KIT_PSC3M5_CC1 PSOC™ Control C3M5 Digital Power Control Card user guide

About this document

Scope and purpose

This document describes the features and hardware details of the PSOC™ Control C3M5 Digital Power Control Card. It is designed to provide an evaluation platform for digital control applications with the PSOC™ Arm® Cortex®-M33 based MCU. This board is part of Infineon's digital power evaluation platform kits.

Intended audience

This document is intended for KIT_PSC3M5_CC1 users, and this board is intended to be used under laboratory conditions.

Important notice

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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

1.1 Kit contents

The following are the kit contents:

- PSOC™ Control C3M5 Digital Power Control Card
- PSOC™ Control C3M5 interface Board
- USB Type-A to Type-C cable
- Quick start guide (printed on the kit package)

1.2 Getting started

The following sections will help you get familiar with this evaluation kit:

- The Kit operation section describes the major features of the PSOC™ Control C3M5 Digital Power Control Card and functionalities such as programming, debugging, USB-UART, and I2C
- The Hardware section provides a detailed hardware description
- Application development using the PSOC™ Control C3M5 Digital Power Control Card is supported in ModusToolbox™ software. ModusToolbox™ software is a free development ecosystem that includes the Eclipse IDE for ModusToolbox™ software and the PSOC™ Control C3M5 SDK with the PSOC™ Control C3M5 MCU. Using ModusToolbox™ software, you can enable and configure device resources, middleware libraries, write `C/assembly` source code, program, and debug the device. You can download the software from the ModusToolbox™ home page. See the ModusToolbox™ software installation guide for additional information
- There are a wide range of code examples to evaluate the PSOC™ Control C3M5 Digital Power Control Card. These examples help you familiarize with the PSOC™ Control C3M5 MCU and create your own design. These examples can be accessed through the ModusToolbox™ Project Creator tool. Alternatively, you can also visit Infineon's code examples for the ModusToolbox™ software page to access these examples

1.3 Key features

The PSOC™ Control C3M5 Digital Power Control Card is equipped with the following features:

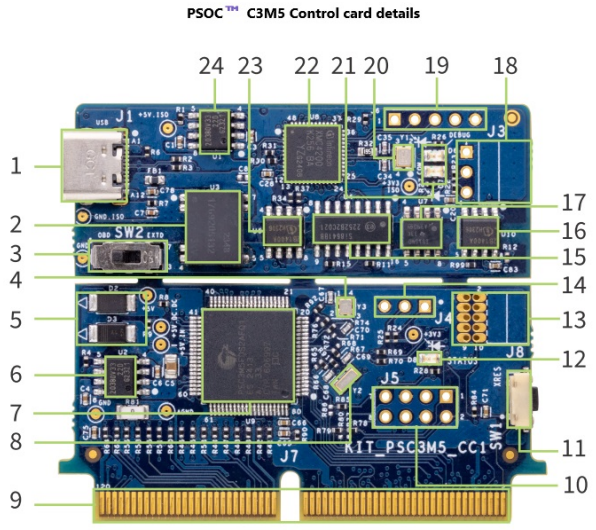
- Infineon PSOC™ Control C3M5 (Arm® Cortex®-M33 based) MCU PSC3M5FDS2AFQ1, 180 MHz, up to 256 KB flash/64 KB SRAM, E-LQFP-80
- Connection to evaluation boards like the Dual Buck Evaluation Board via the 120-pin Edge connector, including analog signals and PWM
- Three LEDs
  - STATUS LED – User-controlled LED
  - DEBUG LED and COM LED – Debugger controlled LEDs
- Isolated debug options (default)
  - On-Board Debugger (SEGGER J-Link LITE) via USB connector
  - Isolation needs to be built between this connector and the computer side to avoid overvoltage in the computer
- Isolated connectivity
  - UART channel of the On-Board Debugger (SEGGER J-Link LITE) via USB connector
- Two non-isolated debug options (default no load)
  - SWD/JTAG via a 10-pin 1.27 mm header
  - SWD/UART via an 8-pin 2.54 mm header

- Power supply of PSOC™ Control C3M5
  - Via evaluation board (5 V) converted to 3.3 V
  - Via debug USB connector, 5 V DC-DC isolater, and converted to 3.3 V
- Power supply of XMC4200 MCU isolated debug domain
  - Via debug USB connector

2 Kit operation

The PSOC™ Control C3M5 Digital Power Control Card is an evaluation board designed to help engineers in learning and testing the digital power control applications. The board features a PSOC™ Control C3M5 MCU based on an Arm® Cortex®-M33 core. The dimensions of the board (52 mm in height and 57 mm in width to the connector) allow the use of this evaluation card in designs with high requirements on power density. The control card integrates an isolated onboard debugger for a plug-and-play experience. The isolated debugger part can be detached once the code is finalized. In particular, the dimensions of the PSOC™ Control C3M5 Digital Power Control Card after the isolated debugger is detached (30 mm in height and 57 mm in width to the connector) are suitable for 1U rack designs.

The following figures provide a detailed description of the hardware and its usage.



1	USB connector (J1)	13	SWD & JTAG header (J8)
2	5 V DC-DC isolator (U3)	14	Non-isolated I2C header (J4)
3	Onboard or External debugger switch (SW2)	15	SWD digital Isolator (U4)
4	16MHz Crystal (Y3)	16	XRES Digital isolator (U10)
5	OR-ing diodes (D2 & D3)	17	I2C digital isolator (U7)
6	3.3 V LDO (U2)	18	Isolated I2C header (J3)
7	PSOC™ CONTROL C3M5 (PSC3M5FDS2AFQ1-U9)	19	OBD header (J6)
8	32.768 KHz crystal (Y2)	20	12 MHz crystal (Y1)
9	120-pin connector (EDGE FINGER)	21	DEBUG & COM LEDs (D6 & D7)
10	SWD & UART header (J5)	22	XMC4200 MCU (XMC4200-Q48F256 BA-U8)
11	Reset button (SW1)	23	UART digital isolator (U6)
12	Status LED (D8)	24	Isolated 3.3 V LDO (U1)

Figure 1 PSOC™ Control C3M5 Digital Power Control Card hardware description (1)

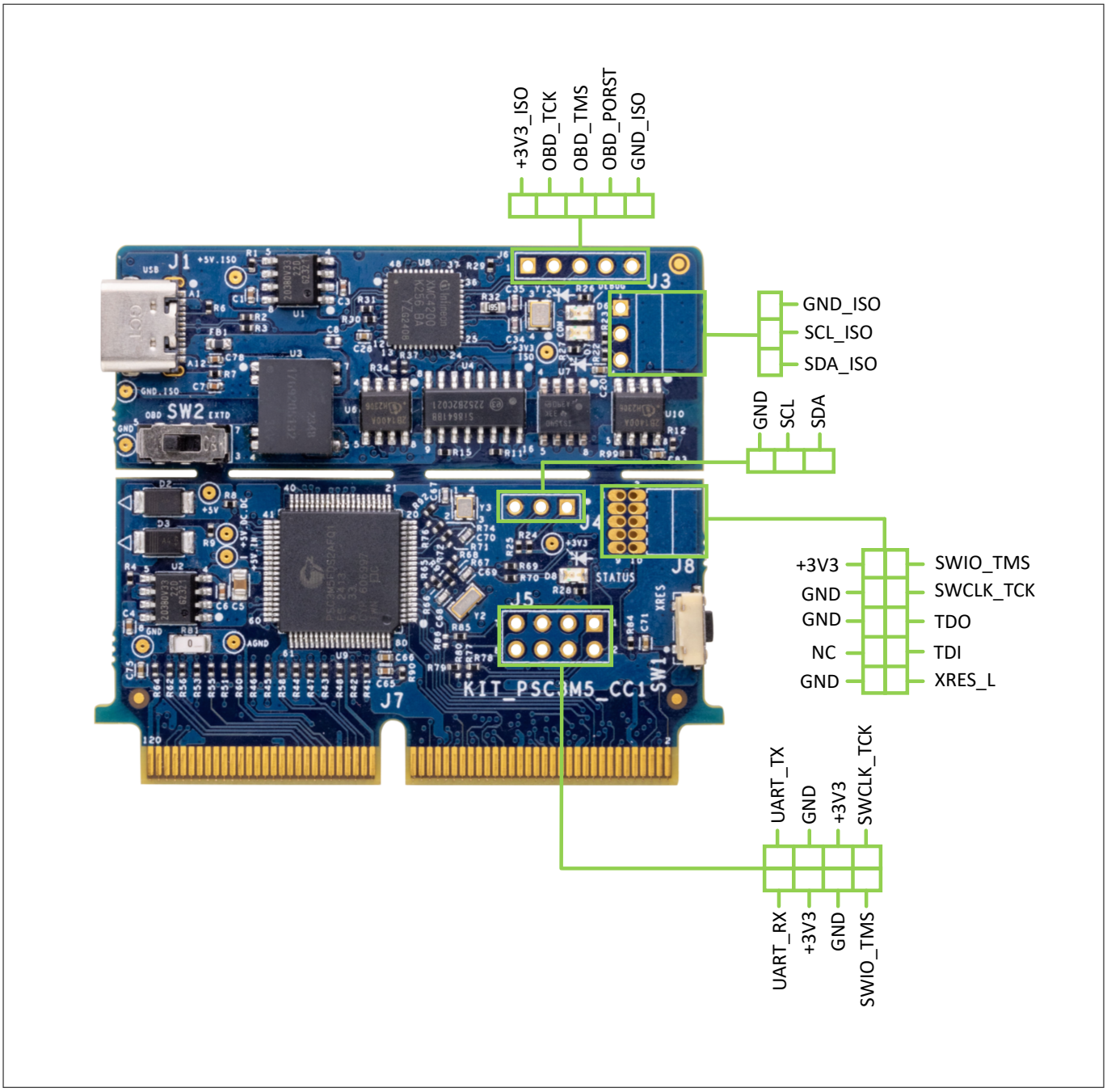


Figure 2 **PSOC™ Control C3M5 Digital Power Control Card hardware description (2)**

2.1 Using the Out of the box example

The PSOC™ Control C3M5 Digital Power Control Card coming with the interface board is by default programmed with the code example, PSOC™ Control MCU: Hello world. For a detailed description of the project, refer to the example's `README.md` file in the GitHub repository. The `README.md` file is also available in the application directory once the application is created using ModusToolbox™.

