Smart Induction Cooktop Reference Design (REF-SHA3K3IHWR5SYS) user guide

About this document

Scope and purpose

This user guide provides an overview of the Smart Induction Cooktop Reference Design (REF-SHA3K3IHWR5SYS) along with its usage, key features, and architecture.

Intended audience

This user guide is intended for all users of the REF-SHA3K3IHWR5SYS.

Note: *The reference design kit is to be used by trained specialists under laboratory conditions only.*

Reference Board/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.

Boards do not necessarily meet safety, EMI, quality standards (for example: UL, CE) requirements.

Document conventions

Reference design coded name	User friendly name
REF-SHA3K3IHWR5SYS	Smart Induction Cooktop Reference Design
REF-SHA3K3IHWR5SYS-INV	Inverter Control Board
REF-SHA3K3IHWR5SYS-HMI	HMI & System Control Board
REF-SHA3K3IHWR5SYS-CON	Connectivity Board

About this document

Important notice

“Evaluation Boards and Reference Boards” shall mean products embedded on a printed circuit board (PCB) for demonstration and/or evaluation purposes, which include, without limitation, demonstration, reference and evaluation boards, kits and design (collectively referred to as “Reference Board”).

Environmental conditions have been considered in the design of the Evaluation Boards and Reference Boards provided by Infineon Technologies AG. The design of the Evaluation Boards and Reference Boards has been tested by Infineon Technologies only as described in this document. The design is not qualified in terms of safety requirements, manufacturing, and operation over the entire operating temperature range or lifetime.

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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 Getting started

The REF-SHA3K3IHWR5SYS is a complete-Infineon solution for smart cooktop system starter kit. It is a three-board system constituting Inverter Control Board, HMI & System Control Board and Connectivity Board. The Inverter Control Board features the Infineon Technologies PSoC™ 6 MCU with a resonant switching control and resonant circuit based on the reverse conducting R6 IGBTs in combination with the level-shift EiceDRIVER™ ICs based on the SOI technology gate driver. The HMI & System Control Board features the PSoC™ 4100S Max MCU with 5th Generation CAPSENSE™ technology providing an easy human machine interface design solution for home appliance designer. The Connectivity Board features PSoC™ 6 with AIROC™ 4347E Wi-Fi Bluetooth® combo module from Laird to provide designers a good reference for IoT features.

The Smart Induction Cooktop Reference Design Kit solution provides a system solution that is modular with all induction cooktop building blocks as independent boards (as shown in Figure 1):

- Inverter Control Board
- HMI & System Control Board
- Connectivity Board

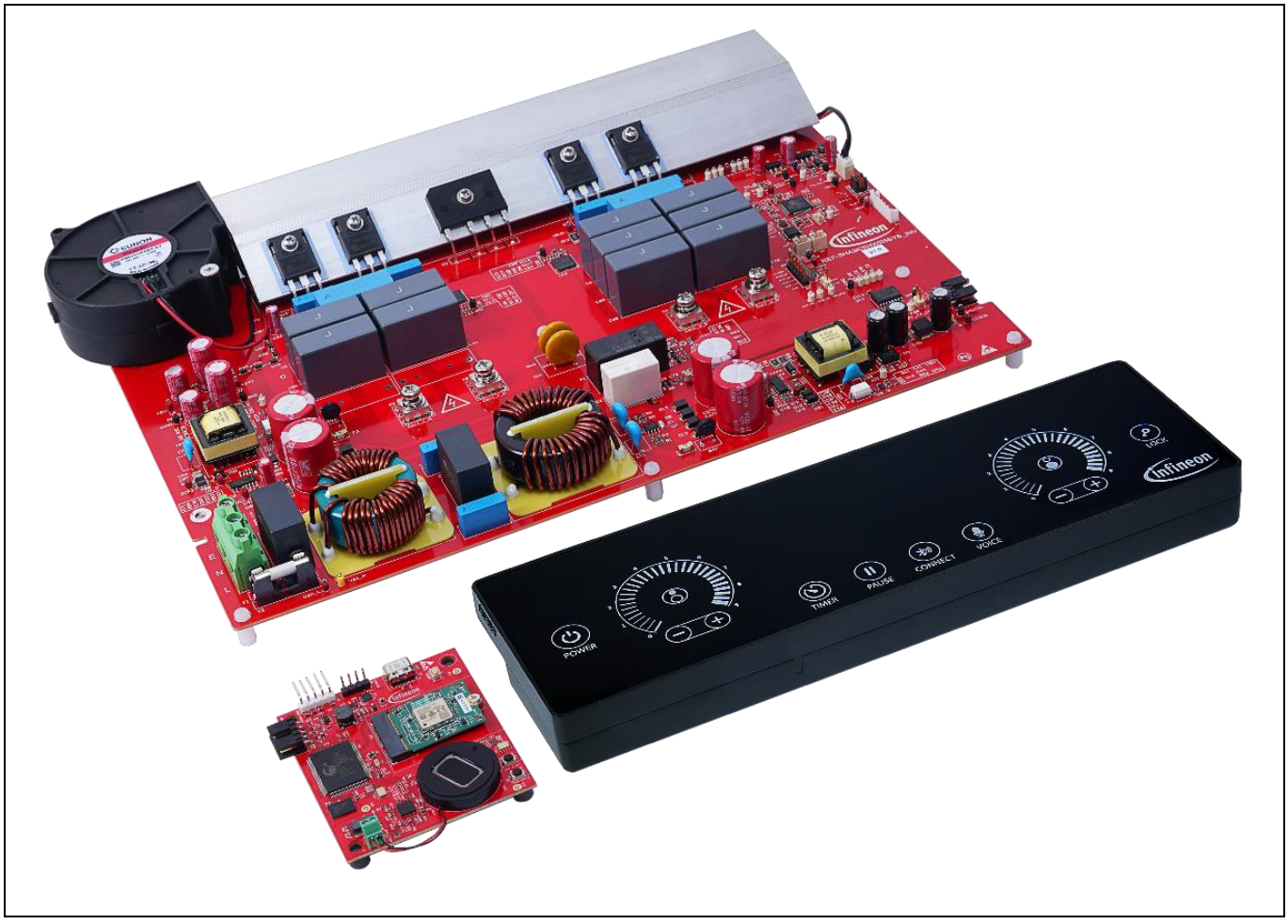


Figure 1 Smart Induction Cooktop Reference Design Kit Boards

1.1 Kit contents

Figure 2 shows the Smart Induction Cooktop Reference Design (REF-SHA3K3IHWR5SYS) Kit contents.

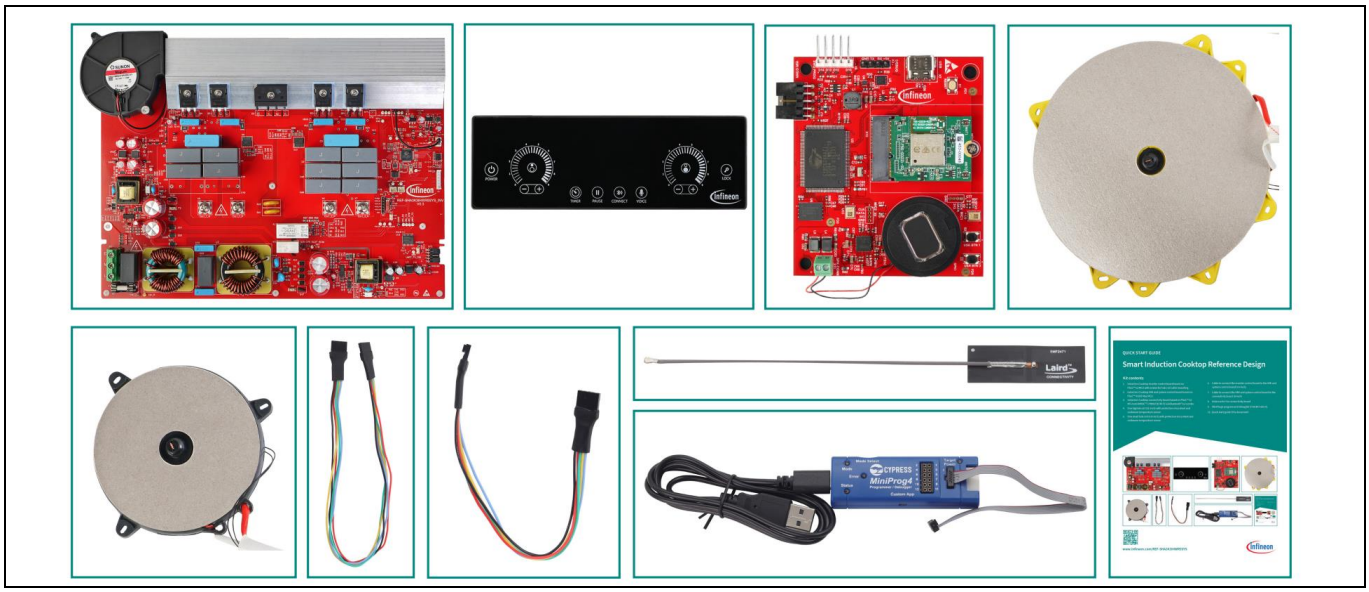


Figure 2 Smart Induction Cooktop Reference Design Kit contents

- Induction Cooktop Inverter Control Board based on the PSoC™ 6 MCU with screws for hob coil cable mounting
- Induction Cooktop Human Machine Interface (HMI) and System Control Board based on the PSoC™ 4100S Max MCU
- Induction Cooktop Connectivity Board based on the PSoC™ 6 MCU and the AIROC™ CYW4373E Wi-Fi 5 and Bluetooth® 5.2 combo chip
- Big hob coil (11 inch) with protective mica sheet and cookware temperature sensor
- Small hob coil (6.8 inch) with protective mica sheet and cookware temperature sensor
- Cable to connect the Inverter Control Board to the HMI and System Control Board (14 inch)
- Cable to connect the HMI and System Control Board to the Connectivity Board (8 inch)
- Antenna for the Connectivity Board
- MiniProg4 program and debug kit (CY8CKIT-005-A)
- Quick start guide

1.2 Kit features

The REF-SHA3K3IHWR5SYS Kit features the following key functionalities:

- Power and size
  a) Two induction hob configurations with one big and one small hob coils
  b) Simultaneous operation of two induction hobs with total system maximum power of 3600 W
    - Big induction hob with maximum power for 2200 W with boost mode support for 3000 W
    - Small induction hob with maximum power of 1400 W with boost mode support for 2000 W
- Features
  a) Full system level power ON/OFF
  b) Individual hob power control using a radial slider and +/- button
  c) Independent hob timer with alarm
  d) 7-segment display to display the hob timer status and the system error state
  e) Pause and resume functionality at the system level to perform urgent tasks during cooking.
  f) Child lock to avoid any hazards
  g) Local voice control with speaker for handsfree operation
  h) Companion mobile application to remotely control and monitor over Bluetooth®.
  i) Integrated active cooling control system to maintain the optimal IGBT temperature for switching
- Safety features
  a) Auto-shutdown on prolonged usage (over 2 hours)
  b) Auto-shutdown on overheating of the coil overlay surface or the internal electronics (IGBT)
  c) Intelligent resonant switching control based on pan detection status
  d) Hardware and software safety control for overcurrent and overvoltage conditions of the resonant circuit

1.3 Setting up the system

Connect the Smart Induction Cooktop contents as shown in the following figure.

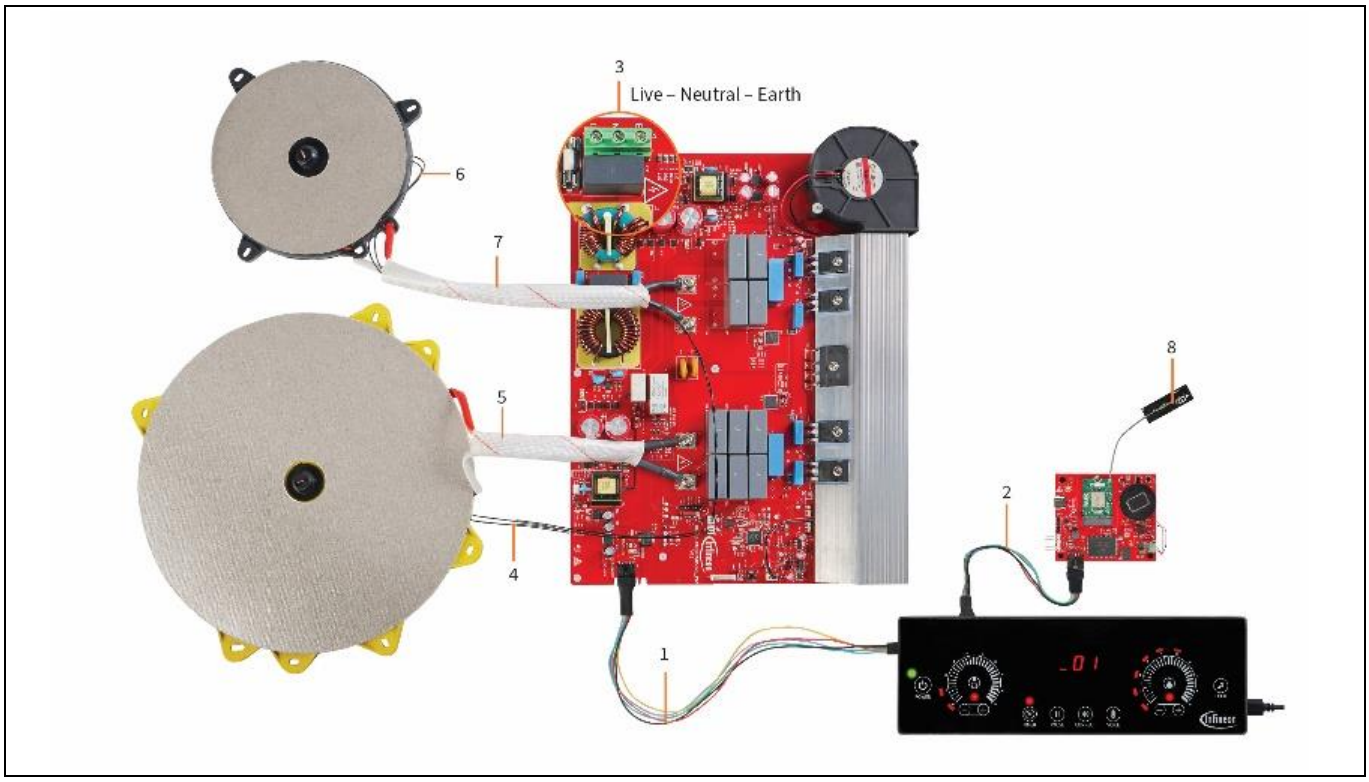


Figure 3 Smart Induction Cooktop setup

1. Connect the Inverter Control Board (X72) to the HMI and System Control Board at the inverter interface using the 14-inch cable provided with the kit
2. Connect the Connectivity Board (X1) to the HMI and System Control Board at the connectivity interface using the 8-inch cable provided along with the kit.
3. Connect the AC power supply to the Inverter Control Board with a power cord rated for 30 A to an AC socket rated for 220~240 V AC/ 30 A.
4. Connect the big coil cookware temperature sensor to the Inverter Control Board using the 2-pin connector (X35).
5. Connect the big coil to the Inverter Control Board using the screws at X6 (red) and X7 (white).
6. Connect the small coil cookware temperature sensor to the Inverter Control Board using the 2-pin connector (X34).
7. Connect the small coil to the Inverter Control Board using screws at X9 (white) and X8 (red).
8. Connect the antenna to the Connectivity Board at ANT0 (Refer to this tutorial video to learn how to connect the antenna to the MHF4L connector).

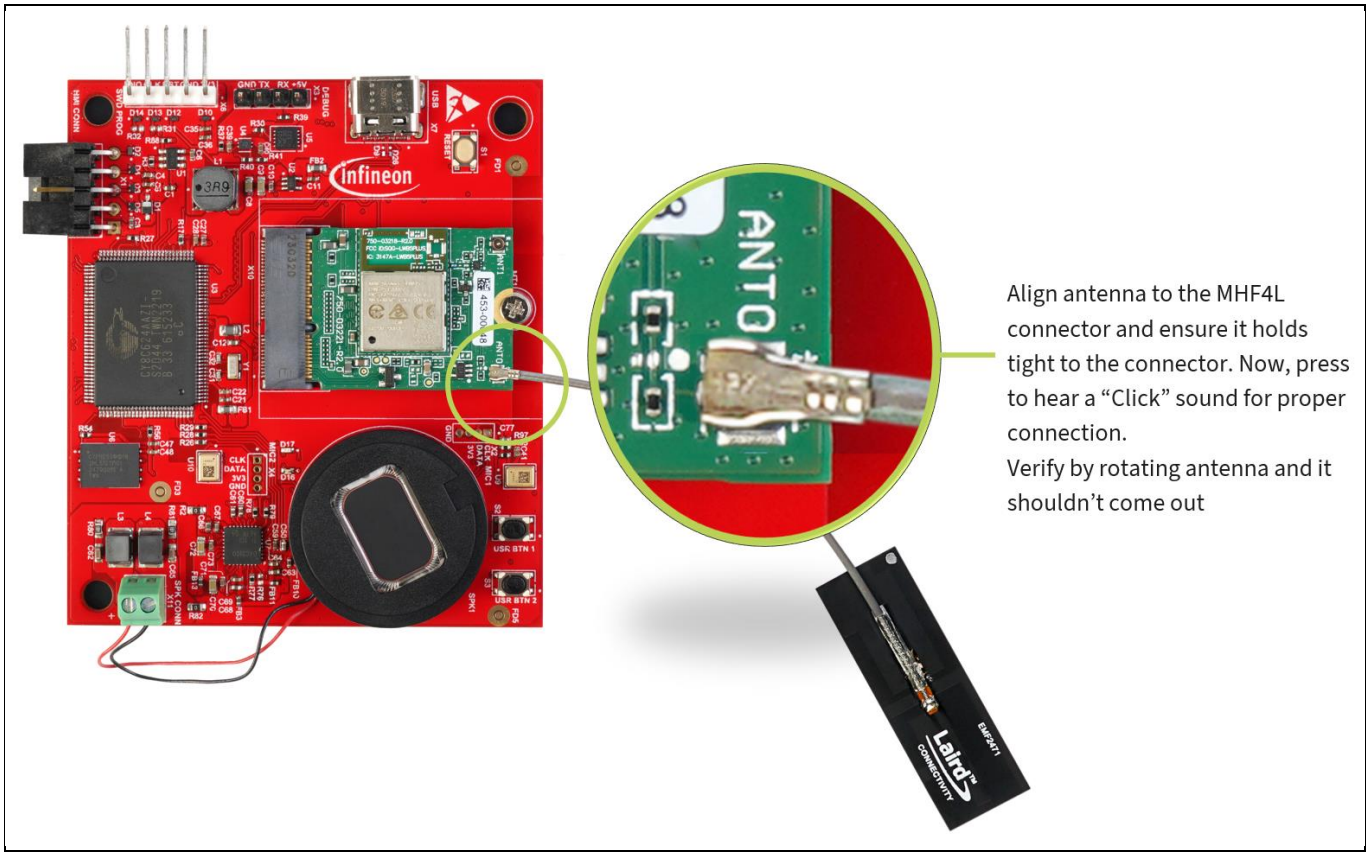


Figure 4 Attaching antenna to Connectivity Board

1.4 Powering the kit

Connect the Inverter Control Board AC input to a 220 V~240 V AC, 30 A socket.

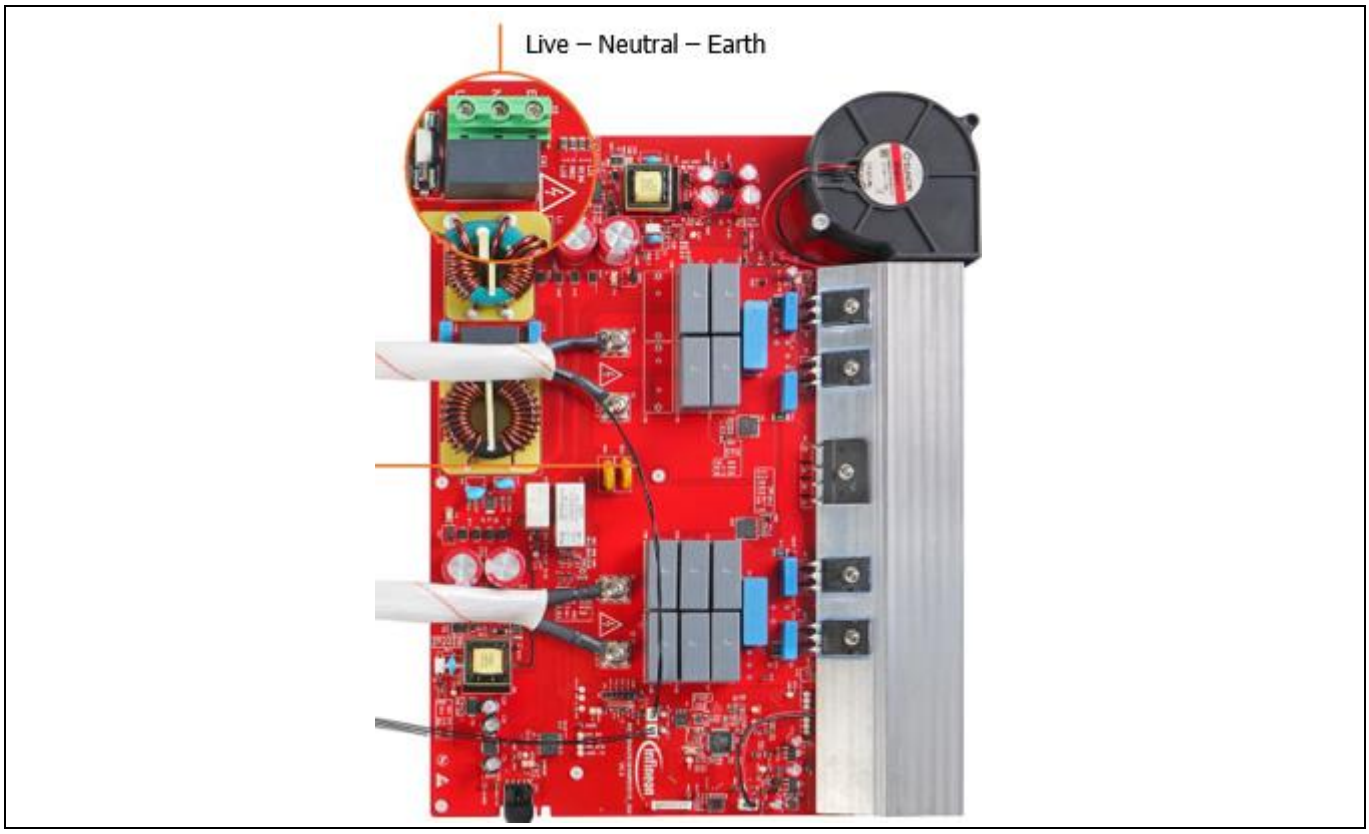


Figure 5 Power connections

1.5 Usage

Pre-requisites to use the system:

- An induction cooktop compliant cookware with some water
- Set up the system as described in the Setting up the system section and connect to the power socket as described in Powering the kit
- Get familiarized with the touch controls as shown in Figure 6 (Refer to the HMI & system control touch interface usage for detailed usage).

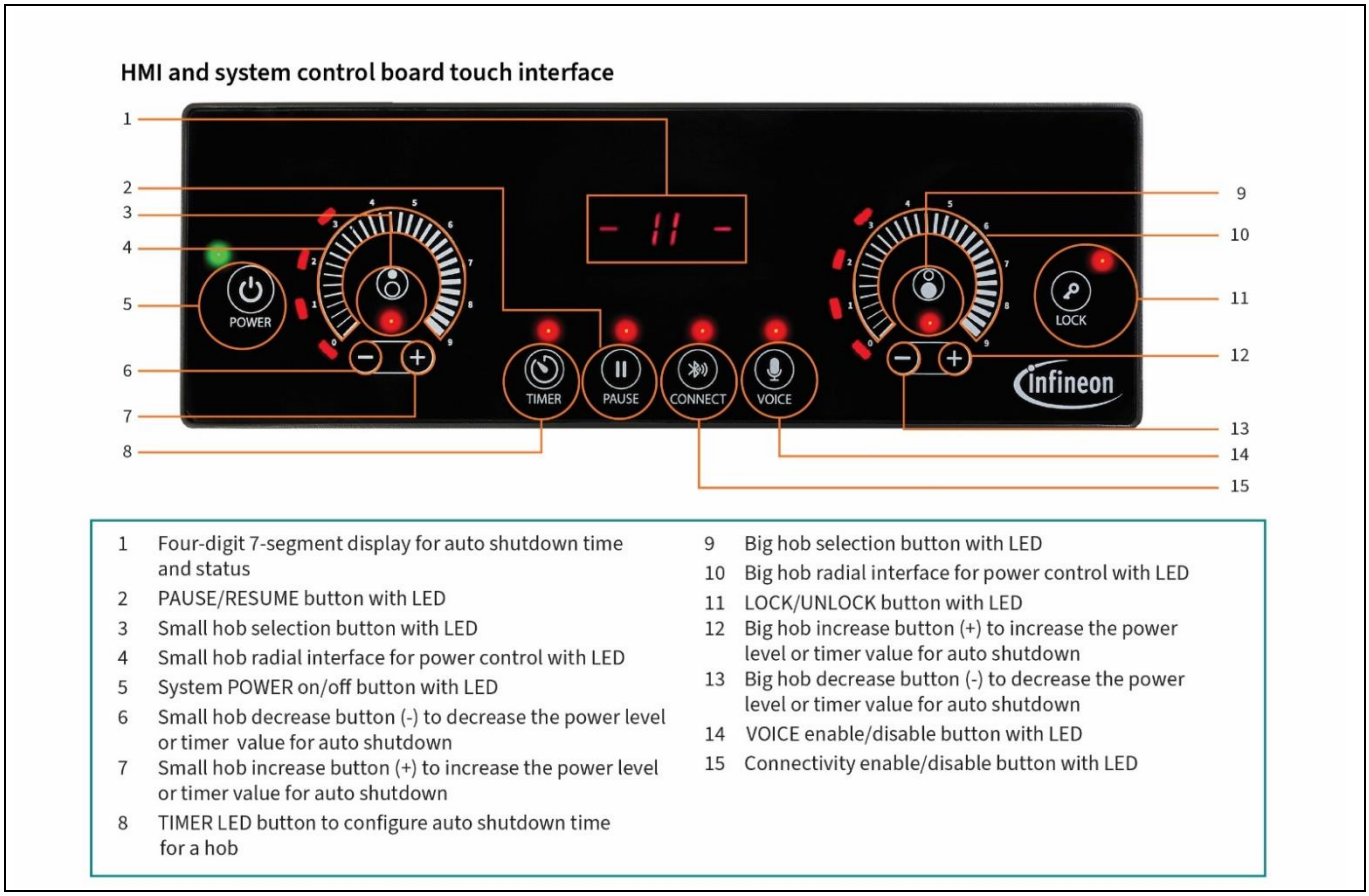


Figure 6 HMI and system control board touch interface

- Install the Infineon's **Induction Cooktop** mobile application from the Apple Appstore or Google Playstore and get familiar with the mobile application. See Mobile application usage section.

Step 1:

Place the induction cooktop compliant cookware with some water on the small hob and power on the AC supply to the system. Upon successfully passing the Class B compliant power-on self-test (POST), the HMI & System Control Board will blink all the LEDs once and the "POWER" LED starts breathing green color indicating that the system is in standby mode.

Step 2:

Power ON the system by long pressing (1 second) the "POWER" button. The POWER LED will stop breathing and becomes solid green color indicating that the system is ON.

Figure 7 Smart induction cooktop powered ON state (Idle state)

Step 3:

By default, connectivity and voice command features are disabled. Enable the connectivity and voice command control features by performing a short press of the CONNECT and VOICE buttons. Once these features are enabled, a solid red color LED will glow.

Figure 8 Smart induction cooktop in idle state with voice and connectivity enabled

Once the Connectivity Board is ON, the Connectivity Board will boot blinking the green and red LEDs for 5 times indicating that the Cyberon offline voice command processing license is available. Post that, the red LED stays ON and the green LED continues blinking while indicating that the Bluetooth® feature is ON and the system is discoverable.

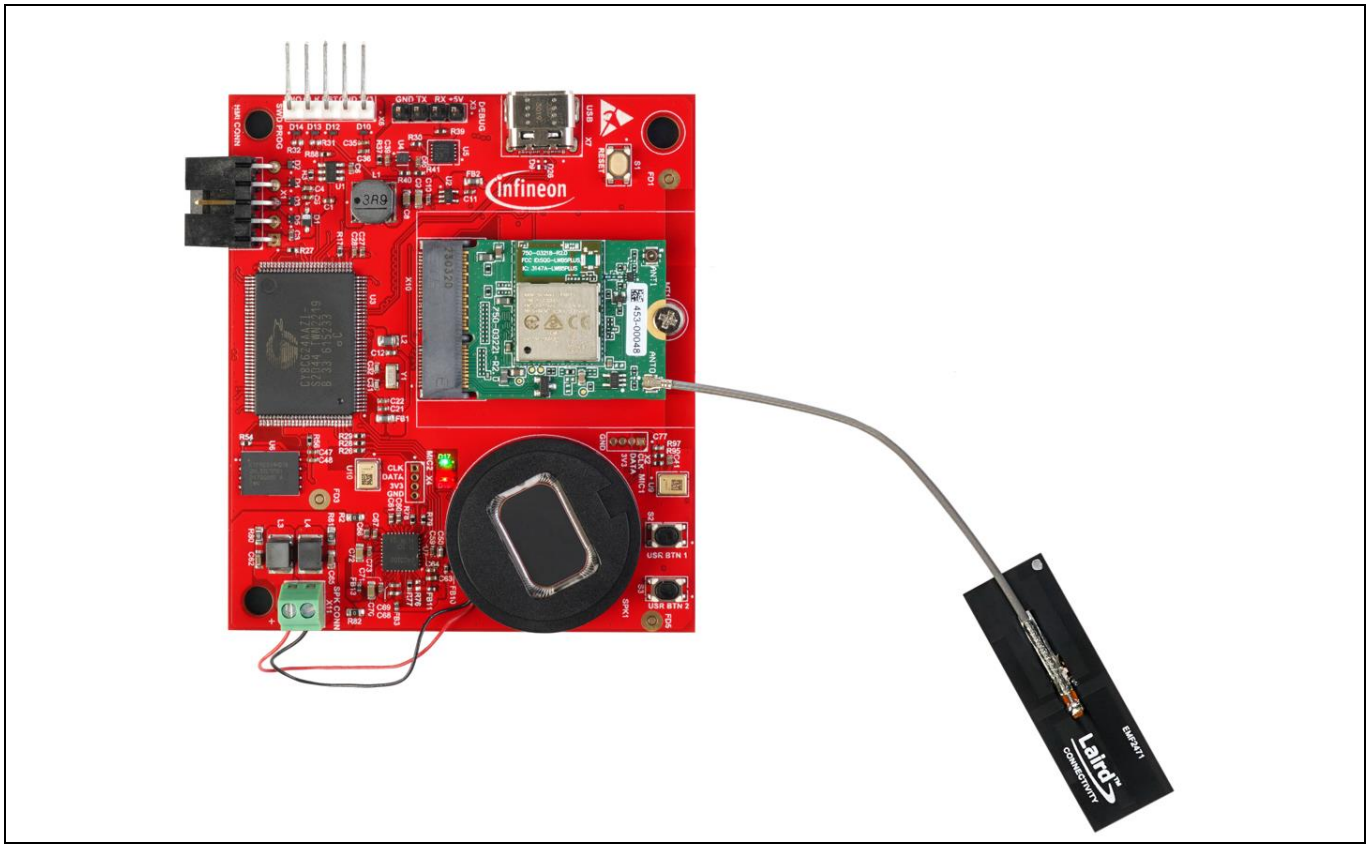


Figure 9 Connectivity Board with red and green LED glowing

Step 4:

Turn the small hob ON by short pressing the small hob selection button. The small hob will turn ON at the power level 0 indicated by the red LED.

Figure 10 HMI & System Control Board with small induction hob powered ON (active mode)

Step 5:

Launch the Induction Cooktop mobile application and connect to the Smart Induction Cooktop Connectivity Board. Figure 11 illustrates detailed steps to launch and add a device in the mobile application. For details, refer to the Mobile Application Control section.

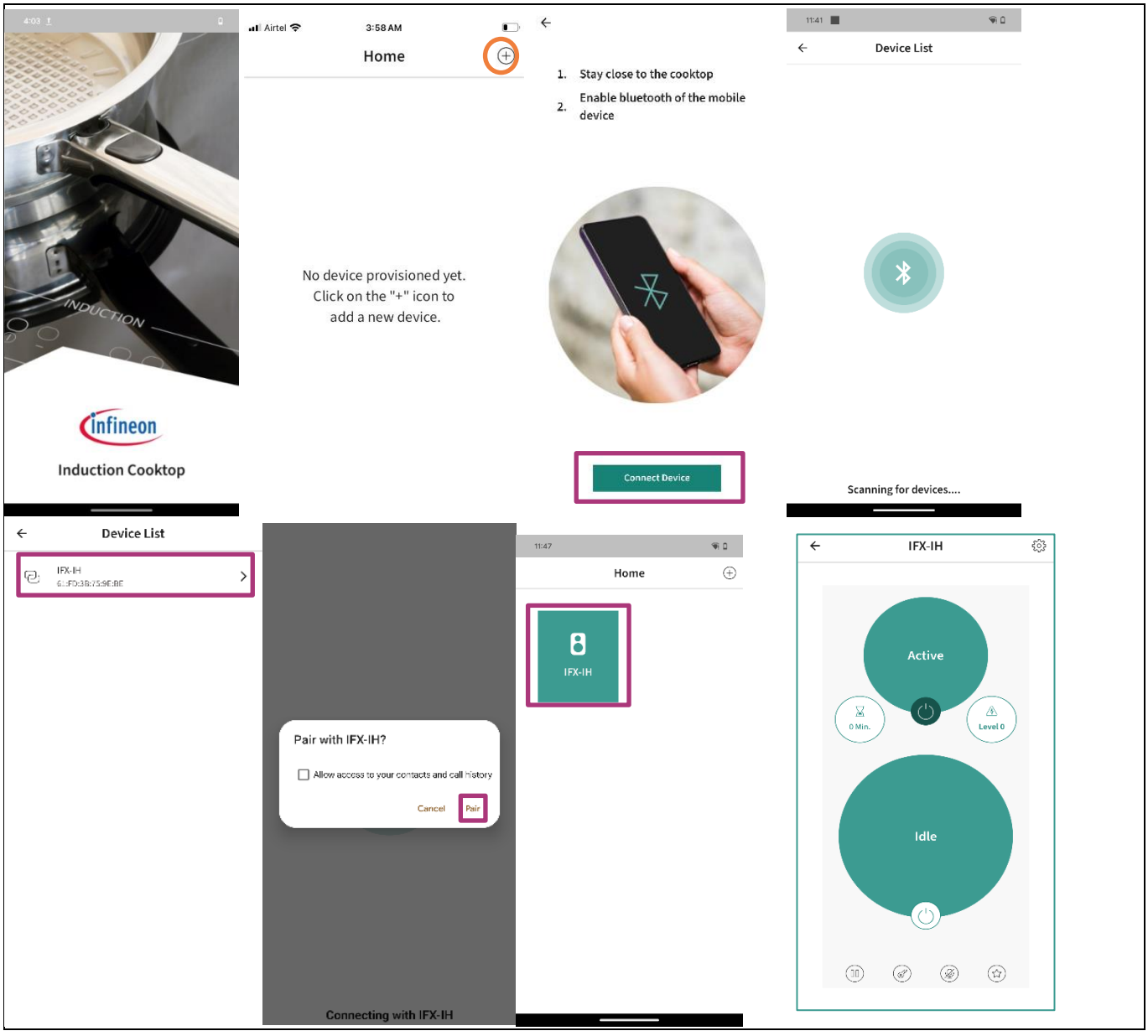


Figure 11 Infineon Induction Cooktop mobile application launch to adding a device

Step 6:

Increase the power level of the small hob using the slider interface to power level 3. Observe the radial power level LED to glow till the power level 3. The same will be reflected on the mobile application.

Figure 12 Small hob power level set to power level 3.

Step 7:

Decrease the power level of the small hob from the mobile application to 2 and observe the HMI LED getting updated.

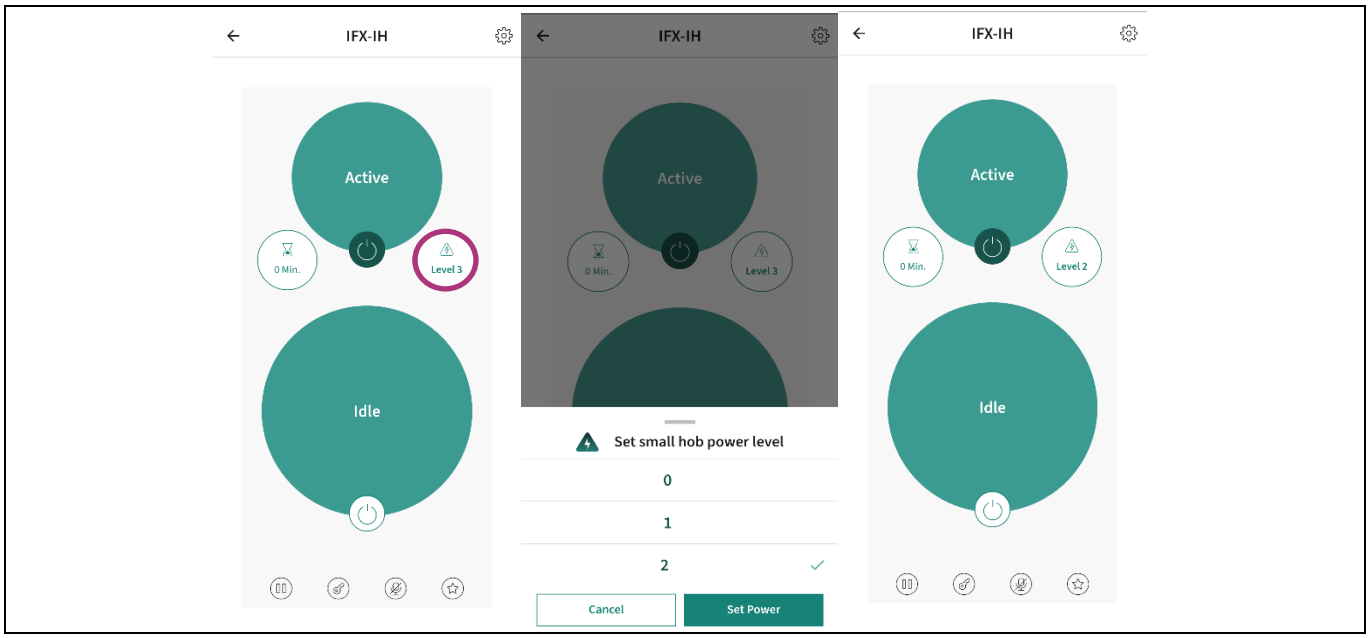


Figure 13 Small hob power level changing to level 2 in Induction Cooktop application

Figure 14 Small hob power level set to power level 2

Step 8:

Increase the power level of the small hob using the following voice commands:

Voice commands	Induction Cooktop voice output
“Hello Cooktop”	“I am listening”
“Set power level to three”	“Small hob active”
“Set power level to three”	“Power level set to three”

As a result, the HMI & System Control Board and the mobile application gets updated to power level 3. For detailed voice commands, refer to the Voice Commands section.

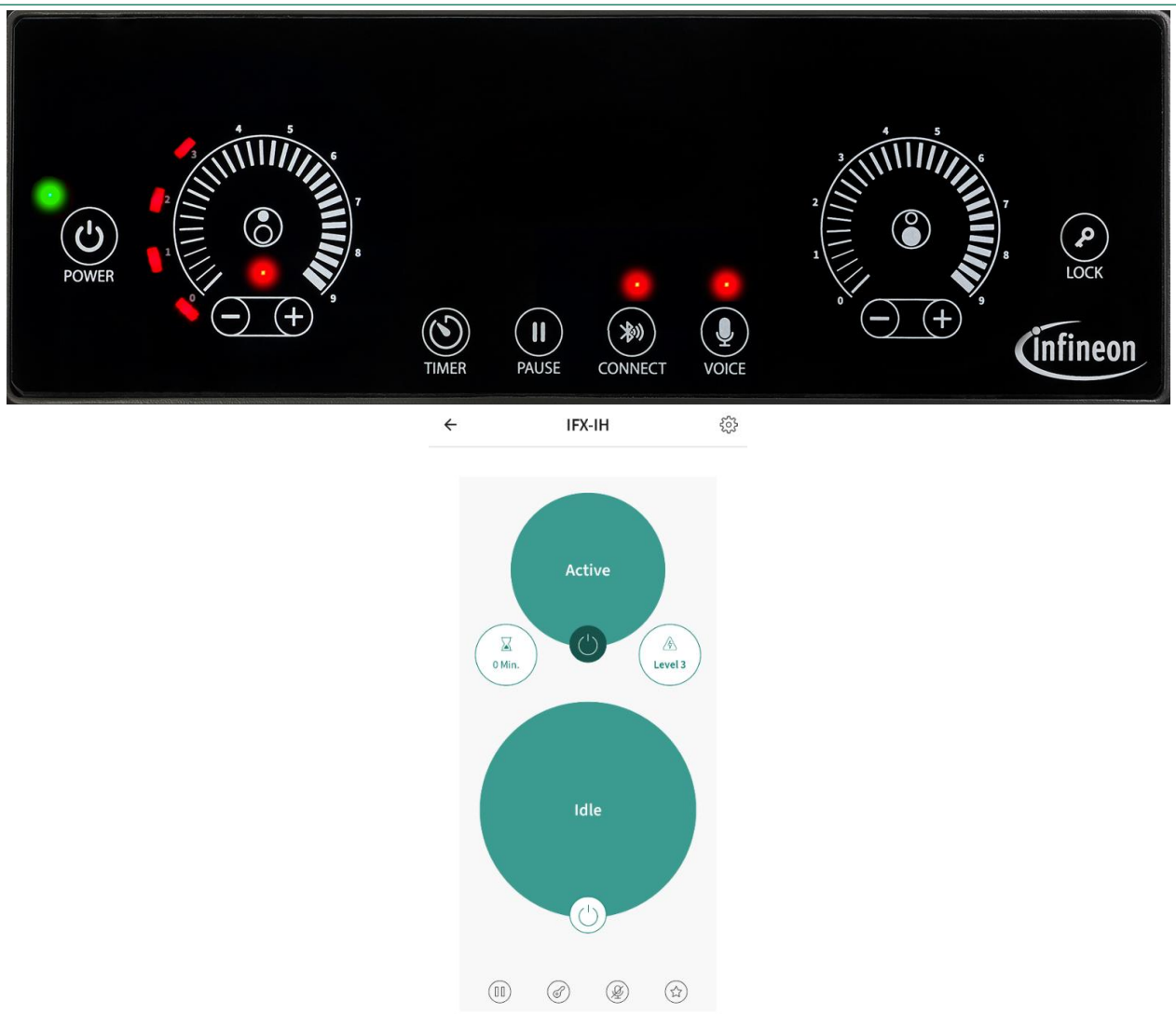


Figure 15 Small hob power level updated to level 3

1.6 Programming the firmware

To experience the latest updated features, update the system with the latest firmware by downloading the firmware package from Infineon website REF-SHA3K3IHWR5SYS.

1.6.1 Inverter Control Board

1.6.1.1 Hardware requirements

- Miniprog4 (shipped as part of the kit)
- UART to USB converter that supports 3.3 V IO logic (for example, C232HD-DDHSP-0)

1.6.1.2 Software requirements

Download and install the following programs:

- Cypress Programmer v4.2
- Serial terminal like TeraTerm or different software to view the UART debug logs.

