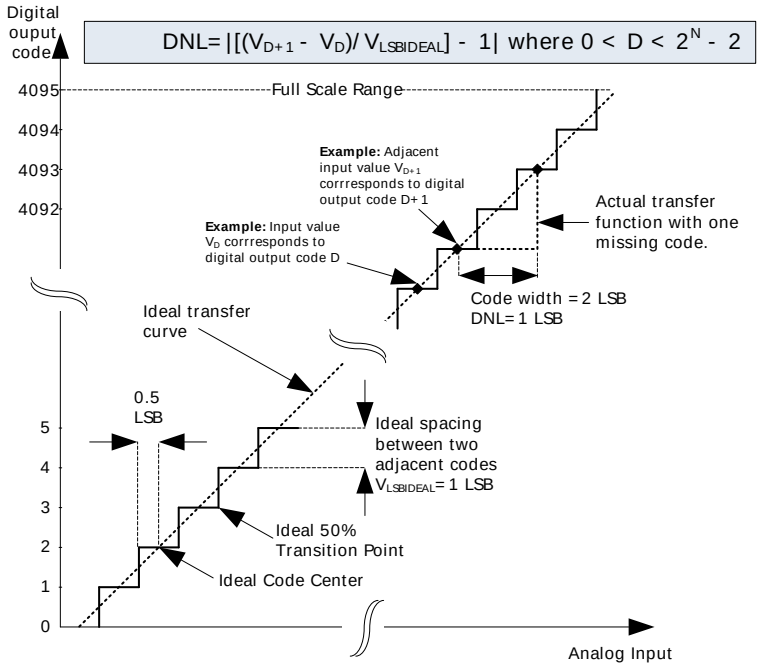
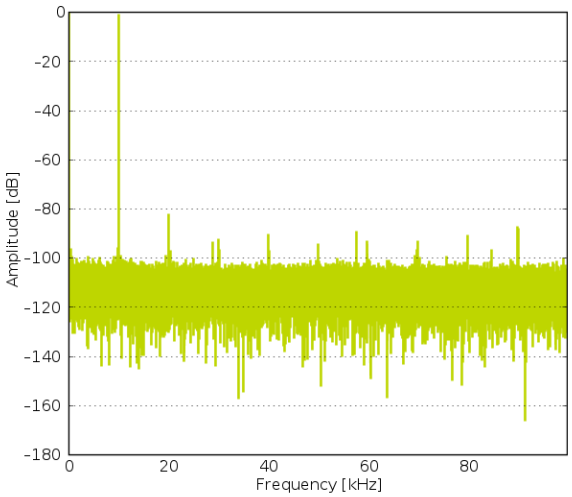


Figure 3.18. Differential Non-Linearity (DNL)

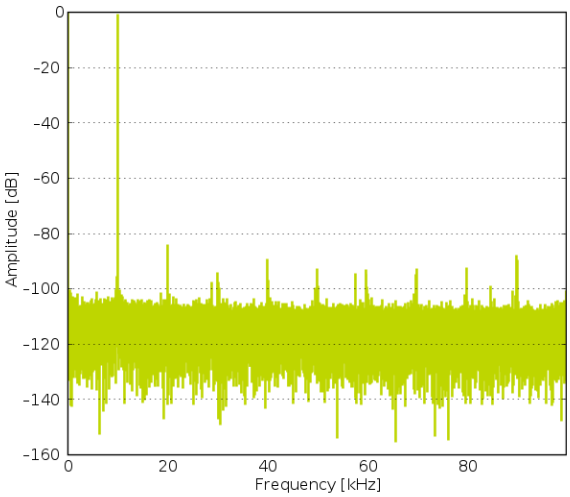


3.10.1 Typical performance

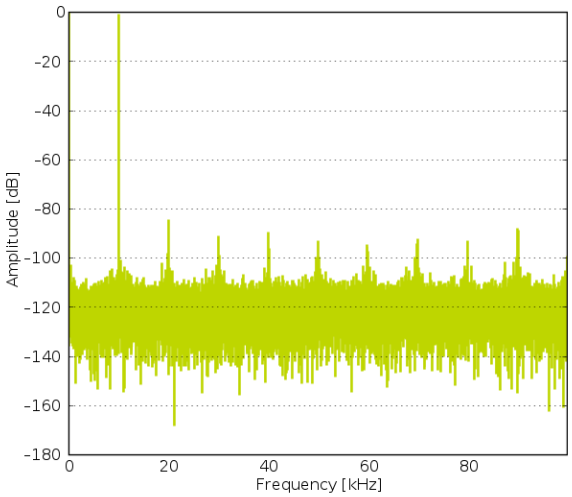
Figure 3.19. ADC Frequency Spectrum, Vdd = 3V, Temp = 25°C



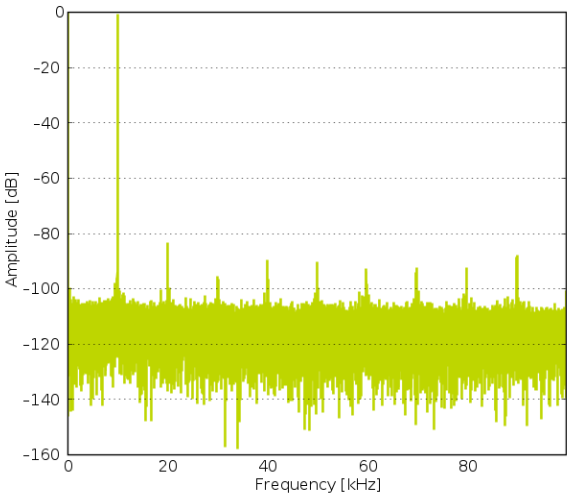
1.25V Reference



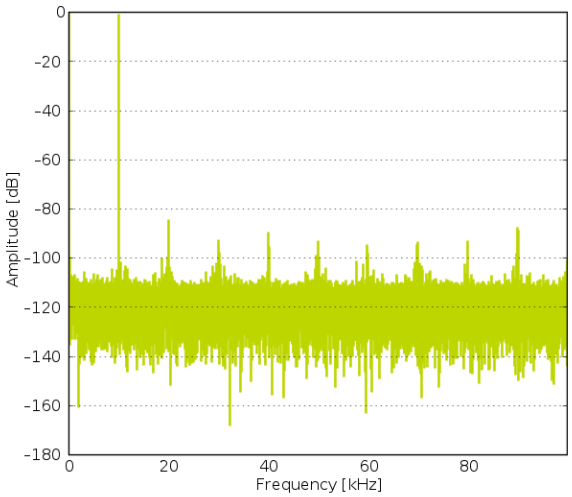
2.5V Reference



2XVDDVSS Reference

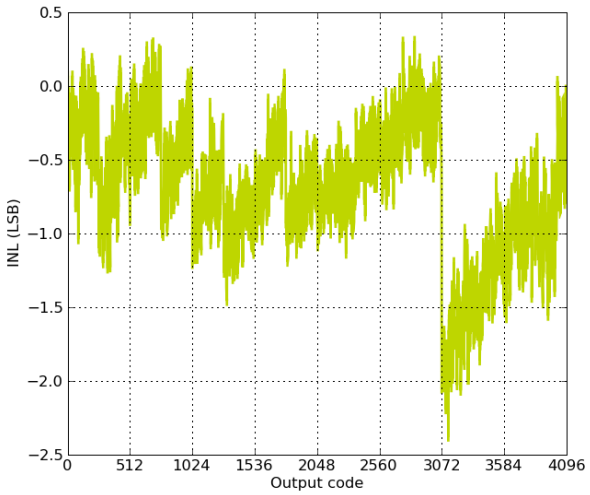


5VDIFF Reference

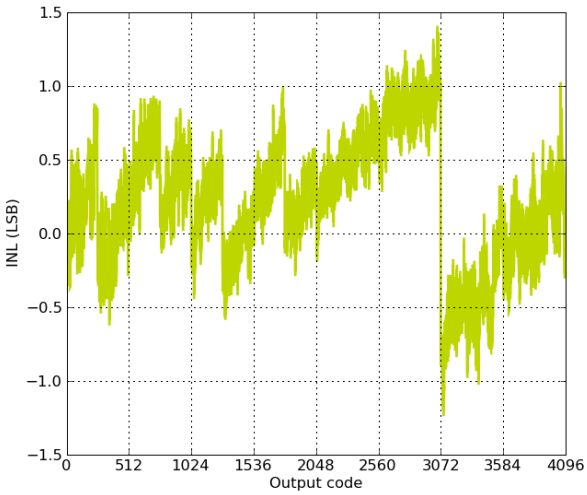


VDD Reference

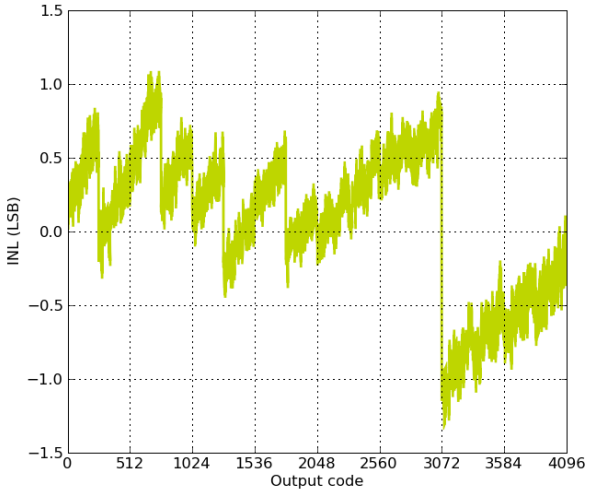
Figure 3.20. ADC Integral Linearity Error vs Code, Vdd = 3V, Temp = 25°C