***Note**: At any point in time, if you overwrite the default application, you can restore it by programming the PSOC™ Control MCU: Hello world.*

The following steps describe how to use the code example:

1. Ensure that the PSOC™ Control C3M5 Digital Power Control Card is mounted on the interface board using the 120-pin Edge connector
2. Connect the kit to your PC using the provided USB cable through the J-Link USB connector
3. Open a terminal program and select the COM port. Set the serial port parameters to 8N1 and 115200 baud
4. Verify that the COM LED on the PSOC™ Control C3M5 Digital Power Control Card is glowing
5. Press the XRES button (SW1) on the board and confirm that the serial terminal application displays the boot-up message, as shown in Figure 3
6. Confirm that the user LED (D8) blinks
7. Follow the instructions on the boot-up message

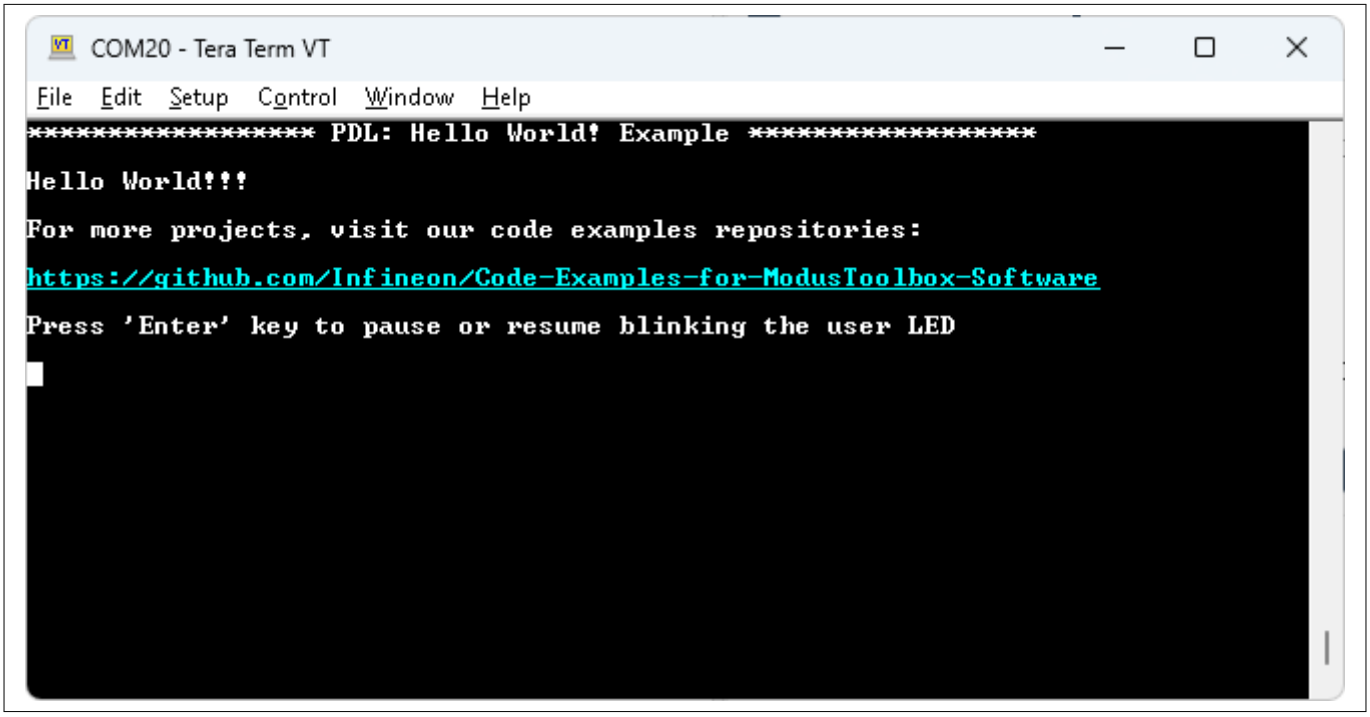


Figure 3 Serial terminal boot message

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

The PSOC™ Control C3M5 Digital Power Control Card can be programmed and debugged using the onboard JLink debugger. This onboard programmer/debugger supports USB-UART Bridge functionality. An XMC4200 device is used to implement the JLink functionality. For more details on the JLink, see the J-Link debug probes.

The following steps briefly introduce project creation, programming, and debugging using ModusToolbox™ software. For detailed instructions, see **Help** > **ModusToolbox™ General Documentation** > **ModusToolbox™ User Guide**.

1. Connect the board to the PC using the provided USB cable through the JLink USB connector, as shown in Figure 4. It enumerates as a USB composite device if you are connecting it to your PC for the first time
2. The debugger on this kit is with JLink and one UART. The COM LED (green) is always ON if the USB is connected

***Note**: The programming can be done either with the onboard JLink debugger or by attaching an external debugger to the connector J8 on the board. The user can easily switch between the onboard debugger or external debugger by setting the switch SW2 to the desired position. It is recommended to use the onboard JLink debugger.*

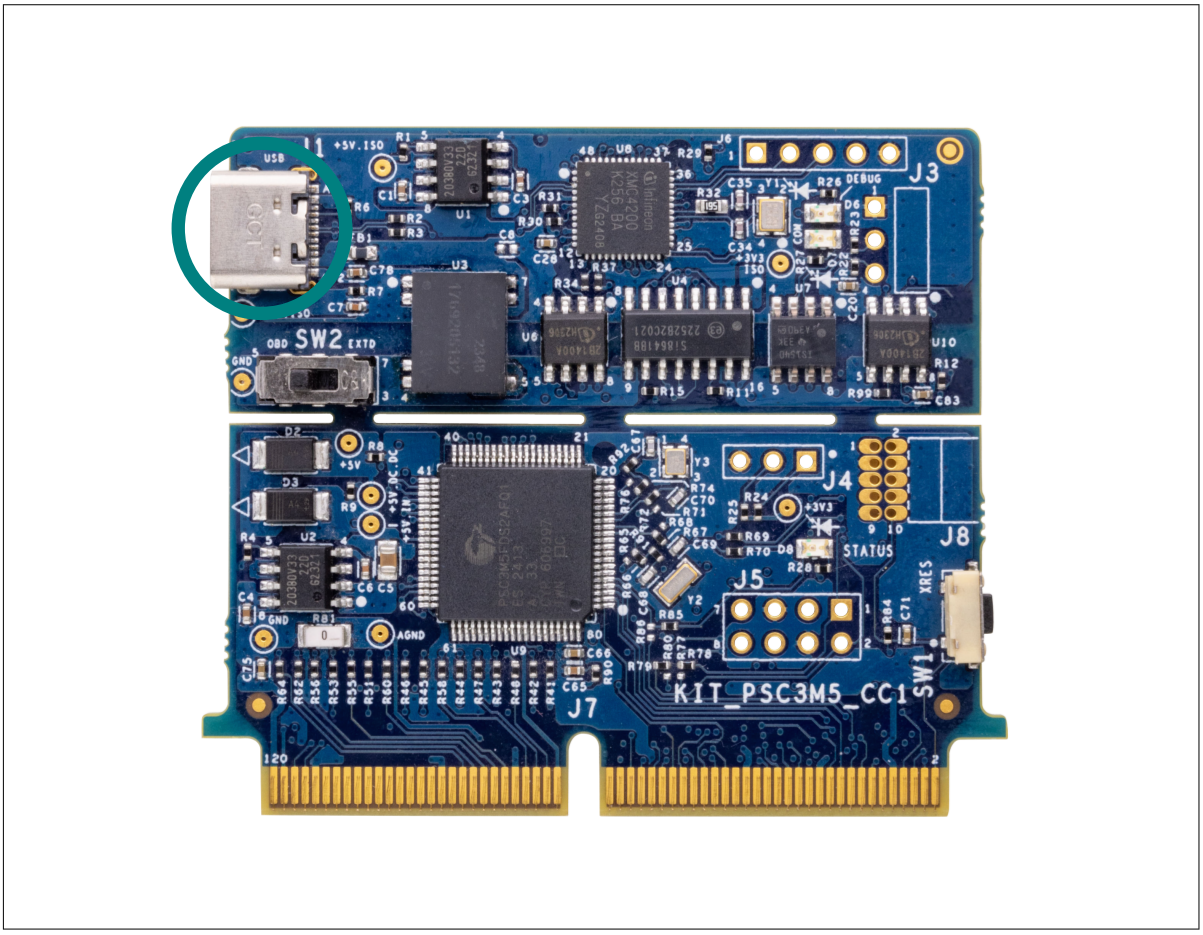


Figure 4 Connect USB cable to USB connector on the board

3. In the Eclipse IDE for ModusToolbox™ software, import the desired code example (application) into a new workspace:

a. In the **Quick Panel**, click **New Application** from the **Start** section

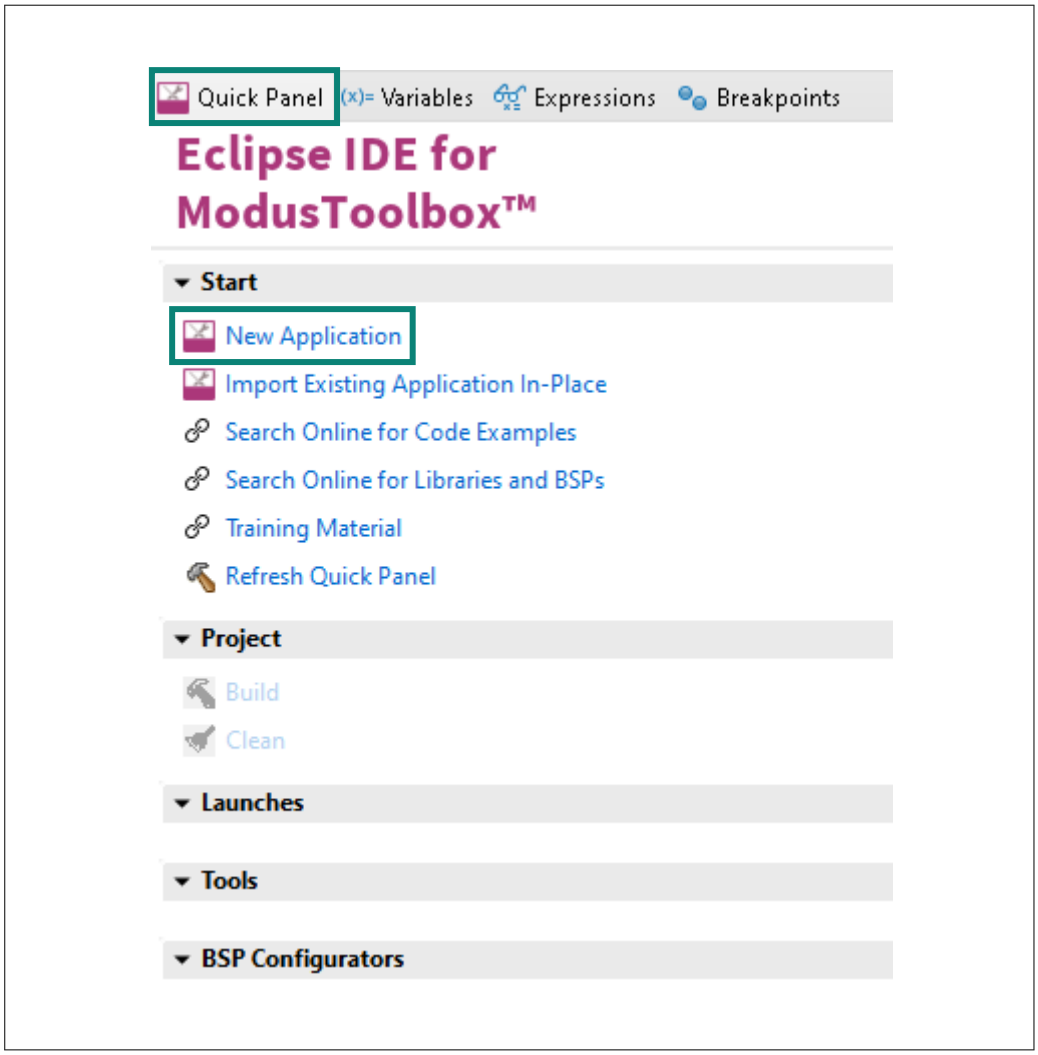


Figure 5 Create new application

b. Select the **BSP -KIT_PSC3M5_CC1** in the **Choose Board Support Package** window and click **Next**

