CY8CPROTO-040T-MS PSOC™ 4000T Multi-Sense Prototyping Kit guide

About this document

Scope and purpose

This document will help you become familiar with the CY8CPROTO-040T-MS PSOC™ 4000T Multi-Sense Prototyping Kit. It explains the kit's operation, the out-of-the-box (OOB) example, and operation, as well as the hardware details.

Intended audience

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

Reference kit

Product(s) embedded on a PCB with a focus on specific applications and defined use cases that may include software. PCB and auxiliary circuits are optimized for the requirements of the target application.

Note*:* *Boards do not necessarily meet safety, EMI, or quality standards (e.g., UL, CE) requirements.*

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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.*
	Caution: *The evaluation or reference board is shipped with packing materials that need to be removed prior to installation. Failure to remove all packing materials that are unnecessary for system installation may result in overheating or abnormal operating conditions.*

Table of contents

1 Introduction

Home appliances like washing machines, refrigerators, and others are becoming increasingly smart and connected. Inductive sensing plays a key role in this trend by enabling robust, reliable, and sleek touch buttons on seamless metallic surfaces. Inductive sensing is inherently immune to liquids, facilitating the development of liquid-tolerant applications like dishwashers, earbuds, and smartwatches. Reed switches can be replaced by proximity sensing using multi-sense converter low-power (MSCLP) inductive sensing technology, offering a contactless, robust design for metal object detection.

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

Appliances like washing machines, dishwashers, and coffee machines can leverage liquid-level sensing and presence detection features to create smarter and more efficient products.

The PSOC™ 4000T series MCU (hereafter called "PSOC™ 4000T") addresses all these challenges by introducing new fifth-generation CAPSENSE™ and multi-sense converter low-power (MSCLP) technology. This offers an ultra-low-power touch HMI solution based on integrated "Always-on" sensing technology. It enables scanning low-power buttons, such as power or wake-up buttons, while the device is in DeepSleep and processes the results to wake the device in the event of a touch. This technology inherently supports autonomous scanning capability, which does not require CPU intervention for scanning sensors; the device can remain in DeepSleep during scanning, thereby reducing power consumption in Active mode as well. It combines multiple sensing technologies cost-effectively to create smarter, future-ready products.

1.1 Features

The CY8CPROTO-040T-MS PSOC™ 4000T Multi-Sense Prototyping Kit allows you to evaluate the features of the PSOC™ 4000T device. The board includes:

- A PSOC™ 4000T device
- An onboard programmer/debugger (KitProg3)
- User LEDs (PWM enabled)
- A user button

The kit also comes with the following expansion boards:

- A Touch-over-Metal (ToM) Keypad-4 board with 14 mm coils
- A Touch-over-Metal (ToM) Keypad-2 board with 22 mm coils
- A flex PCB with 9 sensors, offering a full-scale liquid-level reading of 120 mm
- A hover-touch board with four 10 mm buttons that can detect a touch from a distance of 10 mm

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

- 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 in the 'Monitor data using CAPSENSE™ tuner' section of the CE240146: PSOC™ 4: MSCLP inductive sensing Touch-over-Metal Keypad-4 demo code example's `README` file
- Expansion boards showcase a single device capable of CAPSENSE™, inductive, and liquid level sensing

For more information on the features of the fifth-generation low-power CAPSENSE™ MSCLP technology, see AN85951 - PSOC™ 4 and PSOC™ 6 MCU CAPSENSE™ design guide. See AN239751 flyback inductive sensing design guide and AN239805 Liquid-level sensing with PSOC™ 4 CAPSENSE™ for details on inductive sensing and liquid-level sensing technologies and their features.

Use ModusToolbox™ 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™ IDE, see AN79953 - Getting Started with PSOC™ 4 to help familiarize yourself with PSOC™ 4 and guide you in creating your own designs.

1.2 Kit contents

The CY8CPROTO-040T-MS PSOC™ 4000T Multi-Sense Prototyping Kit includes the following components:

- PSOC™ 4000T Multi-Sense control board
- Inductive Keypad-4 expansion board
- Inductive Keypad-2 expansion board
- Liquid-level sensor expansion board
- Plastic container for liquid-level sensing demonstration
- CAPSENSE™ hover-touch expansion board
- USB Type-A to USB Type-C cable
- Quick start guide

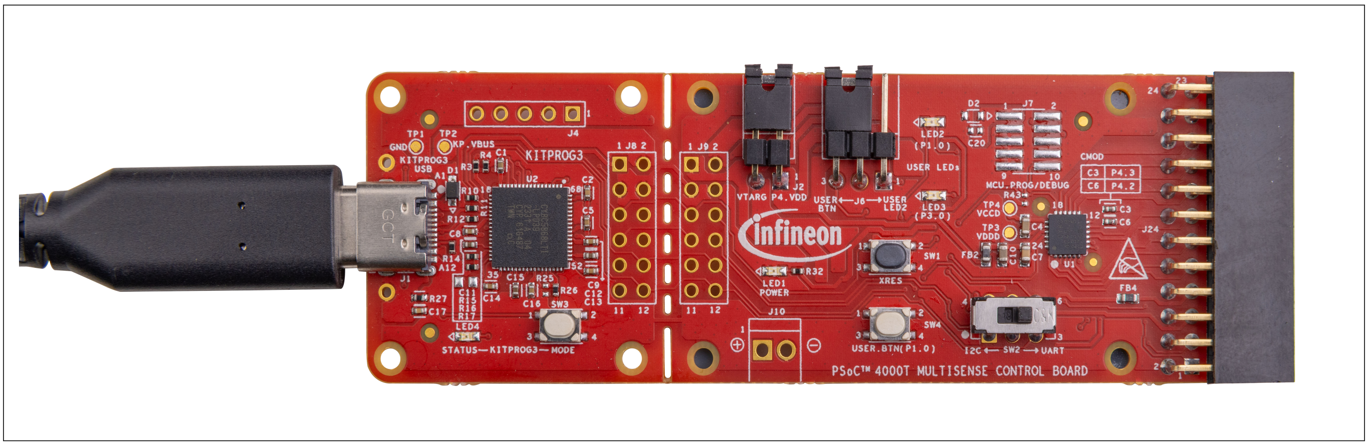


Figure 1 CY8CPROTO-040T-MS PSOC™ 4000T Multi-Sense Control board


QUICK START GUIDE

PSOC™ 4000T Multi-Sense Prototyping Kit

CY8CPROTO-040T-MS

Kit contents

1. PSOC™ 4000T Multi-Sense control board
2. Inductive keypad - 4 expansion board
3. Inductive keypad - 2 expansion board
4. Liquid level sensor expansion board
5. Plastic container for liquid level sensing demonstration
6. CAPSENSE™ hover touch expansion board
7. USB-A to USB-C cable
8. Quick start guide (this document)

www.infineon.com/CY8CPROTO-040T-MS

Figure 2 CY8CPROTO-040T-MS PSOC™ 4000T Multi-Sense Prototyping Kit quick start guide

Inspect the kit's contents. If you find any part missing, contact Infineon Support for assistance.

1.3 Getting started

This guide helps you get acquainted with the PSOC™ 4000T Multi-Sense Prototyping Kit.

- See the Kit operation section for an in-depth understanding of the PSOC™ 4000T device features. See the Using the OOB example - CE240146 section to explore the out-of-the-box (OOB) project preprogrammed in this kit. It also provides steps to create a project and program/debug using ModusToolbox™
- See the Hardware section for the detailed hardware description, kit schematics, rework instructions, and the bill of materials (BOM)

- Use ModusToolbox™ for application development with the PSOC™ 4000T Multi-Sense Prototyping Kit. For the latest software support for this development kit, see the kit webpage
  - ModusToolbox™ is a free development ecosystem that includes the Eclipse IDE for ModusToolbox™ software. With ModusToolbox™, you can enable and configure device resources, middleware libraries, and program and debug the device. For more information, see ModusToolbox™ software user guide
- Explore a wide range of code examples to evaluate the PSOC™ 4000T Multi-Sense Prototyping Kit. These examples will help you familiarize yourself with the PSOC™ 4000T device and create your own designs. Code examples can also be found in the ModusToolbox™ software-based code examples GitHub repository
  - To access code examples through ModusToolbox™, see the 'Software development for PSOC™ 4' section in AN79953 - Getting started with PSOC™ 4

1.4 Additional learning resources

Infineon provides comprehensive data on the PSOC™ 4 product webpage to help you select the appropriate PSOC™ device for your design and integrate it quickly and effectively.

1.5 Technical support

For assistance, contact Infineon Support or visit the Infineon Developer Community webpage to post your questions in the community.

Additionally, use the following support resources for quick assistance:

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

2 Kit operation

This chapter offers an overview of the PSOC™ 4000T device features and a quick review of the out-of-the-box (OOB) project preprogrammed in this kit. It also provides steps to create a project and program/debug using the ModusToolbox™.

2.1 Theory of operation

The PSOC™ 4000T Multi-Sense Prototyping Kit is built around the PSOC™ 4000T device. Figure 3 shows the block diagram of the PSOC™ 4000T device used on the board. For detailed information on the device features, see the device datasheet.

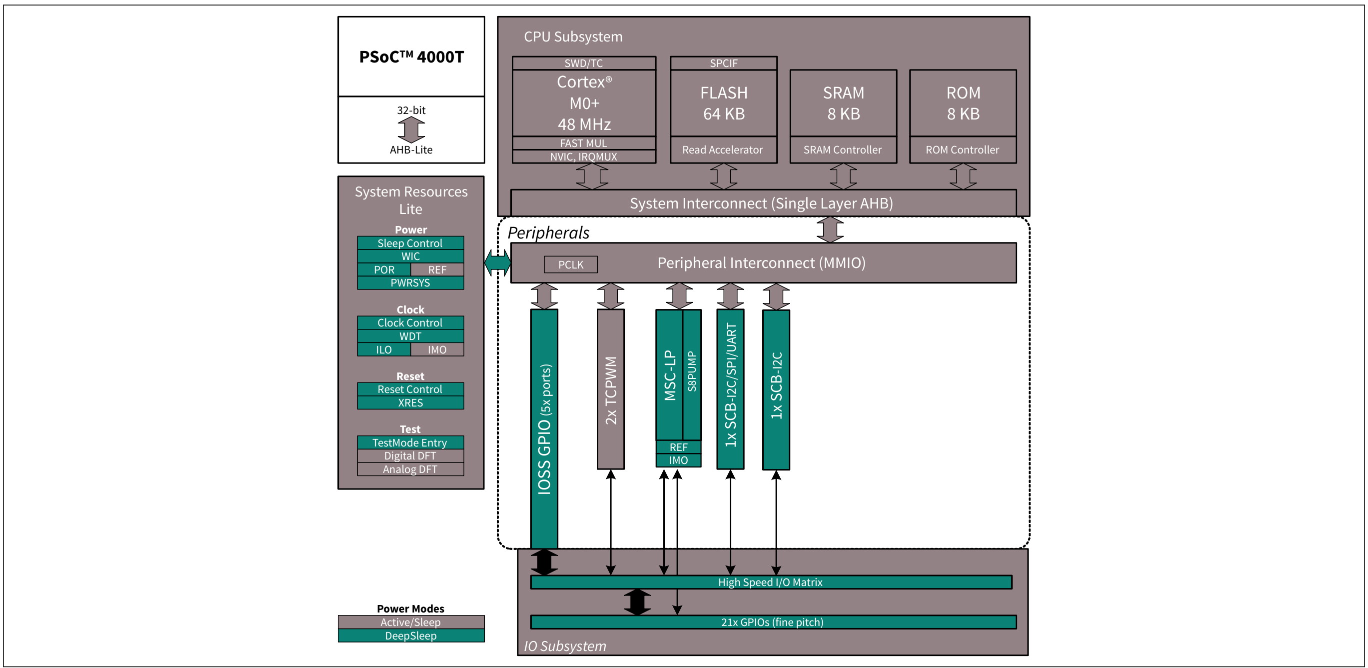


Figure 3 PSOC™ 4000T device block diagram

Figure 4 shows the functional block diagram of the PSOC™ 4000T Multi-Sense Control board.

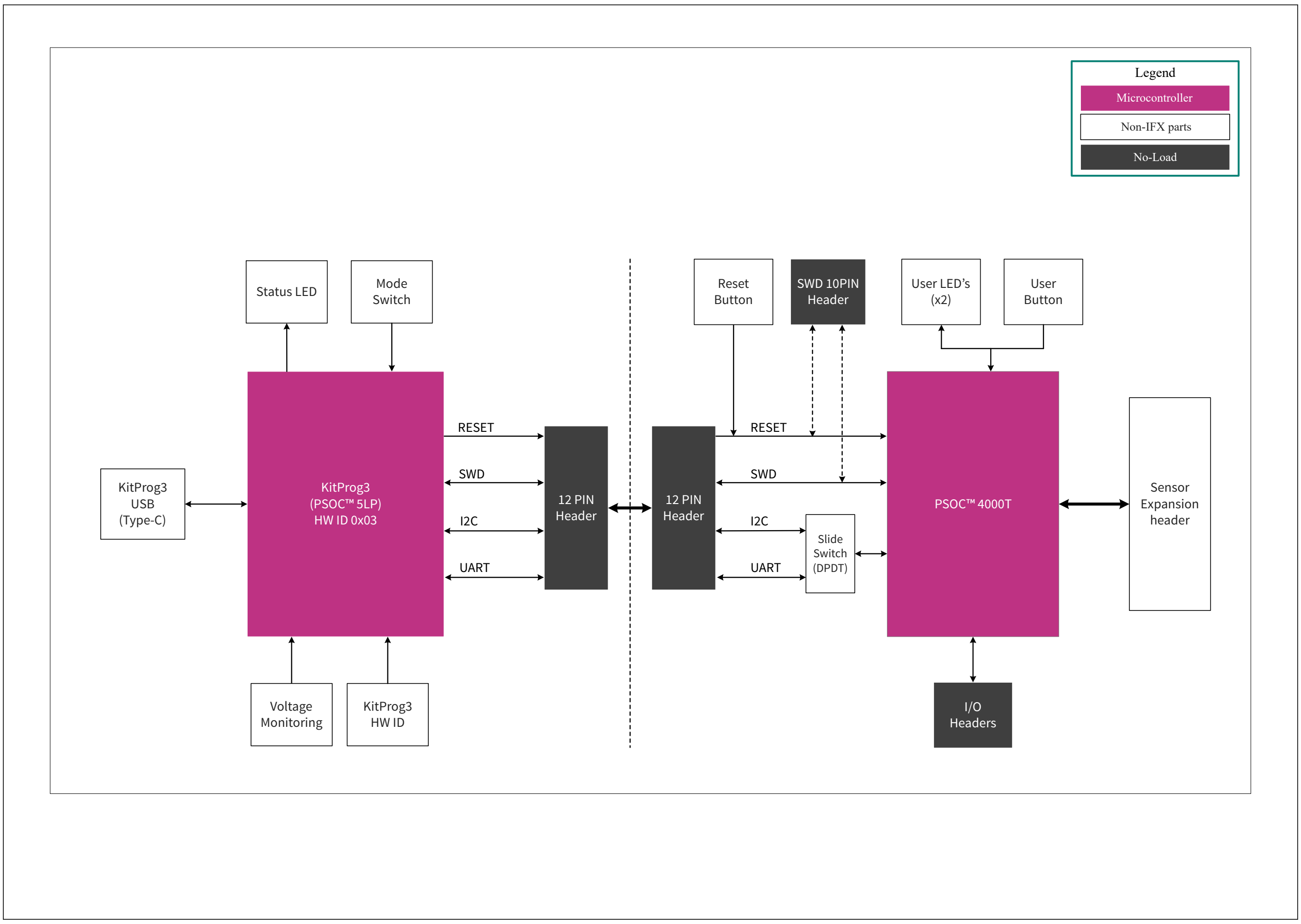


Figure 4 **Functional block diagram of CY8CPROTO-040T-MS PSOC™ 4000T Multi-Sense Control board**

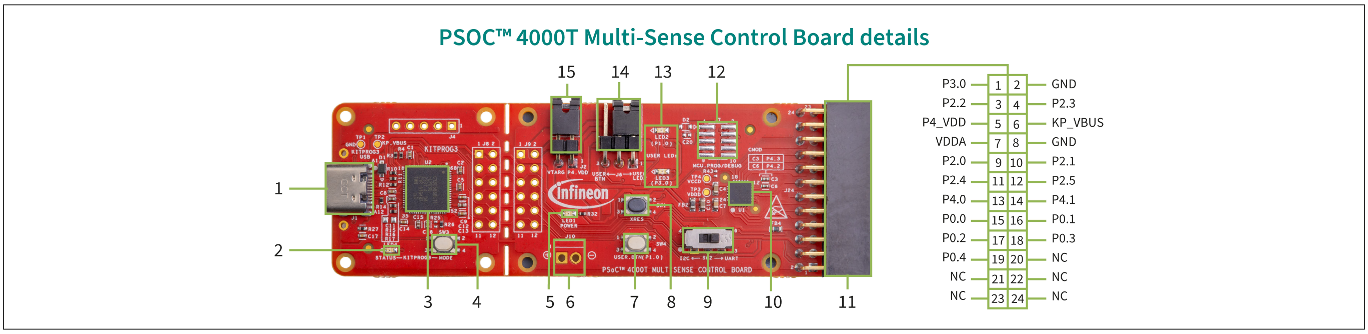


Figure 5 **PSOC™ 4000T Multi-Sense Control board top view**

The PSOC™ 4000T Multi-Sense Prototyping Kit focuses on demonstrating the capabilities of fifth-generation CAPSENSE™ technology, including low-power operation with always-on sensing and enhanced touch-sensing performance. It utilizes the PSOC™ 4000T device to demonstrate CAPSENSE™, inductive sensing, and liquid-level sensing widgets. This board includes the following peripherals:

Table 2 PSOC™ 4000T Multi-Sense Control board details

Sl. No.	Peripheral	Description
1	KitProg3 USB Type-C connector (J1)	Connects to a PC to use the KitProg3 onboard programmer and debugger, as well as to supply power to the board.
2	KitProg3 status LED (LED4)	The Amber LED4 indicates the status of KitProg3. See the KitProg3 user guide for more information on the KitProg3 status.
3	KitProg3 (PSOC™ 5LP) programmer and debugger (CY8C5868LTI-LP039, U2)	The PSOC™ 5LP device (CY8C5868LTI-LP039), which serves as KitProg3, is a multifunctional system that includes an SWD programmer, debugger, USB-I^{2}C 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 different modes of operation for KitProg3. Note that this board supports only CMSIS-DAP BULK mode. For more details, see the KitProg3 user guide. Currently, this button function is reserved for future use.
5	Power LED (LED1)	The amber LED indicates the status of the power supplied to the board.
6	External power supply input provision (J10)	By populating J10, the connection of an external DC power supply input to the PSOC™ 4000T device is enabled.
7	User button (SW4)	Provides an input to the PSOC™ 4000T MCU. Note that the button connects the PSOC™ 4000T MCU pin to ground through a current-limiting resistor when pressed, therefore the PSOC™ 4000T MCU pin should be configured as a digital input with a resistive pull-up to detect the button press. The PSOC™ 4000T MCU pin used for detecting the button press is shared with LED3 via the J6 header. Ensure to short pins 2 and 3 of J6 with a jumper to enable the connection with the PSOC™ 4000T MCU pin.
8	PSOC™ 4000T MCU Reset switch (SW1)	Resets the PSOC™ 4000T MCU by connecting its reset (XRES) pin to ground.
9	Target I^{2}C/UART interface selection switch (SW2)	Use this slide switch to select either the I^{2}C or UART interface of the PSOC™ 4000T MCU with the onboard KitProg3 USB-I^{2}C or USB-UART bridge.
10	PSOC™ 4000T MCU (U1)	This kit highlights the features of the PSOC™ 4000T device and is designed for the 24-pin QFN part with a 64 KB flash capacity.
11	Multi-Sense expansion header (J24)	The PSOC™ 4000T Multi-Sense Control board includes a 24-pin header for connecting and evaluating various expansion boards.
12	PSOC™ 4000T MCU 10-pin SWD program and debug header provision (J7)	Populating this 10-pin header enables you to program and debug the PSOC™ 4000T MCU using an external programmer, such as MiniProg4.

(table continues...)

Table 2 (continued) PSOC™ 4000T Multi-Sense Control board details

Sl. No.	Peripheral	Description
13	User LEDs (LED2, LED3)	The user LEDs can operate across the entire voltage range of the PSOC™ 4000T device, as they are driven by a MOSFET connected to the USB supply. The LEDs are active HIGH, so the pins must be driven to VDDD to turn them on.
14	User LED (LED2) and user button selection header (J6)	Use this header to select either the user LED (LED2) or the user button (SW4).
15	Target MCU current measurement header (J2)	Connect an ammeter to this jumper to measure the current consumed by the PSOC™ 4000T device.

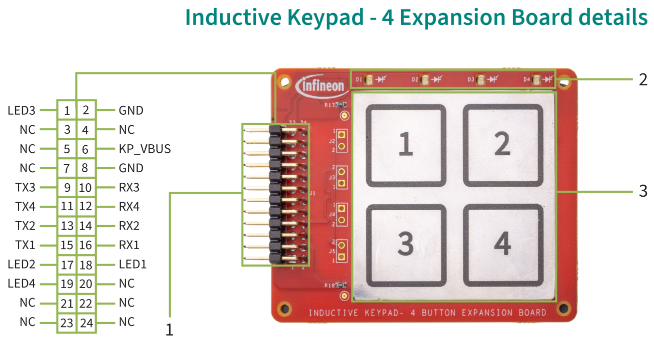


Figure 6 Inductive Keypad - 4 expansion board top view

Table 3 Inductive Keypad - 4 expansion board details

Sl. No.	Peripheral	Description
1	Multi-Sense expansion header (J1)	The 24-pin sensor expansion header connects to the PSOC™ 4000T Multi-Sense control board.
2	Sensor response LEDs (D1, D2, D3, and D4)	The user LEDs can operate across the entire voltage range of the PSOC™ 4000T device, as they are driven by a MOSFET connected to the USB supply. The LEDs are active HIGH, so the pins must be driven to VDDD to turn them on. Whenever one of the buttons is pressed, the respective LED turns on.
3	Inductive sensing-based Touch-over-Metal buttons (Sns1, Sns2, Sns3, and Sns4)	The inductive sensing-based buttons allow you to evaluate Infineon's fifth-generation multi-sense technology. This board features a stainless steel overlay with a thickness of 0.3 mm and an air gap of 0.3 mm between the overlay and the coils.