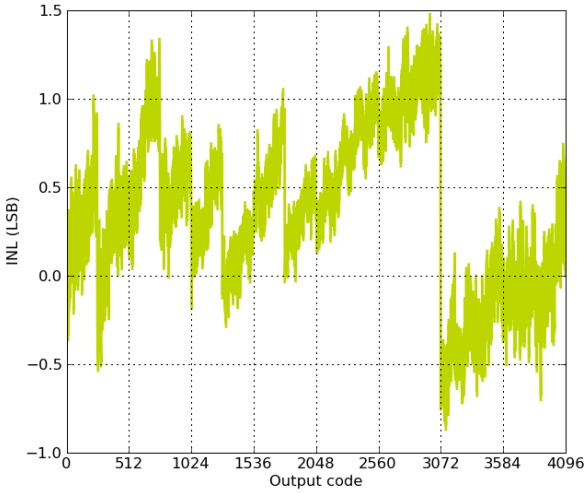
1.25V Reference



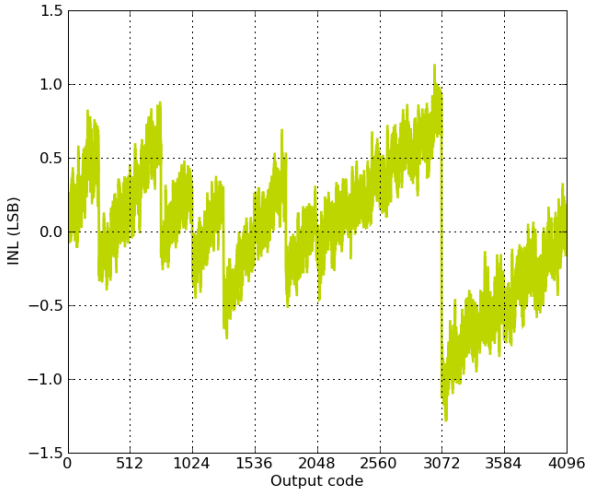
2.5V Reference



2XVDDVSS Reference

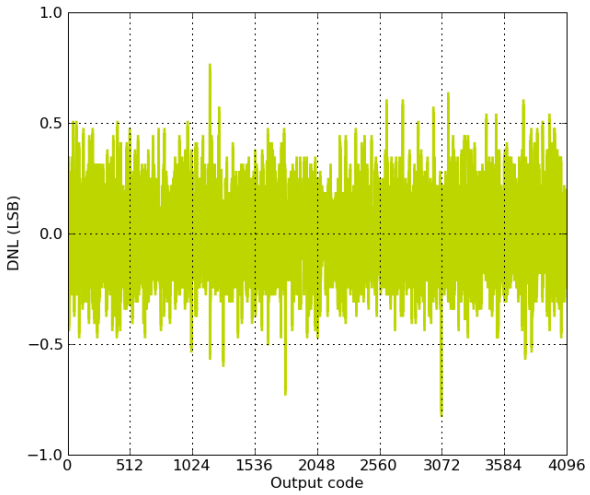


5VDIFF Reference

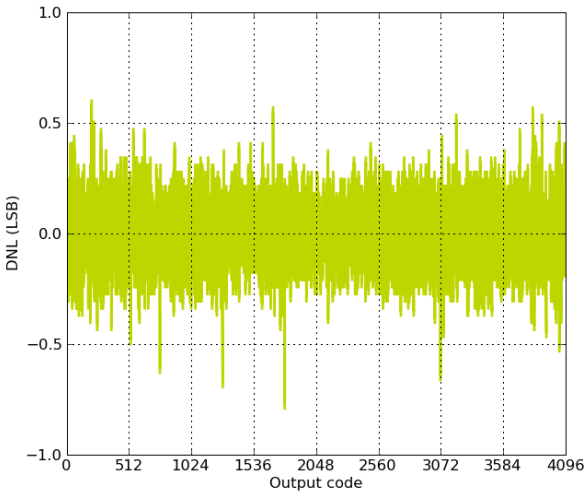


VDD Reference

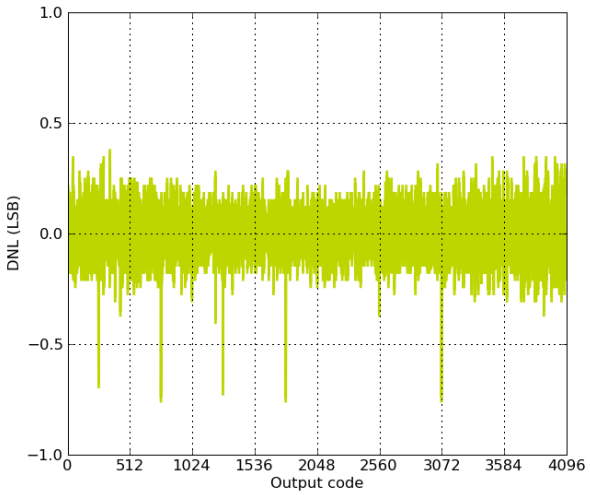
Figure 3.21. ADC Differential Linearity Error vs Code, Vdd = 3V, Temp = 25°C



1.25V Reference



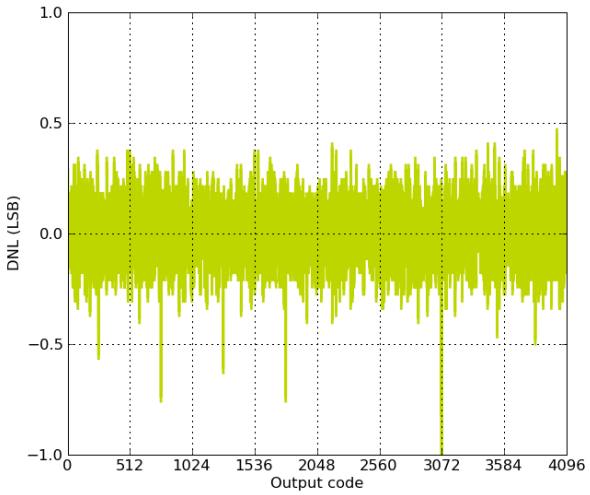
2.5V Reference



2XVDDVSS Reference

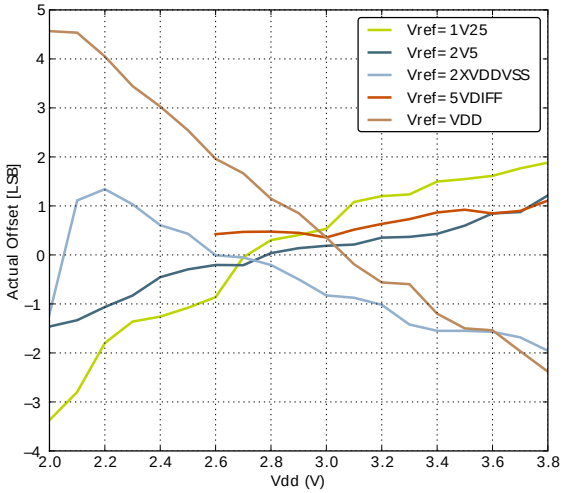


5VDIFF Reference

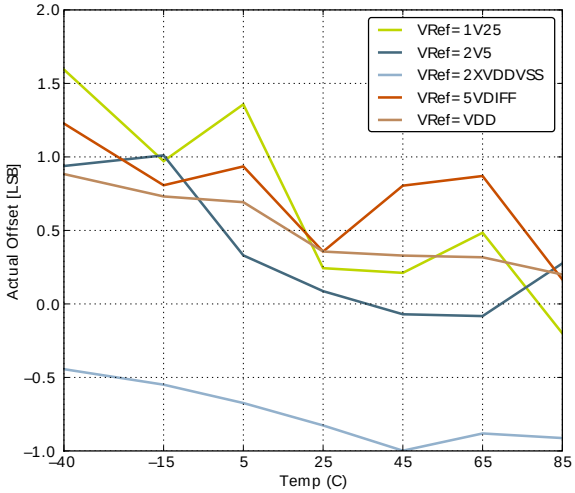


VDD Reference

Figure 3.22. ADC Absolute Offset, Common Mode = Vdd /2

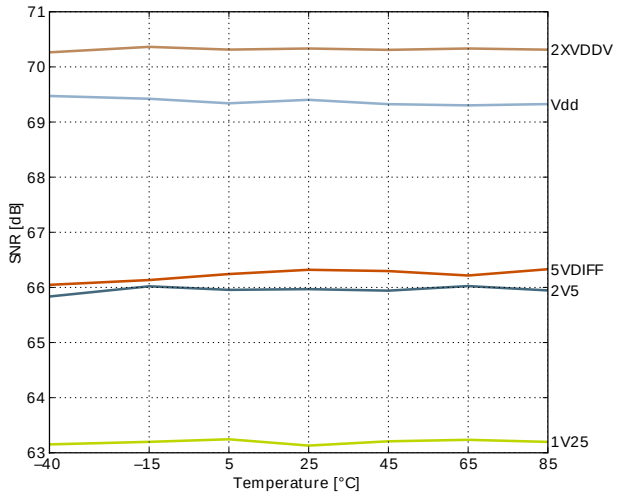


Offset vs Supply Voltage, Temp = 25°C

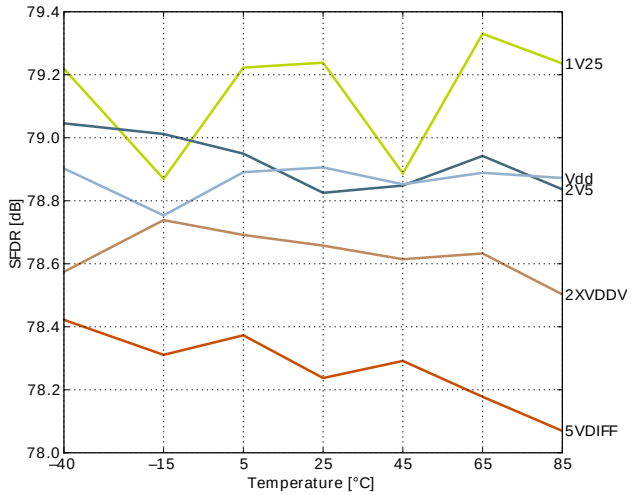


Offset vs Temperature, Vdd = 3V

Figure 3.23. ADC Dynamic Performance vs Temperature for all ADC References, Vdd = 3V



Signal to Noise Ratio (SNR)



Spurious-Free Dynamic Range (SFDR)

3.11 Digital Analog Converter (DAC)

Table 3.15. DAC

Symbol	Parameter	Condition	Min	Typ	Max	Unit
V_{DACOUT}	Output voltage range	VDD voltage reference, single ended	0		V_{DD}	V
V_{DACCM}	Output common mode voltage range		0		V_{DD}	V
I_{DAC}	Active current including references for 2 channels	500 kSamples/s, 12bit		400		µA
		100 kSamples/s, 12 bit		200		µA
		1 kSamples/s 12 bit NORMAL		38		µA
SR_{DAC}	Sample rate				500	ksamples/s