1.6.1.3 Firmware programming

Please follow the following steps:

Note: *Firmware update does not require a complete system with AC supply and can be done with the power supply from the Cypress programmer. Powering with an AC supply will require raw power device debugging precautions.*

1. Set up the hardware as shown in the following figure.

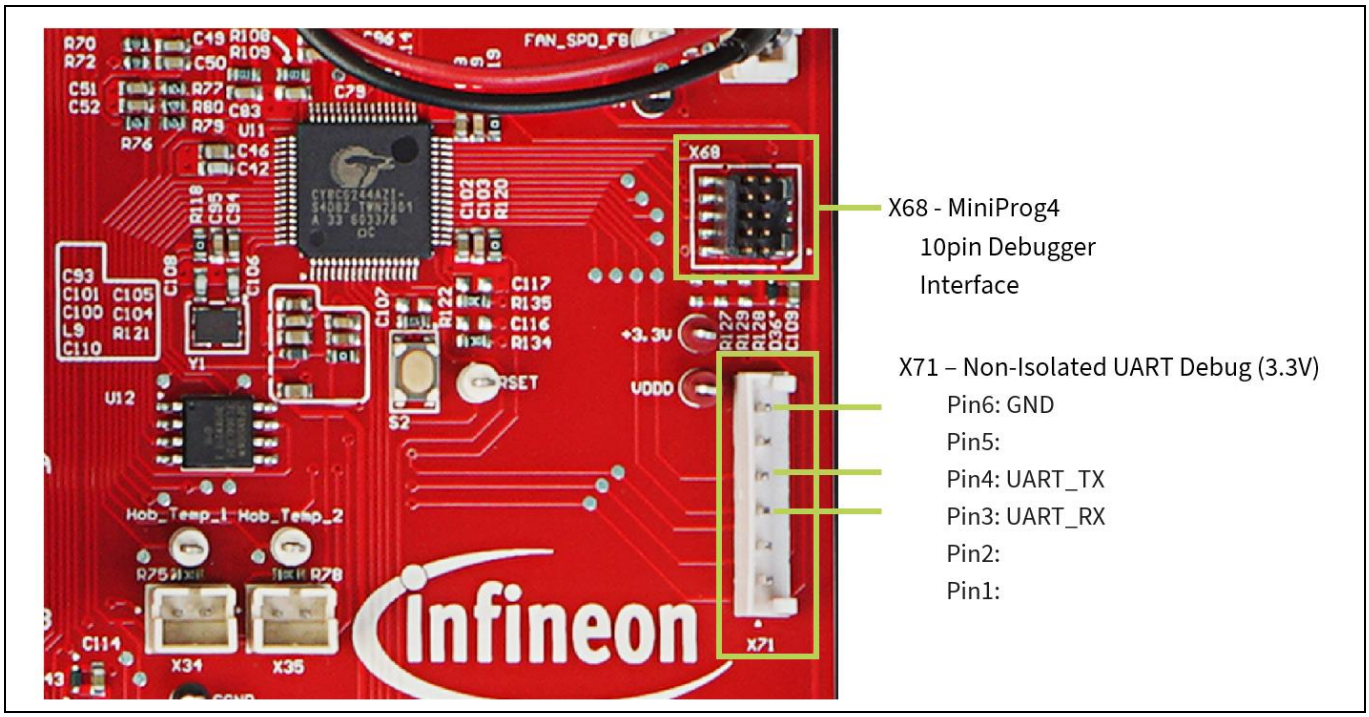


Figure 16 Inverter control board debug interfaces - MiniProg4 and TTL UART to USB

2. Open the Cypress Programmer application.
3. Select PSoC™ 6: Select PSoC™ 61/62/63 from the platform list.

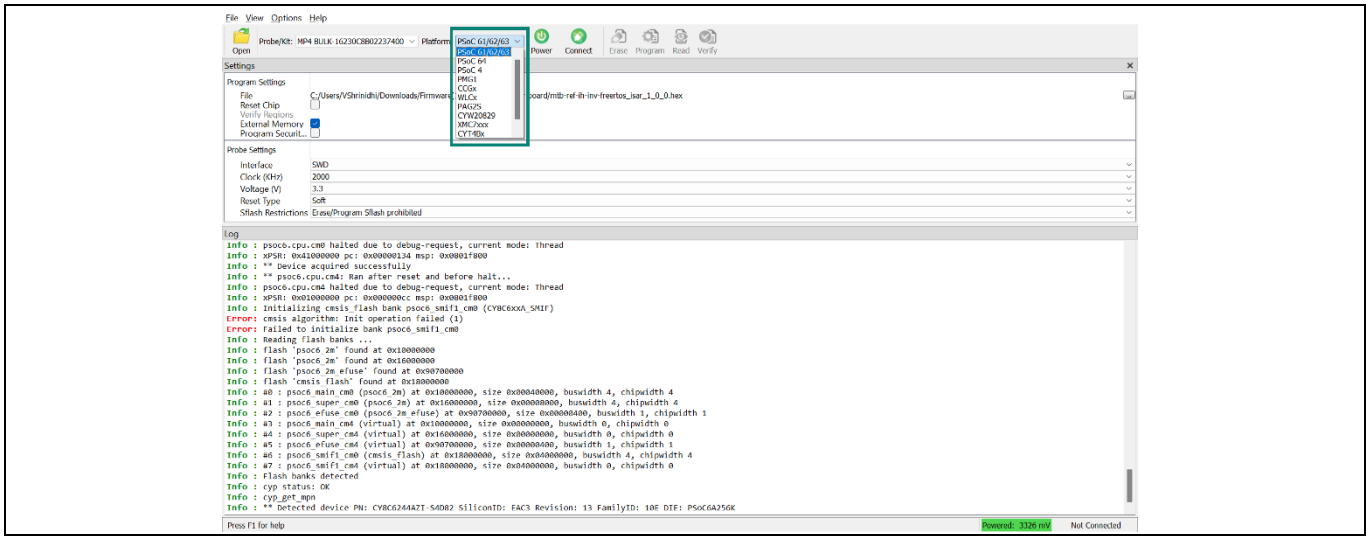


Figure 17 Select microcontroller of Inverter control board

4. Select the kit as shown in the following figure:

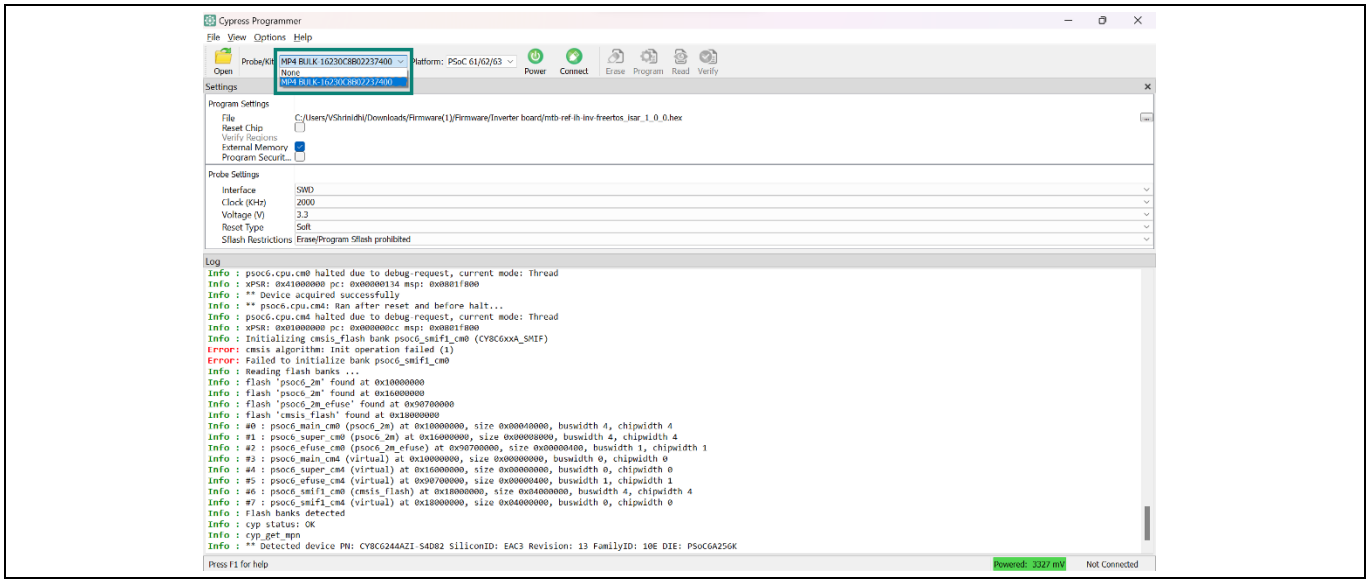


Figure 18 Select MiniProg4 Kit

5. Power on the PSoC™ 6 using the Cypress programmer GUI at 3.3 V.

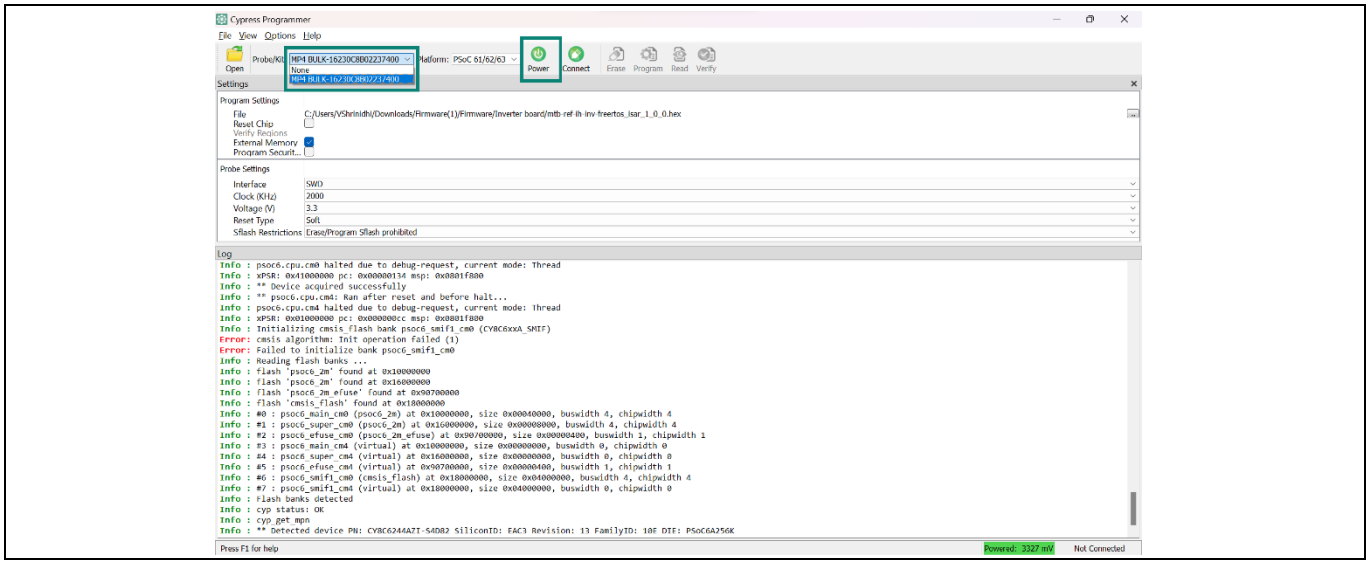


Figure 19 Option to power ON PSoC™ 6

6. In the Program Setting section, select the *mtb-ref-ih-inv-freertos_<latest_version>.hex* binary file that is downloaded.

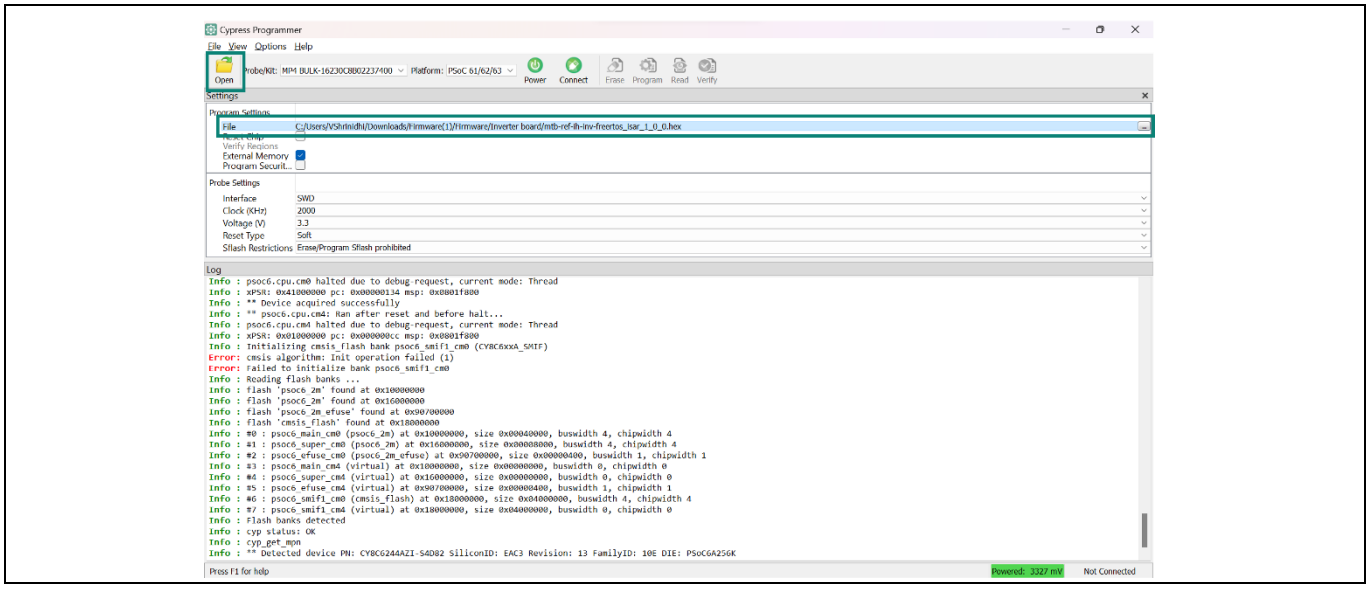


Figure 20 Browsing the binary to flash

7. Click **Erase** and then click **Program**.

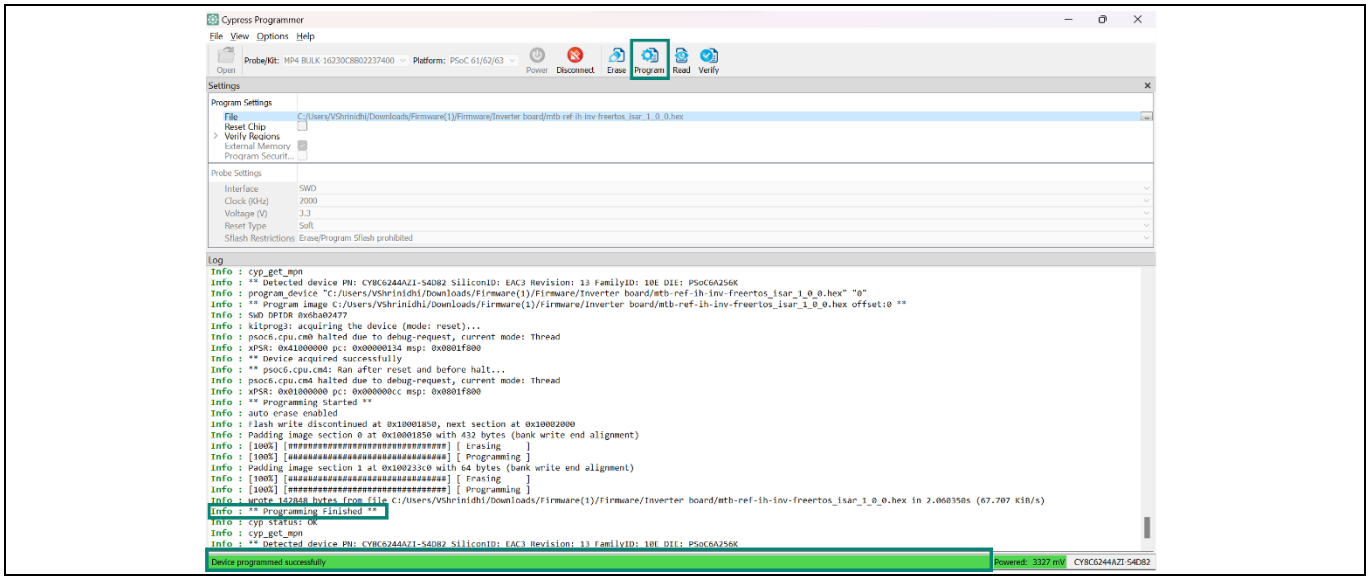


Figure 21 Erase/Program the MCU

Dp the following to verify the flashing with the latest version of the firmware:

1. Disconnect the target on the Cypress programmer.
2. Open a serial terminal with the USB to UART communication port with baud rate 115200, 1 stop bit, no parity, and no HW handshake.

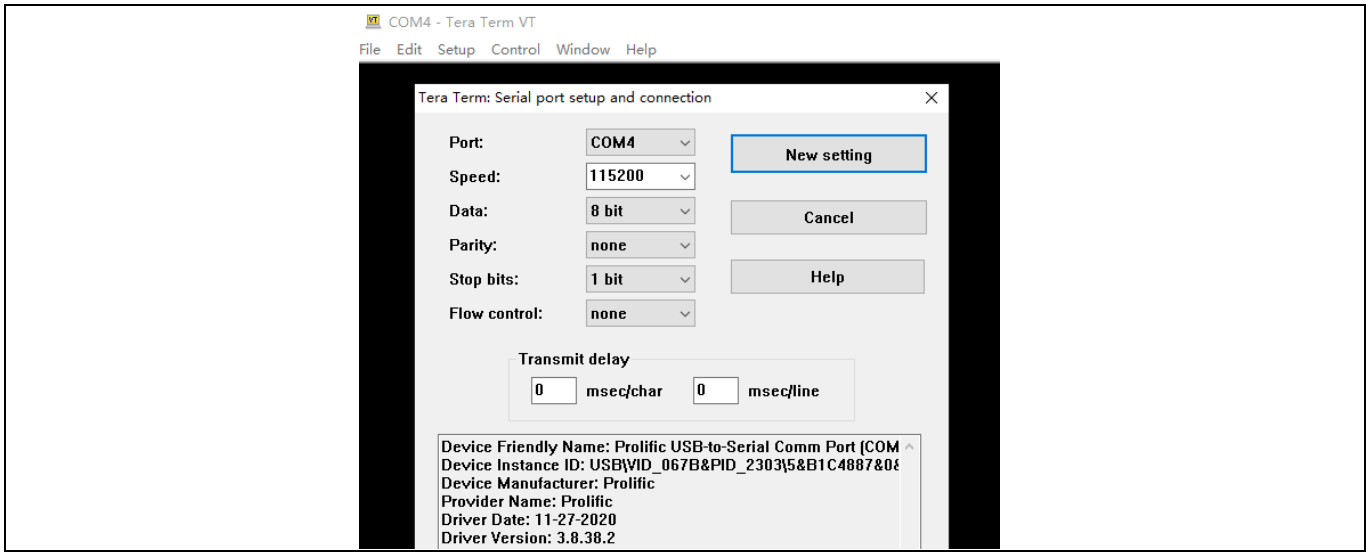


Figure 22 Inverter Control Board debug UART console settings

3. Perform power ON and OFF in the Cypress programmer to see the serial terminal displaying the latest version of the software.

```
=========================Welcome=============================
  Infineon's Smart induction cooktop REF-SHA3K3IHWR5SYS-INV
 ----SW Major-<Major>, SW Minor-<MINOR>-----
=============================================================
```

1.6.2 HMI & System Control Board

1.6.2.1 Hardware requirements

- Miniprog4
- UART to USB cable

1.6.2.2 Software requirement

Download and install the following programs:

- Cypress Programmer v4.2
- Serial terminals like TeraTerm or different software for viewing the UART debug logs.

1.6.2.3 Firmware programming

Do the following:

Note: *Firmware update does not require a complete system and an independent HMI & system control unit can be upgraded.*

1. Set up the hardware as shown in the following figure with MiniProg4 and an external USB debug connected to power the HMI & System Control Board.

Figure 23 HMI & System Control Board debug interfaces - MiniProg4 and USB (power & debug console)

2. Open the Cypress Programmer application.
3. Select PSoC™ 4: Select PSoC™ 4 from the Platform list and set the supply voltage to 5 V.

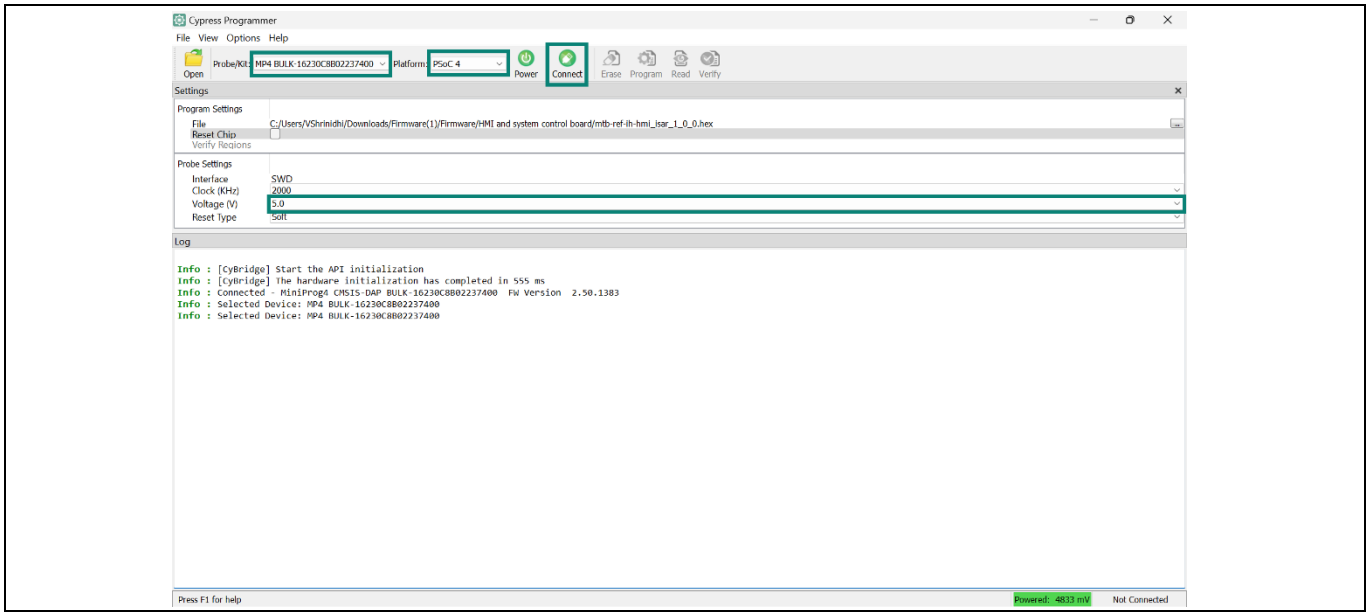


Figure 24 HMI & system control Cypress Programmer configuration

4. Browse and select the latest HMI firmware: *mtb-ref-ih-hmi_<latest_version>.hex*.

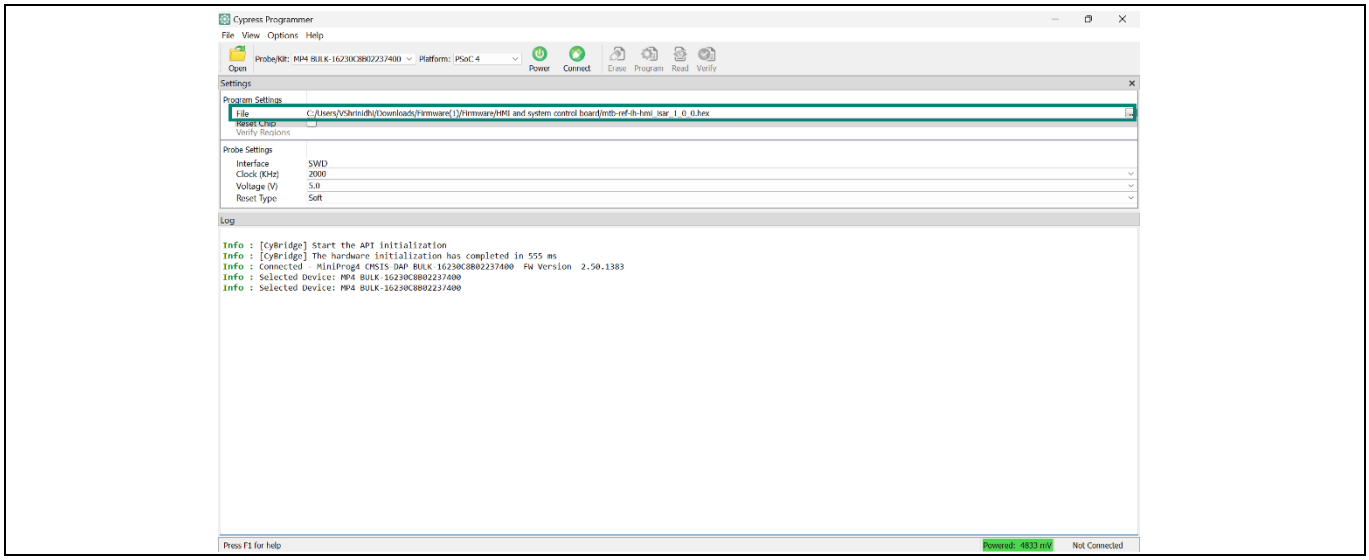


Figure 25 HMI & system controller firmware selection

5. Click **Erase** and then click **Program**.

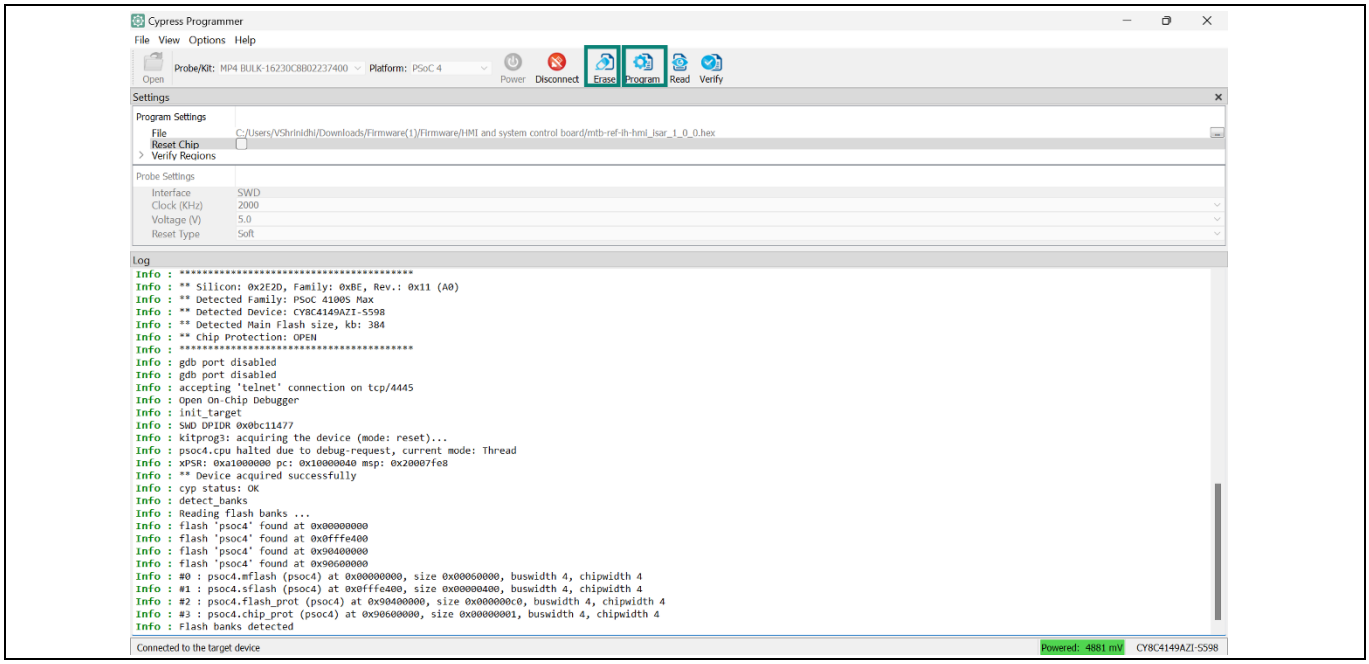


Figure 26 HMI & system control Cypress Programmer firmware programming

6. After successful programming, remove MiniProg4 and open the serial terminal with the USB to UART communication port with baud rate 115200, 1 stop bit, no parity, and no HW handshake.

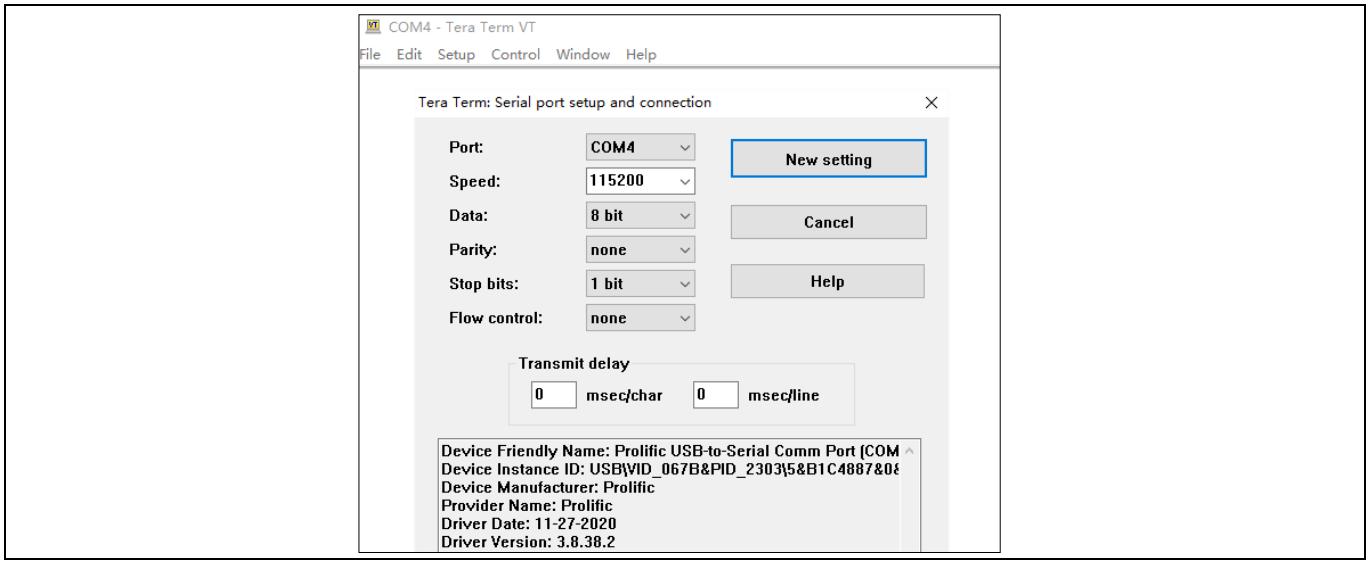


Figure 27 HMI & System Control Board debug UART console settings

7. Perform power ON and OFF to see the serial terminal displaying the latest version of the software.

```
=========================Welcome================================
  Infineon's Smart induction cooktop REF-SHA3K3IHWR5SYS-HMI
 ----SW Major-<Major>, SW Minor-<MINOR>-----
================================================================
```

1.6.3 Connectivity Board

1.6.3.1 Hardware requirements

- MiniProg4 (shipped as part of the kit)
- USB Type-C cable
- TTL UART to USB converter

1.6.3.2 Software requirement

Download and install the following programs:

- Cypress Programmer v4.2 or newer
- Serial terminal software like TeraTerm for viewing the serial debug logs.

1.6.3.3 Firmware programming

Note: *The firmware update does not require a complete system with AC supply and can be done with the power supply from the MiniProg4 cable.*

1. Connect the MiniProg4 to the SWD_PROG connector on the Connectivity Board.

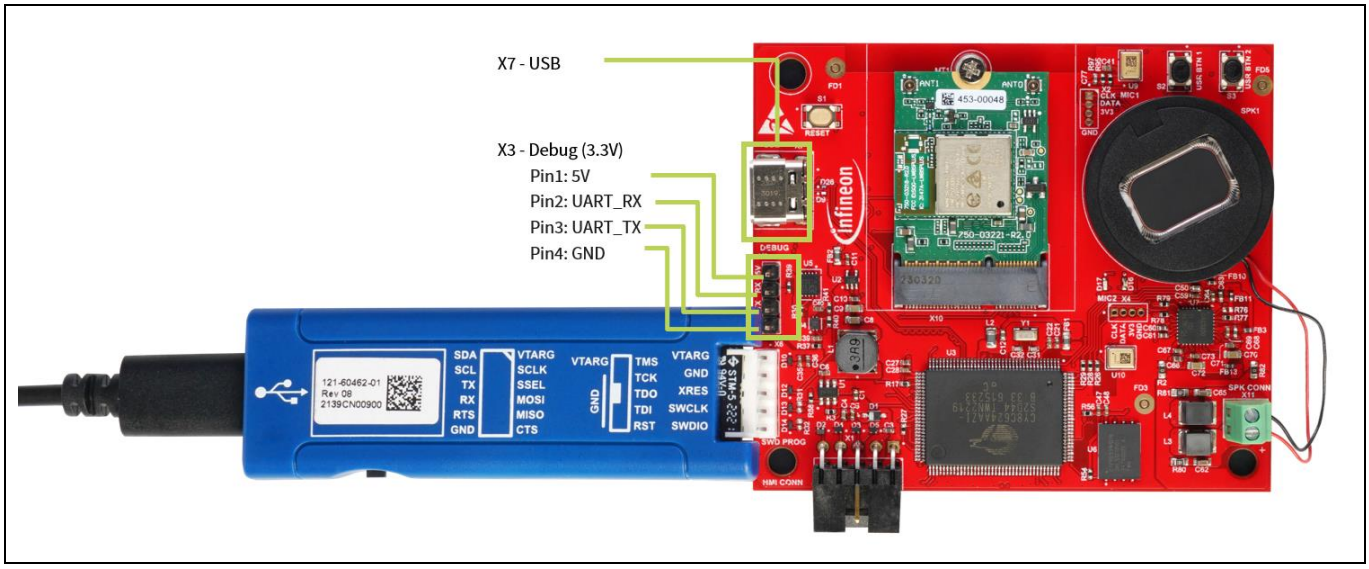


Figure 28 Connectivity Board debug interfaces - MiniProg4, Debug, and USB (Power & debug console)

2. Open the Cypress Programmer application.
3. Select PSoC™ 6: Select “PSoC™ 61/62/63” from the platform.

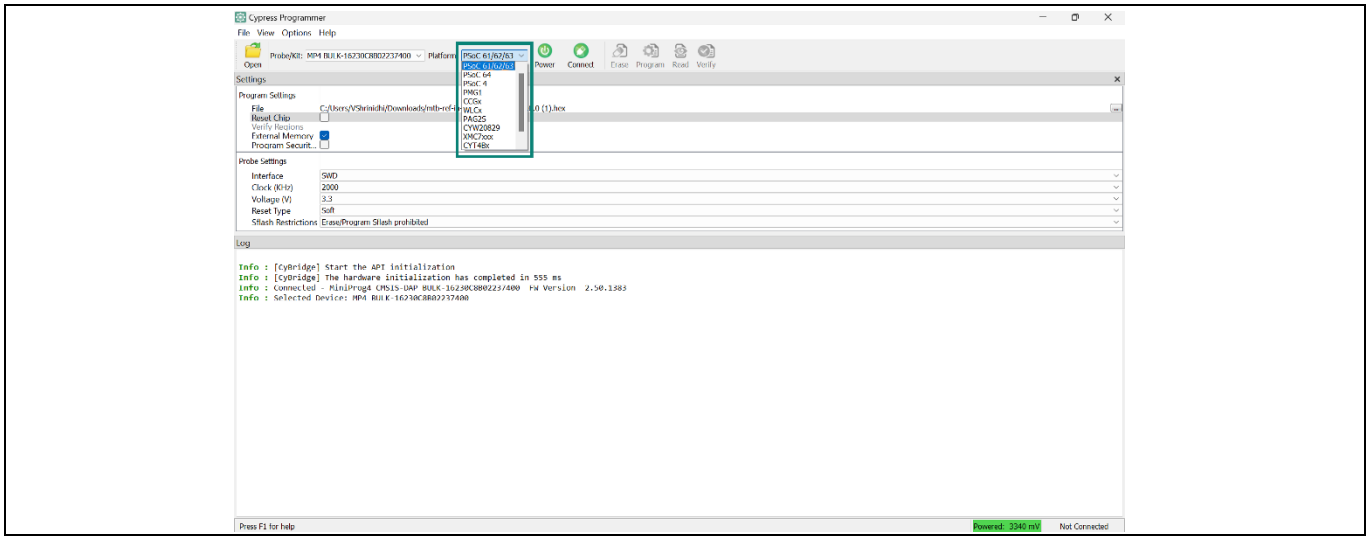


Figure 29 Select microcontroller

4. Select the kit.

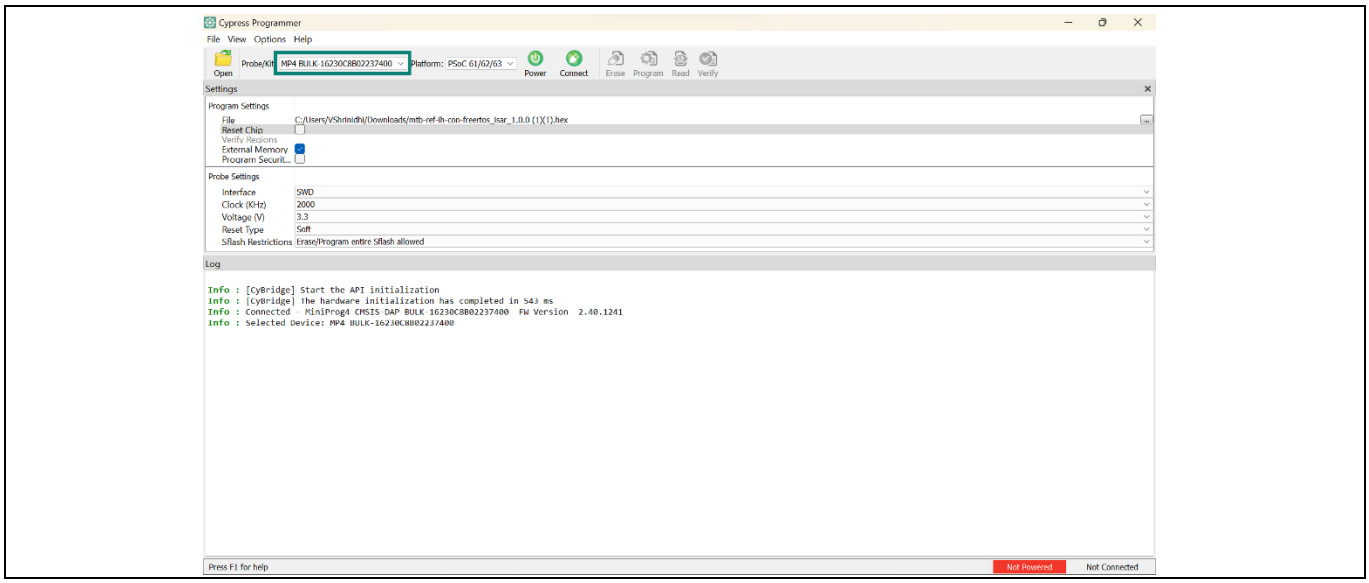


Figure 30 Select the MiniProg4

5. Power on the PSoC™ 6 using Cypress programmer GUI at 3.3 V (If USB is connected, this is not required).

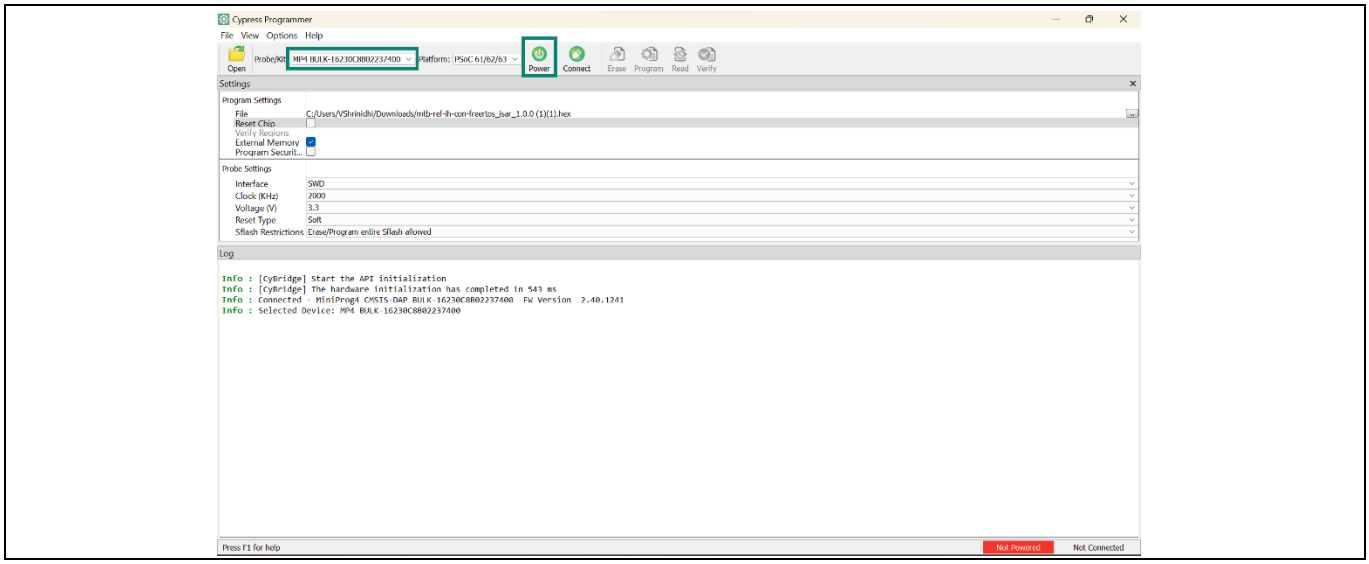


Figure 31 Option to power ON PSoC™ 6 using MiniProg4

6. In the Program Setting section, select the *mtb-ref-ih-con-freertos_<latest_version>.hex* binary file that is downloaded and then select the **External Memory** option.
7. Under the Probe Settings, select **Erase/Program entire Sflash allowed** for the **Sflash Restrictions** parameter.

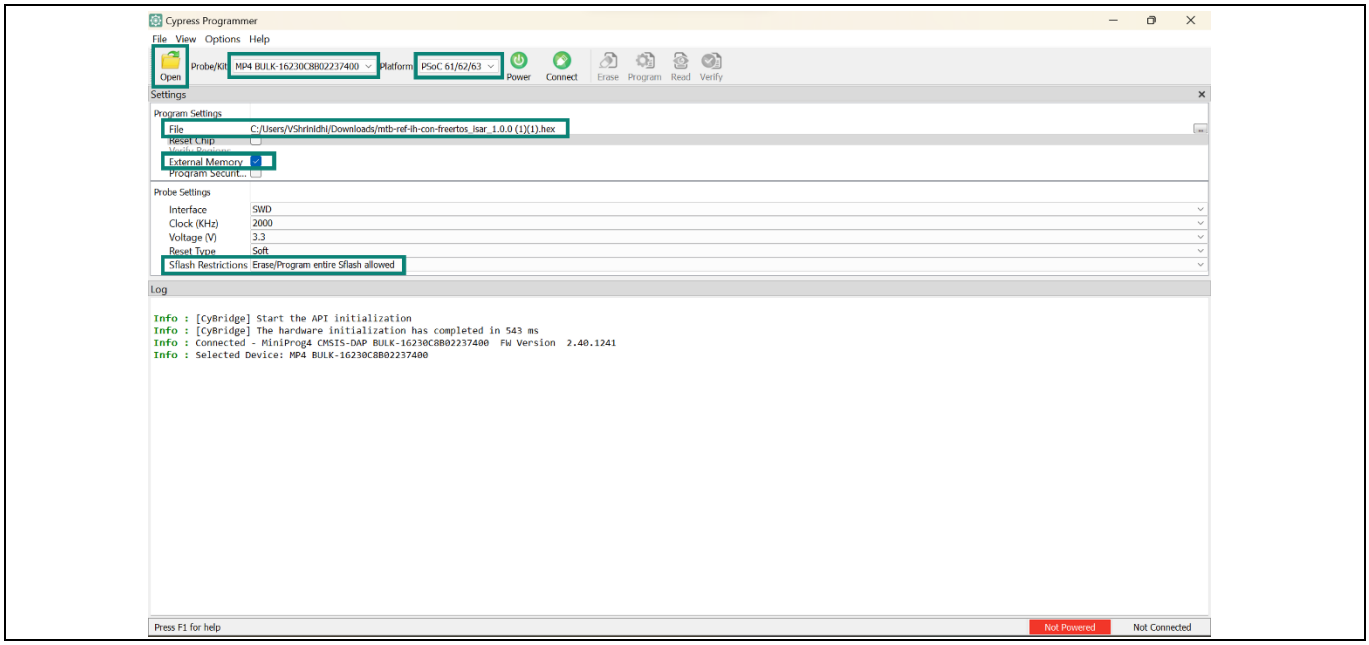


Figure 32 Browsing the binary to flash

8. Click **Program**.

Note: ***Erase option should never be performed.*** *Connectivity Board has Cyberon offline voice command demo license file and erasing the board will erase the license file.*

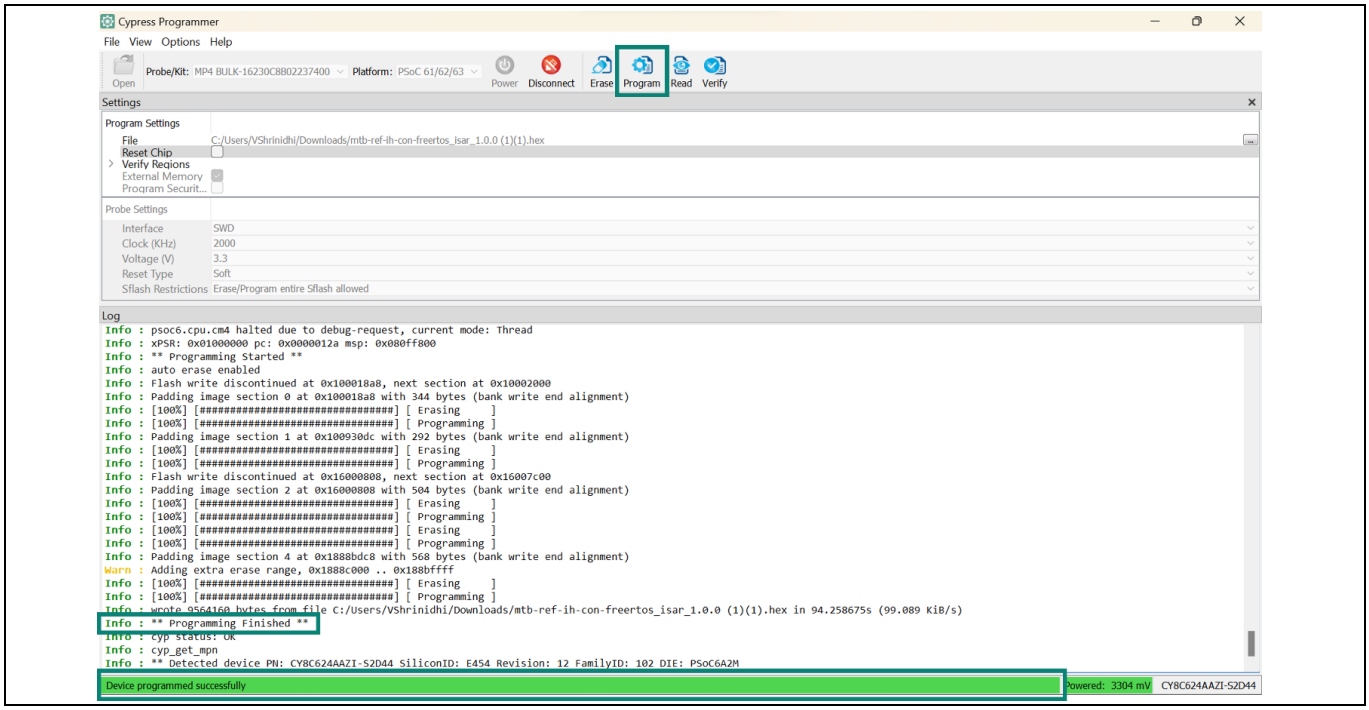


Figure 33 Program the MCU

Verify the flashing by doing the following:

1. Disconnect the target on the Cypress Programmer.
2. Open a serial terminal with the UART to USB communication port with baud rate 115200, 1 stop bit, no parity, and no HW handshake.

Note: *After the firmware upgrade, UART debug is upgraded to USB as the debug port and UART is no more required.*

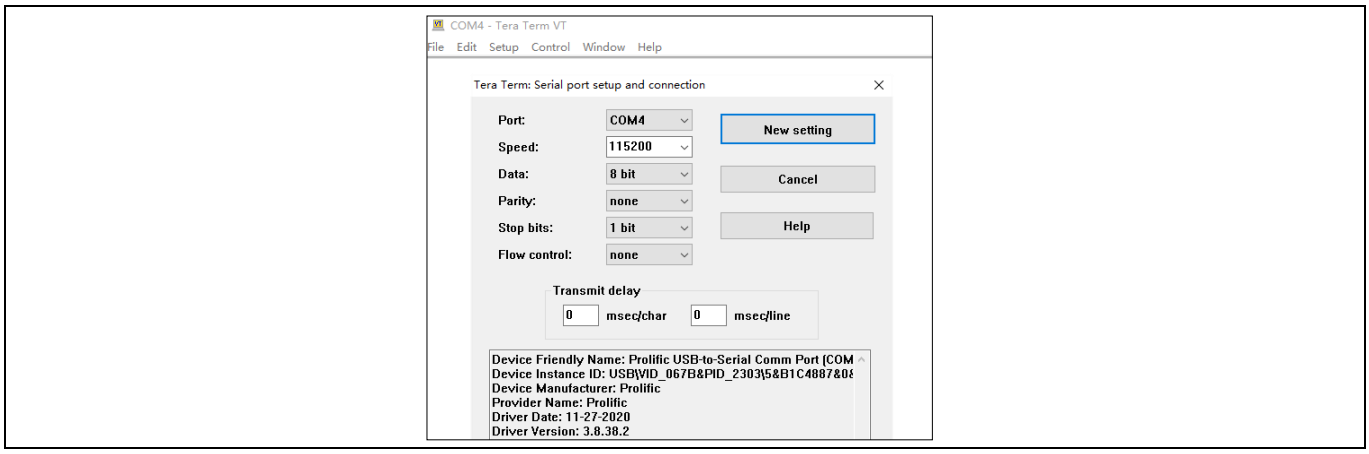


Figure 34 Connectivity Board debug UART console settings

3. Perform power ON and OFF to see the serial terminal displaying the latest version of the software.

```
========================Welcome================================
  Infineon's Smart induction cooktop REF-SHA3K3IHWR5SYS-CON
 ----SW Major-<Major>, SW Minor-<MINOR>-----
===============================================================
```

2 System overview

Figure 35 shows the high-level system block diagram of the Smart Induction Cooktop Reference Design Kit.

