USER MANUAL V0.82

Scavenger Transceiver Module
STM 300 / STM 300C

February 11, 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
0.81	Sections 3.2.x content removed; section 4.2 and 4.3 content removed
0.82	Max. ripple at VDD reduced to 50 mVpp; Connect external 1 kΩ pull-down to RESET and PROG_EN.

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Important!

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Packing: Please use the recycling operators known to you. By agreement we will take packing material back if it is sorted. You must bear the costs of transport. For packing material that is returned to us unsorted or that we are not obliged to accept, we shall have to invoice you for any costs incurred.

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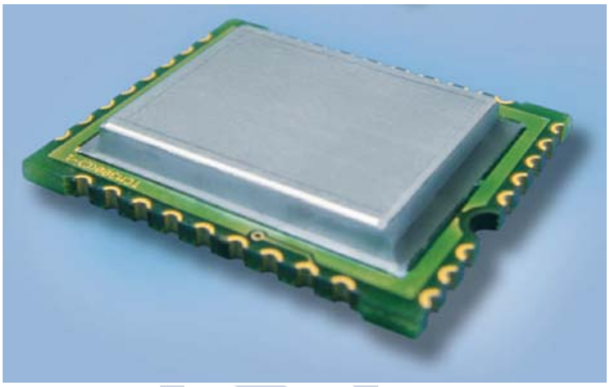
1 GENERAL DESCRIPTION

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:

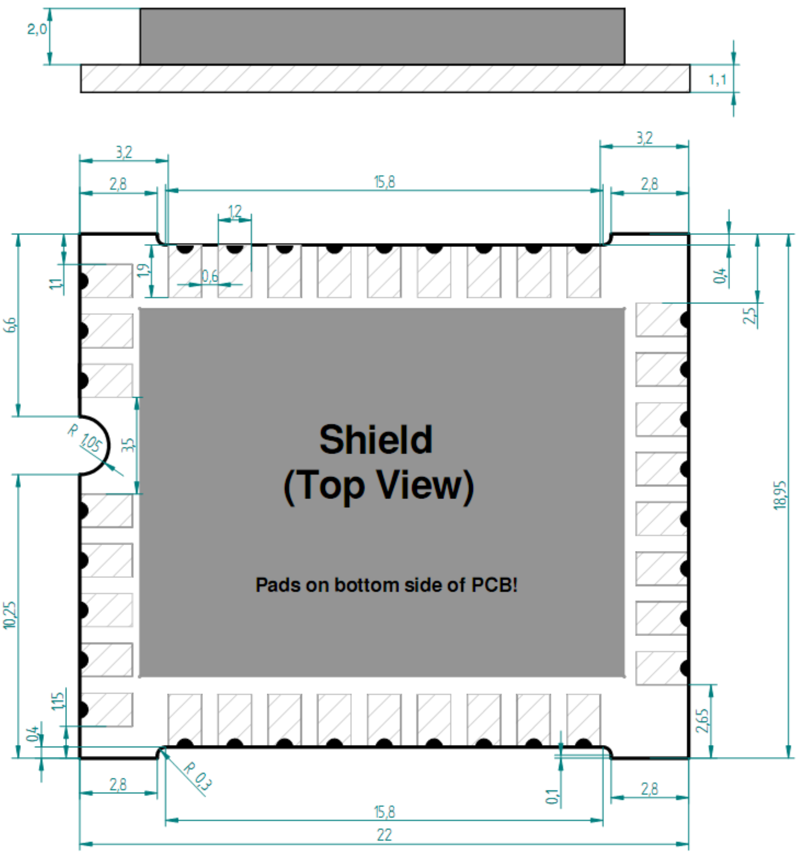
- Integrated 16 MHz 8051 CPU with 32 KB FLASH and 2 kB SRAM
- Receiver functionality
- Various power down and sleep modes down to 0.2 µA current consumption
- Up to 16 configurable I/Os
- 10 bit ADC, 8 bit DAC

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, 2.5 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	0 °C ... +40 °C
Humidity	0% ... 93% r.h., non-condensing