Symbol	Parameter	Condition	Min	Typ	Max	Unit
f_{DAC}	DAC clock frequency	Continuous Mode			1000	kHz
		Sample/Hold Mode			250	kHz
		Sample/Off Mode			250	kHz
$CYC_{DACCONV}$	Clock cyckles per conversion			2		
$t_{DACCONV}$	Conversion time		2			µs
$t_{DACSETTLE}$	Settling time			5		µs
SNR_{DAC}	Signal to Noise Ratio (SNR)	500 kSamples/s, 12 bit, single ended, internal 1.25V reference		58		dB
		500 kSamples/s, 12 bit, single ended, internal 2.5V reference		59		dB
$SNDR_{DAC}$	Signal to Noise-pulse Distortion Ratio (SNDR)	500 kSamples/s, 12 bit, single ended, internal 1.25V reference		57		dB
		500 kSamples/s, 12 bit, single ended, internal 2.5V reference		54		dB
$SFDR_{DAC}$	Spurious-Free Dynamic Range(SFDR)	500 kSamples/s, 12 bit, single ended, internal 1.25V reference		62		dBc
		500 kSamples/s, 12 bit, single ended, internal 2.5V reference		56		dBc
$V_{DACOFFSET}$	Offset voltage	After calibration, single ended		2		mV
DNL_{DAC}	Differential non-linearity			±1		LSB
INL_{DAC}	Integral non-linearity			±5		LSB
MC_{DAC}	No missing codes			12		bits

3.12 Operational Amplifier (OPAMP)

The electrical characteristics for the Operational Amplifiers are based on simulations.

Table 3.16. OPAMP

Symbol	Parameter	Condition	Min	Typ	Max	Unit
I_{OPAMP}	Active Current	OPA2 BIASPROG=0xF, HALFBIAS=0x0, Unity Gain		400		µA
		OPA2 BIASPROG=0x7, HALFBIAS=0x1, Unity Gain		100		µA
		OPA2 BIASPROG=0x0, HALFBIAS=0x1, Unity Gain		13		µA
G_{OL}	Open Loop Gain	OPA2 BIASPROG=0xF, HALFBIAS=0x0		101		dB
		OPA2 BIASPROG=0x7, HALFBIAS=0x1		98		dB
		OPA2 BIASPROG=0x0, HALFBIAS=0x1		91		dB

Symbol	Parameter	Condition	Min	Typ	Max	Unit
GBW_{OPAMP}	Gain Bandwidth Product	OPA0/OPA1 BIASPROG=0xF, HALFBIAS=0x0		16.36		MHz
		OPA0/OPA1 BIASPROG=0x7, HALFBIAS=0x1		0.81		MHz
		OPA0/OPA1 BIASPROG=0x0, HALFBIAS=0x1		0.11		MHz
		OPA2 BIASPROG=0xF, HALFBIAS=0x0		2.11		MHz
		OPA2 BIASPROG=0x7, HALFBIAS=0x1		0.72		MHz
		OPA2 BIASPROG=0x0, HALFBIAS=0x1		0.09		MHz
PM_{OPAMP}	Phase Margin	BIASPROG=0xF, HALFBIAS=0x0, C_L=75 pF		64		°
		BIASPROG=0x7, HALFBIAS=0x1, C_L=75 pF		58		°
		BIASPROG=0x0, HALFBIAS=0x1, C_L=75 pF		58		°
R_{INPUT}	Input Resistance			100		Mohm
R_{LOAD}	Load Resistance	OPA0/OPA1	200			Ohm
		OPA2	2000			Ohm
I_{LOAD_DC}	Load Current	OPA0/OPA1			11	mA
		OPA2			1.5	mA
V_{INPUT}	Input Voltage	OPAxHCMDIS=0	V_{SS}		V_{DD}	V
		OPAxHCMDIS=1	V_{SS}		V_{DD}-1.2	V
V_{OUTPUT}	Output Voltage		V_{SS}		V_{DD}	V
V_{OFFSET}	Input Offset Voltage	Unity Gain, V_{SS}<V_{in}<$_{DD}$, OPAx-HCMDIS=0		6		mV
		Unity Gain, V_{SS}<V_{in}<$_{DD}$-1.2, OPAxHCMDIS=1		1		mV
V_{OFFSET_DRIFT}	Input Offset Voltage Drift				0.02	mV/°C
SR_{OPAMP}	Slew Rate	OPA0/OPA1 BIASPROG=0xF, HALFBIAS=0x0		46.11		V/µs
		OPA0/OPA1 BIASPROG=0x7, HALFBIAS=0x1		1.21		V/µs
		OPA0/OPA1 BIASPROG=0x0, HALFBIAS=0x1		0.16		V/µs
		OPA2 BIASPROG=0xF, HALFBIAS=0x0		4.43		V/µs
		OPA2 BIASPROG=0x7, HALFBIAS=0x1		1.30		V/µs
		OPA2 BIASPROG=0x0, HALFBIAS=0x1		0.16		V/µs

Symbol	Parameter	Condition	Min	Typ	Max	Unit
PU_{OPAMP}	Power-up Time	OPA0/OPA1 BIASPROG=0xF, HALFBIAS=0x0		0.09		µs
		OPA0/OPA1 BIASPROG=0x7, HALFBIAS=0x1		1.52		µs
		OPA0/OPA1 BIASPROG=0x0, HALFBIAS=0x1		12.74		µs
		OPA2 BIASPROG=0xF, HALFBIAS=0x0		0.09		µs
		OPA2 BIASPROG=0x7, HALFBIAS=0x1		0.13		µs
		OPA2 BIASPROG=0x0, HALFBIAS=0x1		0.17		µs
N_{OPAMP}	Voltage Noise	V_{out}=1V, RESSEL=0, 0.1 Hz<f<10 kHz, OPAx-HCMDIS=0		101		$µV_{RMS}$
		V_{out}=1V, RESSEL=0, 0.1 Hz<f<10 kHz, OPAx-HCMDIS=1		141		$µV_{RMS}$
		V_{out}=1V, RESSEL=0, 0.1 Hz<f<1 MHz, OPAxHCMDIS=0		196		$µV_{RMS}$
		V_{out}=1V, RESSEL=0, 0.1 Hz<f<1 MHz, OPAxHCMDIS=1		229		$µV_{RMS}$
		RESSEL=7, 0.1 Hz<f<10 kHz, OPAxHCMDIS=0		1230		$µV_{RMS}$
		RESSEL=7, 0.1 Hz<f<10 kHz, OPAxHCMDIS=1		2130		$µV_{RMS}$
		RESSEL=7, 0.1 Hz<f<1 MHz, OPAxHCMDIS=0		1630		$µV_{RMS}$
		RESSEL=7, 0.1 Hz<f<1 MHz, OPAxHCMDIS=1		2590		$µV_{RMS}$

Figure 3.24. OPAMP Common Mode Rejection Ratio

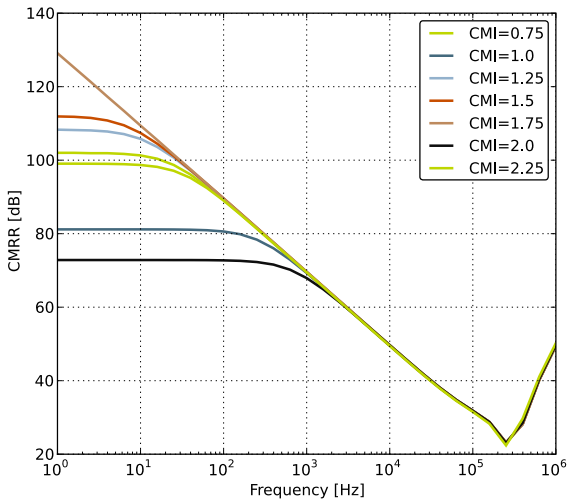


Figure 3.25. OPAMP Positive Power Supply Rejection Ratio

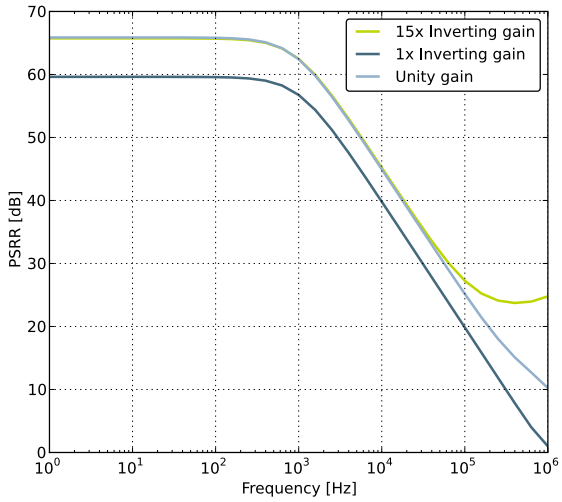


Figure 3.26. OPAMP Negative Power Supply Rejection Ratio

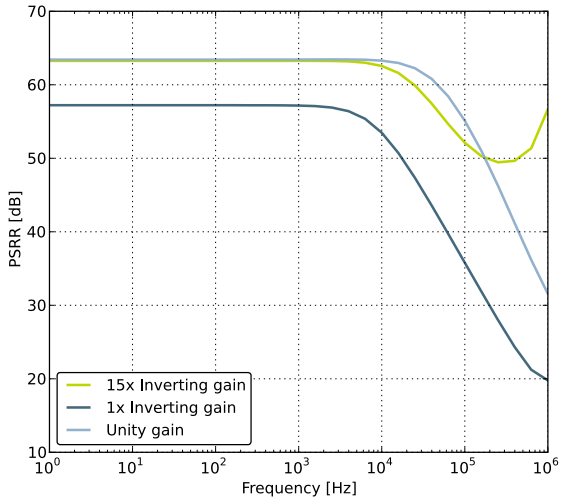


Figure 3.27. OPAMP Voltage Noise Spectral Density (Unity Gain) V_{out}=1V

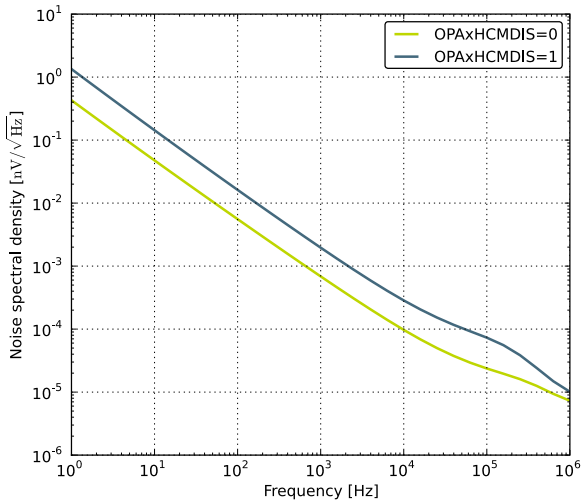
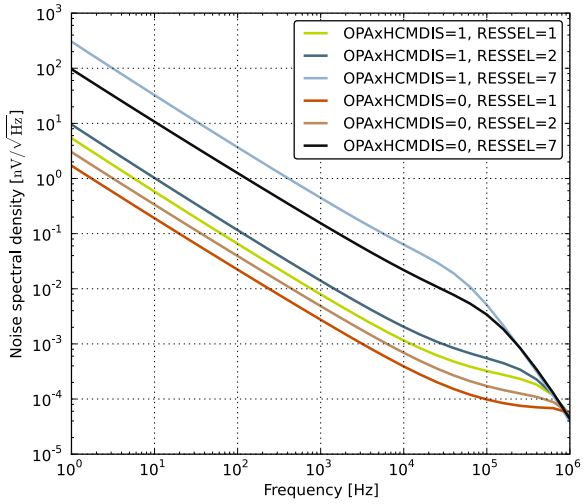