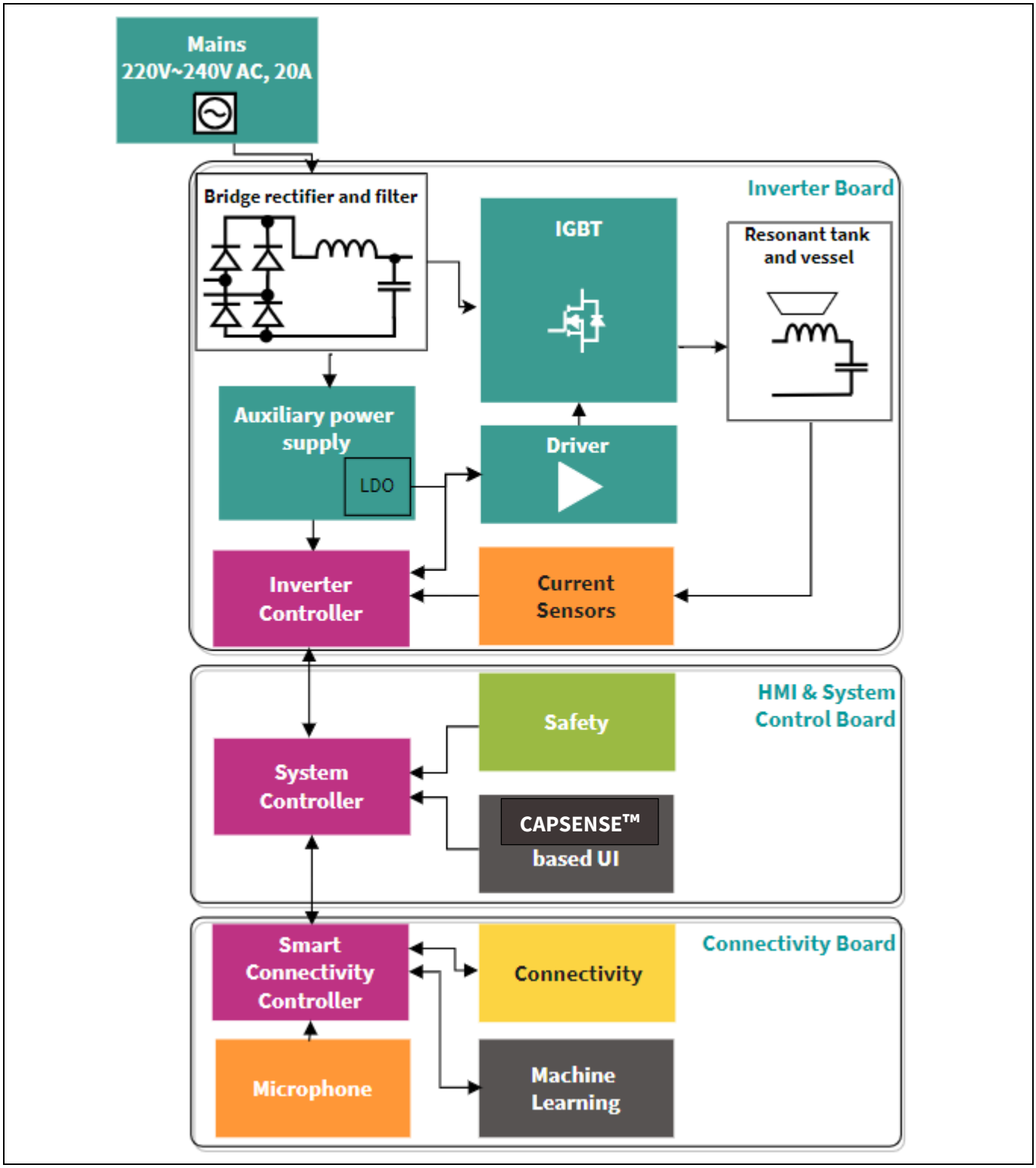


Figure 35 Smart Induction Cooktop high-level block diagram

2.1 Inverter Control Board

2.1.1 Block diagram

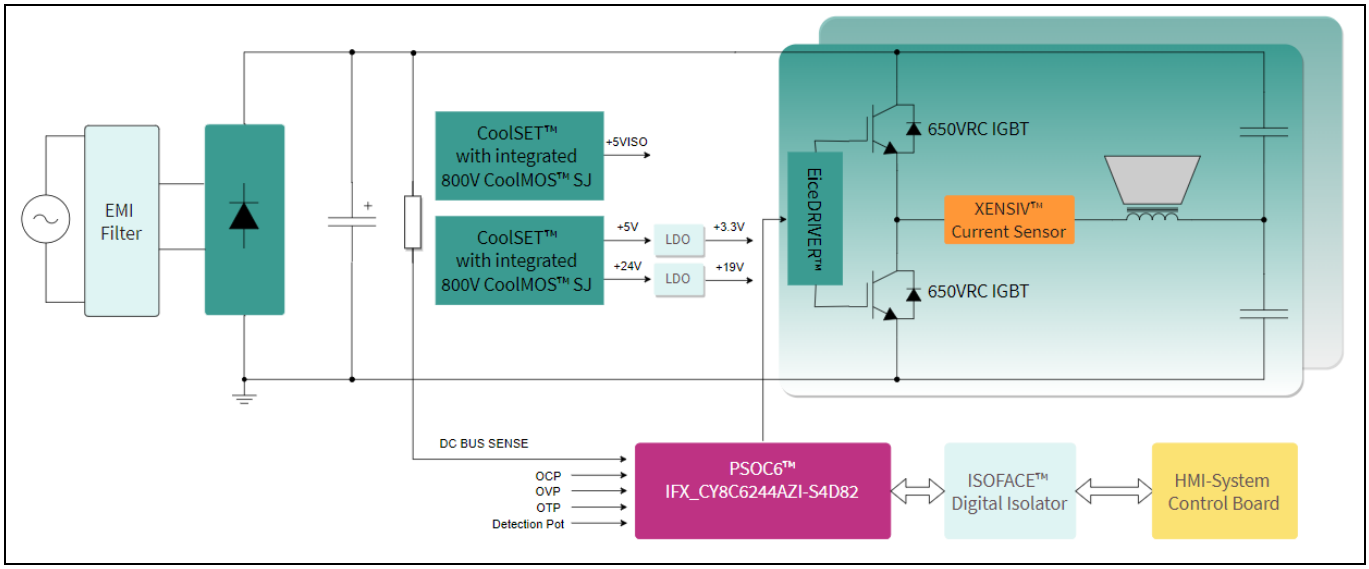


Figure 36 Block diagram of REF-SHA3K3IHWR5SYS-INV

The following are the key components of the Inverter Control Board:

- 4 x reverse conducting R6 650 V, 40 A IGBTs – IHW40N65R6 (2 per Coil)
- 2 x SOI EiceDRIVER™ 650 V, 2.5 A, half-bridge - 2ED21824S06J (1 per Coil)
- 2 x XENSIV™ current sensor TLI4971-A120T5-U-E0001 current sensor (1 per Coil)
- 1 x PSoC™ 6 CY8C6244AZI-S4D82 (for inverter control)
- 2 x CoolSET™ ICE5QR1680BG fly back auxiliary power supply controller
- 1 x TLF1963TE LDO for 5 V DC
- 1 x IFX25001ME LDO for 3.3 V DC
- 1xISOFACE digital isolator 4DIR2401H

2.1.2 Interface details

The following figure shows the functional groups on the top side of the REF-SHA3K3IHWR5SYS-INV Board.

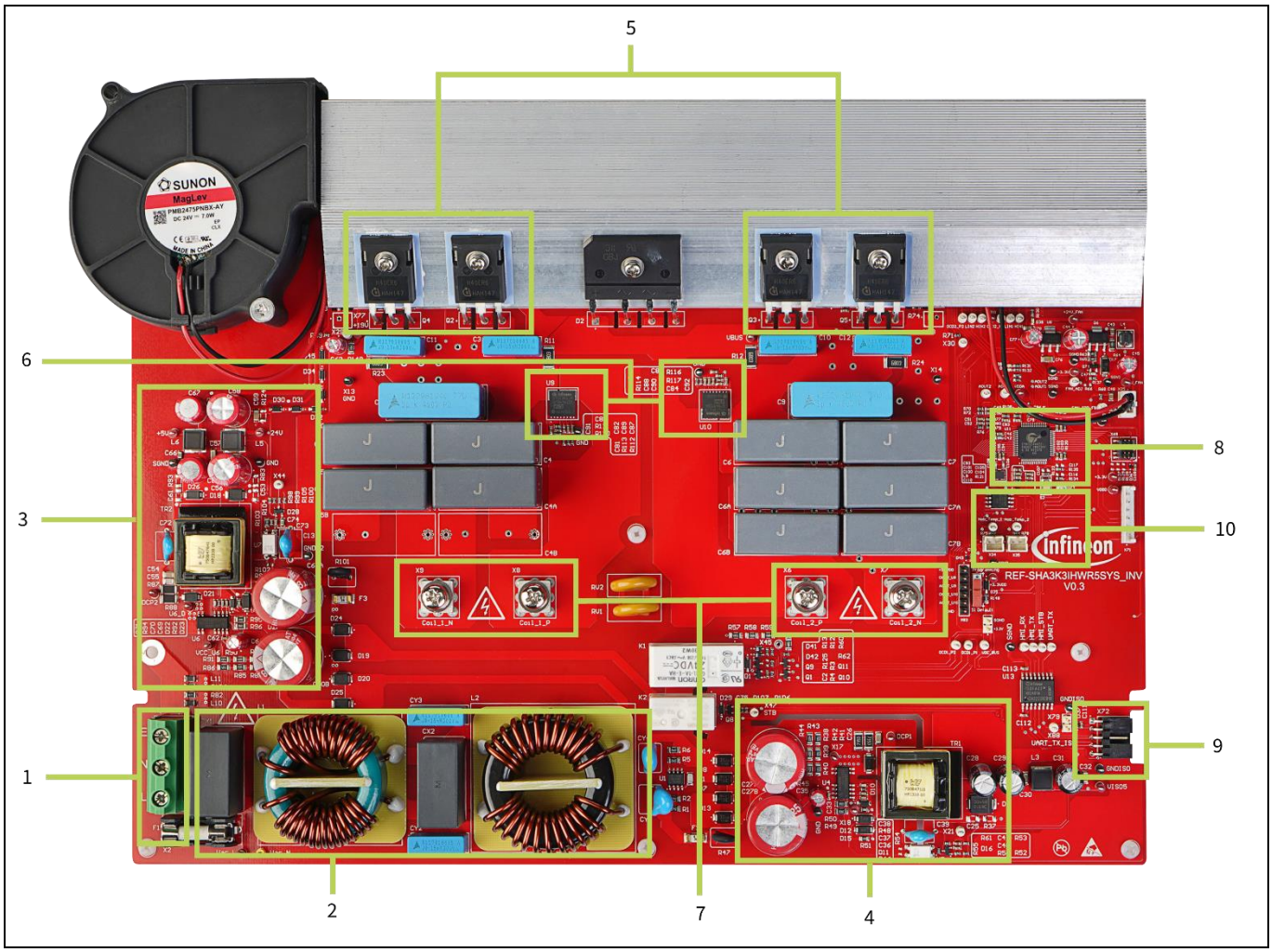


Figure 37 Functional groups of REF-SHA3K3IHWR5SYS-INV

1. AC input
2. EMI filter
3. Auxiliary power supply for Inverter Control Board
4. Isolated auxiliary power supply for HMI & System Control Board and Connectivity Board
5. Dual half bridge inverter IGBTs
6. Current sensor
7. Dual Induction coil sockets
8. Inverter Control Board controller
9. Interface for Isolated power supply and UART interface to HMI & System Control Board control.
10. Induction hob coil surface temperature sensor connectors

2.1.3 Features

The REF-SHA3K3IHWR5SYS-INV Board is a dual induction hob, half bridge inverter, resonant switching reference design for induction cooking application. It board contains the PSoC™ 6 CY8C6244AZI-S4D82 for resonant switching control and IHW40N65R6, a 650 V/40 A reverse conducting IGBT combined with the 2ED21824S06J gate driver IC for half bridge inverter application.

The following are the major characteristics of REF-SHA3K3IHWR5SYS-INV:

- Input voltage 220 V~240 V_{AC}
- Maximum 3600 W at 220 V_{AC} input power for system
- Maximum 2200 W for bigger coil and 1400 W at 220 V_{AC}
- Cooling fan with speed control
- Relay for standby mode and sleep mode
- Standby mode control and UART communication interface to HMI & System Control Board
- Overcurrent and overtemperature protection, fault LED output
- Auxiliary power supply with 24 V, 19 V, 5 V, 3.3 V, and isolated 5 V
- Inverter PCB size is 315 mm × 206 mm, 2 layers, 2 oz. copper

2.1.4 Board parameters and technical data

Table 2 Ratings of major components

Parameter	Value	Unit
Power supply ratings	220-240	V
Big coil inductance value	51	µH
Small coil inductance value	71	µH
Big coil power rating	2200/(3000 in boost mode)	W
Small coil power rating	1400/(2000 in boost mode)	W
Total Inverter Control Board power rating	3600	W

For more details on Inverter Control Board design, refer to Inverter Control Board Architecture and Design.

2.2 HMI & System Control Board

2.2.1 Block diagram

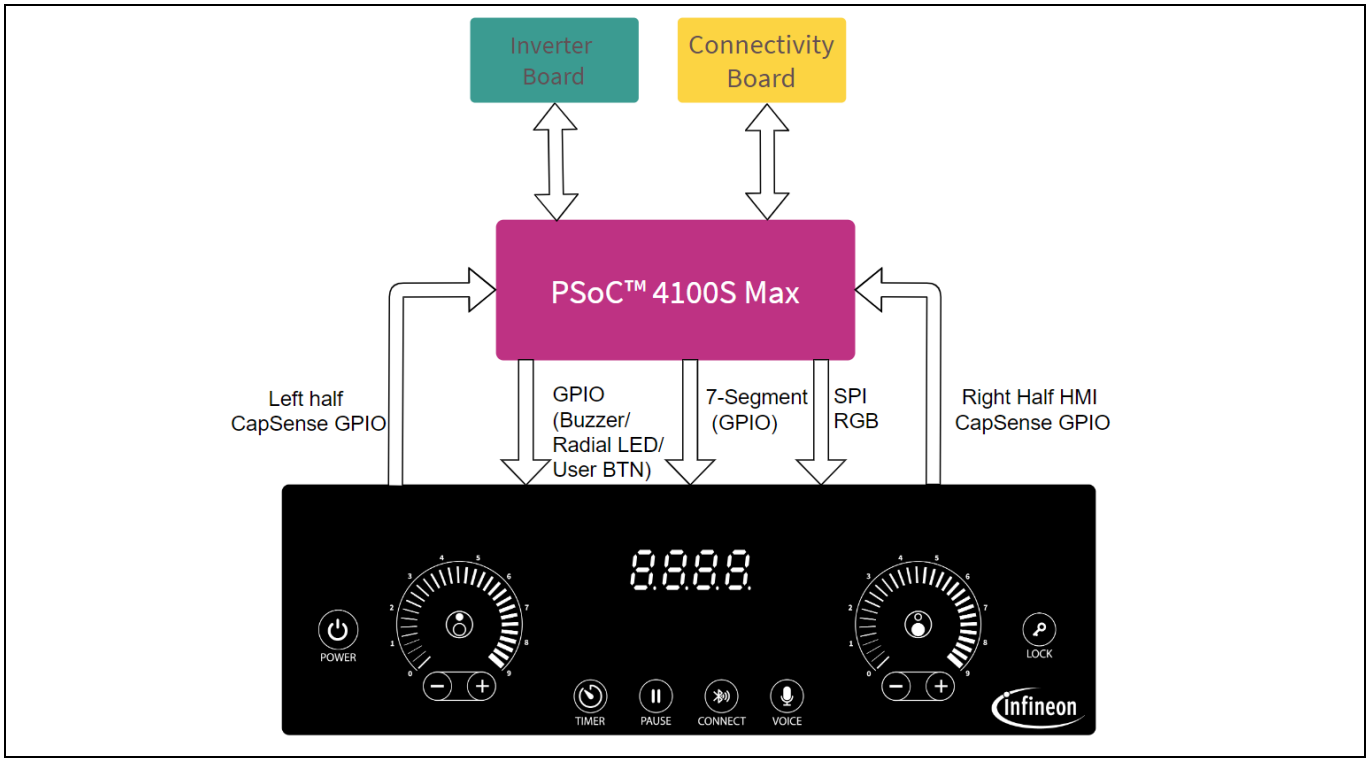


Figure 38 Block diagram of REF-SHA3K3IHWR5SYS-HMI

HMI & System Control Board is realized with a single PSoC™ 4100S MAX, a 128-Pin TQFP chip, which meets all the requirements of the touch interface controls for the two hob induction cooktop. The chip is integrated with the patented 5th generation CAPSENSE™ technology, and a high GPIO count to drive all the LEDs and a 7-segment display.

2.2.2 Interface details

The following figure show the functional groups on the top and bottom sides of the REF-SHA3K3IHWR5SYS-HMI board.

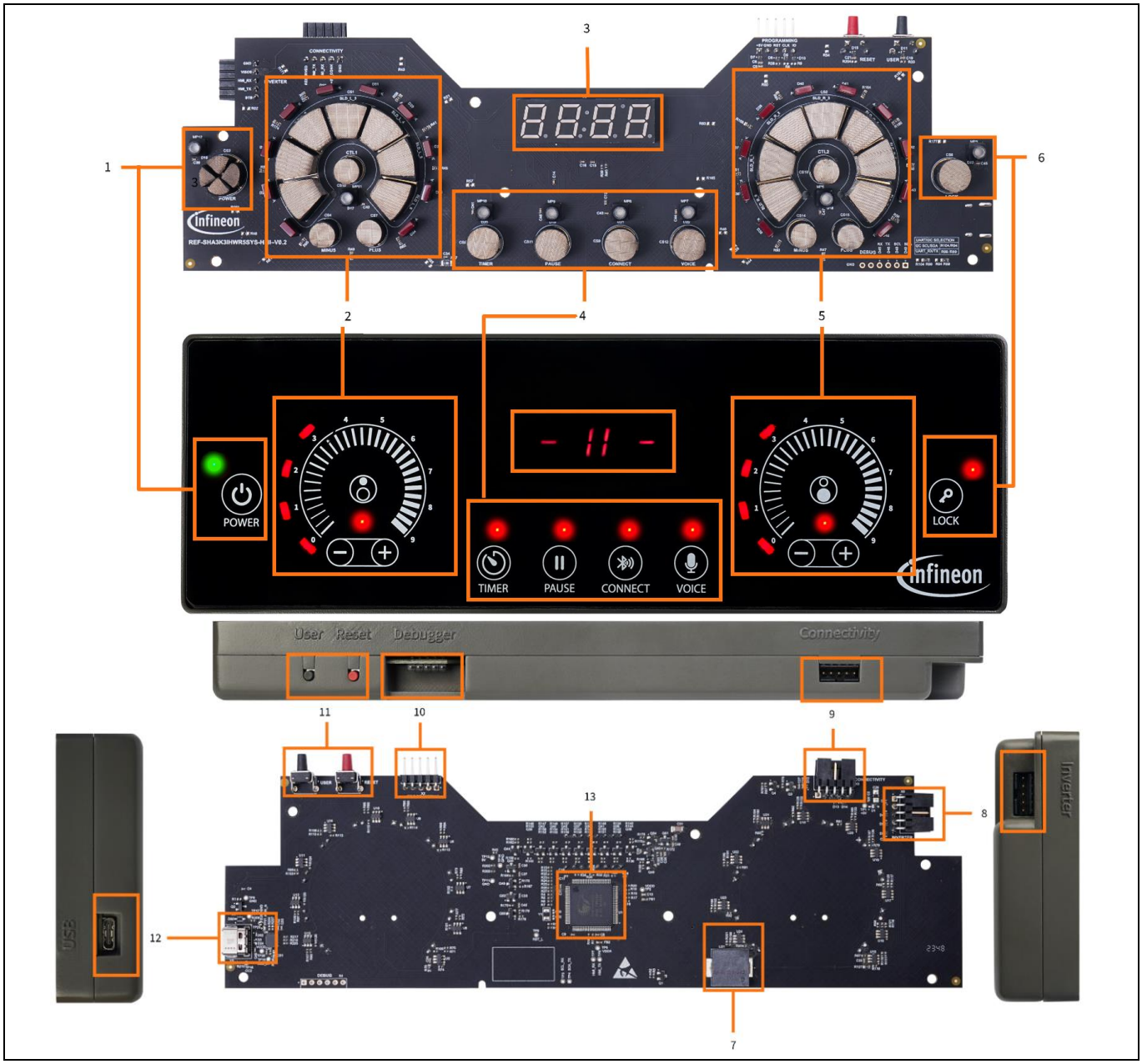


Figure 39 Functional groups of HMI & System Control Board with REF-SHA3K3IHWR5SYS-HMI PCBA Board (top and bottom)

1. System ON/OFF button with LED
2. Small induction hob control interface
3. 7-segment display for timer and status update
4. Features control button with LEDs – Timer, Pause, Connectivity, and Voice
5. Big induction hob control interface
6. Child safety lock
7. Buzzer
8. Input power from the Inverter Control Board with the UART interface
9. Output power for Connectivity Board with the UART interface
10. MiniProg4 debugger connection
11. User & reset buttons

12. USB to UART debug port with option to power unit
13. Main controller CPU – PSoC™ 4100S Max

2.2.3 Features

The REF-SHA3K3IHWR5SYS-HMI board is a full-fledged HMI control interface board based on PSoC™ 4100S MAX and 5th generation CAPSENSE™ to control a two-hob induction cooktop. The HMI Board integrates the PSoC™ 4, IEC 60730 Class B, and IEC 61508 SIL safety software library to make the system robust. HMI CAPSENSE™ interface is liquid tolerant, providing ease of use in a kitchen environment.

Major REF-SHA3K3IHWR5SYS-HMI characteristics include:

- Liquid tolerant CAPSENSE™ touch interface
- System level power ON/OFF control button enabling the complete system to be powered OFF when not in use.
  - This power ON/OFF button is realized using two CAPSENSE™ MSC blocks of PSoC™ 4100S Max to provide failsafe operation.
- Each induction hob has the following dedicated interface:
  - Touch the button to turn ON/OFF or select an induction hob
  - Horseshoe radial slide interface to select 10 levels of power
  - Multi-function +/- buttons to increment and decrement power level or auto-shutdown timer
- Touch the button to enable/disable features
  - Connectivity – Wi-Fi/BT
  - Local voice control via the Connectivity Board
- Touch button for child safety lock
- Buzzer to provide haptic feedback for touch operation and for alarm (timer expiry or error status)
- 7-segment display to display induction hob timer and status of induction hob.

For more details, refer to HMI & System control touch interface detailed usage.

2.2.4 Board parameters and technical data

Table 3 Ratings of major components

Parameter	Value	Unit
Power supply	5	V
Standby power	0.2	W
Parasitic capacitance of buttons/slider	9.7 to 21.8	pF
Buzzer volume	80	dB
Total number of CAPSENSE™ Sensors	27	Count

For more details on the HMI board design, refer to HMI Board architecture and design.

2.3 Connectivity Board

2.3.1 Block diagram

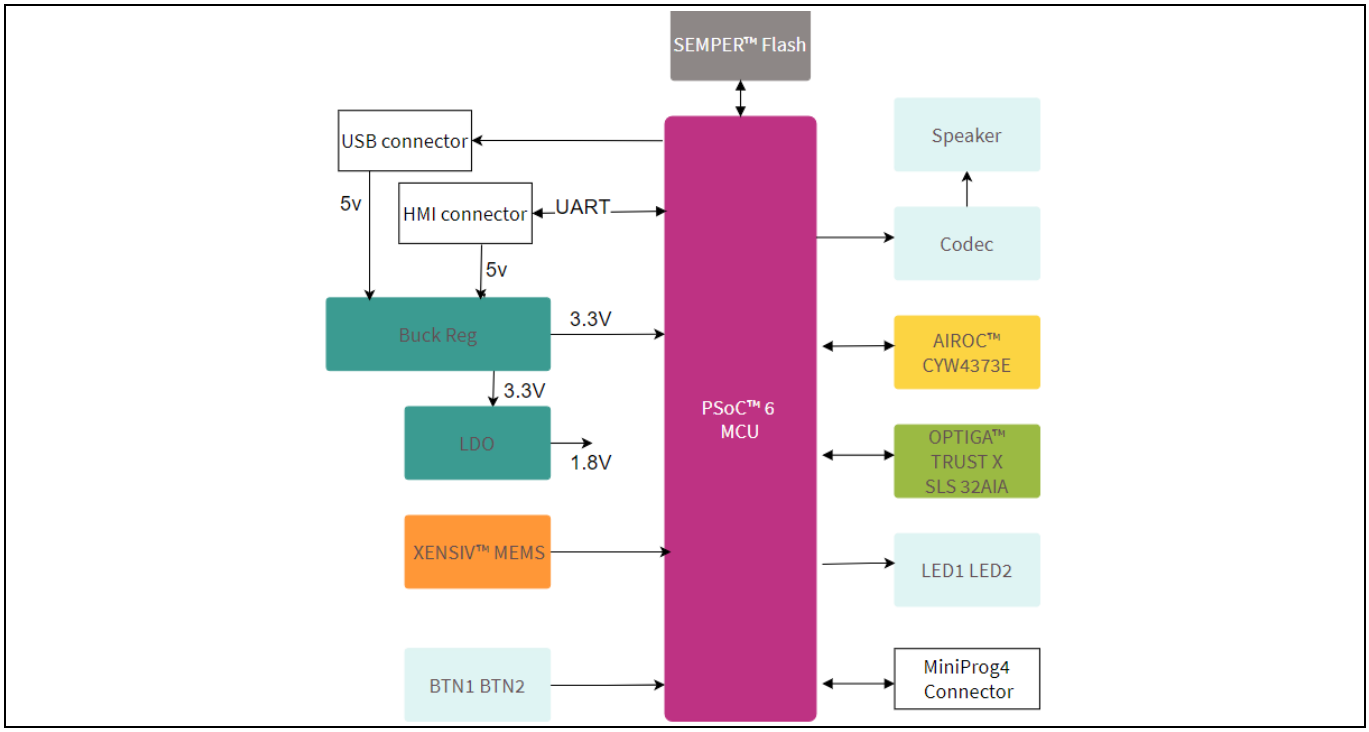


Figure 40 REF-SHA3K3IHWR5SYS-CON block diagram

Following are the key Infineon components of the Connectivity Board:

- 1x PSoC™ 6 MCU - CY8C624AAZI-S2D44
- 1x OPTIGA™ Trust M high-end security controller with I2C Interface - SLS 32AIA
- 1x 512 Mb SEMPER™ flash with Quad SPI - S25HL512TDPNHI010
- 2x High-performance digital XENSIV™ MEMS microphone - IM69D130V01
- 1x Laird LWB5+ M.2 module Wi-Fi/Bluetooth® combo with AIROC™ CYW4373E
- 1x OptiMOS™ small-signal-transistor
- 1x HEXFET™ power MOSFET
- 3x TVS diodes for bidirectional ESD protection
- 2x Silicon Schottky diodes

2.3.2 Interface details

The following figure shows the functional groups on the top side of the REF-SHA3K3IHWR5SYS-CON board.

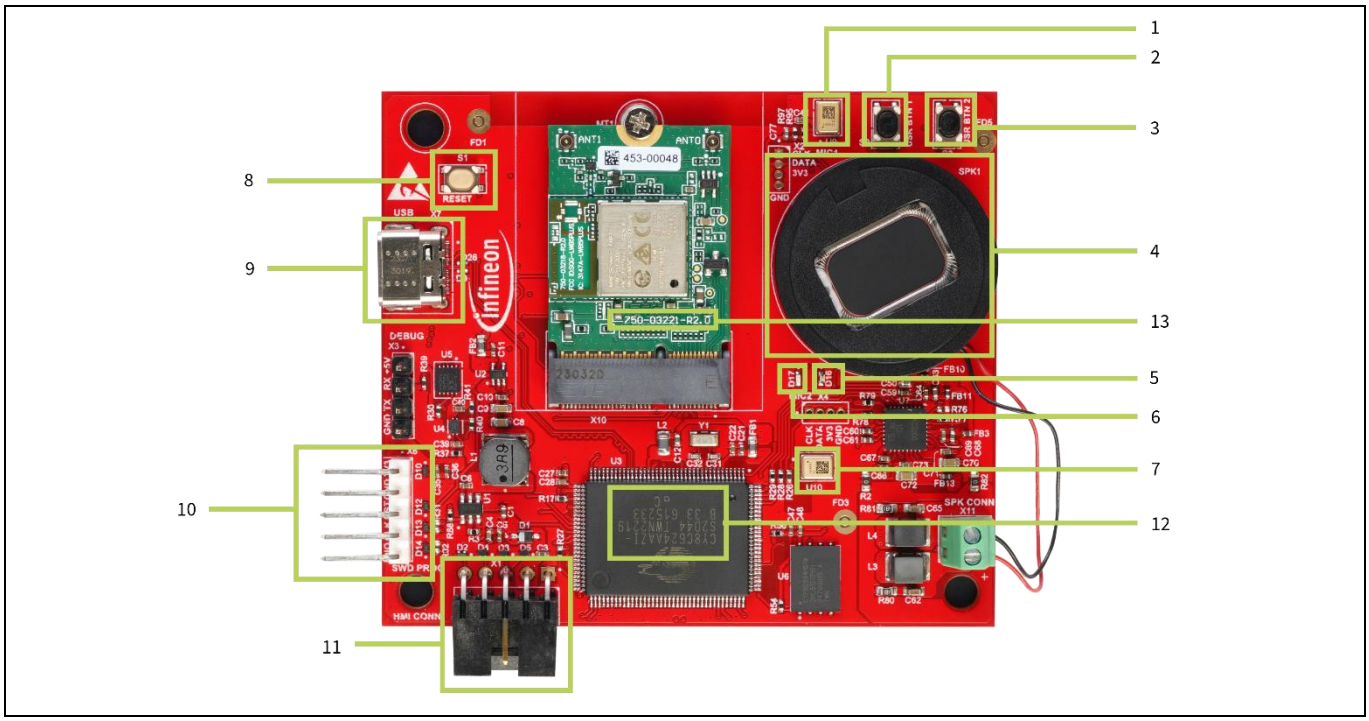


Figure 41 Functional groups of the REF-SHA3K3IHWR5SYS-CON

1. U9 - Digital mic to receive voice command
2. S2 - User button 1
3. S3 - User button 2
4. SPK1 - Speaker for voice command integration
5. D16 - Green LED to indicate Bluetooth® status
6. D17 - Red LED to indicate voice command processing
7. U10 - Digital mic for voice command reception
8. S1 - System reset button
9. X7 - USB port to debug UART or powering the board
10. X6 - PSoC™ 6 MiniProg4 header interface
11. X1 - HMI interface connector
12. U3 - PSoC™ 6 - CY8C624AAZI-S2D44
13. Laird LWB5+ M.2

2.3.3 Features

The REF-SHA3K3IHWR5SYS-CON board is the connectivity control board based on PSoC™ 6 with AIROC™ 4347E WiFi Bluetooth® combo module from Laird to provide reference for the IoT features. The Connectivity Board offers voice control by using Cyberon's offline edge voice processing on PSoC™ 6.

Major REF-SHA3K3IHWR5SYS-CON characteristics include:

- Wired protocol for robust communication with HMI & System Control Board and acts as a gateway between HMI & System Control Board to wireless interfaces – WiFi or Bluetooth® Low Energy
- Voice control using local machine learning from Cyberon on the MCU
- Works with the Infineon Induction Cooktop mobile application over Bluetooth® Low Energy interface over custom GATT characteristic table.
- The mobile application can control and monitor the induction cooktop with the following features:
  - Instant notifications for critical events of induction cooktop status – power level updates from touch or voice command, auto-shutdown timer, pan detection, IGBT temperature and surface temperature
  - Induction cooktop control:
    - Enable/disable voice connectivity
    - Induction cooktop individual hob control – power, auto-shutdown timer, boost mode.
    - Safety features like child lock/unlock, pause/resume, favourite configuration with choice of induction hob, power level, and auto-shutdown timer.

2.3.4 Board parameters and technical data

Board details:

Table 4 Ratings of major components

Parameter	Value	Unit
Power supply	5	V
Current	0.16	A
Bluetooth® Low Energy Range	20	m

For more details, refer to Connectivity Board architecture.

3 Inverter Control Board architecture and design

Induction cooktops usually have two board architecture for the power stage where one board performs the required EMI/EMC filtering for compliance and another board is dedicated for inverter functionality. Smart Induction Cooktop Reference Design Inverter Control Board integrates the EMI filter and tries to optimize the build cost.

3.1 Hardware architecture

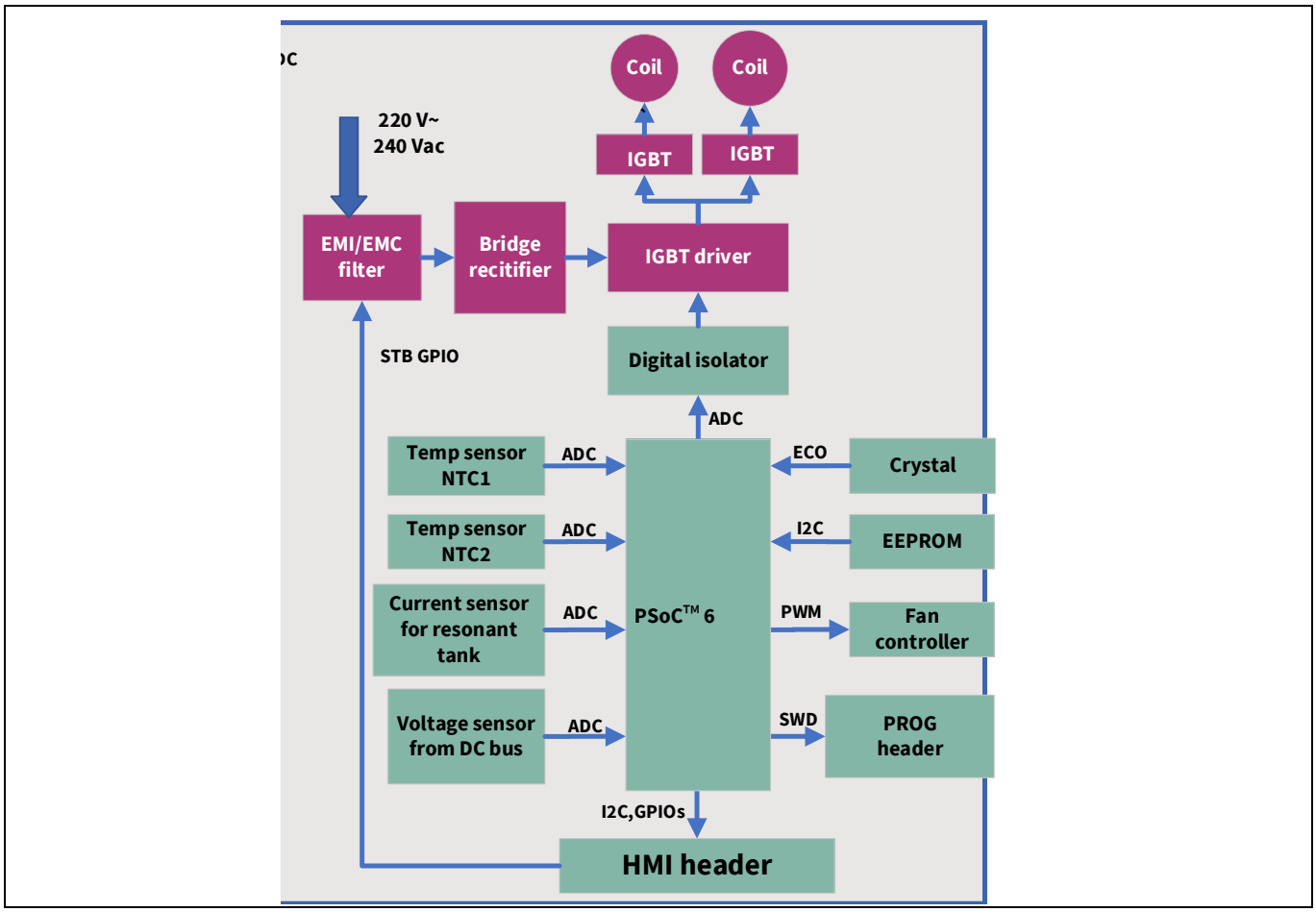


Figure 42 Detailed block diagram of the REF-SHA3K3IHWR5SYS-INV

3.1.1 AC supply

The inverter supports the input voltage ranging from 220 V to 240 V AC. And it generates the following auxiliary DC voltages:

- 24 V for cooling fan
- Isolated 5 V for HMI & System Control Board and Connectivity Board
- 3.3 V for inverter controller circuit
- 19 V for gate driver

3.1.2 Current sensor

The current sensor is used for pan detection, measuring coil current, and overcurrent detection.

Note: *TLI4971-A075T5-E0001 current sensor is used in the Inverter Control Board.*

3.1.3 Bridge rectifier

A bridge rectifier is used to convert the AC signal into a DC signal, which will be used to drive the board.

3.1.4 PSoC™ 62 family MCU

The CY8C6244AZI-S4D82 MCU is used in the Inverter Control Board to drive the firmware.

3.1.5 IGBT and gate driver

- IGBT is used as a switching device in the Inverter Control Board half bridge resonant circuit for high efficiency and
  high-voltage switching.
- In this half bridge circuit, the upper and the lower IGBTs are alternately connected generating an AC voltage with a peak voltage of the bus voltage (Vpeak approximate 310 V ~340 V), which is loaded into the resonant circuit composed of an induction coil(L) and a resonant capacitor.
- The AC current in the coil generates an alternating magnetic field, which is coupled with the cookware to induce eddy current inside the cookware and heat up the cookware.
- The switching frequency is used to excite the series LC resonant tank should be higher than its resonant frequency to keep the load in the inductive region to avoid hard commutation. The further away from the resonant frequency, the smaller the induced current. The heating power can be changed in this way.
- To drive the IGBT, PWM pulses are needed. So, the gate driver will give the PWM pulses to the IGBT.
- The Infineon 2ED21824S06J gate driver is used in the Inverter Control Board.
- Infineon IHW40N65R6 (IGBTs) are used in the Inverter Control Board.

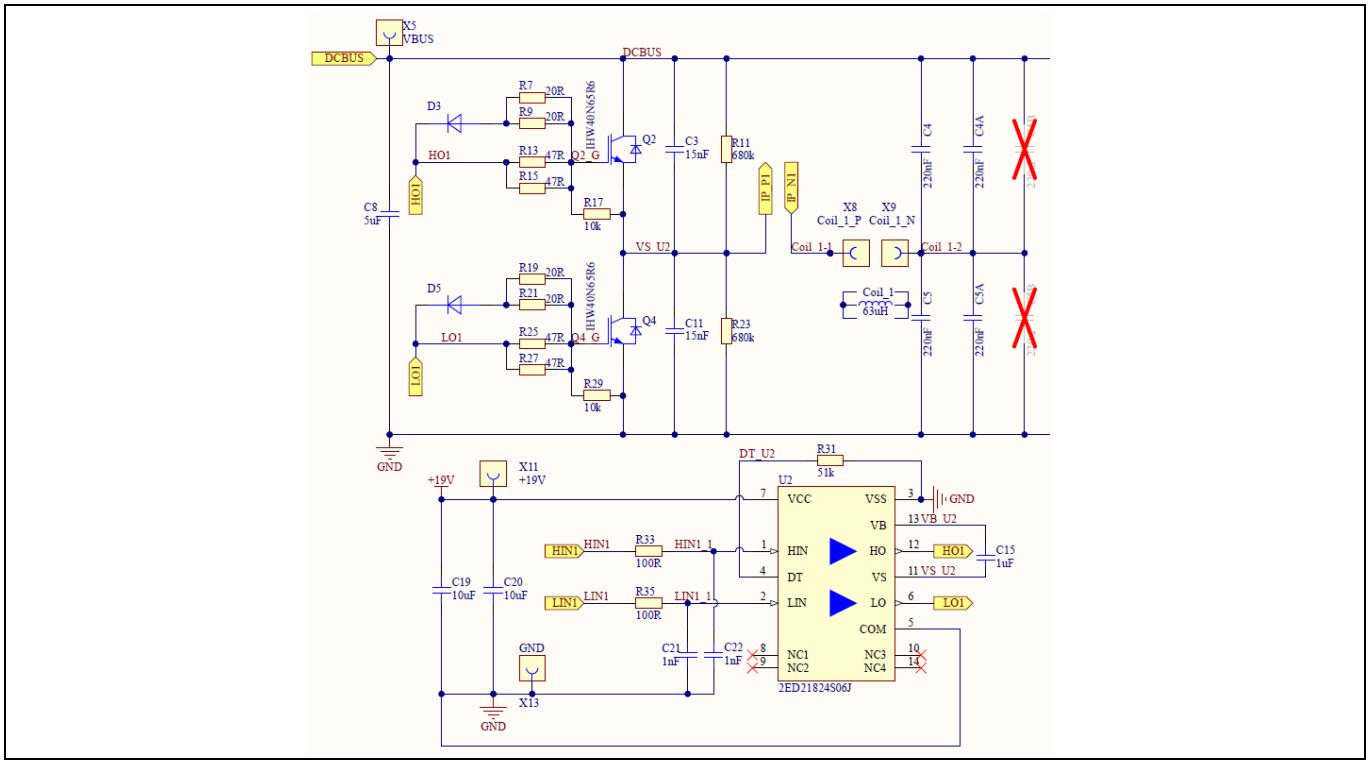


Figure 43 IGBT & Gate driver of REF-SHA3K3IHWR5SYS-INV small hob

3.1.6 Temperature sensor

100k ohms NTCs for pan/IH surface temperature measurement and 2k ohms for IGBTs are used.

3.1.7 DC bus voltage measurement

DC bus voltage is used to measure the voltage utilized for the energy consumption calculation process and for overvoltage detection.

3.1.8 Fan controller

The cooling fan is used to reduce the temperature of the IGBT to avoid any undesired fault conditions.

3.2 Firmware architecture

The Inverter Control Board firmware is intended for end customer usage; therefore it has been designed considering the following parameters:

- Compliant with ModusToolbox™ version 3.1 for delivering as reference example.
- Utilize all the tools provided by ModusToolbox™ for configuring the firmware and performance tuning
  - Device Configurator for GPIO allocation and configuration
  - Library Manager for dependency management
  - QSPI configurator for flash interface configuration

- The firmware uses a layered architecture style. This comprises an application layer, application middleware, a board support package (BSP) containing Hardware Abstraction Layer (HAL)/ Peripheral Driver Library (PDL), and peripheral drivers enabling reuse of the software
  - The BSP layer includes all the underlying libraries that are used by the Middleware. The PDL integrates device header files, startup code, and peripheral drivers into a single package. The HAL in combination with PDL leverages a more generic interface for the application.
  - The Middleware defines attributes related to the defined peripherals.

Application layers implement the features (i.e., application logic) and access the lower-level drivers/hardware via the application middleware API.

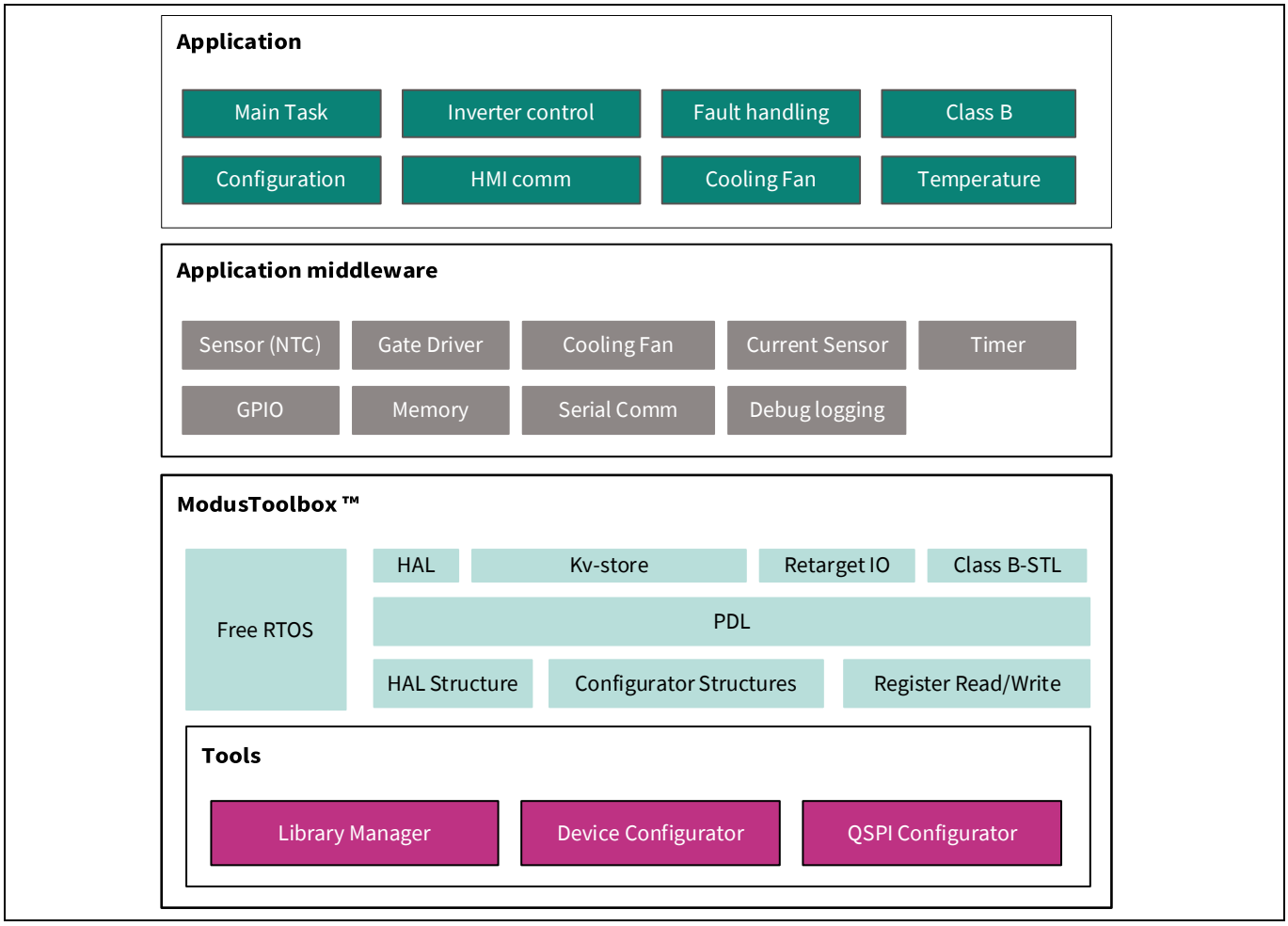


Figure 44 REF-SHA3K3IHWR5SYS-INV firmware layered architecture

3.2.1 Firmware flow diagram

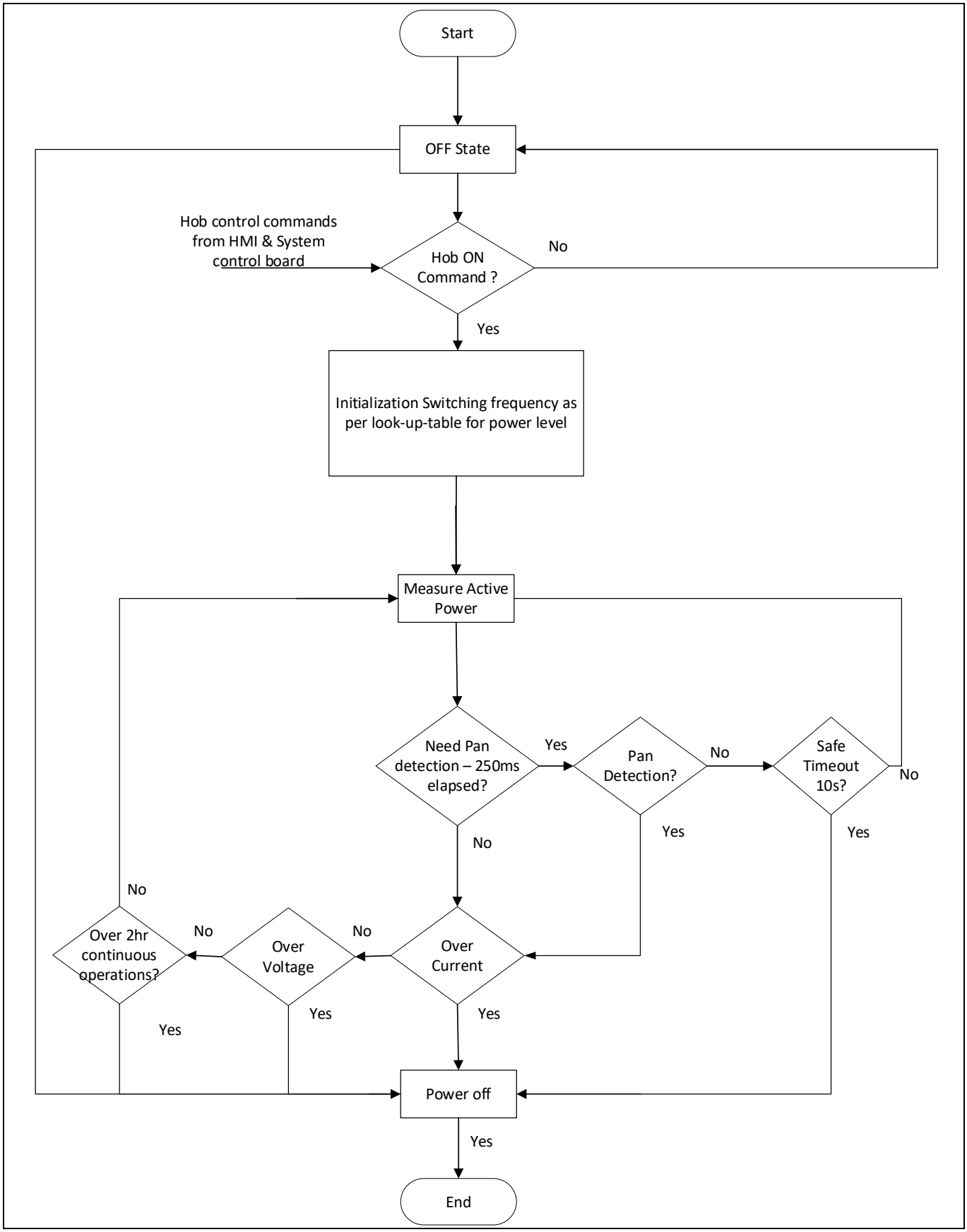


Figure 45 Inverter controller board firmware flow

3.3 Design highlights

3.3.1 Functional safety

Inverter firmware integrates a preliminary Class B library for PSoC™ 6 and realizes power-on self-test (POST) for CPU. Inverter firmware also has a safety auto-shutdown timer for continuous operations that go beyond 2 hours.

