Infineon Mobile Robot (IMR) battery management control

Using DEMO_IMR_BMSCTRL_V1

About this document

Scope and purpose

This document provides a comprehensive functional description and guide for the DEMO_IMR_BMSCTRL_V1 demonstration board. Hardware is shown and explained in detail with software to be updated as soon as available. Furthermore, a basic quick start guide is provided for the intended use as the Infineon mobile robot (IMR) BMS controller.

Intended audience

This document is intended for design engineers, technicians, and developers of electronic systems.

Infineon components featured

- OptiMOS™ BSD235N 2 small-signal transistor
- IRLML6401 Single P-channel power MOSFET
- PSoC™ 6 CY8C6245AZI-S3D72, 32-bit dual-CPU microcontroller with Arm® Cortex®-M4F and M0+
- CY15B256Q-SXA 256 Kb automotive serial (SPI) F-RAM

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Safety precautions

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

Table 1 Safety precautions

	Warning: *The DC link potential of this board is up to 1000 VDC. When measuring voltage waveforms by oscilloscope, high-voltage differential probes must be used. Failure to do so may result in personal injury or death.*
	Warning: *The evaluation or reference board contains DC bus capacitors, which take time to discharge after removal of the main supply. Before working on the drive system, wait 5 minutes for capacitors to discharge to safe voltage levels. Failure to do so may result in personal injury or death. Darkened display LEDs are not an indication that capacitors have discharged to safe voltage levels.*
	Warning: *The evaluation or reference board is connected to the grid input during testing. Hence, high-voltage differential probes must be used when measuring voltage waveforms by an oscilloscope. Failure to do so may result in personal injury or death. Darkened display LEDs are not an indication that capacitors have discharged to safe voltage levels.*
	Warning: *Remove or disconnect power from the drive before you disconnect or reconnect wires, or perform maintenance work. Wait five minutes after removing power to discharge the bus capacitors. Do not attempt to service the drive until the bus capacitors have discharged to zero. Failure to do so may result in personal injury or death.*
	Caution: *The heat sink and device surfaces of the evaluation or reference board may become hot during testing. Hence, necessary precautions are required while handling the board. Failure to comply may cause injury.*
	Caution: *Only personnel familiar with the drive, power electronics and associated machinery should plan, install, commission and subsequently service the system. Failure to comply may result in personal injury and/or equipment damage.*
	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: *A drive that is incorrectly applied or installed can lead to component damage or reduction in product lifetime. Wiring or application errors such as undersizing the motor, supplying an incorrect or inadequate AC supply, or excessive ambient temperatures may result in system malfunction.*
	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.*

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1 Introduction

1.1 Mobile robot general description

Mobile robots are now common in applications from logistics and warehouse centers and production sites to hospitals, restaurants, and schools, and as last-mile package delivery vehicles. On a high level, mobile robots are of two main types:

- **Automated guided vehicles (AGV):** "Fixed" vehicles that follow predefined paths using lasers, barcodes, radio waves, vision sensors, or magnetic tape for navigation.
- **Autonomous mobile robots (AMR):** Not "fixed", and do not need external paths as these use autonomous mapping, localization, navigation, and obstacle avoidance by using sensors.

Usually, robots are battery-powered where the voltage level depends on the size and weight characteristics.

1.2 Infineon Mobile Robot (IMR)

The board described in this document is primarily targeted to be used in combination with the Infineon Mobile Robot (IMR). The IMR is a comprehensive robotic platform for use with a wide variety of boards such as sensors, motor controls, wireless communication, and battery management.

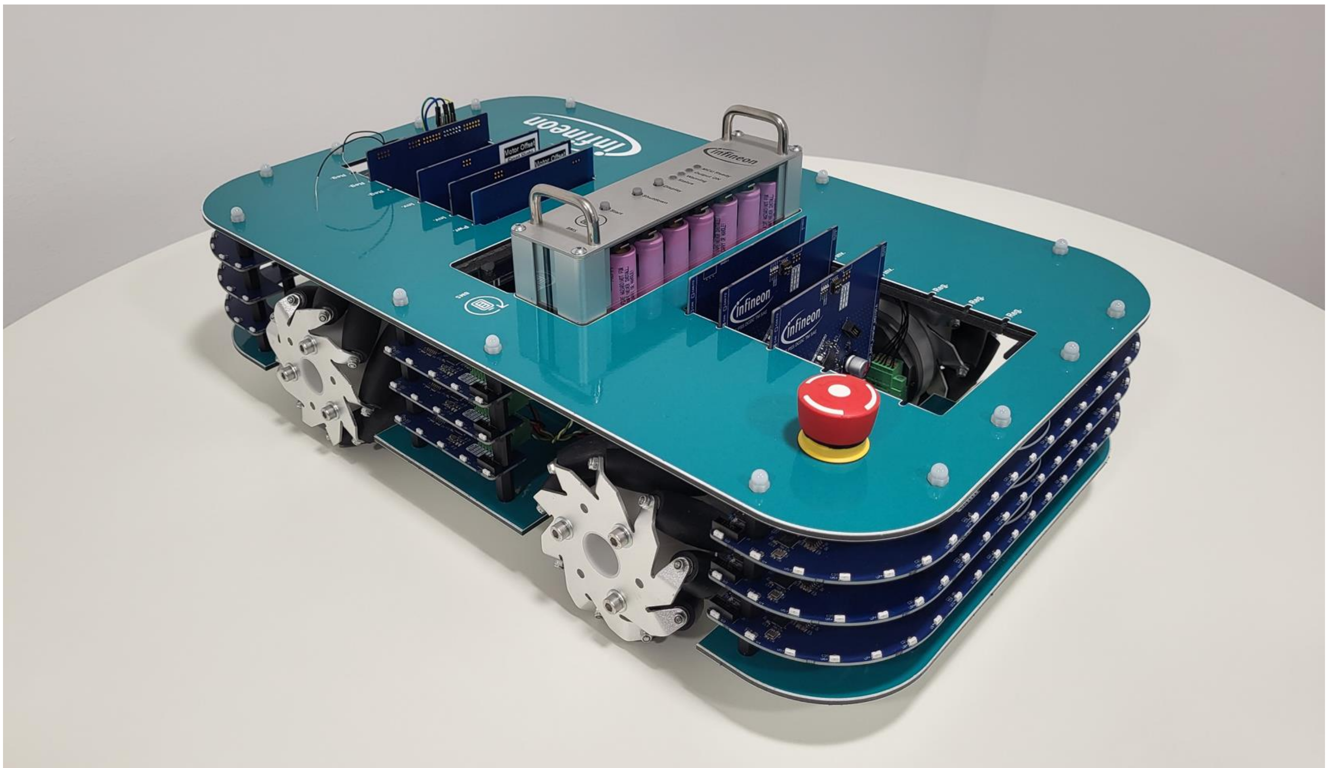

Figure 1 Infineon Mobile Robot (IMR): Isometric view

The IMR is intended to provide a demonstration platform for autonomous service robot functionalities by using Infineon components. This document describes how to use the DEMO_IMR_BMSCTRL_V1 board as the processing unit for all battery management system (BMS) tasks and interface the BMS power board including the following:

- Battery monitoring
- Battery balancing
- Estimation of state of charge (SoC)
- Estimation of state of health (SoH)

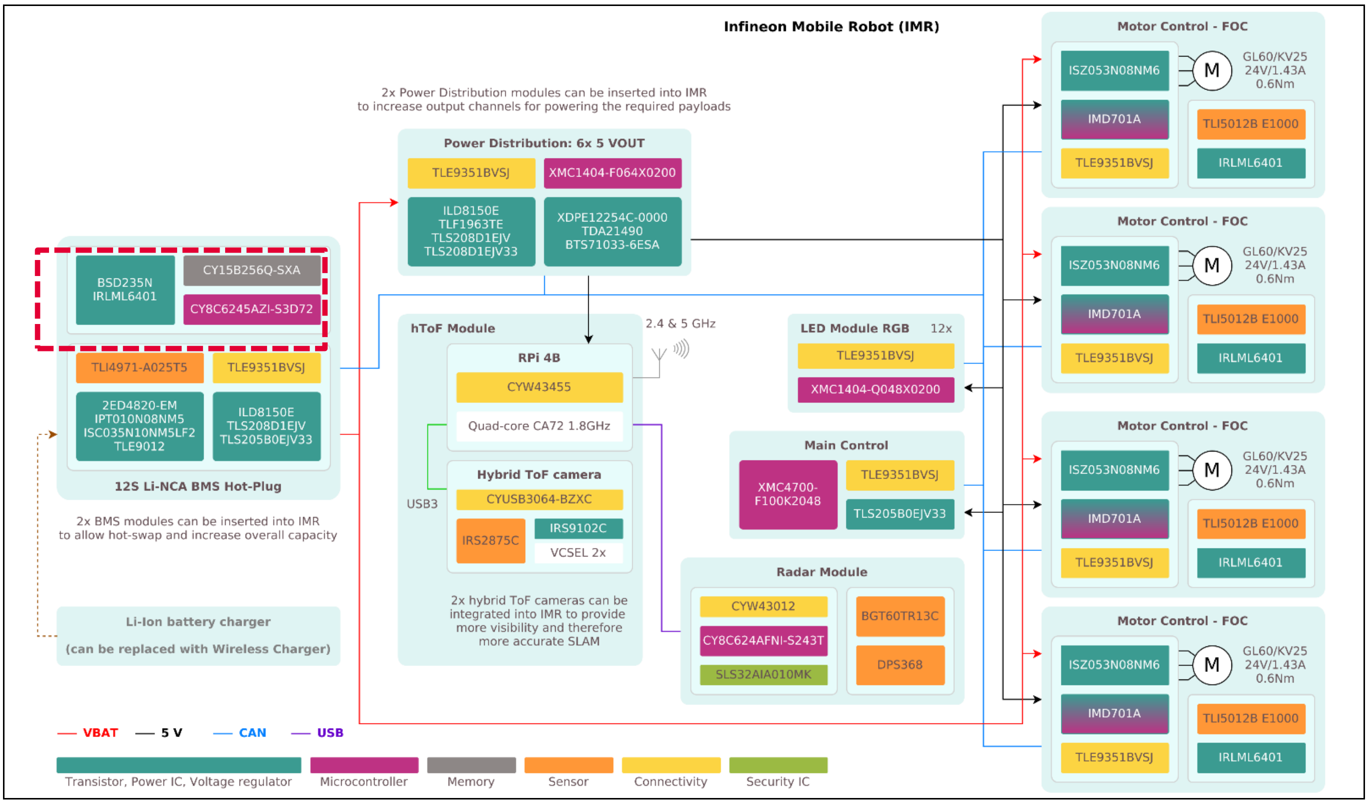

Figure 2 **IMR overview: DEMO_IMR_BMSCTRL_V1 board highlighted in red. Two BMS modules are installed in the IMR to facilitate hot swap and increase the overall capacity.**

1.3 DEMO_IMR_BMSCTRL_V1 demo board

The DEMO_IMR_BMSCTRL_V1 board is a modular battery management solution, specifically designed to work with the battery-driven power board for the IMR. The board features a PSoC™ 6 series Arm® Cortex®-M4/M0+ MCU performing all necessary tasks including measurements and calculations. It estimates the battery's state of charge (SoC) and state of health (SoH) using measured voltages and currents and display the calculated values on the provided ePaper display.

After combining the board with an appropriate IMR battery power board (i.e., DEMO_IMR_BMSPWR_V1), the complete system is installed vertically into one of the IMR's battery management slots. After installation, all necessary communication is handled via the CAN/CAN FD interface. The board's unique CAN identifier can be set using the onboard DIP switch.

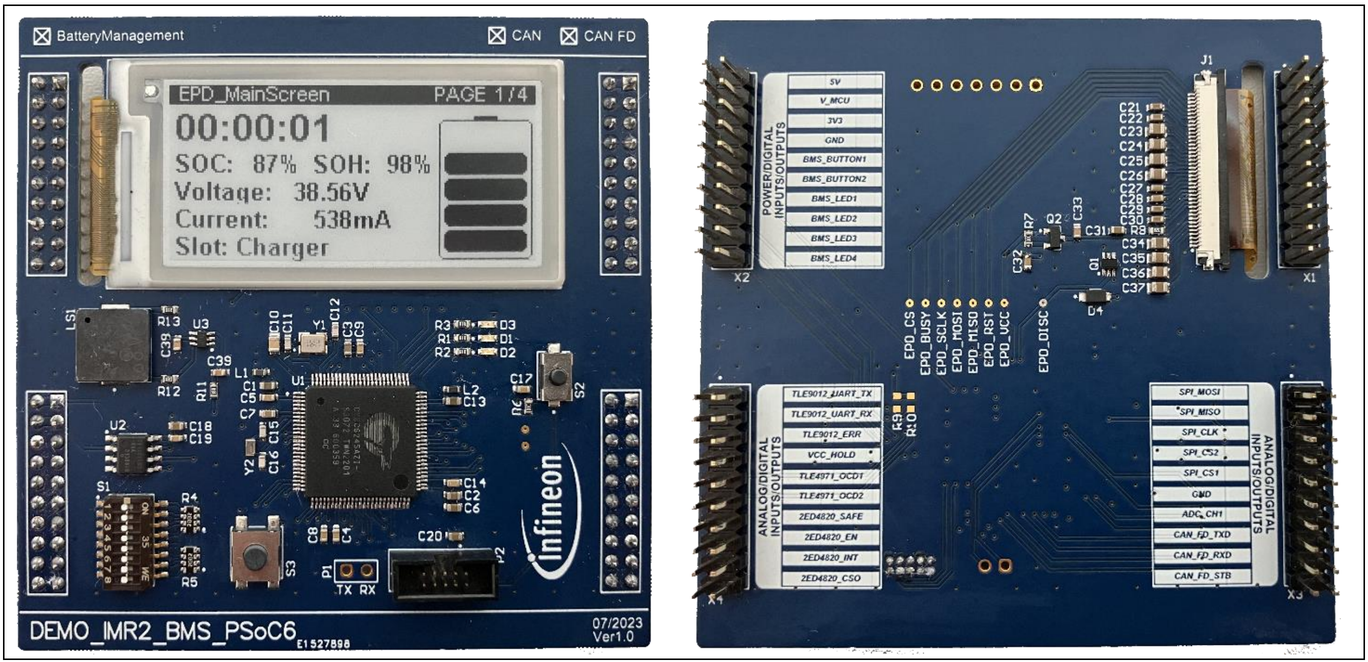

Figure 3 DEMO_IMR_BMSCTRL_V1 board top (left) and bottom (right) view (80 mm x 80 mm)

1.4 Connectors

The DEMO_IMR_BMSCTRL_V1 board provides connectors to support several peripherals, communication protocols, and connections to control the IMR battery power board (DEMO_IMR_BMSPWR_V1). This includes analog, digital, and communication lines for the following:

- Two external BMS buttons
- Four external status LEDs
- SPI serial interface and chip-select lines for two peripherals
- CAN communication lines for an external CAN transceiver
- UART debugging interface
- UART interface for the TLE9012 cell balancing IC
- Additional digital/analog lines for further functionality

In addition to the onboard ePaper display, an additional connector featuring both SPI and I2C interface is available for other displays (e.g., SSD1306). The following schematic shows the four main communication connectors and the debug communication header.

