WHITE beet H module is designed for operation over AC mains, DC lines or "dead wires"
in Home Control / Smart Grid applications over long distance (up to approx. 300 m)
and has coupling transformer with 1:5:4 winding ratio (Tx:Rx:PL).
The module has zero-cross (ZC) detector circuit for synchronizing with AC mains frequency.

Available for purchase from CODICO GmbH

WHITE beet H module provides the necessary hardware to support HomePlug GreenPHY v1.1.1
powerline communication (PLC) over long distance over any kind of wire or transmission channel
including but not limited to AC mains, DC powered lines, "dead wires", twisted pair, Bell wires, CATx
cables, Coax cables, etc.

WHITE beet H module includes STM32 MCU for a transparent bridging powerline traffic to one of
communication interfaces Ethernet, USB, SPI, CAN etc. Module supports EN 55022 and EN 50561-1
configuration settings selectable with a GPIO.

Contents

1. Features

WHITE beet H module comes in a single software configurations PLC Bridging Mode as a closed system.
The module is based on Qualcomm QCA7005-AL33 HomePlug Green PHY automotive IC and together with its TCXO generator it makes possible operation temperature up to +105°C.

The other important key facts about the module:

- STM32F745VGH6 MCU with 1MB internal Flash
- External NOR Flash Memory used as QCA7005 FW storage
- Ethernet host control interface
- UART debug output and configurable GPIOs
- Mains (110V / 240V) zero-cross (ZC) detection and digital input for ZC detection
- Optimized low noise DC/DC power supply for QCA7005
- Very low noise floor implementation on PLC side providing a maximum of SNR for communication
- Operation board temperature range -40°C to +105°C
- Operation ambient temperature range (estimated) -40°C to +85°C
- TCXO generator 25.000 MHz, +/-25ppm tolerance including full operation temperature range and 15 years of aging
- Half via pins in order to allow optical inspection of the soldering of the module and higher mechanical stability for rough environments (e.g. heavy duty machinery)
- Shielding of noise sensitive areas of the module
- Separated dual, low ripple 3.3V DC/DC power supply for QCA7005 and STM32
- Green PHY Firmware options by boot-straps for FW v1.1.0-02 and latest available firmware (currently FW v3.0)
- Boot-strap options for EN55022 / EN50561-1 EMC conformity for Home Control applications
- ARM Serial Wire Debug interface (SWD)
- 50 mm x 50 mm SMD package
- Weight 10.1±0.1 g

NOTE: This documents does not contain any WHITE-beet-H software features related information. Software documentation is provided separately.

2. Block diagram

FIGURE 3-1. WHITE-BEET-H (HOME CONTROL) BLOCK DIAGRAM
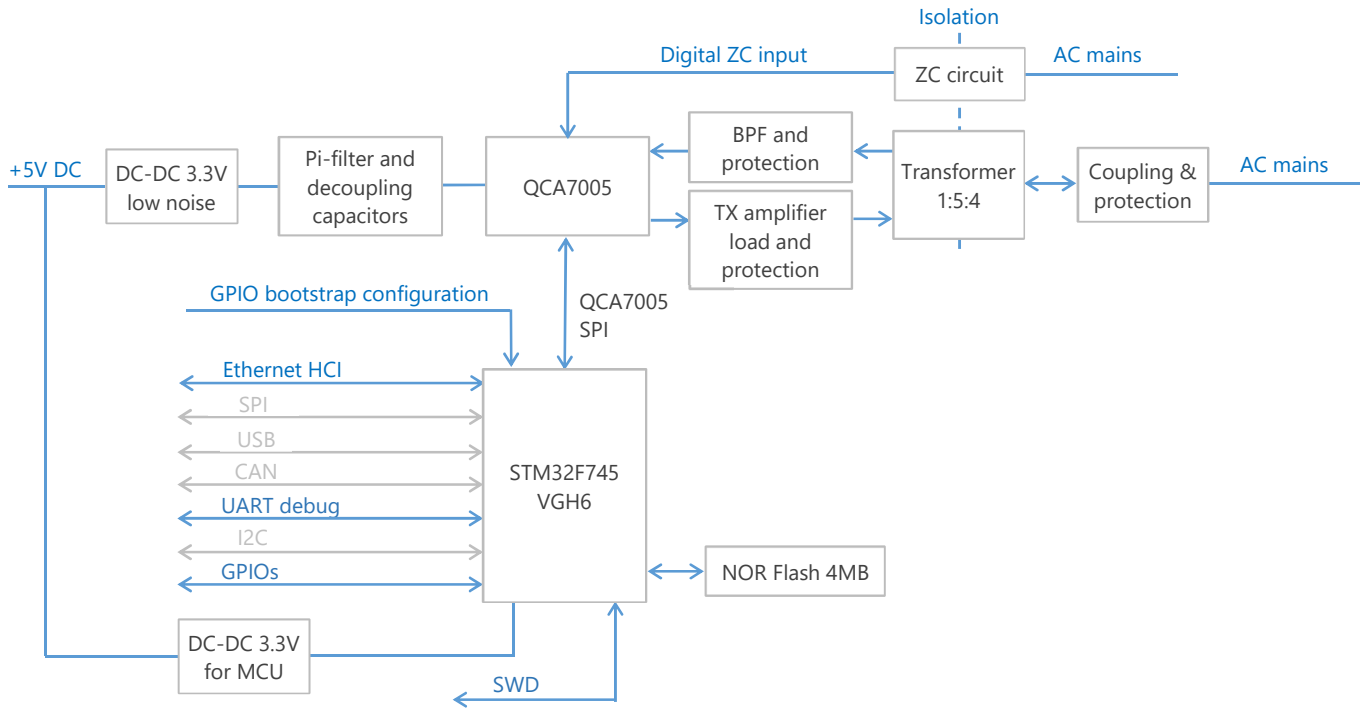
NOTE: HCI = Host Control Interface;