Current sensor monitors the resonant coil current and provides a hardware output signal for over current condition (OCD1_P1 – Coil 1, OCD1_P2 – Coil2), that can be used for turning off the DC supply of the resonant circuit at hardware level without any software latency.

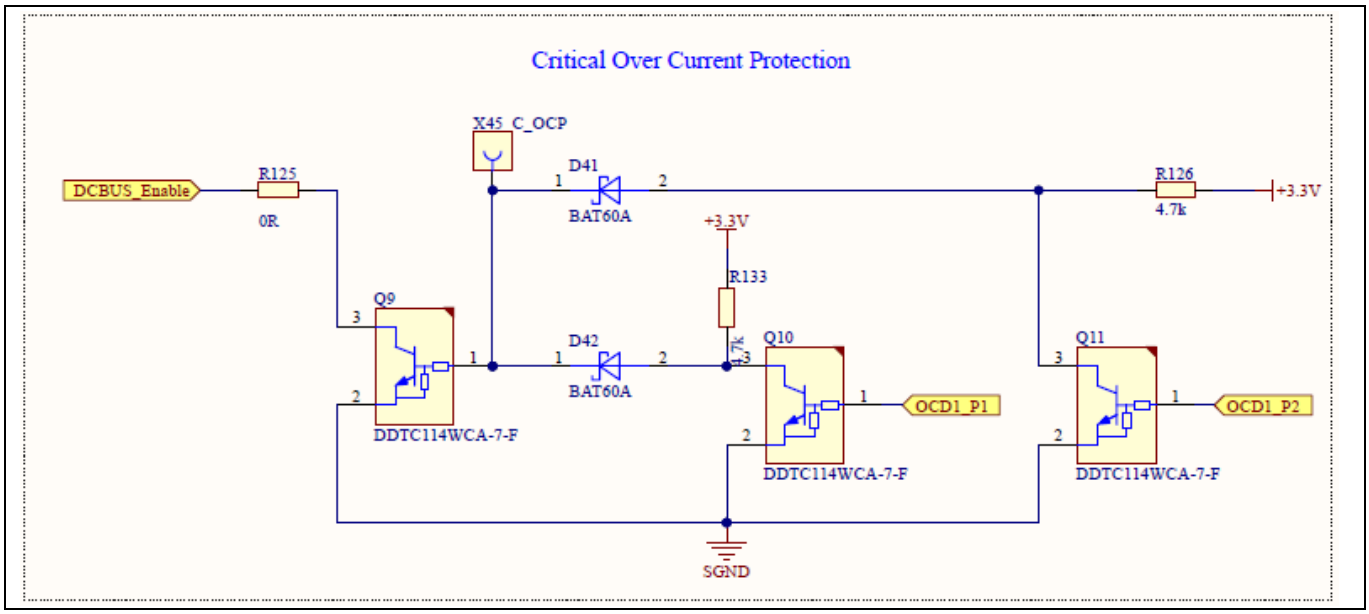


Figure 46 Hardware safety control circuit for overcurrent protection

3.3.2 Current sensor

Figure 47 shows the current sensor circuit for one of the coils with hardware overcurrent protection driving signal (OCD1_PX).

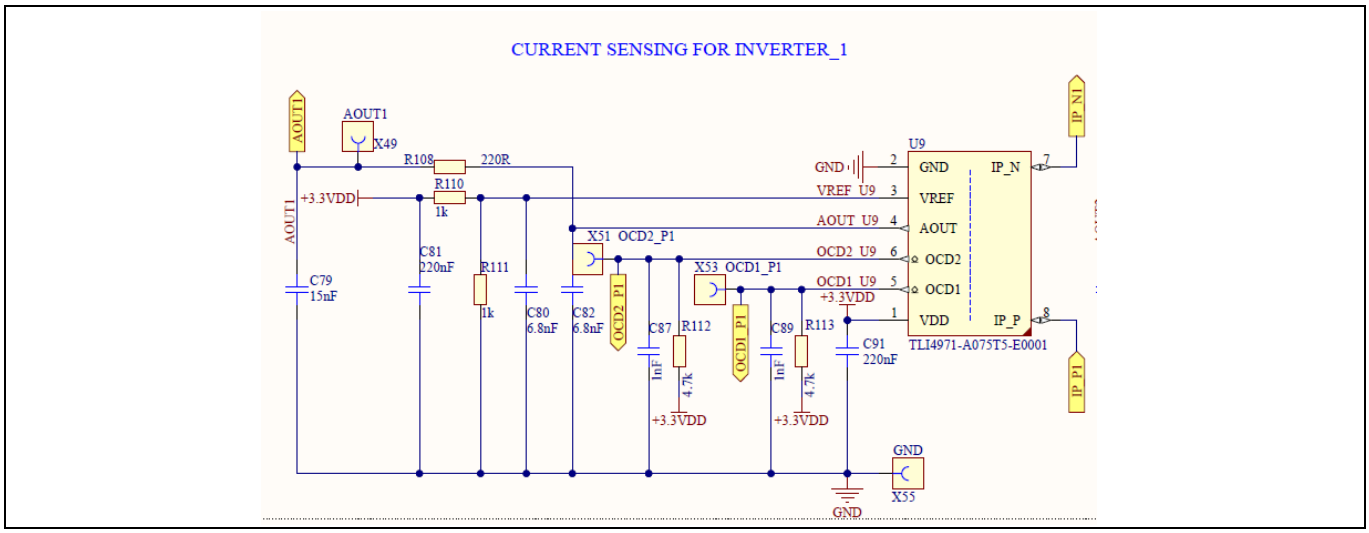


Figure 47 Current sensor circuit for small induction hob

Both the coils have a common current sensor configuration. The following table provides details for each of the current sensor EEPROM configuration.

Parameter	Value
Mode	Single-Ended
Sensitivity	48 mV/A (LSB: 24)
Full Scale Current Range	± 25 A
OCD1 Enable	Yes (1)
OCD2 Enable	Yes (1)
OCD1 Threshold	1.25 * 25 A (0x07)
OCD1 Deglitch Filter	500 ns (0x01)
OCD2 Threshold	0.61 * 25 A (0x06)
OCD2 Deglitch Filter	0 ns (0x00)
Comp Hysteresis	0x03

The output waveform of TLI4971 in a single ended configuration is in the form of raw voltage sine wave in millivolts with an offset equivalent of Vref/2.

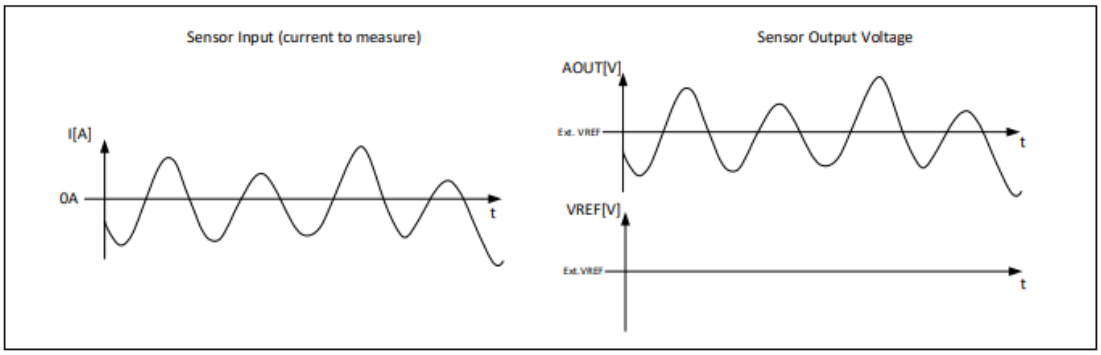


Figure 48 Current sensor Aout signal

The following table provides the PSoC™ 6 ADC configurations for each of the current sensor.

Table 5 ADC configuration used for Induction Hob Current Sensors

Parameter	Value
ADC Channel	SAR ADC 1 Channel 0, 1 (P10.0, P10.1)
Resolution	+2047 /-2048 (2^{12}-1)
V_{ref}	Internal 3.3 V (V_{dda})
V_{ref} Bypass	True
Target Scan Rate	2000000 sps
Achieved Scan Rate	925926 sps
Achieved Scan Duration	1.08 us
Clock	Peripheral Clock Divider (8-bit Divider-1)
Clock Frequency	33.33 MHz (±2.4%)
V_{neg} for Single-Ended Channels	V_{ssa}
Differential Result Format	Signed

Parameter	Value
Single Ended Result Format	Signed
Samples Averaged	2
Scans per Trigger	Single Scan
Averaging Mode	Sequential, Fixed
Minimum Acquisition Time	83 ns
Achieved Acquisition Time	90 ns
Achieved Sample Time	540 ns

3.3.2.1 Current sensor programming

On receiving the new current sensor programming files or if the customer would like to experiment with current sensor limits, do the following to program the configuration files.

Hardware requirements:

- XENSIV™ - TLI4971, TLE4972 current sensor programmer utility board
- Jumper wires – 10 female to female jumper wires

Software requirements:

- XENSIV™ TLx4971 – TLE4972 Current Sensor Programmer app

Do the following:

1. Set switch S1 to enter the current sensor programming mode.

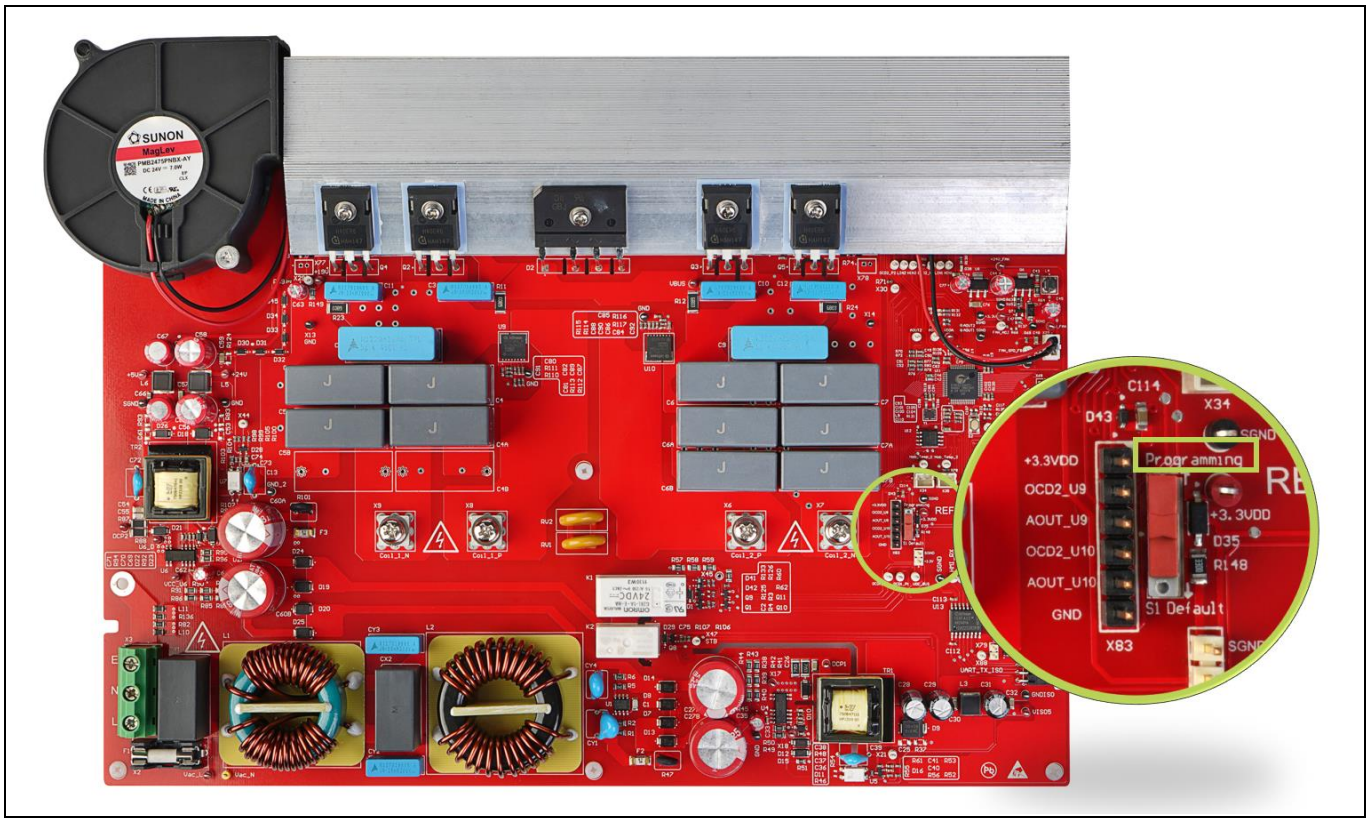


Figure 49 Inverter Control Board switch settings for current sensor programming

2. Without powering the Inverter Control Board, perform the connections of the Inverter Control Board with the Current Sensor Programmer Kit Board.

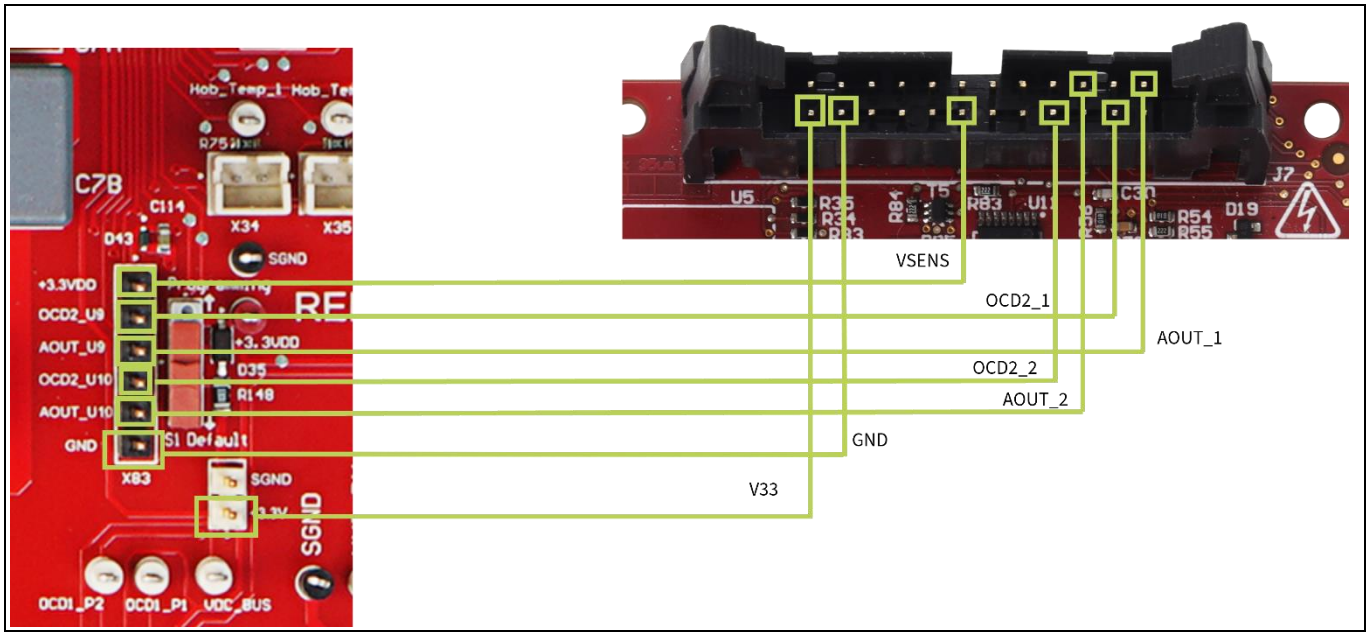


Figure 50 Inverter Control Board current sensor programmer connection diagram

Sl. no.	Inverter Control Board header pin connection (X83)	Current Sensor Programmer DUT pin connection
1	AOUT_U9(Pin3)	AOUT1(Pin1)
2	OCD2_U9 (Pin2)	OCD2_1(Pin4)
3	AOUT_U10(Pin5)	AOUT2 (Pin5)
4	OCD2_U10 (Pin4)	OCD2_2(Pin8)
5	+3.3VDD(Pin1)	VSENS(Pin14)
6	GND(Pin6)	GND (Pin 20)

3. Launch the XENSIV™ TLx4971 – TLE4972 Current Sensor Programmer application and click **Connect to the selected programmer** and select the TLI4971 sensor.

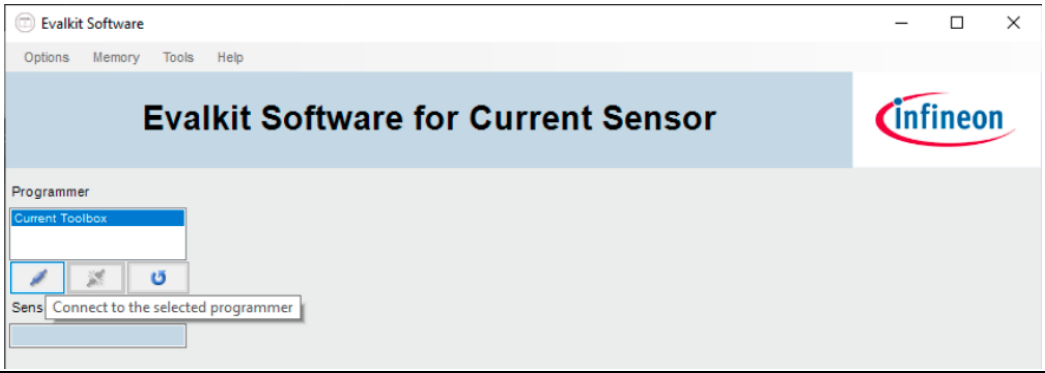


Figure 51 Current Sensor Evaluation Kit GUI

The sensitivity settings window will open.

4. Click **Set**.
5. Open EEPROM Map from Memory tab.

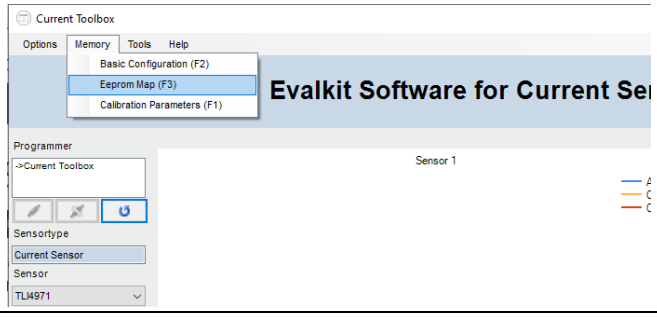


Figure 52 EEPROM Map selection

6. Click **Load** on the EEPROM Mapping window.

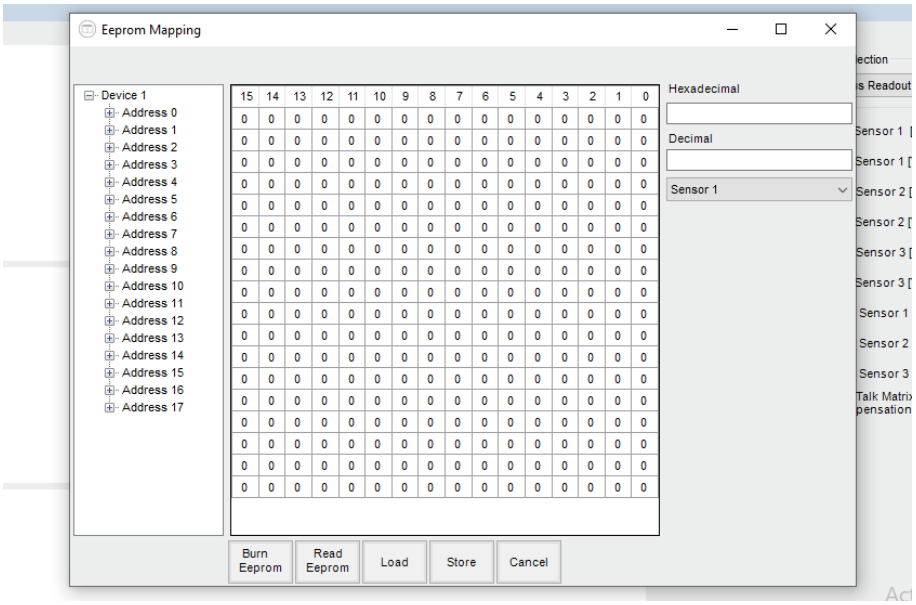


Figure 53 Load *EEPROM.XML* file

7. Browse to the location where the XML file "*Current_Sensor_xxx.xml* " is stored. Select the XML file to start programming the EEPROM.

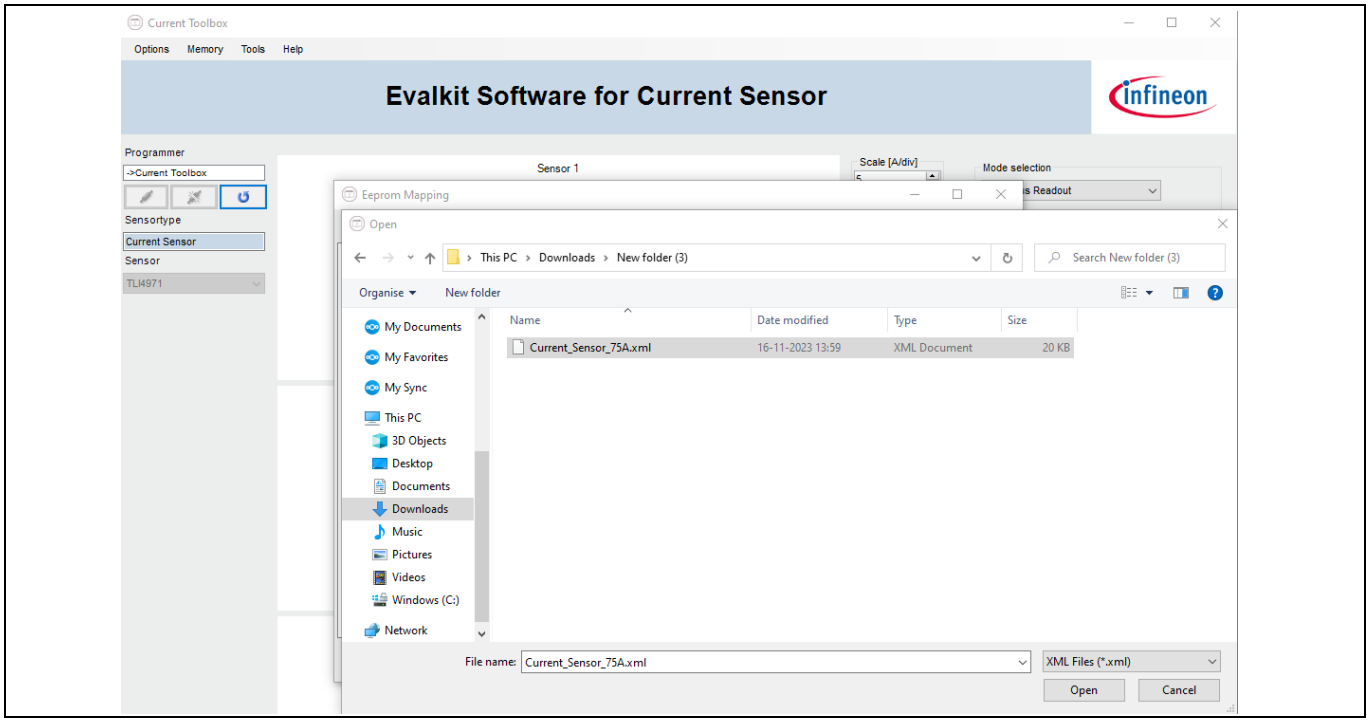


Figure 54 File selection for programming the current sensor

8. Select **Sensor 1** and then click **Burn EEPROM**.

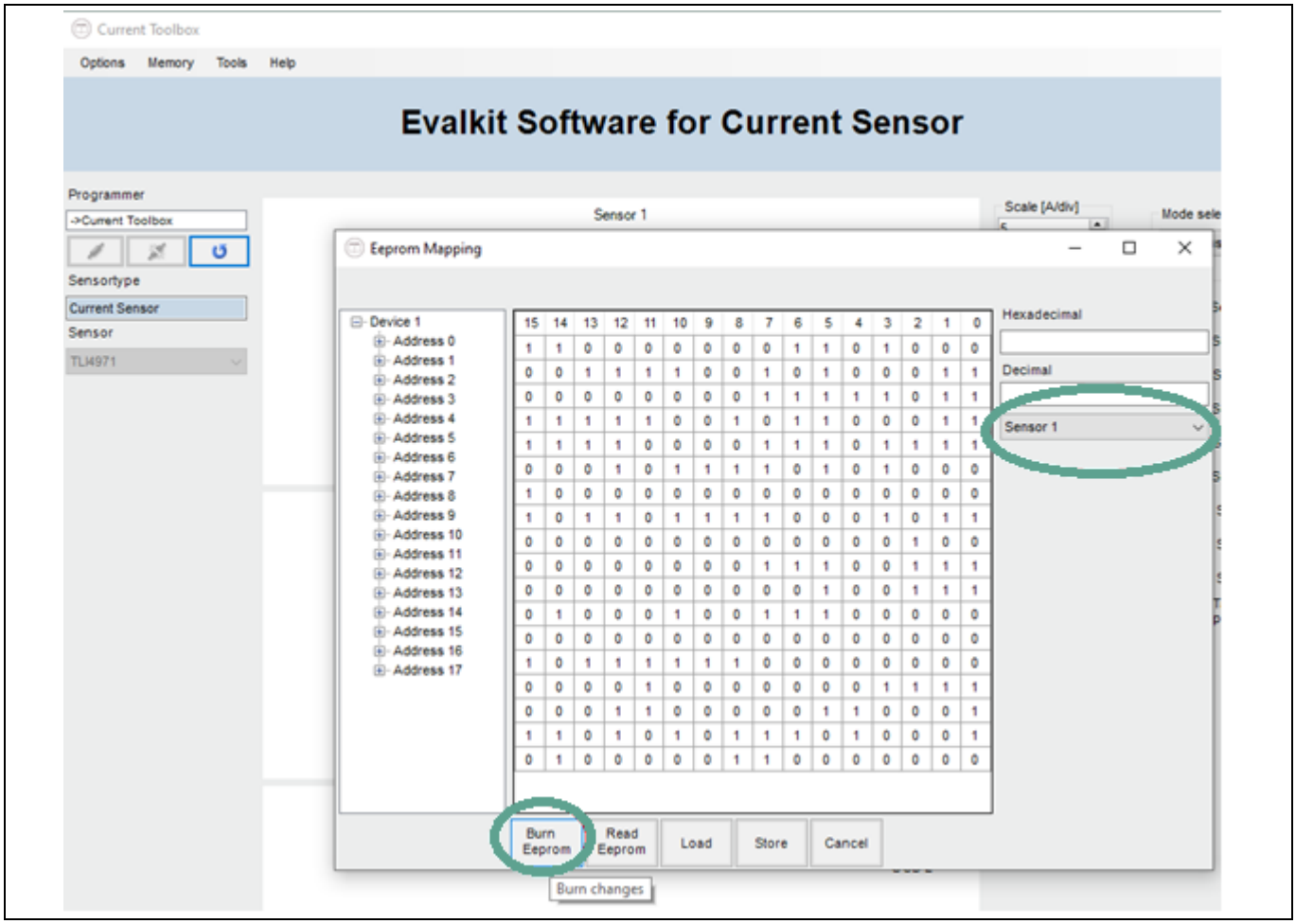


Figure 55 Current sensor programming for Current Sensor 1

On successful programming, you will get the ***Finished Burning EEPROM*** message.

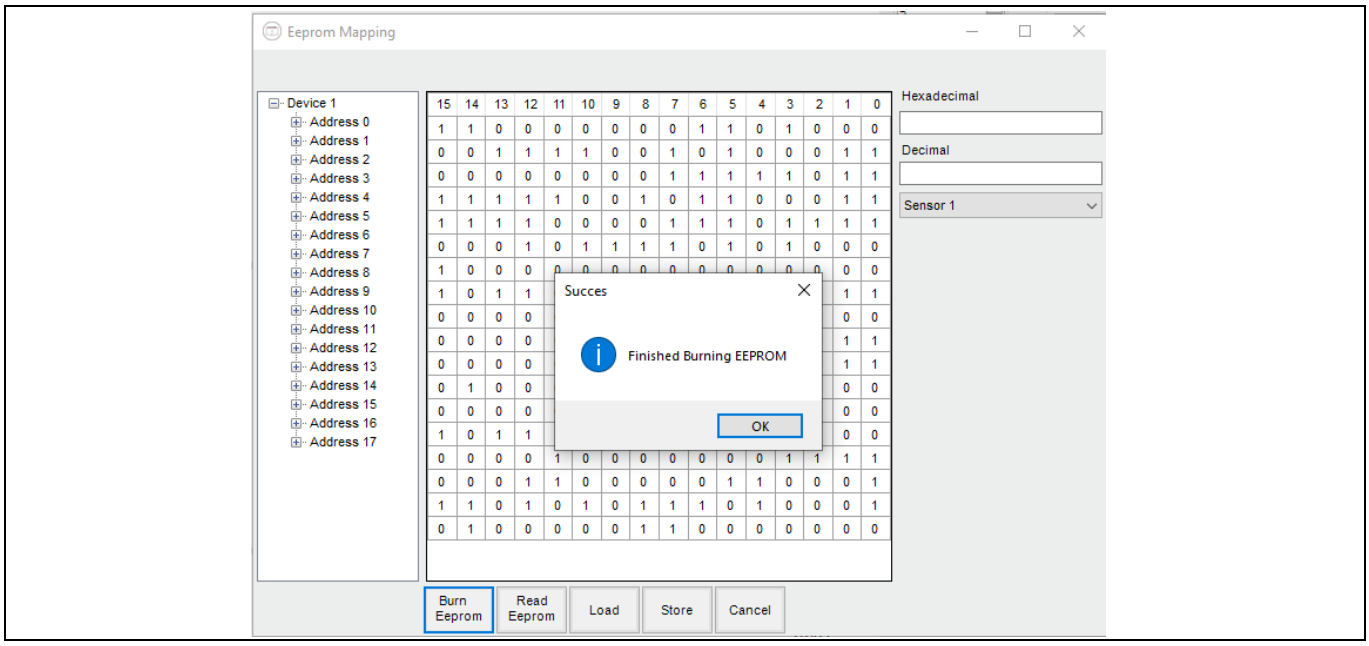


Figure 56 Current sensor successful programming

9. Follow the same procedure with Sensor 2.

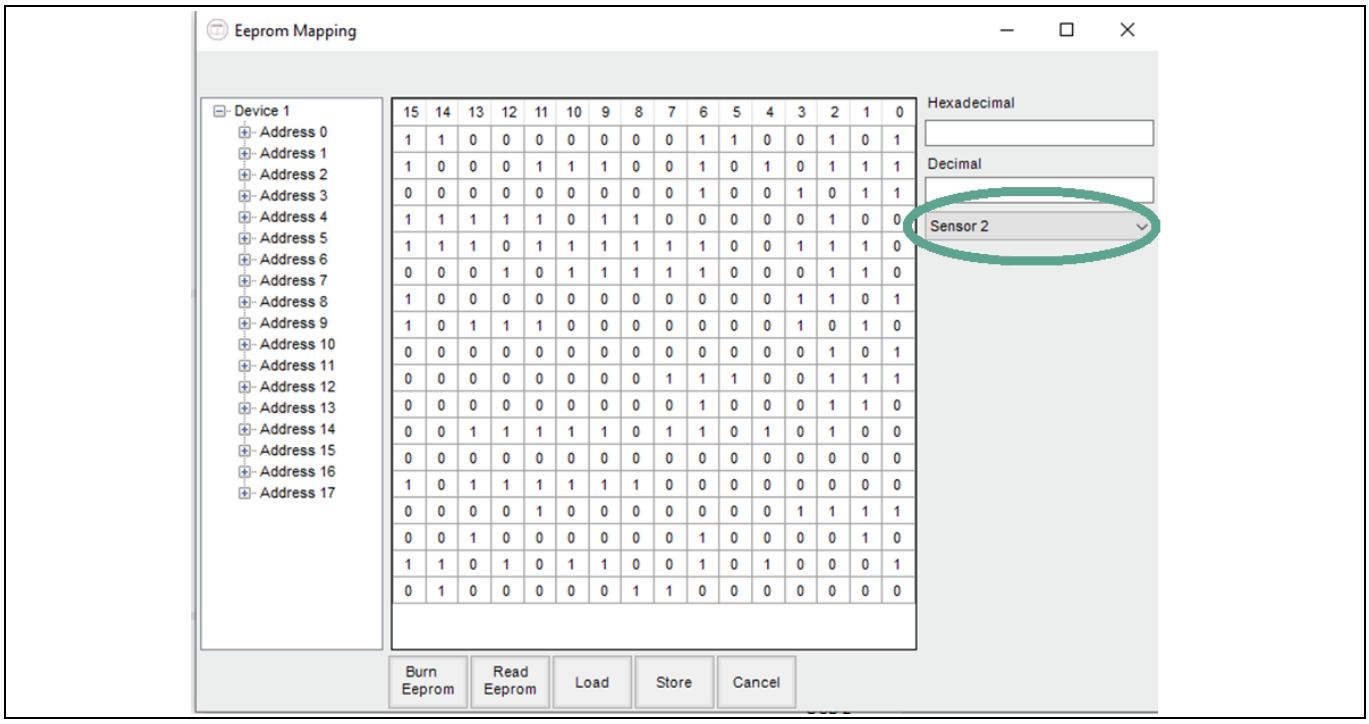


Figure 57 Current sensor 2 program selection

10. After finishing the programming, remove the connections and toggle the programming switch to the default position.

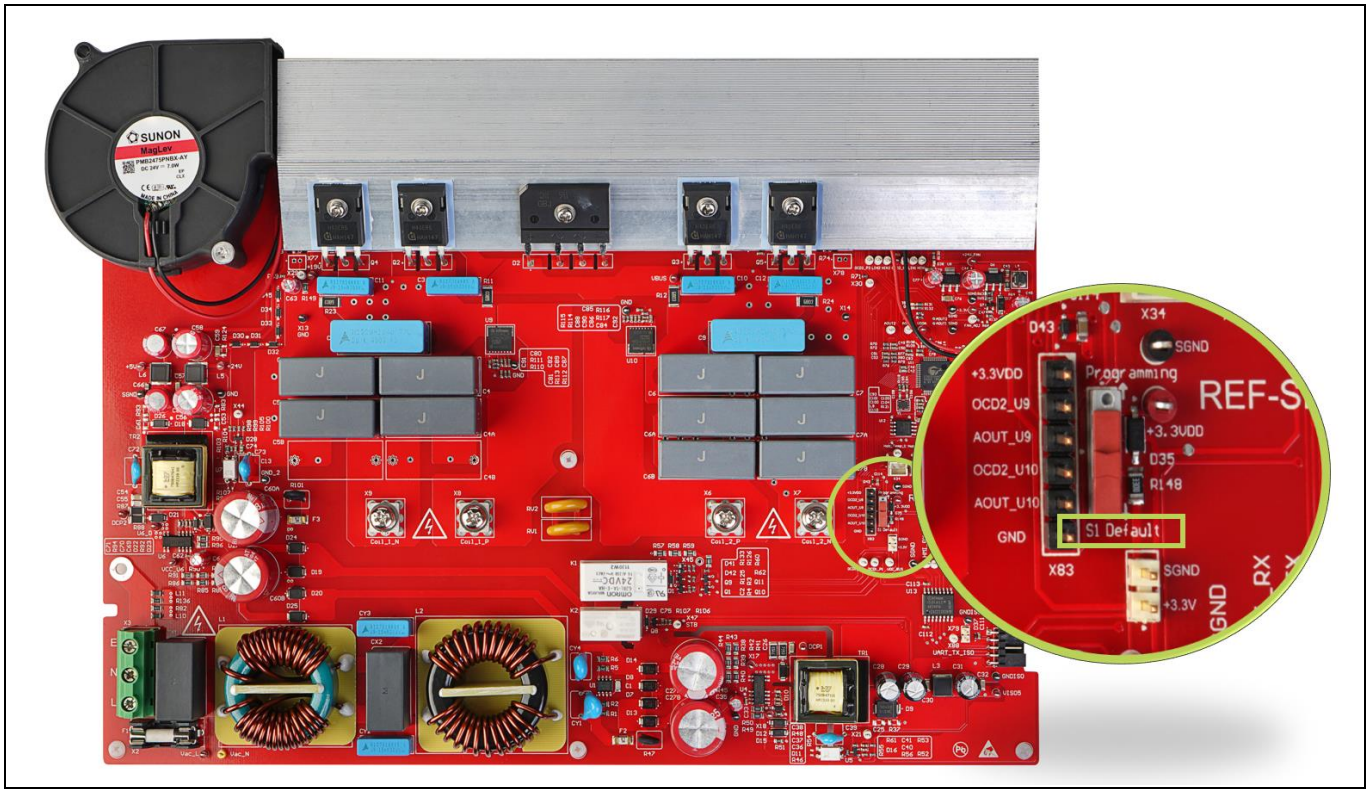


Figure 58 Inverter Control Board current sensor default mode switch setting

3.3.3 Pan detection

The pan detection feature checks for the presence or absence of a pan periodically and automatically shuts down the induction cooktop hob if the pan is not detected within 10 seconds. If a pan is not properly aligned or of the wrong size or material, it indicates as pan absent.

3.3.3.1 Pan detection algorithm

Phase shift of the coil current with respect to the coil voltage is used as a method to distinguish between the pan absence and presence. The period between the rising edge interrupt of high side IGBT PWM pulse and comparator interrupt upon detection of zero crossing is used to detect whether the pan is present or absent. Here, an opamp works in the comparator configuration with V+ as AOUT and V- as 1.65 V. The typical count range for pan detection is less than pan absence as the power factor becomes close to 0 and phase shift close to 90 degrees.

3.3.3.2 Threshold values for pan detection

In the Inverter Control Board firmware, pan detection is performed every 500 ms for each induction hob when both induction hobs are powered on and every 250 ms if only one induction hob is powered on. Pan detection is performed by calculating the timer counts of time elapsed between the high side IGBT PWM rising edge interrupt and the comparator zero crossing interrupt. A zero-crossing count limit is defined for each power level of an individual induction hob for determining the threshold for pan detection.

3.3.4 Boost mode

Boost mode is a mode where each induction hob will deliver more than the rated default maximum power.

Induction hob	Rated max power	Boost mode power
Small	1400 W	2000 W
Big	2200 W	3000 W

The Inverter Control Board supports boost mode for one induction hob at a time with simultaneously allowing other induction hob to be operational without exceeding a total induction cooktop power of 3600 W.

Increasing power increases the current through the IGBT and increase in thermal dissipation. R6 IGBT's superior-reliable thermal performance allows it to be operated at higher temperatures for fixed time based on the system thermal design. The Inverter Control Board thermal design allows the small induction hob to run in boost mode for 3 mins and the big induction hob to run in boost mode for 2 mins.

3.3.5 HMI & system control UART communication

The HMI UART communication uses the UART HDLC protocol that ensures data integrity for exchanging over UART physical interface.

3.3.5.1 Command payload

HMI & System Control Board provides commands to the Inverter Control Board via the following data structure:

Byte	0	1	2	3 to 29	30-31
Data	0x5A	0x01	0x1B	Payload	CRC16

Bytes	Feature	Description
Byte 3	Big hob	Turn ON/OFF big hob
Byte 4	Small hob	Turn ON/OFF small hob
Byte 5	Big hob power level	Set power level for big hob
Byte 6	Small hob power level	Set power level for small hob

3.3.5.2 Status payload

Byte	0	1	2	3-29	30, 31
Data	0x5A	0x02	0x1B	Payload	CRC16

Bytes	**Feature**	**Description**
Byte 3	Non recoverable error part 1(bit field)	**Bit field** / **Description** 0 – Temperature sensor error 1 – Current sensor error 2 – Over Current Hob 1 3 – Over Current Hob 2 4 – Over Voltage

<table>
<tr><th>Bytes</th><th>Feature</th><th>Description</th></tr>
<tr><td>Byte 4</td><td>Non recoverable error part 2(bit field)</td><td>
<table>
<tr><th>Bit field</th><th>Description</th></tr>
<tr><td>0</td><td>Over Temperature IGBT Hob 1</td></tr>
<tr><td>1</td><td>Over Temperature IGBT Hob 2</td></tr>
<tr><td>2</td><td>Over Temperature Coil Hob 1</td></tr>
<tr><td>3</td><td>Over Temperature Coil Hob 2</td></tr>
</table>
</td></tr>
<tr><td>Byte 5</td><td>Device status (bit field)</td><td>
<table>
<tr><th>Bit field</th><th>Description</th></tr>
<tr><td>0</td><td>HMI & System Control Board & Inverter Control Board communication status</td></tr>
<tr><td>1</td><td>HMI & System Control Board & Connectivity Board communication status</td></tr>
<tr><td>2</td><td>Class B POST status</td></tr>
<tr><td>3</td><td>Class B period status test</td></tr>
<tr><td>4</td><td>Cooling fan status</td></tr>
<tr><td>5</td><td>Inverter Control Board standby power relay status</td></tr>
<tr><td>6</td><td>Inverter Control Board half bridge DC bus relay status</td></tr>
</table>
</td></tr>
<tr><td>Byte 6</td><td>Warning (bit field)</td><td>
<table>
<tr><th>Bit field</th><th>Description</th></tr>
<tr><td>0</td><td>Auto-shutdown due to big hob surface over-temperature</td></tr>
<tr><td>1</td><td>Auto-shutdown due to small hob surface over-temperature</td></tr>
<tr><td>2</td><td>Auto-shutdown due to big hob IGBT over-temperature</td></tr>
<tr><td>3</td><td>Auto-shutdown due to small hob IGBT over-temperature</td></tr>
<tr><td>4</td><td>Auto-shutdown due to safety (2 hrs continuous operation)</td></tr>
</table>
</td></tr>
<tr><td>Byte 7</td><td>Reserved field</td><td></td></tr>
<tr><td>Byte 8</td><td>Residual heat indicator- Hob 1</td><td>Residual heat indicator:0/1</td></tr>
<tr><td>Byte 9</td><td>Residual heat indicator- Hob 2</td><td>Residual heat indicator:0/1</td></tr>
<tr><td>Byte 10</td><td>Pan detected- Hob1</td><td>Pan detect: 0/1</td></tr>
<tr><td>Byte 11</td><td>Pan detected- Hob2</td><td>Pan detect: 0/1</td></tr>
<tr><td>Byte 12</td><td>Hob active- Hob1</td><td>Hob 1 ON/OFF</td></tr>
<tr><td>Byte 13</td><td>Hob active- Hob2</td><td>Hob 2 ON/OFF</td></tr>
<tr><td>Byte 14</td><td>Power level- Hob1</td><td>Power level (0-10)</td></tr>
<tr><td>Byte 15</td><td>Power level- Hob2</td><td>Power level (0-10)</td></tr>
</table>

Bytes	Feature	Description
Byte 16	IGBT temperature - Hob1	IGBT temperature Hob 1 (x°- y°)
Byte 17	IGBT temperature - Hob2	IGBT temperature Hob 2 (x°- y°)
Byte 18	Surface temperature - Hob1	Surface temperature Hob 1 (x°- y°)
Byte 19	Surface temperature -Hob2	Surface temperature Hob 2 (x°- y°)
Byte 20	Supply current -Hob1	Supply current Hob 1
Byte 21	Supply current -Hob2	Supply current Hob 2
Byte 22	Power watt LSB- Hob1	Hob 1 power (x W)
Byte 23	Power watt MSB- Hob1	
Byte 24	Power watt LSB- Hob2	Hob 2 power (x W)
Byte 25	Power watt MSB- Hob2	

Note: *Hob 1 is referred as the small hob and Hob 2 is referred as the big hob*

4 HMI & System Control Board architecture and design

4.1 Hardware architecture

Figure 59 shows the block diagram of the HMI & System Control Board with the PSoC™ 4 peripheral usage and HMI touch overlay design.