1.5 Ordering Information

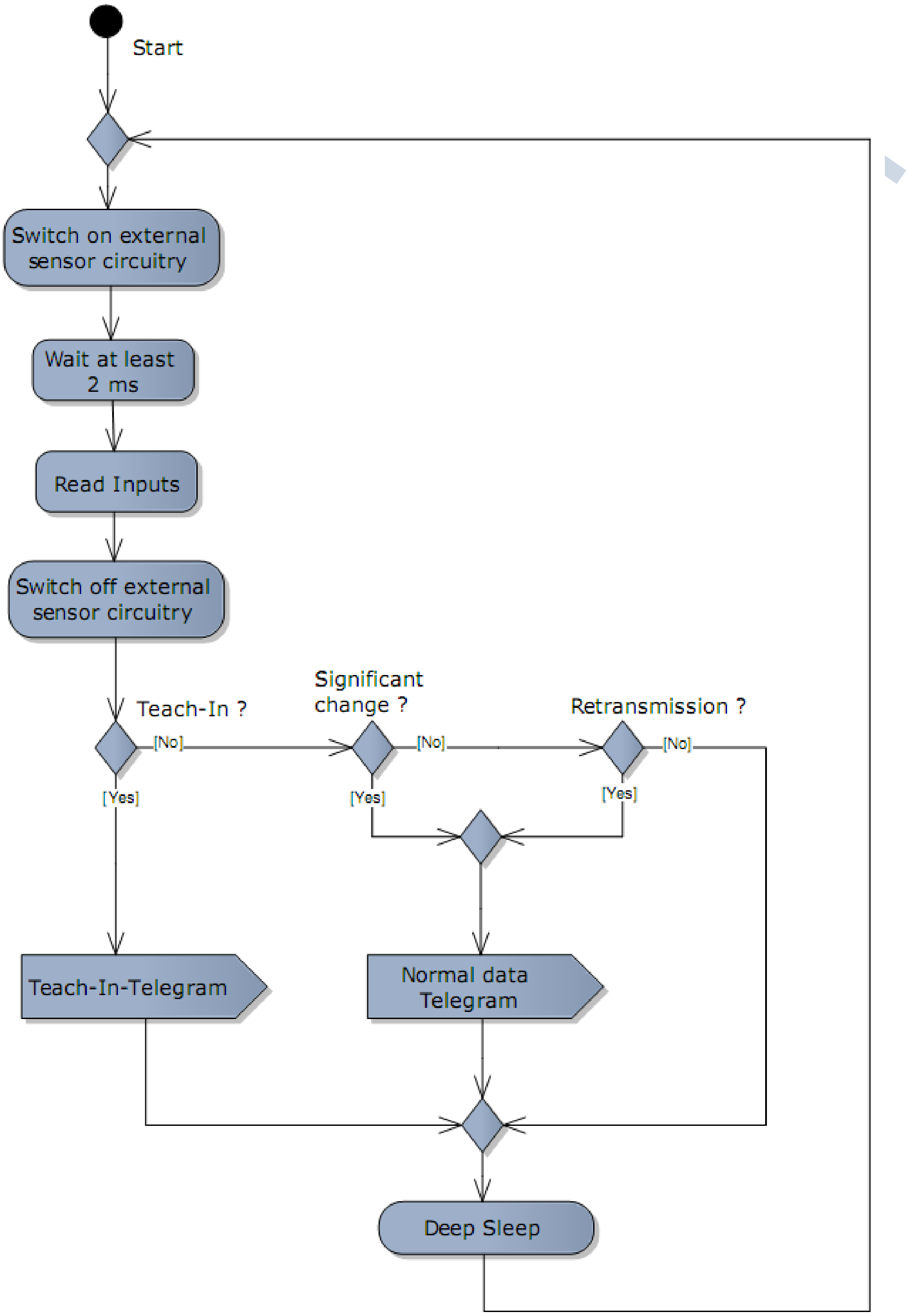
Type	Ordering Code	Frequency
STM 300	S3001-D300	868.3 MHz
STM 300C	S3031-D300	315.0 MHz

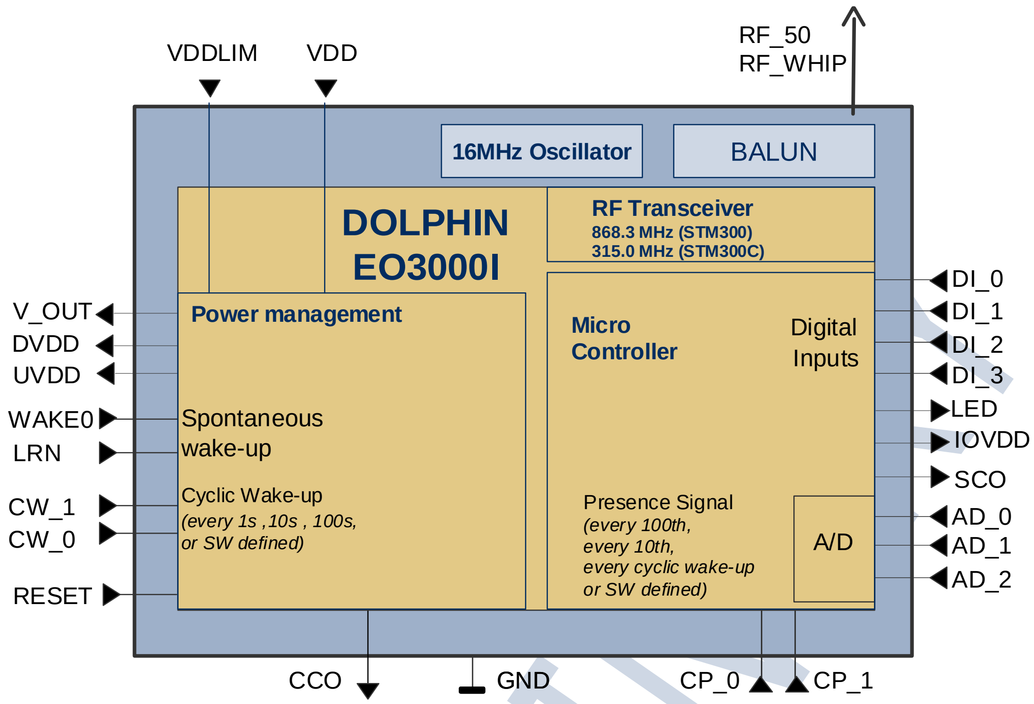
Suited solar cells (for technical details please refer to the ECS3x0 data sheet):