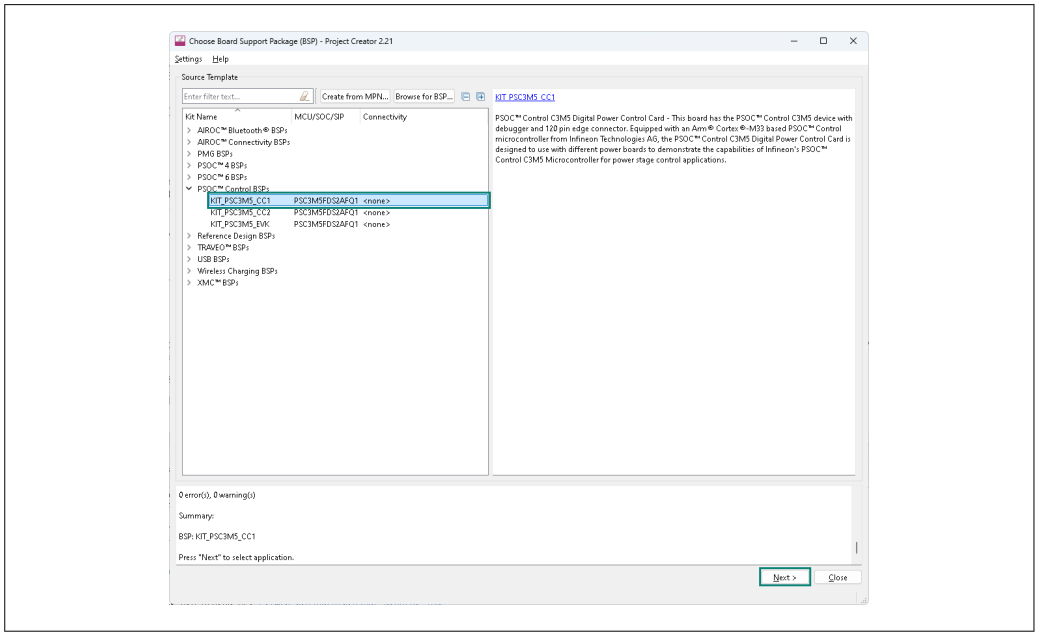


Figure 6 Creating a new application: Choose Board Support Package

c. Select the application in the **Select Application** window and click **Create**

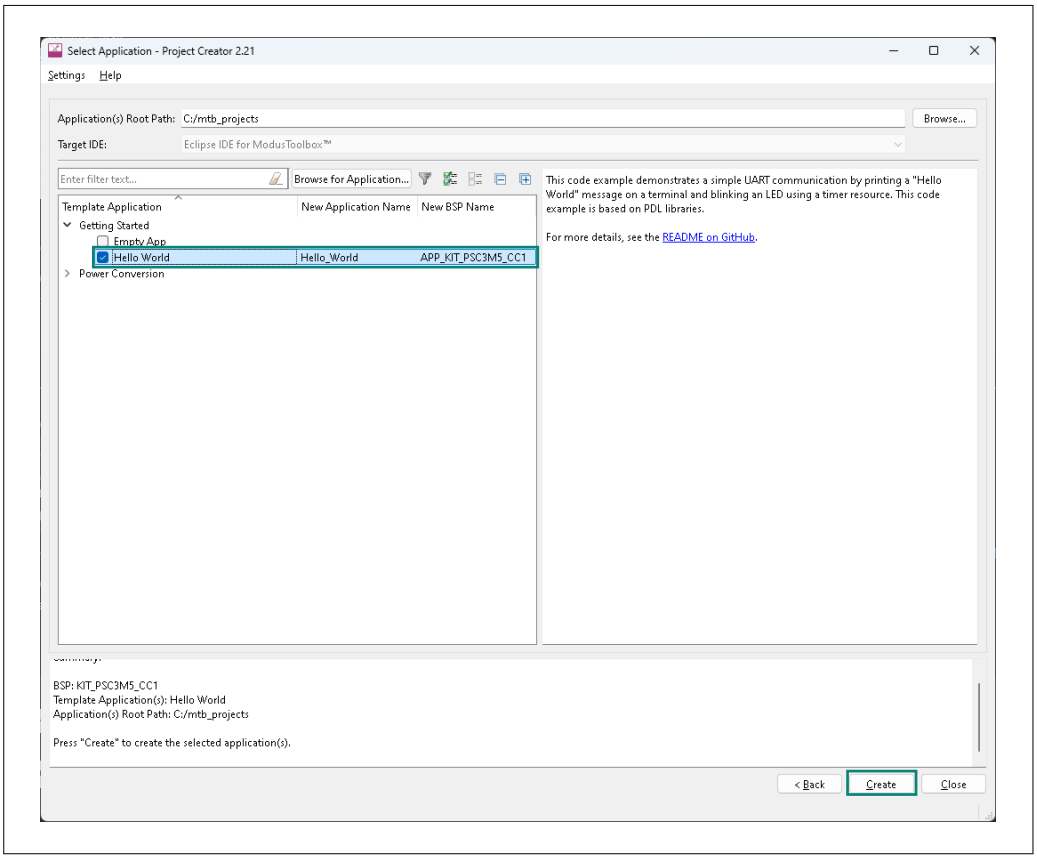


Figure 7 Creating a new application: Select Application

4. To build and program a PSOC™ Control C3M5 MCU application:

a. In the **Project Explorer**, select **<App_Name>** project

b. In the **Quick Panel**, click the **<App_Name> Program (JLink)** configuration from the **Launches** section, as shown in Figure 8

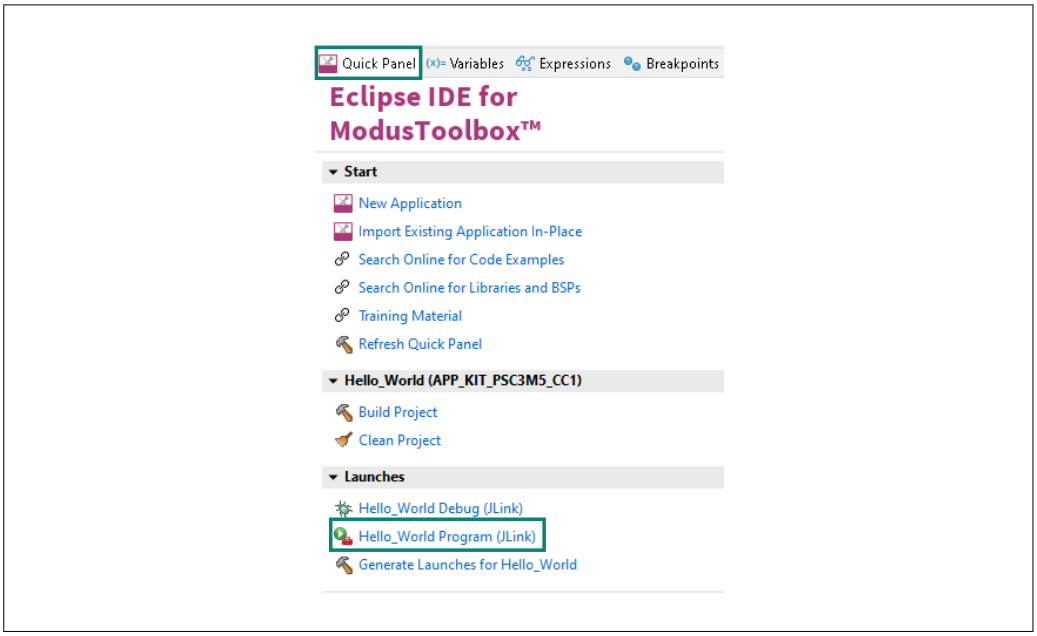


Figure 8 Programming in ModusToolbox™ software

ModusToolbox™ software has an integrated debugger

5. To debug a PSOC™ Control C3M5 MCU application:
   a. In the **Project Explorer**, select **<App_Name>** project
   b. In the **Quick Panel**, click the **<App_Name> Debug (JLink)** configuration from the **Launches** section, as shown in Figure 9

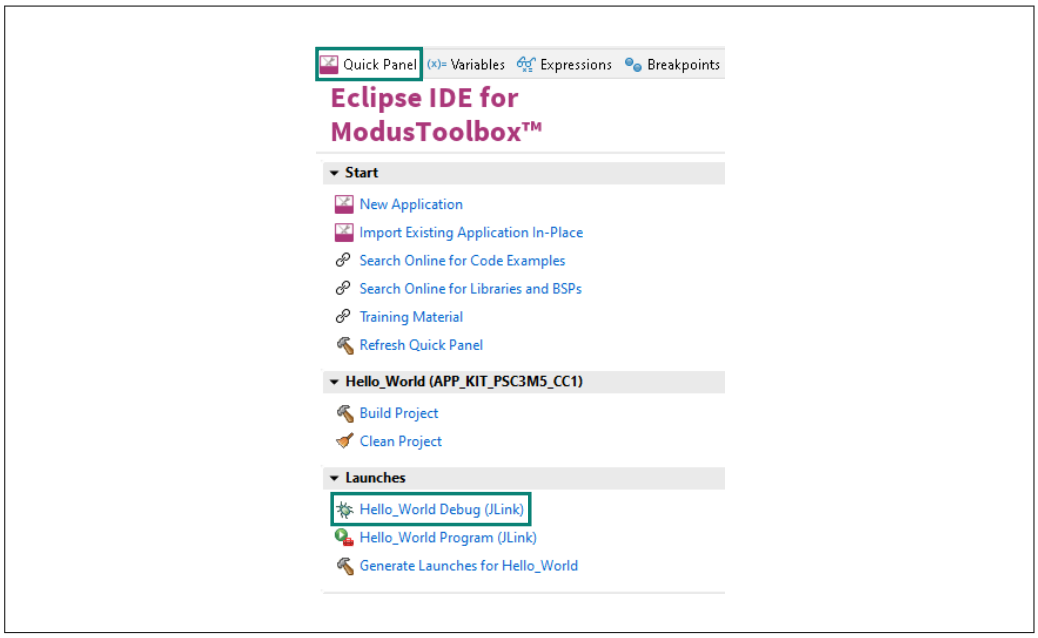


Figure 9 Debugging in ModusToolbox™ software

For more details, see the Program and debug section in the Eclipse IDE for ModusToolbox™ user guide

3 Hardware

3.1 Hardware functional description

This section explains the individual hardware blocks.

