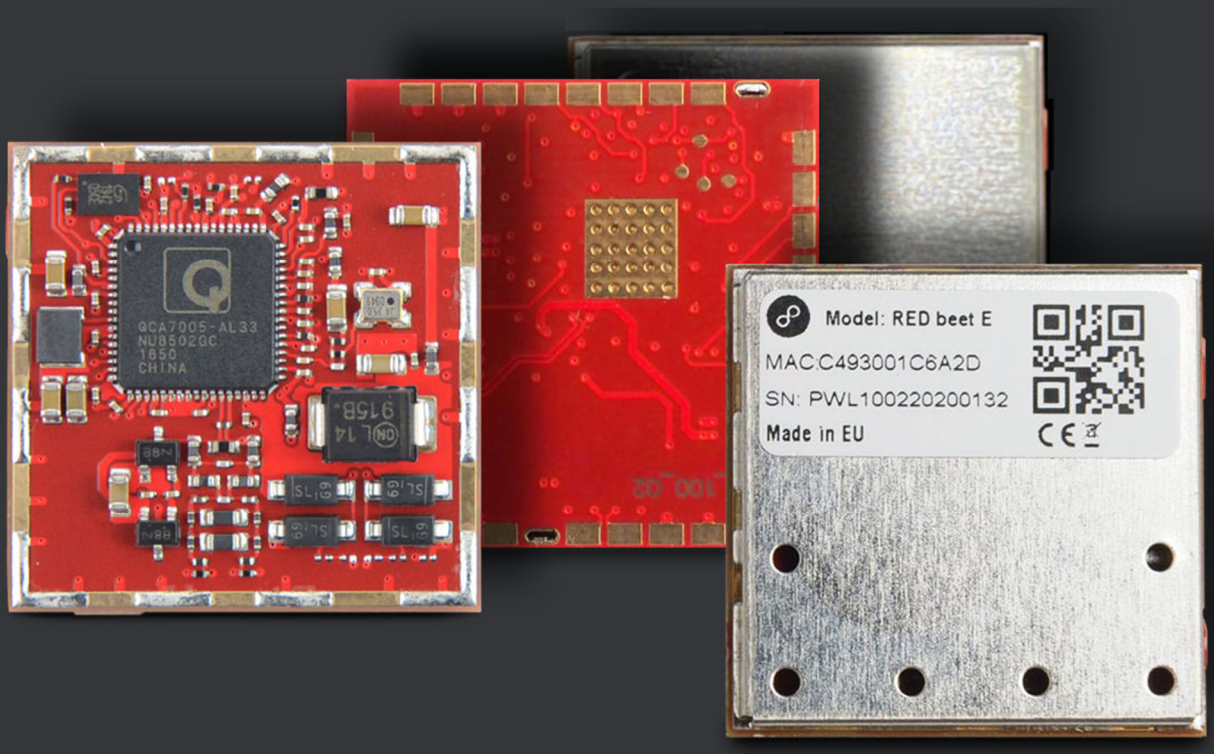


RED-BEET 1.1 is a universal powerline module based on Qualcomm's QCA7005 chip supporting HomePlug GreenPHY standard.

There are various versions of the module and despite primary focus on e-mobility (EVSE and PEV), it also could be used for other applications (e.g. IoT, short range communication applications.

All modules come with extended temperature range making it suitable even for high-end automotive applications.

**Available for purchase from CODICO GmbH*

Quick specs

- Based on QCA7005
- Extended industrial temperature range (up to 95 ºC)
- SPI and GPIO of QCA7005 for connecting host MCU
- Comes in 2 configurations for EV-charging applications: PEV (plug-in electric vehicle) and EVSE (electric vehicle supply equipment)
- SMD module
- Small form factor (23 x 23 x 4 mm)

Table of Contents

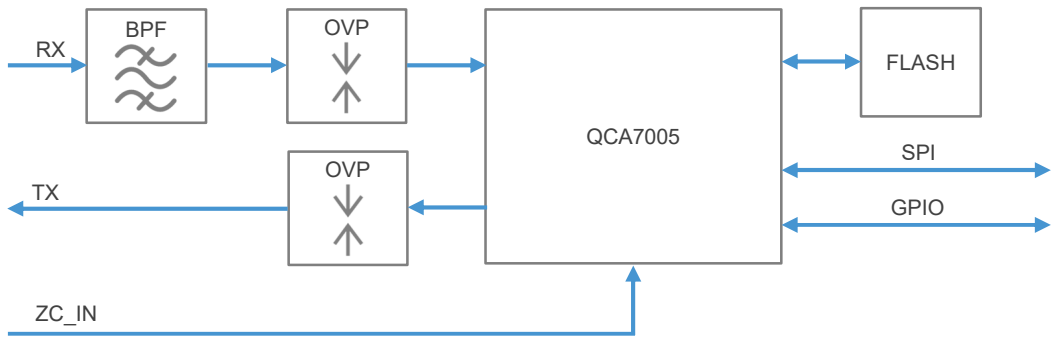
1. Features

TABLE 1-1. RED-BEET 1.1 FEATURES

	RED-BEET-E 1.1	RED-BEET-P 1.1
PLC chip	QCA7005	
Firmware version	Qualcomm HomePlug GreenPHY FW v3.0	
Configuration (PIB)	EVSE (Electric vehicle charging stations)	PEV (Plug-in electric vehicles)
Host interface	SPI	
Power supply	3.3V	
Power consumption	1W (at 25º C)	
Max data rate	9.8 Mbps PHY rate / 4.6 Mbps payload	
Max distance	According to ISO/IEC 15118-3	
Temperature range	-40º C to +95º C (board temperature)	
Size	23.3 x 23.3 x 4 mm	
Weight	2.8 ±0.1 g	
Part number	RED-BEET-E 1.1	RED-BEET-P 1.1

2. Block diagram

FIGURE 2-1. RED-BEET 1.1 MODULE BLOCK DIAGRAM



3. Operating conditions

TABLE 3-1. RECOMMENDED OPERATING CONDITIONS

Parameter		Min	Typical	Max	Units
VDD		3.13	3.3	3.46	V
SPI, GPIO	Low-level input voltage	-	-	0.8	V
	High-level input voltage	2.0	-	-	V
	Low-level output voltage	-	-	0.4	V
	High-level output voltage	2.4	-	-	V
Ambient temperature		-40	-	85	ºC

