The power of unused energy
enocean

RF Sensor Transmitter Module
STM 11x / STM 11xC

User Manual V1.2
July 2007

Revision History

The following major modifications and improvements have been made to the initial version of the document (V1.0) :

Version	Major Changes
1.1	ESD warning added; equivalent schematic of CW_0 and CW_1 corrected.
1.2	Editorial changes; FCC approval requirements modified

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Important!

This information describes the type of component and shall not be considered as assured characteristics. No responsibility is assumed for possible omissions or inaccuracies. Circuitry and specifications are subject to change without notice. For the latest product specifications, refer to the EnOcean website: http://www.enocean.com.

As far as patents or other rights of third parties are concerned, liability is only assumed for modules, not for the described applications, processes and circuits.

EnOcean does not assume responsibility for use of modules described and limits its liability to the replacement of modules determined to be defective due to workmanship. Devices or systems containing RF components must meet the essential requirements of the local legal authorities. The approval requirements described in this document are of best knowledge without any warranty.

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.

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

The extremely power-saving RF transmitter modules STM 11x and STM 11xC from EnOcean enable the implementation of wireless and maintenance-free sensors. Power supply is provided by a solar cell. An integrated energy store allows operation for several days in total darkness.

1.1. Basic Functionality

Three 8-bit A/D converter inputs and 4 digital inputs facilitate multifunctional detector systems, based on passive sensing components. This allows easy and convenient monitoring of temperature, illumination, etc. – or controlling window and door states – or supervising input voltages or input currents respectively.

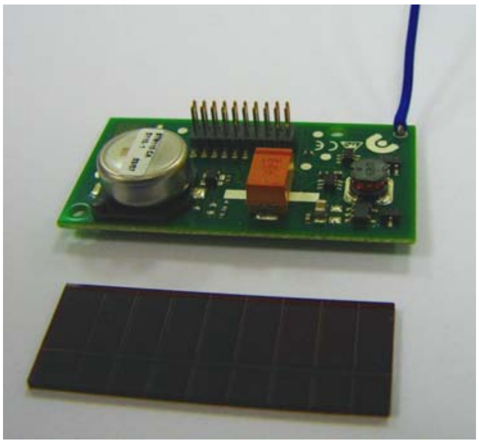


Figure 1: STM 11x sensor transmitter module

1.2. Typical Applications

- **Building installation**
- **Industrial automation**
- **Consumer electronics**

The STM 11x module serves the 868 MHz air interface protocol of EnOcean. Together with the receiver module RCM120, RCM130, this module can be easily integrated into operation and control units for the realization of various application-specific system solutions.

The module is part of a powerful RF system solution from EnOcean for operation and control applications. Because the RF transmitters are self-powered, maintenance-free RF systems can be implemented.

A 315 MHz version (STM 11xC) for use in USA and Canada is also available.

1.3. Technical Data

Power supply: ....Solar Power Generator (discrete optical cell), or 2.2 - 5.0V external

Frequency / transmission power:........................ 868.3 MHz or 315.0 MHz / 10 mW max.

Data rate / modulation type: .... 125 kbps / ASK

Transmission range: .... 300m free field, typ. 30m indoor

Module identifier:... individual 32-bit ID factory-programmed

EnOcean telegram type: .... 4BS ("Four Byte Sensor")

Telegram packet length (sub-telegram):...1.2 ms ±5%

No. of (redundant) packets:........... 3 packets within about 40ms, delay effected at random

Input channels: .... 3 x analog inputs (8-bit resolution), 4 x digital inputs

Spontaneous wake-up: ...... differential external trigger signal, minimum wake interval 7ms

Cyclic wake-up:................. user-configurable (every 1, 10, 100, or 110 s, tolerance ± 20%)

Presence signal:............ user-configurable (every wake-up signal, every 10th or every 100th)

Illumination: ....100 lx up to 100.000 lx

Operation startup time with empty energy store: .... < 10 min @ 400 lx

Operation time during total darkness: .... > 60 h 1)

1) storage is filled @ 1000 lx (4.2V in Goldcap)
RF transmission every 17 min, 100s wake-up, temperature 25°C, Goldcap formatted

Ext. power supply output: .... 3.0 V ±3%, 1mA max., ~2.6ms (during wake-up time)

Ext. voltage reference output: ....2.05V ±3%, 1mA max., ~2.6ms (during wake-up time)

Input sample time after wake-up: ....>1.7 ms

Transmitting indication output (LED): ...... 3.0V ±3%, 2mA max., 3 x 1.2 ms within 40ms

A change of WAKE pin status forces the onboard controller instantly to check all current analog and digital input values. In addition, a user-programmable cyclic wake-up is provided.

After wake-up, a radio telegram (input data, unique 32-bit sensor ID, checksum) is 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 analog values: ≥5LSB of AD_1 input, ≥6LSB of AD_0 or ≥14LSB of AD_2. In case of a triggered wake-up a radio telegram is sent in any case.

In case of no relevant input change, a presence signal is sent after a user-configurable number of wake-ups to announce all current input values (sign of life).

Between the wake-up phases, the module is in sleep mode for minimum power consumption.

There is a serial interface which allows to configure several parameters of the module:

- Threshold values of the AD inputs which lead to immediate radio transmission
- Manufacturer code (information about manufacturer and type of device)

In case a manufacturer code is programmed into the module and DI3=0 at wake-up the module will transmit a dedicated teach-in telegram containing the manufacturer code.

Observe Precautions, electrostatic sensitive devices!

1.4. Physical Dimensions

Dimensions of PCB: .... 21 x 40 x 9 mm (incl. energy store and wiring pins)

Dimensions of solar cell: .... 35.0 x 13.0 x 1.1 mm (for details see chapter 5)

Antenna: .... pre-installed 9 cm (STM11x) or 24 cm (STM11xC) whip antenna

Connector: .... 20 pins, dual row male, grid 1.27 mm

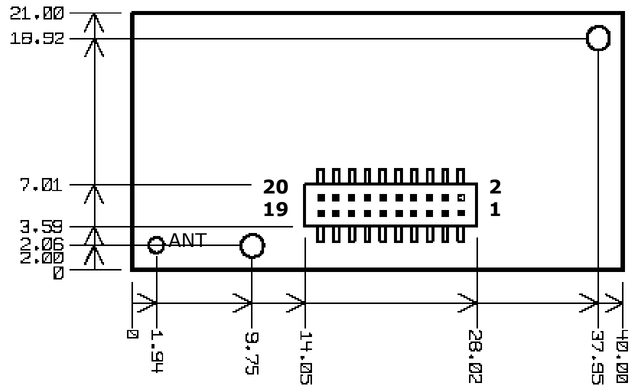


Figure 2: STM 11x package outlines

1.5. Environmental Conditions

Operating temperature: .... -25 up to +65 °C

Storage temperature: .... -25 up to +65 °C

Humidity (PCB): .... 0% to 95% r.h. [1)]

Humidity (Solar cell, rear side): .... 0% to 60% r.h., no condensate [1)]

[1)] For corrosion protection, see chapter 3.5

The product life strongly depends on the temperature as the Goldcap used for energy storage degrades with higher temperature. As a reference the lifetime (capacitance reduced to 70% of nominal value) of the Goldcap is reduced from 100.000 h to 5.000 h when the temperature is raised from 25°C to 65°C.

1.6. Ordering Information

Type	EnOcean Ordering Code	Radio Frequency	Solar Cell
STM 110	**S3001-D110**	**868.3 MHz**	**Included**
STM 111	**S3001-D111**	**868.3 MHz**	**Not included**
STM 110C	**S3031-D110**	**315.0 MHz**	**Included**
STM 111C	**S3031-D111**	**315.0 MHz**	**Not included**