Figure 3.28. OPAMP Voltage Noise Spectral Density (Non-Unity Gain)



3.13 Analog Comparator (ACMP)

Table 3.17. ACMP

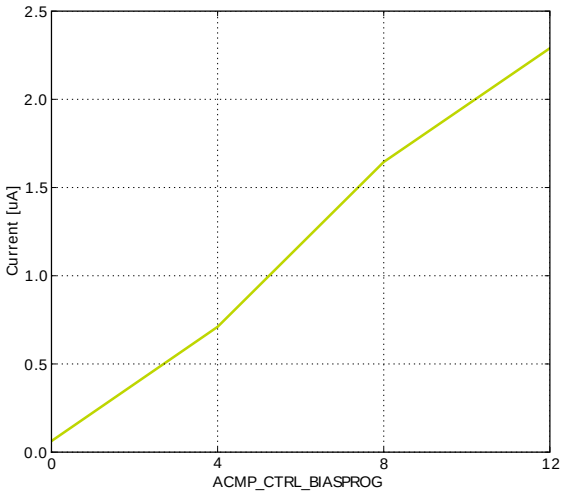
Symbol	Parameter	Condition	Min	Typ	Max	Unit
V_{ACMPIN}	Input voltage range		0		V_{DD}	V
V_{ACMPCM}	ACMP Common Mode voltage range		0		V_{DD}	V
I_{ACMP}	Active current	BIASPROG=0b0000, FULLBIAS=0 and HALFBIAS=1 in ACMPn_CTRL register		0.1		µA
		BIASPROG=0b1111, FULLBIAS=0 and HALFBIAS=0 in ACMPn_CTRL register		2.87		µA
		BIASPROG=0b1111, FULLBIAS=1 and HALFBIAS=0 in ACMPn_CTRL register		195		µA
$I_{ACMPREF}$	Current consumption of internal voltage reference	Internal voltage reference off. Using external voltage reference		0		µA
		Internal voltage reference		5		µA
$V_{ACMPOFFSET}$	Offset voltage	BIASPROG= 0b1010, FULLBIAS=0 and HALFBIAS=0 in ACMPn_CTRL register		0		mV
$V_{ACMPHYST}$	ACMP hysteresis	Programmable		17		mV
R_{CSRES}	Capacitive Sense Internal Resistance	CSRESSEL=0b00 in ACMPn_INPUTSEL		39		kOhm
		CSRESSEL=0b01 in ACMPn_INPUTSEL		71		kOhm
		CSRESSEL=0b10 in ACMPn_INPUTSEL		104		kOhm
		CSRESSEL=0b11 in ACMPn_INPUTSEL		136		kOhm
$t_{ACMPSTART}$	Startup time				10	µs

The total ACMP current is the sum of the contributions from the ACMP and its internal voltage reference as given in Equation 3.1 (p. 41) . $I_{ACMPREF}$ is zero if an external voltage reference is used.

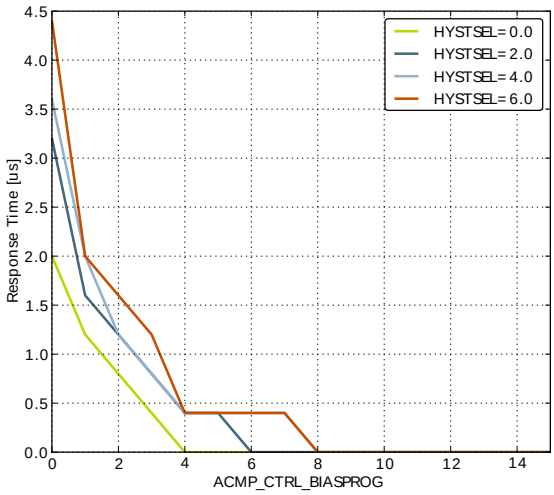
Total ACMP Active Current

$$I_{ACMPTOTAL} = I_{ACMP} + I_{ACMPREF} \quad (3.1)$$

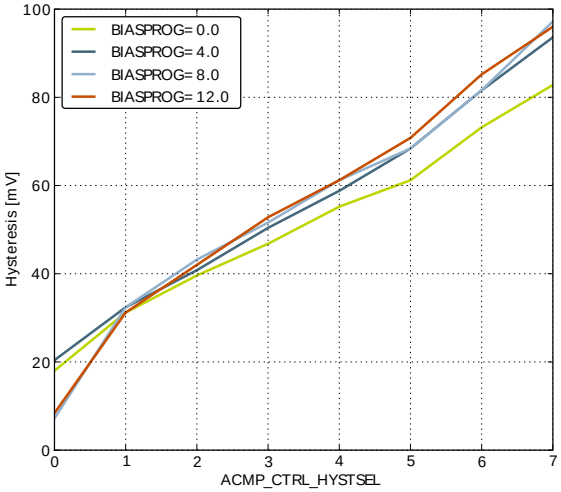
Figure 3.29. ACMP Characteristics, Vdd = 3V, Temp = 25°C, FULLBIAS = 0, HALFBIAS = 1



Current consumption, HYSTSEL = 4



Response time



Hysteresis

3.14 Voltage Comparator (VCMP)

Table 3.18. VCMP

Symbol	Parameter	Condition	Min	Typ	Max	Unit
V_{VCMPIN}	Input voltage range			V_{DD}		V
V_{VCMPCM}	VCMP Common Mode voltage range			V_{DD}		V
I_{VCMP}	Active current	BIASPROG=0b0000 and HALFBIAS=1 in VCMPn_CTRL register		0.1		µA
		BIASPROG=0b1111 and HALFBIAS=0 in VCMPn_CTRL register. LPREF=0.		14.7		µA
$t_{VCMPREF}$	Startup time reference generator	NORMAL		10		µs
$V_{VCMPOFFSET}$	Offset voltage	Single ended		10		mV
		Differential		10		mV
$V_{VCMPHYST}$	VCMP hysteresis			17		mV
$t_{VCMPSTART}$	Startup time				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:

VCMP Trigger Level as a Function of Level Setting

$$V_{DD\ Trigger\ Level}=1.667V+0.034 \times TRIGLEVEL \quad (3.2)$$

3.15 LCD

Table 3.19. LCD

Symbol	Parameter	Condition	Min	Typ	Max	Unit
f_{LCDFR}	Frame rate		30		200	Hz
NUM_{SEG}	Number of segments supported			11×8		seg
V_{LCD}	LCD supply voltage range	Internal boost circuit enabled	2.0		3.8	V
I_{LCD}	Steady state current consumption.	Display disconnected, static mode, framerate 32 Hz, all segments on.		250		nA
		Display disconnected, quadruplex mode, framerate 32 Hz, all segments on, bias mode to ONETHIRD in LCD_DISPCTRL register.		550		nA
$I_{LCDBOOST}$	Steady state Current contribution of internal boost.	Internal voltage boost off		0		µA
		Internal voltage boost on, boosting from 2.2 V to 3.0 V.		8.4		µA
V_{BOOST}	Boost Voltage	VBLEV of LCD_DISPCTRL register to LEVEL0		3.0		V
		VBLEV of LCD_DISPCTRL register to LEVEL1		3.08		V
		VBLEV of LCD_DISPCTRL register to LEVEL2		3.17		V
		VBLEV of LCD_DISPCTRL register to LEVEL3		3.26		V
		VBLEV of LCD_DISPCTRL register to LEVEL4		3.34		V
		VBLEV of LCD_DISPCTRL register to LEVEL5		3.43		V
		VBLEV of LCD_DISPCTRL register to LEVEL6		3.52		V
		VBLEV of LCD_DISPCTRL register to LEVEL7		3.6		V

The total LCD current is given by Equation 3.3 (p. 44) . $I_{LCDBOOST}$ is zero if internal boost is off.

Total LCD Current Based on Operational Mode and Internal Boost

$$I_{LCDTOTAL} = I_{LCD} + I_{LCDBOOST} \quad (3.3)$$

3.16 I2C

Table 3.20. I2C Standard-mode (Sm)

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

[1]For the minimum HFPERCLK frequency required in Standard-mode, see the I2C chapter in the EFM32TG 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] * $f_{HFPERCLK}$ [Hz]) - 4).

Table 3.21. I2C Fast-mode (Fm)

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

[1]For the minimum HFPERCLK frequency required in Fast-mode, see the I2C chapter in the EFM32TG 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] * $f_{HFPERCLK}$ [Hz]) - 4).

Table 3.22. I2C Fast-mode Plus (Fm+)

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

[1]For the minimum HFPERCLK frequency required in Fast-mode Plus, see the I2C chapter in the EFM32TG Reference Manual.

