

# AN0002.1: EFM32 and EFR32 Wireless Gecko Series 1 Hardware Design Considerations



This application note details hardware design considerations for EFM32 and EFR32 Wireless Gecko Series 1 devices. For hardware design considerations for EFM32 and EZR32 Wireless MCU Series 0 devices, refer to *AN0002.0: EFM32 and EZR32 Wireless MCU Series 0 Hardware Design Considerations*.

Topics specifically covered are supported power supply configurations, supply filtering considerations, debug interface connections, and external clock sources.

For more information on hardware design and layout considerations for the DC-DC converter on EFM32 and EFR32 Wireless Gecko Series 1 devices, see *AN0948: Power Configurations and DC-DC*.

For more information on hardware layout considerations for the radio portion of EFR32 Wireless Gecko Series 1 devices, see *AN930: EFR32 2.4 GHz Matching Guide*, *AN933: EFR32 2.4 GHz Minimal BOM*, and *AN928: EFR32 Layout Design Guide*.

## KEY POINTS

- Decoupling capacitors are crucial to ensuring the integrity of the device's power supplies.
- The debug interface consists of two communication pins (SWCLK and SWDIO).
- External clock sources must be connected to the device correctly for proper operation.

## 1. Device Compatibility

This application note supports multiple device families, and some functionality is different depending on the device.

EFM32 Series 1 consists of:

- EFM32 Jade Gecko (EFM32JG1/EFM32JG12)
- EFM32 Pearl Gecko (EFM32PG1/EFM32PG12)
- EFM32 Giant Gecko (EFM32GG11/EFM32GG12)
- EFM32 Tiny Gecko (EFM32TG11)

EFR32 Wireless Gecko Series 1 consists of:

- EFR32 Blue Gecko (EFR32BG1/EFR32BG12/EFR32BG13/EFR32BG14)
- EFR32 Flex Gecko (EFR32FG1/EFR32FG12/EFR32FG13/EFR32FG14)
- EFR32 Mighty Gecko (EFR32MG1/EFR32MG12/EFR32MG13/EFR32MG14)

## 2. Power Supply Overview

### 2.1 Introduction

Although the EFM32 and EFR32 Wireless Gecko Series 1 devices have very low average current consumption, proper decoupling is crucial. As for all digital circuits, current is drawn in short pulses corresponding to the clock edges. Particularly when several I/O lines are switching simultaneously, transient current pulses on the power supply can be in the order of several hundred mA for a few nanoseconds, even though the average current consumption is quite small.

These kinds of transient currents cannot be properly delivered over high impedance power supply lines without introducing considerable noise in the supply voltage. To reduce this noise, decoupling capacitors are employed to supplement the current during these short transients.

### 2.2 Decoupling Capacitors

Decoupling capacitors make the current loop between supply, MCU, and ground as short as possible for high frequency transients. Therefore, all decoupling capacitors should be placed as close as possible to each of their respective power supply pins, ground pins, and PCB (Printed Circuit Board) ground planes.

All external decoupling capacitors should have a temperature range reflecting the environment in which the application will be used. For example, a suitable choice might be X5R ceramic capacitors with a change in capacitance of  $\pm 15\%$  over the temperature range  $-55$  to  $+85$  °C (standard temperature range devices) or  $-55$  to  $+125$  °C (extended temperature range devices).

For regulator output capacitors (DECOUPLE, VREGSW, and VREGO, if available), the system designer should pay particular attention to the characteristics of the capacitor over temperature and bias voltage. Some capacitors (particularly those in smaller packages or using cheaper dielectrics) can experience a dramatic reduction in capacitance value across temperature or as the DC bias voltage increases. Any change pushing the regulator output capacitance outside the data sheet specified limits may result in output instability on that supply.

### 2.3 Power Supply Requirements

An important consideration for all devices is the voltage requirements and dependencies between the power supply pins. The system designer needs to ensure that these power supply requirements are met, regardless of power configuration or topology. Please see the device data sheet for absolute maximum rating and additional details regarding relative system voltage constraints.

#### EFM32 Series 1 Power Supply Requirements

- VREGVDD = AVDD (Must be the highest voltage in the system)
- VREGVDD  $\geq$  DVDD
- VREGVDD  $\geq$  IOVDD
- DVDD  $\geq$  DECOUPLE

#### EFR32 Wireless Gecko Series 1 Power Supply Requirements

- VREGVDD = AVDD (Must be the highest voltage in the system)
- VREGVDD  $\geq$  DVDD
- VREGVDD  $\geq$  PAVDD (For 2.4 GHz or dual-band devices, PAVDD refers to the device pin; for sub-GHz devices, PAVDD refers to the external power amplifier supply)
- VREGVDD  $\geq$  RFVDD
- VREGVDD  $\geq$  IOVDD
- DVDD  $\geq$  DECOUPLE

## Power Supply Pin Overview

Note that not all supply pins exist on all devices. The table below provides an overview of the available power supply pins.

**Table 2.1. Power Supply Pin Overview**

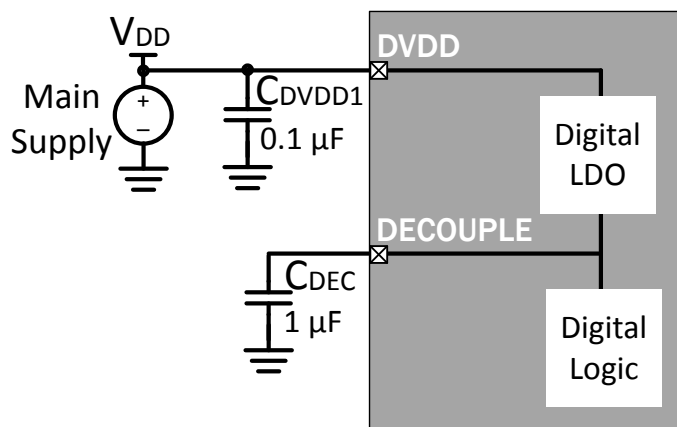
Pin Name	Product Family	Description
AVDD	All devices	Supply to analog peripherals
DECOUPLE	All devices	Output of the internal digital LDO
IOVDD	All devices	GPIO supply voltage
VBUS	All USB-enabled devices	Primary input to the internal 3.3 V LDO, and the USB 5 V sense input. Can be connected to the USB 5 V supply. If unused, may be left floating (a weak internal pull-down will ensure the pin remains at ground).
VREGI	All USB-enabled devices	Secondary input to the internal 3.3 V LDO. Typically connected to the USB 5 V supply. If unused, may be left floating (a weak internal pull-down will ensure the pin remains at ground).
VREGO	All USB-enabled devices	Output of the internal 3.3 V LDO
VREGVDD	All devices	Input to the DC-DC converter
VREGSW	All devices	DC-DC powertrain switching node
VREGVSS	All devices	DC-DC ground
DVDD	All devices	DC-DC feedback node and input to the internal digital LDO
RFVDD	EFR32 Wireless Gecko Series 1 only	Supply to radio analog and HFXO
PAVDD	EFR32 Wireless Gecko Series 1 only	Supply to 2.4 GHz radio power amplifier

## 2.4 DECOUPLE

All EFM32 and EFR32 Wireless Gecko Series 1 devices include an internal linear regulator that powers the core and digital logic. The DECOUPLE pin is the the output of the digital LDO, and requires a 1  $\mu$ F capacitor.

### EFM32xG1 and EFR32xG1 DECOUPLE Pin

On EFM32xG1 and EFR32xG1 devices, the input supply to the digital LDO is the DVDD pin, and the DECOUPLE pin is the output of the LDO.



**Figure 2.1. DVDD and DECOUPLE on EFM32xG1 and EFR32xG1 devices**

## EFM32xG11/12 and EFR32xG12/13/14 DECOUPLE Pin

On EFM32xG11/12 and EFR32xG12/13/14 devices, the input supply to the digital LDO is either the AVDD pin (power on default) or the DVDD pin. The DECOUPLE pin is the output of the LDO. Note that while supplied from the AVDD pin, the digital LDO current is limited to 20 mA. After start up, firmware should configure EMU\_PWRCTRL\_REGPWRSEL to power the digital LDO from DVDD.

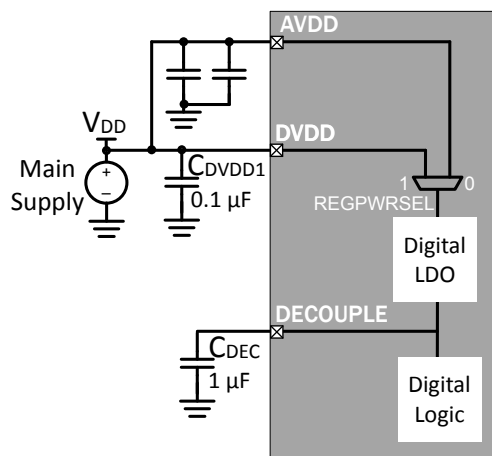


Figure 2.2. DVDD and DECOUPLE on EFM32xG11/12 and EFR32xG12/13/14 devices

## 2.5 IOVDD

The IOVDD pin(s) provide decoupling for all of the GPIO pins on the device. A 0.1 µF capacitor per IOVDD pin is recommended, along with a 10 µF bulk capacitor. The bulk capacitor value may safely be reduced if there are other large bulk capacitors on the same supply (e.g., if IOVDD = AVDD = system main supply, and the main supply already has multiple 10 µF).

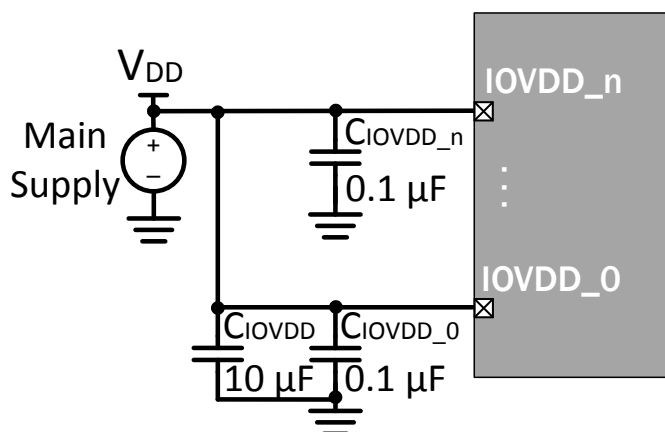


Figure 2.3. IOVDD Decoupling

**Note:** IOVDD should not be supplied from the DC-DC converter on EFM32xG11/12 and EFR32xG12/13/14 devices. At reset, the DC-DC converter defaults to an unconfigured safe state with its output floating such that connected circuits remain unpowered until firmware performs the necessary configuration. Fresh from the factory, a blank device will run the bootloader and fail in its attempt to communicate with a host via the BOOT\_RX and BOOT\_TX pins without IOVDD power. Use of the debug interface (DBG\_SWCLKTCK and DBG\_SWDIOTMS) for initial firmware download would, in this case, be similarly fruitless.

## 2.6 AVDD

The analog peripheral performance of the device is impacted by the quality of the AVDD power supply. For applications with less demanding analog performance, a simpler decoupling scheme for AVDD may be acceptable. For applications requiring the highest quality analog performance, more robust decoupling and filtering is required.

Note that the number of AVDD analog power pins may vary by device and package.