2. FUNCTIONAL DESCRIPTION

2.1. Block Diagram

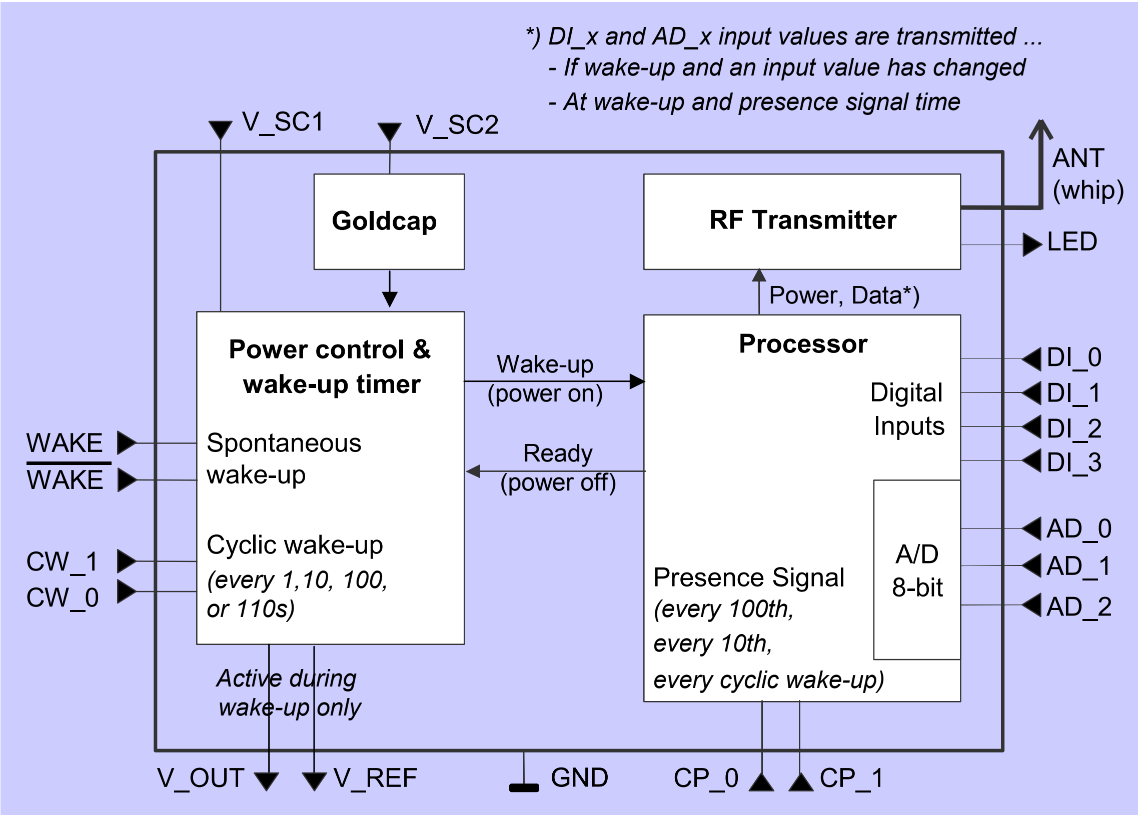


Figure 3: STM 11x block diagram

Module power supply

The supplied solar cell has been designed especially for the STM 11x for maximum module performance at smallest dimensions. The active solar area is divided into two to provide independent module power supplies:

- V_SC1: Main power supply input. Must be connected to the STM 11x solar cell (small active area) or by another external energy source respectively
- V_SC2: Goldcap charging input by connecting to the STM 11x solar cell (big active area)

⚠ The capacitance of the Goldcap may be reduced after long term storage of modules without energy supply. It may take up to one day of charging until the full capacitance is recovered.

⚠ Continuous operation at temperatures higher than 50°C may decrease the capacitance of the Goldcap. This will result in shorter charging times and shorter operating times in total darkness!

Power control

The power control supervises V_SC1 supply and charging status of the energy store. It controls the power supply for wake-up timer, microprocessor, HF transmitter and the supply outputs.

Power supply outputs

Two power supply outputs are available:

a) V_OUT
b) V_REF (stabilized reference voltage)

The outputs are active after wake-up during the active state of the module to drive an external sensor user circuitry.

Wake-up timer

The wake-up timer provides user-programmable wake-up time intervals for activating the processor and an external wake-up opportunity (WAKE pins).

Features:

- Extremely low power consumption during sleeping time period
- Cyclic processor wake-up configurable by user through external pin configuration (CW_0, CW_1)
- The sleep mode can be terminated immediately by changing the pin status of the differential WAKE inputs. Note that the WAKE inputs are part of a special capacitor circuitry that offers lowest operating power consumption (current flow at switching over time only).

WAKE and /WAKE always have to be operated via switch-over as shown in the following:

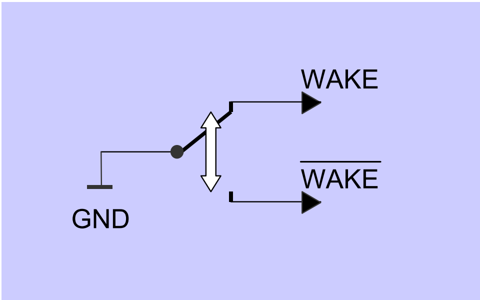


Figure 4: External WAKE pin circuit

A radio telegram is always transmitted after wake-up via WAKE pins! (change compared to STM100!) After transmission the presence signal counter is reset.

See chapter 2.5 for configuration of wake-up cycle times.

Processor

Controls all functionalities after wake-up: First, the values of all measurement inputs are sampled. After that, RF signal transmission is triggered if one or more of the following conditions are met:

a) One of the input values has changed since the last radio transmission (one of the 4 digital inputs has changed or one of the 3 analog inputs has changed equal to or more than a defined value of the total measurement range), or

b) Presence Signal time, that means number of wake-ups that did not cause a radio transmission has been counted to a user-configurable number (CP_0 and CP_1), or

c) The wake-up has been triggered via the WAKE pins

After every RF transmission, all measurement values are stored for data comparison at next wake-up time.

See chapter 2.5 for configuration of presence signal timing.

RF transmitter

The radio transmitter is powered up by the processor when the sending condition is positive. The output LED is activated temporarily during telegram transmission.

2.2. Pin Description and Operational Characteristics

For maximum ratings please refer to chapter 2.3!

Pin No	Symbol	Function	Operational Characteristics
5 6 7	AD_0 AD_1 AD_2	Analog inputs sampled at every wake-up. The analog input values are transmitted as sensor data bytes: AD_0 = DATA_BYTE1 AD_1 = DATA_BYTE2 AD_2 = DATA_BYTE3	Sample moment after wake-up: 1.7 ms … 2.6 ms Resolution: 8-bit Input impedance: ≥100kΩ (1 bit = V_REF/256 = 8mV Accuracy vs. V_REF @25°C typ. ±2LSB, max ±4LSB). Relevant input change: ≥ 5 LSB of AD_1 ≥ 6 LSB of AD_0 ≥ 14 LSB of AD_2 These default values may be changed. See page 23
2 1 4 3	DI_0 DI_1 DI_2 DI_3	Digital inputs sampled at every wake-up. Digital inputs are transmitted within sensor DATA_BYTE0 (least significant 4 bits): DI_0 = Bit 0, DI_1 = Bit 1, DI_2 = Bit 2, DI_3 = Bit3). DI_2 and DI_3 are also used as serial interface pins for the configuration of the module See page 23.	Sample moment after wake-up: 1.7 ms … 2.6 ms Real digital TTL input with internal pull-up (change compared to STM100!) LOW voltage: <0.45 V HIGH voltage: > 2.45V Input impedance ≥100kΩ
18 20	WAKE /WAKE	A signal change of WAKE inputs stops sleep mode immediately. A radio telegram is always transmitted after wake-up via WAKE pins! (change compared to STM100!)	Differential input (capacitive): - connect to GND via switch over only - Resistance to GND < 100 Ω - Switch over time < 1ms - Minimum time between wake signals > 7ms - Pins should be connected to V_SC1 if not needed in application - max. external allowed leakage current 100pA
12 14	CW_0 CW_1	Encoding input for processor wake-up cycle time: 1, 10, 100, or 110 seconds approximately.	Pins should be left open or connected to GND Resistance to GND < 10 Ω Cyclic wake-up time value strongly depends on actual power supply voltage and temperature (up to ±20%)
13 15	CP_0 CP_1	Encoding input for determining the number of cyclic wake-up signals that trigger the Presence Signal: Every wake-up signal, or every 10th, or every 100th or no presence signal.	Pins should be left open or connected to GND Resistance to GND < 100 Ω Input impedance ≥100kΩ
9	V_OUT	Module power supply output available during wake-up phase to drive an external sensor circuitry by the user. Also used for starting serial mode.	3.0V ±3%, ~2.6ms, I_{Vout} = 1 mA max.

10	V_REF	Reference voltage output available during wake-up phase to drive an external sensor circuit by the user.	2.05 V ±3%, ~2.6ms, I_{Vref} = 1 mA max.
11	LED	Output for optional external LED to indicate every telegram transmission (short flashing) Also used for starting serial mode.	3.0 V ±3%, 2 mA max., source impedance 470 Ω ±1%, ~3 x 1.2 ms within 40 ms
19	V_SC1	Main power supply input. Connect V_SC1 in series with a Schottky diode of Type BAS 125 to SOL1 of the STM 11x solar cell (smaller area, see Figure 9). Or connect to another external energy source respectively.	When using other energy source than the supplied solar panel (see chapter 3.6): 2.2 – 5.0 V
17	V_SC2	Goldcap charging input. Connect V_SC2 in series with a Schottky diode of Type BAS 125 to SOL2 of the STM 11x solar cell (bigger area, see Figure 9).	For use with the solar cell only (V_o < 5.0 V)!
8 16	GND	Ground connections	
	ANT	Whip antenna λ/4	Please find recommendations on antenna mounting in chapter 3.2

⚠ **Never connect an input (like CP_0..1, AD_0..2, DI_0..3) to a permanent supply voltage! These inputs should be always left open, connected to GND or connected to the own V_OUT and / or V_REF (active only during measurement time!). Otherwise they would permanently draw current from the permanent power supply and could also damage the device (see absolute maximum ratings 2.3 below)**

If such a function is absolutely needed, please insert a diode to avoid the problem.

For socket positions, see Figure 2.

