USER MANUAL V0.90

Scavenger Transceiver Module
STM 300 / STM 300C

February 26, 2010

Observe precautions! Electrostatic sensitive devices!

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REVISION HISTORY

The following major modifications and improvements have been made to the first version of this document:

No	Major Changes
0.6	Chapter 4 (Agency certifications) modified; Chapter 2.8.1 Order of Data Bytes for 10/8/6 bit option modified Drawing in 1.3 corrected; Chapter 3.4 and 3.5 modified. Charging circuit in chapter 3.1 modified
0.7	Additional function on pin WXIDIO; charging circuit in chapter 3.1 modified; programmable delay time for measurement added in 2.8.2; operating temperature range limited to -25 °C/+85 °C; deep sleep current increased to 0.2 µA; RX sensitivity reduced to -94 dBm; Layout recommendation in 3.5 modified; Maximum Ratings (non-operating) modified in 2.4, Maximum Ratings (operating) added in 2.5
0.75	Section 2.7 and 2.11 modified. Max output currents in 2.3 reduced
0.8	ECS 3x0 solar cells mentioned. Receive current increased to typ.33 mA; Section 2.7 and 2.3.2 modified; Section 3.4 inserted; recommended foot pattern added in 3.6; new drawing in 1.3; section 3.8 Tape&Reel spec added; RX sensitivity reduced to -93 dBm
0.9	Max. ripple at VDD reduced to 50 mVpp; Connect external 1 kΩ pull-down to RESET and PROG_EN.

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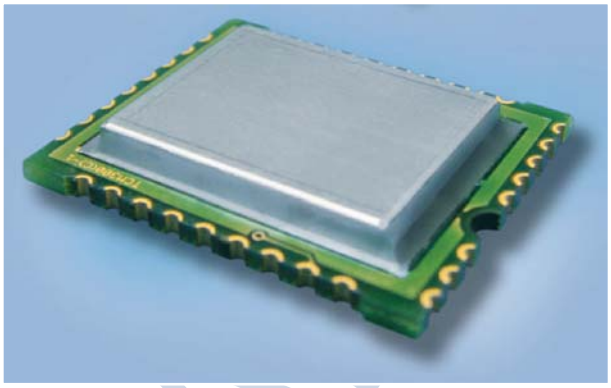
1 GENERAL DESCRIPTION

1.1 Basic functionality



The extremely power saving RF transmitter module STM 300 of EnOcean enables the realization of wireless and maintenance free sensors and actuators such as room operating panels, motion sensors or valve actuators for heating control.

Power supply is provided by an external energy harvester, e.g. a small solar cell (e.g. EnOcean ECS 3x0) or a thermal harvester. An energy storage device can be connected externally to bridge periods with no supply from the energy harvester. A voltage limiter avoids damaging of the module when the supply from the energy harvester gets too high. The module provides a user configurable cyclic wake up. After wake up a radio telegram (input data, unique 32 bit sensor ID, checksum) will be transmitted in case of a change of any digital input value compared to the last sending or in case of a significant change of measured analogue values (different input sensitivities can be selected). In case of no relevant input change a redundant retransmission signal is sent after a user configurable number of wake-ups to announce all current values. In addition a wake up can be triggered externally.

Features with built-in firmware

- 3 A/D converter inputs
- 4 digital inputs
- Configurable wake-up and transmission cycle
- Wake-up via Wake pins
- Voltage limiter
- Threshold detector
- Application notes for calculation of energy budgets and management of external energy storages

Product variants

- STM 300/300C: SMD mountable module for use with external antenna (868/315 MHz)

Features accessible via API

Using the Dolphin API library it is possible to write custom firmware for the module.
STM 300 / STM 300C is in-system programmable. The API provides:

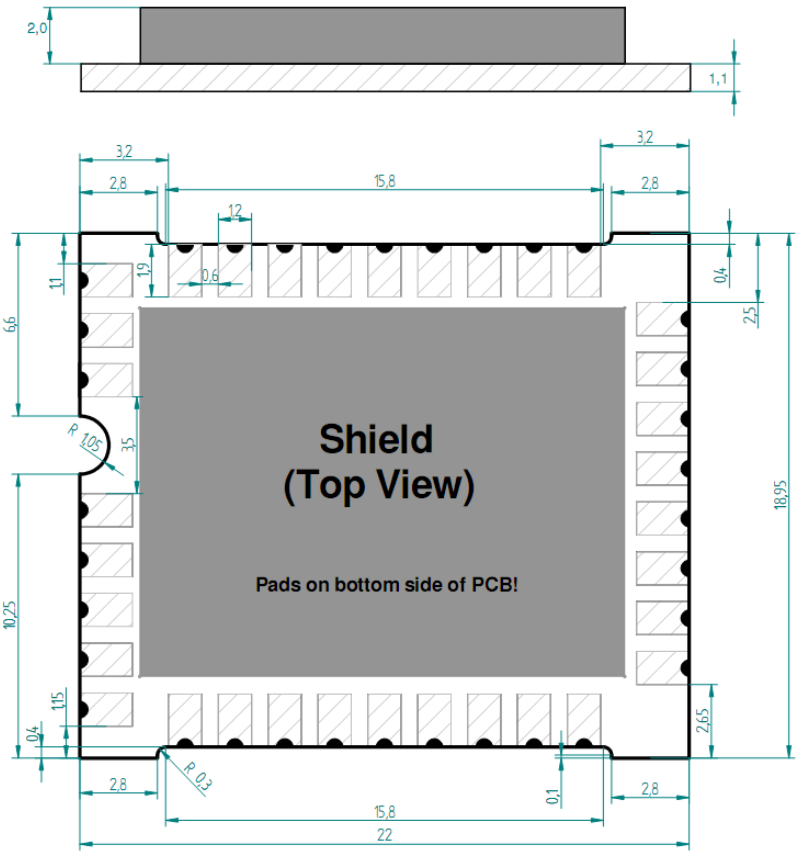
- Integrated 16 MHz 8051 CPU with 32 KB FLASH and 2 kB SRAM
- Receiver functionality
- Various power down and sleep modes down to 0.2 µA current consumption
- Up to 16 configurable I/Os
- 10 bit ADC, 8 bit DAC

1.2 Technical data

Antenna	External whip or 50 Ω antenna mountable
Frequency	315.0 MHz (STM 300C)/868.3 MHz (STM 300)
Radio Standard	EnOcean 868 MHz/315 MHz
Data rate / Modulation type	125 kbps/ASK
Receiver Sensitivity (at 25°C)	typ. –93 dBm, receiver available only via API
Conducted Output Power	typ. 5 dBm
Power Supply	2.1 V–4.5 V, 2.6 V needed for start-up
Current Consumption	Deep Sleep mode : typ. 0.2 µA Transmit mode: typ. 24 mA, max. 33 mA Receive mode (available via API only): typ. 33 mA, max. 43 mA
Input Channels	4x digital input, 2x WAKE input , 3x analog input Resolution: 3x 8 bit or 1x 10 bit, 1x 8 bit, 1x 6 bit
Radio Regulations	R&TTE EN 300 220 (STM 300) FCC CFR-47 Part 15 (STM 300C)

1.3 Physical dimensions

PCB dimensions	STM 300/STM 300C: 22x19x3.1 mm



Unless otherwise specified dimensions are in mm.

Tolerances:

PCB outline dimensions ±0.2 mm

All other tolerances ±0.1 mm

STM 300 / STM 300C (pads on bottom side of PCB!)

1.4 Environmental conditions

Operating temperature	-25 °C … +85 °C
Storage temperature	-40 °C … +85 °C
Storage temperature in tape & reel package	-20 °C … +50 °C
Humidity	0% … 93% r.h., non-condensing

1.5 Ordering Information

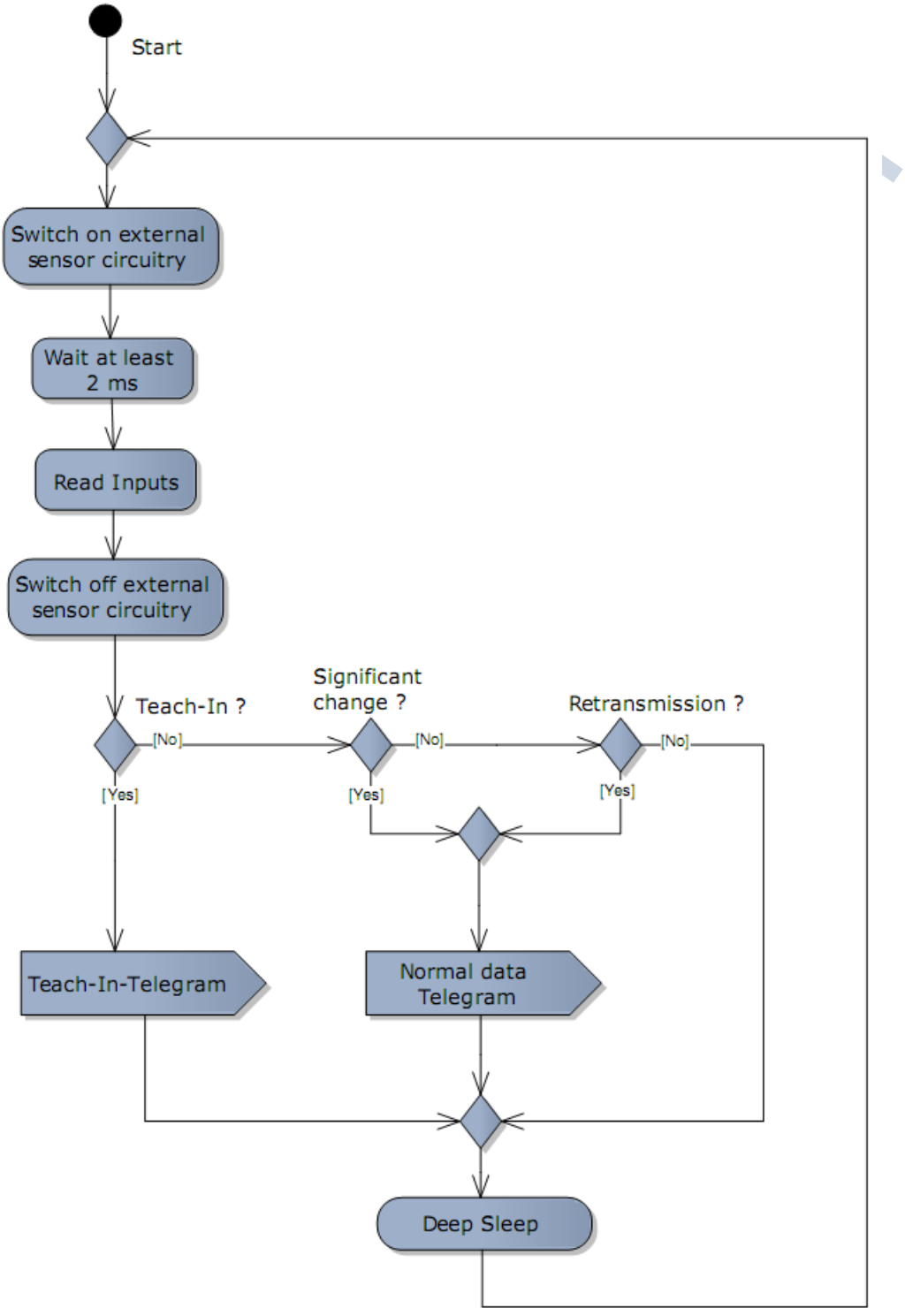
Type	Ordering Code	Frequency
STM 300	**S3001-D300**	**868.3 MHz**
STM 300C	**S3031-D300**	**315.0 MHz**

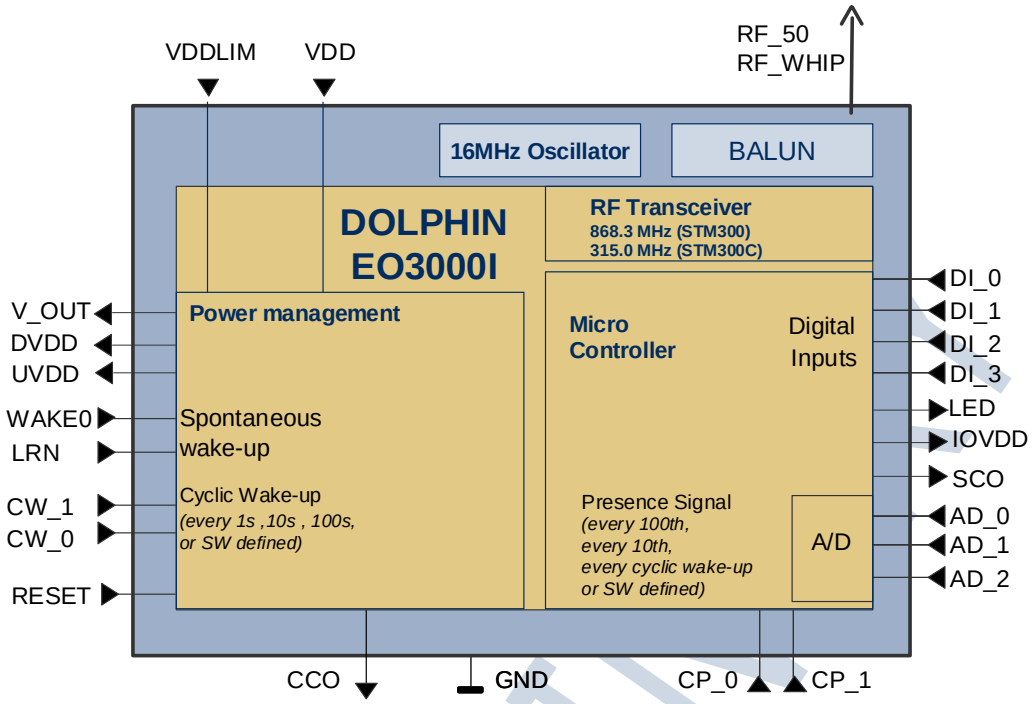
Suited solar cells (for technical details please refer to the ECS3x0 data sheet):

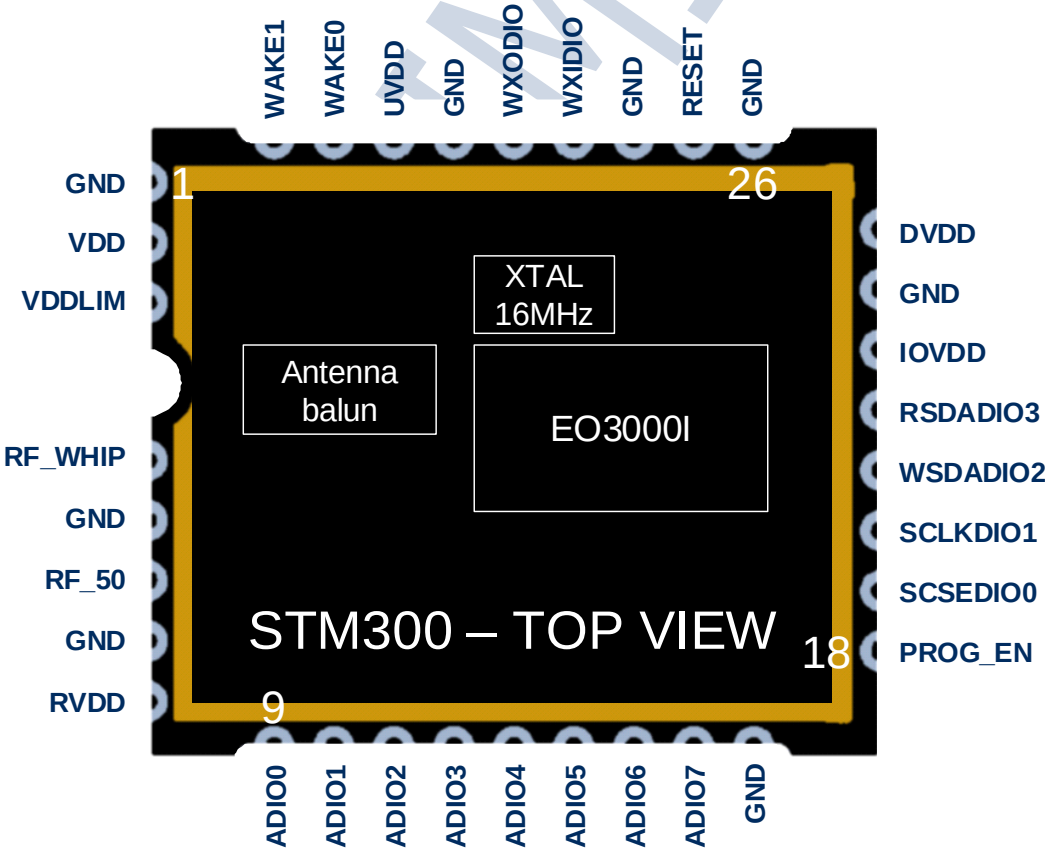
Type	Ordering Code	Size
ECS 300	**S3005-D305**	**35.0×12.8×1.1 mm**
ECS 310	**S3005-D310**	**50.0×20.0×1.1 mm**

2 FUNCTIONAL DESCRIPTION

2.1 Simplified firmware flow chart and block diagram




VDDLIM
VDD
RF_50
RF_WHIP
16MHz Oscillator
BALUN
DOLPHIN
EO3000I
RF Transceiver
868.3 MHz (STM300)
315.0 MHz (STM300C)
Power management
Micro
Controller
Digital
Inputs
V_OUT
DVDD
UVDD
WAKE0
LRN
CW_1
CW_0
RESET
Spontaneous
wake-up
Cyclic Wake-up
(every 1s ,10s , 100s,
or SW defined)
Presence Signal
(every 100th,
every 10th,
every cyclic wake-up
or SW defined)
A/D
DI_0
DI_1
DI_2
DI_3
LED
IOVDD
SCO
AD_0
AD_1
AD_2
CCO
GND
CP_0
CP_1


WAKE1
WAKE0
UVDD
GND
WXODIO
WXIDIO
GND
RESET
GND
GND
VDD
VDDLIM
RF_WHIP
GND
RF_50
GND
RVDD
1
26
9
18
XTAL
16MHz
Antenna
balun
EO3000I
STM300 – TOP VIEW
DVDD
GND
IOVDD
RSDADIO3
WSDADIO2
SCLKDIO1
SCSEDIO0
PROG_EN
ADIO0
ADIO1
ADIO2
ADIO3
ADIO4
ADIO5
ADIO6
ADIO7
GND

2.2 Hardware pin out

The figure above shows the pin out of the STM 300 hardware. The pins are named according to the naming of the EO3000I chip to simplify usage of the DOLPHIN API.
The table in section 2.3 shows the translation of hardware pins to a naming the fits the functionality of the built-in firmware.

2.3 Pin description and operational characteristics

STM 300 Hardware Symbol	STM 300 Firmware Symbol	Function	Characteristics
GND	GND	Ground connection	Must be connected to GND
VDD	VDD	Supply voltage	2.1 V – 4.5 V; Start-up voltage: 2.6 V Maximum ripple: see 2.6
RVDD	V_OUT	RF supply voltage regulator output	1.8 V. Output current: max. 10 mA. See 3.4! Supply for external circuitry, available while not in deep sleep mode.
DVDD	DVDD	Digital supply voltage regulator output	1.8 V. Output current: max. 5 mA Supply for external circuitry, available while not in deep sleep mode.
UVDD	UVDD	Ultra low power supply voltage regulator output	Not for supply of external circuitry! For use with WAKE pins, see section 3.3. Max. 1 µA output current!
VDDLIM	VDDLIM	Supply voltage limiter input	Limitation voltage: 4.5 V Maximum shunting current: 50 mA
IOVDD	IOVDD	Digital interface supply voltage	Must be connected to desired interface supply between 1.8 V and 3.3 V, e.g. to DVDD. See also 2.3.1
RESET	RESET	Reset input Programming I/F	Active high reset (1.8 V) Connect external 1 kΩ pull-down.
PROG_EN	PROG_EN	Programming I/F	HIGH: programming mode active LOW: operating mode Digital input, connect external 1 kΩ pull-down.
ADIO0	AD_0	Analog input	Input read ~2 ms after wake-up. Resolution 8bit. See also 2.3.2.
ADIO1	AD_1	Analog input	Input read ~2 ms after wake-up. Resolution 8 bit (default) or 10 bit. See also 2.3.2.
ADIO2	AD_2	Analog input	Input read ~2 ms after wake-up. Resolution 8 bit (default) or 6 bit. See also 2.3.2.
ADIO3	DI_0	Digital input	Input read ~2 ms after wake-up. See also 2.3.2.
ADIO4	DI_1	Digital input	Input read ~2 ms after wake-up. See also 2.3.2.
ADIO5	DI_2	Digital input	Input read ~2 ms after wake-up. See also 2.3.2.

ADIO6	DI_3	Digital input	Input read ~2 ms after wake-up. See also 2.3.2.
ADIO7	LED	Transmission indicator LED	Max. output current: 2 mA @ IOVDD=3.3 V 0.65 mA @ IOVDD=1.8 V
		Programming I/F	
SCSEDIO0	CW_1	Encoding input for wake-up cycle	Leave open or connect to GND
		Programming I/F	
SCLKDIO1	CW_0	Encoding input for wake-up cycle	Leave open or connect to GND
		Programming I/F	
WSDADIO2	CP_1	Encoding input for retransmission	Leave open or connect to GND
		Programming I/F	
RSDADIO3	CP_0	Encoding input for retransmission	Leave open or connect to GND
		Programming I/F	
WXIDIO	SCO	Sensor control	Digital output, max. current 15 µA HIGH ~x ms before analog inputs are read (x=0…508 ms; default 2 ms.) LOW at wake-up and after reading of analog inputs Polarity can be inverted, delay time can be programmed, see 2.8.2.
WXODIO	CCO	Charge control	Max output current 15 µA See 2.7 for description of behaviour.
WAKE0	WAKE0	Wake input	Change of logic state leads to wake-up and transmission of a telegram. See also 3.3.
WAKE1	LRN	LRN input	Change of logic state to LOW leads to wake-up and transmission of teach-in telegram if a manufacturer code is programmed. See also 2.9.2 and 3.3.
RF_WHIP	RF_WHIP	RF output	Output for whip antenna
RF_50	RF_50	RF output	50 Ohm output for external antenna

2.3.1 Interface supply voltage

For digital communication with other circuitry (peripherals) the digital I/O configured pins of the mixed signal sensor interface (ADIO0 to ADIO7) and the pins of the serial interface (SCSEDIO0, SCLKDIO1, WSDADIO2, RSDADIO3) may be operated from supply voltages different from DVDD. Therefore an interface supply voltage pin IOVDD is available which can be connected either to DVDD or to an external supply within the tolerated voltage range of IOVDD. Please note that the wristwatch XTAL I/Os WXIDIO and WXODIO are always supplied from UVDD.

If DVDD=0 V (e.g. in any sleepmode) and IOVDD is supplied, there may be unpredictable and varying current from IOVDD caused by internal floating nodes. It must be taken care that the current into IOVDD does not exceed 10 mA while DVDD=0 V.
If DVDD=0 V and IOVDD is not supplied, do not apply voltage to any above mentioned pin. This may lead to unpredictable malfunction of the device.

IOVDD voltage must not exceed VDD voltage! A malfunction of the module may be caused by such inverse supply!

For I/O pins configured as analog pins the IOVDD voltage level is not relevant!