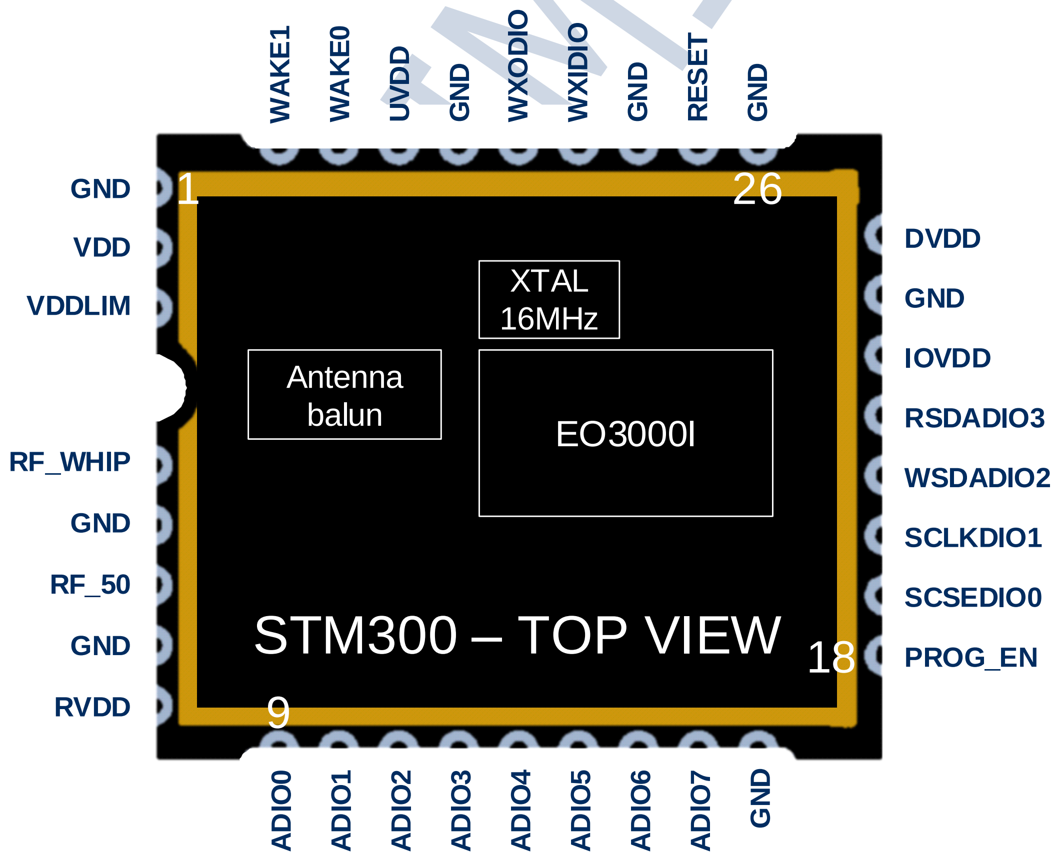
Type	Ordering Code	Size
ECS 300	S3005-D305	35.0×12.8×1.1 mm
ECS 310	S3005-D310	50.0×20.0×1.1 mm

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
XTAL 16MHz
Antenna balun
EO3000I
STM300 – TOP VIEW
18
9
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: 2.5 V Maximum ripple: see 0
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) External 1 kΩ pull-down required!
PROG_EN	PROG_EN	Programming I/F	HIGH: programming mode active LOW: operating mode Digital input, external 1 kΩ pull-down required!
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 8bit (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=0V (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=0V.
If DVDD=0V 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.

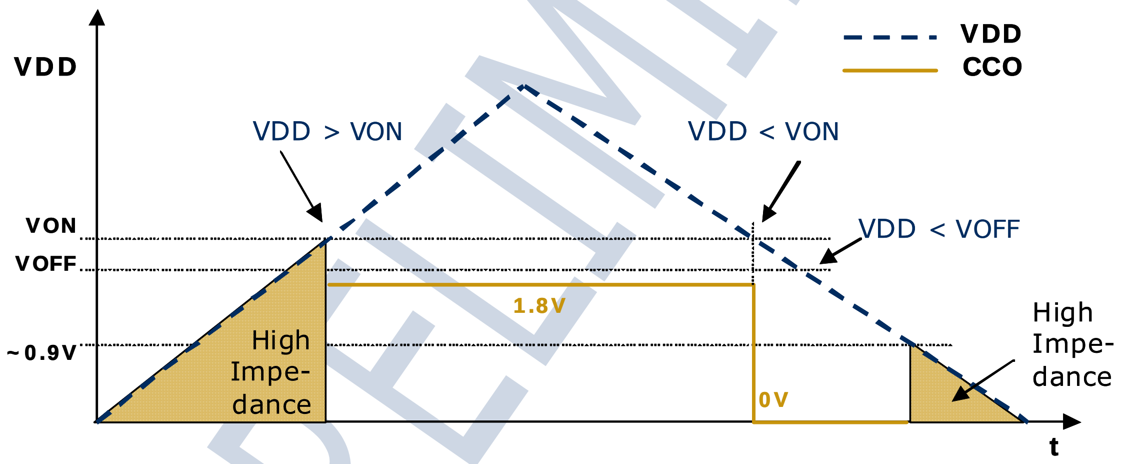
Threshold detector
STM 300 provides an ultra low power ON/OFF threshold detector. If VDD > VON, it turns on the ultra low power regulator (UVDD), the watchdog timer and the WAKE# pins circuitry. If VDD ≤ VOFF it initiates the automatic shut down of STM 300.

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 7th - 14th timer wake-up signal, affected at random
NC	GND	Every 70th - 140th 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!