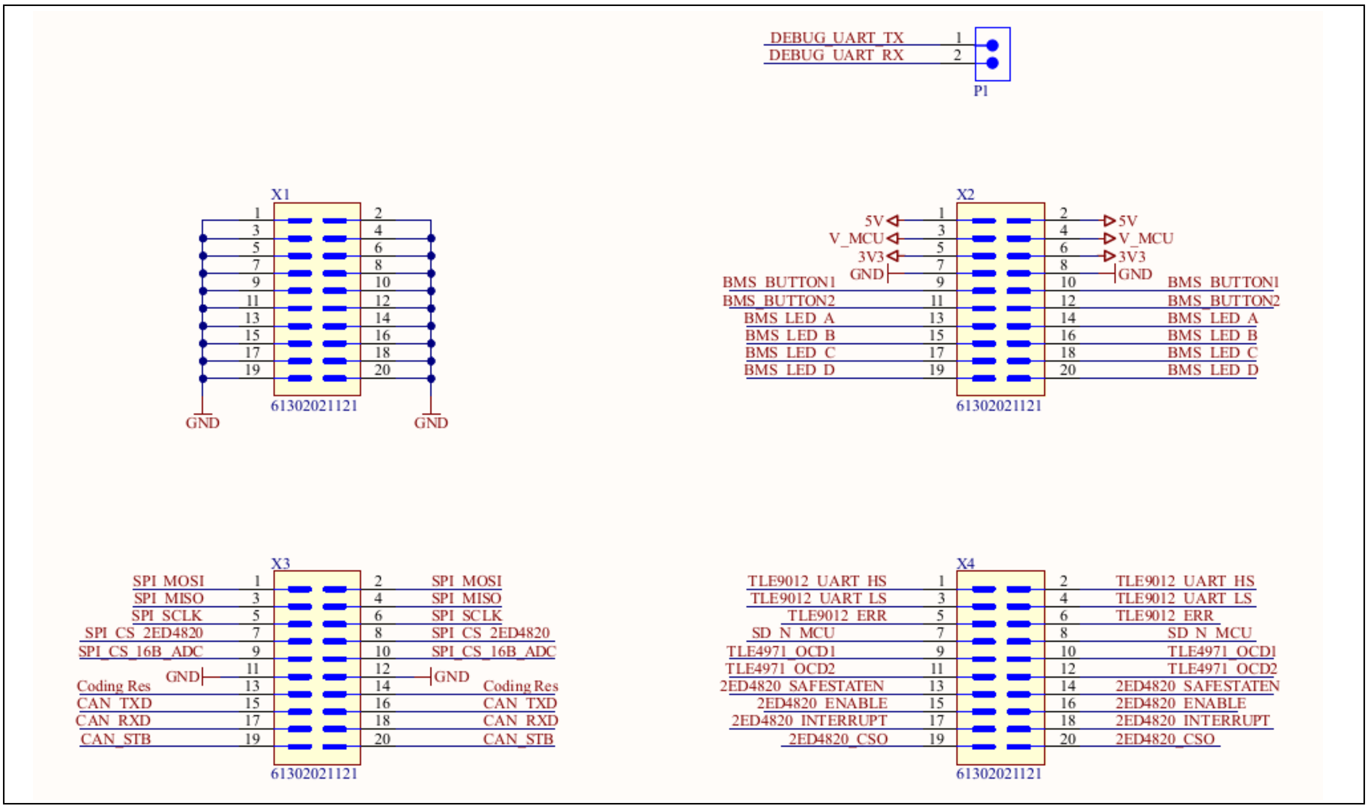

Figure 4 COM_CommunicationPort.SchDoc - Schematic overview of peripheral connectors

Table 1 shows the connection between connector P1 and the corresponding PSoC™ 6 MCU pins (UART transmit/receive lines) for the UART debugging interface. See the Quick start guide section for details of how to use this connector.

Table 2 Connection between connector P1 and PSoC™ 6 MCU for UART debugging interface

Name	PSoC™ 6 MCU pin	Function	Description
DEBUG_UART_TX	P0.3	Serial debug output	UART transmit line
DEBUG_UART_RX	P0.2	Serial debug input	UART receive line

Table 2 shows the common GND connector (X1) closest to the 40-pin FPC e-display connector; it is therefore chosen without any additional communication lines.

Table 3 Connector X1 – Common GND connection

Name	PSoC™ 6 MCU pin	Function	Description
GND	–	Signal ground	–

Table 3 shows the connection between connector X2 and the corresponding PSoC™ 6 MCU pins for LEDs and buttons control. Additionally, both 5 V and 3.3 V are placed on the connector to supply any microcontrollers. The V_MCU line is used to set the digital supply voltage for peripherals on externally connected boards (the BMS power board in this case). The selected voltage for the PSoC™ 6 MCU is 3.3 V; V_MCU is also routed to that voltage level. The 5 V supply is unused.

Table 4 Connection between connector X2 and PSoC™ 6 MCU for BMS control/indicator and power connection

Name	PSoC™ 6 MCU pin	Function	Description
5 V	–	Signal power input	5 V DC power input
V_MCU	–	Signal power output	Peripheral power selector (selected: 3V3)
3V3	–	Signal power input	3.3 V DC power input
GND	–	Signal ground	–
BMS_BUTTON1	P7.1	Digital input/ERU	Digital ERU button input
BMS_BUTTON2	P7.0	Digital input/ERU	Digital ERU button input
BMS_LED_A	P10.5	Digital output	Digital status LED output
BMS_LED_B	P7.7	Digital output	Digital status LED output
BMS_LED_C	P7.6	Digital output	Digital status LED output
BMS_LED_D	P7.5	Digital output	Digital status LED output

Table 4 shows the connection between connector X3 and the corresponding PSoC™ 6 MCU pins for SPI and CAN serial interface lines. Additionally, this connector has an analog input that lets the system detect the hardware that the BMS is currently inserted in. The SPI interface has two Chip Select (CS) lines, which are currently used communication with the following:

- 2ED4820 high-side gate driver
- 16-bit ADC for current and load voltage measurements

Table 5 Connection between connector X3 and PSoC™ 6 MCU for the serial communication

Name	PSoC™ 6 MCU pin	Function	Description
SPI_ MOSI	P11.0	SPI MOSI	SPI master out; slave in
SPI_ MISO	P11.1	SPI MISO	SPI master in; slave out
SPI_ SCLK	P11.2	SPI SCLK	SPI clock
SPI_ CS_2ED4820	P11.4	SPI Chip Select	SPI 2ED4820 Chip Select
SPI_ CS_16B_ADC	P11.3	SPI Chip Select	SPI MCP3465 Chip Select
GND	–	Signal ground	–
Coding_Res	P10.7	Analog input	Analog slot detection
CAN_TXD	P5.1	CAN output	CAN transmit line
CAN_RXD	P5.0	CAN input	CAN receive line
CAN_STB	P5.6	Digital output	Optional CAN standby

Table 5 shows the connection between connector X4 and the corresponding PSoC™ 6 MCU pins for serial communication lines to the following external components on IMR battery power board:

- Main UART communication interface for the TLE9012 battery balancing IC
- Auxiliary digital and analog inputs/outputs for the TLE4971 current sensor and 2ED4820 high-side gate driver

Table 6 Connection between connector X4 and PSoC™ 6 MCU for the serial communication and auxiliary inputs/outputs

Name	PSoC™ 6 MCU pin	Function	Description
TLE9012_UART_HS	P6.0	UART HS	UART TLE9012 HS line
TLE9012_UART_LS	P6.1	UART LS	UART TLE9012 LS line
TLE9012_ERR	P6.5	Digital input	TLE9012 error output
SD_N_MCU	P8.3	Digital output	Power Stay-on output
TLE4971_OCD1	P8.0	Digital input	TLE4971 over-current detection output 1
TLE4971_OCD2	P8.1	Digital input	TLE4971 over-current detection output 2
2ED4820_SAFESTATEN	P7.2	Digital output	2ED4820 safe state enable output
2ED4820_ENABLE	P7.4	Digital output	2ED4820 enable output
2ED4820_INTERRUPT	P7.3	Digital input	2ED4820 error flag output
2ED4820_CSO	P10.6	Analog input	2ED4820 current analog output

In addition to the ePaper display on the board, an additional optional connector (J2) supports an external I2C or SPI TFT display (e.g., SSD1306). The connector is supplied via the 3V3 voltage supplied input.

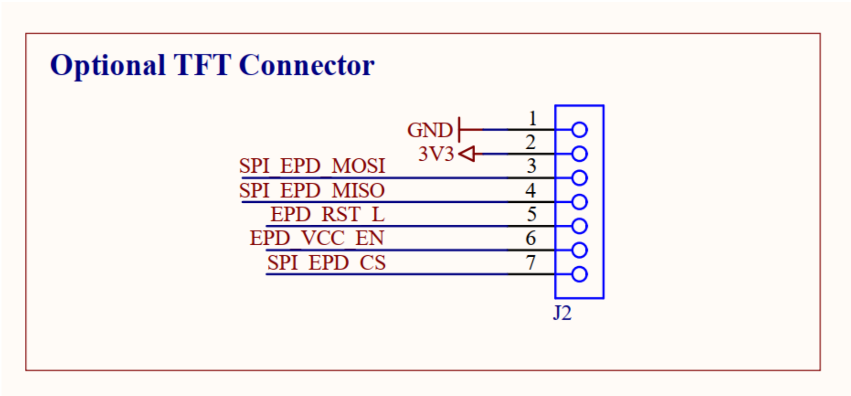

Figure 5 COM_CommunicationPort.SchDoc – Optional TFT connector

Table 7 Connection between connector J2 and PSoC™ 6 MCU – Optional TFT connector for I2C display (e.g., SSD1306)

Function	PSoC™ 6 MCU pin	Function	Description
GND	–	Signal ground	–
3V3	–	Signal power	Regulated 3.3 V DC supply
SPI_EPD_MOSI	P9.0	SPI MOSI	SPI MOSI/I2C SCL
SPI_EPD_MISO	P9.1	SPI MISO	SPI MISO/I2C SDA
EPD_RST_L	P10.4	Digital output	OLED Reset (RST)
EPD_VCC_EN	P12.0	Digital output	OLED Data Comm. (DC)
SPI_EPD_CS	P9.3	SPI CS	OLED Chip Select (CS)

2 Hardware

This chapter describes the most important functional parts of the board hardware. See the Appendix for full schematics, including microcontroller schematics and overview.

2.1 Piezo-electric buzzer circuit

To provide audio feedback, a Piezo-electric sounder and necessary auxiliary components are provided. This provides audio feedback on the following events:

- End of charging
- Low-voltage warning
- Overcurrent warning
- Overtemperature warning

The speaker can be controlled using one of the PSoC™ 6 MCU's digital outputs.

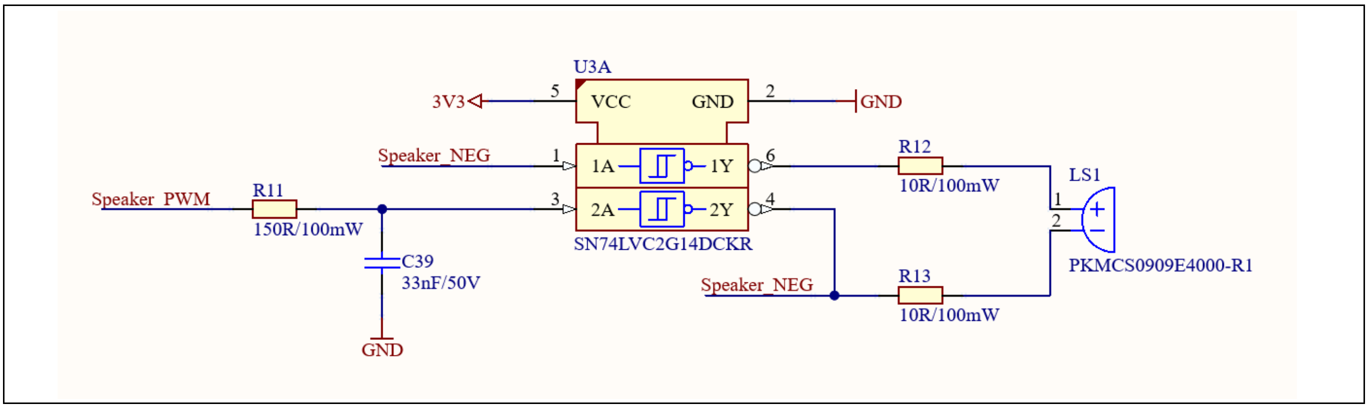

Figure 6 Piezo-electric buzzer circuitry including auxiliary components

2.2 Serial F-RAM memory circuit

The CY15B256Q 256 Kb nonvolatile memory based on an advanced ferroelectric process performs reads and writes similar to a RAM. It provides reliable data retention for 121 years while eliminating the complexities, overhead, and system-level reliability problems of serial flash, EEPROM, and other nonvolatile memories. Unlike serial flash and EEPROM, CY15B256Q performs write operations at bus speed without write delays. Data is written to the memory array immediately after each byte is successfully transferred to the device [1].