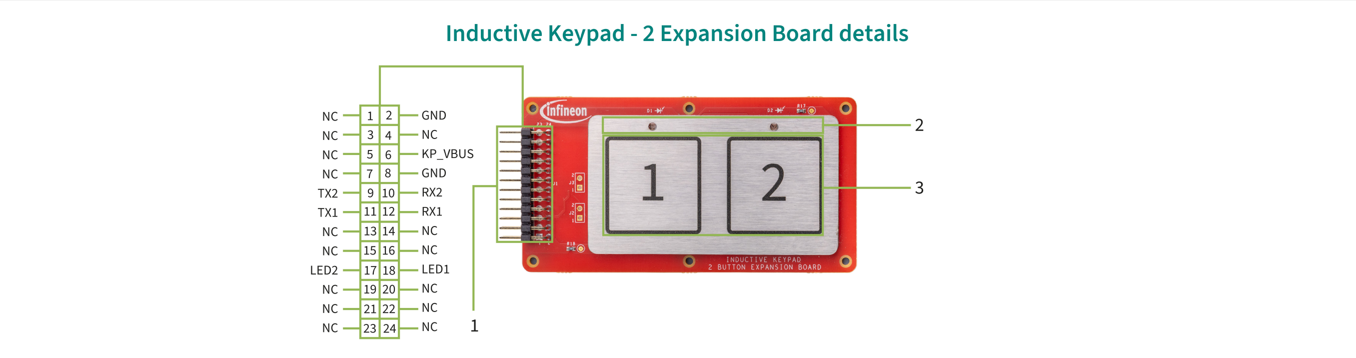


Figure 7 **Inductive Keypad - 2 expansion board top view**

Table 4 **Inductive Keypad - 2 expansion board details**

Sl. No.	Peripheral	Description
1	Multi-Sense expansion header (J1)	The 24-pin sensor expansion header connects to the PSOC™ 4000T Multi-Sense control board.
2	Sensor response LEDs (D1, D2)	The user LEDs can operate across the entire voltage range of the PSOC™ 4000T device, as they are driven by a MOSFET connected to the USB supply. The LEDs are active HIGH, so the pins must be driven to VDDD to turn them on. Whenever one of the buttons is pressed, the respective LED turns on.
3	Inductive sensing-based Touch-over-Metal buttons (Sns1, Sns2)	The inductive sensing-based buttons allow you to evaluate Infineon's fifth-generation multi-sense technology. This board features a stainless steel overlay with a thickness of 0.6 mm and an air gap of 2 mm between the overlay and the coils.

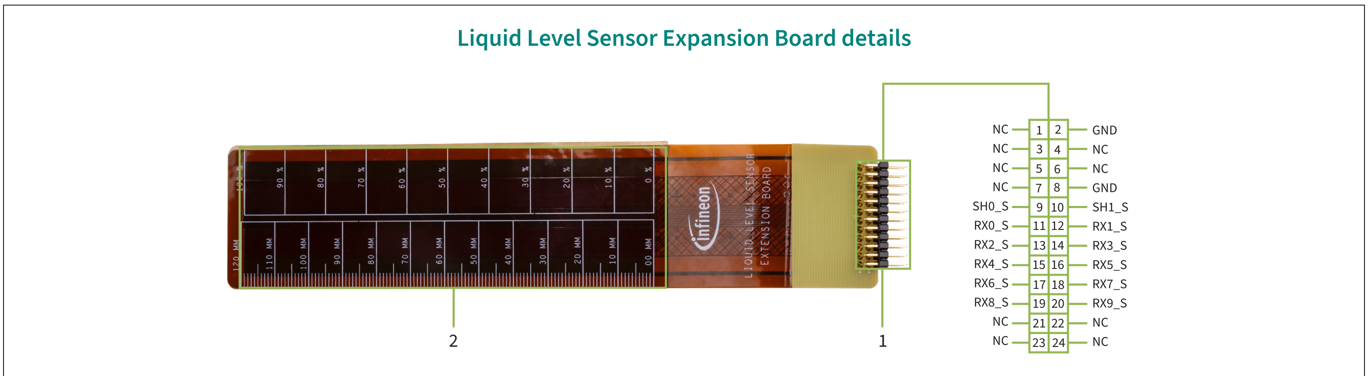


Figure 8 **Liquid-level sensor expansion board**

Table 5 **Liquid-level sensor expansion board details**

Sl. No.	Peripheral	Description
1	Multi-Sense expansion header (J1)	The 24-pin sensor expansion header connects to the PSOC™ 4000T Multi-Sense control board.

(table continues...)

Table 5 (continued) Liquid-level sensor expansion board details

Sl. No.	Peripheral	Description
2	Liquid-level sensor (CSS1)	These are the liquid-level sensor segments created on a flex PCB, which will be used to sense the water level in a container. The flex PCB also features a silkscreen marking of a scale to help visually measure the liquid level in the container. This board allows you to evaluate Infineon's liquid sensing capability using the fifth-generation multi-sense technology.

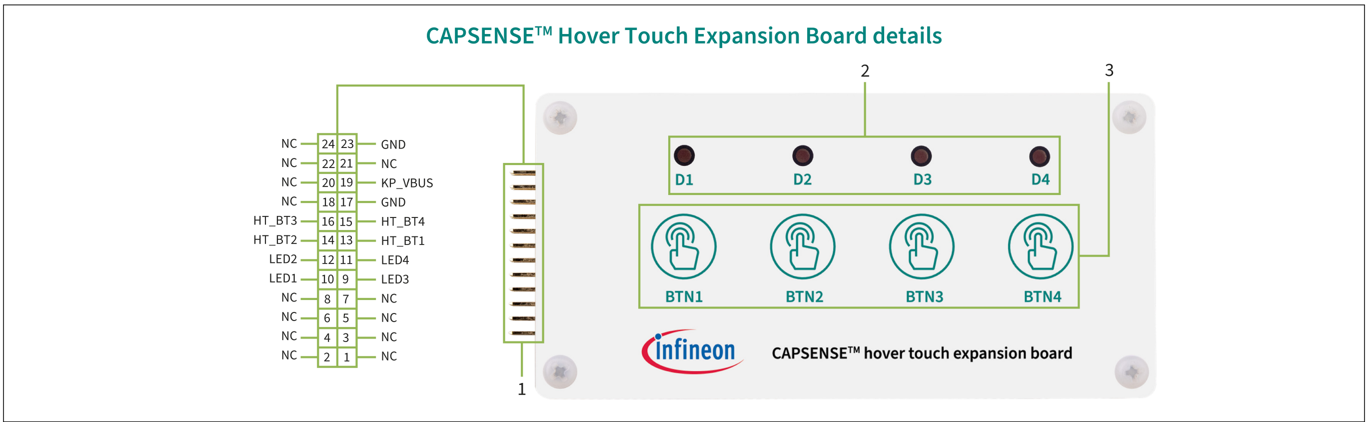


Figure 9 CAPSENSE™ hover touch expansion board details

Table 6 CAPSENSE™ hover-touch expansion board details

Sl. No.	Peripheral	Description
1	Multi-Sense expansion header (J1)	The 24-pin sensor expansion header connects to the PSOC™ 4000T Multi-Sense Control board.
2	Sensor response LEDs (D1, D2)	The user LEDs can operate across the entire voltage range of the PSOC™ 4000T device, as they are driven by a MOSFET connected to the USB supply. The LEDs are active HIGH, so the pins must be driven to VDDD to turn them on. Whenever one of the buttons is pressed, the respective LED turns on.
3	CAPSENSE™ hover-touch buttons	The 10 mmCAPSENSE™ buttons can detect a touch at a distance of 10 mm from the PCB.

See the Hardware functional description section for details on the various hardware blocks.

2.2 Using the OOB example - CE240146

The PSOC™ 4000T Prototyping Kit comes pre-programmed with the CE240146 – PSOC™ 4: MSCLP inductive sensing Touch-over-Metal Keypad-4 demo code example (CE). This CE showcases the key features of fifth-generation low-power CAPSENSE™ technology in PSOC™ 4000T, such as:

- Inductive sensing-based button operation with superior touch-sensing performance
- Low-power wake-on-touch operation

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

1. Connect the board to the PC using the USB cable through the KitProg3 USB connector, as shown in Figure 10

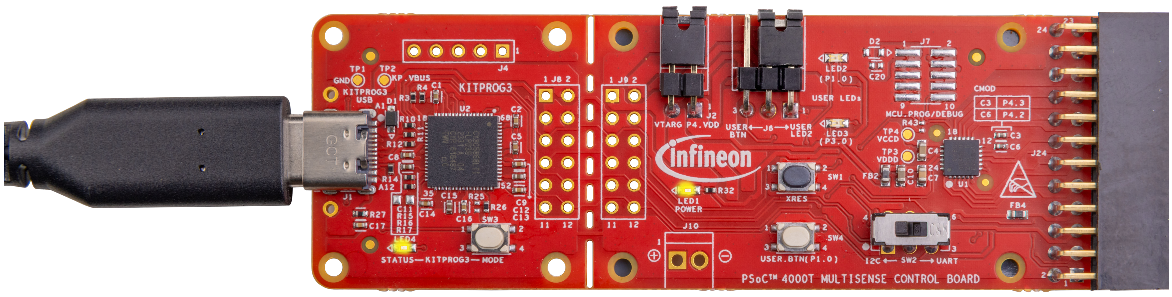


Figure 10 Connect the USB cable to the USB connector on the board

2. Connect the Keypad-4 expansion board at the header as shown in Figure 11

Figure 11 ISX Keypad-4 board connected

3. Press any of the inductive sensing-based buttons with your finger and observe that the corresponding LED turns on (for example, D1 turns on when Button 1 is pressed, and so on)

***Notes**:*

1. *At any time, if you overwrite the OOB example, you can restore it by programming the PSOC™ 4: MSCLP inductive sensing Touch-over-Metal Keypad-4 demo code example. See the Creating a project and program/debug using ModusToolbox™ software section for programming the board*
2. *More code examples are available in the Eclipse IDE for ModusToolbox™ or on the ModusToolbox™ software-based examples GitHub page. These examples can be used to evaluate expansion boards such as:*
   - PSOC™ 4: MSCLP inductive sensing Touch over Metal Keypad-2
   - PSOC™4: MSCLP CAPSENSE™ liquid-level sensing

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

This section provides an overview of creating, programming/debugging projects using ModusToolbox™. For in-depth 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 will enumerate 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 this 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.

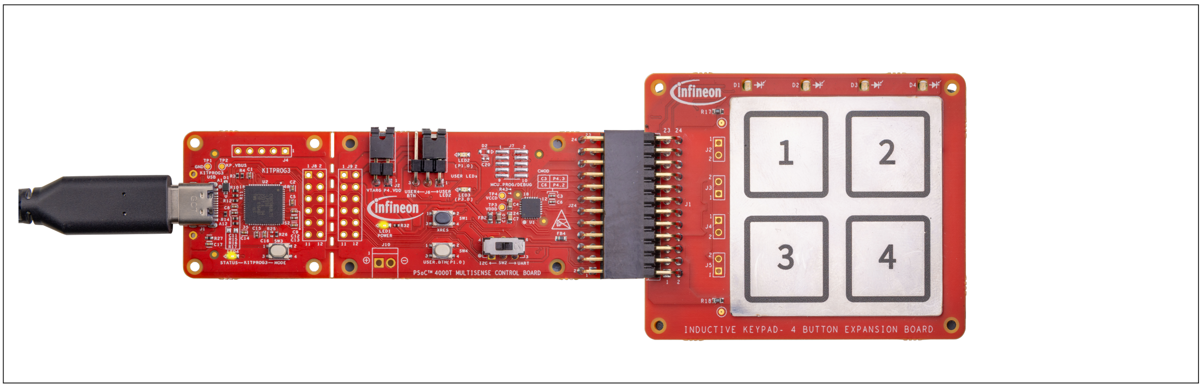


Figure 12 Connect the USB cable to the USB connector on the board

2. To import the required code example (application) into a new workspace in the Eclipse IDE for ModusToolbox™, do the following:

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

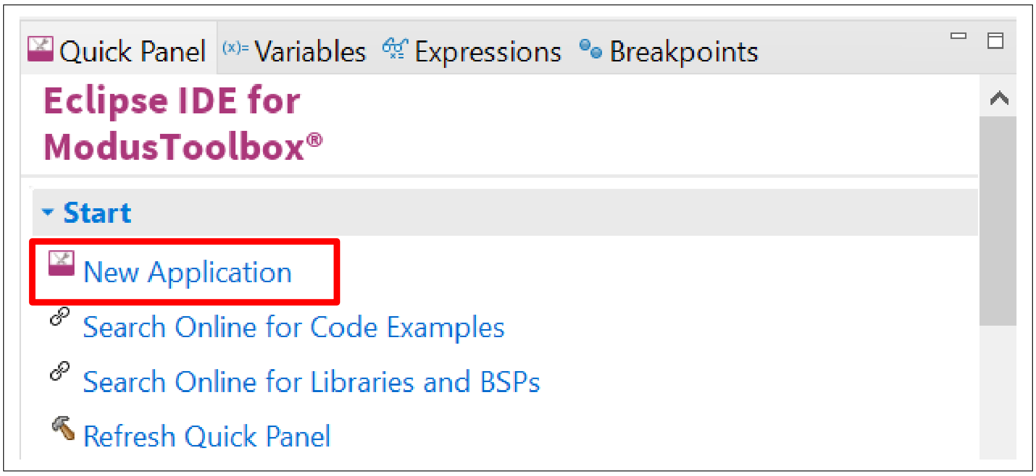


Figure 13 New Application in Quick Panel

   b. In **Choose Board Support Package (BSP) - Project Creator 2.0** window, expand the PSOC™ 4 BSPs

   c. Select **CY8CPROTO-040T-MS**, and click **Next**, as shown in Figure 14

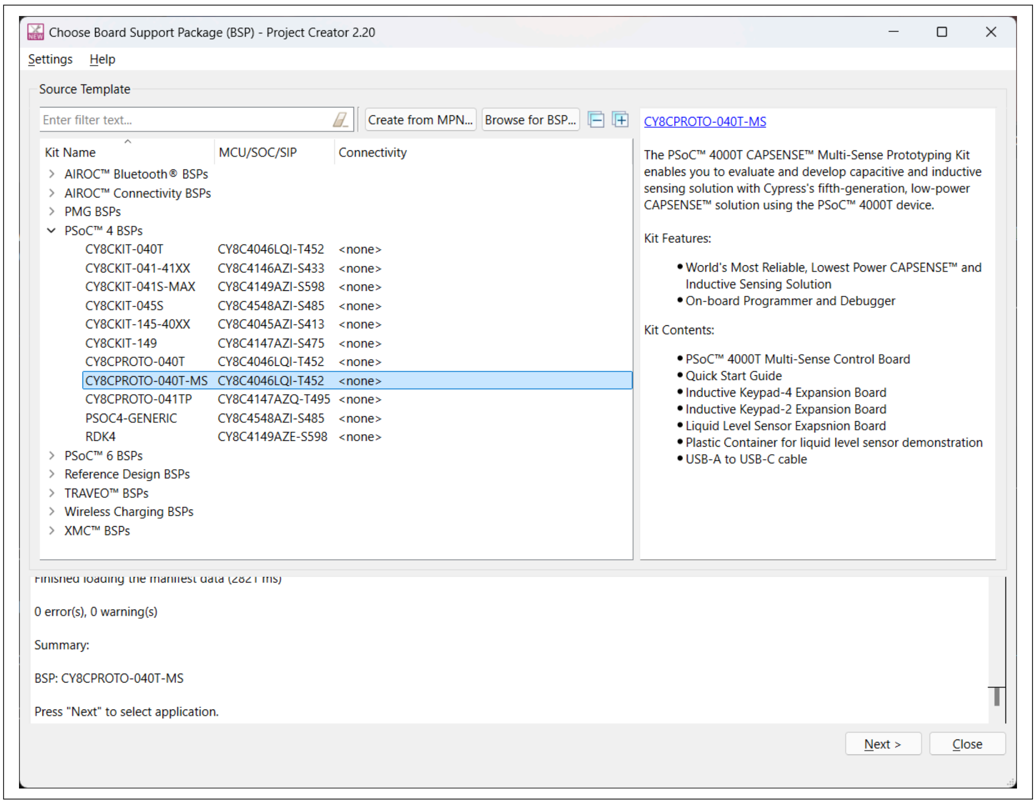


Figure 14 **Creating a new application: Choose Board Support Package**

d. Select the required application and click **Create**, as shown in Figure 15. The right pane will display the code example description and provide a link to view the `README` file on GitHub

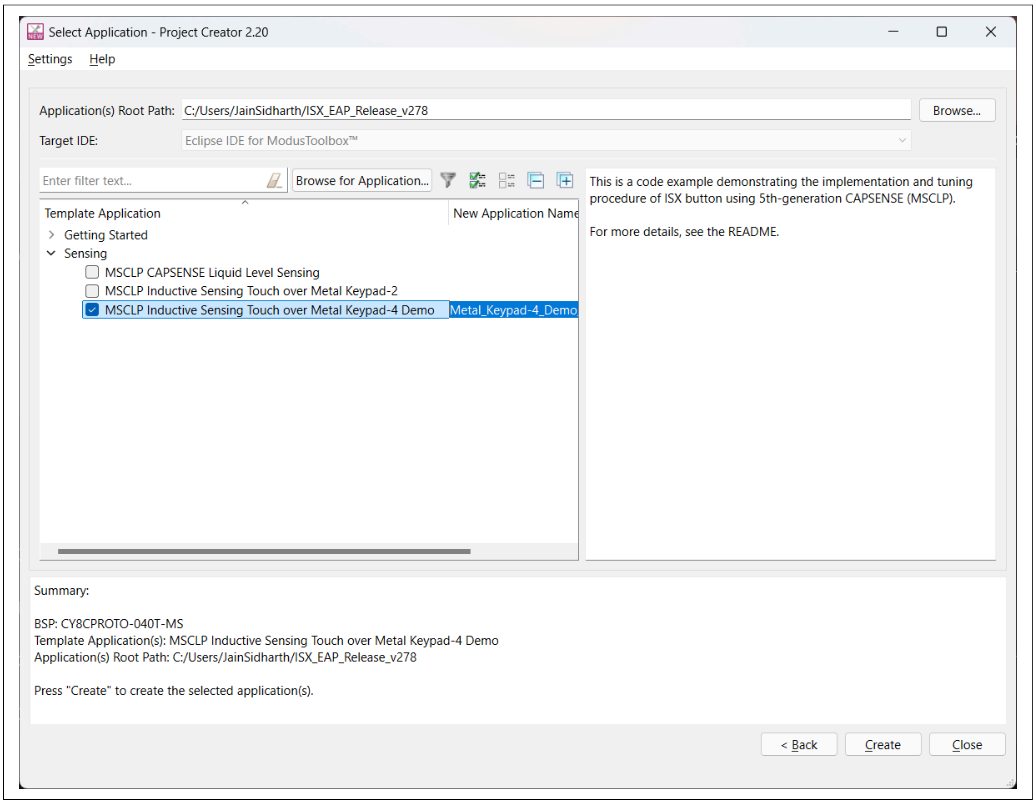


Figure 15 **Creating a new application: Select Application**

3. To build and program a PSOC™ 4000T device application, follow these steps:
   a. In the **Project Explorer** tab, select the **<App_Name>** project
   b. In the **Quick Panel** tab, scroll to the **Launches** section, and click the **<App_Name> Program (KitProg3_MiniProg4)** configuration, as shown in Figure 16

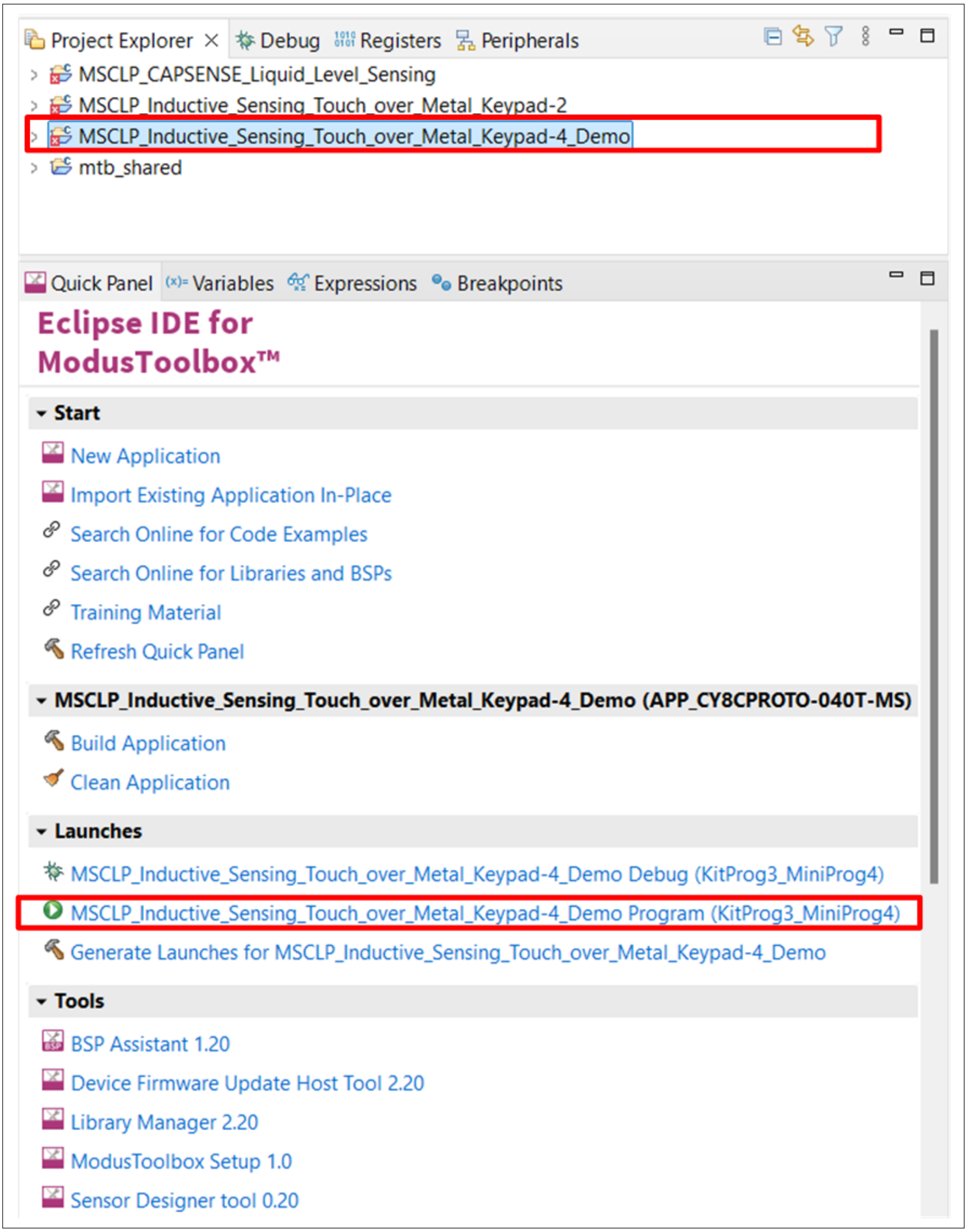


Figure 16 Building and programming the OOB code example

4. ModusToolbox™ has an integrated debugger. To debug a PSOC™ 4000T device application, follow these steps:
   a. In the **Project Explorer** tab, select **<App_Name>** project
   b. In the **Quick Panel**, scroll to the **Launches** section, and click the **<App_Name> Debug (KitProg3_MiniProg4)** configuration, as shown in Figure 17