3.1.1 PSOC™ Control C3M5 Digital Power Control Card

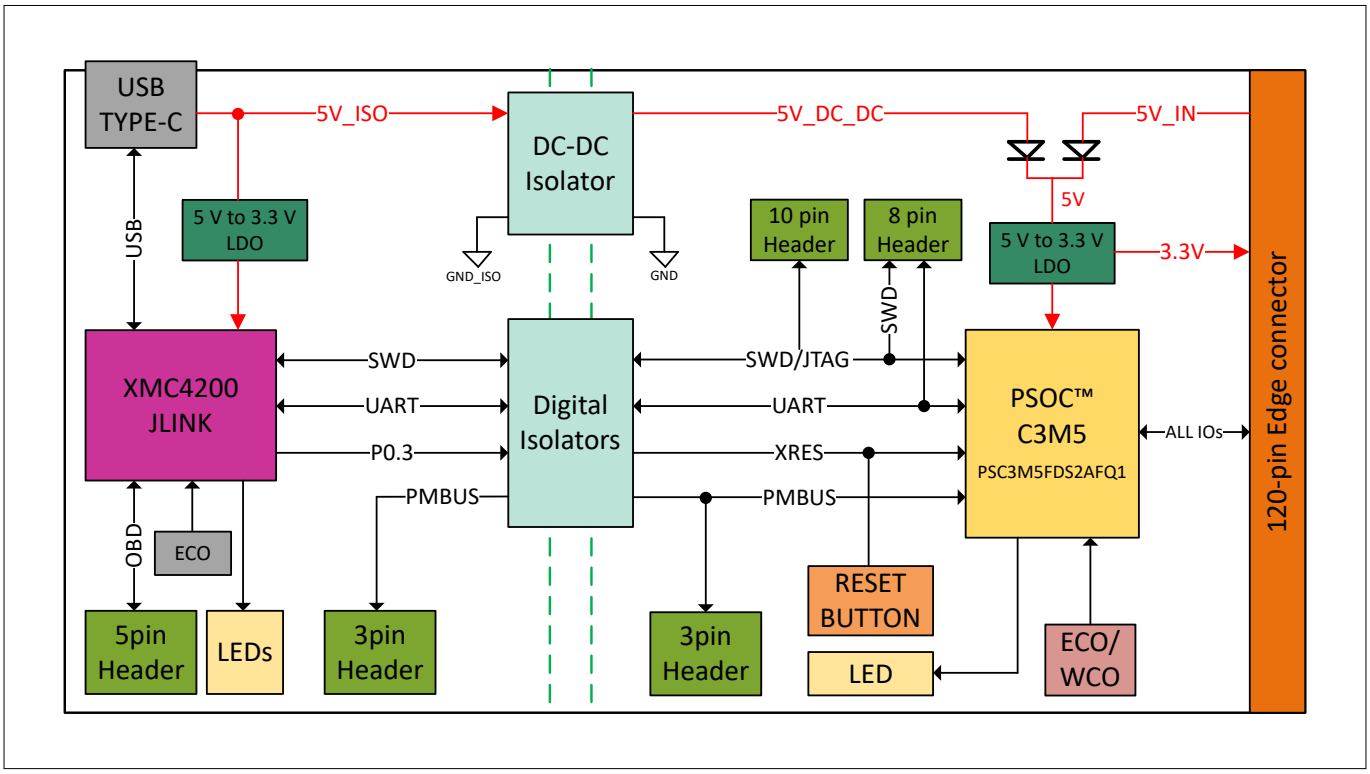


Figure 10 Block diagram PSOC™ Control C3M5 Digital Power Control Card

The control card is designed for the PSOC™ C3M5 MCU in an 80-pin LQFP package. There is an onboard isolated JLink debugger implemented with the XMC4200 MCU. All the IOs from the PSOC™ C3M5 MCU are routed out on a 120-pin Edge finger that can be inserted into a mating connector (MPN: HSEC8-160-01-L-DV-A-BL) on evaluation boards.

3.1.2 PSOC™ Control C3M5 MCU

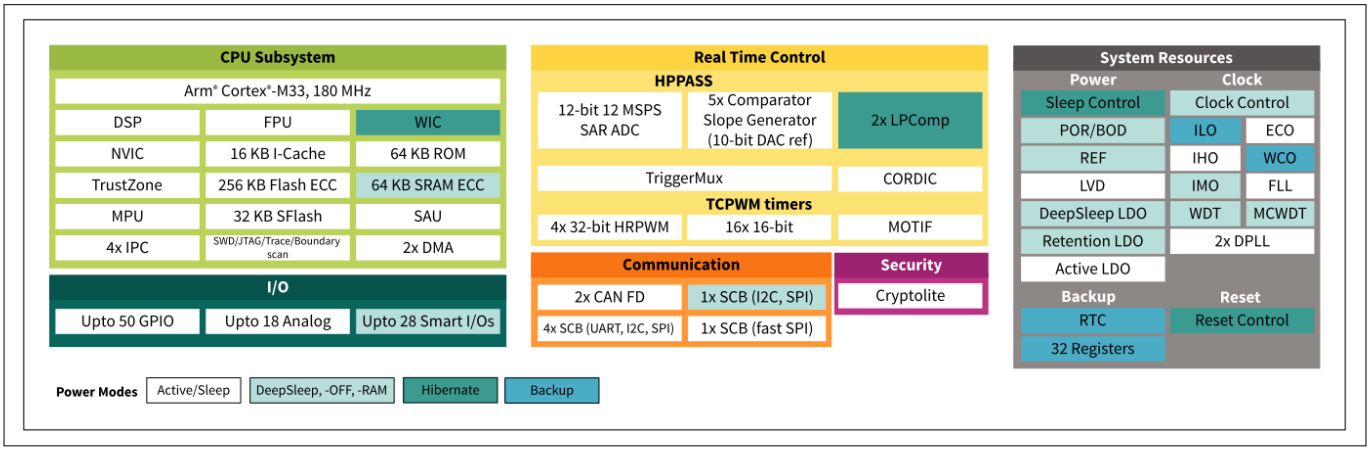


Figure 11 Block diagram PSOC™ Control C3M5 MCU

The PSC3M5xD devices are based on the Arm® Cortex®-M33, running up to 180 MHz with DSP and FPU capability. In addition to the CPU subsystem, the devices contain advanced real-time control peripherals, such as a high-performance programmable analog subsystem, comparators, advanced timers with high-resolution capability, up to six SCBs, and two CAN FDs for communication. The devices support one active and five low-power modes for managing and reducing power consumption, depending on application requirements.

3.1.3 PSOC™ Control C3M5 MCU power supply system

The PSOC™ C3M5 MCU operates using a single regulated VDDD supply within the range of 1.7 V to 3.6 V. In addition, there is an optional VBACKUP supply that can be used, which has a range of 1.4 V to 3.6 V. A linear regulator powers the core logic at four voltage levels: 0.9 V, 1.0 V, 1.1 V, and 1.2 V. Voltage level switching is implemented by writing to the power control registers. The voltage for the core logic can be set based on the application's performance and power requirements.

Typically, the backup domain requires an input voltage of 1.4 V to 3.6 V, which can be provided by connecting a backup battery or a super capacitor to the VBACKUP pin. The internal backup switch automatically selects between VDDD and VBACKUP (when VDDD is no longer available) for powering the backup domain peripherals like RTC, WCO, ILO, and backup registers. Some I/O cells are powered from the VBACKUP supply before the internal backup switch. If the application does not require a dedicated backup source, VBACKUP can be connected to VDDD externally to ensure that the I/O cells powered by VBACKUP are functional.

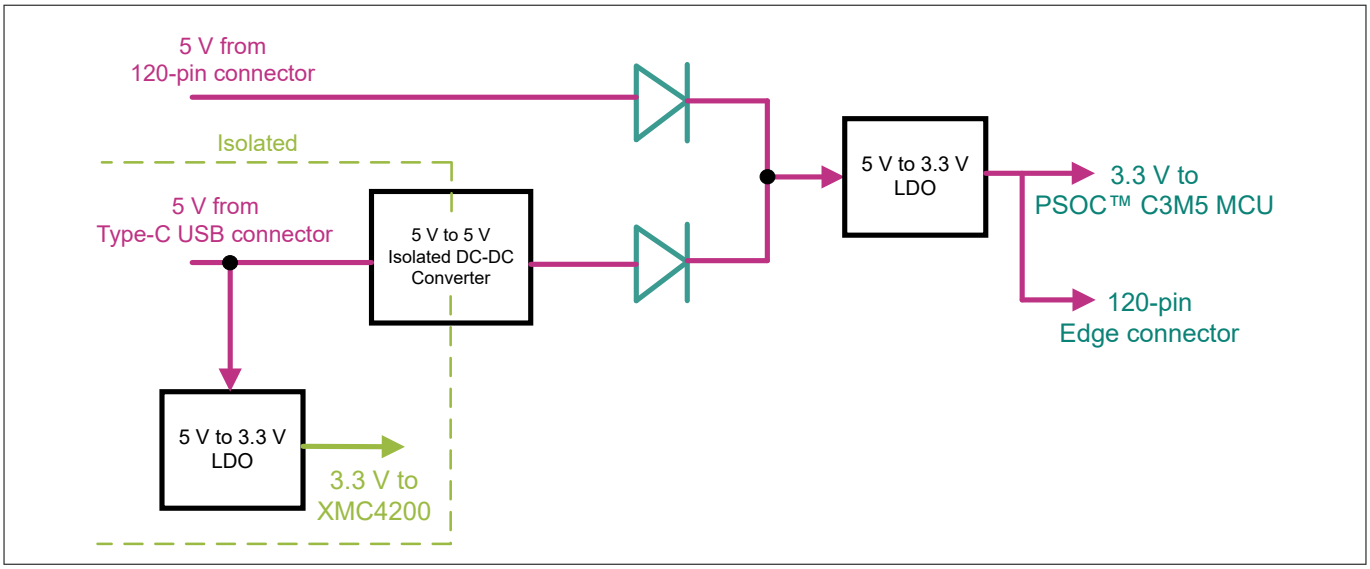


Figure 12 PSOC™ Control C3M5 Digital Power Control Card power tree (1)

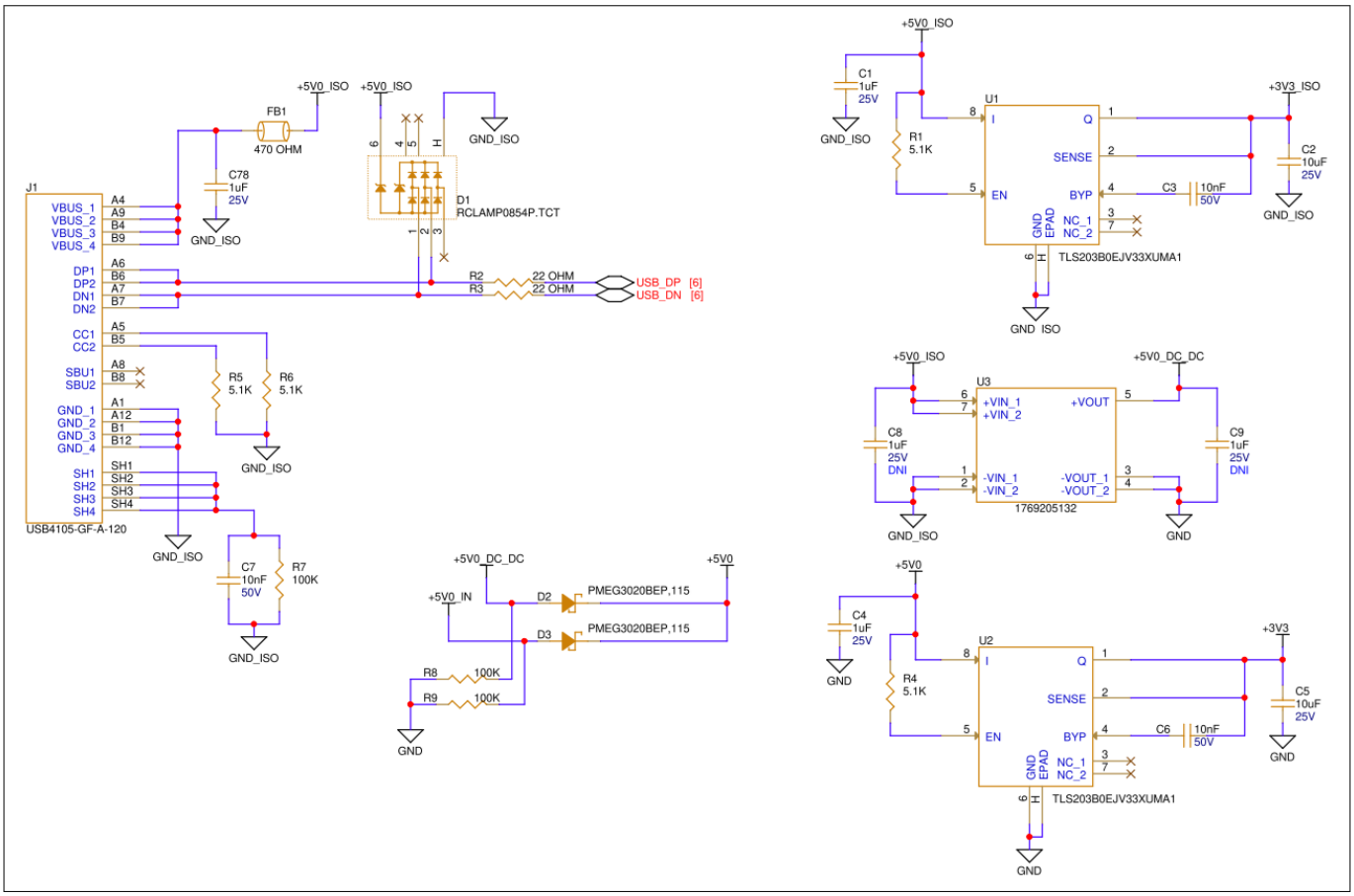


Figure 13 PSOC™ Control C3M5 Digital Power Control Card power tree (2)