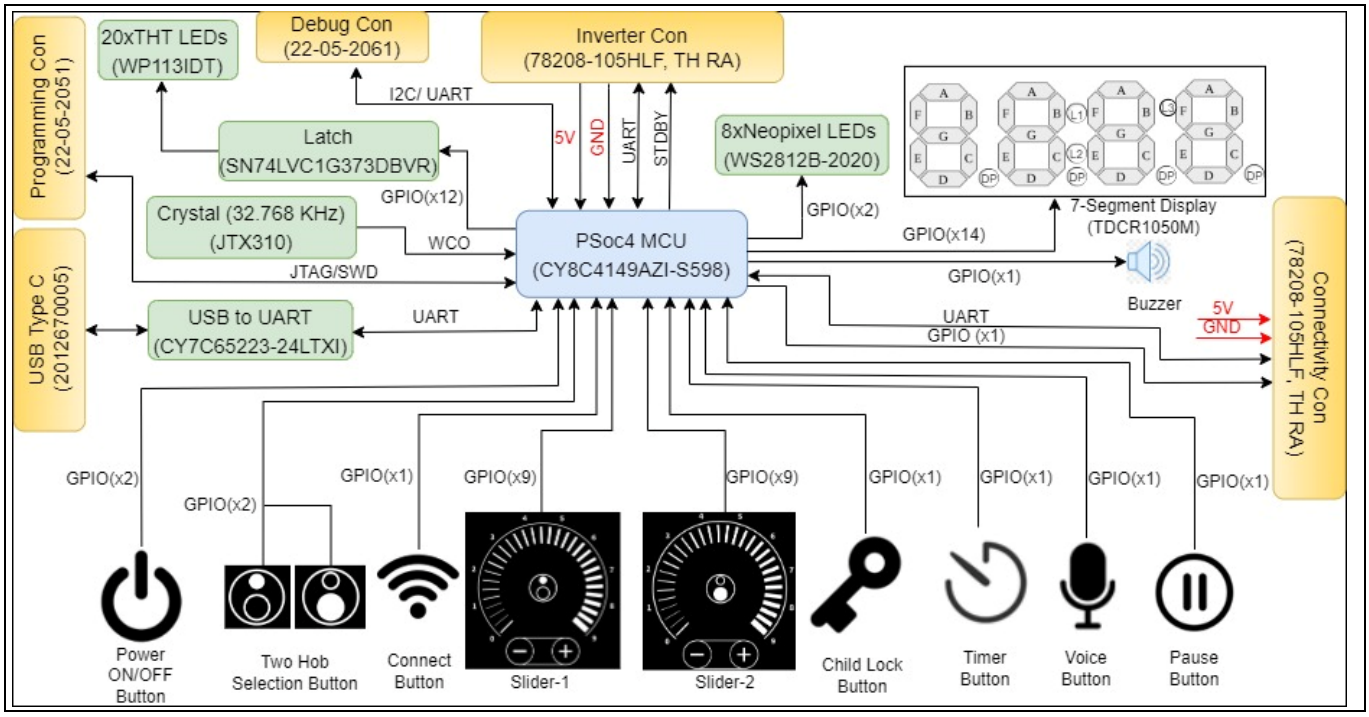


Figure 59 Detailed block diagram of the REF-SHA3K3IHWR5SYS-HMI

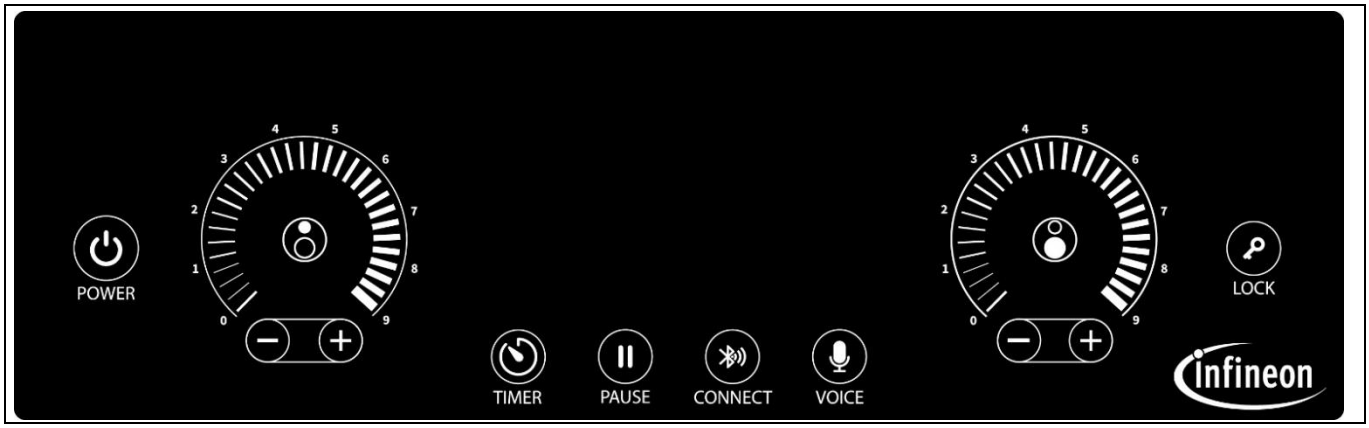


Figure 60 REF-SHA3K3IHWR5SYS-HMI PCBA with induction cooktop complaint glass overlay

PSoC™ 4100S Max powers the HMI & System Control Board. Its large GPIO count (TQFP-100 package), can realize all the required input interfaces, drive 7-segment display, buzzer, and button LEDs. CAPSENSE™ is supported in PSoC™ 4100S Max via the MSC CAPSENSE™ block. There are two independent MSC blocks in it, which can be used to realize a functional safety-compliant HMI input interface without requiring an additional controller. Each MSC CAPSENSE™ block can support up to 16 sensors enabling full-fledged HMI to be realized for a dual induction hob configuration induction cooktop HMI touch interface.

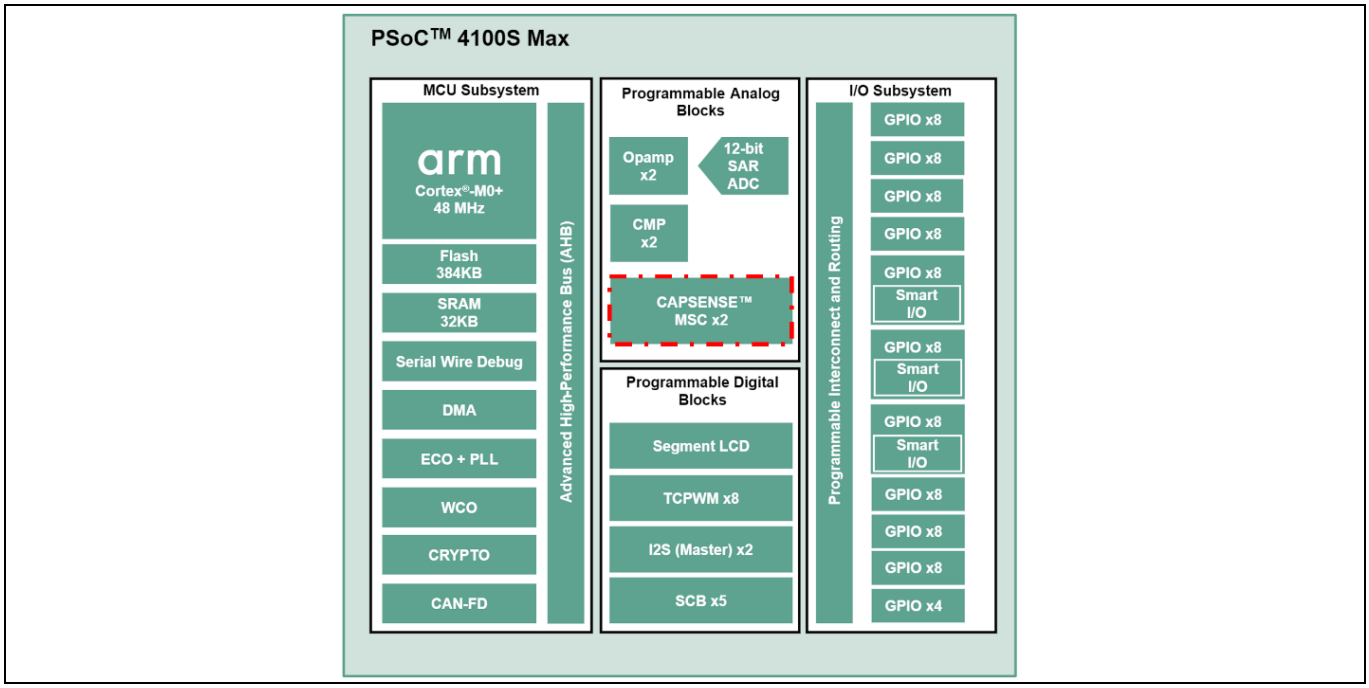


Figure 61 PSoC™ 4 S Max dual CAPSENSE™ MSC

4.1.1 Power supply

The HMI & System Control Board runs on a single 5 V rail and can be powered using an isolated 5 V supply from the Inverter Control Board interface connector or through the Type-C USB interface.

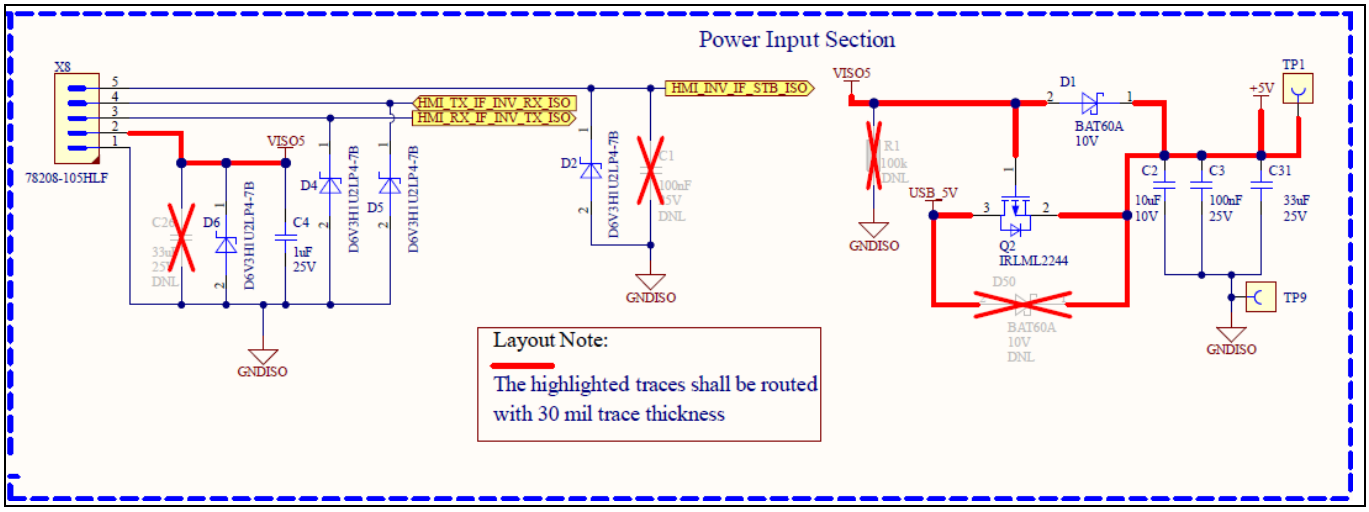


Figure 62 HMI & System Control Board input power

PSoC™ 4100S Max has a wide operating range with no need of an additional regulator. PSoC™ 4100S Max has an internal reference voltage generator and the CAPSENSE™ analog block uses the same to process the CAPSENSE™ buttons and sliders. HMI & System Control Board also provides power supply to the Connectivity Board and can control the supply based on the induction cooktop state.

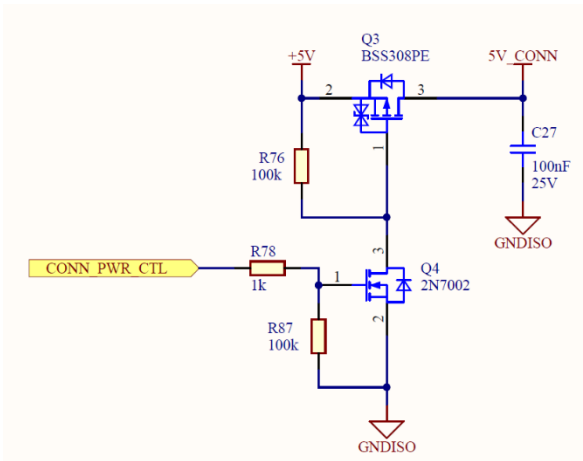


Figure 63 Connectivity Board power control

4.1.2 Input interface

CAPSENSE™ touch buttons and sliders are provided as HMI input touch interfaces. It is realized using the low-cost conductive foams to project the CAPSENSE™ pads of printed circuit board assembly (PCBA) to induction cooktop compliant glass overlay (4 mm).

4.1.2.1 Power touch button

The power touch button has four-quarter circles, where two-quarter circles are connected independently to each of the MSC CAPSENSE™ blocks of PSoC™ 4100S Max to realize redundant fail-safe power button detection and enable functional safety-compliant induction cooktop HMI design.

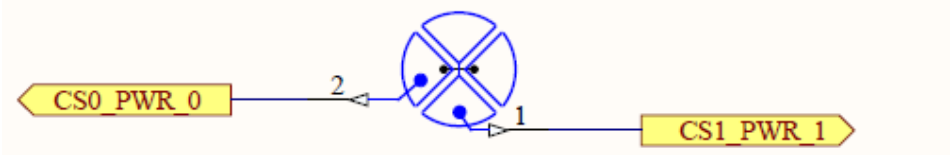


Figure 64 Redundant fail-safe power touch button implementation

4.1.2.2 Horseshoe radial slider touch interface

The horseshoe radial slider touch interface is constructed using seven CAPSENSE™ segments of each MSC CAPSENSE™ block to provide 10 power levels (0 to 9).

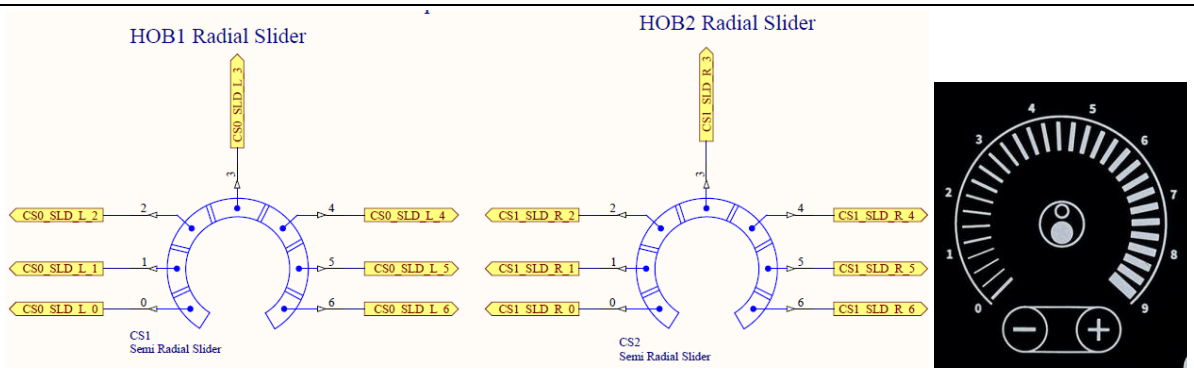


Figure 65 HMI & System Control Board horseshoe radial slider touch interface

4.1.2.3 Standard functional touch buttons

Various round touch buttons of the induction hob are constructed using a simple CAPSENSE™ sensor interface.

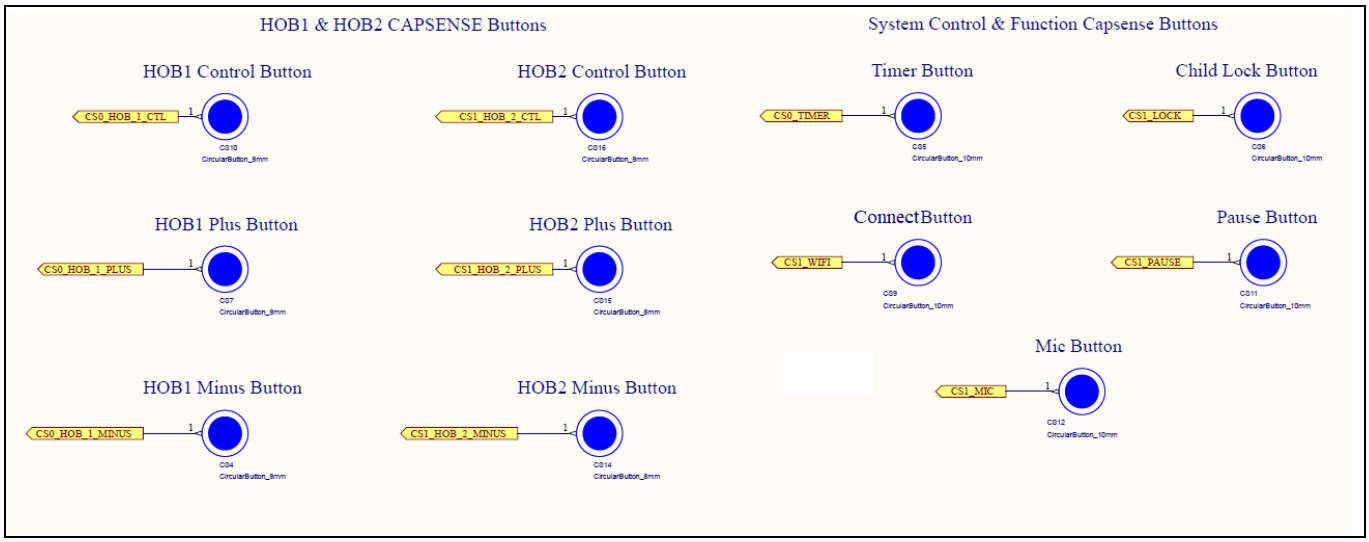


Figure 66 HMI & system control feature control touch buttons

4.1.3 Serial RGB

RGB LED is used for all the standard functional touch buttons to provide advance user experience possibilities.

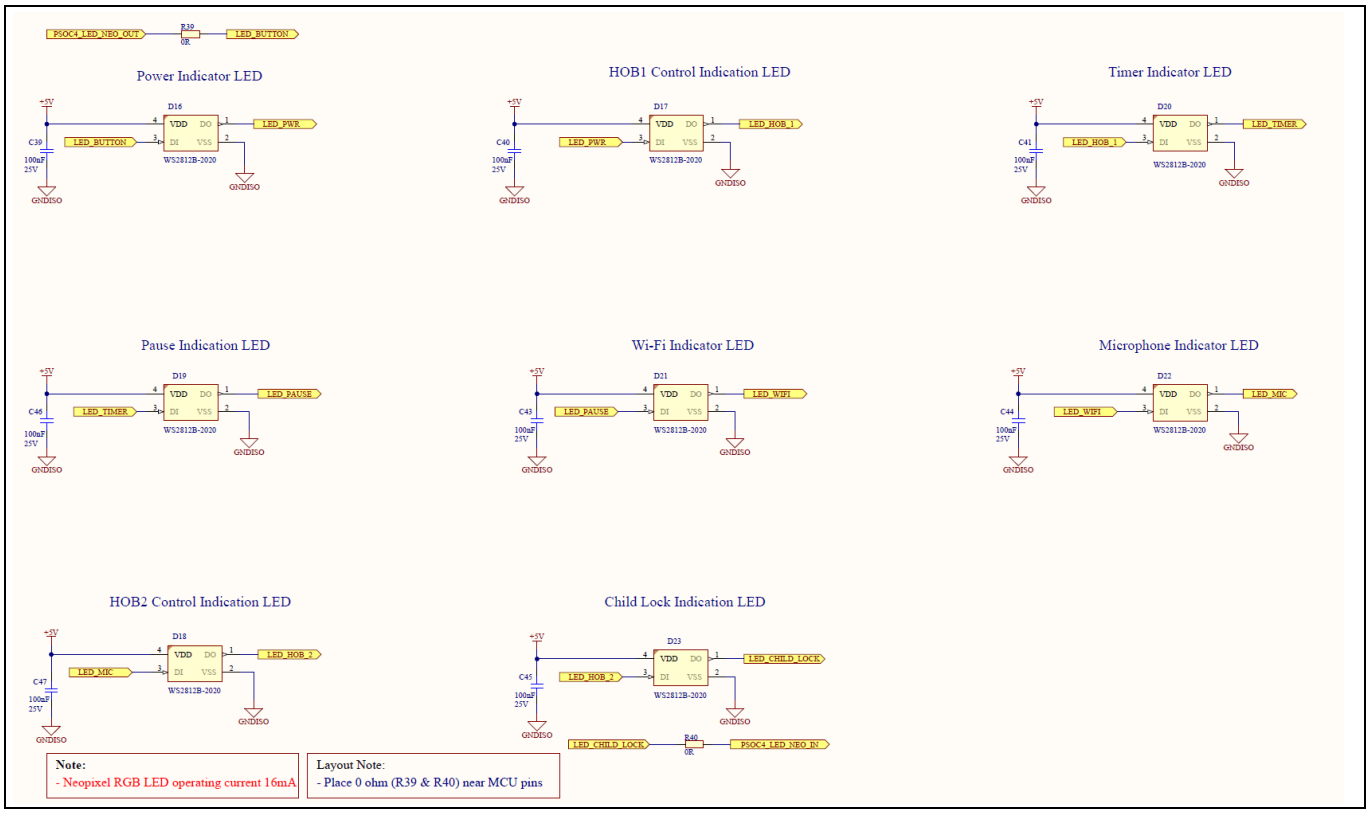


Figure 67 RGB LED interface for standard functional touch buttons

4.1.4 7-Segment display

HMI & System Control Board supports a four-digit 7-segment display using 12 GPIO lines.

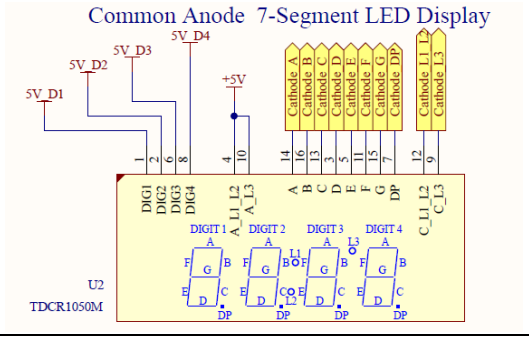


Figure 68 HMI & system control 7-segment interface

4.1.5 Radial LED

HMI & System Control Board provides 10 levels of power configuration for each of the induction hob and the same is represented using 10 red LEDs arranged in a horse shoe shape. Using latches to drive the LEDs, optimize BOM, and provide multiplexing capability to support both induction hobs with just 11 GPIOs.

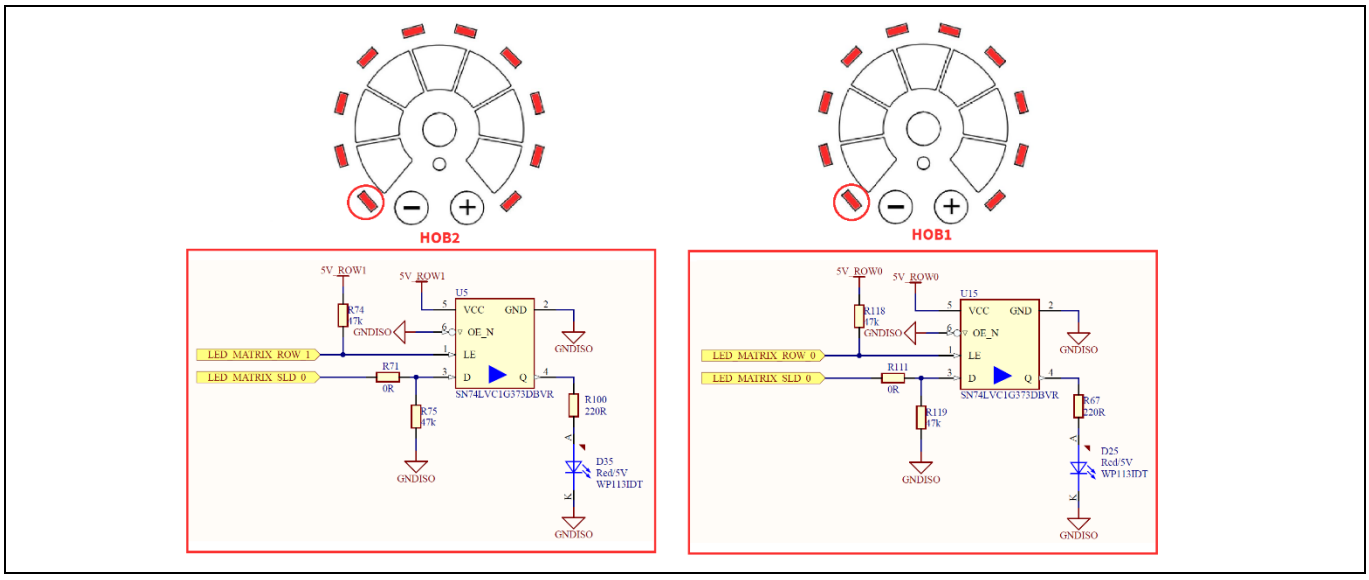


Figure 69 HMI & system control radial touch interface LED

4.2 Firmware architecture

Developed software is intended for end customer customization and hence it has been designed considering following parameters:

- Compliant with ModusToolbox™ 3.1 for delivering as reference example.
- Utilize all the ModusToolbox™ provided tools for configuring the firmware and performance tuning.
  - Device Configurator for GPIO allocation and configuration
  - CAPSENSE™ Configurator for HMI button design
  - CAPSENSE™ Tuner to tune the CAPSENSE™ touch buttons
  - Library Manager for dependency management
- The firmware uses a layered architecture style comprising application layer, application middleware, and BSP containing HAL/PDL, and peripheral drivers enabling the customer to reuse as needed
  - The BSP layer includes all the underlying libraries that are used by the middleware. The PDL integrates device header files, startup code, and peripheral drivers into a single package. The HAL in combination with the PDL leverages a more generic interface for the application.
  - The middleware defines attributes related to the defined peripherals. For example, CAPSENSE™ slider and Icon widgets will define which widget is initialized to a CAPSENSE™ block (MSC0 and MSC1), scan these blocks to get the status of each widget.
  - Application layers implement the features (i.e., application logic) and access the lower-level drivers/hardware via the application middleware API.

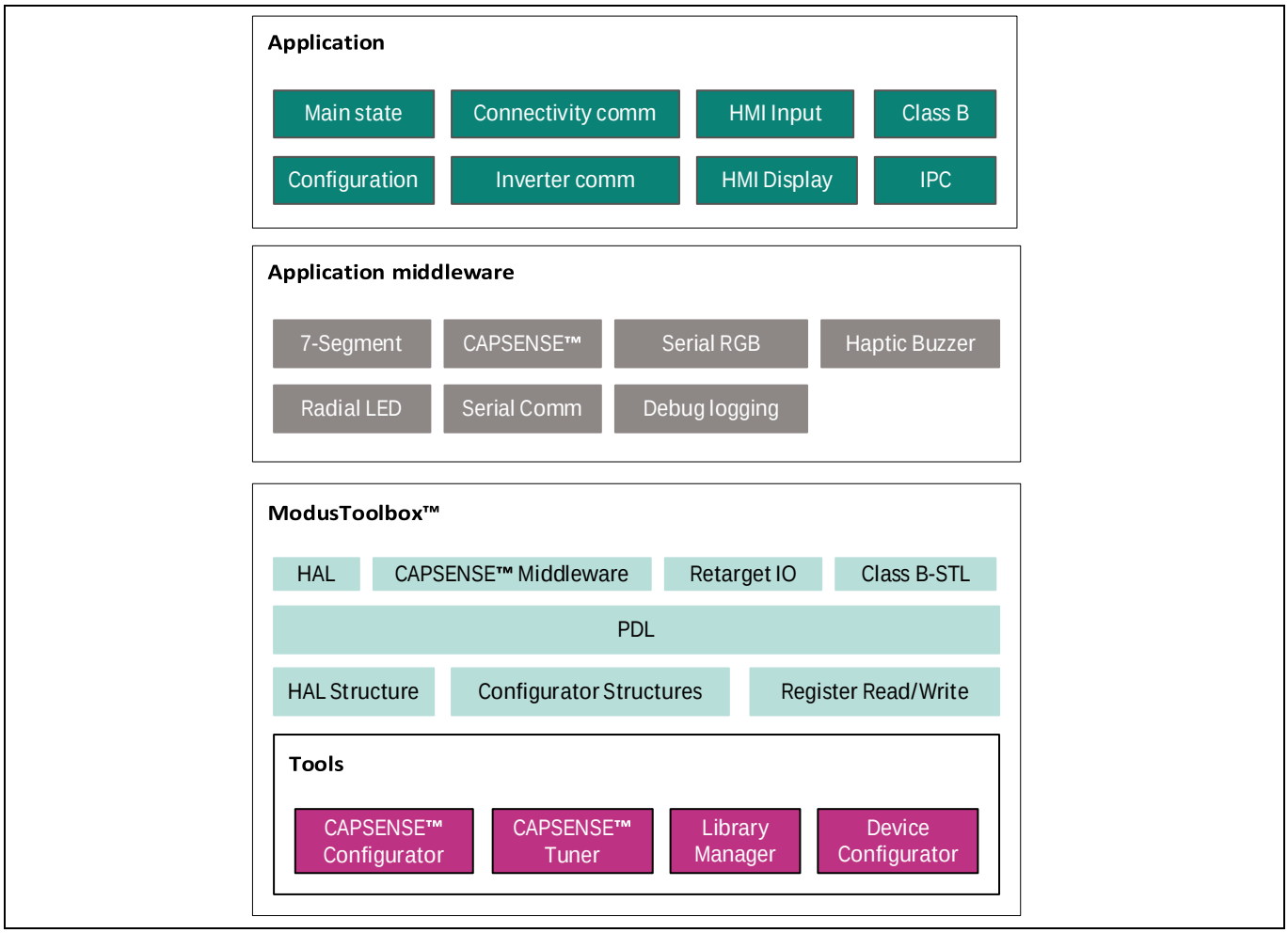


Figure 70 REF-SHA3K3IHWR5SYS-HMI firmware layered architecture

4.2.1 Finite state machine

HMI & System Control Board firmware implements a finite state machine as shown in the following figure.

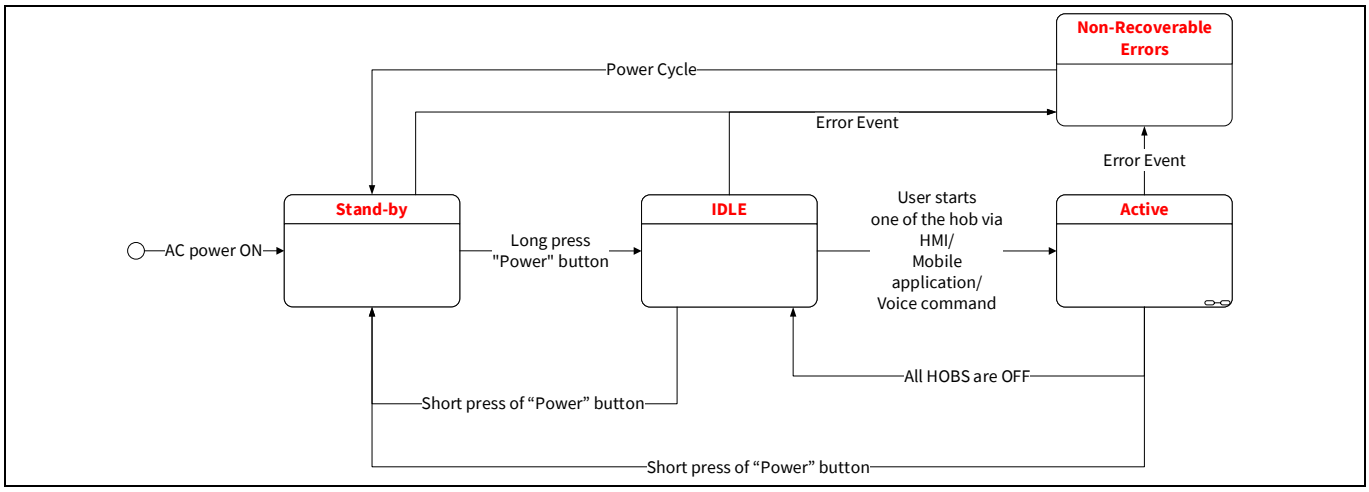


Figure 71 HMI & system control finite state machine

- **Stand-by:** With the AC power ON, the HMI & System Control Board starts and performs the following:
  - HMI performs Class B POST and enables power to the Inverter Control Board.
  - On successful POST, the HMI system will enter the standby mode to provide the lowest power consumption:
    - Power LED to provide a fading effect to reduce continuous peak LED current and meet low standby power.
    - CAPSENSE™ MSC block is configured to only scan “Power” button sensors.
- **IDLE:** Upon long pressing the POWER button, the system will enter idle mode. Depending on the user preference, the Connectivity Board will be enabled. CAPSENSE™ MSC block is configured for limited sensor scanning to just enable/disable induction hob functionality and power control of the system.
- **Active:** With at least one induction hob powered ON, the system will enter the active mode. Active mode enables all the sensors of the CAPSENSE™ MSC block and has multiple sub-states to support various features of the induction hobs.
  - **Lock**: Safety lock to avoid any unintended button operation by a child.
  - **Pause**: Pauses the ongoing cooking by configuring the system to be at its lowest power level and stopping all the active auto-shutdown timers of the induction hob. It allows the user to step away safely from the induction hobs.

Non-recoverable error: When any kind of error event occurs, the HMI & system control will enter a non-recoverable error state with an error code. Refer to the error codes section for more details.

4.3 Design highlights

4.3.1 Functional safety and Class B

HMI system control firmware integrates the pre-certified PSoC™ 4 CPU Class B safety test library(STL). AN236847 provides further details on STL. The following features of the STL are enabled in the HMI system control firmware:

- Flash
- RAM
- Clock
- Watchdog
- Communication
- Stack
- CAPSENSE™

4.3.2 Inverter control UART communication

Refer to the HMI & System control UART communication section of Inverter Control Board architecture & design.

5 Connectivity Board architecture and design

5.1 Hardware architecture

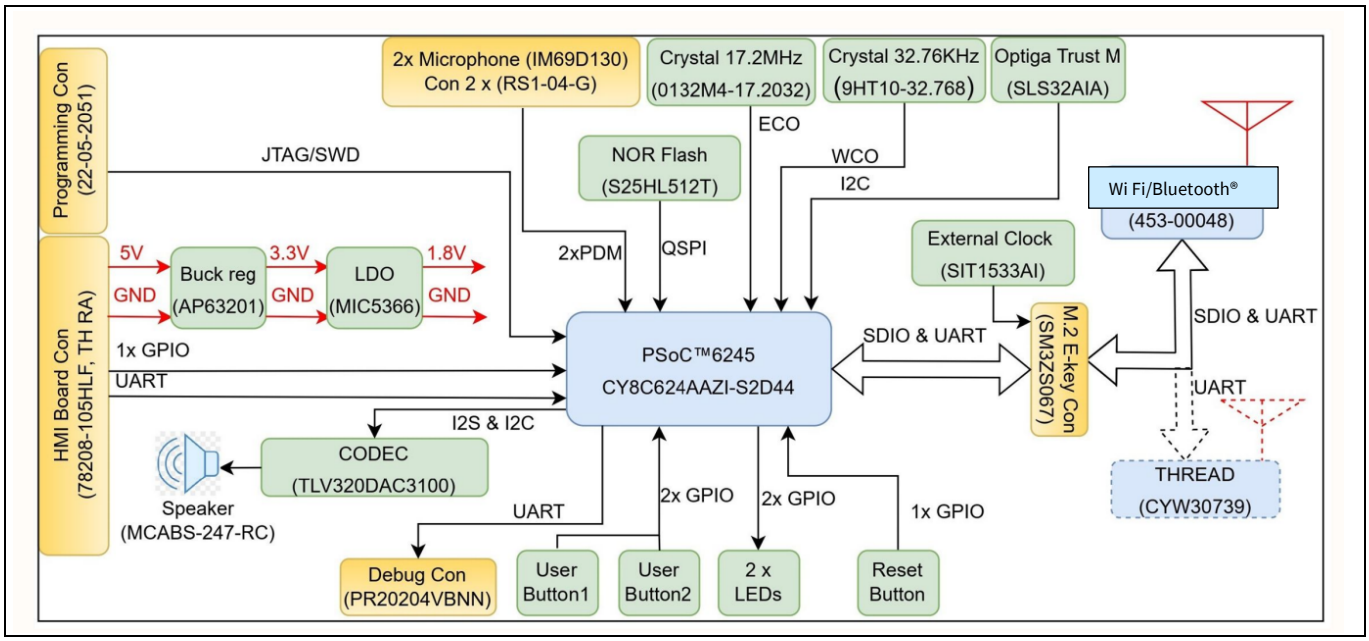


Figure 72 Detailed block diagram of the REF-SHA3K3IHWR5SYS-CON

5.2 Firmware architecture

The software developed is intended for the end customer to realize IoT features and hence it has been designed considering the following parameters:

- Compliant with ModusToolbox™ version 3.1 for delivering as an example for easy customization.
- Utilize all the ModusToolbox™ provided tools for configuring the firmware and performance tuning.
  - Device Configurator for GPIO allocation and configuration
  - Library Manager for dependency management
  - QSPI Configurator for flash interface configuration
  - Bluetooth® Configurator for creating and customizing GATT characteristic table
- The firmware uses a layered architecture style. This comprises an application layer, application middleware, a board support package (BSP) containing Infineon Hardware Abstraction Layer (HAL)/ Peripheral Driver Library (PDL), and peripheral drivers enabling the user to reuse this software as needed.
  - The BSP layer includes all the underlying libraries that are used by the middleware. The PDL integrates device header files, startup code, and peripheral drivers into a single package. The HAL in combination with PDL leverages a more generic interface for the application.
  - The middleware defines attributes related to the defined peripherals.

Application layers implement the features (i.e., application logic) and access the lower-level drivers/hardware via the application middleware API.

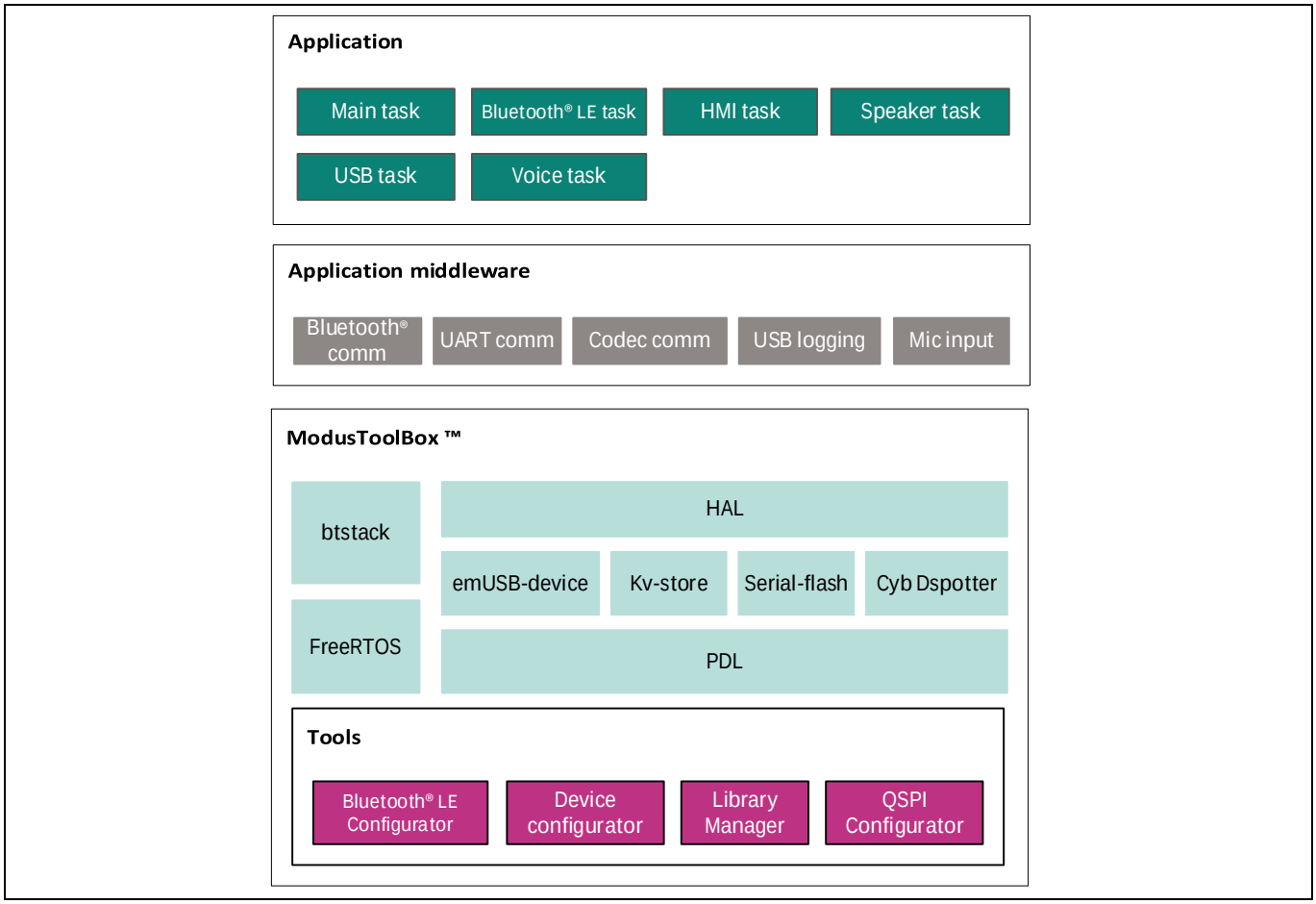


Figure 73 REF-SHA3K3IHWR5SYS-CON firmware layered architecture

5.2.1 Firmware flow diagram

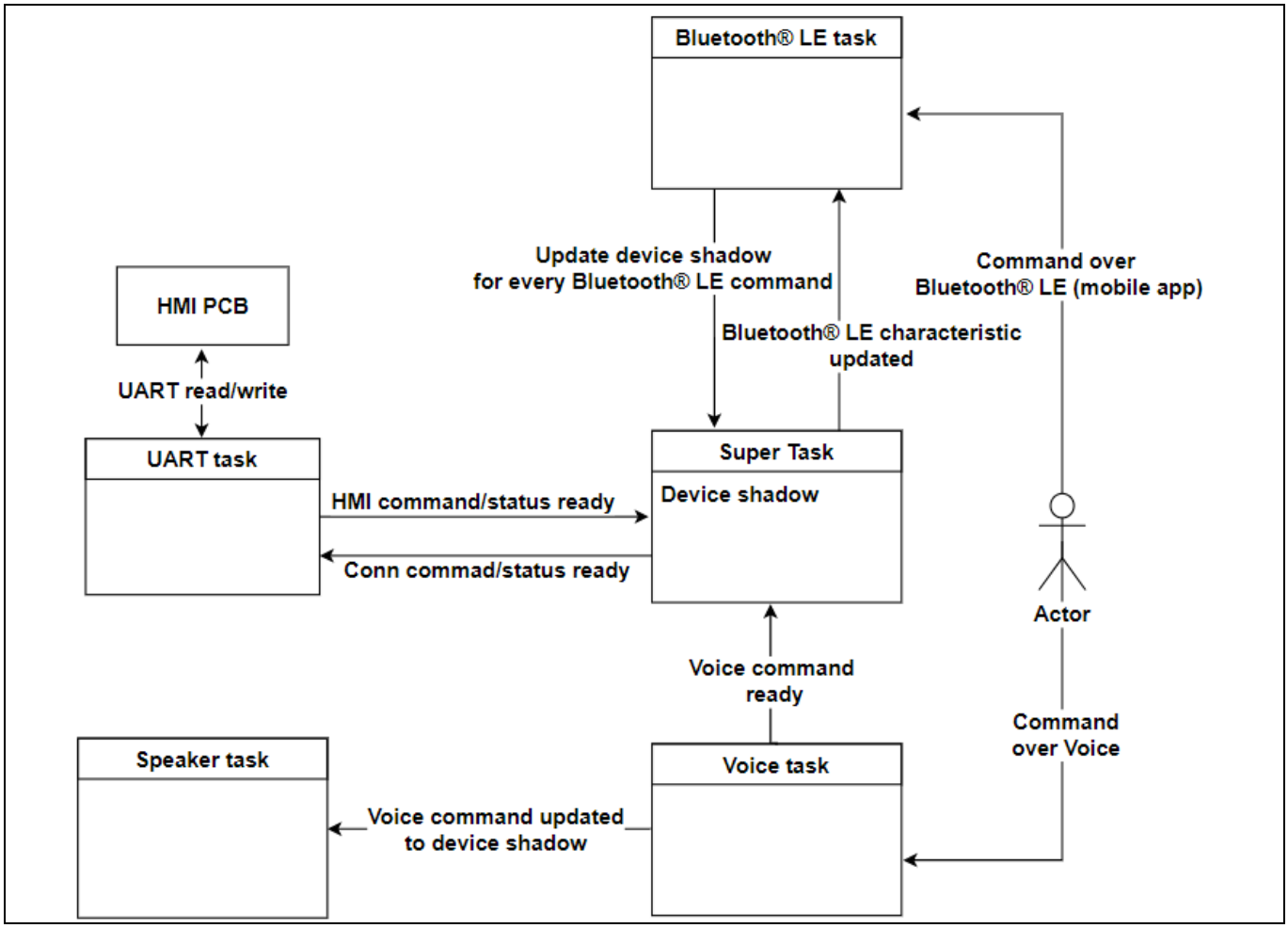


Figure 74 Connectivity Board firmware flow

Main task:

- Maintains an updated central device shadow based on UART, Bluetooth®, and voice commands
- Forwards Bluetooth® Low Energy commands to HMI & system control UART task
- Forwards UART commands to Bluetooth® task

UART task:

- Receives UART packets from HMI & System Control Board and updates the induction cooktop device by sending the data to the main task
- Sends data to HMI & System Control Board on UART upon receiving data from the main task

Bluetooth® task:

- Receives commands from the user over Bluetooth® Low Energy
- Sends data to the main task for each received Bluetooth® Low Energy command
- Sends data to the user over Bluetooth® Low Energy upon receiving a command from the HMI & system control through the main task

Voice task:

- Receives commands from the user over voice through PDM-PCM
- Infers the received command by running the Cyberon ML model
- After inference, sends the appropriate command to HMI through super task.

Speaker task:

- Receives a voice command index number from a voice task
- Drives codec to run speaker output indicating voice command

5.3 Design highlights

5.3.1 Bluetooth® Low Energy characteristics table

The following table details the Bluetooth® control interface details for the mobile application to interact with the Connectivity Board.

Services	Characteristics	UUID(Hex)	Permission
Device Information	Manufacturer Name	2A29	RO, N
	Model_number_string	2A24	RO, N
	Serial_number	2A25	RO, N
Induction Cooktop	child_lock_enabled	40D0D0C0-9894-4938-8BA9-93E0C140B5FF	RW, N
	connect_enabled	EB7D3410-2EF2-43C5-B39B-74412123AA61	RW, N
	voice_cmd_enabled	084FBDBA-CBDA-4796-8B67-370378D31AC2	RW, N
	paused	2896F203-7EEA-4E09-80B8-12073118CDB0	RW, N
	dev_conn_state	5DCB541E-70A4-4AD4-BD03-E622C83126B2	RO, N
	dev_state	159312BE-5653-4413-8B26-F4B9D7AB4E30	RO, N
	inv_comm_good	F5AF70EE-5766-480B-BA3B-190A89B5DFA2	RO, N
	conn_comm_good	5A531E67-C673-427A-8D37-BC271F402CAC	RO, N
	post_success	C6209923-0FBF-496B-8277-403499DA4FE5	RO, N
	classb_success	69D9745F-4B8D-4B39-944C-87A7AD16D148	RO, N
	cool_fan_active	7B278B77-02E9-4AB3-8ADB-12F242765778	RO, N
	dev_inv_stb_aux	062BD80E-C54E-4E88-9070-73E95372F3E5	RO, N
	dev_inv_stb_dcbus	A88729EB-FCA9-4E1D-AF11-AF7DE88C4CD3	RO, N
Hob 1 (Small induction hob)	IH_op_mode	F4268526-6B8D-4E74-A836-2633CCFCF96D	RW, N
	IH_igbt_temp	8545298C-85A3-4440-85EB-7167C9DE8DF0	RO, N
	IH_pwr_lvl	07FF3212-BFB5-4811-980C-14D900412456	RW, N
	IH_timer_mins	77AAF114-3003-486F-AC7A-EE31E86EED26	RW, N
	IH_surf_temp_stat	91CBB2AD-FEC6-42B9-A739-8E9EB8B716BA	RO, N
	IH_surf_temp	3D15E2E0-C64F-4C2C-8D33-0B300A336ADA	RO, N
	pan_status	26F10F6C-4C44-4FD0-9DA7-A7C206DEA6F4	RO, N
Hob2 (Big induction hob)	IH_op_mode	ECF4884A-BEC1-4ECC-AE0E-2881ABF049ED	RW, N
	IH_igbt_temp	91A3DB38-9669-4232-BD84-93573F9E4D15	RO, N

Services	Characteristics	UUID(Hex)	Permission
	IH_pwr_lvl	6DB6CBCF-A84B-4968-8E6F-794EE9693457	RW, N
	IH_timer_mins	DE0E362A-D60E-45A7-803F-17EA9B7F2A5D	RW, N
	IH_surf_temp_stat	482045F5-FDDB-4E73-9460-27B87E9253C4	RO, N
	IH_surf_temp	7799AB4F-B6F9-493B-9D7D-6AAA135A987E	RO, N
	pan_status	5D2CBCF0-CE03-484B-A6AF-82145BBA3DBA	RO, N

5.3.2 HMI control UART communication

HMI UART communication uses UART HDLC protocol that ensures data integrity for exchanging data over UART physical interface.

5.3.2.1 Command packet format from HMI

HMI & System Control Board provides feature enabling and disabling on the Connectivity Board- Connectivity (Enabling/Disabling/Reset) & Voice control (Enabling/Disabling).