2.3.2 Analog and digital inputs

Parameter	Conditions / Notes	Min	Typ	Max	Units
Analog Input					
Measurement range	Single ended	0.05		RVDD-0.05	V
Input coupling			DC		
Measurement bandwidth			100		kHz
Input resistance	Single ended against RGND @ 1 kHz	10			MΩ
Input capacitance	Single ended against RGND @ 1 kHz			10	pF
Effective measurement resolution	Configurable, see 2.8.2	6		10	bit
Relative measurement accuracy	Related to the reference voltage within specified input range			0.6	%
Digital Input Mode					
Input HIGH voltage		2/3 IOVDD			V
Input LOW voltage				1/3 IOVDD	V
Pull up resistor	@IOVDD=1.7 … 1.9 V	90	132	200	kΩ
	@IOVDD=3.0 … 3.6 V	38	54	85	kΩ

2.4 Absolute maximum ratings (non operating)

Symbol	Parameter	Min	Max	Units
VDD VDDLIM	Supply voltage at VDD and VDDLIM	-0.5	5.5	V
IOVDD	Supply voltage for mixed signal sensor interface and serial interface pins	-0.5	3.6	V
GND	Ground connection	0	0	V
VINA	Voltage at every analog input pin	-0.5	2	V
VIND1	Voltage at RESET, WAKE0/1, and every digital input pin except WXIDIO/WXODIO	-0.5	3.6	V
VIND2	Voltage at WXIDIO / WXODIO input pin	-0.5	2	V

2.5 Maximum ratings (operating)

Symbol	Parameter	Min	Max	Units
VDD VDDLIM	Supply voltage at VDD and VDDLIM	VOFF	4.5	V
IOVDD	Digital interface supply voltage (see also 2.3.1)	1.7	MIN (3.6; VDD)	V
GND	Ground connection	0	0	V
VINA	Voltage at every analog input pin	0	2.0	V
VIND1	Voltage at RESET, WAKE0/1, and every digital input pin except WXIDIO / WXODIO	0	3.6	V
VIND2	Voltage at WXIDIO / WXODIO input pin	0	2.0	V

2.6 Power management and voltage regulators

Symbol	Parameter	Conditions / Notes	Min	Typ	Max	Units
Voltage Regulators						
VDDR	Ripple on VDD, where Min(VDD) > VON				50	mV_{pp}
UVDD	Ultra Low Power supply			1.8		V
RVDD	RF supply		1.7	1.8	1.9	V
DVDD	Digital supply		1.7	1.8	1.9	V
Voltage Limiter						
VLIM	Limitation voltage			4.5		V
ILIM	Shunting current				50	mA
Threshold Detector						
VON	Turn on threshold		2.3	2.45	2.6	V
VOFF	Turn off threshold	Automatic shutdown if VDD drops below VOFF	1.85	1.9	2.1	V

Voltage Limiter
STM 300 provides a voltage limiter which limits the supply voltage VDD of STM 300 to a value VDDLIM which is slightly below the maximum VDD ratings by shunting of sufficient current.

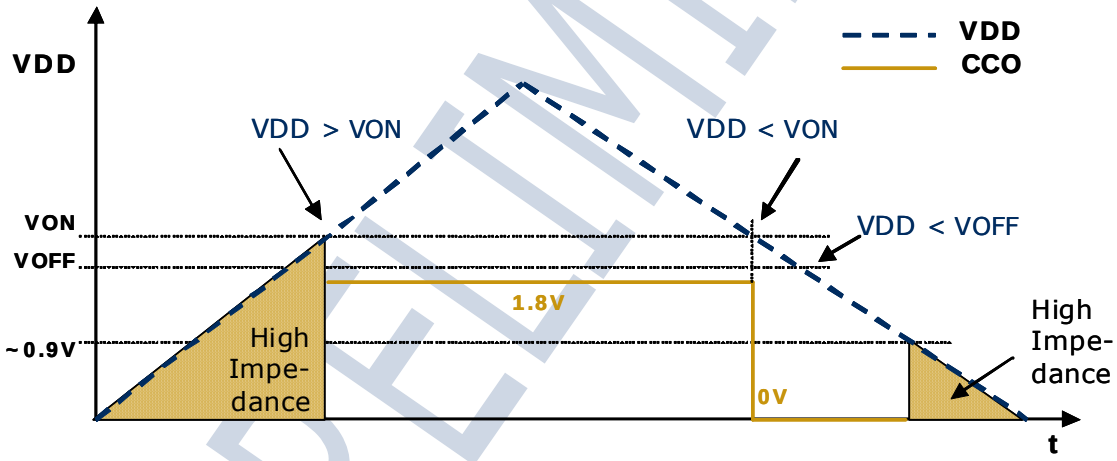
Threshold detector
STM 300 provides an ultra low power ON/OFF threshold detector. If VDD > VON, it turns on the ultra low power regulator (UVDD), the watchdog timer and the WAKE# pins circuitry. If VDD ≤ VOFF it initiates the automatic shut down of STM 300.

2.7 Charge control output (CCO)

After startup STM 300 provides the output signal of the threshold detector at CCO.
CCO is supplied by UVDD. The output value remains stable also when STM 300 is in deep sleep mode.

Behavior of CCO

- At power up: TRISTATE until VDD>VON then HIGH
- if VDD>VON then HIGH
- if VDD<VON then LOW
- if VDD< ~0.9 V TRISTATE until next power up



For definition of VON and VOFF please refer to 2.6.

2.8 Configuration

2.8.1 Configuration via pins

The encoding input pins have to be left open or connected to GND in correspondence with the following connection schemes. These settings are checked at every wake-up.

Wake-up cycle time

CW_0	CW_1	Wake-up cycle time
NC	NC	1 s ±20%
GND	NC	10 s ±20%
NC	GND	100 s ±20%
GND	GND	No cyclic wake-up

Redundant retransmission

Via CP_0 and CP_1 an internal counter is set which is decreased at every wake-up signal. Once the counter reaches zero the redundant retransmission signal is sent.

CP_0	CP_1	Number of wake-ups that trigger a redundant retransmission
NC	NC	Every timer wake-up signal
GND	NC	Every 7^{th} - 14^{th} timer wake-up signal, affected at random
NC	GND	Every 70^{th} - 140^{th} timer wake-up signal, affected at random
GND	GND	No redundant retransmission

A radio telegram is always transmitted after wake-up via WAKE pins!
After transmission the counter is reset to a random value within the specified interval.

According to FCC 15.231a) a redundant retransmission at every timer wake-up to determine the system integrity is only allowed in safety and security applications! In this case the total transmission time must not exceed two seconds per hour, which means that a combination with a 1 s wake-up cycle time is not allowed!

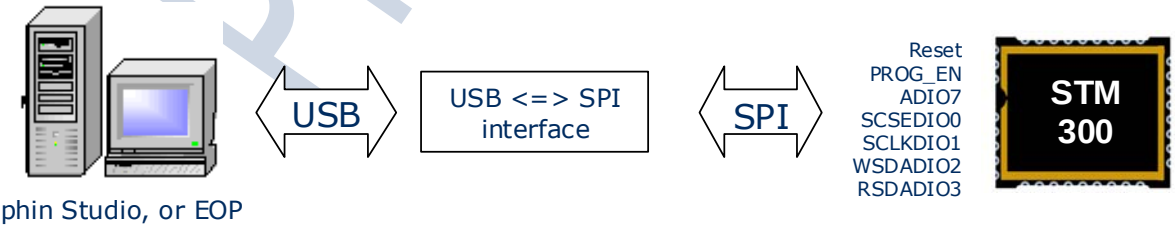
If applied in other (non-safety, non-security) applications a minimum of 10 s between periodic transmissions is required. In addition the device has to comply with the lower field strength limits of 15.231e). The limited modular approval of STM 300C is not valid in this case.

2.8.2 Configuration via serial interface

Via the programming interface the configuration area can be modified. This provides a lot more configuration options. Values set via serial interface override hardware settings! These settings are read after RESET or power-on reset only and not at every wake-up of the module!

Parameter	Configuration via pins	Configuration via serial interface
Wake up cycle	See section 2.8.1	Value can be set from 1 s to 65534 s
Redundant Retransmission cycle	See section 2.8.1	Min…Max values for random interval If Min=Max -> random switched off
Threshold values for analog inputs	No	The default values are: 5 LSB at AD_1 input, 6 LSB at AD_0 and 14 LSB at AD_2. The threshold value can be set between 0 and full scale for every input individually.
Resolution of the analog inputs	No	Default: AD_0: 8 bit, AD_1: 8 bit, AD_2: 8 bit Option: AD_0: 10 bit, AD_1: 6 bit, AD_2: 8 bit
Input mask	No	A digital input mask for ignoring changes on digital input pins. At default all input bits are checked.
Delay time between SCO on and sampling moment	No	Value can be set from 0 ms to 508 ms in steps of 2 ms. Default delay time is 2 ms.
Source of AD_2	No	Select if AD_2 contains measurement value of external ADIO2 pin or from internal VDD/4
Polarity of SCO signal	No	Polarity can be inversed.
Edge of wake pin change causing a telegram transmission	No	Every change of a wake pin triggers a wake-up. For both wake pins it can be configured individually if a telegram shall be sent on rising, falling or both edges.
Manufacturer ID and EEP (EnOcean Equipment Profile)	No	Information about manufacturer and type of device. This feature is needed for "automatic" interoperability of sensors and actuators or bus systems. Information how to set these parameters requires an agreement with EnOcean. Unique manufacturer IDs are distributed by the EnOcean Alliance.

The interface is shown in the figure below:



Dolphin Studio, or EOP

EnOcean provides EOPx (EnOcean Programmer, a command line program) and Dolphin Studio (Windows application for chip configuration, programming, and testing) and the USB/SPI programmer device as part of the EDK 300 developer´s kit.

2.9 Radio telegram

2.9.1 Normal operation

Telegram content (seen at serial interface of RCM 130/TCM 3x0 or at DOLPHIN API):

ORG = 0x07 (Telegram type "4BS")

Data_Byte1..3
3x8bit mode:

DATA_BYTE3 = Value of AD_2 analog input
DATA_BYTE2 = Value of AD_1 analog input
DATA_BYTE1 = Value of AD_0 analog input

1x8bit, 1x6it, 1x10bit mode:

DATA_BYTE3 = Value of AD_2
DATA_BYTE2 = Upper 2 bits of AD_0 and value of AD_1
DATA_BYTE1 = Lower 8 bits Value of AD_0 analog input

DATA_BYTE3								DATA_BYTE2								DATA_BYTE1							
AD_2								AD_1						AD_0									
7	6	5	4	3	2	1	0	5	4	3	2	1	0	9	8	7	6	5	4	3	2	1	0

DATA_BYTE0 = Digital sensor inputs as follows:

Bit 7				Bit 0
Reserved, set to 0	DI_3	DI_2	DI_1	DI_0

ID_BYTE3 = module identifier (Byte3)
ID_BYTE2 = module identifier (Byte2)
ID_BYTE1 = module identifier (Byte1)
ID_BYTE0 = module identifier (Byte0)

The voltages measured at the analog inputs can be calculated from these values as follows:

$U=(\text{Value of AD\_x})/(2^n)\times 1.8\ V$ n=resolution of channel in bit

2.9.2 Teach-in telegram

In case a manufacturer code is programmed into the module the module transmits – instead of transmitting a normal telegram – a dedicated teach-in telegram if

- digital input DI_3=0 at wake-up or
- wake-up via WAKE1 pin (LRN input)

With this special teach-in telegram it is possible to identify the manufacturer of a device and the function and type of a device. There is a list available from the EnOcean Alliance describing the functionalities of the respective products.

If no manufacturer code is programmed the module does not react to signal changes on WAKE1 (LRN input)!

ORG = 0x07 (Telegram type "4BS")

DATA_BYTE0..3 see below
LRN Type = 1
LRN = 0
DI0..DI2: current status of digital inputs
Profile, Type, Manufacturer-ID defined by manufacturer
RE0..2: set to 0

ID_BYTE3 = module identifier (Byte3)
ID_BYTE2 = module identifier (Byte2)
ID_BYTE1 = module identifier (Byte1)
ID_BYTE0 = module identifier (Byte0)

ORG	Data_Byte3	Data_Byte2	Data_Byte1	Data_Byte0	ID

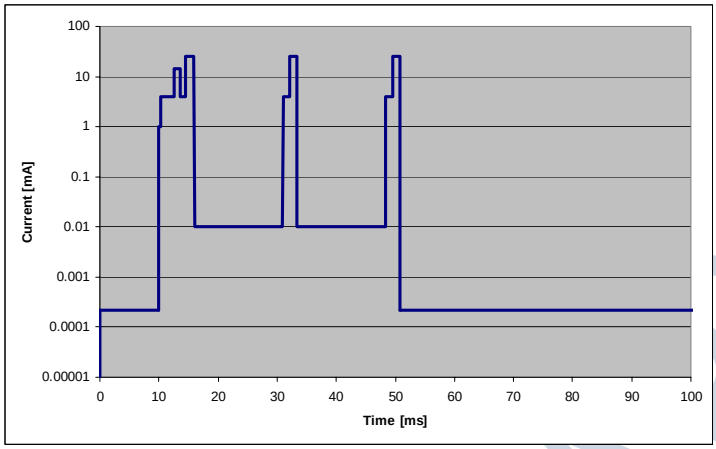
Function 6 Bit	Type 7 Bit	Manufacturer-ID 11 Bit	LRN Type 1Bit	RE2 1Bit	RE1 1Bit	RE0 1Bit	LRN 1Bit	DI2 1Bit	DI1 1Bit	DI0 1Bit

2.10 Transmit timing

The setup of the transmission timing allows avoiding possible collisions with data packages of other EnOcean transmitters as well as disturbances from the environment. With each transmission cycle, 3 identical subtelegrams are transmitted within 40 ms. The transmission of a subtelegram lasts approximately 1.2 ms. The delay between the three transmission bursts is affected at random.

If a new wake-up occurs before all sub-telegrams have been sent, the series of transmissions is stopped and a new series of telegrams with new valid measurement values is transmitted.

2.11 Energy consumption



Current Consumption of STM 300

Charge needed for one measurement and transmit cycle: ~130 µC
Charge needed for one measurement cycle without transmit: ~30 µC
(current for external sensor circuits not included)

Calculations are performed on the basis of electric charges because of the internal linear voltage regulator of the module. Energy consumption varies with voltage of the energy storage while consumption of electric charge is constant.

From these values the following performance parameters have been calculated:

Wake cycle [s]	Transmit interval	Operation Time in darkness [h] when storage fully charged	Required reload time [h] at 200 lux within 24 h for continuous operation	24 h operation after 6 h illumination at x lux	Illumination level in lux for continuous operation	Current in µA required for continuous operation
1	1	0.5	storage too small	storage too small	5220	130.5
1	10	1.7	storage too small	storage too small	1620	40.5
1	100	2.1	storage too small	storage too small	1250	31.3
10	1	5.1	storage too small	storage too small	540	13.5
10	10	16	21	700	175	4.4
10	100	20	16.8	560	140	3.5
100	1	43	7.8	260	65	1.6
100	10	98	3.6	120	30	0.8
100	100	112	3	100	25	0.6

Assumptions:

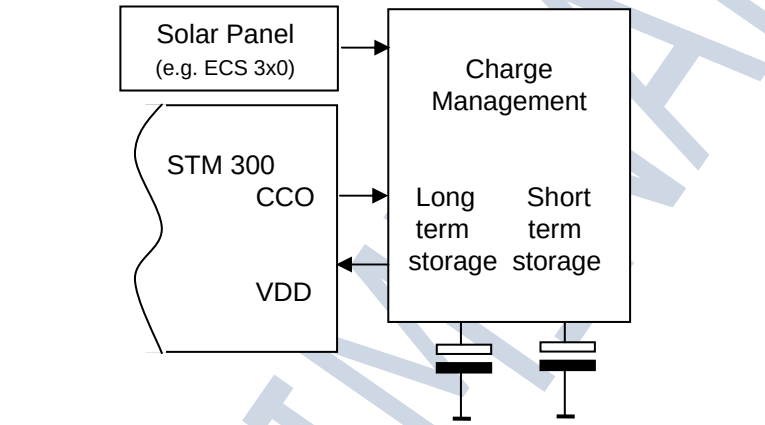
- Storage PAS614 with 0.25 F, Umax=3.2 V, Umin=2.2 V
- Consumption: Transmit cycle 100 µC, measurement cycle 30 µC
- Indoor solar cell, operating values 3 V and 5 µA @ 200 lux fluorescent light (e.g. ECS 300 solar cell)
- Current proportional to illumination level (not true at very low levels!)

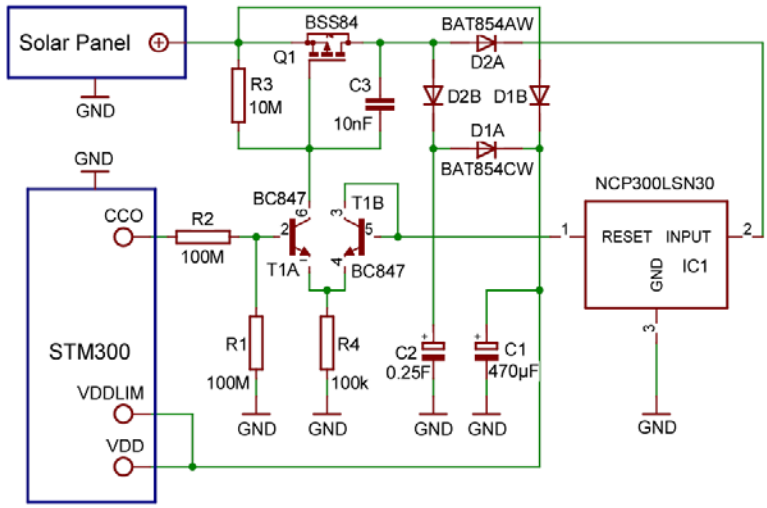
These values are calculated values, the accuracy is about +/-20% !

3 APPLICATIONS INFORMATION

3.1 How to connect an energy harvester and energy storage

STM 300 is designed for use with an external energy harvester and energy storage.
In order to support a fast start-up and long term operation with no energy supply available usually two different storages are used. The small storage fills quickly and allows a fast start-up. The large storage fills slowly but once it is filled up it provides a large buffer for times where no energy is available, e.g. at night in a solar powered sensor.
STM 300 provides a digital output CCO (see also 2.7) which allows controlling the charging of these two storages. At the beginning, as long as the voltage is below the VON voltage only the small storage is filled. Once the threshold is reached the CCO signal changes and the large storage is filled. The short term storage is usually in the range of 470 µF. For the long term storage we suggest a gold cap with a capacity of 0.25 F. Below an overview and the schematics of a charging circuitry is shown:





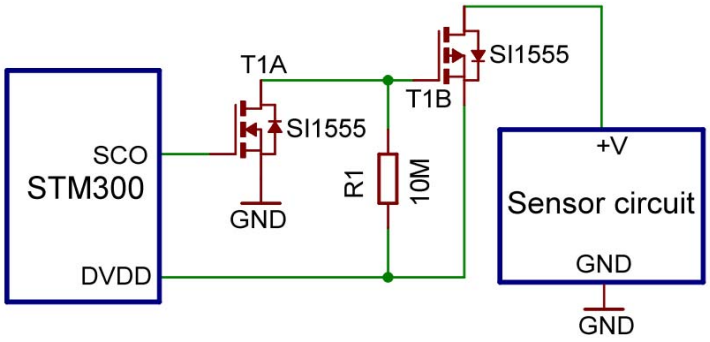
It is important to use matched diode pairs for D2!
This circuit is designed for energy storages specified up to 3.3 V (e.g. PAS614L, please pay attention to manufacturer´s soldering procedures to avoid damage!). NCP300LSN30 is limiting the voltage at C2 < 3.3 V, to avoid damaging of the energy storage. In case a different voltage limit is needed this component has to be exchanged by a suited variant.

The recommendation for C1 is TAJY477K006XNJ from AVX (low leakage current!).
The current consumption of this control circuit is very low. During capacitors charging the current consumption of the charger is about <0.5 µA. In times where no external supply voltage is available (e.g. at night) only a negligible continuous current of about <20 nA is required by this circuit.

For a detailed description of the circuit and more information on various energy harvesters and energy storages please refer to our detailed application notes on this topic.

3.2 Using the SCO pin

STM 300 provides an output signal at SCO which is suited to control the supply of the sensor circuitry. This helps saving energy as the sensor circuitry is only powered as long as necessary. In the default configuration SCO provides a HIGH signal 2 ms (delay time) before the analog inputs are read. Via the serial interface (see 2.8.2) it is possible to adjust the delay time and also the polarity of the signal.



The figure above shows, how the SCO pin (with default polarity) can be used to control an external sensor circuit.

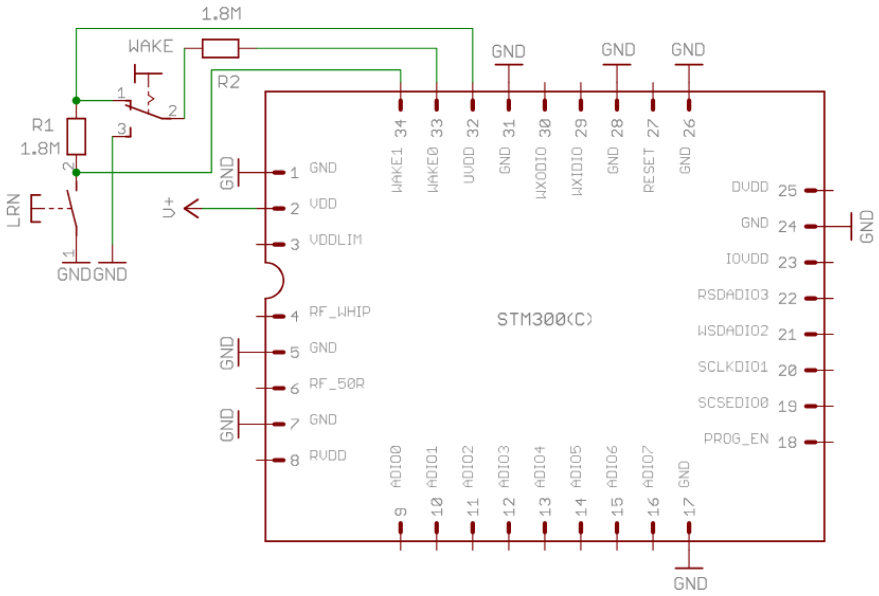
Do not supply sensors directly from SCO as this output can only provide maximum 15 µA!

3.3 Using the WAKE pins

The logic input circuits of the WAKE0 and WAKE1 pins are supplied by UVDD and therefore also usable in "Deep Sleep Mode" or "Flywheel Sleep Mode" (via API only). Due to current minimization there is no internal pull-up or pull-down at the WAKE pins.
When STM 300 is in "Deep Sleep Mode" or "Flywheel Sleep Mode" (via API only) and the logic levels of WAKE0 and / or WAKE1 is changed, STM 300 starts up.

As the there is no internal pull-up or pull-down at the WAKE pins, it has to be ensured by external circuitry, that the WAKE pins are at a defined logic level at any time.

When using the UVDD regulator output as source for the logic HIGH of the WAKE pins, it is strongly recommended to protect the ultra low power UVDD voltage regulator against (accidental) excessive loading by connection of an external 1.8 MΩ series resistor.



The figure above shows two examples how the WAKE inputs may be used. When the LRN button is pressed WAKE1 is pulled to GND and a teach-in telegram is transmitted.
As long as the button is pressed a small current is flowing from UVDD to GND.
WAKE0 is connected to a toggle switch. There is no continuous flow of current in either position of the switch.

3.4 Using RVDD

If RVDD is used in an application circuit a serial ferrite bead shall be used and wire length should be as short as possible (<3 cm). The following ferrite beads have been tested: 74279266 (0603), 74279205 (0805) from Würth. During radio transmission and reception only small currents may be drawn (I<100 µA).
Pulsed current drawn from RVDD has to be avoided. If pulsed currents are necessary, sufficient blocking has to be provided.

3.5 Antenna options

3.5.1 Overview

Several antenna types have been investigated by EnOcean. They all have advantages and disadvantages as shown in the following table.

Advantages	Disadvantages
Whip Antenna (15 cm @ 315 MHz, 8.5 cm @ 868 MHz)	
Cheap	Automatic placement difficult
Omnidirectional	Bending influences performance
	Large size
Chip Antenna (AMD1103-ST01 @ 315 MHz / 868 MHz)	
Omnidirectional	Expensive
Small size	Very sensitive to environment (GND plane, components), minimum distance space to other components needed
Automatic placement possible	
Splatch Antenna (ANT-315-SP1 @ 315 MHz, ANT-868-SP1 @ 868 MHz)	
Omnidirectional	Expensive
Not very sensitive to environment, low distance space to other components required	Large size
Automatic placement possible	
Helical Antenna (ANT-315-HE @ 315 MHz)	
Omnidirectional	Large distance space to other components required
Cheap	Large size (3D)
	Through hole component, no SMT

868 MHz modules used in Europe do not need additional approval if the external antenna fulfils the following requirements:

Antenna type	Passive	Mandatory for radio approval
Frequency band	868 MHz ISM	Antenna must be suited for this band
Impedance	~50 Ohm	Mandatory for radio approval
Maximum gain	≤ 8 dBd	Mandatory for radio approval
VSWR	≤ 1.5:1	Important for compatibility with EnOcean protocol
Return Loss	> 14 dB	Important for compatibility with EnOcean protocol
Bandwidth	≤ 20 MHz	Important if 10 V/m EMI robustness required for device

For 315 MHz modules (STM 300C and TCM 3X0C) please note that a full approval is needed if modules are used with antennas other than the specified whip antenna.