In this application, the CY15B256Q device is used to store the measured individual cell voltages and overall current values for further calculation of SoC and estimation of SoH. The chip provides an SPI interface, which is directly connected to one of the PSoC™ 6 MCU's peripheral SPI blocks. In addition to the common lines for SPI communication, additional pins are provided:

- **Write Protect (WP) pin:** Input that prevents write operations; can be used to prevent unwanted changes to the Status Register
- **HOLD pin:** Input and can be used by the host CPU to determine if it must interrupt a memory operation for another task temporarily

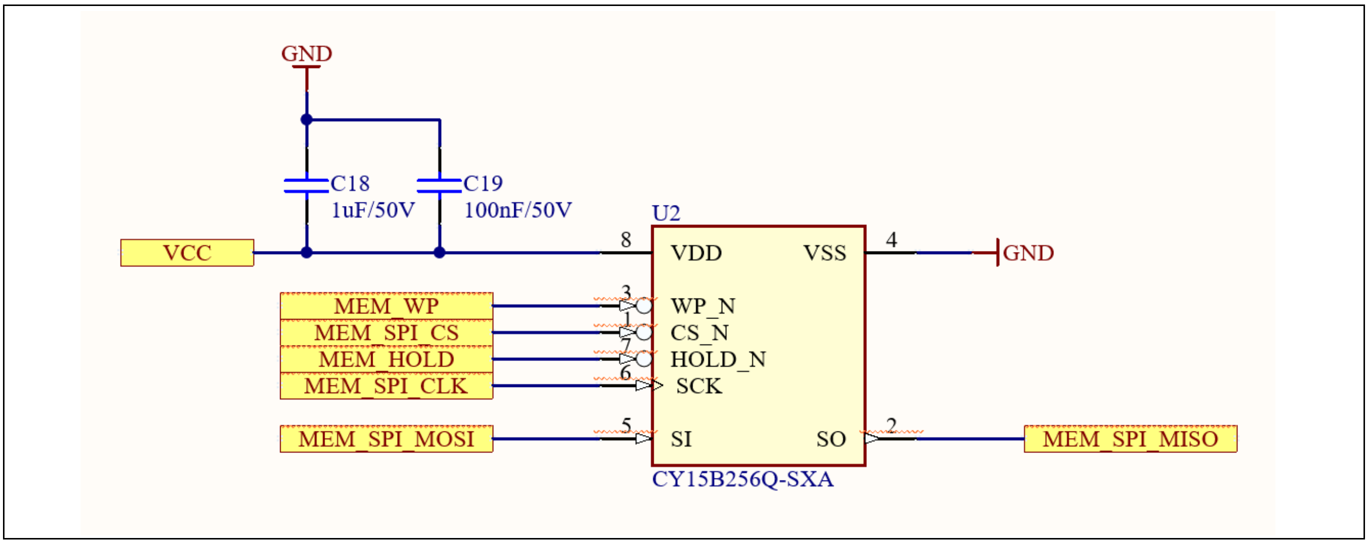

Figure 7 CY15B256Q automotive serial F-RAM circuit (256 Kb) interfaced via SPI

2.3 ePaper display circuitry

The board has an ePaper display to display all necessary information and BMS status, including the last BMS state even when the system is powered off. The display is powered up directly from the microcontroller via IRLML6401 P-channel MOSFET. Necessary discharge lines are driven via the BSD235 dual-package switch. The connector is a 40-pin FPC connected to various auxiliary components. As a reference, the E-ink Display Shield Board (CY8CKIT-028-EPD) is used for auxiliary components and communication lines.

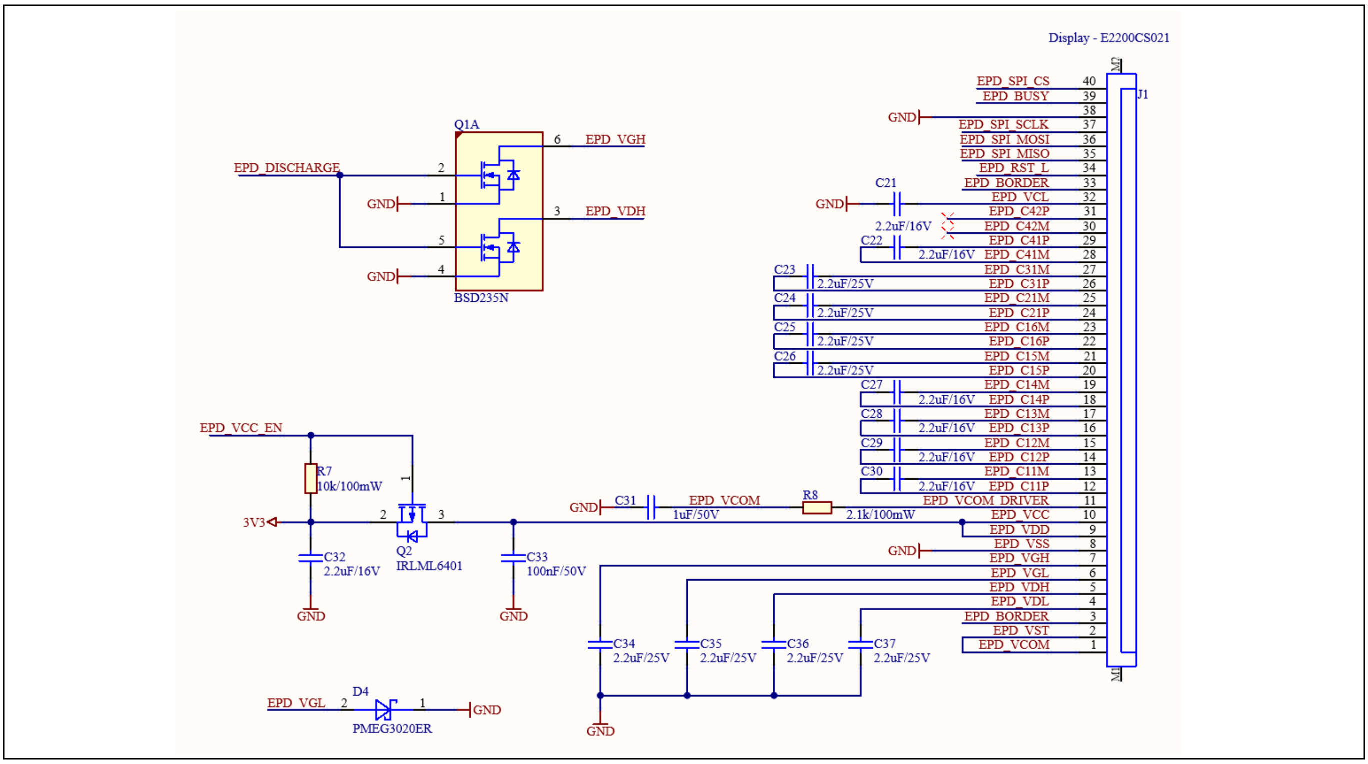

Figure 8 ePaper display connector circuit with auxiliary components (for Pervasive Displays E2200CS021)

2.4 CAN unique identification circuit

To identify each board interfaced via CAN bus uniquely, a DIP switch is implemented. Each pin is pulled up via a 20 kΩ resistor and therefore provides an inverted logic that must be considered when reading the pin via the PSoC™ 6 MCU.

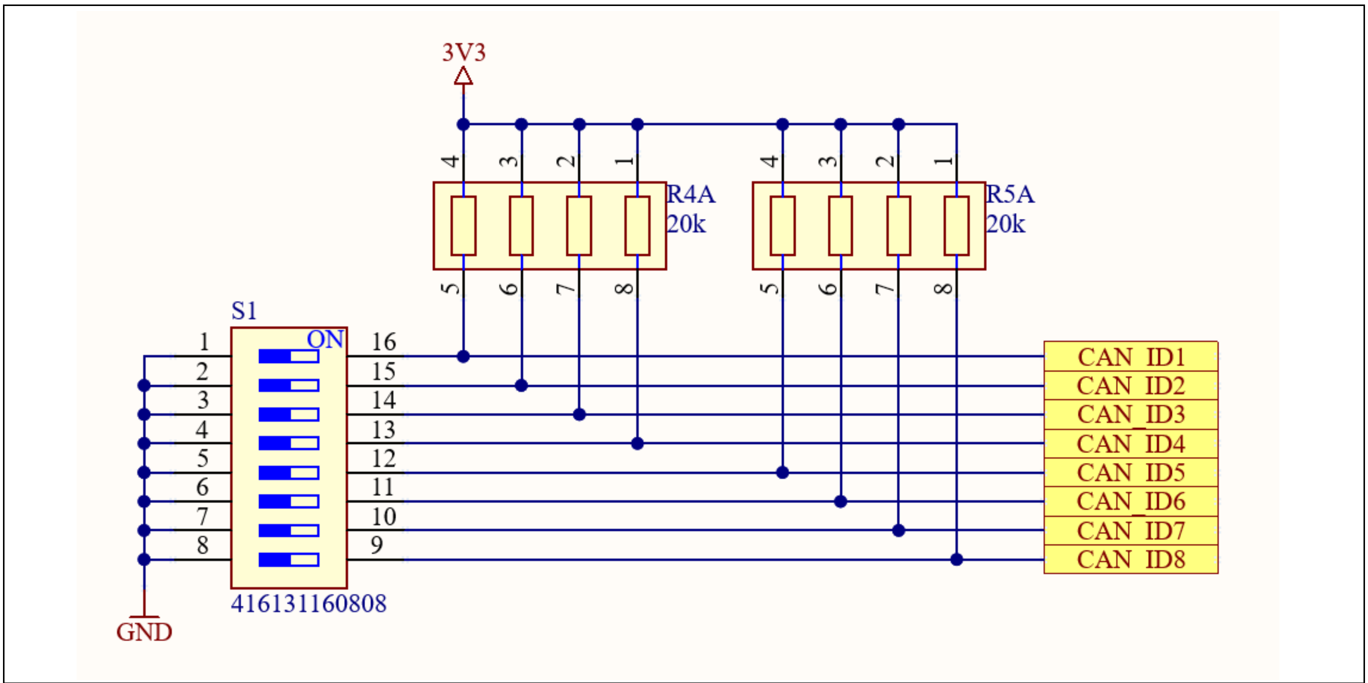

Figure 9 CAN node identification circuit including 8-pin DIP switch

Each switch is connected to a CAN_ID pin of the PSoC™ 6 MCU to individually set up to 255 devices on the same CAN/CAN FD bus. Table 8 shows each DIP switch pin and the corresponding PSoC™ 6 MCU pin for reference, as well as the decimal value assigned to the pin. When pulled up to 3.3 V, the pins follow an inverted logic: the OFF state on the DIP switch represents a logic HIGH on the PSoC™ 6 MCU pin and vice versa.

Table 8 DIP Switch S1 – CAN node identifier logic and pin assignment

CAN ID bit	ID10	ID9	ID8	ID7	ID6	ID5	ID4	ID3	ID2	ID1	ID0
DIP switch	N/A	N/A	N/A	Pin 8 (MSB)	7	6	5	4	3	2	Pin 1 (LSB)
PSoC™ 6 MCU pin	–	–	–	P3.1	P3.0	P2.7	P2.6	P2.1	P2.0	P0.5	P0.4
BMS control CAN ID	0	0	0	0	0	1	1	1	1	0	BMS[0]

3 Firmware

This section introduces the environment of PSoC™ MCUs and the software interfaces used for communication with the BMS.

3.1 PSoC™ MCU

The PSoC™ 6 family is built on an ultra-low-power architecture and the MCUs feature low-power design techniques that are ideal for battery-powered applications. The dual-core Arm® Cortex®-M4 and Cortex®-M0+ architecture lets designers optimize for power and performance simultaneously. Using its dual cores combined with configurable memory and peripheral protection units, the PSoC™ 6 MCU delivers the highest level of protection defined by the Platform Security Architecture (PSA) from Arm® [2].

The CY8C6245AZI-S3D72 device in a 100-pin TQFP100 package supports both a 150 MHz Cortex®-M4F and a 100 MHz Cortex®-M0+ and has 512 KB application flash and 256 KB of SRAM. This device provides programmable power control inside the largest available package with the most I/O pins available for this device family.

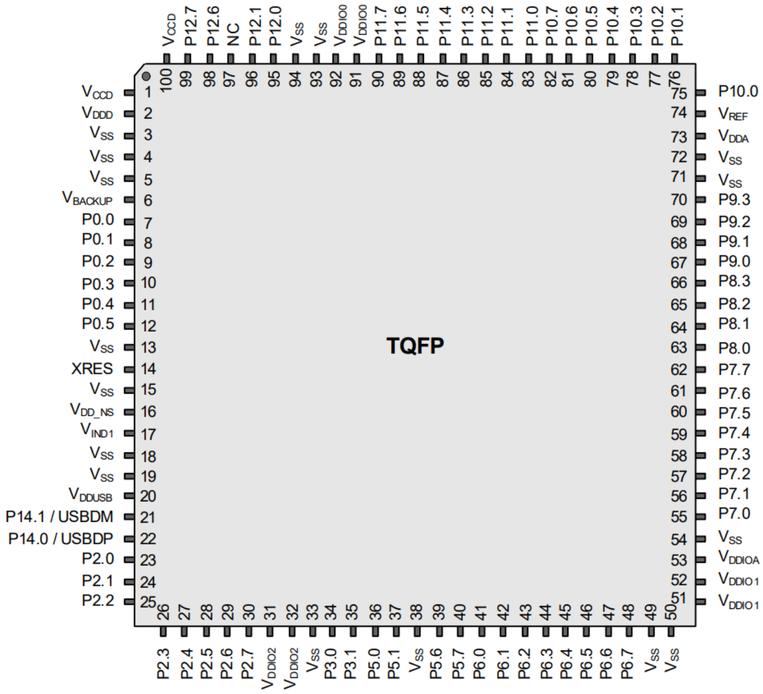

Figure 10 CY8C6245AZI-S3D72 PSoC™ 6 TQFP 100-pin configuration (top view) [2]

3.2 Firmware description and flowcharts

Will be updated in further versions.

3.2.1 CAN message structure

Each CAN message follows the standardized CAN protocol (see Figure 11). In general, each message consists of a unique identifier describing the recipient (11 bits) followed by the data bytes (0 – 64 bits). Bits such as Start of Frame, stuff bits, Data Length Code (DLC), and checksums are included [3].

