Appendix K: Manual

Please see the following pages.

USER MANUAL V0.904

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RF Sensor Transmitter Module
STM110C

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1 GENERAL DESCRIPTION

The extremely power-saving RF transmitter module STM110C from EnOcean enables the implementation of wireless and maintenance-free sensors. Power supply is provided by a solar cell. An integrated energy storage 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.

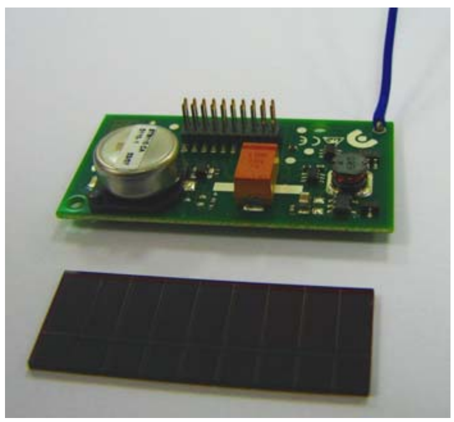


Figure 1: STM110C sensor transmitter module

1.2 Typical Applications

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

The STM110C module serves the 315 MHz air interface protocol of EnOcean. Together with the transceiver modules TCM200 / TCM210C, 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.

1.3 Technical Data

Power supply	Solar Power Generator (discrete optical cell), or 2.2 - 5.0V external
Frequency / Conducted transmission power	315.0 MHz / 12dBm
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%)
Redundant retransmission	user-configurable, affected at random
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 statistically 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 redundant retransmission is sent after a while to announce all current input values. 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	21.0 x 40.0 x 9.0 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 15 cm whip antenna
Connector:	20 pins, dual row male, grid 1.27 mm

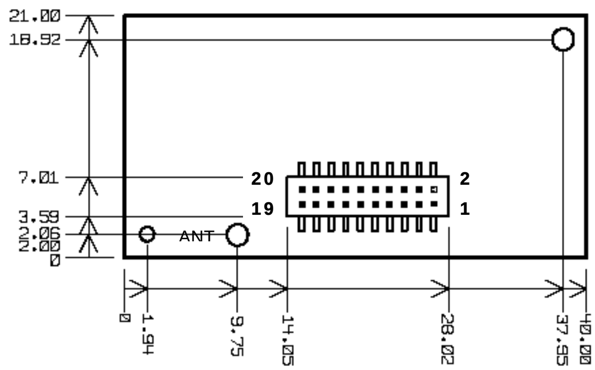


Figure 2: **STM110C package outlines**

1.5 Environmental Conditions

Operating temperature	-25°C up to +65 °C
Storage temperature	-25°C up to +65 °C
Humidity (PCB)	0% to 95% r.h.
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
STM110C	**S3031-D110**	**315.0 MHz**	**Included**
STM111C	**S3031-D111**	**315.0 MHz**	**Not included**