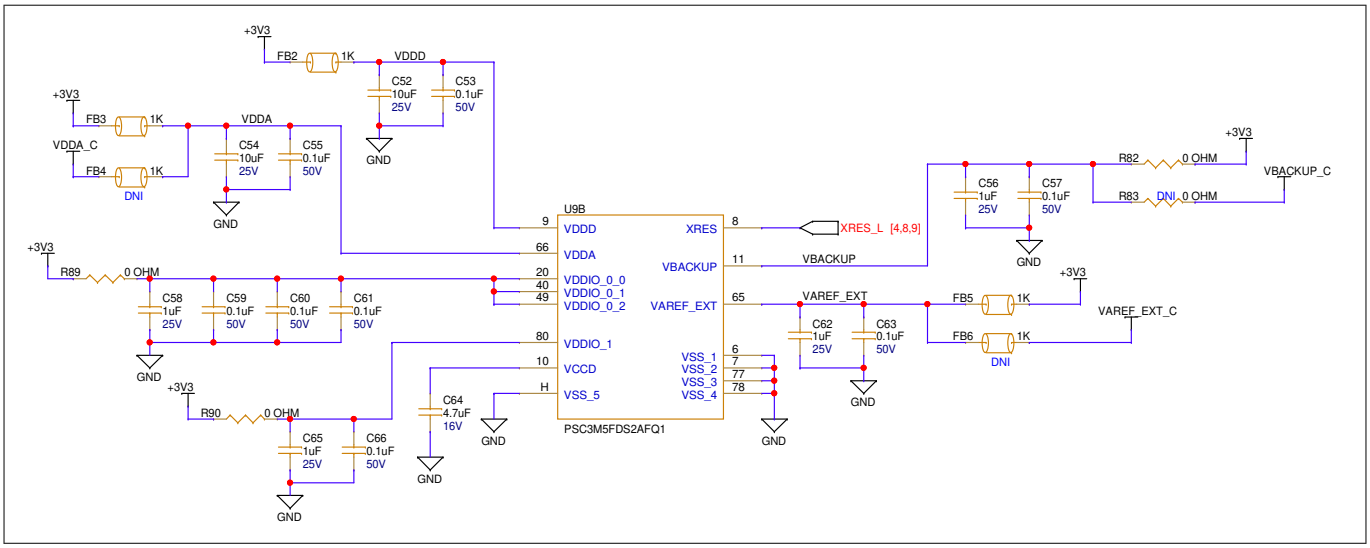


Figure 14 PSOC™ C3M5 power supply system

The control card is fully functional either when connected as a standalone through a USB Type-C connector to an external source, such as a laptop, or by receiving 5 V power from the evaluation board since 5 V power is provided on the 120-pin Edge connector. PSOC™ C3M5 is in fact supplied from an isolated 3.3 V LDO, which is powered through an isolated DC-DC 5 V OR' ed with an evaluation board at 5 V. The XMC4200 JLink is powered by a 3.3 V LDO, which is powered by a USB Type-C connector at 5 V. Also, the 3.3 V generated on the control card is routed to a 120-pin Edge connector for the evaluation board.

3.1.4 PSOC™ Control C3M5 MCU I/Os

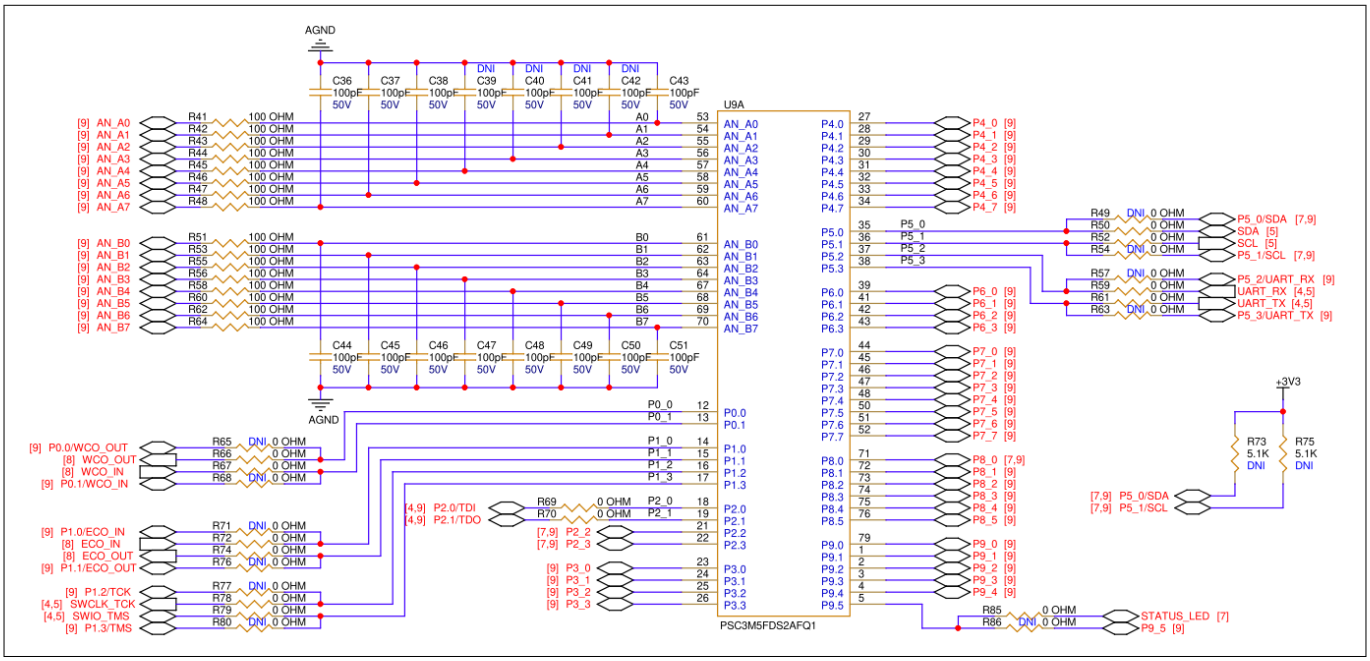


Figure 15 PSOC™ C3M5 MCU IOs

The PSOC™ C3M5 Control Card will bring out all the IOs to the 120-pin Edge finger. The ECO, WCO, SWD/JTAG, UART, and I2C pins are dedicated to the board by default and routed to the Edge finger with zero-ohm options.

3.1.5 120-pin Edge finger interface

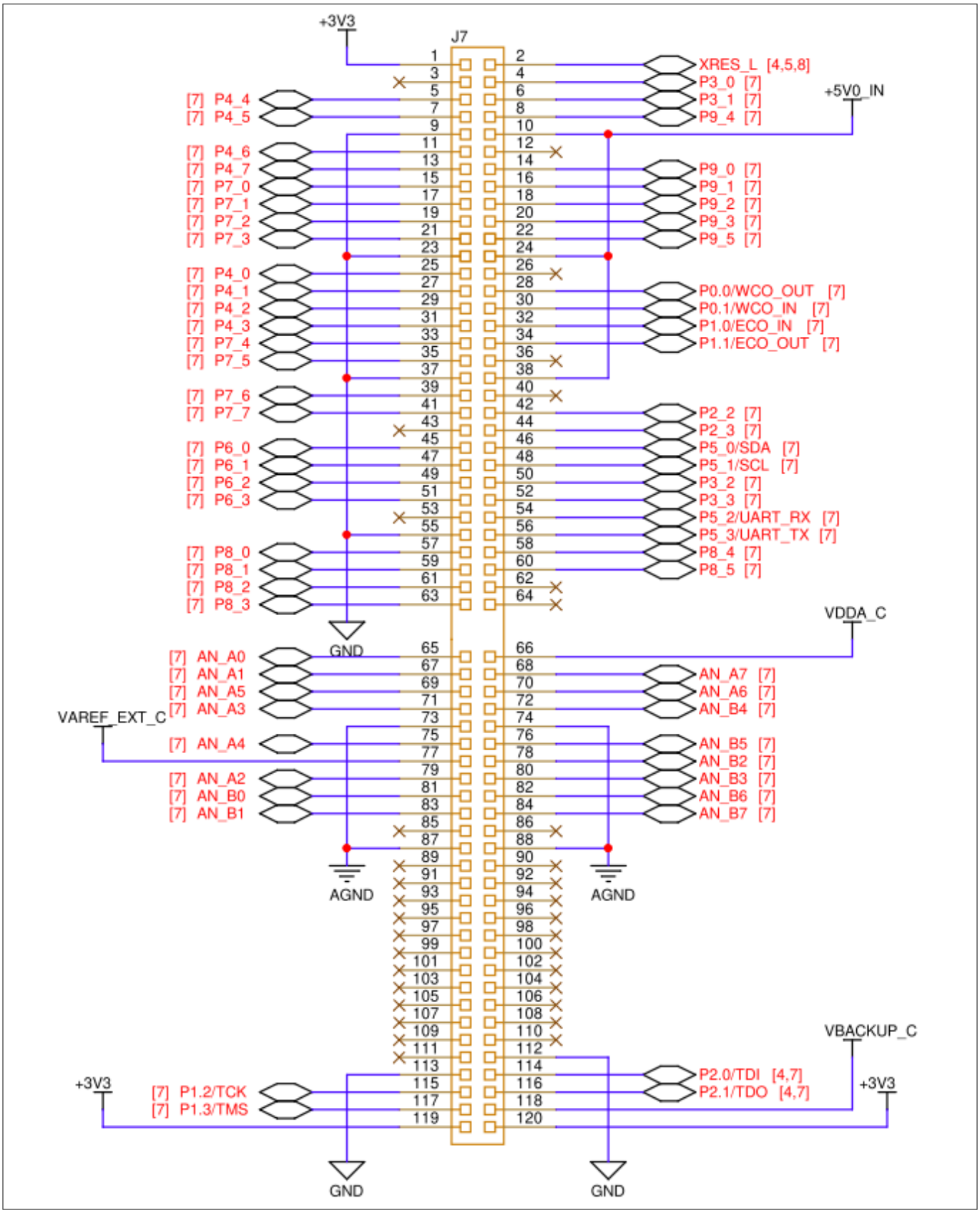


Figure 16 120-pin Edge finger

The control card has a 120-pin Edge finger, which is inserted into a mating connector (HSEC8-160-01-L-DV-A-BL) on evaluation boards. All the IO lines of the PSOC™ C3M5 device are routed to this 120-pin Edge finger. The control card pinout is defined so that it can be used as a generic control card for various types of evaluation boards. There will be different kinds of evaluation boards, such as Dual Buck Evaluation Board, PFC Evaluation Board, and so on. All these evaluation boards are built such that the 120-pin connector on them is compatible with this control card pinout. The edge connector has a 5 V input supply to the control card and a 3.3 V output supply from the control card.