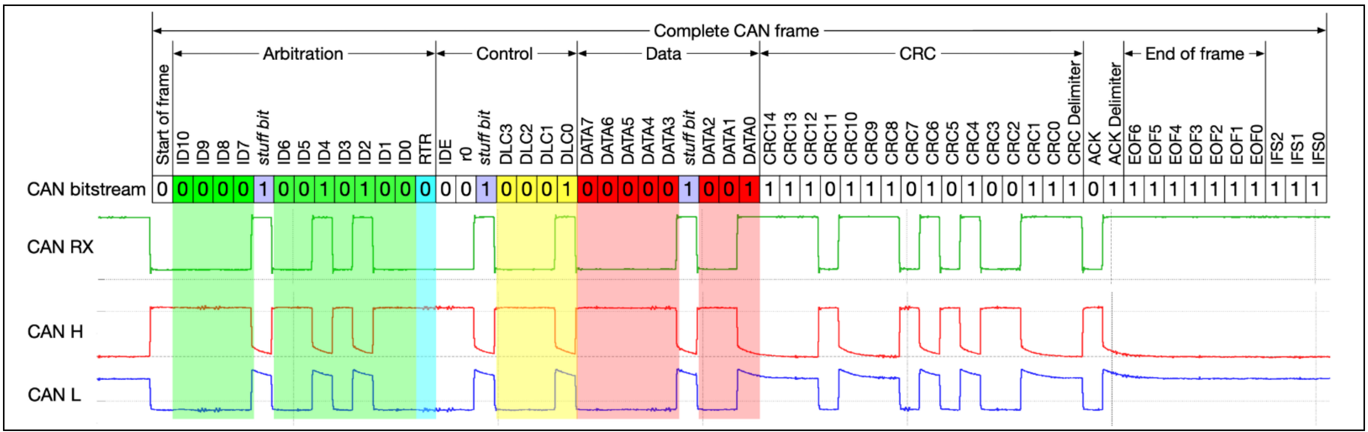

Figure 11 CAN bus frame, including stuff bits, correct CRC, and inter-frame spacing [3]

In the case of the CAN identifier (Arbitration), only 8 bits are used in the IMR to specify the type and specific number of the board (**ID0** to **ID7**). The remaining 3 bits (**ID8** to **ID10**) remain on their original level (logic LOW). For the data frames, **Byte 1** always corresponds to the byte that is transmitted/received first, followed by the other bytes from the same CAN transmission. To distinguish between different hardware on the IMR, each type of board is classified via a specific CAN ID range and therefore reserving a certain address region. Depending on the type of board, specific CAN ID bits can be set differently to differentiate boards from the same type.

A total of eight data bytes can be transmitted in a single CAN message. The CAN communication setup on the IMR consists of a single byte containing the target command, followed by the CAN message sender ID (1 byte), and then up to of six data bytes—see the following table.

Table 9 IMR CAN message data structure overview

	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Byte 8
CAN message	Command	Sender ID	Data[6:0]					

Table 9 shows the CAN messages to and from the DEMO_IMR_BMSCTRL_V1 board with their respective command bytes. The commands are currently reserved for their future purpose.

Table 10 IMR BMS CAN message command overview

	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Byte 8	Description
Reserved	0xB0	Sender ID	N/A	N/A	N/A	N/A	N/A	N/A	Reserved
Reserved	0xB1	Sender ID	N/A	N/A	N/A	N/A	N/A	N/A	Reserved
Reserved	0xB2	Sender ID	N/A	N/A	N/A	N/A	N/A	N/A	Reserved
Reserved	0xB3	Sender ID	N/A	N/A	N/A	N/A	N/A	N/A	Reserved

4 Quick start guide

This section helps you get started with using the board as a battery management module for the Infineon Mobile Robot. Later chapters describe how to program and debug the hardware, and set up the hardware for CAN communication. These sections also describe the relevant buttons, LEDs, and interfaces.

4.1 Software deployment and debugging

The firmware controlling this demo board is developed using ModusToolbox™ Software, a collection of easy-to-use libraries and tools enabling rapid development with Infineon MCUs. Programming and debugging are carried out via the MiniProg4 program and debug kit (CY8CKIT-005). The DEMO_IMR_BMSCTR,L_V1 board is connected to the debug probe using the smaller 1.27 mm pitch ribbon cable and the 10-pin box header P2. Larger connector pins are used only if additional UART is necessary. The debug probe can be used both isolated (default) and non-isolated when using appropriate software such as CYPRESS™ Programmer.

Figure 12 MiniProg4 Program and Debug Kit (CY8CKIT-005)

The project is created within ModusToolbox™. This project contains the device definition, settings, and source files required to compile and build the executable code. You can then download the executable into the flash program memory of the PSoC™ 6 MCU.

1. Select **File** > **Import** > **General** > **Existing Projects into Workspace** to import the ModusToolbox™ project.

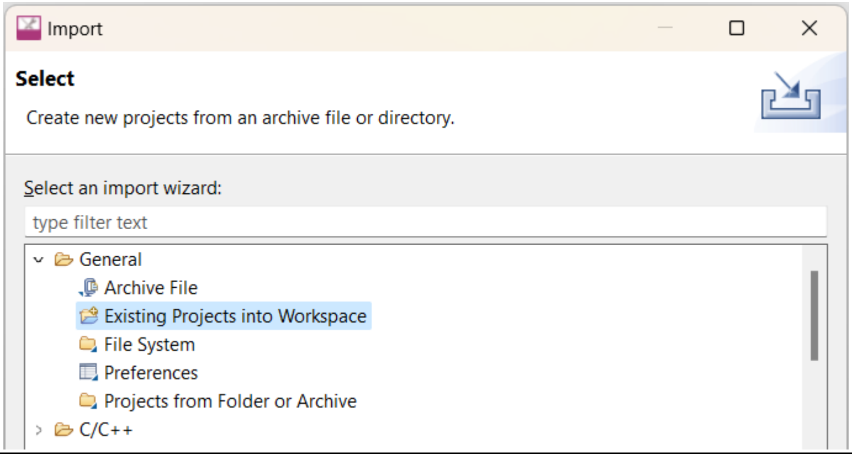

Figure 13 Eclipse IDE for ModusToolbox™ import window

Note the project contents in the Project Explorer tab. Each CPU core owns its own sub-project inside the IDE with separate *main.c* files.

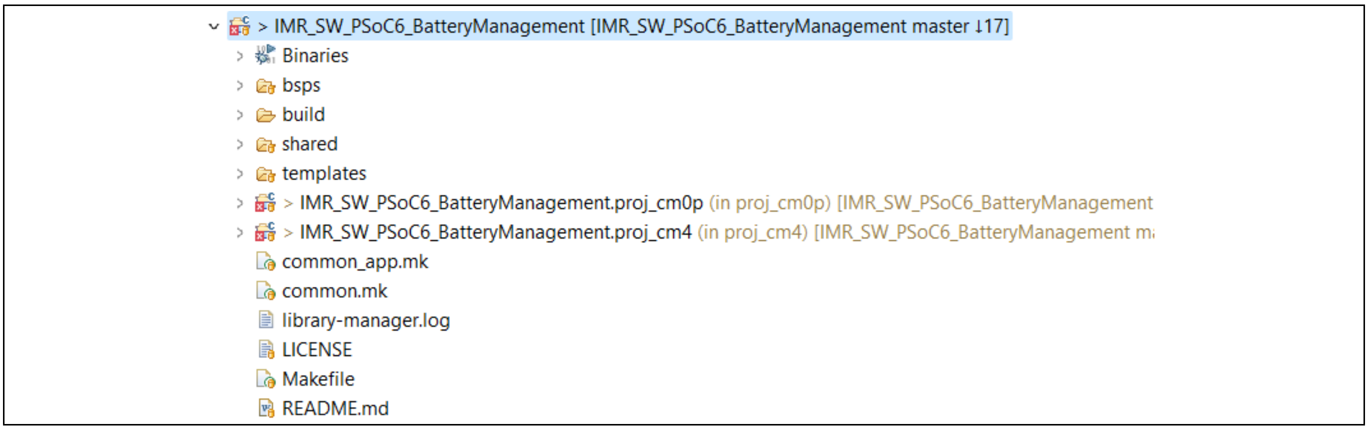

Figure 14 **IMR_SW_PSoC6_BatteryManagement – ModusToolbox™ project structure**

2. Use the **Library Manager** and **Device Configurator** links in the Quick Panel to configure the libraries and pin configurations.
3. Select **Build Application** to compile the firmware.
4. Select **Generate Launches** to apply the imported firmware to the board.
5. Select the Debug option to program the firmware.

The IDE shows the debug screen, where you can launch and debug the program.

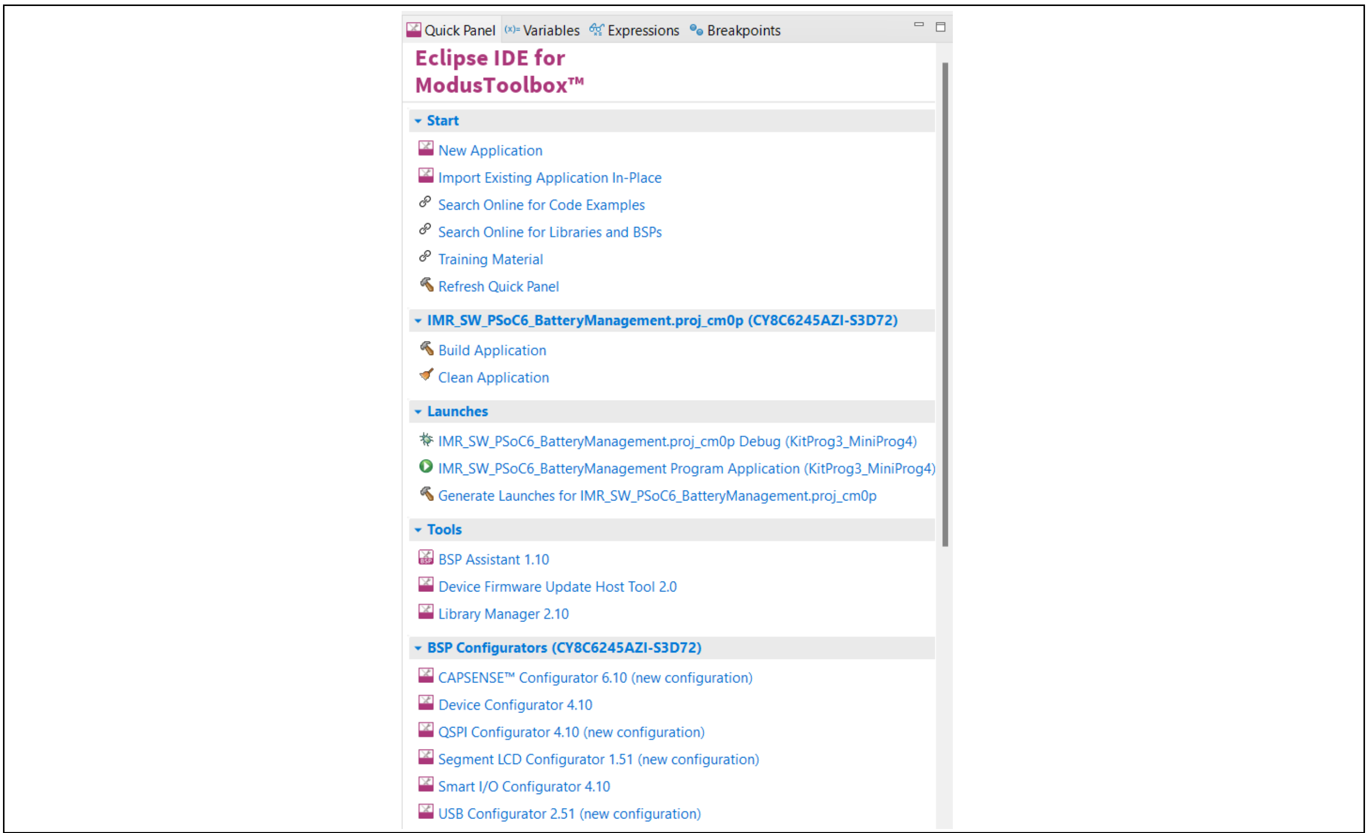

Figure 15 **Eclipse IDE for ModusToolbox™**

4.2 Debugging using onboard UART communication

Additional debugging can be performed using the designated debugging header (P1) on the board. The header provides both RX and TX lines for standalone UART communication. The header can easily be interfaced using the MiniProg4 already used for flashing the board. The debugger provides all necessary pins (pins 6 and 8) to connect with the debugging header.

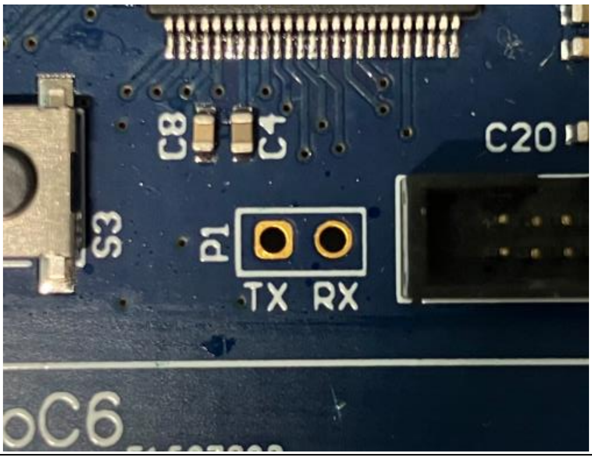

Figure 16 UART debugging connector P1 interfaced using MiniProg4

Use your favorite serial terminal (such as PuTTY or hterm) to read the received debugging messages. You can also use the built-in serial terminal (**Window** > **Show View** > **Other…** > **Terminal** > **Terminal** within the IDE).