2.3. Absolute Maximum Ratings (non operating)

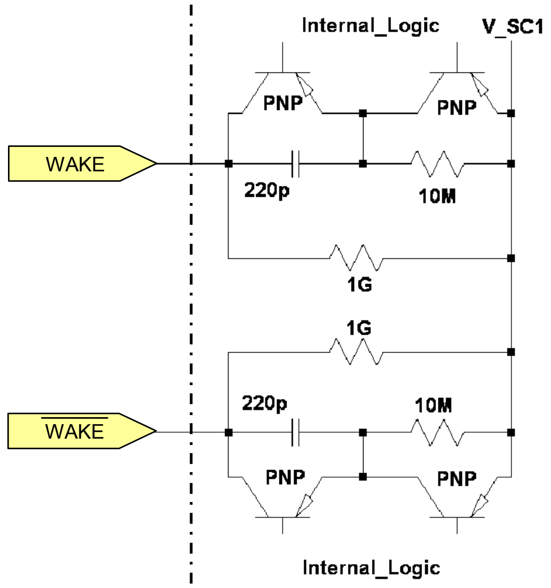
Symbol	Parameter	Min	Max	Units
V_SC1, V_SC2	Input voltage	0	5.5	V
V_SC1	Input current ripple		95	mA
V_SC2	Input current ripple		0.2	A
LED, V_REF, V_OUT, DI0..3, AD0..2, CP_0..1	Input voltage while µC not active (= module completely switched off or sleep timer running)	0	0.7	V
LED, DI0..3, AD0..2	Input voltage while µC active	0	V_OUT	V
V_OUT	Input voltage while serial mode is active	0	3.09	V
CW_0, CW_1	Input voltage		0	V
WAKE, /WAKE	Input voltage	0	V_SC1	V
ANT	Input voltage		5	V
V_REF, V_OUT	Output current		1	mA
LED	Output current		2	mA
V_SC1, V_SC2, CW_0, CW1, WAKE, /WAKE, V_OUT, V_REF, ANT, GND	Electrostatic discharge		1	kV

CP_0, CP_1, LED, DI_0..3, AD_0..2	Electrostatic discharge		2	kV
Module	Temperature	-25	65	°C
Module	Humidity		95	% r.h.
Solar cell	Illumination		100.000	lx
Solar cell	Humidity		60	% r.h.

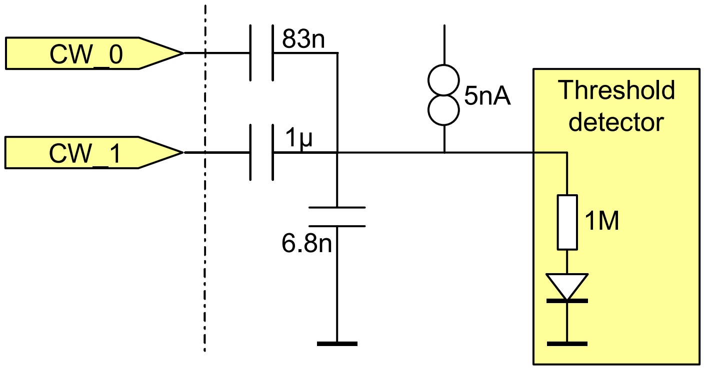
⚠ Exceeding these values may destroy the module!

2.4. Equivalent Schematics of Inputs and Outputs

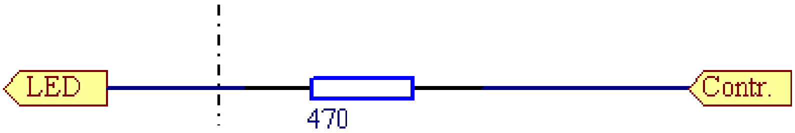
Equivalent schematic of WAKE and /WAKE inputs



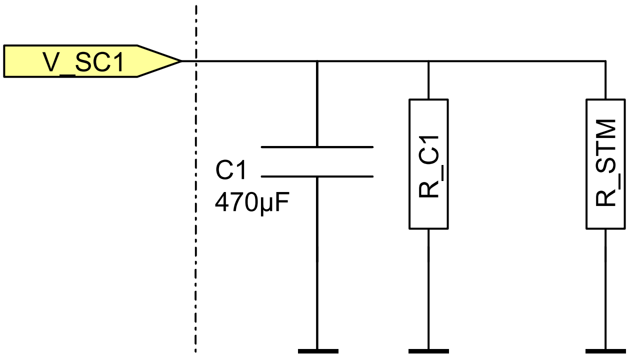
Equivalent schematic of wake-up cycle time inputs CW_0 to CW_1



Equivalent schematic of LED output



Equivalent schematic of V_SC1 input



R_C1: ~6 MΩ after 3 V applied for 10 min, >>10MΩ after 24h.

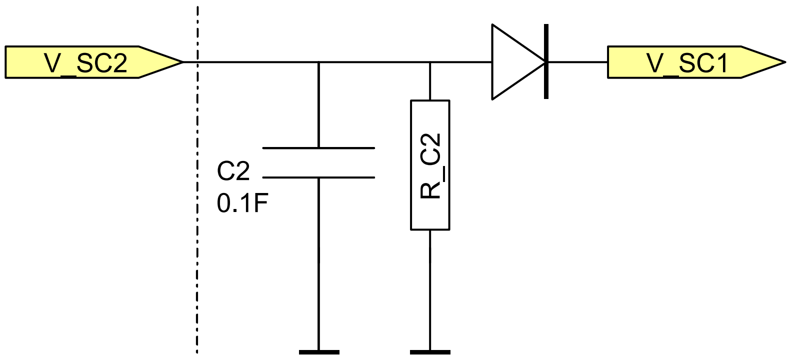
R_STM: depends on wake-up cycle time, transmit intervals and supply voltage.
In the following table R_STM is given at a supply voltage of 3V (typical values):

R_STM [kΩ]	1s	10s	100s	110s
Every wake-up	24	240	2400	2600
Every 10th wake-up	63	630	6300	6900
Every 100th wake-up	75	750	7500	8300

The current consumption is almost independent from the supply voltage (typical values):

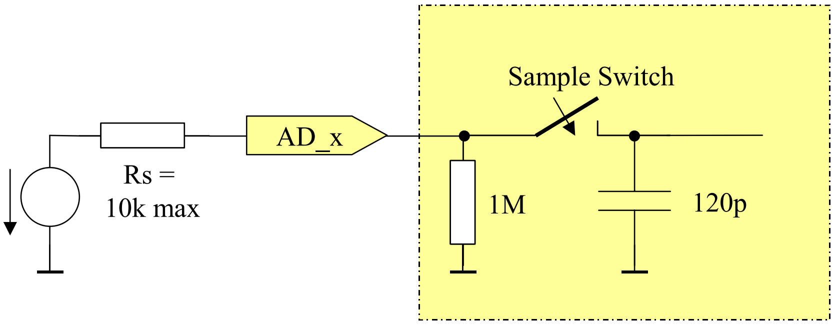
I_STM [µA]	1s	10s	100s	110s
Every wake-up	130	13	1.3	1.1
Every 10th wake-up	50	5.0	0.50	0.45
Every 100th wake-up	40	4.0	0.40	0.35

Equivalent schematic of V_SC2 input

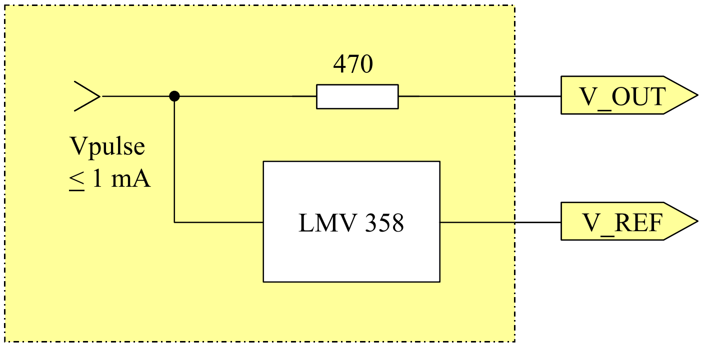


R_C2: ~375 kΩ after 3 V applied for 10 min., ~5MΩ after 24h

Equivalent schematic of analog inputs AD_0 to AD_2



Equivalent schematic of voltage outputs V_0UT and V_REF



2.5. Encoding Scheme of CW and CP Input Pins

The encoding input pins have to be left open or connected to GND in correspondence with the following connection schemes:

Wake-up cycle time

CW_0	CW_1	Wake-up cycle time
NC	NC	1 sec. ±20%
GND	NC	10 sec. ±20%
NC	GND	100 sec. ±20%
GND	GND	110 sec. ±20%

Presence signal time

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 presence signal is transmitted.

CP_0	CP_1	Number of cyclic wake-up signals that trigger the presence signal
NC	NC	Every timer wake-up signal
GND	NC	Every 10th timer wake-up signal
NC	GND	Every 100th timer wake-up signal
GND	GND	No presence signal after timer wake-up

⚠ A radio telegram is always transmitted after wake-up via WAKE pins! (change compared to STM100!) After transmission the presence signal counter is reset.

2.6. Solar Energy Balance Calculation

The following diagrams are showing operational performance data of STM110.