### 2.6.1 AVDD Standard Decoupling

The figure below illustrates a standard approach for decoupling the AVDD pin(s). In general, one 10  $\mu\text{F}$  bulk capacitor ( $C_{\text{AVDD}}$ ), as well as one 10 nF capacitor for each AVDD pin ( $C_{\text{AVDD}_0}$  through  $C_{\text{AVDD}_n}$ ), must be provided.

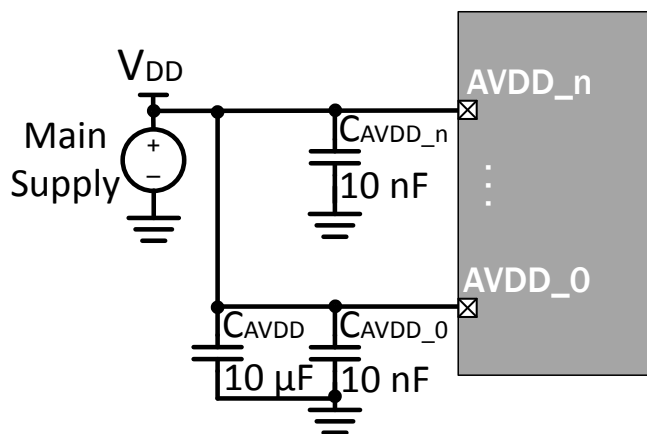


Figure 2.4. AVDD Standard Decoupling

### 2.6.2 AVDD Improved Decoupling

The figure below illustrates an improved approach for decoupling and filtering the AVDD pin(s). In general, one 10  $\mu\text{F}$  bulk capacitor ( $C_{\text{AVDD}}$ ), as well as one 10 nF capacitor for each AVDD pin ( $C_{\text{AVDD}_0}$  through  $C_{\text{AVDD}_n}$ ), must be provided. In addition, a ferrite bead and series 1  $\Omega$  resistor provide additional power supply filtering and isolation.

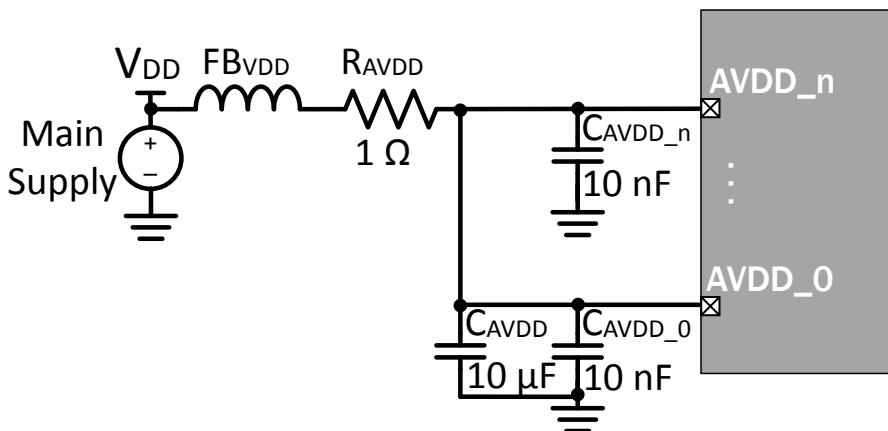


Figure 2.5. AVDD Improved Decoupling

The table below lists some recommended ferrite bead part numbers suitable for AVDD filtering.

**Table 2.2. Recommended Ferrite Beads**

Manufacturer	Part Number	Impedance	I <sub>MAX</sub> (mA)	DCR (Ω)	Operating Temperature (°C)	Package
Würth Electronics	74279266	1 kΩ @ 100 MHz	200	0.600	-55 to +125	0603/1608
Murata	BLM21BD102SN1D	1 kΩ @ 100 MHz	200	0.400	-55 to +125	0805/2012

## 2.7 USB (VREGI & VREGO)

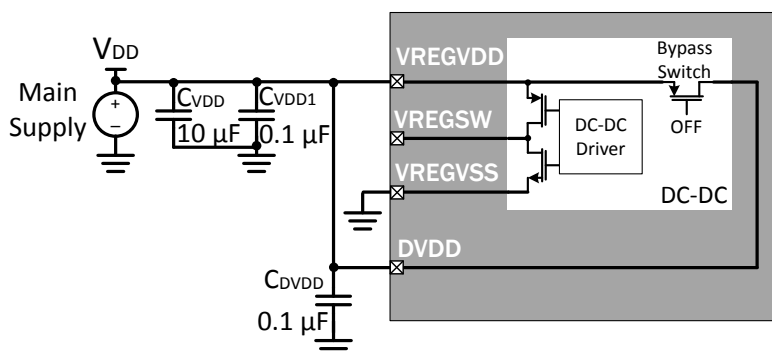
Some EFM32 and EFR32 Wireless Gecko Series 1 devices integrate a USB controller and a 3.3 V LDO. Power supply decoupling, as well as signalling and control signals, are discussed in Section 6. [USB](#).

## 2.8 DC-DC

Some EFM32 and EFR32 Wireless Gecko Series 1 devices provide an on-chip DC-DC converter that can be used for improved power efficiency. However, the additional switching noise present on the DC-DC converter output ( $V_{DCDC}$ ), necessitates the use of specific filtering components.

### 2.8.1 DC-DC — Unused

When the DC-DC converter is not used, the DVDD pin should be shorted to the VREGVDD pin. VREGSW must be left floating, and VREGVSS should be grounded.

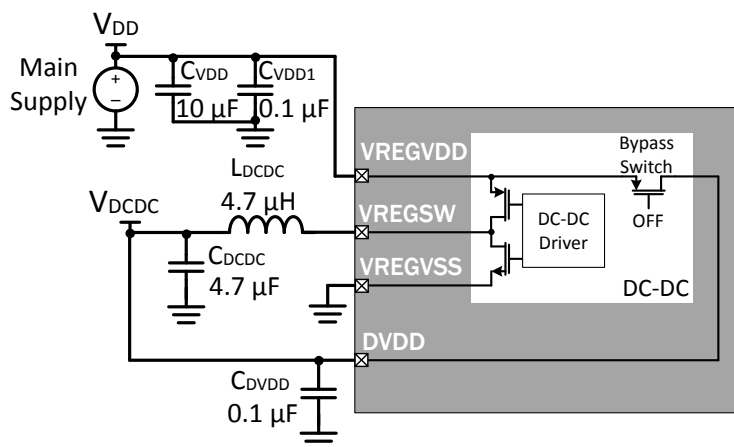


**Figure 2.6. Configuration when the DC-DC converter is unused**

## 2.8.2 DC-DC — Powering DVDD

For the lowest power applications, the DC-DC converter can be used to power the DVDD supply (as well as RFVDD and PAVDD on EFR32 Wireless Gecko Series 1) as shown in the figure below. In this configuration, the DC-DC Output ( $V_{\text{DCDC}}$ ) is connected to DVDD. In addition to being the DC-DC converter feedback path, the DVDD pin powers the internal digital LDO, which in turn powers the digital circuits.

The system designer should pay particular attention to the characteristics of the DC-DC output capacitor ( $C_{\text{DCDC}}$ ) over temperature and bias voltage. Some capacitors, particularly those in smaller packages or using cheaper dielectrics, can experience a dramatic reduction in nominal capacitance in response to temperature changes or as the DC bias voltage increases. Any change pushing the DC-DC output capacitance outside the datasheet specified limits may result in output instability on that supply.



**Figure 2.7. DC-DC Converter Powering DVDD**

**Note:**  $C_{\text{DCDC}}$  was 1.0  $\mu\text{F}$  in some previous revisions of this application note. Although 1.0  $\mu\text{F}$  may still be used, 4.7  $\mu\text{F}$  is now recommended for new designs due to its improved performance under dynamic load conditions and during mode changes. Silicon Labs EFR32xG1 reference radio boards still use 1.0  $\mu\text{F}$ ; therefore, the EFR32xG1 software defaults to using 1.0  $\mu\text{F}$  (use of `emuDcdcLnCompCtrl_1u0F` rather than `emuDcdcLnCompCtrl_4u7F`). Use of 4.7  $\mu\text{F}$  on EFR32xG1 requires modification of the Low Noise Mode Compensator Control `emuDcdcLnCompCtrl` value. For EFR32xG12 and later, both the radio reference board hardware and the software default to 4.7  $\mu\text{F}$ .

## 2.9 Radio (RFVDD & PAVDD) — EFR32 Wireless Gecko Series 1

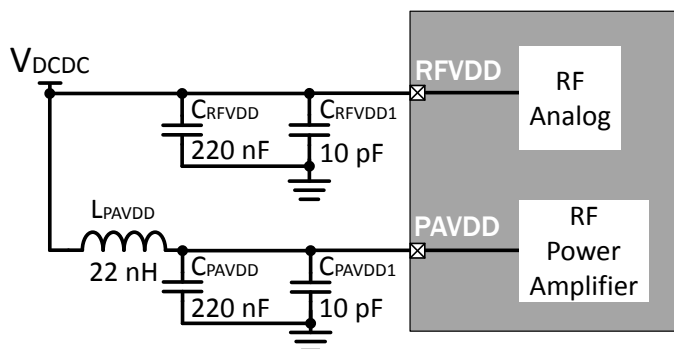
On EFR32 Wireless Gecko Series 1 devices, the radio power supplies (PAVDD and RFVDD) are typically powered from one of two sources:

1. The integrated DC-DC converter. This option provides improved power efficiency but is limited to 13 dBm maximum transmit power. Additional switching noise present on the DC-DC converter output ( $V_{\text{DCDC}}$ ), necessitates the use of specific filtering components.
2. The main supply. This option is less efficient but permits simpler filtering and supports systems that require transmit power in excess of 13 dBm.



### 2.9.1 RFVDD and PAVDD — Powered from DC-DC

Both RFVDD and PAVDD can be supplied from the DC-DC converter output ( $V_{DCDC}$ ) for lowest power operation. Note, however, that when  $V_{DCDC}$  supplies PAVDD the maximum transmit power is limited to 13 dBm. If higher power is required, PAVDD must be powered from the main supply instead of the DC-DC output.



**Figure 2.8. RFVDD and PAVDD Decoupling (2.4 GHz application, both supplies powered from DC-DC output)**

The minimal BOM option eliminates  $C_{RFVDD1}$  and  $C_{PAVDD1}$ , which may allow acceptable RF performance at lower power levels. For more complete details on the minimal BOM option, along with performance comparisons, refer to *AN933: EFR32 2.4 GHz Minimal BOM*.

**Table 2.3. RFVDD & PAVDD Decoupling Values, Powered from DC-DC Converter**

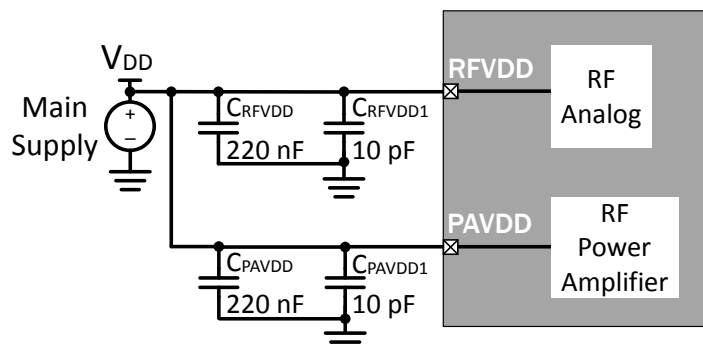
Application	$C_{RFVDD}$	$C_{RFVDD1}$	$L_{PAVDD}$	$C_{PAVDD}$	$C_{PAVDD1}$
2.4 GHz	220 nF	10 pF	22 nH	220 nF	10 pF
2.4 GHz (minimal BOM)	220 nF	-	22 nH	220 nF	-
sub-GHz	220 nF	56 - 270 pF	100 - 270 nH	220 nF	56 - 270 pF
sub-GHz (minimal BOM)	220 nF	-	100 - 270 nH	220 nF	-

**Table 2.4. Recommended  $L_{PAVDD}$  22 nH Inductor**

Manufacturer	Part Number	Inductance (nH)	$I_{MAX}$ (mA)	DCR ( $\Omega$ )	Operating Temperature ( $^{\circ}\text{C}$ )	Package
Murata	LQG15HS22NJ02D	$22 \pm 5\%$	300	0.420	-55 to +125	0402/1005

## 2.9.2 RFVDD and PAVDD — Powered from Main Supply

When greater than 13 dBm transmit power is required, PAVDD should be powered directly from the main supply, and RFVDD may be powered from either the main supply or the DC-DC output ( $V_{\text{DCDC}}$ ). Note that in this configuration, the  $L_{\text{PAVDD}}$  filter inductor is not shown on the PAVDD input, because the main supply is presumed to be less noisy than  $V_{\text{DCDC}}$ .



**Figure 2.9. RFVDD and PAVDD Decoupling (2.4 GHz application, both supplies powered from main supply)**

The minimal BOM option eliminates  $C_{\text{RFVDD1}}$  and  $C_{\text{PAVDD1}}$ , which may allow acceptable RF performance at lower power levels. For more complete details on the minimal BOM option, along with performance comparisons, refer to *AN933: EFR32 2.4 GHz Minimal BOM*.

**Table 2.5. RFVDD & PAVDD Decoupling Values, Powered from Main Supply**

Application	$C_{\text{RFVDD}}$	$C_{\text{RFVDD1}}$	$L_{\text{PAVDD}}$	$C_{\text{PAVDD}}$	$C_{\text{PAVDD1}}$
2.4 GHz	220 nF	10 pF	—	220 nF	10 pF
2.4 GHz (minimal BOM)	220 nF	—	—	220 nF	—
sub-GHz	220 nF	56 - 270 pF	—	220 nF	56 - 270 pF
sub-GHz (minimal BOM)	220 nF	—	—	220 nF	—

### 3. Example Power Supply Configurations

#### 3.1 EFM32 and EFR32 Wireless Gecko Series 1 Configuration after POR

##### 3.1.1 EFM32xG1 and EFR32xG1 Startup Configuration

During power-on reset (POR), EFM32xG1 and EFR32xG1 devices boot up in a safe startup configuration that supports all available power configurations.

In the startup configuration:

- The DC-DC converter's bypass switch is on (the VREGVDD pin is shorted internally to the DVDD pin).
- The analog blocks are powered from the AVDD supply pin (EMU\_PWRCTRL\_ANASW = 0).

After power on, firmware can configure the device based on the external hardware configuration.

**Note:** Figure 3.1 EFM32xG1 and EFR32xG1 Startup Configuration on page 11 is only provided to show the device startup default supply configuration; it is **not** a usable application configuration.

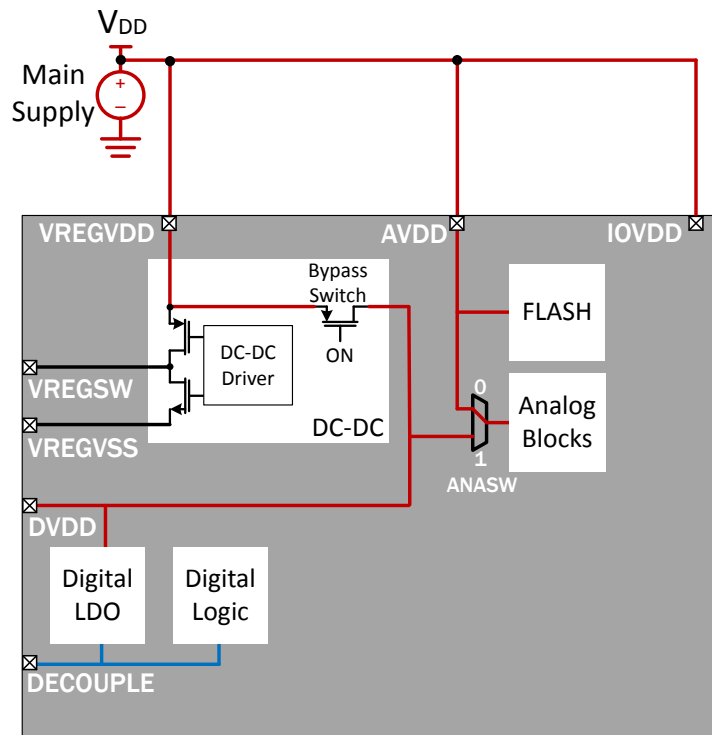


Figure 3.1. EFM32xG1 and EFR32xG1 Startup Configuration

### 3.1.2 EFM32xG11/12 and EFR32xG12/13/14 Unconfigured Configuration

Upon power-on reset (POR) or entry into EM4 Shutoff (EM4S), EFM32xG11/12 and EFR32xG12/13/14 devices are configured in a safe state that supports all available power configurations.

In this unconfigured configured state:

- The DC-DC converter's bypass switch is off.
- The internal digital LDO is powered from the AVDD pin (EMU\_PWRCTRL\_REGPWRSEL = 0). Note the maximum allowable current into the LDO when REGPWRSEL = 0 is 20 mA. For this reason, immediately after startup firmware must configure REGPWRSEL = 1 to power the digital LDO from DVDD.
- The analog blocks are powered from the AVDD supply pin (EMU\_PWRCTRL\_ANASW = 0).

After power on, firmware can configure the device based on the external hardware configuration.

**Note:** Figure 3.2 EFM32xG11/12 and EFR32xG12/13/14 Unconfigured Configuration on page 12 is only provided to show the device startup default supply configuration; it is **not** a usable application configuration.

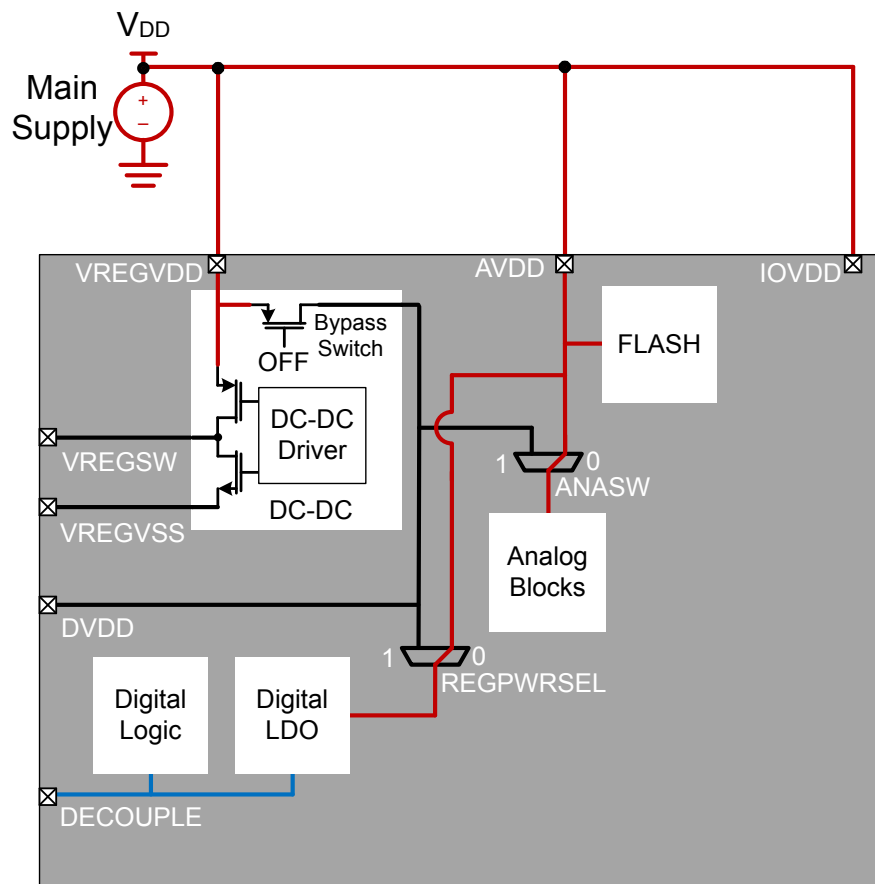


Figure 3.2. EFM32xG11/12 and EFR32xG12/13/14 Unconfigured Configuration

### 3.2 EFR32 Wireless Gecko Series 1 — No DC-DC, 2.4 GHz, $\leq 13$ dBm Example

For space- or cost-sensitive applications or when power efficiency is not a factor, the DC-DC converter may be left unused. In this configuration:

- The DC-DC converter is programmed to the off mode, and the bypass switch is off.
- The DVDD pin must be powered externally; typically, it is shorted to the main supply.
- DVDD supplies the internal digital LDO (EMU\_PWRCTRL\_REGPWRSEL = 1 on EFR32xG12/13/14), which powers the digital circuits.
- In addition, RFVDD, PAVDD, IOVDD, and AVDD are all connected to the main supply.
- VREGSW is left disconnected.