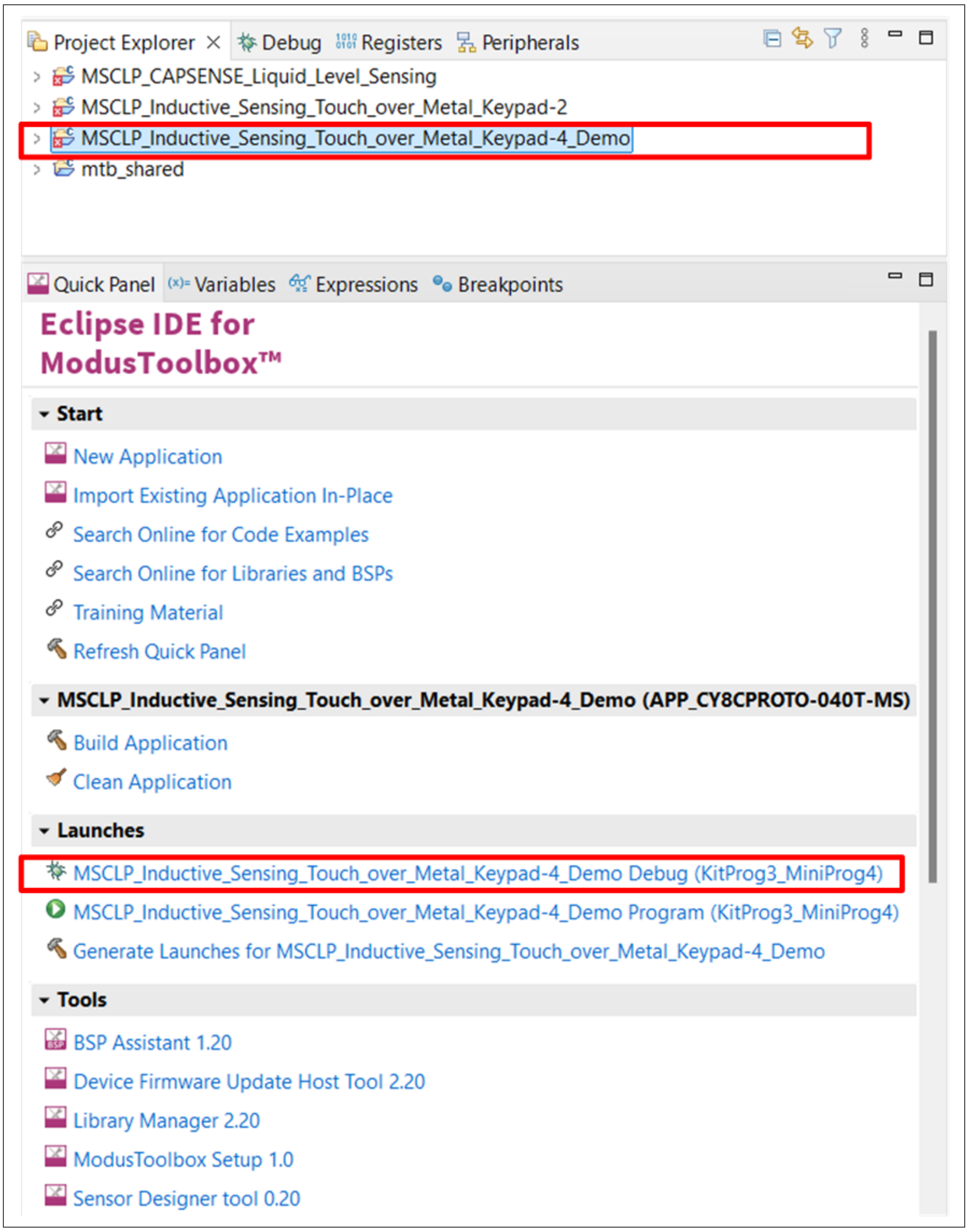


Figure 17 Debugging the code example

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

3 Hardware

3.1 Schematics

See the schematic files available on the kit webpage.

3.2 Hardware functional description

This section describes the individual hardware blocks of the kit. The kit includes a PSOC™ 4000T Multi-Sense Control board and a set of expansion boards designed to demonstrate various sensing methods and use cases. The kit is equipped with expansion boards to demonstrate inductive sensing-based HMI use cases and capacitive sensing-based liquid level measurement. The following sections provide detailed information about the PSOC™ 4000T Multi-Sense Control board and the expansion boards included with the kit.

3.2.1 PSOC™ 4000T Multi-Sense Control board

The PSOC™ 4000T Multi-Sense Control board consists of the PSOC™ 4000T device, KitProg3 programmer/debugger, and bridge, a sensor interface header to support different sets of expansion boards demonstrating various sensing methods, two user LEDs, a user button, a DPDT slide switch for interface selection (I^2C or UART), and other passive components required for the essential operation of the kit.

3.2.1.1 PSOC™ 4000T MCU features

This kit features a PSOC™ 4000T MCU, a member of the PSOC™ 4 platform with a scalable and reconfigurable architecture and 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.

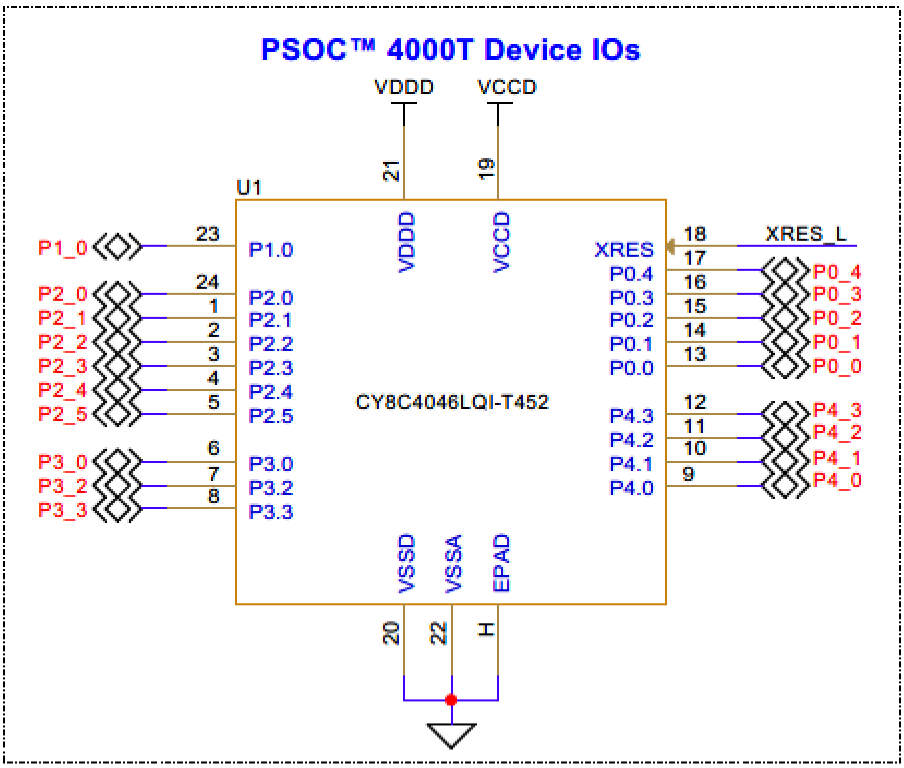


Figure 18 Schematics of the PSOC™ 4000T MCU I/Os

Table 7 Pin assignment of the PSOC™ 4000T MCU in the Prototyping Kit

Pin details	Primary onboard function	Secondary onboard function
P0[0]	-	Connected to an external sensor interface expansion header (J24) used as: • General-purpose I/O • CAPSENSE™ I/O
P0[1]	–	Connected to an external sensor interface expansion header (J24) used as: • General-purpose I/O • CAPSENSE™ I/O
P0[2]	–	Connected to an external sensor interface expansion header (J24) used as: • General-purpose I/O • CAPSENSE™ I/O
P0[3]	–	Connected to an external sensor interface expansion header (J24) used as: • General-purpose I/O • CAPSENSE™ I/O
P0[4]	–	Connected to an external sensor interface expansion header (J24) used as: • General-purpose I/O • CAPSENSE™ I/O
P1[0]	User LED (LED2)	User button (SW4)
P2[0]	–	Connected to an external sensor interface expansion header (J24) used as: • General-purpose I/O • CAPSENSE™ I/O
P2[1]	–	Connected to an external sensor interface expansion header (J24) used as: • General-purpose I/O • CAPSENSE™ I/O
P2[2]	KitProg3 I^{2}C interface clock (KP_ SCL)	• KitProg3 UART interface TX (KP_ UART_TX) • MCU I^{2}C interface clock for expansion boards
P2[3]	KitProg3 I^{2}C interface data (KP_ SDA)	• KitProg3 UART interface RX (KP_ UART_RX) • MCU I^{2}C interface data for expansion boards
P2[4]	–	Connected to an external sensor interface expansion header (J24) used as: • General-purpose I/O • CAPSENSE™ I/O

(table continues...)

Table 7 (continued) Pin assignment of the PSOC™ 4000T MCU in the Prototyping Kit

Pin details	Primary onboard function	Secondary onboard function
P2[5]	–	Connected to an external sensor interface expansion header (J24) used as: • General-purpose I/O • CAPSENSE™ I/O
P3[0]	User LED 2 (LED2)	Connected to an external sensor interface expansion header (J24) used as: • General-purpose I/O • TCPWM I/O • SPI MOSI
P3[2]	SWD interface data I/O – SWDIO	External programmer SWD interface data I/O – SWDIO
P3[3]	SWD interface clock – SWDCLK	External programmer SWD interface clock – SWDCLK
P4[0]	–	Connected to an external sensor interface expansion header (J24) used as: • General-purpose I/O • CAPSENSE™ I/O
P4[1]	–	Connected to an external sensor interface expansion header (J24) used as: • General-purpose I/O • CAPSENSE™ I/O
P4[2]	CAPSENSE™ CMOD1 capacitor	–
P4[3]	CAPSENSE™ CMOD2 capacitor	–
XRES	Hardware reset	–

3.2.1.2 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 ranging from 2.0 V to 5.5 V, which is ideal for battery-powered operations. 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.

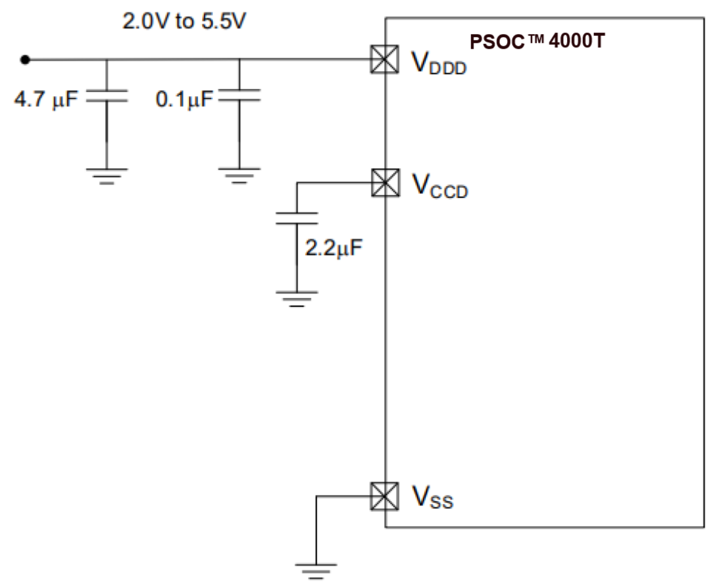


Figure 19 **PSOC™ 4000T device schematic with 2.0 V to 5.5 V external supply**

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

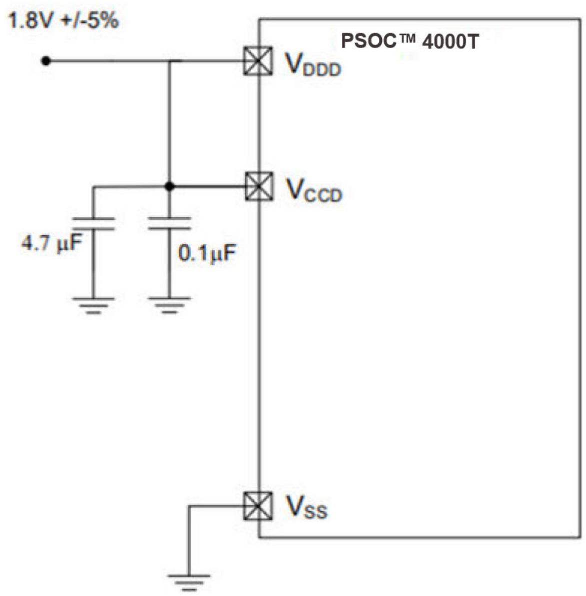


Figure 20 **PSOC™ 4000T device schematic with 1.8 V ±5% external supply**

The PSOC™ 4000T device on the prototyping board operates at 3.3 V in its default configuration (Mode 1). The target voltage for the PSOC™ 4000T device is supplied through a ferrite bead (FB2) to filter noise on the power rail. Provisions are provided for powering the kit such that if the target MCU voltage is configured to operate at 1.8 V (by feeding 1.8 V through an external power input), the PSOC™ 4000T device core-voltage supply *VCCD* needs to be shorted with *VDDD* by populating R45 or by populating a J13 header and shorting it with a jumper. The default configuration supports 3.3 V and 5 V operation.

By default, the PSOC™ 4000T device is configured to operate at a 3.3 V regulated supply provided from U4. For more details about the power supply configurations, see Power supply system.

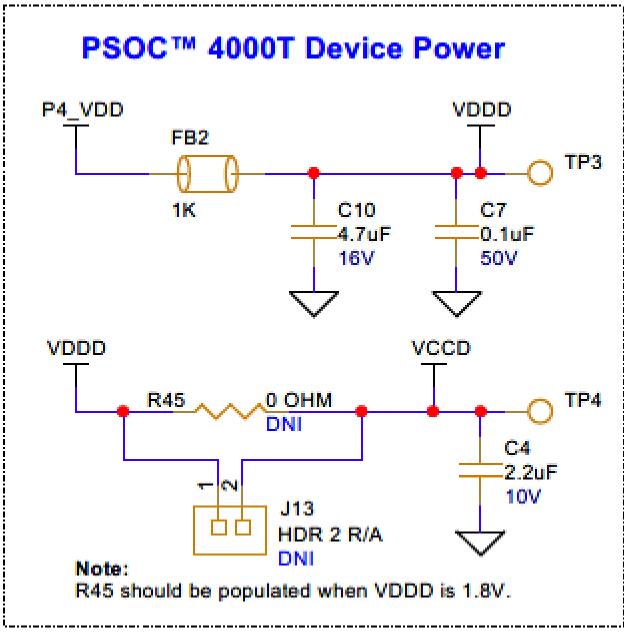


Figure 21 **Schematic of PSOC™ 4000T device power**

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

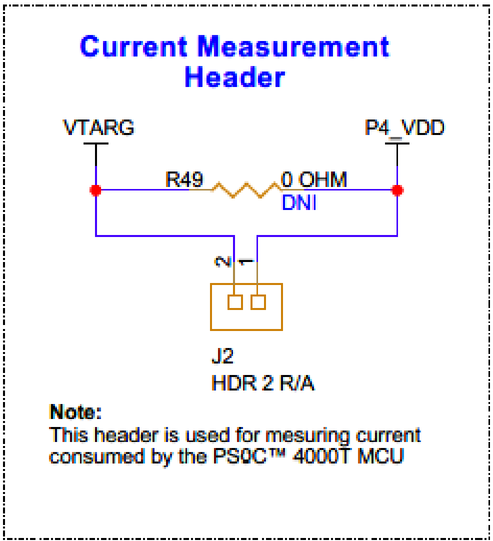


Figure 22 **Schematic of the current measurement header (J2)**

For current measurement, remove the jumper and connect a current measurement device (ammeter) between the pins of J2, as shown in Figure 23.

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

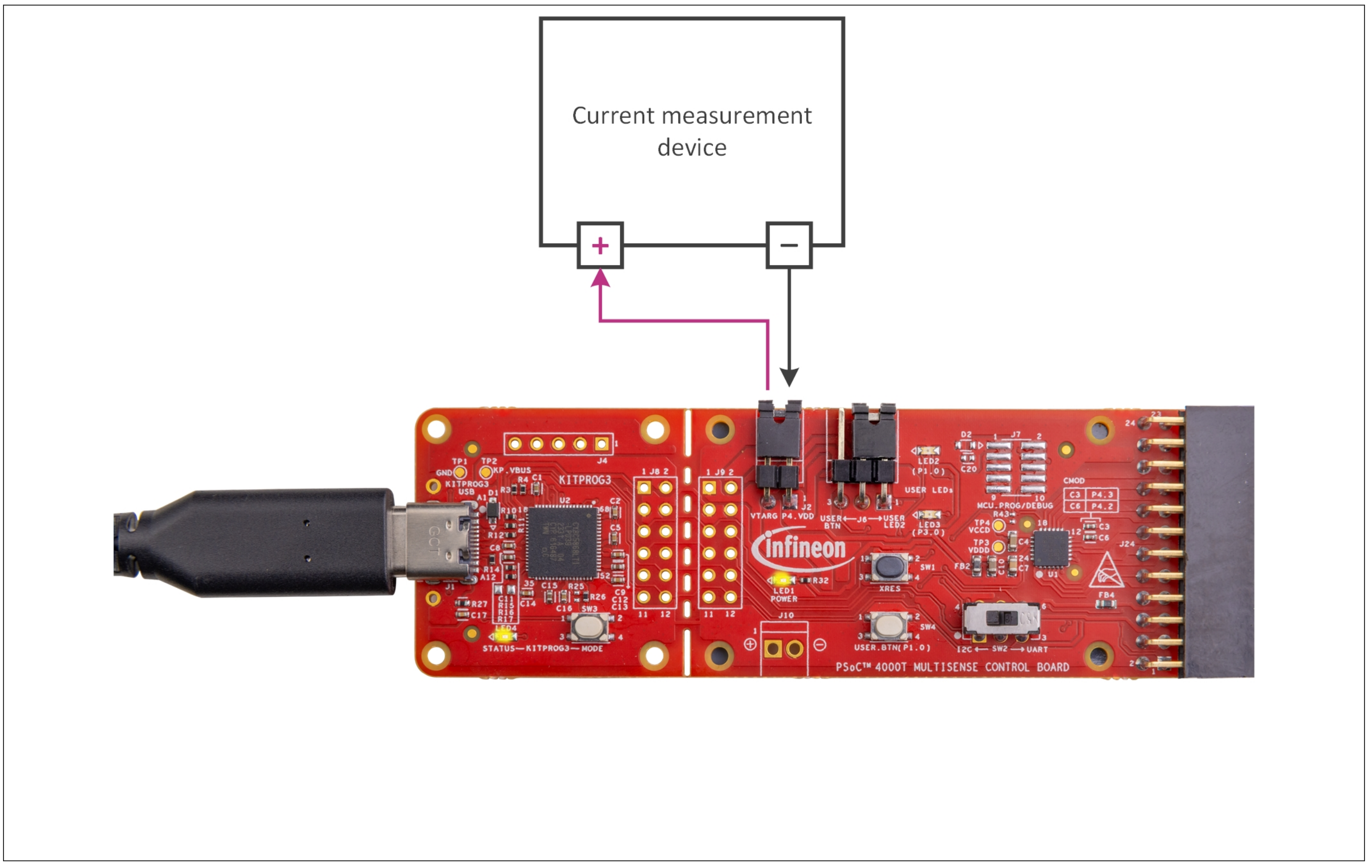


Figure 23 **Connecting the current measurement device with the J2 header**

The onboard LED (LED1) indicates the status of the PSOC™ 4000T device power.

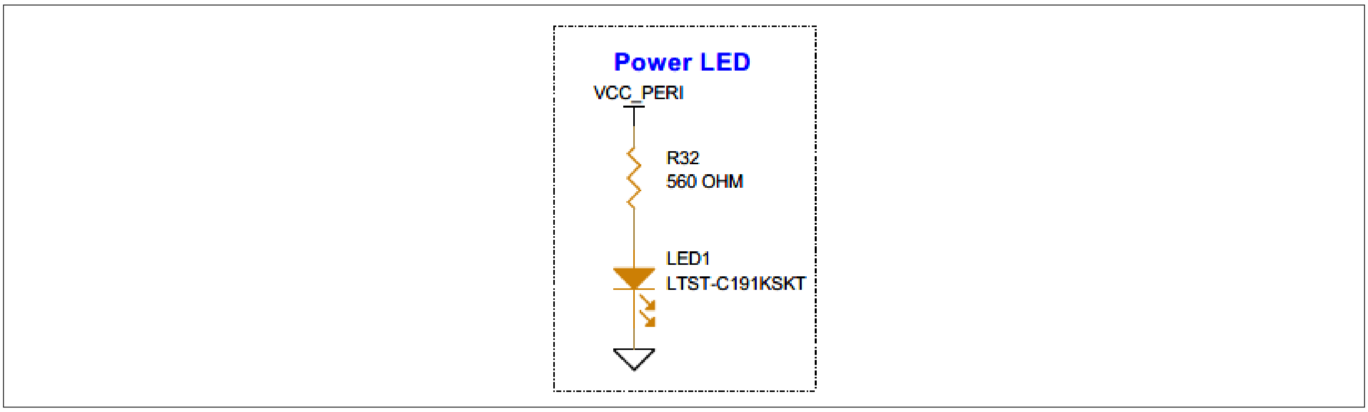


Figure 24 **Power LED indication (LED1) schematic**

3.2.1.3 PSOC™ 4000T device external programming/debugging header

In the PSOC™ 4000T Prototyping board, the default programming/debugging interface is through the onboard KitProg3 programmer/debugger. Additionally, you can use an external MiniProg4 programmer/debugger through the 10-pin header (J7), which is not populated by default.