Interfaces which have grey text color are not supported in the software at the moment.

3. Operational conditions

TABLE 3-1. STANDARD OPERATING CONDITIONS

Parameter	Min	Typical	Max	Units
Power supply voltage (VDD)	4.9	5	5.2	V
GPIOs, communication interfaces input voltage	-	3.3	3.46	V
Power consumption (at +25 °C)	-	1	1.6	W
Operating (board) temperature	-40	-	+95	°C
Ambient temperature (approximation)	-40	-	+85	°C
AC mains voltage (ZC_LINE, AC_LINE)	-	240 120	-	V_{RMS}

TABLE 3-2. ABSOLUTE MAXIMUM CONDITIONS

Parameter	Min	Typical	Max	Units
Power supply voltage (VDD)	4.75	5	5.25	V
Power supply noise and ripples voltage	-	-	40	mV_{p-p}
GPIOs, communication interfaces input voltage	-0.3	-	3.6	V
Operating (board) temperature	-40	-	+105	°C
Storage temperature	-40	-	+150	°C
AC mains voltage (ZC_LINE, AC_LINE)	112	-	265	V_{RMS}
RESETN input pulse duration	0.3	-	-	us

TABLE 3-3. ZERO-CROSS DETECTOR INPUT SPECIFICATION

Parameter	Min	Typical	Max	Units
ZC_LINE AC mains frequency (F)	48.4 57.7	50 60	51.6 62.3	Hz
Active high / low time	0.4 0.4	10.0 8.3	19.6 16.2	ms
Rise / fall time	0.001	-	-	ms
Offset from zero-crossing	0 0	- -	20.0 16.6	ms
ZC_DIGITAL pulse voltage	0.1	0.25	3.3	V_{p-p}

4. Module pinout and pin description

TABLE 4-1. WHITE-BEET-H MODULE PINOUT INFORMATION

| Pin	WHITE-BEET-H	Main function type	Main function description
PAD 1	HEART-BEAT	O	Heard-beat signal for LED
PAD 2	GND	-	Ground connection
PAD 3	ETH_MDC	O	Ethernet HCI MII Clock
PAD 4	ETH_MDIO	I/O	Ethernet HCI MII Data
PAD 5	ETH_RXD0	I	Ethernet HCI MII Receive Data[0]
PAD 6	ETH_REF_CLK	I	Ethernet HCI MII Receive Clock
PAD 7	ETH_RXD1	I	Ethernet HCI MII Receive Data[1]
PAD 8	ETH_CRS_DV	I	Ethernet HCI MII Receive Data Valid
PAD 9	ETH_TXD1	O	Ethernet HCI MII Transmit Data[1]
PAD 10	ETH_TX_EN	O	Ethernet HCI MII Transmit Enable
PAD 11	ETH_TXD0	O	Ethernet HCI MII Transmit Data[0]
PAD 12	GND	-	Ground connection
PAD 13	ETH_RSTN	I	Ethernet Chip Reset (active Low)
PAD 14	RESERVED	I	GPIO reserved for future SW feature, please connect to GND
PAD 15	RESERVED	I	GPIO reserved for future SW feature, please connect to GND
PAD 16	RESERVED	I	GPIO reserved for future SW feature, please connect to GND
PAD 17	RESERVED	I	GPIO reserved for future SW feature, please connect to GND
PAD 18	RESERVED	I	GPIO reserved for future SW feature, please connect to GND
PAD 19	RESERVED	I	GPIO reserved for future SW feature, please connect to GND
PAD 20	RESERVED	I	GPIO reserved for future SW feature, please connect to GND
PAD 21	RESERVED	I	GPIO reserved for future SW feature, please connect to GND
PAD 22	RESERVED	I	GPIO reserved for future SW feature, please connect to GND
PAD 23	RESERVED	I	GPIO reserved for future SW feature, please connect to GND
PAD 24	RESERVED	I	GPIO reserved for future SW feature, please connect to GND
PAD 25	RESERVED	I	GPIO reserved for future SW feature, please connect to GND
PAD 26	RESERVED	I	GPIO reserved for future SW feature, please connect to GND
PAD 27	RESERVED	I	GPIO reserved for future SW feature, please connect to GND
PAD 28	RESERVED	I	GPIO reserved for future SW feature, please connect to GND
PAD 29	RESERVED	I	GPIO reserved for future SW feature, please connect to GND
PAD 30	RESERVED	I	GPIO reserved for future SW feature, please connect to GND
PAD 31	RESETN	I	Module Reset (active Low)
PAD 32	BS_1	I	QCA7005 FW & PIB version selection ("H" = v3.0, "L" = v1.1.0-02) Has internal pull-down resistor 10k Ohm
PAD 33	+5V	-	5V power supply
PAD 34	GND	-	Ground connection
PAD 35	RESERVED	I	GPIO reserved for future SW feature, please connect to GND
PAD 36	RESERVED	I	GPIO reserved for future SW feature, please connect to GND