3.17 Digital Peripherals

Table 3.23. Digital Peripherals

Symbol	Parameter	Condition	Min	Typ	Max	Unit
I_{USART}	USART current	USART idle current, clock enabled		7.5		µA/MHz
I_{UART}	UART current	UART idle current, clock enabled		5.63		µA/MHz
I_{LEUART}	LEUART current	LEUART idle current, clock enabled		150		nA
I_{I2C}	I2C current	I2C idle current, clock enabled		6.25		µA/MHz
I_{TIMER}	TIMER current	TIMER_0 idle current, clock enabled		8.75		µA/MHz
$I_{LETIMER}$	LETIMER current	LETIMER idle current, clock enabled		150		nA
I_{PCNT}	PCNT current	PCNT idle current, clock enabled		100		nA
I_{RTC}	RTC current	RTC idle current, clock enabled		100		nA
I_{LCD}	LCD current	LCD idle current, clock enabled		100		nA
I_{AES}	AES current	AES idle current, clock enabled		2.5		µA/MHz
I_{GPIO}	GPIO current	GPIO idle current, clock enabled		5.31		µA/MHz
I_{PRS}	PRS current	PRS idle current		2,81		µA/MHz
I_{DMA}	DMA current	Clock enable		8.12		µA/MHz

4 Pinout and Package

Note

Please refer to the application note "AN0002 EFM32 Hardware Design Considerations" for guidelines on designing Printed Circuit Boards (PCB's) for the EFM32TG825.

4.1 Pinout

The *EFM32TG825* pinout is shown in Figure 4.1 (p. 47) and Table 4.1 (p. 47). 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 4.1. EFM32TG825 Pinout (top view, not to scale)

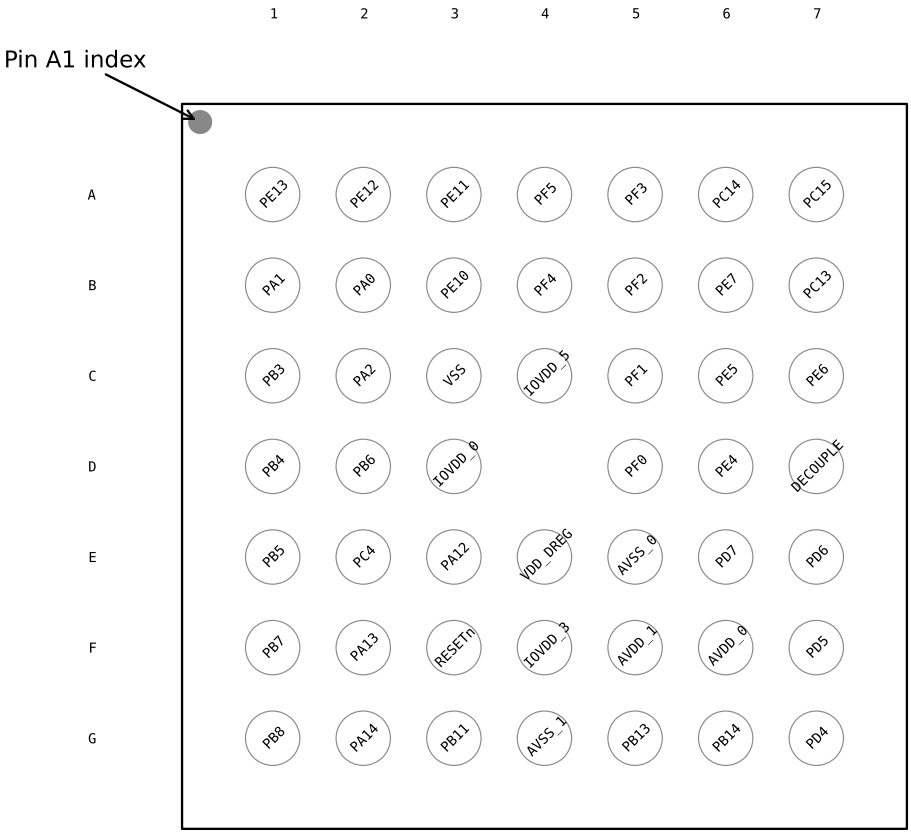


Table 4.1. Device Pinout

BGA48 Pin# and Name		Pin Alternate Functionality / Description			
Pin #	Pin Name	Analog	Timers	Communication	Other
A1	PE13	LCD_SEG9		US0_TX #3 US0_CS #0 I2C0_SCL #6	LES_ALTEX7 #0 ACMP0_O #0 GPIO_EM4WU5
A2	PE12	LCD_SEG8	TIM1_CC2 #1	US0_RX #3 US0_CLK #0 I2C0_SDA #6	CMU_CLK1 #2 LES_ALTEX6 #0

BGA48 Pin# and Name		Pin Alternate Functionality / Description			
Pin #	Pin Name	Analog	Timers	Communication	Other
A3	PE11	LCD_SEG7	TIM1_CC1 #1	US0_RX #0	LES_ALTEX5 #0 BOOT_RX
A4	PF5	LCD_SEG3			PRS_CH2 #1
A5	PF3	LCD_SEG1			PRS_CH0 #1
A6	PC14	ACMP1_CH6 DAC0_OUT1ALT #2/ OPAMP_OUT1ALT	TIM1_CC1 #0 PCNT0_S1IN #0	US0_CS #3	LES_CH14 #0
A7	PC15	ACMP1_CH7 DAC0_OUT1ALT #3/ OPAMP_OUT1ALT	TIM1_CC2 #0	US0_CLK #3	LES_CH15 #0 DBG_SWO #1
B1	PA1	LCD_SEG14	TIM0_CC1 #0/1	I2C0_SCL #0	CMU_CLK1 #0 PRS_CH1 #0
B2	PA0	LCD_SEG13	TIM0_CC0 #0/1/4	LEU0_RX #4 I2C0_SDA #0	PRS_CH0 #0 GPIO_EM4WU0
B3	PE10	LCD_SEG6	TIM1_CC0 #1	US0_TX #0	BOOT_TX
B4	PF4	LCD_SEG2			PRS_CH1 #1
B5	PF2	LCD_SEG0	TIM0_CC2 #5	LEU0_TX #4	ACMP1_O #0 DBG_SWO #0 GPIO_EM4WU4
B6	PE7	LCD_COM3		US0_TX #1	
B7	PC13	ACMP1_CH5 DAC0_OUT1ALT #1/ OPAMP_OUT1ALT	TIM1_CC0 #0 TIM1_CC2 #4 PCNT0_S0IN #0		LES_CH13 #0
C1	PB3	LCD_SEG20/ LCD_COM4			
C2	PA2	LCD_SEG15	TIM0_CC2 #0/1		CMU_CLK0 #0
C3	VSS	Ground			
C4	IOVDD_5	Digital IO power supply 5.			
C5	PF1		TIM0_CC1 #5 LETIM0_OUT1 #2	US1_CS #2 LEU0_RX #3 I2C0_SCL #5	DBG_SWDIO #0/1 GPIO_EM4WU3
C6	PE5	LCD_COM1		US0_CLK #1	
C7	PE6	LCD_COM2		US0_RX #1	
D1	PB4	LCD_SEG21/ LCD_COM5			
D2	PB6	LCD_SEG23/ LCD_COM7			
D3	IOVDD_0	Digital IO power supply 0.			
D5	PF0		TIM0_CC0 #5 LETIM0_OUT0 #2	US1_CLK #2 LEU0_TX #3 I2C0_SDA #5	DBG_SWCLK #0/1
D6	PE4	LCD_COM0		US0_CS #1	
D7	DECOUPLE	Decouple output for on-chip voltage regulator. An external capacitance of size $C_{DECOUPLE}$ is required at this pin.			
E1	PB5	LCD_SEG22/ LCD_COM6			
E2	PC4	ACMP0_CH4 DAC0_P0 / OPAMP_P0	LETIM0_OUT0 #3		LES_CH4 #0
E3	PA12	LCD_BCAP_P			

BGA48 Pin# and Name		Pin Alternate Functionality / Description			
Pin #	Pin Name	Analog	Timers	Communication	Other
E4	VDD_DREG	Power supply for on-chip voltage regulator.			
E5	AVSS_0	Analog ground 0.			
E6	PD7	ADC0_CH7 DAC0_N1 / OPAMP_N1	TIM1_CC1 #4 LETIM0_OUT1 #0 PCNT0_S1IN #3	US1_TX #2 I2C0_SCL #1	CMU_CLK0 #2 LES_ALTEX1 #0 ACMP1_O #2
E7	PD6	ADC0_CH6 DAC0_P1 / OPAMP_P1	TIM1_CC0 #4 LETIM0_OUT0 #0 PCNT0_S0IN #3	US1_RX #2 I2C0_SDA #1	LES_ALTEX0 #0 ACMP0_O #2
F1	PB7	LFXTAL_P	TIM1_CC0 #3	US0_TX #4 US1_CLK #0	
F2	PA13	LCD_BCAP_N			
F3	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.			
F4	IOVDD_3	Digital IO power supply 3.			
F5	AVDD_1	Analog power supply 1.			
F6	AVDD_0	Analog power supply 0.			
F7	PD5	ADC0_CH5 OPAMP_OUT2 #0		LEU0_RX #0	
G1	PB8	LFXTAL_N	TIM1_CC1 #3	US0_RX #4 US1_CS #0	
G2	PA14	LCD_BEXT			
G3	PB11	DAC0_OUT0 / OPAMP_OUT0	TIM1_CC2 #3 LETIM0_OUT0 #1		
G4	AVSS_1	Analog ground 1.			
G5	PB13	HFXTAL_P		US0_CLK #4/5 LEU0_TX #1	
G6	PB14	HFXTAL_N		US0_CS #4/5 LEU0_RX #1	
G7	PD4	ADC0_CH4 OPAMP_P2		LEU0_TX #0	

4.2 Alternate Functionality Pinout

A wide selection of alternate functionality is available for multiplexing to various pins. This is shown in Table 4.2 (p. 49). 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 LOCATION 0.

Table 4.2. Alternate functionality overview

Alternate	LOCATION							
Functionality	0	1	2	3	4	5	6	Description
ACMP0_CH4	PC4							Analog comparator ACMP0, channel 4.
ACMP0_O	PE13		PD6					Analog comparator ACMP0, digital output.