TABLE 3-2. ABSOLUTE MAXIMUM RATINGS

Parameter	Min	Typical	Max	Units
VDD, SPI, GPIO	-0.3	-	3.6	V
Operating temperature (board)	-40	-	95	ºC
Storage temperature	-40	-	150	ºC
RESETN active pulse duration	100	-	-	us

TABLE 3-3. RED-BEET 1.1 MODULE POWER CONSUMPTION (+25ºC AMBIENT TEMPERATURE)

Operation mode	Typical	Units
Transmit Mode	1000	mW
Receive Mode	700	mW
Idle Mode (no communication)	330	mW
RESETN Pin Active Mode	200	mW
Sleep Mode (power saving mode)	100	mW

NOTE: Operation at maximum temperature limit may increase power consumption up to 25%.
RED-BEET 1.1 power supply should have extra 25% power margin and be capable of providing power up to 1600 mW

TABLE 3-4. ZERO-CROSS DETECTOR INPUT SIGNAL SPECIFICATION

Parameter	Pin	Min	Typical	Max	Units
Zero-cross frequency	ZC_IN	48.4 57.7	50 60	51.6 62.3	Hz
Active high / low time	ZC_IN	0.4 0.4	10.0 8.3	19.6 16.2	ms
Rise / fall time	ZC_IN	0.001	-	-	ms
Offset from zero-crossing	ZC_IN	0 0	- -	20.0 16.6	ms
Peak to peak voltage	ZC_IN	0.1	0.25	3.3	V

NOTE: Zero-cross detector input signal has to have a nominal frequency of 50 or 60 Hz.

4. Module pinout and pin description

FIGURE 4-1. PIN ASSIGNMENTS (BOTTOM VIEW)

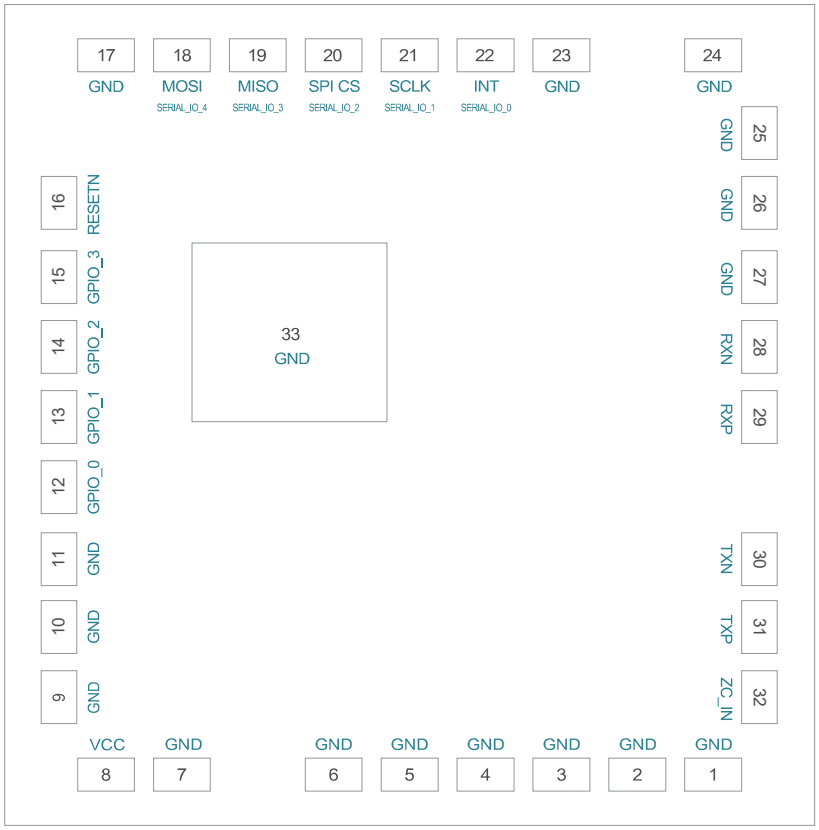


TABLE 4-1. PIN DESCRIPTION

Pin number	Name	Type	Description
1	GND	-	Ground
2	GND	-	Ground
3	GND	-	Ground
4	GND	-	Ground
5	GND	-	Ground
6	GND	-	Ground
7	GND	-	Ground
8	VCC	-	3.3V power supply
9	GND	-	Ground
10	GND	-	Ground
11	GND	-	Ground
12	GPIO_0	I/O	Pull-up on the module internal (10k Ohm) Bootstrap setting: boot from Flash
13	GPIO_1	I/O	Pull-down on the module internal (10k Ohm) Bootstrap setting: required for QCA7005
14	GPIO_2	I/O	Pull-up on the module internal (10k Ohm) Bootstrap setting: SPI burst mode

TABLE 4-1. PIN DESCRIPTION (CONTINUATION)

Pin number	Name	Type	Description
15	GPIO_3	I/O	Input with weak internal pull-down (min. 75k Ohm)
16	RESETN	I	Reset (active low)
17	GND	-	Ground
18	MOSI (SERIAL_IO_4)	I	SPI MOSI
19	MISO (SERIAL_IO_3)	O	SPI MISO
20	CS (SERIAL_IO_2)	I	SPI CS
21	SCLK (SERIAL_IO_1)	I	SPI CLK
22	INT (SERIAL_IO_0)	O	SPI INT (interrupt)
23	GND	-	Ground
24	GND	-	Ground
25	GND	-	Ground
26	GND	-	Ground
27	GND	-	Ground
28	RXN	I	PLC receive input negative
29	RXP	I	PLC receive input positive
30	TXN	O	PLC transmit output negative
31	TXP	O	PLC transmit output positive
32	ZC_IN	I	Zero-cross detector input (analog, refer to TABLE 3-4) at EVSE side it is mandatory to provide Zero-cross signal at side EV ZC_IN has to be connected to GND
33	THERMAL PAD (GND)	-	Thermal pad (requires connection to GND plane)

NOTE: Thermal pad shall have a good connection to the GND plane to improve heat dissipation.
It is recommended to have 9 vias 0.3 mm in diameter (formed as a square of 3x3 vias) to the GND plain.

TABLE 4-2. BOOT STRAP GPIO CONFIGURATION

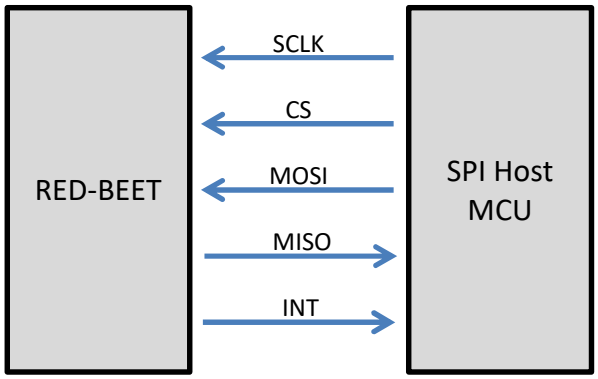
GPIO number	Function	PU (pull-up)	PD (pull-down)
GPIO_0	Boot source	Flash (default)	Host
GPIO_1	Host interface	-	SPI slave (default)
GPIO_2	SPI slave mode	Burst (default, mandatory for EV applications)	Legacy

NOTE: PU/PD internal resistors (10k Ohm) are placed on the RED-BEET 1.1 module.
To overrule internal settings place external resistor of 1k Ohm or less.
If you keep the default bootstrap settings you do not require to place resistors at the GPIO_0, GPIO_1, GPIO_2.

5. Host interface

QCA7005/QCA7000 SPI slave port uses the standard 4-wire Motorola SPI protocol in Mode 3 (CPOL negative, CPHA negative), plus an interrupt pin (INT). The SPI slave port is used for loading the firmware into NOR Flash, booting from a Host MCU as well as for communication with a Host MCU.
QCA7005's maximum slave SPI clock frequency is 12 MHz. More details on SPI behavior, working modes and registers description could be found in the Application note QCA700x SPI device driver reference.

FIGURE 5-1. SPI BUS DIAGRAM



SPI slave interface timing requirements are shown in the Figure 4-2 and Table 4-1 below.

FIGURE 5-2. DATA TRANSFER REQUEST FROM SLAVE TO HOST INITIATED BY SLAVE INTERRUPT

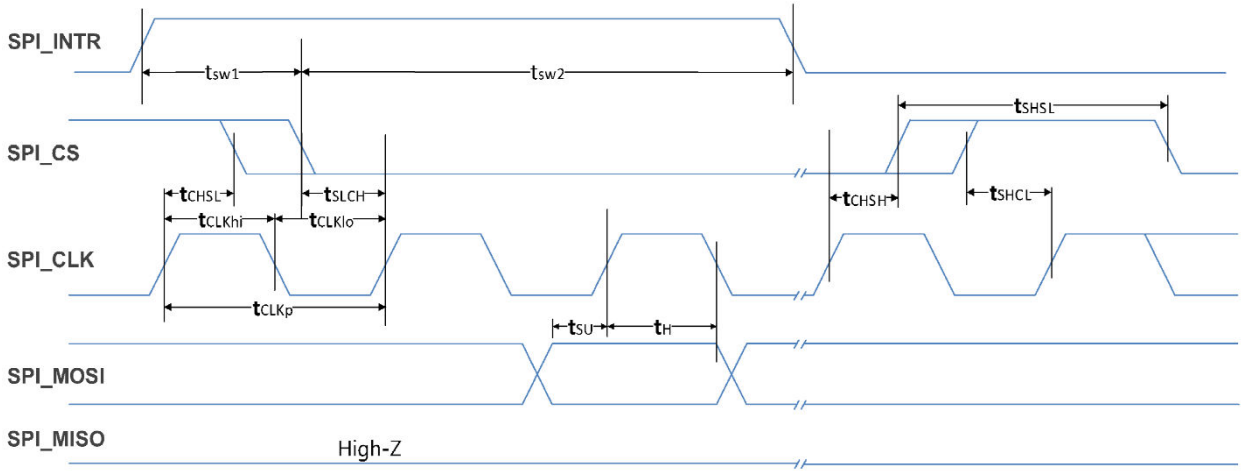


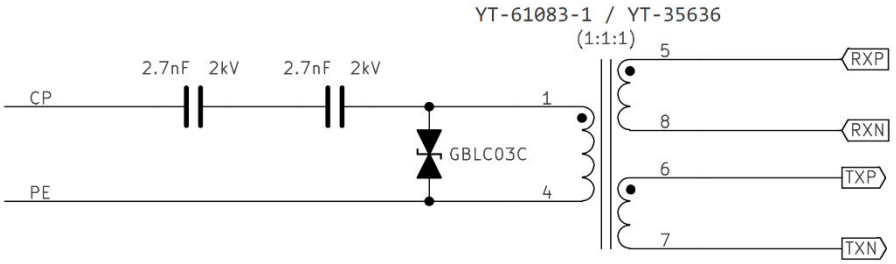
TABLE 5-1. SPI SLAVE TO HOST TIMING SPECIFICATIONS

Symbol	Parameter	Min	Max	Unit
t_{CLKp}	SPI Slave CLK Period	83.3	–	ns
t_{CLKhi}	SPI Slave CLK High Time	39	–	ns
t_{CLKlo}	SPI Slave CLK Low Time	39	–	ns
t_{SU}	Input Setup Time	–	5	ns
t_{H}	Input Hold Time	5	–	ns
t_{CHSL}	SPI Slave CLK high to chip select low	5	–	ns
t_{SLCH}	Chip select low to next SPI slave CLK high	5	–	ns
t_{CHSH}	SPI Slave CLK high to chip select high	5	–	ns
t_{SHCL}	Chip select low to SPI slave CLK high	5	–	ns
t_{SHSL}	Chip Select high to next chip select low	39	–	ns

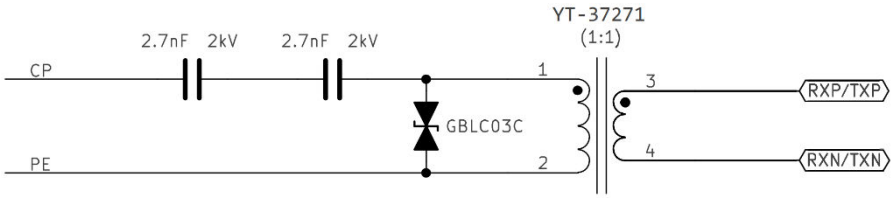
6. Coupling circuitries

The coupling circuit for **RED-BEET-E/-P 1.1** modules (Figures 6-1 and 6-2) is designed for use on CP/PE (Control Pilot / Protective Earth) in e-mobility applications.
PLC signal surge protection (3V rated TVS diode with 3pF junction capacitance) is shown on the schematic, but surge protection for CP for PWM 1kHz related circuit should be considered extra, it is highly recommended to use 12V rated TVS diode with junction capacitance less than 10pF (e.g. GBLC12C).
Recommended PLC transformer part numbers are: YT-61083-1, YT-35636, YT-37271.