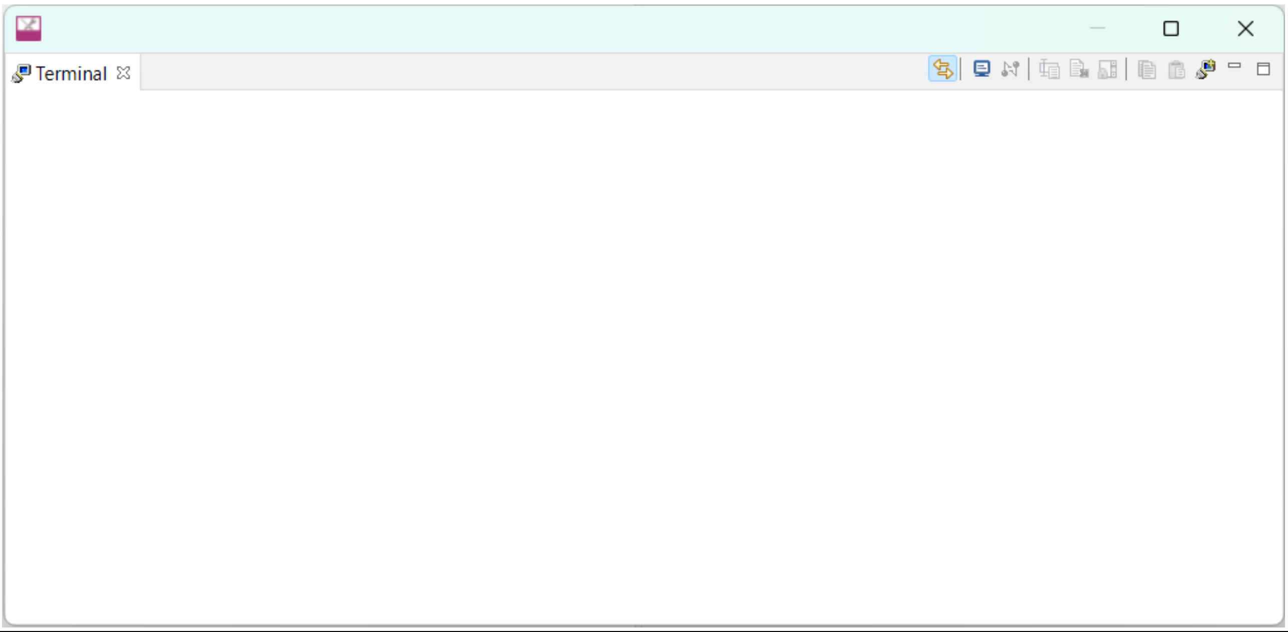

Figure 17 UART debugging connector P1 interfaced using MiniProg4

4.3 Setting the CAN node identification

After flashing the board with the firmware, you need to set the board's CAN node unique identification by using the 8-pin DIP switch S1. See the Hardware section.

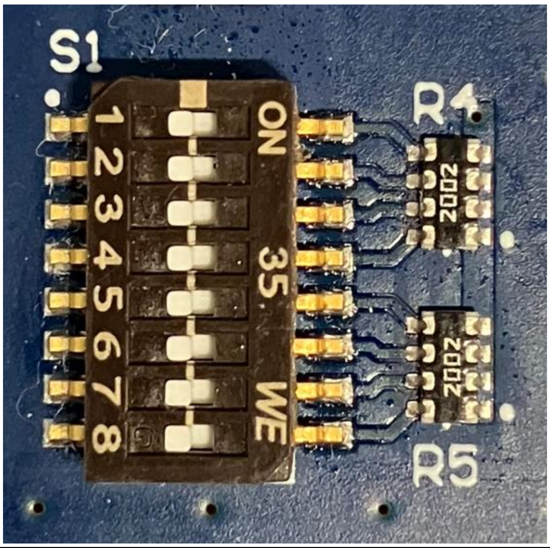

Figure 18 DIP switch to set unique CAN node ID for the board

Example: This example describes the result of the following switch position on the CAN node identifier module.

Table 11 DIP Switch S1 – CAN node identifier example

DIP switch	Pin 8 - MSB	Pin 7	Pin 6	Pin 5	Pin 4	Pin 3	Pin 2	Pin 1 - LSB
Switch position	–	–	–	–	–	–	–	OFF
BMS[0]	–	–	–	–	–	–	–	0

This example DIP switch configuration sets the CAN node identifier for the DEMO_IMR_BMSCTRL_V1 board as **60 (DEC)** or **0x3C (HEX)**. This value is based on the board's CAN mask (see Table 5) and the selected switches shown in the table above. This identifier helps other boards present to communicate with the DEMO_IMR_BMSCTRL_V1 board through CAN messages.

4.4 BMS control buttons and LEDs

The board provides the following onboard buttons and LEDs (on the top of the system to be easily visible and reachable) to interface BMS functions without using onboard CAN communication.

- **Start:** Long-press the button until the MCU Ready LED glows. This powers the system on and enables all functions.
- **Shutdown:** Press this button to make the system disengage the output power supply and turn off the system completely when ready
- **Display:** Display the next available page on the ePaper display

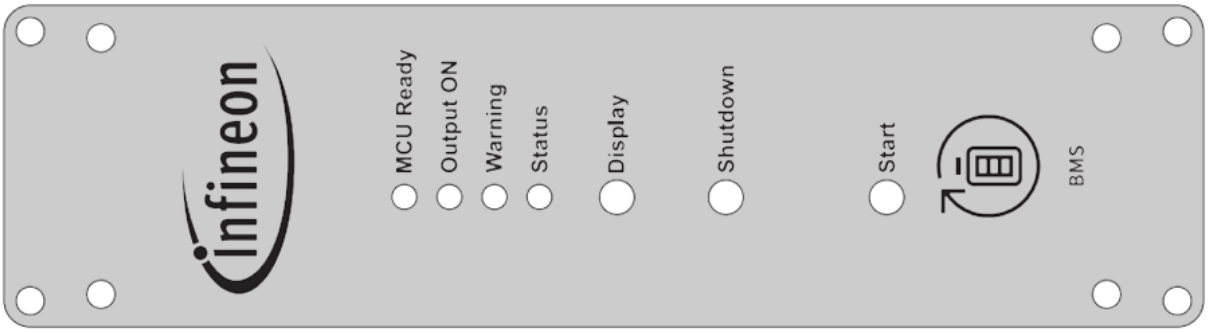

Figure 19 Top view of IMR BMS controls and indicators

The following LEDs are provided indicate the current system status:

- **MCU Ready:** Indicates whether the system is currently powered. Press the **Start** button to display the current status:
  - *LED ON:* System powered on
  - *LED blinking:* Shutdown sequence active
  - *LED OFF:* System powered off
- **Output ON:** Shows the status of the controlled system output. Indicates whether the system was able to turn on the output successfully:
  - *LED ON:* Output active
  - *LED blinking:* Pre-charge sequence active
  - *LED OFF:* Output not active
- **Warning:** Indicates whether a system error is detected, such as pre-charge failure:
  - *LED ON:* System error detected
  - *LED blinking:* Not applicable
  - *LED OFF:* No system error
- **Status:** Indicates the communication with the target system:
  - *LED ON:* Communication active
  - *LED blinking:* Not applicable
  - *LED OFF:* Communication not active

4.5 Charging and discharging using the BMS interfacing board

This section describes how to charge and discharge the BMS system (BMS power board and BMS controller board). To interface the system, the BMS motherboard (DEMO_IMR_BMS_MOBO_V1) with the corresponding onboard resistor settings must be set.

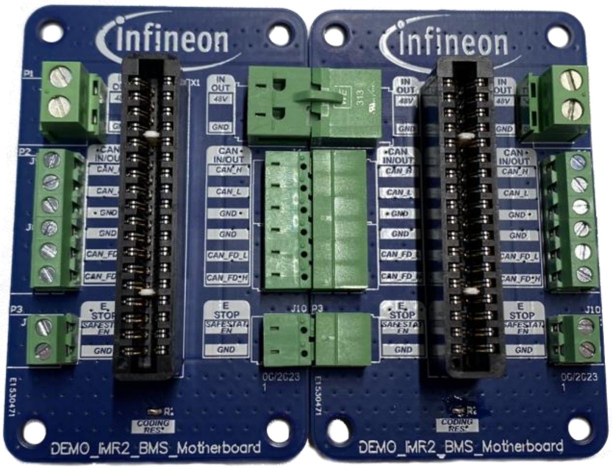

Figure 20 DEMO_IMR_BMS_MOBO_L_V1 and DEMO_IMR_BMS_MOBO_R_V1 board in IMR

To use the system as a standalone power supply solution for your application, the BMS motherboard must be configured with the resistor R1 = 10 kΩ. This allows the system to detect if the inserted slot is designed to charge or discharge the BMS. In the image below, both interface cards can be seen in the IMR in the discharging configuration. After inserting the system into the slot, it can be powered-on using the **Start** button; after a successful initialization, the IMR is powered up.

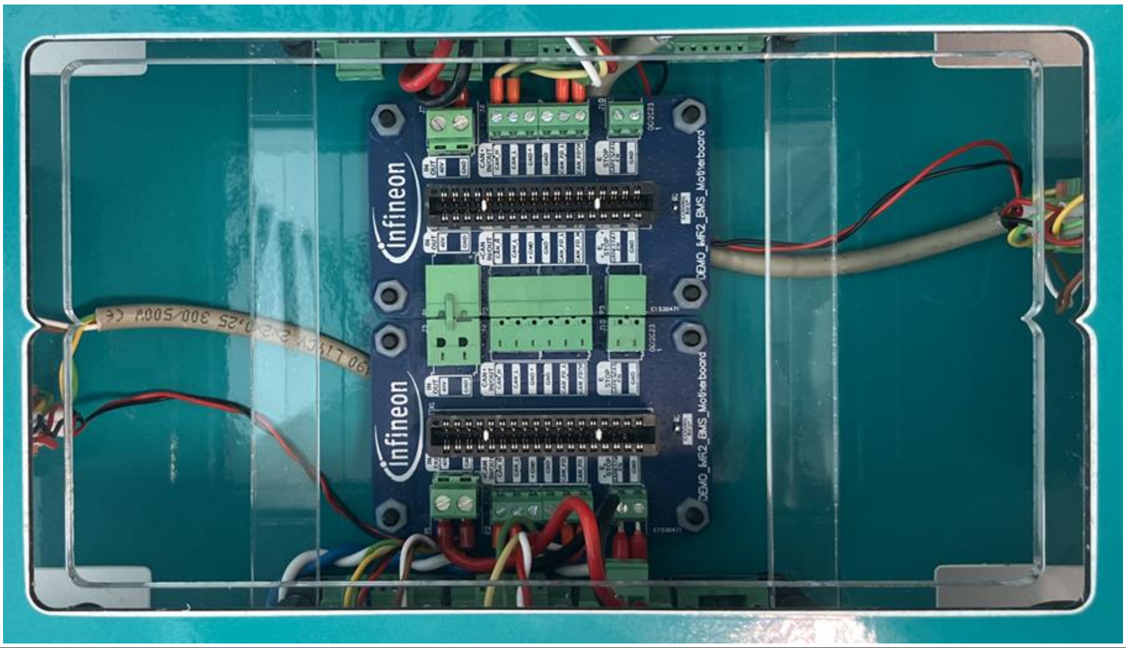

Figure 21 Using the BMS as the IMR power supply (discharging)

To charge the BMS, you need to use an external charging unit in combination with the BMS motherboard (in this case with the resistor R1 = 0 Ω). You must ensure that the charging voltage and current are set according to the limits specified for Li-Ion batteries used.

Do the following to charge the batteries:

1. Insert the system into the slot.
2. Press the **Start** button to power on.

Wait for successful initialization. Charging starts.

Figure 22 Recharging onboard batteries in the external charging unit (charging)

5 Bill of materials (BOM)

Table 12 Bill of materials

Designator	Manufacturer	Part Number	Quantity	Value/Rating
C1, C13	Würth Elektronik	885012106031	2	10 µF/25 V/0603/20%
C2, C3, C4, C18, C20, C31	Würth Elektronik	885012206076	6	1 µF/25 V/0603/10%
C5, C6, C7, C8, C9, C14, C17, C19, C33, C38	Würth Elektronik	885012206071	10	100 nF/25 V/0603/10%
C10	Würth Elektronik	885012107018	1	4.7 µF/25 V/0805/10%
C11, C12	Würth Elektronik	885012006093	2	8.2 pF/100 V/0603/10%
C15, C16	Würth Elektronik	885012006050	2	6.8 pF/50 V/0603/10%
C21, C22, C27, C28, C29, C30, C32	Würth Elektronik	885012106029	7	2.2 µF/16 V/0603/10%
C23, C24, C25, C26, C34, C35, C36, C37	Würth Elektronik	885012207079	8	2.2 µF/25 V/0805/10%
C39	Würth Elektronik	885012206092	1	33 nF/50 V/0603/10%
D1	Würth Elektronik	150060BS75000	1	Blue/470 nm
D2	Würth Elektronik	150060GS75000	1	Green/525 nm
D3	Würth Elektronik	150060RS75000	1	Red/625 nm
D4	Nexperia	PMEG3020ER	1	Low VF Schottky 30 V/2 A
J1	Würth Elektronik	687140183722	1	WR-FPC SMT ZIF 40p Horizontal Low Profile
J2	Würth Elektronik	61300711821	DNP	WR-PHD 7p 2.54 mm
L1, L2	Würth Elektronik	742792663	2	1k@100 MHz 100 mA
LS1	Murata	416131160808	1	Piezo Buzzer 4 kHz
P1	Würth Elektronik	61300211121	1	WR-PHD 2p 2.54 mm
P2	Würth Elektronik	62701021621	1	WR-BHD 10p 1.27 mm
Q1	Infineon Technologies	BSD235N	1	OptiMOS™ Dual N-Channel small-signal MOSFET
Q2	Infineon Technologies	IRLML6401	1	HEXFET™ P-Channel power MOSFET
R1, R2, R3	Vishay	CRCW06031K00FK	3	1k/100 mW/0603/1%
R4, R5	Bourns	CAT16A-2002F4LF	2	20k/63 mW/1206/1%
R6, R7, R14, R15	Vishay	CRCW060310K0FKEA	4	10k/100 mW/0603/1%
R8	Vishay	CRCW06032K10FK	1	2k1/100 mW/0603/1%
R9, R10	Yageo	RC0603FR-074K7L	2	4k7/100 mW/0603/1%
R11	Vishay	CRCW0603150RFK	1	150 R/100 mW/0603/1%
R12, R13	Vishay	CRCW060310R0FKEA	2	10 R/100 mW/0603/1%
S1	Würth Elektronik	416131160808	1	WS-DISV 8p DIP Switch

Designator	Manufacturer	Part Number	Quantity	Value/Rating
S2	Würth Elektronik	434121025816	1	WS-TASV Tact Switch
S3	Würth Elektronik	430481031816	1	WS-TASV SMT Switch
U1	Infineon Technologies	CY8C6245AZI-S3D72	1	32-bit PSoC™ 6 Arm® Cortex®-M4/M0+
U2	Infineon Technologies	CY15B256Q-SXA	1	256-Kbit (32K × 8) Automotive Serial F-RAM
U3	Texas Instruments	SN74LVC2G14DCKR	1	Dual Schmitt-Trigger Inverter
X1, X2, X3, X4	Würth Elektronik	61302021121	4	WR-PHD Dual Row 20p 2.54 mm
Y1	Würth Elektronik	830108207309	1	24 MHz/8 pF/10 ppm
Y2	Würth Elektronik	830105946101	1	32.768 kHz/7 pF/20 ppm