Byte	0	1	2	3 to 29	30-31
Data	0x4A	0x01	0x1B	Payload	CRC16

A detailed description of the packet payload is as following:

Sr No	Bytes	Feature	Description
1	Byte 0	Device ID	Fixed value: 4 A
2	Byte 1	Command type	0x01
3	Byte 2	Length	
4	Byte 3	Dev_connect	
5	Byte 4	Dev_voice_cmd	
6	Byte 5	Reset	Reset credentials/configuration connectivity interfaces on Connectivity Board.
7	Byte 30	CRC 16 (LSB)	CRC16
8	Byte 31	CRC 16 (MSB)	

5.3.2.2 Status update packet format from HMI

Byte	0	1	2	3-29	30,31
Data	0x4A	0x06	0x1B	Payload	CRC16

Bytes	**Feature**	**Description**
Byte 0	Device ID	Fixed value: 4 A
Byte 1	Command type	0x06
Byte 2	Length	
Byte 3	System_State	**Byte value** / **Description** 1 / HMI & system control in standby 2 / HMI & system control in idle 3 / HMI & system control in active 4 / HMI & system control in child lock 5 / HMI & system control in non-recoverable error
Byte 4	Warning_state(BitField)	**Bit field** / **Description** 0 / Auto-shutdown due to big hob surface over temperature 1 / Auto-shutdown due to small hob surface over temperature 2 / Auto-shutdown due to big hob IGBT over temperature 3 / Auto-shutdown due to small hob IGBT over temperature 4 / Auto-shutdown due to safety 2 hrs continuous operation
Byte 5	Non-recoverable error Part 1 (bit field)	**Bit field** / **Description** 0 / Temperature sensor error 1 / Current sensor error 2 / Over Current Hob 1 3 / Over Current Hob 2 4 / Over Voltage
Byte 6	Non-recoverable error part 2 (bit field)	**Bit field** / **Description** 0 / Over Temperature IGBT Hob 1 1 / Over Temperature IGBT Hob 2 2 / Over Temperature Coil Hob 1 3 / Over Temperature Coil Hob 2

<table>
<tr><th>Bytes</th><th>Feature</th><th>Description</th></tr>
<tr><td>Byte 7</td><td>Dev_status (bitfield)</td><td>
<table>
<tr><th>Bit field</th><th>Description</th></tr>
<tr><td>0</td><td>HMI & System Control Board & Inverter Control Board communication status</td></tr>
<tr><td>1</td><td>HMI & System Control Board & Connectivity Board communication status</td></tr>
<tr><td>2</td><td>Class B POST status</td></tr>
<tr><td>3</td><td>Class B period status test</td></tr>
<tr><td>4</td><td>Cooling fan status</td></tr>
<tr><td>5</td><td>Inverter Control Board standby power relay status</td></tr>
<tr><td>6</td><td>Inverter Control Board half bridge DC bus relay status</td></tr>
</table>
</td></tr>
<tr><td>Byte 8</td><td>Dev_child_lock</td><td></td></tr>
<tr><td>Byte 9</td><td>Dev_pause</td><td></td></tr>
<tr><td>Byte 10</td><td>IH_1_op_mode</td><td></td></tr>
<tr><td>Byte 11</td><td>IH_1_igbt_temp</td><td></td></tr>
<tr><td>Byte 12</td><td>IH_1_pwr_lvl</td><td></td></tr>
<tr><td>Byte 13</td><td>IH_1_timer_mins</td><td></td></tr>
<tr><td>Byte 14</td><td>IH_1_surf_temp</td><td></td></tr>
<tr><td>Byte 15</td><td>IH_1_surf_temp_stat</td><td></td></tr>
<tr><td>Byte 16</td><td>IH_1_pan_status</td><td></td></tr>
<tr><td>Byte 17</td><td>IH_2_op_mode</td><td></td></tr>
<tr><td>Byte 18</td><td>IH_2_igbt_temp</td><td></td></tr>
<tr><td>Byte 19</td><td>IH_2_pwr_lvl</td><td></td></tr>
<tr><td>Byte 20</td><td>IH_2_timer_mins</td><td></td></tr>
<tr><td>Byte 21</td><td>Hob_2_surf_temP</td><td></td></tr>
<tr><td>Byte 22</td><td>Hob_2_surf_temp_stat</td><td></td></tr>
<tr><td>Byte 23</td><td>Hob_2_pan_status</td><td></td></tr>
<tr><td>Byte 24</td><td>Power watt LSB- Hob1</td><td></td></tr>
<tr><td>Byte 25</td><td>Power watt MSB – hob 1</td><td></td></tr>
<tr><td>Byte 26</td><td>Power watt LSB – hob2</td><td></td></tr>
<tr><td>Byte 27</td><td>Power watt MSB – Hob2</td><td></td></tr>
<tr><td>Byte 28</td><td>Reserved</td><td></td></tr>
<tr><td>Byte 29</td><td>Reserved</td><td></td></tr>
<tr><td>Byte 30</td><td>CRC 16 (LSB)</td><td></td></tr>
<tr><td>Byte 31</td><td>CRC16 (MSB)</td><td></td></tr>
</table>

Note: Hob 1/IH_1 are referred to small hob and Hob 2/IH_2 are referred to big hob

5.3.2.3 Ready to receive packet format from HMI

Byte	0	1	2
Data	0x4A	0x05	0x00

5.3.2.4 Status response packet format from connectivity to HMI & system control

Byte	0	1	2	3-29	30,31
Data	0x4A	0x06	0x1B	Payload	CRC16

Detail description of the packet payload is as below:

Bytes	**Feature**	**Description**
Byte 0	Device ID	Fixed value: 4 A
Byte 1	Command type	0x06
Byte 2	Length	
Byte 3	Dev_connect_state	**Status Code** / **Description** 0 / Inactive 1 / Active- BLE connected 2 / Bluetooth® advertisement status 3 / CONN_ACTIVE_BT_WIFI_CONNECTED 4 / CONN_ACTIVE_BT_WIFI_NO_CONNECT 5 / CONN_ACTIVE_BT_WIFI_NO_NET 6 / CONN_ACTIVE_WIFI_CONNECTED 7 / CONN_ACTIVE_WIFI_NO_CONNECT 8 / CONN_ACTIVE_WIFI_NO_NET 9 / CONN_DEV_ERROR
Byte 4	Dev_voice_cmd	
Byte 5	Reset	
Byte 6	Post success	
Byte 7	Class B success	
Byte 30	CRC 16 (LSB)	CRC 16
Byte 31	CRC 16 (MSB)	

5.3.2.1 Command packet format from connectivity

Byte	0	1	2	3-29	30,31
Data	0x4A	0x01	0x1B	Payload	CRC16

Bytes	**Feature**	**Description**
Byte 0	Device ID	Fixed value: 4 A
Byte 1	Command type	0x01
Byte 2	Length	
Byte 3	CONN_command_active	
Byte 4	IH_control_command	
Byte 5	Dev_pause	
Byte 6	Dev_connect	
Byte 7	Dev_voice_cmd	
Byte 8	IH_1_op_mode	
Byte 9	IH_1_pwr_lvl	
Byte 10	IH_1_timer_mins	
Byte 11	IH_2_op_mode	
Byte 12	IH_2_pwr_lvl	
Byte 13	IH_2_timer_mins	
Byte 14	Dev_child_lock	
Byte 30	CRC 16 (LSB)	CRC 16
Byte 31	CRC 16 (MSB)	

5.3.3 USER buttons and LEDs

The Connectivity Board has two user buttons and two LED's to receive input from the user and to communicate the status of the device. Refer to Connectivity Board interface details for more details.

USR BTN1: Used to enable/disable independent board evaluation of the Connectivity Board. Pressing it for 2 s will move the Connectivity Board to independent board evaluation mode.

USR BTN2: Used to verify whether the Cyberon offline voice command demo license is available. If a valid license is available, the speaker output will be: "Yes, it is correct voice model license". If no valid license file is available, the speaker output will be: "No, it is wrong voice model license".

The connectivity has two LEDs:

- Red
- Green

The following table provides the status information for both LEDs:

STATE	Green LED	Red LED
Continuous blinking	Bluetooth® Low Energy advertisement	Device is in Independent mode
Blink	For every Bluetooth® communication	
Stable	Bluetooth® Low Energy connection is established	Device powered ON

6 ModusToolbox™ Smart Induction Cooktop Pack

Smart Induction Cooktop comes with complete reusable modular software for each of the boards as a single ModusToolbox™ Smart Induction Cooktop Pack via the Infineon Development Center Launcher. Reach out to your respective sales and marketing team to get access to the ModusToolbox™ Smart Induction Cooktop Technology Pack.

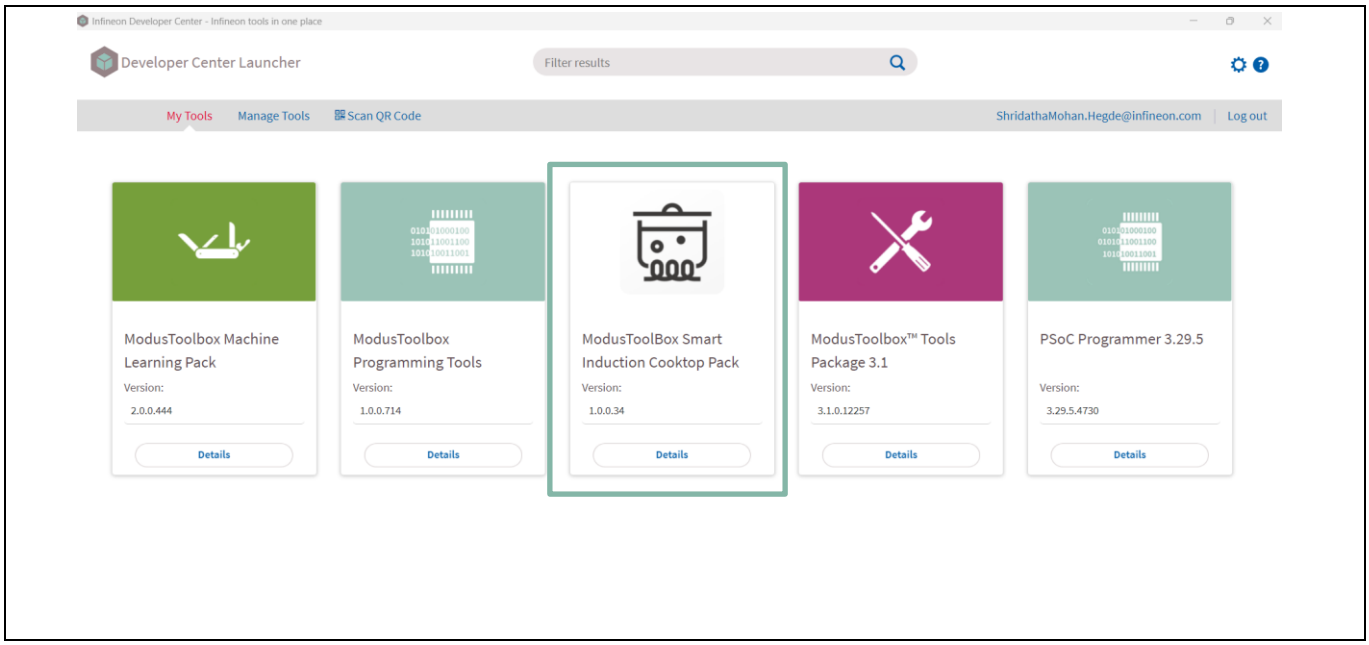


Figure 75 Infineon Development Center for ModusToolbox™ Smart Induction Cooktop pack (NOTE: Version number is for illustration)

1. Install the ModusToolbox™ Smart Induction Cooktop Pack by following the default installation instructions provided at Infineon Development Center Launcher and use the default settings of the installation pack for the current user.
2. Open Eclipse IDE for ModusToolbox™ 3.1 in a new workspace.

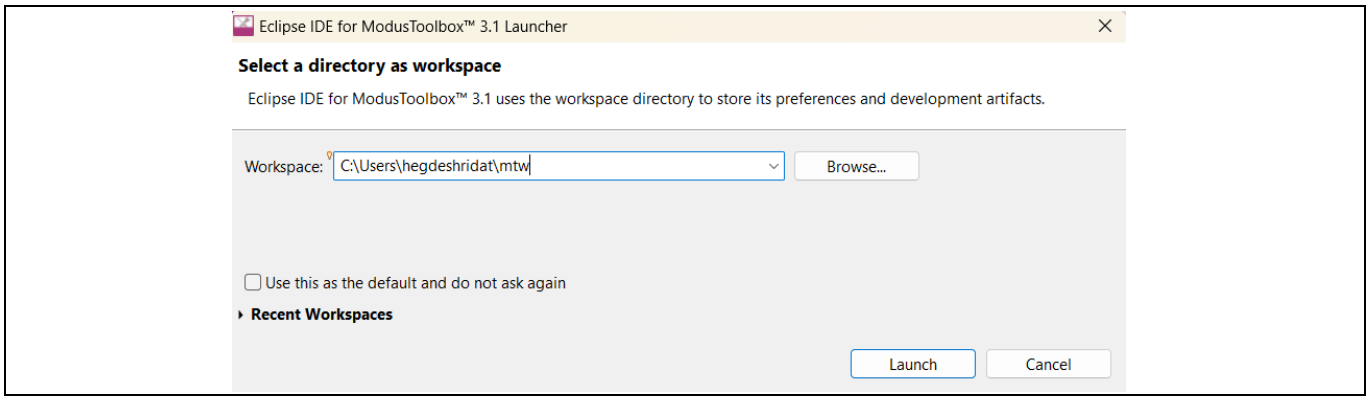


Figure 76 Creating new workspace “mtw”

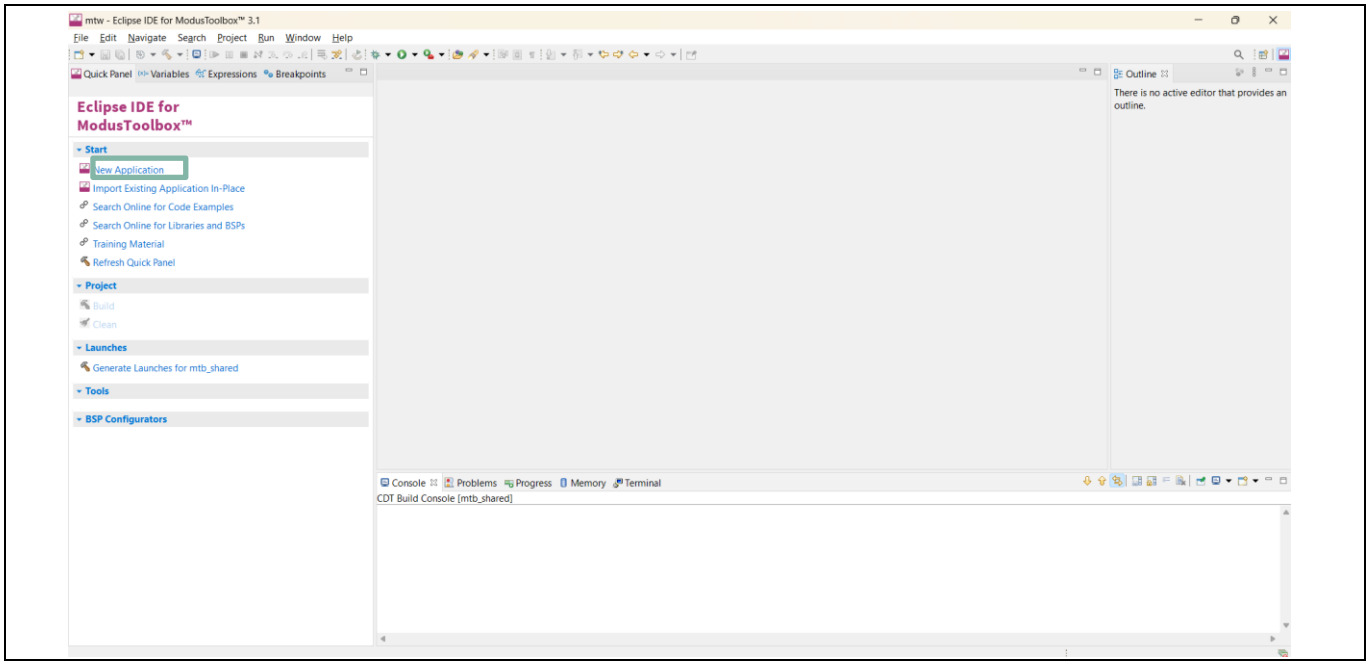


Figure 77 Creating a New Application

Smart Induction Cooktop has three boards and each board BSP is listed under “Reference Design BSPs” as three separate BSPs “INDUCTION-COOKTOP-CONNECTIVITY”, “INDUCTION-COOKTOP-HMI” and “INDUCTION-COOKTOP-INVERTER”.

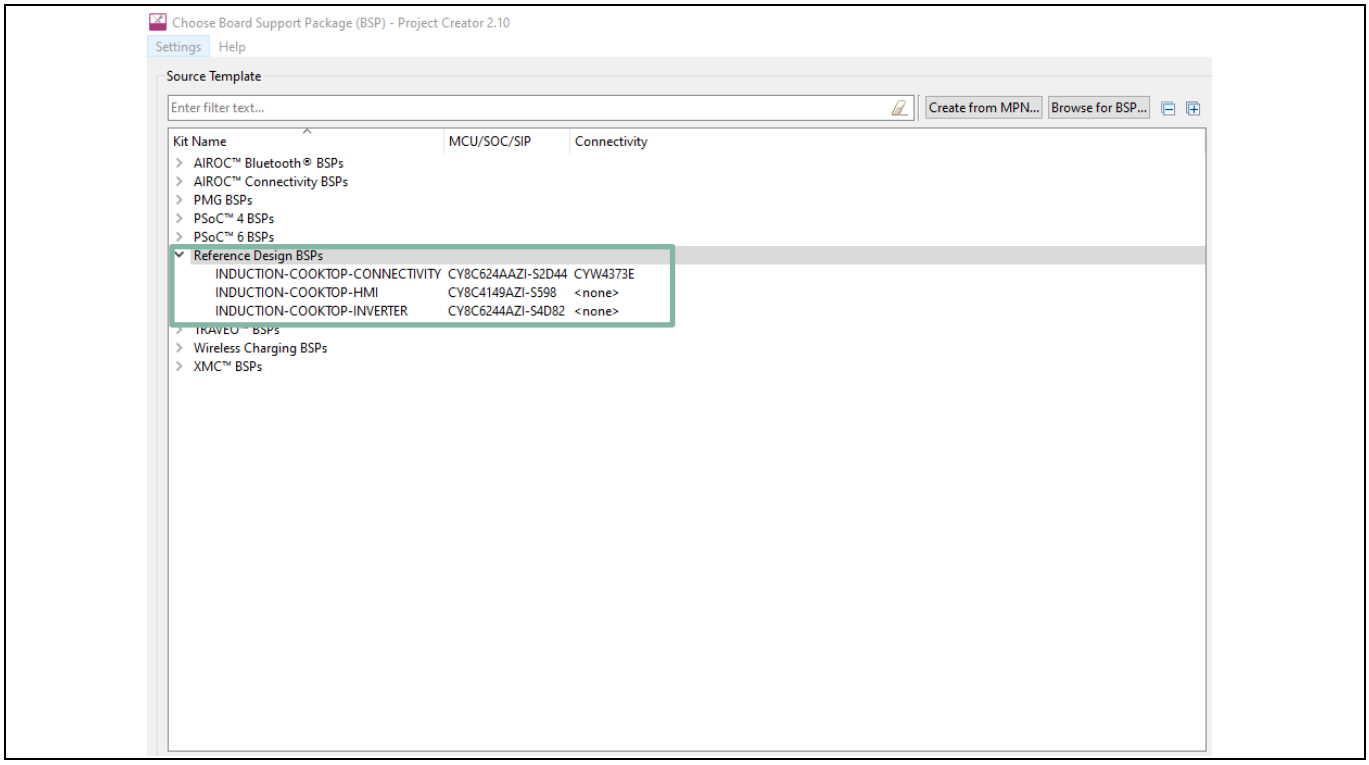


Figure 78 Options for different board BSP of Smart Induction Cooktop

3. Select the required BSP.

Based on selected BSP, respective applications are available to create projects for the respective boards.

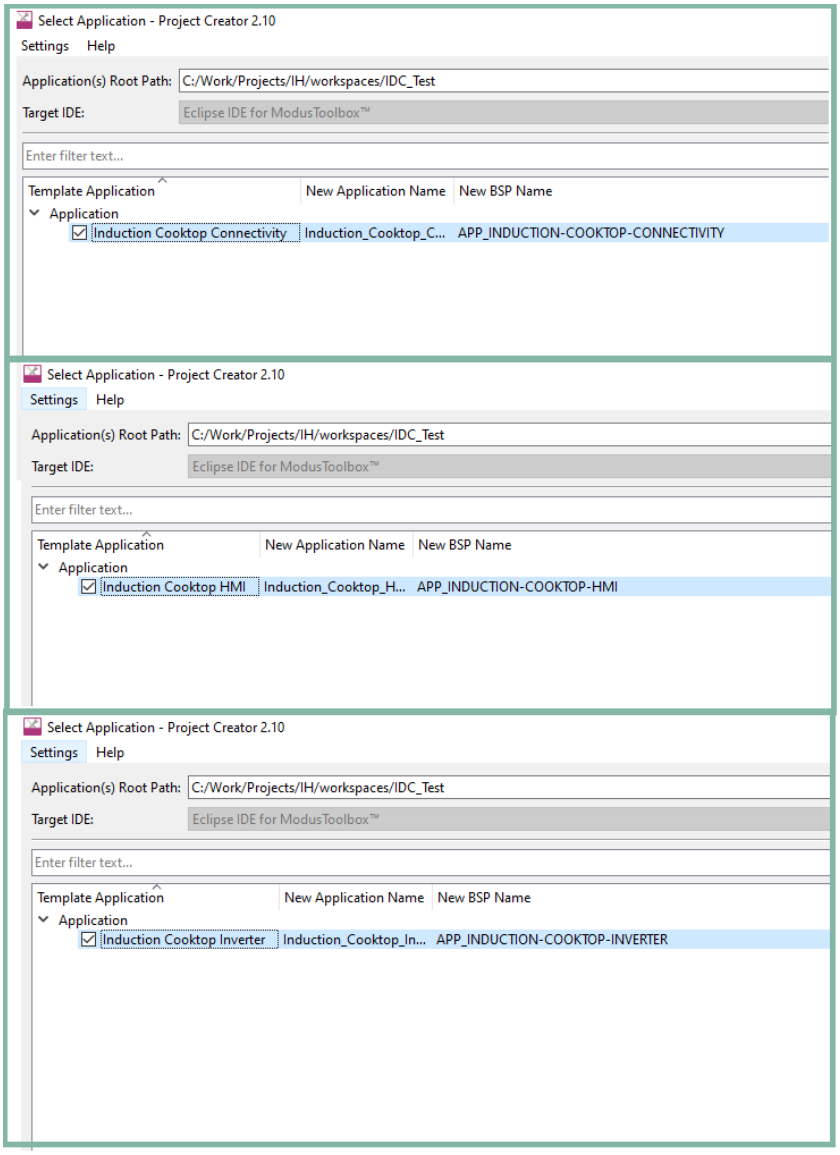


Figure 79 Reference application firmware options for different board BSP of Smart Induction Cooktop

Each board firmware is compliant to the Class B implementation and whenever the communication failure happens between the boards. Each board enters to error mode. The following table provides the inter-board communication dependency and error entering scenarios.

Board	Dependency	Precautions/care
Inverter Control Board	1. HMI & System Control Board controls the power and turns the Inverter Control Board ON only when one of the induction hobs of induction cooktop is active. 2. During active state, HMI & System Control Board polls Inverter Control Board status for every 3 seconds and if Inverter Control Board fails to respond 3 consecutive requests, HMI & System Control Board will shutdown the Inverter Control Board for communication failure.	1. Inverter Control Board is powered by the AC supply and hence the required isolations need to be taken to connect the debugger and debug console port to the PC 2. On entering a break point, within 6 seconds need to exit from break-point state so that HMI & system control do not enter communication failure error state.

Board	Dependency	Precautions/care
HMI & System Control Board	1. HMI & System Control Board is master and controls both the Inverter and Connectivity Boards. 2. Connectivity Board on receiving a voice command or mobile application control command, an interrupt is generated to HMI & System Control Board. If HMI & System Control Board fails to service, Connectivity Board enters communication failure error state, and further HMI & System Control Board enter communication failure state.	1. During HMI & System Control Board debugging, do not perform any mobile operations or voice control commands [Note: Connectivity and voice can be disabled]
Connectivity Board	1. Dependent on HMI & System Control Board for getting the status	

6.1 Inverter Control Board

Upon successful creation of an Inverter Control Board project, the *readme* file will be displayed in ModusToolbox™ IDE on selecting the “Induction_Cooktop_Inverter” project. Go through the *readme* file for more details on the features and configurations.

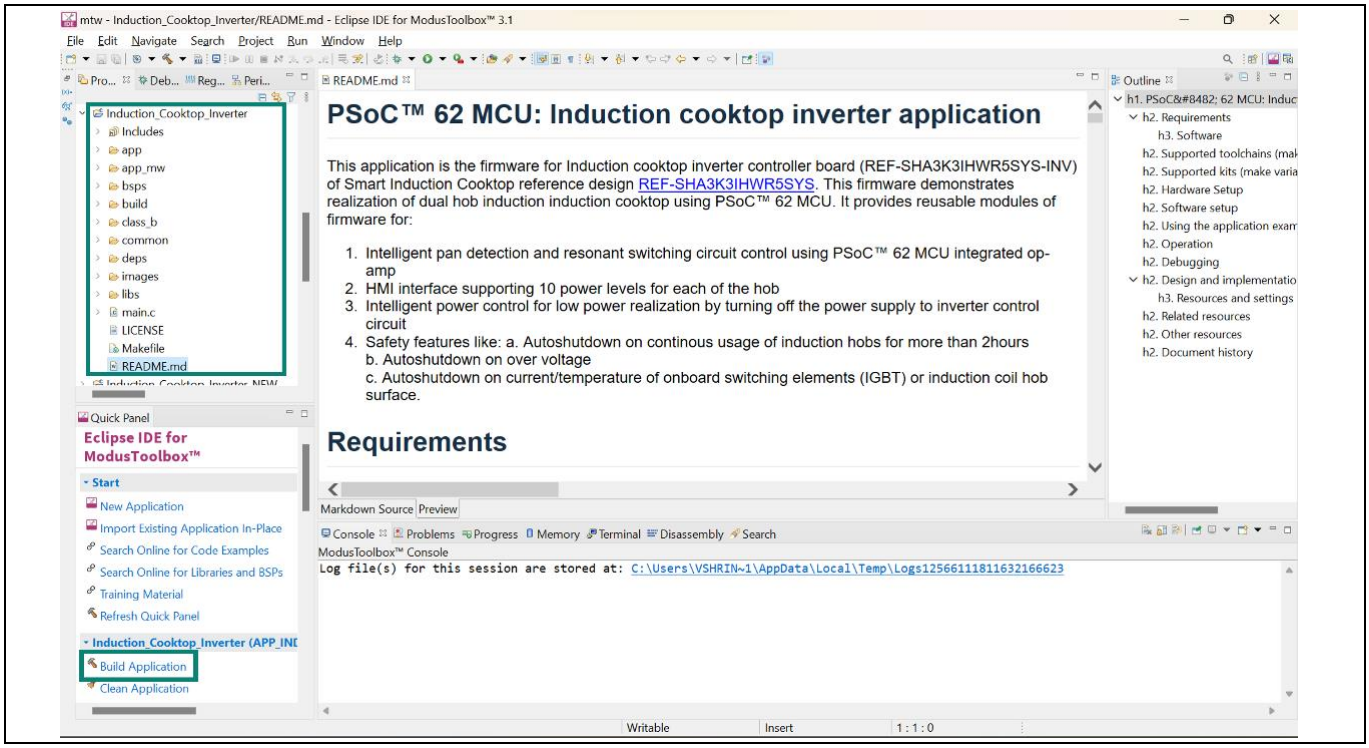


Figure 80 Inverter Control Board application project browsing and build option

Build the application by selecting **Build Application** from the **Quick Panel**.

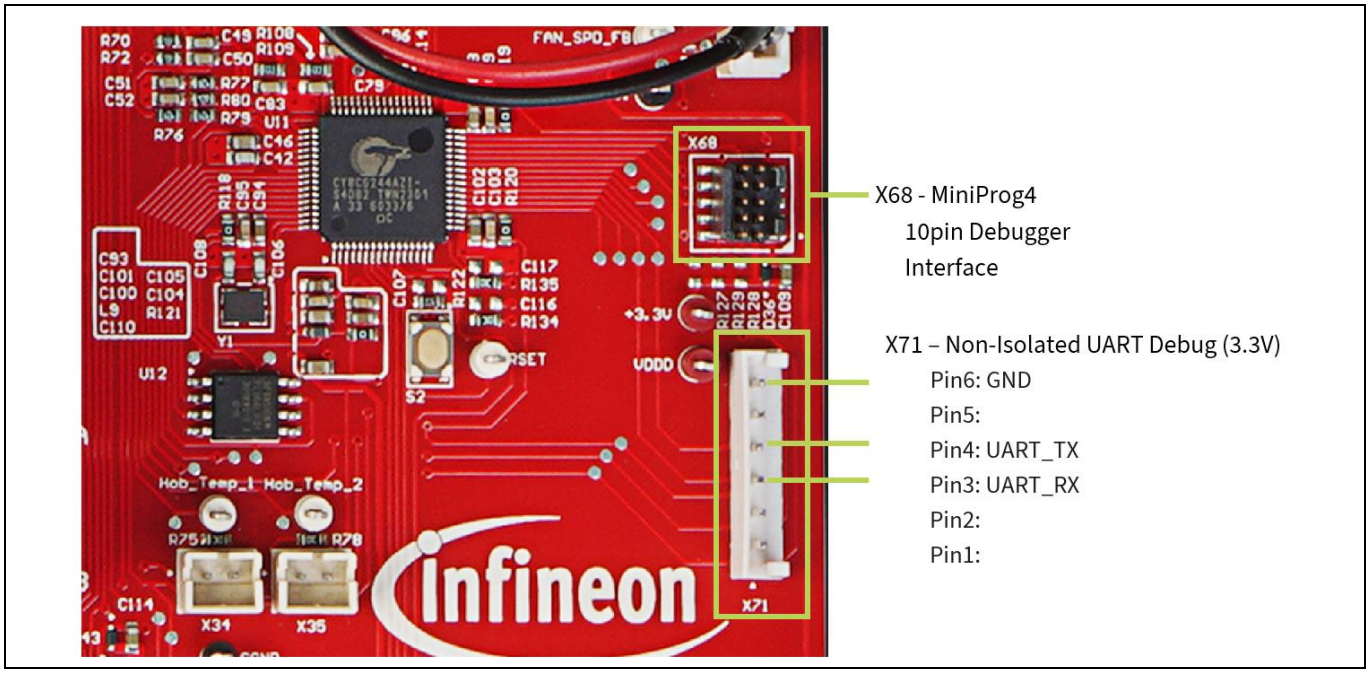


Figure 81 Inverter Control Board debug interfaces - MiniProg4 and TTL UART to USB

To debug the application, before powering on the AC supply:

1. Program the built firmware, using the Cypress Programmer as described in Programming the firmware for the Inverter Control Board.
2. Set up the induction cooktop system.

Note: *Please use the laptop with an isolation transformer or without the AC supply.*

3. Power ON the induction cooktop and power ON one of the induction hobs of the cooktop.
4. After successfully building the application, flash the binary to the Inverter Control Board by following the procedure described in the Programming the firmware subsection of the Inverter Control Board section.

Firmware debugging requires powering one of the induction hobs ON to enable the power supply to the Inverter Control Board and perform attach to the target. It will take around a couple of mins to attach to the target.

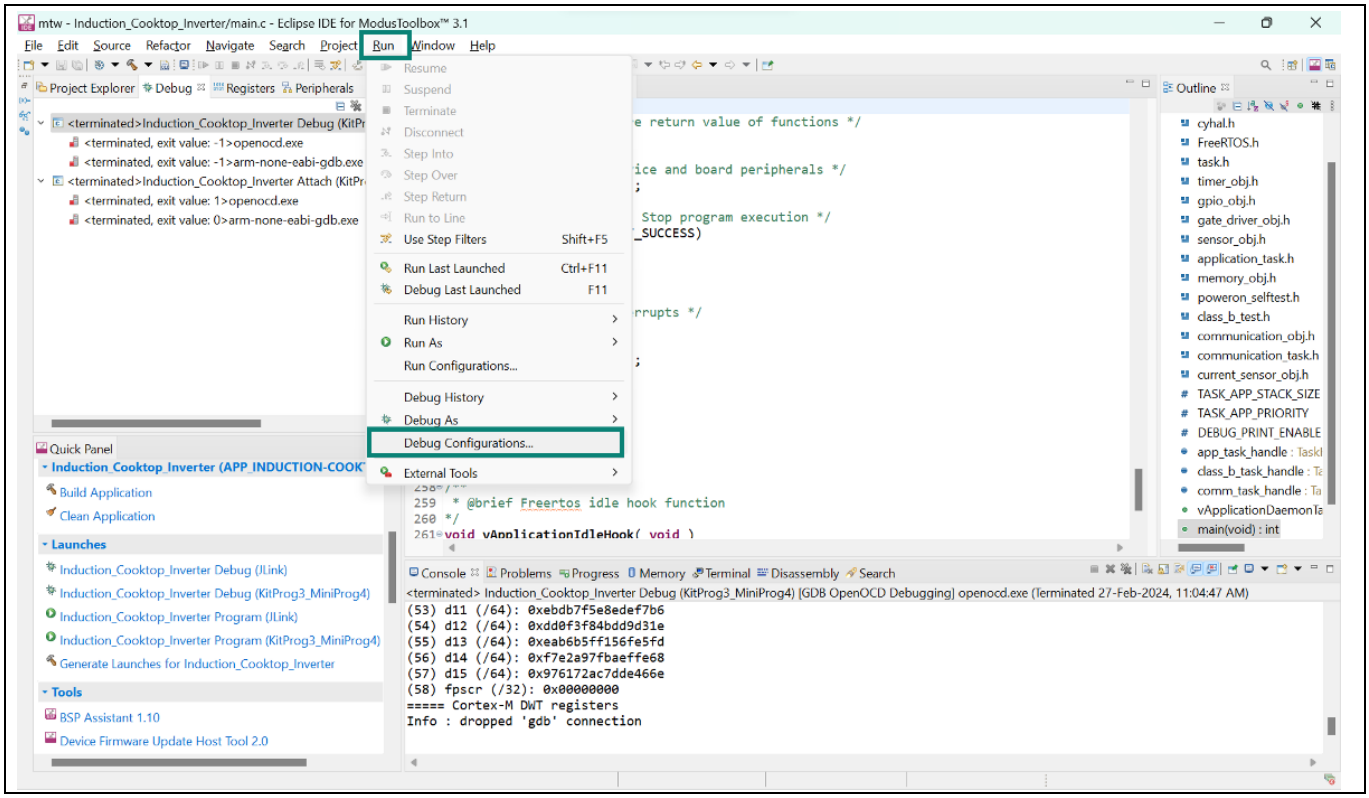


Figure 82 Selecting Inverter Control Board application debugging configuration

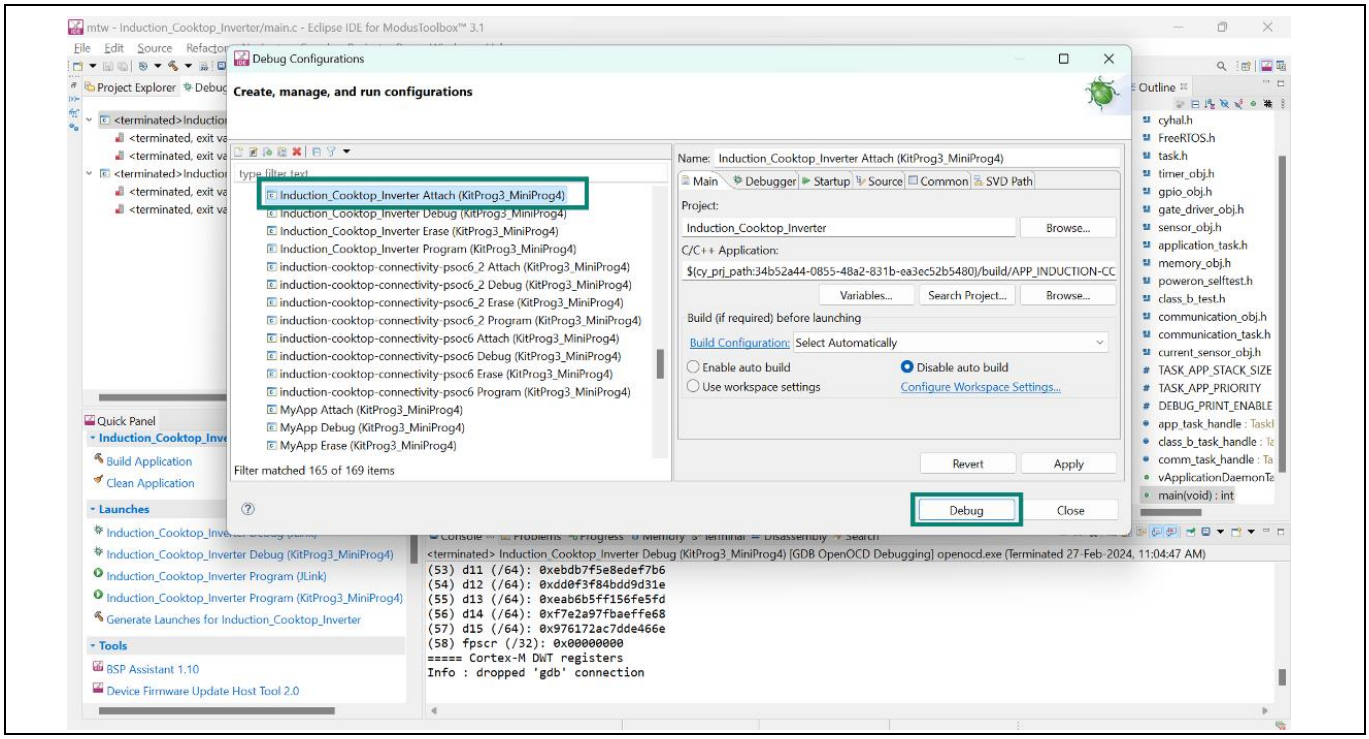


Figure 83 Attaching debugger to a running inverter application PSoC™ 6

5. After attaching, to perform debugging, select the *ELF* file.

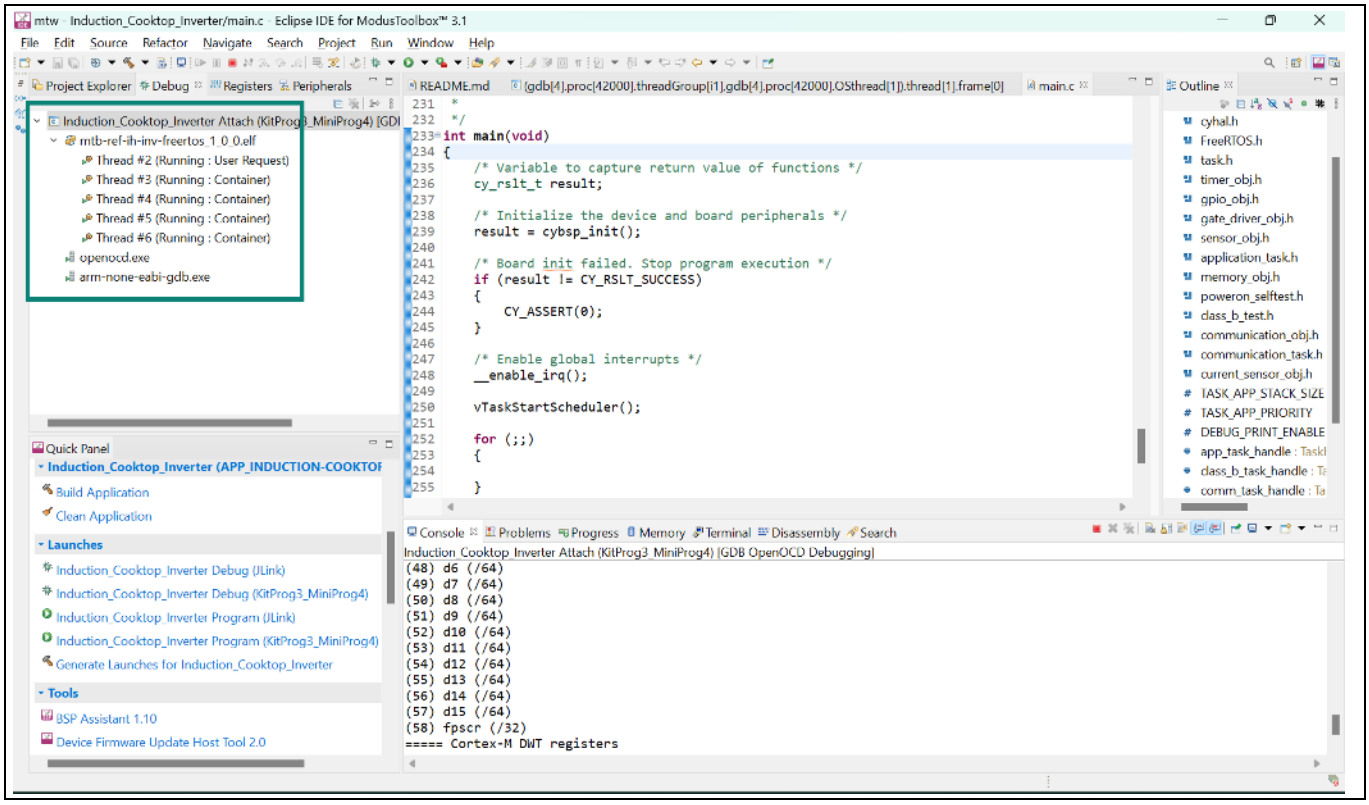


Figure 84 Entering debugging mode after debugging attaching to PSoC™ 6

6. For debug console logs, open the USB to TTL UART with the following configurations to receive the logs.

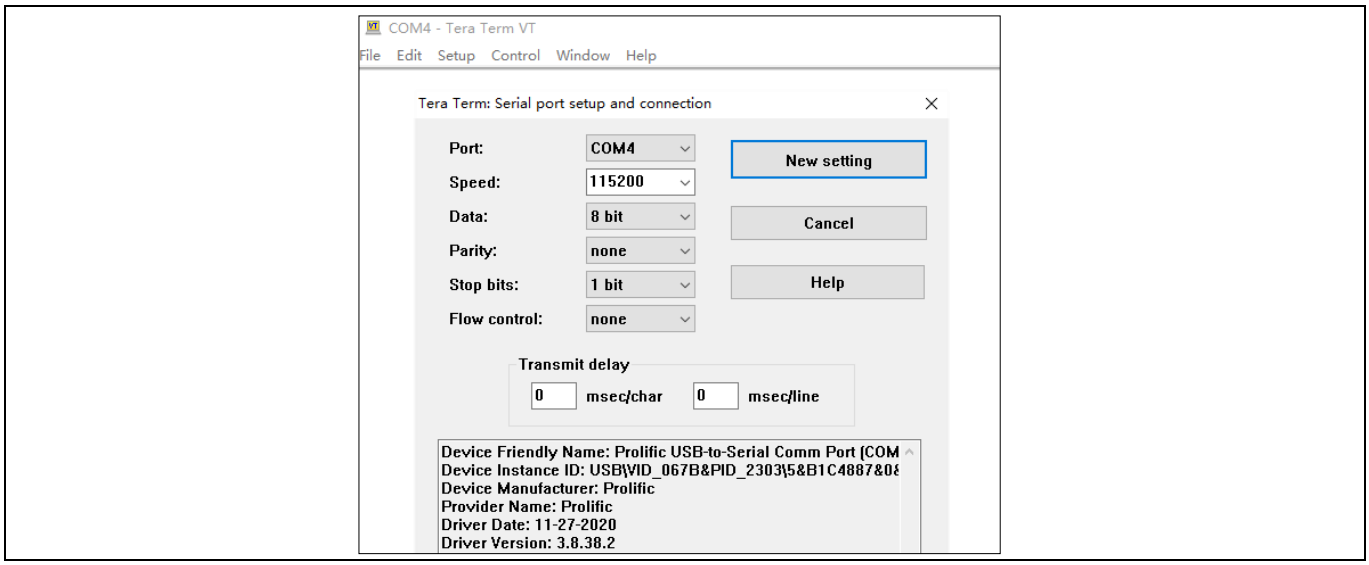


Figure 85 TeraTerm UART configuration

For more details on debugging application, see the Eclipse IDE for ModusToolbox™ software user guide (locally available at *{ModusToolbox™ software install directory}/docs_{version}/mt_ide_user_guide.pdf*).

6.2 HMI & System Control Board

After the successful creation of an HMI & System Control Board project, the *readme* file will be displayed in ModusToolbox™ IDE when the “Induction_Cooktop_HMI” project is selected. Go through the *readme* file for more details on the features and configurations that the software offers.

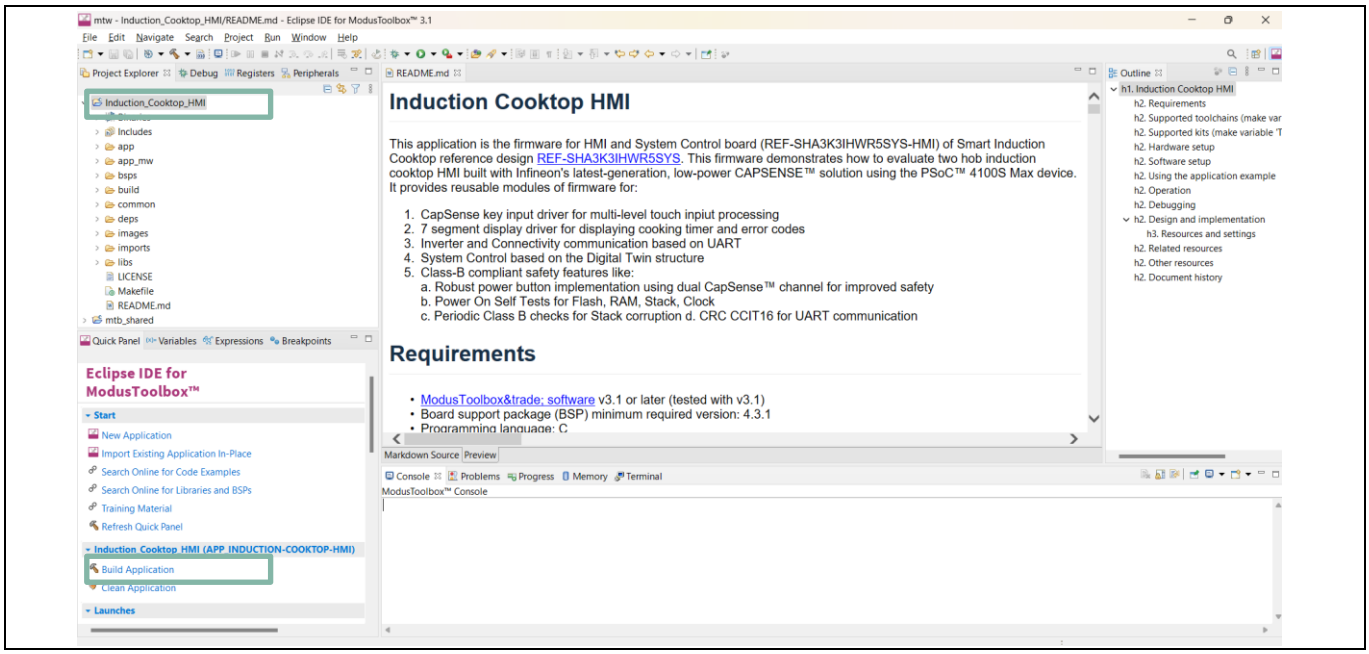


Figure 86 ModusToolbox™ after creating/importing Induction Cooktop HMI & System Control Board application

Build the application by selecting **Build Application** from the **Quick Panel**.

After successfully building the program, you can debug the same by connecting the MiniProg4 and debug consoles over a USB interface.