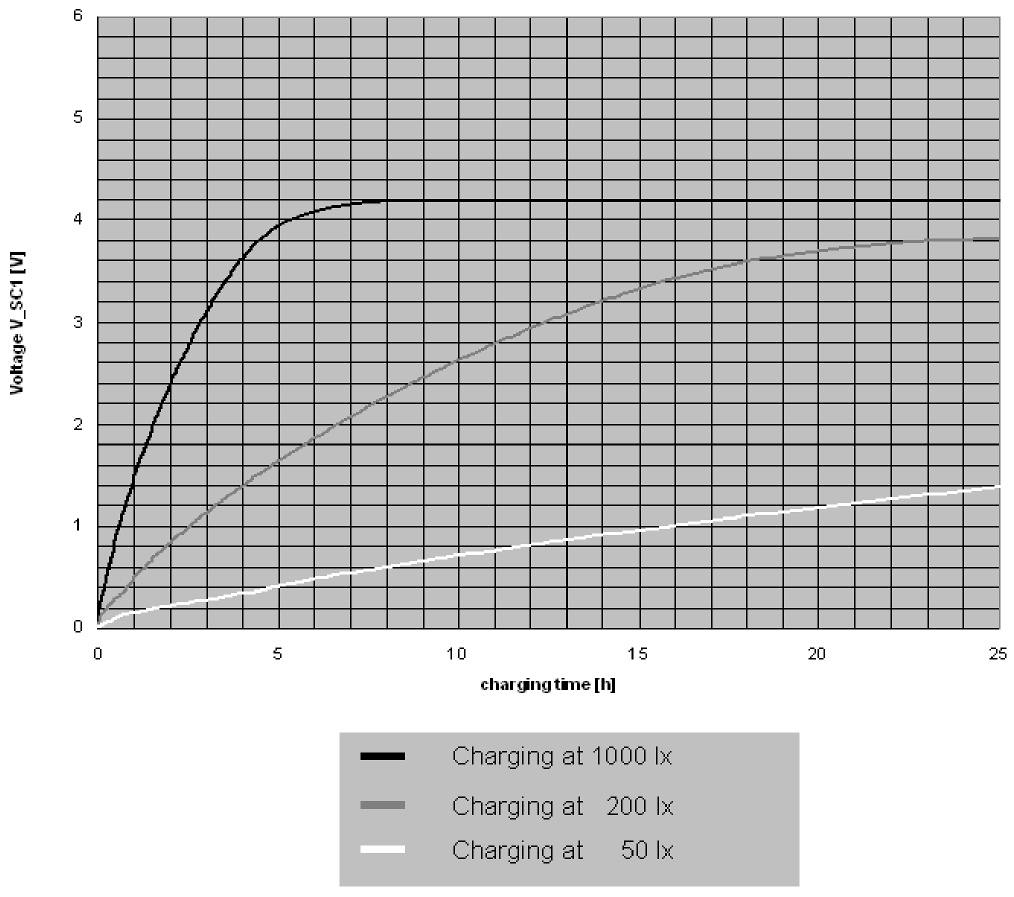


Figure 5: Graphs of the goldcap charging process (typ. @25°C). Measured with white light LEDs, illustration of the illumination level as fluorescent lamp equivalent (EL). Measured with 100s wake up timer.

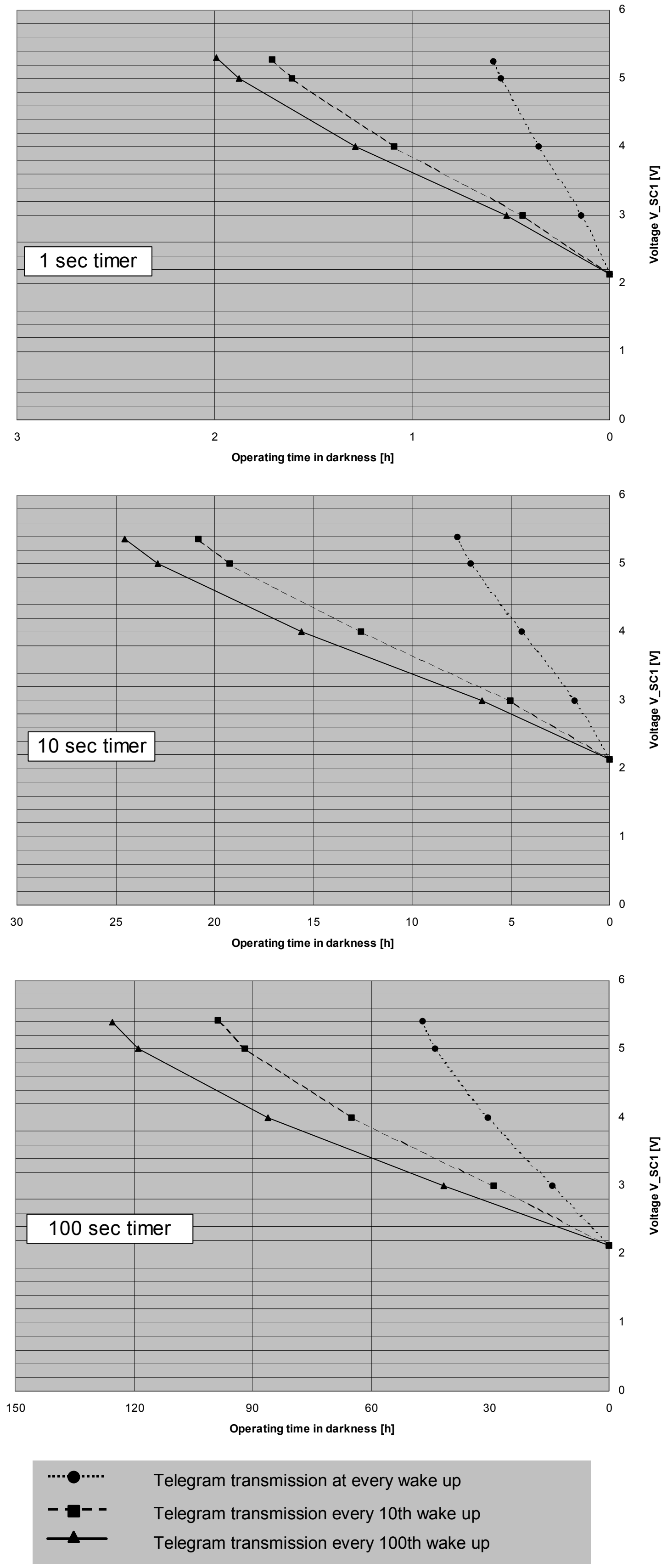


Figure 6: STM110 operation time in darkness (typ. @25°C)

2.7. Radio Telegram of STM 11x

Frequency range and modulation scheme

The STM 11x operates the 868.3 MHz radio channel (868.0 – 868.6 MHz), which is exclusively released for short-time data transmission in Europe. Timing conditions can be found in chapter 3.8 of this paper.

Because of the very low radiated field strength on average, products based on STM 11xC (315.0 MHz) can be approved in the USA and in Canada. The approval requirements can be found in chapter 3.9 of this paper.

STM11x/STM11xC are based on ASK (amplitude shift keying) modulation with a bit rate of 125 kbit/s.

Telegram content

The payload of the telegram consists of:

8 bit	8 bit	8 bit	4 bit	32 bit
AD_2	AD_1	AD_0	DI_3..0	ID

Transmission timing

The transmission timing of the radio module STM 11x has been developed to avoid 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. The transmission of a subtelegram lasts approximately 1.2 ms. To optimize data security, each telegram is repeated twice within about 40 ms, whereas the delay between the three transmission bursts is effected at random.

2.8. Serial Interface for module configuration

It is possible to change some parameters of the module via a serial interface:

- Read / write threshold values of AD_0 to AD_2 which lead to a transmission of a radio protocol
- Read the firmware version of the module
- Read / write manufacturer ID, device profile and type

The following pins are needed:

- LED
- V_OUT
- DI_3 as USR_RX
- DI_2 as USR_TX

In order to activate the serial mode please take the following steps:

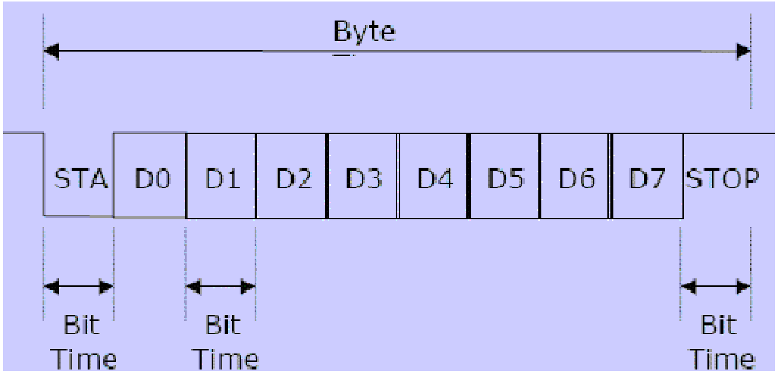
1. Connect LED pin to V_OUT pin
2. Activate STM11x using the timer or the WAKE inputs.

The module will then enter the serial mode. It will receive information via the USR_RX (DI_3) pin and transmit information via the USR_TX (DI_2) pin. It will not react on WAKE signals or timer interrupts while in serial mode.

In order to terminate the serial mode the LED pin has to be connected to GND.

Serial protocol

The data rate is 9600 baud, 1 start bit ,1 stop bit, LSb first. The inter byte time out is 50ms. The default logic value is 1(3V).



A serial command consists of 14 bytes as shown in the following.

SYNC_BYTE1 (A5 Hex)
SYNC_BYTE0 (5A Hex)
HEADER
ORG
DATA_BYTE0
DATA_BYTE1
DATA_BYTE2
DATA_BYTE3
DATA_BYTE4
DATA_BYTE5
DATA_BYTE6
DATA_BYTE7
DATA_BYTE8
CHECKSUM

SYNC_BYTE1	(8 bit) =	0xA5 (fixed)	
SYNC_BYTE0	(8 bit) =	0x5A (fixed)	
HEADER	(8 bit) =	0x8B telegram sent from STM 0xAB telegram sent to STM	
ORG	(8 bit) =	0 .. 255	telegram type (see description of commands)
DATA_BYTE0..8	(8 bit) =	0 .. 255	information
CHECKSUM	(8 bit) =	0 .. 255	checksum (Last 8LSB from addition of all octets except sync bytes and checksum)

Command list

WR_SYS_AD_THRES

Description:
With this command the user can modify the threshold values at the analog inputs which lead to a radio transmission. The default values are 6LSB on AD_0, 5LSB on AD_1 and 14 LSB on AD_2.