6 PCB layout

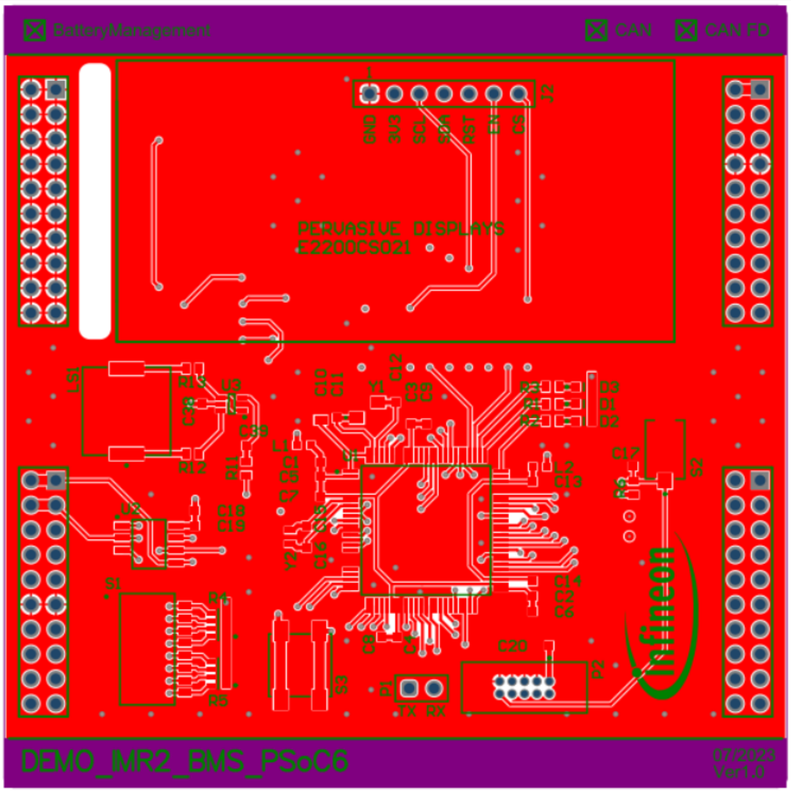

Figure 23 DEMO_IMR_BMSCTRL_V1 board top view

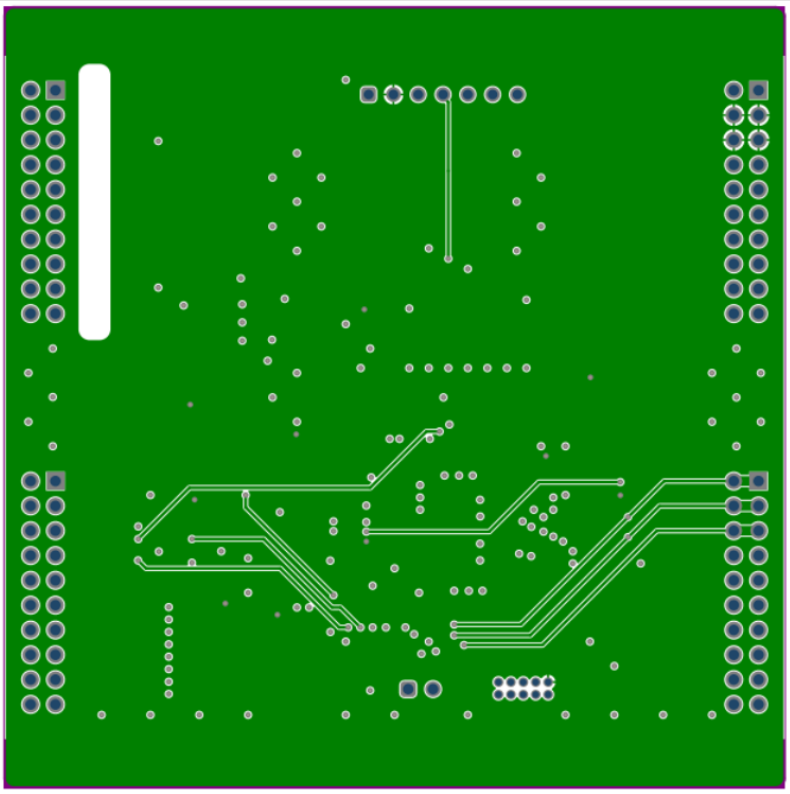

Figure 24 DEMO_IMR_BMSCTRL_V1 board first inner layer

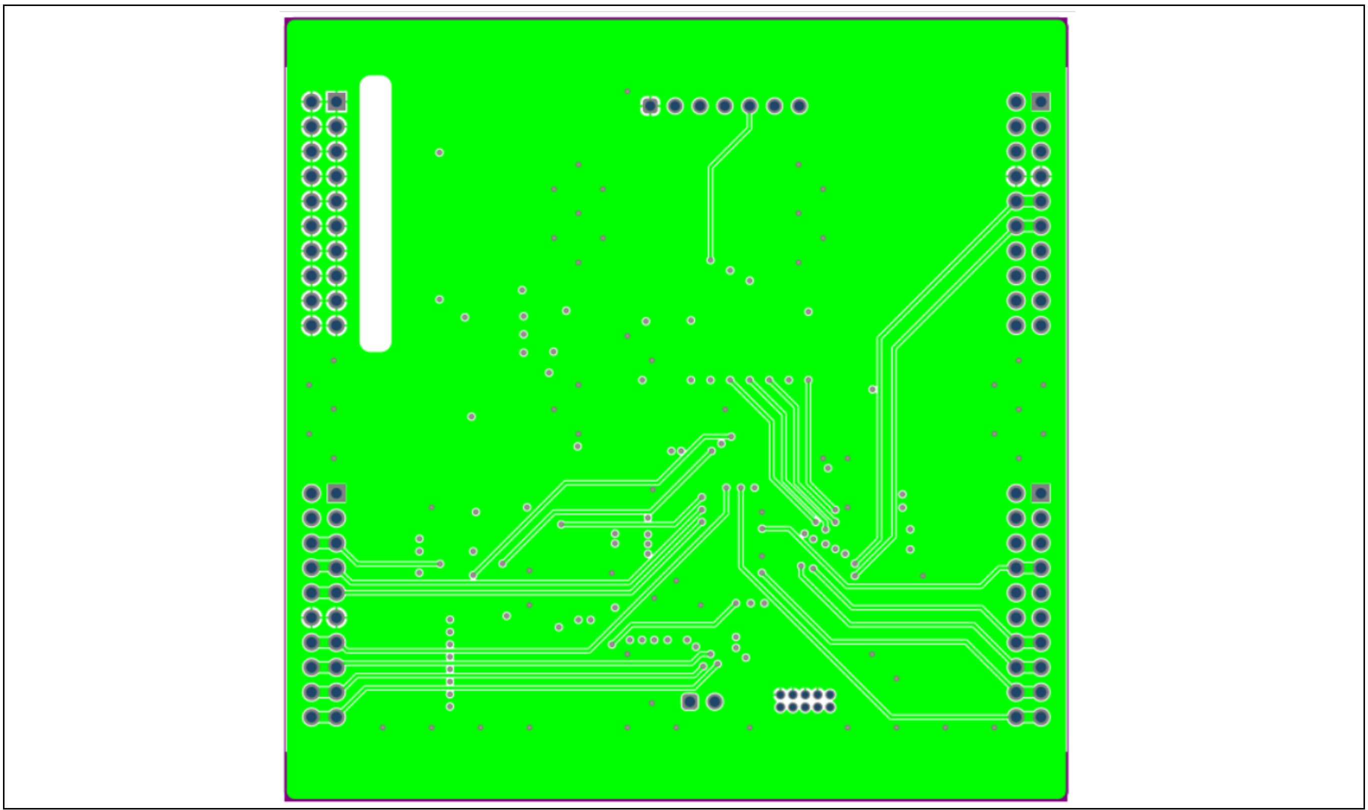

Figure 25 DEMO_IMR_BMSCTRL_V1 board second inner layer

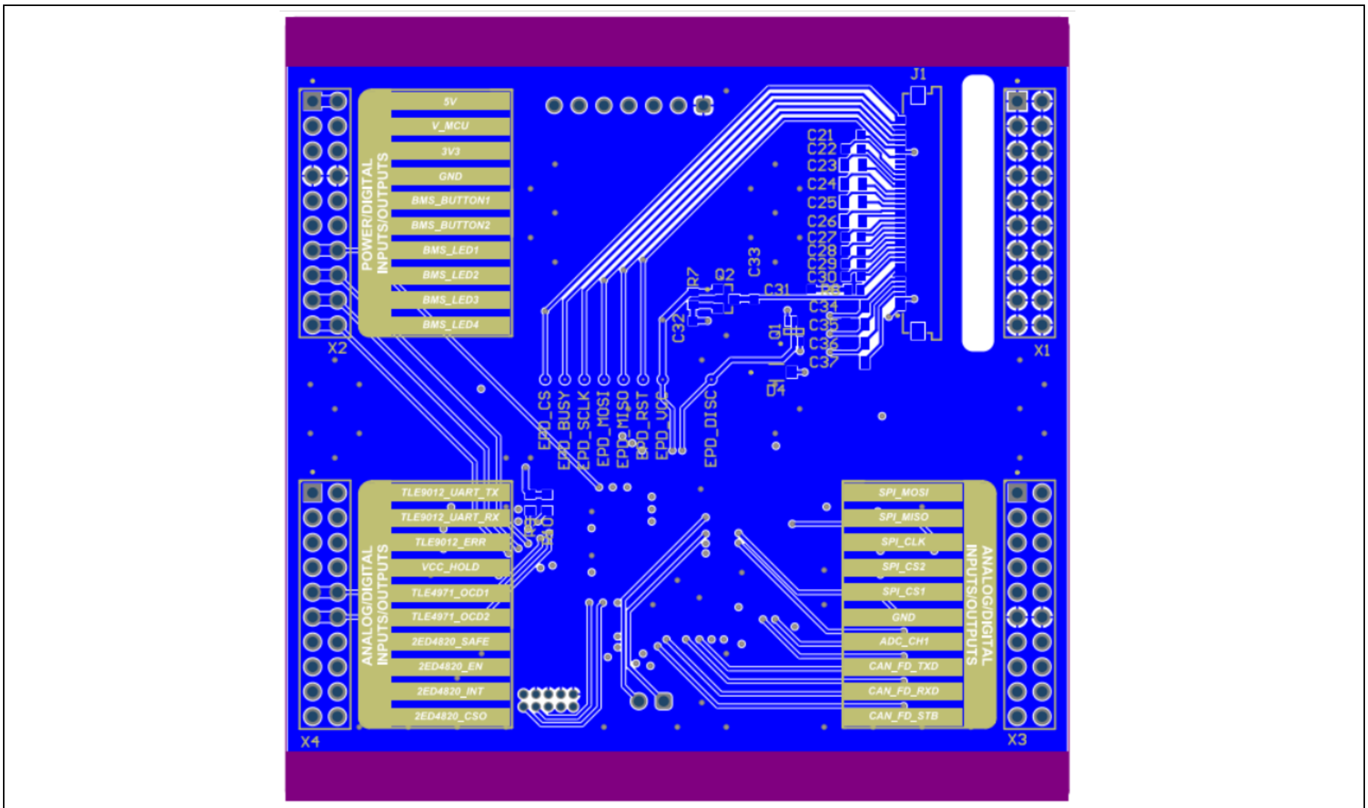

Figure 26 DEMO_IMR_BMSCTRL_V1 board bottom side

7 Appendix

7.1 Schematics

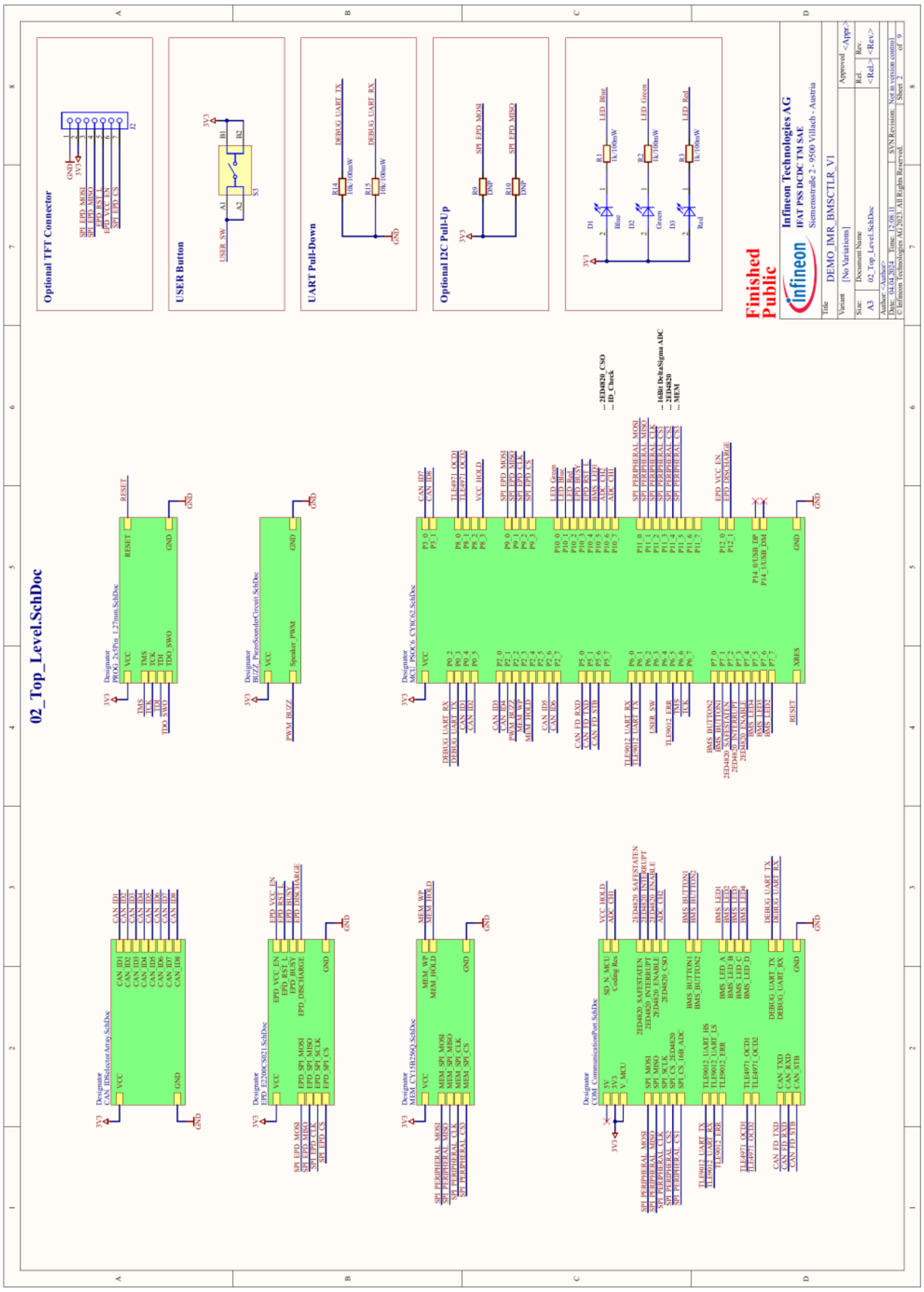

Figure 27 DEMO_IMR_BMSCTRL_V1 – 02_Top_Level.SchDoc

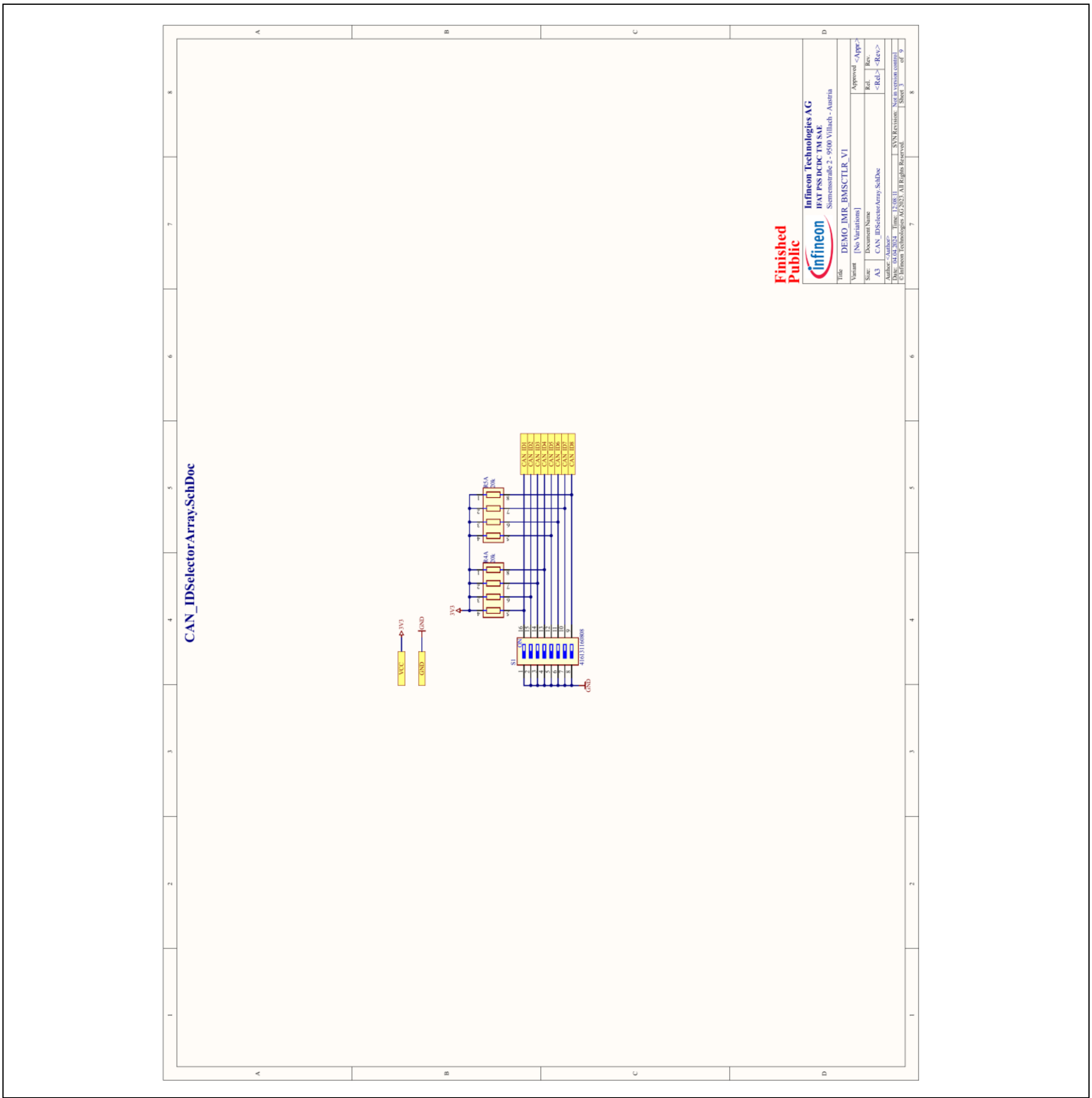

Figure 28 DEMO_IMR_BMSCTRL_V1 – CAN_IDSelectorArray.SchDoc