Figure 87 HMI & System Control Board debug interfaces - MiniProg4 and USB(power & debug console)

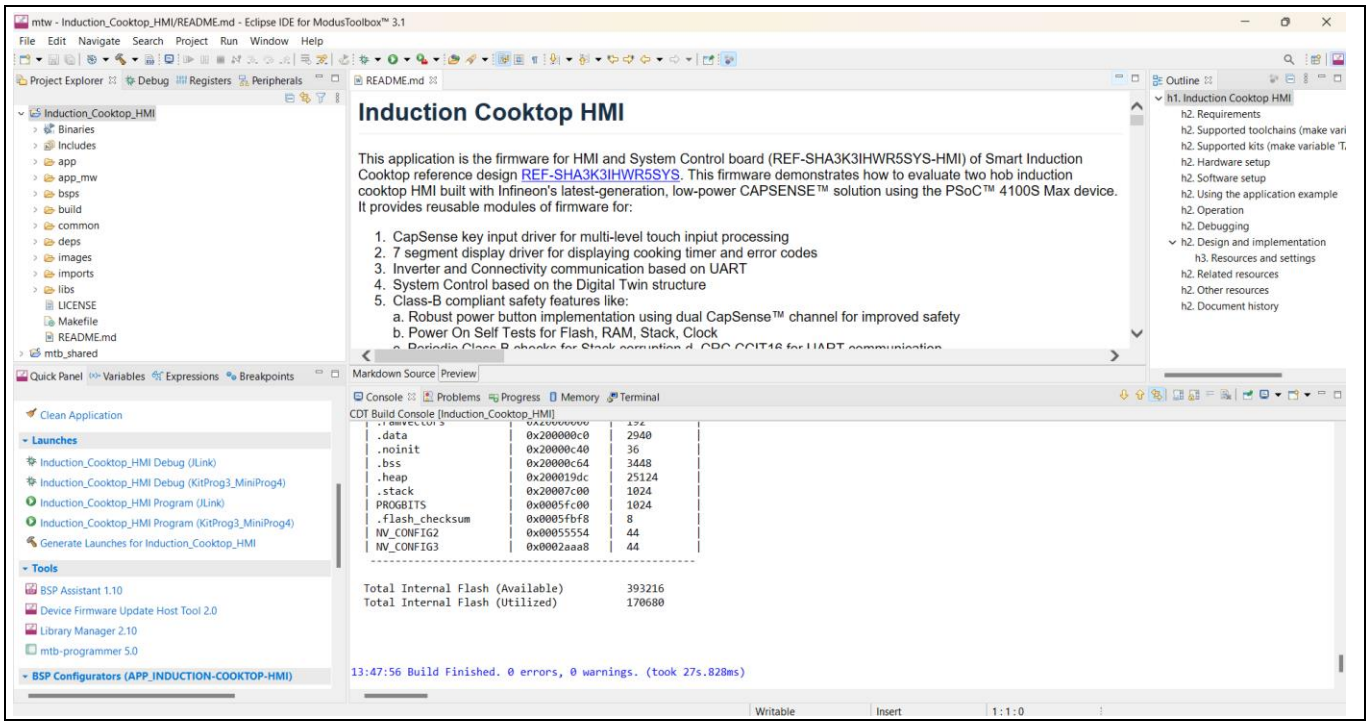


Figure 88 Successful induction cooktop HMI application building

For debug console logs, open the USB to UART with the following configurations to receive the logs.

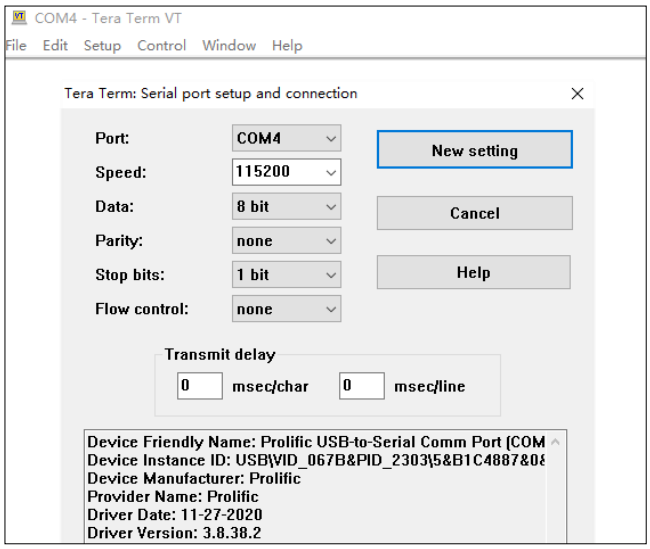


Figure 89 TeraTerm UART configuration

For more details on debugging the application, see the Eclipse IDE for ModusToolbox™ software user guide (locally available at *{ModusToolbox™ software install directory}/docs_{version}/mt_ide_user_guide.pdf*).

6.3 Connectivity Board

After creating a Connectivity Board project successfully, the *readme* file will be displayed in ModusToolbox™ IDE when the “Induction_Cooktop_Connectivity” project is selected. Go through the *readme* file for more details on the features and configurations that the software offers.

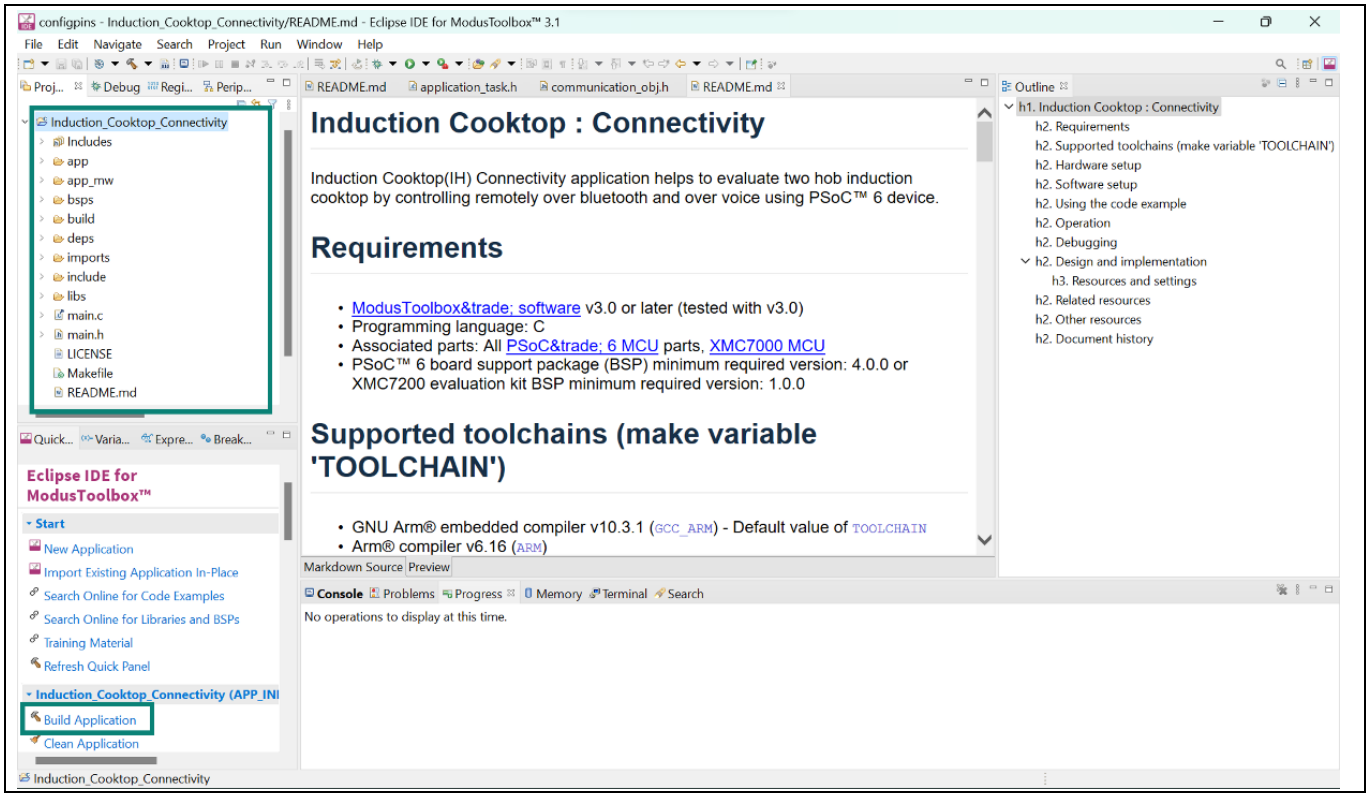


Figure 90 ModusToolbox™ after creating/importing Induction Cooktop Connectivity Board application with build option

Build the application by selecting **Build Application** from the **Quick Panel**.

After successfully building the program, you can debug it by connecting the MiniProg4 and debug consoles over USB interface or TTL UART.

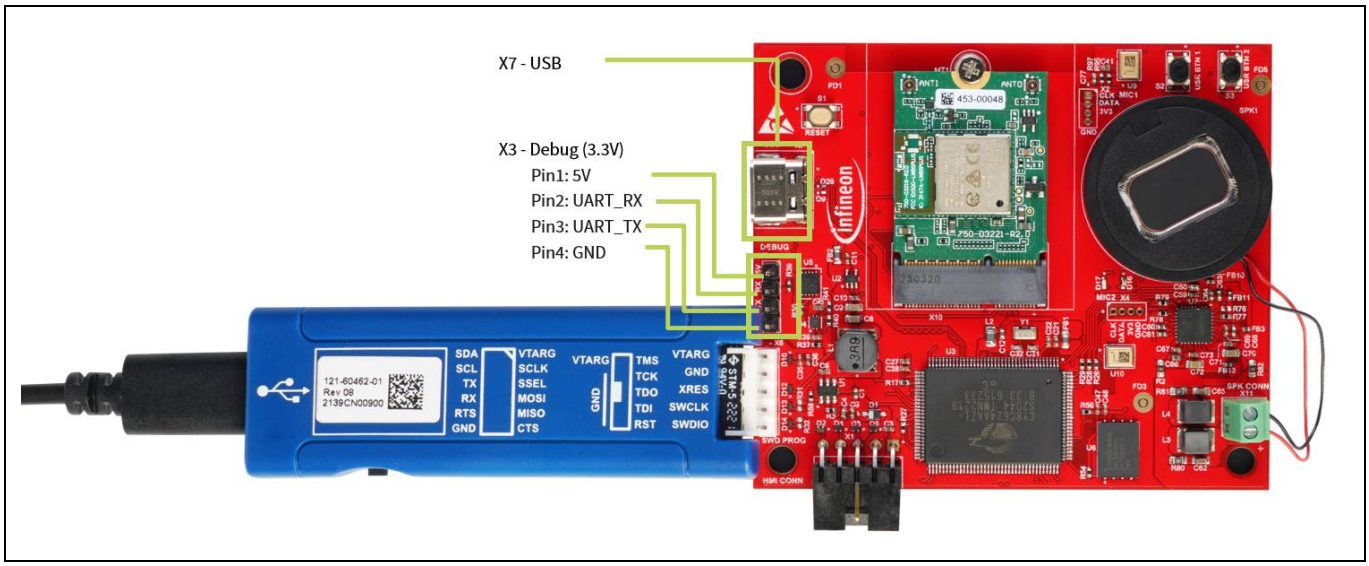


Figure 91 Connectivity Board debug interfaces - MiniProg4, Debug, and USB (Power & debug console)

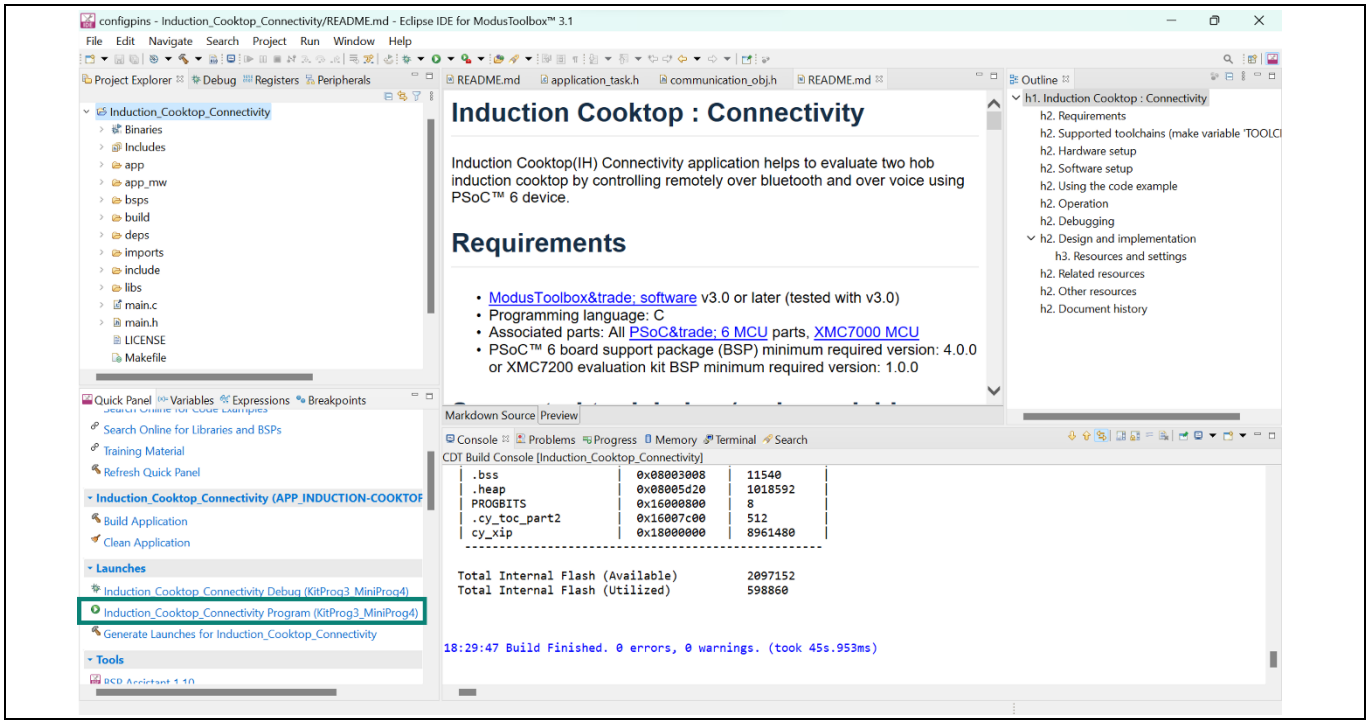


Figure 92 Programming Connectivity Board from ModusToolbox™

For debug console logs, open the USB to UART with the following configurations to receive the logs.

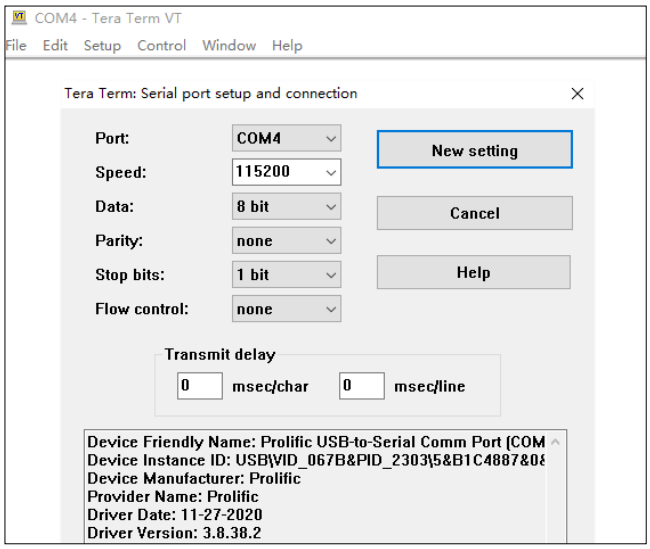


Figure 93 TeraTerm UART configuration

For more details on debugging the application, see the Eclipse IDE for ModusToolbox™ software user guide (locally available at *{ModusToolbox™ software install directory}/docs_{version}/mt_ide_user_guide.pdf*).

7 System performance

System provides a low stand-by power of less than 0.5 W when the AC power supply is applied to the complete induction cooktop (Standby mode).

Figure 94 Standby power consumption of Smart Induction Cooktop Reference Design

7.1 Inverter Control Board

This section shows examples of switching waveforms using an Inverter Control Board PCBA. The waveforms in the following figure represent the low-side IGBT VCE, VGE (gate to emitter voltage) and IC (coil current) waveforms, where the system operates at an input power of 1.8 kW with the coil and cooking vessel suitable for induction cooking.

The specification of the coil and vessel assembly is provided in section 1.3. With an input voltage of 240 V, the switching frequency to achieve 1.8 kW is shown in the following figure.

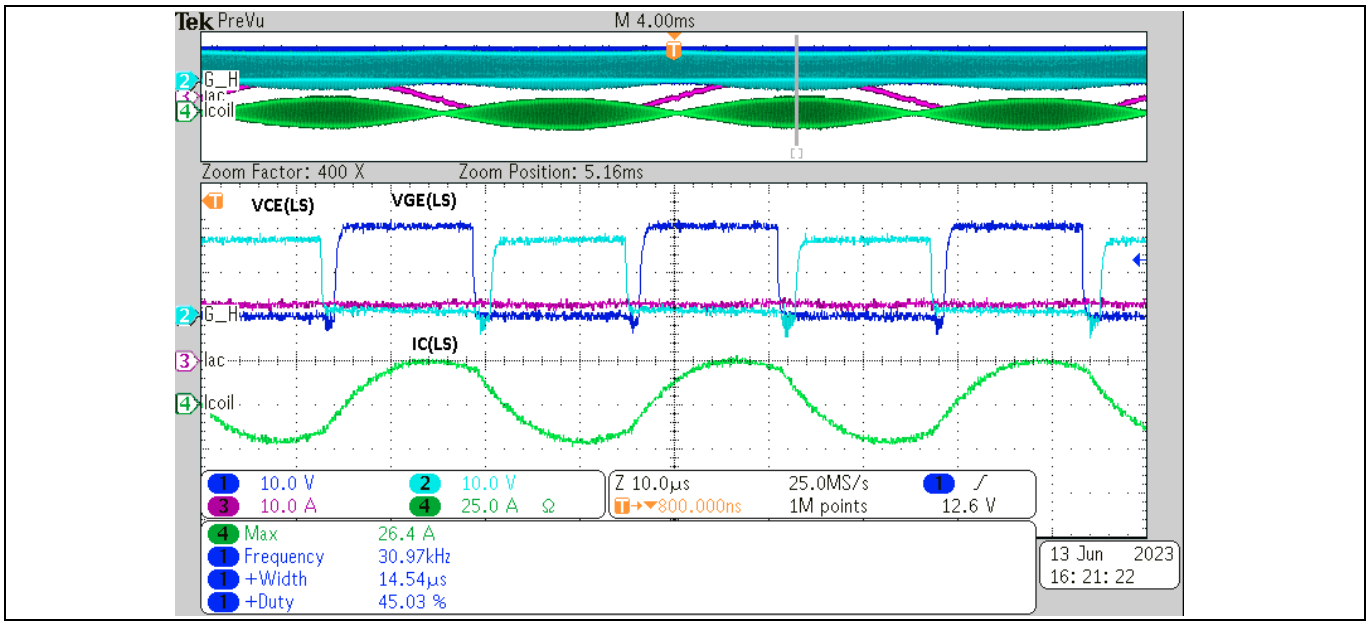


Figure 95 Typical waveforms of the Inverter Control Board PCBA as a low-side switch

7.2 HMI & System Control Board

PSoC™ 4100S Max can support wide parasitic capacitance for touch input processing and HMI & System Control Board touch interfaces demonstrates the same and associated SNR values for each of the sense element:

C_p(pF): 9.08 pF to 21.82 pF

SNR: 20 to 58

Sl. no.	Sensor	C_p(pF)	SNR
1	CS0_PWR_0	20.26	22:1
2	CS1_PWR_1	20.72	20:1
3	CS0_Timer	9.7	58:1
4	CS0_HOB_1_MINUS	13.6	27:1
5	CS0_HOB_1_PLUS	12.84	31:1
6	CS0_HOB_1_CTL	14.96	20:1
7	CS1_PAUSE	13.68	38:1
8	CS1_LOCK	20.94	40:1
9	CS1_HOB_2_PLUS	21	25:1
10	CS1_HOB_2_MINUS	13.28	25:1
11	CS1_HOB_2_CTL	16.56	20:1
12	CS1_VOICE	11.76	32:1
13	CS1_CONNECT	9.08	35:1
14	CS0_SLD_0	21.82	43:1
15	CS0_SLD_1	19.52	53:1
16	CS0_SLD_2	18.22	43:1
17	CS0_SLD_3	16.54	40:1
18	CS0_SLD_4	14.96	58:1
19	CS0_SLD_5	14.24	57:1
20	CS0_SLD_6	12.64	54:1
21	CS1_SLD_0	14.32	37:1
22	CS1_SLD_1	14.32	42:1
23	CS1_SLD_2	14.22	32:1
24	CS1_SLD_3	16.18	44:1
25	CS1_SLD_4	15.96	43:1
26	CS1_SLD_5	19.58	31:1
27	CS1_SLD_6	21.22	48:1

8 Appendices

8.1 HMI & System Control Board detailed usage

8.1.1 Touch interface

Sl. no.	Touch type	Duration (ms)	Description
1	Short	50	
2	Long	1000	
3	Continuous	1700	
4	Error	30000	Any press beyond 30 s is considered as error in touch interface

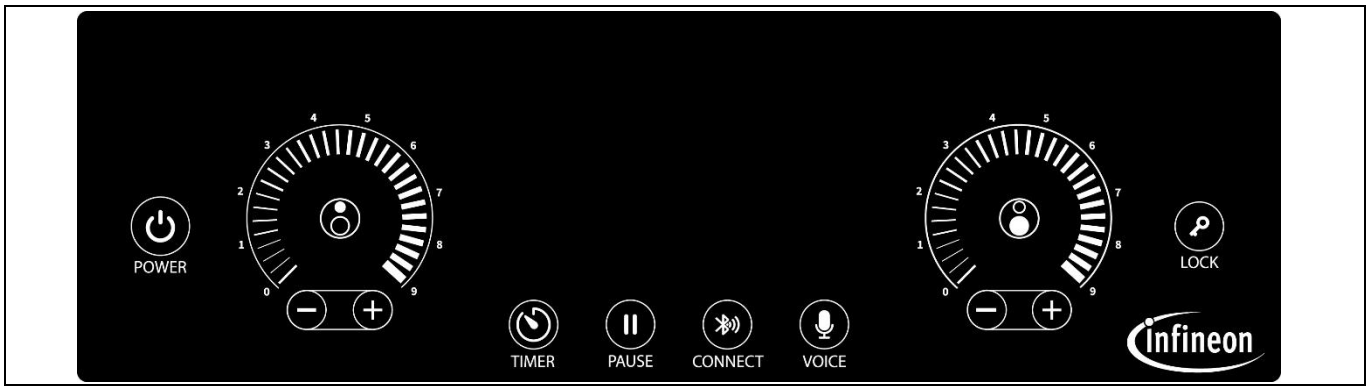
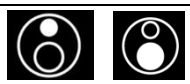
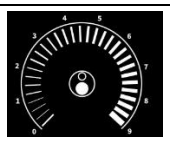


Figure 96 Smart Induction cooktop top view

Sl. no.	Sensor	Sensor name	Function
1		Power button	Turn ON/OFF the entire system
2		Induction hob select	Select the cooking zone/induction hob. Filled dot represent size of the induction hob.
3		Horseshoe radial slider	Set power level for the induction hob/cooking zone
4		Plus /minus button	Set power/timer for the induction hob/cooking zone
5		Timer	Enable/disable Timer functionality
6		Pause	Enable/disable Pause functionality

7		Connect	Enable/disable Bluetooth® connection with the iOS/ Android mobile app
8		Voice	Enable/disable microphone functionality
9		Lock	Enable/disable Child lock functionality

8.1.2 7-segment display

Sl. no.	Display	Function
1	_99	Auto-shutdown timer value for big induction hob
2	_99	Auto-shutdown timer value for small induction hob
3	b.002	Boost mode with auto-shutdown timer. Radial LED to be blinking.
4	L	Chile lock enabled
5	- 11 -	Induction cooktop in pause mode
6	Lb.02	Child lock enabled in boost mode
7	L_99	Child lock enabled auto-shutdown timer value for big induction hob
8	L-99	Child lock enabled auto-shutdown timer value for small induction hob
9	Er00	Non-recoverable. Only AC power on-off may recover the system.
10	IH	Independent Mode evaluation for experiencing and validating HMI interface.

8.1.3 Error codes

Error code	Description
Er00	Over-temperature of big IH IGBT
Er01	Over-temperature of small IH IGBT
Er02	Over-temperature of big IH surface
Er03	Over-temperature of small IH surface
Er04	Error in processing input CAPSENSE™ sensors
Er05	Error in timer peripheral
Er06	Error in seven segment interface
Er07	Error in buzzer interface
Er08	Error due to failure of Class B test
Er09	Error due to failure of communication with the Inverter Controllrer Board
Er 10	Error due to temperature sensor failure
Er 11	Error due to current sensor failure
Er 12	Error due to overcurrent in small IH inverter circuit
Er 13	Error due to overcurrent in big IH inverter circuit
Er 14	Error due to over input voltage

8.1.4 Buzzer

Sl. no.	Buzzer beep type	Duration (ms)	Feedback
1	Short	100	Short press of button widgets, cooking timer expiry
2	Long	500	Long press of button widgets
3	Wrong	300	Wrong usage of button widgets

8.1.5 Induction Cooktop Control

8.1.5.1 Switching the system ON/OFF

The HMI is the master controller unit and it enables/ disables power supply to the Inverter and Connectivity MCU. When *Power* button is pressed for a long duration (1s), it turns ON

the system and Connectivity, making the system to enter IDLE mode from standby.

In any mode of operation, if the Power button is pressed with short/long press, the system enters to standby state.

System ON		Long press
System OFF		Short press Long press

8.1.5.2 ON/OFF and power level

Once the system is in the idle state, the induction hobs can be enabled by performing a short press on the induction hob **Select** button.

Widget Name	Widget	Short press	Long press
Small IH		Power ON Select	Shutdown
Big IH		Power ON Select	Shutdown

- If one of the induction hob's is powered ON, the power supply to the inverter is enabled.
- Using the respective induction hob's ***horseshoe radial slider*** or **+/-** buttons power levels from 0-9 can be set. Using the ***Plus*** button for a long press will enable the respective induction hobs to enter the *boost* mode (power level 10).

Widget name	Widget	Short press	Long press
Small induction hob		Increase/decrease power level	Only **"+"** supports. If power level is 9, then boost mode is entered for a fixed duration of 3 minutes
Big IH		Increase/decrease power level	Only **"+"** supports. If power level is 9, then boost mode is entered for a fixed duration of 2 minutes

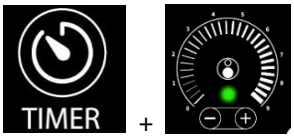
Note: *To keep the overall power consumption of the system within the rated 3600 W, only one of the induction hobs can be in boost mode. The power levels of the non-boost induction hob can be increased till predefined power levels as per the following table.*

Sl. no.	Boost enabled induction hob	Maximum power level of non-boost hob
1	Small	Big induction hob can go up to power level 3
2	Big (10)	Big induction hob can go up to power level 4

The auto-shutdown cooking timer for the respective cooking zones can be set if the induction hob is active and PAN detection is successful.

- A short press on the Timer button enables the timer input mode for the cooking induction hob. If only one of the induction hobs is active, the timer input is enabled for the active induction hob. In case if both induction hobs are active, the hob select LED will blink a green LED, waiting for the user to select the cooking zone.

Widget name	Widget	Short press	Long press	Continuous press
Timer button		Initiate auto-shutdown timer setting for an induction hob	Turn OFF All active auto shut down timers of induction hobs	

Widget name	Widget	Short press
Small hob		Select auto-shutdown timer mode for small induction hob for entering timer value.
Big hob		Select auto-shutdown timer mode for big induction hob for entering timer value.

- Once the intended induction hob is selected the user will be able to set the timer using the plus/minus button. By default, the auto-shutdown timer starts with 5 min. If there is no user input for 7 seconds after enabling the auto-shutdown input timer mode for an induction hob, the auto-shutdown timer for the selected induction hob will be 5 mins.

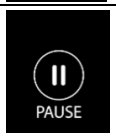
Widget name	Widget	Short press	Long press	Continuous press
Plus /minus button in timer mode		Increment/decrement the timer value by 1		Increment/decrement the timer value by 5
7-segment for small hob timer input				
7-segment for big hob timer input				

Note: *The cooking timer for each induction hob has a maximum value of 99 minutes. To adjust the timer, the user may press the plus or minus button for a short duration to increment or decrement the timer in 1-minute intervals. Alternatively, if the plus or minus button is continuously pressed, the timer value will increment or decrement in 5 minute intervals.*

- Switching OFF the timer can be done by long pressing the Timer button. This will reset the cooking timer to default value of 5 mins.

4. Pause/resume

The HMI includes a pause and resume feature that allows the user to pause the cooking timer and set the power level of the cooking zone to a minimum (power level 0) by performing a long press on the Pause button. To resume cooking, the Pause button can be long pressed again, and the system will restore the previous power levels and cooking timer settings.

Widget name	Widget	Long press
Pause		Pause both hobs
Resume		Resume both hobs

Note: *During the pause state, the power level and cooking timer settings are disabled for cooking zones.*

5. Lock/unlock

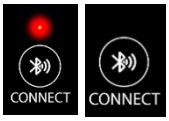
For safety reasons, the HMI includes a child lock feature that deactivates all widgets on the panel except for the power button. This feature ensures that the device cannot be unintentionally operated. To activate the lock feature, the user may perform a long press on the Lock button, and to unlock the device, the user can again perform a long press on the same Lock button.

Widget name	Widget	Long press
Lock		Enable child lock
Unlock		Disable child lock

Note: *Locking or unlocking the device will not impact the normal operation of the system, and all active operations will continue to function normally.*

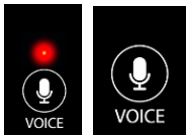
6. Connect/disconnect Bluetooth®

To connect with the mobile application, the user needs to enable the Bluetooth® interface on the Connectivity Board. Pressing the Connect button for a short duration will either start or stop the Bluetooth® interface. If the Connect button is long pressed, the pairing & bonding information will be erased in the Connectivity Board.

Widget name	Widget	Short press	Long press
Bluetooth® connect/disconnect		Enable/disable Bluetooth® advertisement	Reset the Bluetooth® credentials

7. Microphone

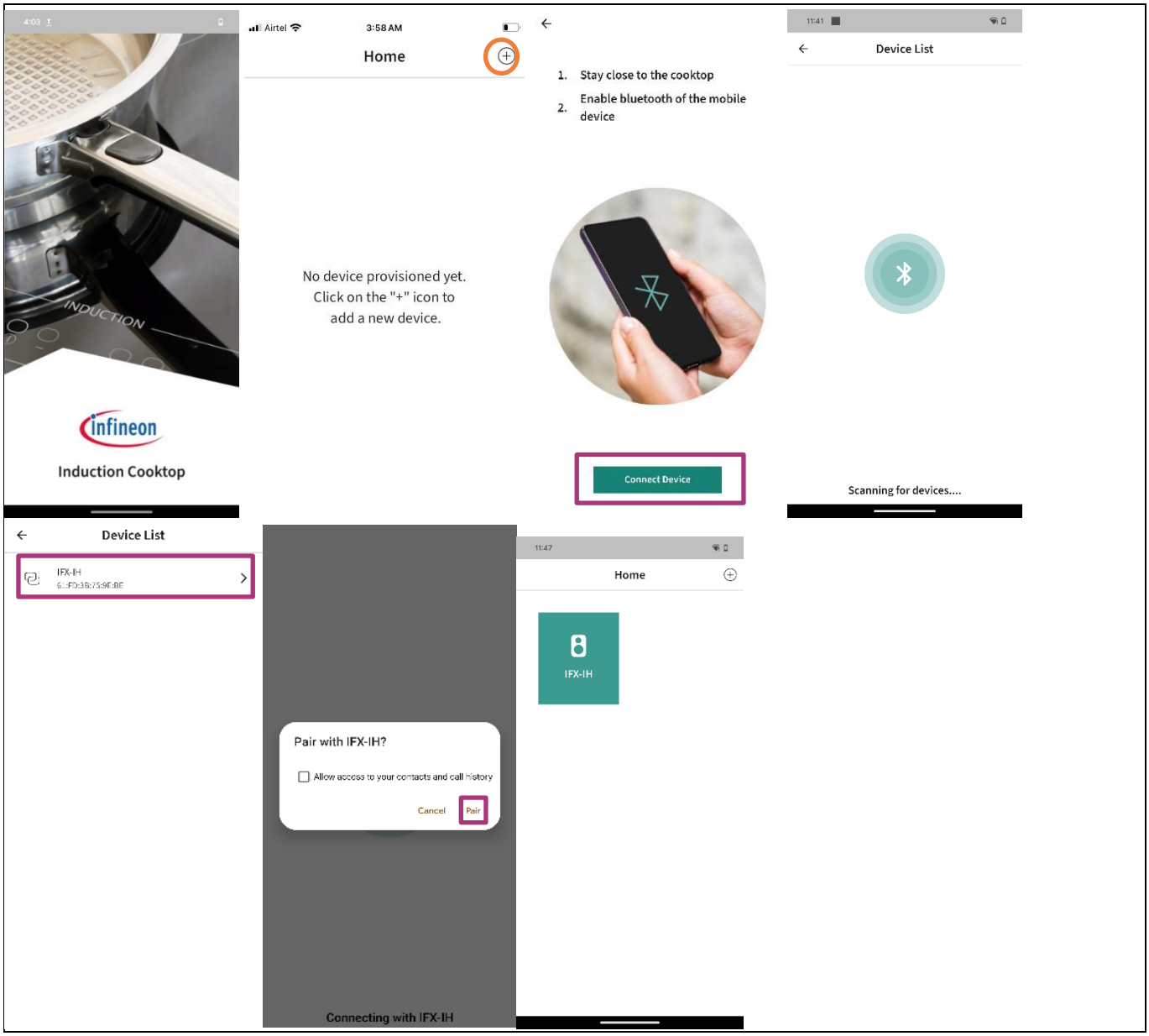
The system can be controlled using voice commands, and to enable or disable the microphone, the user needs to perform a short press on the *Voice* button.

Widget name	Widget	Short press
Voice Enable/disable		Enable/disable Voice

8.2 Mobile application usage

Download and install Induction Cooktop by Infineon Technologies from the Apple or Google application stores.

8.2.1 Adding Induction Cooktop to Mobile application



8.2.2 Dashboard/home screen

Connected and offline induction cooktop and addition controls.

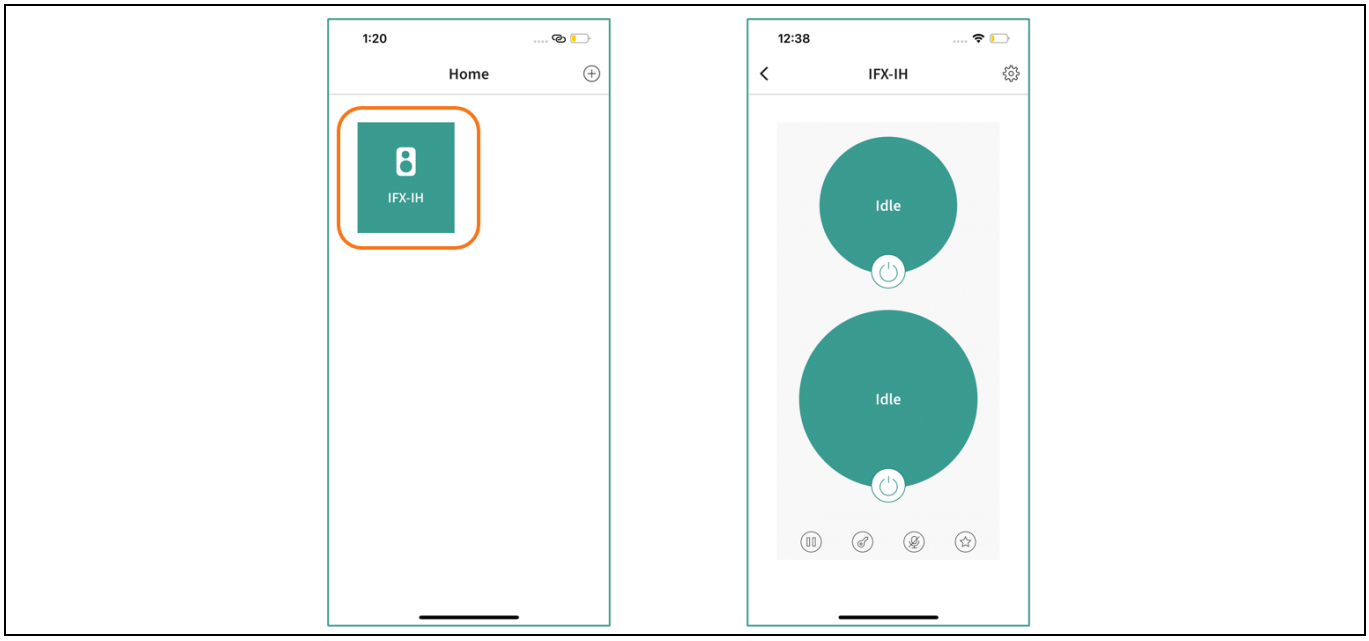


Figure 97 Connected Induction Cooktop and controlling.

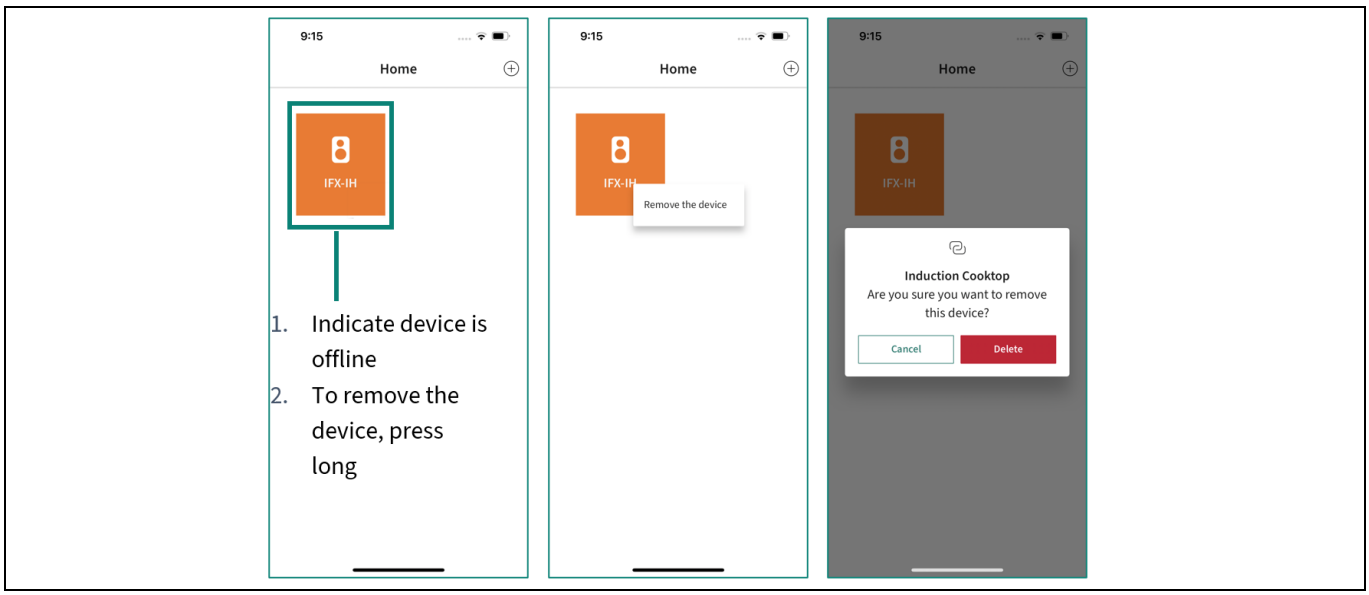


Figure 98 Offline Induction cooktop and removing the device if needed

8.2.3 Device control

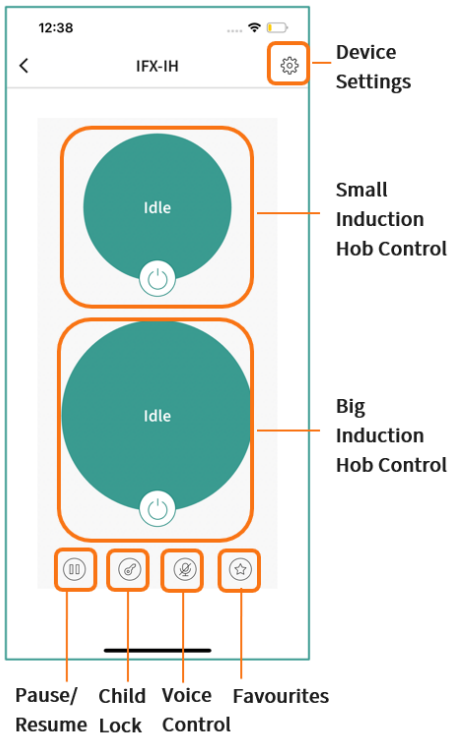


Figure 99 Induction Cooktop controls

8.2.4 Powering ON/OFF an Induction Hob

By default, the induction hob starts with power level 0 and timer value 0.

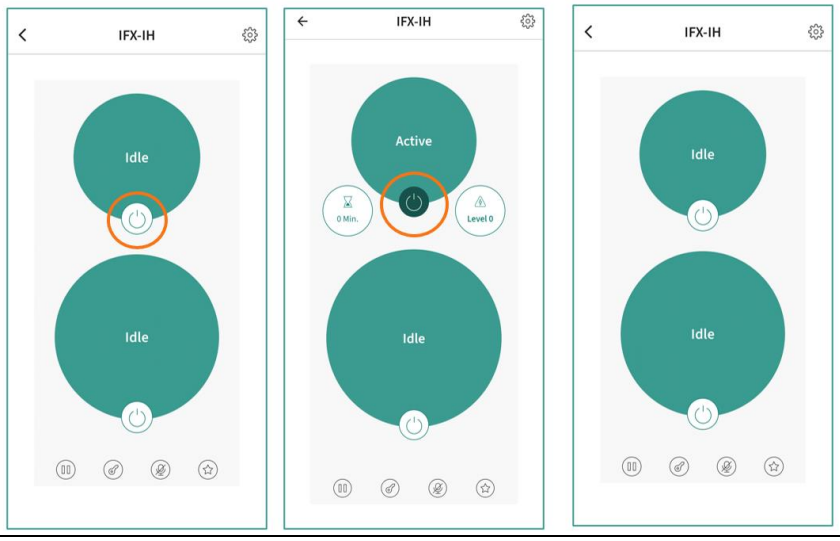


Figure 100 Navigation sequence for powering (ON/OFF) small hob

8.2.5 Induction hob power level

Each induction hob provides a power level from 0 to 9 and a boost mode.