The module will answer with OK_SYS_WR or ERR_SYS_WR.

Command encoding
Bit 7 *Bit 0*

0xA5
0x5A
0xAB
0x02
AD_2_MIN_VARIATION
AD_1_MIN_VARIATION
AD_0_MIN_VARIATION
0xXX
0xXX
0xXX
0xXX
0xXX
0xXX
ChkSum

AD_2_MIN_VARIATION:	*Treshold at AD_2: 0..0xFF LSB*
AD_1_MIN_VARIATION:	*Treshold at AD_1: 0..0xFF LSB*
AD_0_MIN_VARIATION:	*Treshold at AD_0: 0..0xFF LSB*
0xXX	*Ignored field*

⚠ A reduction of the threshold values may lead to a higher number of transmissions and therefore increased energy consumption! The measurement accuracy versus V_REF is typ. ±2LSB, max ±4LSB!

RD_SYS_MEM

Description:
With this command the user can retrieve all the configuration data from the module.

The module answers with 3 telegrams:
- INF_SYS_SW_VERSION
- INF_SYS_ID_DEV_MAN
- INF_SYS_AD_THRES

Command encoding

Bit 7 *Bit 0*

0xA5
0x5A
0xAB
0x40
0xXX
0xXX
0xXX
0xXX
0xXX
0xXX
0xXX
0xXX
0xXX
ChkSum

0xXX *ingored field*

INF_SYS_ID_DEV_MAN

Description:
This message contains the manufacturer ID, and the device profile and type.

Command encoding
Bit 7 *Bit 0*

0xA5
0x5A
0x8B
0x00
DATA_BYTE3
DATA_BYTE2
DATA_BYTE1
0x00
ID_Byte3
ID_Byte2
ID_Byte1
ID_Byte0
0x00
ChkSum

Data_Byte3..0: *as follows:*

Data_Byte3								***Data_Byte2***								***Data_Byte1***							
7	*6*	*5*	*4*	*3*	*2*	*1*	*0*	*7*	*6*	*5*	*4*	*3*	*2*	*1*	*0*	*7*	*6*	*5*	*4*	*3*	*2*	*1*	*0*
Profile						***Type***							***Manufacturer ID***										

ID_Byte3..0: *STM11x ID bytes.*

In order to prevent fraudulent use, the commands for writing manufacturer ID, device profile and type to the module are only available to customers signing an agreement with EnOcean!

INF_SYS_SW_VERSION

Description:
This telegram contains the SW version of the module.

Command encoding
Bit 7 *Bit 0*

0xA5
0x5A
0x8B
0x8C
SW Version Byte3
SW Version Byte2
SW Version Byte1
SW Version Byte0
0x00
0x00
0x00
0x00
0x00
ChkSum

SW Version Byte3..0: *Software version, MSB first*

INF_SYS_AD_THRES

Description:
This telegram contains the current threshold values at the analog inputs which lead to a radio transmission.

Command encoding
Bit 7 *Bit 0*

0xA5
0x5A
0x8B
0x01
AD_2_MIN_VARIATION
AD_1_MIN_VARIATION
AD_0_MIN_VARIATION
0x00
0x00
0x00
0x00
0x00
0x00
ChkSum

AD_2_MIN_VARIATION: *Treshold at AD_2: 0..0xFF LSB*
AD_1_MIN_VARIATION: *Treshold at AD_1: 0..0xFF LSB*
AD_0_MIN_VARIATION: *Treshold at AD_0: 0..0xFF LSB*

OK_SYS_WR

Description:
This message is sent after successful execution of a user request.

Command encoding

Bit 7 *Bit 0*

0xA5
0x5A
0x8B
0x58
0x00
0x00
0x00
0x00
0x00
0x00
0x00
0x00
0x00
ChkSum

ERR_SYS_WR

Description:
This message is sent if the execution of a user request has failed.

Command encoding

Bit 7 *Bit 0*

0xA5
0x5A
0x8B
0x19
0x00
0x00
0x00
0x00
0x00
0x00
0x00
0x00
0x00
ChkSum

2.9. Serial Data Reception via Receiver Modules RCM 120 / RCM 130C

For a detailed description please refer to the User Manuals of RCM 120 and RCM 130C.

Type of STM 11x protocol which is seen at the serial outputs of the receiver modules is “4BS” (4 Byte Sensor):

Description of STM 11x radio data content:

ORG = 7 dec. always (EnOcean module type “4BS”)

DATA_BYTE3 = Value of AD_2 analog input
DATA_BYTE2 = Value of AD_1 analog input
DATA_BYTE1 = Value of AD_0 analog input
DATA_BYTE0 = Digital sensor inputs as follows:

Bit 7 … Bit 0

Reserved	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)

In case manufacturer ID, device profile and type have been stored in the module the following telegram will be seen on the RCM 120 / 130C serial interface if DI_3=0:

Description of STM 11x learn telegram:

ORG = 7 dec. always (EnOcean module 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
ID_BYTE3 = module identifier (Byte3)
ID_BYTE2 = module identifier (Byte2)
ID_BYTE1 = module identifier (Byte1)
ID_BYTE0 = module identifier (Byte0)

		Data_Byte2	Data_Byte1		

Profile 6 Bit	Type 7 Bit	Manufacturer-ID 11 Bit	LRN Type 1Bit	RE2 1Bit	RE1 1Bit	1Bit	1Bit	1Bit	1Bit	1Bit

With this special learn telegram it is possible to identify the manufacturer of a device and the profile and type of a device. There is a list available describing the functionalities of the respective products. Please contact EnOcean to receive this list.

3. APPLICATIONS INFORMATION

3.1. Module Mounting

The STM 11x module requires some external circuitry configuration and connecting to the application-specific sensorics circuit. This external circuitry should easily find place on a small PCB that can be connected upside down to the EnOcean module via the STM dual row header. This allows the realization of very compact sensor units.

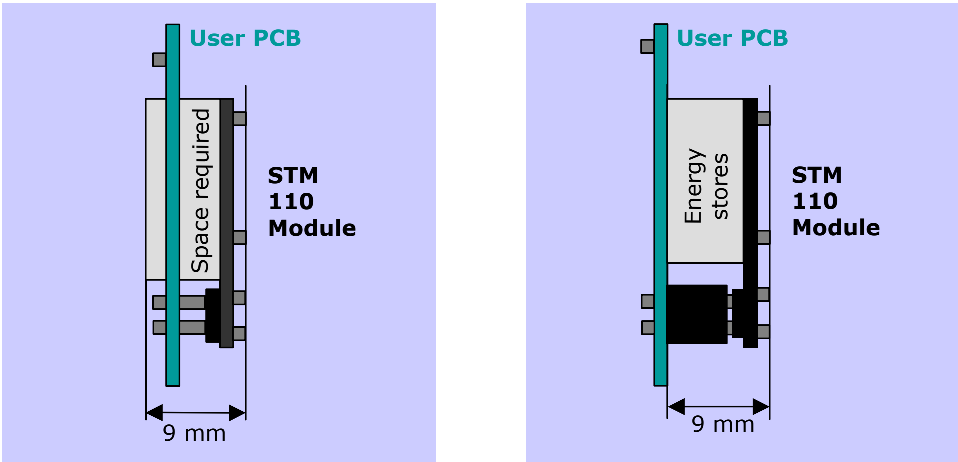


Figure 7: Examples of compact sensor unit

The following features have to be available on the user PCB:

- Power supply by connecting V_SC1 and V_SC2 to the supplied solar cell or by connecting V_SC1 to another suitable external energy source
- Configuration of the STM firmware by connecting the input pins CW_0..1 and CP_0..1
- If needed, an application-specific sensor circuitry connected to analog input pins (AD_0, AD_1, and/or AD_2) and powered by V_OUT, V_REF and GND
- If needed, connections to digital signal inputs DI_0..3. The digital inputs can also be used for an individual sensor type identification defined by the user.
- If needed, a changeover switch connected to the differential WAKE pins for providing spontaneous wake-up
- If needed, a light emitting diode connected between the LED and GND pins for providing optical feedback of sending

⚠ To avoid radio frequency pickup from the environment, strip lines of the user circuit should be designed as short as possible, and the use of a PCB ground plane layer is recommended.

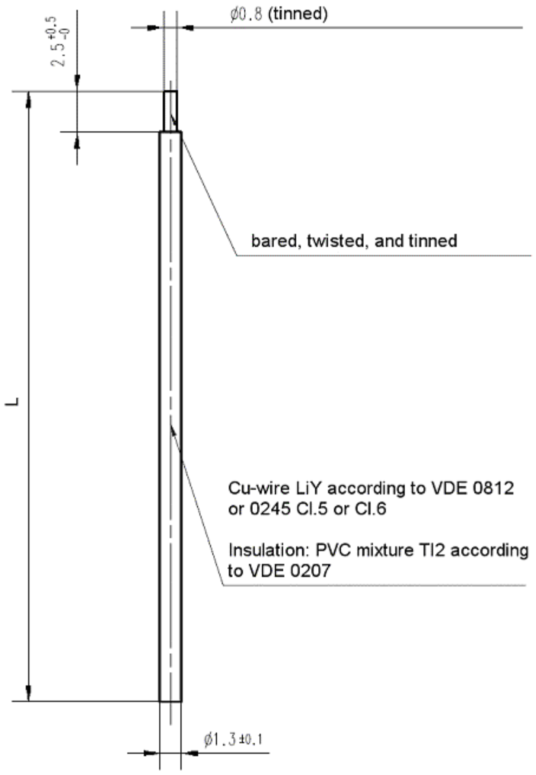
3.2. Antenna Mounting

Positioning and choice of receiver and transmitter antennas are the most important factor in determining system transmission range. The STM11x / STM11xC transmitter module is supplied with a soldered whip antenna as standard. By using that antenna, very compact sensor equipment can be implemented with good radio transmission characteristics. For mounting the antenna, some notes should be considered to optimize system performance:

For best transmitter performance, the space immediately around the antenna has to be strictly considered, since this has a strong influence on screening and detuning the antenna. The antenna should be drawn out as far as possible and must be never cut off. Mainly the far end of the wire should be mounted as far as possible away from all metal parts, PCB strip lines and fast logic components (e.g. the STM microprocessor). Don't short the whip ($\lambda/4$).