TABLE 4-1 (CONTINUATION). WHITE-BEET-H MODULE PINOUT INFORMATION

Pin	WHITE-BEET-H	Main function type	Main function description
PAD 37	RESERVED	I	GPIO reserved for future SW feature, please connect to GND
PAD 38	RESERVED	I	GPIO reserved for future SW feature, please connect to GND
PAD 39	GND	-	Ground connection
PAD 40	RESERVED	I	GPIO reserved for future SW feature, please connect to GND
PAD 41	RESERVED	I	GPIO reserved for future SW feature, please connect to GND
PAD 42	RESERVED	I	GPIO reserved for future SW feature, please connect to GND
PAD 43	RESERVED	I	GPIO reserved for future SW feature, please connect to GND
PAD 44	RESERVED	I	GPIO reserved for future SW feature, please connect to GND
PAD 45	GND	-	Ground connection
PAD 46	RESERVED	I	GPIO reserved for future SW feature, please connect to GND
PAD 47	RESERVED	I	GPIO reserved for future SW feature, please connect to GND
PAD 48	GND	-	Ground connection
PAD 49	RESERVED	I	GPIO reserved for future SW feature, please connect to GND
PAD 50	RESERVED	I	GPIO reserved for future SW feature, please connect to GND
PAD 51	BOOT	I	Boot memory selection, please connect to GND
PAD 52	SWDIO	I/O	Serial Wire Debug Data
PAD 53	SWCLK	I	Serial Wire Debug Clock
PAD 54	RESERVED	I	GPIO reserved for future SW feature, please connect to GND
PAD 55	NC	-	No connection on the module
PAD 56	NC	-	No connection on the module
PAD 57	AC_LINE	HV	AC mains LINE
PAD 58	AC_LINE	HV	AC mains LINE
PAD 59	AC_NEUTRAL	HV	AC mains NEUTRAL
PAD 60	AC_NEUTRAL	HV	AC mains NEUTRAL
PAD 61	NC	-	No connection on the module
PAD 62	NC	-	No connection on the module
PAD 63	NC	-	No connection on the module
PAD 64	ZC_LINE	HV	AC mains LINE for zero-cross detector input Must be connected to GND when ZC_DIGITAL is used instead
PAD 65	NC	-	No connection on the module
PAD 66	NC	-	No connection on the module
PAD 67	NC	-	No connection on the module
PAD 68	ZC_NEUTRAL	HV	AC mains NEUTRAL for zero-cross detection
PAD 69	ZC_NEUTRAL	HV	AC mains NEUTRAL for zero-cross detection
PAD 70	NC	-	No connection on the module
PAD 71	ZC_DIGITAL	I	Digital zero-cross input. Has internal pull-up resistor 40k Ohm Must be left not connected (NC) when not used
PAD 72	RESERVED	I	GPIO reserved for future SW feature, please connect to GND
PAD 73	RESERVED	I	GPIO reserved for future SW feature, please connect to GND
PAD 74	RESERVED	I	GPIO reserved for future SW feature, please connect to GND

TABLE 4-1 (CONTINUATION). WHITE-BEET-H MODULE PINOUT INFORMATION

| Pin	WHITE-BEET-H	Main function type	Main function description
PAD 75	UART_RX (debug)	I	UART Receive Data
PAD 76	UART_TX (debug)	O	UART Transmit Data
PAD 77	RESERVED	I	GPIO reserved for future SW feature, please connect to GND
PAD 78	RESERVED	I	GPIO reserved for future SW feature, please connect to GND
PAD 79	RESERVED	I	GPIO reserved for future SW feature, please connect to GND
PAD 80	RESERVED	I	GPIO reserved for future SW feature, please connect to GND
PAD 81	RESERVED	I	GPIO reserved for future SW feature, please connect to GND
PAD 82	RESERVED	I	GPIO reserved for future SW feature, please connect to GND
PAD 83	RESERVED	I	GPIO reserved for future SW feature, please connect to GND
PAD 84	RESERVED	I	GPIO reserved for future SW feature, please connect to GND
PAD 85	RESERVED	I	GPIO reserved for future SW feature, please connect to GND
PAD 86	THERMAL PAD	-	Thermal pad, has to be connected to GND