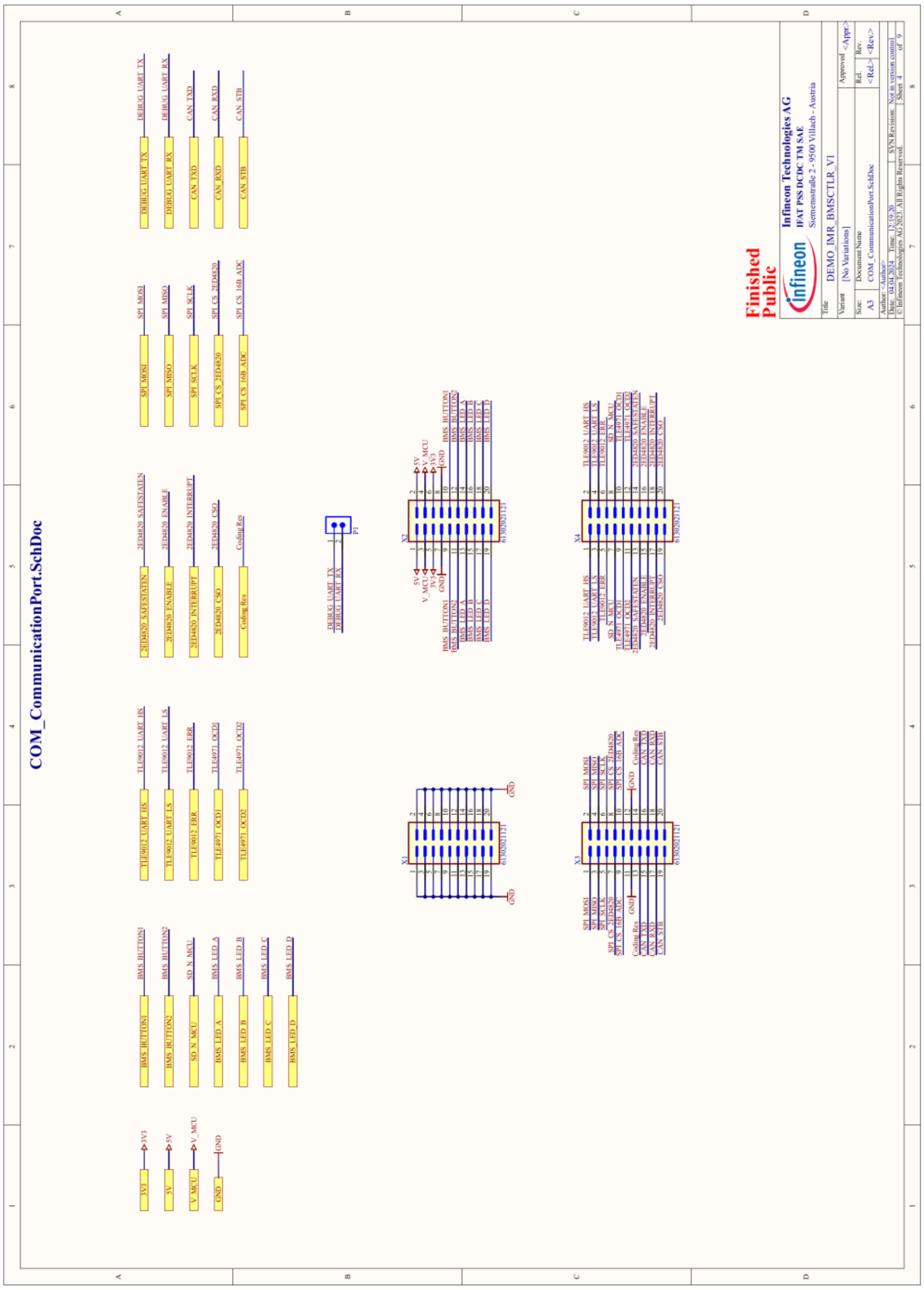

Figure 29 DEMO_IMR_BMSCTRL_V1 – COM_CommunicationPort.SchDoc

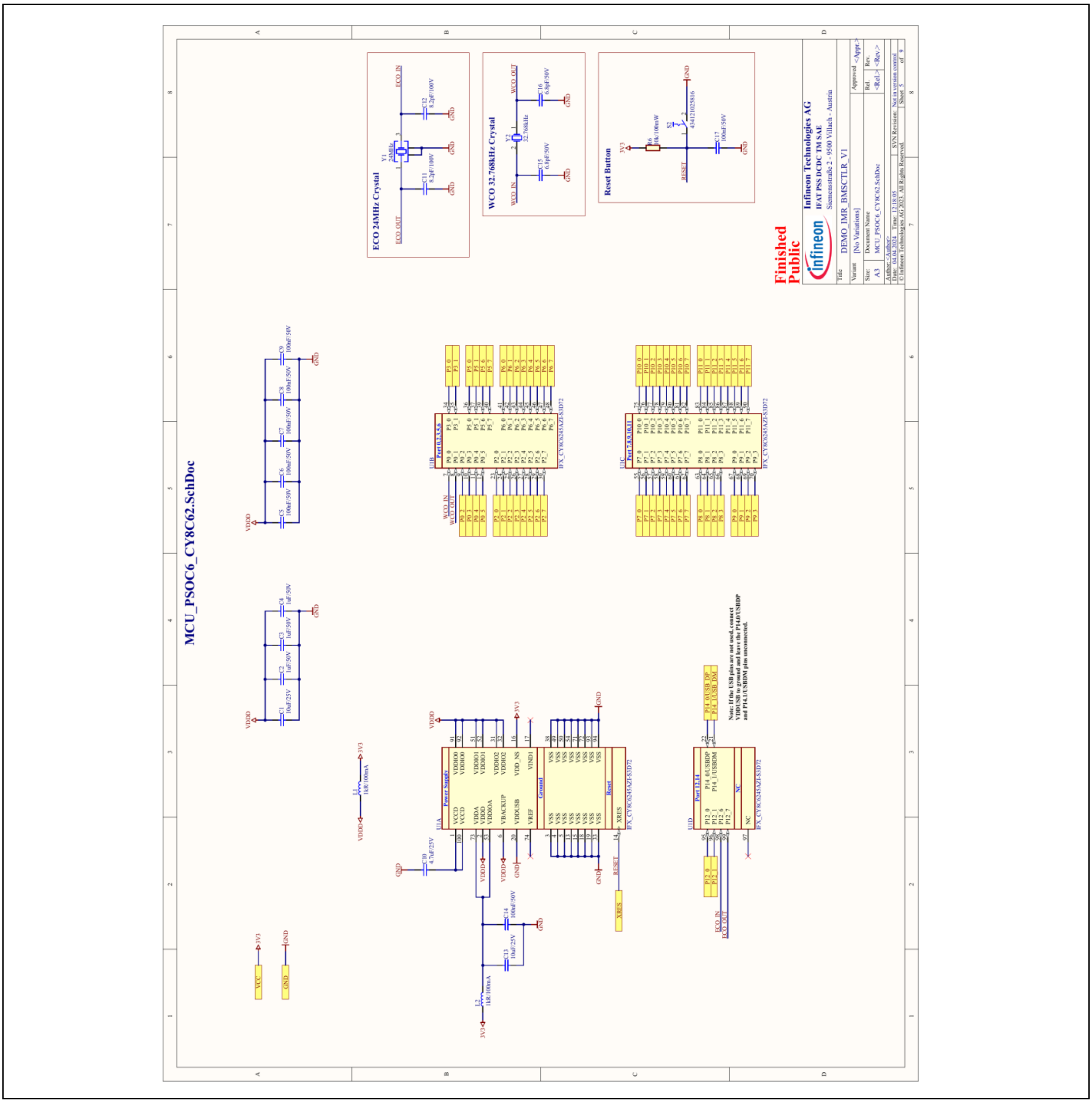

Figure 30 DEMO_IMR_BMSCTRL_V1 – MCU_PSOC6_CY8C62.SchDoc

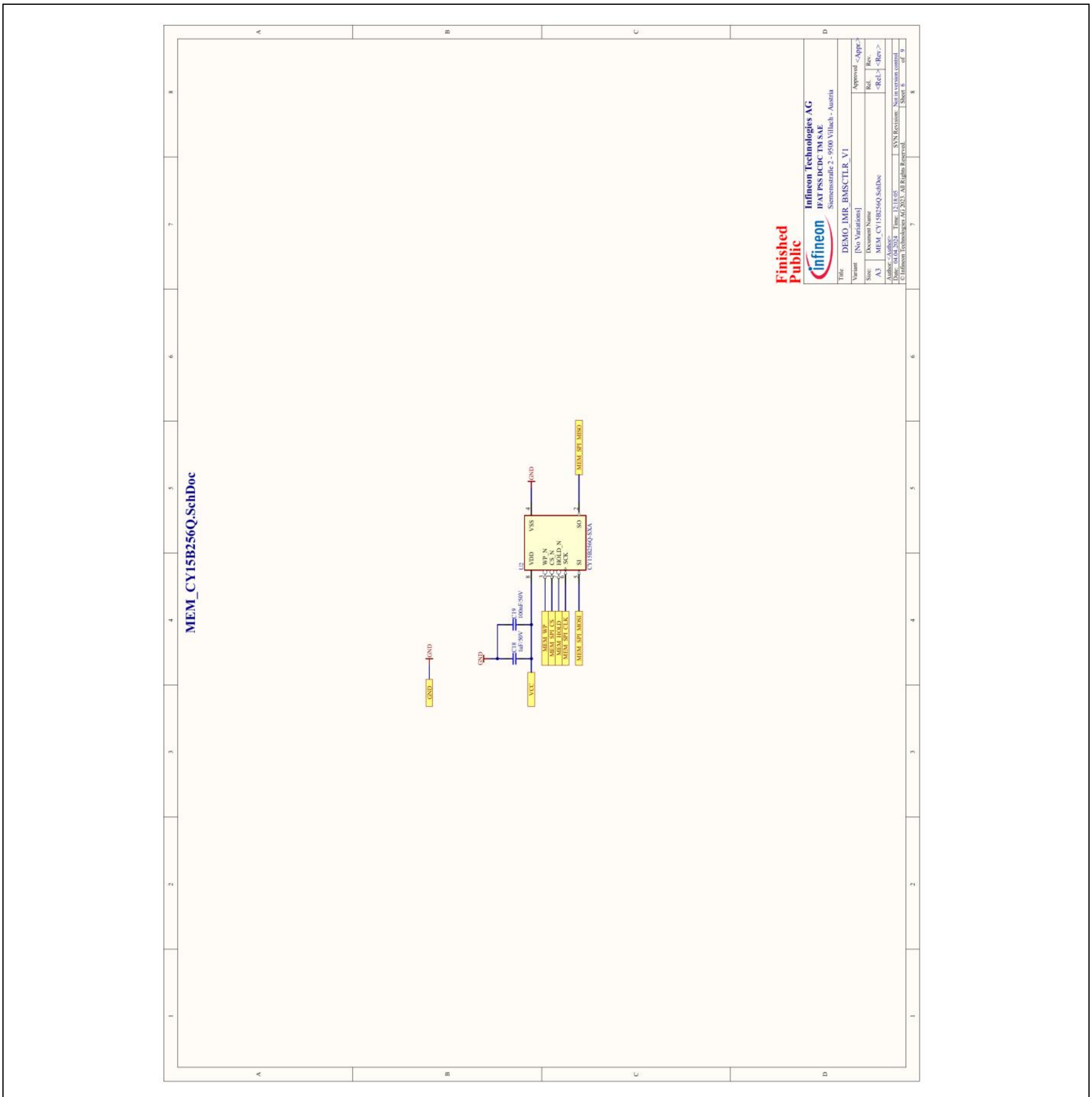

Figure 31 DEMO_IMR_BMSCTRL_V1 – MEM_CY15B256Q.SchDoc

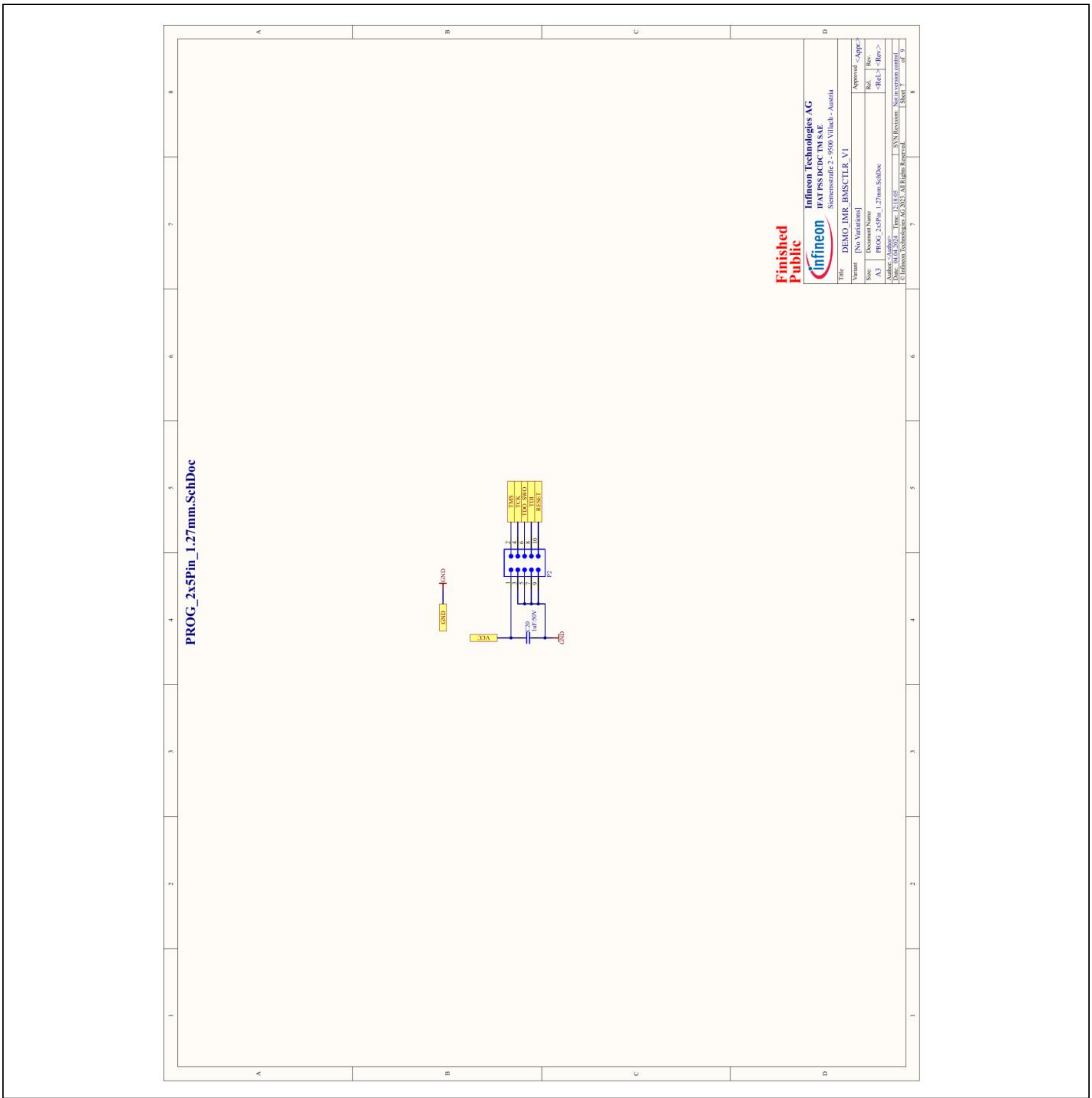

Figure 32 DEMO_IMR_BMSCTRL_V1 – PROG_2x5Pin_1.27mm.SchDoc

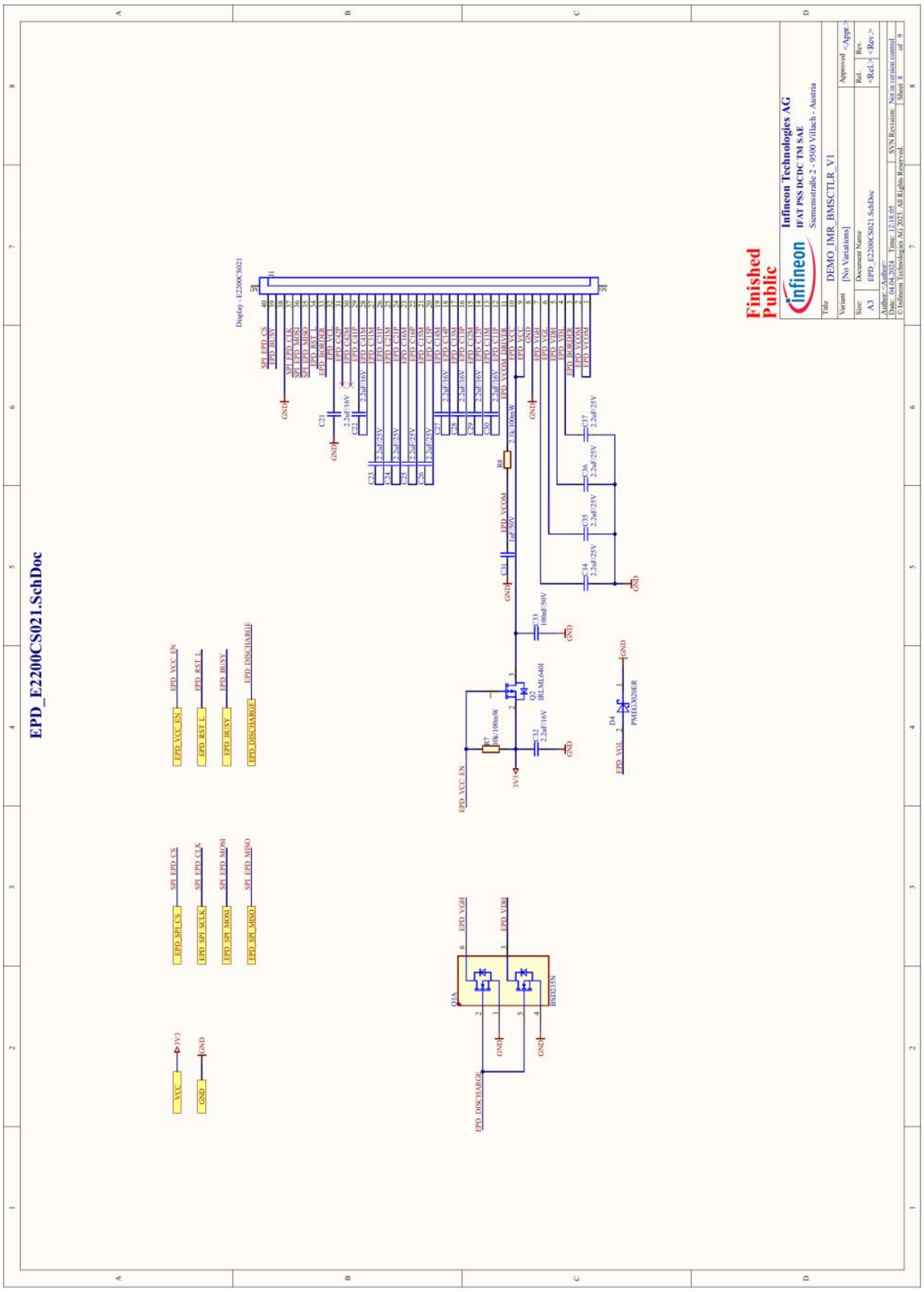

Figure 33 DEMO_IMR_BMSCTRL_V1 – EPD_E2200CS021.SchDoc

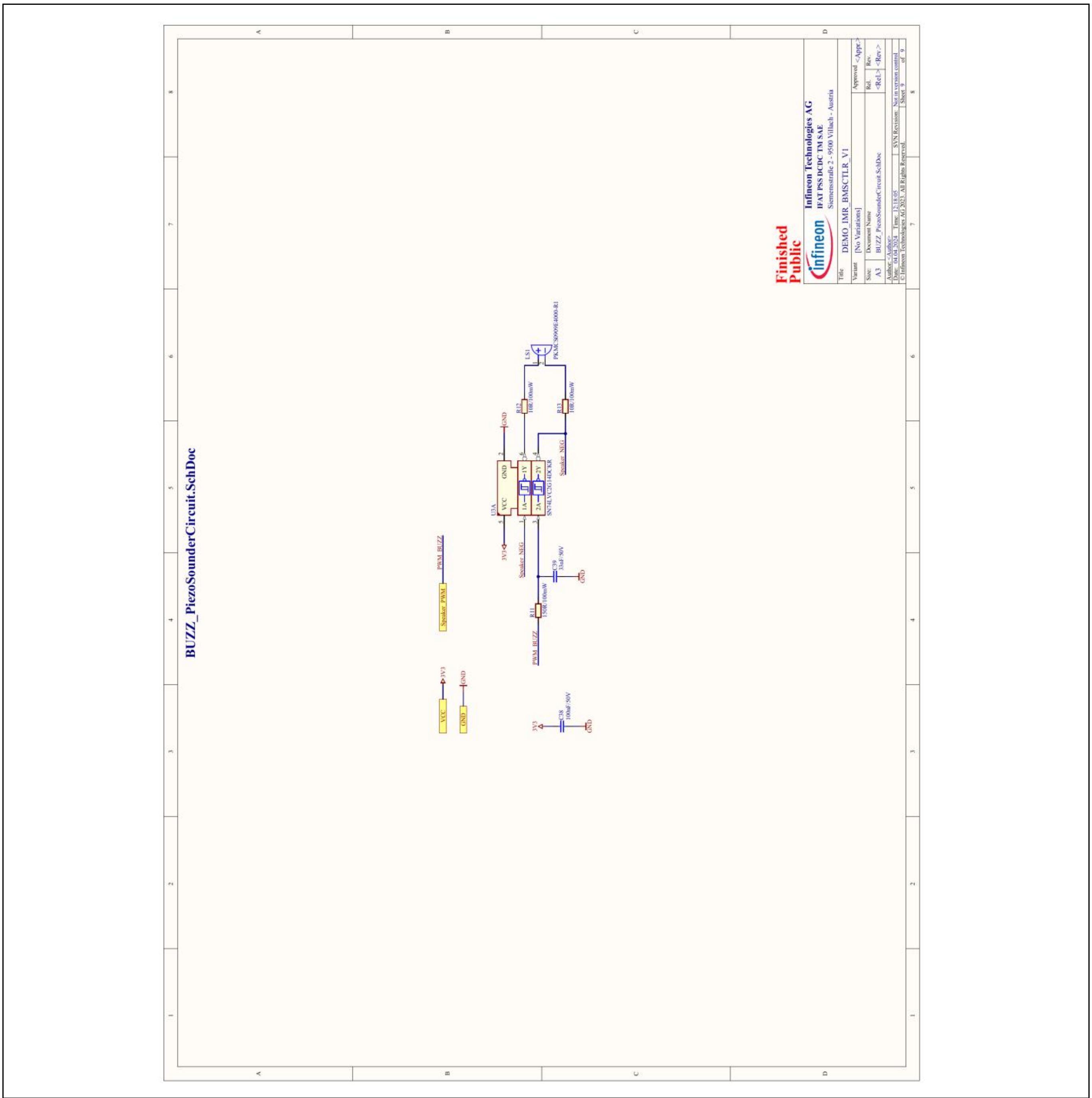

Figure 34 DEMO_IMR_BMSCTRL_V1 – BUZZ_PiezoSounderCircuit.SchDocz

7.2 Firmware

Will be included in further versions.

References

[1] Infineon Technologies AG: *PSoC™ 6 MCU: CY8C62x5 Datasheet Rev. *M (2022-10);* Available online

[2] Infineon Technologies AG: *32-bit PSoC™ 6 Arm® Cortex®-M4 / M0+ Overview*; Available online

[3] Canis Automotive Labs: *'The canframe.py tool', 25 October 2020*; Available online [accessed 18 March 2024]

Glossary

IMR
Infineon Mobile Robot (IMR)

BMS
Battery Management System (BMS)

SoC
State of Charge (SoC)

SoH
State of Health (SoH)

Revision history

Document revision	Date	Description of changes
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