Document Number: KTFRDMBC3770UG
Rev. 2.0, 8/2016

Freedom expansion boards FRDM-BC3770-EVB and FRDM-BC3770-EVM

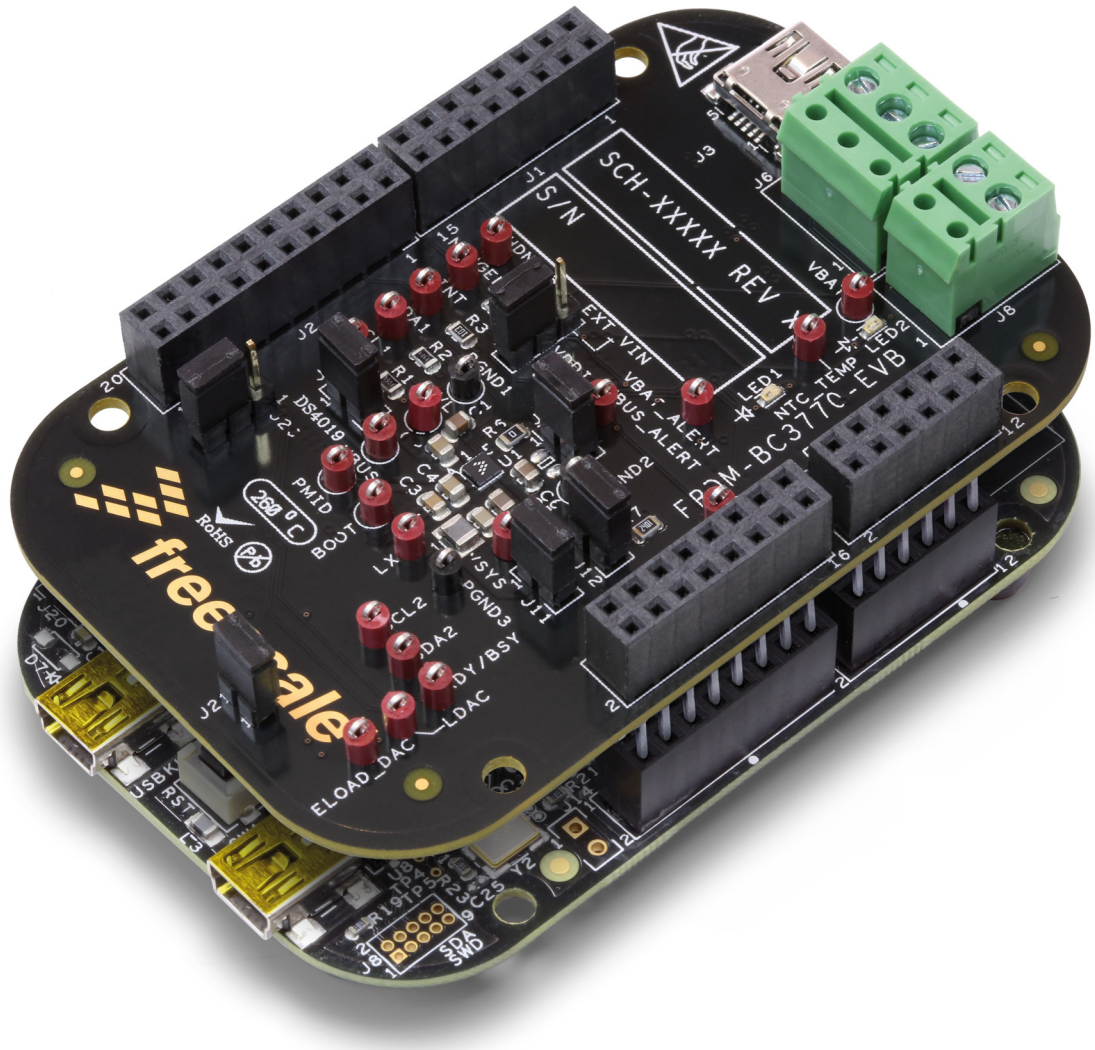


Figure 1. FRDM-BC3770-EVM

Contents

1 Important notice

NXP provides the enclosed product(s) under the following conditions:

This evaluation kit is intended for use of ENGINEERING DEVELOPMENT OR EVALUATION PURPOSES ONLY. It is provided as a sample IC pre-soldered to a printed circuit board to make it easier to access inputs, outputs, and supply terminals. This evaluation board may be used with any development system or other source of I/O signals by simply connecting it to the host MCU or computer board via off-the-shelf cables. This evaluation board is not a Reference Design and is not intended to represent a final design recommendation for any particular application. Final device in an application will be heavily dependent on proper printed circuit board layout and heat sinking design as well as attention to supply filtering, transient suppression, and I/O signal quality.

The goods provided may not be complete in terms of required design, marketing, and or manufacturing related protective considerations, including product safety measures typically found in the end product incorporating the goods. Due to the open construction of the product, it is the user's responsibility to take any and all appropriate precautions with regard to electrostatic discharge. In order to minimize risks associated with the customers applications, adequate design and operating safeguards must be provided by the customer to minimize inherent or procedural hazards. For any safety concerns, contact NXP sales and technical support services.

Should this evaluation kit not meet the specifications indicated in the kit, it may be returned within 30 days from the date of delivery and will be replaced by a new kit.

NXP reserves the right to make changes without further notice to any products herein. NXP makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does NXP assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation consequential or incidental damages. “Typical” parameters can and do vary in different applications and actual performance may vary over time. All operating parameters, including “Typical”, must be validated for each customer application by customer’s technical experts.

NXP does not convey any license under its patent rights nor the rights of others. NXP products are not designed, intended, or authorized for use as components in systems intended for surgical implant into the body, or other applications intended to support or sustain life, or for any other application in which the failure of the NXP product could create a situation where personal injury or death may occur.

Should the Buyer purchase or use NXP products for any such unintended or unauthorized application, the Buyer shall indemnify and hold NXP and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges NXP was negligent regarding the design or manufacture of the part. NXP™ and the NXP logo are trademarks of NXP Semiconductors. All other product or service names are the property of their respective owners.

2 Getting started

2.1 Kit contents/packing list

2.1.1 FRDM-BC3770-EVM

If you ordered the FRDM-BC3770-EVM, your kit contents include:

- Assembled and tested evaluation board/module in anti-static bag.
- FRDM-KL25Z Freedom board with programming loaded
- Two USB Mini-B to Standard-A cables
- Quick Start Guide, Analog Tools
- Warranty card

2.1.2 FRDM-BC3770-EVB

If you ordered the FRDM-BC3770-EVB, your kit contents include:

- Assembled and tested evaluation board/module in anti-static bag.
- Quick Start Guide, Analog Tools
- Warranty card

2.2 Jump start

NXP's analog product development boards help to easily evaluate NXP products. These tools support analog mixed signal and power solutions including monolithic ICs using proven high-volume SMARTMOS mixed signal technology, and system-in-package devices utilizing power, SMARTMOS and MCU dies. NXP products enable longer battery life, smaller form factor, component count reduction, ease of design, lower system cost, and improved performance in powering state of the art systems.

- Go to www.nxp.com/FRDM-BC3770-EVB
- Review your Tool Summary Page
- Look for

Jump Start Your Design

- Download documents, software, and other information

Once the files are downloaded, review the user guide in the bundle. The user guide includes setup instructions, BOM, and schematics. Jump start bundles are available on each tool summary page with the most relevant and current information. The information includes everything needed for design.

2.3 Required equipment and software

To use this kit, you need:

- A Win 32 or higher PC
- A Lithion Ion (or Lithium Polymer) battery 3.7 V – 4.2 V, Max Charge Current 2.0 A
- Two USB Mini-B (Male) to Standard-A (Male) cables (included in FRDM-BC3770-EVM kit)
- A FRDM-KL25Z board with programming loaded (included in FRDM-BC3770-EVM kit)

2.4 System requirements

The kit requires the following to function properly with the software:

- Windows® XP, Windows 7, or Vista in 32- and 64-bit versions, Windows 8

3 Understanding the Freedom platform

The NXP Freedom development platform is a small, low-power, cost-effective evaluation and development system for quick application prototyping and demonstration of Kinetis MCU families. The assembled platform incudes the FRDM-BC3770-EVB expansion board mounted to the KL25Z board.

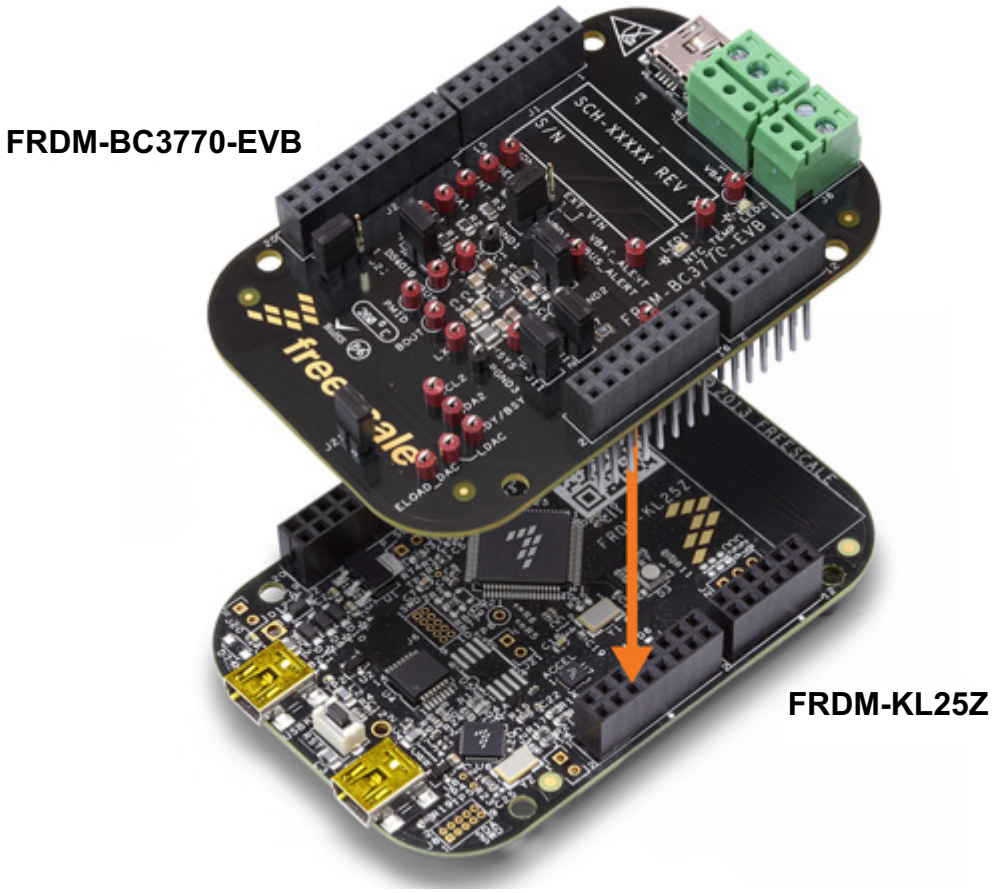


Figure 2. Freedom development platform

3.1 FRDM-BC3770-EVB

The Freedom expansion board FRDM-BC3770-EVB is a fully programmable switching charger with dual-path output for single-cell Li-Ion and Li-Polymer battery. This dual-path output allows mobile applications with fully discharged battery or dead battery to boot up the system. The high-efficiency and switch-mode operations of the BC3770 reduce heat dissipation and allow a higher current capability for a given package size. In addition, the FRDM-BC3770-EVB features a single 20 V maximum input and charges the battery with a current of up to 2.0 A. The charging parameters and operating modes are fully programmable over an I^2C Interface operating up to 400 kHz.

Features

- The FRDM-BC3770-EVB is a highly integrated synchronous switch-mode charger, featuring integrated OVP and Power FET.
- The charger and boost regulator circuits switch at 1.5 MHz to minimize the size of external passive components
- The BC3770 is able to operate as a boost regulator for USB-OTG function via either I^2C command or an external pin from the host/processor
- The BC3770 is available in a 25-bump, 2.27 mm x 2.17 mm, WLCSP package

3.2 FRDM-KL25Z

The FRDM-KL25Z is an ultra-low-cost development platform for Kinetis L Series KL1x (KL14/15) and KL2x (KL24/25) MCUs built on the ARM® Cortex™-M0+ processor. Features include easy access to MCU I/O, battery-ready, low-power operation, a standard-based form factor with expansion board options, and a built-in debug interface for flash programming and run-control. The FRDM-KL25Z is supported by a range of NXP and third-party development software.

The user can use mbed.org at no charge, with full access to the online SDK, tools, reusable code (no downloads, installations or licenses), and an active community of developers.

3.2.1 Features

- MKL25Z128VLK4 MCU - 48 MHz, 128 KB flash, 16 KB SRAM, USB OTG (FS), 80LQFP
- Capacitive touch “slider,” MMA8451Q accelerometer, tri-color LED
- Easy access to MCU I/O
- Sophisticated OpenSDA debug interface
- Mass storage device flash programming interface (default) - no tool installation required to evaluate demo apps
- P&E Multilink interface provides run-control debugging and compatibility with IDE tools
- Open-source data logging application provides an example for customer, partner and enthusiast development on the OpenSDA circuit
- mbed™ enabled

To view an online video providing an introduction to using the FRDM-KL25Z, go to the following URL:
http://www.NXP.com/webapp/video_vault/videoSummary.sp?code=FRDMKL25ZINTRO_VID

3.3 Block diagram

The high level system block diagram here outlines the way the NXP standard products are used to implement an example airbag ECU.

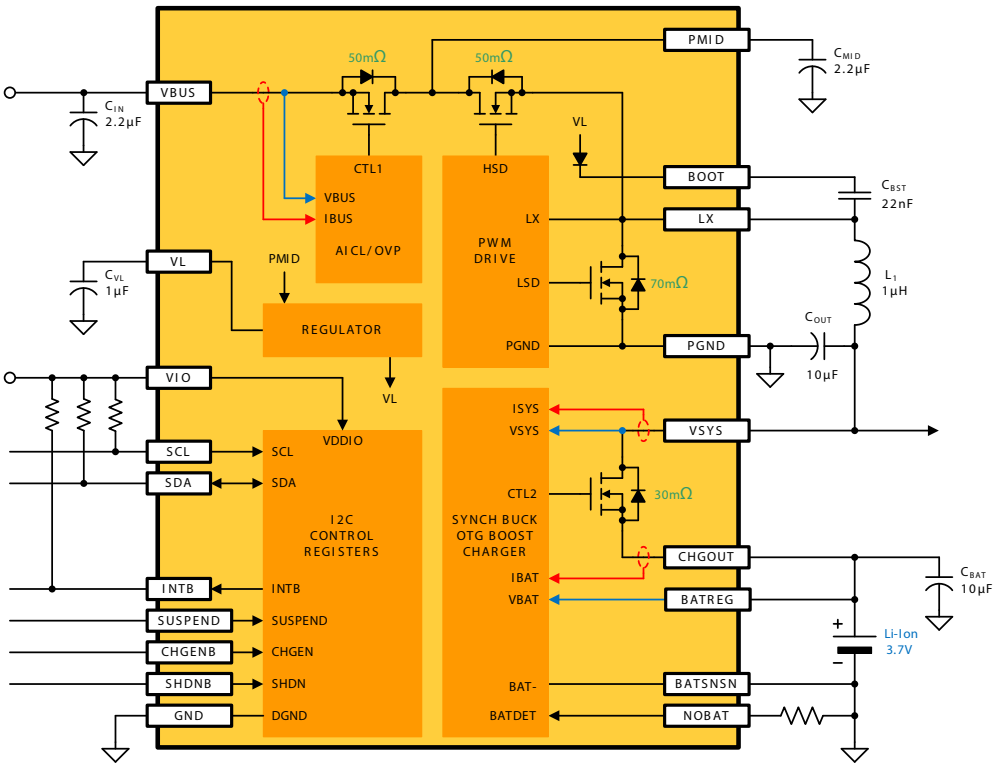


Figure 3. BC3770 simplified block diagram

4 Getting to know the hardware

The Freedom platform consists of the FRDM-BC3770-EVB board mounted to a FRDM-KL25Z board.

4.1 FRDM-BC3770-EVB board overview

The FRDM-BC3770-EVB expansion Board (EVB) is an easy-to-use circuit board allowing the user to exercise all the functions of the MC32BC3770CS fully programmable switching charger. A PC communicates to the EVB through the FRDM-KL25Z's USB communication port.

4.1.1 FRDM-BC3770-EVB board description

The FRDM-BC3770-EVB board consists of the MC32BC3770CS chip and its associated circuitry.

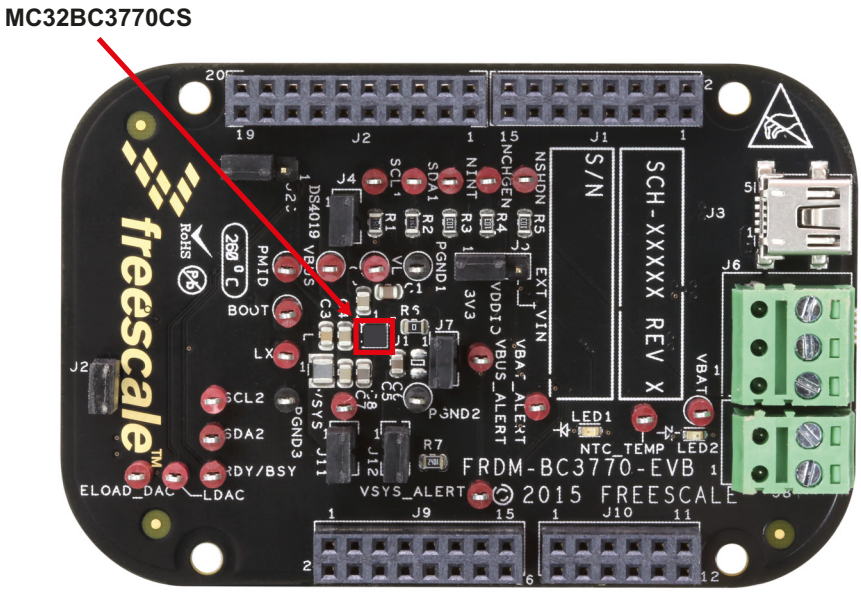


Figure 4. FRDM-BC3770-EVB (top view)

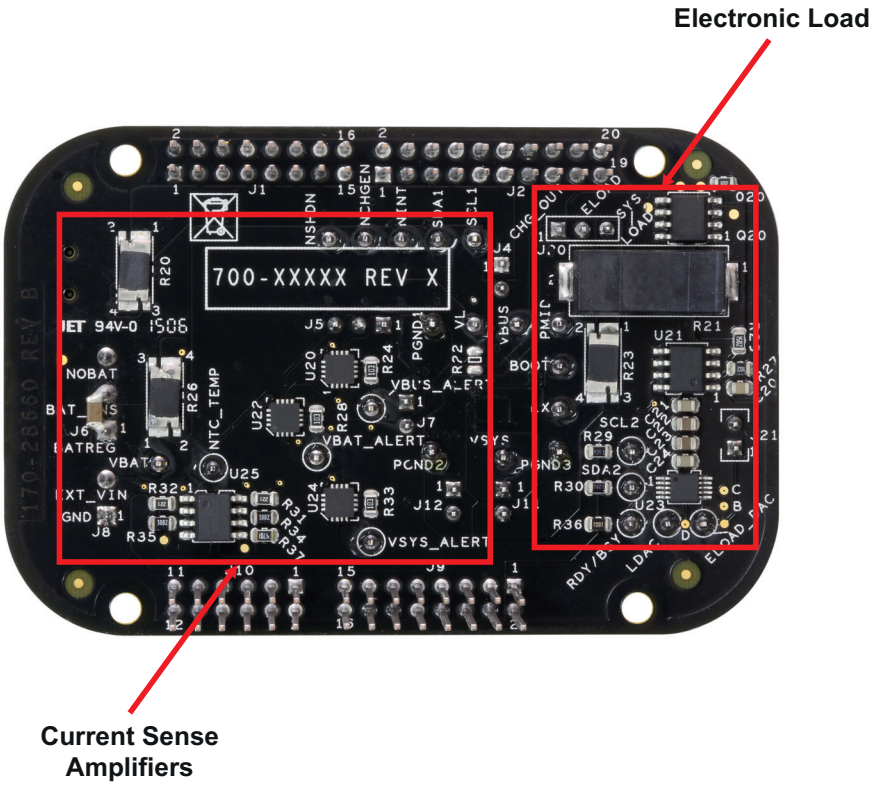


Figure 5. FRDM-BC3770-EVB (bottom view)

Table 1. Board description

Name	Description
MC32BC3770CS	A fully programmable switching charger with dual-path output for single-cell Li-Ion and Li-Polymer battery
Current Sense Amplifiers	Three integrated current sense amplifiers (CSAs) permit the real-time measurement of current and voltage on the VBUS input supply, the VSYS output supply and the battery (VBAT)
Power Supply	A programmable electronic load (ELOAD), 0 A to 1.0 A, in 50 mA steps. It is used to demonstrate system performance with an active load applied to either the VSY supply, or the battery VBAT. When attached to the battery, the ELOAD can be used to discharge the battery in a controlled manner

4.1.2 LED display

The following LEDs are provided as visual indicators on the FRDM-BC3770-EVB evaluation board:

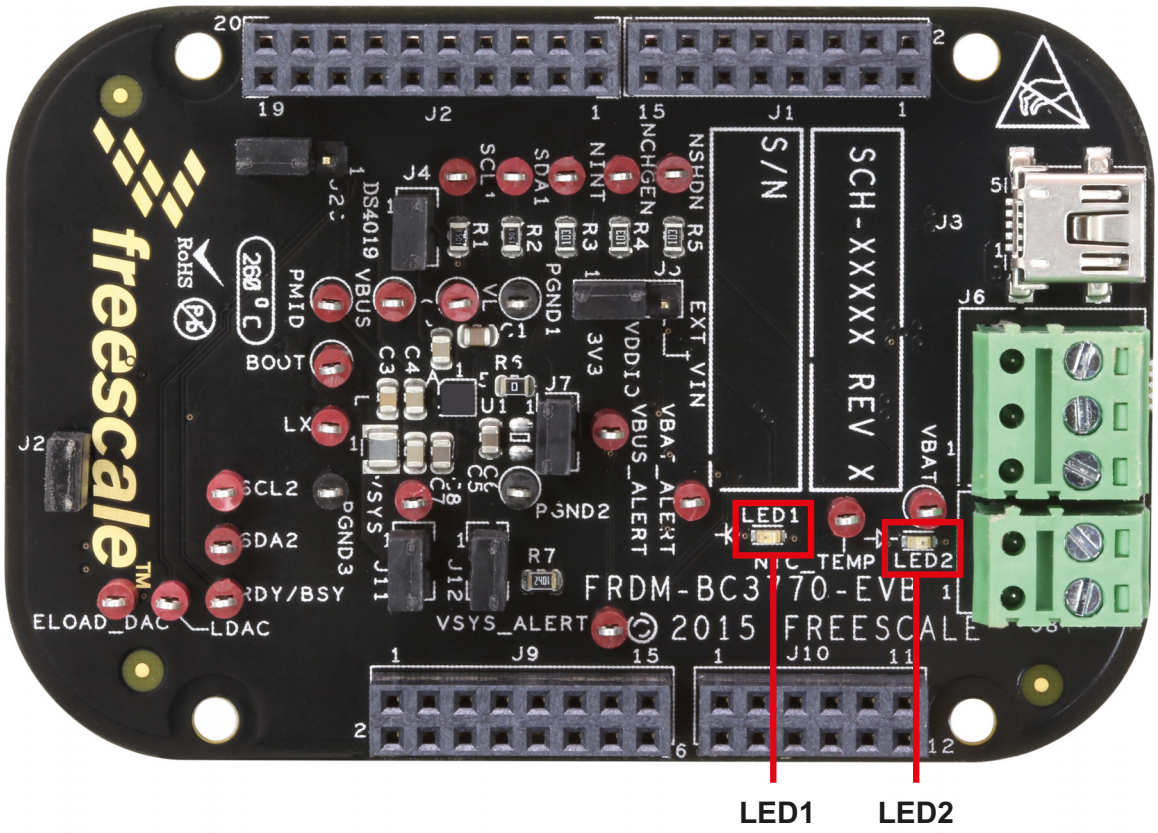


Figure 6. LED locations on the FRDM-BC3770-EVB evaluation board

Table 2. LEDs

Schematic label	Name	Description
LED1	LED Green	This indicates the target has been selected/deselected through the GUI. It turns on when the target is selected and turns off when the target is deselected. (Note: Exiting the GUI while the target is still selected results in the LED remaining on.)
LED2	LED Red	This indicates the presence of charge current. It turns on when a charge current of 10 mA or greater occurs.