IMAGE 4-1. MODULE PIN ASSIGNMENTS (BOTTOM VIEW)
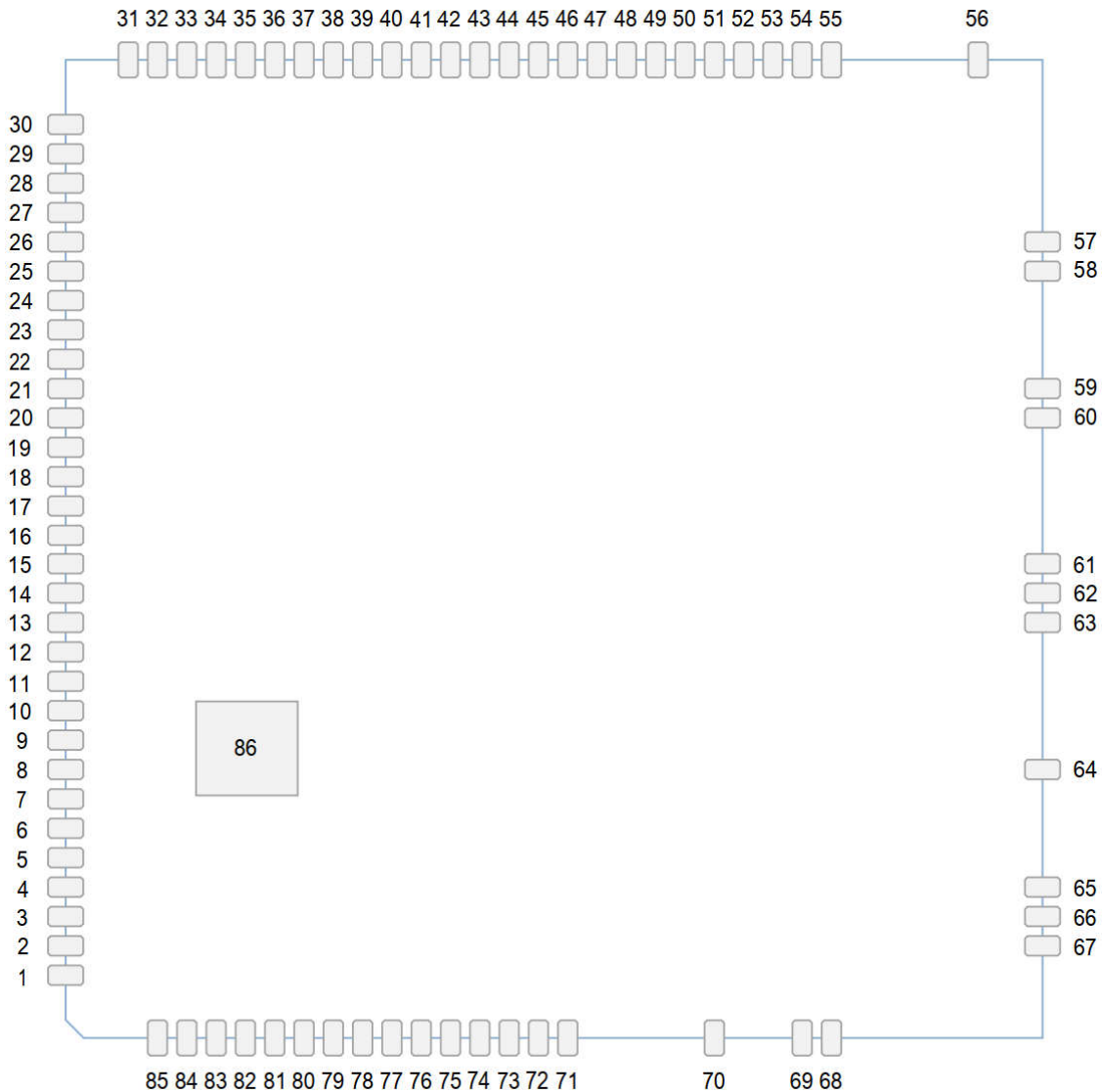
5. Reference design schematics

Please follow design recommendations given in the WHITE-BEET reference design schematic and PLC Design Guide documents in the PLC documentation area on https://downloads.codico.com/misc/plc