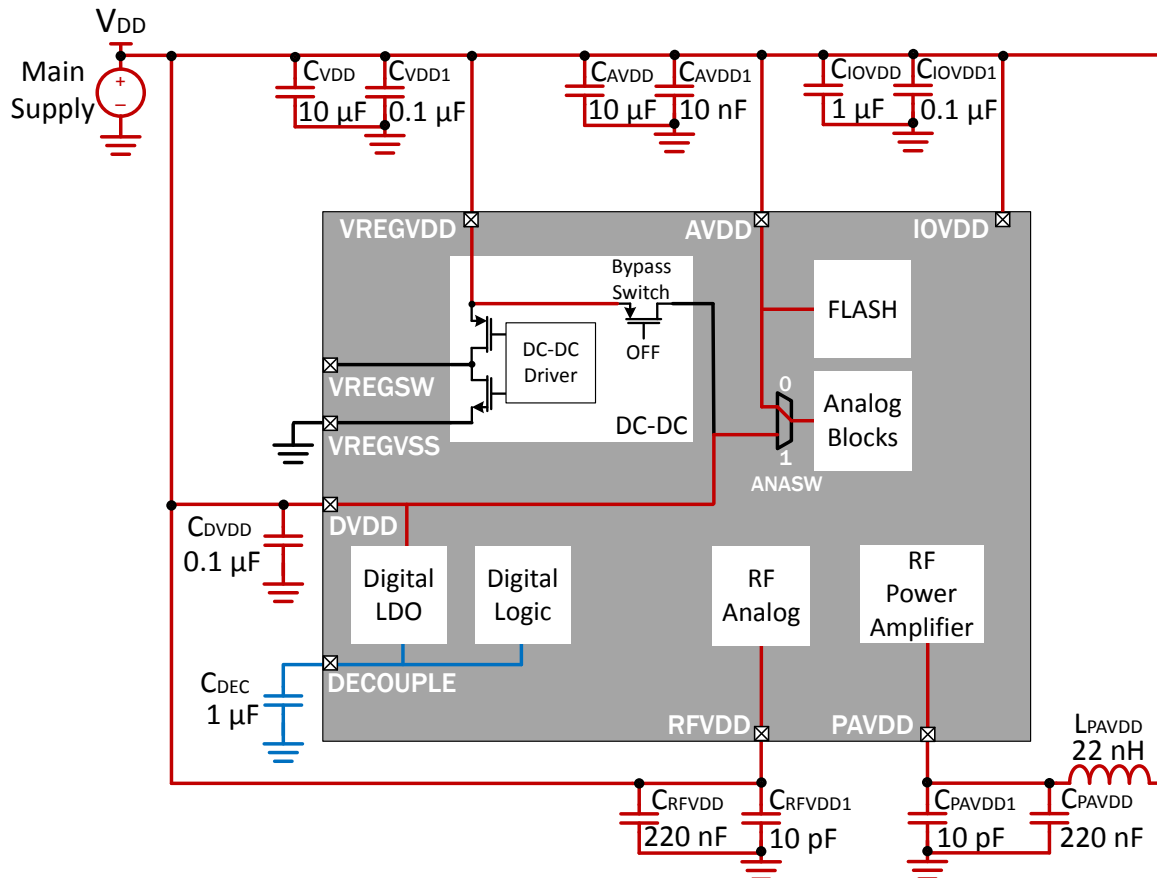


Figure 3.3. EFR32xG1 No DC-DC, 2.4 GHz,  $\leq 13$  dBm Example

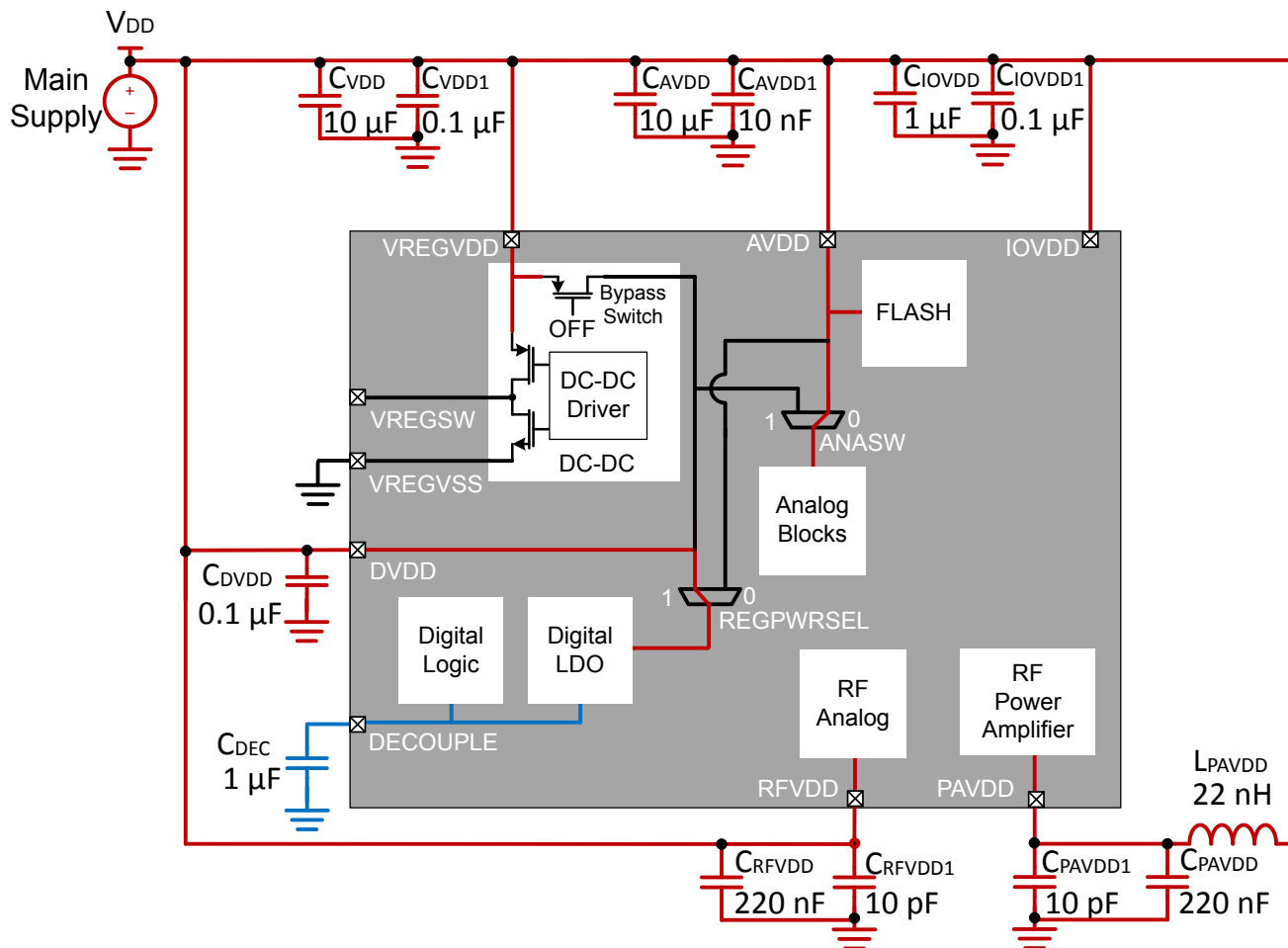


Figure 3.4. EFR32xG12/13/14 No DC-DC, 2.4 GHz, ≤ 13 dBm Example

### 3.3 EFR32 Wireless Gecko Series 1 — DC-DC, 2.4 GHz, ≤ 13 dBm Example

EFM32 and EFR32 Wireless Gecko Series 1 applications should use the DC-DC converter to maximize power savings. The DC-DC converter requires an external inductor and capacitor, in addition to the standard decoupling capacitors on each power net. For detailed information on DC-DC converter operation, emlib programming, recommended DC-DC components, and supported power configurations, see application note *AN0948: Power Configurations and DC-DC*.

For the lowest power radio applications, the DC-DC converter can be used to supply DVDD, as well as RFVDD and PAVDD. In this configuration:

- The DC-DC output ( $V_{DCDC}$ ) is connected to DVDD, which powers the internal digital LDO (REGPWRSEL = 1 on EFR32xG12/13/14), and, therefore, the digital circuits.
- Both radio power supplies (RFVDD and PAVDD) are also powered from the DC-DC output.
- AVDD is connected to the main supply. Internal analog blocks may be powered from AVDD or DVDD, depending on the state of the EMU\_PWRCTRL\_ANASW bit. Flash is always powered from the AVDD.
- IOVDD is connected to the main supply, although this is not required so long as  $V_{REGVDD} \geq IOVDD$  as discussed in [2.3 Power Supply Requirements](#).

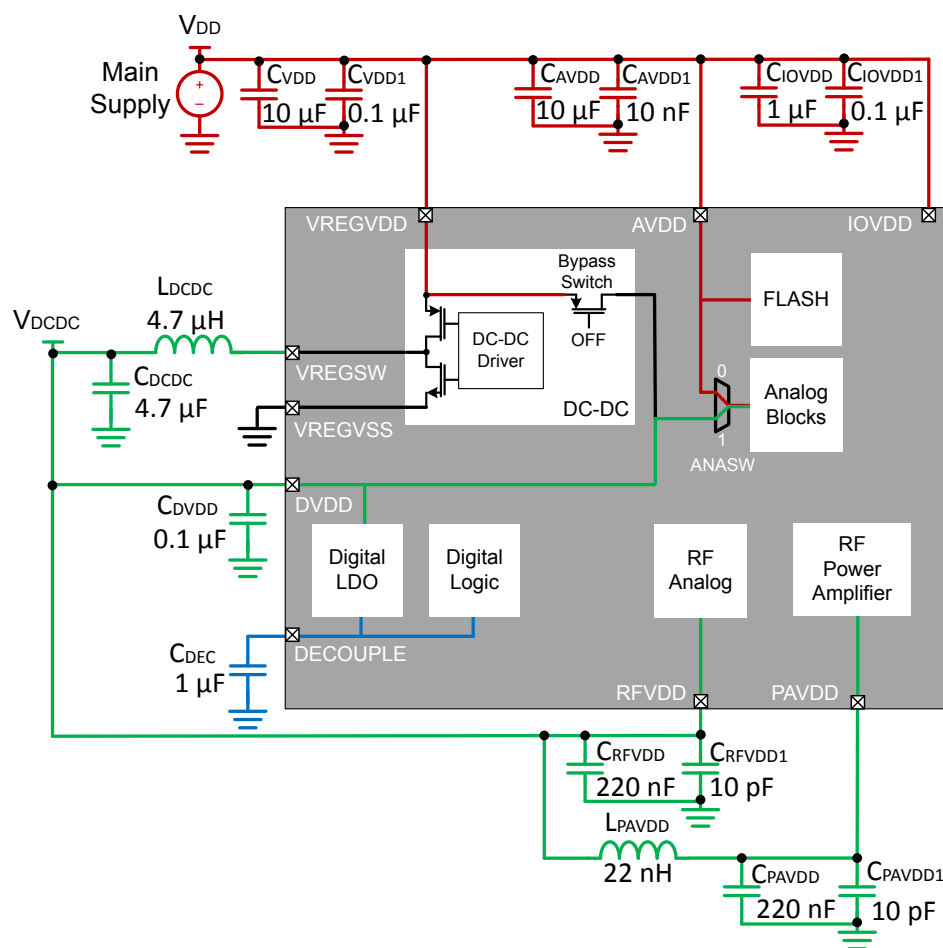


Figure 3.5. EFR32xG1 DC-DC, 2.4 GHz, ≤ 13 dBm Example

**Note:**  $C_{DCDC}$  was 1.0 µF in some previous revisions of this application note. Although 1.0 µF may still be used, 4.7 µF is now recommended for new designs due to its improved performance under dynamic load conditions and during mode changes. Silicon Labs EFR32xG1 reference radio boards still use 1.0 µF; therefore, the EFR32xG1 software defaults to using 1.0 µF (use of `emuDcdcLnCompCtrl_1u0F` rather than `emuDcdcLnCompCtrl_4u7F`). Use of 4.7 µF on EFR32xG1 requires modification of the Low Noise Mode Compensator Control `emuDcdcLnCompCtrl` value. For EFR32xG12 and later, both the radio reference board hardware and the software default to 4.7 µF.