The following are the signals available on the edge finger:

- Eight pairs of HRPWM signals (line and complimentary)
- 16 ADC analog inputs
- One UART channel
- One I2C channel
- JTAG signals
- 22 general purpose IO pins

3.1.6 Analog-to-digital converter (ADC) input filter

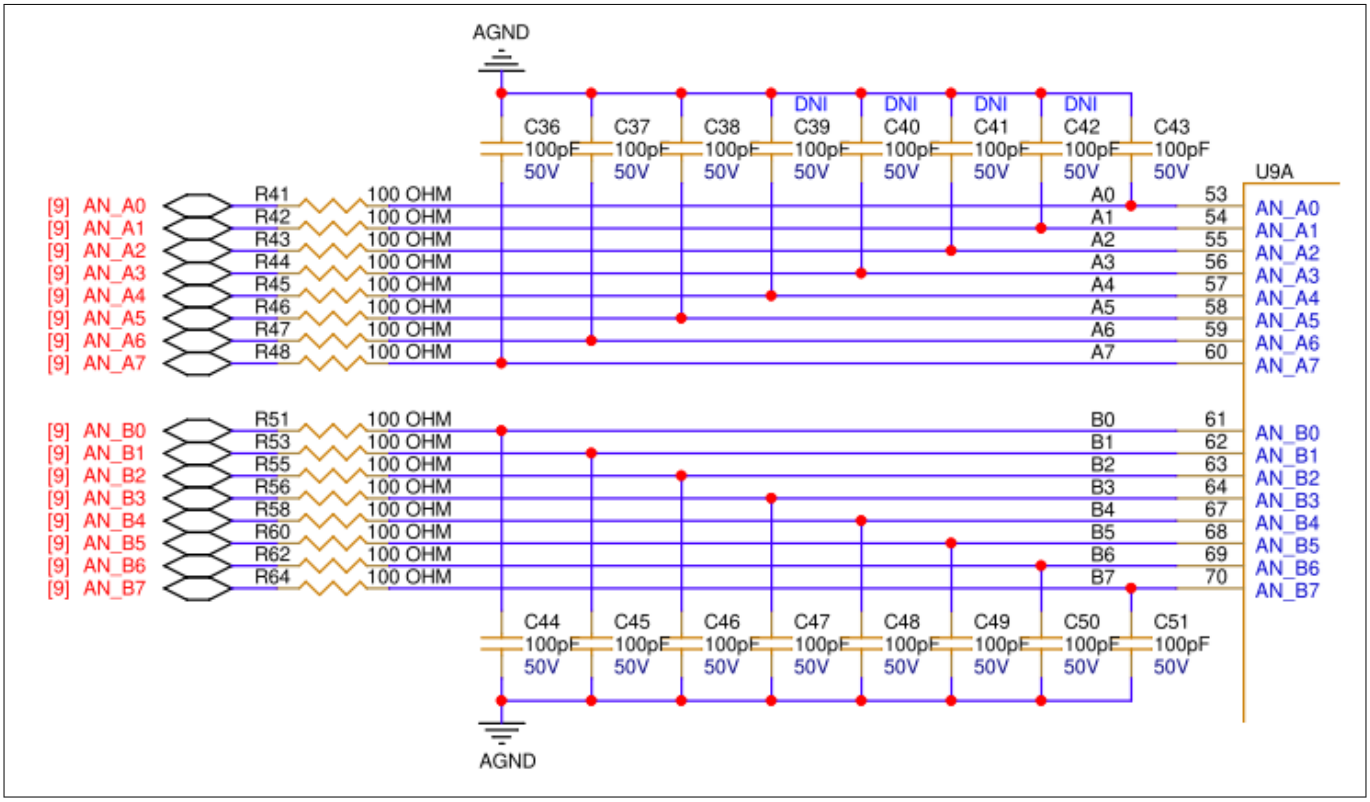


Figure 17 ADC input RC filter

All ADC inputs on the control card are filtered with a high-frequency cross-over frequency RC filter, as shown in Figure 17. This will help to remove undesired high-frequency noise from the input signals. As a result, it will improve the measurement performance of the MCU.

3.1.7 Reset button

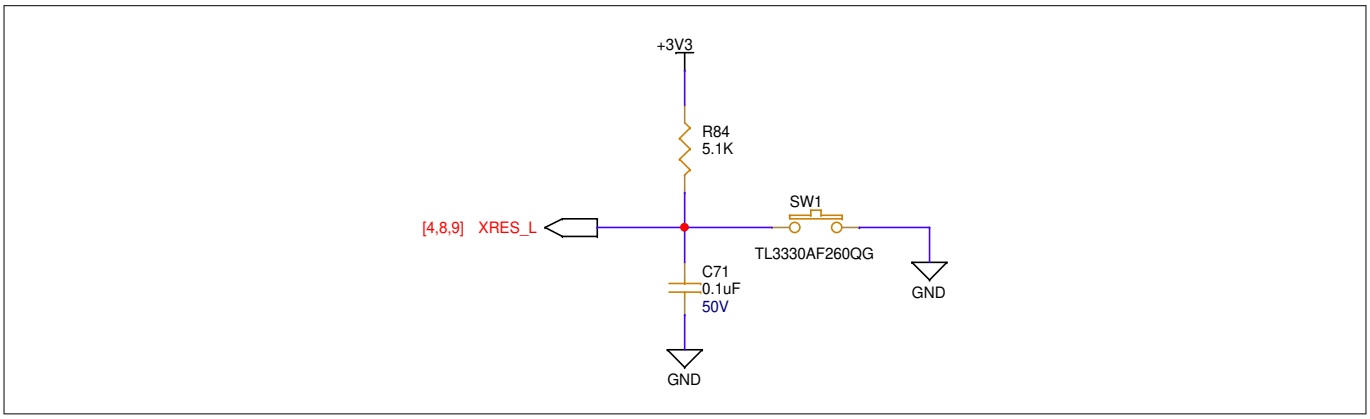


Figure 18 Reset button

The control card contains one reset button (SW1) for resetting the PSOC™ Control C3M5 MCU. When this SW1 button is pressed, the XRES_L line of the PSOC™ Control C3M5 MCU is pulled to the ground, which in turn resets the target device.

3.1.8 LEDs

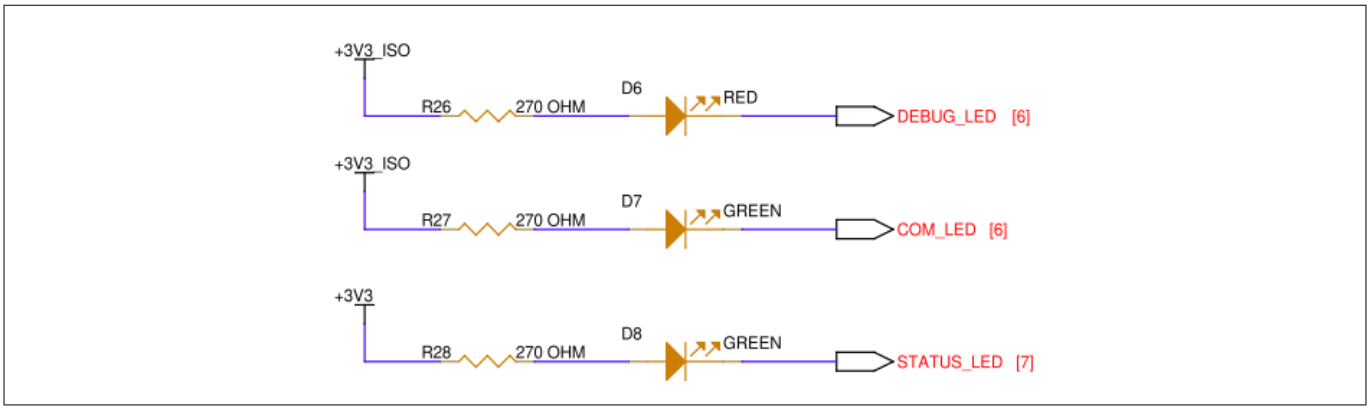


Figure 19 LEDs

The control card contains three discrete LEDs:

- One user-controlled LED D8 (green-STATUS LED) is connected to the P9.5 GPIO of the PSOC™ C3M5 MCU. This user LED is active low, so the P9.5 pin must be driven low to turn ON this LED
- Two debug controller LEDs, D6 (red-DEBUG LED) and D7 (green-COM LED), are connected to XMC4200 MCU pins and are not user-controlled

3.1.9 Digital isolators

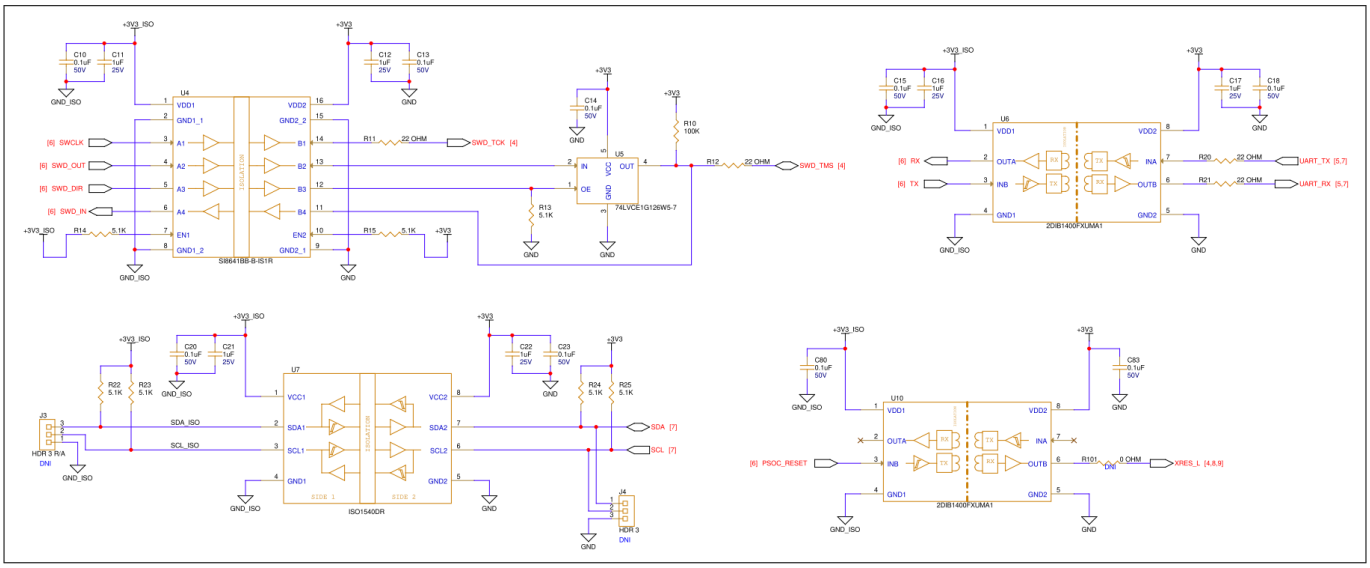


Figure 20 Digital isolators

The control card has an onboard XMC4200-based JLink debugger. All the signals connected between the XMC4200 and PSOC™ C3M5 devices are isolated with digital isolators. These digital isolators can provide capacitive isolation up to 2.5 KVrms. Also, there is a DC-DC isolator that provides 5 V to 5 V isolation between the XMC4200 and PSOC™ C3M5 sides. All the digital isolators are placed on the breakable side of the control card. When the user breaks off the debugger section of the PCB, the control card will not have any isolation. There are a total of four digital isolators on the control card, with 9 (4+2+2+1) channels. A 4-channel digital isolator is used for SWD interface isolation; a 2-channel digital isolator is connected between UART lines; one isolation channel is used to connect the PSOC™ C3M5 XRES pin to the XMC4200 P0.3 pin, and another 2-channel bidirectional digital isolator is used for I2C interface isolation. This isolated I2C interface can be accessed through a 3-pin header (J3). This same I2C interface can also be accessed from another 3-pin header (J4) directly from PSOC™ C3M5 MCU pins, which are not isolated. The user must make sure while accessing I2C through the J4 header to use external galvanic isolation (typically 1 kV) to avoid damage due to high voltages in the computer.