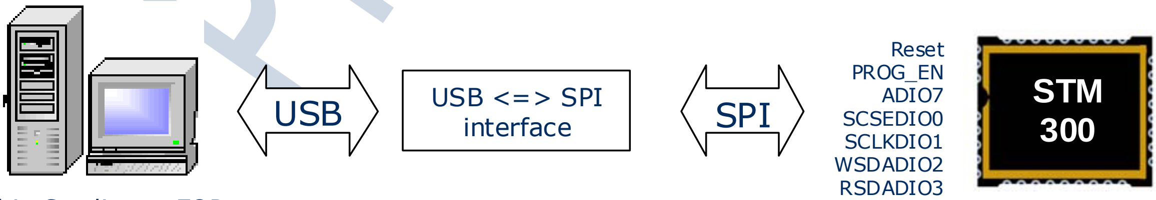
If applied in other (non-safety, non-security) applications a minimum of 10 s between periodic transmissions is required. In addition the device has to comply with the lower field strength limits of 15.231e). The limited modular approval of STM 300C is not valid in this case.

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

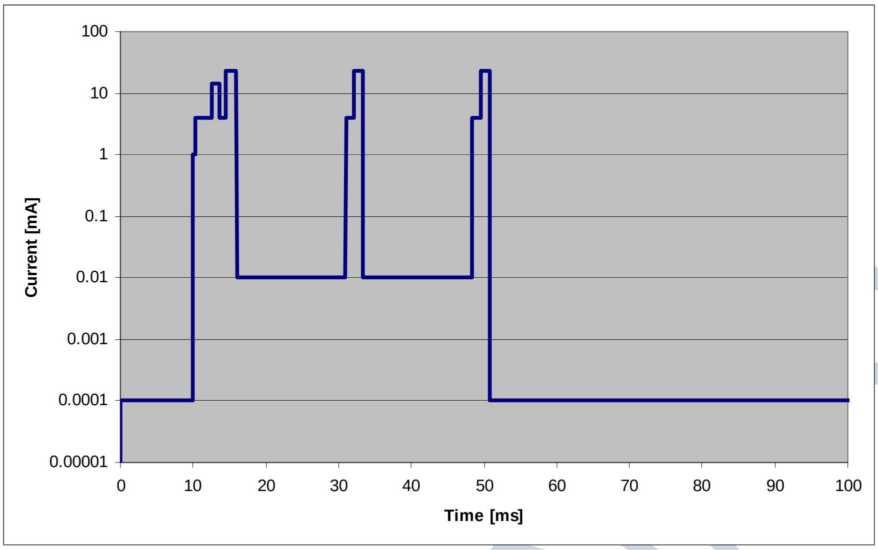
Function 6 Bit	Type 7 Bit	Manufacturer-ID 11 Bit	LRN Type 1Bit	RE2 1Bit	RE1 1Bit	RE0 1Bit	LRN 1Bit	DI2 1Bit	DI1 1Bit	DI0 1Bit

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 40ms. 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)

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 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

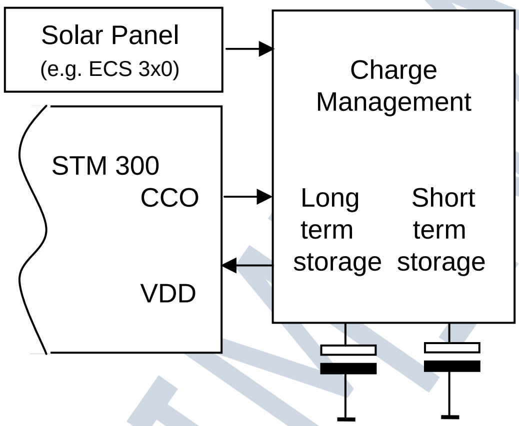
Assumptions:
- Storage PAS614 with 0.25 F, Umax=3.2 V, Umin=2.2 V
- Consumption: Transmit cycle 100 µC, measurement cycle 30 µC
- Indoor solar cell, operating values 3 V and 5 µA @ 200 lux fluorescent light (~ECS 300 solar cell)
- Current proportional to illumination level (not true at very low levels!)

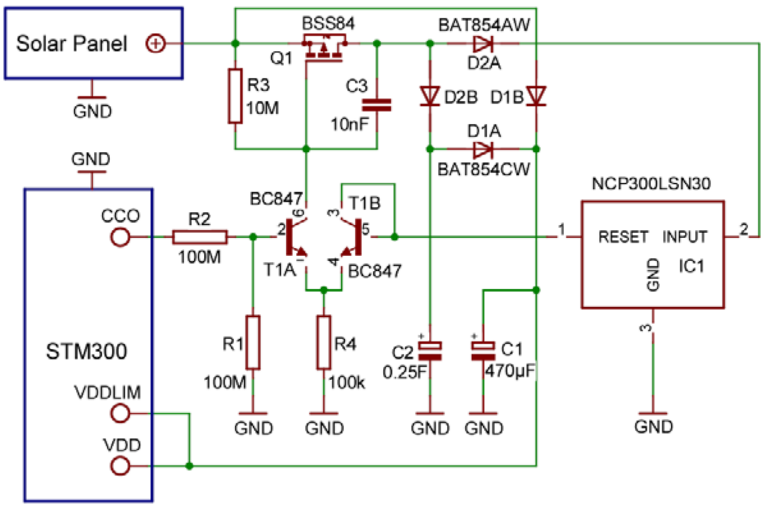
These values are calculated values, the accuracy is about +/-20% !