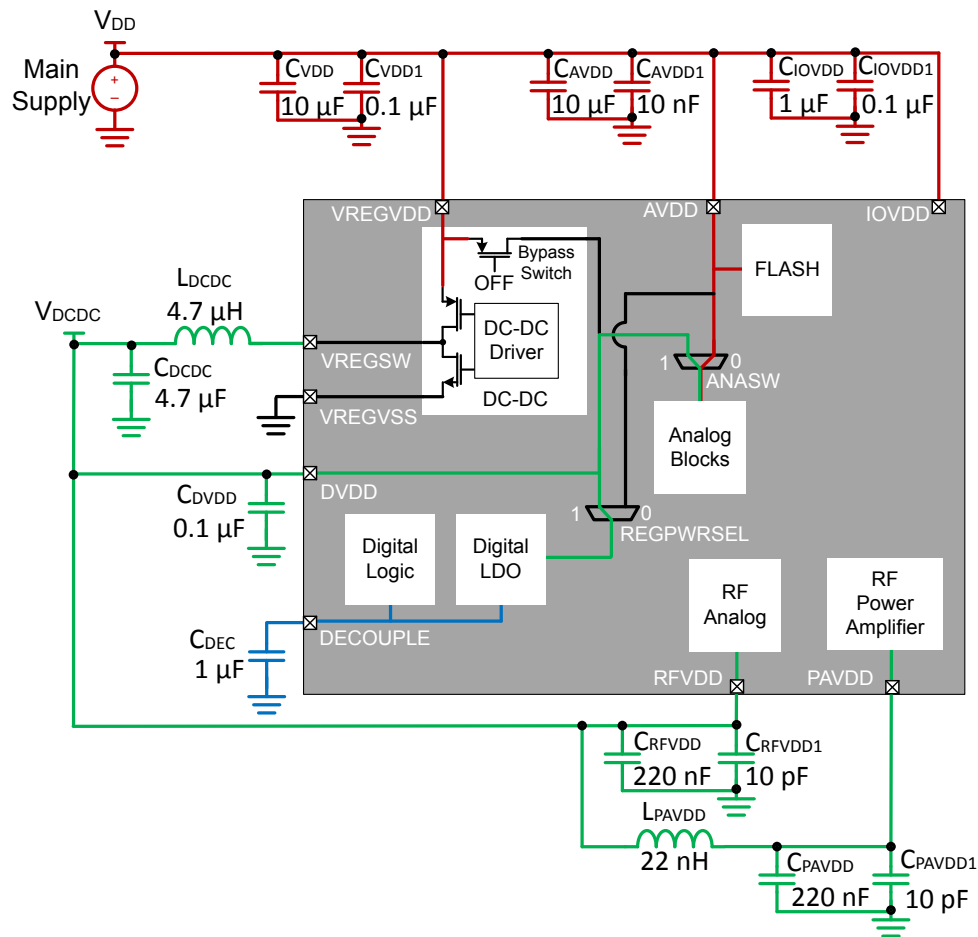


Figure 3.6. EFR32xG12/13/14 DC-DC, 2.4 GHz, ≤ 13 dBm Example



### 3.4 EFR32 Wireless Gecko Series 1 — DC-DC, 2.4 GHz, > 13 dBm Example

EFM32 and EFR32 Wireless Gecko Series 1 applications should use the DC-DC converter to maximize power savings. The DC-DC converter requires an external inductor and capacitor, in addition to the standard decoupling capacitors on each power net. For detailed information on DC-DC converter operation, emlib programming, recommended DC-DC components, and supported power configurations, see application note *AN0948: Power Configurations and DC-DC*.

When high radio output power (>13 dBm) is required, PAVDD must be connected to the main supply. DVDD and RFVDD can still be supplied from the output of the DC-DC converter. This configuration is illustrated below.

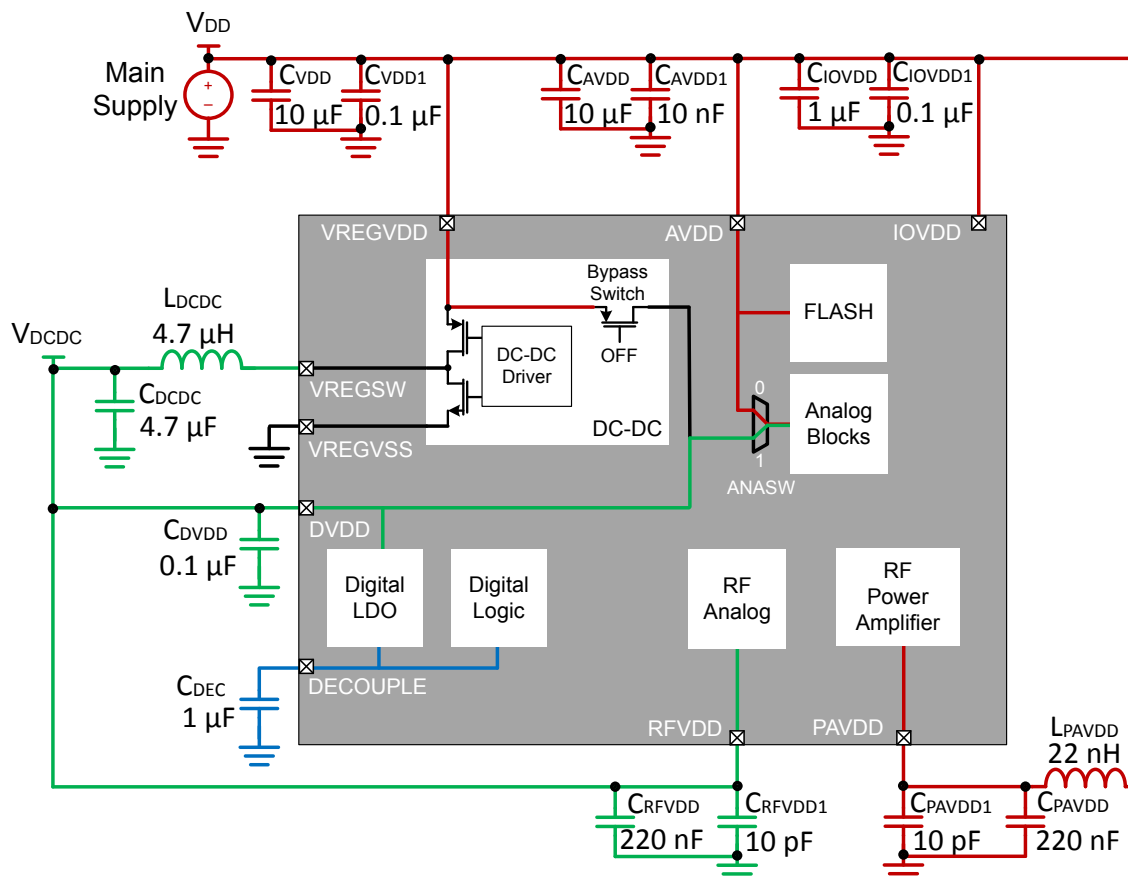
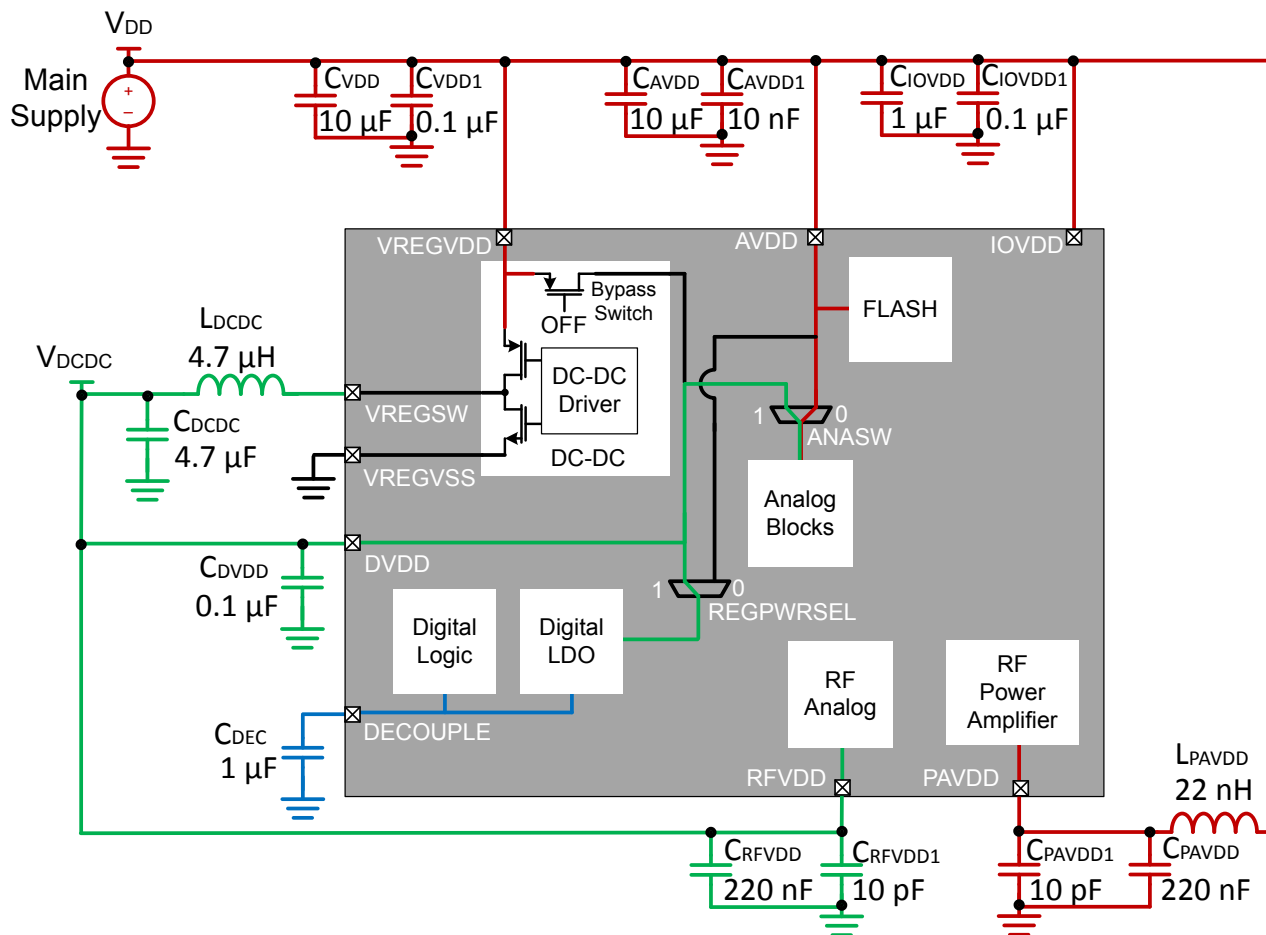


Figure 3.7. EFR32xG1 DC-DC, 2.4 GHz, > 13 dBm Example

**Note:**  $C_{DCDC}$  was 1.0  $\mu\text{F}$  in some previous revisions of this application note. Although 1.0  $\mu\text{F}$  may still be used, 4.7  $\mu\text{F}$  is now recommended for new designs due to its improved performance under dynamic load conditions and during mode changes. Silicon Labs EFR32xG1 reference radio boards still use 1.0  $\mu\text{F}$ ; therefore, the EFR32xG1 software defaults to using 1.0  $\mu\text{F}$  (use of `emuDcdcLnCompCtrl_1u0F` rather than `emuDcdcLnCompCtrl_4u7F`). Use of 4.7  $\mu\text{F}$  on EFR32xG1 requires modification of the Low Noise Mode Compensator Control `emuDcdcLnCompCtrl` value. For EFR32xG12 and later, both the radio reference board hardware and the software default to 4.7  $\mu\text{F}$ .



### 3.5 EFM32 Series 1 — DC-DC Example

The diagrams below illustrate a typical configuration for EFM32 Series 1 devices using the DC-DC converter.

In this configuration:

- The DC-DC output ( $V_{DCDC}$ ) is connected to DVDD, which powers the internal digital LDO (REGPWRSEL = 1 on EFM32xG11/12), and, therefore, the digital circuits.
- AVDD is connected to the main supply. The internal analog blocks may be powered from AVDD or DVDD, depending on the state of the EMU\_PWRCTRL\_ANASW bit. Flash is always powered from the AVDD pin.
- IOVDD is connected to the main supply, although this is not required so long as  $V_{REGVDD} \geq IOVDD$  as discussed in [2.3 Power Supply Requirements](#).

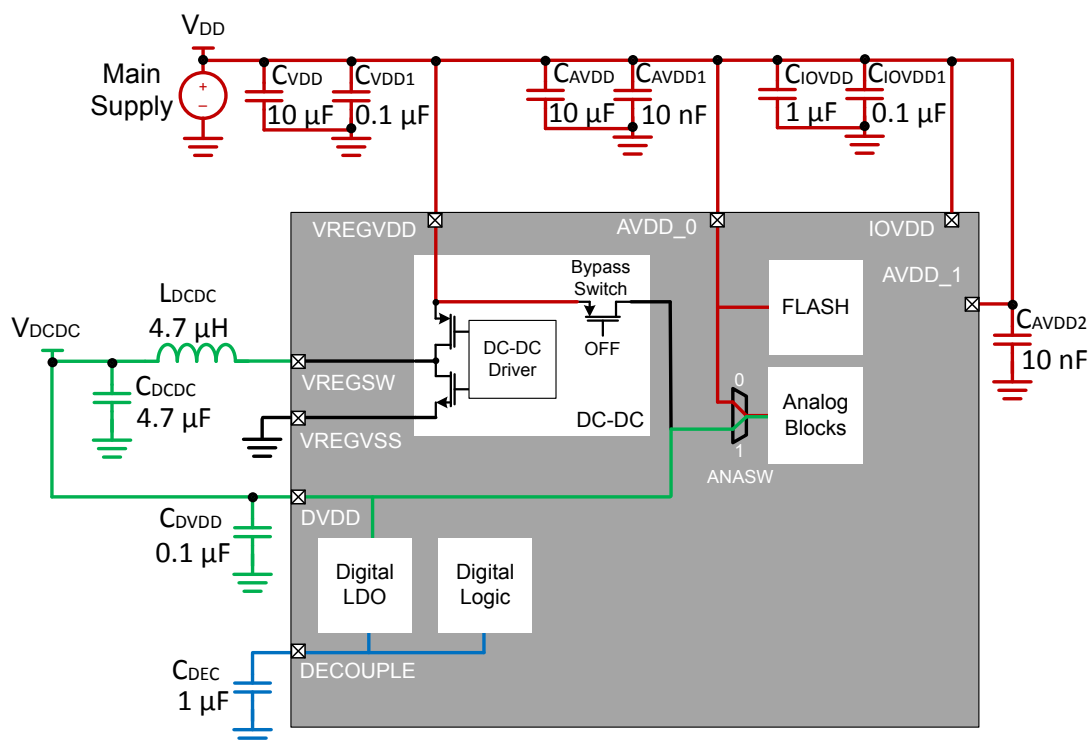
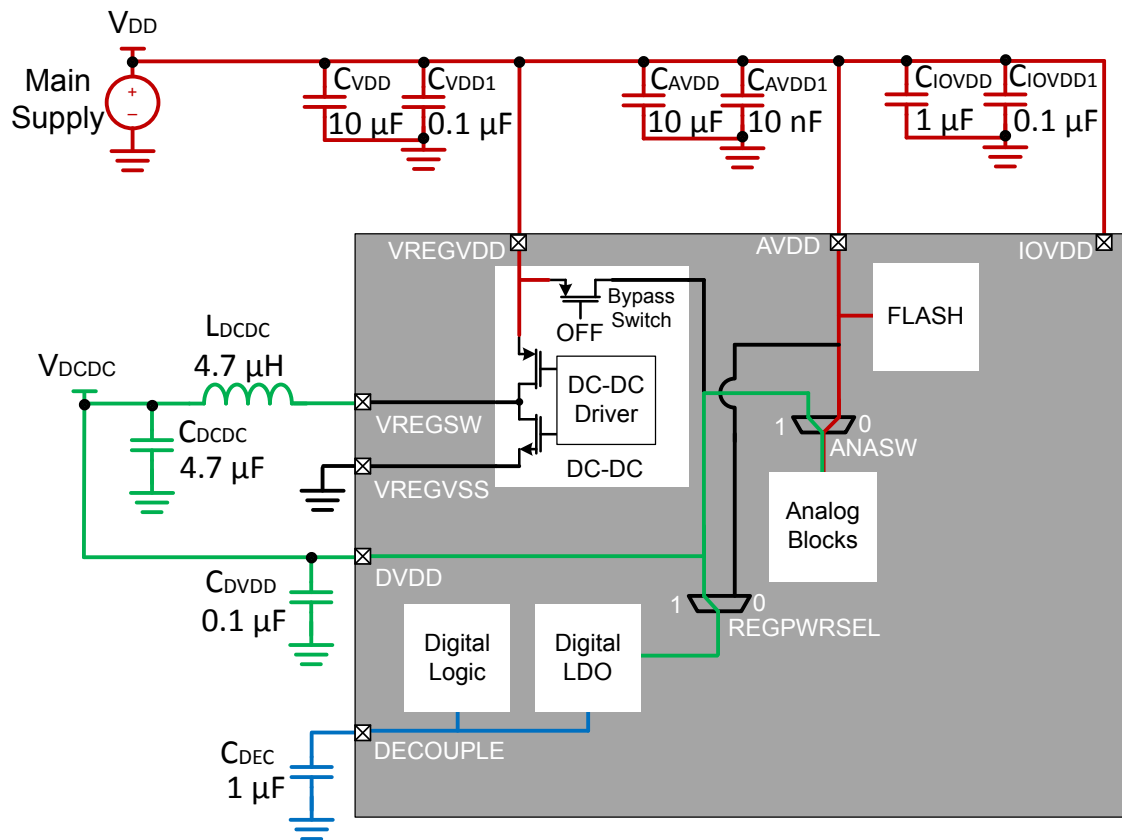


Figure 3.9. EFM32xG1 DC-DC Example

**Note:**  $C_{DCDC}$  was 1.0  $\mu\text{F}$  in some previous revisions of this application note. Although 1.0  $\mu\text{F}$  may still be used, 4.7  $\mu\text{F}$  is now recommended for new designs due to its improved performance under dynamic load conditions and during mode changes. The Silicon Labs EFM32PG1 Starter Kit board still uses 1.0  $\mu\text{F}$ ; therefore, EFM32xG1 software defaults to using 1.0  $\mu\text{F}$  (use of `emuDcdcLnCompCtrl_1u0F` rather than `emuDcdcLnCompCtrl_4u7F`). Use of 4.7  $\mu\text{F}$  on EFM32xG1 requires modification of the Low Noise Mode Compensator Control `emuDcdcLnCompCtrl` value. For all subsequent EFM32 devices, both the Starter Kit hardware and corresponding software default to 4.7  $\mu\text{F}$ .

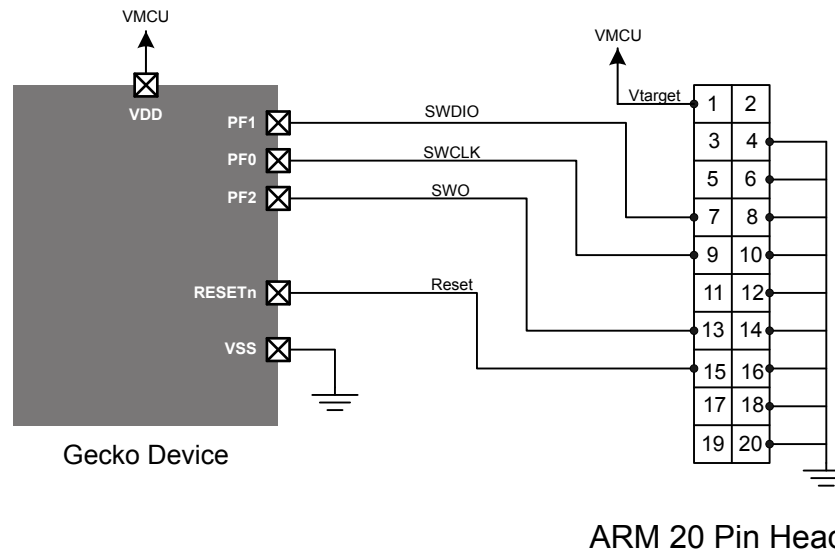


## 4. Debug Interface and External Reset Pin

### 4.1 Serial Wire Debug

The Serial Wire Debug (SWD) interface is supported by all EFM32 and EFR32 Wireless Gecko Series 1 devices and consists of the SWCLK (clock input) and SWDIO (data in/out) lines, in addition to the optional SWO (serial wire output). The SWO line is used for instrumentation trace and program counter sampling, and is not needed for flash programming and normal debugging. However, it can be valuable in advanced debugging scenarios, and designers are strongly encouraged to include this along with the other SWD signals.

Connections to the standard ARM 20-pin debug header are shown in the following figure. Pins that are not connected to the microcontroller, power supply, or ground should be left unconnected.



**Figure 4.1. EFM32 and EFR32 Wireless Gecko Series 1 SWD Connection to the ARM 20-pin Debug Header**

**Note:**

1. The  $V_{\text{target}}$  connection does not supply power. The debugger uses  $V_{\text{target}}$  as a reference voltage for its level translators.
2. PF2 is the default location for the SWO signal and is adjacent or in close proximity to PF0 (SWCLK) and PF1 (SWDIO) on any given package. SWO can be mapped to certain other pins. Refer to the datasheet for the device in question.

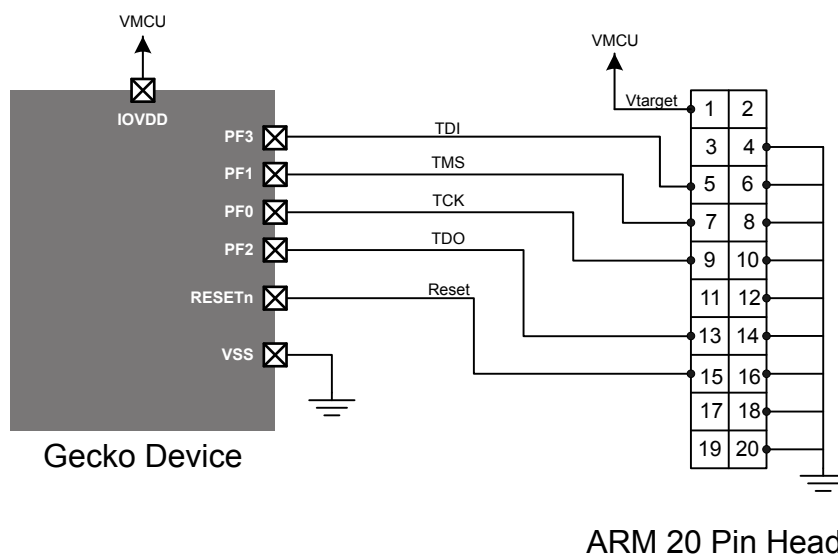
For additional debug and programming interfaces, see Application Note *AN958: Debugging and Programming Interfaces for Custom Designs*.

## 4.2 JTAG Debug

EFM32 and EFR32 Wireless Gecko Series 1 devices optionally support JTAG debug using the TCK (clock), TDI (data input), TDO (data output), and TMS (input mode select) lines. TCK is the JTAG interface clock. TDI carries input data, and is sampled on the rising edge of TCK. TDO carries output data and is shifted out on the falling edge of TCK. Finally, TMS is the input mode select signal, and is used to navigate through the Test Access Port (TAP) state machine.

**Note:** The JTAG implementation on EFM32 and EFR32 Wireless Gecko Series 1 devices does not support boundary scan testing. It can operate in pass-through mode and participate in a chain with other devices that do implement JTAG for firmware programming or boundary scan purposes.

The connection to an ARM 20-pin debug connector is shown in the following figure. Pins with no connection should be left unconnected.



**Figure 4.2. EFM32 and EFR32 Wireless Gecko Series 1 JTAG Connection to the ARM 20-pin Debug Header**

**Note:** The  $V_{\text{target}}$  connection does not supply power. The debugger uses  $V_{\text{target}}$  as a reference voltage for its level translators.

For additional debug and programming interfaces, see Application Note AN958: *Debugging and Programming Interfaces for Custom Designs*.

## 4.3 External Reset Pin (RESETn)

EFM32 and EFR32 Wireless Gecko Series 1 processors are reset by driving the RESETn pin low. A weak internal pull-up device holds the RESETn pin high, allowing it to be left unconnected if no external reset source is required. Also connected to RESETn is a low-pass filter to prevent noise glitches from causing unintended resets. The characteristics of the pull-up device and input filter are identical to those present on any GPIO pin and are specified in the device data sheet.

**Note:** The internal pull-up ensures that the reset is released. When the device is not powered, RESETn must not be connected through an external pull-up to an active supply or otherwise driven high as this could damage the device. This is especially critical when using back-up power mode. Because the internal pull-up device is automatically switched to the back-up power rail, it can back-power other devices in the system through an external pull-up connected to RESETn.

## 5. External Clock Sources

### 5.1 Introduction

EFM32 and EFR32 Wireless Gecko Series 1 devices support different external clock sources to provide the high- and low-frequency clocks in addition to the internal LF and HF RC oscillators. Possible external clock sources for both the LF and HF domains are crystals, ceramic resonators, and external oscillators (square or sine wave). This section describes how external clock sources are connected.

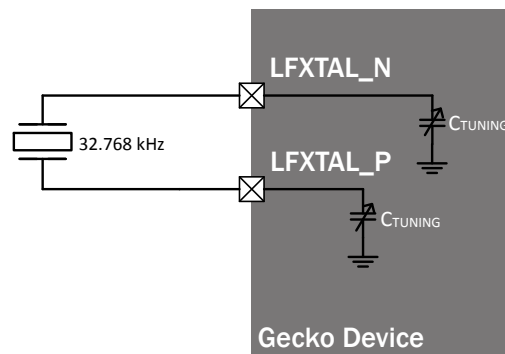
For additional information on the external oscillators, refer to the application note, [AN0016.1: Oscillator Design Considerations](#). Application notes can be found on the Silicon Labs website ([www.silabs.com/32bit-appnotes](http://www.silabs.com/32bit-appnotes)) or in Simplicity Studio.

### 5.2 Low-Frequency Clock Sources

An external low-frequency clock can be supplied from a crystal or ceramic resonator or from an external clock source.

#### 5.2.1 Low-Frequency Crystals

A crystal is connected as shown in the figure below across the LFXTAL\_N and LFXTAL\_P pins on EFM32 and EFR32 Wireless Gecko Series 1 devices.



**Figure 5.1. Low-Frequency Crystal Oscillator**

Low frequency crystals connected to EFM32 and EFR32 Wireless Gecko Series 1 devices do not require external load capacitors, as these load capacitors are included on-chip and can be tuned by register bit fields under software control, thus reducing BOM cost and saving space in the PCB footprint. The EFM32 and EFR32 Wireless Gecko Series 1 LFXO supports 32.768 kHz crystals. Check device-specific data sheets for supported crystal load capacitance and ESR values and refer to device-specific reference manuals for on-chip load capacitor tuning instructions.

## 5.2.2 Low-Frequency External Clocks

EFM32 and EFR32 Wireless Gecko Series 1 devices can source a low-frequency clock from an external source such as a TCXO or VCXO. To select a proper external oscillator, consider specifications such as frequency, aging, stability, voltage sensitivity, rise and fall time, duty cycle, and signal levels. The external clock signal can be either a square wave or a sine wave with a frequency of 32.768 kHz. The external clock source must be connected as shown in [Figure 5.2 Low-Frequency External Clock on page 24](#).

Bypass and buffered input modes are supported for external clock sources. A CMOS square wave that toggles between 0 and  $V_{IOVDD}$  volts with a duty cycle of 50% can be used when `CMU_LFXOCTRL_MODE = DIGEXTCLK`, which bypasses the LFXO. An external sine wave source (`CMU_LFXOCTRL_MODE = BUFEXTCLK`) having minimum and maximum amplitudes of 800 mV and 1.2 volts, respectively, can be connected in series with the `LFXTAL_N` pin and is AC-coupled internally. The sine wave minimum voltage must be higher than ground and the maximum voltage less than 1.4 volts.

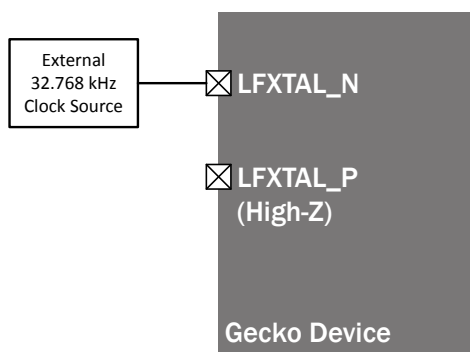


Figure 5.2. Low-Frequency External Clock

## 5.3 High Frequency Clock Sources

An external high-frequency clock can be supplied from a crystal or ceramic resonator or from an external clock source.

### 5.3.1 High-Frequency Crystals and Ceramic Resonators

A crystal or ceramic resonator is connected as shown in [Figure 5.3 High-Frequency Crystal Oscillator on page 24](#) across the `HFXTAL_N` and `HFXTAL_P` pins on EFM32 and EFR32 Wireless Gecko Series 1 devices.

External load capacitors are not required on EFM32 and EFR32 Wireless Gecko Series 1 devices. These have been moved on-chip and can be tuned by register bit fields under software control, thus reducing BOM cost and saving space in the PCB footprint. Check device-specific data sheets for the supported range of crystal frequencies, load capacitance tuning, and ESR values. In particular, specific crystal frequencies are mandatory when using on-chip radios and their associated protocol stacks; use of other values is expressly **not** supported.

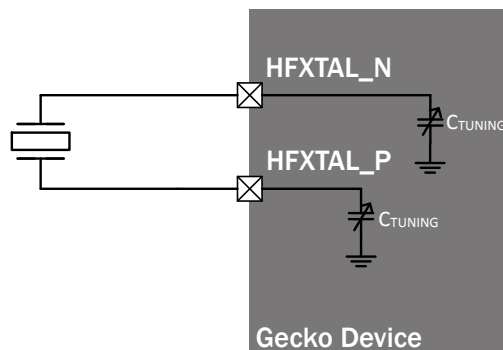


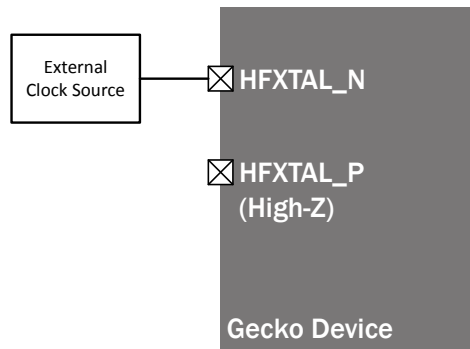
Figure 5.3. High-Frequency Crystal Oscillator



### 5.3.2 High Frequency External Clocks

EFM32 and EFR32 Wireless Gecko Series 1 devices can source a low-frequency clock from an external source such as a TCXO or VCXO. To select a proper external oscillator, consider specifications such as frequency, aging, stability, voltage sensitivity, rise and fall time, duty cycle, and signal levels. The external clock signal can be either a square wave or a sine wave with a frequency in accordance with the device data sheet. The external clock source must be connected as shown in [Figure 5.4 External High-Frequency Clock on page 25](#).

Unlike the LFXO, which has specific modes for a buffered or digital external clock, some EFM32 and EFR32 Wireless Gecko Series 1 devices have more limited high-frequency clock input options. On all such devices, an externally-buffered sine wave having minimum and maximum amplitudes of 800 mV and 1.2 V, respectively, can be connected in series with the HFXTAL\_N pin. The sine wave minimum voltage must be higher than ground and the maximum voltage less than 1.4 V. Refer to the device-specific datasheet and reference manual for the options and limitations that apply when sourcing a high-frequency clock.



**Figure 5.4. External High-Frequency Clock**

## 6. USB

Some EFM32 Series 1 devices integrate a USB controller and a 3.3V LDO. The following sections illustrate several different configurations for decoupling the USB power and connecting the bus and control signals.

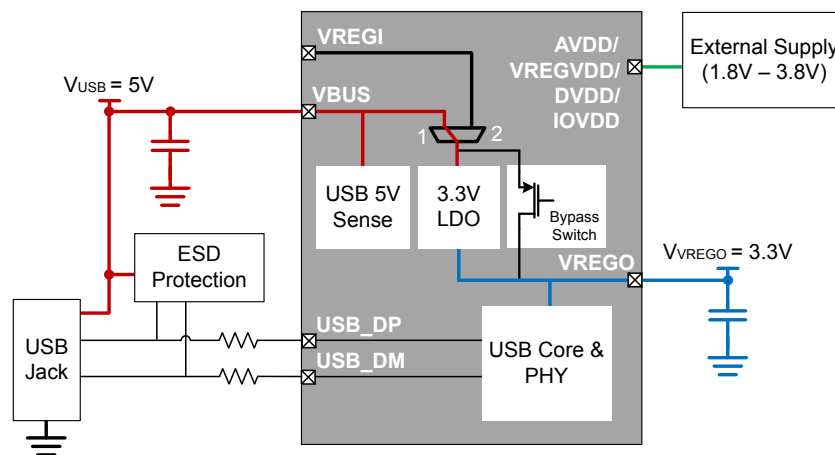
To avoid violating the USB specification, the total capacitance on  $V_{USB}$  must not exceed 10  $\mu\text{F}$ . Consult *AN0046: USB Hardware Design Guide* for detailed hardware guidance for USB applications.

### 6.1 USB Self-Powered

In a typical EFM32 Series 1 self-powered USB device application, the internal 3.3 V LDO powers the PHY only (although it may also be used to power other external components), and the rest of the system is powered from an external 1.8 V to 3.8 V supply. Note that per USB compliance specifications, the supply to the USB PHY must meet be between 3.0 V and 3.6 V.

If unused, the VREGI input may be left floating; a weak internal pull-down ensures that this pin remains at ground.

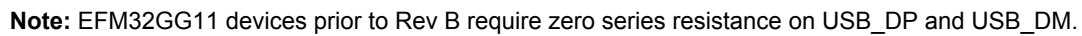
Bypass capacitors unrelated to USB are not shown below.



**Note:** EFM32GG11 devices prior to Rev B require zero series resistance on USB\_DP and USB\_DM.

**Figure 6.1. Self-Powered USB Application**

Bypass capacitors unrelated to USB are not shown below.



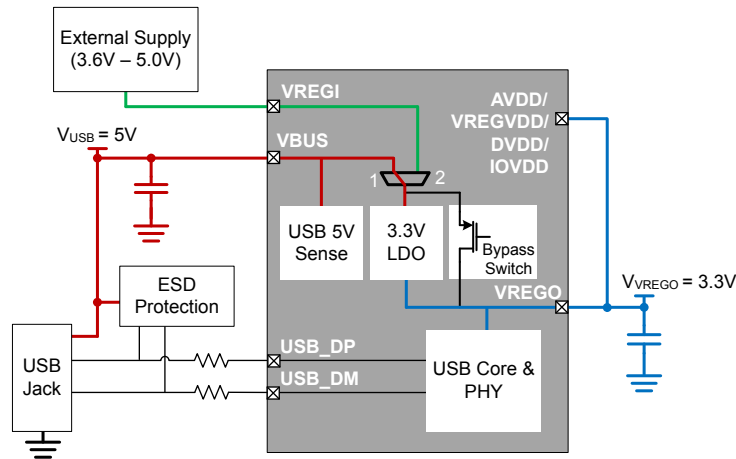
### Figure 6.2. Bus-Powered USB Application

### 6.3 USB Dual-Powered

A dual-powered USB configuration is shown in [Figure 6.3 Dual-Powered USB Application on page 28](#). This configuration is useful for extending the life of battery-powered devices, as it allows a battery- or externally-powered device to switch its power supply to the USB 5 V supply when connected to a USB host. An internal switch permits the 3.3 V LDO input to be seamlessly switched between a battery (or other external supply) on the VREGI pin and the USB 5 V supply on the VBUS pin.

Typically, firmware would configure the 3.3 V LDO to be powered from the higher of the two supply inputs (VREGI or VBUS). When unused, or unconnected, the VREGI and VBUS inputs are pulled to ground through a weak internal pull-downs.

Bypass capacitors unrelated to USB are not shown below.



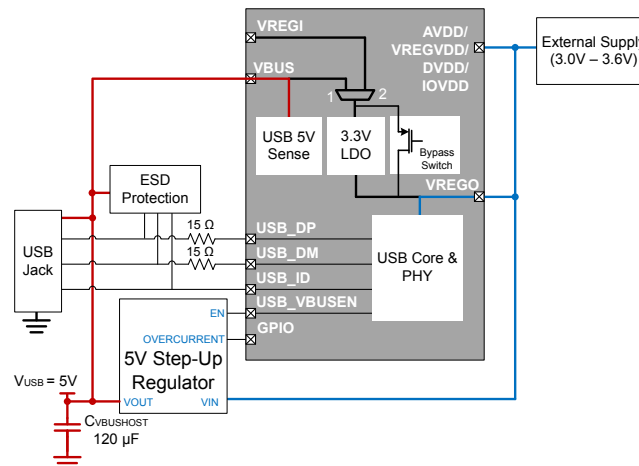
**Note:** EFM32GG11 devices prior to Rev B require zero series resistance on USB\_DP and USB\_DM.

**Figure 6.3. Dual-Powered USB Application**

### 6.4 USB Host

A typical EFM32 Series 1 host configuration using an external 5 V step-up regulator is shown in [Figure 6.4 Host USB Application on page 28](#). In this configuration, the internal 3.3 V LDO is unused, and the VREGO pin is driven directly from an external 3.0 V to 3.6 V source. The VREGI input is left floating; a weak internal pull-down ensures this pin remains at ground. The VBUS input is still used to detect the 5 V supply.

In host mode, the minimum USB 5 V decoupling capacitance is 120  $\mu$ F. Bypass capacitors unrelated to USB are not shown below.



**Note:** EFM32GG11 devices prior to Rev B require zero series resistance on USB\_DP and USB\_DM.

**Figure 6.4. Host USB Application**

## 7. Backup Power Domain

### 7.1 Overview

EFM32 Series 1 Giant Gecko and Tiny Gecko devices can be partly powered by a backup battery. These devices have a dedicated power domain for the RTCC and its 128 bytes of retention registers along with the CRYOTIMER that can be retained in the event main power is lost. When this happens, the system enters a low energy mode, equivalent to EM4 Hibernate, and automatically switches over to the backup power supply.

**Note:** The power supply relationship requirements given in [2.3 Power Supply Requirements](#) must always be adhered to. This means that even when the main supply (VREGVDD/AVDD) falls, these relationships must stay valid, e.g.  $AVDD \geq IOVDD$  in all scenarios.

### 7.2 Connections

The backup power domain interface consists of three pins. BU\_VIN is connected directly to the backup power supply and is the only one required for operation. BU\_VOUT can power external devices from the backup supply, while BU\_STAT is simply driven to BU\_VIN when backup mode is active and to ground otherwise.

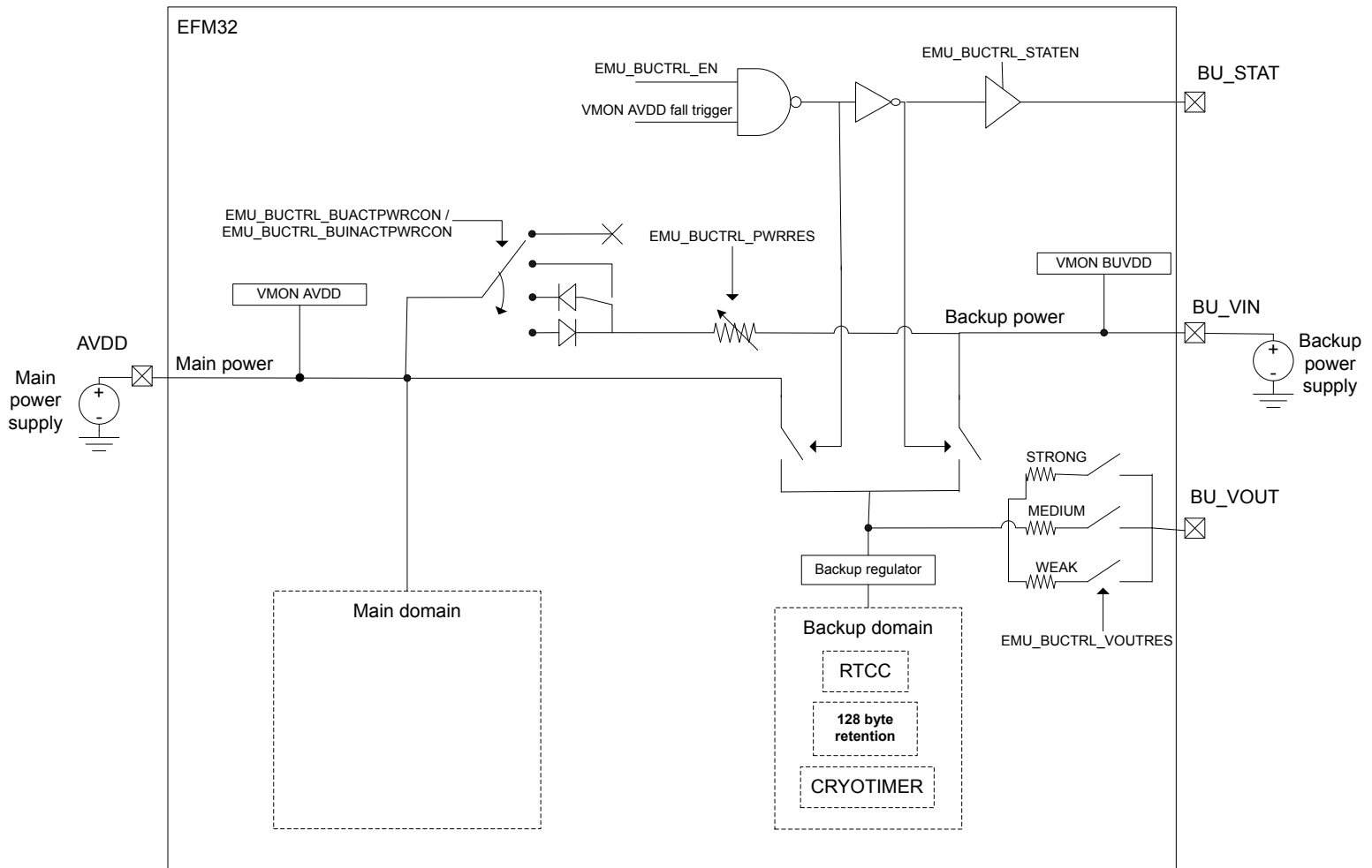


Figure 7.1. Backup Power Domain

**Note:** All three pins are shared with GPIO and peripheral functionality and each must be configured as follows for proper backup domain operation:

- Disabled via its mode register (GPIO\_Px\_MODEL/GPIO\_Px\_MODEH)
- Output set to 0 in GPIO\_Px\_DOUT (if set, the pin is pulled up, even when disabled)
- Locked by setting its respective bit in GPIO\_Px\_PINLOCKN

Allowable sources for the backup supply input include batteries and supercapacitors with output voltages in the same range as that permitted for the device. Charging of the backup power source via the main power supply is possible. Low current external circuitry can also be connected to the BU\_VOUT pin and powered by the backup power supply along with the on-chip backup domain when main power fails.

**Note:** When using this feature, it is imperative that such circuits are not connected to or are otherwise electrically isolated from the rest of the system. Failure to observe this requirement will result in some level of back-powering and rapid depletion of the backup supply.

## 8. Revision History

### Revision 1.54

June, 2020

- Added EFM32GG12 to [1. Device Compatibility](#).
- Corrected required amplitude of a sine wave oscillator input in [5.2.2 Low-Frequency External Clocks](#) and [5.3.2 High Frequency External Clocks](#).

### Revision 1.53

December, 2019

- Added reference to AN958 in [4.1 Serial Wire Debug](#) and [4.2 JTAG Debug](#).
- Corrected minor typos throughout the document.

### Revision 1.52

August, 2018

- Updated series resistance on USB\_DP and USB\_DM to 33 ohms, except in the case of EFM32GG11 rev A/X (which requires zero ohms).

### Revision 1.51

May, 2018

- Clarified that the PAVDD pin is only the supply input for the 2.4 GHz power amplifier (for sub-GHz, the power amplifier is powered externally).

### Revision 1.50

January, 2018

- Removed EFM32JG13 and EFM32PG13 part compatibility.
- The note regarding decoupling capacitors in has been reworded to reflect what the EFM32PG1 Starter Kit uses versus the Starter Kits for subsequent EFM32 Series 1 devices.

### Revision 1.49

September, 2017

- Added references to EFR32xG14.
- Added references to EFM32TG11.
- Added backup domain section.
- Section [High Frequency External Clocks](#) rewritten to reflect differences between EFM32xG1 and EFR32xG1 and later Series 1 family members.

### Revision 1.48

June, 2017

- Added reference to EFM32GG11.
- Added VBUS to Power Supply Pin Overview.
- Renamed USB\_VREGO and USB\_VREGI to VREGO and VREGI.
- Added Section [USB](#).

**Revision 1.47**

January, 2017

- Split application note into multiple application notes, based on family.
- Updated content for EFM32xG11/12 and EFR32xG12/13/14 devices.
- Changed default DCDC output capacitor from 1.0 uF to 4.7 uF.
- Added note advising the system designer to check the capacitance vs temperature characteristics for regulator and dc-dc output capacitors.



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