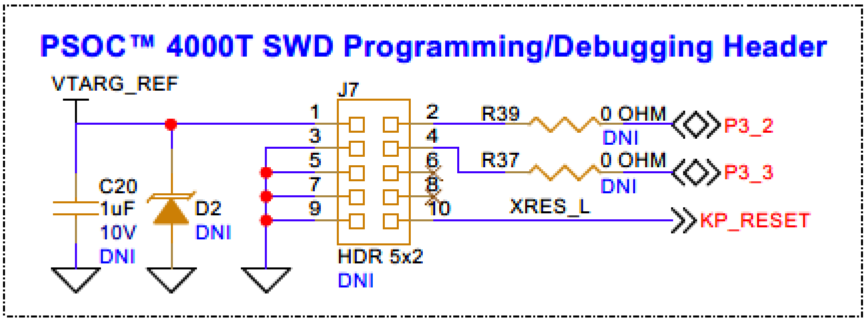


Figure 25 Schematic of the PSOC™ 4000T device 10-pin programming/debugging header

To use the external programming/debugging interface, populate J7, D2, C20, and resistors R37 and R39. Additionally, depopulate resistors R38 and R40.

3.2.1.4 PSOC™ 4000T device I²C/UART interface selection

The PSOC™ 4000T device can be interfaced with the onboard KitProg3 over I²C or UART using a DPDT slide switch (SW2). By default, SW2 is positioned to select the I²C interface. To enable the UART interface, change the position of SW2 from the default setting.

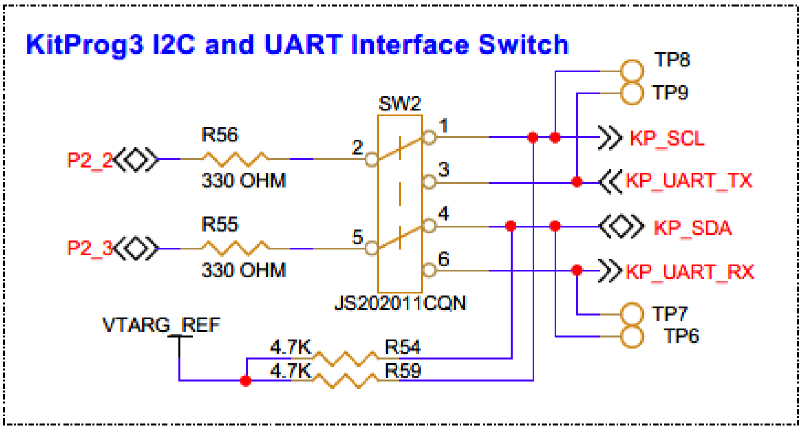


Figure 26 Schematic of the PSOC™ 4000T device I²C/UART interface selection switch

3.2.1.5 Reset button

Use the push button (SW1) on the PSOC™ 4000T Multi-Sense Control board to reset the PSOC™ 4000T. SW1 provides an active-LOW signal.

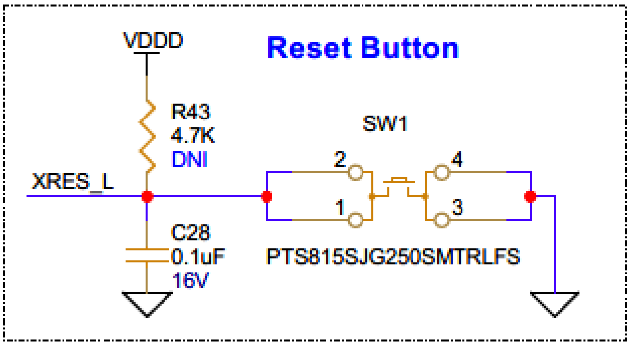


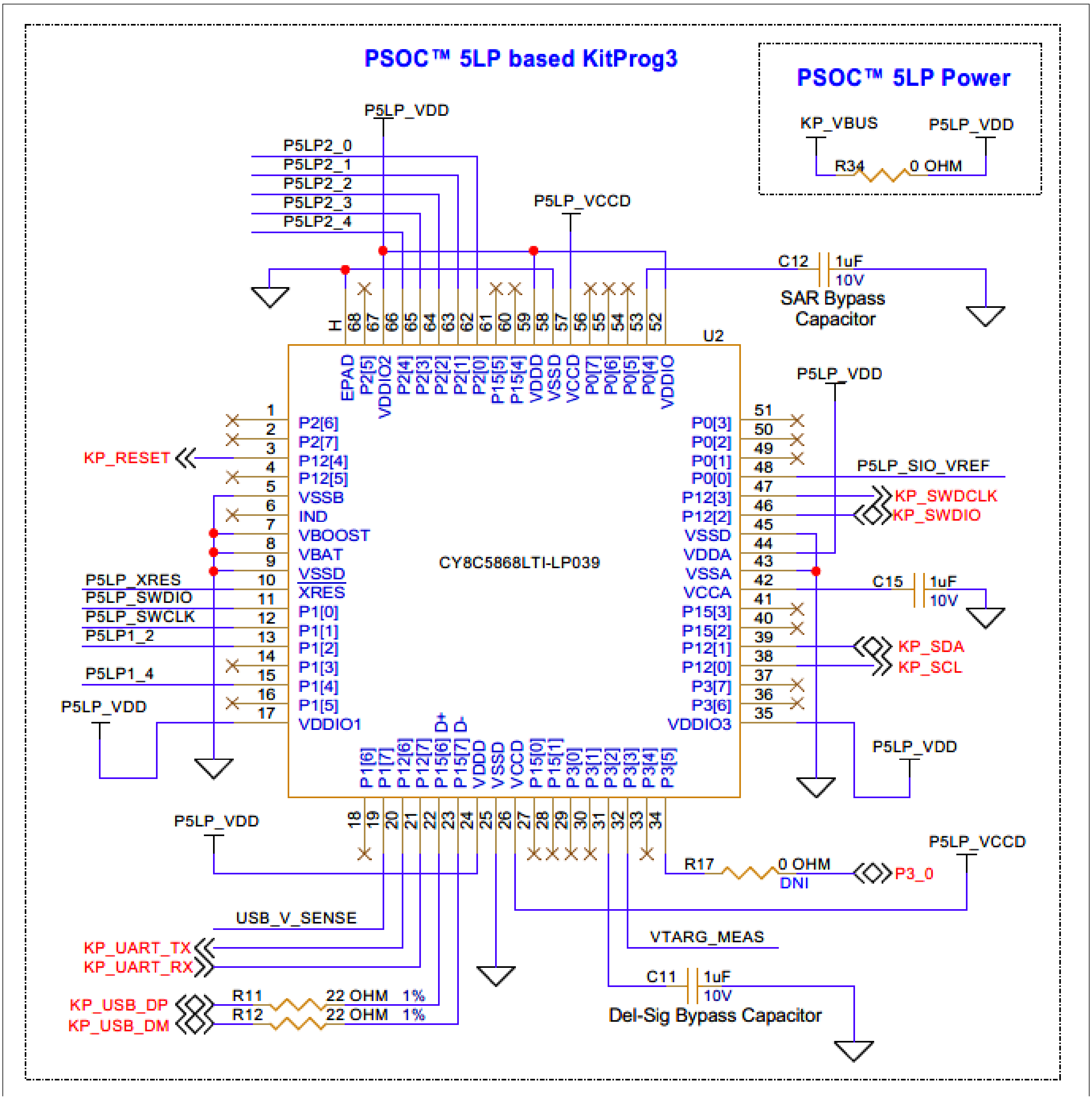
Figure 27 **Schematic of the reset button (SW1)**

3.2.1.6 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 USB Type-C 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


PSOC™ 5LP based KitProg3
PSOC™ 5LP Power
KP_VBUS
P5LP_VDD
R34
0 OHM
P5LP2_0
P5LP2_1
P5LP2_2
P5LP2_3
P5LP2_4
P5LP_VCCD
C12
1uF
10V
SAR Bypass Capacitor
U2
CY8C5868LTI-LP039
KP_RESET
P5LP_XRES
P5LP_SWDIO
P5LP_SWCLK
P5LP1_2
P5LP1_4
P5LP_SIO_VREF
KP_SWDCLK
KP_SWDIO
C15
KP_SDA
KP_SCL
R17
0 OHM
DNI
P3_0
USB_V_SENSE
VTARG_MEAS
KP_UART_TX
KP_UART_RX
KP_USB_DP
KP_USB_DM
R11
22 OHM 1%
R12
22 OHM 1%
C11
Del-Sig Bypass Capacitor

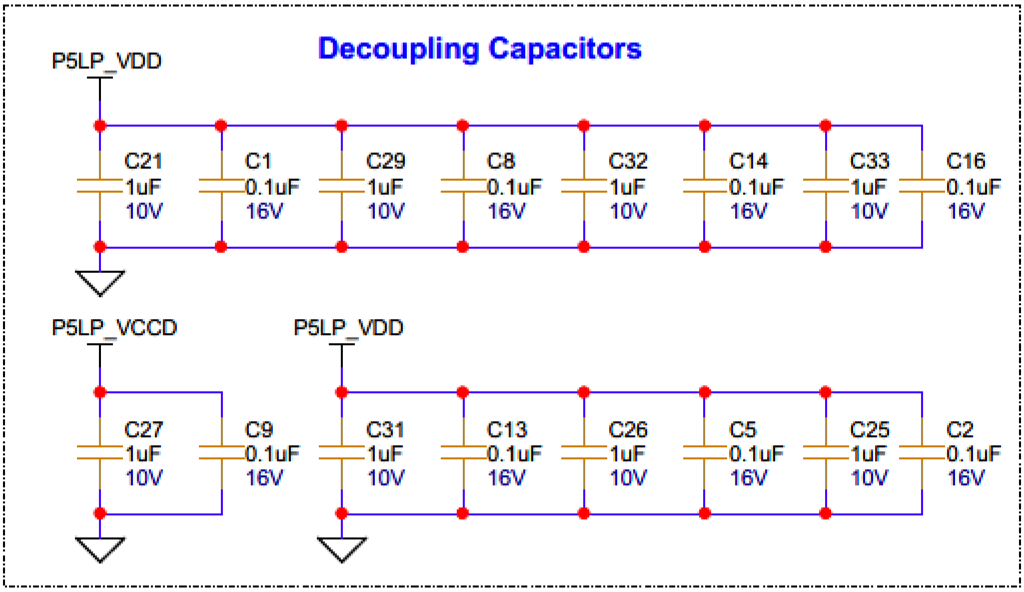


Figure 28 **Schematic of PSOC™ 5LP-based KitProg3**

3.2.1.7 KitProg3 onboard target voltage measurement

PSOC™ 5LP of KitProg3 uses an ADC to measure the onboard target voltage. A voltage divider is placed before the ADC input to bring the target voltage within the dynamic range.

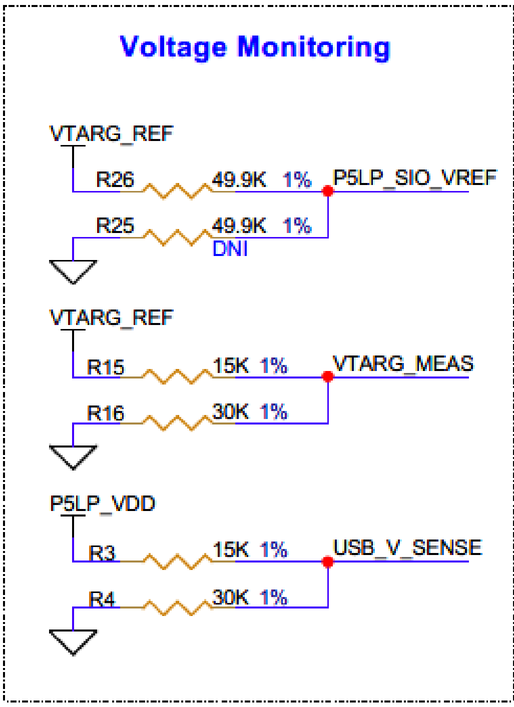


Figure 29 **Schematic of KitProg3 on board target voltage monitoring circuit**

3.2.1.8 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, and enabling bootloader mode). Note that KitProg3 on this board supports 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.

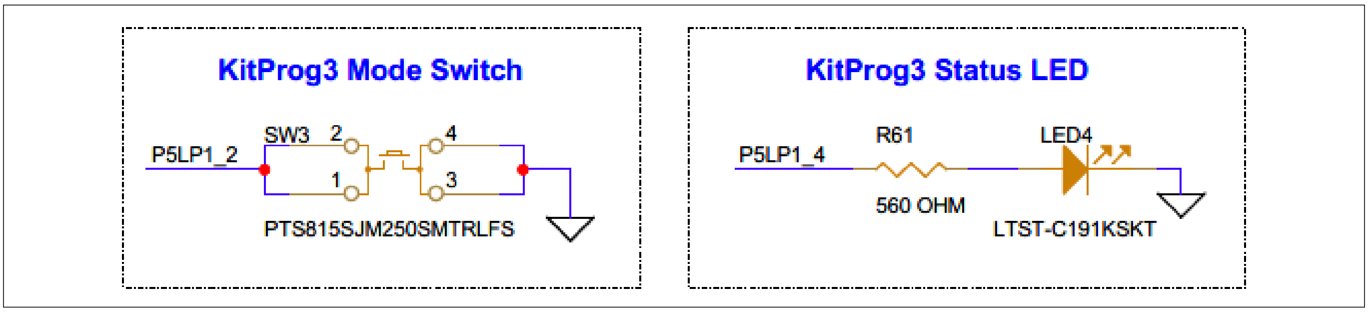


Figure 30 **Schematic of KitProg3 mode selection button (SW3) and status LED (LED4)**

3.2.1.9 Power supply system

The PSOC™ 4000T Multi-Sense control board has a default input supply from the USB Type-C connector (J1), with low-capacitance bidirectional TVS diodes (D1 and U3). These diodes provide ESD and overvoltage protection (OVP) for both power and data signals. Additionally, this 5 V supply is provided to the LDO voltage regulator (U4) to generate a 3.3 V supply for the target MCU through a ferrite bead (FB1).

The power block diagram of the PSOC™ 4000T Multi-Sense Control board with the default input supply is shown in Figure 31.

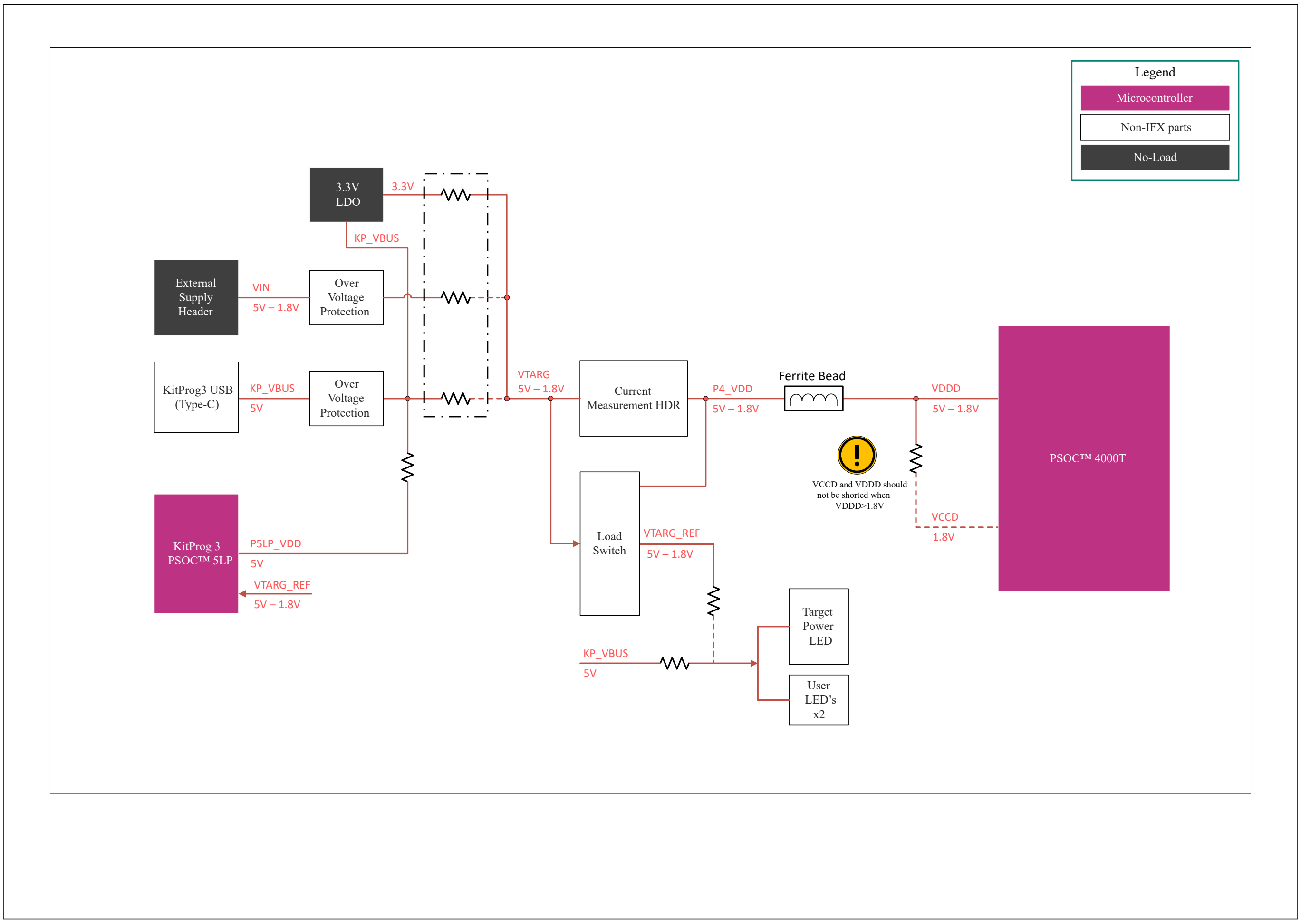


Figure 31 **Power block diagram of the PSOC™ 4000T Multi-Sense Control board**

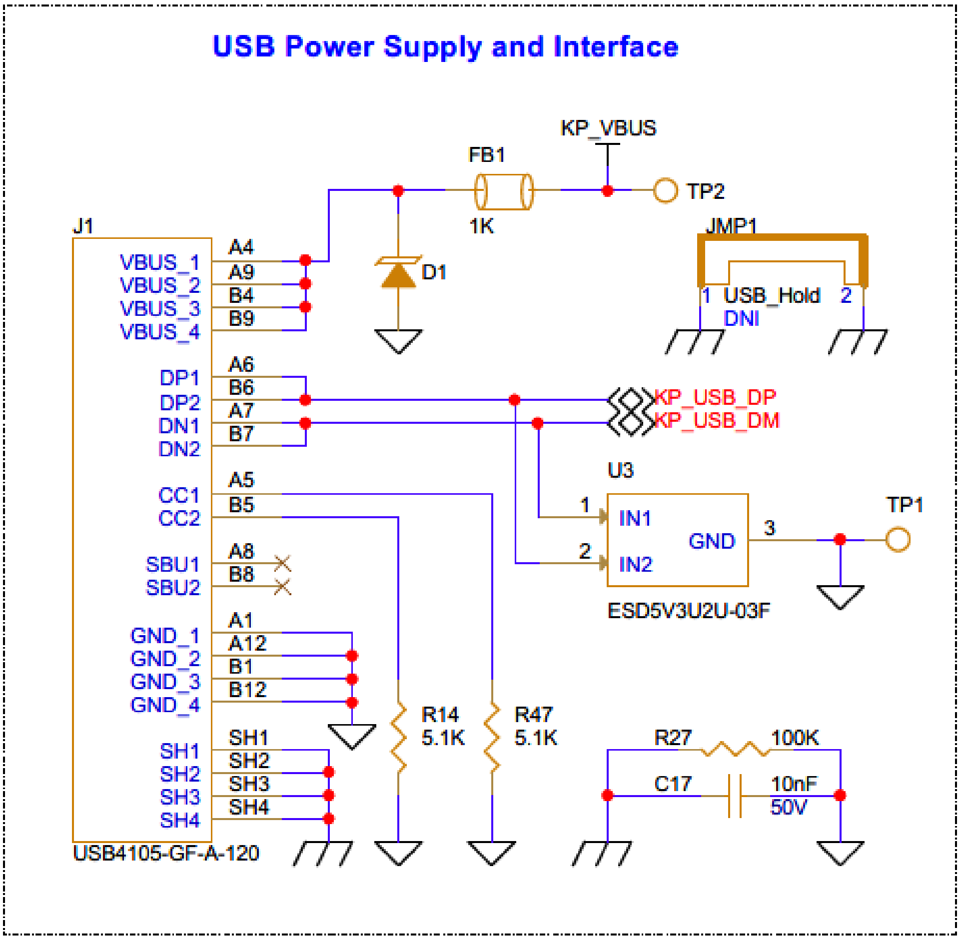


Figure 32 Schematic of the USB Type-C connector (J1) and ESD protection (D1, U3)

This board has a linear voltage regulator at U4 for powering the PSOC™ 4000T device with a regulated 3.3 V supply derived from the 5 V supply coming from the USB Type-C connector.

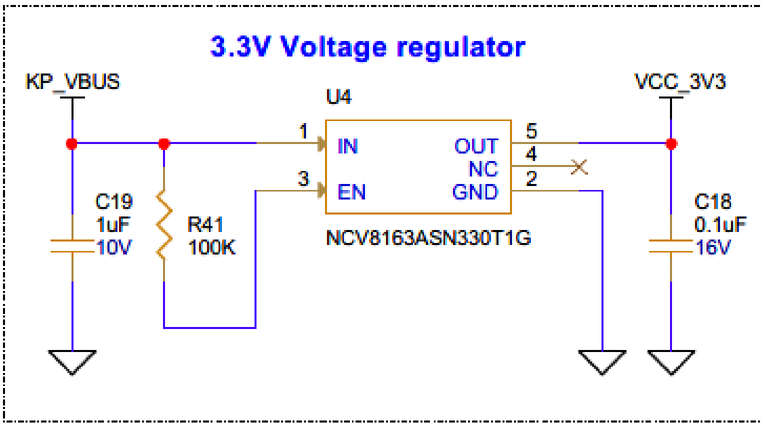


Figure 33 Schematic of the 3.3 V voltage regulator (U4)

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

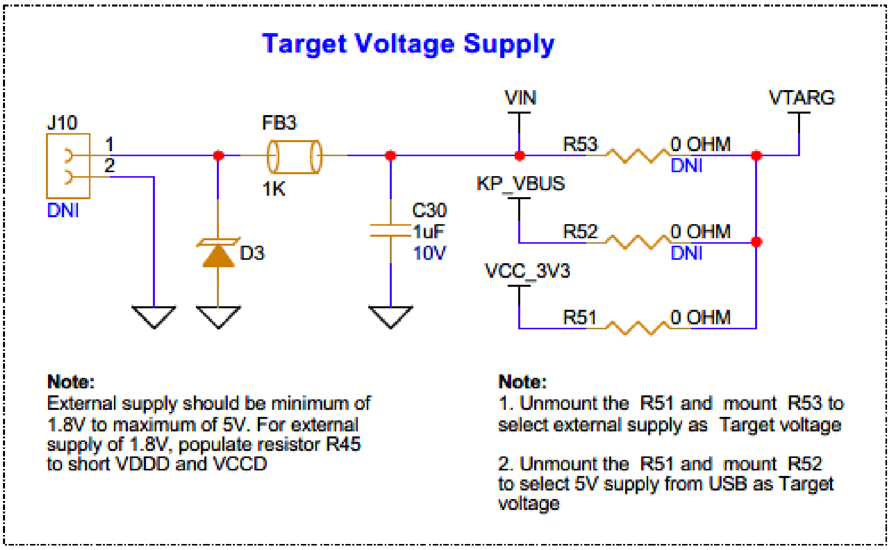


Figure 34 **Schematic of the external power supply input (J10)**

These powering options enable the kit to operate at different voltages by configuring the appropriate provisions and selecting the required powering option by populating the corresponding selection resistors (R53, R52, or R51).