3.1.10 PSOC™ C3M5 Interface Board

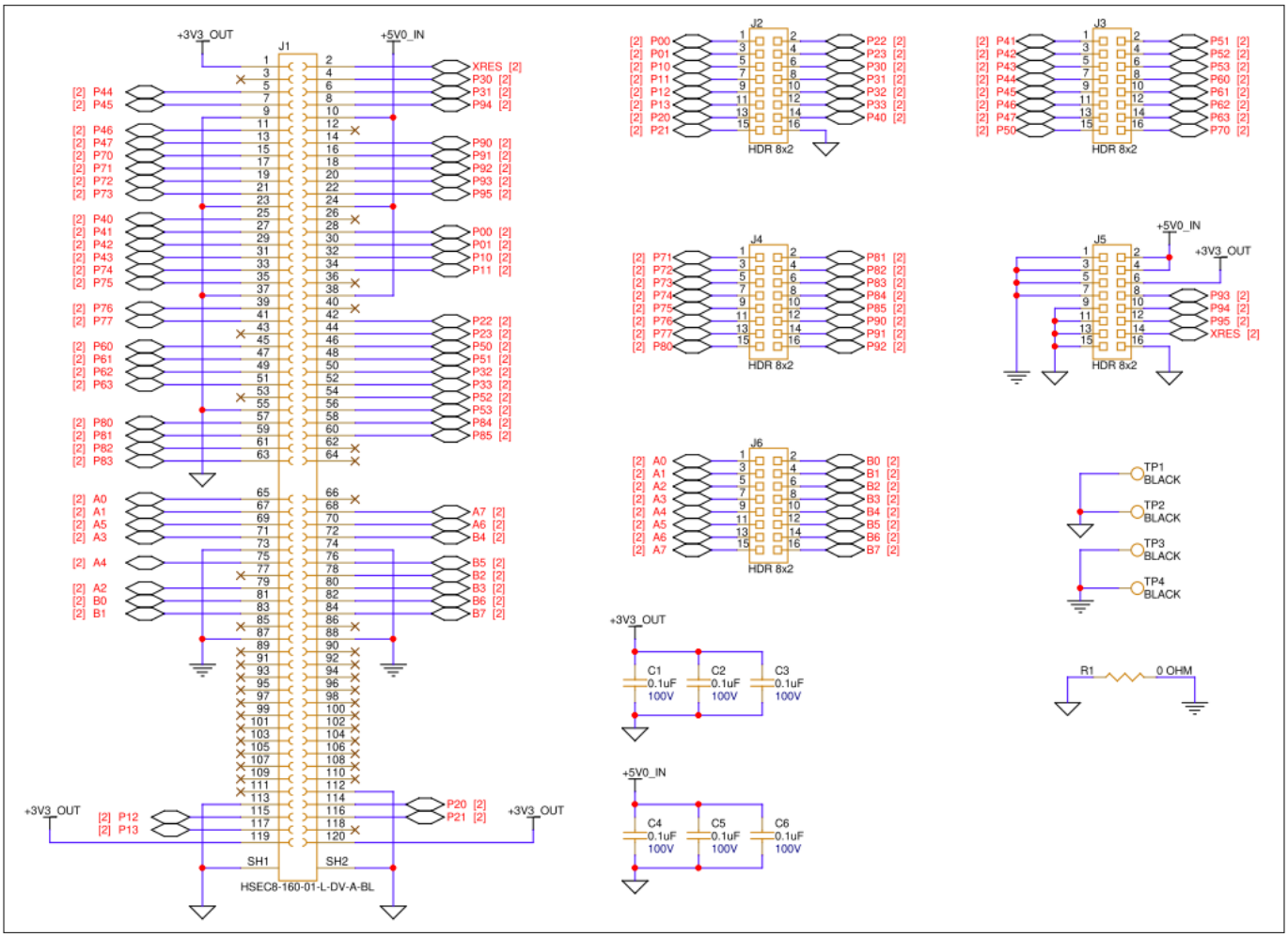


Figure 21 PSOC™ C3M5 Interface Board schematics

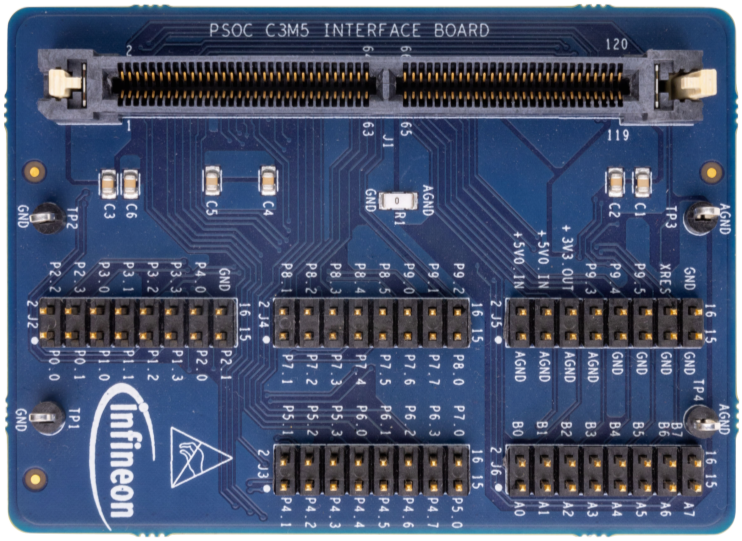


Figure 22 PSOC™ C3M5 Interface board

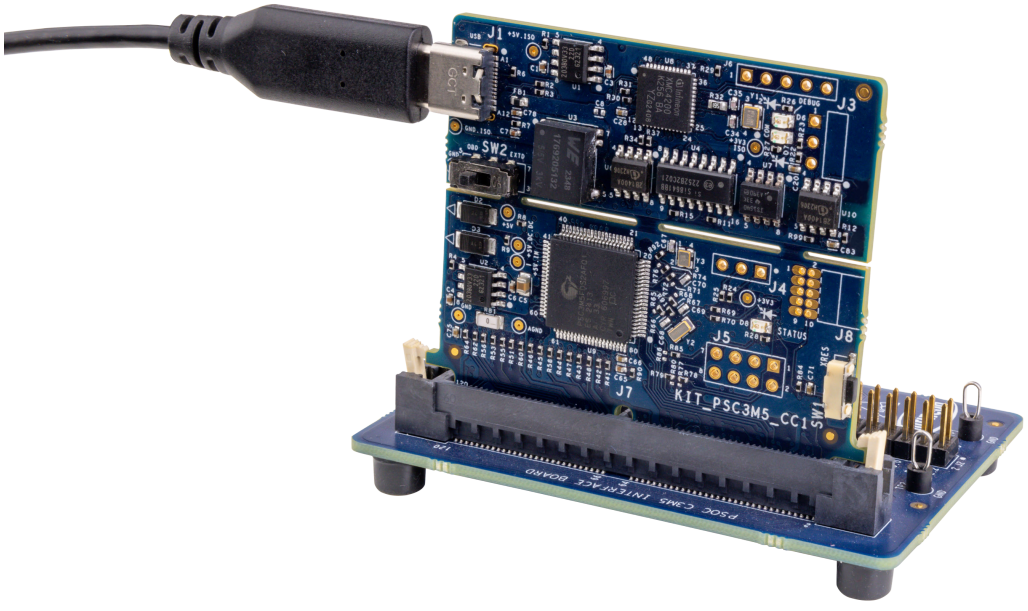


Figure 23 PSOC™ C3M5 Interface Board and Control Card

The interface board is made as an interface for the PSOC™ C3M5 Control Card. When no evaluation board is present, this interface board can be used to easily access the IO pins of the PSOC™ C3M5 controller. The interface board has a 120-pin mating connector (HSEC8-160-01-L-DV-A-BL) and five numbers of 2.54 mm 2x8 headers. The interface board does not require any power as it has no active components. When the PSOC™ C3M5 Control Card is not powered through the USB Type-C connector, a 5 V input can be supplied to it through the J5 header of the interface board. The control card provides a 3.3 V rail to the interface board, with the current limited to less than 100 mA.

3.1.11 PSOC™ Control C3M5 MCU clock architecture

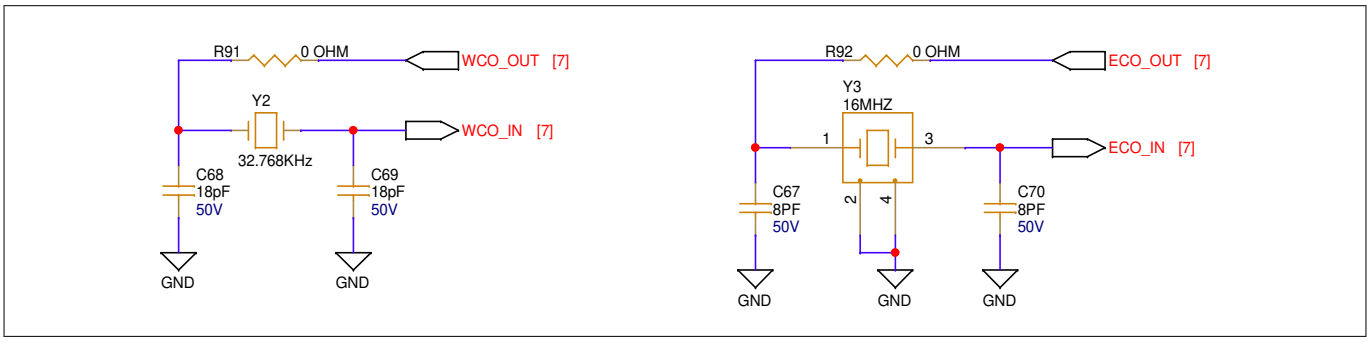


Figure 24 PSOC™ C3M5 clock sources

The control card includes 16 MHz ECO (Y3) and 32.768 kHz WCO (Y2) for the PSOC™ Control C3M5 MCU device.