Alternate	LOCATION							
Functionality	0	1	2	3	4	5	6	Description
ACMP1_CH5	PC13							Analog comparator ACMP1, channel 5.
ACMP1_CH6	PC14							Analog comparator ACMP1, channel 6.
ACMP1_CH7	PC15							Analog comparator ACMP1, channel 7.
ACMP1_O	PF2		PD7					Analog comparator ACMP1, digital output.
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	PE11							Bootloader RX
BOOT_TX	PE10							Bootloader TX
CMU_CLK0	PA2		PD7					Clock Management Unit, clock output number 0.
CMU_CLK1	PA1		PE12					Clock Management Unit, clock output number 1.
DAC0_N1 / OPAMP_N1	PD7							Operational Amplifier 1 external negative input.
DAC0_OUT0 / OPAMP_OUT0	PB11							Digital to Analog Converter DAC0_OUT0 / OPAMP output channel number 0.
DAC0_OUT1ALT / OPAMP_OUT1ALT		PC13	PC14	PC15				Digital to Analog Converter DAC0_OUT1ALT / OPAMP alternative output for channel 1.
OPAMP_OUT2	PD5							Operational Amplifier 2 output.
DAC0_P0 / OPAMP_P0	PC4							Operational Amplifier 0 external positive input.
DAC0_P1 / OPAMP_P1	PD6							Operational Amplifier 1 external positive input.
OPAMP_P2	PD4							Operational Amplifier 2 external positive input.
DBG_SWCLK	PF0	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	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.
DBG_SWO	PF2	PC15						Debug-interface Serial Wire viewer Output. Note that this function is not enabled after reset, and must be enabled by software to be used.
GPIO_EM4WU0	PA0							Pin can be used to wake the system up from EM4
GPIO_EM4WU3	PF1							Pin can be used to wake the system up from EM4
GPIO_EM4WU4	PF2							Pin can be used to wake the system up from EM4
GPIO_EM4WU5	PE13							Pin can be used to wake the system up from EM4
HFXTAL_N	PB14							High Frequency Crystal negative pin. Also used as external optional clock input pin.
HFXTAL_P	PB13							High Frequency Crystal positive pin.
I2C0_SCL	PA1	PD7				PF1	PE13	I2C0 Serial Clock Line input / output.
I2C0_SDA	PA0	PD6				PF0	PE12	I2C0 Serial Data input / output.
LCD_BCAP_N	PA13							LCD voltage booster (optional), boost capacitor, negative pin. If using the LCD voltage booster, connect a 22 nF capacitor between LCD_BCAP_N and LCD_BCAP_P.
LCD_BCAP_P	PA12							LCD voltage booster (optional), boost capacitor, positive pin. If using the LCD voltage booster, connect a 22 nF capacitor between LCD_BCAP_N and LCD_BCAP_P.

Alternate	LOCATION							
Functionality	0	1	2	3	4	5	6	Description
LCD_BEXT	PA14							LCD voltage booster (optional), boost output. If using the LCD voltage booster, connect a 1 uF capacitor between this pin and VSS. An external LCD voltage may also be applied to this pin if the booster is not enabled. If AVDD is used directly as the LCD supply voltage, this pin may be left unconnected or used as a GPIO.
LCD_COM0	PE4							LCD driver common line number 0.
LCD_COM1	PE5							LCD driver common line number 1.
LCD_COM2	PE6							LCD driver common line number 2.
LCD_COM3	PE7							LCD driver common line number 3.
LCD_SEG0	PF2							LCD segment line 0. Segments 0, 1, 2 and 3 are controlled by SEGEN0.
LCD_SEG1	PF3							LCD segment line 1. Segments 0, 1, 2 and 3 are controlled by SEGEN0.
LCD_SEG2	PF4							LCD segment line 2. Segments 0, 1, 2 and 3 are controlled by SEGEN0.
LCD_SEG3	PF5							LCD segment line 3. Segments 0, 1, 2 and 3 are controlled by SEGEN0.
LCD_SEG6	PE10							LCD segment line 6. Segments 4, 5, 6 and 7 are controlled by SEGEN1.
LCD_SEG7	PE11							LCD segment line 7. Segments 4, 5, 6 and 7 are controlled by SEGEN1.
LCD_SEG8	PE12							LCD segment line 8. Segments 8, 9, 10 and 11 are controlled by SEGEN2.
LCD_SEG9	PE13							LCD segment line 9. Segments 8, 9, 10 and 11 are controlled by SEGEN2.
LCD_SEG13	PA0							LCD segment line 13. Segments 12, 13, 14 and 15 are controlled by SEGEN3.
LCD_SEG14	PA1							LCD segment line 14. Segments 12, 13, 14 and 15 are controlled by SEGEN3.
LCD_SEG15	PA2							LCD segment line 15. Segments 12, 13, 14 and 15 are controlled by SEGEN3.
LCD_SEG20/ LCD_COM4	PB3							LCD segment line 20. Segments 20, 21, 22 and 23 are controlled by SEGEN5. This pin may also be used as LCD COM line 4
LCD_SEG21/ LCD_COM5	PB4							LCD segment line 21. Segments 20, 21, 22 and 23 are controlled by SEGEN5. This pin may also be used as LCD COM line 5
LCD_SEG22/ LCD_COM6	PB5							LCD segment line 22. Segments 20, 21, 22 and 23 are controlled by SEGEN5. This pin may also be used as LCD COM line 6
LCD_SEG23/ LCD_COM7	PB6							LCD segment line 23. Segments 20, 21, 22 and 23 are controlled by SEGEN5. This pin may also be used as LCD COM line 7
LES_ALTEX0	PD6							LESENSE alternate exite output 0.
LES_ALTEX1	PD7							LESENSE alternate exite output 1.
LES_ALTEX5	PE11							LESENSE alternate exite output 5.
LES_ALTEX6	PE12							LESENSE alternate exite output 6.
LES_ALTEX7	PE13							LESENSE alternate exite output 7.
LES_CH4	PC4							LESENSE channel 4.
LES_CH13	PC13							LESENSE channel 13.
LES_CH14	PC14							LESENSE channel 14.

Alternate	LOCATION							
Functionality	0	1	2	3	4	5	6	Description
LES_CH15	PC15							LESENSE channel 15.
LETIM0_OUT0	PD6	PB11	PF0	PC4				Low Energy Timer LETIM0, output channel 0.
LETIM0_OUT1	PD7		PF1					Low Energy Timer LETIM0, output channel 1.
LEU0_RX	PD5	PB14		PF1	PA0			LEUART0 Receive input.
LEU0_TX	PD4	PB13		PF0	PF2			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	PC13			PD6				Pulse Counter PCNT0 input number 0.
PCNT0_S1IN	PC14			PD7				Pulse Counter PCNT0 input number 1.
PRS_CH0	PA0	PF3						Peripheral Reflex System PRS, channel 0.
PRS_CH1	PA1	PF4						Peripheral Reflex System PRS, channel 1.
PRS_CH2		PF5						Peripheral Reflex System PRS, channel 2.
TIM0_CC0	PA0	PA0			PA0	PF0		Timer 0 Capture Compare input / output channel 0.
TIM0_CC1	PA1	PA1				PF1		Timer 0 Capture Compare input / output channel 1.
TIM0_CC2	PA2	PA2				PF2		Timer 0 Capture Compare input / output channel 2.
TIM1_CC0	PC13	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	PC13			Timer 1 Capture Compare input / output channel 2.
US0_CLK	PE12	PE5		PC15	PB13	PB13		USART0 clock input / output.
US0_CS	PE13	PE4		PC14	PB14	PB14		USART0 chip select input / output.
US0_RX	PE11	PE6		PE12	PB8			USART0 Asynchronous Receive. USART0 Synchronous mode Master Input / Slave Output (MISO).
US0_TX	PE10	PE7		PE13	PB7			USART0 Asynchronous Transmit.Also used as receive input in half duplex communication. USART0 Synchronous mode Master Output / Slave Input (MOSI).
US1_CLK	PB7		PF0					USART1 clock input / output.
US1_CS	PB8		PF1					USART1 chip select input / output.
US1_RX			PD6					USART1 Asynchronous Receive. USART1 Synchronous mode Master Input / Slave Output (MISO).
US1_TX			PD7					USART1 Asynchronous Transmit.Also used as receive input in half duplex communication. USART1 Synchronous mode Master Output / Slave Input (MOSI).

4.3 GPIO Pinout Overview

The specific GPIO pins available in *EFM32TG825* is shown in Table 4.3 (p. 53). Each GPIO port is organized as 16-bit ports indicated by letters A through F, and the individual pin on this port in indicated by a number from 15 down to 0.

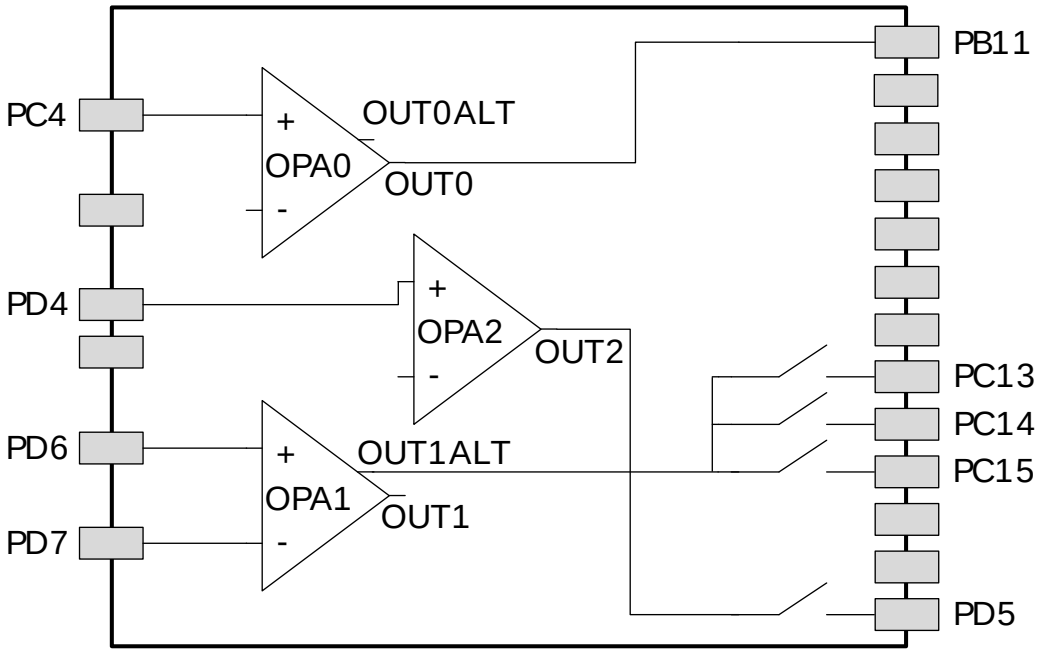
Table 4.3. GPIO Pinout

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	-	PA14	PA13	PA12	-	-	-	-	-	-	-	-	-	PA2	PA1	PA0
Port B	-	PB14	PB13	-	PB11	-	-	PB8	PB7	PB6	PB5	PB4	PB3	-	-	-
Port C	PC15	PC14	PC13	-	-	-	-	-	-	-	-	PC4	-	-	-	-
Port D	-	-	-	-	-	-	-	-	PD7	PD6	PD5	PD4	-	-	-	-
Port E	-	-	PE13	PE12	PE11	PE10	-	-	PE7	PE6	PE5	PE4	-	-	-	-
Port F	-	-	-	-	-	-	-	-	-	-	PF5	PF4	PF3	PF2	PF1	PF0

4.4 Opamp Pinout Overview

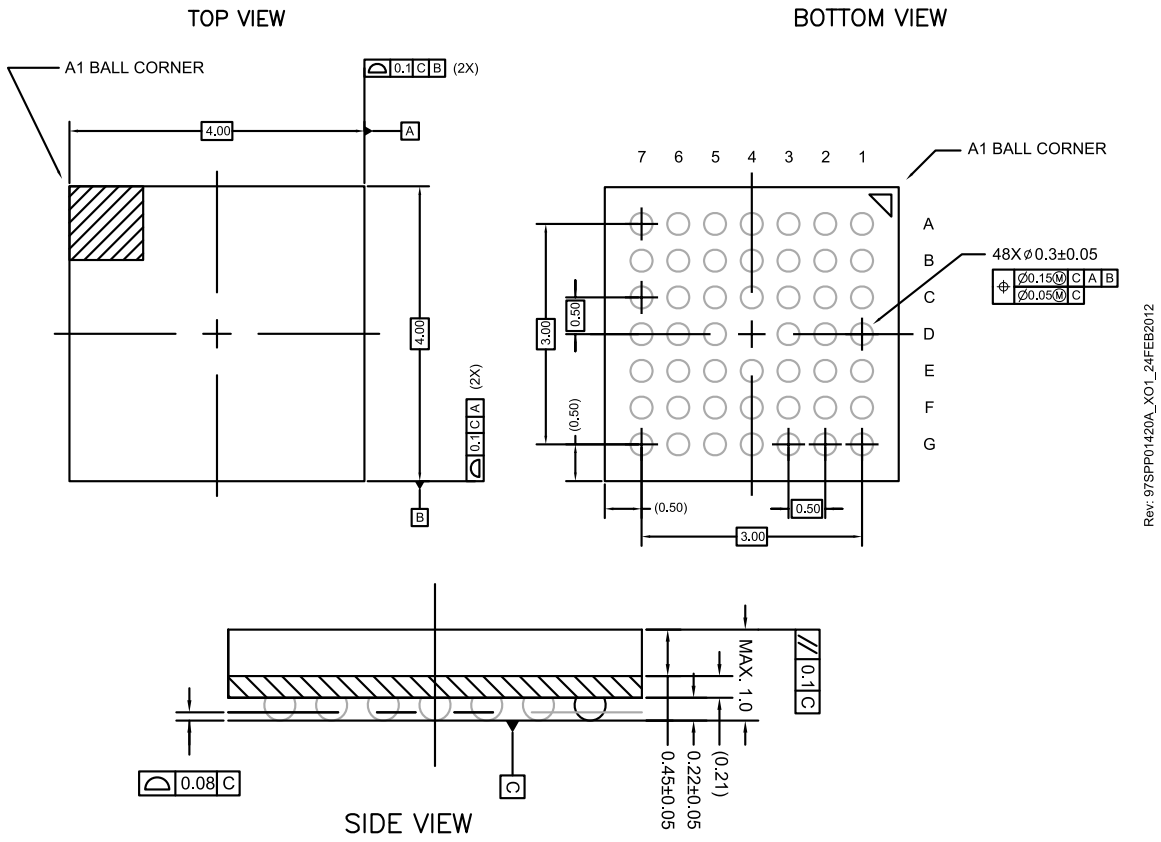
The specific opamp terminals available in *EFM32TG825* is shown in Figure 4.2 (p. 53) .

Figure 4.2. Opamp Pinout



4.5 BGA48 Package

Figure 4.3. BGA48



Note:

1. The dimensions in parenthesis are reference.
2. Datum 'C' and seating plane are defined by the crown of the solder balls.
3. All dimensions are in millimeters.

The BGA48 Package uses SAC105 solderballs.

All EFM32 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

5 PCB Layout and Soldering

5.1 Recommended PCB Layout

Figure 5.1. BGA48 PCB Land Pattern

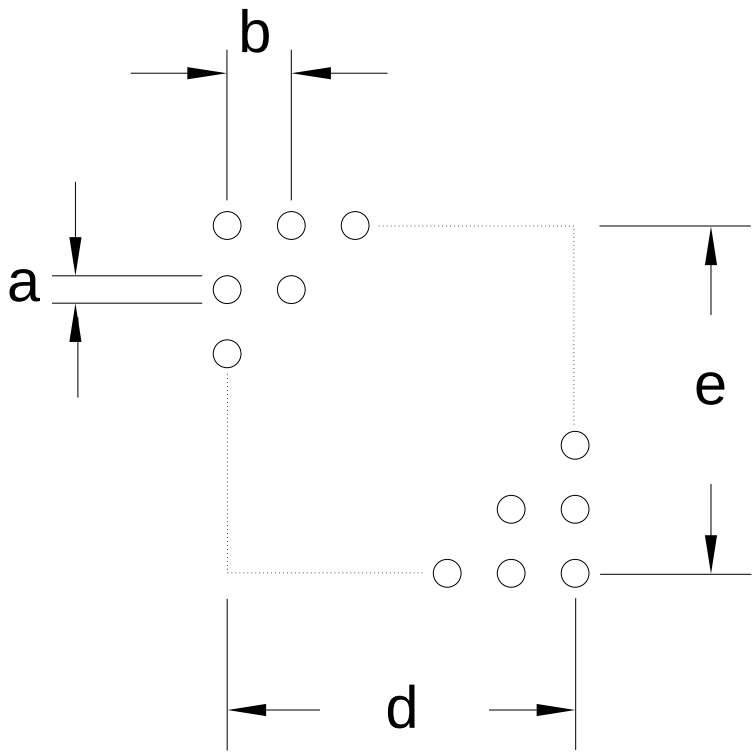


Table 5.1. BGA48 PCB Land Pattern Dimensions (Dimensions in mm)

Symbol	Dim. (mm)	Symbol	Row name and column number
a	0.25	r1	A
b	0.50	rn	G
d	3.00	c1	1
e	3.00	cn	7

Figure 5.2. BGA48 PCB Solder Mask

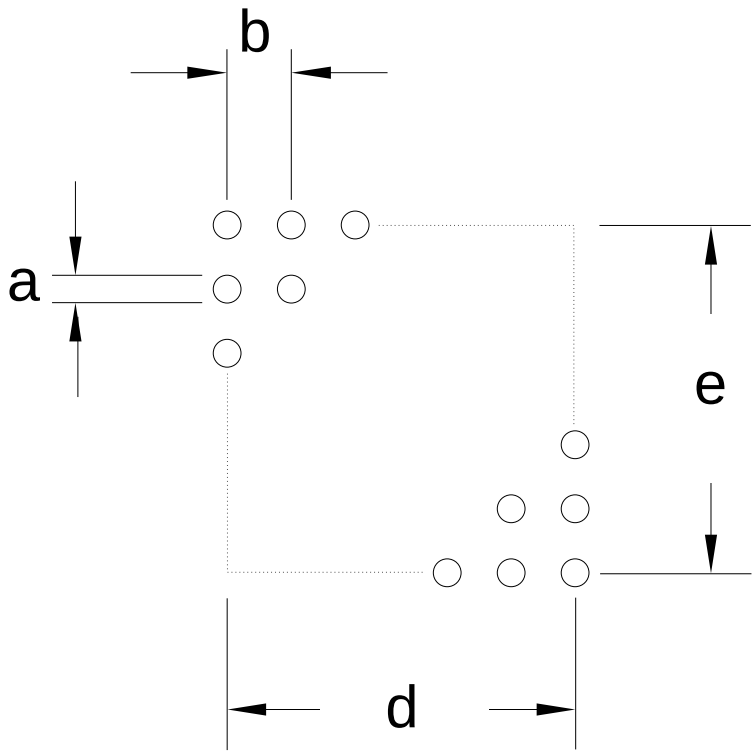


Table 5.2. BGA48 PCB Solder Mask Dimensions (Dimensions in mm)

Symbol	Dim. (mm)
a	0.28
b	0.50
d	3.00
e	3.00

Figure 5.3. BGA48 PCB Stencil Design

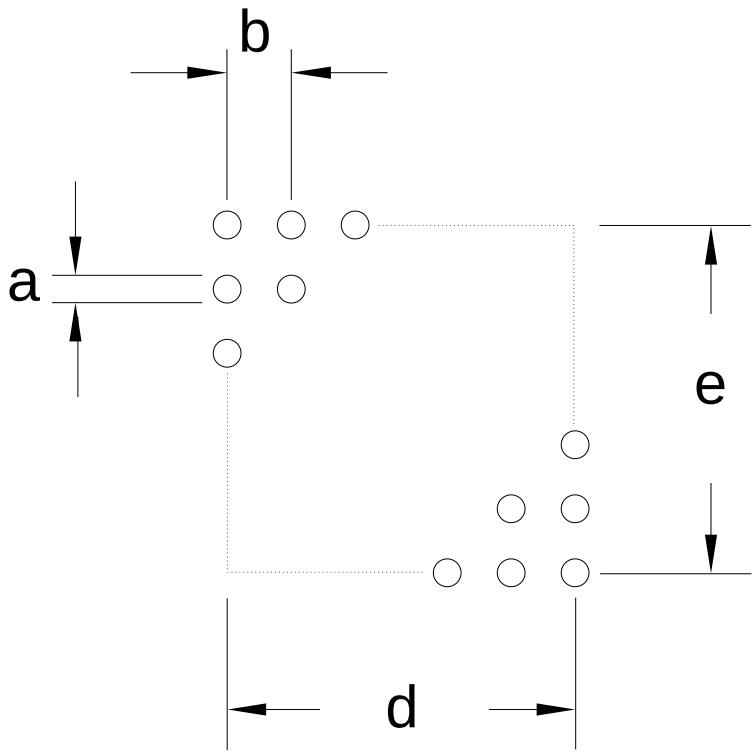


Table 5.3. BGA48 PCB Stencil Design Dimensions (Dimensions in mm)

Symbol	Dim. (mm)
a	0.25
b	0.50
d	3.00
e	3.00

1. The drawings are not to scale.
2. All dimensions are in millimeters.
3. All drawings are subject to change without notice.
4. The PCB Land Pattern drawing is in compliance with IPC-7351B.
5. Stencil thickness 0.125 mm.
6. For detailed pin-positioning, see Figure 4.3 (p. 54) .