⚠ For a good antenna performance don't roll up or twist the whip and please draw attention to an overall whip distance of at least 10 mm (20 mm is better) from any PCB strip, ground plane and conductive part or electric part.

Note that whip antennas do not show any directional effects under free-field radio-wave propagation conditions (spot-wise radiator). The RSSI voltage output of the receiver module can be used for evaluating the influence of intuitive RF optimizations.



STM11x : L=89 ± 2 mm, color blue

STM11xC: L=242 ± 2 mm, color orange

Figure 8: Specification of the whip antenna

3.3. 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 particular application.

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

- ***Line-of-sight connections:*** Typically 30m range in corridors, up to 100m in halls
- ***Plasterboard walls / dry wood:*** Typically 30m range, through max. 5 walls
- ***Brick walls / aerated concrete:*** Typically 20m range, through max. 3 walls
- ***Ferroconcrete walls / ceilings:*** Typically 10m 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 0.5m.

3.4. Connecting the solar cell

The supplied solar cell has been designed especially for maximum module performance at smallest dimensions. The active solar area is divided into two to provide independent module power supplies:

- V_SC1: Main power supply input. Must be connected to the small active area of the solar cell or to another external energy source respectively
- V_SC2: Goldcap charging input. Must be connected to big active area of solar cell

The solar cell must be connected to the module in series with Schottky Diodes of type BAS 125. In Figure 9 the dual diode BAS 125-07 (SMD, parallel pair) is used.

⚠ For outdoor use in addition the BZX84-B5V1 diodes (leakage current at 2V must be below 2µA) are needed to avoid damage of the module by over voltage.

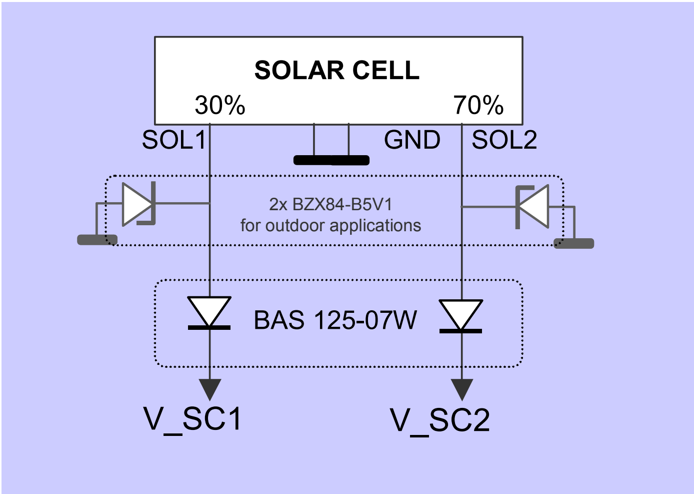


Figure 9: Connecting the solar cell

3.5. Solar Cell Handling, Soldering & Mounting

The EnOcean solar cell technology guarantees the highest stabilized efficiency values. At the front, the solar modules have a glass covering that protects the photovoltaic layer from the effects of the environment and weather. The rear features contacts for the electrical connection.

Handling

- Prevent injuries due to the sharp glass edges.
- Always handle the modules carefully, avoid damage of the glass edges that leads to glass breakage or glass chips. The layers are sensitive to punctual pressure, scratching or grinding. During handling and processing, always make sure that no particles are pushed into the coating. Scratches, imprints or particles pushed into the layer can lead to short-circuiting of the module, thus deterioration.
- The processing of the modules with lacquer spray processes or edge grinding could lead to an impairment of the electrical function of the module (electrostatic influences).
- In case of necessary module cleaning, the following cleaning agents are suggested: Kleenex (200 tissues, Code 7107, D 0261 8930, Kimberly-Clark) / highpure DI- water / Ethanol (min. 99,8 Vol.%).

Soldering

The solar panel has 3 connection pads on the rear side. On one side you will see the minus sign. This is the GND connection.

Apparatus

- Soldering iron: Temperature-controlled type with 60W heater at least and +/- 5°C control range is recommended.
- Soldering iron tip: Slant type or point type.
- Temperature Measuring Device: A calibrated contact-type temperature meter (e.g. Anritsu Model No. HL-100).

Materials

- Pb-free solder wire: Sn96.5/Ag3.0/Cu0.5, ∅ 0.8 mm, (e.g. Kester 245)
- Lead wire: Dependent on the type of solar cell, use 20 - 30 AWG multi-threads stranded type. For Pb-free soldering, the lead wire component shall be complied with RoHS requirement.

Procedure for hand soldering

- Environment: Soldering operation shall be performed in a clean environment with ventilation to remove soldering fume during the operation.
- Soldering temperature calibration
  - Temperature measuring device: The device (e.g. Anritsu Model No. HL-100) shall be stabilized at room temperature prior to and during calibration.
  - Timing: Calibrate the soldering iron tip before the operation or every 30 minutes after the soldering.
  - Procedure
    (a) In Pb alloy soldering, the soldering iron shall be set up and stabilized at 240°C before and in the calibration. For Pb-free solder wire, the soldering iron shall be set up and stabilized at 255°C before and in the calibration.

(b) Take little solder wire on the soldering iron tip and put the tip in contact with the contact-pad of the temperature meter for 1 minute.
(c) Temperature shown on the temperature meter shall be 255°C (Pb-free) at least for one minute otherwise re-adjust the temperature setting of the soldering iron.

- Soldering operation

Step 1: Make soldering iron tip and solder wire contact with the copper paste of solar cell together. At this moment, tin pot formed in a shape of half ball type or makes a plane type on the copper paste. All the processes shall be well done less than 2 seconds.

Step 2: Melt solder wire on the top of solder lead wire. Weld the tin pot again and put the lead wire into the inside of tin pot. Take off the solder iron tip. Finish this step within 2 second also.

Soldering operation on the solar cell shall be non-destructive. At any time, only make the soldering iron tip contact the copper paste of the solar cell less than 2 seconds.

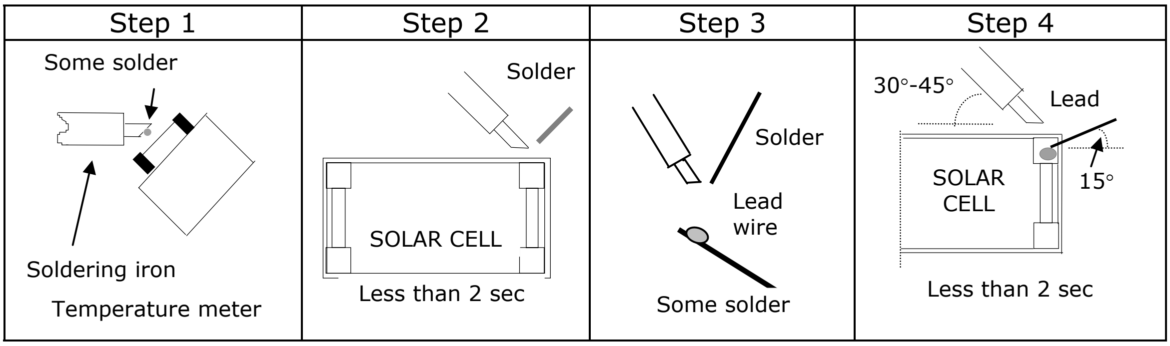
- Attention
  - Hold the soldering iron at an angle of 30° to 45° with the solar cell in the welding process
  - Lead wire is in the contact with the copper paste at an angle of 15°
  - Make sure the welding process not more than the time limit and the lead wire in good contact with copper paste through the solder. Please watch out the loose contact between the lead wire and the copper paste if any
  - Do not move the lead wires and solar cell before cooling the tin pots
  - Weld soldering is always with smooth surface and with shine.

- Test criteria
  - Pull strength in vertical direction: more than 500 gram
  - Pull strength in horizontal direction: more than 200 gram

Note 1: For pull strength test, the lead wire used should be 28-30 AWG multi-threads stranded type

Note 2: Lead wire breakage is excluded

- Operation illustration



The function of the solar module may be impaired by exceeding the recommended soldering temperature and the specified soldering time!

Gluing

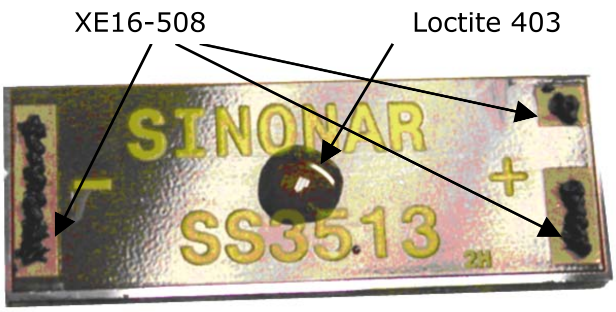


Figure 10: Gluing the solar cell

Instead of soldering it is also possible to glue the solar cell onto a PCB.