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.*

3.2.1.10 Target reference voltage switch

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

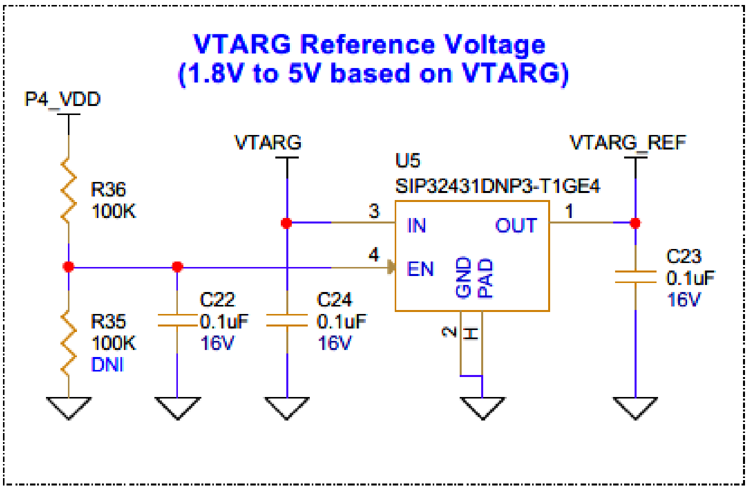


Figure 35 **Schematic of target reference voltage switch (U5)**

3.2.1.11 User LEDs

The PSOC™ 4000T Multi-Sense Control board has the following two user LEDs: LED2 and LED3. These LEDs are driven by the Q1 MOSFET to isolate the LED current from the PSOC™ 4000T device current (the GPIO peripheral current consumption will still be part of the PSOC™ 4000T device current). By default, the LEDs are driven from the KP_VBUS USB power input. There is a provision on the board to drive the LEDs from the VTARG_REF power rail.

***Note**: P1.0 is shared between LED3 and SW4 through a 3-pin header, where you can select either of them by populating the jumper between J6.1 and J6.2, or J6.2 and J6.3.*

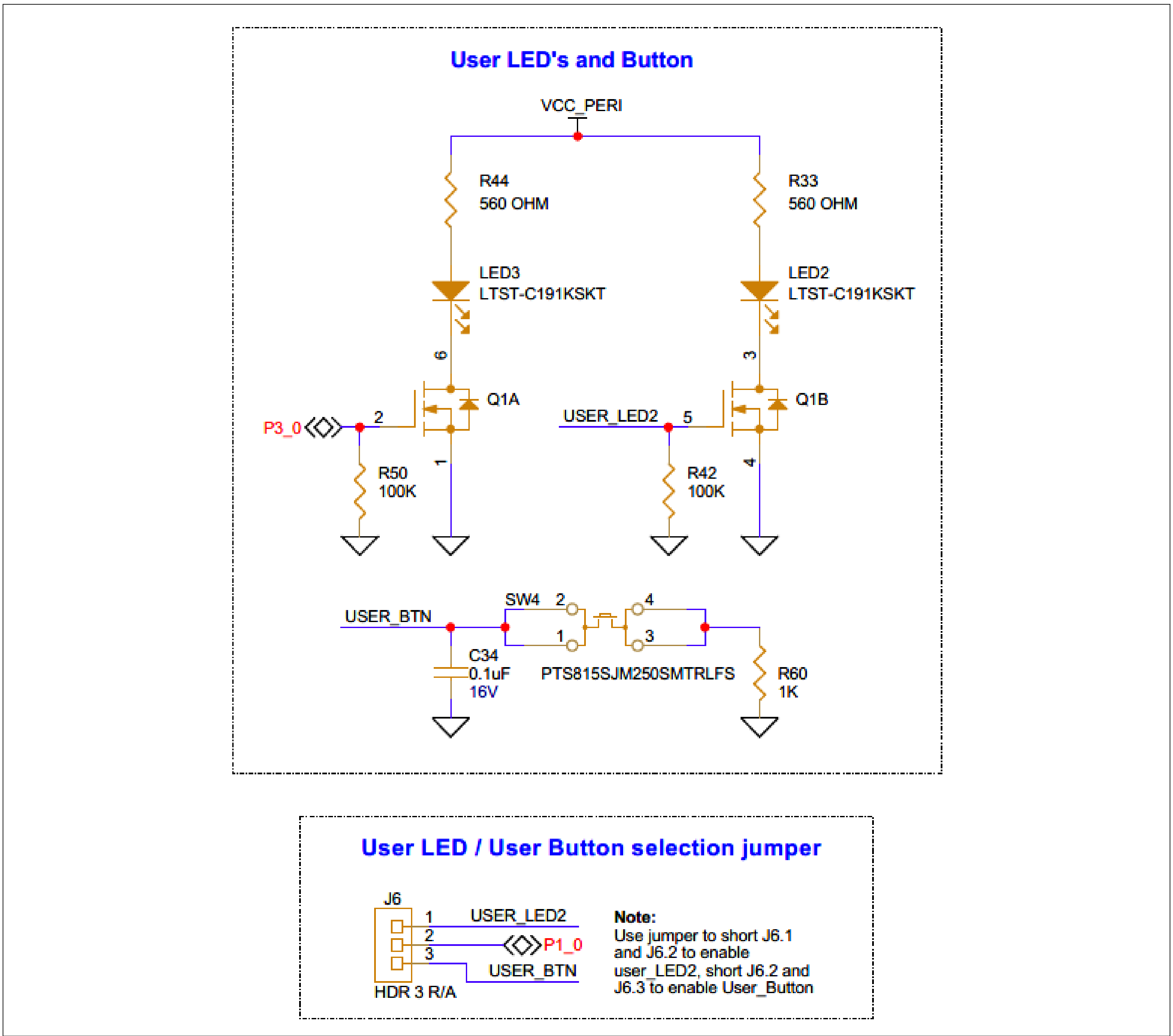


Figure 36 User LEDs schematic

3.2.1.12 User button

The PSOC™ 4000T Multi-Sense Control 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.

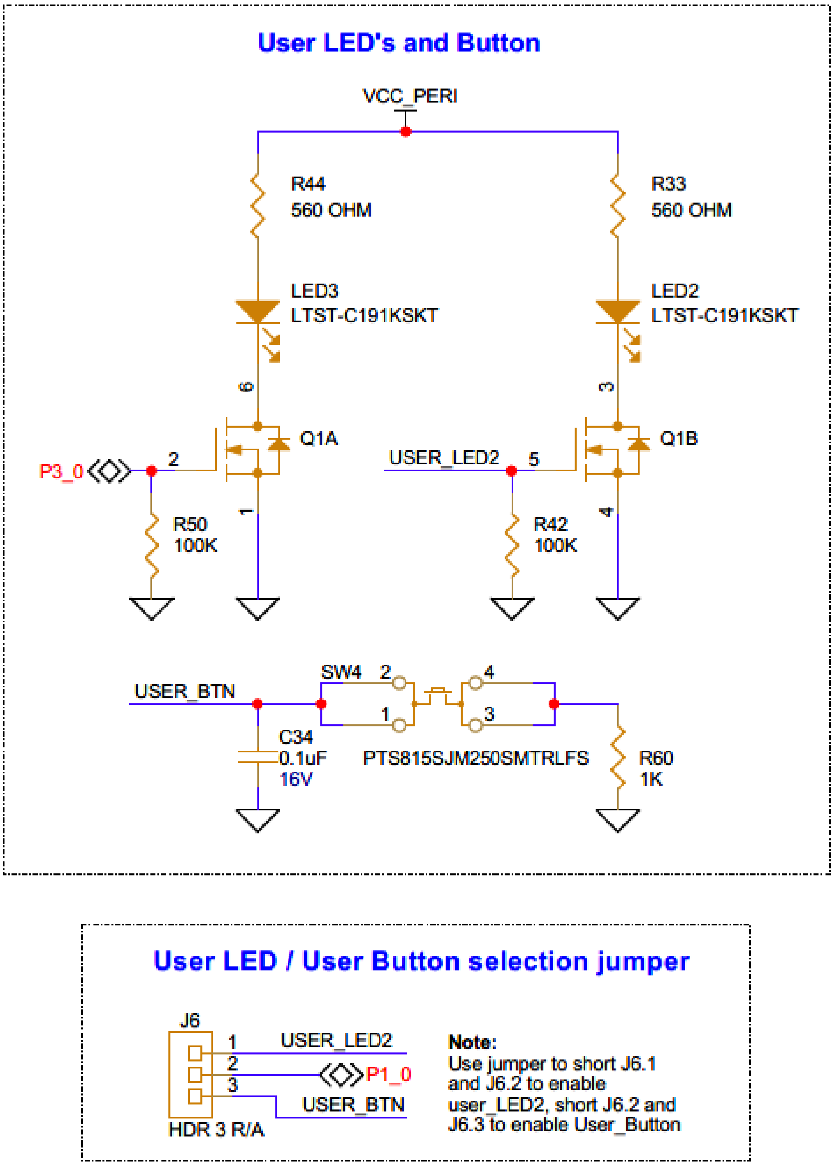


Figure 37 **User button schematic**

3.2.1.13 Sensor interface expansion header

The PSOC™ 4000T Multi-Sense Control board features a 24-pin sensor interface header (J24) that provides a convenient and flexible way to connect various sensors and interfaces.

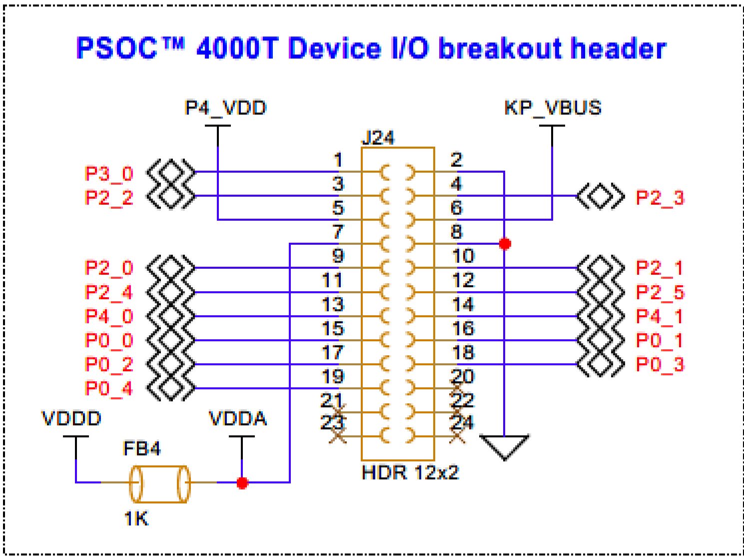


Figure 38 **Schematic of the sensor interface expansion header**

This header is divided into three main sections:

- Power supply
- Digital interface
- Sensor interface

3.2.1.13.1 Power supply

The power supply section of the header provides power to the sensor expansion board. These pins can be used to power sensors, interfaces, and other devices on the expansion board.

Table 8 **Pin assignment of power supply domains**

Pin number	Power supply domain	Description
J24.5	P4_VDD	Should be used for I/O reference only, not for powering devices on sensor expansion boards.
J24.6	KP_VBUS (5 V)	Can be used to power devices on sensor expansion boards.
J24.7	VDDA	Should be used for analog reference only, not for powering devices on sensor expansion boards.
J24.2, J24.8	GND	Ground

3.2.1.13.2 Digital interface

The digital interface section of the header provides digital communication pins for devices on the sensor expansion boards. These pins can be used to transmit digital signals between the MCU and the connected devices.

Table 9 **Pin assignment of digital interface signals**

Pin number	MCU pin number	Primary digital interface	Secondary digital interface
J24.1	P3[0]	GPIO and PWM supported digital output	SPI MOSI interface
J24.3	P2[2]	I^2C Clock signal	-
J24.3	P2[3]	I^2C Data signal	-

3.2.1.13.3 Sensor interface

The sensor interface section of the header provides PSOC™ 4000T device signal pins for connecting sensors and interfaces. These pins can be used to connect capacitive touch sensors and other sensors with analog output. The PSOC™ 4000T device's built-in ADC can be used to measure the analog signal levels from these devices.

Table 10 **Pin assignment of sensor interface signals**

Pin number	MCU pin number	Primary digital interface
J24.9	P2[0]	Connected to an external sensor interface expansion header (J24) used as: • General-purpose I/O • CAPSENSE™ I/O
J24.10	P2[1]	Connected to an external sensor interface expansion header (J24) used as: • General-purpose I/O • CAPSENSE™ I/O
J24.11	P2[4]	Connected to an external sensor interface expansion header (J24) used as: • General-purpose I/O • CAPSENSE™ I/O
J24.12	P2[5]	Connected to an external sensor interface expansion header (J24) used as: • General-purpose I/O • CAPSENSE™ I/O
J24.13	P4[0]	Connected to an external sensor interface expansion header (J24) used as: • General-purpose I/O • CAPSENSE™ I/O
J24.14	P4[1]	Connected to an external sensor interface expansion header (J24) used as: • General-purpose I/O • CAPSENSE™ I/O

(table continues...)

Table 10 (continued) Pin assignment of sensor interface signals

Pin number	MCU pin number	Primary digital interface
J24.15 to J24.19	P0[0] - P0[4]	Connected to an external sensor interface expansion header (J24) used as: • General-purpose I/O • CAPSENSE™ I/O

3.2.2 Inductive sensing expansion boards

The PSOC™ 4000T Multi-Sense Prototyping Kit comprises the following inductive sensing expansion boards designed to demonstrate the flyback Inductive sensing method for Touch-over-Metal button use cases:

- Inductive Keypad-4 expansion board
- Inductive Keypad-2 expansion board

These expansion boards connect to the PSOC™ 4000T Multi-Sense Control board using the 24-pin connector (J24), which interfaces the I/Os of the PSOC™ 4000T MCU to Touch-over-Metal inductive sensing buttons.

3.2.2.1 Touch-over-Metal inductive buttons

Touch-over-Metal inductive buttons are a form of user-interface technology that utilizes flyback inductive sensing to detect button presses on a flat metal surface. For more details about flyback inductive sensing technology, refer to an inductive sensing design guide. This technology provides a robust and aesthetically pleasing alternative to traditional mechanical buttons.

Touch-over-Metal inductive buttons operate based on the principle of inductance change. A flat metal surface is placed above an inductor, typically a coil printed on a printed circuit board (PCB). When the metal surface is pressed, even with a light force, the inner surface of the metal deflects towards the PCB, causing a detectable shift in the inductance of the coil. This change in inductance is interpreted by a PSOC™ 4000T device as a button press.

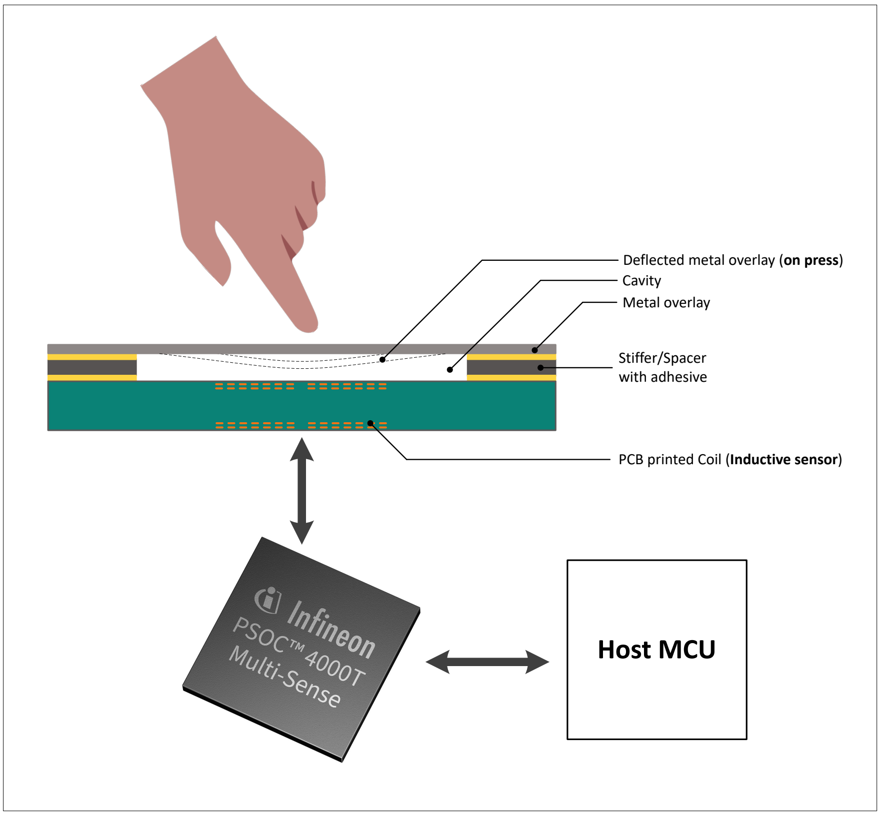


Figure 39 System block diagram of Touch-over-Metal inductive buttons

The construction of an inductive-sensing touch system over metal buttons comprises three main components:

- A metal overlay
- Spacer or stiffener
- Sensor coil on the PCB

3.2.2.1.1 Metal overlay

The metal overlay serves as the touch surface and is typically made from non-ferrous metals like aluminum and stainless steel. It is designed to balance durability and electromagnetic transparency. The surface finish can range from polished to brushed, enhancing both aesthetics and wear resistance. The overlay is cut or stamped into the required shape and may include mounting holes or slots for secure attachment to the spacer or base structure.

3.2.2.1.2 Spacer or stiffener

The spacer, or stiffener, positioned between the metal overlay and the sensor coil, ensures proper spacing and structural support. It is typically made from non-conductive materials such as plastics (e.g., polycarbonate) and adhesives. The thickness of the spacer is crucial for maintaining the correct distance for effective sensing. It may be in the form of a continuous sheet or individual standoffs, often incorporating adhesive layers to secure it in place and provide stability to the metal overlay.

3.2.2.1.3 Sensor coil on PCB

The sensor coil, etched from copper traces on the PCB, generates the electromagnetic field necessary for inductive sensing. The coil's design, including the number of turns and the trace width, is precisely aligned beneath the metal overlay. The PCB may be either single-layer or multi-layer, depending on the required sensing range, and includes mounting features to ensure it remains securely in place during operation.

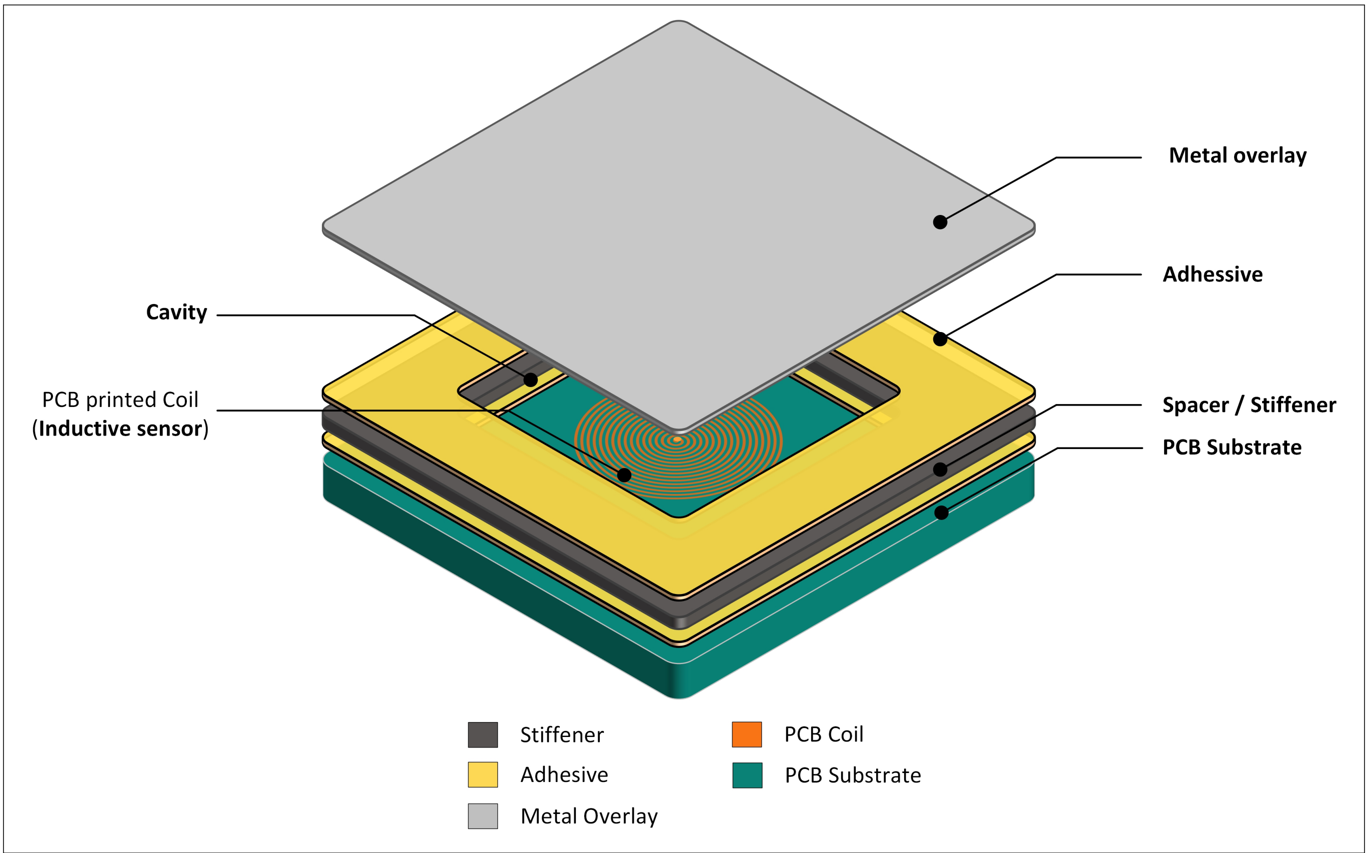


Figure 40 Implementation of Touch-over-Metal inductive buttons

For more detailed information and design optimization, refer to the inductive sensing design guide. The PSOC™ 4000T Multi-Sense Prototyping Kit includes two expansion boards that demonstrate the functionality of Touch-over-Metal inductive buttons.