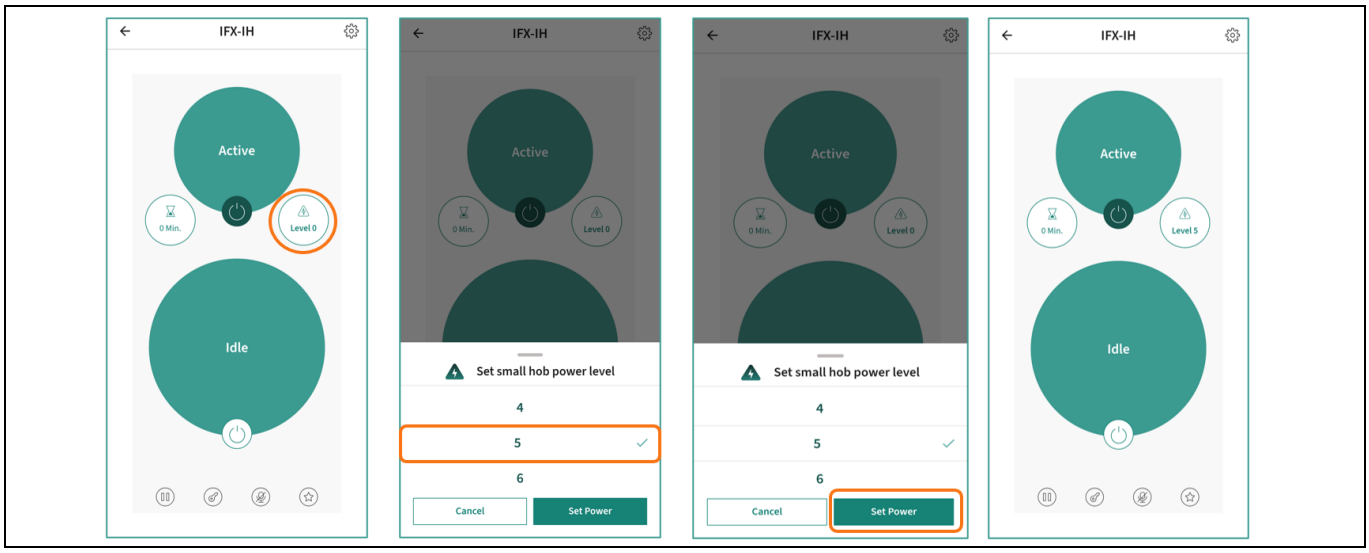


Figure 101 Navigation sequence for setting power level of small hob

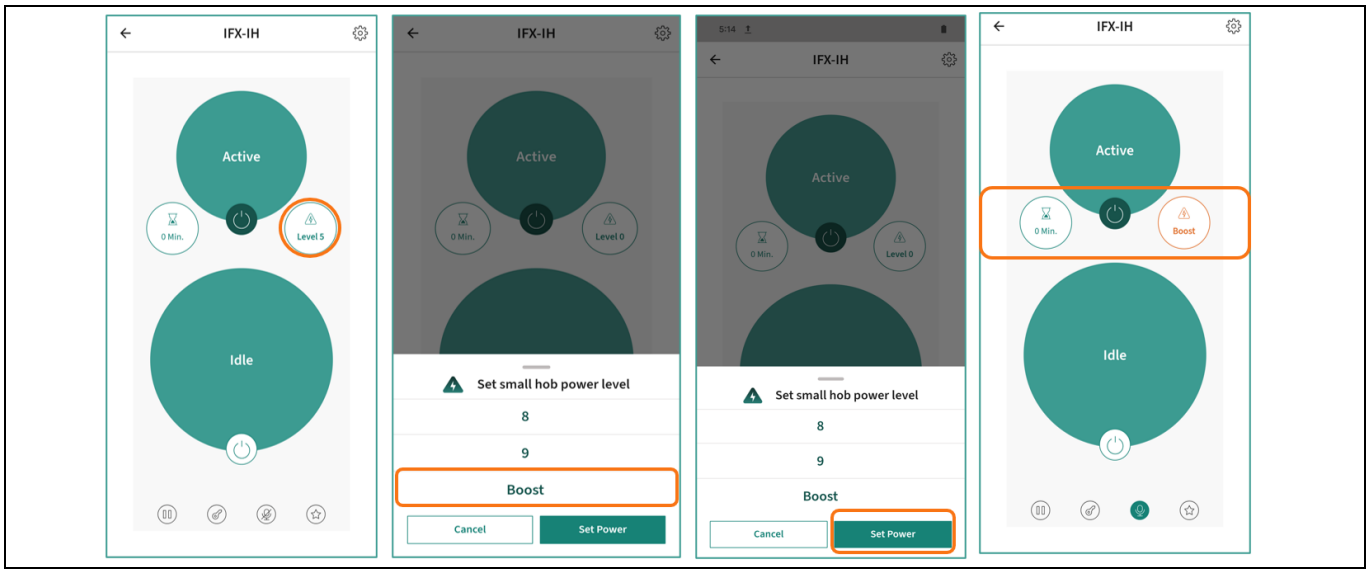


Figure 102 Navigation sequence for setting boost mode of small hob

8.2.6 Induction hob auto shut down timer control

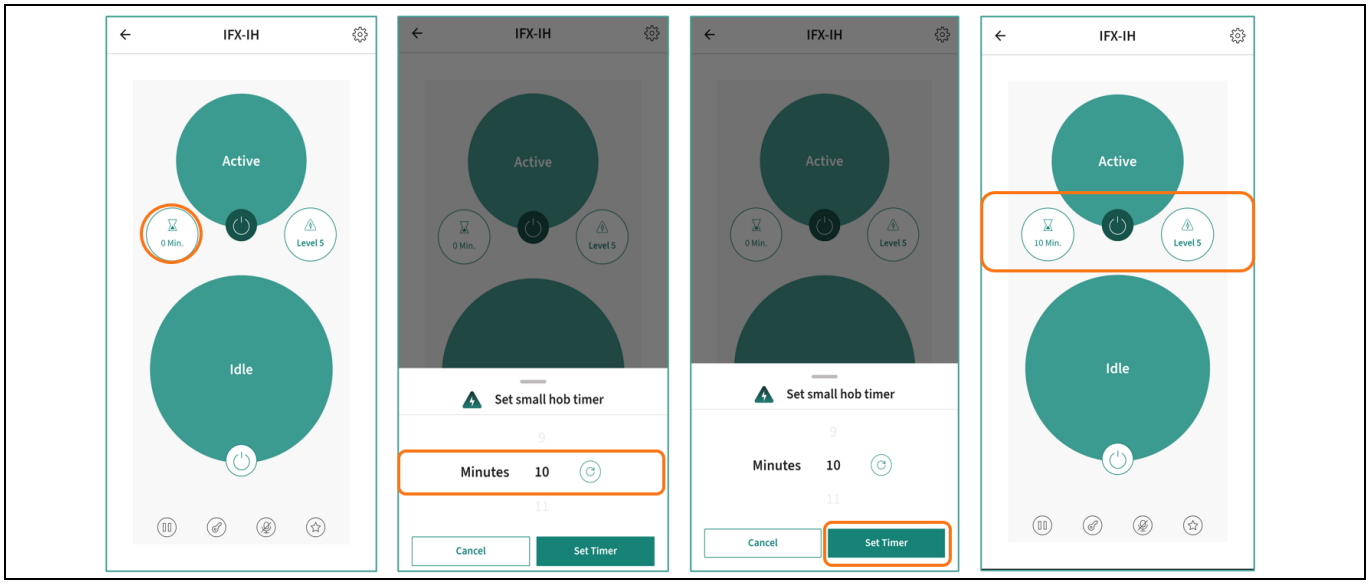


Figure 103 Navigation sequence for setting auto-shutdown timer for small hob

8.2.7 Enabling/Disabling Child lock control

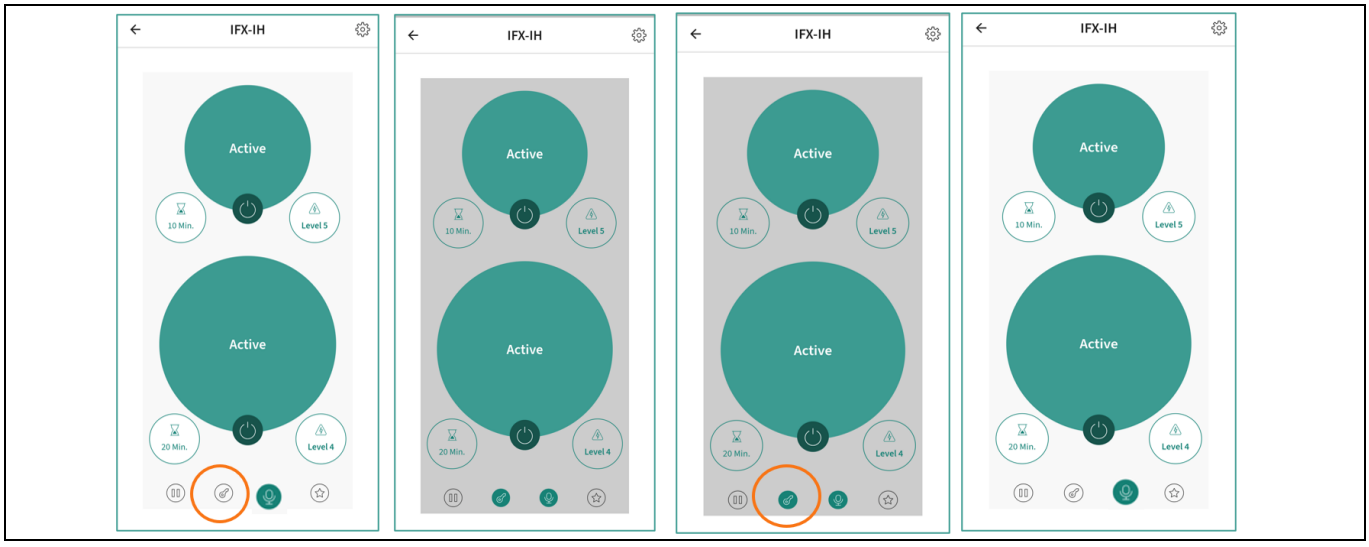


Figure 104 Navigation sequence for child lock of HMI & system control touch interface

8.2.8 Pause and resume

Figure 105 Navigation sequence for entering pause and resuming induction cooktop

8.2.9 Enable/disable voice control

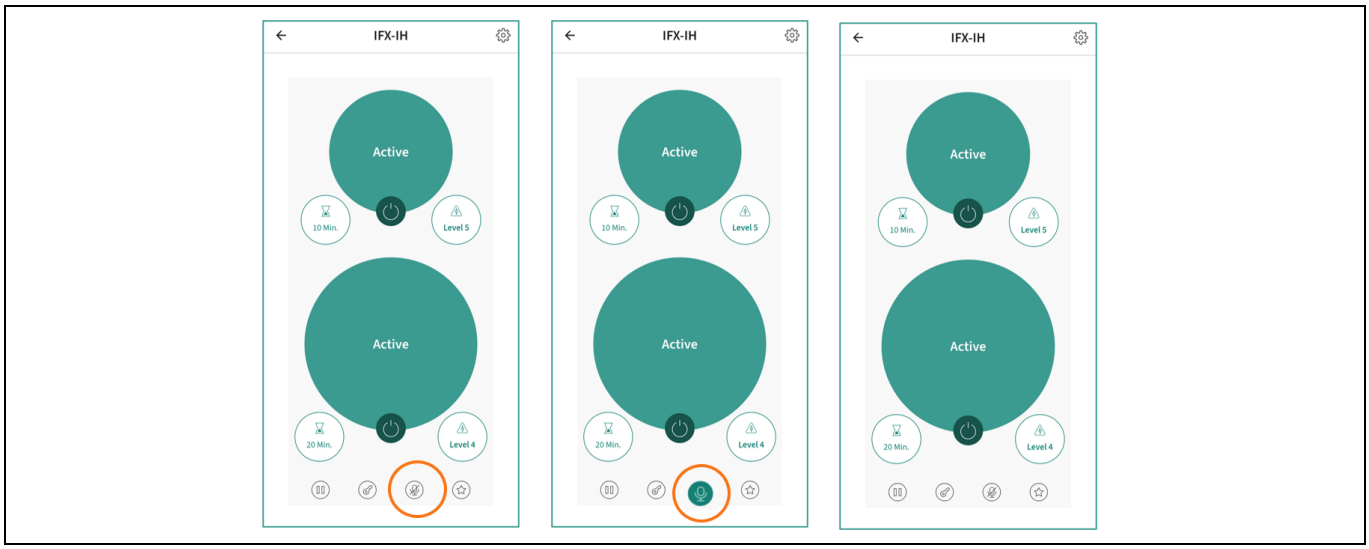


Figure 106 Enabling and disabling of off-line voice control

8.2.10 Adding favourites

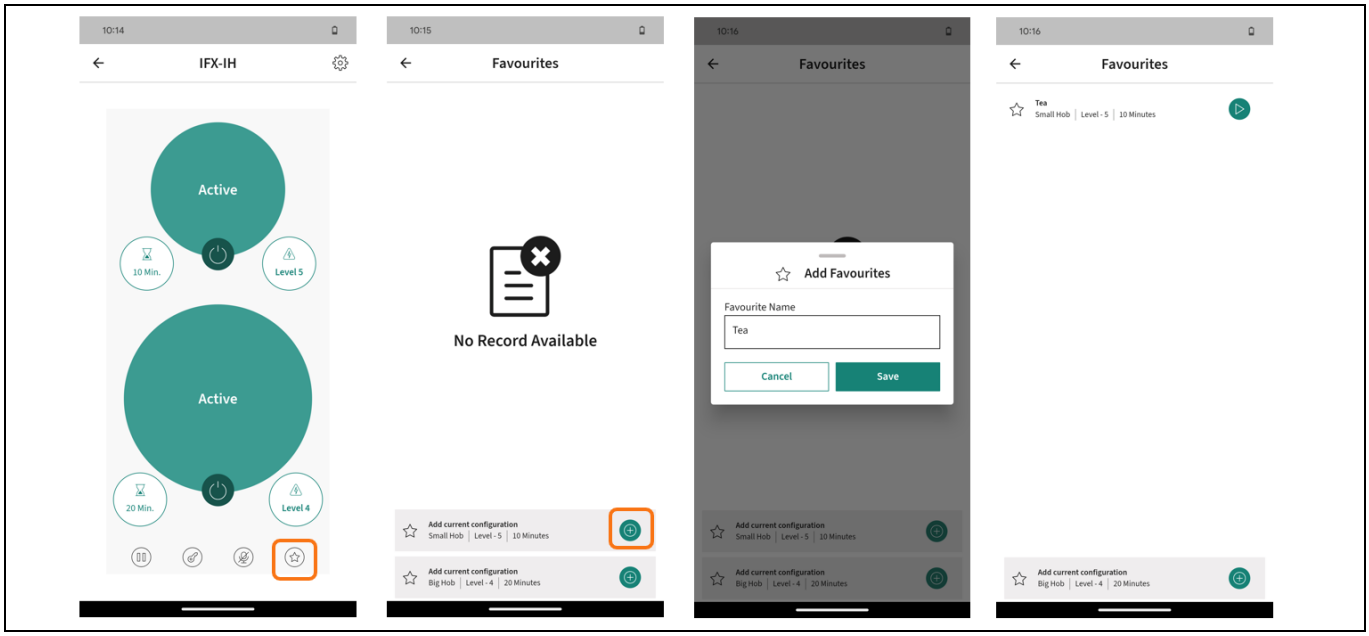


Figure 107 Navigation sequence for adding existing active hob to favourites

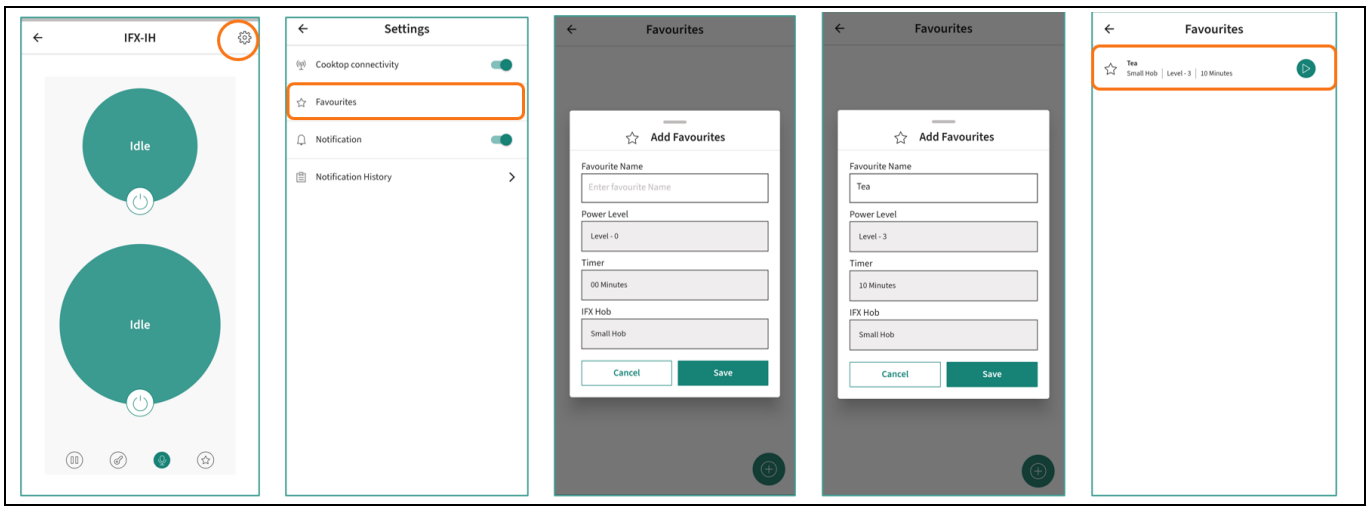


Figure 108 Navigation sequence for creating favourites from settings

8.2.11 Starting favourite configuration

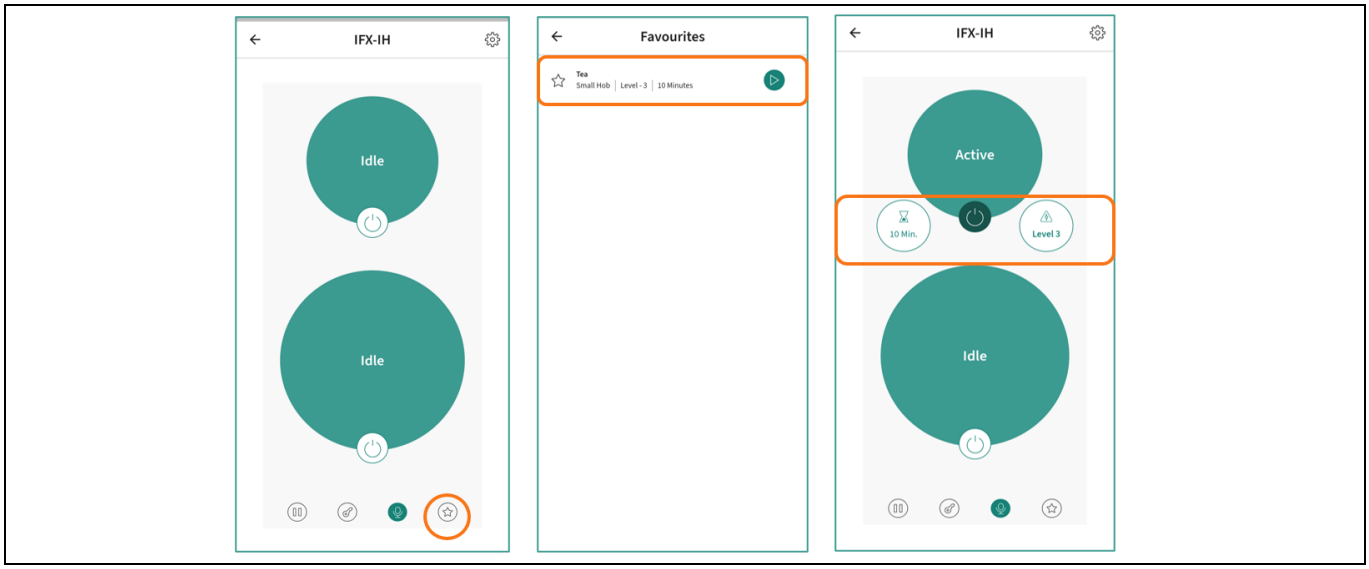


Figure 109 Navigation for starting induction cooktop with favourites option

8.2.12 Settings

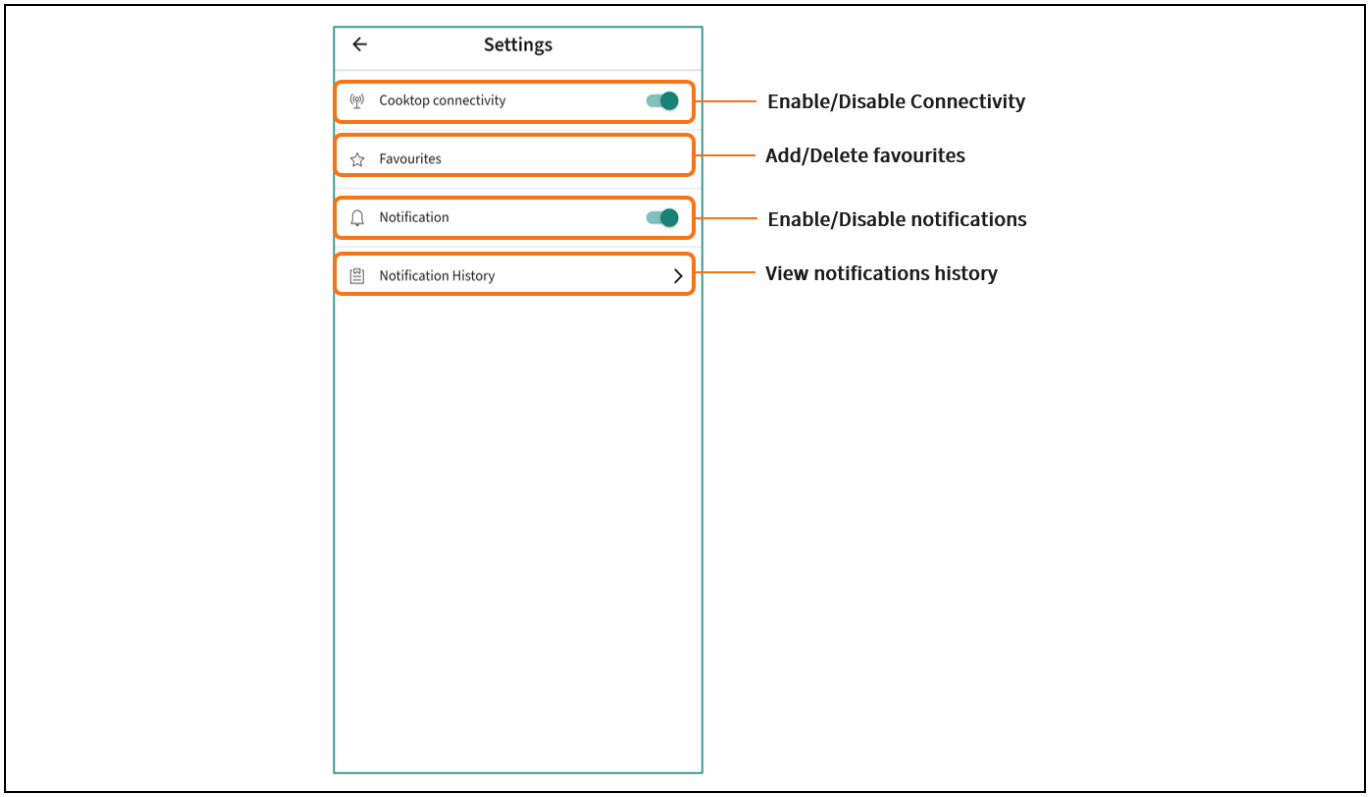


Figure 110 Induction cooktop device configuration settings

8.2.13 Notifications

Notification history or notifications for the mobile phone.

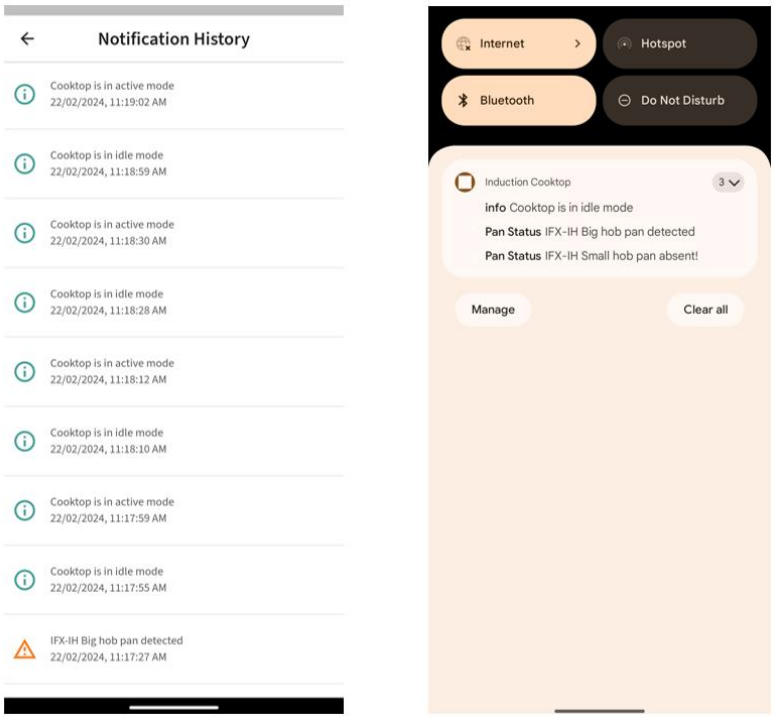


Figure 111 View of Induction cooktop device notifications

8.3 Voice commands – Speaker output

A fixed local voice command set is supported by the induction cooktop. It has a “Wake word” to trigger the system to enter to listening mode and support two level of intents for providing commands to induction cooktop. After wake-word or after first intent, if the user does not provide any next level of command within 5 seconds (a tone is generated), the user need to wake up the induction cooktop again. Note that, though the cooktop supports an auto-shutdown timer for 99 minutes but voice command support only till 30 minutes. Setting timer without setting power level will start the induction hob with power level 0.

Wake word	First intent	Second intent	Speaker response
Hello cooktop			I am listening
	Switch ON big hob		Big hob is active
	Switch ON small hob		Small hob is active
	Turn OFF big hob		Big hob is turned off
	Turn OFF small hob		Small hob is turned off
	Power OFF the cooktop		Cooktop is powered off
	Pause cooking		Cooking is paused
	Resume cooking		Cooking is resumed
	Turn off voice control		Voice control is disabled
	Enable child lock		Child lock is enabled
	Disable child lock		Child lock is disabled

Wake word	First intent	Second intent	Speaker response
	Control big hob		Big hob is selected
	Control small hob		Small hob is selected
	Enable Connectivity		Enabling Connectivity
	Disable Connectivity		Disabling Connectivity
	< *Control big hob/ Control small hob*>	Adjust power to level zero	Power level is set to zero
	< *Control big hob/ Control small hob*>	Adjust power to level one	Power level is set to one
	< *Control big hob/ Control small hob*>	Adjust power to level two	Power level is set to two
	< *Control big hob/ Control small hob*>	Adjust power to level three	Power level is set to three
	< *Control big hob/ Control small hob*>	Adjust power to level four	Power level is set to four
	< *Control big hob/ Control small hob*>	Adjust power to level five	Power level is set to five
	< *Control big hob/ Control small hob*>	Adjust power to level six	Power level is set to six
	< *Control big hob/ Control small hob*>	Adjust power to level seven	Power level is set to seven
	< *Control big hob/ Control small hob*>	Adjust power to level eight	Power level is set to eight
	< *Control big hob/ Control small hob*>	Adjust power to level nine	Power level is set to nine
	< *Control big hob/ Control small hob*>	Adjust power to level ten	Power level is set to boost
	< *Control big hob/ Control small hob*>	Set timer zero minutes	Timer is set to zero minutes
	< *Control big hob/ Control small hob*>	Set timer one minute	Timer is set to one minute
	< *Control big hob/ Control small hob*>	Set timer two minutes	Timer is set to two minutes
	< *Control big hob/ Control small hob*>	Set timer three minutes	Timer is set to three minutes
	< *Control big hob/ Control small hob*>	Set timer four minutes	Timer is set to four minutes
	< *Control big hob/ Control small hob*>	Set timer five minutes	Timer is set to five minutes
	< *Control big hob/ Control small hob*>	Set timer six minutes	Timer is set to six minutes
	< *Control big hob/ Control small hob*>	Set timer seven minutes	Timer is set to seven minutes

Wake word	First intent	Second intent	Speaker response
	< Control big hob/ Control small hob>	Set timer eight minutes	Timer is set to eight minutes
	< Control big hob/ Control small hob>	Set timer nine minutes	Timer is set to nine minutes
	< Control big hob/ Control small hob>	Set timer ten minutes	Timer is set to ten minutes
	< Control big hob/ Control small hob>	Set timer eleven minutes	Timer is set to eleven minutes
	< Control big hob/ Control small hob>	Set timer twelve minutes	Timer is set to twelve minutes
	< Control big hob/ Control small hob>	Set timer thirteen minutes	Timer is set to thirteen minutes
	< Control big hob/ Control small hob>	Set timer fourteen minutes	Timer is set to fourteen minutes
	< Control big hob/ Control small hob>	Set timer fifteen minutes	Timer is set to fifteen minutes
	< Control big hob/ Control small hob>	Set timer sixteen minutes	Timer is set to sixteen minutes
	< Control big hob/ Control small hob>	Set timer seventeen minutes	Timer is set to seventeen minutes
	< Control big hob/ Control small hob>	Set timer eighteen minutes	Timer is set to eighteen minutes
	< Control big hob/ Control small hob>	Set timer nineteen minutes	Timer is set to nineteen minutes
	< Control big hob/ Control small hob>	Set timer twenty minutes	Timer is set to twenty minutes
	< Control big hob/ Control small hob>	Set timer twenty-one minutes	Timer is set to twenty-one minutes
	< Control big hob/ Control small hob>	Set timer twenty-two minutes	Timer is set to twenty-two minutes
	< Control big hob/ Control small hob>	Set timer twenty-three minutes	Timer is set to twenty-three minutes
	< Control big hob/ Control small hob>	Set timer twenty-four minutes	Timer is set to twenty-four minutes
	< Control big hob/ Control small hob>	Set timer twenty-five minutes	Timer is set to twenty-five minutes
	< Control big hob/ Control small hob>	Set timer twenty-six minutes	Timer is set to twenty-six minutes
	< Control big hob/ Control small hob>	Set timer twenty-seven minutes	Timer is set to twenty-seven minutes
	< Control big hob/ Control small hob>	Set timer twenty-eight minutes	Timer is set to twenty-eight minutes

Wake word	First intent	Second intent	Speaker response
	< Control big hob/ Control small hob>	Set timer twenty-nine minutes	Timer is set to twenty-nine minutes
	< Control big hob/ Control small hob>	Set timer thirty minutes	Timer is set to thirty minutes

8.4 UART HDLC protocol

The custom UART HDLC protocol is implemented with a fixed 32-bytes packet size. Packet structure for the same is as shown in the following tables.

8.4.1 Command/status packet format

Byte offset	Feature	Description
Byte 0	Device ID	Source of packet Inverter- 0x5A Connectivity- 0x4A
Byte 1	Packet type	0x01- Send Command 0x02- Request Status 0x03- ACK 0x04- NACK 0x05- Request Command 0x06- Send Status
Byte 2	Length	Payload length- 0x1B
Byte 3- 29	Payload	Command payload Status payload
Byte 30	CRC 16 (LSB)	CRC CCITT16 Compliant to Class B specifications.
Byte 31	CRC 16 (MSB)	

8.4.2 ACK packet format

Byte	0	1	2
Data	0x4A	0x03	0x00

8.4.3 NACK packet format

Byte	0	1	2
Data	0x4A	0x04	0x00

Note: *One time UART packet at boot up from Connectivity to HMI with BYTE 1 = 0X02, to get the latest status from HMI.*

8.4.4 Successful communication

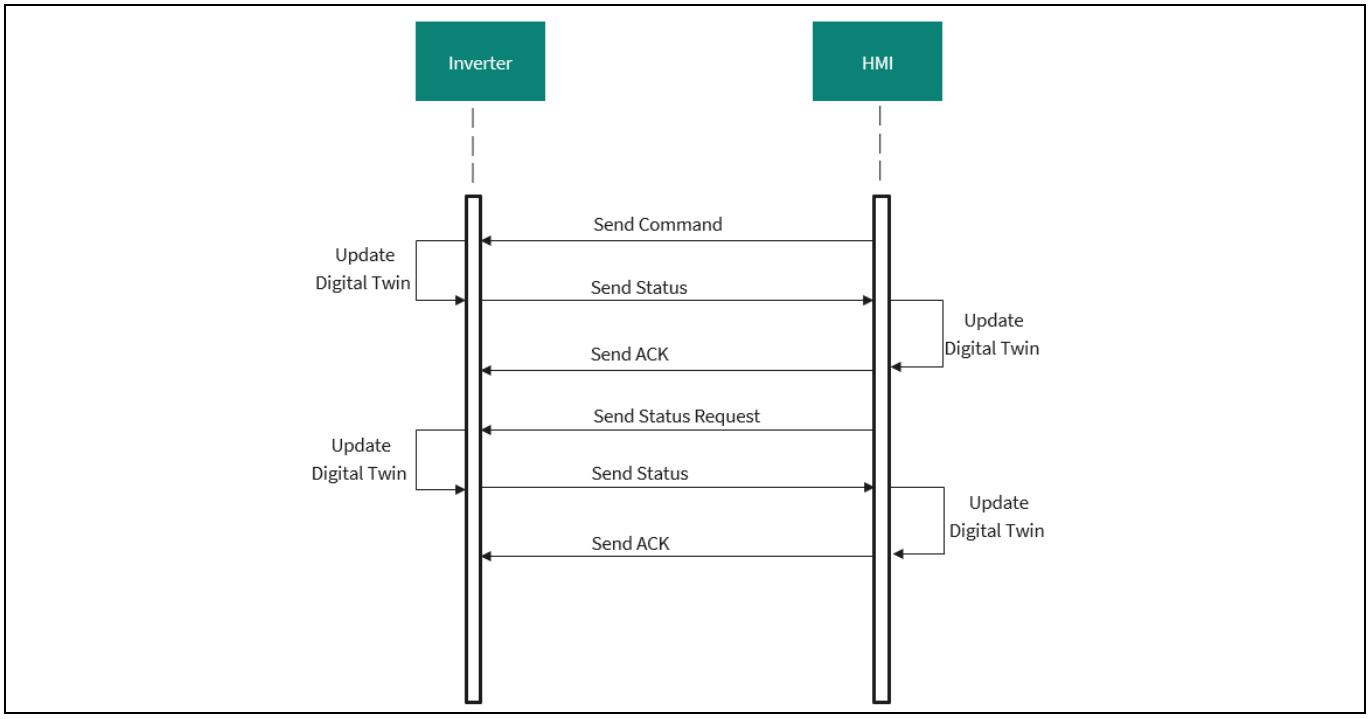


Figure 112 Sequence diagram for successful command and status exchange between inverter and HMI & System Control Board

8.4.5 Failed communication

8.4.5.1 Corrupt command from HMI

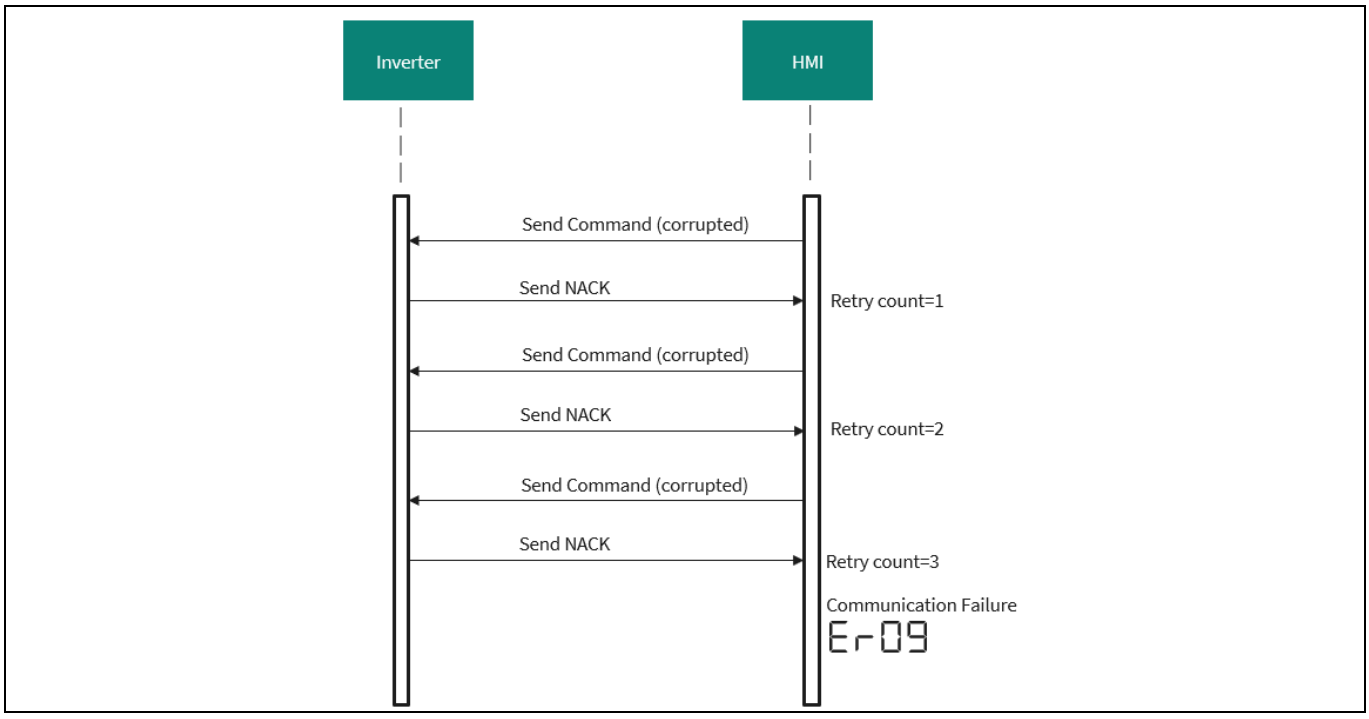


Figure 113 Sequence diagram for command CRC failure and entering to communication error status

8.4.5.2 Corrupt status from inverter

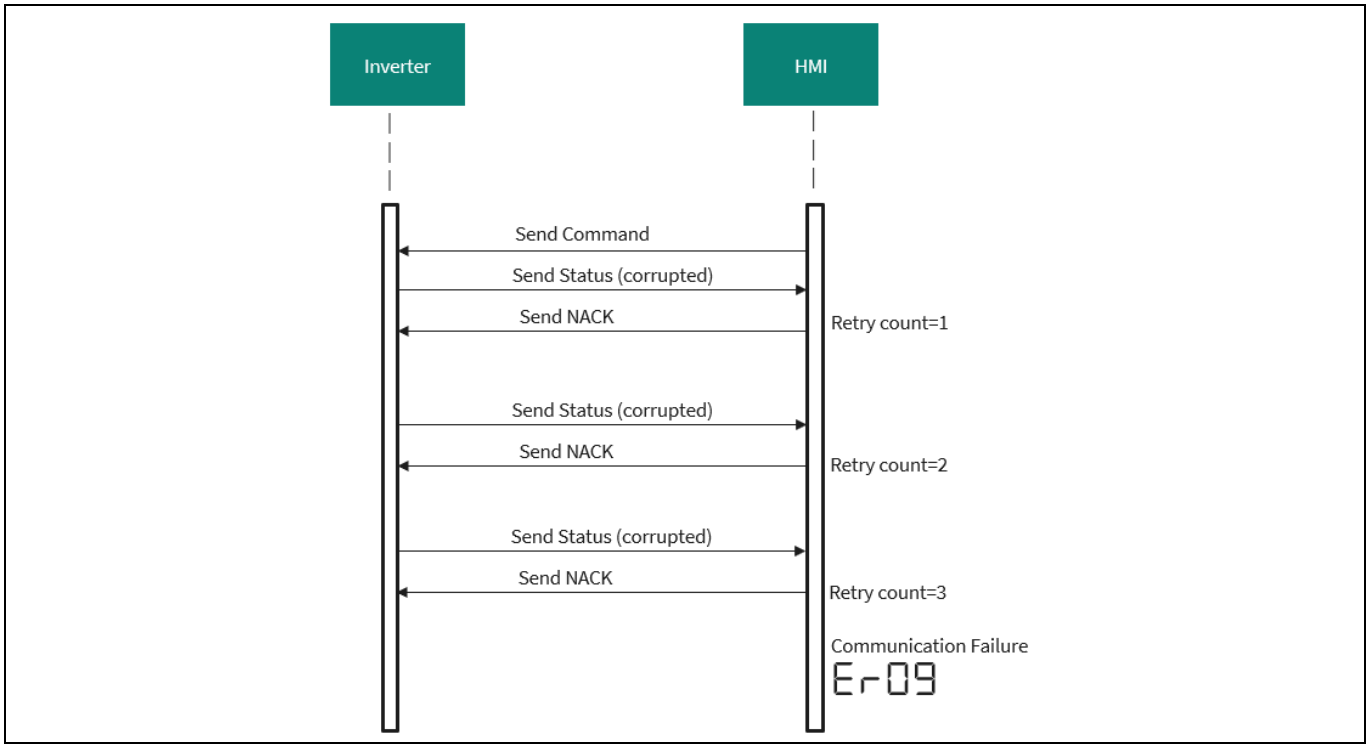


Figure 114 Sequence diagram for status CRC failure and entering to communication error status

8.4.5.3 Timeout

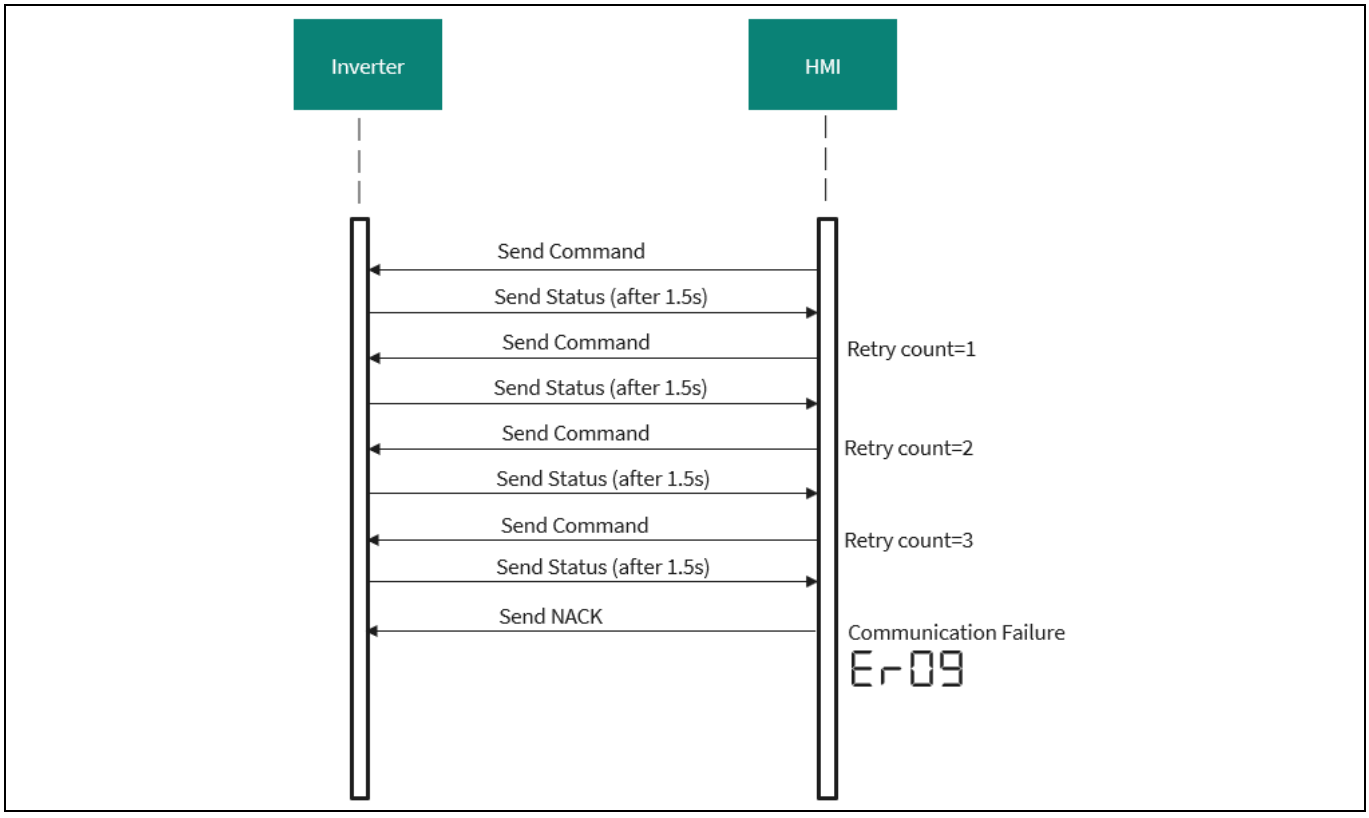


Figure 115 Sequence diagram for status failure from Inverter Control Board and entering to communication error status

8.5 Independent evaluation

To enable evaluation of Smart Induction Cooktop without the complete setup, HMI & System Control Board and Connectivity Board can be operated in independent mode.

8.5.1 HMI & System Control Board

The HMI has an independent evaluation mode that does not require an inverter or connectivity. To activate this mode, the user should press and hold the user button for 3 seconds until a buzzer beep is heard, and the seven segments on the panel displays 1X.

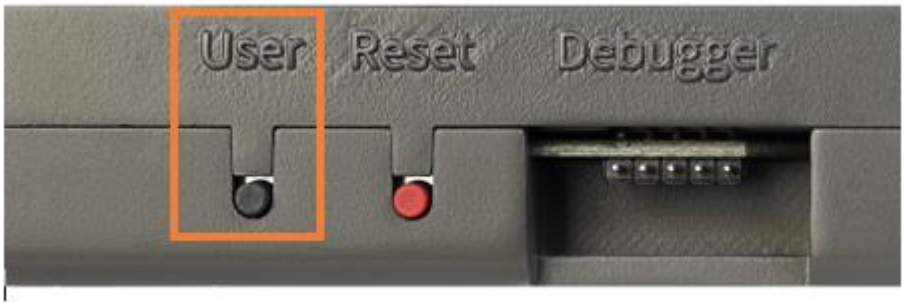


Figure 116 HMI & System Control Board user button for entering independent mode

Figure 117 HMI & System Control Board in independent mode

All the touch HMI operations can be experienced in this mode. To return to integrated mode, the user needs to power cycle the unit.

Note: *If the UART connection to the inverter is absent, and the user attempts to control the induction hob without pressing the user button, the device will display the error code Er09. To resolve this issue, the user should perform a power recycle and enter independent mode for experiencing the touch interface of the HMI & System Control Board.*

8.5.2 Connectivity Board

To evaluate the capabilities of the Connectivity Board in independent mode without the complete Smart Induction Cooktop Reference Kit set, do the following:

- Press user button 1 for more than 2 seconds, until both LEDs blink twice.
- A Red LED blinking indicates that the Connectivity Board is in standalone mode.
- A green LED blinking indicates that Bluetooth® Low Energy is in advertising mode and ready to connect with mobile application.
- Now on-board the device on Induction Cooktop mobile application. The green LED would stop blinking and would be ON, always indicating that the device is connected to the mobile application over Bluetooth® Low Energy.
- If the User Button 1 is pressed for less than 1 sec, then Connectivity Board simulates HMI communication and sends notifications to the mobile application for every 5 seconds.
- To come out of independent mode, press on the reset button or power cycle the Connectivity Board.

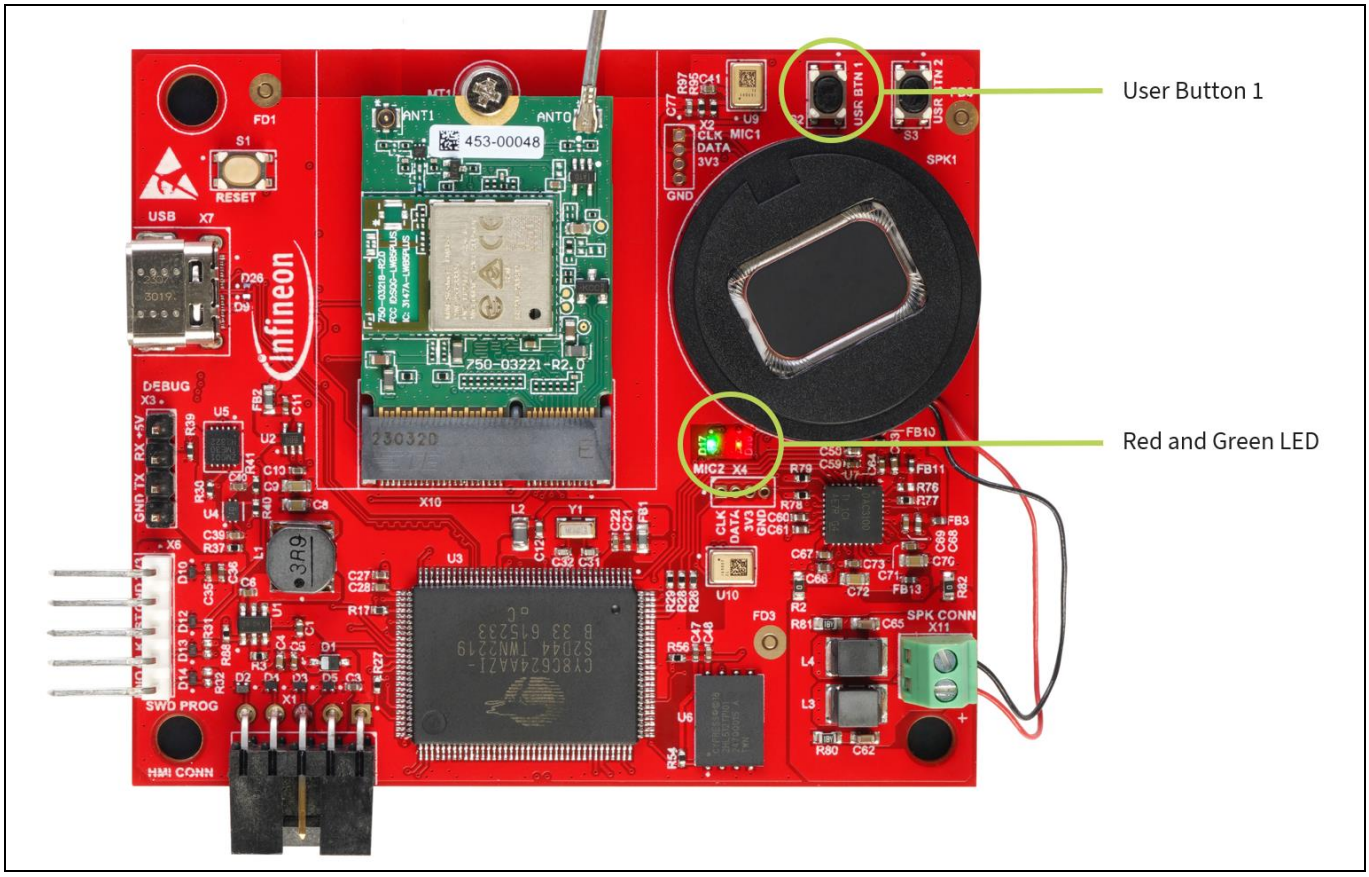


Figure 118 Connectivity Board user button 1 and LED indication

Abbreviations and definitions

Table 6 Abbreviations

Abbreviation	Meaning
CE	Conformity European
EMI	Electromagnetic Interference
POST	Power-On Self-Test
IH	Induction Hob
PCB	Printed Circuit Board
EMI	Electromagnetic Interference
A	Ampere
V	Voltage
uH	Micro Henry
W	Watt
USB	Universal Serial Bus
NTC	Negative Temperature Coefficient
PC	Personal Computer
LSB	Least Significant Bit
LED	Light-Emitting Diode
BOM	Bill of Materials
DC	Direct Current
IGBT	Insulated-Gate Bipolar Transistor
HW	Hardware
SW	Software
UART	Universal Asynchronous Receiver-Transmitter
HMI	Human Machine Interface
PWM	Pulse Width Modulation
MCU	Micro Controller Unit
HAL	Hardware Abstraction Layer
PDL	Peripheral Driver Level
BSP	Board Support Package
EEPROM	Electrically Erasable Programmable Read Only Memory
ML	Machine Learning
ELF	Executable & Linkable Format

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Glossary

AA
active authentication (AA)

AAUI
application activation user interface (AAUI)

AC
alternating current (AC)

AC
access control (AC)

ACLB
advanced contactless bridge (ACLB)
The ACLB interface is used to connect the security controller acting in the role of contactless IC (CIC) to an external analog contactless frontend (ACF), both together forming (part of) a “Boosted NFC” system. The data exchange via the ACLB interface is based on symbol level.

BDT
buffered data transfer (BDT)
The controller is in a low-power state while a communication peripheral transfers data to or from an I/O buffer.

BER
basic encoding rules (BER)

BIST
built-in self-test (BIST)
A mechanism that permits the chip to test itself.

Etc.

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Document revision	Date	Description of changes
V1.0	2024-03-26	Initial release.

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