IMAGE 5-1. PLC DOCUMENTATION AREA LOGIN PAGE
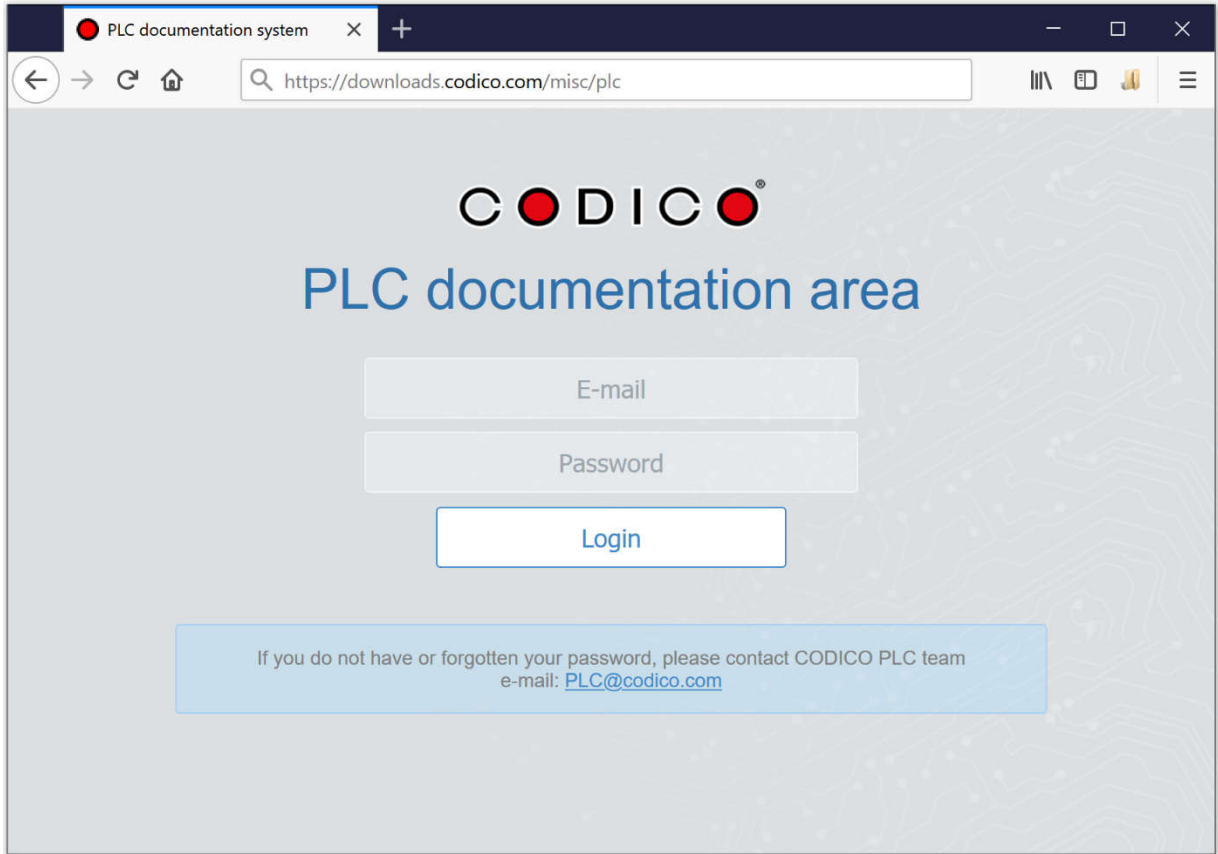
6. Module marking information

Model: WHITE beet EI	
MAC: C493000FEA47	
SN: PWL6004172000001	
Made in EU	CE

Each module is marked with a label containing the following data:

1. Ordering code
2. QCA7005 MAC Address (contains no separator, OUI C49300)
3. Serial Number in a format PWL600VWWYYNNNNNN, where:

   PWL600   - product code for WHITE beet

   V   - module configuration:

            1 for WHITE-beet-H,

            2 for WHITE-beet-EO,

            3 for WHITE-beet-PO,

            4 for WHITE-beet-EI,

            5 for WHITE-beet-PI,

            6 for WHITE-beet-ES,

            7 for WHITE-beet-PS,

   WWYY   - data code as a calendar week of production followed by a year

   NNNNNN   - serial number in a production lot
4. QR-code containing MAC Address
5. Additionally each label contains 8Devices logo which also indicates pin 1 position