3.2.2.2 Inductive Keypad-4 expansion board

The Inductive Keypad-4 expansion board is a demonstration platform for Touch-over-Metal inductive buttons, featuring four buttons arranged in a 2x2 matrix. This board is designed to showcase the capabilities of PSOC™ 4000T devices in implementing inductive-sensing buttons for compact human-machine interface applications.

3.2.2.2.1 Button layout and design

The four buttons on the Inductive Keypad-4 expansion board are arranged in a compact layout, with two buttons in a row and two buttons in a column. Each button has a rounded-square shape, measuring 17 mm x 17 mm. The center-to-center spacing between the buttons is 22 mm.

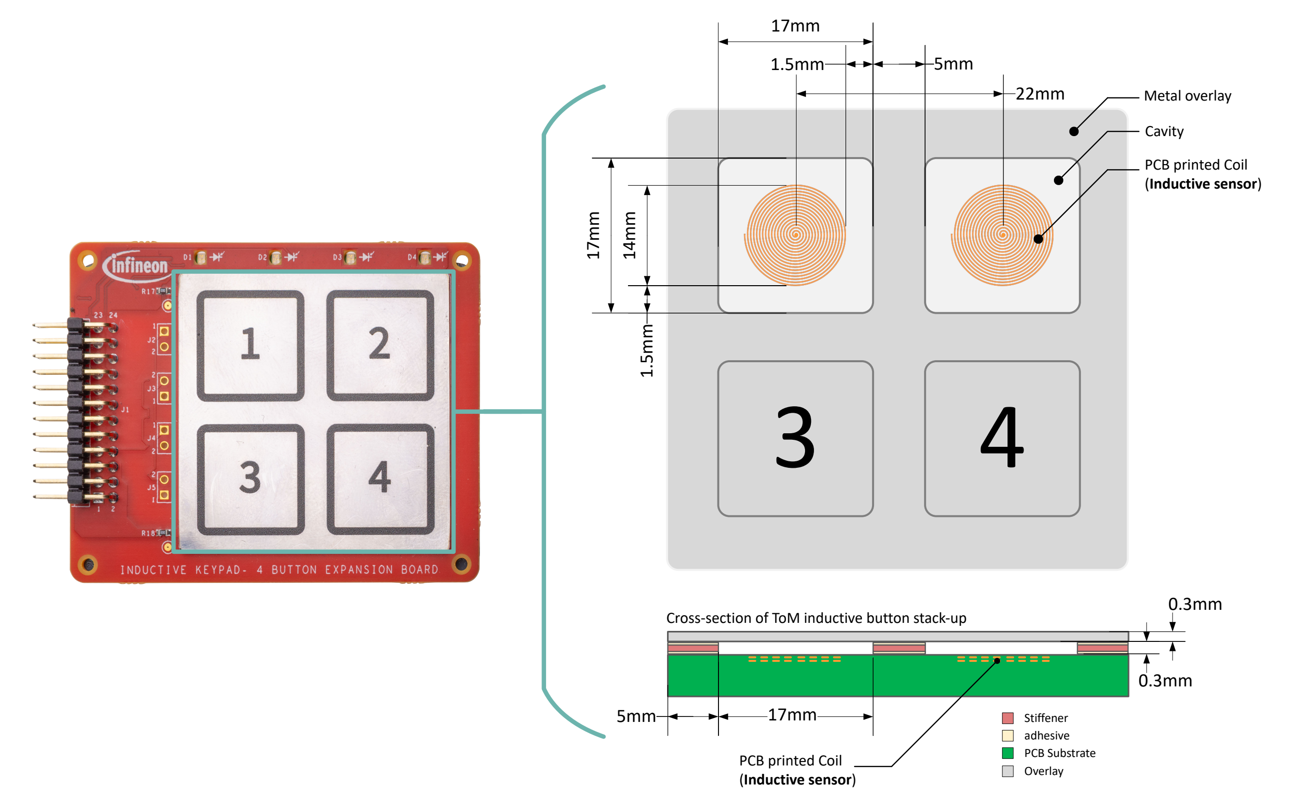


Figure 41 **Touch-over-Metal induction button layout**

3.2.2.2.2 Specifications of Inductive Keypad-4 expansion board

The sensor coils on the Inductive Keypad-4 expansion board are designed to detect changes in inductance caused by metal overlay deflection. The sensor coil specifications are as follows:

Parameter	Value
Number of sensors	4
Button shape and size	Rounded square, 17 mm x 17 mm
Button center-to-center spacing	22 mm
Indication of button	Location printed on the overlay
Sensor coil shape and size	Circle, 14 mm diameter
Stack-up of the coil	2 layer (first 2 layers in a 4-layer board)
Metal overlay material	304-grade stainless steel
Metal overlay thickness	0.3 mm
Spacer or stiffener thickness	0.3 mm

Sensor coil design: The sensor coil on the Inductive Keypad-4 expansion board is designed to generate an electromagnetic field to detect changes in inductance caused by metal overlay deflection. The coil is etched from copper traces on the PCB and has a circular shape with a diameter of 14 mm.

Metal overlay: The metal overlay on the Inductive Keypad-4 expansion board is made of 304-grade stainless steel with a thickness of 0.3 mm. The spacer/stiffener ensures proper spacing and provides structural support between the metal overlay and the sensor coil.

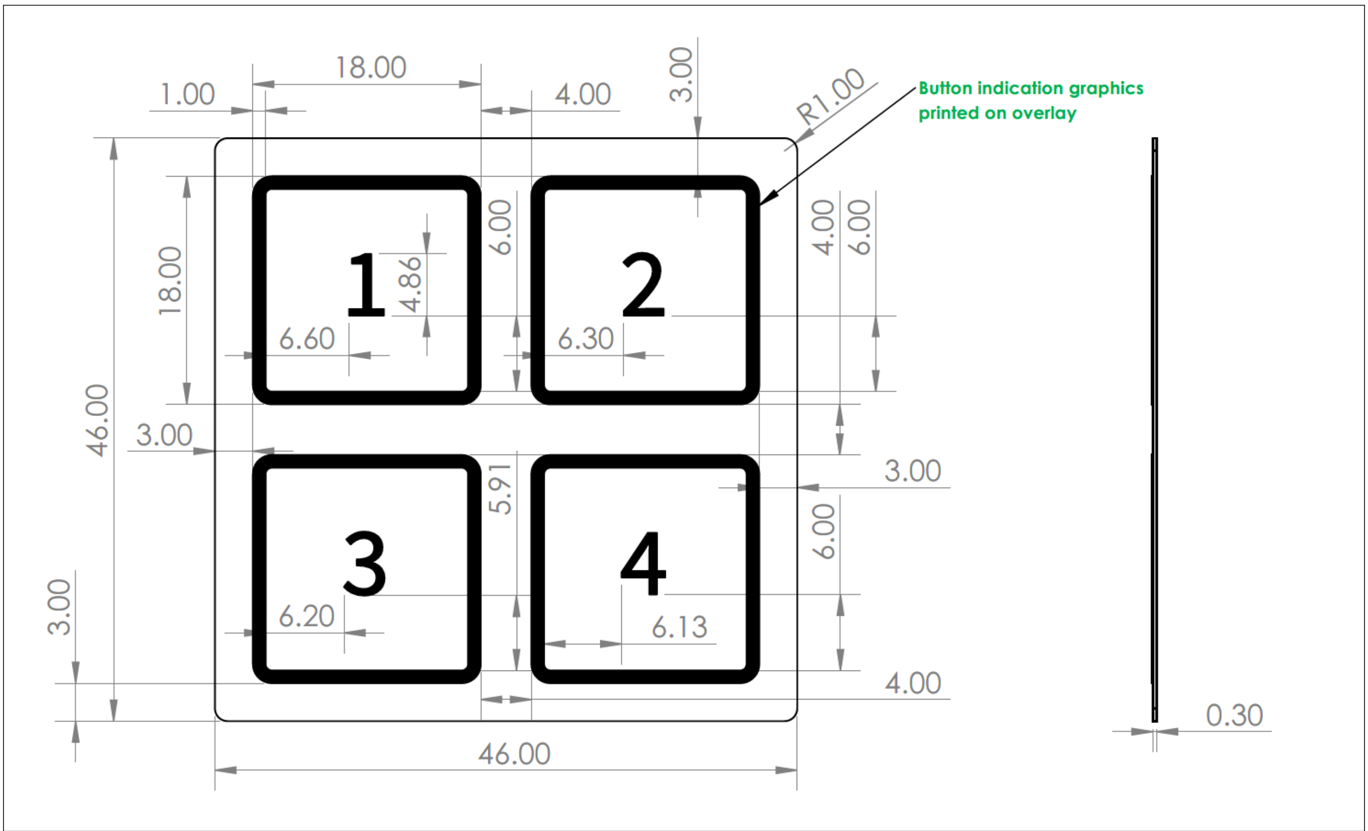


Figure 42 **Metal overlay dimensions**

Note: *All dimensions mentioned in Figure 42 are in millimeters.*

Spacer or stiffener and cavity shape: The spacer or stiffener is made of a non-conductive material with a thickness of 0.3 mm. The cavity shape and dimensions on the Inductive Keypad-4 expansion board are designed to accommodate deflections in the metal overlay. The cavity shape is square with a side length of 17 mm and rounded corners.

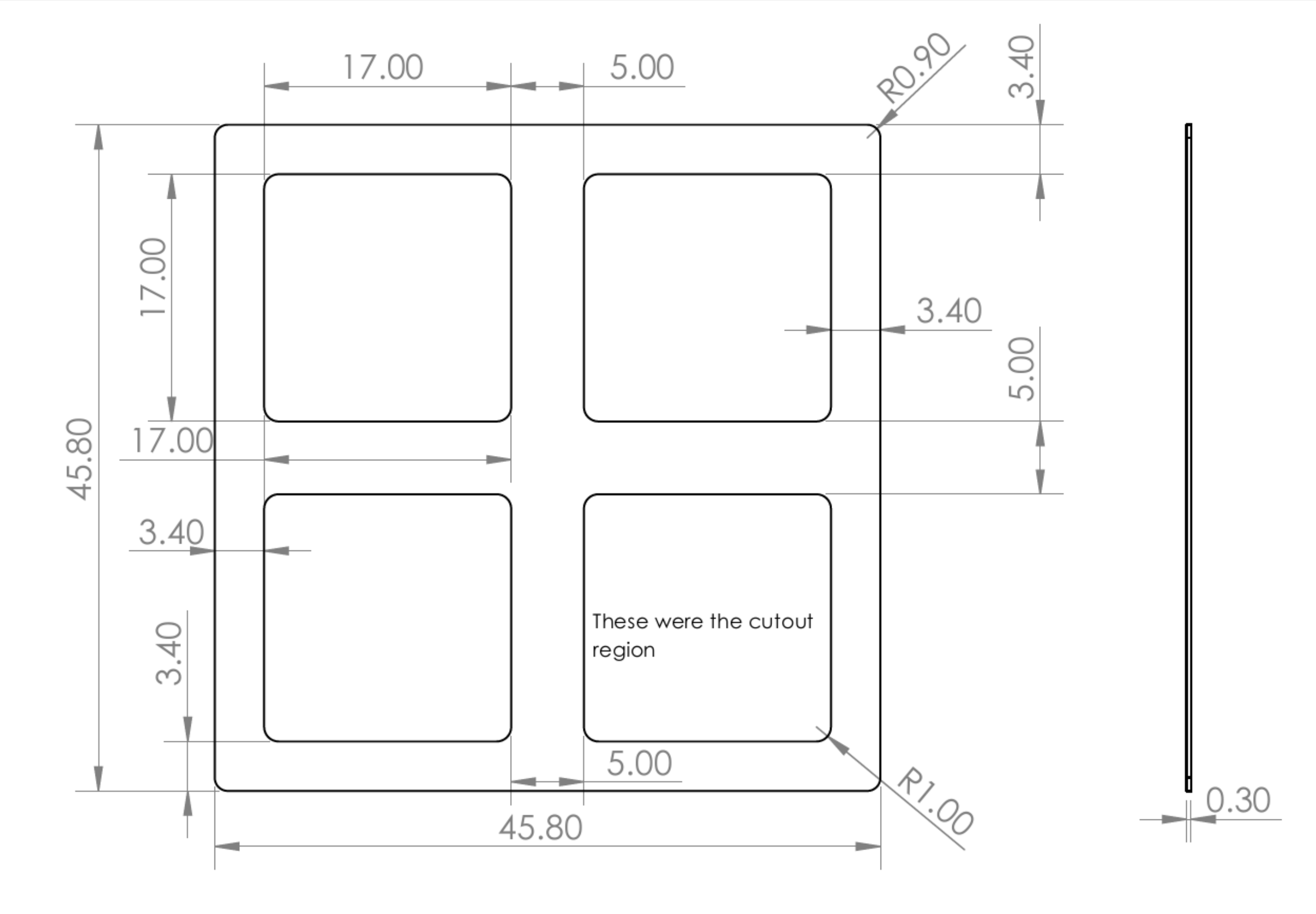


Figure 43 **Spacer or stiffener dimensions**

***Note**: All dimensions mentioned in Figure 43 are in millimeters.*

3.2.2.2.3 Hardware configuration

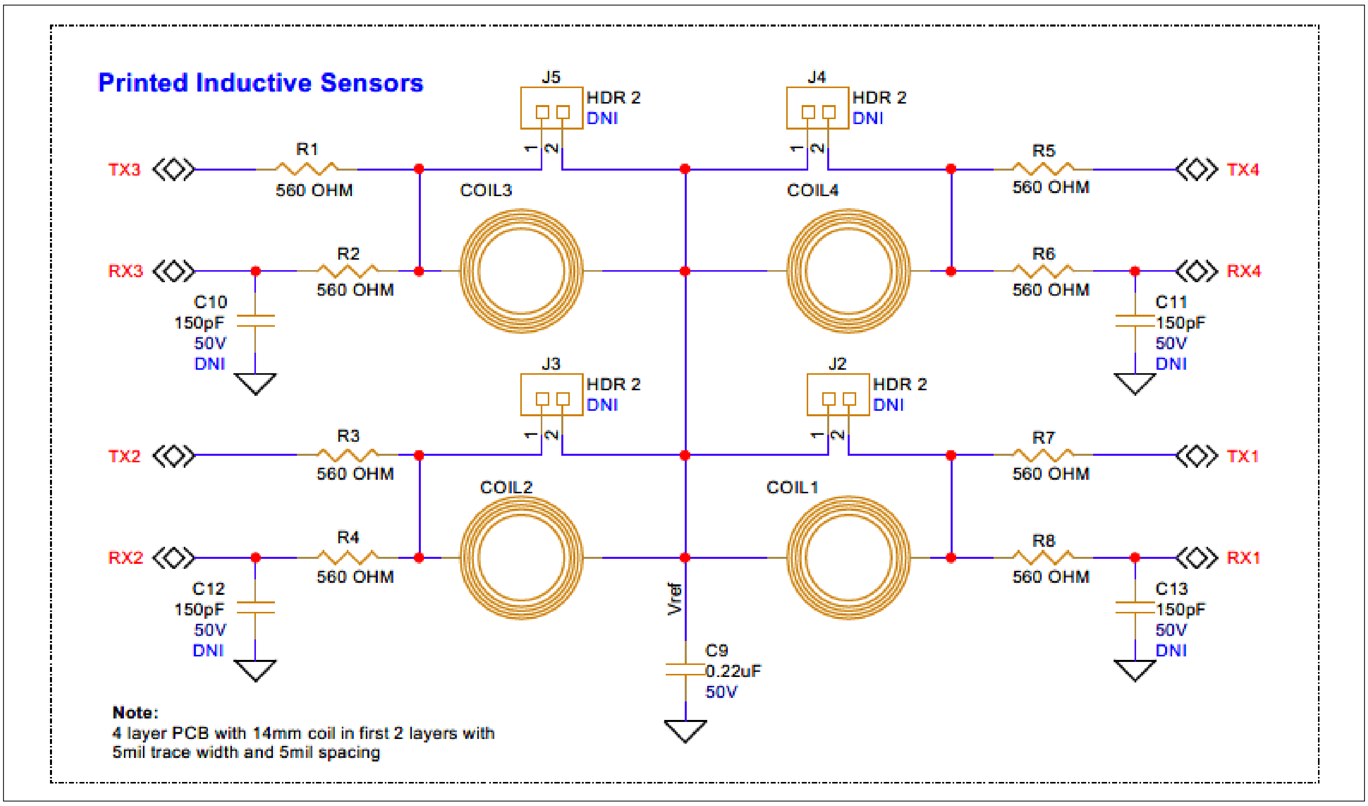


Figure 44 Inductive sensors schematic

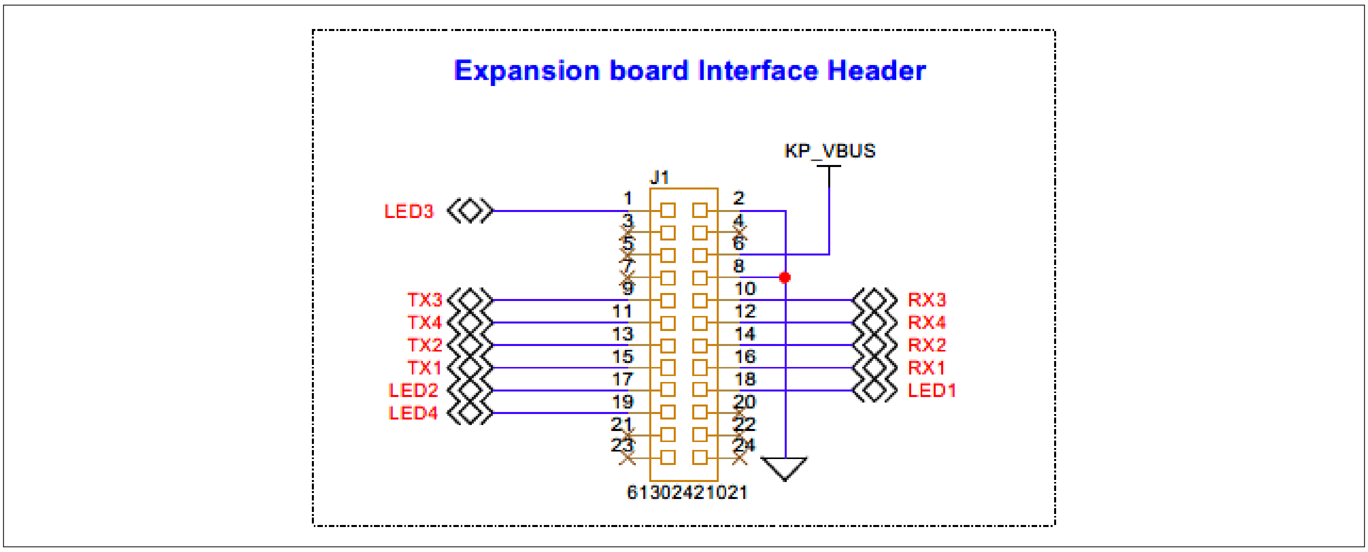


Figure 45 Expansion header interface schematic

Table 11 Pin assignment of sensor interface expansion header

Pin number	Pin detail	Description	Control board pin assignment
J24.1	LED3	Output signal to drive LED3	P3[0]
J24.2, J24.8	GND	Power supply ground	GND

(table continues...)

Table 11 (continued) Pin assignment of sensor interface expansion header

Pin number	Pin detail	Description	Control board pin assignment
J24.6	KP_VBUS	5 V power supply	KP_VBUS
J24.9	TX3	LX signal of Coil3	P2[0]
J24.10	RX3	RX signal of Coil3	P2[1]
J24.11	TX4	LX signal of Coil4	P2[4]
J24.12	RX4	RX signal of Coil4	P2[5]
J24.13	TX2	LX signal of Coil2	P4[0]
J24.14	RX2	RX signal of Coil2	P4[1]
J24.15	TX1	LX signal of Coil1	P0[0]
J24.16	RX1	RX signal of Coil1	P0[1]
J24.17 to J24.19	LED2, LED1, and LED4	Output signals for driving LED1, LED2, and LED4	P0[2] (for LED2), P0[3] (for LED1) and P0[4] (for LED4)

3.2.2.3 Inductive Keypad-2 expansion board

The Inductive Keypad-2 expansion board is another demonstration platform for Touch-over-Metal inductive buttons, featuring two buttons arranged in a single row. This board is designed to showcase the capabilities of PSOC™ 4000T devices in implementing larger-size inductive-sensing buttons with a larger air gap (the distance between the metal overlay and the sensor).

3.2.2.3.1 Button layout and design

The two buttons on the Inductive Keypad-2 expansion board are arranged in a single row, with a center-to-center spacing of 35 mm. Each button has a rounded-square shape with a size of 25 mm x 25 mm, and the center-to-center spacing between the buttons is 33 mm.