5.2 Soldering Information

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

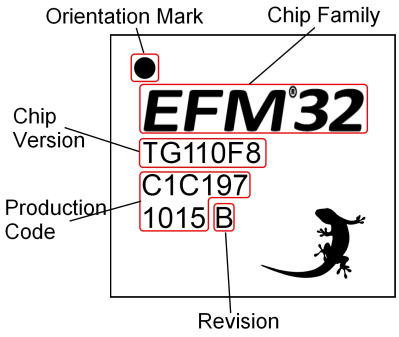
The packages have a Moisture Sensitivity Level rating of 3, please see the latest IPC/JEDEC J-STD-033 standard for MSL description and level 3 bake conditions.

6 Chip Marking, Revision and Errata

6.1 Chip Marking

In the illustration below package fields and position are shown.

Figure 6.1. Example Chip Marking (top view)



6.2 Revision

The revision of a chip can be determined from the "Revision" field in Figure 6.1 (p. 58) .

6.3 Errata

Please see the errata document for EFM32TG825 for description and resolution of device erratas. This document is available in Simplicity Studio and online at: http://www.silabs.com/support/pages/document-library.aspx?p=MCUs--32-bit

7 Revision History

7.1 Revision 1.30

July 2nd, 2014

Corrected single power supply voltage minimum value from 1.85V to 1.98V.

Updated current consumption.

Updated transition between energy modes.

Updated power management data.

Updated GPIO data.

Updated LFXO, HFXO, HFRCO and ULFRCO data.

Updated LFRCO and HFRCO plots.

Updated ACMP data.

7.2 Revision 1.21

November 21st, 2013

Updated figures.

Updated errata-link.

Updated chip marking.

Added link to Environmental and Quality information.

Re-added missing DAC-data.

7.3 Revision 1.20

September 30th, 2013

Added I2C characterization data.

Corrected GPIO operating voltage from 1.8 V to 1.85 V.

Corrected the ADC gain and offset measurement reference voltage from 2.25 to 2.5V.

Corrected the ADC resolution from 12, 10 and 6 bit to 12, 8 and 6 bit.

Document changed status from "Preliminary".

Updated Environmental information.

Updated trademark, disclaimer and contact information.

Other minor corrections.

7.4 Revision 1.10

June 28th, 2013

Updated PCB Land Pattern, PCB Solder Mask and PCB Stencil Design figures.

Updated power requirements in the Power Management section.

Removed minimum load capacitance figure and table. Added reference to application note.

Other minor corrections.

7.5 Revision 1.00

September 11th, 2012

Updated the HFRCO 1 MHz band typical value to 1.2 MHz.

Updated the HFRCO 7 MHz band typical value to 6.6 MHz.

Added GPIO_EM4WU3, GPIO_EM4WU4 and GPIO_EM4WU5 pins and removed GPIO_EM4WU1 in the Alternate functionality overview table.

Other minor corrections.

7.6 Revision 0.96

May 4th, 2012

Added PCB land pattern, Stencil design and solder mask.

7.7 Revision 0.95

February 27th, 2012

Initial preliminary release.

A Disclaimer and Trademarks

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Table of Contents

1. Ordering Information 2
2. System Summary 3
2.1. System Introduction 3
2.2. Configuration Summary 7
2.3. Memory Map 8
3. Electrical Characteristics 9
3.1. Test Conditions 9
3.2. Absolute Maximum Ratings 9
3.3. General Operating Conditions 9
3.4. Current Consumption 11
3.5. Transition between Energy Modes 13
3.6. Power Management 13
3.7. Flash 14
3.8. General Purpose Input Output 14
3.9. Oscillators 22
3.10. Analog Digital Converter (ADC) 26
3.11. Digital Analog Converter (DAC) 35
3.12. Operational Amplifier (OPAMP) 36
3.13. Analog Comparator (ACMP) 41
3.14. Voltage Comparator (VCMP) 43
3.15. LCD 44
3.16. I2C 45
3.17. Digital Peripherals 46
4. Pinout and Package 47
4.1. Pinout 47
4.2. Alternate Functionality Pinout 49
4.3. GPIO Pinout Overview 52
4.4. Opamp Pinout Overview 53
4.5. BGA48 Package 54
5. PCB Layout and Soldering 55
5.1. Recommended PCB Layout 55
5.2. Soldering Information 57
6. Chip Marking, Revision and Errata 58
6.1. Chip Marking 58
6.2. Revision 58
6.3. Errata 58
7. Revision History 59
7.1. Revision 1.30 59
7.2. Revision 1.21 59
7.3. Revision 1.20 59
7.4. Revision 1.10 59
7.5. Revision 1.00 60
7.6. Revision 0.96 60
7.7. Revision 0.95 60
A. Disclaimer and Trademarks 61
A.1. Disclaimer 61
A.2. Trademark Information 61
B. Contact Information 62
B.1. 62

List of Figures

2.1. Block Diagram 3
2.2. *EFM32TG825* Memory Map with largest RAM and Flash sizes 8
3.1. EM2 current consumption. RTC prescaled to 1kHz, 32.768 kHz LFRCO. 12
3.2. EM3 current consumption. 12
3.3. EM4 current consumption. 12
3.4. Typical Low-Level Output Current, 2V Supply Voltage 16
3.5. Typical High-Level Output Current, 2V Supply Voltage 17
3.6. Typical Low-Level Output Current, 3V Supply Voltage 18
3.7. Typical High-Level Output Current, 3V Supply Voltage 19
3.8. Typical Low-Level Output Current, 3.8V Supply Voltage 20
3.9. Typical High-Level Output Current, 3.8V Supply Voltage 21
3.10. Calibrated LFRCO Frequency vs Temperature and Supply Voltage 23
3.11. Calibrated HFRCO 1 MHz Band Frequency vs Supply Voltage and Temperature 24
3.12. Calibrated HFRCO 7 MHz Band Frequency vs Supply Voltage and Temperature 24
3.13. Calibrated HFRCO 11 MHz Band Frequency vs Supply Voltage and Temperature 25
3.14. Calibrated HFRCO 14 MHz Band Frequency vs Supply Voltage and Temperature 25
3.15. Calibrated HFRCO 21 MHz Band Frequency vs Supply Voltage and Temperature 25
3.16. Calibrated HFRCO 28 MHz Band Frequency vs Supply Voltage and Temperature 26
3.17. Integral Non-Linearity (INL) 31
3.18. Differential Non-Linearity (DNL) 31
3.19. ADC Frequency Spectrum, Vdd = 3V, Temp = 25°C 32
3.20. ADC Integral Linearity Error vs Code, Vdd = 3V, Temp = 25°C 33
3.21. ADC Differential Linearity Error vs Code, Vdd = 3V, Temp = 25°C 34
3.22. ADC Absolute Offset, Common Mode = Vdd /2 35
3.23. ADC Dynamic Performance vs Temperature for all ADC References, Vdd = 3V 35
3.24. OPAMP Common Mode Rejection Ratio 38
3.25. OPAMP Positive Power Supply Rejection Ratio 39
3.26. OPAMP Negative Power Supply Rejection Ratio 39
3.27. OPAMP Voltage Noise Spectral Density (Unity Gain) V_{out}=1V 39
3.28. OPAMP Voltage Noise Spectral Density (Non-Unity Gain) 40
3.29. ACMP Characteristics, Vdd = 3V, Temp = 25°C, FULLBIAS = 0, HALFBIAS = 1 42
4.1. *EFM32TG825* Pinout (top view, not to scale) 47
4.2. Opamp Pinout 53
4.3. BGA48 54
5.1. BGA48 PCB Land Pattern 55
5.2. BGA48 PCB Solder Mask 56
5.3. BGA48 PCB Stencil Design 57
6.1. Example Chip Marking (top view) 58

List of Tables

1.1. Ordering Information 2
2.1. Configuration Summary 7
3.1. Absolute Maximum Ratings 9
3.2. General Operating Conditions 9
3.3. Environmental 10
3.4. Current Consumption 11
3.5. Energy Modes Transitions 13
3.6. Power Management 13
3.7. Flash 14
3.8. GPIO 14
3.9. LFXO 22
3.10. HFXO 22
3.11. LFRCO 23
3.12. HFRCO 23
3.13. ULFRCO 26
3.14. ADC 26
3.15. DAC 35
3.16. OPAMP 36
3.17. ACMP 41
3.18. VCMP 43
3.19. LCD 44
3.20. I2C Standard-mode (Sm) 45
3.21. I2C Fast-mode (Fm) 45
3.22. I2C Fast-mode Plus (Fm+) 46
3.23. Digital Peripherals 46
4.1. Device Pinout 47
4.2. Alternate functionality overview 49
4.3. GPIO Pinout 53
5.1. BGA48 PCB Land Pattern Dimensions (Dimensions in mm) 55
5.2. BGA48 PCB Solder Mask Dimensions (Dimensions in mm) 56
5.3. BGA48 PCB Stencil Design Dimensions (Dimensions in mm) 57

List of Equations

3.1. Total ACMP Active Current 41
3.2. VCMP Trigger Level as a Function of Level Setting 43
3.3. Total LCD Current Based on Operational Mode and Internal Boost 44

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ZERO
ARM Cortex-M0+
TINY
ARM Cortex-M3
GECKO
ARM Cortex-M3
LEOPARD
ARM Cortex-M3
GIANT
ARM Cortex-M3
WONDER
ARM Cortex-M4