7. Mechanical characteristics
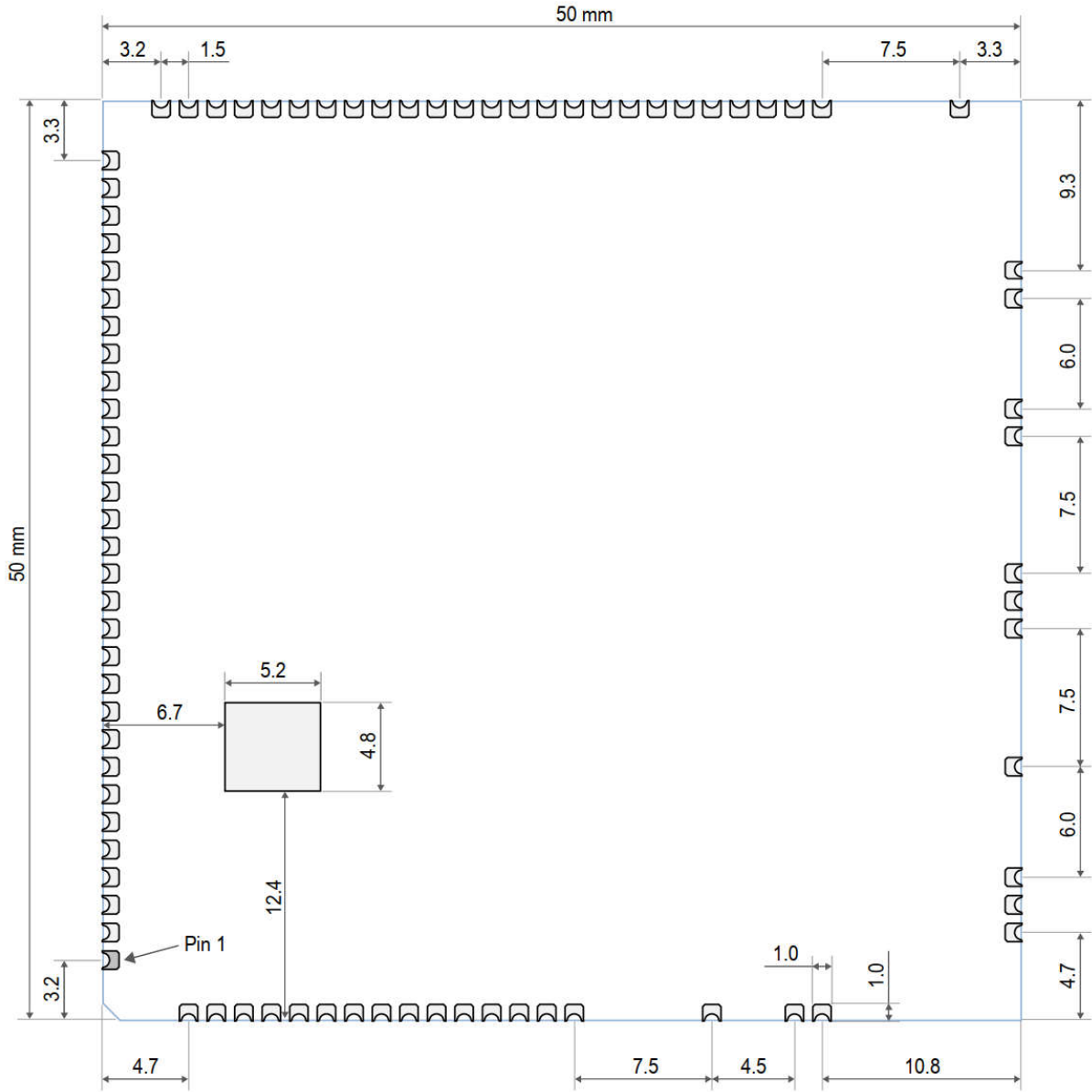
IMAGE 7-1. PIN DIMENSIONS (BOTTOM VIEW)
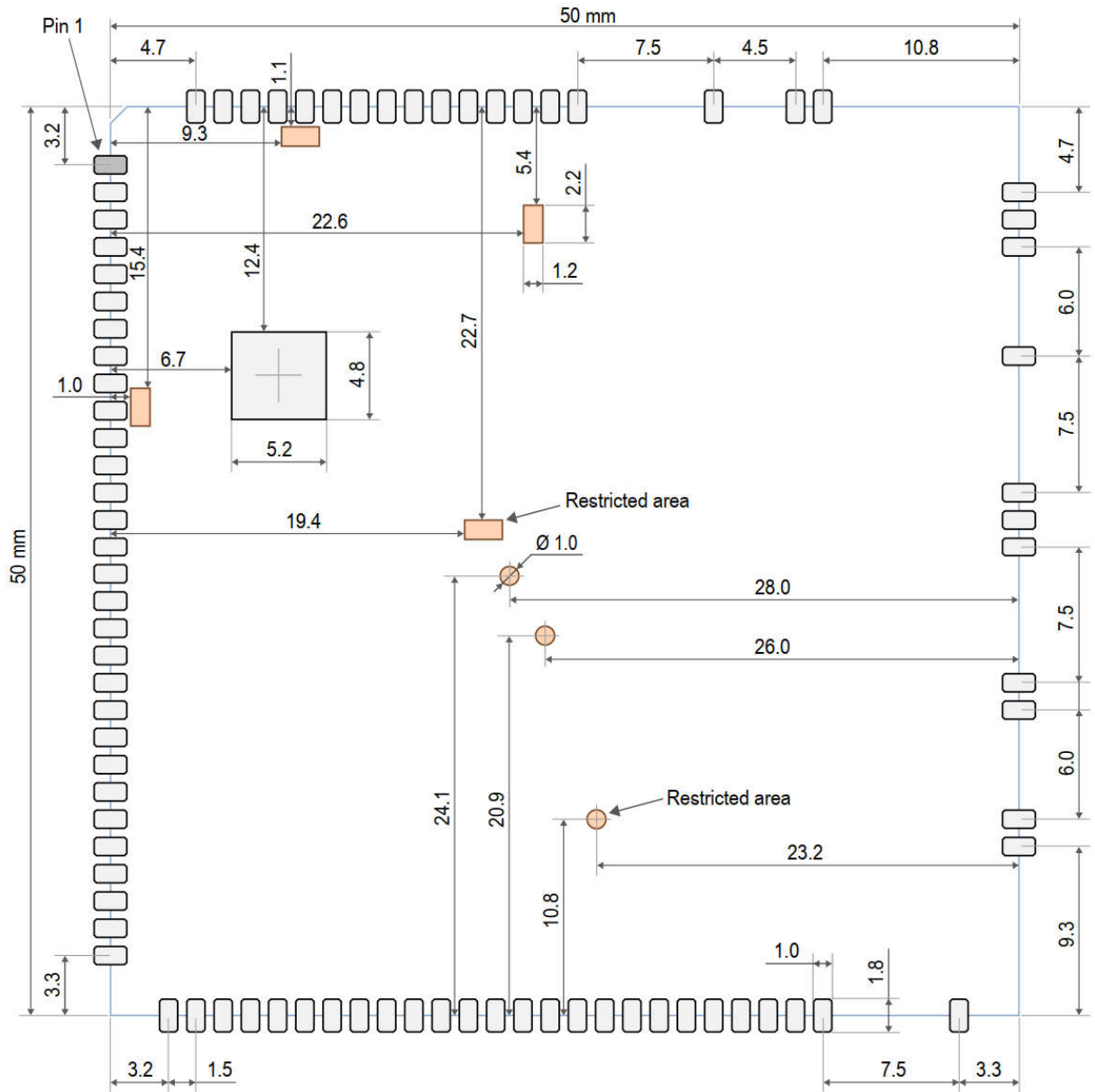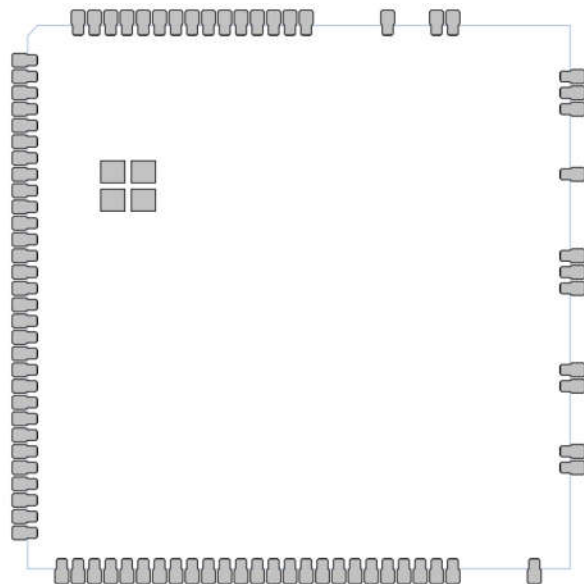
IMAGE 7-2. PCB FOOTRINT (TOP VIEW)