FIGURE 6-1. RED-BEET-E/-P 1.1 CIRCUIT FOR COUPLER TO CP/PE



Alternative PLC transformer with 1:1 winding ratio



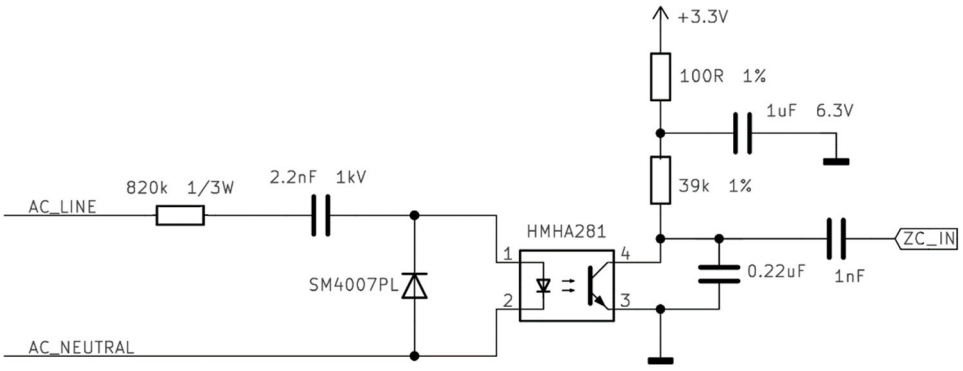
Use of zero-cross detection is mandatory in all types of EVSE applications (including AC/DC/CCS charging stations).
Zero-cross circuit for connecting to AC mains with voltage up to 250Vrms (RED-BEET-E 1.1) does not contain a circuit and surge protection, but it should be implemented extra (such as Varistor / MOV, Fuse, TVS diode).

There are 2 options for providing the Zero-cross detector input signal:

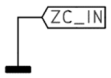
1. Using the circuitry shown on the FIGURE 6-2.
2. Providing a digital 3.3V logic signal that represents the Zero-cross signal of AC main. This signal has to be coupled with a 1nF serial capacitor to the ZC_IN pin.

FIGURE 6-2. RED-BEET-E/-P 1.1 CIRCUIT FOR ZC_IN

ZERO-CROSS INPUT FOR RED-BEET-E 1.1



ZERO-CROSS INPUT FOR RED-BEET-P 1.1



7. References

QCA7000/5 SPI driver is a part of Linux kernel since v3.18. QCA7000/5 driver forwards Ethernet frames between Ethernet and SPI interfaces using HAL drivers.

Various application notes, including the ones for SPI device driver, PIB (Parameter Information Block) configuration for different application, PSD calibration and Noise measurements, and other materials could be found on CODICO PLC documentation area:
https://downloads.codico.com/misc/plc

RED-BEET 1.1 module as HomePlug GreenPHY device can be configured and controlled using a set of command line tools open-plc-utilities. Source codes of open-plc-utilities and manuals can be found on Github repository:
https://github.com/qca/open-plc-utils

In the PLC Documentation Area https://downloads.codico.com/misc/plc the following software related Application Notes can be found:

AppNote_underNDA_QCA700x_SPI_device_driver_reference with details of QCA7005 slave SPI operation which are also helpful for development of own QCA7005 SPI driver.

AppNote_underNDA_QCA700x_PIB_config_for_EV_charging_applications with details of QCA7005 PIB file (Parameter Information Block) configuration.

AppNote_underNDA_PSD_Calibration_and_Noise_Measurement for EVSE and EV sides with mandatory procedure (by ISO15118-3) of calibration transmit power of HomePlug GreenPHY PLC equipment.

AppNote_norm_QCA700x_zero-cross_for_EVSE for more information regarding ZC input.

AppNote_underNDA_BEET_modules_design_guidelines for details of hardware design (including PCB layout).

8. Module marking information

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

1. Ordering code
2. QCA7005 MAC Address (contains no separator, OUI C4:93:00)
3. Serial Number in a format **PWL1004WWYYNNNNNN**, where:

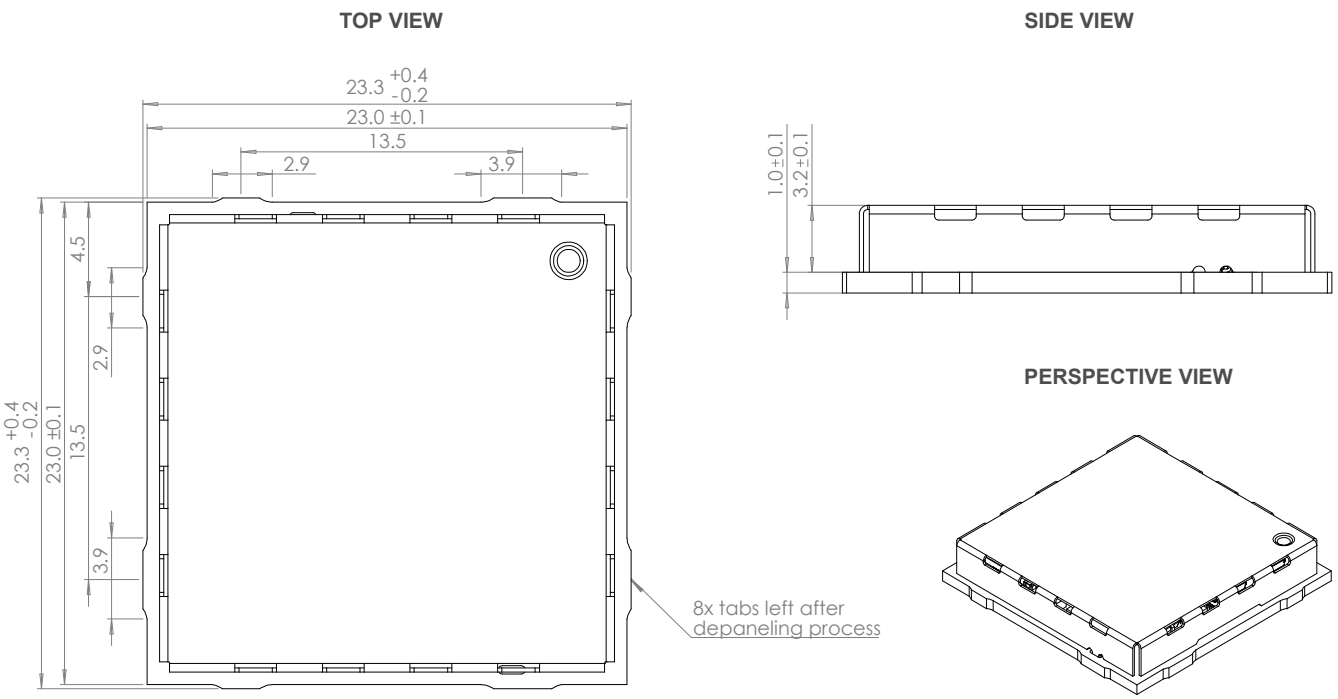
   PWL1004 – product code for RED-BEET 1.1

   WWYY – date code as a calendar week of production followed by a year

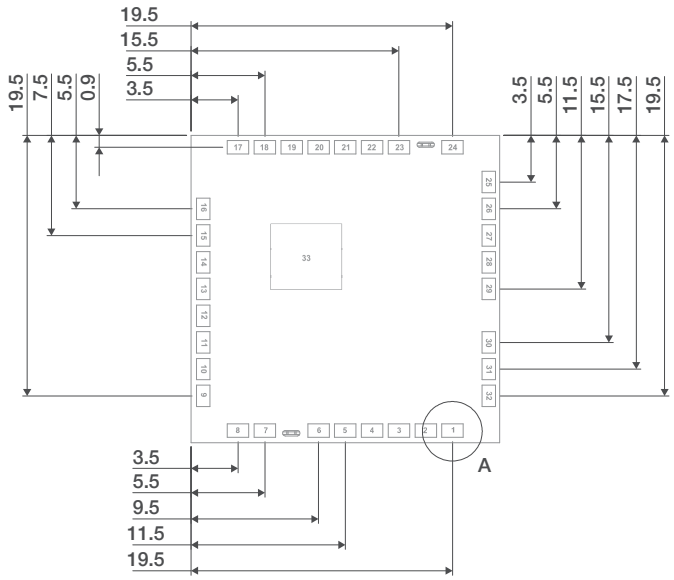
   NNNNNN – serial number in a production lot
4. QR-code containing MAC Address
5. Additionally, each label contains 8Devices logo which also indicates pin 1 position