It is proposed to use the following adhesives:

a) GE Bayer Silicones XE16-508 (electroconductive adhesive)
b) Loctite 403 (to increase mechanical stability)

First the XE16-508 is put onto the contact pads of the solar cell. Then a drop of Loctite 403 is put in the middle of the solar cell.

After that the solar cell is put onto the PCB. Then the solar cell is pressed onto the PCB accompanied by small rotary movements (<<1mm).

Wear gloves to avoid finger prints on solar cell!

The curing time of Loctite 403 is only 5 seconds once the solar cell is pressed onto the PCB. Positioning must be finished by then!

Corrosion protection

Corrosion protection is essential to the lifetime of the solar module. The solar module is extremely resistant to temperature effects. But mounting must particularly provide protection against humidity. The proper choice of suitable sealing material is important.

The best method is protection by a transparent cover, mainly important for outdoor applications. Also well-suited is a casing by silicone (not acrylic!). With every kind of protection solution, it is very important that the cell edges and the metallic contact areas are covered.

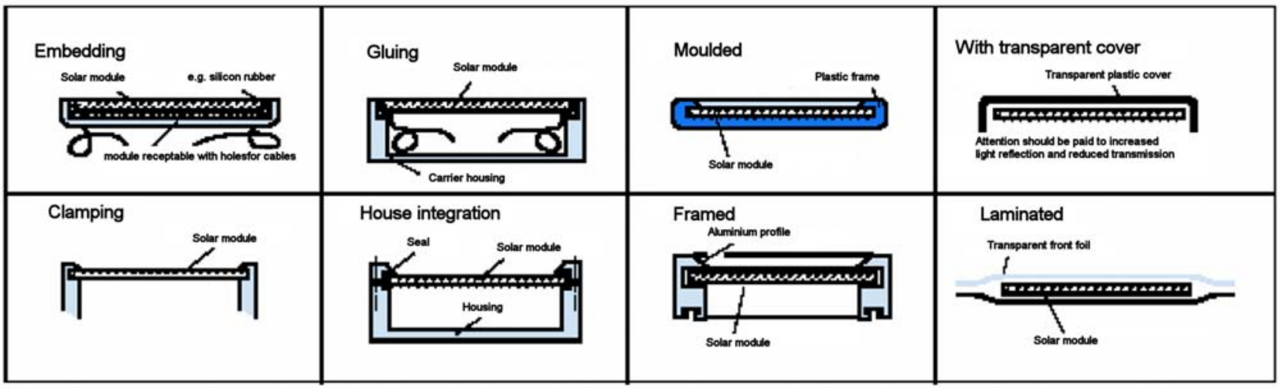


Figure 11: Examples of solar cell mounting

Shade

During installation, care should be taken to ensure that the active photovoltaic area is not shaded. The cells (strips), which produce the least current due to shade, determine the total module current.

3.6. Using an Alternative Power Supply, e.g. Battery

Alternatively to the use of the supplied solar cell, the module power supply input V_SC1 can be driven by another suitable external energy source.

The external energy source must fulfill the following requirements:

Parameter	Min	Typ	Max	Unit
Open circuit voltage	2.2		5.0	V
Ampacity (Peak)	10			mA
Ampacity (continuous)	1			µA

⚠ When using a battery please take care that the transistion resistance between battery and battery holder is << 10Ω to avoid voltage drop!

⚠ Wrong polarity will damage the module!

3.7. Learn Push Button

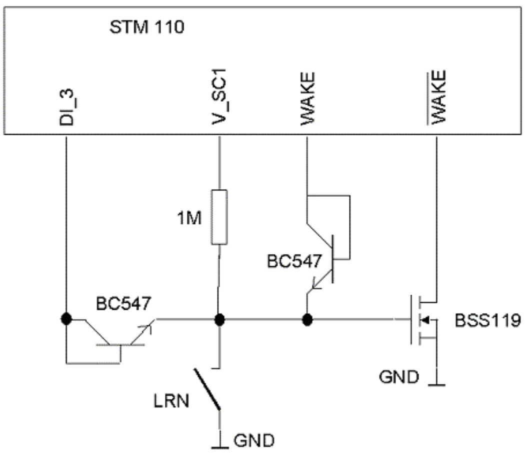
There are two fundamental methods for transmitter assignments to a receiver:

1.) Manual input of the transmitter ID into the receiver system

2.) The receiver systems automatically learns the ID of a received radio telegram by a special teach-in routine

In the second case please note that cyclic sending sensors can be unintentionally learned, mainly if there are some sensors in operation at the same time. Because of that it is recommended to implement a learn procedure that is reacting to a dedicated "Learn Telegram" only. This special learn procedure has to be realized by the system intelligence after RCM 120 serial interface. RCM 130/130C features a special learn mode which allows to learn 4BS transmitters only with LRN bit (DI_3=0). For example this can be realized as follows.

Recommendation for the realization of a learn push button:



3.8. CE Approval Requirements STM 11x

The STM 11x 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 11x 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. For approval aspects, it must be ensured that the STM 11x radio module does not transmit measuring data more than 9000 times per hour. For this calculation the extraordinary short telegram length is considered including all subtelegrams. Also a tolerance of 5% in telegram length is included.

3.9. FCC/IC Approval Requirements STM 11xC

Because of the very low radiated field strength on average, the EnOcean radio technology can be approved in the USA and in Canada. If the STM 11xC is operated in compliance with the following requirements, a finished sensor unit containing this radio will comply with Part 15 of the FCC Rules and with RSS-210 of Industry Canada.

Because dedicated timing limit conditions are claimed, no STM 11xC module approval is possible in general. The finished radio sensor unit has to be approved by a notified body for operating free of charge in the area of the United States of America ("FCC approval") and in Canada ("IC approval").

FCC/IC operational and timing requirements:

Field strength:

Because of the very low average to peak factor, the (corrected) field strengths of EnOcean transmitters meet the field strength limit values according to FCC 15.231 (e):

Duty Cycle:

The length of one packet is 1.21 ms. Within a packet the duty cycle is ~50%, ~ 0.6 ms.

Periodic transmissions:
One pulse train consists of 3 packets within 100 ms.
Added we have a TX-time 3*0.6 ms within 100ms, this is a duty cycle of 1.8 %.
The average value is (Peak -20*log(1.8/100)) = Peak – 34.9 dB.

Radiated field strength is 75.7 dBµV/m at 3m distance PEAK .
The calculated AVERAGE is 75.7 dBµV/m – 34.9 dB = 40.8 dBµV/m at 3m distance.

The limit for 315 MHz according to FCC15.231 (e) is 67.7 dBµV/m.

The product complies with the FCC and IC requirements for periodic transmissions

A test report containing the measurement results is available from EnOcean on request.

Periodic transmissions:

In addition to the field strength limits according to FCC 15.231 (e) the silent period between periodic transmissions must in no case be less than 10 seconds. As the STM11xC module also allows other configurations this must be ensured in the development of the finished radio sensor unit.

Control signals:

On manually triggered wake-up the module may – according to FCC 15.231 (a) – transmit a control signal including data. [1]

[1] according to FCC 01-290: "It may be possible to design a device that sends data signals under one set of provisions and control signals under the other…"

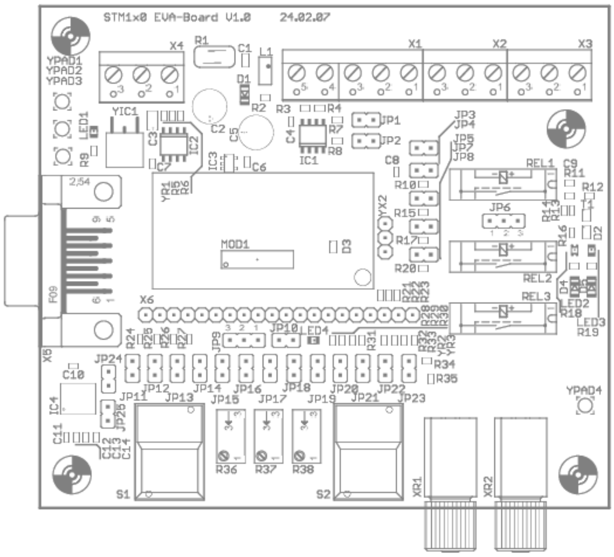
4. DEVELOPMENT TOOLS

4.1. Evaluation Kit EVA 120 / EVA 120C

EVA 120 is an evaluation kit for the solar powered sensor module STM110.

EVA 120 contains an evaluation board, a USB adapter and an STM110 module. The evaluation board is designed to allow easy evaluation of STM110 product features and to support the development of customer specific products based on STM110. The main features of the evaluation board are listed below.

A US version for 315MHz is also avaliable. EVA 120C contains an STM 110C module.