IMAGE 7-3. SOLDERING PASTE FOOTPRINT (TOP VIEW)

8. Reflow profile information

Reflow profile recommendation

Ramp up rate	3°C/second max
Maximum time maintained above 217°C	120 seconds
Peak temperature	250°C
Maximum time within 5°C of peak temperature	20 seconds
Ramp down rate	6°C/second max

Reflow profile
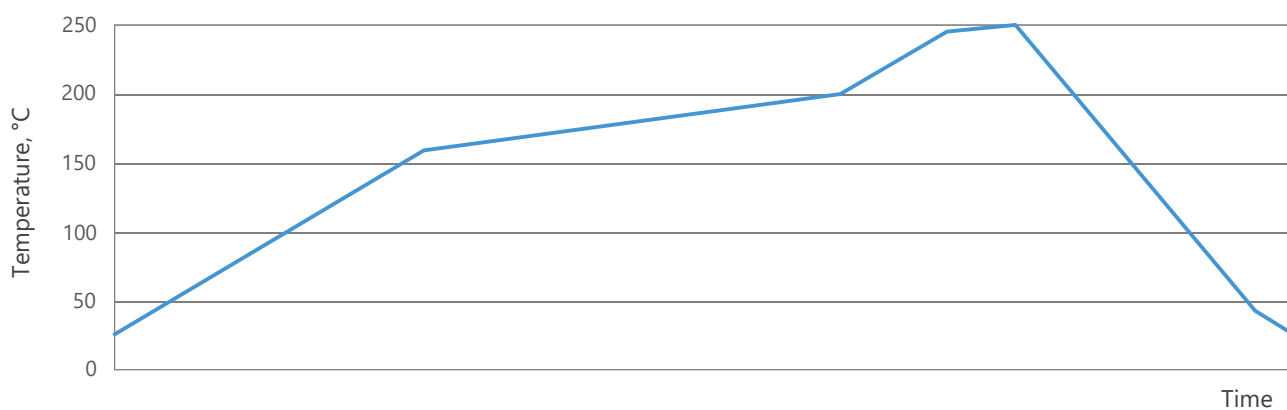
9. Evaluation board

WB-CARRIER-BOARD is an evaluation and development board for WHITE-beet modules. It contains WHITE-BEET module populated on the carrier board and protected with a plastic cover.

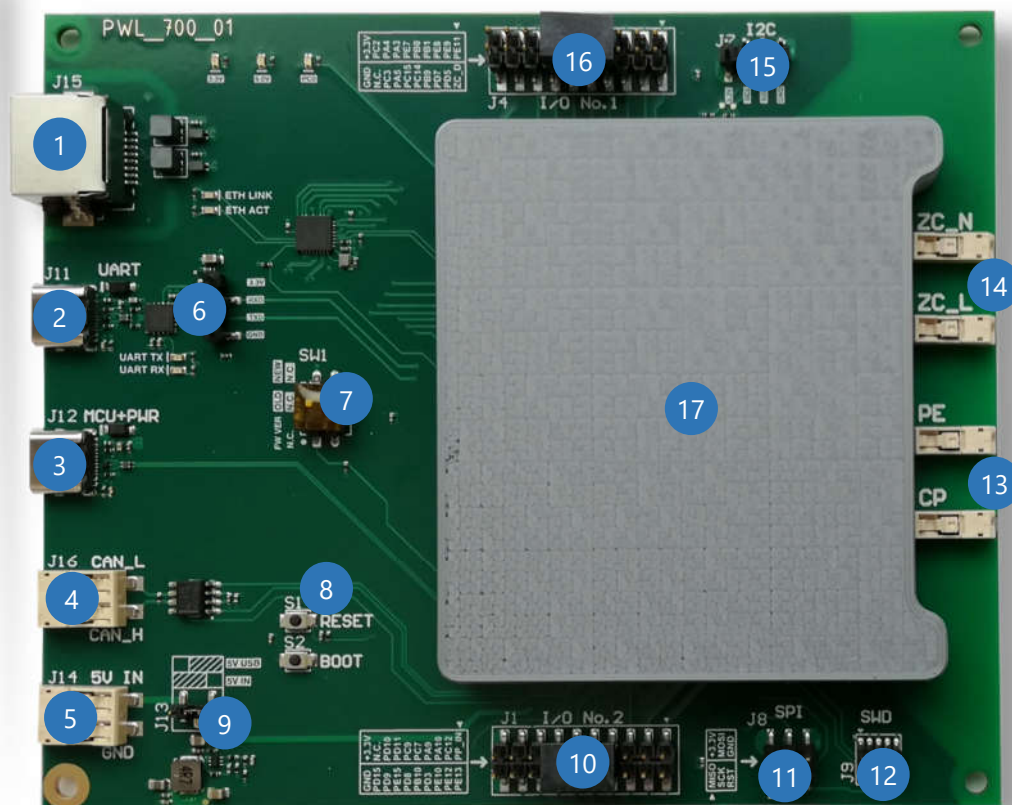IMAGE 9-1. WB-CARRIER-BOARD (TOP VIEW)

TABLE 9-1. WB-CARRIER-BOARD MAIN SECTIONS

Item number	Description
1	J15 Ethernet interface RJ45 connector
2	J11 USB-C connector for UART debugging console
3	J12 USB-C connector for +5V DC power supply and USB communication
4	J16 CAN interface connector
5	J5 Alternative +5V DC power supply connector
6	J10 4-pin UART debugging console header
7	SW1 Micro switch to select active QCA7005 firmware version
8	S1 RESET button and (S2) Boot button (required for software development)
9	J13 Jumper for +5V DC power supply source selection
10	J1 20-pin GPIOs header #2
11	J8 6-pin SPI interface header
12	J9 10-pin SWD interface header for programming and debugging
13	Control Pilot (CP) and Protected Earth (PE) connectors
14	Zero-cross input (ZC_L / ZC_N) connectors
15	J7 4-pin I2C interface header
16	J4 20-pin GPIOs header #1
17	Plastic cover for WHITE BEET module (placed for a safety reasons)

10. Packaging and ordering information

WHITE beet modules are packed into trays. Each tray fits 15 modules. Every 5 trays are vacuum sealed and one standard packing box contains 375 modules.

TABLE 10-1. MODULE ORDERING OPTIONS

Part number	Description
WHITE-BEET-ES #292206	EVSE side e-mobility HW with transparent bridging / SLAC software
WHITE-BEET-EI #292207	EVSE side e-mobility HW with ISO 15118 / DIN 70121 / SAE J2847/2 software stack (support of V2G, EMI, PnC, BPT)
WHITE-BEET-EO #292208	EVSE side e-mobility without embedded software included, SDK open option
WHITE-BEET-PS #292210	PEV side e-mobility HW with transparent bridging / SLAC software
WHITE-BEET-PI #295426	PEV side e-mobility HW with ISO 15118 / DIN 70121 / SAE J2847/2 software stack (support of V2G, EMI, PnC, BPT)
WHITE-BEET-PO #295427	PEV side e-mobility without embedded software included, SDK open option
WHITE-BEET-H #292209	Home control / smart grid HW with transparent bridging software

More PEV / EVSE - configured eMobility related products can be found in CODICO Sample Shop:
https://www.codico.com/en/products/powerline-communication

11. Document revision history

Revision	Revision Date	Description
0.2	2020.06.01	Product brief (preliminary information)
0.9	2020.11.05	Draft pre-release
1.00	2020.11.27	Customer release
1.01	2020.12.04	Figure 3-1. Table 4-1 and Table 10-1 correction
1.02	2021.07.28	Correction over all the chapters including block diagram and pin descriptions (Table 4-1).
1.02c	2022.06.30	Table 4-1, PAD32 correction