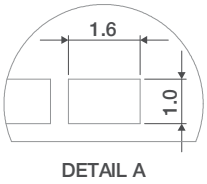
9. Mechanical characteristics

Shielding variant used since September 2022



BOTTOM VIEW



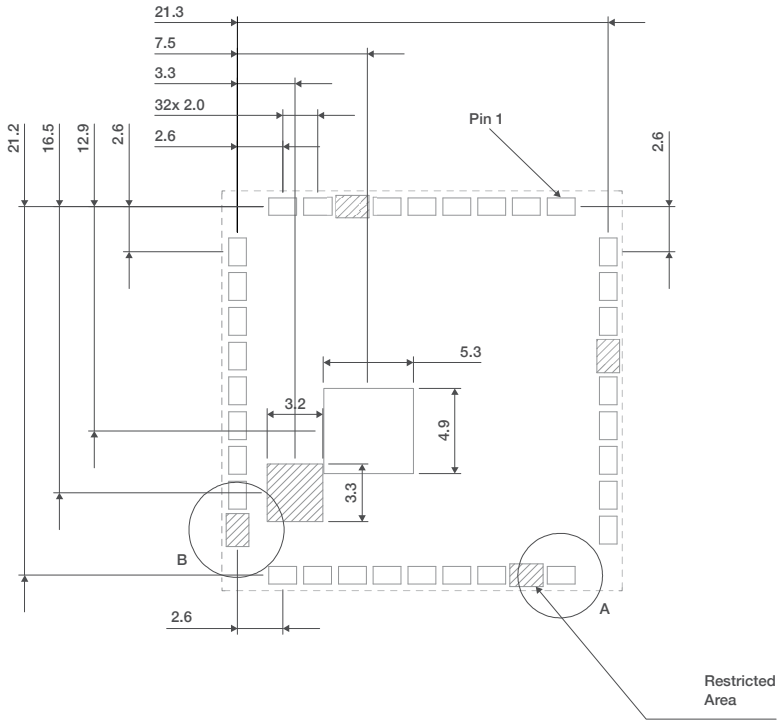


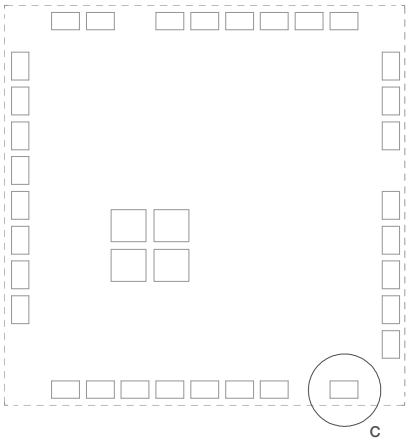
DETAIL A

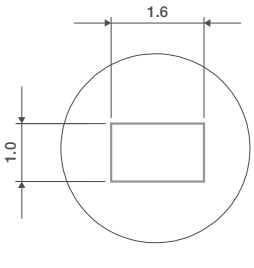
PCB footprint

Soldering paste footprint

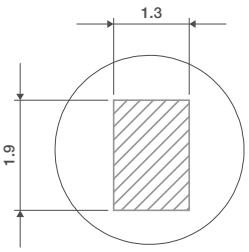
TOP VIEW



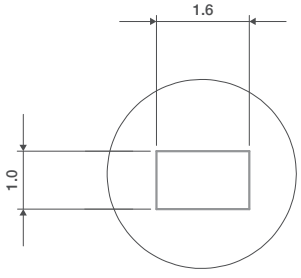




DETAIL A



DETAIL B



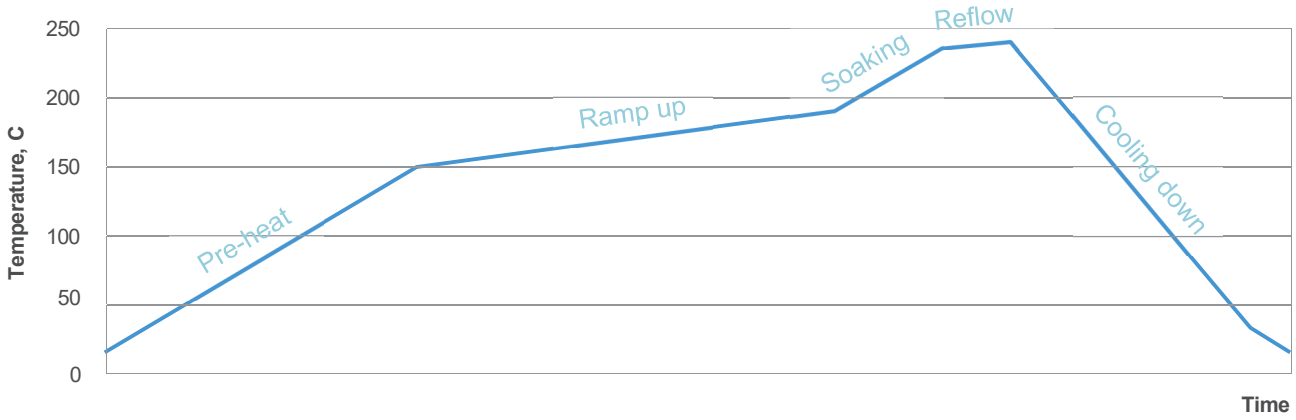
DETAIL C

10. 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
Cooling down (ramp down) rate	6°C/second max

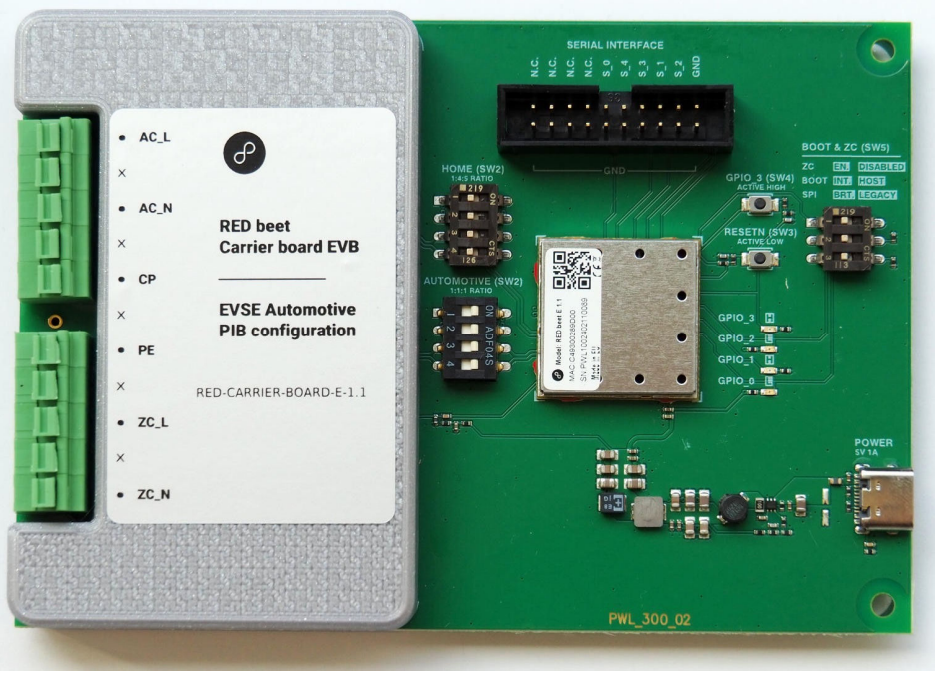
Reflow profile



11. Evaluation board

In order to evaluate HomePlug GreenPHY PLC technology and RED-BEET 1.1 modules operation in particular, there is the evaluation board **RED-CARRIER-BOARD 1.1** coming with 2 different configurations (EVSE and PEV sides)
The board comes with line coupling for EV-charging applications. A standard 20-pin header connector is available for connection to an external MCU via SPI. For more details, please refer to RED-CARRIER-BOARD 1.1 datasheet.

FIGURE 11-1. RED-CARRIER-BOARD 1.1



12. Ordering information

TABLE 12-1. ORDERING PART NUMBERS

Part number	Description
RED-BEET-E 1.1 #300060	RED-BEET 1.1 module for EVSE (Electric vehicle supply equipment)
RED-BEET-E-TR 1.1 #307634	RED-BEET 1.1 module for EVSE, Tape&Reel package
RED-BEET-P 1.1 #300062	RED-BEET 1.1 module for PEV (Plug-in electric vehicle)
RED-CARRIER-BOARD-E 1.1 #301492	Carrier board for development and testing with line coupling and SPI interface for external MCU with EVSE configuration
RED-CARRIER-BOARD-P 1.1 #301494	Carrier board for development and testing with line coupling and SPI interface for external MCU with PEV configuration

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

13. Packaging

Tray packaging

When RED-BEET 1.1 modules are packed into trays each tray fits 54 modules.
Every 5 trays are vacuum sealed and one standard packing box contains 1350 modules.

FIGURE 13-1. RED-BEET 1.1 TRAY DIMENSIONS

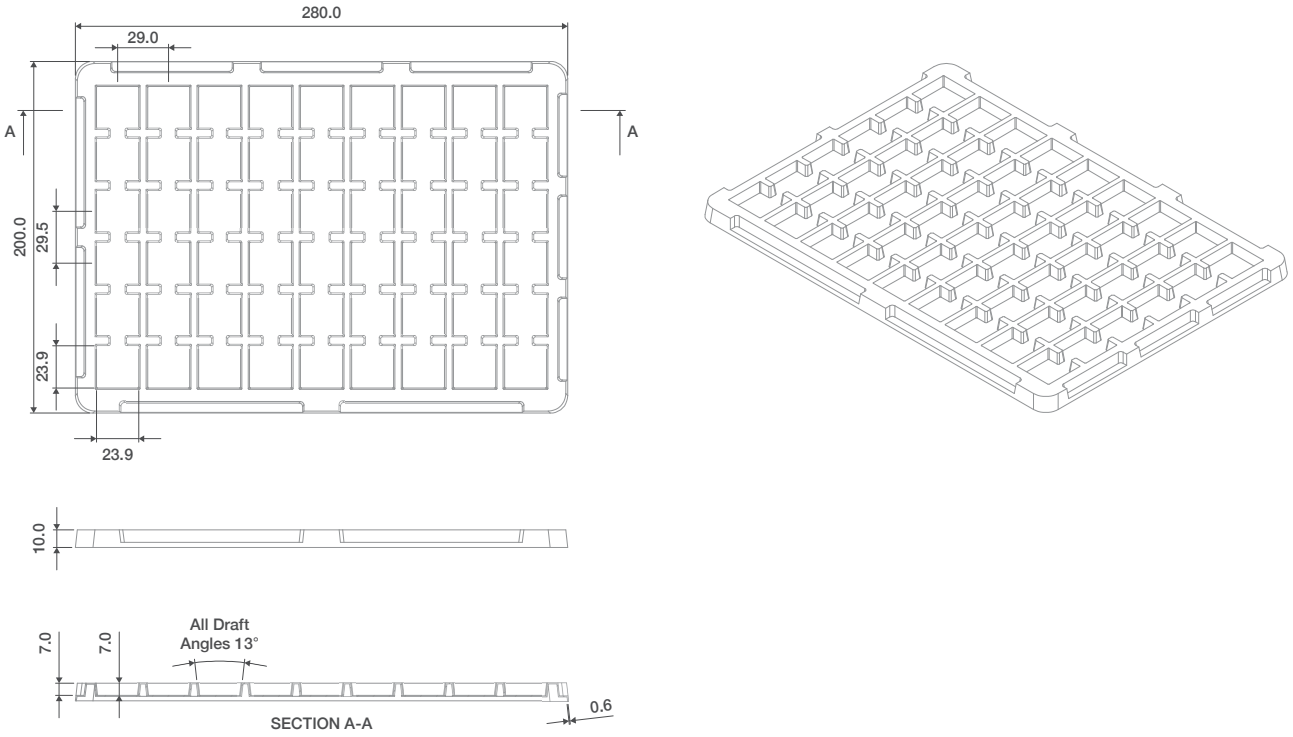
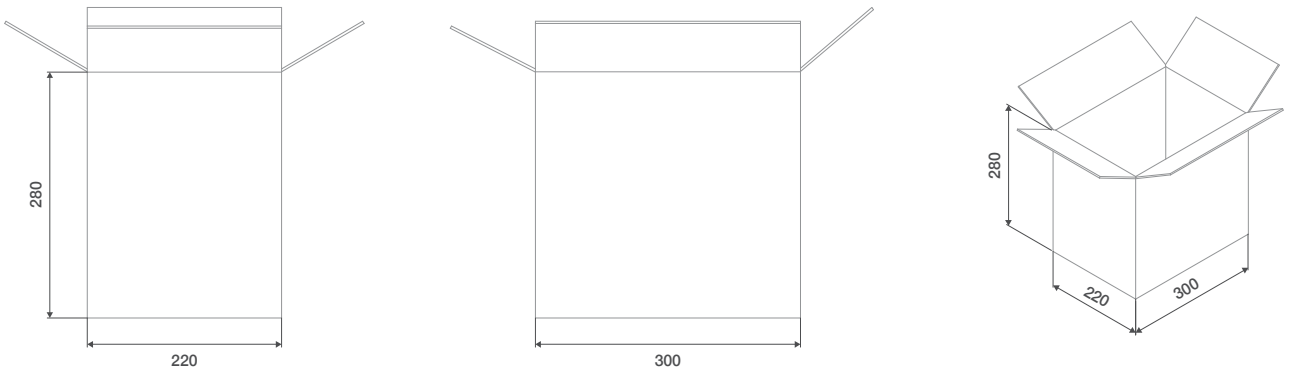


FIGURE 13-2. RED-BEET 1.1 STANDARD PACKING BOX DIMENSIONS



Tape&Reel packaging

When RED-BEET 1.1 modules are packed into Tape&Reel, each reel contains 400 modules.
There are 5 reels in one standard packing box.
First 5 slots of every tape are empty, beginning of the tape on the FIGURE 13-3 is on the right side.

FIGURE 13-3. RED-BEET 1.1 CARRIER TAPE DIMENSIONS

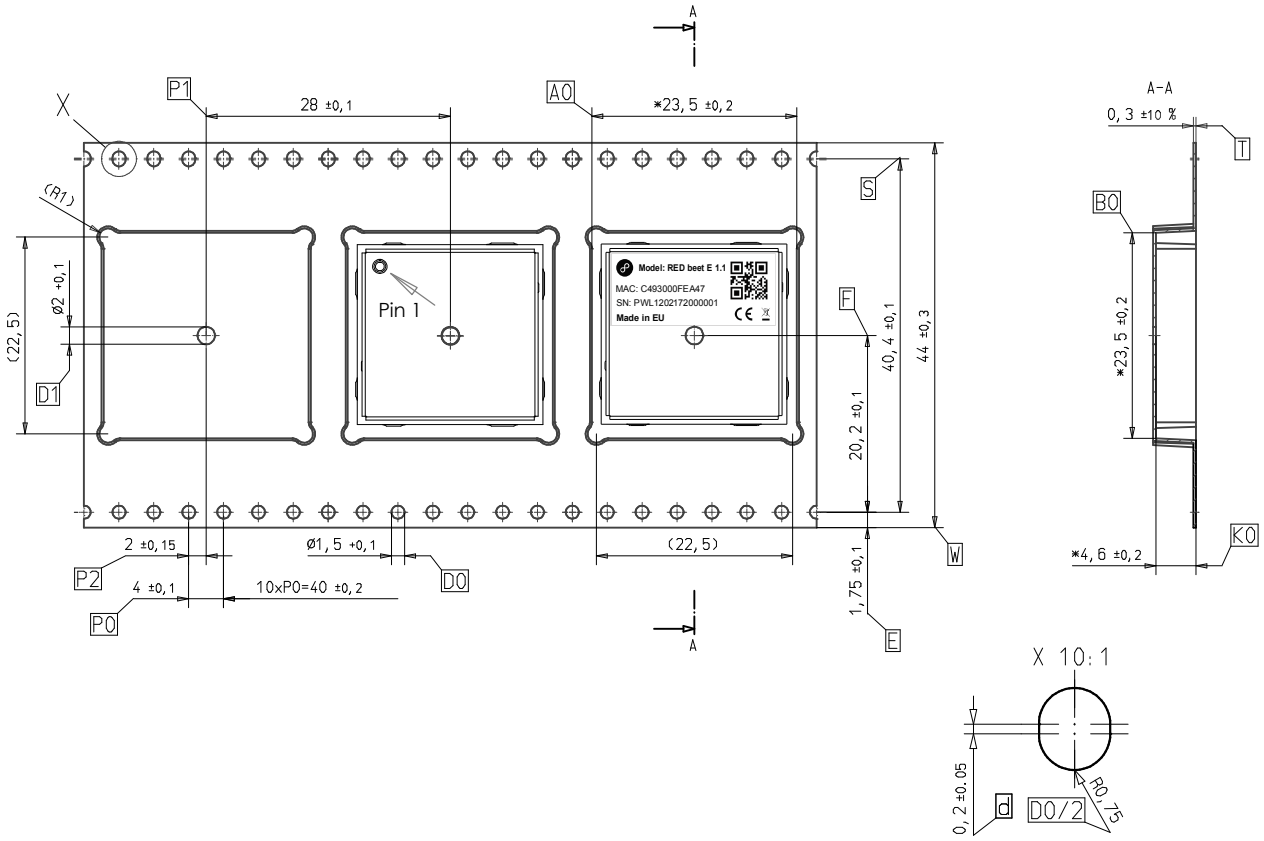
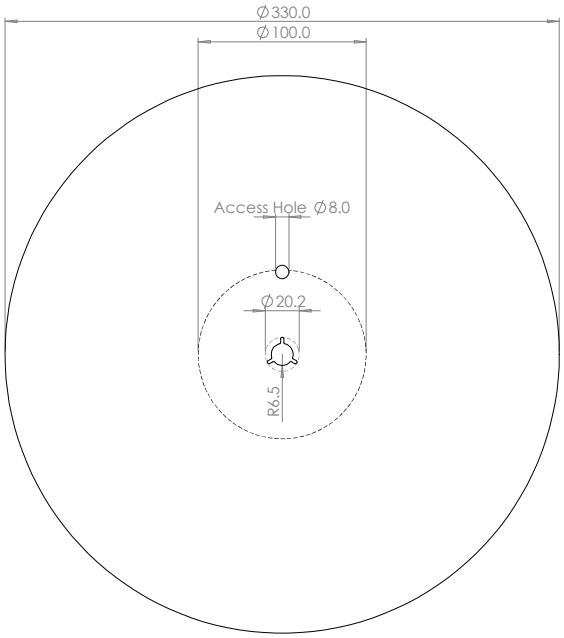
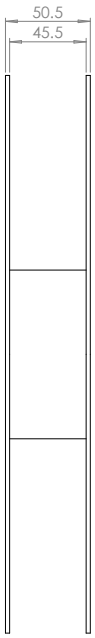


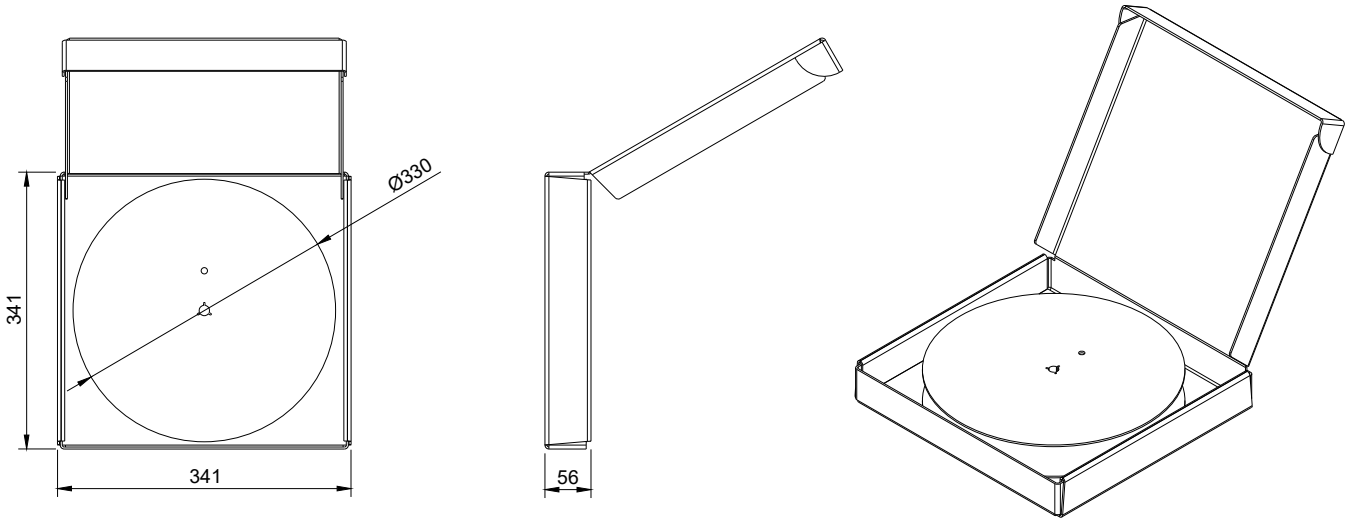
FIGURE 13-4. RED-BEET 1.1 PACKAGING REEL DIMENSIONS





Unspecified tolerances: DIN ISO 2768-fH			
Tolerance			Position Tolerances
Nominal			Straight holes and threads ⌖ Ø 0.2
>	≤	±	
	6	0.1	
6	30	0.2	
30	120	0.3	Countersunk holes ⌖ Ø 0.1
120	315	0.4	
315	1000	0.6	
1000	2000	1.0	

FIGURE 13-5. RED BEET 1.1 REEL PACKAGING BOX WITH REEL



14. Document revision history

Revision	Revision Date	Description
1.17	2020.12.11	Initial release as a copy of RED-BEET datasheet rev.1.16 Chapter 5 and Table 12-1 (ordering information) updated Product change information added (difference between new RED-BEET 1.1 and old RED-BEET)
1.18	2021.02.25	A note that UART mode is not recommended interface is added
1.19	2022.04.12	Chapter 9 – mechanical characteristics corrected Chapter 11 – new picture of evaluation board added Chapter 12 – ordering products list actualized, packaging moved into a new Chapter 13 Chapter 13 – T&R information is added Further minor corrections and References to Application Notes added
1.20	2022.09.22	Added shielding options into Chapter 9, correction of Chapter 13
1.50	2023.12.22	Split of the original datasheet into EV-charging (RED-BEET-E/P 1.1) and Long-reach (RED-BEET-H 1.1) applications. All the chapters were corrected and modified.