4.1.3 Connectors

Input/output connectors function as follows:

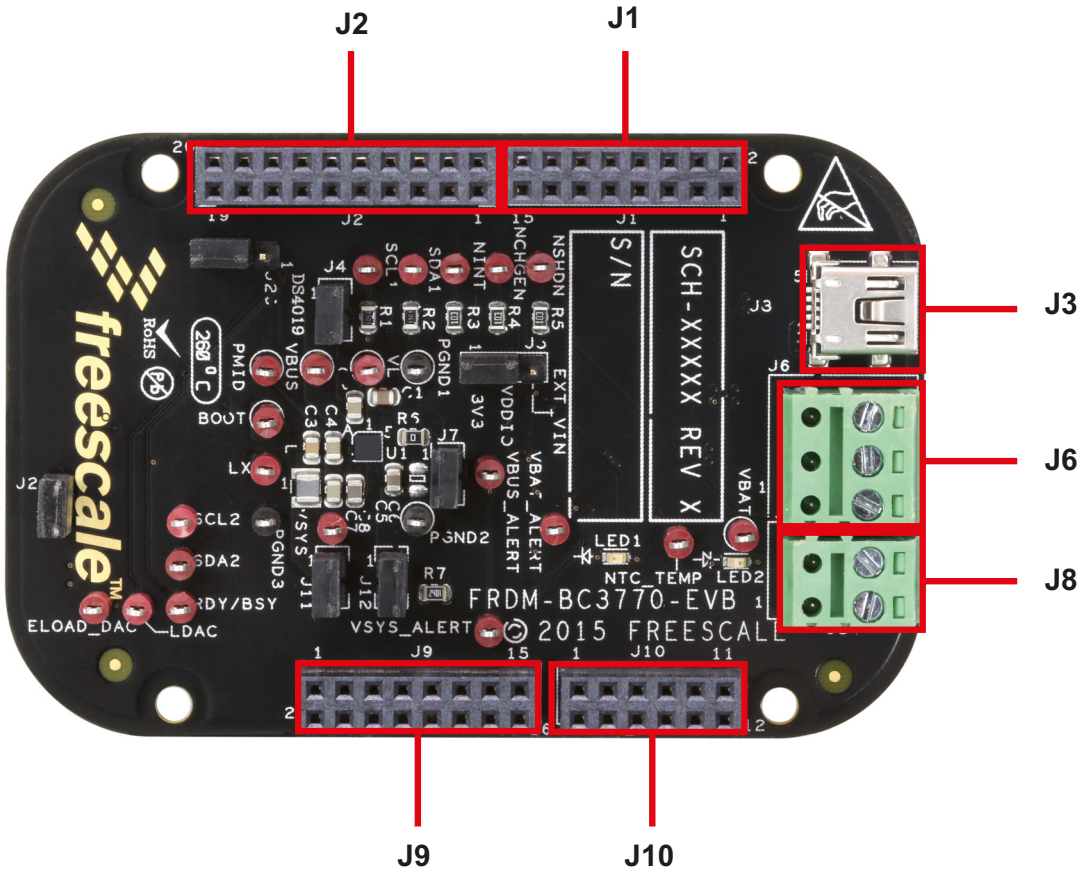


Figure 7. Connector locations on the FRDM-BC3770-EVB evaluation board

Table 3. Connectors

Schematic label	Name	Description
J1	CON_2X8	2 x 8 Female Arduino connector. Supports addition of shield boards.
J2	CON_2X10	2 x 10 Female Arduino connector. Supports addition of shield boards.
J3	USB MINI-B	USB Mini port supplies power to the Freedom platform
J6	TB_3x1	Three-position detachable terminal block. The bottom terminal connects to positive battery pole and the middle terminal connects to negative battery pole. The top terminal is used for battery detection.
J8	TB_2x1	Two-position detachable terminal block. Supports eternal temperature measurement (NTC). Note: currently not supported in software.
J9	CON_2X8	2 x 8 Female Arduino connector. Supports addition of shield boards.
J10	CON_2X6	2 x 6 Female Arduino connector. Supports addition of shield boards.

4.1.4 Test point definitions

Figure 8 and Table 4 define the evaluation board test points and their locations.

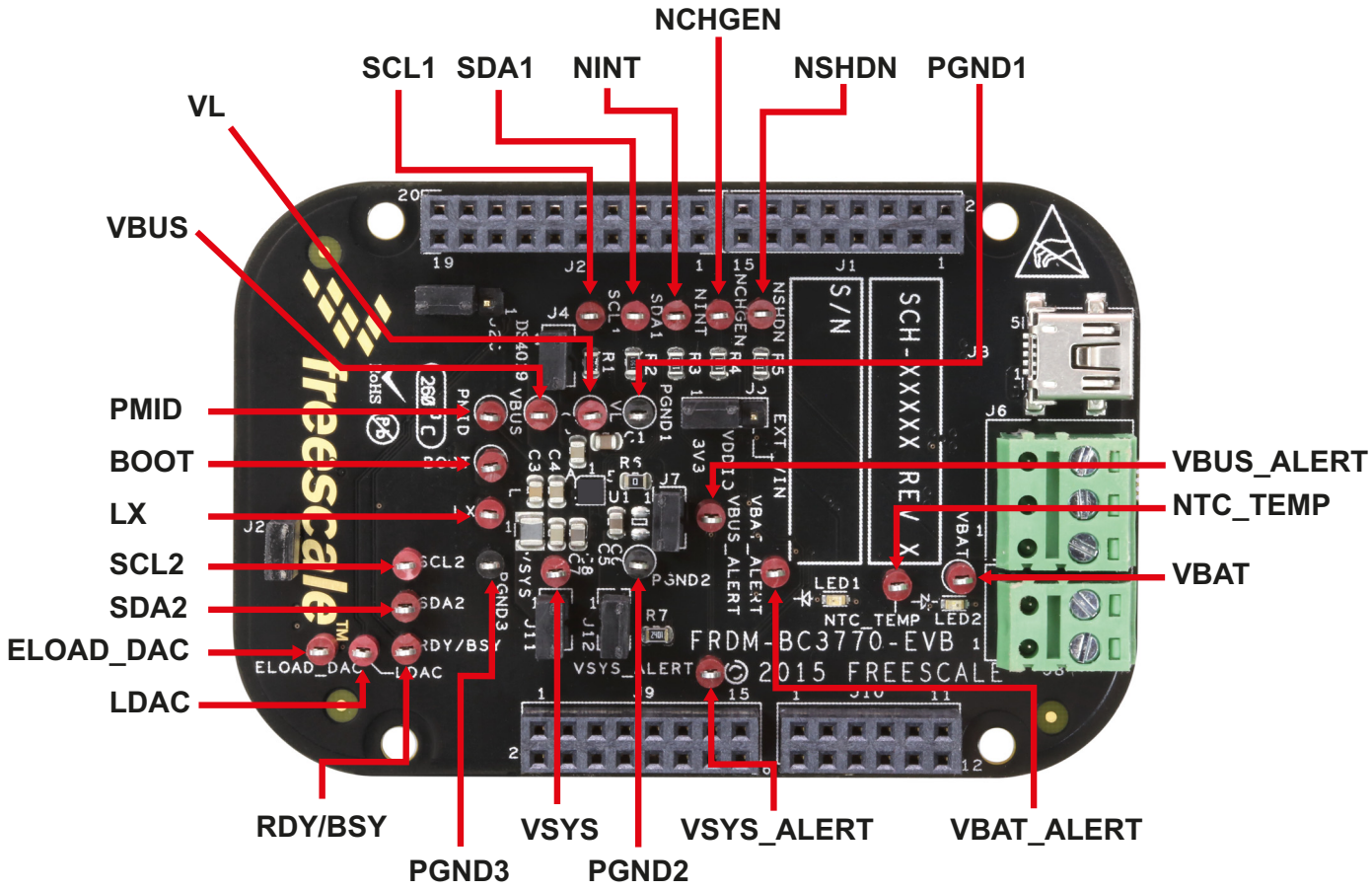


Figure 8. Test point locations on the FRDM-BC3770-EVB evaluation board

The following test-point jumpers provide access to signals on the MC32BC3770CS IC:

Table 4. Test points

Schematic label	Description
BOOT	Bootstrap Capacitor Voltage
ELOAD_DAC	Voltage DAC Output
LDAC	DAC Address Latch
LX	Buck Supply Switching Node
NCHGEN	Charger Enable (Active Low)
NINT	Interrupt Out (Active Low)
NSHDN	Charger Shutdown (Active Low)
NTC_TEMP	NTC Thermistor Voltage
PMID	BC3770 VBUS Bypass Output
RDY/BSY	DAC Ready/Busy Output
SCL1	I^2C Clock Signal to the BC3770

Table 4. Test points (continued)

Schematic label	Description
SCL2	I^2C Clock Signal to other devices
SDA1	I^2C Data Signal to/from BC3770
SDA2	I^2C Data Signal to/from other devices
VBAT	Battery Positive Terminal
VBAT_ALERT	VBAT CSA Interrupt
VBUS	USB/Charge Source Input
VBUS_ALERT	VBUS CSA Interrupt
VL	BC3770 Internal Regulator Output (Do not Load)
VSYS	System Supply Output
VSYS_ALERT	VSYS CSA Interrupt
PGND1	Analog Power Ground
PGND2	Analog Power Ground
PGND3	Analog Power Ground

4.1.5 Jumper definitions

The following table defines the evaluation board jumper positions and explains their functions.

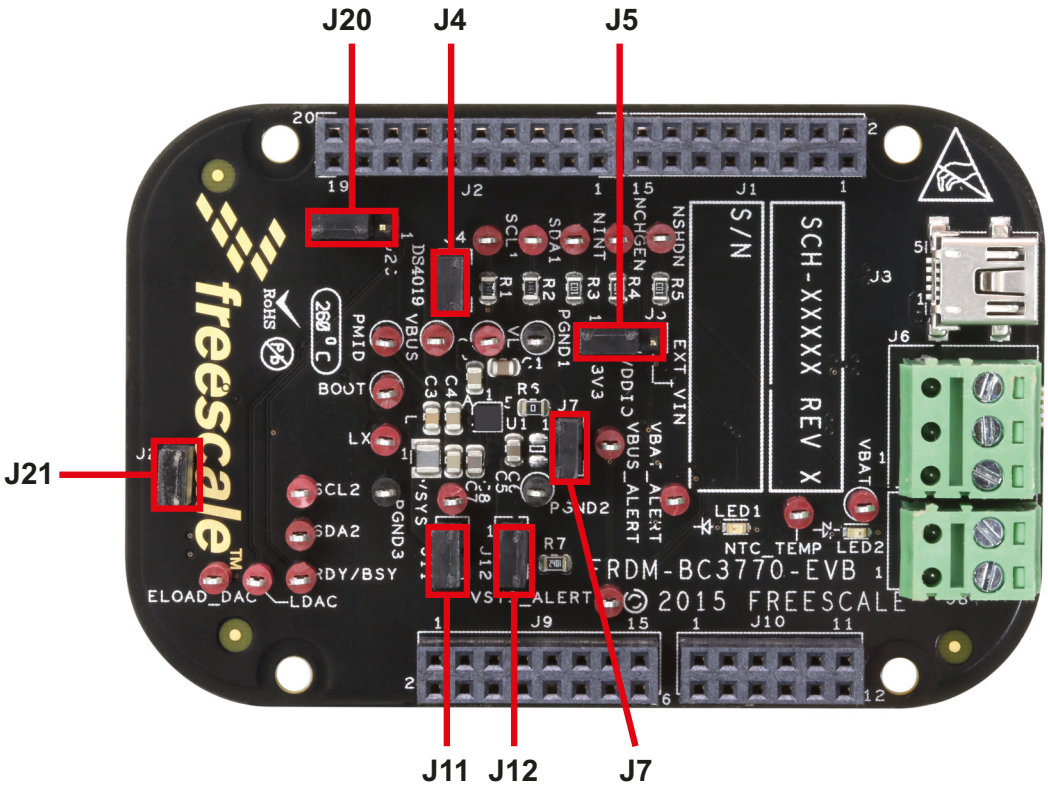


Figure 9. Jumper locations on the FRDM-BC3770-EVB evaluation board

.

Table 5. Jumpers

Jumper	Name	Description	Pins 1-2 (default)	Pins 2-3
J4	VBUS	Input Power Source For Charger	Shorted	–
J5	VDDIO	Power Source for Digital Interface	Shorted	–
J7	CHGOUT	Charger Output to Battery	Shorted	–
J11	VSYS	Power Output to System Load	Shorted	–
J12	NOBAT		Shorted	–
J20	ELOAD SELECT	Connects ELOAD to VBAT or VSYS	VBAT	VSYS
J21	VDAC	VDAC Output to drive ELOAD	Shorted	–

4.2 Accessory interface board

The FRDM-BC3770-EVB kit is typically used with the FRDM-25KLZ shown in Figure 10. The FRDM-KL25Z is an ultra-low-cost development platform for Kinetis L Series KL1x (KL14/15) and KL2x (KL24/25) MCUs built on ARM® Cortex™-M0+ processor. Its features include easy access to MCU I/O, battery-ready, low-power operation, a standard-based form factor with expansion board options, and a built-in debug interface for flash programming and run-control. The FRDM-KL25Z is supported by a range of NXP and third-party development software.

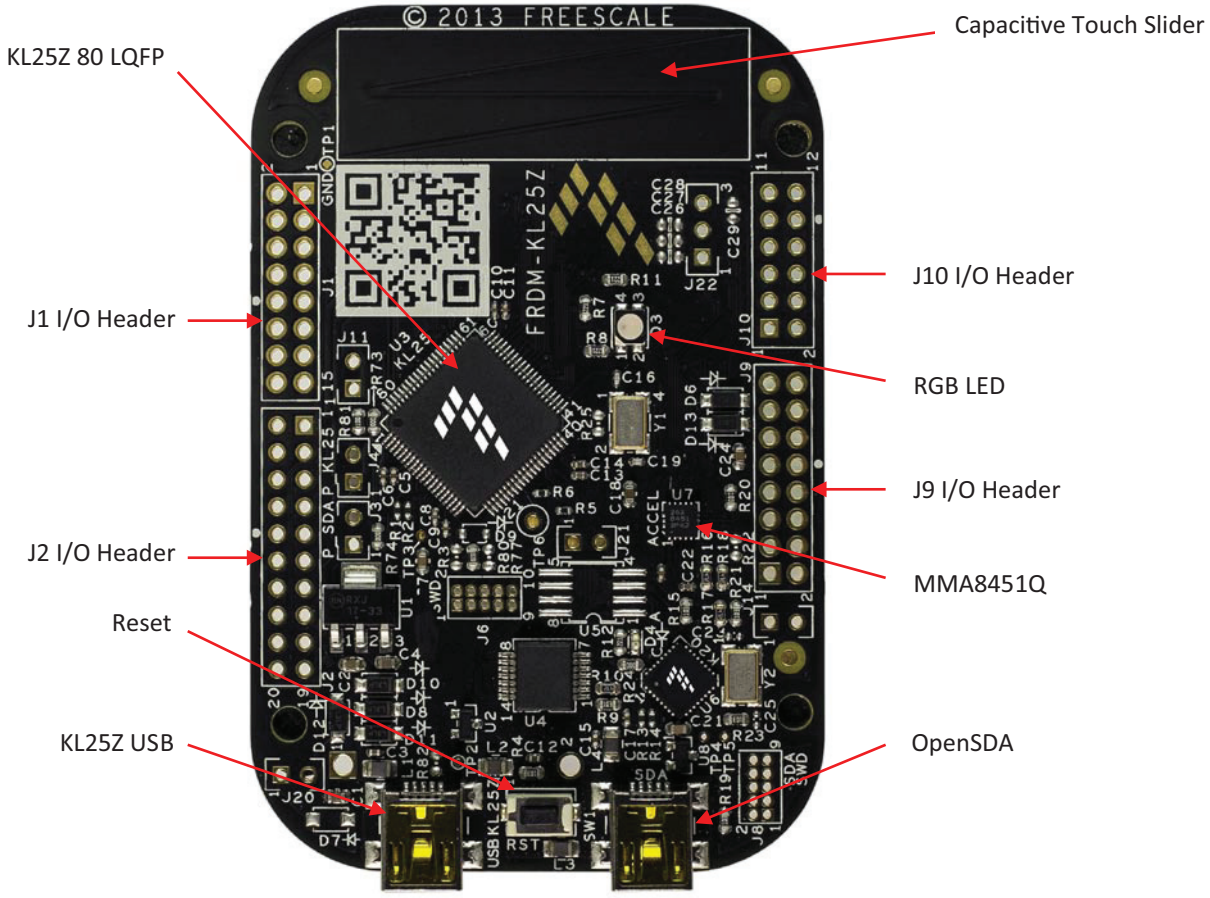


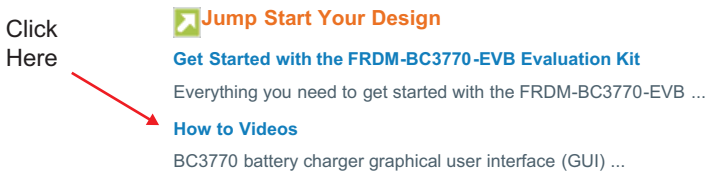
Figure 10. FRDM-KL25Z Freedom development platform

For more information on the FRDM-KL25Z board, go to the NXP product summary page at:
http://www.NXP.com/webapp/sps/site/prod_summary.jsp?code=FRDM-KL25Z

5 Installing the software and setting up the hardware

5.1 Video tutorials

A series of video tutorials provide in depth information on the operations described in this section. To access these tutorials, go to the following url:http://www.nxp.com/webapp/sps/site/prod_summary.jsp?code=FRDM-BC3770-EVB. In the “Jump Start Your Design” block, click on the “How To Videos” link.



The following tutorials apply to this section

Table 6. Video tutorials

Title	Description
01A - BC3770 GUI Install Video	Describes how to download and install the GUI on a PC
01B - BC3770 Battery Connections Video	Describes the Freedom platform links to a Lithium Ion battery, the PC, and a power supply
01C - BC3770 GUI Launch Video	Describes how to launch the GUI and verify the connections
02 - BC3770 GUI Main Log Video	Describes the GUI Startup screen and the use of the Main Log
03 - BC3770 GUI I^2C Communication Video	Describes how to control 1^2C Communications through the GUI
04 - BC3770 GUI Control Registers Video	Describes the GUI Control Register functions (System, VBUS, Charger, and Interrupt register parameters)
05 - BC3770 GUI Script Editor Video	Describes GUI scripting capability
06 - BC3770 GUI Charge Plots Video	Describes the GUI Charge Plot function
07 - BC3770 GUI Discharge Plots Video	Describes the GUI Discharge Plot function
08A - BC3770 GUI Load Sharing Video	Describes the load sharing support via the GUI
08B - BC3770 GUI Battery Supplement Video	Describes battery supplement support via the GUI
08C - BC3770 GUI OTG Boost video	Describes OTG Boost support via the GUI

5.2 Installing the MC32BC3770 graphical user interface on the computer

The latest version of the MC32BC3770 GUI is designed to run on any Windows 8, Windows 7, Vista, or XP-based operating system.
To install the software:

- Go to www.nxp.com/analogtools and select the kit.
- Click on the link to open the corresponding Tool Summary Page.
- Look for “Jump Start Your Design”.
- Download the MC32BC3770_GUI(x.x.x.x) file to a directory on the computer.
- Open the MC32BC3770_GUI_(x.x.x.x).zip file and extract the compressed files. (The software creates a subdirectory containing the extracted files.)
- Open the subdirectory containing the extracted files and run the setup.exe file. The Installation Wizard guides the user through the rest of the process.
- When the installation completes, the MC32BC3770 Charger Panel GUI automatically opens on the computer. In addition, a BC3770_GUI icon appears on the desktop.

For an in-depth tutorial on installing the MC32BC3770 GUI, see the video “01A - BC3770 GUI Install Video” in the FRDM-BC3770-EVB Product Summary page.

5.3 Starting the MC32BC3770 GUI

To launch the MC32BC3770 GUI:

- From your desktop, click on the BC3770_GUI icon. The Graphic User Interface (GUI) appears.

5.3.1 The MC32BC3770 GUI startup screen

Figure 11 shows the MC32BC3770 GUI Graphical User Interface (GUI) screen displayed at startup. A row of tabs along the top of the screen selects among four types of control panel functions. (At startup the Control Register function is active.) The display related to the selected function appears immediately below the row of tabs.

The USB Connection Panel at the top left of the screen verifies the GUI is properly connected to the target. It also controls certain parameters related to the connection. For complete instructions on using the USB Connection Panel, see the video “01C - BC3770 GUI Launch Video” in the FRDM-BC3770-EVB Product Summary page.

A Main Log in the middle left panel maintains a running record of all events occurring during the MC32BC3770 GUI session. For instructions on using the Main Log, see the video “02 - BC3770 GUI Main Log Video” in the FRDM-BC3770-EVB Product Summary page. The Direct 1^2C Communication Panel at the bottom left of the screen reads and writes bytes to the 1^2C registers. For complete instructions on using the 1^2C Communication Panel, see the video“03 - BC3770 GUI I^2C Communication Video” in the FRDM-BC3770-EVB Product Summary page.

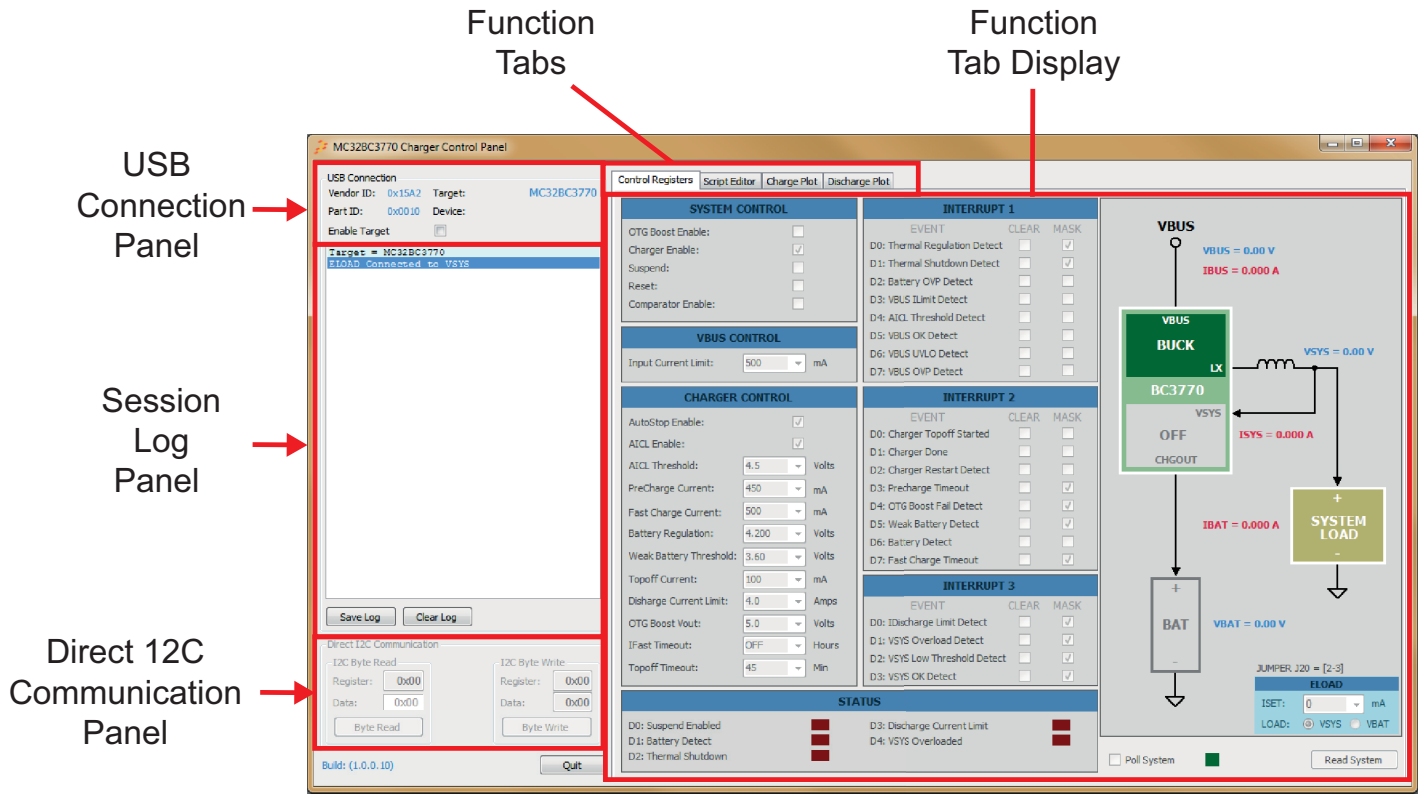


Figure 11. GUI startup screen

5.3.2 The control registers screen

Figure 12 shows the Control Register screen. The parameter control panel on the left manipulates system VBUS and charger control parameters. It also controls events related to the MC32BC3770's three interrupt registers. Finally, the panel at the bottom left provides a snapshot of the MC32BC3770 status registers. For instructions on using the Control Register Panel, see the video "04 - BC3770 GUI Control Registers Video" in the FRDM-BC3770-EVB Product Summary page.

The real-time system performance measurements panel on the right controls load sharing, battery supplement, and OTG boost functions in real-time. Clicking on the Read System button at the bottom right updates the panel. If the Poll System check box is set, the panel automatically updates on a periodic basis.

For a tutorial on using the Control Registers screen to support load sharing, see the video "08A - BC3770 GUI Load Sharing Video" in the FRDM-BC3770-EVB Product Summary page.
For a tutorial on using the Control Registers screen to battery supplement, see the video "08B - BC3770 GUI Battery Supplement Video" in the FRDM-BC3770-EVB Product Summary page.
For a tutorial on using the Control Registers screen to support OTG boost, see the video "08C - BC3770 GUI OTG Boost video" in the FRDM-BC3770-EVB Product Summary page.