2 FUNCTIONAL DESCRIPTION

2.1 Block Diagram

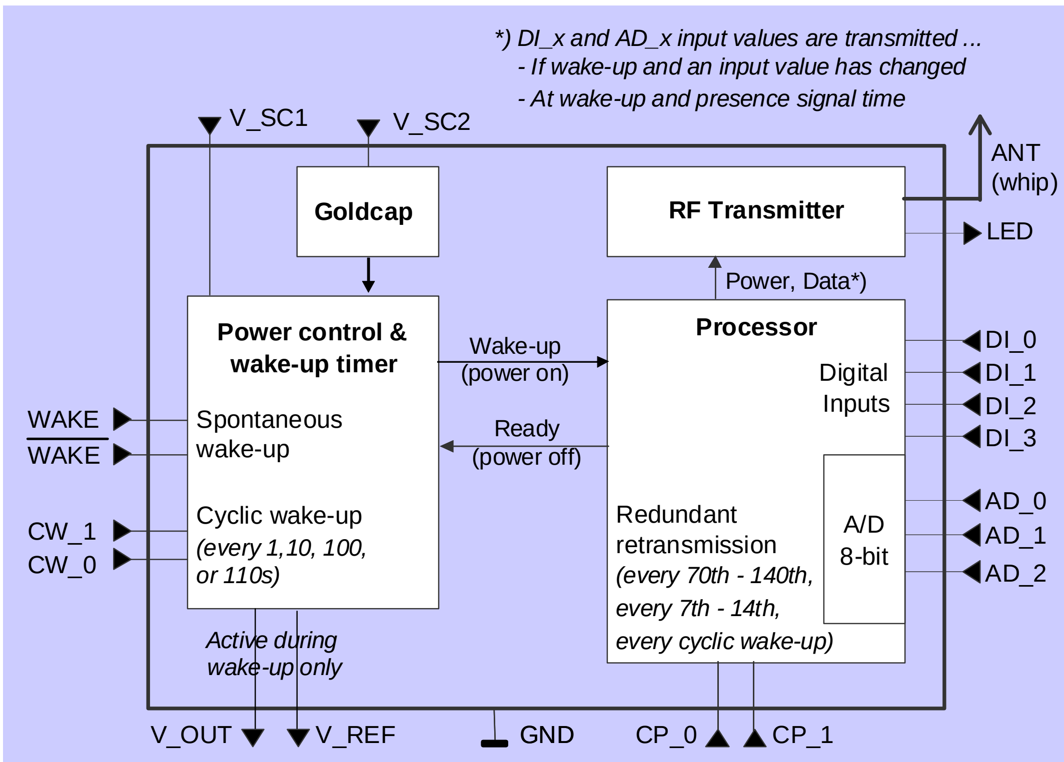


Figure 3: STM110C block diagram

Module power supply

The supplied solar cell has been designed especially for the STM110C 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 STM110C solar cell (small active area) or by another external energy source respectively
- V_SC2: Goldcap charging input by connecting to the STM110C 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:

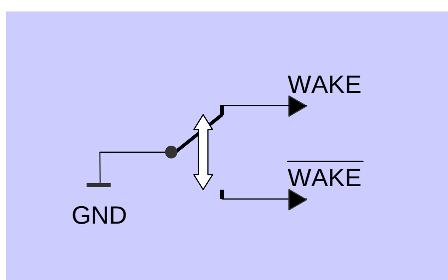


Figure 4: External WAKE pin circuit

⚠ A radio telegram is always transmitted after wake-up via WAKE pins!
After transmission the counter for redundant retransmission is reset to a random number in the configured range.

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) Counter for redundant retransmission is elapsed

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 timing of redundant retransmission.

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

Pin	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 21.	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 redun-	Pins should be left open or connected to GND Resistance to GND < 100 Ω

		dant retransmission: Every wake-up signal, or every 7th - 14th, or every 70th - 140th or no redundant retransmission.	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 STM110C 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 STM110C 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.

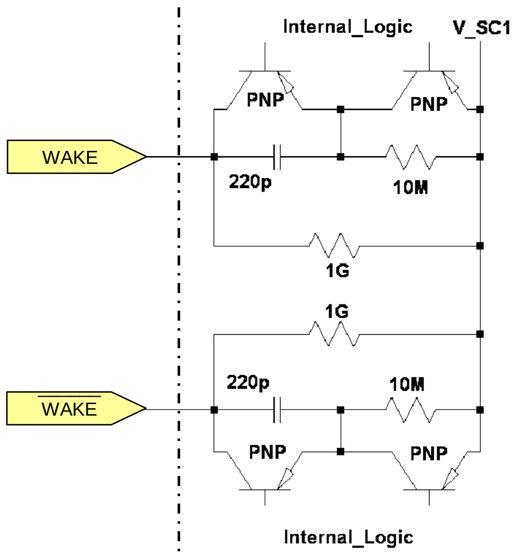
2.3 Absolute maximum ratings

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.

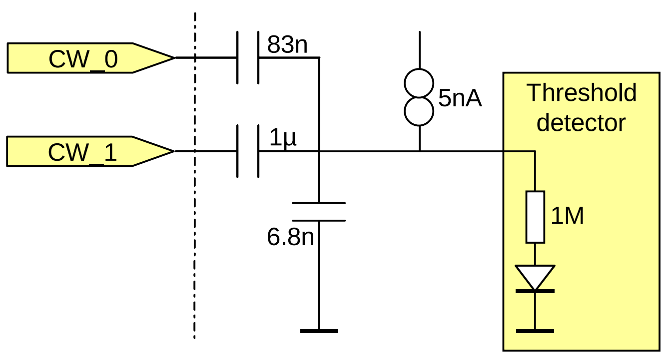
⚠ Exceeding these values may destroy the module!

2.4 Equivalent schematics of Inputs and Outputs

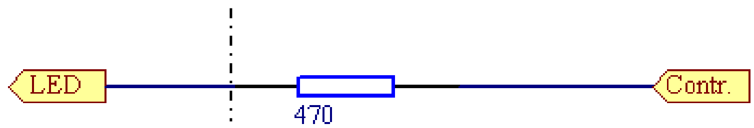
Equivalent schematic of WAKE and /WAKE inputs



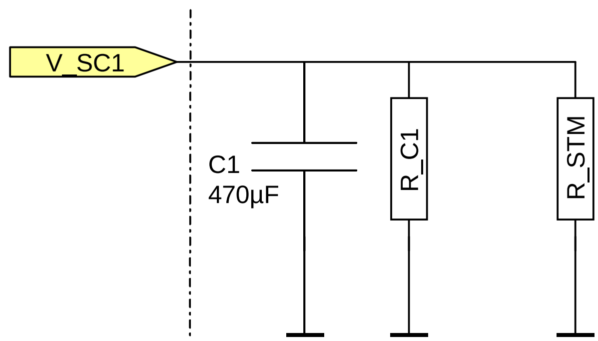
Equivalent schematic of wake-up cycle time inputs CW_0 to CW_1



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.

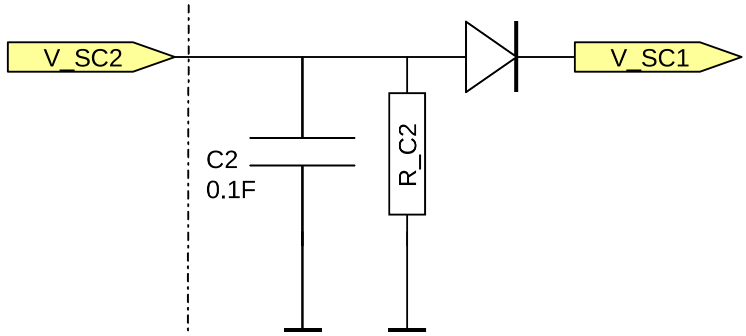
R_STM: depends on wake-up cycle time, transmit intervals and supply voltage.
In the following table R_STM is given at a supply voltage of 3V (typical values):

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

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

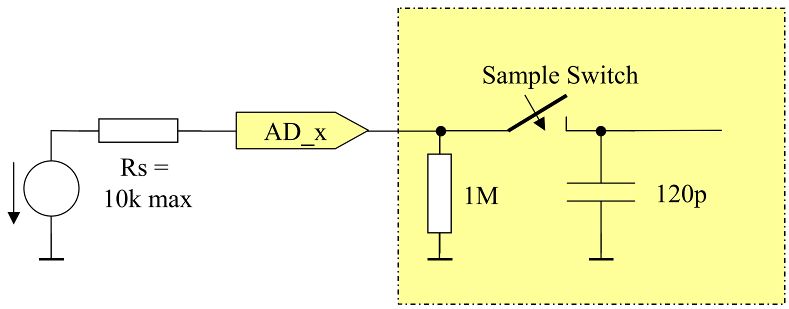
I_STM [µA]	1s	10s	100s	110s
Every wake-up	130	13	1.3	1.1
Every 10th wake-up (average)	50	5.0	0.50	0.45
Every 100th wake-up (average)	40	4.0	0.40	0.35

Equivalent schematic of V_SC2 input

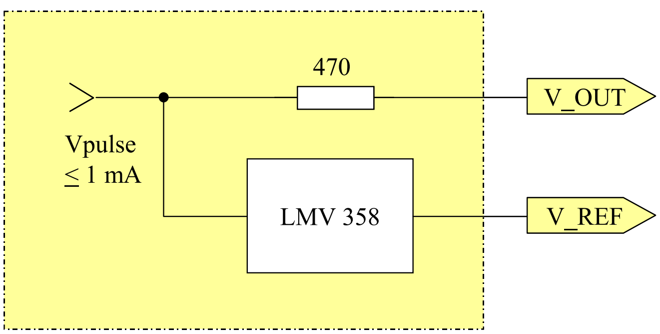


R_C2: ~375 kΩ after 3 V applied for 10 min., ~5MΩ after 24h

Equivalent schematic of analog inputs AD_0 to AD_2



Equivalent schematic of voltage outputs V_OUT 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%

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 1s wake-up cycle time is not allowed!

If applied in other (non-safety, non-security) applications a minimum of 10s 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 STM110C is not valid in this case.

2.6 Solar Energy Balance Calculation

The following diagrams are showing operational performance data of STM110C.

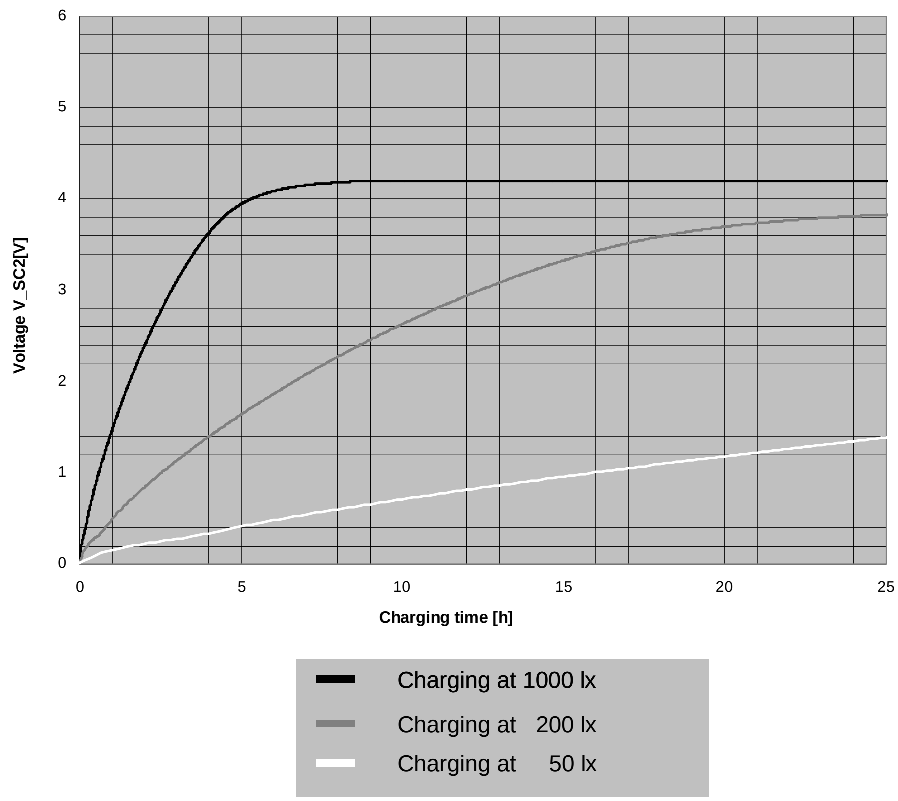


Figure 5: Graphs of the goldcap charging process (typ. @25°C). Measured with white light LEDs, illustration of the illumination level as fluorescent lamp equivalent (EL). Measured with 100s wake up timer.

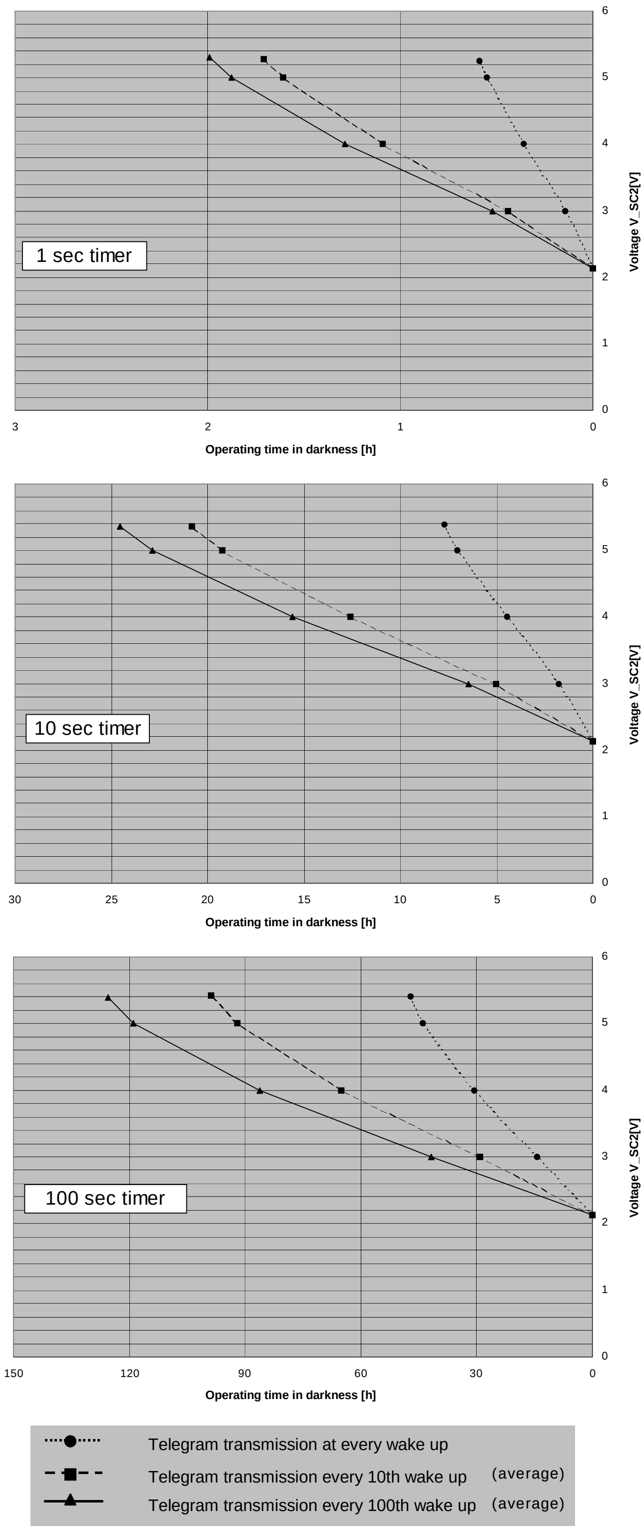


Figure 6: STM110C operation time in darkness (typ. @25°C)

In the figure left typical values are shown. In worst case the operating time in darkness may be 20% less!

2.7 Radio Telegram of STM110C

Frequency range and modulation scheme

Because of the very low radiated field strength on average, products based on STM110C (315.0 MHz) can be approved in the USA and in Canada. The approval requirements can be found in chapter 4 of this paper.

STM110C is 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 STM110C 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.

2.7 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:

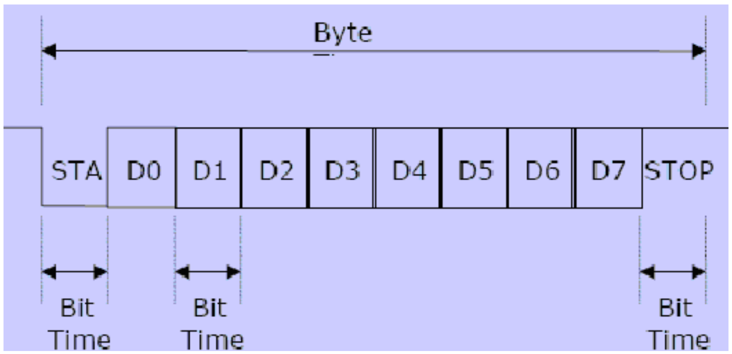
1. Connect LED pin to V_OUT pin
2. Activate STM110C using the timer or the WAKE inputs.

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: *STM110 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*

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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

2.8 Serial Data Reception via Transceiver Modules TCM 200C / TCM 210C

For a detailed description please refer to the User Manual of TCM200C/TCM210C.

Type of STM110C protocol which is seen at the serial outputs of the receiver modules is “4BS” (4 Byte Sensor):

Description of STM110C 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 TCM200C/TCM210C serial interface if DI_3=0:

Description of STM110C 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)

ORG	Data_Byte3	Data_Byte2	Data_Byte1	Data_Byte0	ID

Profile	Type	Manufacturer-ID	LRN Type	RE2	RE1	RE0	LRN	DI2	DI1	DI0
6 Bit	7 Bit	11 Bit	1Bit	1Bit	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 STM110C 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.

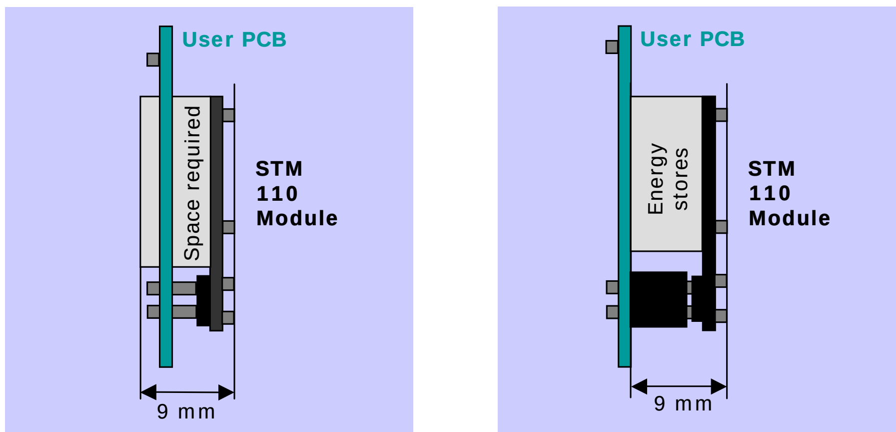


Figure 7: Examples of compact sensor unit

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.

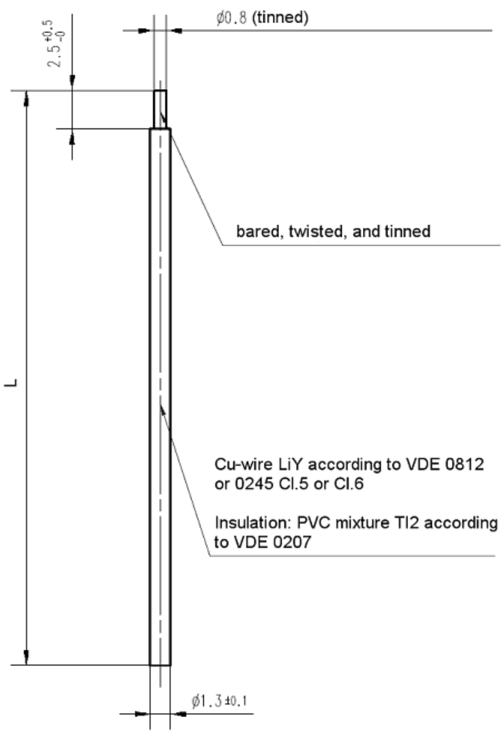
3.2 Antenna Mounting

Positioning and choice of receiver and transmitter antennas are the most important factor in determining system transmission range. The STM110C 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.



STM110C: L=150 ± 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 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.

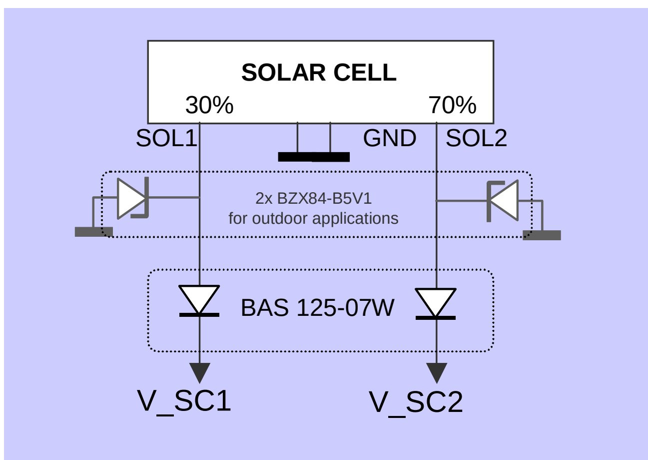


Figure 9: Connecting the solar cell

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

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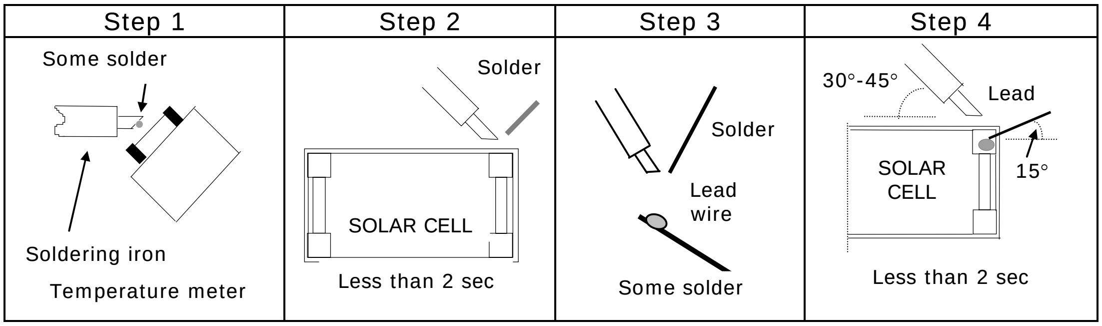
- Operation illustration



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

Gluing

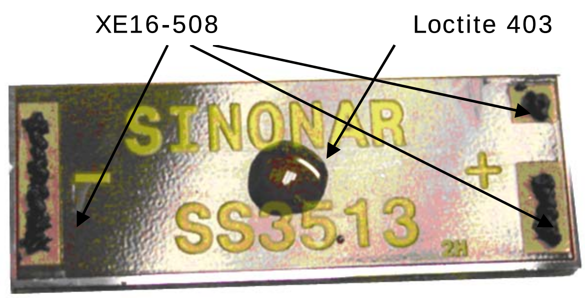


Figure 10: Gluing the solar cell

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.

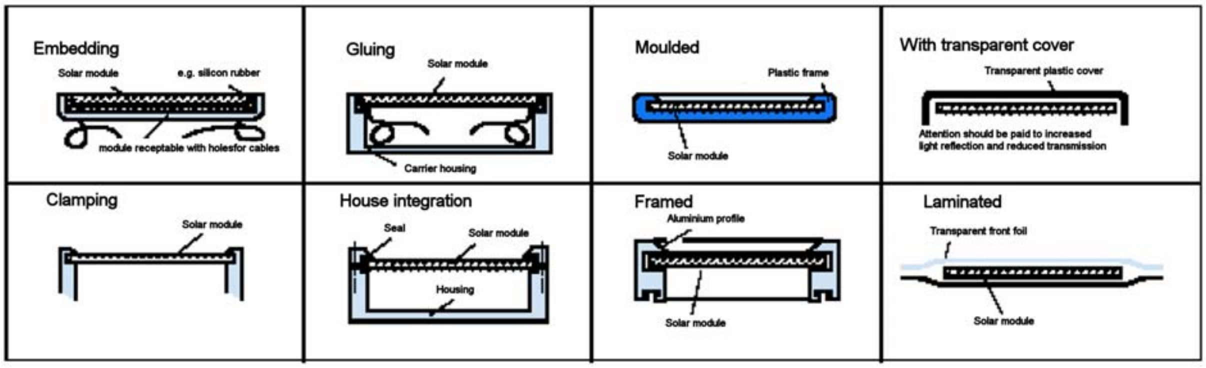


Figure 11: Examples of solar cell mounting

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.

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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

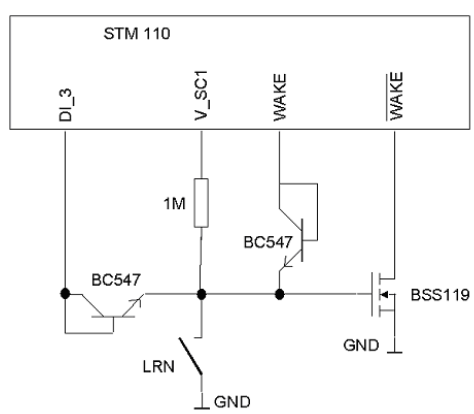
There are two fundamental methods for transmitter assignments to a receiver:

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 TCM200C/TCM210C serial interface. For example this can be realized as follows.

Recommendation for the realization of a learn push button:



4 AGENCY CERTIFICATIONS

4.1 FCC (United States) Certification

STM110C 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 STM110C 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.

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-STM110C
  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.	Integrated Wire/Monopole	1.0 dBi

4.2 IC (Industry Canada) Certification

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: 5731A-STM110C

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

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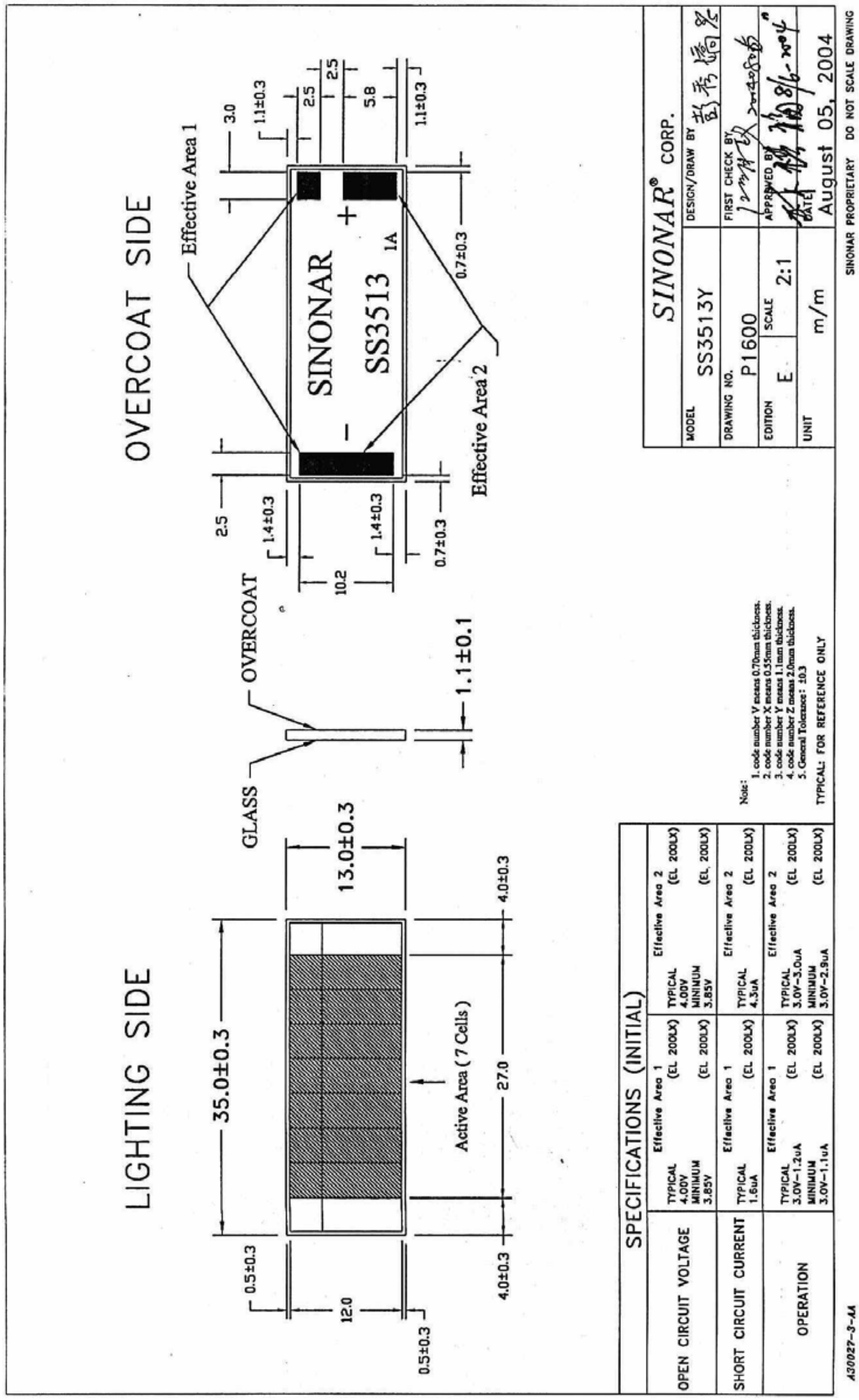
LIGHTING SIDE
35.0±0.3
0.5±0.3
12.0
0.5±0.3
4.0±0.3
27.0
4.0±0.3
13.0±0.3
Active Area (7 Cells)
GLASS
OVERCOAT
1.1±0.1
OVERCOAT SIDE
Effective Area 1
Effective Area 2
SINONAR
SS3513
1A
+
-
3.0
1.1±0.3
2.5
2.5
5.8
1.1±0.3
0.7±0.3
2.5
1.4±0.3
10.2
1.4±0.3
0.7±0.3
SPECIFICATIONS (INITIAL)
OPEN CIRCUIT VOLTAGE
Effective Area 1 TYPICAL 4.00V MINIMUM 3.85V (EL 200LX)
Effective Area 2 TYPICAL 4.00V MINIMUM 3.85V (EL 200LX)
SHORT CIRCUIT CURRENT
Effective Area 1 TYPICAL 1.6uA (EL 200LX)
Effective Area 2 TYPICAL 4.3uA (EL 200LX)
OPERATION
Effective Area 1 TYPICAL 3.0V–1.2uA MINIMUM 3.0V–1.1uA (EL 200LX)
Effective Area 2 TYPICAL 3.0V–3.0uA MINIMUM 3.0V–2.9uA (EL 200LX)
Note:
1. code number V means 0.70mm thickness.
2. code number X means 0.55mm thickness.
3. code number Y means 1.1mm thickness.
4. code number Z means 2.0mm thickness.
5. General Tolerance: ±0.3
TYPICAL: FOR REFERENCE ONLY
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
A30027-3-AA