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:





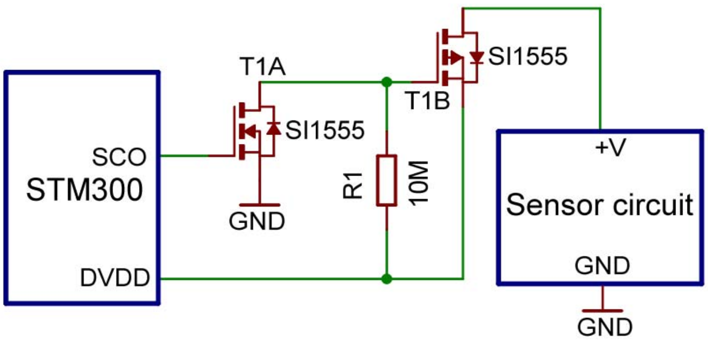
It is important to use matched diode pairs for D2!
This circuit is designed for energy storages specified up to 3.3 V (e.g. PAS614L).
NCP300LSN30 is limiting the voltage at C2 < 3.3 V, to avoid damaging of the energy storage. In case a different voltage limit is needed this component has to be exchanged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

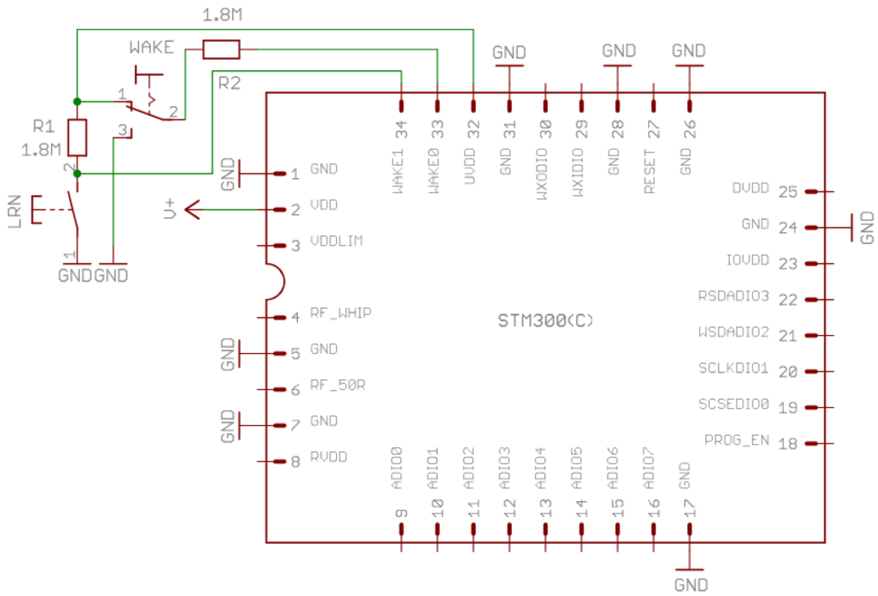
⚠ Do not supply sensors directly from SCO as this output can only provide maximum 15 µA!

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 (<3cm). 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
Center Frequency	868.3 MHz	Mandatory for radio approval
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 EMC 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

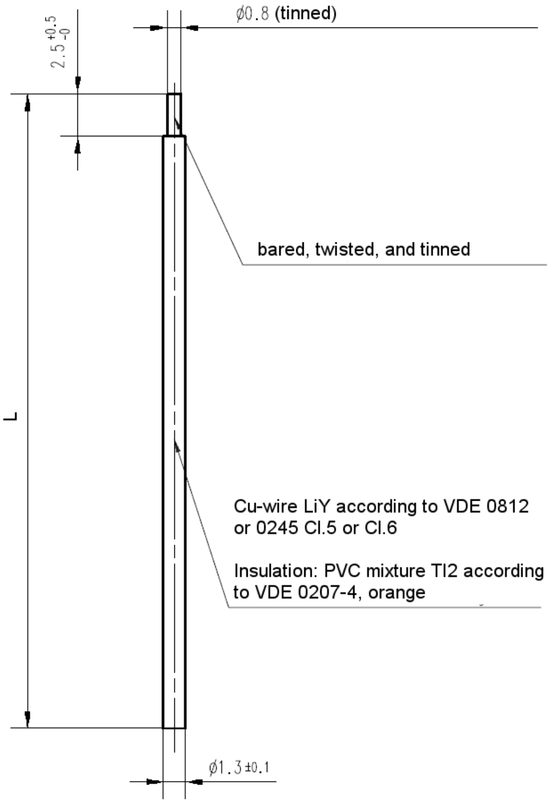
Antenna: 150 mm wire, connect to RF_WHIP

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

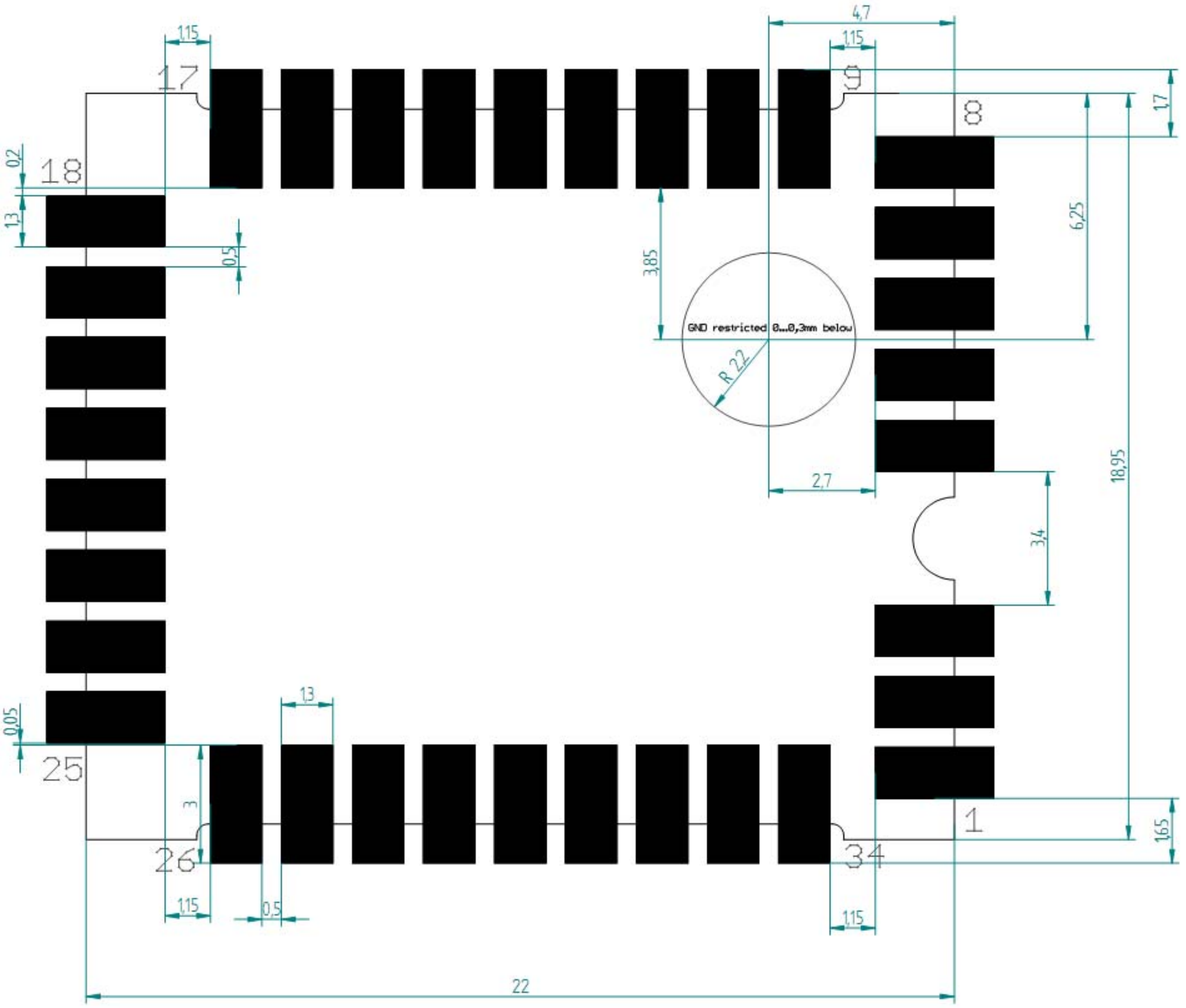
3.5.3 Chip antenna: in preparation

3.5.4 Splatch antenna: in preparation

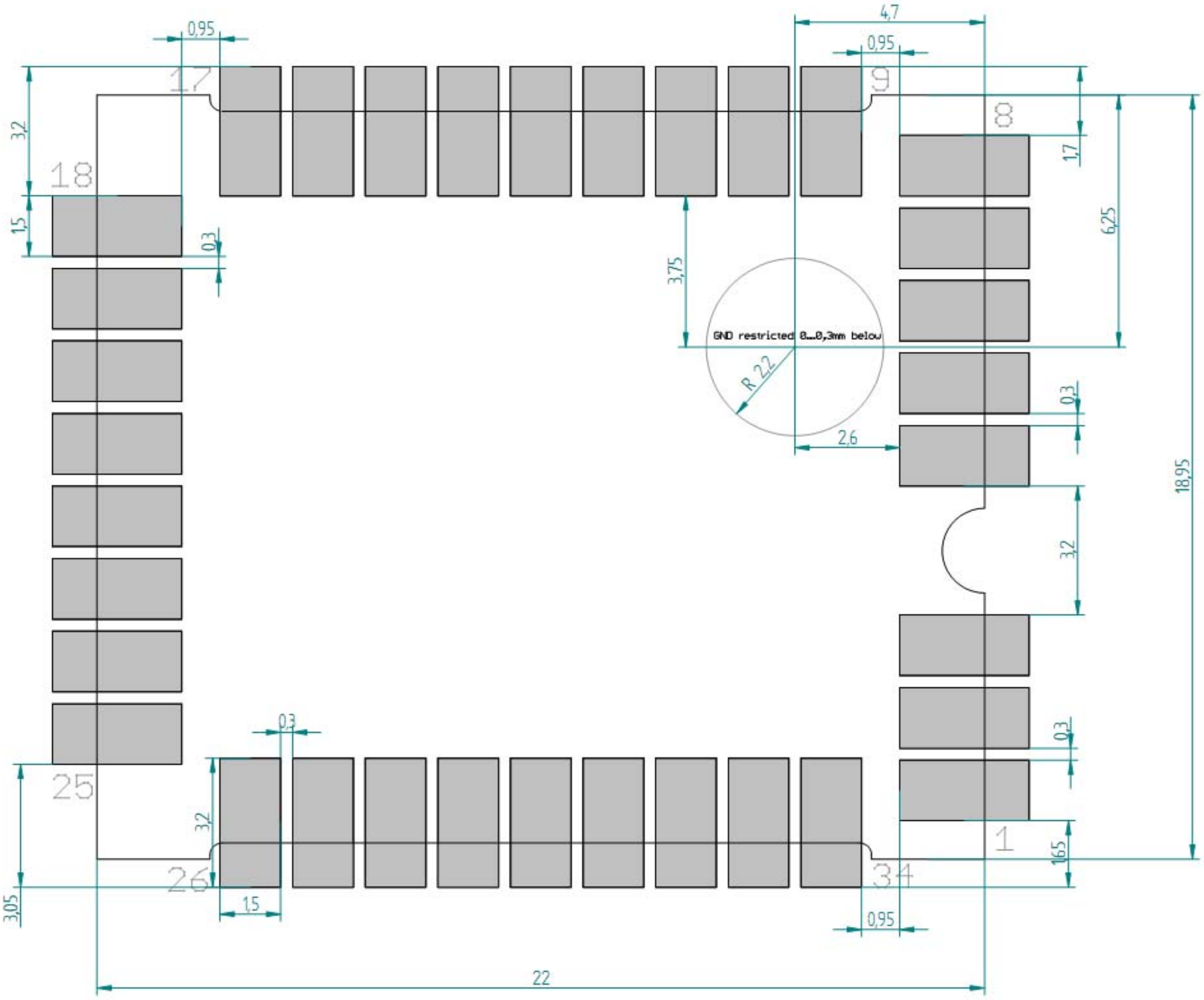
3.5.5 Helical antenna: in preparation

3.6 Layout recommendations for foot pattern

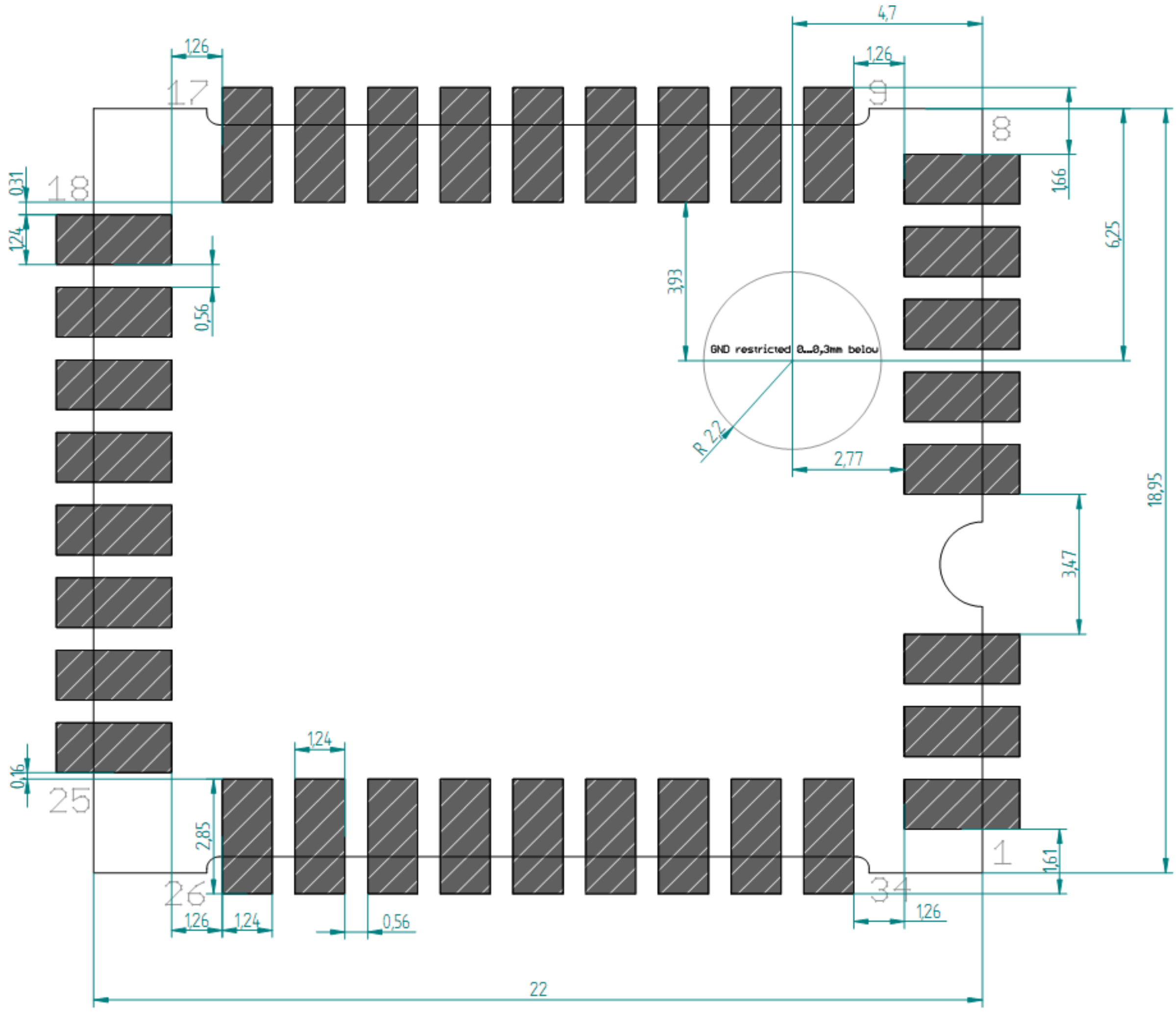
Top layer



Solder resist top layer



Solder paste top layer



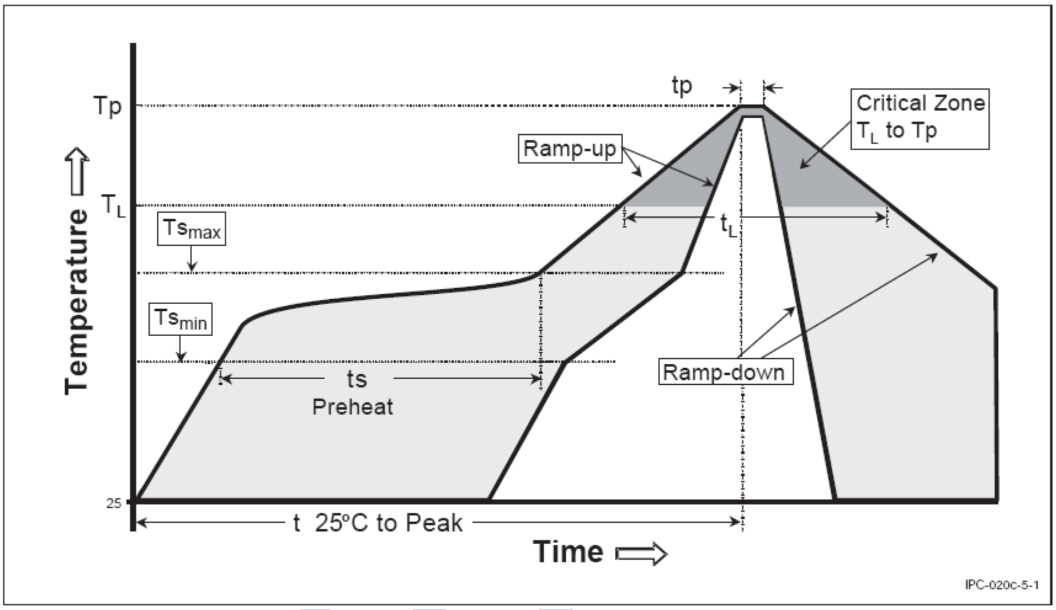
The data above is also available as EAGLE library.

3.7 Soldering information

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.

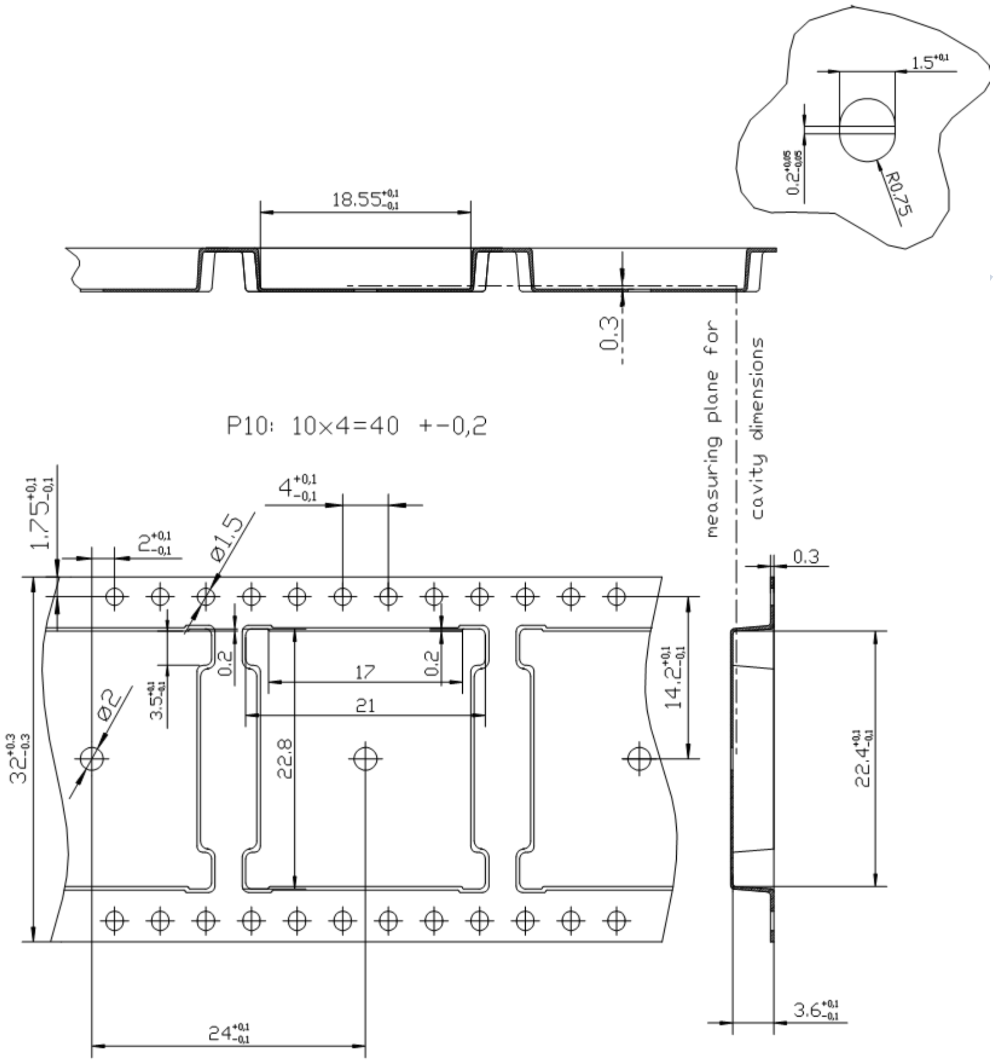


STM 300 shall be handled according to Moisture Sensitivity Level MSL4 which means a floor time of 72 h. STM 300 may be soldered only once, since one time is already consumed at production of the module itself.

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

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
	Center Frequency	868.3 MHz
	Impedance	~50 Ohm
	Maximum gain	≤ 8 dBd

4.2 FCC (United States) certification: in preparation

4.3 IC (Industry Canada) certification: in preparation