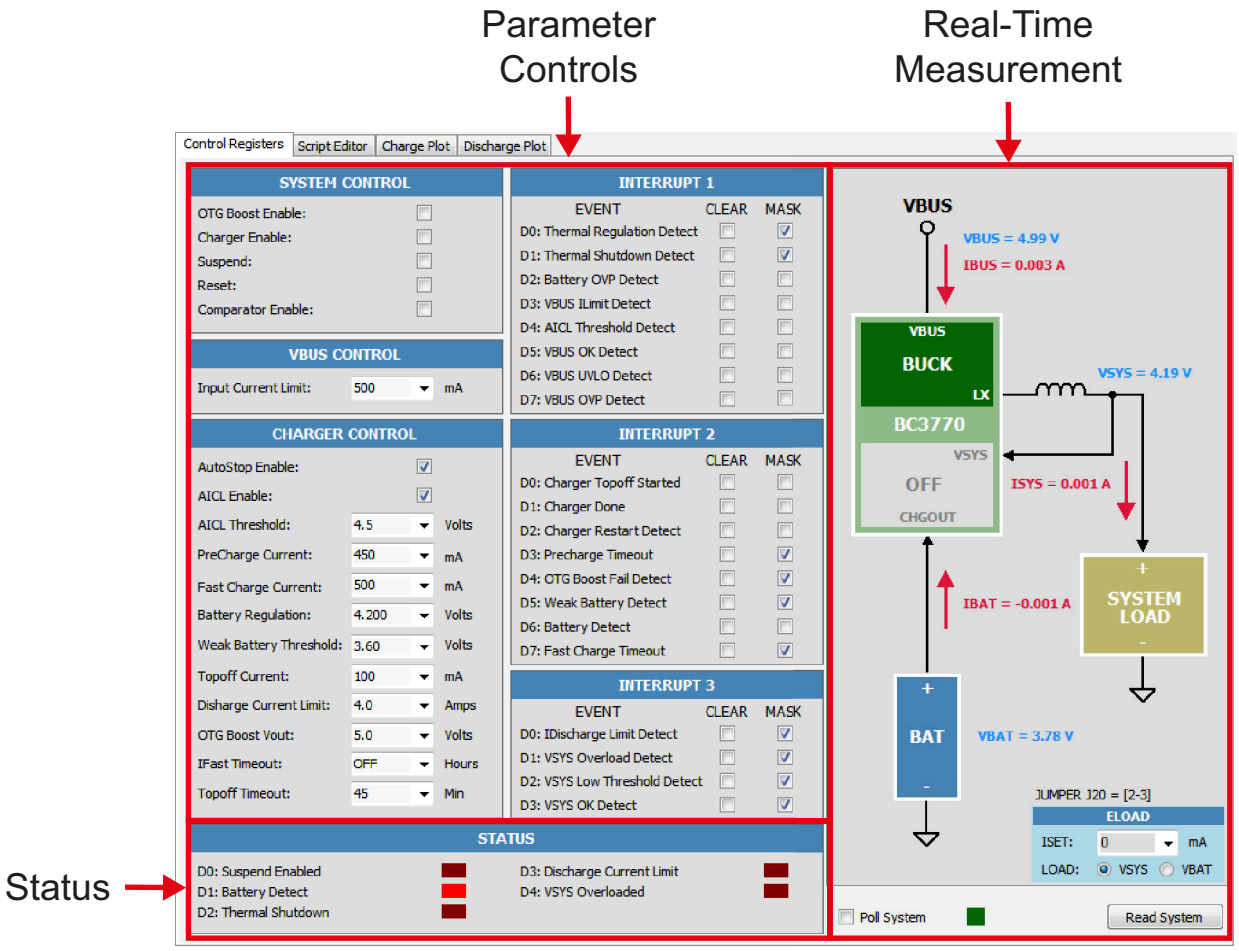


Figure 12. Control register screen

5.3.3 Script editor screen

The Script Editor tab loads and runs scripts automating the execution of Charger Control Panel commands. **Figure 13** shows the Script Editor screen.

The panel on the left is the script editor window. Enter commands directly into this window from the keyboard, or click on the Commands button at the bottom of the window. Doing so opens a panel to select commands and enter values for their associated variables. These commands automatically load into the editor in the sequence they were selected. Other buttons below this panel load, save, run, and clear the script. The Insert Line Separator button enters a full line of dashes at the cursor location in the Script Editor.

The panel on the right shows a log of events occurring as the script executes. Buttons below this panel clears or saves the log. For complete instructions on using the Script Editor panel, see the video “05 - BC3770 GUI Script Editor Video” in the FRDM-BC3770-EVB Product Summary page.

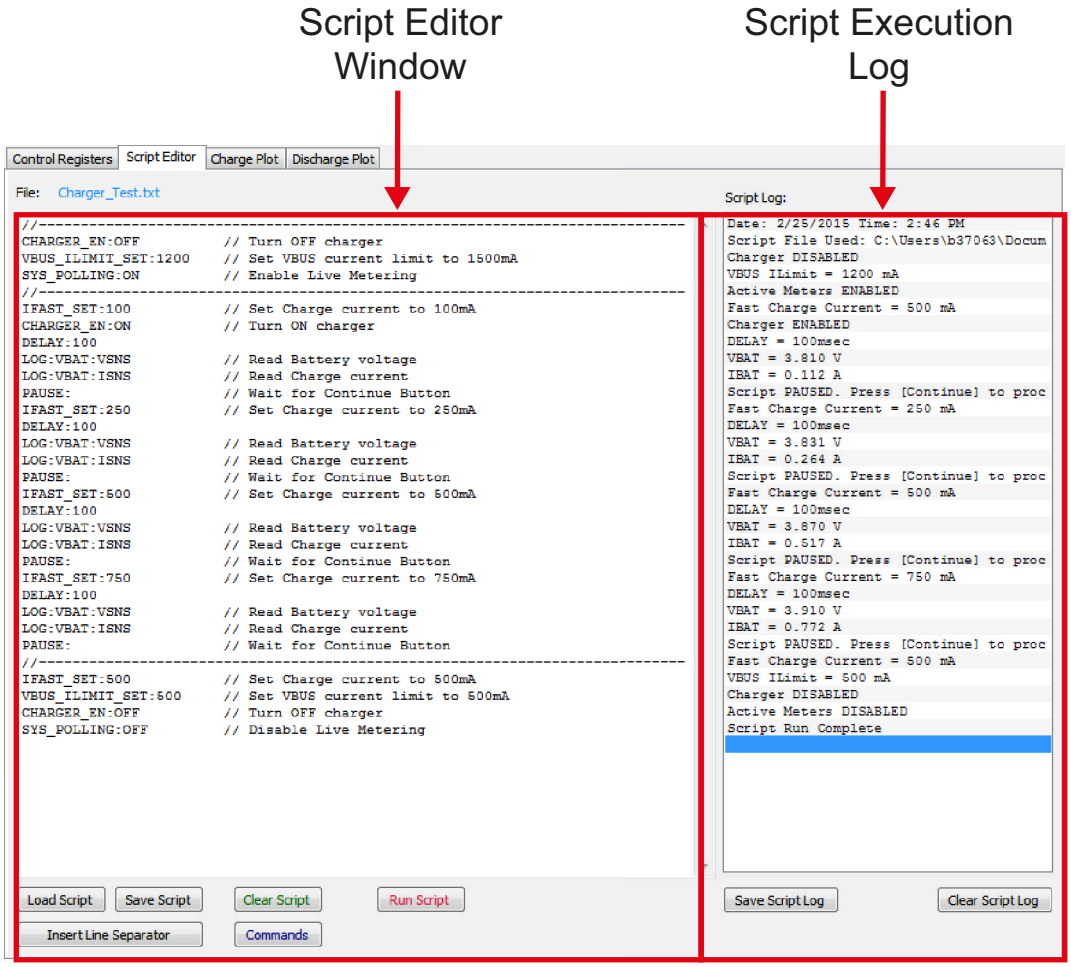


Figure 13. Script editor screen

5.3.4 Charge plot screen

The Charge Plot tab graphs voltage and current in real-time as the battery charges. Save the resulting plot data as an Excel file. Figure 14 shows the Charge Plot screen during a battery charging session. The panel on the upper left displays a log of events occurring during the charging session. Clear or save the log by clicking the corresponding buttons below the log. The Charge Parameters panel controls the current and voltage related to the battery charging session. The Plot Parameters panel controls the appearance of the graph. The Charge State panel shows the current status of the charging session. It also starts, stops, clears, and saves the results of a battery charging session.

For complete instructions on using the Charge Plot panel, see the video “06 - BC3770 GUI Charge Plots Video” in the FRDM-BC3770-EVB Product Summary page.

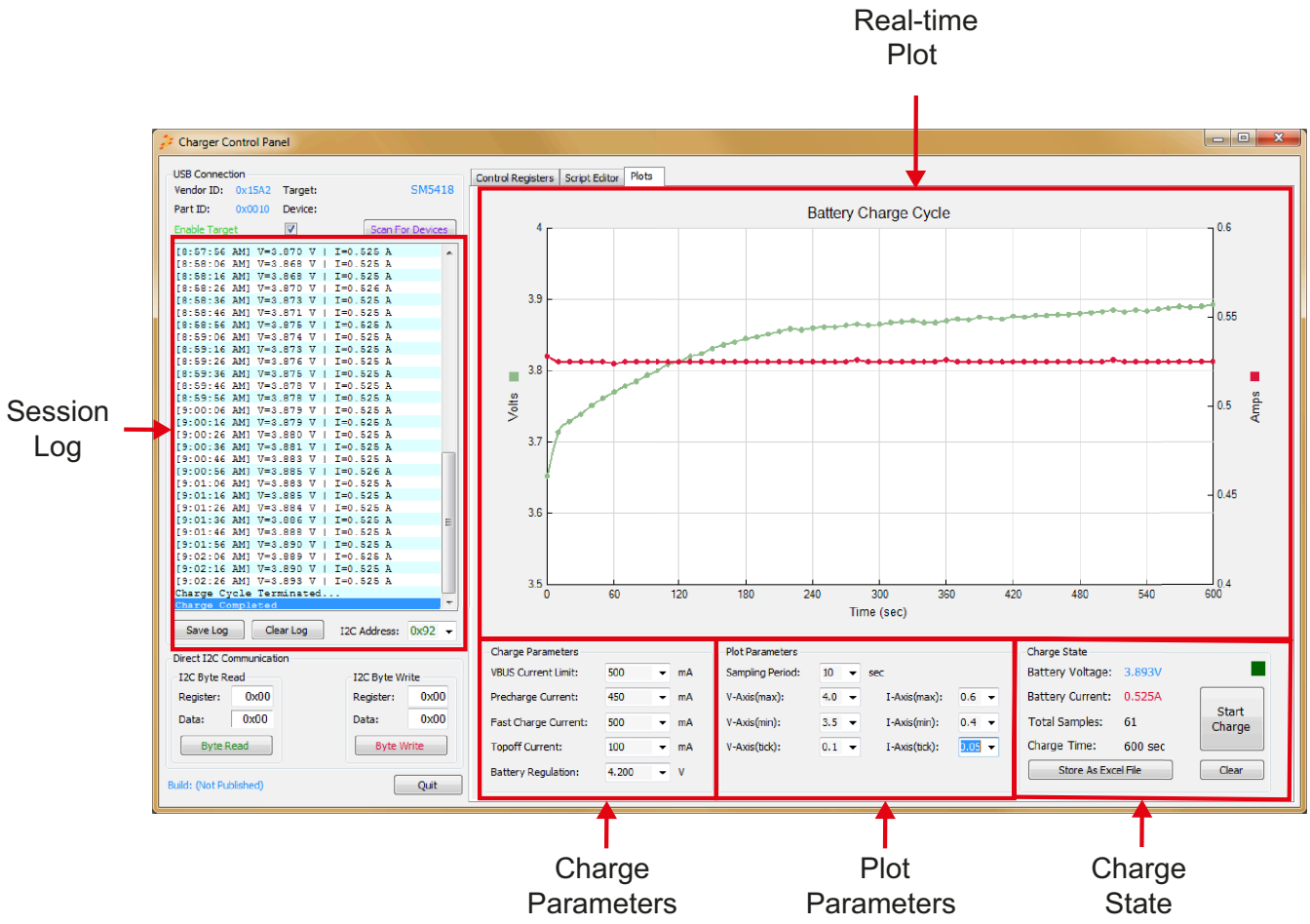


Figure 14. Charge plot screen

5.3.5 The discharge plot screen

The Discharge Plot tab graphs voltage and current in real-time as the battery discharges. Save the resulting plot data as an Excel file. Figure 15 shows the Discharge Plot screen during a battery charging session. The panel on the upper left displays a log of events occurring during the charging session. Clear or save the log by clicking the corresponding buttons below the log. The Discharge Parameters panel controls the current and voltage related to the battery charging session. The Plot Parameters panel controls the appearance of the graph. The Discharge State panel shows the current status of the discharging session. It also starts, stops, clears, and saves the results of a battery charging session.

For complete instructions on using the Discharge Plot panel, see the video “07 - BC3770 GUI Discharge Plots Video” in the FRDM-BC3770-EVB Product Summary page.

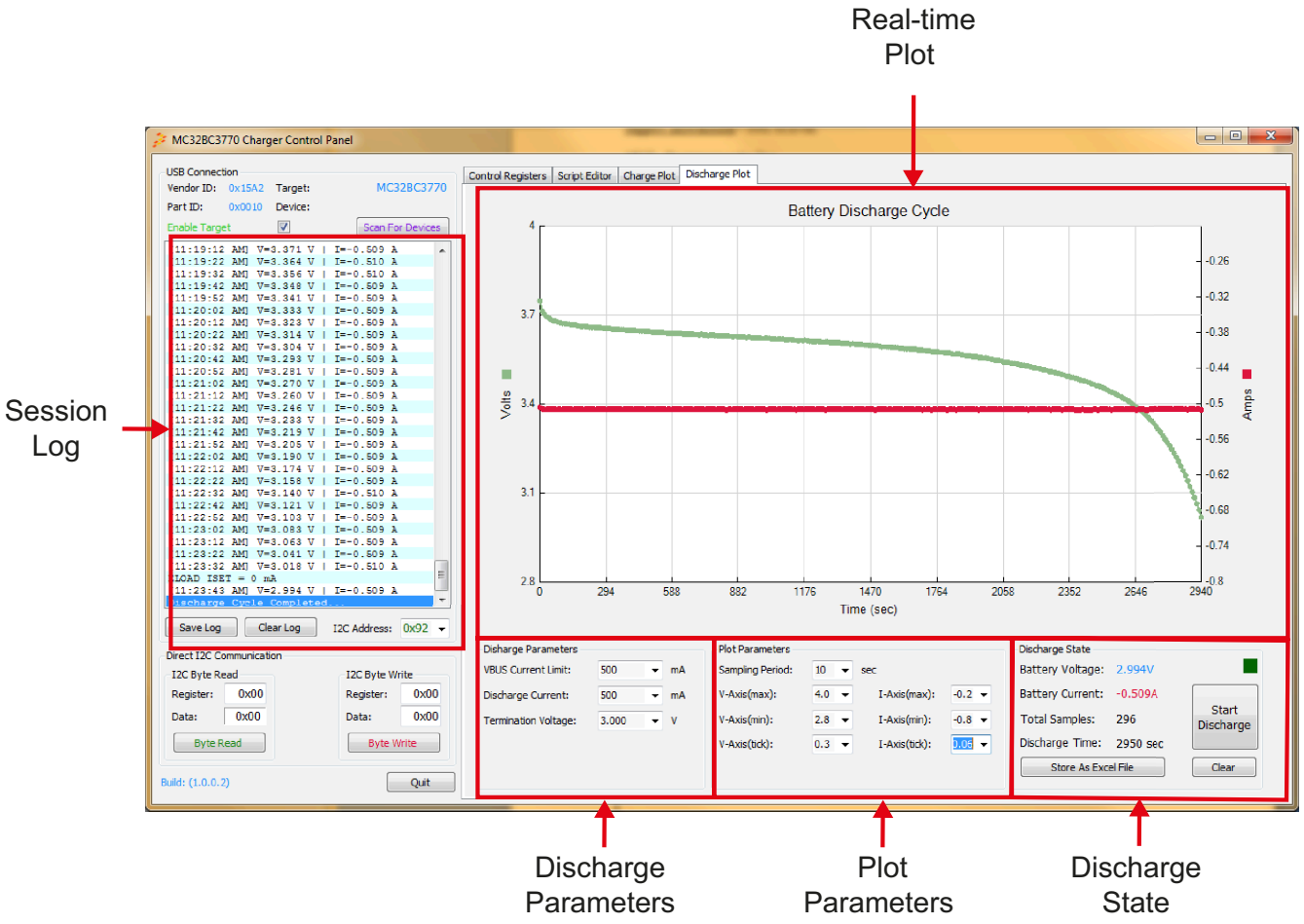


Figure 15. Discharge plot screen

5.4 Configuring the hardware

Figure 16 shows the hardware setup using the FRDM-BC3770-EVB and the FRDM-KL25Z boards. For a tutorial on setting up the FRDM-BC3770-EVB/FRDM-KL25Z platform, see the video “01B - BC3770 Battery Connections Video” in the FRDM-BC3770-EVB Product Summary page.

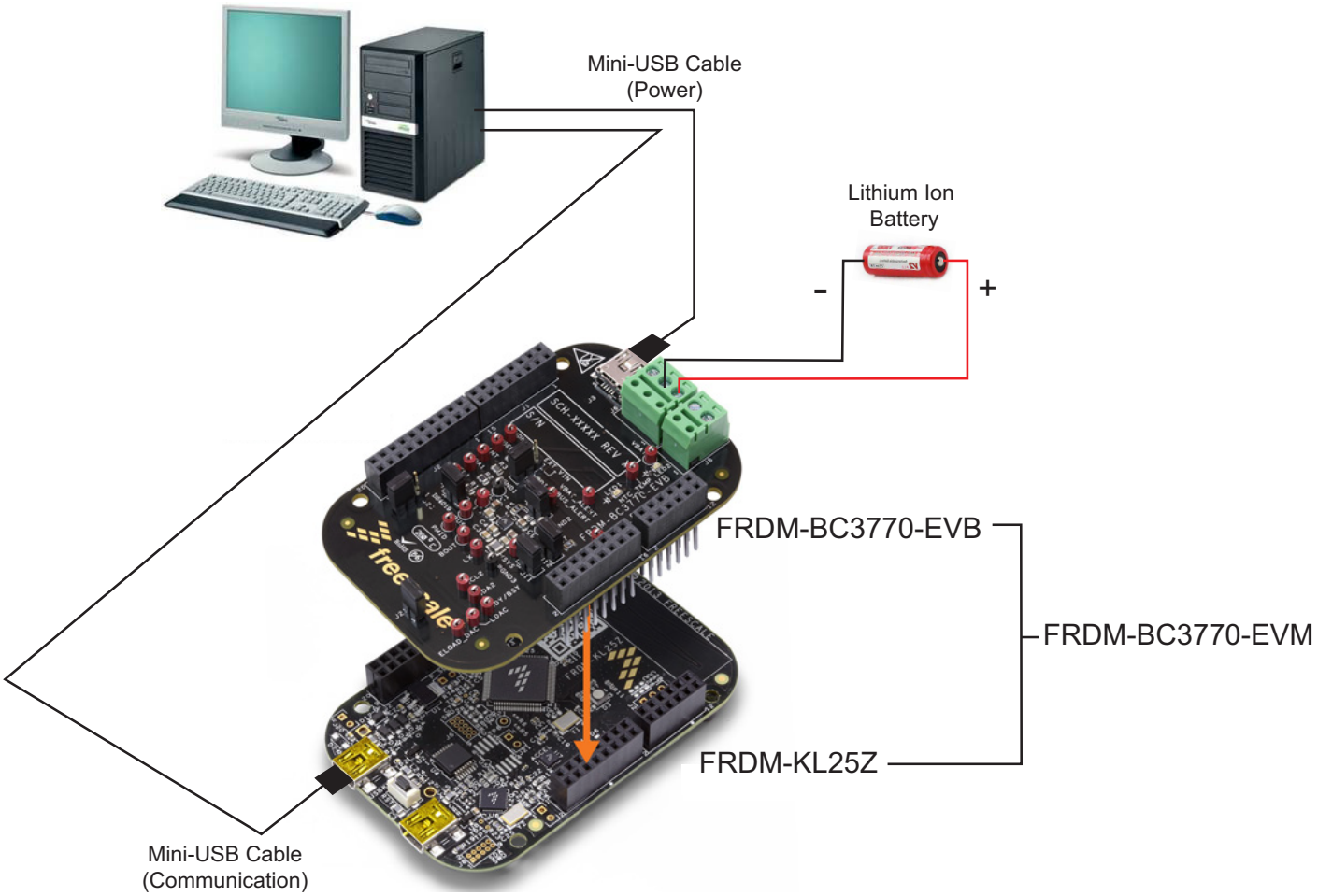


Figure 16. FRDM-BC3770-EVM hardware configuration

5.4.1 Step-by-step instructions for setting up the hardware

To perform the demonstration examples, the following connections and setup must be performed:

1. Mount the FRDM-BC3770-EVB board firmly to the Arduino connectors on the FRDM-KL25Z board. (If purchasing the FRDM-BC3770-EVM kit, the boards are already mounted.)
2. Solder a wire lead to each pole of the Lithium Ion battery.
3. Attach the Lithium Ion leads to the two-pole terminal block (J8) on FRDM-BC3770-EVB. The negative lead goes to the inboard connector. The positive lead goes to the outboard connector.
4. Connect the FRDM-BC3770-EVB board to a power supply. There are two methods of making this connection.
   - Attach a USB mini-cable between the PC and the USB mini-plug connector on the FRDM-BC3770-EVB board. This draws power from the PC via the USB port. However, because of the USB power supply is relatively low, the battery charges more slowly.
   - Cut the Standard-A plug off the USB cable. Identify and separate out the USB power lines in the cable. Attached the USB power lines to a power source (either a power supply or a power adaptor.) Note that the source connected must supply 2.0 A current at 5.0 V. Attach the min-plug end of the cable to the USB port on the FRDM-BC3770-EVB board.
5. Attach a USB mini-cable between the PC and the USB communication port on the FRDM-KL25Z board. This cable serves as the communication link between the Freedom platform and the PC.

6 Using BC3770 components with Processor Expert

6.1 Installing CodeWarrior

This procedure explains how to obtain and install the latest version of CodeWarrior (version 10.6 in this guide).

NOTE

The sample software in this kit requires CodeWarrior 10.6 or newer. The component and some examples in the component package are intended for Kinetis Design Studio 3.0.0. If CodeWarrior 10.6 and Kinetis Design Studio 3.0.0 are already installed on the system, skip this section.

1. Obtain the latest CodeWarrior installer file from the NXP CodeWarrior website here: www.nxp.com/webapp/sps/site/homepage.jsp?code=CW_HOME&tid=vanCODEWARRIOR.
2. Run the executable file and follow the instructions.
3. In the Choose Components window, select the Kinetis component and click on **Next** to complete the installation.

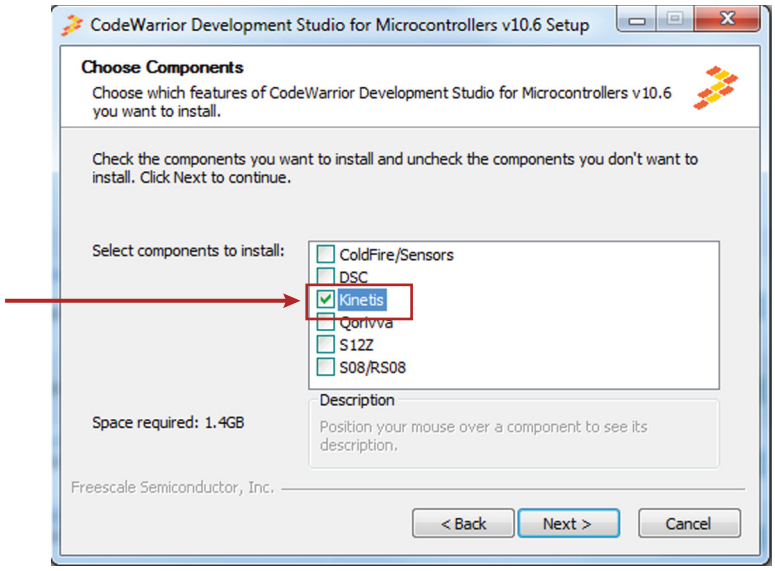


Figure 17. Choose components window

6.2 Downloading the components and example projects

The examples used in this section are based on a pre-configured CodeWarrior project. To download the project and its associated components:

1. Go to the NXP website www.npx.com/BC3770-PEXPERT
2. Download the zip file containing components and example projects.
3. Unzip the downloaded file and check to see the folder contains the files listed in Table 7.

Table 7. BC3770 example project and components

Folder name	Folder contents
Components	Component folder
BC_MC32BC3770_b15xx.PEupd	Battery charger BC3770 component
FRDM_BC3770_b15xx.PEupd	Freedom board FRDM-BC3770 component
ChannelAllocator_b15xx.PEupd	Component for ADC channel allocation
Examples	
Battery_Charger_BC3770_Control	Folder containing application files used in BCF_KLxxZ_Battery_Charger_BC3770_Control_Usb_Hid example
CodeWarrior_Examples	Example project folder for CodeWarrior
BCF_KL25Z_BC3770_GUI_Usb_Hid	Example with BC3770_GUI for FRDM-KL25Z
BCF_KLxxZ_Battery_Charger_BC3770_Control_Usb_Hid	Example showing usage of BC_MC32BC3770 and FRDM_BC3770 methods with Battery_Charger_BC3770_Control application for FRDM-KL25Z, FRDM-KL26Z and FRDM-KL46Z (where xx is the MCU)
BCF_KLxxZ_Monitoring_CDC	
KDS_Examples	Example project folder for Kinetis Design Studio 3.0.0 or newer
BCF_KL25Z_BC3770_GUI_Usb_Hid	Example with BC3770_GUI for FRDM-KL25Z
BCF_KL25Z_Battery_Charger_BC3770_Control_Usb_Hid_IAR	Example showing usage of BC_MC32BC3770 and FRDM_BC3770 methods with Battery_Charger_BC3770_Control application for FRDM-KL25Z and IAR Embedded Workbench.
BCF_KLxxZ_Battery_Charger_BC3770_Control_Usb_Hid	Example showing usage of BC_MC32BC3770 and FRDM_BC3770 methods with Battery_Charger_BC3770_Control application for FRDM-KL25Z, FRDM-KL26Z and FRDM-KL46Z (where xx is the MCU)
BCF_KLxxZ_Monitoring_CDC	Example showing current, voltage and temperature measurement with output to terminal for FRDM-KL25Z, FRDM-KL26Z and FRDM-KL46Z
Readme.pdf	Read me file with installation instructions.

6.2.1 Import the BC3770 components into the Processor Expert library

1. Launch CodeWarrior by clicking on the CodeWarrior icon (located on the desktop or in Program Files -> NXP CodeWarrior folder.) When the CodeWarrior IDE opens, go to the menu bar and click **Processor Expert** -> **Import Component(s)**.
2. In the pop-up window, locate the component file (.PEupd) in the Components and Example Projects folder BC3770_PEx_SW\Component. Select **BC_MC32BC3770_bxxxx.PEupd, FRDM_BC3770_bxxxx.PEupd,** and **ChannelAllocator_bxxxx.PEupd** files then click **Open** (see Figure 18).

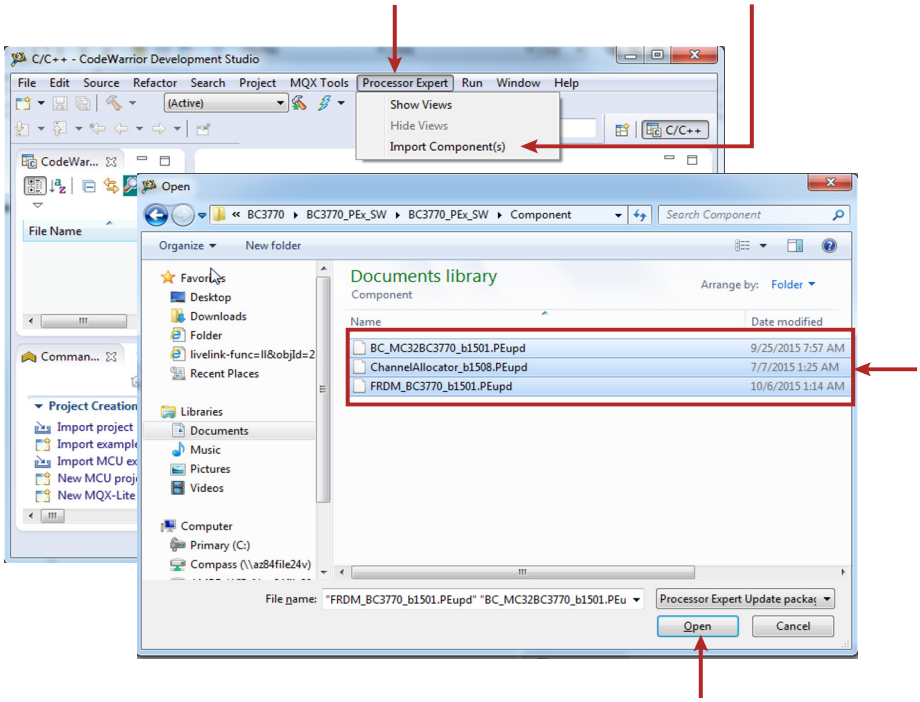


Figure 18. Import the BC3770 components

3. If the import is successful, the BC3770 and FRDM_BC3770 component appears in Components Library -> SW -> User Component (see Figure 19). Note that the component **ChannelAllocator** is hidden and is not accessible to users. This component is used by the BC3770 components only.

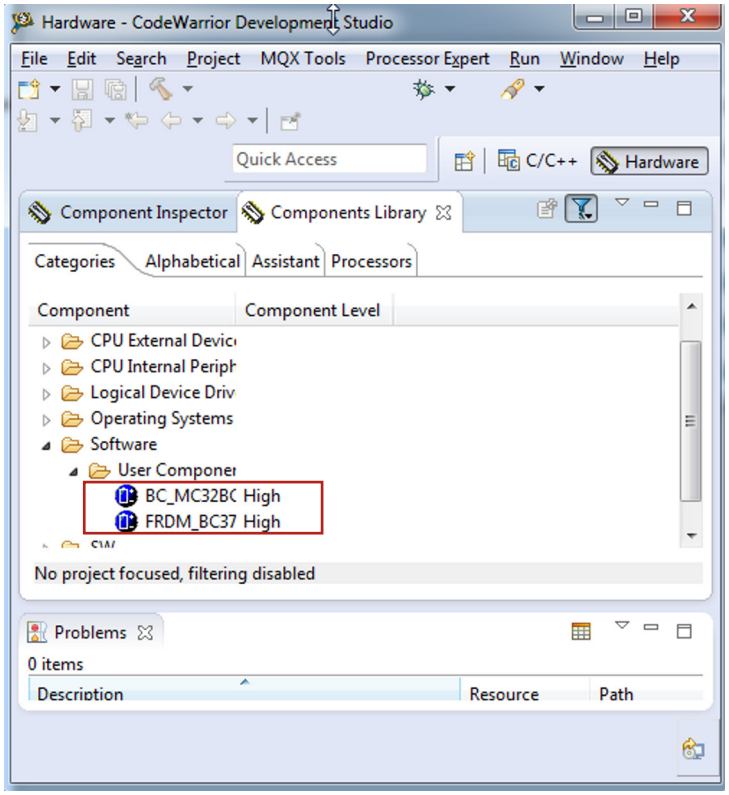


Figure 19. BC3770 components location after CodeWarrior Import

The BC3770 components are ready to use.

6.2.2 Importing an example project into the Processor Expert library

The following steps show how to import an example from the downloaded zip file into CodeWarrior.

1. In the CodeWarrior menu bar, click **File** -> **Import**… In the pop-up window, select **General** -> **Existing Projects into Workspace** and click **Next**.

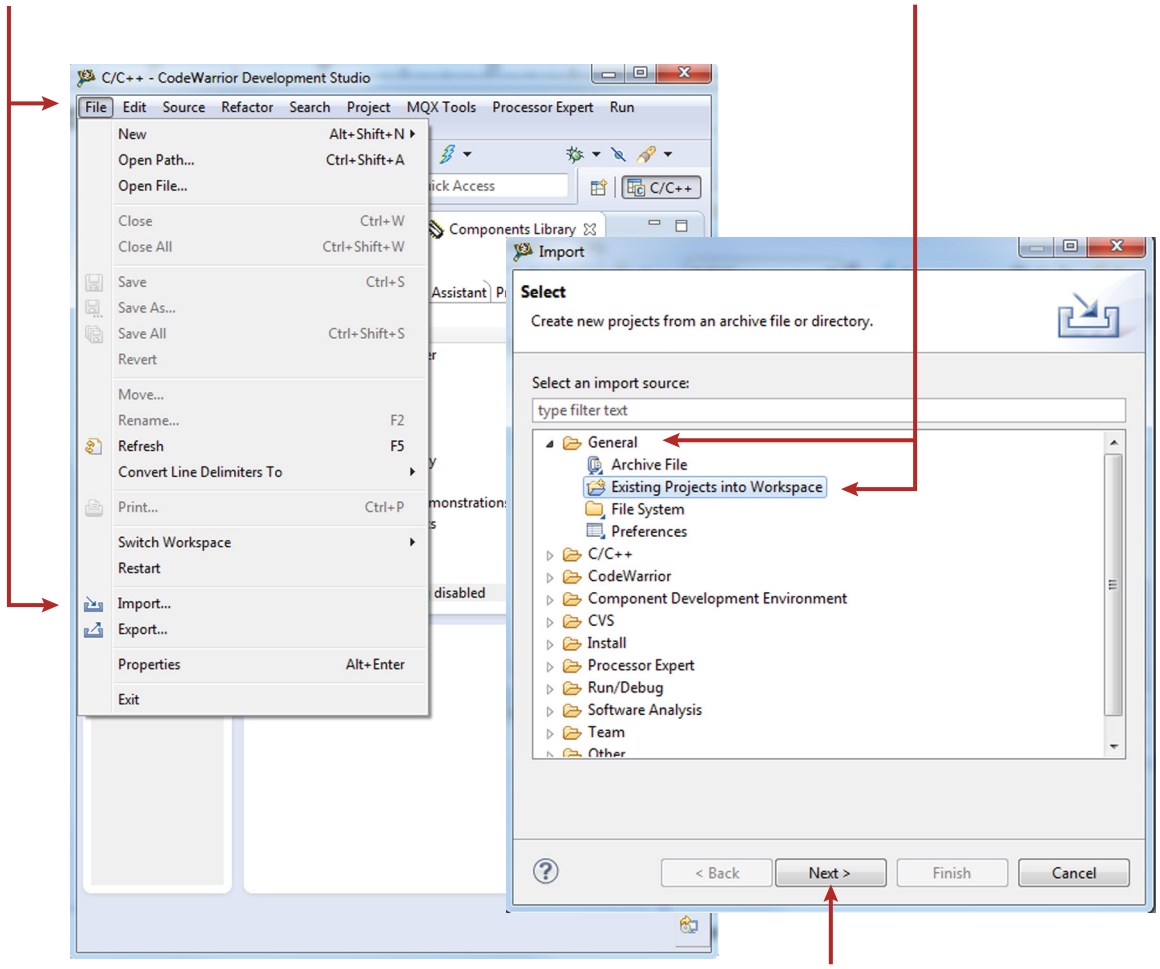


Figure 20. Importing an example file (a)

2. Click **Browse** and locate the folder where you unzipped the downloaded example files. Find the folder BC3770_PEx_SW\Examples\CodeWarrior_Examples and select a project to import. (see Figure 21, which shows BCF_KL25A_Battery_Charger_BC3770_Control_Usb_Hid as the imported project). Then click **OK**.

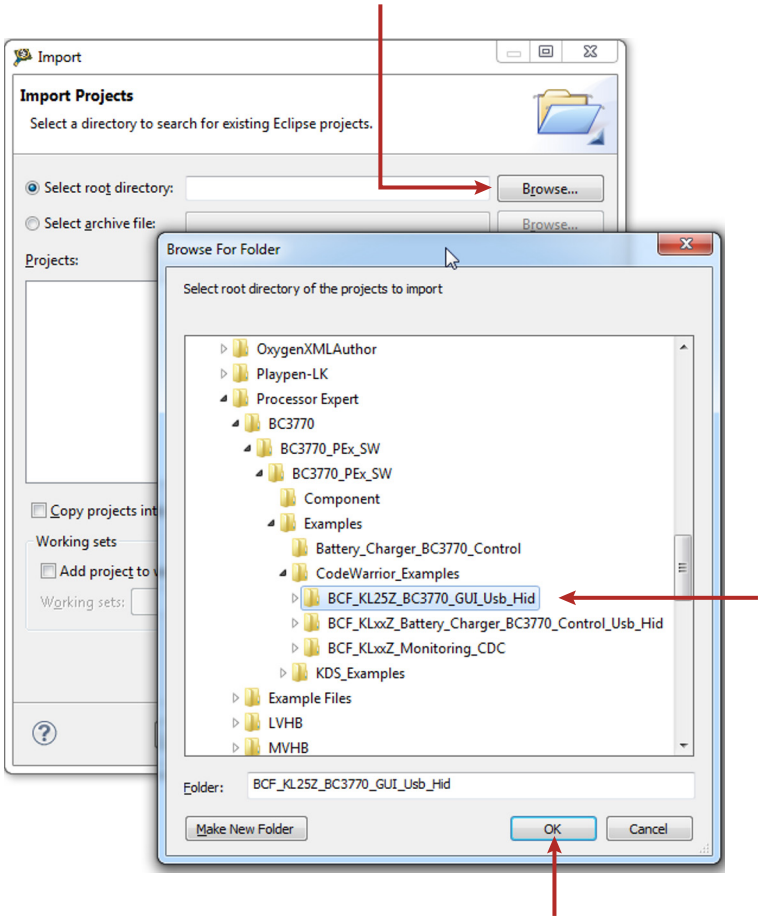


Figure 21. Importing an example file (b)

3. With your project now loaded in the **Select root directory** box, click on the **Copy projects into workspace** check box. Then click **Finish**. Figure 22 shows the CodeWarrior **Projects** panel and the **Components** panel after the project has been successfully imported.

The project is now in the CodeWarrior workspace where you can build and run it.

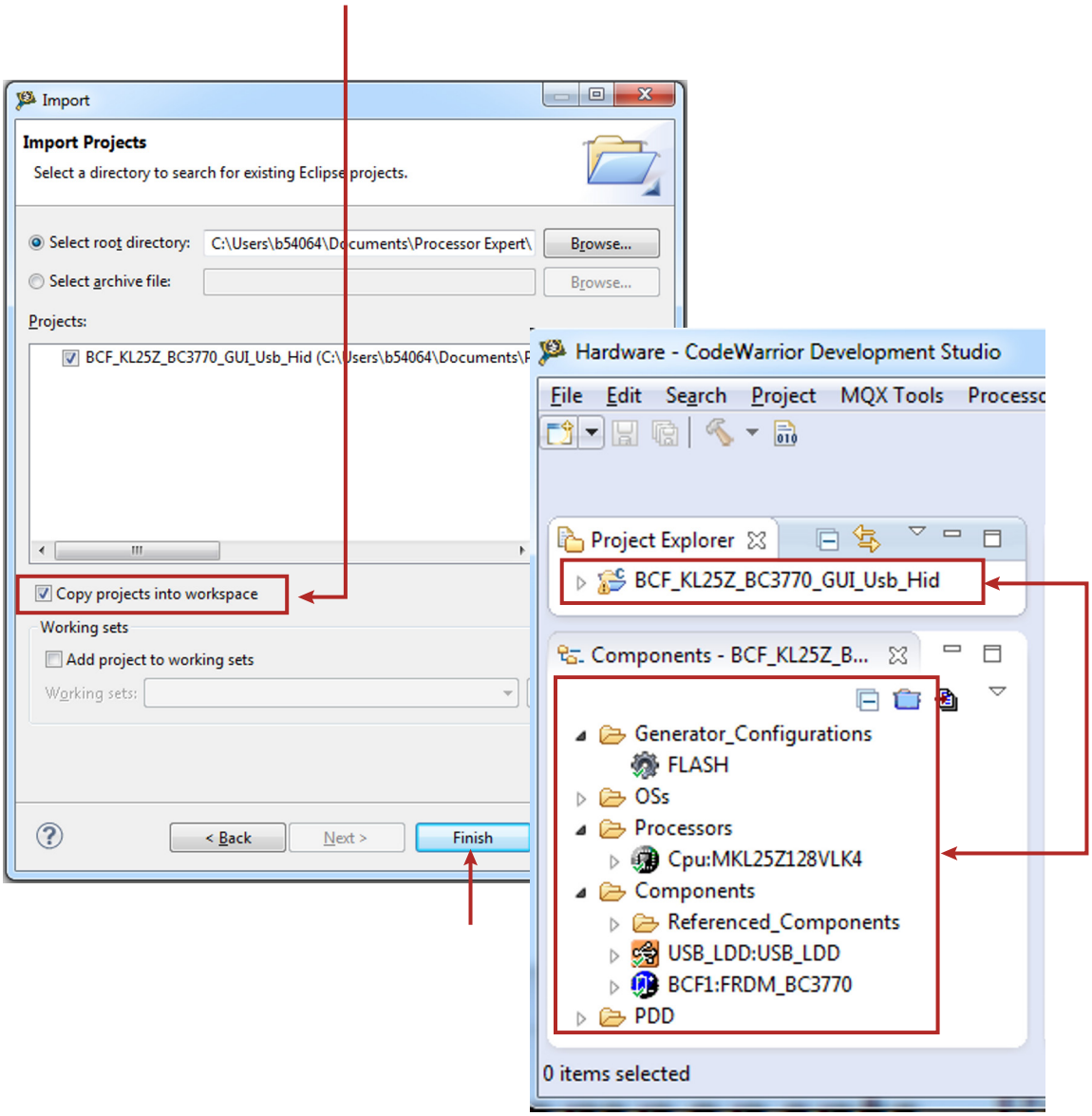


Figure 22. Importing an example file (c)

6.3 Creating a new project with Processor Expert and the BC3770 components

If you choose not to use the example projects, the following instructions describe how to create and setup a new project using the BC3770 components. If you do not have the BC3770 components in the Processor Expert Library, please follow steps in Section 6.2.1, Import the BC3770 components into the Processor Expert library, page 25.

To create a new project do the following:

1. In the CodeWarrior menu bar, select **File** -> **New** -> **Bareboard Project**. When the **New Bareboard Project** dialog box opens, enter a project name into the text box and then click **Next**. (see Figure 23).

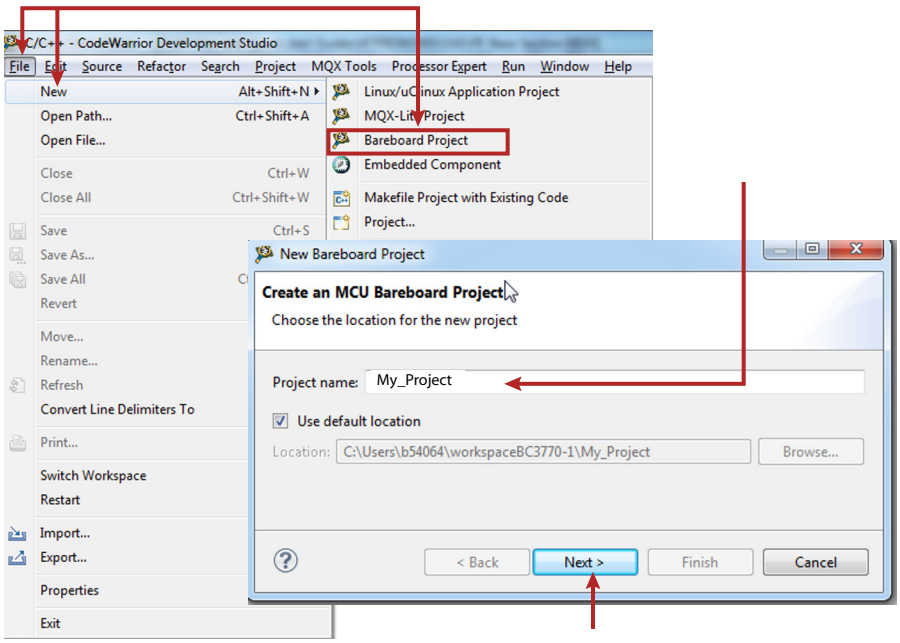


Figure 23. Creating an MCU Bare-board Project

2. In the **Devices** dialog box, select the MCU class for the appropriate MCU (In Figure 24, MKL25Z128 has been selected). Then click **Next**.
3. In the **Connections** dialog box, select the type of connection the project uses. (In Figure 24 **P&E USB Multilink Universal [FX]/USB MultiLink** has been selected). Then click **Next**.

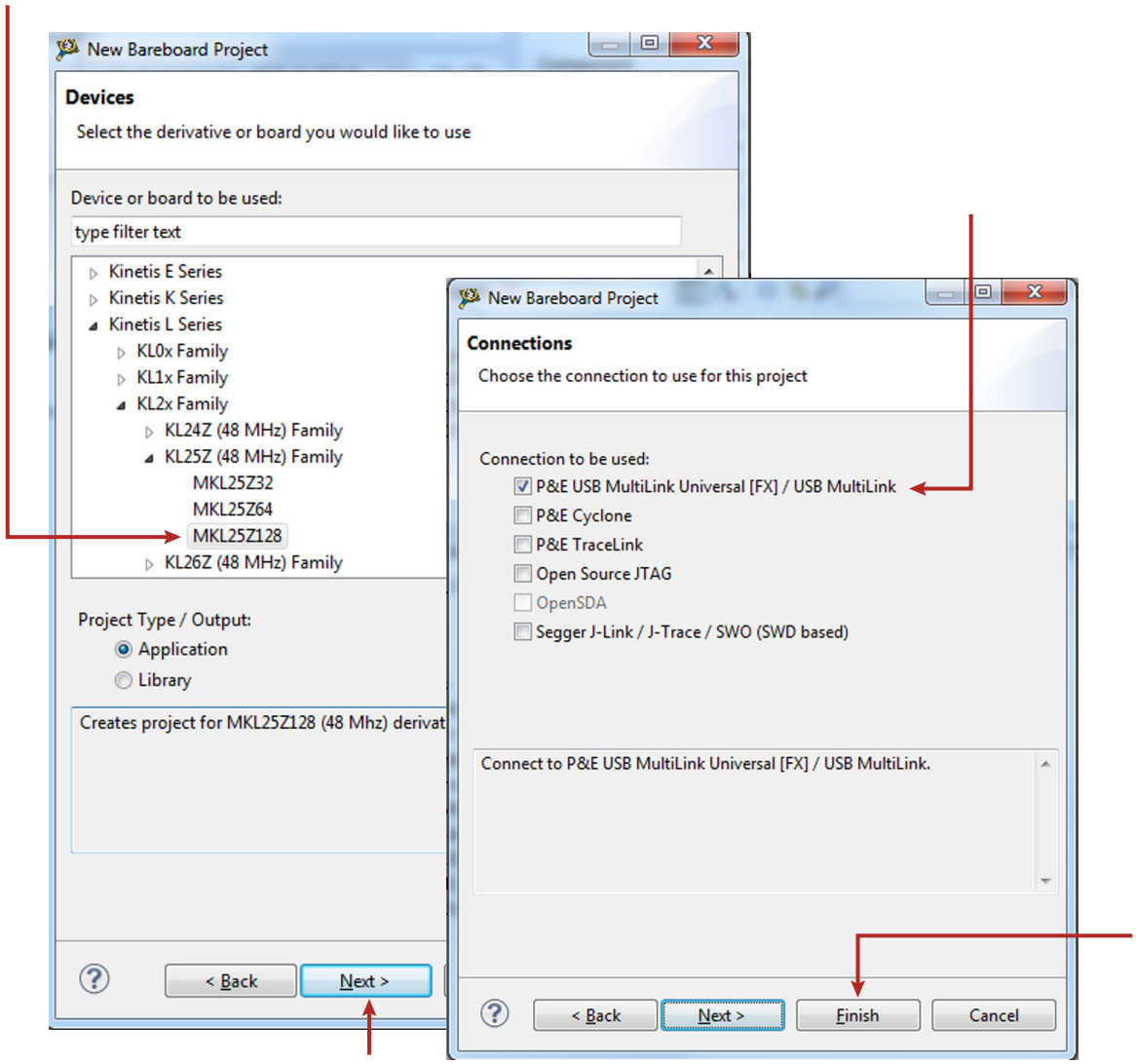


Figure 24. Selecting a device and a connection

4. In the **Language and Build Tools Options** dialog box, select the options for the project. (In Figure 25, the default options are selected.) Then click **Next**.
5. In the **Rapid Application Development** dialog box, make sure the **Processor Expert** button is selected. Then click **Finish**

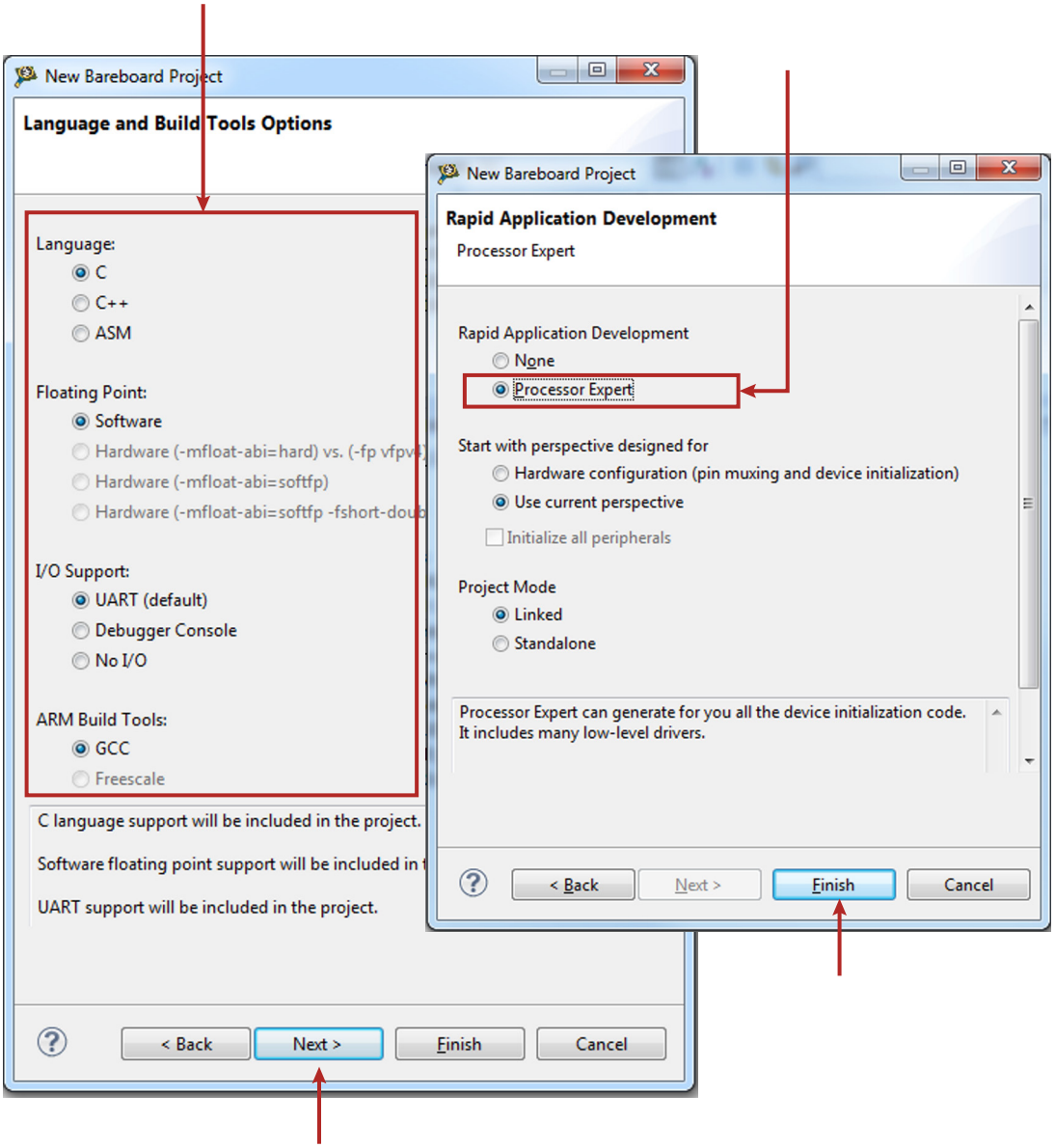


Figure 25. Selecting the language, build tools, and the rapid application development options

6. Figure 26 shows the CodeWarrior Projects panel and the Components panel after the project has been successfully created. Before the project can be built and run, add the component (imported in Section 6.2.2, Importing an example project into the Processor Expert library, page 27) into the project. Section 6.3.1, Adding a BC3770 component into the project, page 34 outlines this procedure.

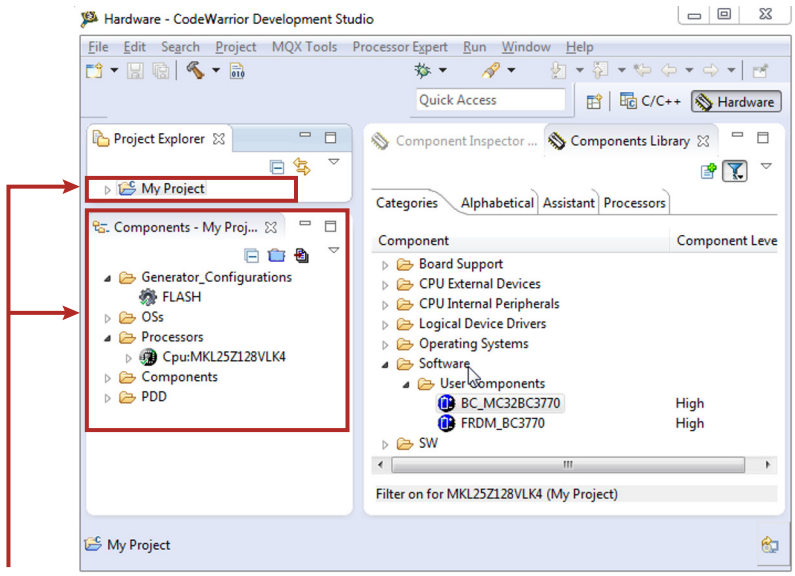


Figure 26. CodeWarrior projects and components panels with project created

6.3.1 Adding a BC3770 component into the project

1. Find the BC3770 component in the Components Library and add it into the project (see Figure 27).

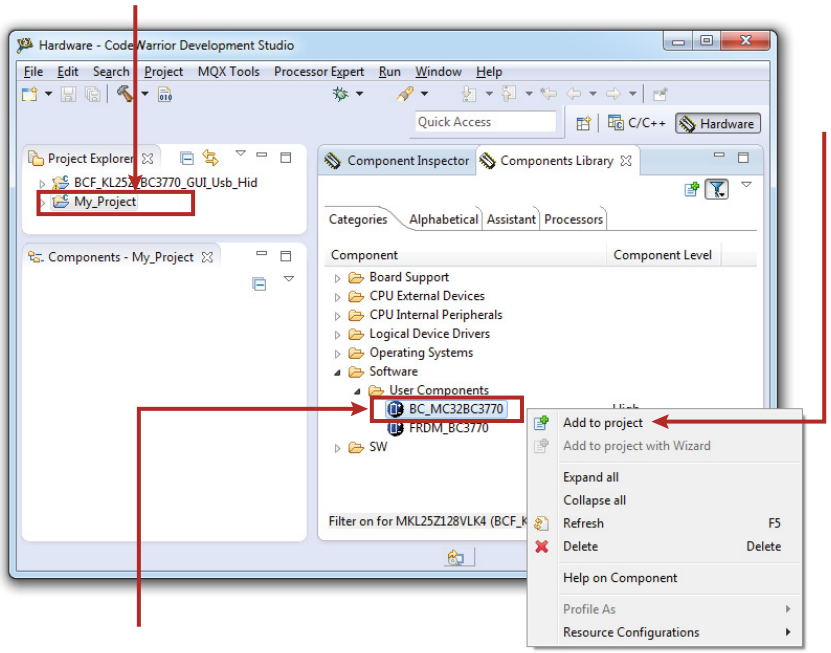


Figure 27. Add the BC3770 component to the project

2. Figure 28 shows the Components panel after the component was added. To view the Component Inspector options, double click on the BC3770 component in the Components panel.

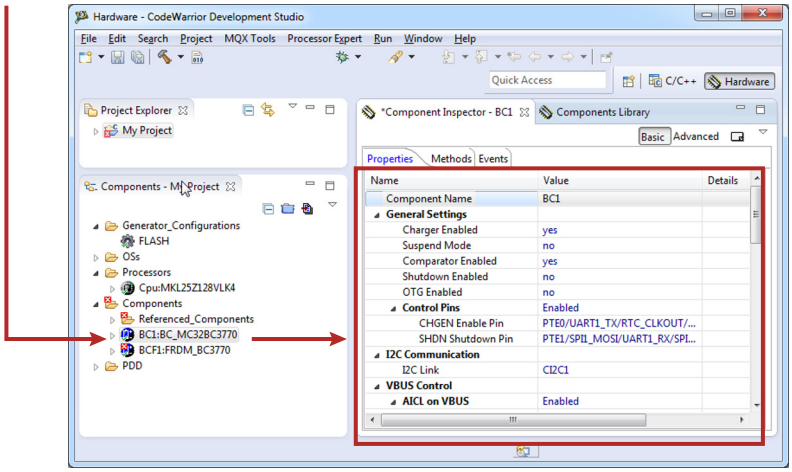


Figure 28. Select the component

6.3.2 General component inspector view for the BC3770 components

The **Component Inspector** view provides a means of accessing and modifying component properties. When CodeWarrior is set to the **Classic** view, properties in the **Component Inspector** are arranged in a collapsible tree-structure. Property names appear in the **Name** column. The **Values** column lists the current value assigned to the property. Values not greyed-out in this column may be modified. The **Details** column contains additional information (including error conditions) about the selected property. (If CodeWarrior preferences are set to the **Tab** view, properties are arranged differently in the Component Inspector; However, the same definitions apply.)

CodeWarrior provides on-screen help for events, methods, and properties. To view a brief description of a method or an event, hover the mouse pointer over the respective item in the **Components** panel. A pop-up with a brief description of the item appears (see Figure 29.) The same technique applies for component events, methods, and properties in **Component Inspector** view.

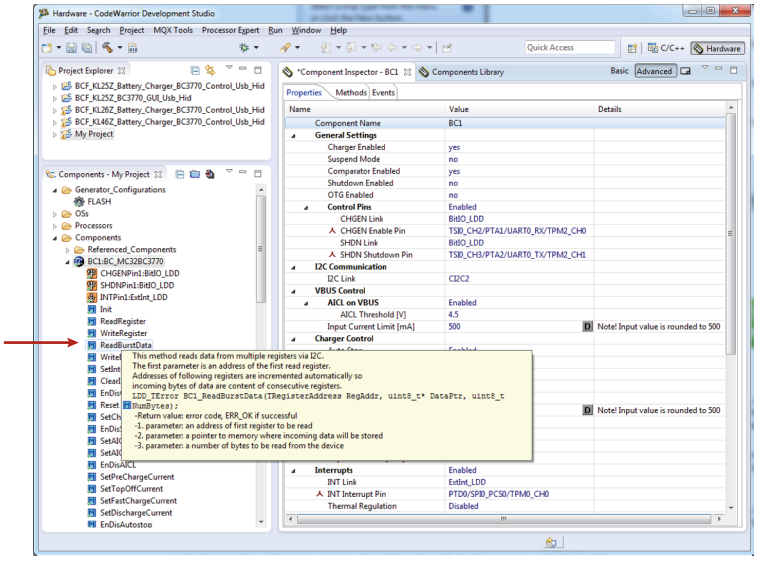


Figure 29. Component on-screen help feature

To view on-line documentation for a component, right click on the component in the **Components** panel. In the pop-up menu, click **Help on Component** (see Figure 30.)

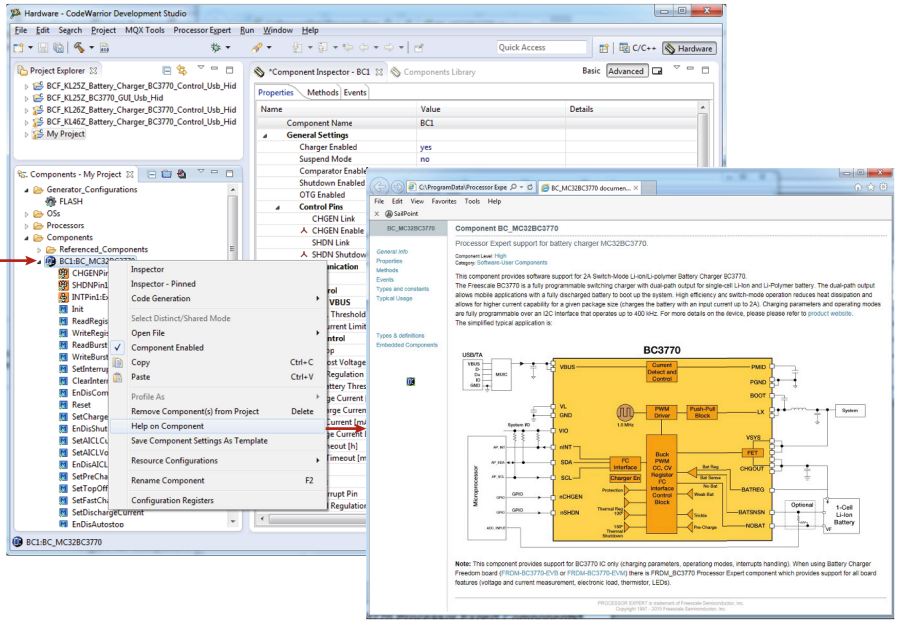


Figure 30. Component on-line help feature

6.4 BC_MC32BC3770 and FRDM_BC3770 Processor Expert components

FRDM_BC3770 and BC_MC32BC3770 Processor Expert components are software drivers which encapsulate the functionality of the MC32BC3770CS battery charger device and its companion evaluation board, the FRDM-BC3770-EVB. These components provide an API layer between the hardware and the user application. The BC3770 components make application development less time consuming by offering an easy to use interface allowing the user to set options for charging parameters, register settings, measurements, and testing. The BC_MC32BC3770 component contains MC32BC3770CS battery charger methods allowing the user to set charger modes, interrupts, and charging parameters. The FRDM_BC3770 component encapsulates all the functionality of the FRDM-BC3770-EVB Freedom board. It contains methods for current, voltage, and temperature measurement. This component uses Current Sense Amplifiers, enabling current and voltage sensing on the power supply (VBUS), the battery charger output (VSYS), and the battery (VBAT). FRDM_BC3770 component methods also offer electronic load settings making it possible to test user applications in real time.

6.4.1 The BC_MC32BC3770 Processor Expert Component

This section summarizes main features of BC_MC32BC3770 component and provides an overview of the properties appearing in the Component Inspector view. Table 8 lists all of the methods and events related to the component. Figure 31 shows typical Component Inspector properties for a project using the BC_MC32BC3770 component.

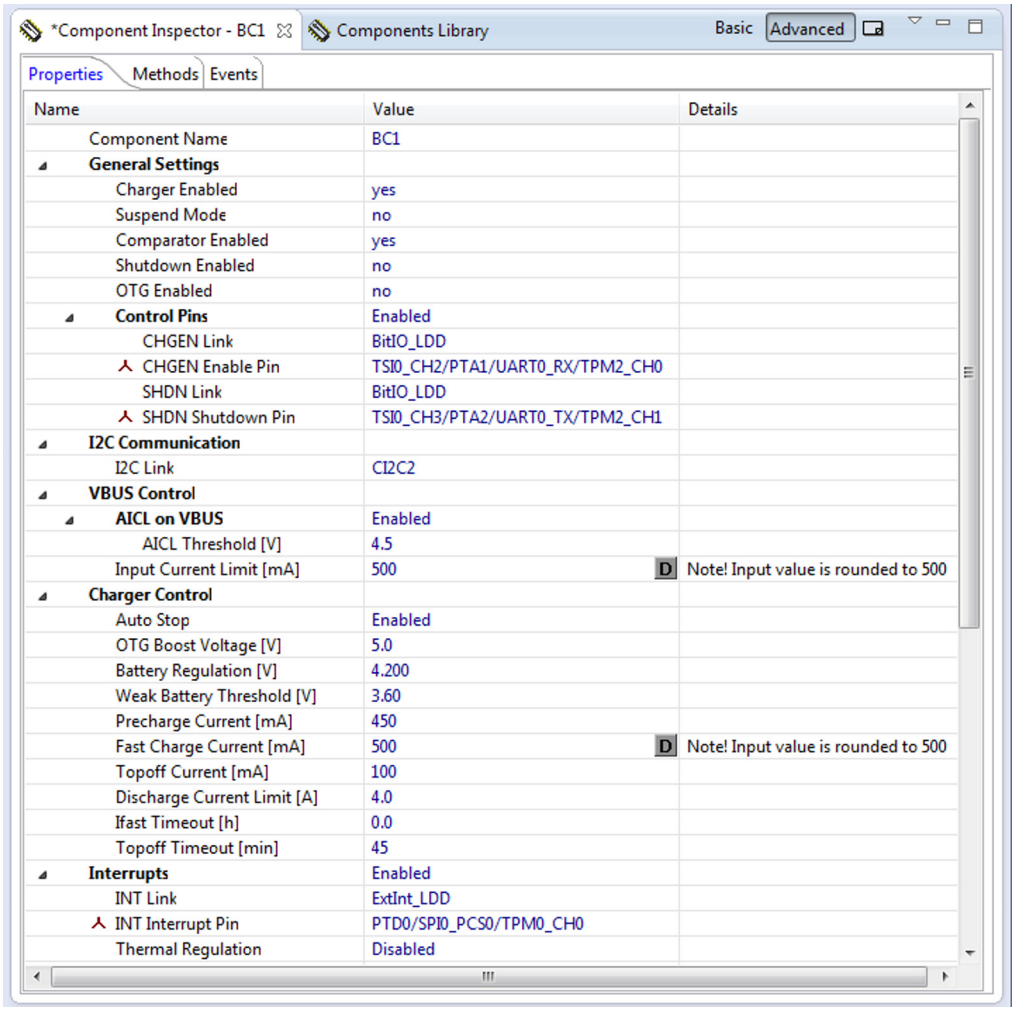


Figure 31. Component inspector view - BC_MC32BC3770

Component properties are grouped into five main sections: **General Settings**, **I²C Communication**, **VBUS Control**, **Charger Control**, and **Interrupts**.

General Settings encompasses charger mode settings. When the **Charger Enabled** property is set to **No**, the battery charger is disabled and the battery is not charged. However, other circuits and blocks (I²C, AICL, etc.) remain fully functional. If the **Charger Enabled** property is set to **Yes**, the battery charger either charges the battery or maintains constant voltage on the battery, if it is fully charged. In **Suspend** mode, PMID output is bypassed to VBUS, meaning the charger does not affect output voltage or current. In Boost (**OTG Enabled**) mode the device provides a regulated output voltage to VBUS from the battery. In **Shutdown Enabled** mode, if there is no valid input source, the charger remains functional except for the I²C interface, which is turned off to minimize power consumption. Setting the **Shutdown Enabled** mode is not effective as long as a valid input source is present.

I²C Communication allows the selection of linked **I2C_LDD** components which are used for communication with the battery charger.

VBUS Control contains options for settings the Adaptive-Input Current Limit (AICL) feature of the battery charger. This feature is useful when the current and voltage power supply is limited. Under such circumstances, AICL prevents the power supply from collapsing when the required input current exceeds the maximum output current of the supply. The battery charger in Start-up mode automatically starts incrementing the input current limit to either the default or the pre-programmed value until either the input current limit (IIN_LIM) is detected or the VBUS voltage (VAICL_TH) detects the AICL threshold (see Figure 32). If the input current exceeds the power supply current limit, the AICL function takes over and lowers the charge current below the programmed value. See the battery charger data sheet for more information.

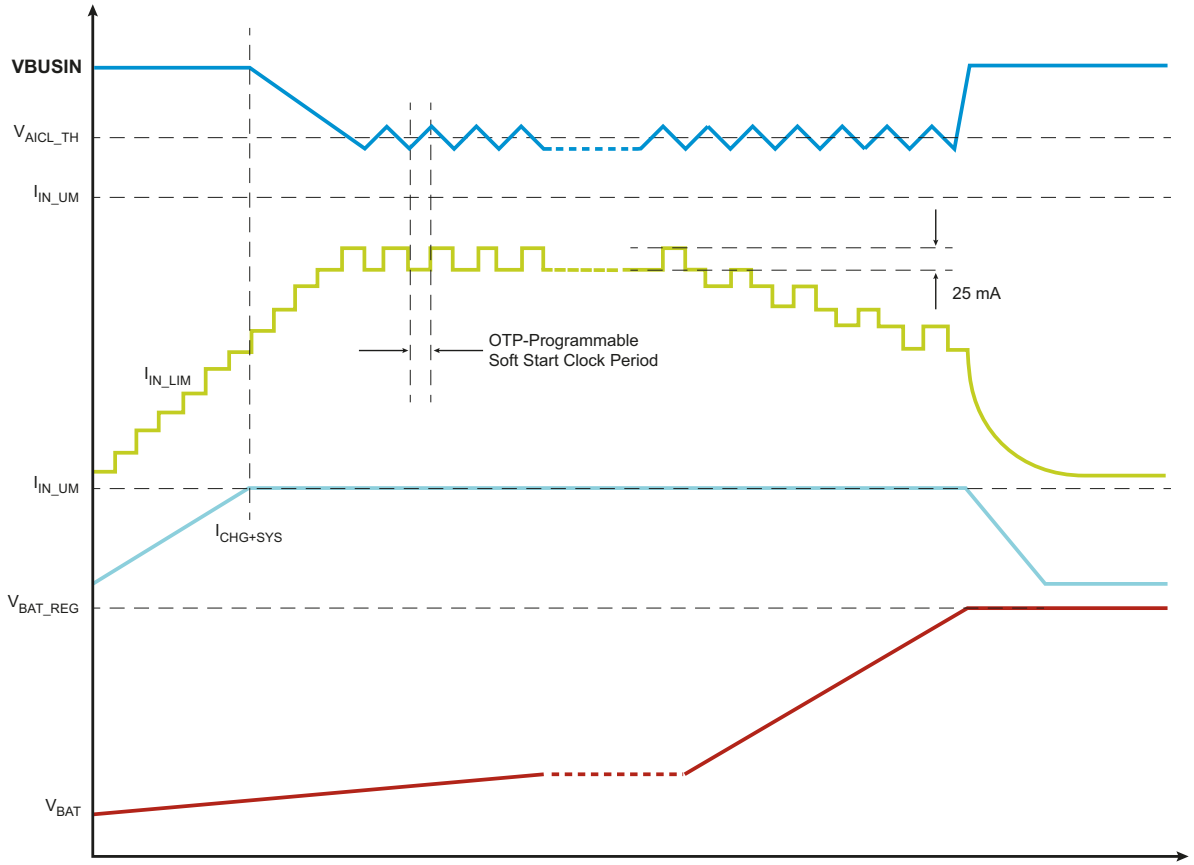


Figure 32. Adaptive-input current limit

The **Charger Control** section contains charging parameter options. **Auto Stop** controls battery charger behavior after the charging process is finished. When **Auto Stop** is enabled, the battery charger turns off and goes into the DONE state when the Topoff timer expires (i.e. the charging process is finished). Otherwise, the battery charger remains on continuously and stays in Constant Voltage mode after charging, which means it maintains a certain voltage level on the battery. This section also contains options for current settings in current settings in **Pre-charge**, **Fast charge**, and **Top-off** mode. Note that you cannot switch between these modes. The battery charger continually transits from one mode to the next based on the battery voltage. **IFast Timeout [h]** and **Topoff Timeout [min]** are safety timers. If the battery voltage does not reach a certain voltage threshold before the timer expires, charging is suspended and a fault signal is asserted.

Battery Regulation [V] sets the voltage maintained on the battery when the battery charger is on (**Auto Stop** is disabled) and the battery is fully charged. If the battery charger is off after charging, the battery voltage decreases until it reaches the **Weak Battery Threshold [V]** value, at which point an interrupt is asserted. For more information please see the MC32BC3770 battery charger data sheet.

6.4.1.1 BC_MC32BC3770 component API

Table 8 describes all of the public Methods and Events related to the BC_MC32BC3770 component. Component Methods are also listed in the **Components** panel, as depicted in Figure 33. Methods and Events marked with green check marks are included when source code is generated; Methods and Events marked with black crosses are not included (see Figure 33). To change these settings, go to the **Component Inspector** panel and select the **Methods** tab (see Figure 34). Note that some of Methods/Events are always generated because they are needed for proper functionality.

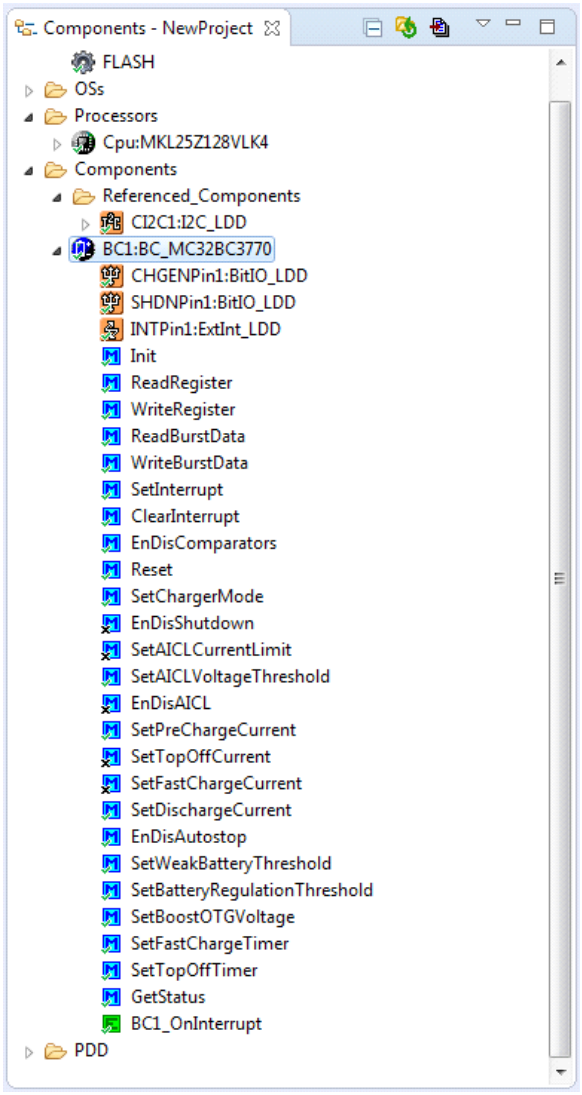


Figure 33. BC_MC32BC3770 methods in the components panel

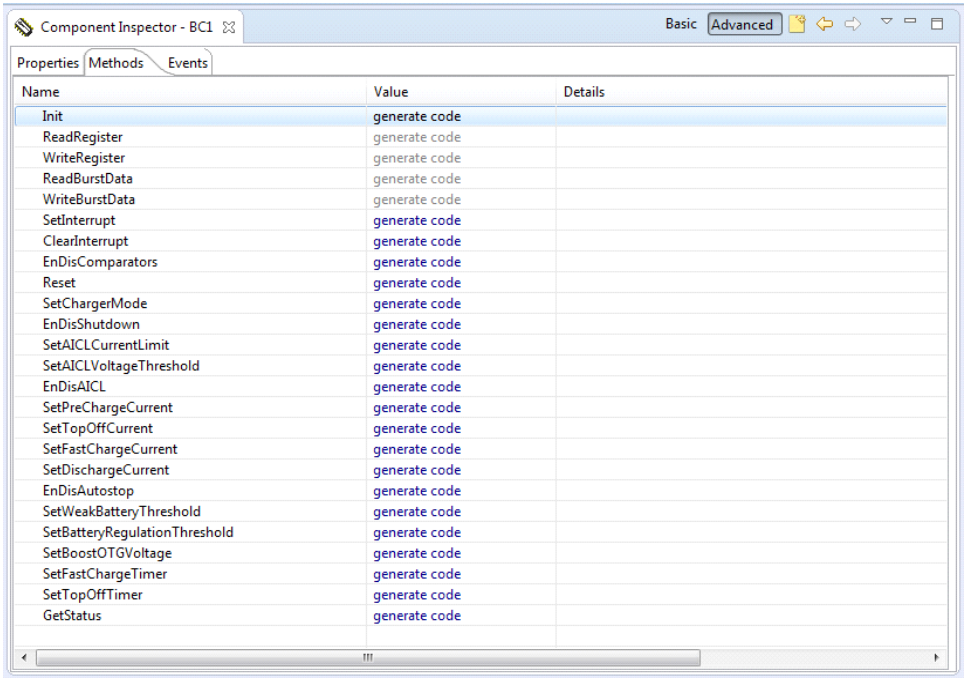


Figure 34. BC_MC32BC3770 generated methods

Table 8. BC_MC32BC3770 methods and events

Methods/events	Description
Init	Initializes the device according to the component properties. This method writes data according to the component properties into registers via I^2C. When auto initialization is enabled, this method is called automatically within the PE initialization function - PE_low_level_init().
ReadRegister	Reads data from a single register defined by RegAddr argument. If the method returns ERR_OK, it doesn't necessarily mean the reception was successful. The actual state of the reception is detectable by means of events (OnMasterSendComplete or OnError).
WriteRegister	Writes data to a single register defined by RegAddr argument.
ReadBurstData	This method reads data from multiple registers via I^2C. The first parameter is an address of the first read register. Addresses of following registers increment automatically, so incoming bytes of data represent the content of consecutive registers.
WriteBurstData	This method writes data to multiple registers via I^2C. The first parameter is an address of the first register to be written. Addresses of following registers increment automatically, so out coming data is written to consecutive registers automatically
SetInterrupt	Enables or disables an interrupt. Interrupts can be set either individually or all at once. It is not possible to set, for example, two interrupts at once.
ClearInterrupt	Clears interrupt flags in INT1…3 register. Interrupt flags can be cleared either individually or all at once. It is not possible to clear, for example, two interrupts.
EnDisComparators	This method enables/disables comparators enabled by default. The comparators detect weak battery, supply voltage status, battery OVP, and discharge limit.
Reset	This method resets the device's registers, except INTMASK and STATUS.
SetChargerMode	This method sets Charger mode. The charger can be on or off. When the charger is on, it charges the battery or maintains constant voltage on the battery. In Suspend mode, the PMID output is bypassed to VBUS, which means the charger does not influence output voltage and current. In Boost mode, the device provides a regulated output voltage to VBUS from the battery. In Shutdown mode, if there is not valid input source, the charger is functional except for the I^2C interface, which is turned off to minimize power consumption. The device enters Charge mode when a valid input source is present.

Table 8. BC_MC32BC3770 methods and events

Methods/events	Description
EnDisShutdown	Enables/disables the shutdown pin, which means the device is put in Shutdown mode. In Shutdown mode the I^2C interface is turned off to minimize power consumption. However, this applies only in case of an invalid input power source. This pin is not effective as long as a valid input power source is present.
SetFastChargeTimer	Fast charge timer watches the device during Fast-charge mode. An interrupt is asserted if the battery voltage does not reach its required value within this “fast-charge” time frame. Possible values are 3.5, 4.5, and 5.5 hours, or the timer can be disabled.
SetTopOffTimer	Top-off timer watches the device during Top-off mode. An interrupt is asserted if the battery voltage does not reach its required value within this “top-off” time frame. Possible values are: 10, 20, 30, or 45 minutes.
GetStatus	This method returns the content of the status register.
SetPreChargeCurrent	Pre-charge current is current charging the battery in pre-charge mode. The battery charger enters Pre-charge mode when battery voltage is higher than 2.5 V. If the battery voltage does not exceed the VSYS_MIN threshold before the pre-charge timer expires, charging is suspended and a fault signal is asserted via the INTB pin.
SetFastChargeCurrent	Fast-charge current is current charging the battery in Fast-charge mode. The Fast-charge mode is entered when the battery voltage exceeds the VSYS_MIN threshold of a typical 3.6 V. If the battery voltage does not reach the VBAT_REG threshold before the timer expires, charging is suspended and a fault signal is asserted via the INTB pin.
SetTopOffCurrent	Top-off-charge current is current charging the battery in Top-off mode. After the top-off timer expires, the top-off event is reported to the processor via the INTB pin, which means the battery is fully charged. As soon as the processor reads the interrupt registers, the processor is able to turn off the charger.
SetDischargeCurrent	This method sets the discharge current limit in Discharge mode.
SetBatteryRegulation Threshold	Based on this threshold, the charger transits from Fast-charge mode (Constant-current mode) to Full-charge mode (Constant-voltage mode). In Full-charge mode, the fast charge current is reduced to a programmable top-off current. Up to this threshold the VSYS output tracks the battery voltage in Trickle and Pre-charge mode.
SetWeakBattery Threshold	This method sets the weak battery threshold voltage. The threshold ranges from 3.0 V to 3.75 V in 50 mV steps. A weak battery detection function allows the processor to acknowledge the low-battery condition by asserting an INTB event.
SetBoostOTGVoltage	This method sets OTG voltage in Boost (OTG) mode. In Boost mode the device provides a regulated output voltage to VBUS from the battery.
EnDisAutostop	This method enables or disables the autostop feature. If autostop is enabled after the top-off timer expires, the charger turns off and goes into DONE state. If it is disabled, the charger is on continuously and stays in CV mode after the top-off timer is expires.
EnDisAICL	Enables/disables adaptive-input current limit (AICL). AICL is mostly used at the beginning of the charging process when current dissipation is higher than the current the power source can provide. This feature prevents the power source from collapsing.
SetAICLVoltage Threshold	This method sets AICL threshold voltage on VBUS. To keep the device functional with a current and voltage limited VBUS source, the device in Start-up mode automatically starts incrementing the input current limit to either the default or pre-programmed value until either the input current limit is detected or the VBUS voltage detects the AICL threshold. This keeps input supply voltage as a valid power source to provide the load for the application. The device allows the maximum current the input supply can possibly provide without severely collapsing.
SetAICLCurrentLimit	This method sets the input current limit by writing to VBUSCTRL register. This value limits the fast-charge current when the device is in Fast-charge mode. It also sets the limit for the adaptive-input current limit (AICL) when a device in Start-up mode automatically starts incrementing the input current limit to either the default or pre-programmed value until either the input current limit is detected or the VBUS voltage detects the AICL threshold. This keeps input supply voltage as a valid power source to provide the load for the application.
OnInterrupt	Interrupt event handler from battery charger. This event is invoked every time there is a falling edge on the INT interrupt pin. Contents of the registers in the device structure are updated prior to this event, so the interrupt registers directly from this structure (without sending I^2C command) can be read.

6.4.1.2 Interrupt handling

If an interrupt from the battery charger occurs, an **OnInterrupt** event is invoked. (This interrupt handler is located in the **Events.c** file in the **Sources** folder of your project.) When such an interrupt occurs, there are two options. The first is to read the Interrupt registers directly from Battery charger. The second is to read the interrupt registers from the data structure **DeviceData**, which is updated prior to the **OnInterrupt** event being invoked. The **OnInterrupt** event is useful when setting a flag to report some event has occurred is needed.

6.4.2 FRDM_BC3770 Processor Expert component

While the BC_MC32BC3770 component provides an interface for the battery charger, the FRDM_BC3770 component covers all the functionality of the FRDM-BC3770-EVB Freedom board. The FRDM_BC3770 component facilitates user application testing and evaluation by providing an API for current, voltage, and temperature measurement, and for Electronic load settings.

This section summarizes main features of the FRDM_BC3770 component and provides an overview of the properties appearing in the Component Inspector view. Table 9 lists all of the methods and events related to the component. Figure 35 shows typical Component Inspector properties for a project using the FRDM_BC3770 component.

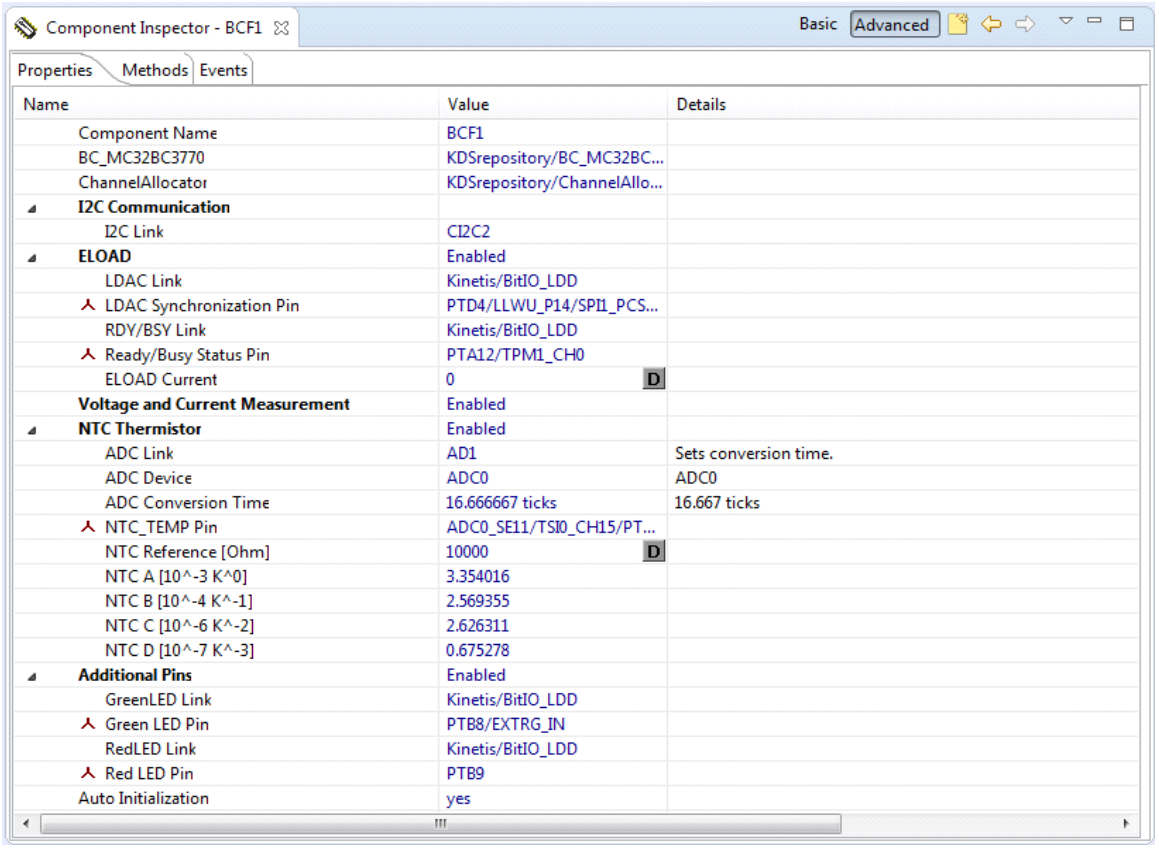


Figure 35. FRDM_BC3770 properties

In the Component Inspector view, the FRDM_BC3770 component properties are divided into five sections:

1. **I²C Communication** provides selection of the linked **I2C_LDD** component used for communication with the Current Sense Amplifiers and Electronic load.
2. **ELOAD** (Electronic load) contains pin settings for the Electronic load's **LDAC** and **Ready/Busy** pins. **LDAC** is used as a flag for transferring the contents of the input registers to their corresponding DAC output registers. **Ready/Busy** pin is a status indicator of EEPROM programming activity. **ELOAD Current** sets the amount of current which the electronic load sinks from either battery or VSYS output.
3. **Voltage and Current Measurement** enables the Current Sense Amplifiers (CSA) to measure VBUS, VSYS, and VBAT voltage and current.
4. **NTC Thermistor** contains settings for temperature measurement. The **ADC Link** property links **ADC_LDD** component to the FRDM_BC3770. The **NTC A/B/C/D** properties are coefficients of the Steinhart-Hart equation used as an approximation for temperature calculation from voltage measured on NTC thermistor. Find these coefficients in the data sheet for the NTC thermistor. Note: make sure the number format of coefficients in the data sheet corresponds to the format in component properties. For example, if the first coefficient NTC A is given as 0.5E-04 (or $0.5x10^{-4}$), convert it to 0.05E-3 and enter only the significant part of the number (i.e. 0.05). Otherwise the calculated value cannot correspond to the real temperature. The NTC reference value is thermistor resistance at 25 °C.
5. **Additional Pins** offers pin settings for the green and red LEDs, which can be used as an indicator of some event in the user application.

6.4.2.1 I²C configuration

The FRDM_BC3770 component requires two different I2C_LDD components — one for FRDM_BC3770 and the other for BC_MC32BC3770. This is because there are two I²C interfaces used on the Freedom evaluation board. One interface is used for communication with the battery charger and the other handles communication with current sense amplifiers and electronic load. If the project is not configured with two different I2C_LDD components, the Processor Expert reports an error.

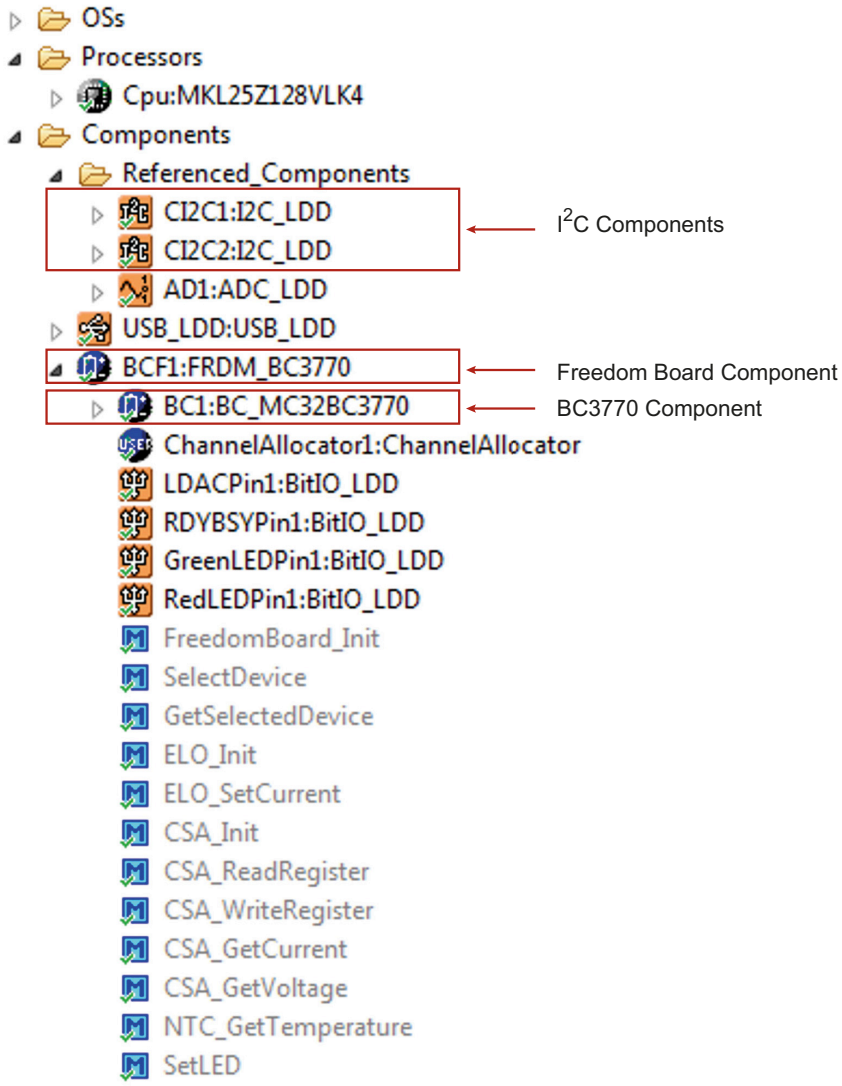


Figure 36. FRDM_BC3770 components panel with two I²C components

6.4.2.2 FRDM_BC3770 component API

Table 9 describes all of the public methods and events related to the FRDM_BC3770 component. Component methods are also listed in the **Components** panel as depicted in Figure 36. Methods and events marked with green check marks are included when source code is generated; Methods and events marked with black crosses are not included (see Figure 36). To change these settings, go to the **Component Inspector** panel and select the **Methods** tab. Note that some of methods/events are always generated, because they are needed for proper functionality.

Table 9. BC_MC32BC3770 methods and events

Methods/events	Description
FreedomBoard_Init	Initializes devices on the board (current sense amplifiers and electronic load) assigns user defined data structure describing the board.
SelectDevice	This method selects one of the devices on the board: electronic load or some of the current sense amplifiers to measure current or voltage.
GetSelectedDevice	This method returns last selected device.
ELO_Init	This method initializes electronic load (ELOAD). Device MPC4728 is initialized with default values. Outputs B, C, and D are in Power-down mode. Only output A, used for ELOAD control, is in Normal mode.
ELO_SetCurrent	This method sets the ELOAD set point (the amount of current ELOAD sinks). This method is the same as the internal ELO_SetPointEload except for the function parameter, which is a real number [mA]. This method sends command 'new value' to the output register of channel A. Resolution of output voltage is 12 bits. Command 'send new value' sets default settings for other registers.
CSA_Init	Initializes the device and sets the default configuration (see documentation of INA230) of VBUS, VSYS, BATTERY amplifier and settings of calibration register.
CSA_GetCurrent	This method reads the content of the Current Register for the selected device and converts it to current in milliamperes [mA]. To change the selected device, use the CSA_SelectDevice method.
CSA_GetVoltage	This method reads the Bus Voltage or Shunt Voltage register of the selected device according to the first parameter. The value of the register is converted to voltage in millivolts [mV].
CSA_ReadRegister	Reads the content of the selected Current Sense Amplifier register.
CSA_WriteRegister	Writes value to the selected Current Sense Amplifier register.
NTC_GetTemperature	This method measures the voltage on NTC thermistor and calculates temperature according to the Steinhart-Hart equation. Returned temperature is in Kelvin scale - T[K]. The precision of the resulting temperature depends on the NTC constants of the equation. Add the correct constants A, B, C, D from data sheet of your NTC thermistor.
SetLED	This method turns on/off the green or red LED.

6.5 Generating driver source code

After you have completed configuring the components, the application is ready to generate the driver code to be incorporated. The process is as follows:

1. Click on the **Generate Processor Expert Code** icon in the upper right corner of the **Components** panel.

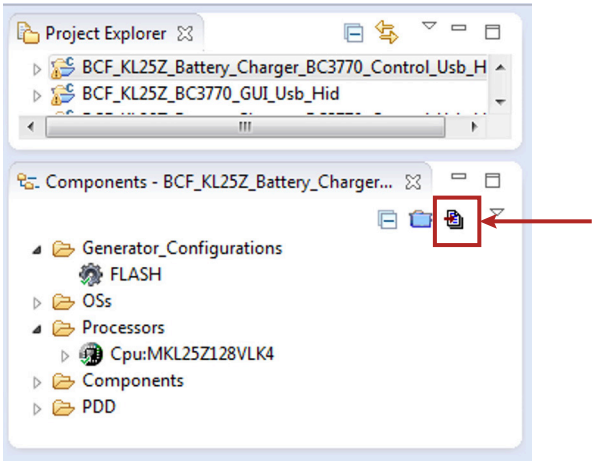


Figure 37. Generating the source code

2. The driver code for the device is generated into the **Generated_Code** folder in the **Project** panel. The component only generates the driver code. It does not generate application code. Figure 38 shows the locations of the generated driver source code, Events source code, and the appropriate location for user application code.

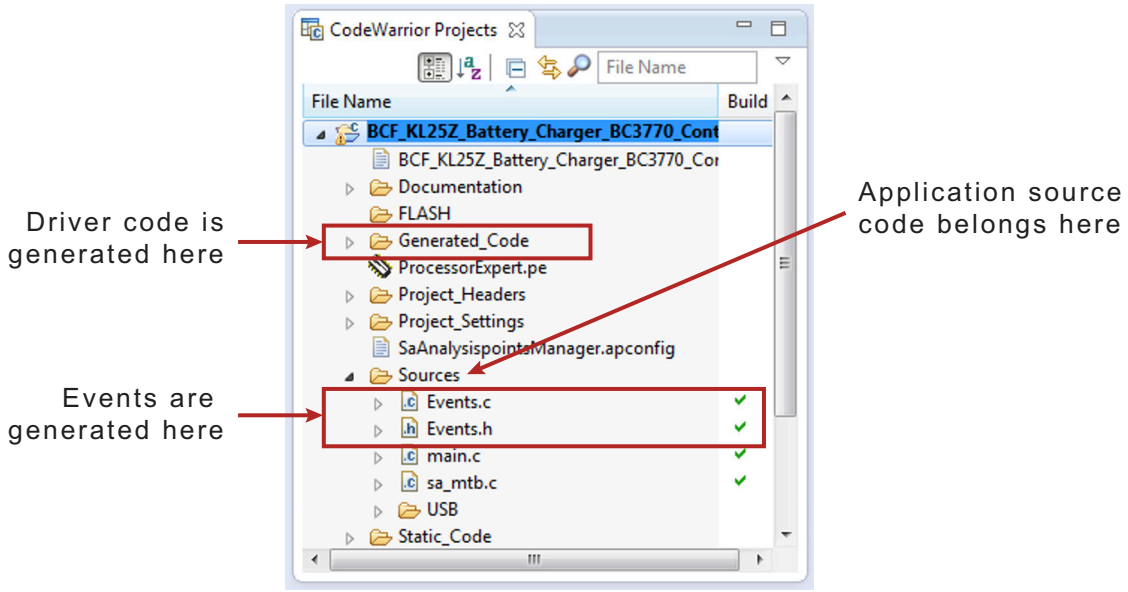


Figure 38. Source code locations

6.6 Developing application code in Processor Expert

Processor Expert allows you to write application code, add component methods, and build your application without leaving the CodeWarrior environment.

6.6.1 Writing the application code

All of the application code must reside in the **Sources** folder in the project directory. The code may modified in **main.c** and **Events.c**, but retain the original comments related to usage directions.

6.6.2 Adding component methods

To add a component method into the application source code:

1. In the **Components** panel for the project, click on **Components**. Find the desired method to add to the code.
2. Drag and drop the method directly into the source code panel.
3. Add the appropriate parameters to the method. (Hovering the mouse over the method displays a a list of the required parameters.)

Figure 39 shows an example of how to add a component method into the application source code. The example uses the MVHBridge component. The process is the same for adding a BC3770 component method.

In the example, the MVHBridge component method list is opened, the **RotateProportional** method is dragged and dropped into **main.c** and the necessary parameters are added.

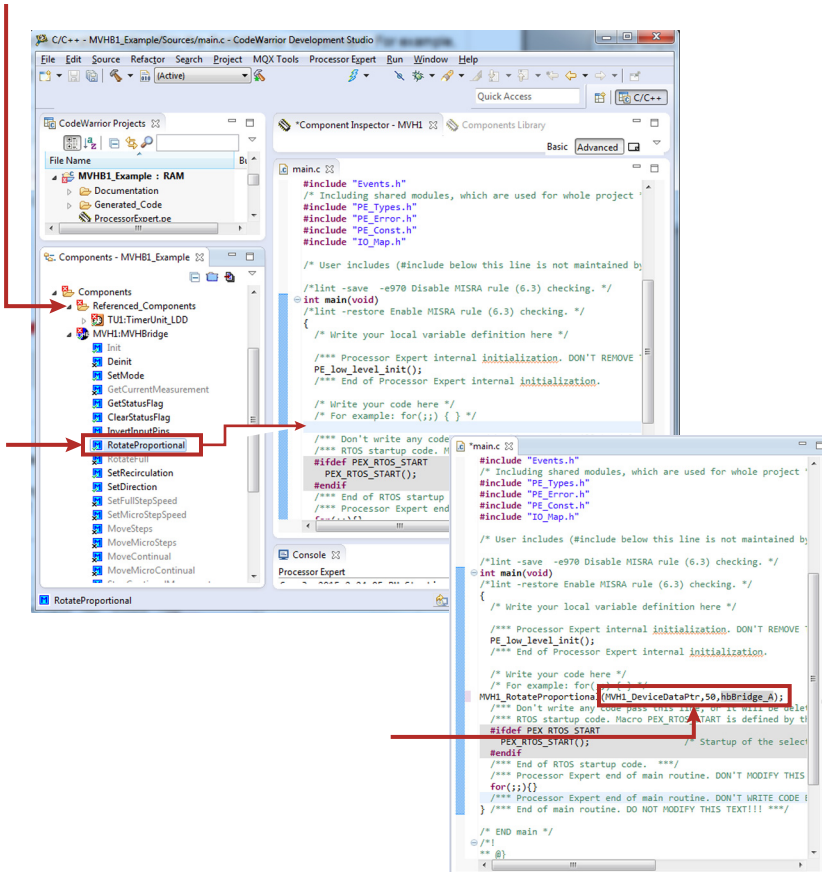


Figure 39. Adding component methods

6.6.3 Jumping into function source code

CodeWarrior is based on the Eclipse IDE allowing jumps directly into the source code of a function from within the main routine while editing. To do so, CTRL and click. The source code appears in the edit window.

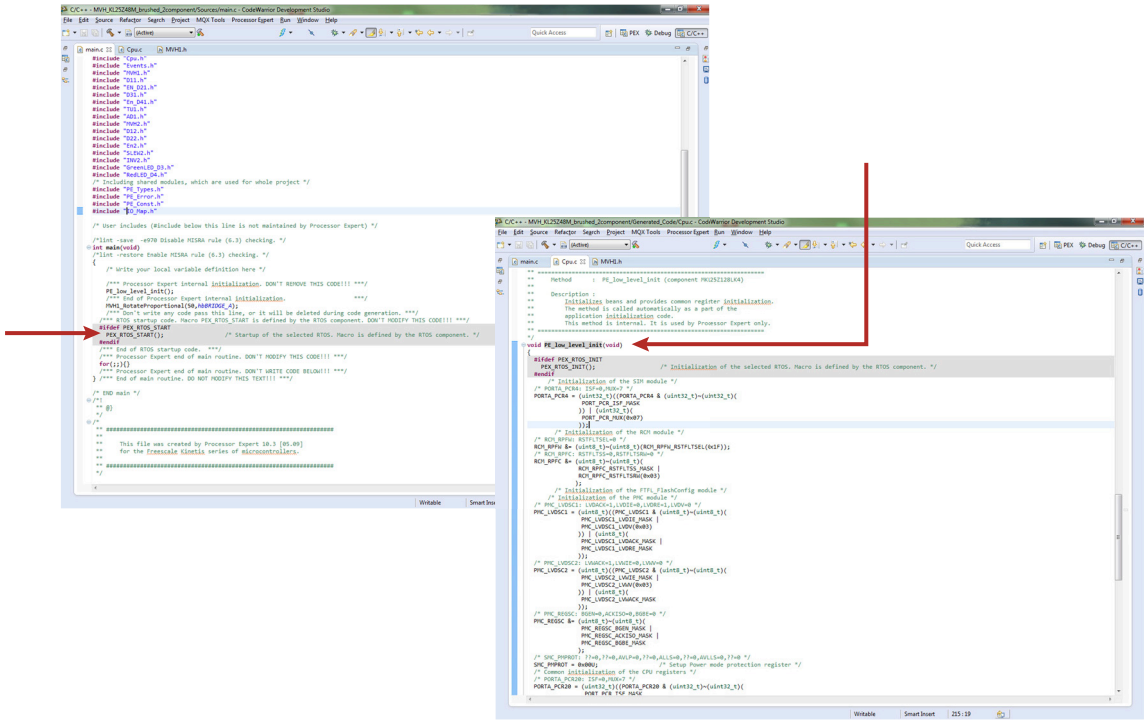


Figure 40. Jumping into a function's source code

6.6.4 Building the project

To build the project, click on the hammer icon in the tool bar (see Figure 41). Alternatively, initiate a build by entering CTRL + B from the keyboard.

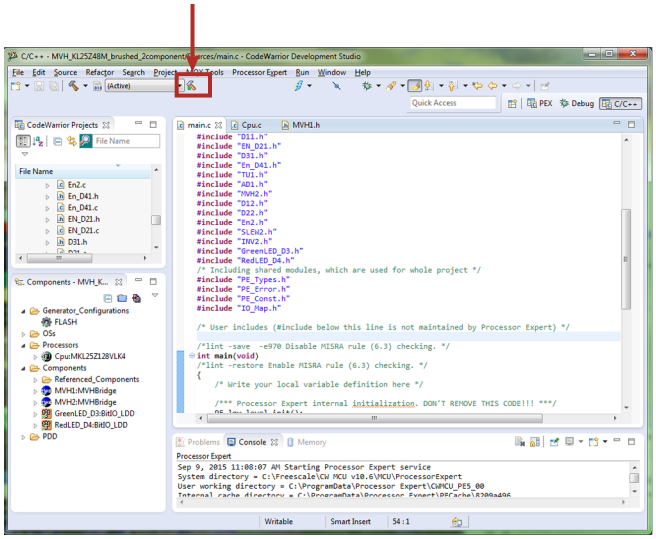


Figure 41. Compiling and downloading the application

7 Schematics

7.1 Charger

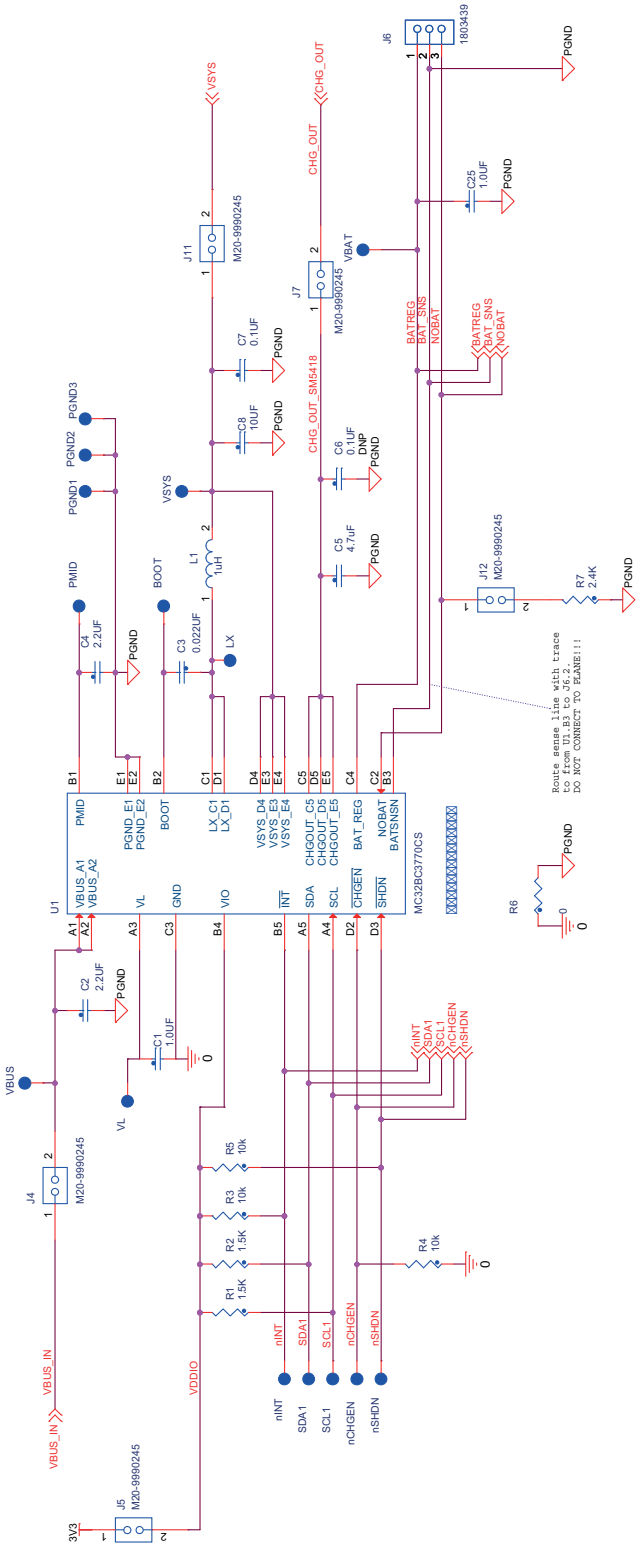


Figure 42. BC3770 charger

7.2 USB connector

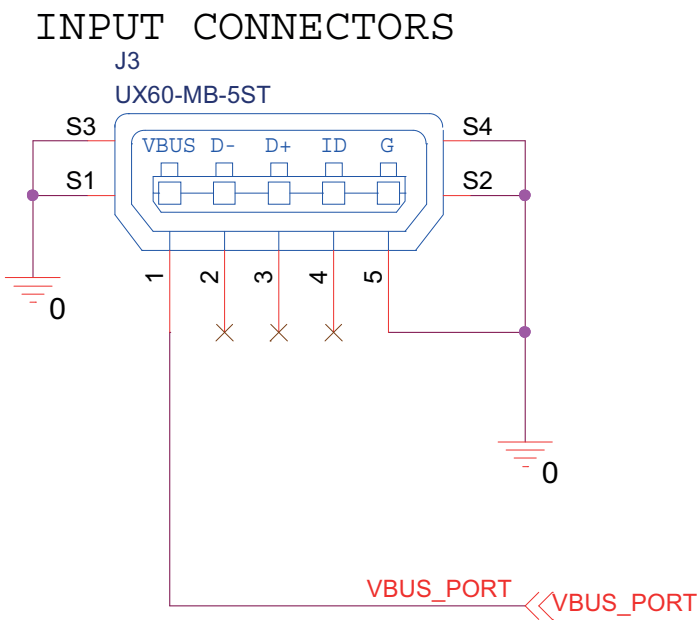


Figure 43. USB connector

7.3 VBUS current sense amplifier (CSA)

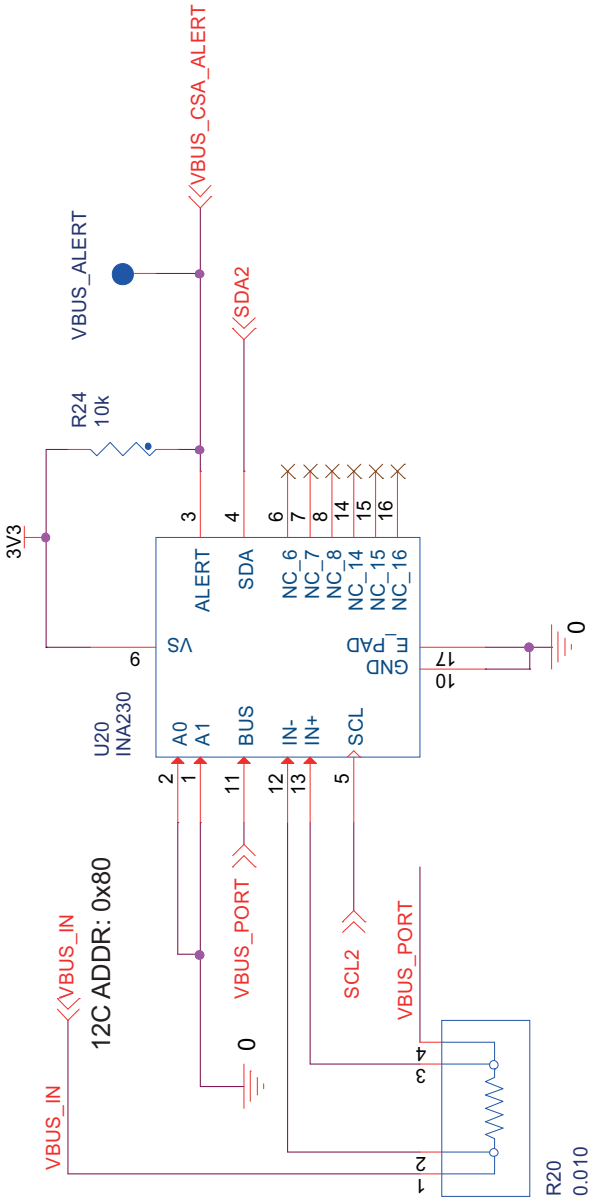


Figure 44. VBUS current sense amplifier (CSA)

7.4 VSYS current sense amplifier

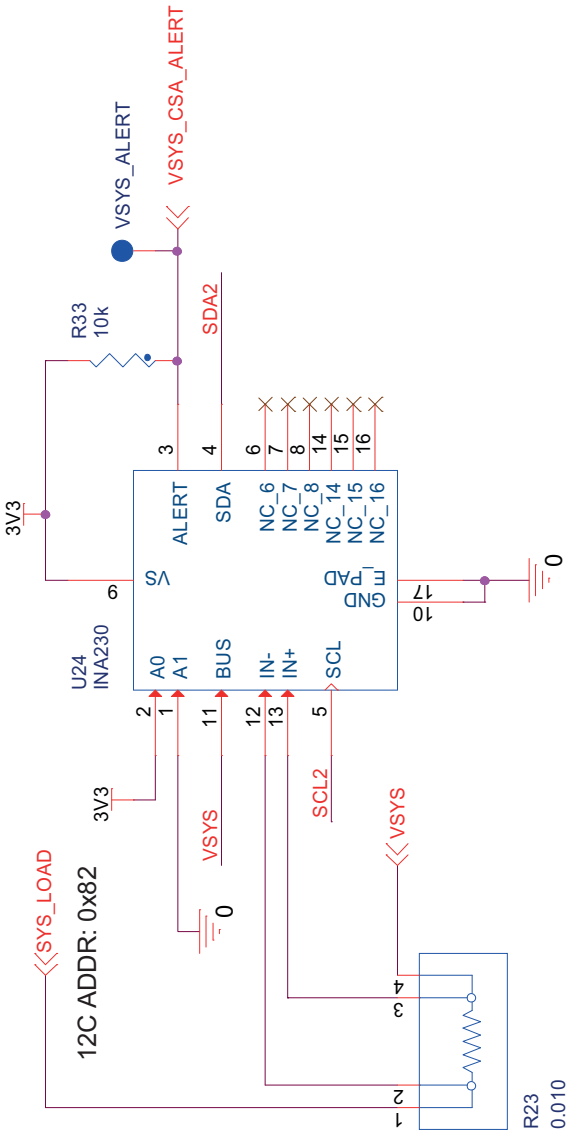


Figure 45. VSYS current sense amplifier

7.5 VBAT current sense amplifier

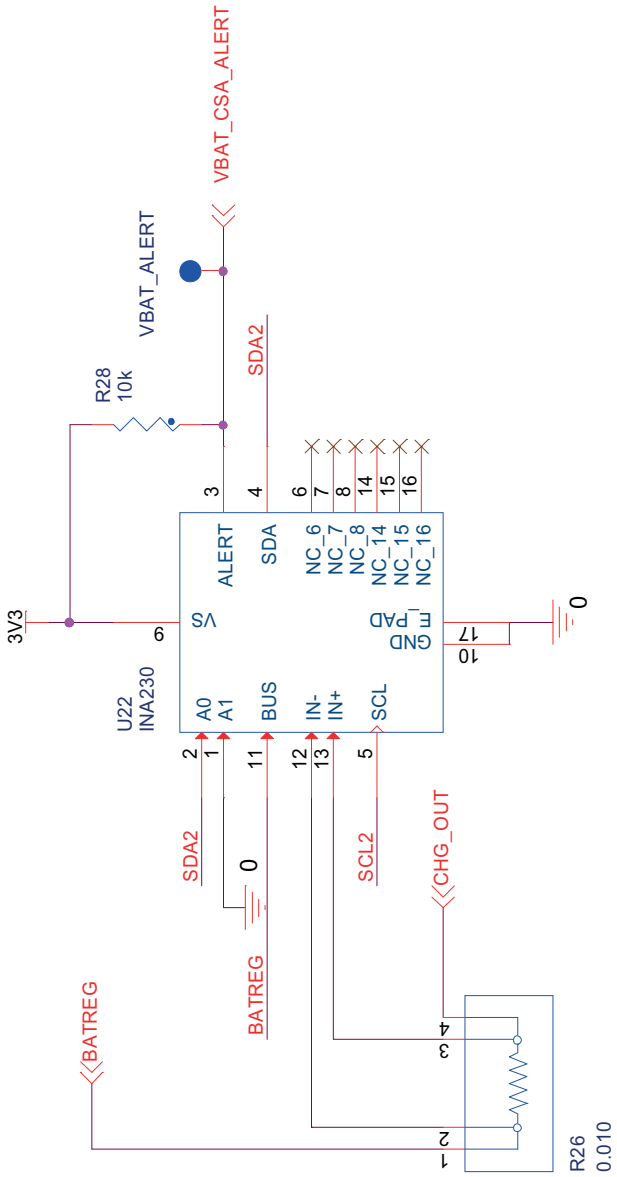


Figure 46. VBAT current sense amplifier

7.6 Electronic load (ELOAD)

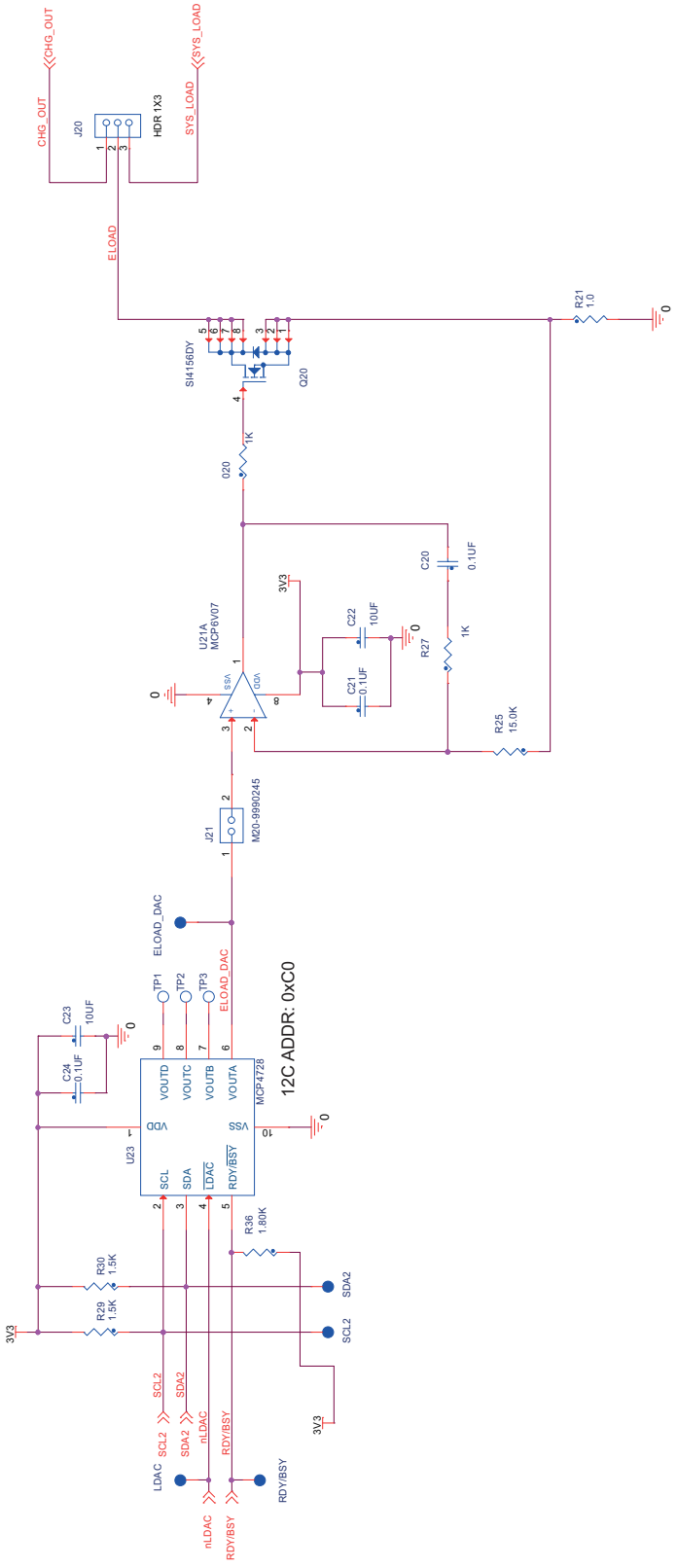


Figure 47. Electronic load (ELOAD)

7.7 KL25Z interface

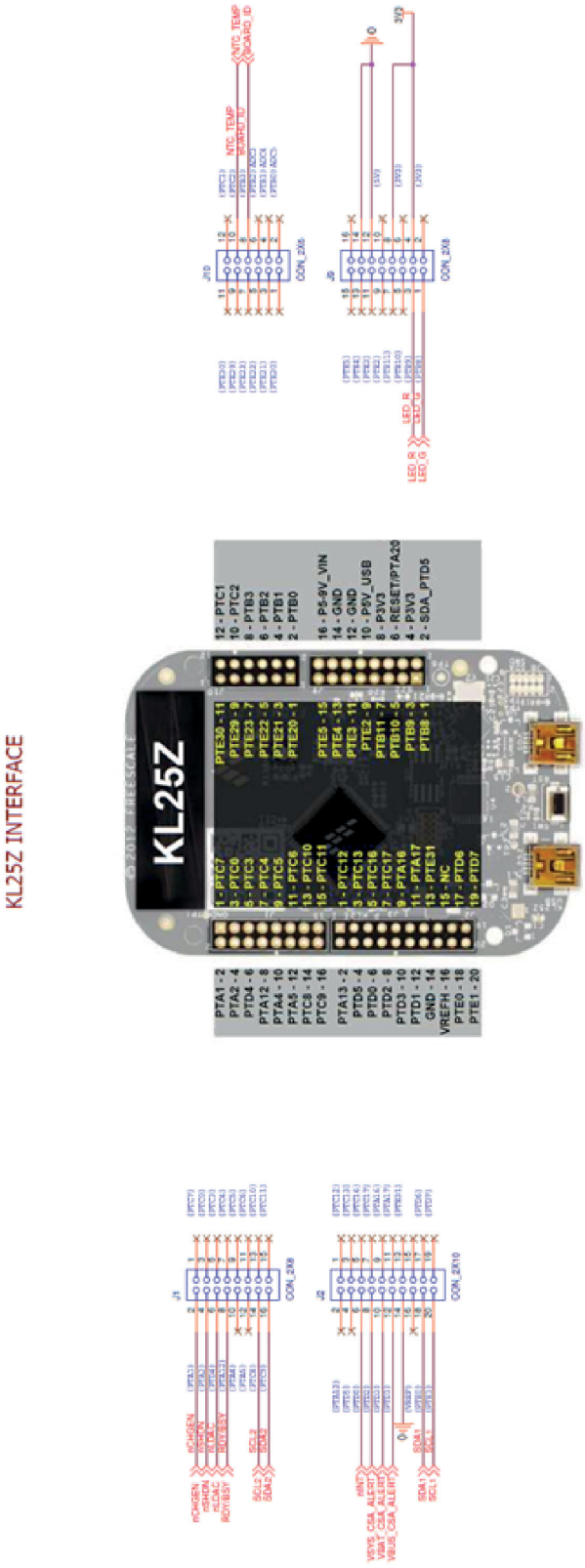


Figure 48. KL25Z interface

7.8 NTC thermistor interface

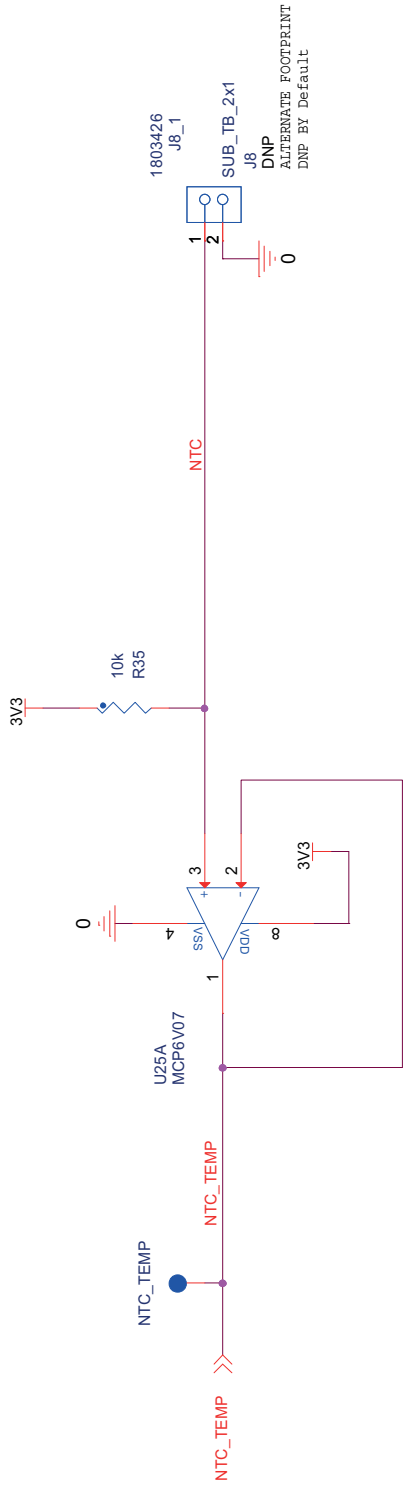


Figure 49. NTC thermistor interface

7.9 Board ID

MC32BC3770	0.5V	1.8K 1%
RESERVED	1.0V	4.7K 1%
RESERVED	1.5V	8.45K 1%
RESERVED	2.0V	15.4K 1%

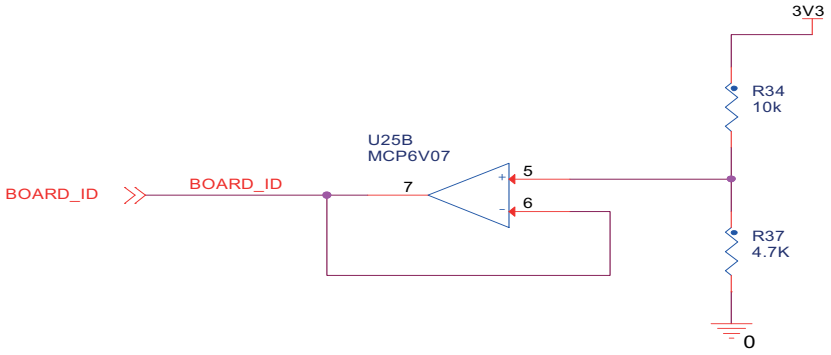


Figure 50. Board ID

7.10 LED indicators

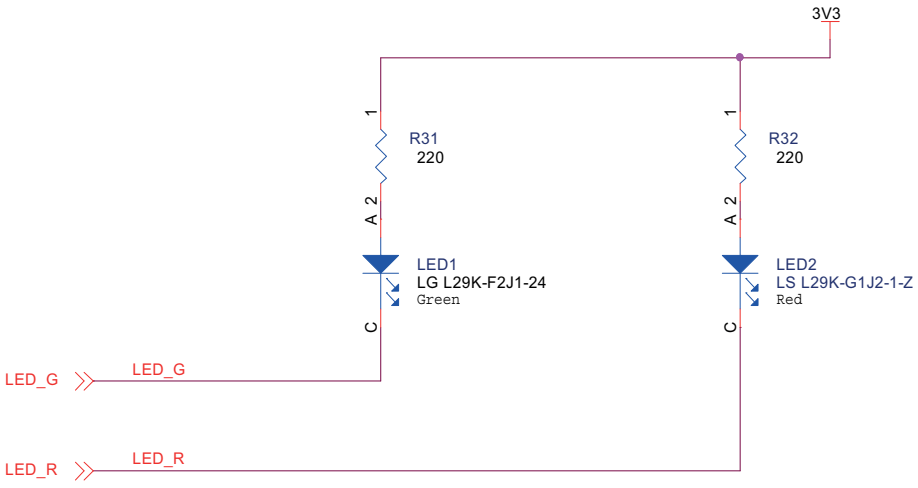


Figure 51. LED indicators

8 Board layout

8.1 Silkscreen - FRDM-BC3770-EVB

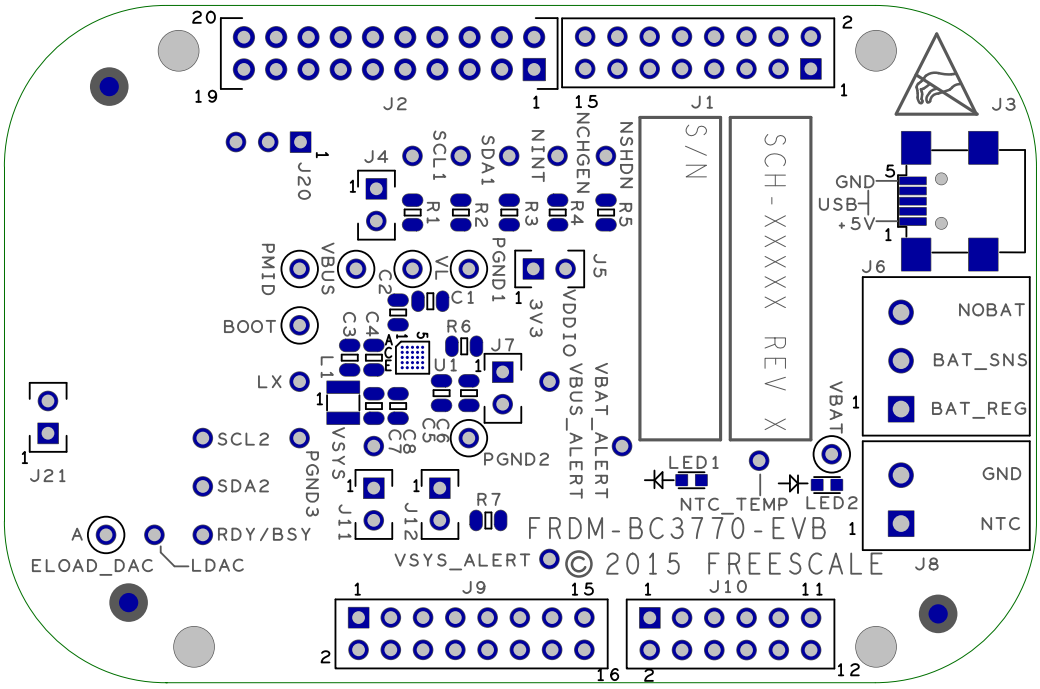


Figure 52. Assembly layer top

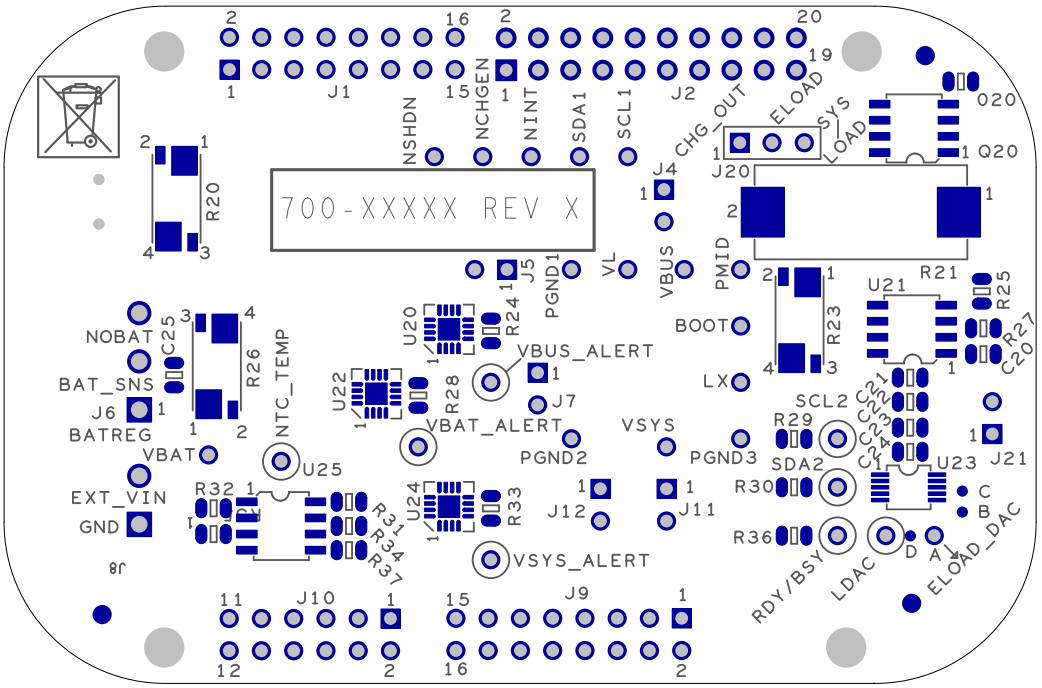


Figure 53. Assembly layer bottom

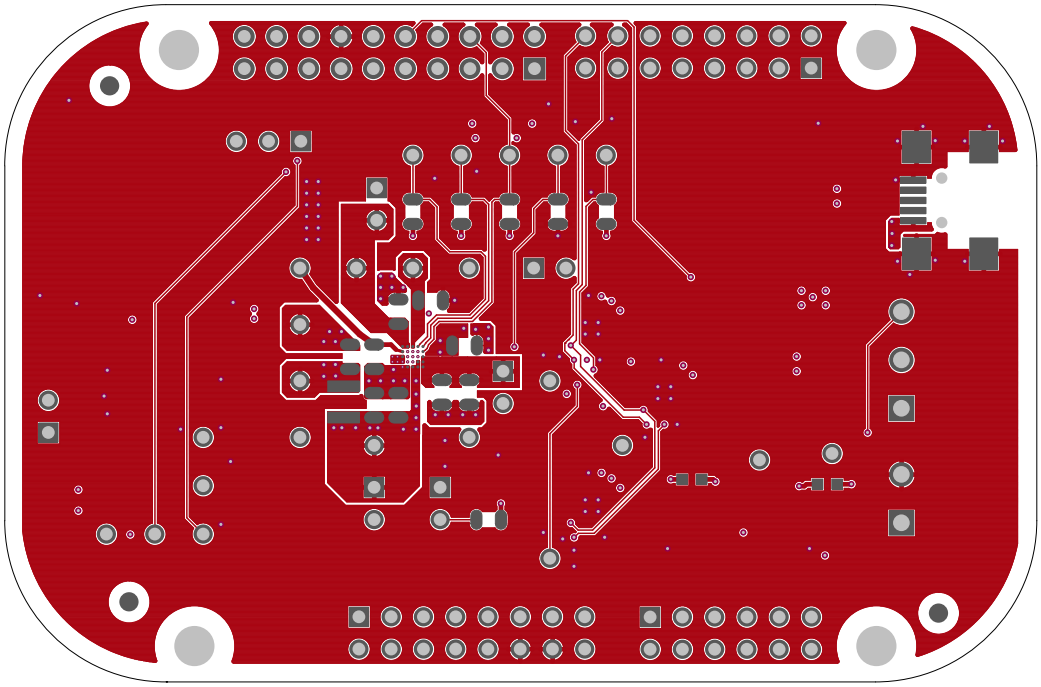


Figure 54. Top layer routing

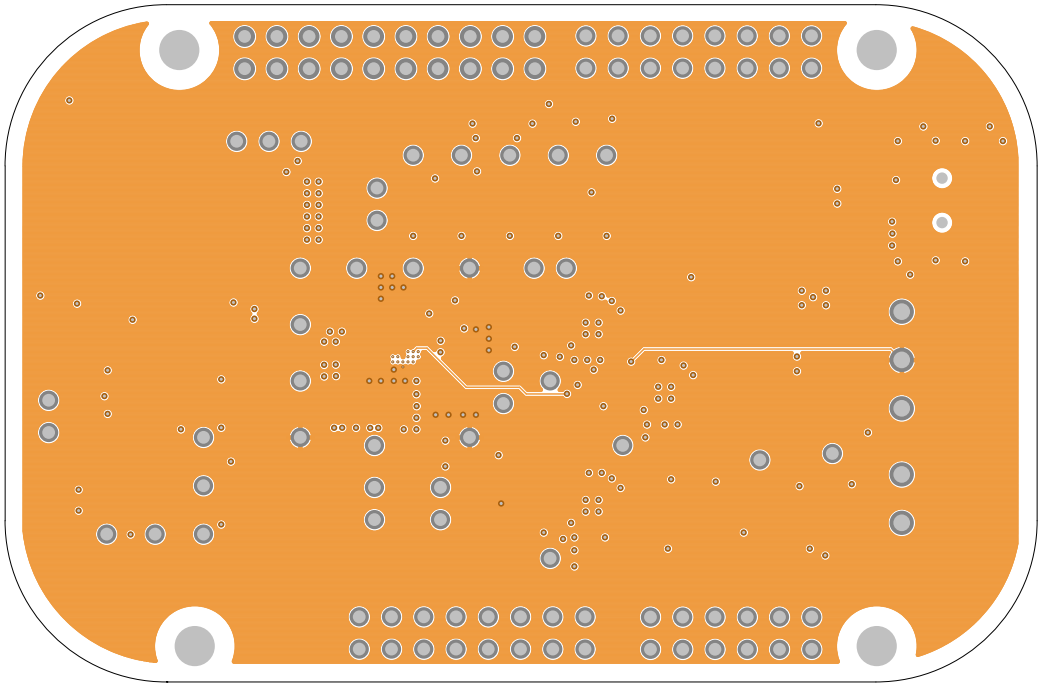


Figure 55. Inner layer1 routing

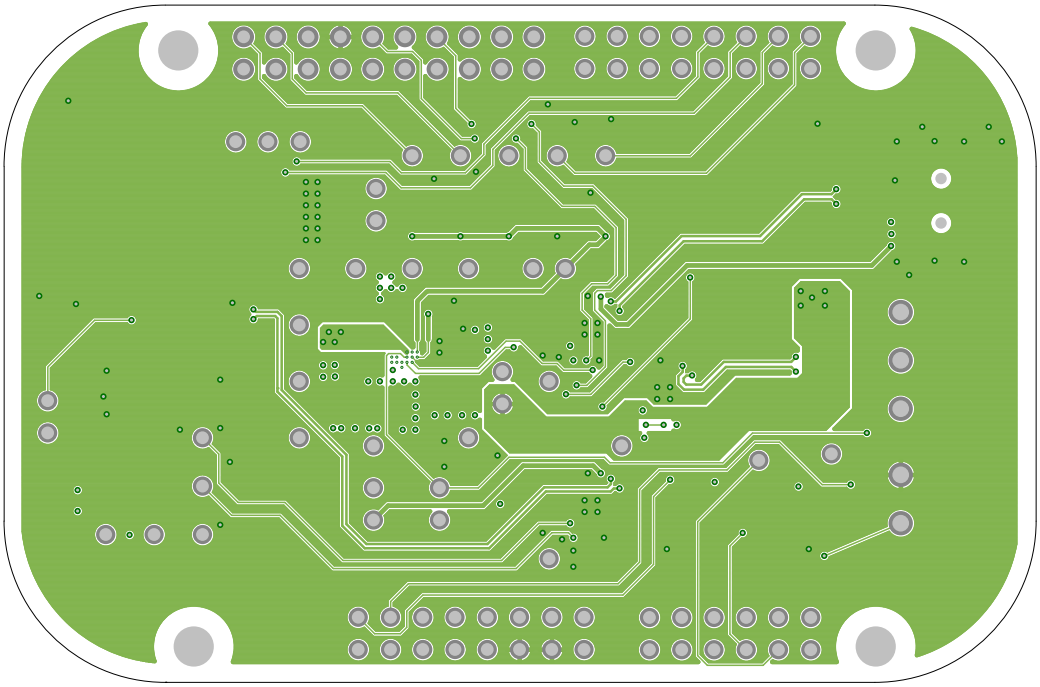


Figure 56. Inner layer2 routing

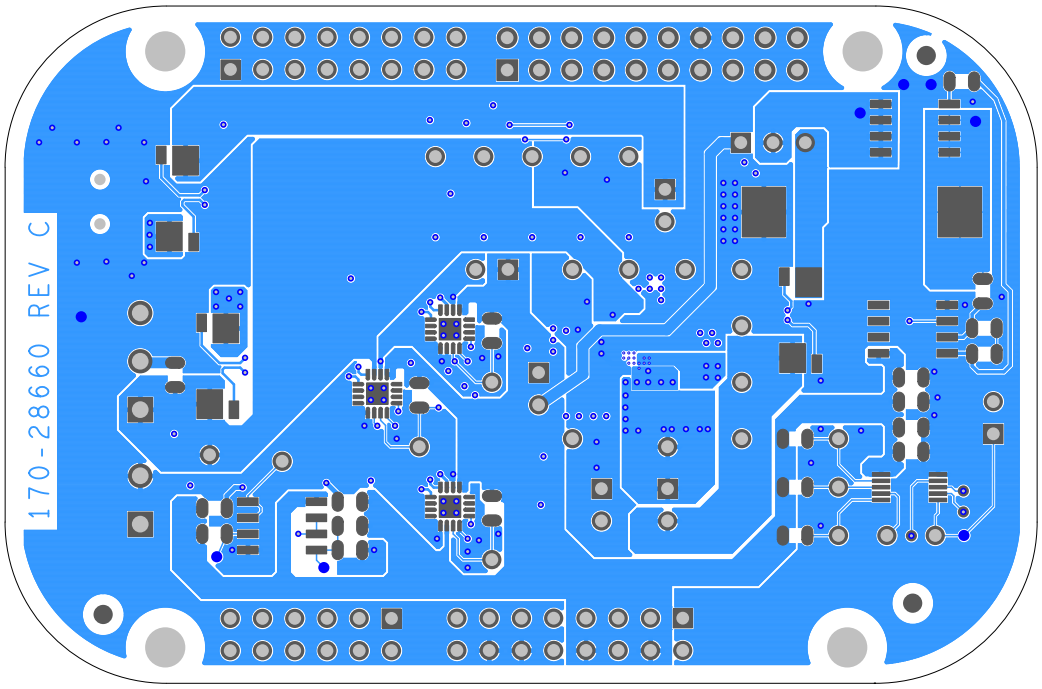


Figure 57. Bottom layer routing

9 Board bill of materials

Table 10. Bill of materials [(1)]

Item	Qty	Schematic label	Value	Description	Part number	Assy opt
NXP Components						
1	1	U1		IC PROGM SWT CHARGER 1.5 MHz W/DUAL OUT 5–5.2 V WLCSP25	MC32BC3770CS	
Active components						
2	3	U20, U22, U24		IC CURRENT SHUNT MONI-TOR 2.7–5.5 V QFN16 - Texas Instruments	INA230AIRGTT	
3	1	U23		IC DAC QUAD 12BIT 2.7–5.5 V MSOP10 - Microchip Technology Inc	MCP4728-E/UN	
4	2	U21, U25		IC LIN OPAMP DUAL AUTO-ZERO 1.8–5.5 V SOIC8 - Microchip Technology Inc	MCP6V07-E/SN	
Capacitors						
5	2	C1, C25	1.0 µF	CAPACITOR CER 1.0 UF 10 V 10% X5R 0805 - TDK	C2012X5R1A105K	
6	2	C2, C4	2.2 µF	CAPACITOR CER 2.2 uF 25 V 10% X7R 0805 - AVX	08053C225KAT2A	
7	1	C3	0.022 µF	CAPACITOR CER 0.022 UF 16 V 20% X7R 0805 - AVX	0805YC223MAT2A	
8	1	C5	4.7 µF	CAPACITOR CER 4.7 UF 16 V 10% X7R 0805 - Kemet	C0805C475K4RACTU	
9	1	C6	0.1 µF	CAPACITOR CER 0.1 UF 25 V 10% X7R 0805 - Murata	GRM21BR71E104KA01L	[(2)]
10	4	C7, C20, C21, C24	0.1 µF	CAPACITOR CER 0.1 UF 25 V 10% X7R 0805 - Murata	GRM21BR71E104KA01L	
11	3	C8, C22, C23	10 µF	CAPACITOR CER 10 UF 16 V 10% X5R 0805 - AVX	0805YD106KAT2A	
Inductors						
12	1	L1	1.0 µH	INDUCTOR PWR 1 uH@1MHZ 2.2 A 20% 2520 - SAMSUNG	CIG22E1R0MNE	
Resistors						
13	2	020, R27	1.0 K	RESISTOR MF 1 K 1/8 W 5% 0805 - YAGEO AMERICA	RC0805JR-071KL	
14	4	R1, R2, R29, R30	1.5 K	RESISTOR MF 1.5 K 1/8 W 5% 0805 - KOA SPEER	RK73B2ATTD152J	
15	8	R3, R4, R5, R24, R28, R33, R34, R35	10.0 K	RESISTOR MF 10.0 K 1/8 W 0.1% 0805 - BOURNS	CRT0805-BY-1002ELF	
16	1	R6	0 Ω	RESISTOR MF ZERO OHM 1/8W -- 0805 - YAGEO AMERICA	RC0805JR-070RL	
17	1	R7	2.4 K	RESISTOR MF 2.4 K 1/8 W 1% 0805 - YAGEO AMERICA	232273462402L	
18	3	R20, R23, R26	0.01 Ω	RESISTOR METAL STRIP 0.01 OHM 1 W 1% 2512 - VISHAY INTERTECHNOLOGY	WSK2512R0100FEA	
19	1	R21	1.0 Ω	RESISTOR WW 1.0 OHM 3.0 W 5% SMT - OHM-ITE MANUFACTURING	RW3R0DB1R00JET	

Table 10. Bill of materials [(1)] (continued)

Item	Qty	Schematic label	Value	Description	Part number	Assy opt
20	1	R25	15.0 K	RESISTOR MF 15.0 K 1/8 W 1% 0805 - KOA SPEER	RK73H2ATTD1502F	
21	2	R31, R32	220 Ω	RESISTOR MF 220 OHM 1/8 W 5% 0805 - VEN-KEL COMPANY	CR0805-8W-221JT	
22	1	R36	1.8 K	RESISTOR MF 1.80 K 1/8 W 1% 0805 - BOURNS	CR0805-FX-1801ELF	
23	1	R37	4.7 K	RESISTOR MF 4.70 K 1/8 W 1% 0805 - BOURNS	CR0805-FX-4701ELF	
Switches, connectors, jumpers and test points						
24	2	J1, J9		HDR 2x8 2.54 MM FEMALE (STACKABLE) - SAMTEC	SSQ-108-23-G-D	
25	1	J2		HDR 2x10 2.54 MM FEMALE (STACKABLE) - SAMTEC	SSQ-110-23-G-D	
26	1	J3		CON 1x5 USB MINI-B RA SHLD SKT SMT 0.8 MM SP 156HAU -- HIROSE	UX60-MB-5ST	
27	6	J4, J5, J7, J11, J12, J21		HDR 1x2 TH 100 MIL SP 339H AU 118L - HAR-WIN INC	M20-9990245	
28	1	J6		CON 1X3 TB TH 3.81 MM SP 201H -- 138L + TERM BLOCK PLUG 3.81 MM 3POS - SUBAS-SEMBLY	210-80099, 211-79220	
29	1	J8		CON 1X2 TB TH 3.81 MM SP 201H -- 138L + TERM BLOCK PLUG 3.81 MM 2POS - SUBAS-SEMBLY	210-8009, 210-80098	[(2)]
30	1	J10		CON 2X10 SKT TH 2.54 MM CTR 340H AU 394L - SAMTEC	SSQ-106-23-G-D	
31	1	J20		HDR 1x3 TH 100 MIL SP 340H AU 118L - HAR-WIN INC	M20-9990345	
32		J6_1		CON 1X3 TB TH 150 MIL SP 363H SN 134L - Phoenix Contact	1803439	
33		J8_1		CON 1X2 TB TH 150 MIL SP 363H SN 134L - Phoenix Contact	1803426	
34	1	LED1		LED GRN SGL 20 MA 0603 NRND - OSRAM	LG L29K-F2J1-24-Z	
35	1	LED2		LED RED SGL 30 MA 0603 - OSRAM	LS L29K-G1J2-1-Z	
36	1	Q20		TRANS NMOS PWR 24 A 30 V SO8 - Vishay Technology	SI4156DY-T1-GE3	
37	21	BOOT, ELOAD_DAC, LDAC, LX, NCHGEN, NINT, NSHDN, NTC_TEMP, PMID, RDY/BSY, SCL1, SCL2, SDA1, SDA2, VBAT, VBAT_ALERT, VBUS, VBUS_ALERT, VL, VSYS, VSYS_ALERT		TEST POINT RED 40 MIL DRILL 180 MIL TH - KEYSTONE ELECTRONICS	5000	[(2)]
38	3	PGND1, PGND2, PGND3		TEST POINT BLACK 40 MIL DRILL 180 MIL TH - KEYSTONE ELECTRONICS	5001	[(2)]

Notes
1. NXP does not assume liability, endorse, or warrant components from external manufacturers are referenced in circuit drawings or tables. While NXP offers component recommendations in this configuration, it is the customer's responsibility to validate their application.
2. Do Not Populate

10 References

Following are URLs where you can obtain information on related NXP products and application solutions:

Table 11. References

NXP.com support pages	Description	URL
FRDM-BC3770-EVB	Tool Summary Page	http://www.nxp.com/webapp/sps/site/prod_summary.jsp?code=FRDM-BC3770-EVB
MC32BC3770	Product Summary Page	http://www.nxp.com/webapp/sps/site/prod_summary.jsp?code=BC3770
FRDM-KL25Z	Product Summary Page	http://www.nxp.com/webapp/sps/site/prod_summary.jsp?code=FRDM-KL25Z
CodeWarrior	Tool Summary Page	http://www.nxp.com/webapp/sps/site/homepage.jsp?code=CW_HOME&tid=vanCODEWARRIOR
Processor Expert Code Model	Code Walkthrough Video	http://www.nxp.com/video/processor-expert-code-model-codewarrior-code-walkthrough:PROEXPCODMODCW_VID

NXP.com videos	Description	URL
FRDMKL25ZINTRO_VID	Freedom Introduction Video	http://www.nxp.com/webapp/video_vault/videoSummary.sp?code=FRDMKL25ZINTRO_VID
FRDM-BC3770-EVB Quick Startup	Startup Instructions	http://www.nxp.com/webapp/sps/site/prod_summary.jsp?code=FRDM-BC3770-EVB
USB Connection Panel	Configuring USB Connections	http://www.nxp.com/webapp/sps/site/prod_summary.jsp?code=FRDM-BC3770-EVB
Direct 12C Communication Panel	Configuring Direct 1^2C Communications	http://www.nxp.com/webapp/sps/site/prod_summary.jsp?code=FRDM-BC3770-EVB
Control Registers Panel	Configuring Control Registers	http://www.nxp.com/webapp/sps/site/prod_summary.jsp?code=FRDM-BC3770-EVB
Script Editor Panel	Editing and running scripts	http://www.nxp.com/webapp/sps/site/prod_summary.jsp?code=FRDM-BC3770-EVB
Charge Plots	Monitoring battery charging	http://www.nxp.com/webapp/sps/site/prod_summary.jsp?code=FRDM-BC3770-EVB
Discharge Plots	Monitoring Discharge Plots	http://www.nxp.com/webapp/sps/site/prod_summary.jsp?code=FRDM-BC3770-EVB
Load Sharing	Describes the load sharing support via the GUI	http://www.nxp.com/webapp/sps/site/prod_summary.jsp?code=FRDM-BC3770-EVB
Battery Supplement	Describes battery supplement support via the GUI	http://www.nxp.com/webapp/sps/site/prod_summary.jsp?code=FRDM-BC3770-EVB
OTG Boost	Describes OTG Boost support via the GUI	http://www.nxp.com/webapp/sps/site/prod_summary.jsp?code=FRDM-BC3770-EVB

10.1 Support

Visit www.nxp.com/support for a list of phone numbers within your region.

10.2 Warranty

Visit www.nxp.com/warranty to submit a request for tool warranty.

11 Revision history

Revision	Date	Description of changes
1.0	03/2015	• Initial Release
2.0	12/2015	• Added Processor Expert Section
	12/2015	• Corrected copyright information
	7/2016	• Updated to NXP document form and style

How to Reach Us:

Home Page:
NXP.com

Web Support:
http://www.nxp.com/support

Document Number: KTFRDMBC3770UG
Rev. 2.0
8/2016