Features of the evaluation board:

- Supply of STM110 via solar cell, battery or external power supply
- External control of charge / discharge cycles
- Optical interface for WAKE inputs
- Push-button connected to WAKE inputs
- Push-button to initiate learn telegram
- RS232 interface and USB adapter for configuration of the module
- Jumpers for setting wake and transmit cycles
- Potentiometers to set analog values, jumpers for digital inputs
- Buffered measurement of V_SC1 and V_SC2
- Transmission indicator LED
- Temperature range –25°C / +65°C

Type	EnOcean Ordering Code	Scope of supply
EVA 120	**H3004-G120**	• 1x Evaluation board • 1x STM110 • 1x RS232/USB adapter • 1x CDROM
EVA 120C	**H3034-G120**	• 1x Evaluation board • 1x STM110C • 1x RS232/USB adapter • 1x CDROM

4.2. Evaluation Kit EVA 100 / EVA 105C

EVA 100 / 100C is an evaluation kit to support a simple setting-up operation of the receiver side when the EnOcean sensor transmitter module STM 11x / STM 11xC is evaluated. EVA 100 / 105C supports a rapid evaluation of the serial receiver mode and supports the fast development of applications.

Type	EnOcean Ordering Code	Scope of supply
EVA 100	**H3004-G100**	• Evaluation board EVA-PCB • EnOcean 868 MHz radio devices STM 11x, PTM 200, RCM 110 and RCM 120 • CD with RS232 PC-link monitor software and detailed kit documentation • 230V wall power supply for EVA-PCB • Convenient equipment case
EVA 105C	**H3034-G105**	• Evaluation board EVA-PCB • EnOcean 315 MHz radio devices STM 11xC, PTM 200C, RCM 110C and RCM 130C • CD with RS232 PC-link monitor software and detailed kit documentation • Convenient equipment case • 120V wall power supply

4.3. Field Intensity Meter EPM 100 / EPM 100C

The EPM100 / EPM100C is a mobile field-intensity meter that helps the engineer to find the best installation positions for sensor and receiver. It can also be used to check disturbances in links to already installed equipment. The EPM100 / EPM100C displays the field intensity of received radio telegrams and interfering radio signals in the 868MHz / 315MHz range.

The simplest procedure for determining the best installation positions for the radio sensor/receiver:

- Person 1 operates the radio sensor and generates pushbutton radio telegrams.
- Person 2 checks the received field intensity on the meter display to find the optimal installation position.

Type	EnOcean Ordering Code	Frequency
EPM 100	**S3004-J100**	**868 MHz**
EPM 100C	**S3034-J100**	**315 MHz**

5. SPECIFICATION OF SS3513 SOLAR CELL

1. SCOPE

THESE SPECIFICATIONS ARE APPLICABLE FOR **SINONAR** AMORPHOUS SOLAR CELL SUPPLIED TO **SIEMENS.**

2. GENERAL FEATURES

2.1 MODEL NO.

SS3513Y (SOLAR CELL)

2.2 DIMENSIONS REFER TO DRAWING NO. P1600, EDITION E
ALL TOLERANCES ARE SPECIFIED ON THE DRAWING AND NUMBERS WITHOUT TOLERANCES ARE FOR REFERENCE ONLY.

2.3 OPERATING TEMPERATURE RANGE

-25℃ TO 65℃

2.4 STORAGE TEMPERATURE RANGE (Please Solder in 3 months)

-25℃ TO 85℃ ， 0% TO 60% RH

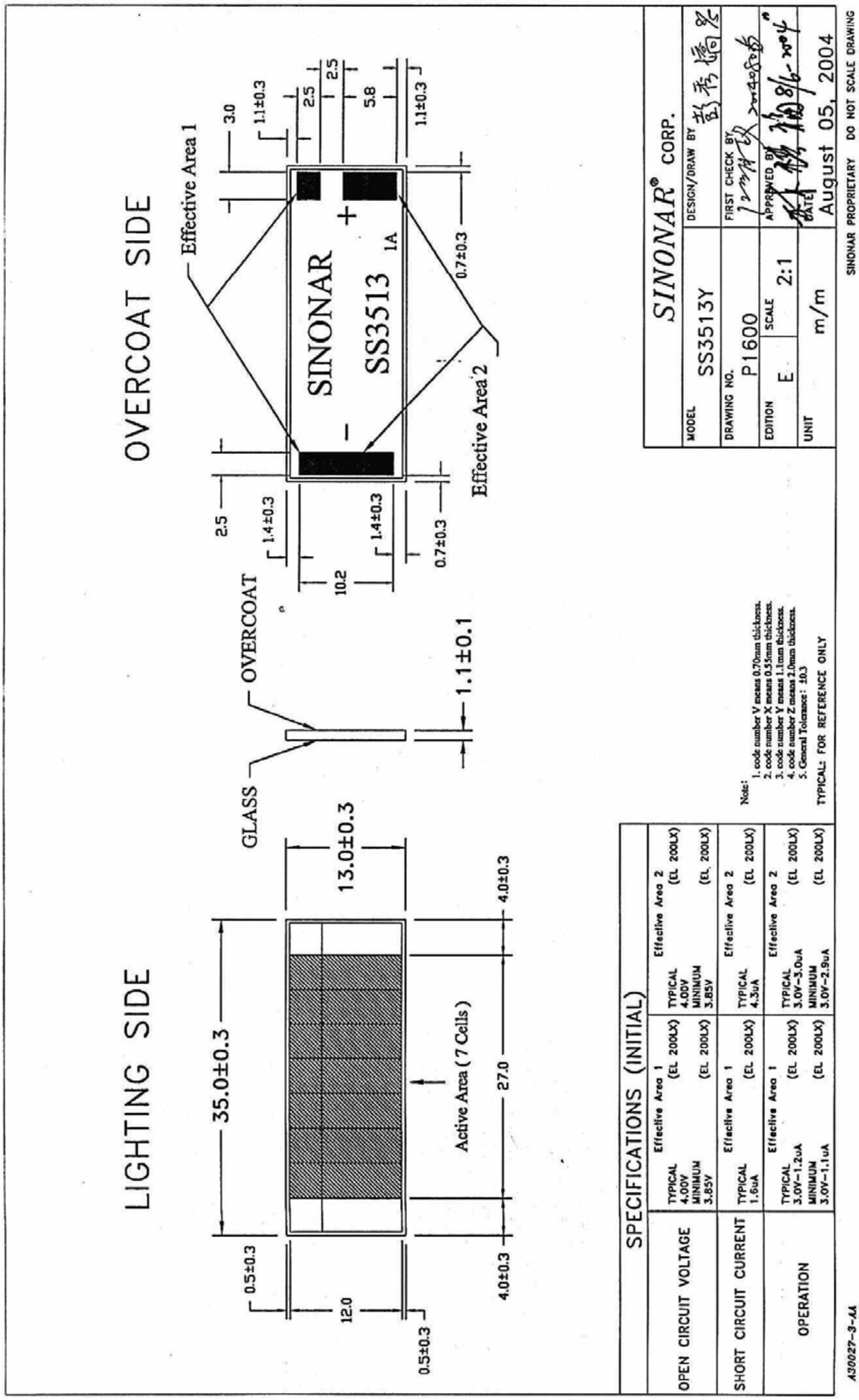
3. FUNCTIONAL SPECIFICATIONS

(at 200 Lux EL, 25℃)

Item	Specification (Initial)			
	Effective Area 1		Effective Area 2	
Open Circuit Voltage	Typical	4.00 V	Typical	4.00 V
	Minimum	3.85 V	Minimum	3.85 V
Short Circuit Current	Typical	1.6 uA	Typical	4.3 uA
Operating Voltage and Current	Typical	3.0 V – 1.2 uA	Typical	3.0 V – 3.0 uA
	Minimum	3.0 V – 1.1 uA	Minimum	3.0 V – 2.9 uA
Resistance	2,727 KΩ		1,034 KΩ	

EL： Electro Luminescent Lamp

NOTICE



LIGHTING SIDE
OVERCOAT SIDE
35.0±0.3
13.0±0.3
12.0
27.0
4.0±0.3
0.5±0.3
Active Area (7 Cells)
GLASS
OVERCOAT
1.1±0.1
SINONAR
SS3513
1A
Effective Area 1
Effective Area 2
10.2
1.4±0.3
2.5
0.7±0.3
3.0
1.1±0.3
5.8
SPECIFICATIONS (INITIAL)
OPEN CIRCUIT VOLTAGE
SHORT CIRCUIT CURRENT
OPERATION
SINONAR® CORP.
MODEL SS3513Y
DRAWING NO. P1600
EDITION E
SCALE 2:1
UNIT m/m
DESIGN/DRAW BY
FIRST CHECK BY
APPROVED BY
DATE August 05, 2004
SINONAR PROPRIETARY DO NOT SCALE DRAWING
TYPICAL: FOR REFERENCE ONLY
A30027-3-AA

6. DECLARATION OF CE CONFORMITY

EnOcean GmbH
Kolpingring 18a
D 82041 Oberhaching
www.enocean.com

Declaration of Conformity

CE

We:	**EnOcean GmbH** **Kolpingring 18a** **D 82041 Oberhaching** **Germany**
Declare:	**under our sole responsibility that the following labeled product:** **Transmitter: STM110** **to which this declaration relates, is, when used according to specification, in conformity with the technical requirements of the standards and the provisions of the essential requirements of the Directives detailed below.**
Directives:	**Electromagnetic Compatibility Directive 89/336/EC** **Radio and Telecommunications Terminal Equipment Directive R&TTE 1999/5/EC**
Standards:	**ETSI EN 301 489-1: 2005-09, ETSI EN 301 489-3: 2002-08 (SRD class 2)** **ETSI EN 300 220-3: 2000-09**
Recommendations:	**ERC Recommendation 70-03: 2005-11**

Place of issue: Oberhaching
Quality Manager:
Manfred Schmelig
Signature:

Date of issue: 5. April 2007
General Manager:
Markus Brehler
Signature: