CY8CPROTO-040T PSoC™ 4000T CAPSENSE™ Prototyping Kit guide

About this document

Scope and purpose

This guide helps you get acquainted with the CY8CPROTO-040T PSoC™ 4000T CAPSENSE™ Prototyping Kit. The document explains the kit operation, describes the out-of-the-box (OOB) example and its operation, and the hardware details of the board.

Intended audience

This kit is intended for all technical specialists familiar with PSoC™ 4 MCU and CAPSENSE™.

***Note**: Use this kit under laboratory conditions.*

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Safety precautions

***Note**: Please note the following warnings regarding the hazards associated with development systems*

Table 1 Safety precautions

	**Caution:** *The evaluation or reference board contains parts and assemblies sensitive to electrostatic discharge (ESD). Electrostatic control precautions are required when installing, testing, servicing or repairing the assembly. Component damage may result if ESD control procedures are not followed. If you are not familiar with electrostatic control procedures, refer to the applicable ESD protection handbooks and guidelines.*

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1 Introduction

Wearable technology devices from fitness trackers to smart glasses and smart clothes are becoming increasingly popular. Capacitive sensing is one of the key features of any wearable solution. Battery life is the major challenge in any wearable technology today; therefore, there is a constant need to lower the power consumption while still needing the devices to be ON and responsive all the time.

PSoC™ 4000T series MCU (hereafter called “PSoC™ 4000T”) addresses this challenge by introducing the new fifth-generation CAPSENSE™ and multi-sense low-power (MSC-LP) technology, offering an ultra-low-power touch HMI solution based on an integrated “Always-on” sensing technology. It enables scanning low-power buttons such as power/wakeup buttons while the device is in deep sleep and processing the results to wake the device in the event of a touch. This technology has an inherent autonomous scanning capability, which does not need CPU intervention for scanning sensors; the device can be kept in deep sleep while scanning, so reducing the power in active mode as well.

The CY8CPROTO-040T PSoC™ 4000T CAPSENSE™ Prototyping Kit lets you evaluate the features of the PSoC™ 4000T device. The board has the following features:

- A PSoC™ 4000T device
- An on board programmer/debugger (KitProg3)
- A self-capacitance based button
- A mutual-capacitance based button
- A capacitive proximity sensor
- A capacitive slider
- User LEDs (PWM enabled)
- A User button

This kit demonstrates the following key capabilities of the fifth-generation low-power CAPSENSE™ technology:

1. Superior touch-sensing performance
   - Best-in-class sensitivity, SNR, and immunity to harsh environmental conditions such as temperature and moisture. To evaluate the SNR performance, follow the steps mentioned in the ‘Monitor data using CAPSENSE™ tuner’ section of the PSoC™ 4: MSCLP low-power CSD button’ code example’s README
2. Ultra-low-power capability based on "Always-On" sensing.
   - Ability to obtain power numbers as low as 3.7 µA in the Wake-On-Touch mode and 67 µA in Active mode (see CE238817 for the scan conditions for achieving this), making it ideal for battery-operated wearable devices

See the AN85951 - PSoC™ 4 and PSoC™ 6 MCU CAPSENSE™ design guide for details of the features of the fifth-generation low-power CAPSENSE™ - MSC-LP.

You can use ModusToolbox™ software to develop and debug your PSoC™ 4 projects. ModusToolbox™ software is a set of tools that enables you to integrate Infineon devices into your existing development methodology.

If you are new to PSoC™ 4 and ModusToolbox™ software IDE, see the application note AN79953 - Getting started with PSoC™ 4 to help familiarize yourself with the PSoC™ 4 and help you create your own design.

1.1 Kit contents

The CY8CPROTO-040T PSoC™ 4000T CAPSENSE™ Prototyping Kit contains the following, as shown in Figure 1:

- PSoC™ 4000T CAPSENSE™ Prototyping Board
- Quick start guide (part of packaging)

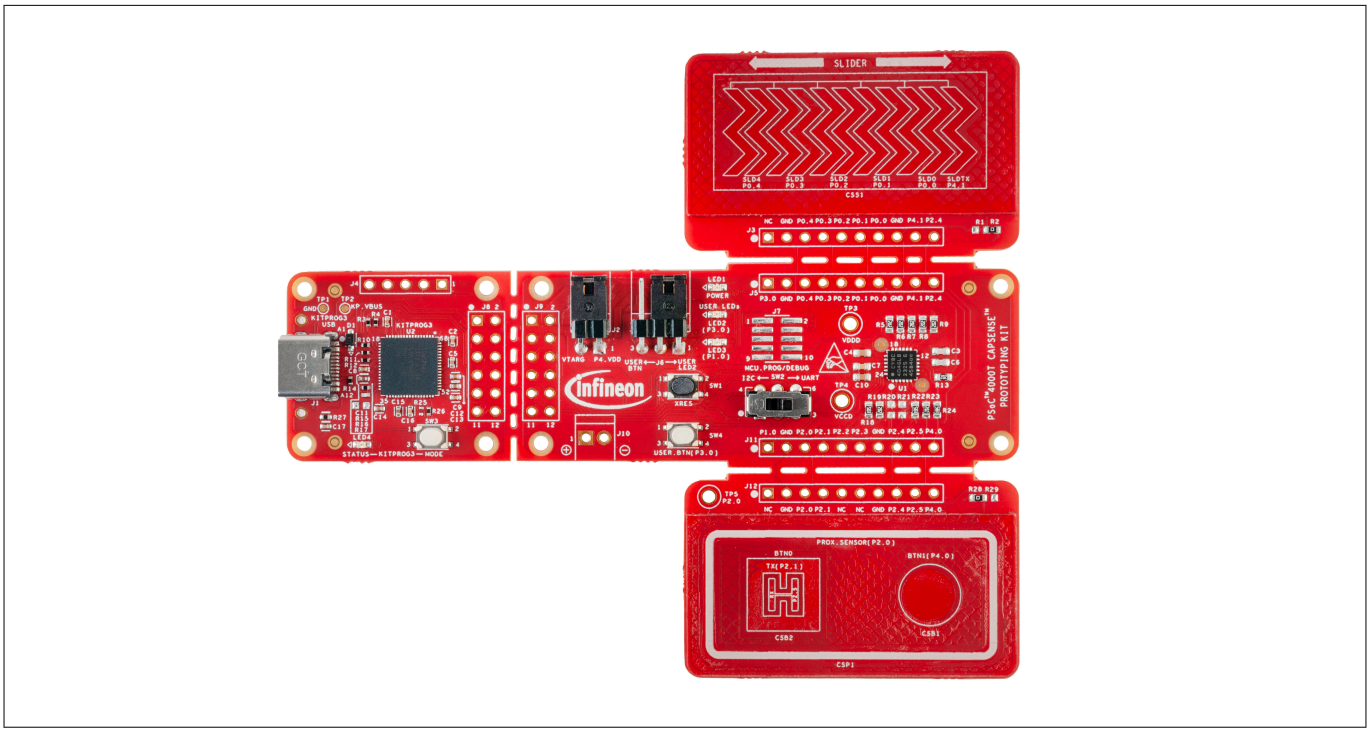

Figure 1 CY8CPROTO-040T PSoC™ 4000T CAPSENSE™ Prototyping Board

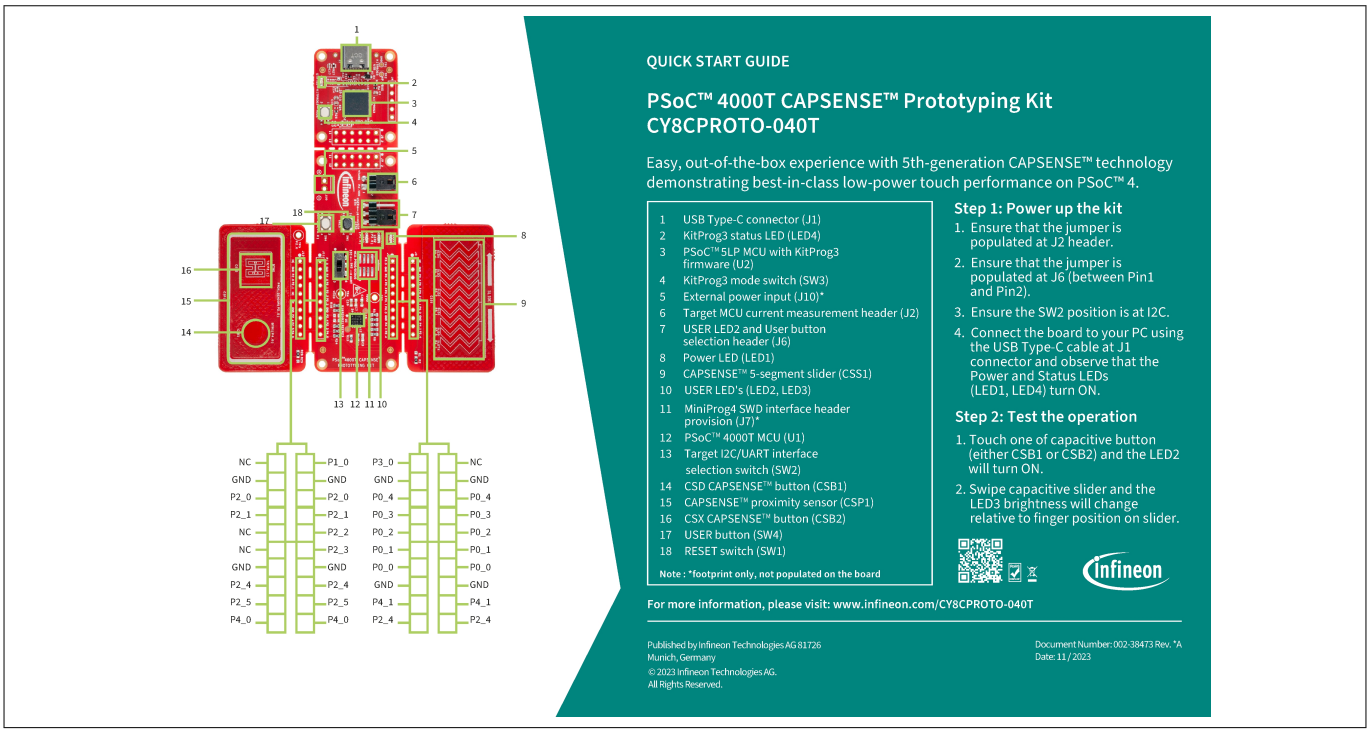

Figure 2 CY8CPROTO-040T PSoC™ 4000T CAPSENSE™ Prototyping Kit Quick start guide

Inspect the kit's contents; if you find any part missing, go to Infineon's Support page for assistance.

1.2 Getting started

This guide helps you get acquainted with the PSoC™ 4000T CAPSENSE™ Prototyping Kit.

- See the Kit operation section for an overview of PSoC™ 4000T device features. Follow the Using the OOB example – CE238817 section to have a quick review of the OOB project preprogrammed in this kit. It also provides the steps to create a project and program/debug using the ModusToolbox™ software
- See the Hardware section for detailed hardware description, kit schematics, rework instructions, and the bill of materials (BOM)
- Use ModusToolbox™ software for application development using the PSoC™ 4000T CAPSENSE™ Prototyping Kit. For the latest software support for this development kit, see the kit webpage
  - ModusToolbox™ software is a free development ecosystem that includes the Eclipse IDE for the ModusToolbox™ software. Using the ModusToolbox™ software, you can enable and configure device resources, middleware libraries, and program and debug the device. You can download the software from the ModusToolbox™ software home page. For additional information, see the ModusToolbox™ software user guide
- See the wide range of code examples to evaluate the PSoC™ 4000T CAPSENSE™ Prototyping Kit. These examples help you familiarize with the PSoC™ 4000T device and create the design. You can also find code examples on the GitHub page dedicated to ModusToolbox™ software-based examples
  - To access code examples through ModusToolbox™ software, see the “Software development for PSoC™ 4” section in AN79953 - Getting started with PSoC™ 4 under “PSoC™ 4 software resources”

1.3 Additional learning resources

Infineon provides a wealth of data in the PSoC™ 4 product webpage to help you to select the suitable PSoC™ device for your design and to help you quickly and effectively integrate the device into your design.

1.4 Technical support

For assistance, visit Infineon support or visit community.infineon.com to ask your questions in the Infineon developer community.

You can also use the following support resources if you need quick assistance:

- Self-help (Technical documents)
- Local sales office locations

1.5 Documentation conventions

Table 2 Document conventions for guides

Convention	Usage
`Courier New`	Displays commands, user entered text, and source code: `cd mtb`
Italics	Displays file names and reference documentation: Read about the `sourcefile.hex` file in the PSoC™ Creator user guide.
File > **Open**	Represents menu paths: File > Open > New Project

(table continues...)

Table 2 (continued) Document conventions for guides

Convention	Usage
Bold	Displays commands, menu paths, and icon names in procedures: Click the **File** icon and then click **Open**.
Times New Roman	Displays an equation: 2 + 2 = 4
Text in gray boxes	Describes Cautions or unique functionality of the product.

2 Kit operation

This chapter provides an overview of the features of the PSoC™ 4000T device and a quick review of the OOB project preprogrammed in this kit. It also provides the steps to create a project and program/debug using the ModusToolbox™ software.

2.1 Theory of operation

The PSoC™ 4000T CAPSENSE™ Prototyping Kit is built around a PSoC™ 4000T device. Figure 3 shows the block diagram of the PSoC™ 4000T device used on the board. For details of device features, see the device datasheet.

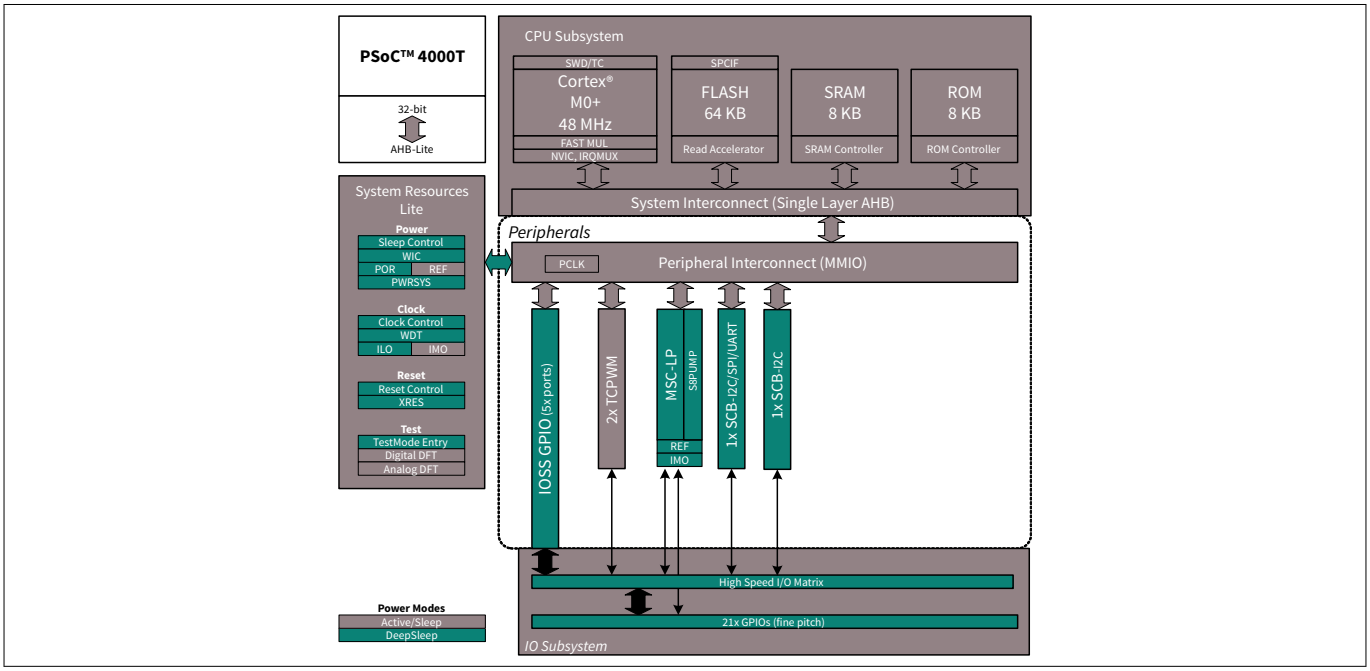

Figure 3 PSoC™ 4000T device block diagram

Figure 4 shows the functional block diagram of the PSoC™ 4000T CAPSENSE™ Prototyping Board.

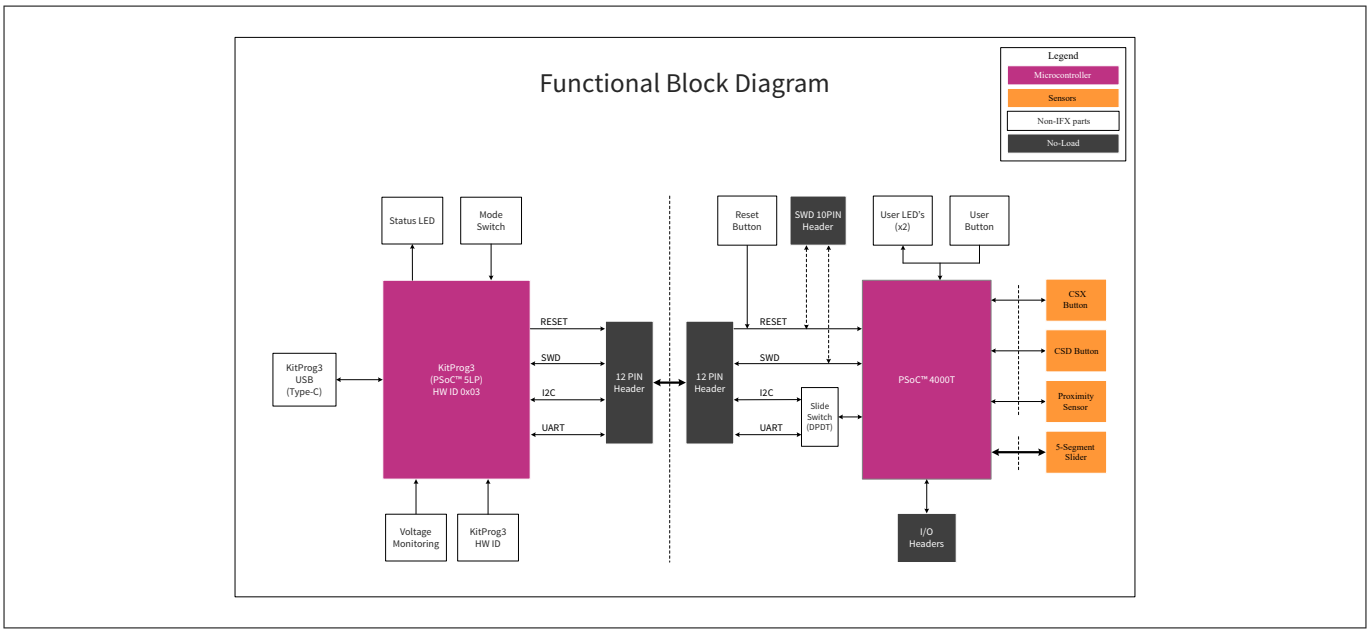

Figure 4 Functional block diagram of CY8CPROTO-040T PSoC™ 4000T CAPSENSE™ Prototyping Board

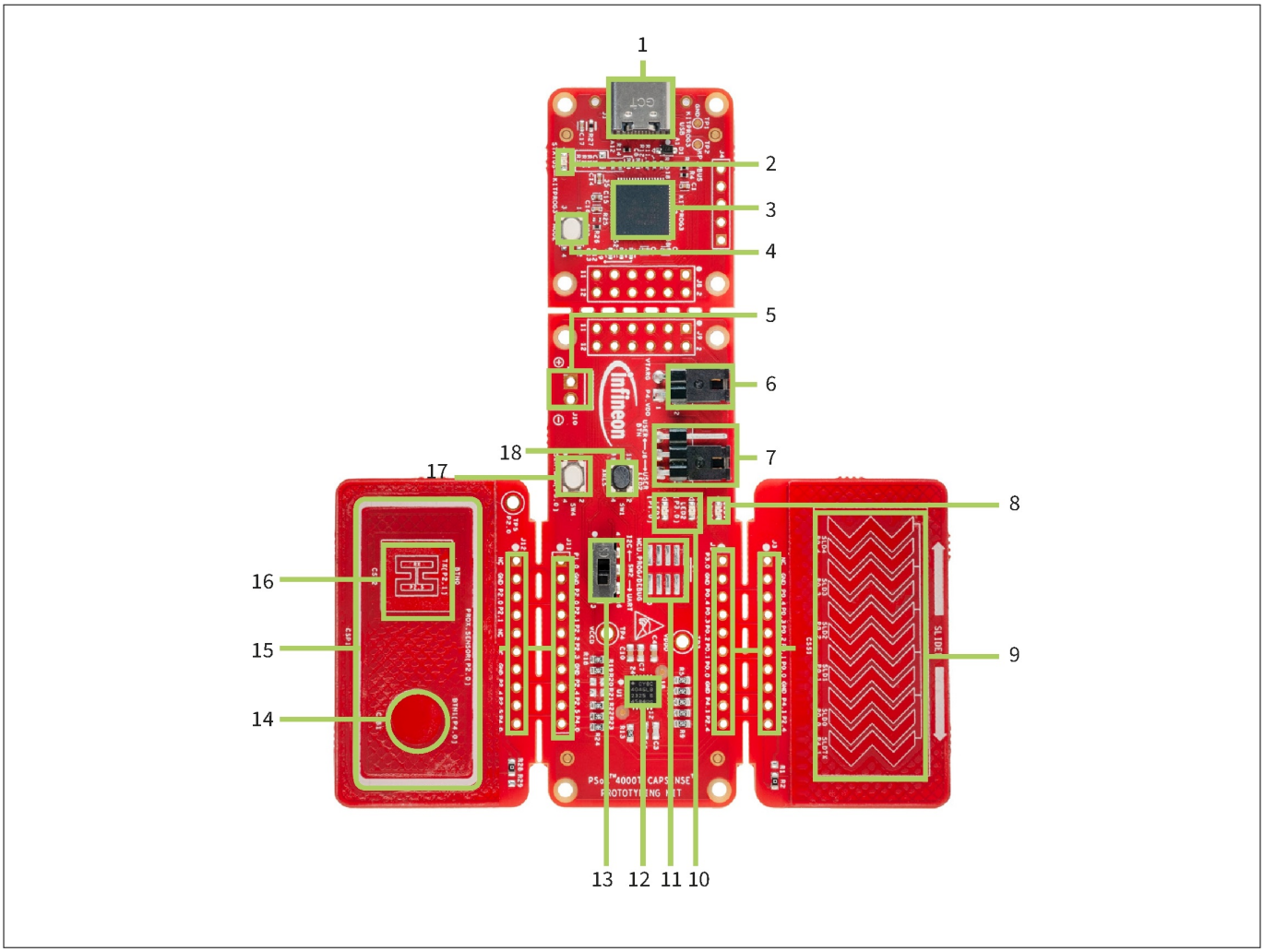

Figure 5 PSoC™ 4000T CAPSENSE™ Prototyping Board top view

PSoC™ 4000T CAPSENSE™ Prototyping Kit focuses on demonstrating the capabilities of 5th-generation CAPSENSE™ technology like low power operation with always-on sensing, and improved touch sensing performance with CAPSENSE™ widgets using PSoC™ 4000T device. This board has the following peripherals:

Table 3 Peripheral details

Sl. No.	Peripheral	Description
1.	KitProg3 Type-C USB connector (J1)	Connect to a PC to use the KitProg3 on-board programmer and debugger and to provide power to the board
2.	KitProg3 status LED (LED4)	Amber LED4 indicates the status of KitProg3. For details on the KitProg3 status, see the KitProg3 user guide.
3.	KitProg3 (PSoC™ 5LP) programmer and debugger (CY8C5868LTI-LP039, U2)	The PSoC™ 5LP device (CY8C5868LTI-LP039) serving as KitProg3, is a multifunctional system, which includes a SWD programmer, debugger, USB-I2C bridge and USB-UART bridge. For more details, see the KitProg3 user guide.
4.	KitProg3 programming mode selection button (SW3)	Use this button to switch between various modes of operation of KitProg3. Note that this board supports only CMSIS-DAP BULK mode. For more details, see the KitProg3 user guide. This button function is reserved for future use.

(table continues...)

Table 3 (continued) Peripheral details

Sl. No.	Peripheral	Description
5.	External power supply input provision (J10)	By populating J10 enables the connection of an external DC power supply input to the PSoC™ 4000T device.
6.	Target MCU current measurement header (J2)	Connect an ammeter to this jumper to measure the current consumed by the PSoC™ 4000T device.
7.	USER LED (LED2) and USER button selection header (J6)	Use this header for selecting either USER LED (LED2) or USER button (SW4)
8.	Power LED (LED1)	Amber LED that indicates the status of the power supplied to board.
9.	CAPSENSE™ 5-segment slider (CSS1)	The CAPSENSE™ touch-sensing slider which is capable of both self-capacitance (CSD) and mutual-capacitance (CSX) operation, allow you to evaluate Infineon's fifth-generation CAPSENSE™ technology. The slider have a 1-mm acrylic overlay for smooth touch sensing.
10.	USER LED's (LED2, LED3)	The user LED's can operate at the entire operating voltage range of the PSoC™ 4000T device as these are driven by MOSFET connected USB supply. The LED's are active HIGH, so the pins must be driven to VDDD to turn ON the LED's.
11.	PSoC™ 4000T MCU 10-pin SWD program and debug header provision (J7)	By populating this 10-pin header allows you to program and debug the PSoC™ 4000T MCU using an external programmer such as MiniProg4.
12.	PSoC™ 4000T MCU (U1)	This kit highlights the features of the PSoC™ 4000T device and has been designed for the 24-pin QFN part with 64 KB flash capacity.
13.	Target I2C/UART interface selection switch (SW2)	Use this slide switch to select I2C or UART interface of PSoC™ 4000T MCU with on board KitProg3 USB-I2C or USB-UART bridge.
14.	CSD CAPSENSE™ button (CSB1)	This CAPSENSE™ touch-sensing button which is capable of self-capacitance (CSD) based sensing operation, allow you to evaluate Infineon's fifth-generation CAPSENSE™ technology. This button have a 1-mm acrylic overlay for smooth touch sensing.
15.	CAPSENSE™ proximity sensor (CSP1)	The CAPSENSE™ proximity sensing loop which works in self-capacitance (CSD) sensing mode, allow you to evaluate Infineon's fifth-generation CAPSENSE™ technology. The proximity sensor have a 1 mm acrylic overlay for smooth touch sensing.
16.	CSX CAPSENSE™ button (CSB2)	The CAPSENSE™ touch-sensing button which is capable of both self-capacitance (CSD) and mutual-capacitance (CSX) operation, allow you to evaluate Infineon's fifth-generation CAPSENSE™ technology. This button have a 1 mm acrylic overlay for smooth touch sensing.

(table continues...)

Table 3 (continued) Peripheral details

Sl. No.	Peripheral	Description
17.	USER button (SW4)	Provide an input to PSoC™ 4000T MCU. Note that the button connects the PSoC™ 4000T MCU pin to ground through a current limiting resistor when pressed, so you need to configure the PSoC™ 4000T MCU pin as a digital input with resistive pull-up for detecting the button press. PSoC™ 4000T MCU pin used for detecting button press is shared with LED3 via J6 header. ensure to short pin 2 and 3 of J6 with jumper to enable the connection with PSoC™ 4000T MCU pin.
18.	PSoC™ 4000T MCU RESET switch (SW1)	Resets PSoC™ 4000T MCU. It connects the PSoC™ 4000T MCU reset (XRES) pin to ground

See the Functional description section for details on various hardware blocks.

2.2 Using the OOB example – CE238817

The PSoC™ 4000T CAPSENSE™ Prototyping Kit is pre-programmed with the CE238817 – PSoC™ 4: CY8CPROTO-040T Demo code example (CE). This CE demonstrates the key features of fifth-generation low-power CAPSENSE™ technology in PSoC™ 4000T, such as the following:

- Self-cap button, Mutual-cap button, and Self-cap slider operation with superior touch-sensing performance
- Low-power wake-on-touch approach using a ganged sensor (power consumption is optimized for battery-powered devices)

Do the following to use the example. For a detailed description of the project, see the example's README file in the GitHub repository or from the application's top-level directory when the example is created using ModusToolbox™ software.

***Note**: At any point in time, if you overwrite the OOB example, you can restore it by programming the PSoC™ 4: CY8CPROTO-040T demo code example. See Creating a project and program/debug using ModusToolbox™ software for programming the board.*

1. Connect the board to the PC using the USB cable through the KitProg3 USB connector, as shown in Figure 6.

2 Kit operation

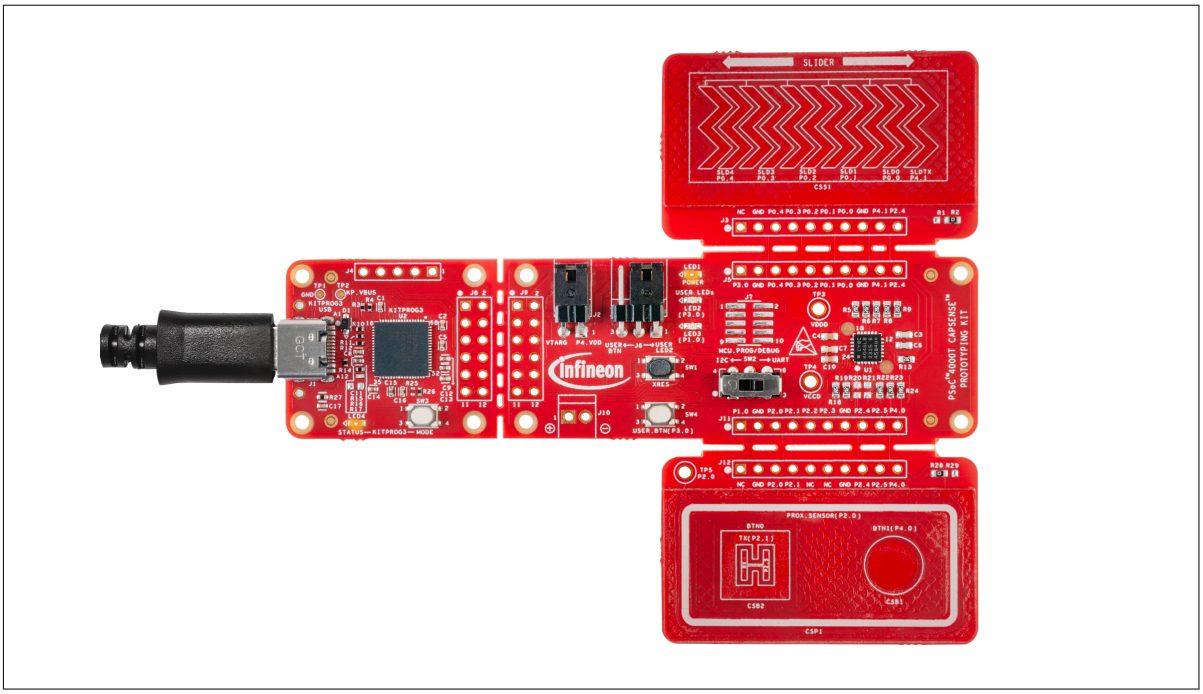

Figure 6 Connect the USB cable to the USB connector on the board

2. Touch the self-capacitance-based button(CSB1) or the mutual-capacitance-based button(CSB2) with the finger and observe the LED2 turns ON, as shown in Figure 7.

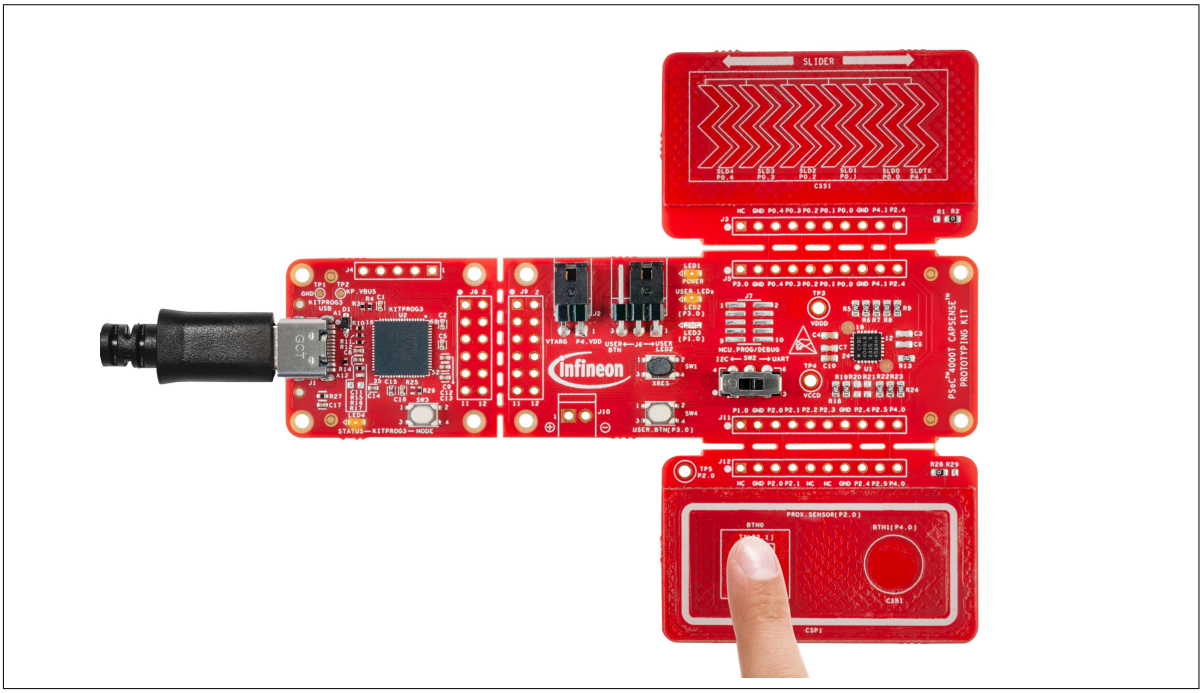

Figure 7 CAPSENSE™ button operation with LED indication

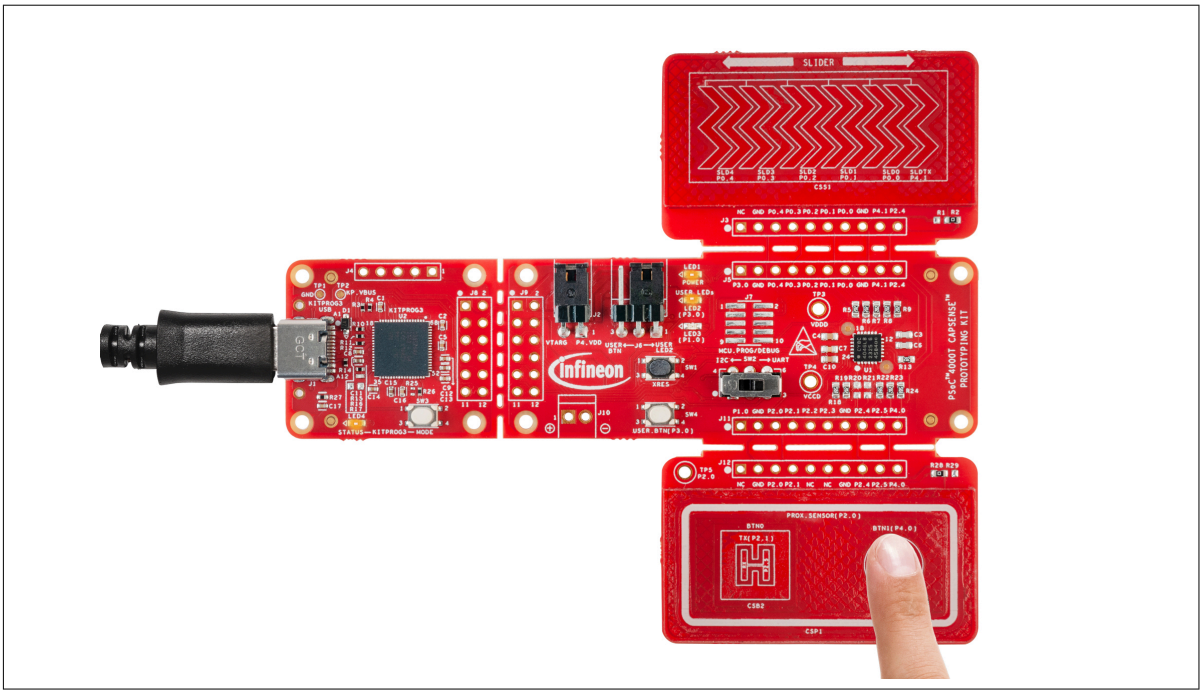

Figure 8 CAPSENSE™ button operation with LED indication

3. Touch the slider with the finger and observe that LED3 turns ON, as shown in Figure 9. The LED brightness will vary based on the touch position. Move the finger along the slider to observe this variation.

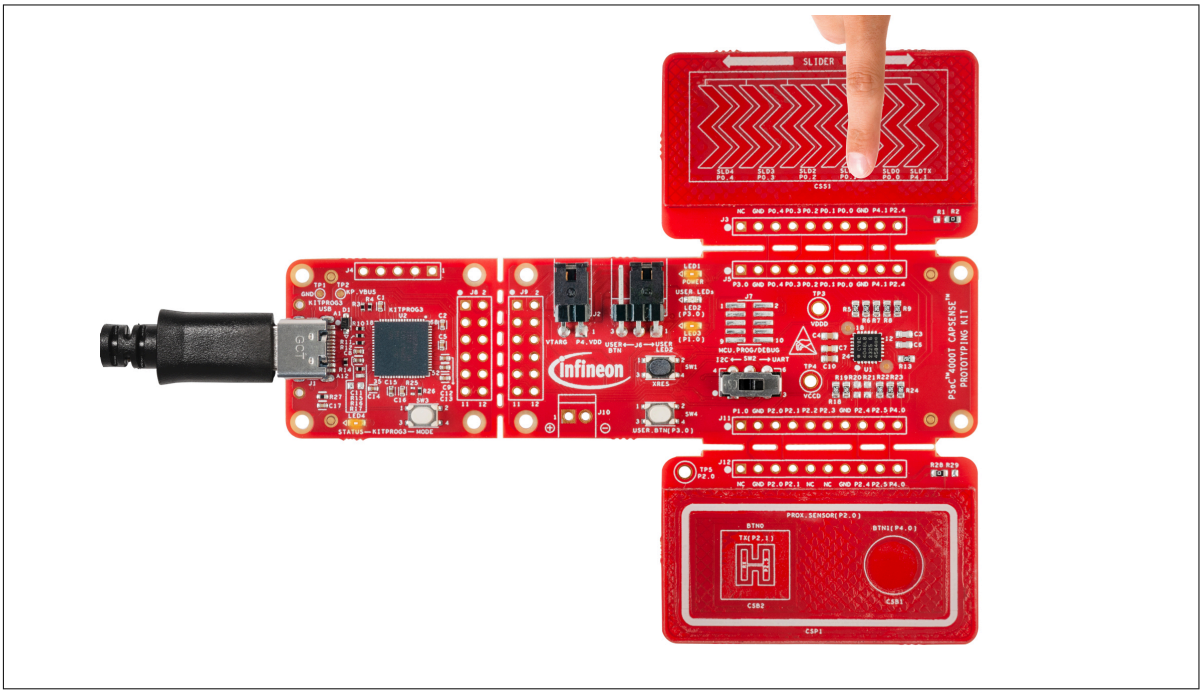

Figure 9 Capacitive slider operation with LED indication

4. Evaluate the low-power performance by measuring the current values in active, active low refresh rate, and wake-on-touch modes as explained in the “Measure current at different application states” section of the code example’s README

***Note**: More code examples are available in the Eclipse IDE for the ModusToolbox™ software (see Figure 13) or on the GitHub page dedicated to ModusToolbox™ software-based examples to evaluate the board such as the following:*

- PSoC™ 4: MSCLP Low Power CSD Button
- PSoC™4: MSCLP Low Power CSX Button
- PSoC™ 4: MSCLP Low Power CSD Slider

2.3 Creating a project and program/debug using ModusToolbox™ software

This section briefly introduces the project creation, programming, and debugging using the ModusToolbox™ software. For detailed instructions, see **Help** > **ModusToolbox™ General Documentation** > **ModusToolbox™ User Guide**.

1. Connect the board to the PC using the USB cable through the KitProg3 USB connector (**J1**).

The kit enumerates as a USB composite device if you are connecting it to the PC for the first time. KitProg3 operates in CMSIS-DAP Bulk mode; the status LED4 (amber) is always ON in CMSIS-DAP Bulk mode.

If you do not see the correct LED status, see the KitProg3 user guide for details on the KitProg3 status and troubleshooting instructions.

For updating the KitProg3 firmware, see the "Updating KitProg3" section in the KitProg3 user guide. For commands, see the Firmware Loader user guide.

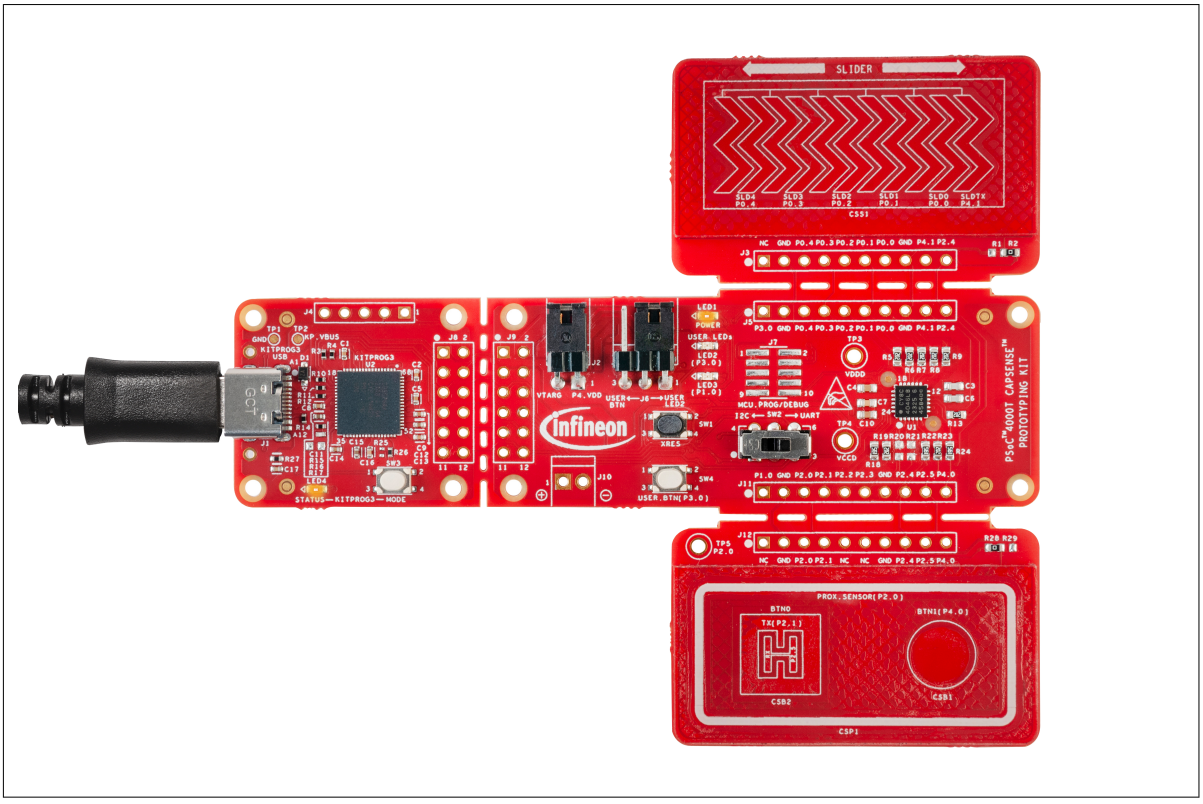

Figure 10 Connect the USB cable to the USB connector on the board

2. Import the required code example (application) into a new workspace in Eclipse IDE for theModusToolbox™ software.

a. Click **New Application** on the **Quick Panel**.

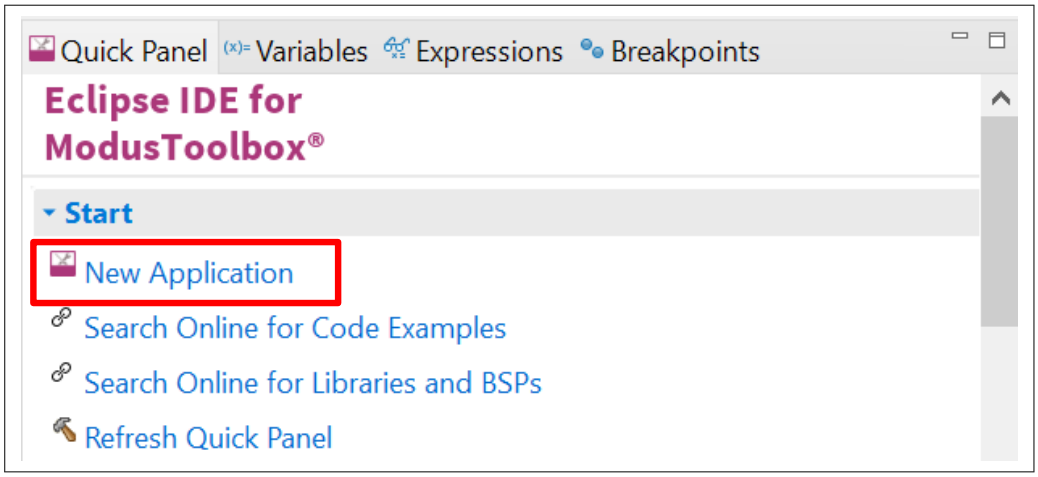

Figure 11 New Application in Quick Panel

In **Choose Board Support Package (BSP) - Project Creator 2.0** window, expand PSoC™ 4 BSPs, select **CY8CPROTO-040T**, and click **Next**, as shown in Figure 12.

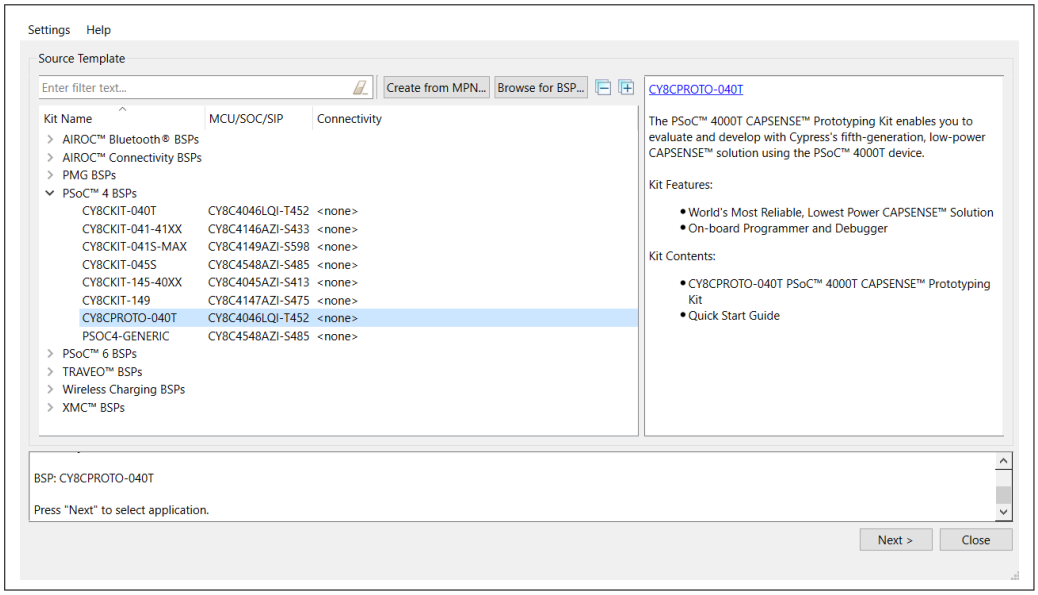

Figure 12 Creating a new application: Choose Board Support Package

b. Select the required application and click **Create**, as shown in Figure 13.

The right pane shows the code example description and the link to view the README file on GitHub.

2 Kit operation

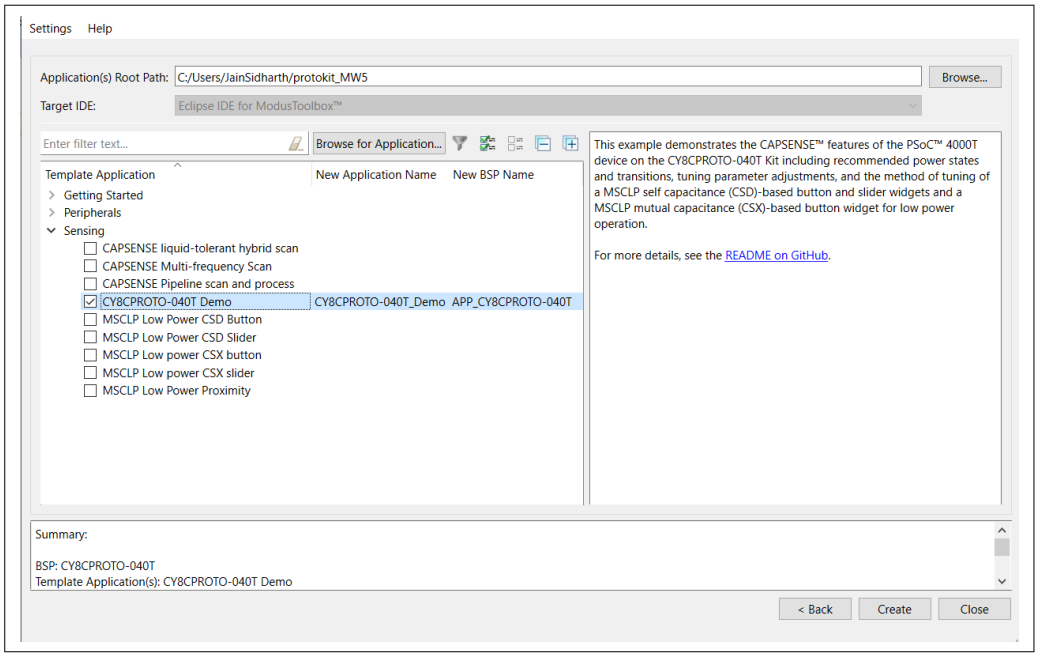

Figure 13 Creating a new application: Select Application

3. Select **<App_Name>** project in the **Project Explorer** tab to build and program a PSoC™ 4000T device application.

   In the **Quick Panel** tab, scroll to the Launches section, and click the **<App_Name> Program (KitProg3_MiniProg4)** configuration, as shown in Figure 14.

2 Kit operation

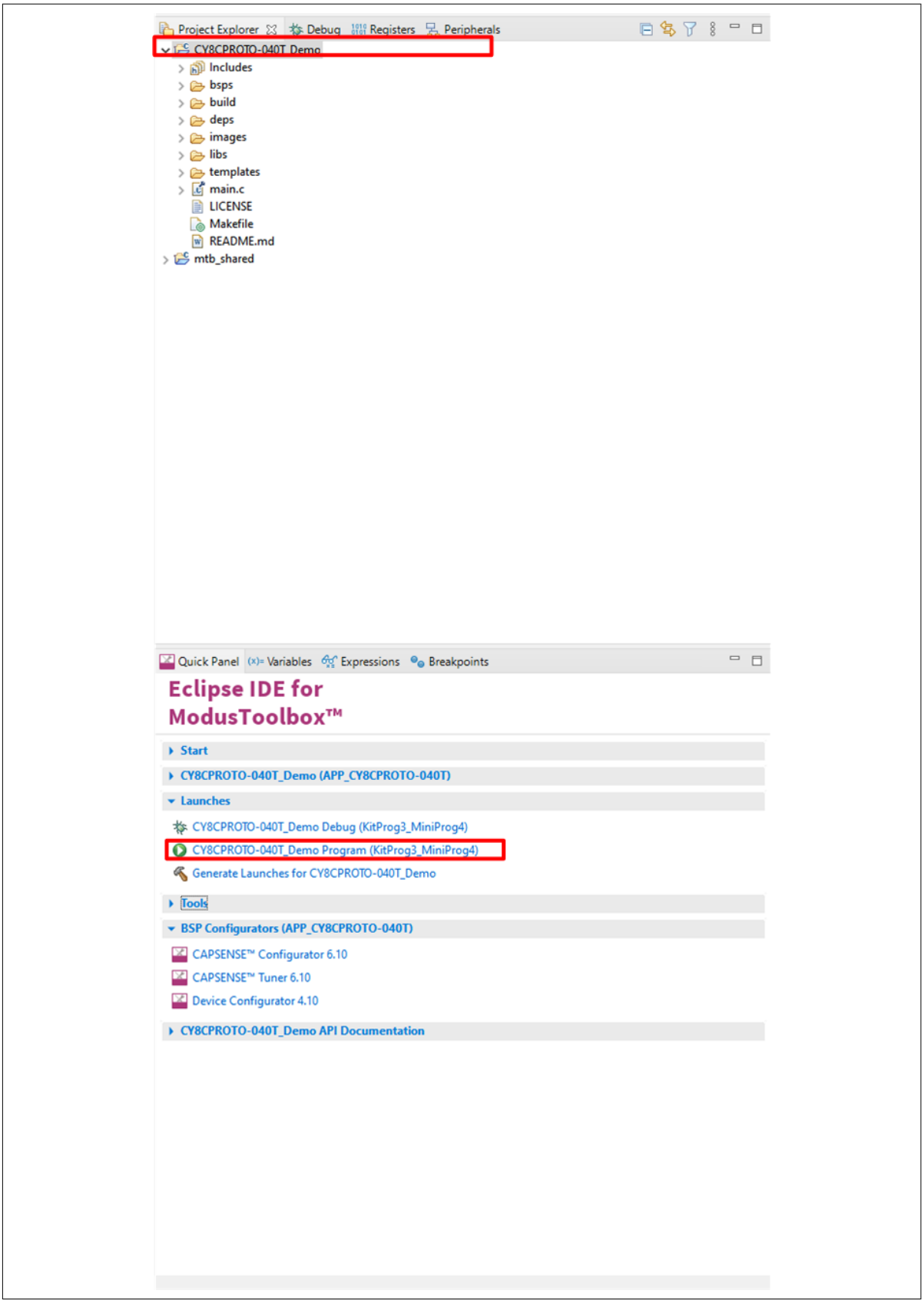

Figure 14 Building and programming the code example

4. ModusToolbox™ software has an integrated debugger. To debug a PSoC™ 4000T device application, in the **Project Explorer** tab, select **<App_Name>** project.

2 Kit operation

In the **Quick Panel**, scroll to the **Launches** section, and click the **<App_Name> Debug (KitProg3_MiniProg4)** configuration, as shown in Figure 16.

For a detailed explanation on how to debug using ModusToolbox™software, see "Program and debug" section in Eclipse IDE for ModusToolbox™ user guide.

***Note**: Debug is disabled by default in the Code Example to reduce power consumption. Enable Debug in the Device Configurator, as shown in Figure 15.*

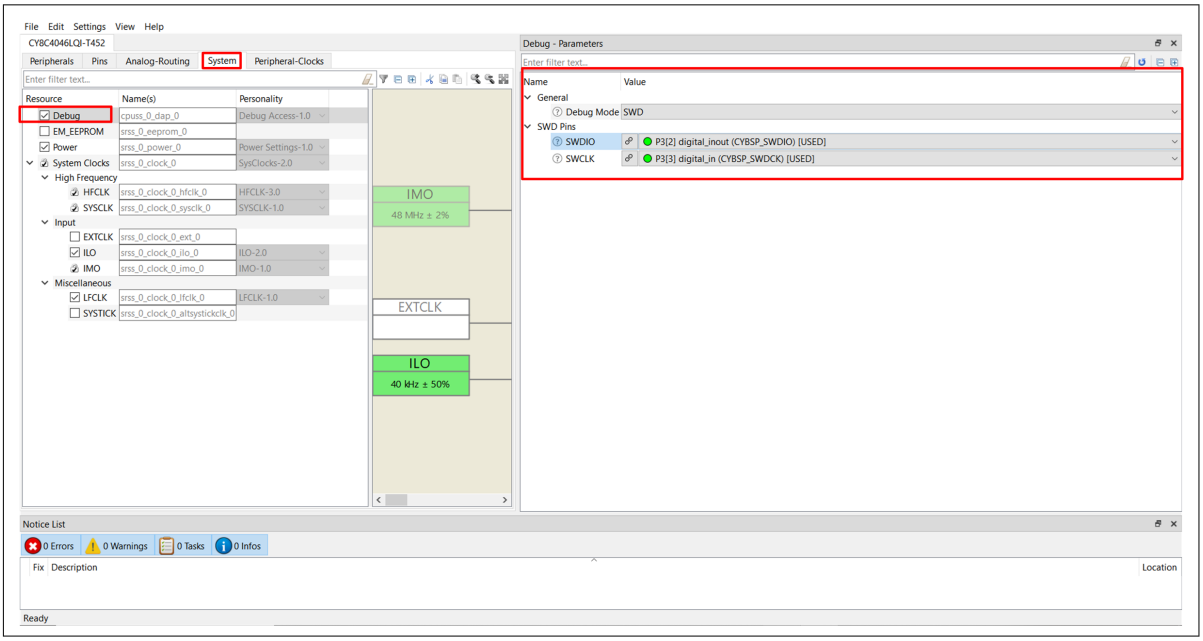

Figure 15 Enabling Debug in the Device Configurator

2 Kit operation

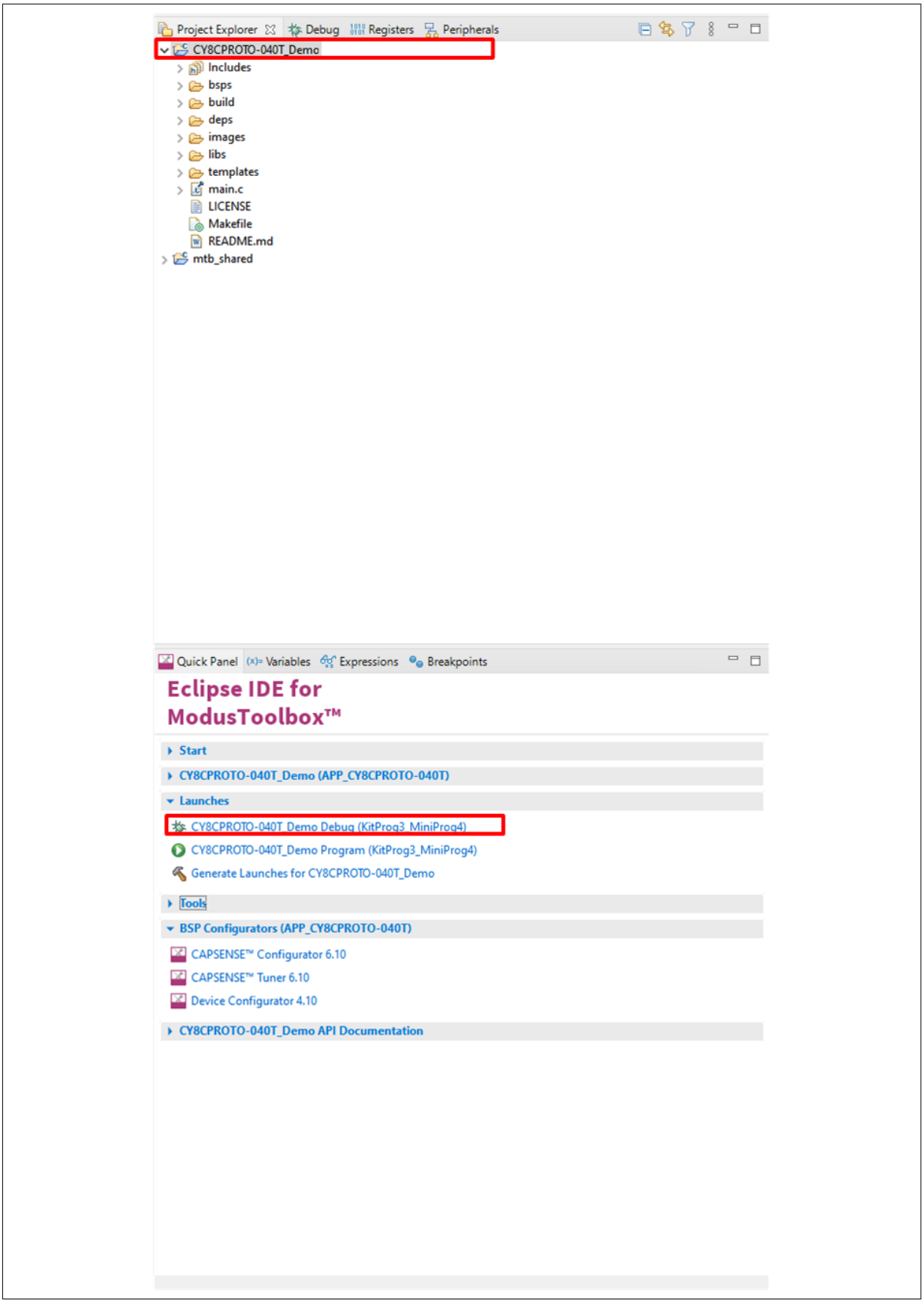

Figure 16 Debugging the code example

3 Hardware

3.1 Schematics

See the schematic files available on the kit webpage.

3.2 Functional description

This section describes the individual hardware blocks. The kit comes with a PSoC™ 4000T CAPSENSE™ Prototyping Board which consists of the PSoC™ 4000T device, KitProg3 programmer/debugger and bridge, CAPSENSE™ buttons supporting CSD and CSX modes, CAPSENSE™ proximity sensor, CAPSENSE™ 5-segment slider supporting both CSX and CSD mode, two user LED's, a user button, a DPDT slide switch for interface selection and other passives required for the essential operation of the kit.

3.2.1 PSoC™ 4000T MCU features

This kit features a PSoC™ 4000T MCU, a member of the PSoC™ 4 platform with scalable and reconfigurable architecture with an Arm® Cortex®-M0+ CPU. It combines a high-performance capacitive sensing subsystem, and programmable, reconfigurable analog and digital blocks.

For more information, see the PSoC™ 4000T MCU family datasheet.

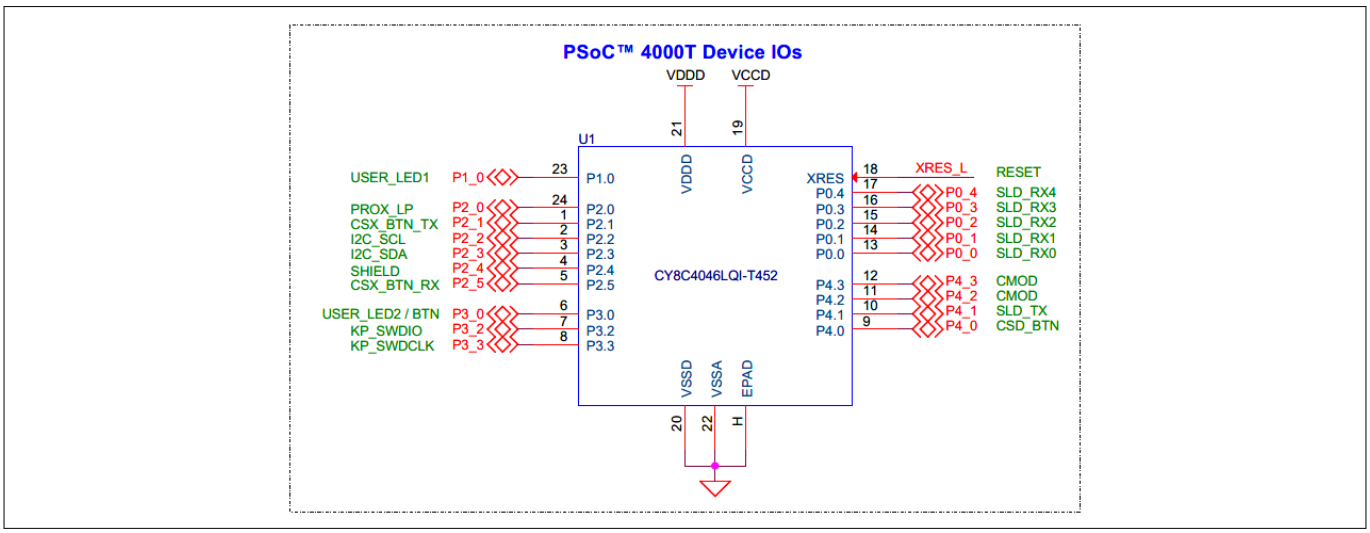

Figure 17 Schematics of the PSoC™ 4000T MCU

Table 4 Pin assignment of PSoC™ 4000T MCU in the Prototyping Kit

Pin details	Primary on board function	Secondary on board function
P0[0]	CAPSENSE™ slider RX0 (CSS1.RX0)	–
P0[1]	CAPSENSE™ slider RX1 (CSS1_RX1)	–
P0[2]	CAPSENSE™ slider RX2 (CSS1_RX2)	–
P0[3]	CAPSENSE™ slider RX3 (CSS1_RX3)	–
P0[4]	CAPSENSE™ slider RX4 (CSS1_RX4)	–
P1[0]	User LED 1 (LED3)	–
P2[0]	CAPSENSE™ proximity sensor (CSP1)	–

(table continues...)

Table 4 (continued) Pin assignment of PSoC™ 4000T MCU in the Prototyping Kit

Pin details	Primary on board function	Secondary on board function
P2[1]	CAPSENSE™ CSX button TX (CSB2_TX)	–
P2[2]	KitProg3 I2C interface clock (KP_ SCL)	KitProg3 UART interface TX (KP_ UART_TX)
P2[3]	KitProg3 I2C interface data (KP_ SDA)	KitProg3 UART interface RX (KP_ UART_RX)
P2[4]	CAPSENSE™ driven shield (SHIELD)	–
P2[5]	CAPSENSE™ CSX button RX (CSB2_RX)	–
P3[0]	User LED 2 (LED2)	User Button
P3[2]	SWD interface data I/O – SWDIO	–
P3[3]	SWD interface clock – SWDCLK	–
P4[0]	CAPSENSE™ CSD button (CSD_BTN)	–
P4[1]	CAPSENSE™ slider TX (CSS1_TX4)	–
P4[2]	CAPSENSE™ CMOD1	–
P4[3]	CAPSENSE™ CMOD2	–
XRES	Hardware reset	–

3.2.1.1 PSoC™ 4000T device power

The PSoC™ 4000T device has two distinct modes of operation, each with its own power supply requirements. In mode 1, the chip can be powered by an external power supply that ranges from 2.0 V to 5.5 V, which is ideal for battery-powered operation. The internal regulator of the PSoC™ 4000T device supplies the internal logic, and its output is connected to the VCCD pin. To ensure proper functioning, the VCCD pin must be bypassed to the ground via an external capacitor of 2.2 µF (X5R ceramic or better). It must not be connected to anything else.

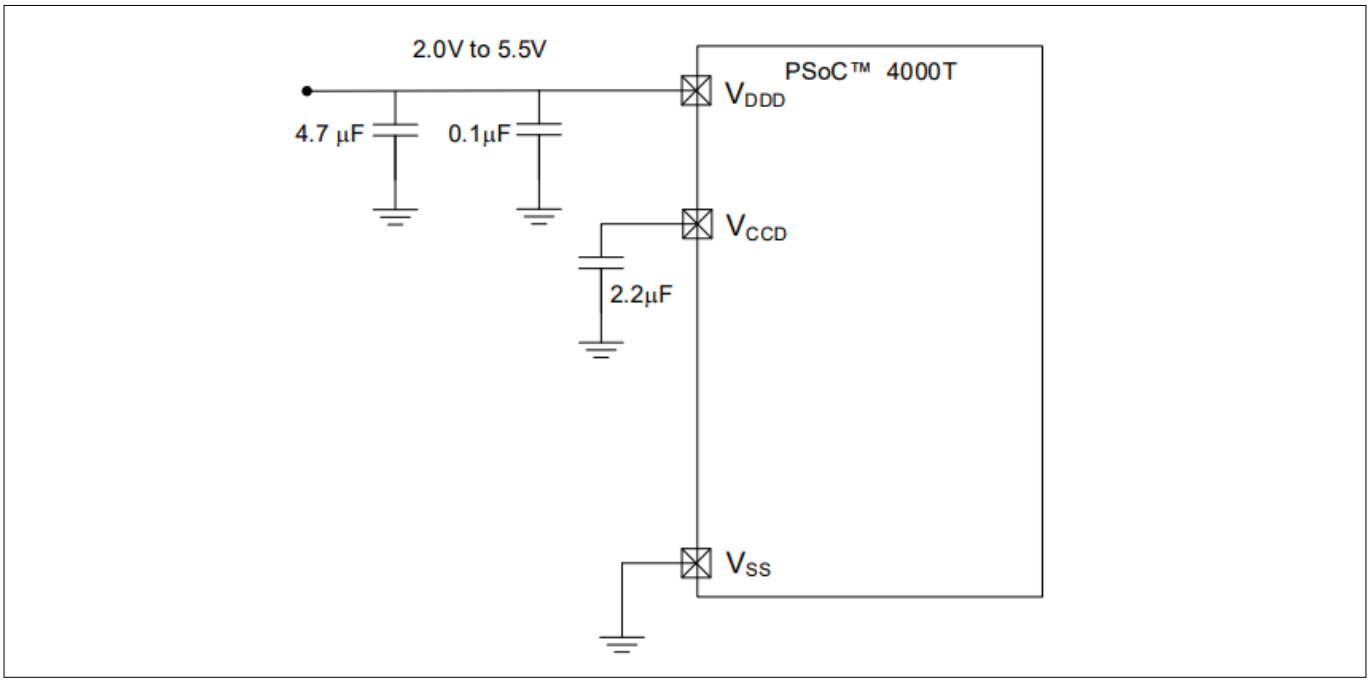

Figure 18 PSoC™ 4000T device schematic with 2.0 V to 5.5 V external supply

In mode 2, the power supply must be regulated externally and must be within the range of 1.71 to 1.89 V, which includes the power supply ripple. In this mode, the VDDD, and VCCD pins are shorted together and bypassed. The internal regulator must be kept enabled. To optimize bypassing, bypass capacitors must be used from VDDD to ground. The standard practice is to use a capacitor in parallel with a smaller capacitor (0.1 µF, for example).

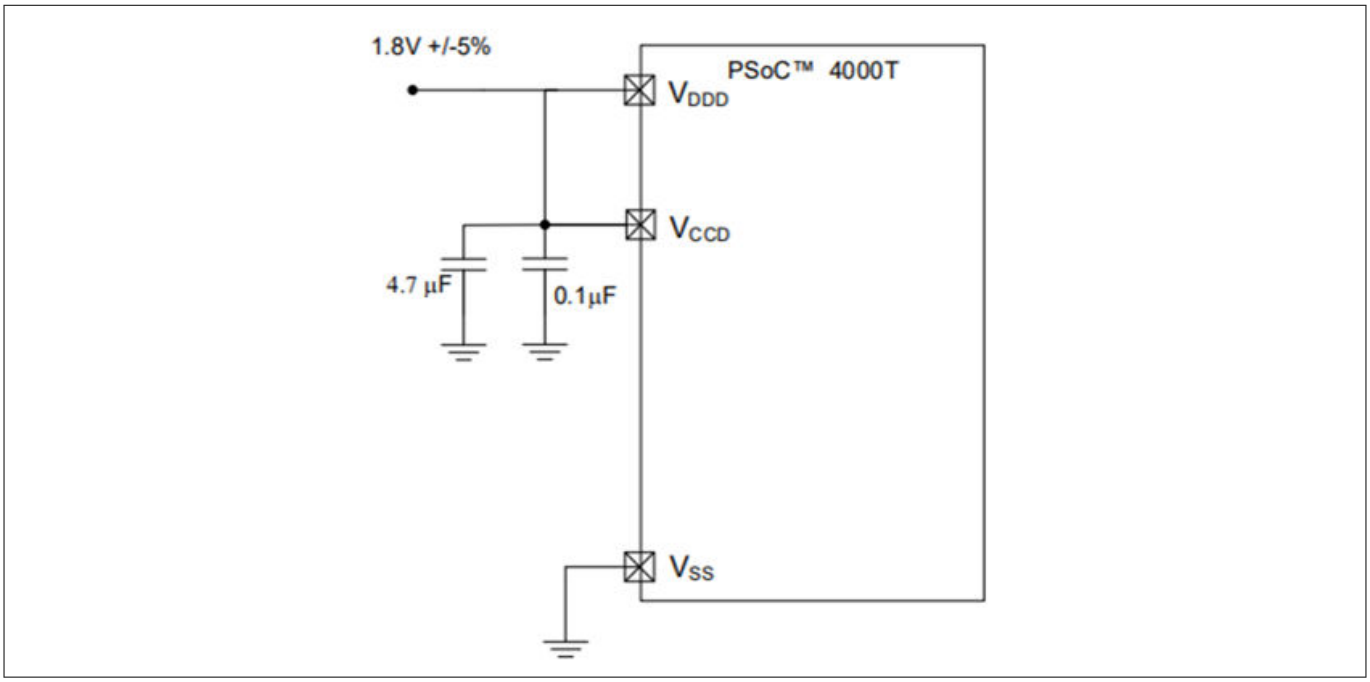

Figure 19 PSoC™ 4000T device schematic with 1.8 V ±5% external supply

The PSoC™ 4000T device on the prototyping board operates at 5 V in default configuration (in mode 1). The target voltage for the PSoC™ 4000T device is supplied through a Ferrite bead (**FB2**) to filter the noise on the power rail. Provisions are provided for powering a kit in which if the target MCU voltage is configured to operate at 1.8 V (by feeding 1.8 V through an external power input or enabling 1.8 V LDO voltage-regulated supply), the PSoC™ 4000T device core-voltage supply **VCCD** is needed to short with **VDDD** by populating **R45** or by populating a **J13** header and shorting with a jumper (**ACC17**). The default configuration works for 3.3 V and 5 V operation.

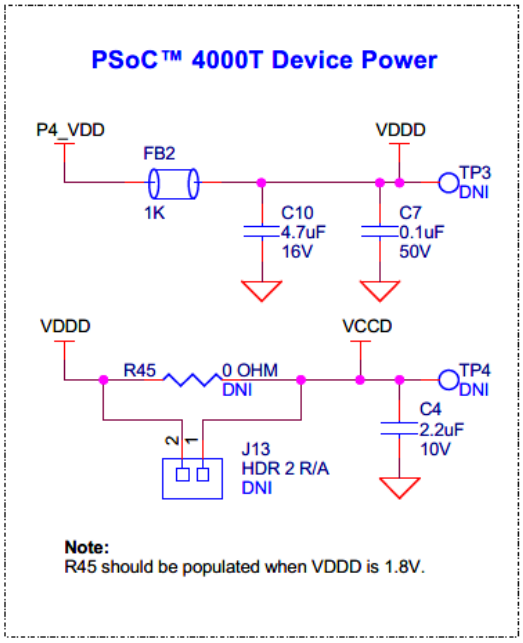

Figure 20 Schematic of PSoC™ 4000T device power

A set of decoupling capacitors are provided for both digital and core voltage rails of the MCU (**VDDD** and **VCCD**). Use header **J2** in the power rail of the PSoC™ 4000T target device to measure the current consumption at different modes of operation. By default, **J2** is shorted with a jumper (**ACC7**).

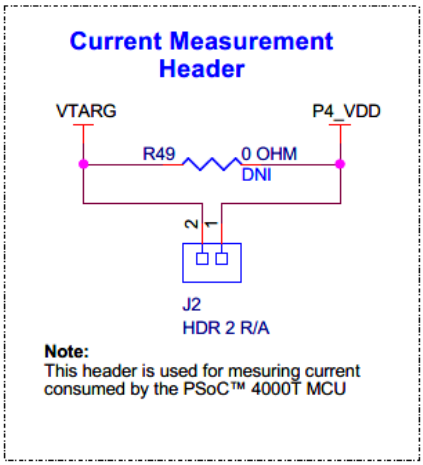

Figure 21 Current measurement header (J2) schematic

For current measurement, remove this jumper and connect it to a current measurement device (ammeter) between the pins of **J2**, as shown in Figure 22.

***Note**: Do not remove the jumper while the target device is powered.*

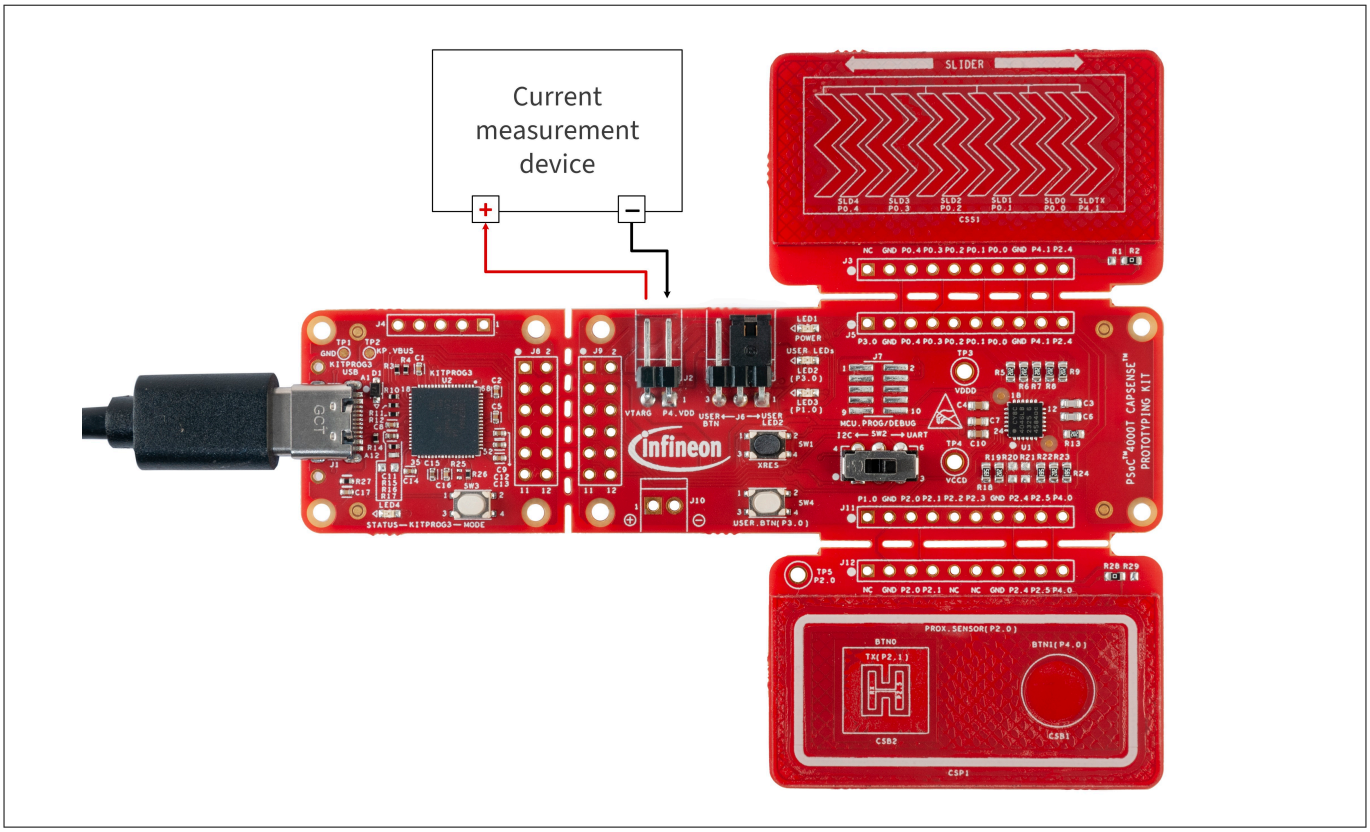

Figure 22 Connecting the current measurement device with the J2 header

The on board LED (**LED1**) indicates the status of PSoC™ 4000T device power.

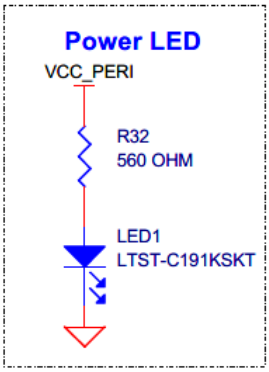

Figure 23 Schematic of power LED indication (LED1)

3.2.1.2 PSoC™ 4000T device external programming/debugging header

In the PSoC™ 4000T Prototyping Board, a default programming/debugging interface is through the onboard KitProg3 programmer/debugger. In addition, you can use an external MiniProg4 programmer/debugger through the 10-pin header (**J7**) provision (not populated by default).

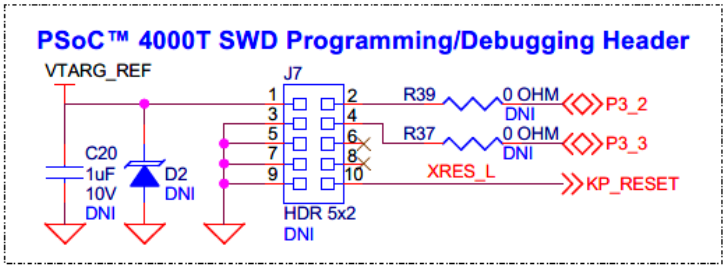

Figure 24 Schematic of PSoC™ 4000T device 10-pin programming/debugging header

For using the external programming/debugging interface, populate **J7**, **D2**, **C20** and resistors **R37**, **R39** and depopulate **R38**, **R40**.

3.2.1.3 PSoC™ 4000T device I2C/UART interface selection

The PSoC™ 4000T device can be interfaced with an onboard KitProg3 over I2C or UART using a DPDT slide switch **SW2**. By default, SW2 is positioned to select the I2C interface. For enabling the UART interface, the **SW2** position must be changed from the default position.

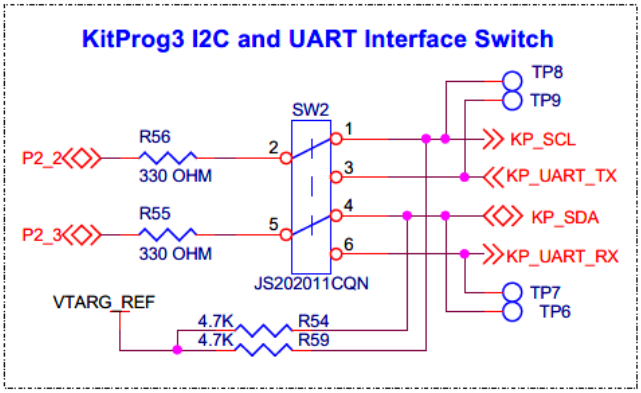

Figure 25 Schematic of PSoC™ 4000T device I2C/UART interface selection switch

3.2.1.4 Reset button

Use the push button (**SW1**) on the PSoC™ 4000T CAPSENSE™ Prototyping Board to reset the PSoC™ 4000T. **SW1** provides an active LOW signal.

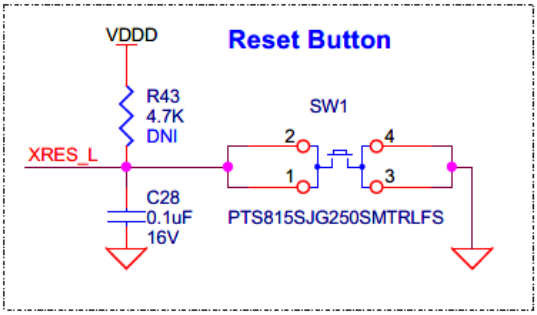

Figure 26 Reset button (SW1) schematic

3.2.2 PSoC™ 5LP-based KitProg3 programmer and debugger

An onboard PSoC™ 5LP (CY8C5868LTI-LP039 - **U2**) device is used as the KitProg3 programmer/debugger to program and debug the PSoC™ 4000T device. The PSoC™ 5LP device is connected to the USB port of a PC through a Type-C USB connector and to the SWD and other communication interfaces of the PSoC™ 4000T device.

For more information, see the following:

- PSoC™ 5LP webpage
- CY8C58LPxx family datasheet

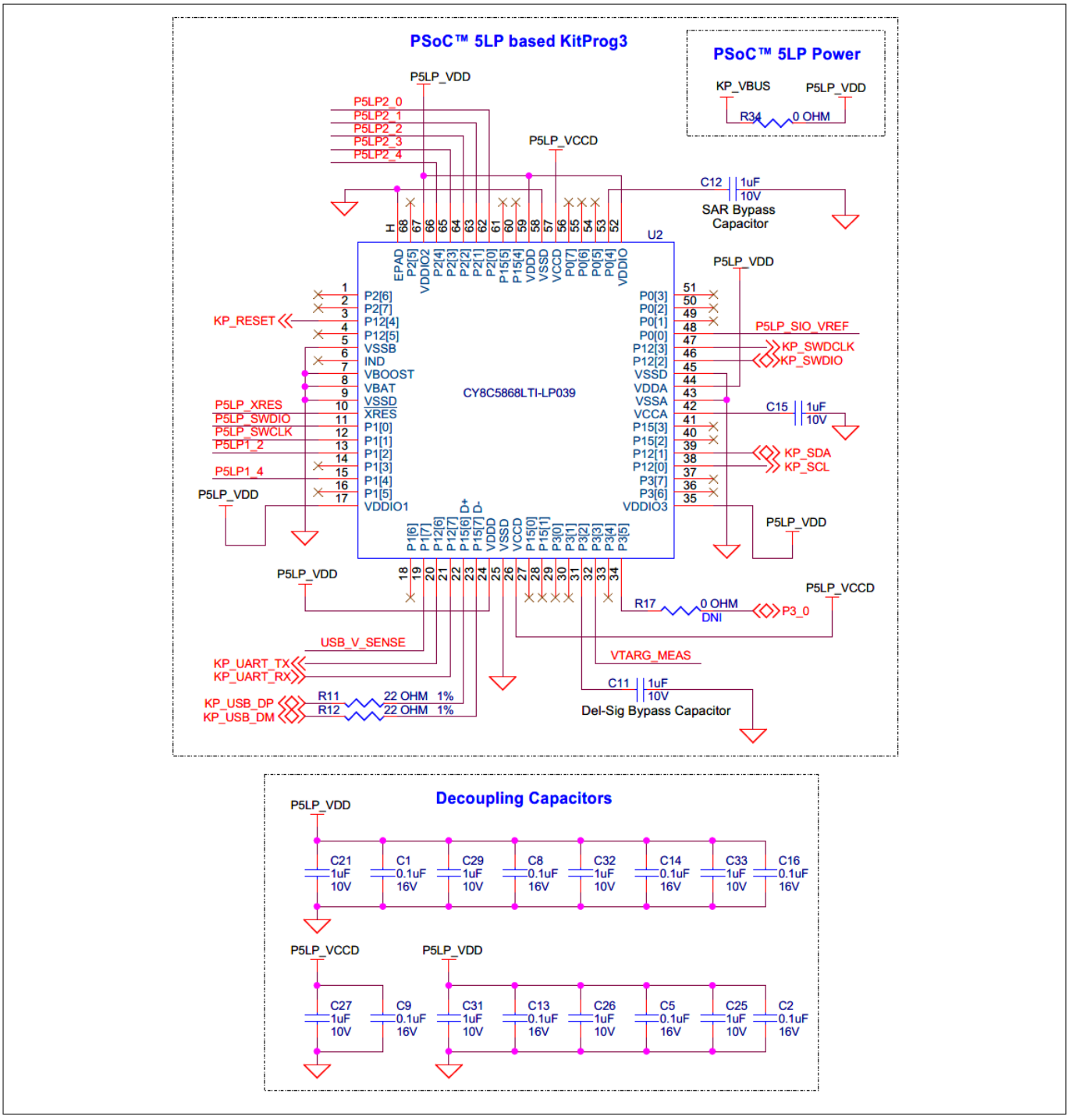

Figure 27 Schematic of PSoC™ 5LP-based KitProg3

3.2.2.1 KitProg3 onboard target voltage measurement

PSoC™ 5LP of KitProg3 uses an ADC to measure the onboard target voltage. There is a voltage divider before the ADC input to bring the target voltage within the dynamic range.

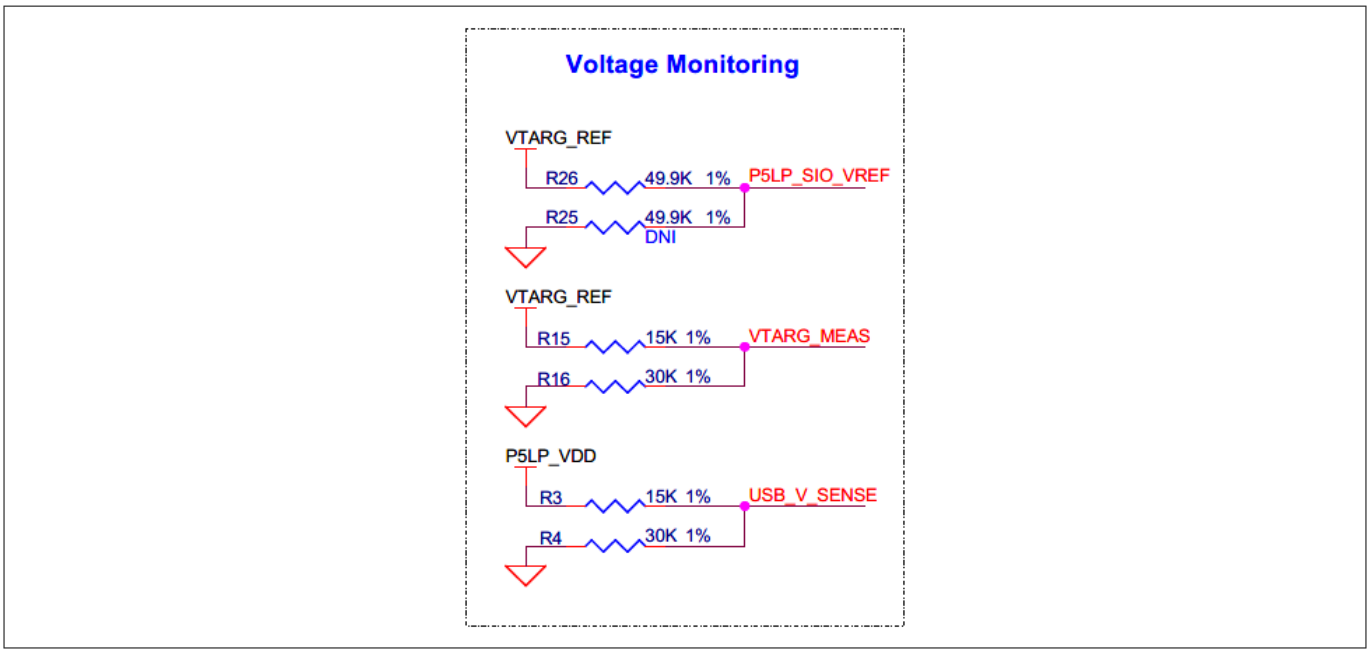

Figure 28 Schematic of KitProg3 onboard target voltage monitoring circuit

3.2.2.2 KitProg3 programming mode selection button and status LED

Use the **SW3** button to switch between various modes of KitProg3 operation (from CMSIS-DAP HID to BULK mode, enabling the boot loader mode). Note that KitProg3 on this board supports the CMSIS-DAP BULK mode by default. This button function is also reserved for future use. The status LED (**LED4**) indicates the current mode of KitProg3. For more details, see the KitProg3 user guide.

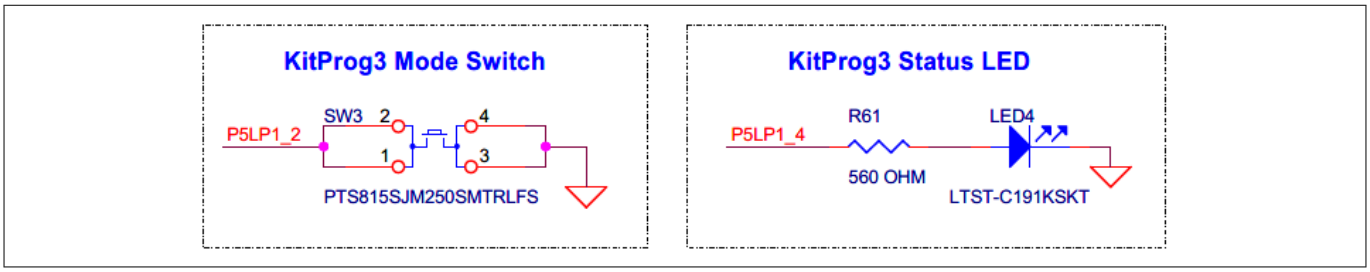

Figure 29 Schematic of KitProg3 mode selection button (SW3) and status LED (LED4)

3.2.3 Power supply system

This prototyping board has a default input supply from the USB Type-C connector (**J1**) with low-capacitance bidirectional TVS diodes (**D1** and **U3**). This provides the ESD and overvoltage protection (OVP) for both power and data signals. Additionally, this provides the 5 V supply for the target MCU through a ferrite bead (**FB1**).

Figure 30 shows the power block diagram of the PSoC™ 4000T CAPSENSE™ Prototyping Board with a default input supply.

3 Hardware

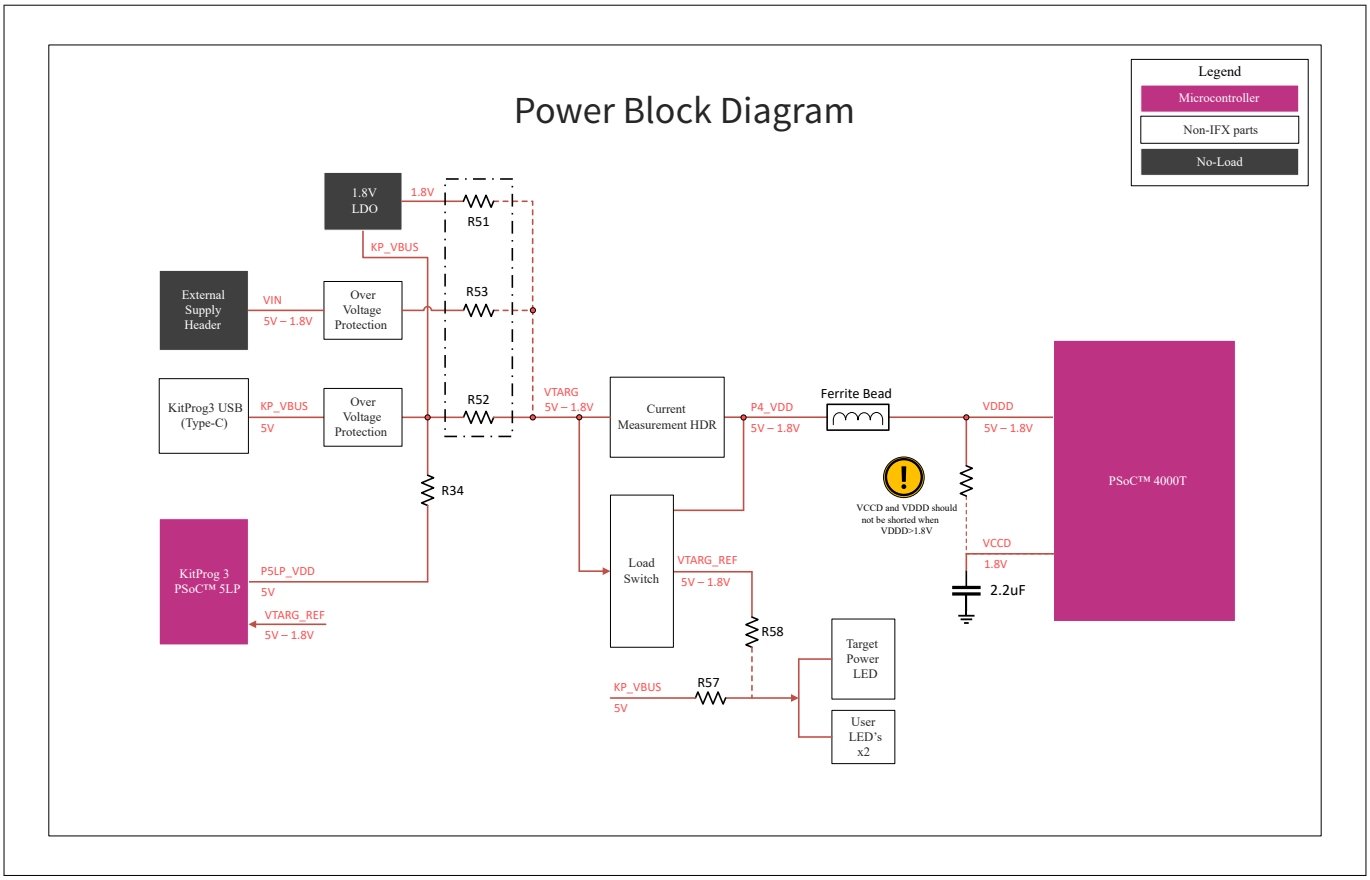

Figure 30 Power block diagram

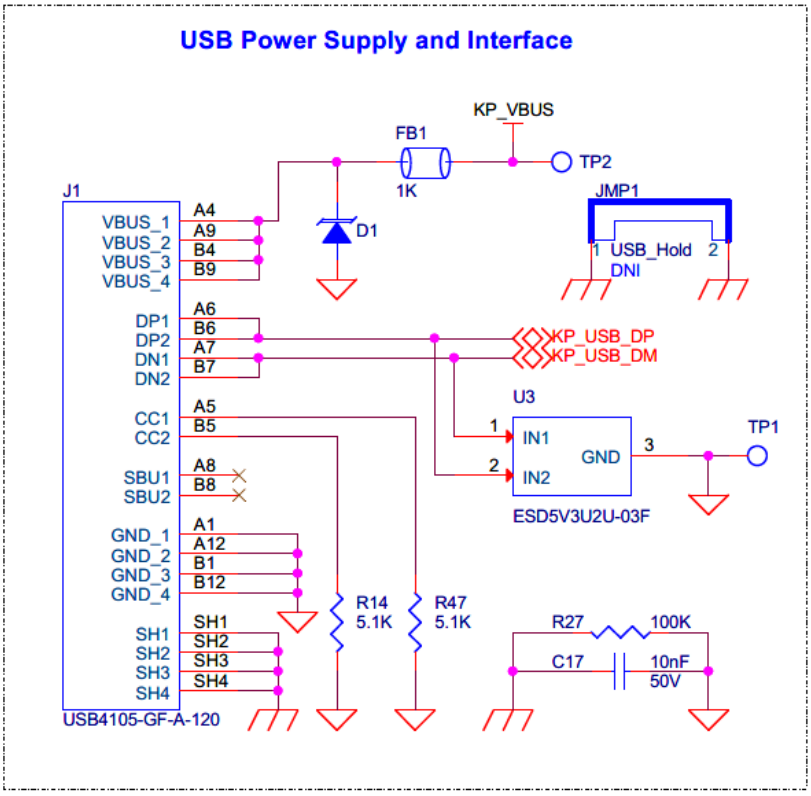

Figure 31 Schematic of USB Type-C connector (J1) and ESD protection (D1, U3)

3 Hardware

This board has a provision of a linear voltage regulator at **U4** for powering the PSoC™ 4000T device with a regulated 1.8 V supply derived from the 5 V supply coming from the USB Type-C connector.

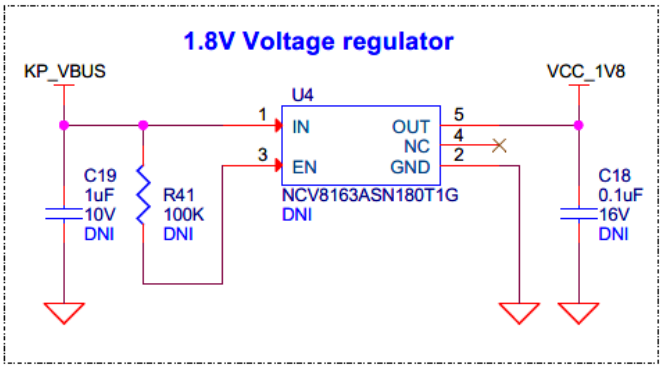

Figure 32 Schematic of a 1.8 V voltage regulator (U4)

The header **J10** (not populated by default) can be used as an external power supply input to power the PSoC™ 4000T device from 1.8 V to 5 V.

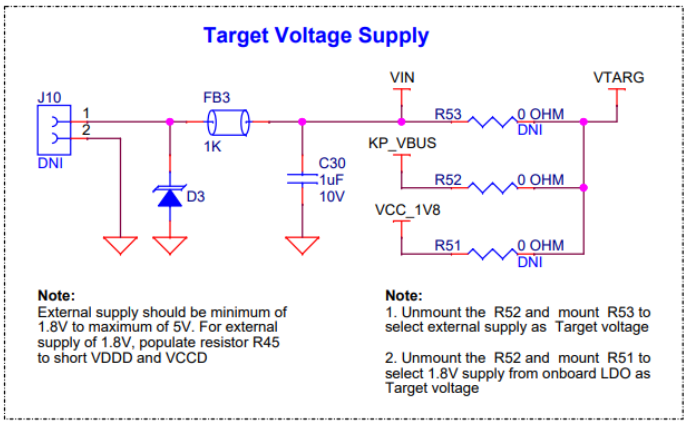

Figure 33 Schematic of external power supply input (J10)

These powering options enable the kit to operate at different voltages by enabling these provisions and a selection-required powering option by populating the corresponding selection resistors (by populating any one of the **R53**, **R52**, and **R51** resistors).

***Note**: If the supply voltage (VDDD) is 1.8 V, short the PSoC™ 4000T device core supply VCCD with VDDD using the resistor R45, as shown in* Figure 34*.*

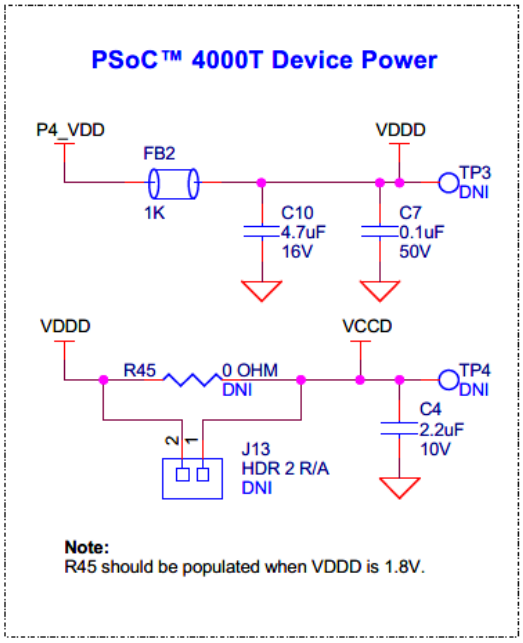

Figure 34 Schematic of PSoC™ 4000T device power

3.2.3.1 Target reference voltage switch

A load switch **U5** is used to generate target reference voltage to isolate the leakage currents by the voltage divider used for target voltage measurement.

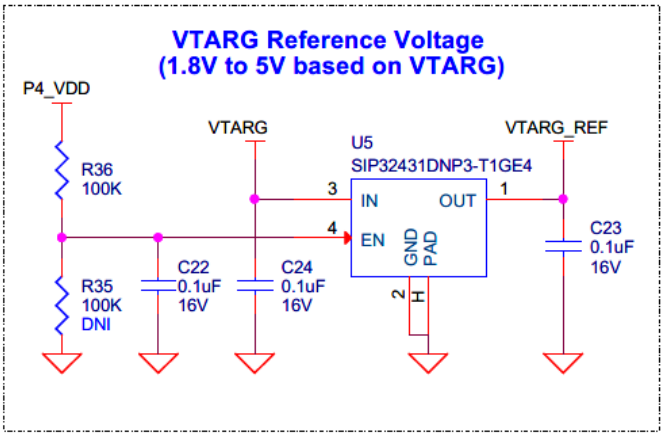

Figure 35 Schematic of target reference voltage switch (U5)

3.2.4 CAPSENSE™

3.2.4.1 Capacitive sensing

The PSoC™ 4000T Prototyping Board consists of the following:

- A 5-segment CAPSENSE™ Slider (CSS1), which supports both CSX and CSD modes
- Two CAPSENSE™ buttons (CSB1 and CSB2), in which CSB1 supports only CSD mode, and CSB2 supports both CSD and CSX modes
- A proximity sensor (CSP1)

Two external modulation capacitors (CMOD capacitors C3 and C6) on the board enable the CAPSENSE™ functionality. The board supports a driven shield that can drive the hatch pattern surrounding the sensor region; by default, all the hatch patterns are connected to the shield.

For details on using CAPSENSE™, including design guidelines, see the PSoC™ 4 and PSoC™ 6 MCU CAPSENSE™ design guide.

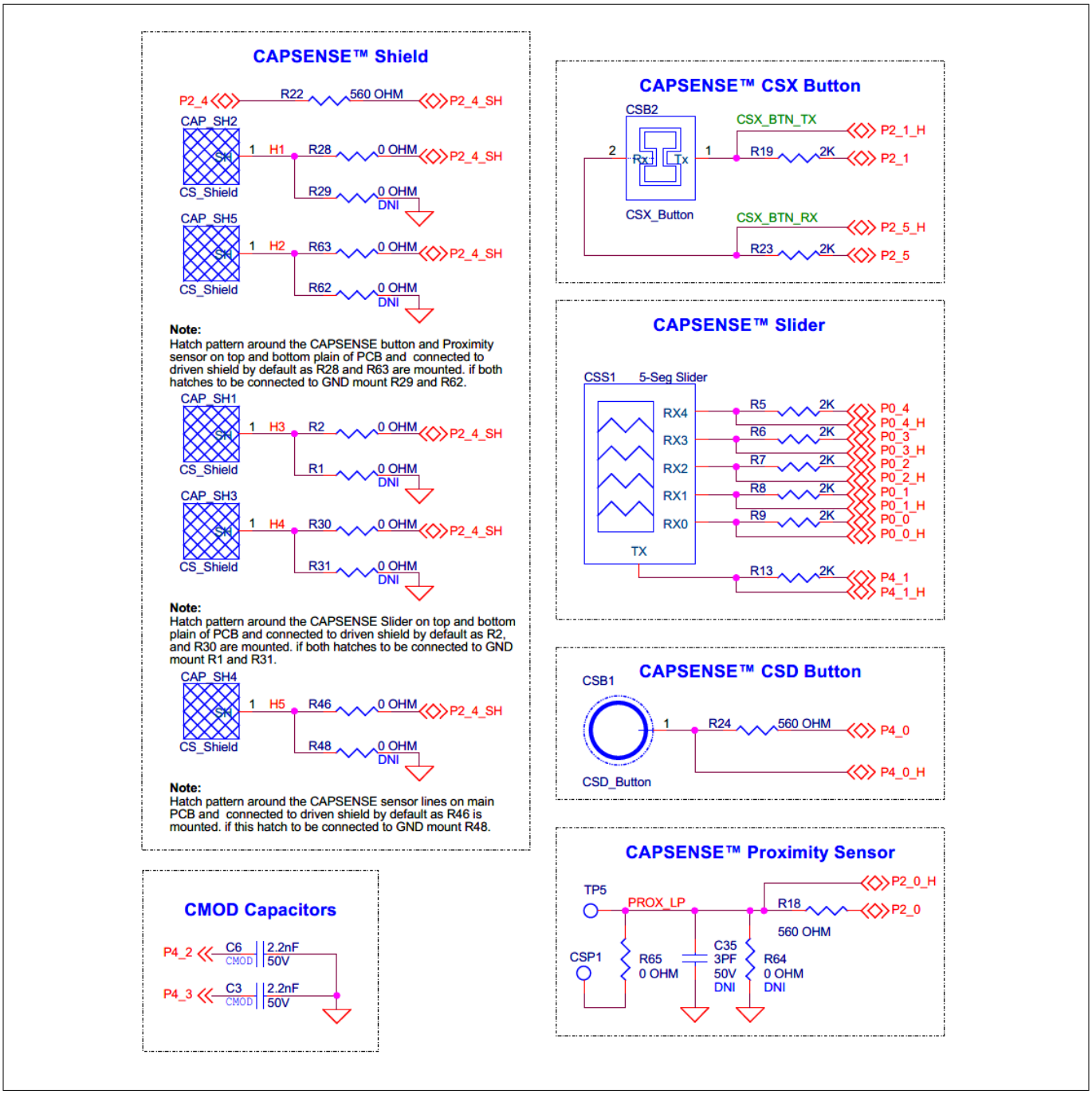

Figure 36 Schematic of capacitive sensing widgets

3.2.5 User LEDs

The PSoC™ 4000T CAPSENSE™ Prototyping Board has the following two user LED's: **LED2** and **LED3**. These LED's are driven by the **Q1** MOSFET to isolate the LED current from the PSoC™ 4000T device current (GPIO peripheral current consumption will be still a part of PSoC™ 4000T device current). By default, LED's are driven from the

KP_VBUS USB power input. There is a provision provided on the board to drive LED's from the **VTARG_REF** power rail.

Note: *P3.0 is shared between **LED2** and **SW4** through a 3-pin header where you can select either of them by populating the jumper between **J6.1**, **J6.2** or **J6.2**, **J6.3**.*

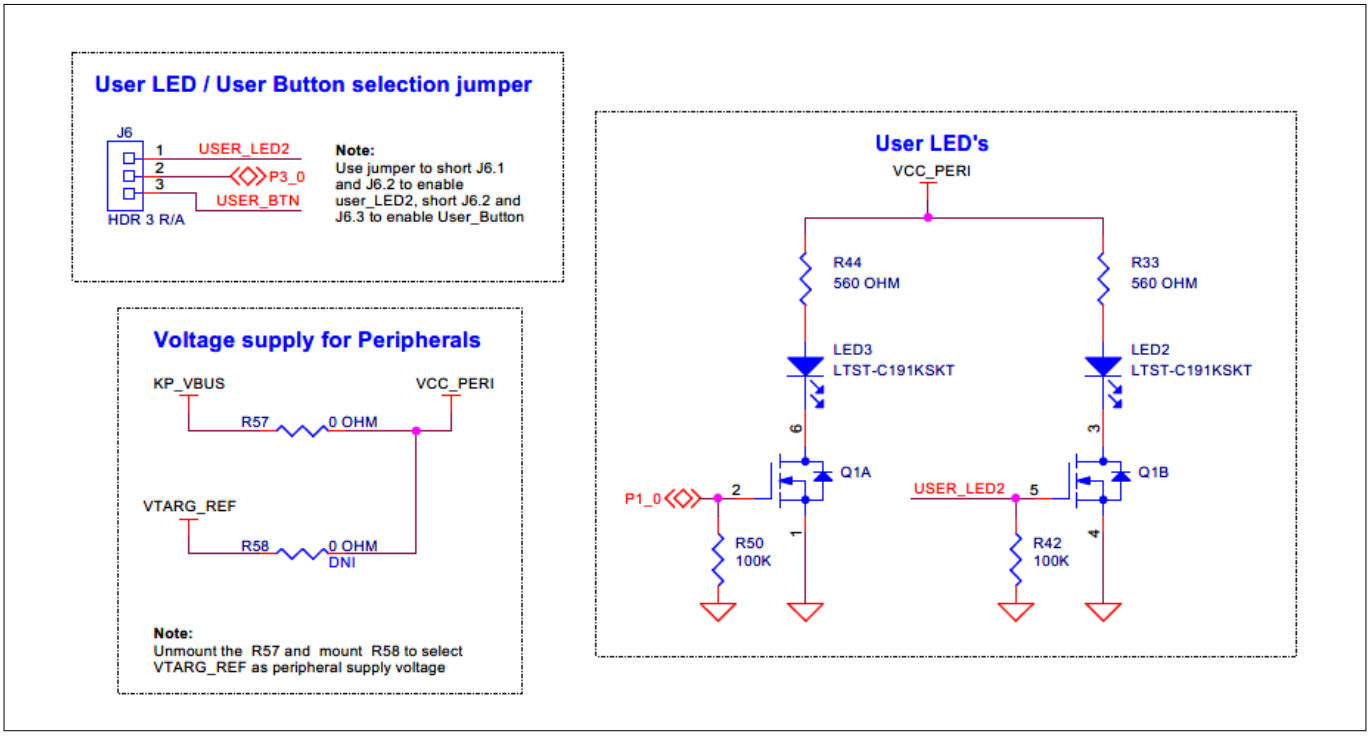

Figure 37 User LED's schematic

3.2.6 User button

The PSoC™ 4000T CAPSENSE™ Prototyping Board has a user button **SW4** connected to **P3[0]** of the PSoC™ 4000T device through a 3-pin header **J6** by shorting **J6.2** and **J6.3**.

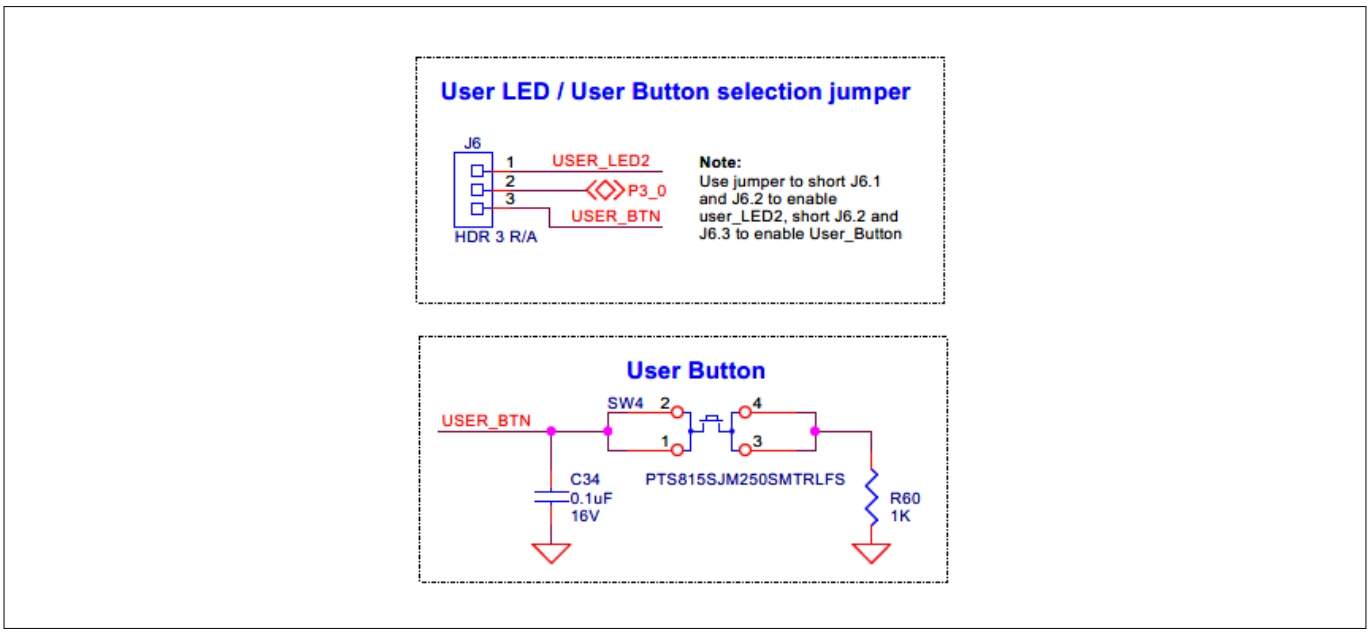

Figure 38 User button schematic

3.3 CY8CPROTO-040T kit rework for evaluating additional features

This section explains modifications to the board to evaluate different features that are not available out of the box.

3.3.1 Enabling the external programming/debugging interface to PSoC™ 4000T device

The default programming/debugging interface for PSoC™ 4000T device is the on-board KitProg3. A 10-pin header (**J7**) is provided on the kit to interface an external programmer such as MiniProg4. By populating the **J7** header and the series resistors (**R39**, **R37**), MiniProg4 can be directly connected to PSoC™ 4000T device.

The prototyping board also has a provision for ESD and decoupling capacitors for **VTARG** power rail. To enable ESD protection, populate **D2**. To filter the noise on the target reference voltage, populate **C20**.

Table 5 Rework components with reference and manufacturer details

Reference	Description	Manufacturer	Manufacturer part number
J7	CONN, HDR, MALE, DUAL, 10POS, 1.27 mm, GOLD, STR, SMD	Samtec	FTSH-105-01-L-DV-K-P-TR
D2	DIO, TVS, UNIDIR, 5 V, 18.6 V, 174 W, SOD-523	MCC	ESD5V0D5-TP
C20	CAP, CER, 1 uF, 10%, X5R, 10 V, 0402	Yageo	CC0402KRX5R6BB105
R39, R37	RES, Fixed, 0 OHM, JUMPER, 1A, 0603	Yageo	RC0603JR-070RL

Figure 39 shows the reworked schematic sections.

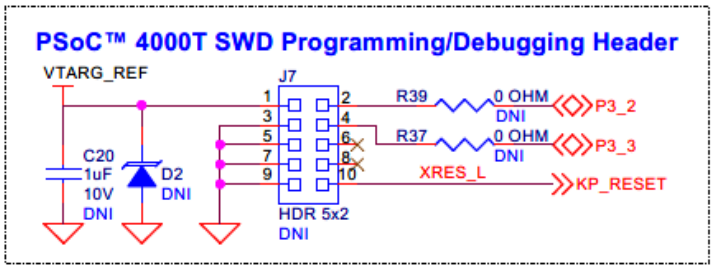

Figure 39 Schematic of rework regions to enable the external programming interface

Table 6 J7 header pin assignment for interfacing with MiniProg4

Pin details	Kit function	MiniProg4 interface function
J7.1	VTAR_REF, PSoC™ 4000T device voltage reference	VTARG, to sense the target MCU voltage
J7.2	P3[2], Port 3 Pin 2 GPIO of PSoC™ 4000T device that supports the SWD interface with an SWDIO signal connection to the target MCU	SWDCLK, SWD data in/out interface with the target MCU
J7.3	GND, ground reference of prototyping board	GND, ground reference of MiniProg4
J7.4	P3[3], Port 3 Pin 3 GPIO of PSoC™ 4000T device that supports the SWD interface with an SWDCLK signal connection to the target MCU	SWDIO, SWD clock interface with the target MCU
J7.5	GND, ground reference of prototyping board	GND, ground reference of MiniProg4
J7.6	N.C.	N.C.

(table continues...)

Table 6 (continued) J7 header pin assignment for interfacing with MiniProg4

Pin details	Kit function	MiniProg4 interface function
J7.7	GND, ground reference of prototyping board	GND, ground reference of MiniProg4
J7.8	N.C.	N.C.
J7.9	GND, ground reference of prototyping board	GND, ground reference of MiniProg4
J7.10	XRES_L, reset signal for PSoC™ 4000T device	XRES, reset signal for the target MCU

3.3.2 Enabling the external power input for PSoC™ 4000T device

A 2-pin screw terminal header (**J10**) provision is provided on prototyping board to interface an external power supply input for powering PSoC™ 4000T device by populating the J10 header and associated resistor (**R53**).

Table 7 Rework components with reference and manufacturer details

Reference	Description	Manufacturer	Manufacturer part number
J10	CONN, TERMINAL BLOCK, 2.54MM, 2POS, 6A, STR, TH	On Shore Technology Inc.	OSTVN02A150
R53	RES, Fixed, 0 OHM, JUMPER, 1A, 0603	Yageo	RC0603JR-070RL

Figure 40 shows the reworked schematic section.

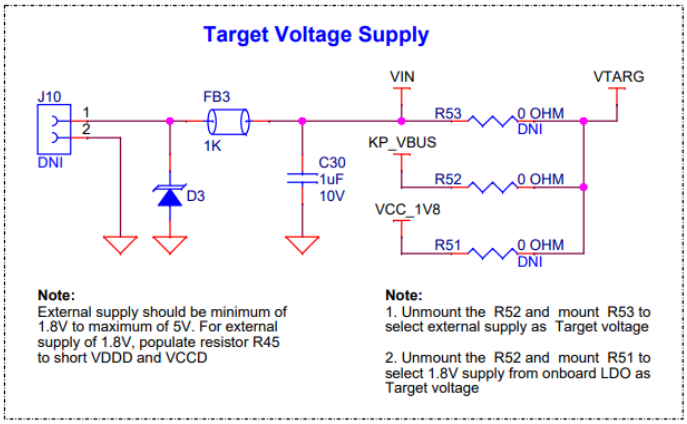

Figure 40 Schematic of rework regions to enable the external power input for PSoC™ 4000T device

3.3.3 Enabling 1.8 V supply for PSoC™ 4000T device

By default, PSoC™ 4000T device is powered by 5 V supply from USB Type -C connector. This board has provision of linear voltage regulator at **U4** for powering PSoC™ 4000T device with regulated 1.8 V supply, derived from the 5 V supply coming from USB Type-C connector.

Table 8 Rework components with reference and manufacturer details

Reference	Description	Manufacturer	Manufacturer part number
U4	IC, REG, LDO, 1CH, Fixed, 1.8 V, 0.25 A, 2.2 V to 5.5 V, TSOP-5	On Semi	NCV8163ASN180T1G

(table continues...)

Table 8 (continued) Rework components with reference and manufacturer details

Reference	Description	Manufacturer	Manufacturer part number
C19	CAP, CER, 1 µF, 10%, X5R, 10V, 0402	Yageo	CC0402KRX5R6BB105
C18	CAP, CER, 0.1 µF, 10%, X5R, 16V, 0402	Walsin	0402X104K160CT
R41	RES, Fixed, 100K, 5%, 1/16W, 0402	Yageo	RC0402JR-07100KL

Figure 41 shows the reworked schematic sections.

***Note**: Populate **R45** to short between VCCD and VDDD when PSoC™ 4000T device is powered with 1.8 V supply.*

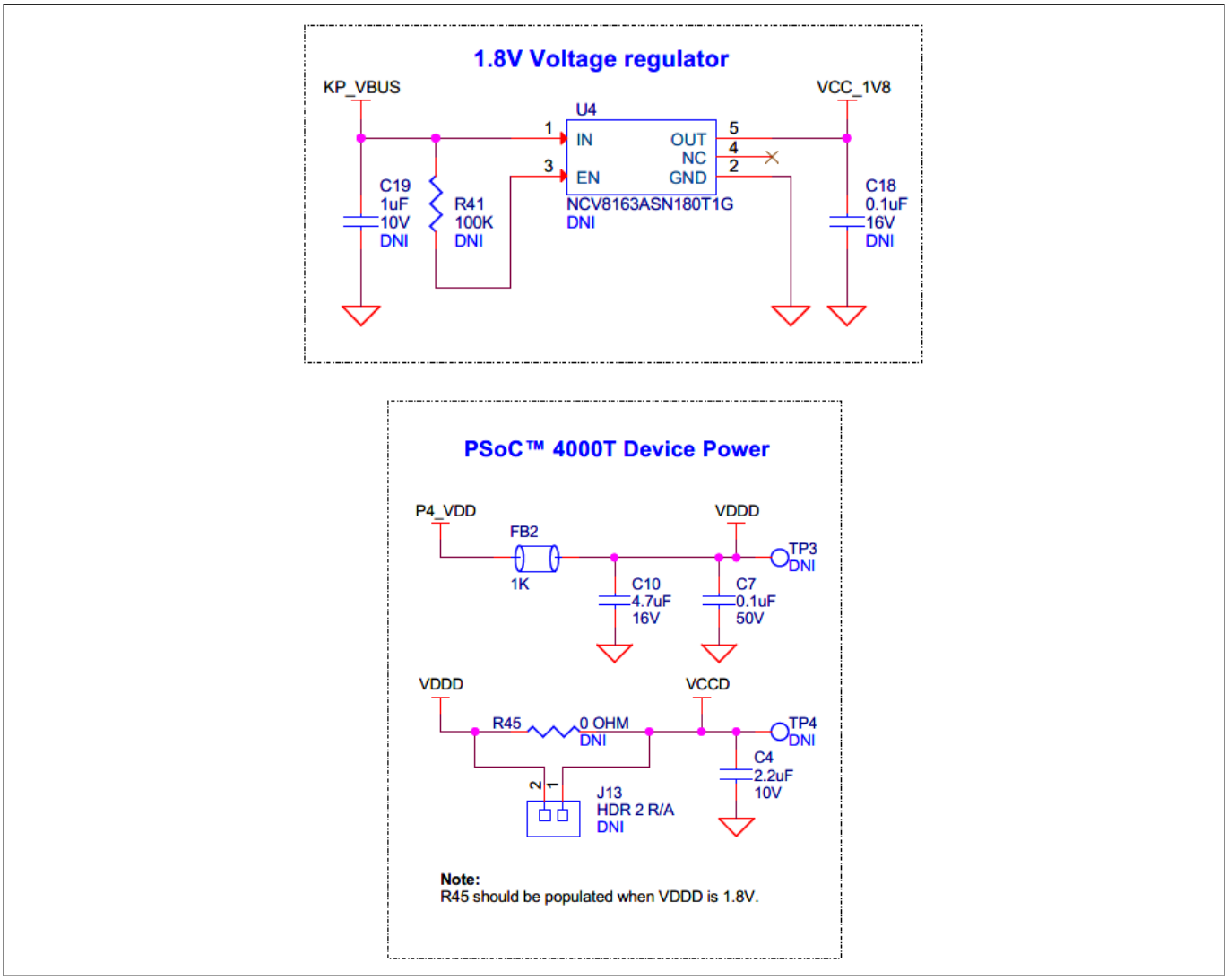

Figure 41 Schematic of rework regions to enable 1.8 V powering option for PSoC™ 4000T device

3.4 Bill of materials

See the BoM files available on the kit webpage.

Glossary

BOM
bill of materials
BSP
board support package
CLI
command-line interface
CMOD
modulator capacitor
CMSIS-DAP
Cortex® Microcontroller System Interface Standard – Debug Access Port
CPU
central processing unit
CSD
self-capacitance
CSX
mutual-capacitance
EMC
electromagnetic compatibility
ESD
electrostatic discharge
GND
ground
GPIO
general-purpose input/output
HMI
human-machine interface
I2C
inter-integrated circuit
IDE
integrated development environment
LED
light emitting diode
MCU
microcontroller unit
MSC
multi-sense converter
OOB
out-of-the-box
PSoC™
programmable system-on-chip
SCL
serial clock (I2C)
SDA
serial data (I2C)

Glossary

SWD
Serial Wire Debug
UART
Universal Asynchronous Receiver-Transmitter
USB
Universal Serial Bus
XRES
external reset

Revision history

Document revision	Date	Description of changes
**	2023-11-29	Initial release

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