3.5.2 Whip antenna

315 MHz

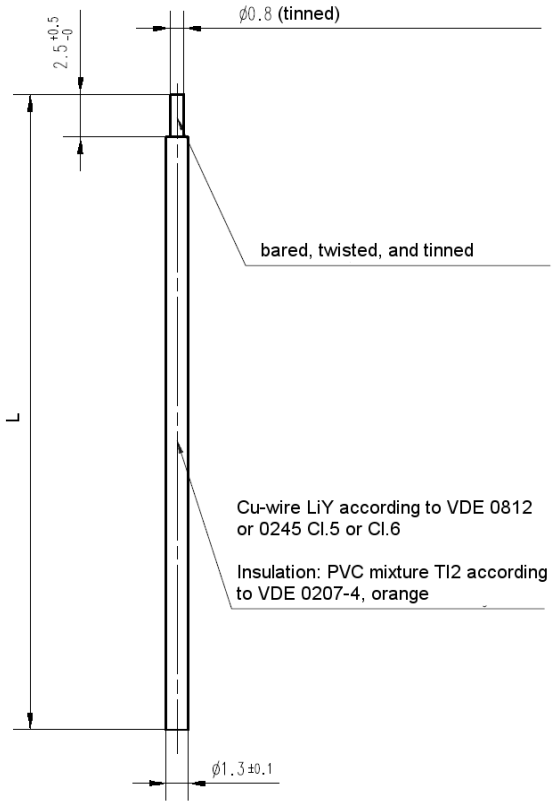
Antenna: 150 mm wire, connect to RF_WHIP

Minimum GND plane: 50 mm x 50 mm
Minimum distance space: 10 mm

868 MHz

Antenna: 86 mm wire, connect to RF_WHIP

Minimum GND plane: 38 mm x 18 mm
Minimum distance space: 10 mm

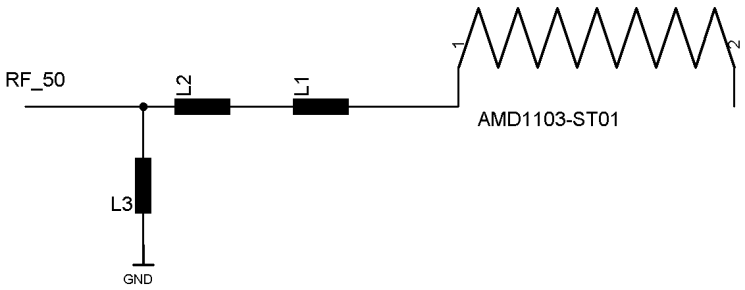


Specification of the whip antenna; L=150 mm @ 315 MHz, L=86 mm @ 868 MHz

3.5.3 Chip antenna

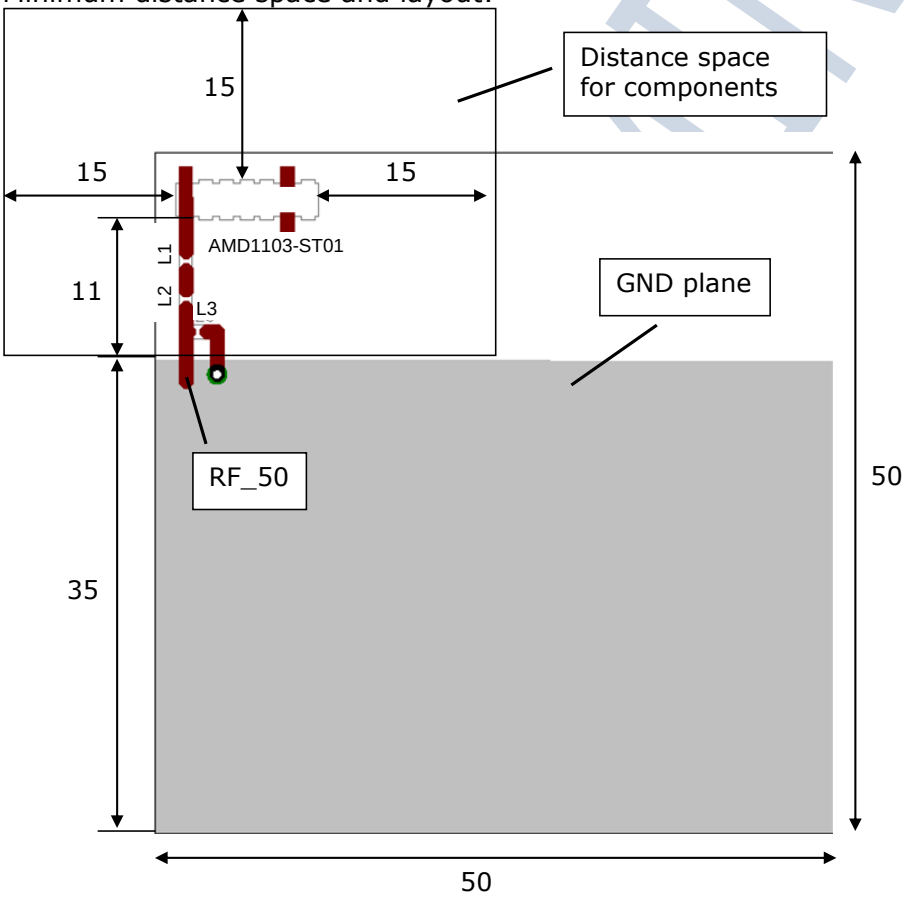
315 MHz

Antenna: AMD1103-ST01
Manufacturer: Mitsubishi
Matching circuit:



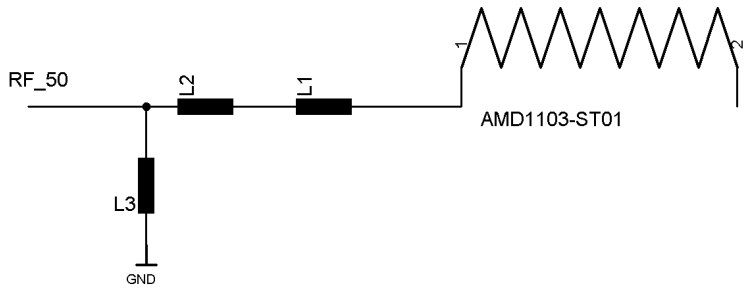
L1=47 nH
L2=390 nH
L3 optional for additional optimization

Minimum distance space and layout:



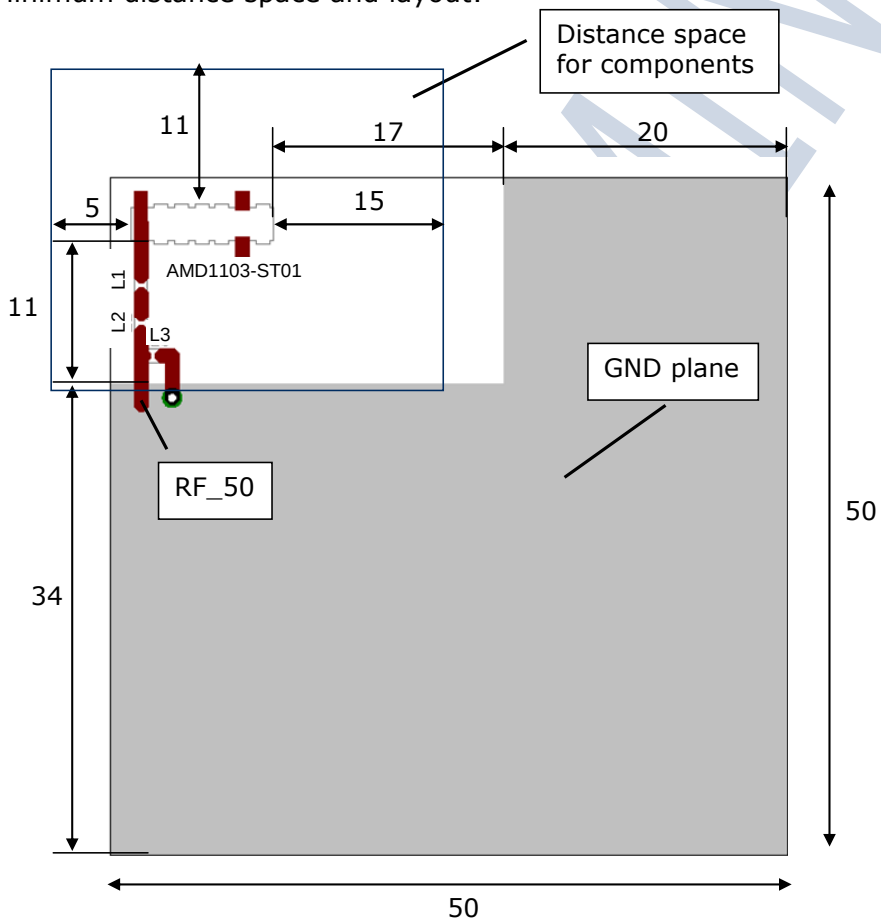
Minimum distance space above and below PCB: 11 mm

868 MHz
Antenna: AMD1103-ST01
Manufacturer: Mitsubishi
Matching circuit:



L1=6.8 nH
L2=39 nH
L3=8.2 nH

Minimum distance space and layout:



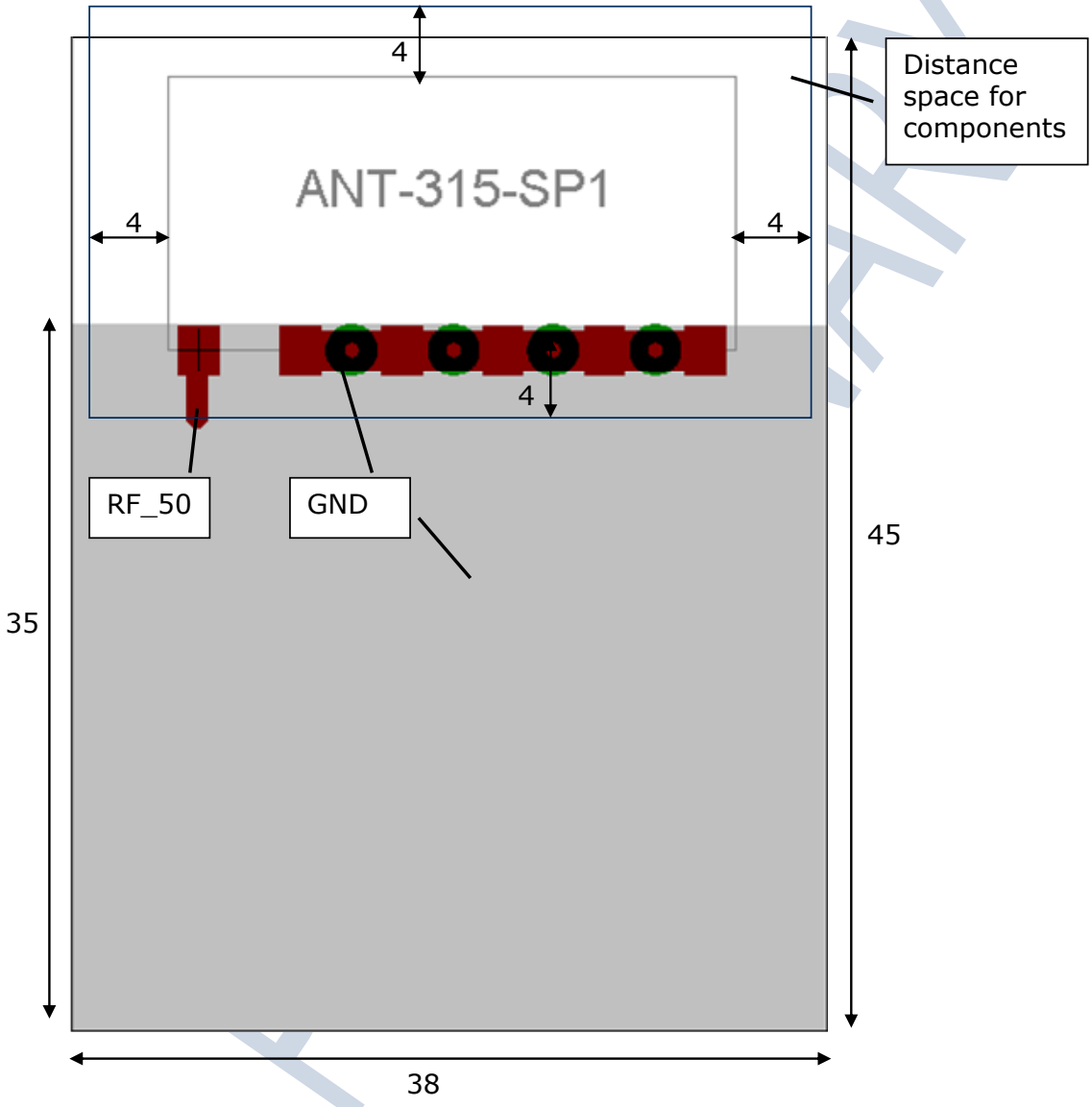
Minimum distance space above and below PCB: 11 mm

3.5.4 Splatch antenna

315/868 MHz

Antenna: ANT-315-SP
Manufacturer: Linx Technologies / Antenna Factor
Matching circuit: Not needed

Minimum distance space and layout:

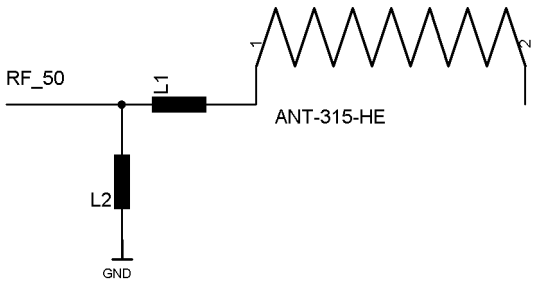


Minimum distance space above and below PCB: 12 mm

3.5.5 Helical antenna

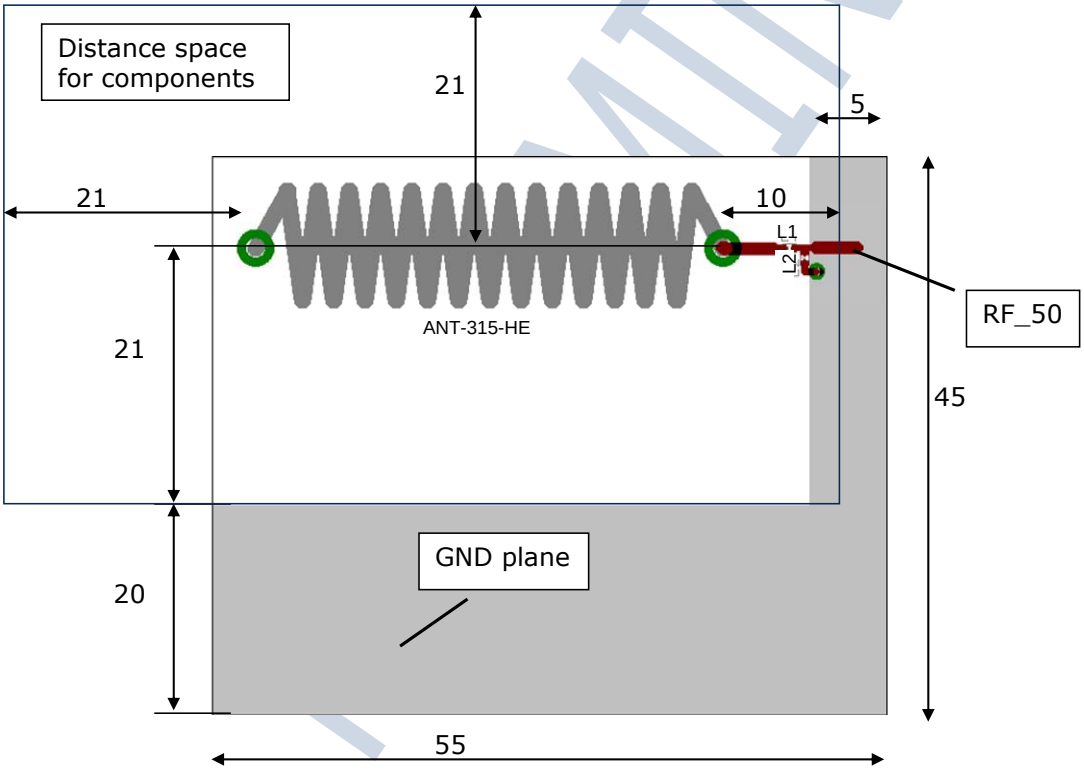
315 MHz

Antenna: ANT-315-HE
Manufacturer: Linx Technologies / Antenna Factor
Matching circuit:



L1=5.1 nH
L2=18 nH

Minimum distance space and layout:



Minimum distance above and below axis of antenna: 21 mm

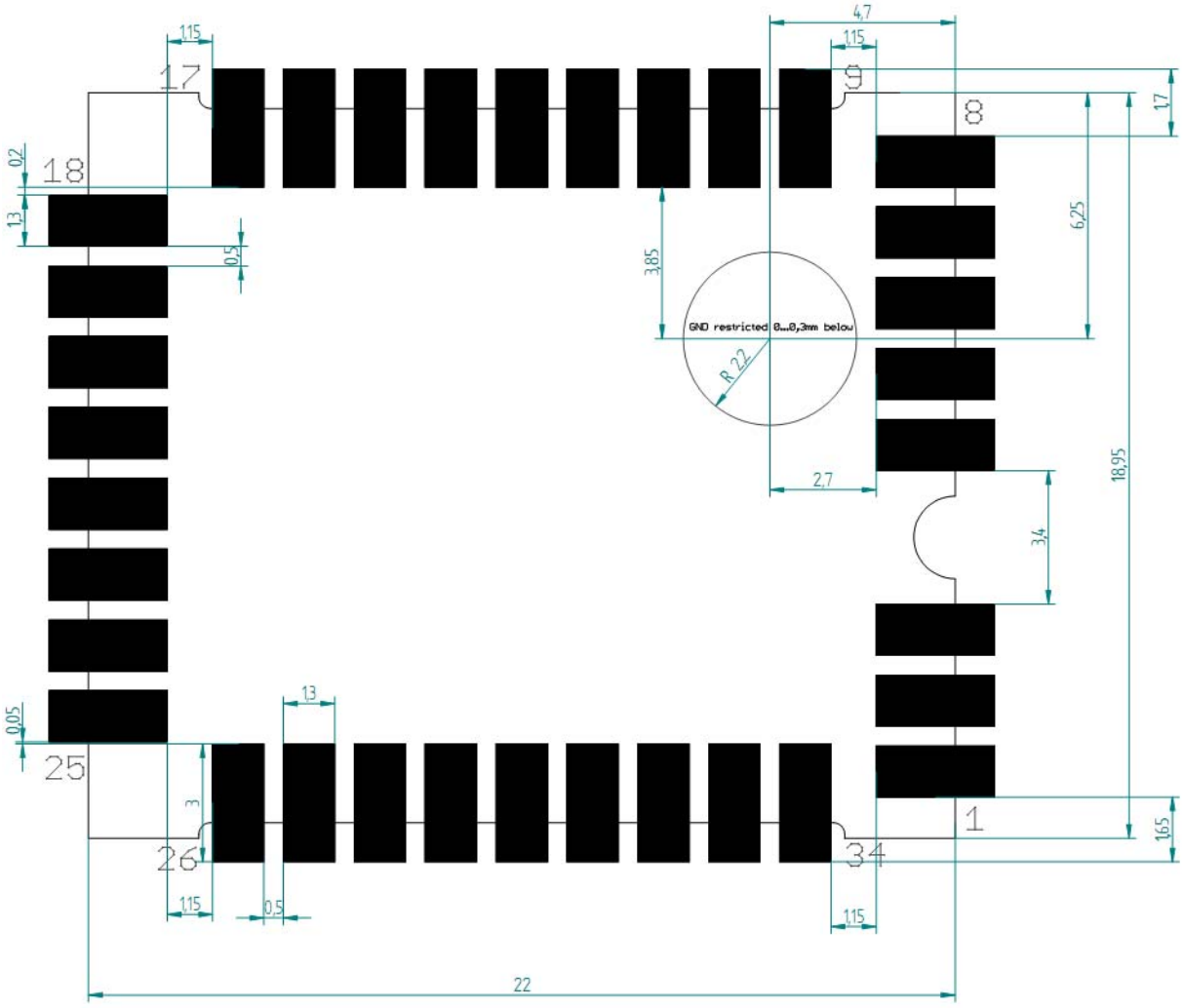
3.6 Layout recommendations for foot pattern

The length of lines connected to I/Os should not exceed 5 cm.

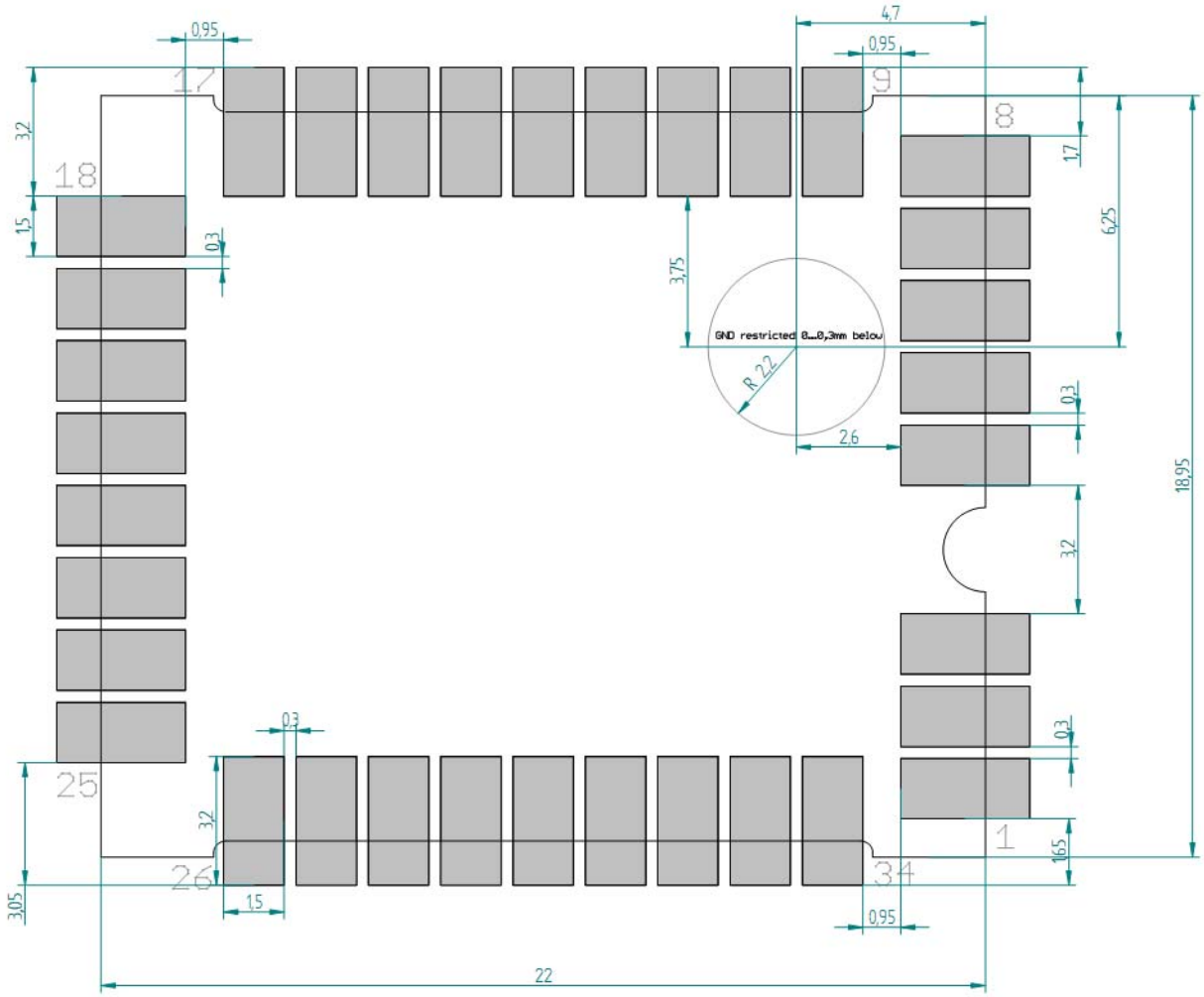
It is recommended to have a complete GND layer, at least below the module and directly connected components.

The RVDD line should be kept as short as possible. Please consider recommendations in section 3.4.

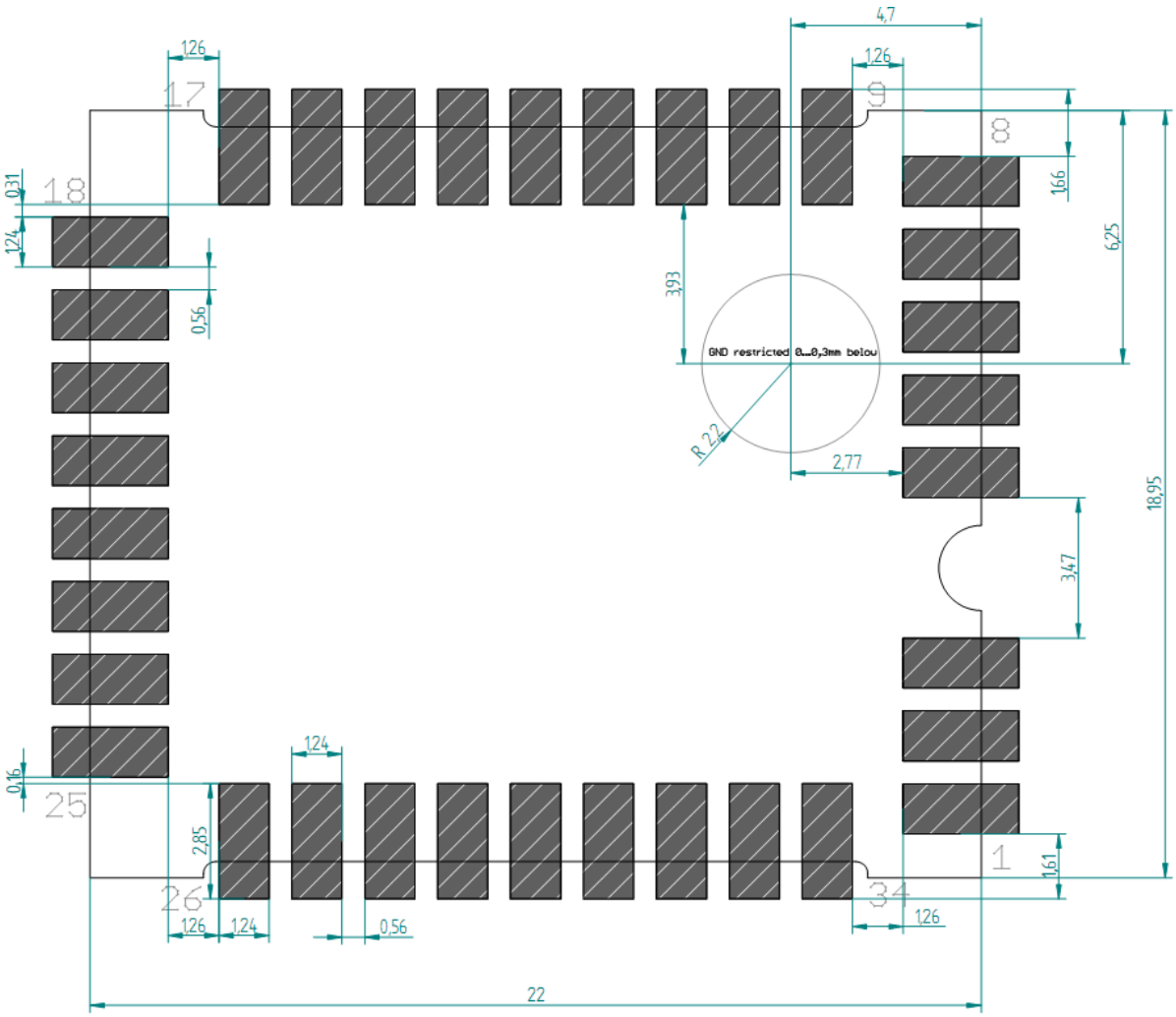
Top layer



Solder resist top layer



Solder paste top layer



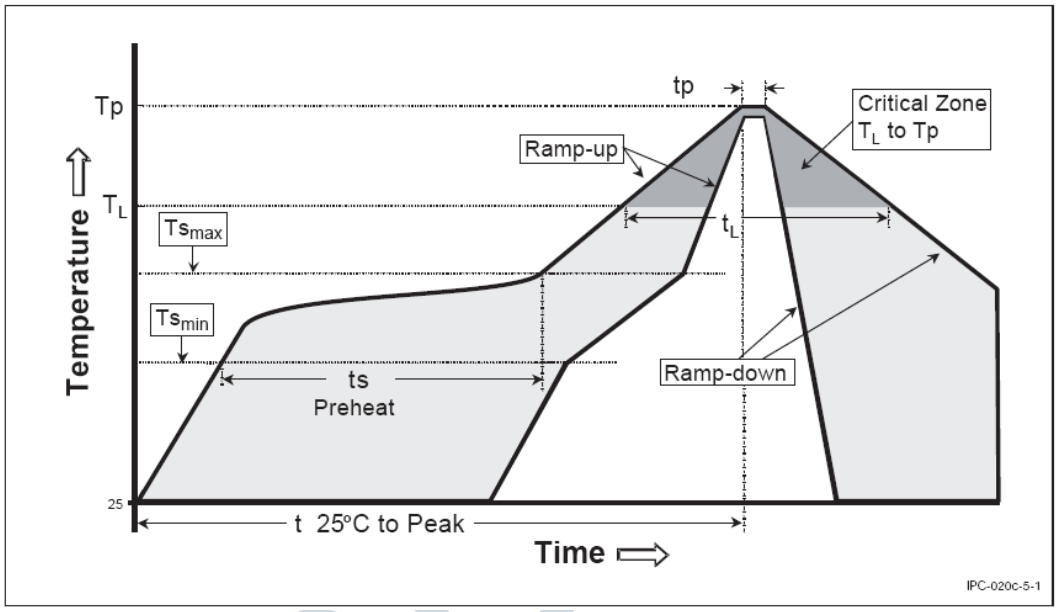
The data above is also available as EAGLE library.

3.7 Soldering information

STM 300 has to be soldered according to IPC/JEDEC J-STD-020C standard.

Profile Feature	Pb-Free Assembly
Average Ramp-Up Rate (Ts_{max} to Tp)	3° C/second max.
Preheat – Temperature Min (Ts_{min}) – Temperature Max (Ts_{max}) – Time (ts_{min} to ts_{max})	 150 °C 200 °C 60-180 seconds
Time maintained above: – Temperature (T_L) – Time (t_L)	 217 °C 60-150 seconds
Peak/Classification Temperature (Tp)	260 °C
Time within 5 °C of actual Peak Temperature (tp)	20-40 seconds
Ramp-Down Rate	6 °C/second max.
Time 25 °C to Peak Temperature	8 minutes max.

Note 1: All temperatures refer to topside of the package, measured on the package body surface.

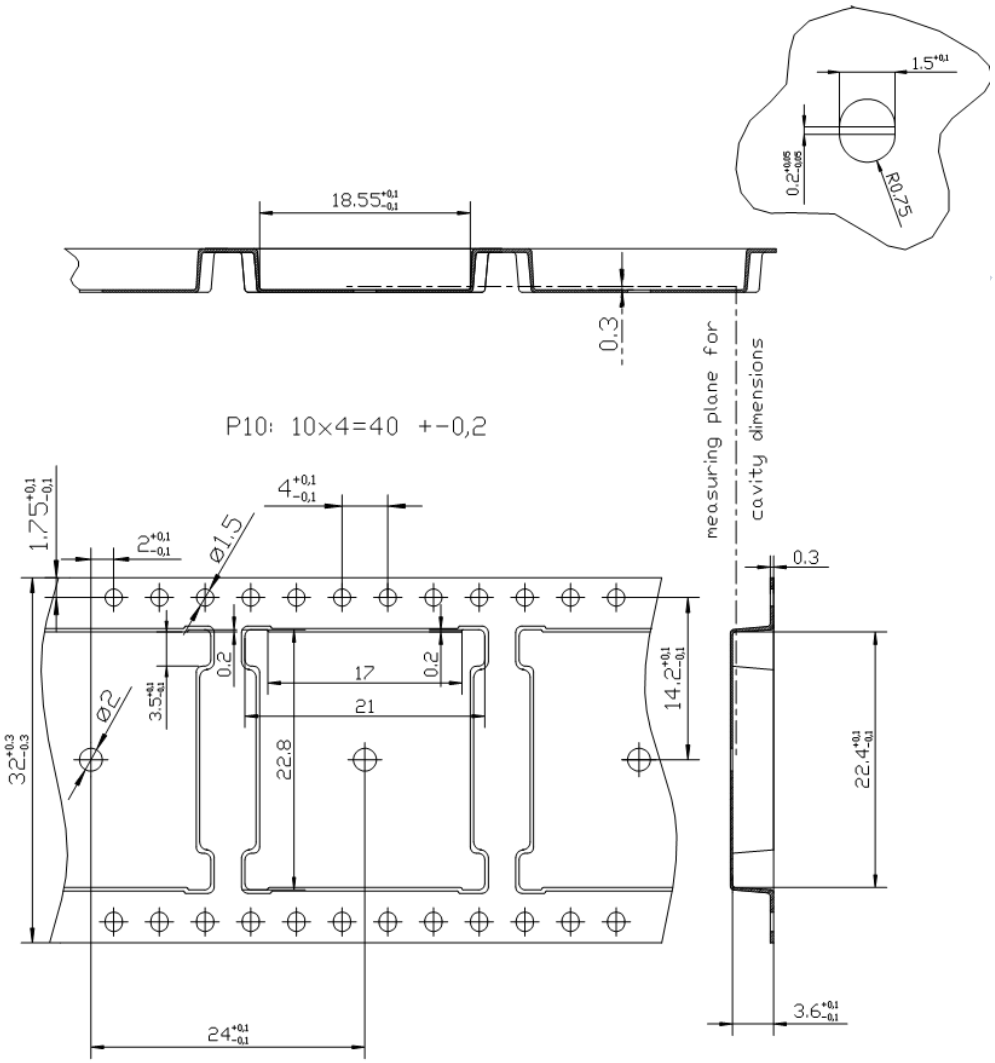


STM 300 shall be handled according to Moisture Sensitivity Level MSL4 which means a floor time of 72 h. STM 300 may be soldered only once, since one time is already consumed at production of the module itself.

Once the dry pack bag is opened, the desired quantity of units should be removed and the bag resealed within two hours. If the bag is left open longer than 30 minutes the desiccant should be replaced with dry desiccant. If devices have exceeded the specified floor life time of 72 h, they may be baked according IPC/JEDEC J-STD-033B.
Devices packaged in moisture-proof packaging should be stored in ambient conditions not exceeding temperatures of 40 °C or humidity levels of 90% r.h.

STM 300 modules have to be soldered within 6 months after delivery!

3.8 Tape & Reel specification



3.9 Transmission range

The main factors that influence the system transmission range are type and location of the antennas of the receiver and the transmitter, type of terrain and degree of obstruction of the link path, sources of interference affecting the receiver, and "Dead" spots caused by signal reflections from nearby conductive objects. Since the expected transmission range strongly depends on this system conditions, range tests should categorically be performed before notification of a particular range that will be attainable by a certain application.

The following figures for expected transmission range are considered by using a PTM, a STM or a TCM radio transmitter device and the TCM radio receiver device with preinstalled whip antenna and may be used as a rough guide only:

- Line-of-sight connections: Typically 30 m range in corridors, up to 100 m in halls
- Plasterboard walls / dry wood: Typically 30 m range, through max. 5 walls
- Line-of-sight connections: Typically 30 m range in corridors, up to 100 m in halls
- Ferroconcrete walls / ceilings: Typically 10 m range, through max. 1 ceiling
- Fire-safety walls, elevator shafts, staircases and supply areas should be considered as screening.

The angle at which the transmitted signal hits the wall is very important. The effective wall thickness – and with it the signal attenuation – varies according to this angle. Signals should be transmitted as directly as possible through the wall. Wall niches should be avoided. Other factors restricting transmission range:

- Switch mounted on metal surfaces (up to 30% loss of transmission range)
- Hollow lightweight walls filled with insulating wool on metal foil
- False ceilings with panels of metal or carbon fiber
- Lead glass or glass with metal coating, steel furniture

The distance between EnOcean receivers and other transmitting devices such as computers, audio and video equipment that also emit high-frequency signals should be at least 0.5 m

A summarized application note to determine the transmission range within buildings is available as download from www.enocean.com.

4 AGENCY CERTIFICATIONS (after release for series production)

The modules have been tested to fulfil the approval requirements for CE (STM 300) and FCC/IC (STM 300C) based on the built-in firmware.

When developing customer specific firmware based on the API for this module, special care must be taken not to exceed the specified regulatory limits, e.g. the duty cycle limitations!

4.1 CE Approval

The STM 300 module bears the EC conformity marking CE and conforms to the R&TTE EU-directive on radio equipment. The assembly conforms to the European and national requirements of electromagnetic compatibility. The conformity has been proven and the according documentation has been deposited at EnOcean. The modules can be operated without notification and free of charge in the area of the European Union and in Switzerland.

- EnOcean RF modules must not be modified or used outside their specification limits.
- EnOcean RF modules may only be used to transfer digital or digitized data. Analog speech and/or music are not permitted.
- EnOcean RF modules must not be used with gain antennas, since this may result in allowed ERP or spurious emission levels being exceeded.
- The final product incorporating EnOcean RF modules must itself meet the essential requirement of the R&TTE Directive and a CE marking must be affixed on the final product and on the sales packaging each. Operating instructions containing a Declaration of Conformity has to be attached.
- If the STM 300 transmitter is used according to the regulations of the 868.3 MHz band, a so-called "Duty Cycle" of 1% per hour must not be exceeded. Permanent transmitters such as radio earphones are not allowed.
- The module must be used with only the following approved antenna(s).

Type	Parameter	Value
Wire/Monopole at RF_WHIP	Maximum gain	1.0 dBi
External antenna at RF_50	Antenna type	Passive
	Impedance	~50 Ohm
	Maximum gain	≤ 8 dBd

4.2 FCC (United States) certification

STM 300C LIMITED MODULAR APPROVAL

This is an RF module approved for Limited Modular use operating as an intentional transmitting device with respect to 47 CFR 15.231(a-c) and is limited to OEM installation. The module is optimized to operate using small amounts of harvested energy, such as can be collected by a small solar cell exposed to ambient light. The module transmits short radio packets comprised of control signals, (in some cases the control signal may be accompanied with data) such as those used with alarm systems, door openers, remote switches, and the like. The module does not support continuous streaming of voice, video, or any other forms of streaming data; it sends only short packets containing control signals and possibly data and is typically powered by a solar cell in ambient light. The module is designed to comply with, has been tested according to 15.231(a-c), and has been found to comply with each requirement. Thus, a finished device containing the STM 300C radio module can be operated in the United States without additional Part 15 FCC approval (approval(s) for unintentional radiators may be required for the OEM's finished product), under EnOcean's FCC ID number. This greatly simplifies and shortens the design cycle and development costs for OEM integrators.

The module can be triggered manually or automatically, which cases are described below.

Manual Activation
The radio module can be configured to transmit a short packetized control signal if triggered manually. The module can be triggered, by pressing a switch, for example. The packet contains one (or more) control signals that is(are) intended to control something at the receiving end. The packet may also contain data. Depending on how much energy is available from the energy source, subsequent manual triggers can initiate the transmission of additional control signals. This may be necessary if prior packet(s) was (were) lost to fading or interference. Subsequent triggers can also be initiated as a precaution if any doubt exists that the first packet didn't arrive at the receiver. Each packet that is transmitted, regardless of whether it was the first one or a subsequent one, will only be transmitted if enough energy is available from the energy source.

Automatic Activation
The radio module also can be configured to transmit a short packetized control signal if triggered automatically, by a relevant change of its inputs, for example. Again, the packet contains a control signal that is intended to control something at the receiving end and may also contain data. As above, it is possible for the packet to get lost and never reach the receiver. However, if enough energy is available from the energy source, and the module has been configured to do so, then another packet or packets containing the control signal may be transmitted at a later, unpredictable time.

The device is capable to operate as a repeater, which can receive signals from the following list of FCC/IC approved transmitters, and retransmit the signals.

PTM 200C	FCC ID:SZV-PTM200C	IC:5713A-PTM200C
STM 110C	FCC ID:SZV-STM110C	IC:5713A-STM110C
TCM 200C	FCC ID:SZV-TCM2XXC	IC:5713A-TCM2XXC
TCM 220C	FCC ID:SZV-TCM2XXC	IC:5713A-TCM2XXC
TCM 300C	FCC ID:SZV-STM300C	IC:5713A-STM300C
STM 300C	FCC ID:SZV-STM300C	IC:5713A-STM300C
TCM 320C	FCC ID:SZV-TCM320C	IC:5713A-TCM320C

OEM Requirements

In order to use EnOcean's FCC ID number, the OEM must ensure that the following conditions are met.

- End users of products, which contain the module, must not have the ability to alter the firmware that governs the operation of the module. The agency grant is valid only when the module is incorporated into a final product by OEM integrators.
- The end-user must not be provided with instructions to remove, adjust or install the module.
- The Original Equipment Manufacturer (OEM) must ensure that FCC labeling requirements are met. This includes a clearly visible label on the outside of the final product. Attaching a label to a removable portion of the final product, such as a battery cover, is not permitted. The label must include the following text:

  Contains FCC ID: SZV-STM 300C
  The enclosed device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (i.) this device may not cause harmful interference and (ii.) this device must accept any interference received, including interference that may cause undesired operation.
- The user manual for the end product must also contain the text given above.
- Changes or modifications not expressly approved by EnOcean could void the user's authority to operate the equipment.
- The OEM must ensure that timing requirements according to 47 CFR 15.231(a-c) are met.
- The OEM must sign the OEM Limited Modular Approval Agreement with EnOcean
- The module must be used with only the following approved antenna(s).

Part Number	Type	Gain
N.A.	Wire/Monopole	1.0 dBi

4.3 IC (Industry Canada) certification

In order to use EnOcean's IC number, the OEM must ensure that the following conditions are met:

- Labeling requirements for Industry Canada are similar to those required by the FCC. The Original Equipment Manufacturer (OEM) must ensure that IC labeling requirements are met. A clearly visible label on the outside of a non-removable part of the final product must include the following text:

  Contains IC: 5713A-STM 300C
- The OEM must sign the OEM Limited Modular Approval Agreement with EnOcean

USER MANUAL V0.90

Transceiver Module
TCM 300 / TCM 300C
TCM 320 / TCM 320C

February 26, 2010

Observe precautions! Electrostatic sensitive devices!

Patent protected:
WO98/36395, DE 100 25 561, DE 101 50 128,
WO 2004/051591, DE 103 01 678 A1, DE 10309334,
WO 04/109236, WO 05/096482, WO 02/095707,
US 6,747,573, US 7,019,241

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REVISION HISTORY

The following major modifications and improvements have been made to the first version of this document:

No	Major Changes
0.6	Chapter 4 modified, Drawing in 1.3 corrected; Chapter 3.6 added.
0.7	Chapter 3.8 added; Operating temperature range limited to -25 °C/+85 °C; RX sensitivity reduced to -94 dBm; Layout recommendation in 3.5 modified; Change in 2.2.: Do not connect pins marked as n.c.; Maximum Ratings (non-operating) modified in 2.3; Maximum Ratings (operating) added in 2.4
0.75	Section 2.2.1 updated; output currents reduced in 2.2
0.8	Receive current increased to typ. 33 mA; Section 3.5 modified; recommended foot pattern added in 3.6.1;new drawings in 1.3; section 2.7 Repeater Configuration added; section 2.10 Smart Acknowledge added; section 3.8 Tape&Reel spec. added; RX sensitivity reduced to -93dBm; section 3.10 added
0.9	Max. ripple at VDD reduced to 50 mVpp; Connect external 1 kΩ pull-down to RESET and PROG_EN; Supply voltage range modified: starting at 2.6V; section 3.11 added

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Important!

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The modules must not be used in any relation with equipment that supports, directly or indirectly, human health or life or with applications that can result in danger for people, animals or real value.
Components of the modules are considered and should be disposed of as hazardous waste. Local government regulations are to be observed.
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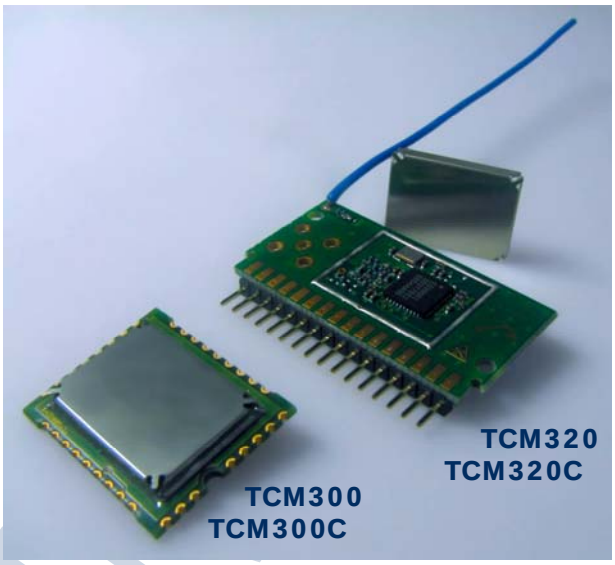
1 GENERAL DESCRIPTION

1.1 Basic functionality

The transceiver modules TCM 300 / 300C and TCM 320 / 320C enable the realization of highly efficient RF repeaters and transceivers for the EnOcean 868 MHz and 315 MHz radio systems.

The module provides several built-in operating modes. In addition repeater functionality (1 or 2 level) can be activated. Using the Dolphin API library it is possible to write custom software for the module. All module variants are in-system programmable.



Built-in operating modes

- Unidirectional serial communication
- Bidirectional serial communication
- 1-channel relay mode
- 4-channel relay mode
- 1-channel dimming mode

Product variants

- TCM 300/300C: SMD mountable module for use with external antenna (868/315 MHz)
- TCM 320/320C: Variant for vertical mounting with pin connector. Whip antenna. (868/315 MHz). TCM 320C is backward compatible to TCM 220C

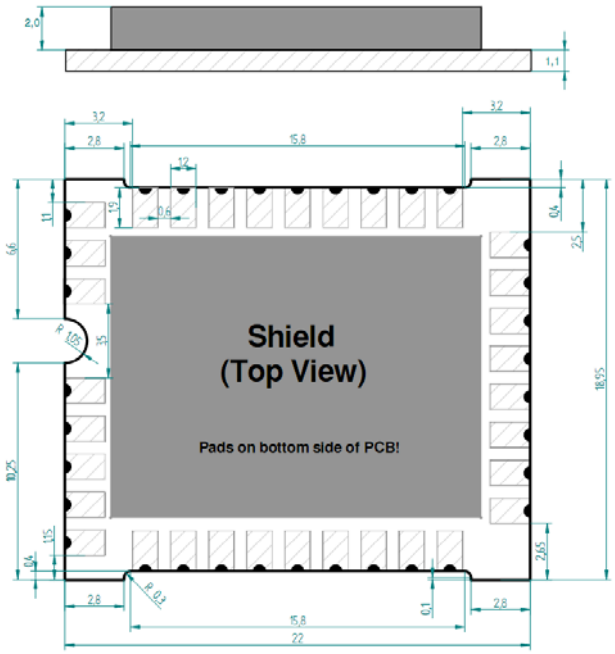
Features accessible via API:

- Integrated 16 MHz 8051 CPU with 32 KB FLASH and 2 kB SRAM
- Various power down and sleep modes down to 0.2 µA current consumption (TCM 320/TCM 320C limited to 1.4 mA current consumption!)
- Up to 14 configurable I/Os
- 10 bit ADC, 8 bit DAC

1.2 Technical data

Antenna	Pre-installed 8.6 cm/15 cm whip antenna (TCM 320/TCM 320C) External whip or 50 Ω antenna mountable (TCM 300/TCM 300C)
Frequency	315.0 MHz (TCM 3X0C)/868.3 MHz (TCM 3X0)
Radio Standard	EnOcean 868 MHz/315 MHz
Data rate / Modulation type	125 kbps/ASK
Receiver Sensitivity (at 25°C)	typ. –93 dBm
Conducted Output Power	typ. 5 dBm
Power Supply	2.6 V–3.3 V (TCM 320/320C), 2.6 V–4.5 V (TCM 300/300C)
Current Consumption	Receive mode: typ. 33 mA, max. 43 mA (RX) Transmit mode: typ. 24 mA, max. 33 mA (TX)
Radio Regulations	R&TTE EN 300 220 (TCM 300/TCM 320) FCC CFR-47 Part 15 (TCM 300C/TCM 320C)

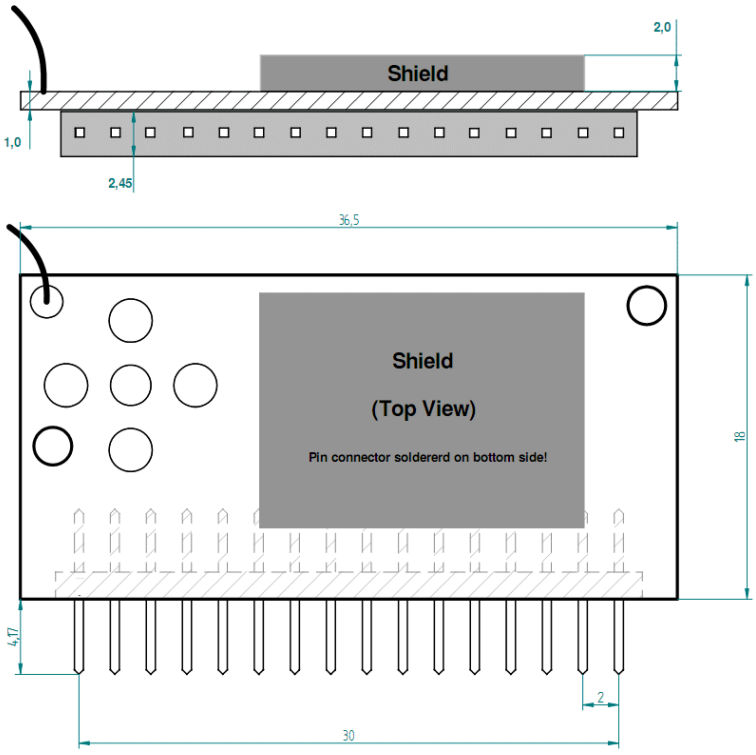
1.3 Physical dimensions



Unless otherwise specified dimensions are in mm.

Tolerances:
PCB outline dimensions ±0.2 mm
All other tolerances ±0.1 mm

TCM 300 / TCM 300C (pads on bottom side of PCB!)



Unless otherwise specified dimensions are in mm.

Tolerances:
PCB outline dimensions ±0.2 mm
All other tolerances ±0.1 mm

TCM 320 / TCM 320C

PCB dimensions	TCM 320/TCM 320C (without pin connector): 36.5 x 19 x 5.5 mm TCM 300/TCM 300C: 22 x 19 x 3.1 mm
Pin connector	16 pins, grid 2.0 mm (4.0 mm in length, ☐ 0.5 mm)

1.4 Environmental conditions

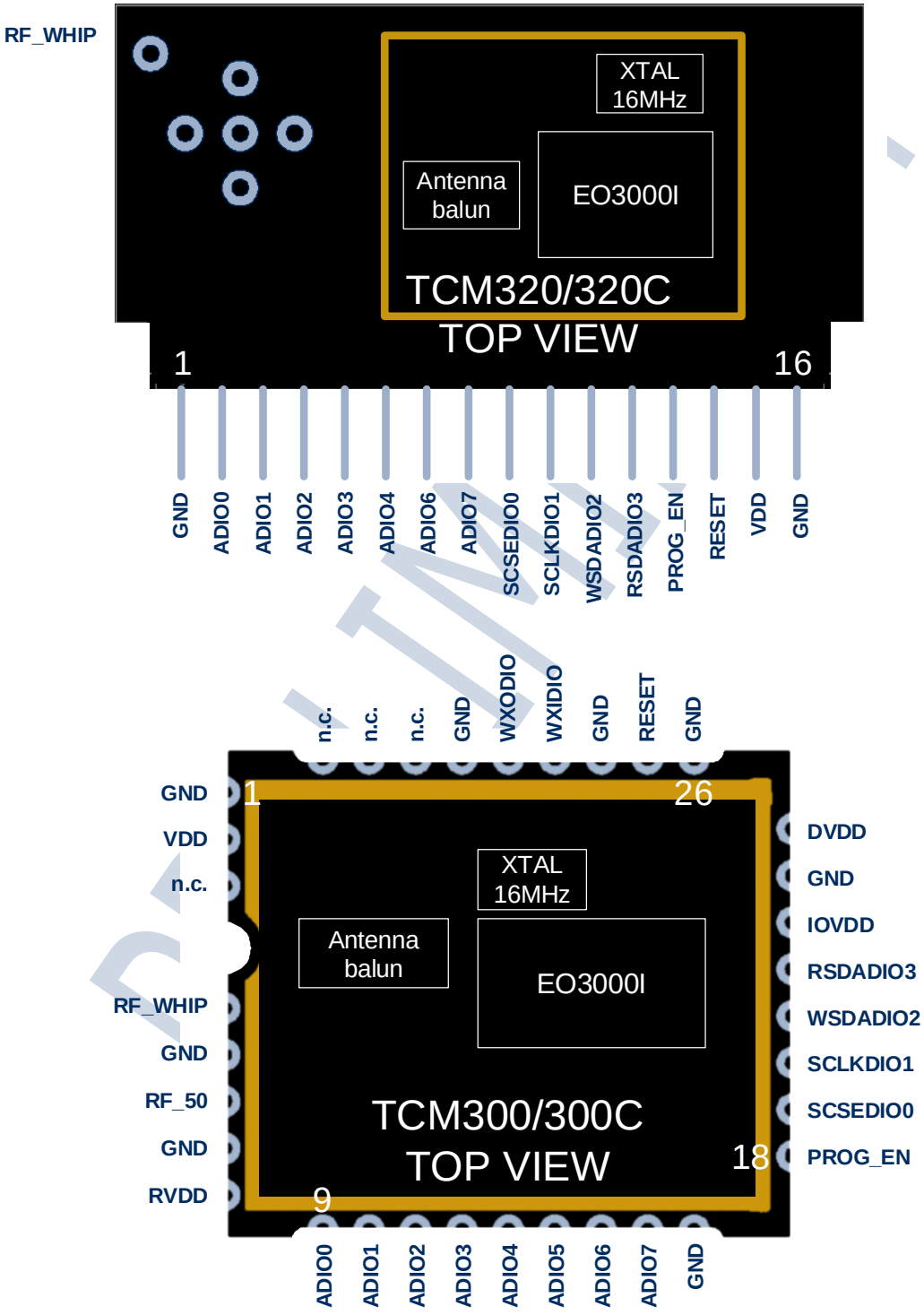
Operating temperature	-25 °C … +85 °C
Storage temperature	-40 °C … +85 °C
Storage temperature in tape & reel package	-20 °C … +50 °C
Humidity	0% … 93% r.H., non-condensing

1.5 Ordering information

Type	Ordering Code	Frequency
TCM 300	S3003-K300	868.3 MHz
TCM 320	S3003-K320	868.3 MHz
TCM 300C	S3033-K300	315.0 MHz
TCM 320C	S3033-K320	315.0 MHz

2 FUNCTIONAL DESCRIPTION

2.1 Pin out



2.2 Pin description and operational characteristics

Symbol	Function	Characteristics
GND	Ground connection	Must be connected to GND
VDD	Supply voltage	TCM 300/300C: 2.6 V – 4.5 V TCM 320/320C: 2.6 V – 3.3 V Max. ripple: see 2.4
RVDD	RF supply voltage regulator output	1.8 V Output current: ■ max. 100 µA with built-in firmware (RX on) ■ max. 10 mA while not in RX/TX mode
DVDD	Digital supply voltage regulator output	1.8 V Output current: max. 5 mA
IOVDD	Digital interface supply voltage	TCM 320/320C: internally connected to VDD TCM 300/300C: Must be connected to desired interface supply between 1.8 V and 3.3 V See also 2.2.1.
RESET	Reset input Programming I/F	Active high reset (1.8 V). External 1 kΩ pull-down required.
PROG_EN	Programming I/F	HIGH: programming mode active LOW: operating mode Digital input, external 1 kΩ pull-down required.
ADIO0	MODE_SEL	Analog input: At start-up input voltage is measured and mode is selected. See chapter 0
ADIO1	MODE 0: not used	In mode 0 the repeater level is 1 and cannot be modified.
	MODE 1-4: REP_LEVEL	Mode 1-4: At start-up the repeater level is selected: Repeater level 1: LOW Repeater level 2: HIGH Digital input, internal pull-up active
ADIO2	REPEATER	At start-up the repeater can be switched on: Repeater on: LOW Repeater off: HIGH Digital input, internal pull-up active
ADIO3	MODE 0: Sensitivity	Low sensitivity: LOW High sensitivity: HIGH Digital input, internal pull-up active
	MODE 1-4: LRN	Enter/leave teach-in mode. See chapter 2.8 Digital input, internal pull-up active
ADIO4	MODE 0: not used	Internal pull-up active
	MODE 1-4: CLR	Clear ID memory. See chapter 2.8 Digital input, internal pull-up active
ADIO5	Not used	Digital output, internally set to LOW
ADIO6	MODE 0-1: SER_RX	UART input
	MODE 2-4: not used	Digital input, internal pull-up active

ADIO7	MODE 0-1: SER_TX	UART output Max. output current: 2 mA @ IOVDD=3.3 V 0.65 mA @ IOVDD=1.8 V
	MODE 2-3: CHANNEL0	Digital output channel 0 Max. output current: 2 mA @ IOVDD=3.3 V 0.65 mA @ IOVDD=1.8 V
	MODE 4: not used	Digital output, internally set to LOW
	Programming I/F	
SCSEDIO0	MODE 0, 2: not used	Digital output, internally set to LOW
	MODE 1: LRN_TOGGLE	Digital output Max. output current: 2 mA @ IOVDD=3.3 V 0.65 mA @ IOVDD=1.8 V
	MODE 3: CHANNEL1	Digital output channel 1 Max. output current: 2 mA @ IOVDD=3.3 V 0.65 mA @ IOVDD=1.8 V
	MODE 4: PWM	Dimmer output, 50 kHz
	Programming I/F	
SCLKDIO1	MODE 0-2: not used	Digital output, internally set to LOW
	MODE 3: CHANNEL2	Digital output channel 2 Max. output current: 2 mA @ IOVDD=3.3 V 0.65 mA @ IOVDD=1.8 V
	MODE 4: PWM_IND	Indicating if PWM is active. Digital output. Max. output current: 2 mA @ IOVDD=3.3 V 0.65 mA @ IOVDD=1.8 V
	Programming I/F	
WSDADIO2	MODE 0-2, 4: not used	Digital output, internally set to LOW
	MODE 3: CHANNEL3	Digital output channel 3 Max. output current: 2 mA @ IOVDD=3.3 V 0.65 mA @ IOVDD=1.8 V
	Programming I/F	
RSDADIO3	MODE 0: RMI	Normal operation: Digital output, internally set to LOW Remote Management: ACTION command indicator (see 2.9.1) Max. output current: 2 mA @ IOVDD=3.3 V 0.65 mA @ IOVDD=1.8 V
	MODE 1-4: LMI	Normal operation: Learn mode indicator Remote Management: ACTION command indicator (see 2.9.1) Digital output

		Max. output current: 2 mA @ IOVDD=3.3 V 0.65 mA @ IOVDD=1.8 V
	Programming I/F	
WXIDIO	Not used	Digital output, internally set to LOW
WXODIO	Not used	Digital output, internally set to LOW
RF_WHIP	RF output	Output for whip antenna
RF_50	RF output	50 Ohm output for external antenna
n.c.	Not connected	Do not connect!

2.2.1 Interface supply voltage - IOVDD

For digital communication with other circuitry (peripherals) the digital I/O configured pins of the mixed signal sensor interface (ADIO0 to ADIO7) and the pins of the serial interface (SCSEDIO0, SCLKDIO1, WSDADIO2, RSDADIO3) may be operated from supply voltages different from DVDD. Therefore an interface voltage supply pin IOVDD is available which can be connected either to DVDD or to an external supply within the tolerated voltage range of IOVDD.

If DVDD=0 V (e.g. in any sleepmode) and IOVDD is supplied, there may be unpredictable and varying current from IOVDD caused by internal floating nodes. It must be taken care that the current into IOVDD does not exceed 10 mA while DVDD=0.
If DVDD=0 V and IOVDD is not supplied, do not apply voltage to any above mentioned pin. This may lead to unpredictable malfunction of the device.

In TCM 320/TCM 320C VDD is internally connected to IOVDD! Therefore the above mentioned issues have to be considered when writing own firmware based on API.

IOVDD voltage must not exceed VDD voltage! A malfunction of the module may be caused by such inverse supply!

For I/O pins configured as analog pins the IOVDD voltage level is not relevant!

2.3 Absolute maximum ratings (non operating)

Symbol	Parameter	Min	Max	Units
VDD	Supply voltage at VDD TCM 300 TCM 320 (limitation due to internal VDD-IOVDD connection)	 -0.5 -0.5	 5.5 3.6	 V V
IOVDD	Supply voltage for mixed signal sensor interface and serial interface pins	-0.5	3.6	V
GND	Ground connection	0	0	V
VINA	Voltage at every analog input pin	-0.5	2	V
VIND1	Voltage at RESET, and every digital input pin except WXI-DIO/WXODIO	-0.5	3.6	V
VIND2	Voltage at WXIDIO / WXODIO input pin	-0.5	2	V

2.4 Maximum ratings (operating)

Symbol	Parameter	Min	Max	Units
VDD	Supply voltage at VDD TCM 300 TCM 320	 2.6 2.6	 4.5 3.6	 V V
IOVDD	Digital interface supply voltage (see also 2.2.1)	1.7	MIN (3.6; VDD)	V
GND	Ground connection	0	0	V
VINA	Voltage at every analog input pin	0	2.0	V
VIND1	Voltage at RESET, and every digital input pin except WXIDIO / WXODIO	0	3.6	V
VIND2	Voltage at WXIDIO / WXODIO input pin	0	2.0	V
VDDR	Max. ripple at VDD		50	mVpp

2.5 Operating modes

Mode	Function	Output signal description	No. of channels
0	Unidirectional serial interface compatible with TCM 220C, no teach-in capability	SER_TX: UART output, supplies standard data blocks of information from all received EnOcean radio telegrams (9600 bps; 8 data bits, no parity bit, one start bit, one stop bit). For further information see chapter A.1	
1	Bidirectional serial interface, teach-in capability for up to 30 entries[1]	SER_RX, SER_TX: Asynchronous bidirectional Interface, supplies standard data blocks of information from all received EnOcean radio telegrams (9600 bps; 8 data bits, no parity bit, one start bit, one stop bit). For further information see chapter A.1 LRN_TOGGLE: Learning mode status indicator	
2	Rocker Switch - 1 channel, teach-in capability for up to 30 entries[1]	Supplies the desired logic switching state "on/off" at CHANNEL0 when pushing the switch rockers	1
3	Rocker Switch - 4 channels, teach-in capability for up to 30 entries[2]	Same as Mode 2 but operation of 4 receiver channels (CHANNEL0, CHANNEL1, CHANNEL2, CHANNEL3)	4
4	Dimming - 1 channel, teach-in capability for up to 30 entries[1]	PWM is the PWM output ■ I-button pressed for shorter than 0.5 s: ON (Restore duty cycle stored before last switch-off). ■ O-button pressed for shorter than 0.5 s: OFF ■ O-/I-button pressed longer than 0.5 s: Duty cycle variation from 10% up to 100% (O=less, I=more). Duty cycle variation stops when button is released. PWM_IND is active as long as duty cycle is not 0%	1
5	Reserved		

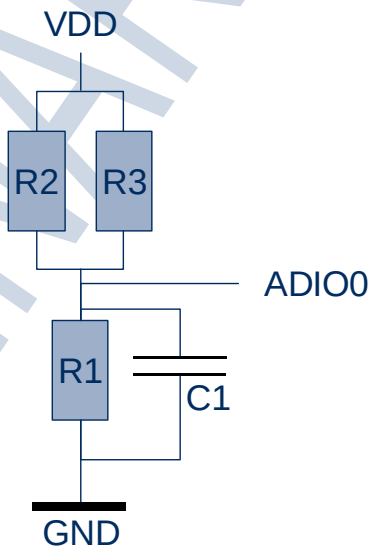
[1] Each rocker of a PTM transmitter is counted as 1 entry
[2] Each rocker is counted as 1 entry. If the same rocker is teached into several channels, 1 entry per channel is needed.

2.6 Mode selection

The operating mode is defined at start-up of the module via a measurement of the voltage at ADIO0.

As long as IDs are stored in ID memory, the operating mode can only be changed after deleting all IDs from memory, e.g. via CLR!

Mode	ADIO0 (MODE_SEL) input voltage range	Proposed component values
0	0% to 3.99% VDD	R1: 0 Ohm R2: leave open R3: leave open C1: leave open
1	4% to 11.99% VDD	R1: 1k2 ±1% R2: 15k ±1% R3: 150k ±1% C1: 100p
2	12% to 19.99% VDD	R1: 2k2 ±1% R2: 12k ±1% R3: 270k ±1% C1: 100p
3	20% to 27.99% VDD	R1: 3k9 ±1% R2: 15k ±1% R3: 68k ±1% C1: 100p
4	28% to 35.99% VDD	R1: 4k7 ±1% R2: 12k ±1% R3: 56k ±1% C1: 100p
5	36% to 39.99% VDD	R1: 5k6 ±1% R2: 10k ±1% R3: 56k ±1% C1: 100p



2.7 Repeater configuration

TCM 3x0 provides the option to activate a one or two-level repeater for EnOcean radio telegrams.
1-level repeater: If a received telegram is a valid and original (not yet repeated), the telegram is repeated after a random delay.

2-level repeater: If a received telegram is valid and original or repeated once, the telegram is repeated after a random delay.

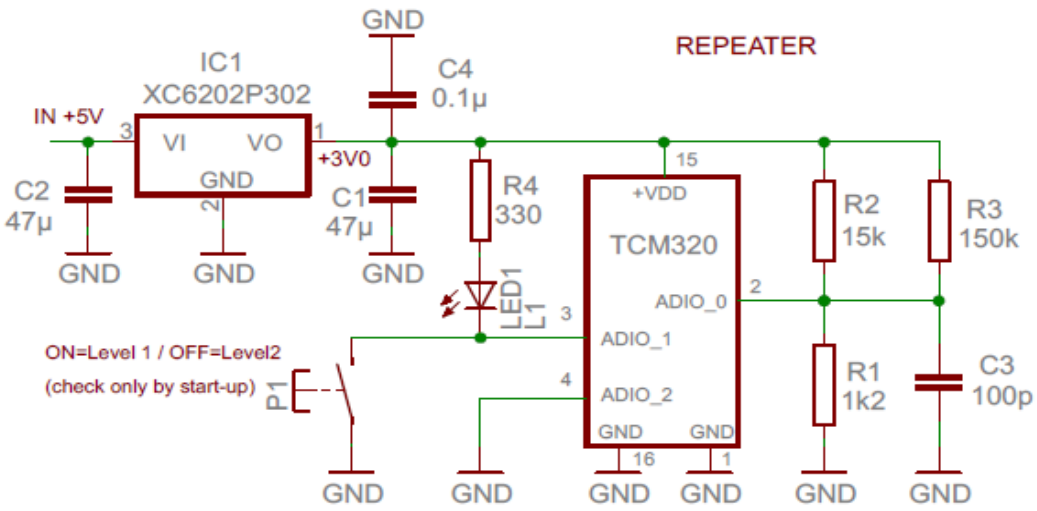
2-level repeating function should only be activated if really needed! Otherwise the system function can be compromised by collisions of telegrams.
The repeated telegram is marked as "repeated" by an increased repeater counter.

Setting the repeater level:

At start-up of the module repeater on/off and repeater level are determined.
Please refer to the table in 2.2 regarding the configuration options.

Please note that in Mode 0 2-level repeating is not possible (for backward compatibility to TCM 220C)!

The figure below shows an example circuit for a repeater.



2.8 Teach-in procedure

Modes 1 to 4 support teach-in of transmitters.

Please make sure not to remove supply voltage while in LRN mode! The flash content could get corrupted!

2.8.1 Setting the receiver to learning mode

- **Via CLR Pin (ADIO4):** Contact to GND longer than t = 2 seconds. Learning Mode LRN is entered after clearing ID memory.
- **Via LRN Pin (ADIO3):** Contact to GND longer than t = 0.5 seconds. In multi-channel receiver mode, the pin has to be contacted several times until the desired channel number is selected (the number of channels is given by the selected operating mode).
- **Via Remote Config Control**: Please refer to documentation of remote management.

2.8.2 Confirmation of Learning Mode

Mode	Confirmation
0	No Learn capability
1	LMI HIGH continuously, LRN_TOGGLE toggling every 1 s.
2	LMI HIGH continuously, CHANNEL0 toggling every 1 s.
3	LMI HIGH continuously, current CHANNELx toggling every 1 s.
4	LMI HIGH continuously, DIM IND HIGH, and PWM toggling every 1 s between 10% and 100%
5	Reserved for future use

2.8.3 Teaching in a transmitter

In learning mode LRN, the sensitivity of the module is limited to in-room operations and learning of repeater powered signals is disabled (to avoid unintentional learning). Therefore ensure that the associated radio transmitter will be in a distance less than 5 m to the receiver (not necessary within Remote Learn Mode).

Trigger the telegram of the associated radio transmitter within 30 seconds:

- Operate the switch radio transmitter (RPS or HRC) at least once (press I-button or O-button of the rocker that is to be assigned to the selected receiver channel). If the same rocker is operated again within 4 seconds it will still be learned. If the same rocker is operated again after more than 4 seconds it will be deleted again. Please note that teach-in without rocker information is not possible" Please note that scene switches (HRC and last 3 ID bits 0B111) cannot be teach-in!

- Or activate the sensor radio transmitter (1BS, 4BS) least once with active LRN bit (DI_3=0, please refer to "Standardization EnOcean Communication Profiles"). If the same transmitter is operated again after more than 4 seconds with active LRN bit it will be deleted again.

Please note that in modes 2, 3, and 4 only RPS or HRC telegrams can be learned!

2.8.4 Confirmation of correct learning / deletion

The output which is toggling every second while in teach-in mode (see above) will stay switched high for 4 seconds to signal that a transmitter has been learned. In case a transmitter ID has been deleted it will stay 4 seconds low.

2.8.5 Learning of further transmitters

After confirmation, the receiver changes again to readiness for learning. Further transmitters can be learned immediately. If available the next receiver channel can be entered by connecting the LRN pin to GND longer than t = 0.5 seconds. A maximum of 30 radio transmitters can be learned (further attempts will be ignored; instead of learning confirmation, operating mode is entered). Each rocker of a radio transmitter is counted as one transmitter.

2.8.6 Selecting the next channel

By fresh contacting of the LRN pin to GND the next remaining channel is selected. In one-channel mode or after the last channel, the operating mode is entered again.

2.8.7 Leaving learning mode

LRN mode is left in either one of the following events:

- Output of last available channel is toggling and a fresh contacting of the LRN pin to GND for 0.5 seconds is performed
- No ID has been added/deleted during the last 30 seconds.
- Memory was full and another ID was sent to be learnt

2.8.8 Deleting a transmitter

Deletion of one specific transmitter: Use the same procedure as learning the associated transmitter.

As transmitter delete confirmation, the corresponding function outputs remain in inactive state for 4 seconds while LMI keeps active. After that, a wrongly deleted transmitter can be learned again immediately.

In order to delete a PTM transmitter the same rocker as during learn has to be operated. If several rockers of a PTM transmitter have been learned, all have to be deleted separately.

Deletion of all learned transmitters: Connect the CLR pin longer than 2 seconds to GND

All learned transmitters on all channels are deleted at the same time. After this, the receiver enters Learning Mode.

2.9 Remote management

TCM 300 supports the remote management specification which is available from EnOcean upon request. This allows controlling the teach-in procedure via a Remote Config Control device.

2.9.1 Remote Management Control Commands (RMCC)

All RMCCs supported.

Mode	Reaction to ACTION COMMAND (Function code 0x005)
0	RMI HIGH for 1 s.
1	LMI HIGH, and LRN_TOGGLE on for 1 s.
2	LMI HIGH, and CHANNEL0 invert for 1 s.
3	LMI HIGH, and all CHANNELx inverted for 1 s.
4	LMI HIGH, DIM IND inverted, and PWM inverted for 1 s.
5	Reserved for future use

2.9.2 Remote Procedure Calls (RPC)

Supported RPCs:
- Remote learn command, function code 0x201
- Smart ACK: Read mailbox settings, function code 0x205, settings type 0x01
- Smart ACK: Delete mailbox, function code 0x206, operation type 0x02

REMOTE LEARN COMMAND:
EEP: 0x000000

Mode	Flag in command	Reaction
0	n.a.	No reaction, no Learn Mode available
1	0x01 0x03	Start Remote Learn Mode Stop Remote Learn Mode
2	0x01 0x03	Start Remote Learn Mode Stop Remote Learn Mode
3	0x01 0x02 0x03	Start Remote Learn Mode Next channel Stop Remote Learn Mode
4	0x01 0x03	Start Remote Learn Mode Stop Remote Learn Mode
5	n.a.	No reaction, reserved for future use

The signalling is the same as described above in 2.8.
Differences between remote learn mode and normal learn mode:
- In remote learn mode also repeated telegrams will be accepted
- 3 transmissions within 2 seconds are required, instead of 1 transmission

For detailed information on remote management please refer to the Remote Management system specification.

2.10 Smart Acknowledge

TCM 3x0 provides a post master function with 15 mail boxes for systems using EnOcean smart acknowledge technology. This functionality is switched on in all operating modes. For detailed information on smart acknowledge please refer to the Smart Acknowledge system specification.

When teaching-in a device using Smart Acknowledge please take care to switch off all TCM3xy devices which are not continuously powered. Otherwise these TCM3xy modules could be declared postmaster. As soon as the power supply is switched off a postmaster would be missing and Smart Acknowledge would not work any longer!

2.11 Transmit timing

The setup of the transmission timing allows avoiding possible collisions with data packages of other EnOcean transmitters as well as disturbances from the environment. With each transmission cycle, 3 identical subtelegrams are transmitted within 40 ms. The transmission of a subtelegram lasts approximately 1.2 ms. The delay between the three transmission bursts is affected at random.

3 APPLICATIONS INFORMATION

3.1 Transmission range

The main factors that influence the system transmission range are type and location of the antennas of the receiver and the transmitter, type of terrain and degree of obstruction of the link path, sources of interference affecting the receiver, and "dead" spots caused by signal reflections from nearby conductive objects. Since the expected transmission range strongly depends on this system conditions, range tests should categorically be performed before notification of a particular range that will be attainable by a certain application.

The following figures for expected transmission range are considered by using a PTM, a STM or a TCM radio transmitter device and the TCM radio receiver device with preinstalled whip antenna and may be used as a rough guide only:

- Line-of-sight connections: Typically 30 m range in corridors, up to 100 m in halls
- Plasterboard walls / dry wood: Typically 30 m range, through max. 5 walls
- Line-of-sight connections: Typically 30 m range in corridors, up to 100 m in halls
- Ferro concrete walls / ceilings: Typically 10 m range, through max. 1 ceiling
- Fire-safety walls, elevator shafts, staircases and supply areas should be considered as screening.

The angle at which the transmitted signal hits the wall is very important. The effective wall thickness – and with it the signal attenuation – varies according to this angle. Signals should be transmitted as directly as possible through the wall. Wall niches should be avoided. Other factors restricting transmission range:

- Switch mounted on metal surfaces (up to 30% loss of transmission range)
- Hollow lightweight walls filled with insulating wool on metal foil
- False ceilings with panels of metal or carbon fibre
- Lead glass or glass with metal coating, steel furniture

The distance between EnOcean receivers and other transmitting devices such as computers, audio and video equipment that also emit high-frequency signals should be at least 0.5 m

A summarized application note to determine the transmission range within buildings is available as download from www.enocean.com.

3.2 Antenna options TCM 300 / TCM 300C

3.2.1 Overview

Several antenna types have been investigated by EnOcean. They all have advantages and disadvantages as shown in the following table.

Advantages	Disadvantages
Whip Antenna (15 cm @ 315 MHz, 8.6 cm @ 868 MHz)	
Cheap	Automatic placement difficult
Omnidirectional	Bending influences performance
	Large size
Chip Antenna (AMD1103-ST01 @ 315 MHz / 868 MHz)	
Omnidirectional	Expensive
Small size	Very sensitive to environment (GND plane, components), minimum distance space to other components needed
Automatic placement possible	
Splatch Antenna (ANT-315-SP1 @ 315 MHz, ANT-868-SP1 @ 868 MHz)	
Omnidirectional	Expensive
Not very sensitive to environment, low distance space to other components required	Large size
Automatic placement possible	
Helical Antenna (ANT-315-HE @ 315 MHz)	
Omnidirectional	Large distance space to other components required
Cheap	Large size (3D)
	Through hole component, no SMT

868 MHz modules used in Europe do not need additional approval if the external antenna fulfils the following requirements:

Antenna type	Passive	Mandatory for radio approval
Frequency band	868MHz ISM	Antenna must be suited for this band
Impedance	~50 Ohm	Mandatory for radio approval
Maximum gain	≤ 8 dBd	Mandatory for radio approval
VSWR	≤ 1.5:1	Important for compatibility with EnOcean protocol
Return Loss	> 14 dB	Important for compatibility with EnOcean protocol
Bandwidth	≤ 20 MHz	Important if 10 V/m EMI robustness required for device

For 315 MHz modules (STM 300C and TCM 3X0C) please note that a full approval is needed if modules are used with antennas other than the specified whip antenna.

3.2.2 Whip antenna

315 MHz

Antenna: 150 mm wire, connect to RF_WHIP

Minimum GND plane: 50 mm x 50 mm
Minimum distance space: 10 mm

868 MHz

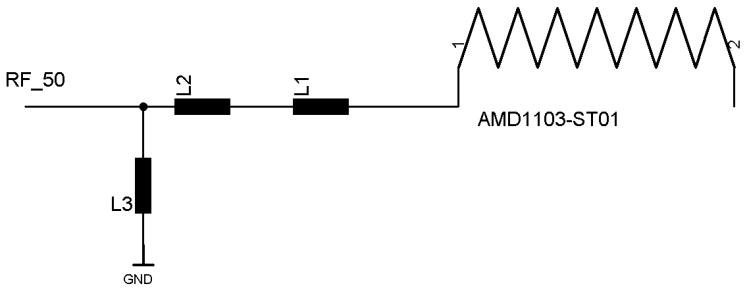
Antenna: 86 mm wire, connect to RF_WHIP

Minimum GND plane: 38 mm x 18 mm
Minimum distance space: 10 mm

3.2.3 Chip antenna

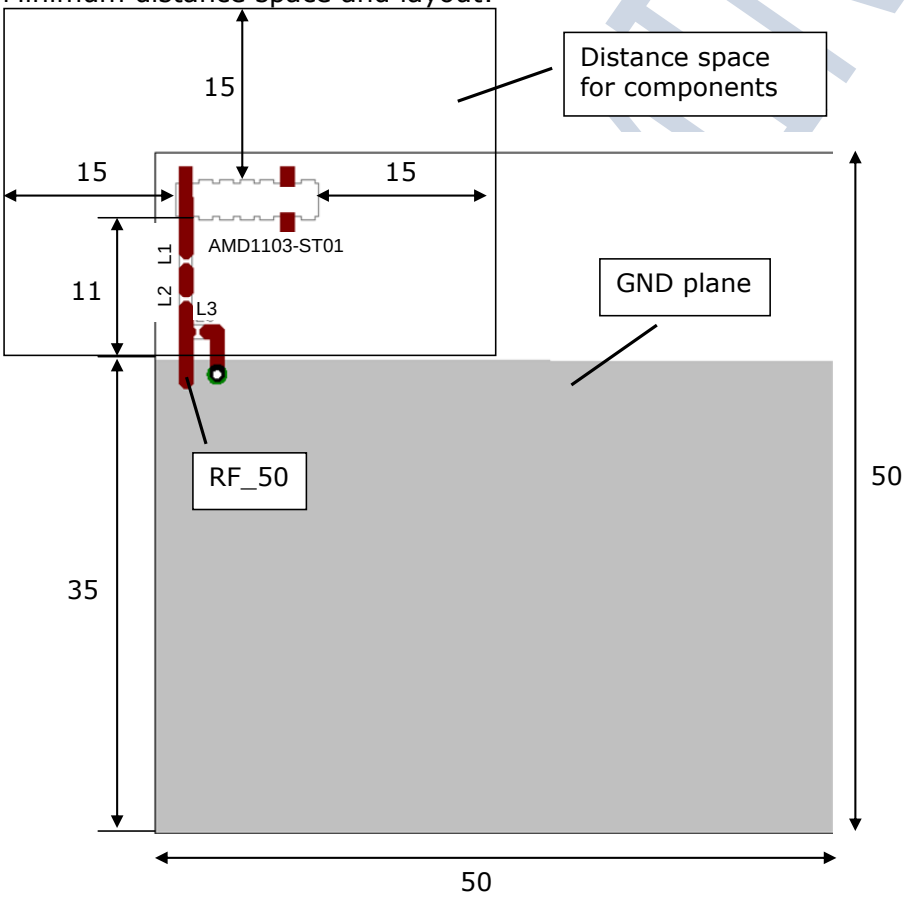
315 MHz

Antenna: AMD1103-ST01
Manufacturer: Mitsubishi
Matching circuit:



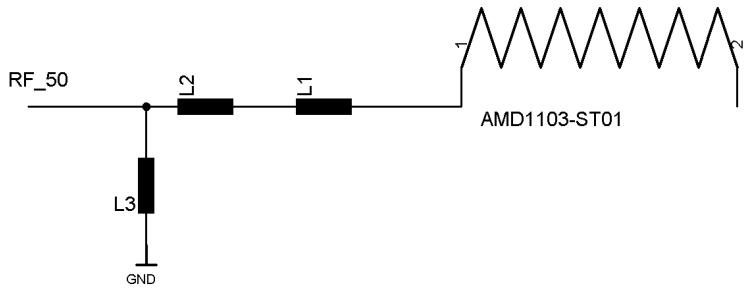
L1=47 nH
L2=390 nH
L3 optional for additional optimization

Minimum distance space and layout:



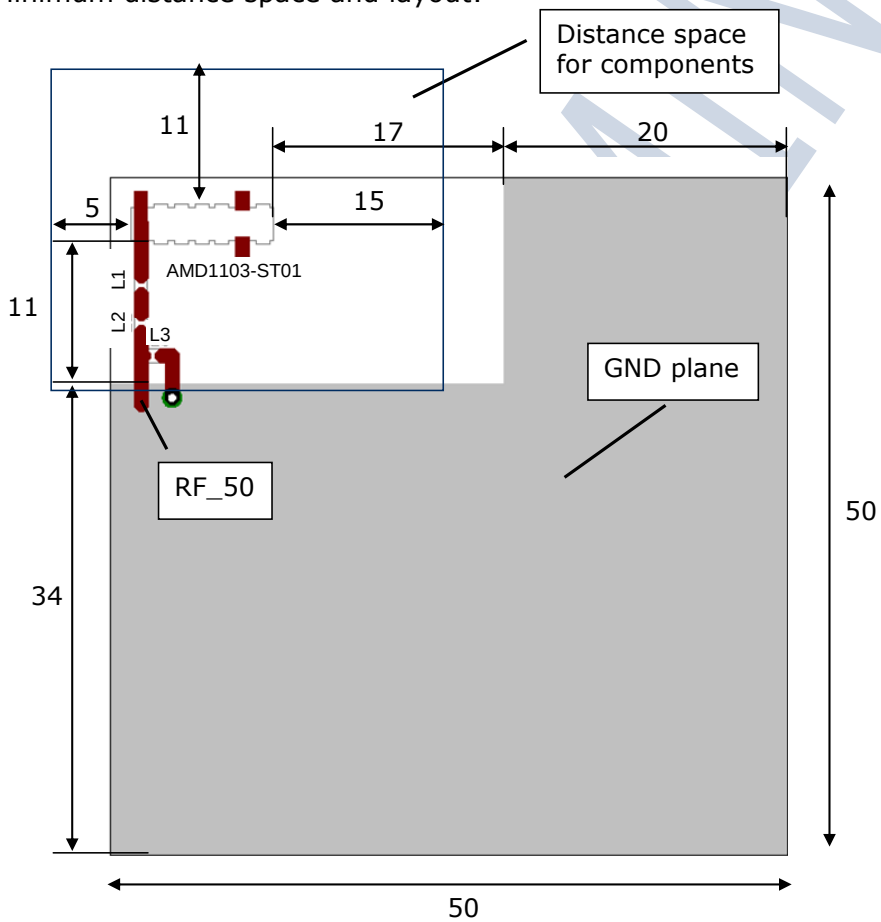
Minimum distance space above and below PCB: 11 mm

868 MHz
Antenna: AMD1103-ST01
Manufacturer: Mitsubishi
Matching circuit:



L1=6,8 nH
L2=39 nH
L3=8,2 nH

Minimum distance space and layout:



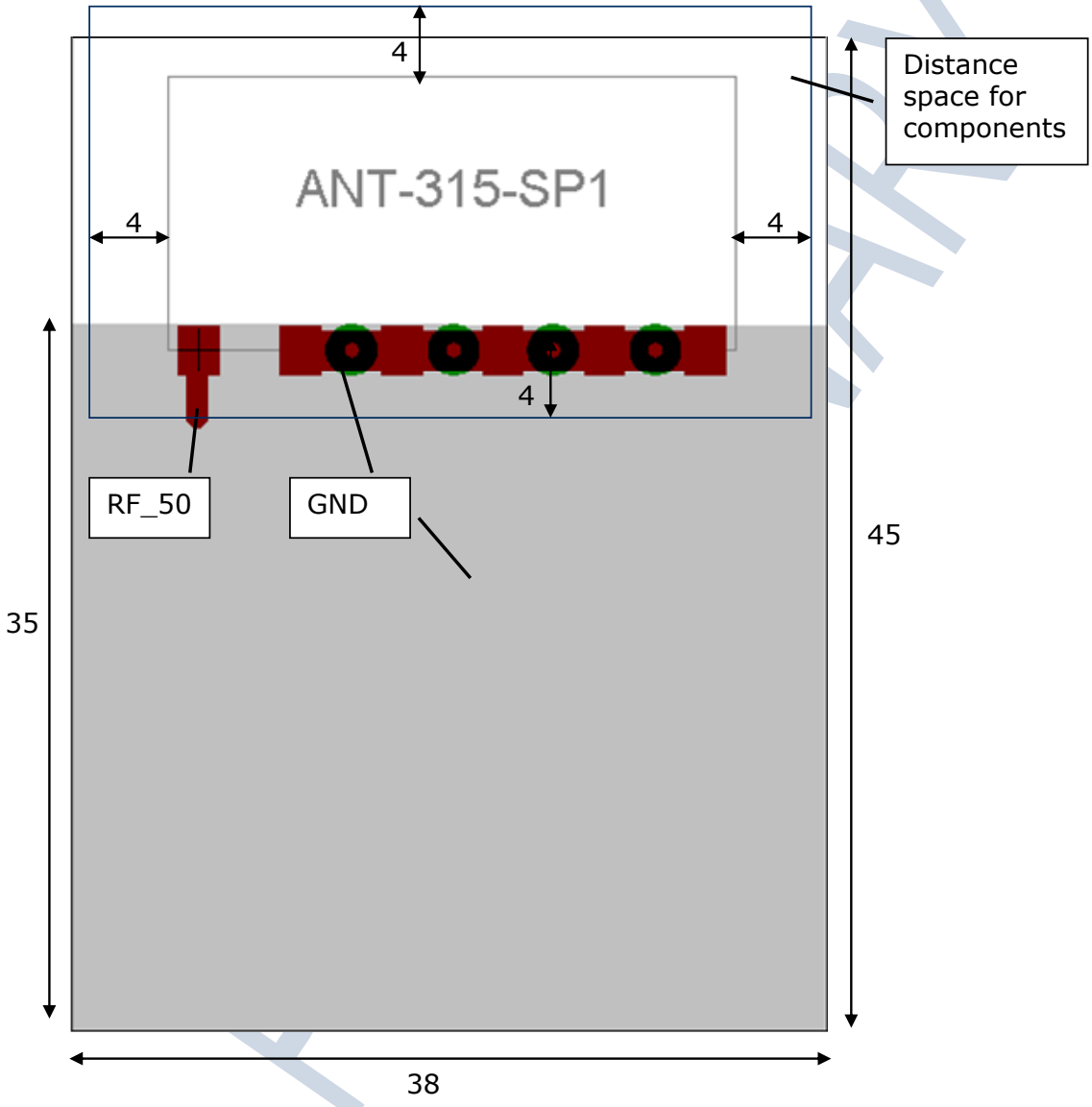
Minimum distance space above and below PCB: 11 mm

3.2.4 Splatch antenna

315/868 MHz

Antenna: ANT-315-SP
Manufacturer: Linx Technologies / Antenna Factor
Matching circuit: Not needed

Minimum distance space and layout:

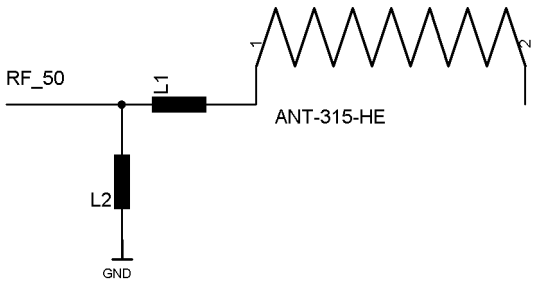


Minimum distance space above and below PCB: 12 mm

3.2.5 Helical antenna

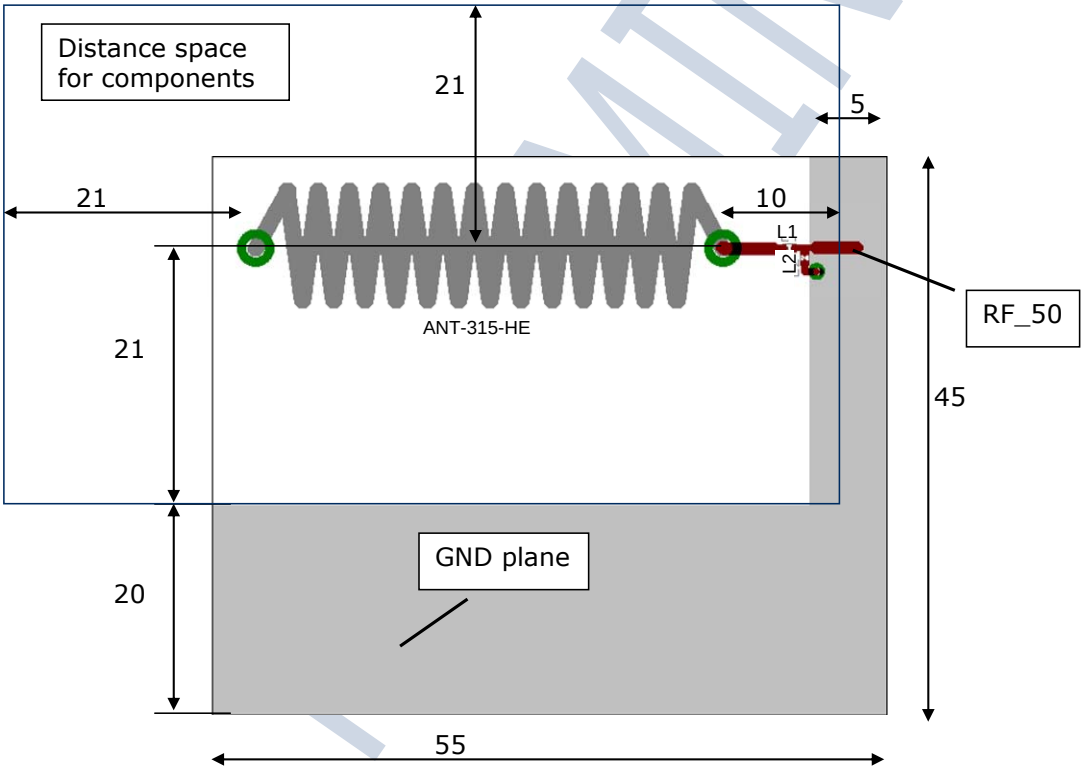
315 MHz

Antenna: ANT-315-HE
Manufacturer: Linx Technologies / Antenna Factor
Matching circuit:



L1=5,1 nH
L2=18 nH

Minimum distance space and layout:



Minimum distance above and below axis of antenna: 21 mm

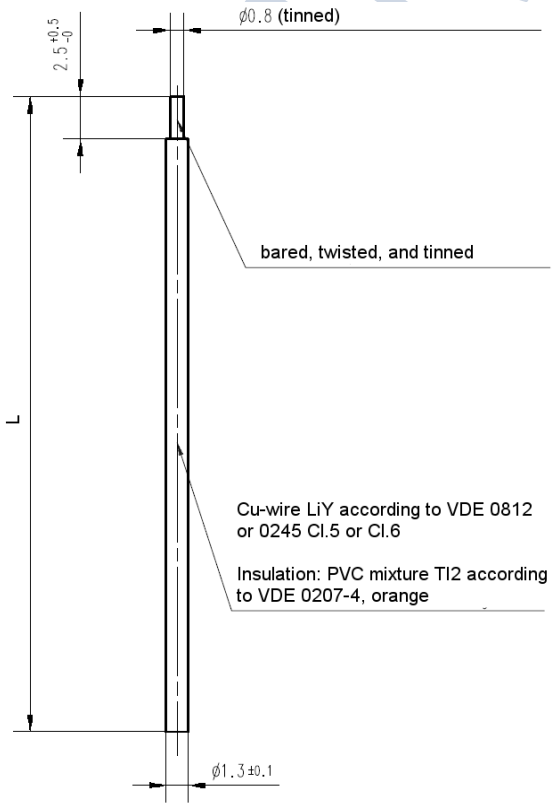
3.3 Antenna options TCM 320 / 320C

Positioning and choice of receiver and transmitter antennas are the most important factors in determining system transmission range.

3.3.1 Mounting the whip antenna

For good receiver performance, great care must be taken about the space immediately around the antenna since this has a strong influence on screening and detuning the antenna. The antenna should be drawn out as far as possible and must never be cut off. Mainly the far end of the wire should be mounted as far away as possible (at least 15 mm) from all metal parts, ground planes, PCB strip lines and fast logic components (e.g. microprocessors).
Do not roll up or twist the whip antenna!

Radio frequency hash from the motherboard desensitizes the receiver. Therefore:
- PCB strip lines on the user board should be designed as short as possible
- A PCB ground plane layer with sufficient ground vias is strongly recommended
- See also section 3.5 for power supply requirements. Problems may especially occur with switching power supplies!



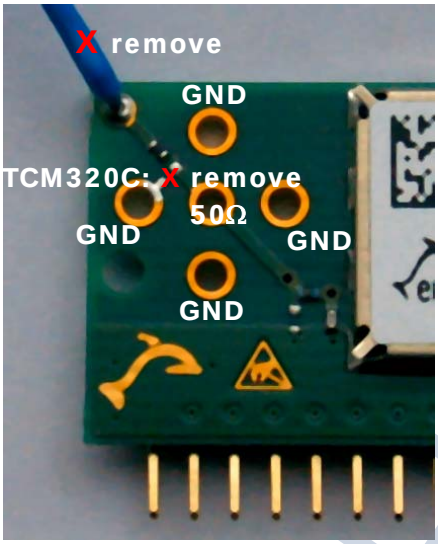
Specification of the TCM whip antenna; L=150 mm @ 315 MHz, L=86 mm @ 868 MHz

Isolation material may brake at temperatures below -15 °C.
Please take care to fix the antenna cable in case vibrations are expected.

3.3.2 Mounting 50 Ω antennas

For mounting the receiver at bad RF locations (e.g. within a metal cabinet), an external 50 Ω antenna may be connected. The whip antenna must be removed in this case!

TCM 320 provides soldering pads for an SMA connector, e.g. from Tyco Electronics:



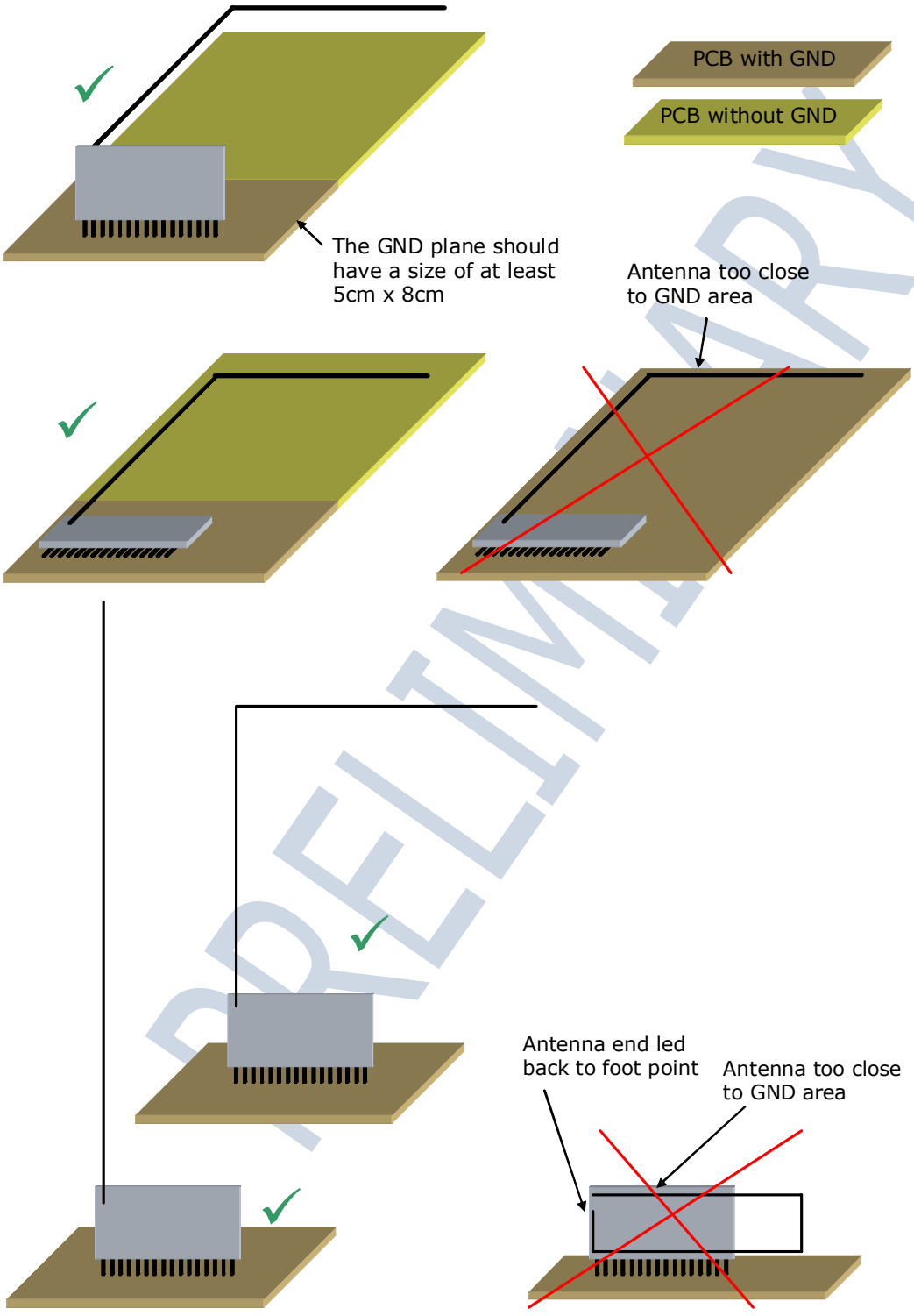
Modification procedure:

- TCM320: Remove whip antenna and mount SMA connector
- TCM320C: Remove whip antenna and 12pF capacitor (see figure above). Then mount SMA connector

For 315 MHz modules (TCM 300C and TCM 320C) please note that a full approval is needed if modules are used with external antennas other than the pre-installed whip antenna.

When using the SMA connector pads please make sure no mechanical forces are exerted on the 16-pin connector! It is recommended to use a strain relief for that purpose.

3.4 Recommendations for laying a whip antenna



3.5 Power supply requirements

In order to provide a good radio performance, great attention must be paid to the power supply and a correct layout and shielding. It is recommended to place a 22 µF ceramic capacitor between VDD and GND close to the module (material: X5R, X7R, min 6.3 V to avoid derating effects). In addition a 470 nH coil shall be inserted (Murata LQW18A, 0603) in the power supply line.

It is recommended to keep the ripple on the power supply rail below 10 mVpp (see 2.4).

3.6 Layout recommendations

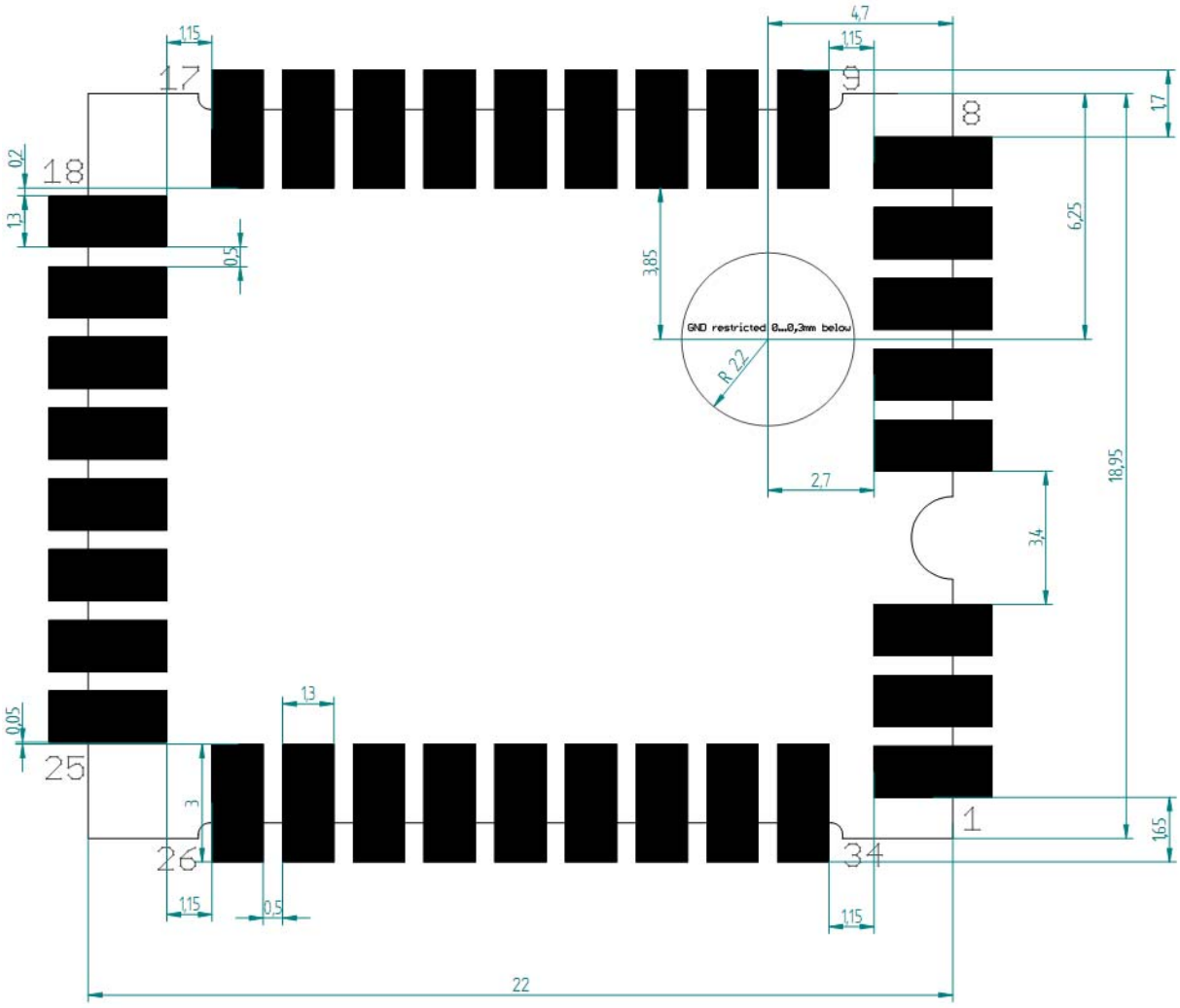
The length of lines connected to I/Os should not exceed 5cm.

It is recommended to have a complete GND layer, at least below the module and directly connected components.

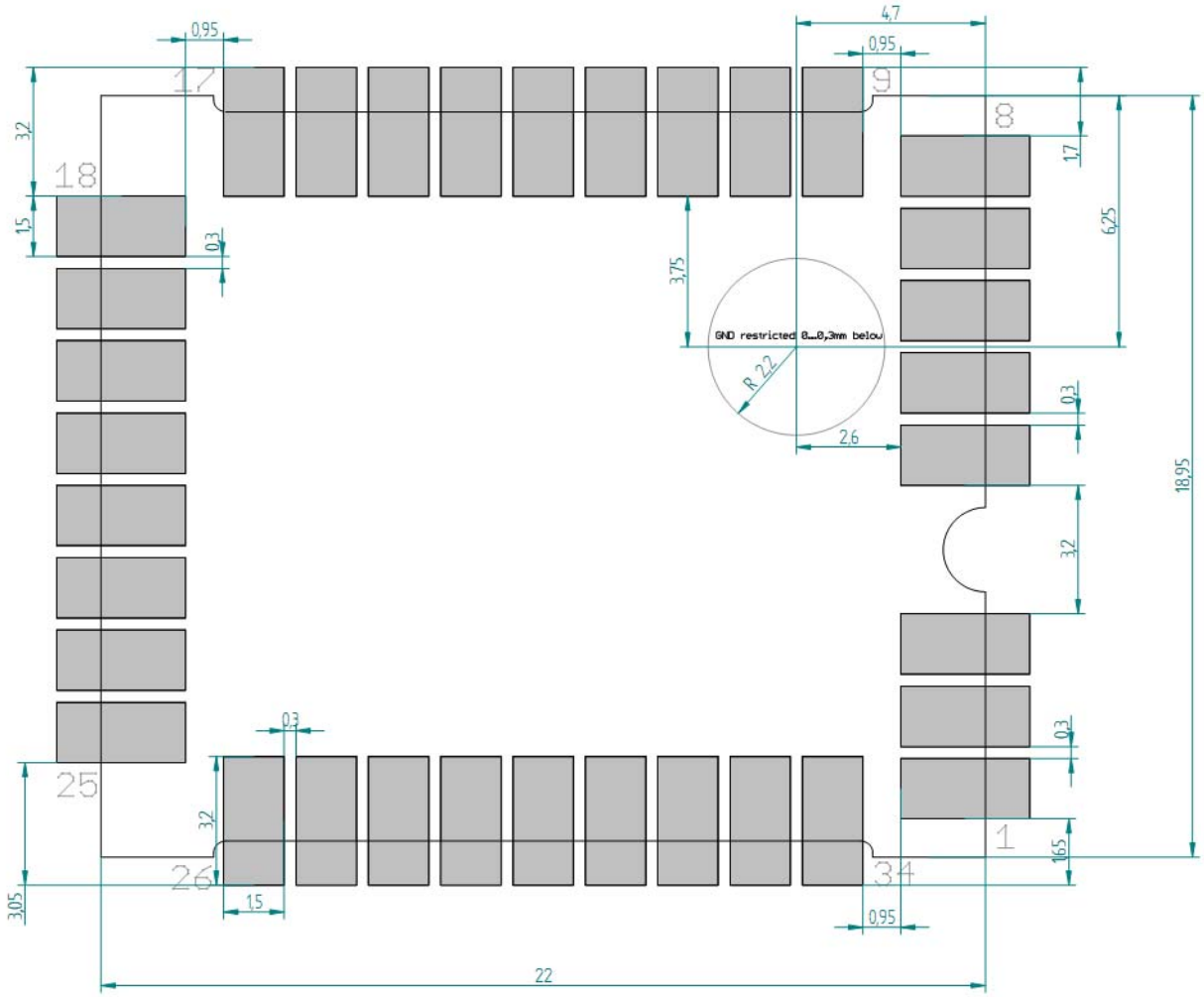
The RVDD line should be kept as short as possible. Please consider recommendations in section 3.10.

3.6.1 TCM 300/300C recommended foot pattern

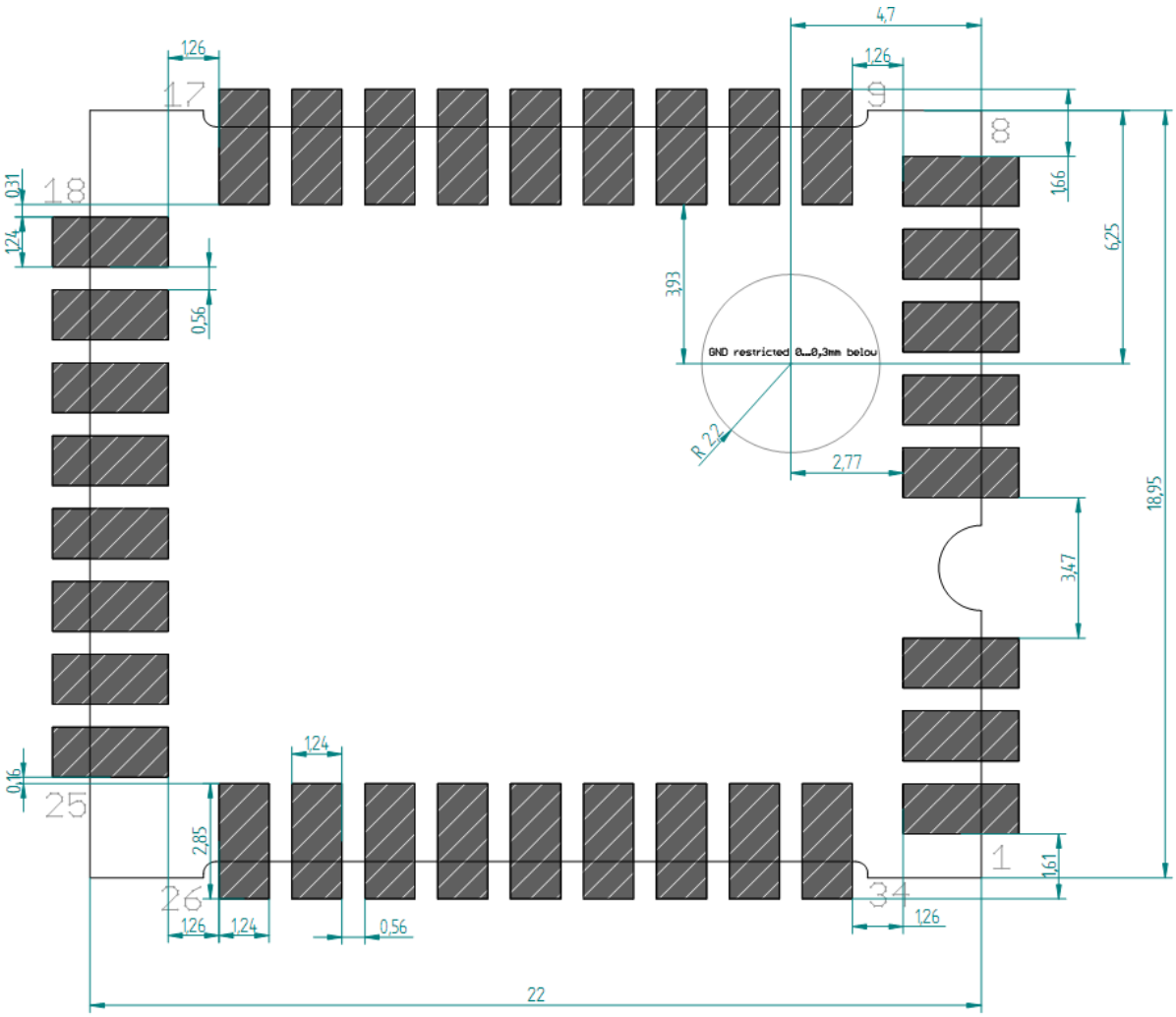
Top layer



Solder resist top layer



Solder paste top layer



The data above is also available as EAGLE library.

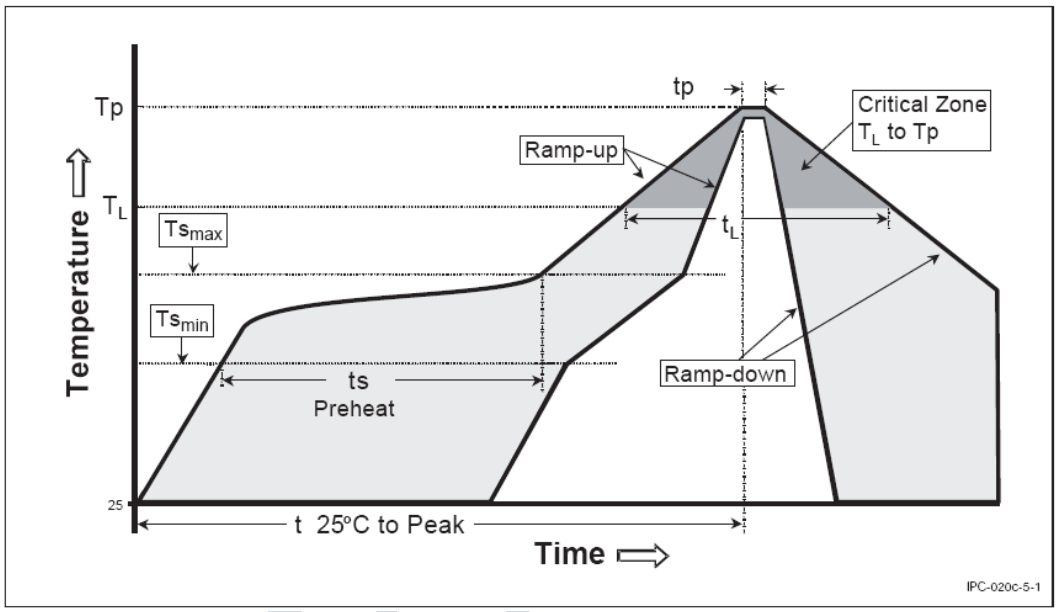
3.7 Soldering information

3.7.1 TCM 300 / TCM 300C

TCM 300 has to be soldered according to IPC/JEDEC J-STD-020C standard.

Profile Feature	Pb-Free Assembly
Average Ramp-Up Rate (Ts_{max} to Tp)	3° C/second max.
Preheat – Temperature Min (Ts_{min}) – Temperature Max (Ts_{max}) – Time (ts_{min} to ts_{max})	 150 °C 200 °C 60-180 seconds
Time maintained above: – Temperature (T_L) – Time (t_L)	 217 °C 60-150 seconds
Peak/Classification Temperature (Tp)	260 °C
Time within 5 °C of actual Peak Temperature (tp)	20-40 seconds
Ramp-Down Rate	6 °C/second max.
Time 25 °C to Peak Temperature	8 minutes max.

Note 1: All temperatures refer to topside of the package, measured on the package body surface.



TCM 300 shall be handled according to Moisture Sensitivity Level MSL4 which means a floor time of 72 h. TCM 300 may be soldered only once, since one time is already consumed at production of the module itself.

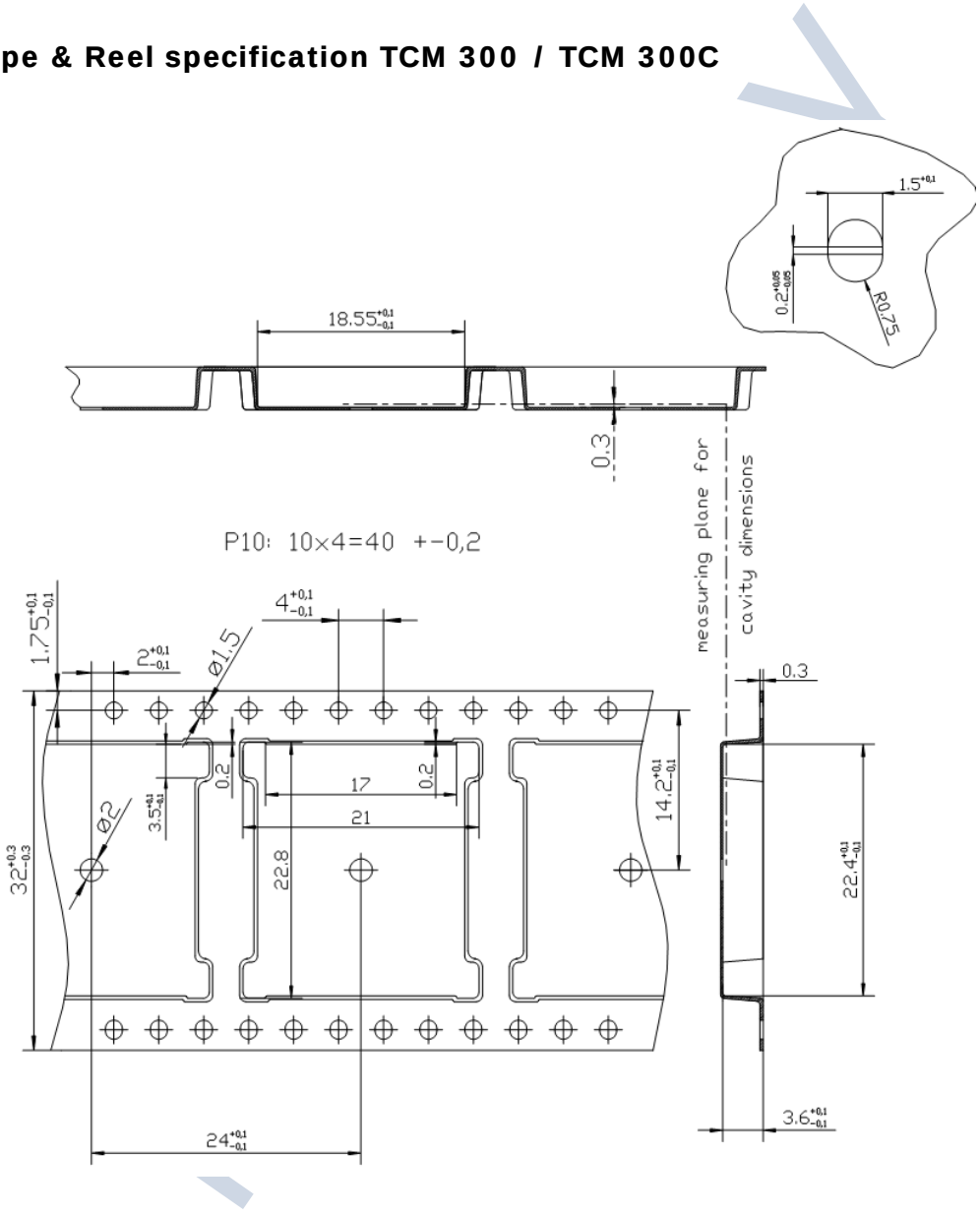
Once the dry pack bag is opened, the desired quantity of units should be removed and the bag resealed within two hours. If the bag is left open longer than 30 minutes the desiccant should be replaced with dry desiccant. If devices have exceeded the specified floor life time of 72 h, they may be baked according IPC/JEDEC J-STD-033B.
Devices packaged in moisture-proof packaging should be stored in ambient conditions not exceeding temperatures of 40 °C or humidity levels of 90% r.H.

TCM 300 modules have to be soldered within 6 months after delivery!

3.7.2 TCM 320 / TCM 320C

The EO3000I chip inside the module is a moisture sensitive device. In case of wave soldering the modules should be baked in advance.

3.8 Tape & Reel specification TCM 300 / TCM 300C



3.9 Backward compatibility to TCM 220C

In Mode 0 TCM 320C is backward compatible to its predecessor TCM 220C.

There are a few minor restrictions of compatibility which are listed here:

Parameter	TCM 220C	TCM 320C
Maximum current consumption	34 mA	43 mA
Maximum output current of outputs	25 mA	2 mA (external driver transistor may be needed)
Thickness of module	4.6 mm	5.5 mm
Maximum voltage rating at pin7 (TCM 320C: ADIO6; TCM 220C: IN_5)	6 V	3.6 V
Minimum HIGH voltage level at input pins	1.55 V	2.0 V
Post master function for systems with smart acknowledge	No	Yes, 15 mail boxes

3.10 Using RVDD

If RVDD is used in an application circuit a serial ferrite bead shall be used and wire length should be as short as possible (<3 cm). The following ferrite beads have been tested: 74279266 (0603), 74279205 (0805) from Würth. During radio transmission and reception only small currents may be drawn (I<100 µA).
Pulsed current drawn from RVDD has to be avoided. If pulsed currents are necessary, sufficient blocking has to be provided.

3.11 Voltage dips

The moduls are supporting the handling of supply voltage dips (as requested e.g. by EN60669-2-1). As soon as the supply voltage drops below the VON threshold level the current consumption is reduced. TCM 300 will enter standby sleep mode (worst case 35µA), TCM 320 will enter short term sleep mode (1.8mA) for 200 ms. As long as the voltage at VDD does not drop below VOFF during that phase the module will restore the output state as set before the voltage dip. The minimal difference between VON and VOFF is 0.35 V.

The electric charge needed to bridge this interval is:
1.8mA x 200ms = 360µC for TCM 320
0.035mA x 200ms = 7µC for TCM 300

This electric charge can be stored in an external capacitor. The required capacity (do not forget to add component specific tolerances and some extra margin) calculates as:
360µC / 0.35V = 1028µF for TCM 320
7µC / 0.35V = 20 µF for TCM 300

If other external circuitry has to be supplied the calculations have to be done accordingly, using the total current consumption of module and external circuitry.

4 AGENCY CERTIFICATIONS (after release for series production)

The modules have been tested to fulfil the approval requirements for CE (TCM 3x0) and FCC/IC (TCM 3x0C) based on the built-in firmware.

When developing customer specific firmware based on the API for this module, special care must be taken not to exceed the specified regulatory limits, e.g. the duty cycle limitations!

4.1 CE approval

The modules bear the EC conformity marking CE and conforms to the R&TTE EU-directive on radio equipment. The assembly conforms to the European and national requirements of electromagnetic compatibility. The conformity has been proven and the according documentation has been deposited at EnOcean. The modules can be operated without notification and free of charge in the area of the European Union, and in Switzerland. The following provisos apply:

- EnOcean RF modules must not be modified or used outside their specification limits.
- EnOcean RF modules may only be used to transfer digital or digitized data. Analog speech and/or music are not permitted.

- The final product incorporating EnOcean RF modules must itself meet the essential requirement of the R&TTE Directive and a CE marking must be affixed on the final product and on the sales packaging each. Operating instructions containing a Declaration of Conformity has to be attached.
- If the transmitter is used according to the regulations of the 868.3 MHz band, a so-called "Duty Cycle" of 1% per hour must not be exceeded. Permanent transmitters such as radio earphones are not allowed.
- The module must be used with only the following approved antenna(s).

Type	Parameter	Value
Wire/Monopole at RF_WHIP	Maximum gain	1.0 dBi
External antenna at RF_50	Antenna type	Passive
	Impedance	~50 Ohm
	Maximum gain	≤ 8 dBd

4.2 FCC (United States) Certification

TCM 300C and TCM 320C LIMITED MODULAR APPROVAL

This is an RF module approved for Limited Modular use operating as an intentional transmitting device with respect to 47 CFR 15.231(a-c) and is limited to OEM installation. The module is optimized to operate using small amounts of energy, and may be powered by a battery. The module transmits short radio packets comprised of control signals, (in some cases the control signal may be accompanied with data) such as those used with alarm systems, door openers, remote switches, and the like. The module does not support continuous streaming of voice, video, or any other forms of streaming data; it sends only short packets containing control signals and possibly data. The module is designed to comply with, has been tested according to 15.231(a-c), and has been found to comply with each requirement. Thus, a finished device containing the TCM 300C/TCM 320C radio module can be operated in the United States without additional Part 15 FCC approval (approval(s) for unintentional radiators may be required for the OEM's finished product), under EnOcean's FCC ID number. This greatly simplifies and shortens the design cycle and development costs for OEM integrators. The module can be triggered manually or automatically, which cases are described below.

Manual Activation

The radio module can be configured to transmit a short packetized control signal if triggered manually. The module can be triggered, by pressing a switch, for example.
The packet contains one (or more) control signals that is(are) intended to control something at the receiving end. The packet may also contain data. Depending on how much energy is available from the energy source, subsequent manual triggers can initiate the transmission of additional control signals. This may be necessary if prior packet(s) was(were) lost to fading or interference. Subsequent triggers can also be initiated as a precaution if any doubt exists that the first packet didn't arrive at the receiver. Each packet that is transmitted, regardless of whether it was the first one or a subsequent one, will only be transmitted if enough energy is available from the energy source.

Automatic Activation

The radio module also can be configured to transmit a short packetized control signal if triggered automatically, by a relevant change of its inputs or in response to receiving a signal from another transmitter, for example. Again, the packet contains a control signal that is intended to control something at the receiving end and may also contain data. As above, it is possible for the packet to get lost and never reach the receiver. However, if enough energy is available from the energy source, and the module has been configured to do so, then another packet or packets containing the control signal may be transmitted at a later time.

The device is capable to operate as a repeater, which can receive signals from the following list of FCC/IC approved transmitters, and retransmit the signals.

■ PTM 200C	FCC ID:SZV-PTM200C	IC:5713A-PTM200C
■ STM 110C	FCC ID:SZV-STM110C	IC:5713A-STM110C
■ TCM 200C	FCC ID:SZV-TCM2XXC	IC:5713A-TCM2XXC
■ TCM 220C	FCC ID:SZV-TCM2XXC	IC:5713A-TCM2XXC
■ TCM 300C	FCC ID:SZV-STM300C	IC:5713A-STM300C
■ STM 300C	FCC ID:SZV-STM300C	IC:5713A-STM300C
■ TCM 320C	FCC ID:SZV-TCM320C	IC:5713A-TCM320C

OEM Requirements
In order to use EnOcean's FCC ID number, the OEM must ensure that the following conditions are met:

- End users of products, which contain the module, must not have the ability to alter the firmware that governs the operation of the module. The agency grant is valid only when the module is incorporated into a final product by OEM integrators.
- The end-user must not be provided with instructions to remove, adjust or install the module.
- The Original Equipment Manufacturer (OEM) must ensure that FCC labeling requirements are met. This includes a clearly visible label on the outside of the final product. Attaching a label to a removable portion of the final product, such as a battery cover, is not permitted. The label must include the following text:

  TCM300C:

  Contains FCC ID: SZV-STM300C
  The enclosed device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (i.) this device may not cause harmful interference and (ii.) this device must accept any interference received, including interference that may cause undesired operation.

  TCM320C:

  Contains FCC ID: SZV-TCM320C
  The enclosed device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (i.) this device may not cause harmful interference and (ii.) this device must accept any interference received, including interference that may cause undesired operation.

  The user manual for the end product must also contain the text given above.
- Changes or modifications not expressly approved by EnOcean could void the user's authority to operate the equipment.
- The module must be used with only the following approved antenna(s).

Part Number	Type	Gain
N.A.	Wire/Monopole	1.0 dBi

- The OEM must ensure that timing requirements according to 47 CFR 15.231(a-c) are met.
- The OEM must sign the OEM Limited Modular Approval Agreement with EnOcean

4.3 IC (Industry Canada) Certification

In order to use EnOcean's IC number, the OEM must ensure that the following conditions are met:

- Labeling requirements for Industry Canada are similar to those required by the FCC. The Original Equipment Manufacturer (OEM) must ensure that IC labeling requirements are met. A clearly visible label on the outside of a non-removable part of the final product must include the following text:

  TCM300C:

  Contains IC: 5713A-STM300C

  TCM320C:

  Contains IC: 5713A-TCM320C

- The OEM must sign the OEM Limited Modular Approval Agreement with EnOcean

A APPENDIX

A.1 EnOcean serial protocol

When the receiver is in "Serial Interface" mode, it transfers out data blocks of information from the received RF telegrams. As long as no transmitter has been learned, all received EnOcean telegrams are transferred. As soon as at least one transmitter has been learned only telegrams of transmitters learned by the receiver are transmitted via the serial interface. The data block format is explained later in this document; it depends on the type of sensor from which the telegram has been received.

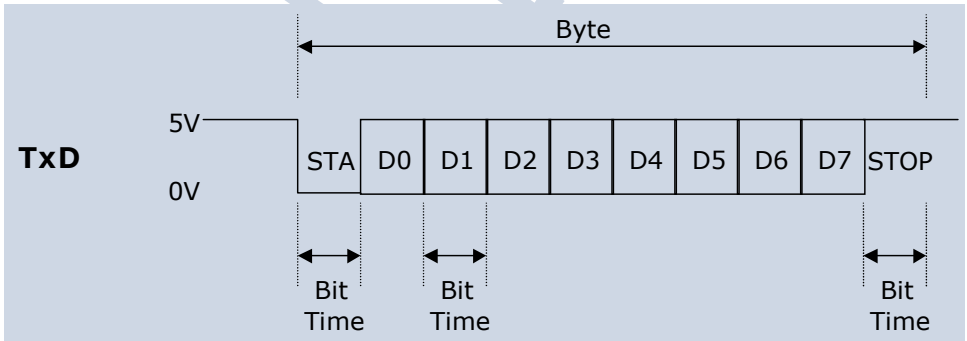
A.1.1 Message format

The following figure shows the message format. A block is composed of 2 synchronization bytes, 1 byte for the header and N bytes for the message data.

Message format for asynchronous serial communication

A.1.2 Byte signals and bit order

- 9600 bps; 8 data bits, no parity bit, one start bit, one stop bit
- Line idle is binary 1 (standard)
- Each character has one start bit (binary 0), 8 information bits (least significant bit first) and one stop bit (binary 1)



Signals and bit order sending a byte

A.2 Radio transmission / reception commands

The following commands are used to transmit and receive radio telegrams.

Command	Response (RMT)
TX_TELEGRAM (TRT)	OK, ERR, ERR_TX_IDRANGE
RX_TELEGRAM (RRT)	

The TX_TELEGRAM and RX_TELEGRAM telegrams have the same structure. The only difference is in the H_SEQ code, TX_TELEGRAM is identified by "3". RX_Telegrams are identified by the H_SEQ codes according to table in A.2.1.

A.2.1 Description of serial data structure

Bit 7 Bit 0

SYNC_BYTE1 (A5 Hex)	
SYNC_BYTE0 (5A Hex)	
H_SEQ	LENGTH
ORG	
DATA_BYTE3	
DATA_BYTE2	
DATA_BYTE1	
DATA_BYTE0	
ID_BYTE3	
ID_BYTE2	
ID_BYTE1	
ID_BYTE0	
STATUS	
CHECKSUM	

SYNC_BYTE 0..1 (8 bit each) Synchronization Bytes
H_SEQ (3 bit) Header identification

H_SEQ	Meaning	Mode
0b000	• Unknown transmitter ID received (serial telegram only if no ID has been learned so far!) • For *RPS* also: o Known transmitter ID and unknown rocker o U-message from known transmitter ID received • For *HRC* also: o Known transmitter ID and unknown rocker o Scene switch command (last three bits of ID 0b*111*) from known transmitter ID (only first 29 bits are compared!)	Operating Mode
0b001	• For 1BS and 4BS: Known transmitter ID received • For RPS: Known transmitter ID and at least 1 known rocker (1 or 2 rockers operated) • For HRC: Known transmitter ID and known rocker	Operating Mode
0b010	• New transmitter learned (If a switch telegram is received (RPS or HRC), the rocker code (RID) is stored together with the ID.)	Learn Mode
0b110	• Transmitter just deleted (If a switch telegram is received (RPS or HRC), the rocker code (RID) and module ID are checked. The entry is only deleted if module ID and rocker are known.)	Learn Mode

LENGTH	(5 bit)	Number of octets following the header octet (11 dec)
ORG	(8 bit)	Type of telegram (see detailed description below)
DATA_BYTE 0..3	(8 bit each)	Data bytes 0..3 (see detailed description below)
ID_BYTE 0..3	(8 bit each)	32-bit transmitter ID[3] For transmission of unique ID enter 0x00000000
STATUS	(8 bit)	Status field (see detailed description below)
CHECKSUM	(8 bit)	Checksum (Last LSB from addition of all octets except sync bytes and checksum)

A.2.2 Detailed description of ORG field

ORG field (hex)	Acronym	Description
0x05	RPS Repeated Switch	Telegram from a PTM switch module received (e.g. PTM 100 or PTM 200)
0x06	1BS 1 Byte Sensor	1 byte data telegram from a STM sensor module (e.g. STM 250)
0x07	4BS 4 Byte Sensor	4 byte data telegram from a STM sensor module (e.g. STM 100)
0x08	HRC Hand Remote Con-trol	Telegram from a CTM module received
0xC5	SYS_EX System Extended	Remote Management Telegrams (see separate specification)

Please note that 6DT and MDA telegrams, which were available in TCM 1x0 / TCM 200C are no longer supported!

A.2.3 Detailed description of STATUS field

If ORG = 5 (Telegram from a PTM switch module):

7				0
Reserved	**T21**	**NU**	**RP_COUNTER**	

Reserved	(2 bit)	For future use
T21	(1 bit)	T21=0 → PTM switch module of type 1, T21=1 → PTM switch module of type 2
NU	(1 bit)	NU=1 → N-message, NU=0 → U-message.
RP_COUNTER	(4 bit) =0..15	Repeater level: 0 is original message (not repeated)

IMPORTANT NOTE FOR SYSTEMS USING AN ENOCEAN RADIO REPEATER:
Within toggle switch applications using the serial receiver mode in combination with a separate repeater, please ensure that no serial command interpretation error may occur at the connected control unit. A toggle signal means that the same telegram is sent for switching something on and off. If e.g. the light is

[3] This module allows using a unique ID or one of 128 IDs starting from BaseID. See A.3.1.

switched on receiving the I-button telegram from a PTM 200C, the repeated telegram (delay <100 ms) may switch off the light again. It is therefore mandatory to interpret the RP_COUNTER field. If a repeated telegram (RP_COUNTER>0) is received it has to be verified if the same telegram with a lower RP_COUNTER state has already been received in the previous 100 ms. In this case the repeated message has to be discarded.

PTM switch modules of Type 2 (e.g. PTM 200) allow interpretation of operating two buttons simultaneously:

- N-message received → Only one or two pushbuttons have been pressed.
- U-message received → No pushbutton was pressed when activating the energy generator, or more than two pushbuttons have been pressed.

Note for telegrams from PTM transmitters: Due to the mechanical hysteresis of the energy bow, in most rocker switch device implementations, pressing the rocker sends an N-message and releasing the rocker sends a U-message!

If ORG = 6, 7 or 8 (all other telegrams):

7							0
Reserved							**RP_COUNTER**

Reserved	(4 bit)	For future use
RP_COUNTER	(4 bit)	Repeater level: 0 is original message (not repeated)

Please consider the "IMPORTANT NOTE" above!

A.2.4 Detailed description of DATA_BYTE 3..0 fields

If ORG = 5 and NU = 1 (N-message from a PTM switch module):

DATA_BYTE2..0 always = 0
DATA_BYTE3 as follows:

7					0
RID	**UD**	**PR**	**SRID**	**SUD**	**SA**

RID	(2 bit)	Rocker ID, from left (A) to right (D): 0, 1, 2 and 3
UD	(1 bit)	UD=1 → O-button, UD=0 → I-button
PR	(1 bit)	PR=1 → Energy bow pressed, PR=0 → Energy bow released
SRID	(2 bit)	Second Rocker ID, from left to right: 0, 1, 2 and 3
SUD	(1 bit)	(Second) SUD=1 → O-button, SUD=0 → I-button
SA	(1 bit)	SA=1 → Second action (2 buttons pressed simultaneously), SA=0 → No second action

If ORG = 5 and NU = 0 (U-message from a PTM switch module):

DATA_BYTE2..0 always = 0
DATA_BYTE3 as follows:

7			0
BUTTONS	**PR**	**Reserved**	

BUTTONS (3 bit) Number of simultaneously pressed buttons, as following:

PTM 100 (Type1):	PTM200 (Type2):
0 = 0 Buttons	0 = 0 Button
1 = 2 Buttons	1 = not possible
2 = 3 Buttons	2 = not possible
3 = 4 Buttons	3 = 3 or 4 buttons
4 = 5 Buttons	4 = not possible
5 = 6 Buttons	5 = not possible
6 = 7 Buttons	6 = not possible
7 = 8 Buttons	7 = not possible

PR (1 bit) PR = 1 → Energy bow pressed,
PR = 0 → Energy bow released

Reserved (4 bit) for future use

If ORG = 6 (Telegram from a 1 Byte STM sensor):

DATA_BYTE2..0 always = 0
DATA_BYTE3 Sensor data byte.

If ORG = 7 (Telegram from a 4 Byte STM sensor):

DATA_BYTE3 Value of third sensor analog input (AD_2)
DATA_BYTE2 Value of second sensor analog input (AD_1)
DATA_BYTE1 Value of first sensor analog input (AD_0)
DATA_BYTE0 Sensor digital inputs as follows:

7				0
Reserved	**DI_3**	**DI_2**	**DI_1**	**DI_0**

According to "Standardization EnOcean Communication Profiles" which defines interoperable communication profiles for devices based on EnOcean Technology DI_3=0 indicates a teach-in telegram! DI_3 should therefore not be used for other purposes than signalling a teach-in telegram.

If ORG = 8 (Telegram from a HRC transmitter):

DATA_BYTE2..0 always = 0
DATA_BYTE3 as follows:

7				0
RID	**UD**	**PR**	**SR**	**Reserved**

RID	(2 bit)	Rocker ID, from left (A) to right (D): 0, 1, 2 and 3
UD	(1 bit)	UD=1 → O-button, UD=0 → I-button
PR	(1 bit)	PR=1 → Button pushed, PR=0 → Button released
SR	(1 bit)	SR=1 → Store, SR=0 → Recall (see note)
Reserved	(3 bit)	for future use

Note: The bit SR is used only when the lower 3 Bits from ID_BYTE0 = 0b*111* (scene switch), and RID ≠ 0 (indicates that the memory buttons M0-M5 are operated in the hand-held remote control).

A.3 Command telegrams and messages

A.3.1 ID Range commands

Every TCM 300 supports a unique 32 bit ID and in addition a range of 128 IDs starting at an BaseID address. At production, every TCM 300 is programmed with a unique ID and a BaseID address. The BaseID number can be read via the serial interface. In order to allow a replacement of one unit with another unit (without having to go through the learning procedure with every receiver), the ID range can be changed via the serial interface.
The allowed ID range is from 0xFF800000 to 0xFFFFFFFF.
In order to prevent misuse, this feature can only be used 10 times!
Please note: The unique ID cannot be changed.

Command (TCT)	Response (RMT)
SET_BASEID	OK, ERR, ERR_IDRANGE
RD_BASEID	INF_BASEID

A.3.2 Receiver sensitivity commands

The receiver sensitivity can be changed by the following commands. In LOW sensitivity mode, only transmitters in the vicinity of the module are received.

Command (TCT)	Response (RMT)
SET_RX_SENSITIVITY	OK
RD_RX_SENSITIVITY	INF_RX_SENSITIVITY

A.3.3 Reset command

Command (TCT)	Response (RMT)
RESET	

A.3.4 SW Version

Command (TCT)	Response (RMT)
RD_SW_VER	INF_SW_VER

A.3.5 Error messages

Error Messages (RMT)
ERR
ERR_TX_IDRANGE
ERR_IDRANGE
ERR_SYNTAX

A.3.6 Command Encoding

OK

Bit 7	Bit 0
0xA5	
0x5A	
0x8B	
0x58	
X	
X	
X	
X	
X	
X	
X	
X	
X	
ChkSum	

Standard message used to confirm that an action was performed correctly by the TCM.
In case of full duplex communication it may happen that serial telegrams get corrupted and lost. Therefore it is recommended to check for "OK" where applicable.

ERR

Bit 7	Bit 0
0xA5	
0x5A	
0x8B	
0x19	
X	
X	
X	
X	
X	
X	
X	
X	
X	
ChkSum	

Standard error message response if after a TCT command the operation could not be carried out successfully by the TCM.

SET_BASEID

Bit 7	Bit 0
0xA5	
0x5A	
0xAB	
0x18	
BaseIDByte3	
BaseIDByte2	
BaseIDByte1	
BaseIDByte0	
X	
X	
X	
X	
X	
ChkSum	

With this command the user can rewrite its ID range base number. The most significant ID byte is BaseIDByte3. The information of the 25 most significant bits is stored in FLASH.
The allowed ID range is from 0xFF800000 to 0xFFFFFFFF.

32							0	
25 most significant bits	0	0	0	0	0	0	0	BaseID

This command can only be used a maximum number of 10 times. After successfully ID range reprogramming, the TCM answers with an OK telegram. If reprogramming was not successful, the TCM answers sending an ERR telegram if the maximum number of 10 times is exceeded or an ERR_IDRANGE telegram if the BaseID is not within the allowed range.

RD_BASEID

Bit 7 Bit 0

0xA5
0x5A
0xAB
0x58
X
X
X
X
X
X
X
X
X
ChkSum

When this command is sent to the TCM, the base ID range number is retrieved though an INF_BASEID telegram.

INF_BASEID

Bit 7 Bit 0

0xA5
0x5A
0x8B
0x98
BaseIDByte3
BaseIDByte2
BaseIDByte1
BaseIDByte0
X
X
X
X
X
ChkSum

This message informs the user about the ID range base number.

BaseIDByte3 is the most significant byte.

SET_RX_SENSITIVITY

Bit 7 Bit 0

0xA5
0x5A
0xAB
0x08
Sensitivity
X
X
X
X
X
X
X
X
ChkSum

This command is used to set the TCM radio sensitivity.
In LOW radio sensitivity, signals from remote transmitters are not detected by the TCM receiver. This feature is useful when only information from transmitters in the vicinity should be processed. An OK confirmation telegram is generated after TCM sensitivity has been changed.

Sensitivity=0x00 Low sensitivity
Sensitivity=0x01 High sensitivity

RD_RX_SENSITIVITY

Bit 7 Bit 0

0xA5
0x5A
0xAB
0x48
X
X
X
X
X
X
X
X
X
ChkSum

This command is sent to the TCM to retrieve the current radio sensitivity mode (HIGH or LOW).
This information is sent via a INF_RX_SENSITIVITY command.

INF_RX_SENSITIVITY

Bit 7 Bit 0

0xA5
0x5A
0x8B
0x88
Sensitivity
X
X
X
X
X
X
X
X
ChkSum

This message informs the user about the current TCM radio sensitivity.
Sensitivity= 0x00 Low sensitivity
Sensitivity= 0x01 High sensitivity

RESET

Bit 7 *Bit 0*

0xA5
0x5A
0xAB
0x0A
X
X
X
X
X
X
X
X
X
ChkSum

Performs a reset of the TCM microcontroller.

RD_SW_VER

Bit 7 Bit 0

0xA5
0x5A
0xAB
0x4B
X
X
X
X
X
X
X
X
X
ChkSum

This command requests the TCM to send its current software version number.
This information is provided via an INF_SW_VER telegram by the TCM.

INF_SW_VER

Bit 7 Bit 0

0xA5
0x5A
0x8B
0x8C
TCM SW Version Pos.1
TCM SW Version Pos.2
TCM SW Version Pos.3
TCM SW Version Pos.4
API Version Pos.1
API Version Pos.2
API Version Pos.3
API Version Pos.4
X
ChkSum

Informs the user about the current software version of the TCM.
Example: Version 1.0.1.16
TCM SW Version Pos.1 = 1
TCM SW Version Pos.2 = 0
TCM SW Version Pos.3 = 1
TCM SW Version Pos.4 =16

ERR_SYNTAX

Bit 7 Bit 0

0xA5
0x5A
0x8B
Field
X
X
X
X
X
X
X
X
X
ChkSum

This telegram is sent automatically through the serial port after the TCM has detected a syntax error in a TCT telegram.
Errors can occur in the H_SEQ, LENGTH, ORG or CHKSUM fields/bytes.

Field code:
H_SEQ=0x08 ORG=0x0B
LENGTH=0x09 CHKSUM=0x0A

ERR_TX_IDRANGE

Bit 7 Bit 0

0xA5
0x5A
0x8B
0x22
X
X
X
X
X
X
X
X
X
ChkSum

When a radio telegram intended to be sent has an ID number outside the ID range, this error message is generated. The radio telegram is not delivered.

ERR_ IDRANGE

Bit 7 Bit 0

0xA5
0x5A
0x8B
0x1A
X
X
X
X
X
X
X
X
X
ChkSum

This message is generated when the user tries to change the ID range base using the SET_BASEID command to a value outside the allowed range from 0xFF800000 to 0xFFFFFFFF.