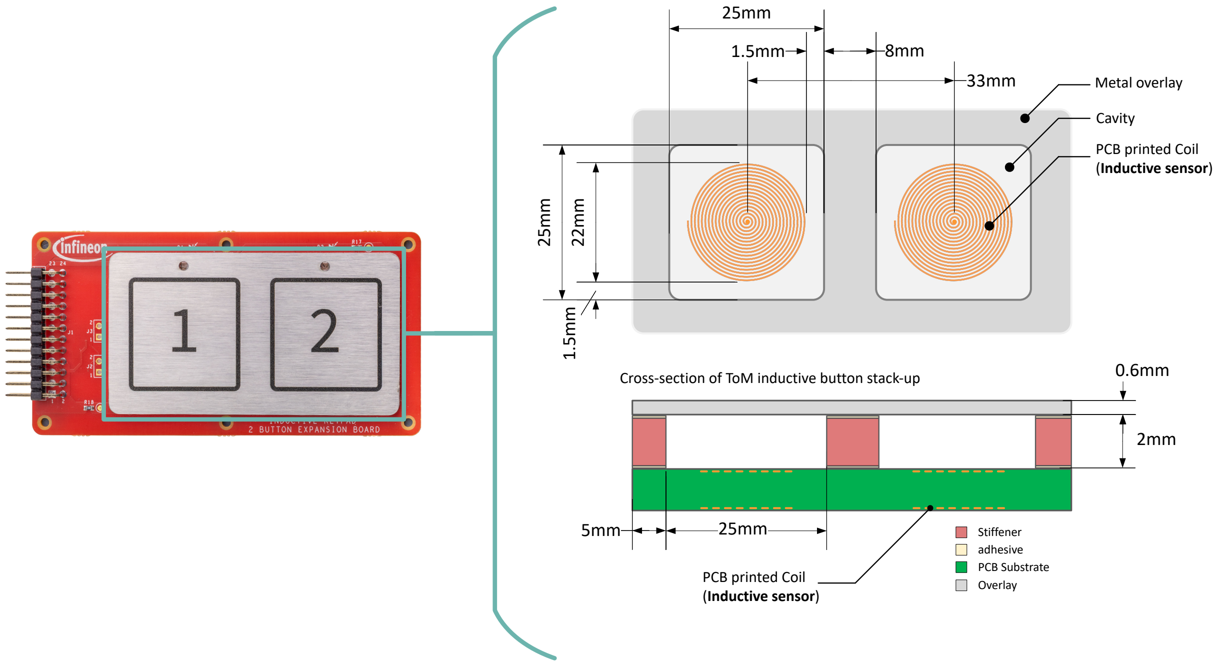


Figure 46 **Touch-over-Metal induction button layout**

3.2.2.3.2 Specifications of Inductive Keypad-2 expansion board

The sensor coils on the Inductive Keypad-2 expansion board are designed to detect changes in inductance caused by metal overlay deflection. The sensor coil specifications are as follows:

Parameter	Value
Number of sensors	2
Button shape and size	Rounded square, 25 mm x 25 mm
Button center-to-center spacing	33 mm
Indication of button	Location printed on the overlay
Sensor coil shape and size	Circle, 22 mm diameter
Stack-up of the coil	2 layers
Metal overlay material	304-grade stainless steel
Metal overlay thickness	0.6 mm
Spacer or stiffener thickness	2 mm

Sensor coil design: The sensor coil on the Inductive Keypad-2 expansion board is designed to generate an electromagnetic field that detects changes in inductance caused by metal overlay deflection. The coil is etched from copper traces on the PCB and has a circular shape with a diameter of 22 mm.

Metal overlay: The metal overlay on the Inductive Keypad-2 expansion board is made of 304-grade stainless steel with a thickness of 0.6 mm. The spacer/stiffener ensures proper spacing and structural support between the metal overlay and the sensor coil.

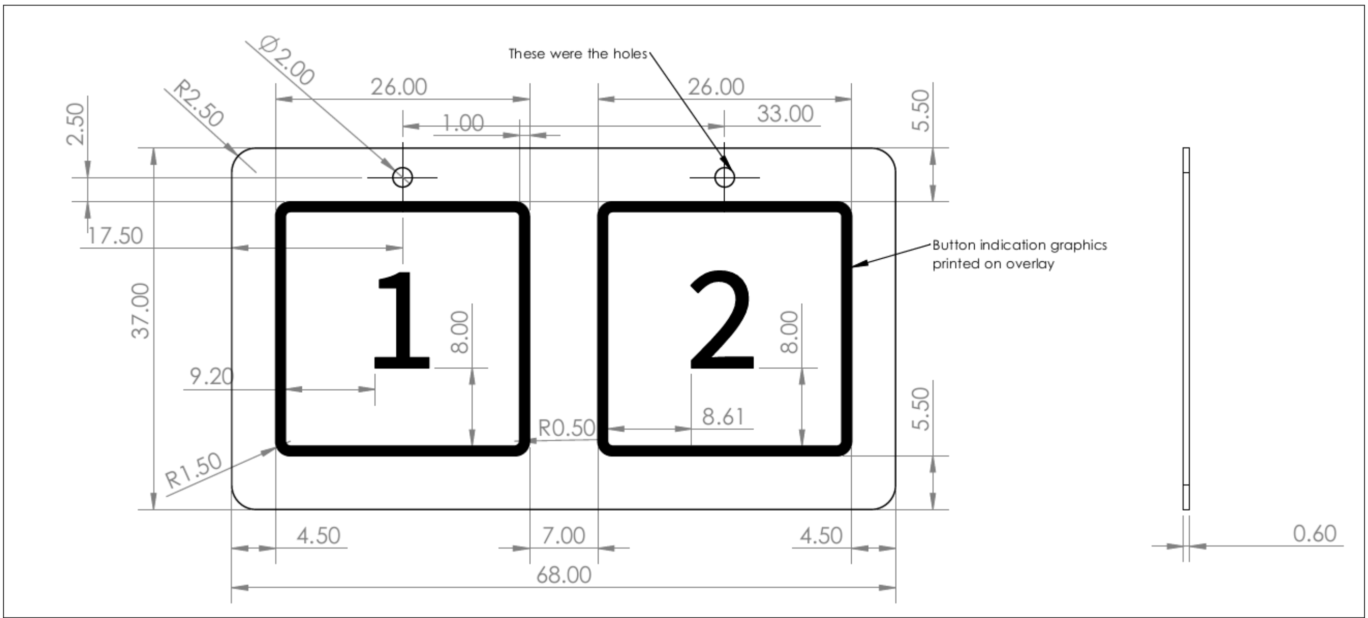


Figure 47 **Metal overlay dimensions**

Note: *All dimensions mentioned in Figure 47 are in millimeters.*

Spacer or stiffener and cavity shape: The spacer or stiffener is made of a non-conductive material with a thickness of 2 mm. The cavity shape and dimensions on the Inductive Keypad-2 expansion board are designed to accommodate deflections in the metal overlay. The cavity shape is square with a side length of 25 mm and rounded corners.

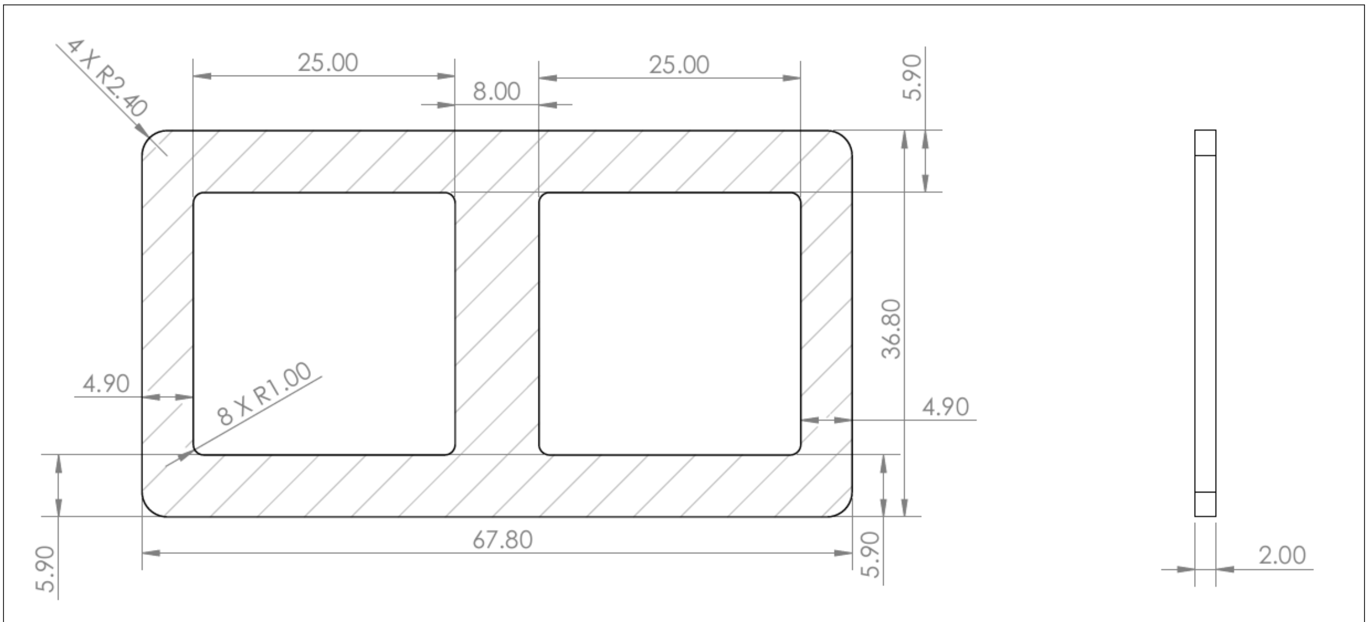


Figure 48 **Spacer or stiffener dimensions**

Note: *All dimensions mentioned in Figure 48 are in millimeters.*

3.2.2.3.3 Hardware configuration

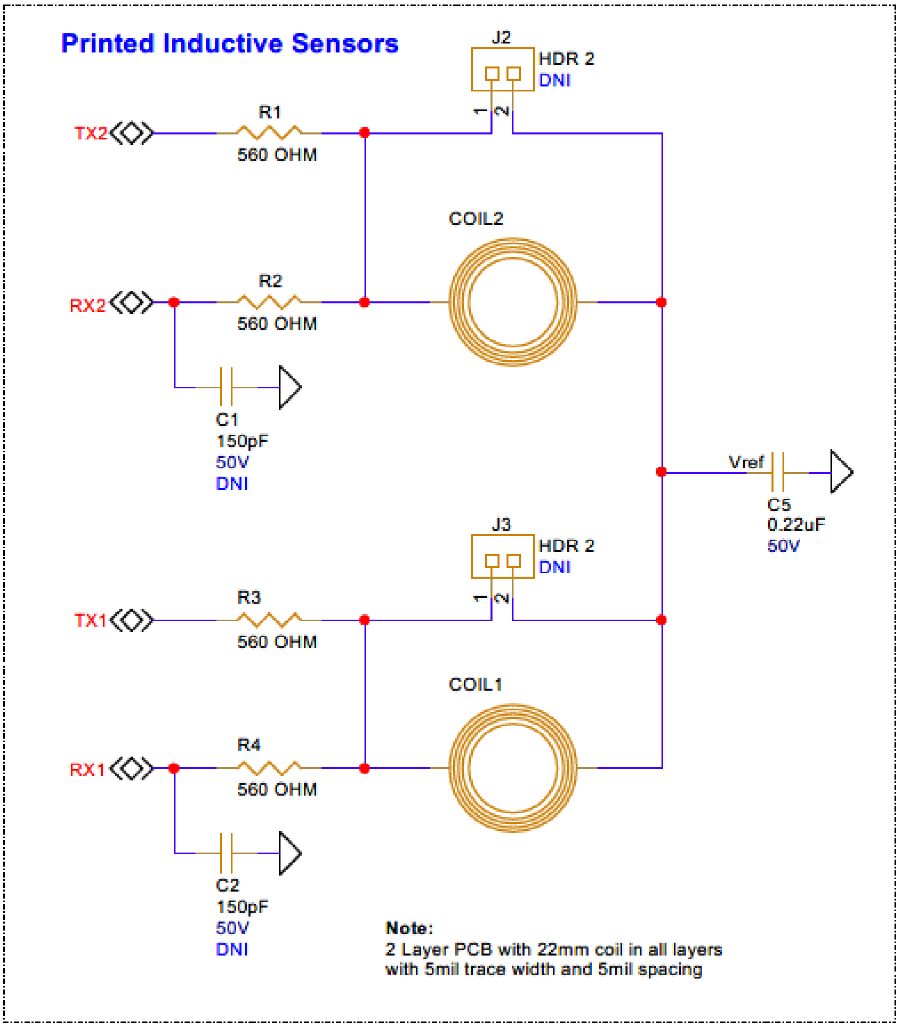


Figure 49 Inductive sensors schematic

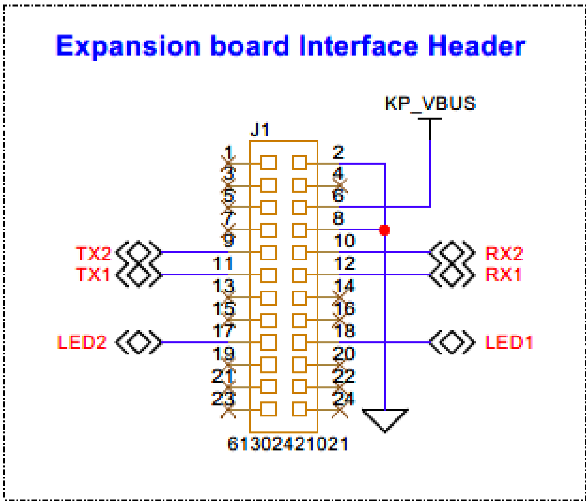


Figure 50 Expansion header interface schematic

Table 12 Pin assignment of sensor interface expansion header

Pin number	Pin detail	Description	Control board pin assignment
J24.2, J24.8	GND	Power supply ground	GND
J24.6	KP_VBUS	5 V power supply	KP_VBUS
J24.9	TX2	LX signal of Coil2	P2[0]
J24.10	RX2	RX signal of Coil2	P2[1]
J24.11	TX1	LX signal of Coil1	P2[4]
J24.12	RX1	RX signal of Coil1	P2[5]
J24.17	LED2	Output signals for driving LED2	P0[2]
J24.18	LED1	Output signals for driving LED1	P0[3]

3.2.3 Liquid-level sensing expansion board

The liquid-level sensor expansion board is a flexible PCBA to be used with the CY8CPROTO-040T-MS controller board to measure liquid levels in containers.

The CY8CPROTO-040T-MS kit includes all the necessary hardware for a liquid level sensing application demo.

Contents of the kit include:

- Liquid-level sensor expansion board with adhesive: Flex PCBA
- A container for liquid measurement
- Main controller board (CY8CPROTO-040T-MS)

The liquid-level sensor expansion board is designed to measure liquid levels up to a height of 120 mm. The kit is packaged with a container for liquid filling purposes, and the Flex PCBA comes with adhesive to stick onto the container for liquid level measurement.

The kit is supported in Infineon's ModusToolbox™ application, providing readily available code examples specific to liquid level sensing. CAPSENSE™ Tuner and CAPSENSE™ Configurator applications offer a user-friendly and collaborative graphical user interface for user-specific application development.

3.2.3.1 Features of the expansion board

The liquid-level sensor expansion board features a flexible printed circuit board assembly (PCBA) with the necessary capacitive sensors (segments) embedded in the hardware. The Flex PCBA is designed specifically for liquid level sensing and also aids in foam rejection and accurate liquid level measurement.

The liquid-level sensor expansion board includes a Flex PCBA with embedded sensors, active shields, a connector, and discrete resistors for liquid level sensing. The PCBA has a connector at the edge of the flex to interface with the controller board (CY8CPROTO-040T-MS).

Table 13 Liquid level sensor expansion Flex PCBA design measures

Description	Measures
Sensor electrodes	09
Active shield	02
Overall sensor height (mm)	120

(table continues...)

Table 13 (continued) Liquid level sensor expansion Flex PCBA design measures

Description	Measures
Electrode height (mm)	12.6
Electrode width (mm)	17
Sensor pitch (mm)	0.68
Length of the PCBA (mm)	188.67
Width of the PCBA (mm)	41
PCB layers	2

Eleven GPIOs are utilized from the controller board CY8CPROTO-040T-MS to enable the liquid level sensing functionality. Each sensor and active shield has a series resistor of 560 Ω connected on the sensor line for performance measures.

The shield pin is connected across the PCBA, isolating GND, and sensor signals for better sensitivity. A hatch pattern for the active shield SH0 is connected to SH1 via a 560-Ω resistor. A series resistor of 560 Ω is located at each of the active shield signals. By default, two pins are utilized for driving the active shield. Provision is given to isolate one of the shields and drive the shield with a single pin. However, connecting both the shields SH0 and SH1 will increase drive capability for enhanced performance.

To use the liquid level sensing system, the controller board (CY8CPROTO-040T-MS) needs to be connected to the Liquid Level Sensor Expansion Board.

The code example used for liquid level sensing is CE240535 - PSOC™ 4: MSCLP CAPSENSE™ Liquid Level Sensing. This code example is tuned for the liquid level sensing hardware included in this kit. The goal is to measure the level of liquid in the bottle and display the measurement in the CAPSENSE™ Tuner.

To get started:

1. Refer to the section **Create the project** of the above-mentioned code example to create the project
2. After the project has been created, open the project by referring to the **Open the Project** section of the code example
3. Refer to the **Operation** section of the code example, and program the board

Now the system is ready to measure the level of the liquid present in the bottle included in this kit.

To monitor and measure the liquid level, refer to the section **Monitor data using CAPSENSE™ Tuner** of the code example. This section describes how to open and set up the CAPSENSE™ Tuner to observe the level of the water measured by the liquid level sensor.

3.2.3.2 Pinout information

Table 14 24-pin connector pin assignment

Pin no.	Signal on flex PCB
1	NC
2	GND
3	NC
4	NC
5	NC
6	NC

(table continues...)

Table 14 (continued) 24-pin connector pin assignment

Pin no.	Signal on flex PCB
7	NC
8	GND
9	SH0
10	SH1
11	RX0
12	RX1
13	RX2
14	RX3
15	RX4
16	RX5
17	RX6
18	RX7
19	RX8
20	NC
21	NC
22	NC
23	NC
24	NC

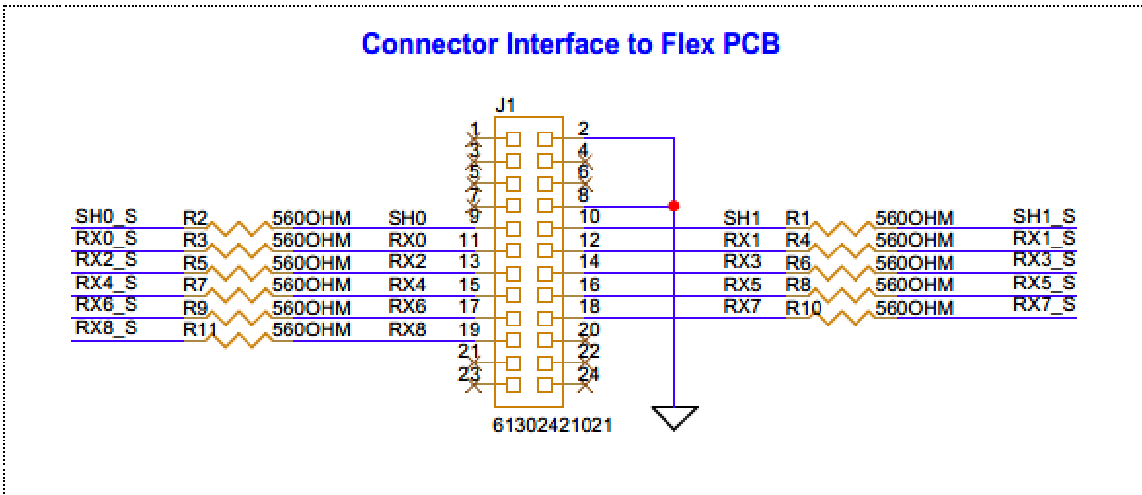


Figure 51 24-pin connector interface between liquid level sensor expansion board and CY8CPROTO-040T-MS

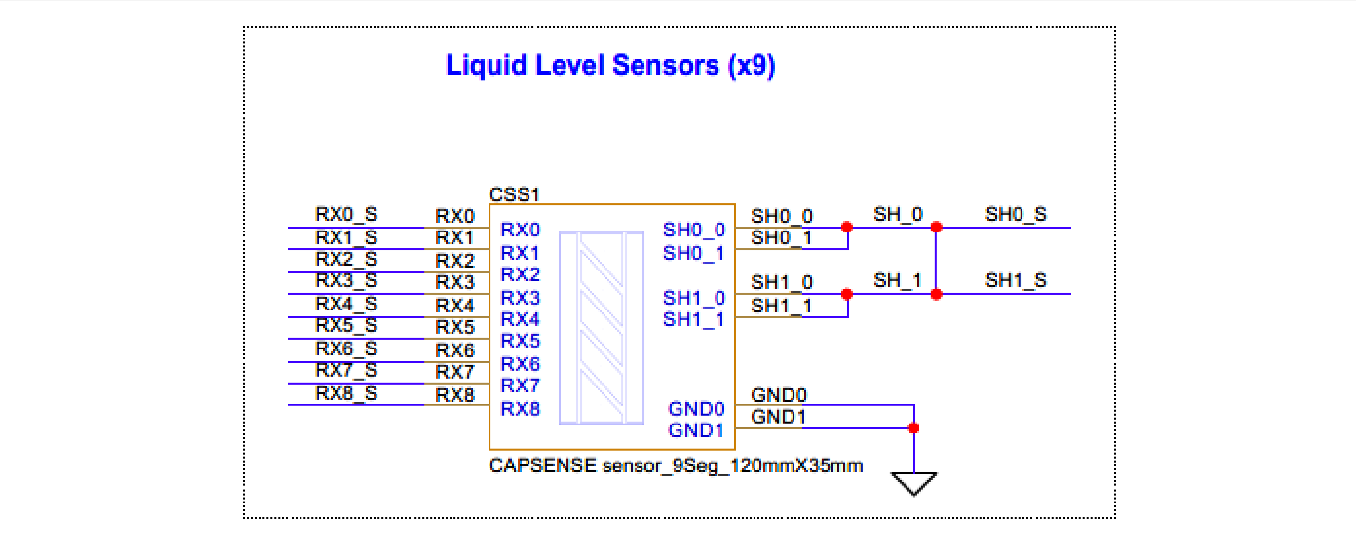


Figure 52 **Sensor and active shield pinout design**

3.2.3.3 Using the liquid level sensor expansion board

To use the expansion board:

1. Paste the Flex PCBA onto a container containing liquid, such as water, oil, or water with foam
2. Ensure the connector on the Flex PCBA is connected to the controller kit (CY8CPROTO-040T-MS), which is then connected to the test system via a USB Type-C cable
3. Use the CAPSENSE™ Tuner to configure and tune the system for performing liquid level measurements

***Notes**:*

1. The orientation of the Flex PCBA should be straight, with the connector end towards the bottom of the container. The adhesive part of the Flex PCBA should be firmly pasted onto the container to avoid any performance-related degradations

2. The Flex PCBA is sensitive and subject to wear and tear when handled inappropriately

Figure 53 **PSOC™ 4000T Multi-Sense Control board interface with liquid level expansion board**

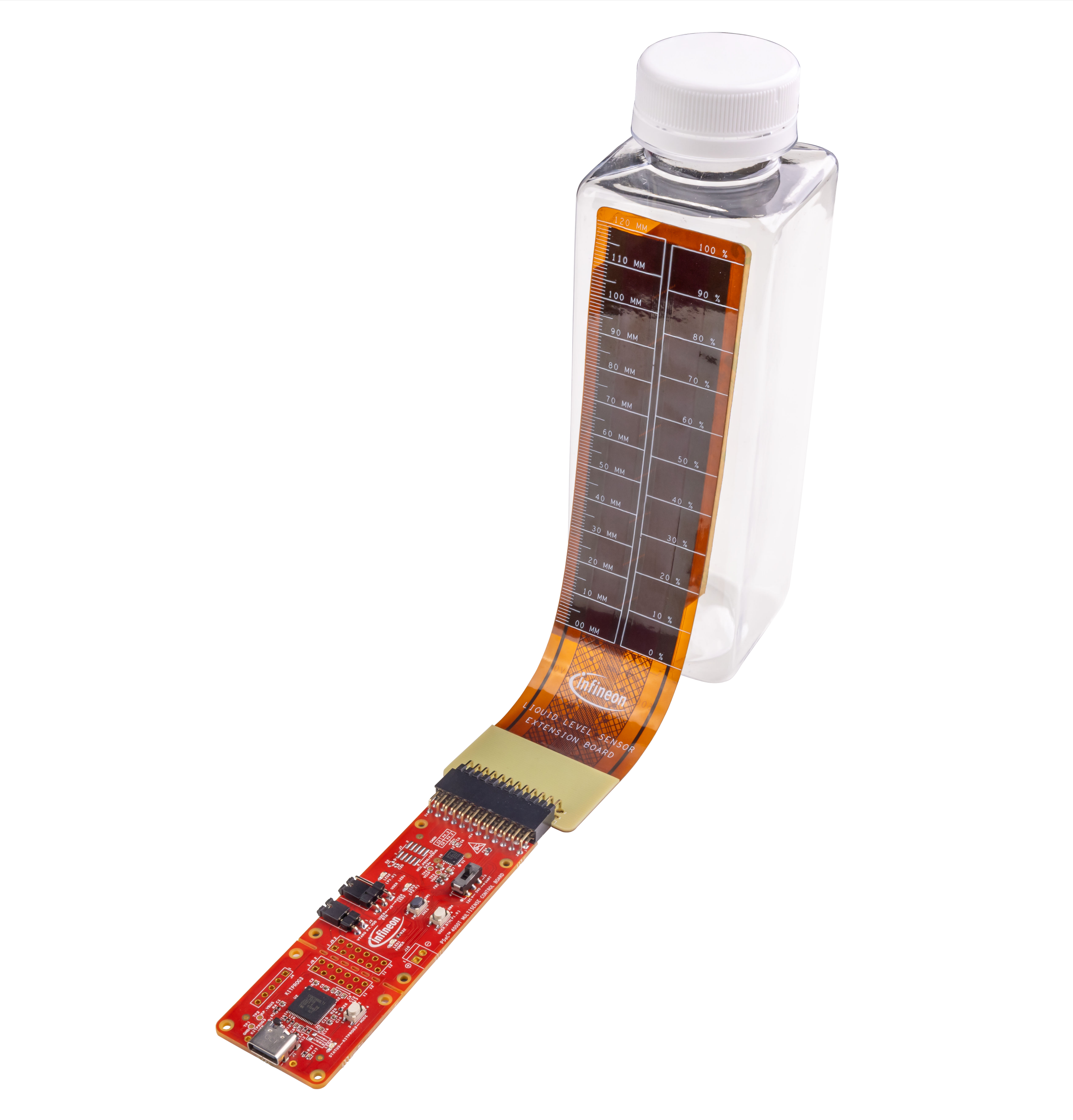


Figure 54 **Liquid level sensing setup with container**

3.2.4 CAPSENSE™ hover-touch expansion board

The CAPSENSE™ hover-touch expansion board is a demonstration platform designed to highlight the capabilities of capacitive-sensing technology in hover-touch applications. It is specifically built to work with the CY8CPROTO-040T-MS PSOC™ 4000T Multi-Sense Prototyping kit, a versatile development kit that demonstrates various sensing applications, including inductive sensing, hover-touch using capacitive sensing, and capacitive sensing-based liquid-level sensing technology.

The CAPSENSE™ hover-touch expansion board is designed to provide a ready-to-use platform for developers and engineers to evaluate and develop capacitive-sensing-based hover-touch applications. The board includes a set of capacitive-sensing buttons with a 2 mm thick overlay placed at a 10 mm distance above the buttons. The overlay has markings that serve as touch interface, where the capacitive buttons are fine-tuned as proximity sensors to enable touch functionality for human-machine interface (HMI) applications.

With its 10 mm air-gap interface, the hover-touch expansion board eliminates the need for conductive materials, reducing the overall cost of the system-level bill of materials.

3.2.4.1 Button layout and design

The CAPSENSE™ hover-touch expansion board has a total of four touch buttons arranged in a single row, with a spacing of 10 mm. Each button has a circle with a diameter of 10 mm. There are a total of four LEDs, which will be used to indicate the touch status of the hover-touch buttons.

The CAPSENSE™ hover-touch expansion board features a stack-up design that ensures reliable and accurate detection of user input. A critical component of this design is the additional ground board, which provides shielding and reduces proximity interference from the bottom side.

The additional ground board offers several key benefits the include:

- **Reduced interference**: Shields capacitive-sensing buttons from external sources of interference, such as electronic components or conductive objects
- **Improved signal quality**: Enhances the signal-to-noise ratio, enabling more accurate detection of user input
- **Increased reliability**: Prevents false triggers and ensures reliable operation in various environments

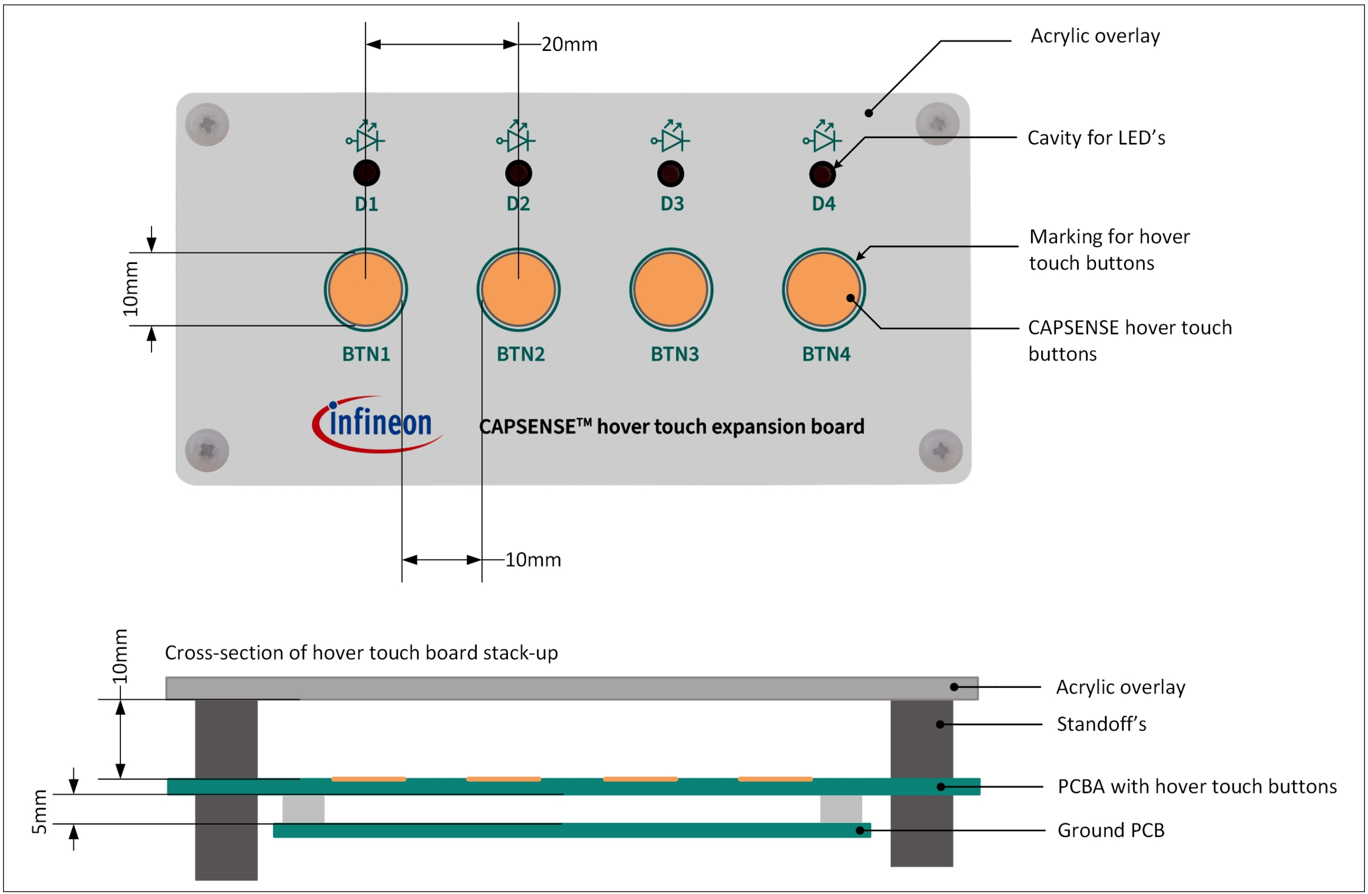


Figure 55 CAPSENSE™ hover-touch expansion board stack up

The CAPSENSE™ hover-touch expansion board stack-up consists of an overlay on top, the PCBA with capacitive-sensing buttons in the middle, and an additional ground board on the bottom. The ground board, placed under the capacitive-sensing buttons, provides shielding and reduces proximity interference.

3.2.4.2 Hardware configuration

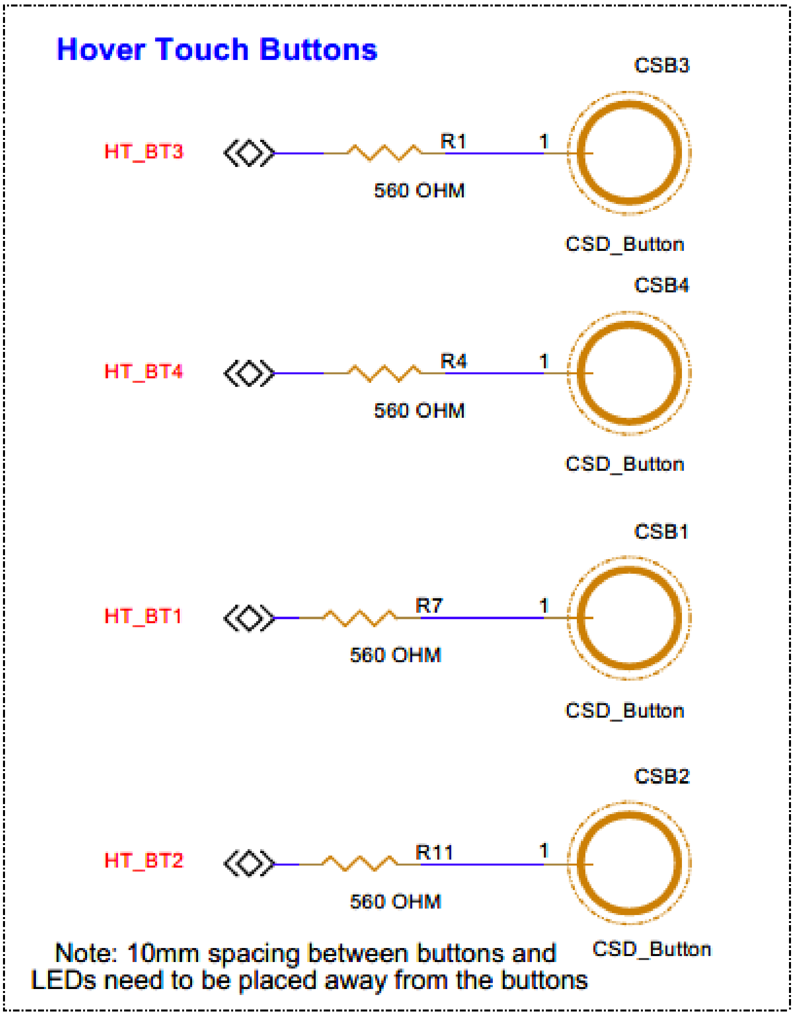


Figure 56 CAPSENSE™ hover-touch buttons schematic

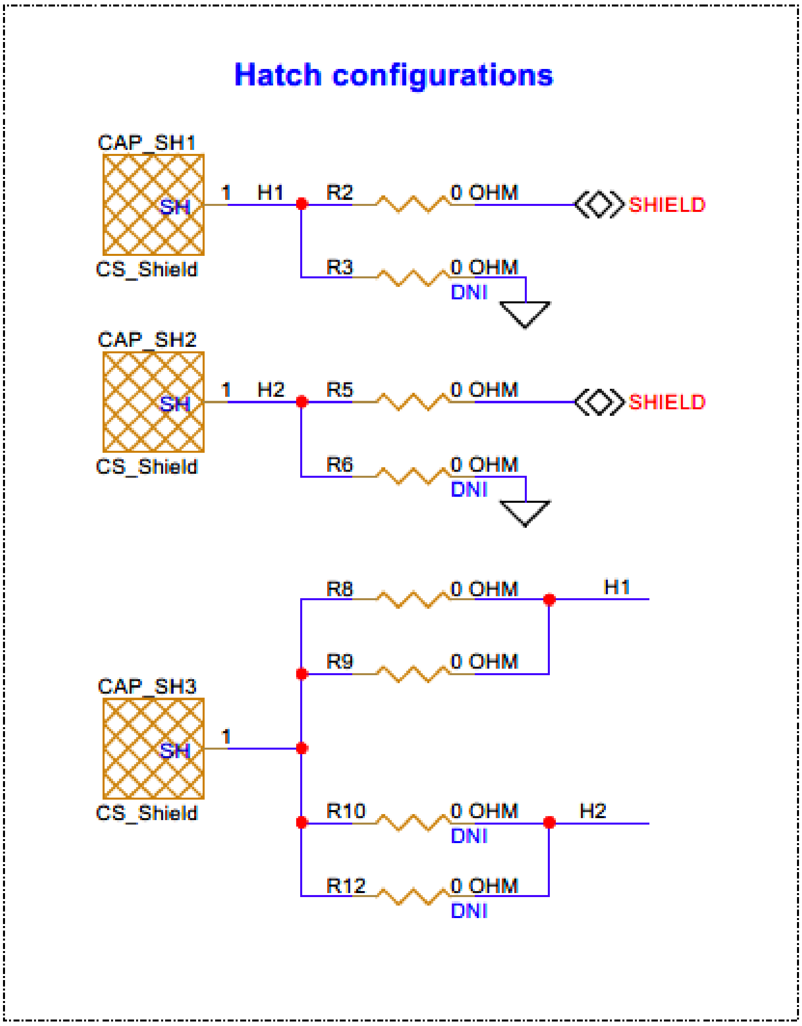


Figure 57 CAPSENSE™ hover-touch board shield configurations schematic

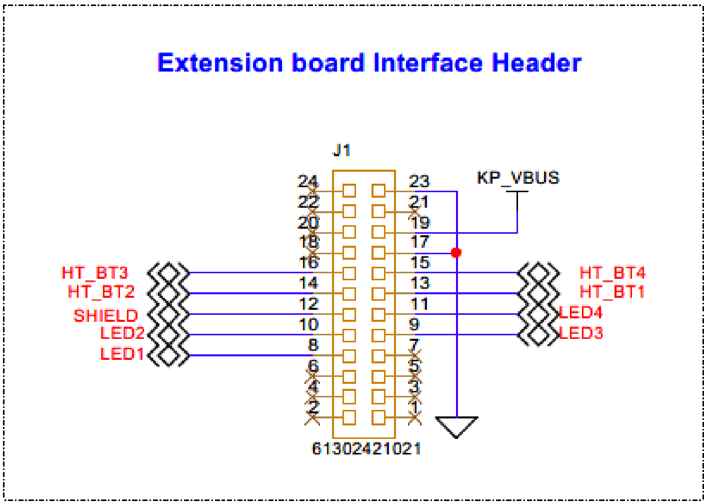


Figure 58 Expansion header interface schematic

Table 15 Pin assignment of sensor interface expansion header

Pin number	Pin detail	Description	Control board pin assignment
J24.23, J24.17	GND	Power supply ground	GND
J24.19	KP_VBUS	5 V power supply	KP_VBUS
J24.16	HT_BT3	Hover-touch button 3	P2[0]
J24.15	HT_BT4	Hover-touch button 4	P2[1]
J24.14	HT_BT2	Hover-touch button 2	P2[4]
J24.13	HT_BT1	Hover-touch button 1	P2[5]
J24.12	SHIELD	Driven shield for hover-touch buttons	P4[0]
J24.11 to J24.8	LED4, LED3, LED2 and LED1	Output signals for driving LED4, LED3, LED2, and LED1	P4[1] (for LED4), P0[0] (for LED3), P0[1] (for LED2), and P0[2] (for LED1)

***Note**: The expansion header for the hover-touch expansion board is located on the bottom side of the PCB, resulting in a swapped pin assignment compared to the PSOC™ 4000T Multi-Sense Control Card.*

3.3 CY8CPROTO-040T-MS Kit rework

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

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

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

Table 16 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 Ω, JUMPER, 1 A, 0603	Yageo	RC0603JR-070RL

Figure 59 shows the reworked schematic sections.

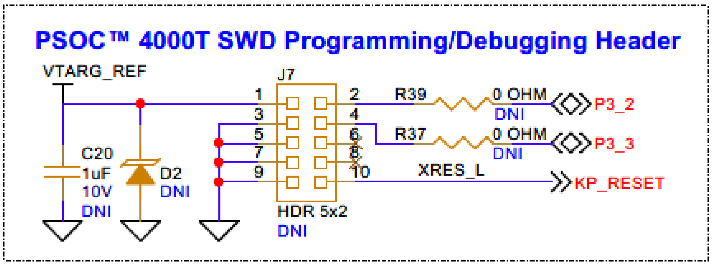


Figure 59 Schematic of rework regions to enable the external programming interface

Table 17 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 the 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.
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 the PSOC™ 4000T device	XRES: Reset signal for the target MCU

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

A 2-pin screw terminal header (J10) provision is available on the prototyping board to interface with an external power supply input for powering the PSOC™ 4000T device. This can be done by populating the J10 header and the associated resistor (R53).

Table 18 Rework components with reference and manufacturer details

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

Figure 60 shows the reworked schematic section.

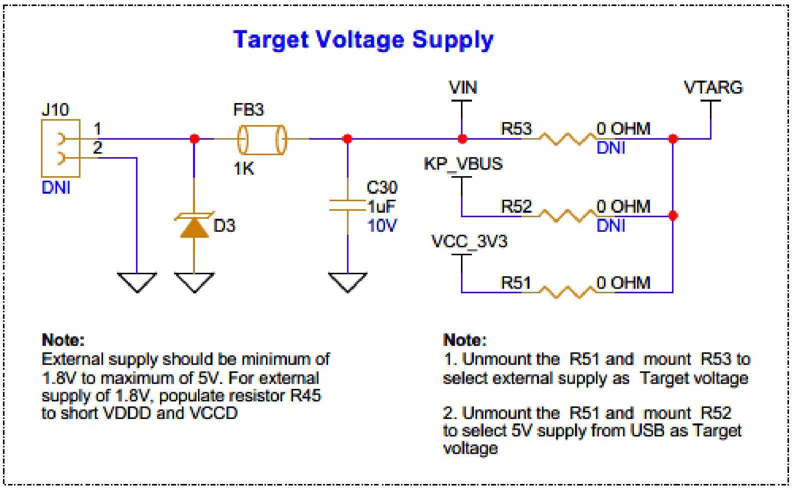


Figure 60 **Schematic of rework regions to enable the external power input for PSOC™ 4000T device**

3.3.3 Enabling 5 V supply for the PSOC™ 4000T device

By default, the PSOC™ 4000T device is powered by a 3.3 V supply from the LDO voltage regulator. This board has a provision to bypass the linear voltage regulator at U4, allowing the PSOC™ 4000T device to be powered by the 5 V supply from the USB Type-C connector.

Table 19 **Rework components with reference and manufacturer details**

Reference	Description	Manufacturer	Manufacturer part number
R52	RES, Fixed, 0 Ω, JUMPER, 1 A, 0603	Yageo	RC0603JR-070RL

Figure 61 shows the reworked schematic sections. Populate R52 and de-populate R51 to enable the 5 V power option.

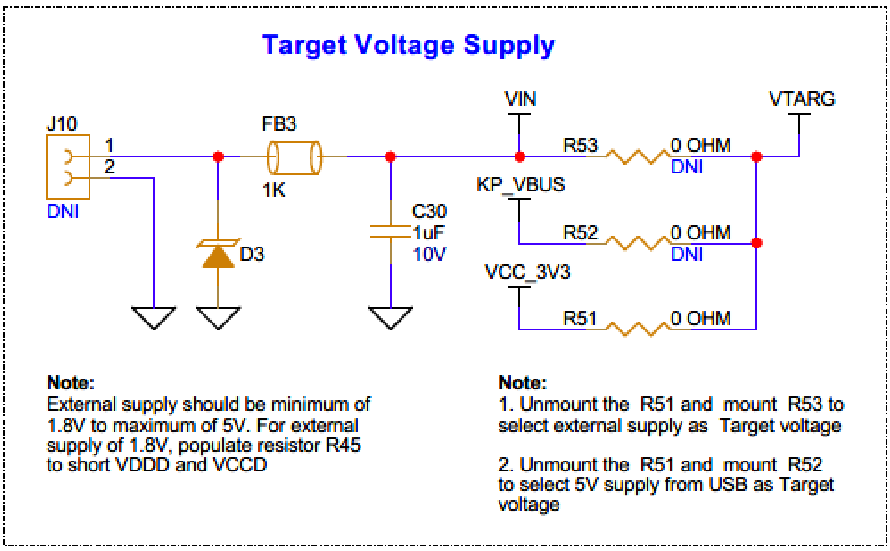


Figure 61 **Schematic of rework regions to enable 5 V powering option for the PSOC™ 4000T device**

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

ISX
Inductive sensing

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)

SWD

Serial wire debug

ToM

Touch-over-Metal

UART

Universal Asynchronous Receiver-Transmitter

USB

Universal Serial Bus

XRES

External reset

Revision history

Document revision	Date	Description of changes
**	2024-12-13	Initial release.
*A	2025-01-13	Added the CAPSENSE™ hover-touch expansion board section.

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