3.1.12 PSOC™ Control C3M5 MCU external program/debug headers

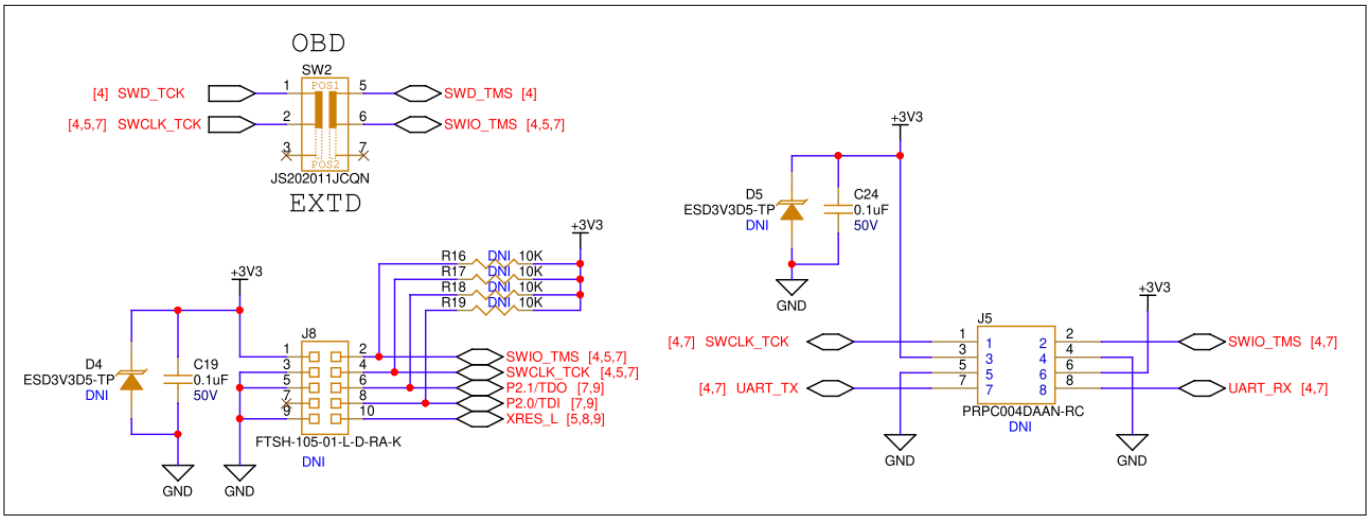


Figure 25 PSOC™ C3M5 external program/debug headers

The control card has an isolated XMC4200 MCU-based JLink programmer/debugger onboard. Alternately, the PSOC™ Control C3M5 MCU can be programmed through a 10-pin SWD/JTAG header (J8) using MiniProg4 or any third-party programmer. Switch SW2 let users select between onboard debugger (OBD) or external debugger (EXTD). The user must make sure that the external debugger box used provides galvanic isolation (typically 1 kV) to avoid damage due to high voltages in the computer.

PSOC™ Control C3M5 MCU or any other onboard peripheral cannot be powered from the 10-pin SWD/JTAG header (J8). This is to protect the external programmer from overloading, making sure that the kit does not draw any current from the external programmer through J8. Additionally, an 8-pin SWD/UART header (J5) is also provided for programming or debugging the PSOC™ Control C3M5 MCU.

PSOC™ Control C3M5 Digital Power Control Card includes two external connector options (J8 and J5) for debugging. The default configuration of the control card is prepared for onboard JLINK debug with switch SW2 set to the OBD position, and therefore, none of the two connector options (J8 and J5) are assembled. If required, the user has to mount the corresponding headers (J8 or J5) and make sure to set the switch SW2 to the EXTD position on the control card.

3.1.13 XMC4200 as onboard programmer/debugger

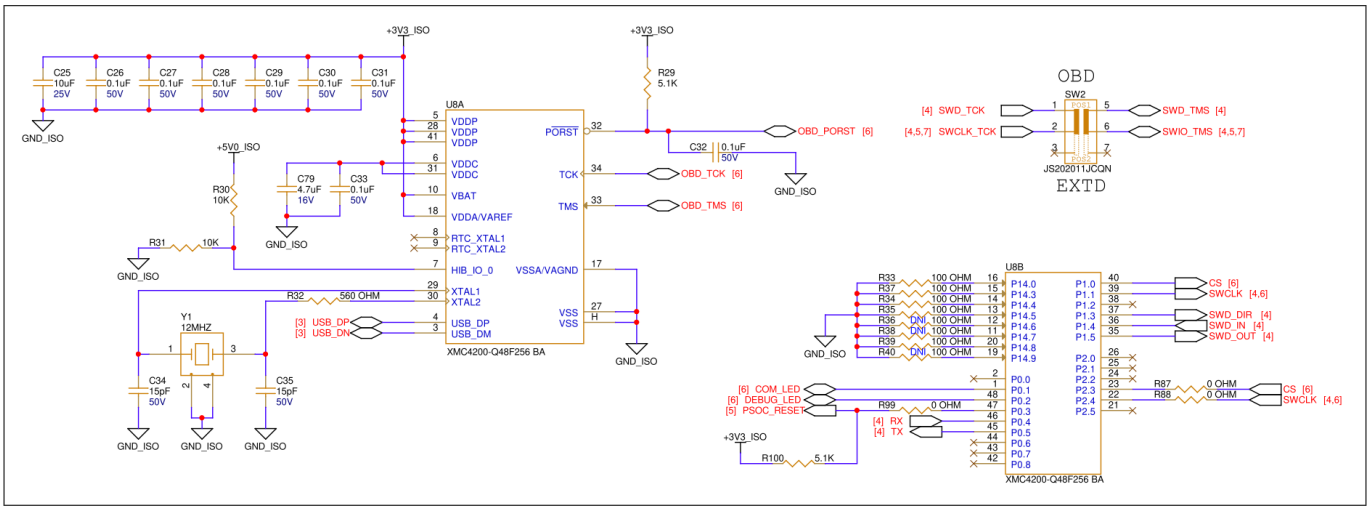


Figure 26 XMC4200 MCU based on board JLink programmer/debugger

The PSOC™ Control C3M5 Digital Power Control Card supports on board isolated debug interface:

- XMC4200-based JLink-isolated On-Board Debugger (OBD). Switch SW2 is set to the OBD position to support the onboard debugger. This is the default connection. It is powered through a USB Type-C connector (5 V) converted to an isolated 3.3 V

The control card includes a debugger controller and isolation up to 2.5 kV to protect the computer. Connect the Control card to a computer with a USB cable.

The on board debugger (OBD) supports:

- Serial Wire Debug (SWD)
- UART communication via a virtual COM port

***Note**: The firmware of the OBD requires the latest JLink driver and a serial port driver (CDC driver) installed on your computer. Check "Install J-Link Serial Port Driver" when installing the latest JLink driver.*

3.1.14 Removing the onboard debugger

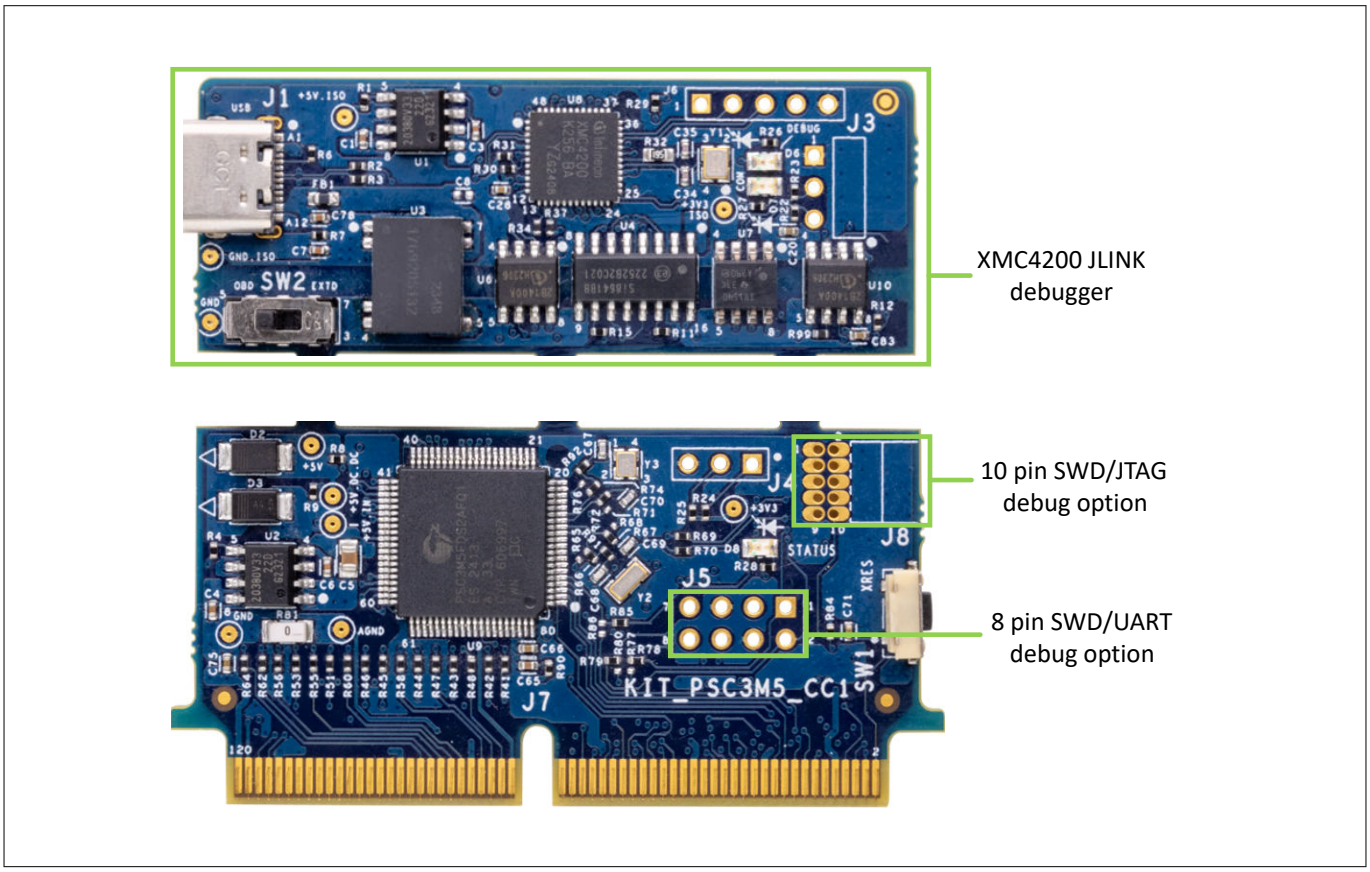


Figure 27 Debug options when removing debugger part of control card

PSOC™ Control C3M5 Digital Power Control Card can be broken off into two parts by breaking the PCB, as shown in Figure 27. This will reduce the size of the main controller part so that it can fit into 1U standard-sized rack systems once programmed. The control card can still be debugged in two different ways if the debugger part is removed.

1. Connecting a ribbon cable to an 8-pin connector (J5) or,
2. Using the 10-pin connector (J8) option with an external debugger box

By default, these connectors (J8 and J5) are not loaded. The user can install these connectors when the onboard debugger is broken. When the onboard debugger is not broken and these J5 or J8 connectors are installed, then the user must make sure to set the switch SW2 to the EXTD position to make the external debugger work.

***Note**: When using external debuggers, make sure that the debugger box includes galvanic isolation for the computer. If the control card is exposed to high voltages, this can cause damage to the computer.*

4 Production data

The board has been designed with Allegro. The full PCB design data (schematics, layout, and BOM) of this board can also be downloaded from the kit webpage.

Revision history

Document revision	Date	Description of changes
**	2024-07-16	Initial release
*A	2024-08-01	Replaced the word "Expansion" with "Evaluation" in the document
*B	2024-12-16	Updated: Safety precautions Kit contents Getting started Key features Kit operation Figure 1 Figure 2 Using the Out of the box example Figure 3 Creating a project and program/debug using ModusToolbox™ software Figure 4 PSOC™ Control C3M5 Digital Power Control Card 120-pin Edge finger interface PSOC™ C3M5 Interface Board Figure 22 Figure 23 PSOC™ Control C3M5 MCU external program/debug headers XMC4200 as onboard programmer/debugger Removing the onboard debugger Figure 27 Publish to web

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Edition 2024-12-16

Published by

Infineon Technologies AG

81726 Munich, Germany

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Document reference
IFX-zru1720684801316

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