Scavenger Transmitter Module
STM 431T

July 29, 2019

Observe precautions! Electrostatic sensitive devices!

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

REVISION HISTORY

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

No	Major Changes
1.0	Initial version

Published by EnOcean GmbH, Kolpingring 18a, 82041 Oberhaching, Germany
www.enocean.com, info@enocean.com, phone ++49 (89) 6734 6890

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 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.

TABLE OF CONTENT

1 GENERAL DESCRIPTION

1.1 Basic functionality

The extremely power saving RF transmitter modules 43xJ of EnOcean are optimized for realization of wireless and maintenance free temperature sensors, or room operating panels including set point dial and occupancy button.
They require only a minimum number of external components and provide an integrated and calibrated temperature sensor.
Power supply is provided by a small solar cell, an external energy harvester or an external 3 V backup battery.
An energy storage element is installed in order to bridge periods with no supply from the energy harvester. The module provides a user configurable cyclic wake up.
After wake up, the internal microcontroller reads the status of the temperature sensor and optional set point dial. A radio telegram will be transmitted in case of a significant change of measured temperature or set point values or if the external occupancy button is pressed.
In case of no relevant input change, a redundant retransmission signal is sent after a user configurable number of wake-ups to announce all current values.
In addition to the cyclic wake-up, a wake up can be triggered externally using the input for the occupancy button or the internal LRN button.
The firmware can be configured to use different EEPs / GPs according to the availability set point dial and occupancy button.
STM 431T provides enhanced security features with encrypted communication. The modules can be switched from transport mode to standard or secure mode.

Features with built-in firmware

- Pre-installed solar cell
- On-board energy storage and charging circuit
- On-board LRN button
- On-board TX indicator LED
- Calibrated internal temperature sensor
- Input for external occupancy button and set point dial
- Configurable wake-up and transmission cycle
- Wake-up via Wake pins or LRN button
- Support for humidity sensor module HSM 100
- Enhanced Security communication
  (to enable this feature, the receiver or gateway has to support EnOcean security)

Features accessible via API

Using the Dolphin V4 API library it is possible to write custom firmware for the module.
The API provides:

- Integrated 16.384 MHz 8051 CPU with 64 kB FLASH and 4 kB SRAM
- Integrated temperature sensor
- Various power down and sleep modes down to typ. 100 nA current consumption
- Up to 13 configurable I/Os
- 10 bit ADC, 8 bit DAC

1.2 References

[1] Security of EnOcean Radio Networks - http://www.enocean.com/en/security-specification/
[2] Dolphin V4 Core Description - http://www.enocean.com/dolphin-v4-core-description/
[3] Dolphin V4 API - http://www.enocean.com/en/enocean-software/

[4] AN509 Explanation of EnOcean security in applications - http://www.enocean.com/en/application-notes/
[5] AN510 Adding Security to EnOcean Receivers - http://www.enocean.com/en/application-notes/
[6] AN511 Advanced security in self-powered wireless applications - http://www.enocean.com/en/application-notes/
[7] Microchip EEPROM Memory - www.microchip.com/serialeeprom/
[8] Generic Profiles Specification - http://www.enocean.com/en/knowledge-base/
[9] EnOcean Radio Protocol 2 - https://www.enocean.com/en/knowledge-base/

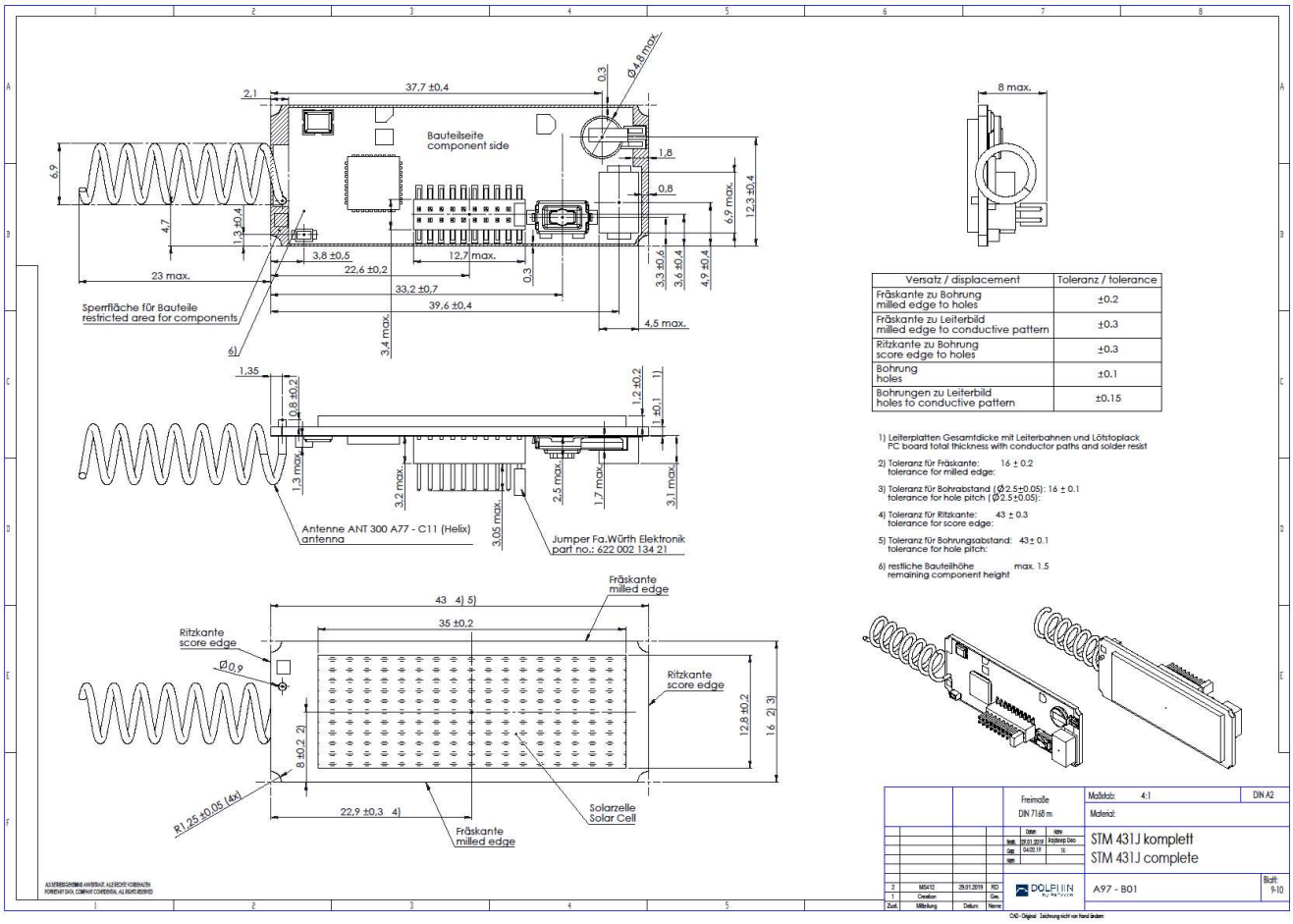
1.3 Technical data

Antenna	Helix antenna (STM 431T)
Frequency	921.4 MHz
Data rate/Modulation type	125 kbps/FSK
Radiated Output Power	Typ. 0dBm
Power Supply @ VDD	Pre-installed solar cell Illumination 50-100000 lux 2.1 V–5.0 V, 2.6 V needed for start-up
Operation time in darkness @ 25°C	min. 10 days, if energy storage is fully charged[1]
Operation start up time with empty energy store	typ. < 2.5 min @ 400 lux / 25 °C incandescent or fluorescent light
Input Channels	Internal: temperature sensor, LRN button External: occupancy button, set point dial, HSM 100
Temperature sensor	Measurement range 0-40 °C, resolution 0.16 K Accuracy typ. ±0.5 K between 17 °C and 27 °C typ. ±1 K between 0 °C and 40 °C
EnOcean Equipment Profiles	configurable EEPs: A5-02-05 (default), A5-10-05, A5-10-03 and with HSM 100: A5-04-01, A5-10-10, A5-10-12 SIGNAL 0x0E (Entering Transport Mode)
Generic Profiles Profiles	Temp : 0 – 40 Celsius, with 8, 10, 12 ,16 bit resolution More options available with source code change
Enhanced Security features	CMAC (3 bytes) / RLC (3 bytes) / VAES
Connector	20 pins, grid 1.27 mm, □ 0.4 mm
Radio Regulations	ARIB STD-T108
Security Level Format	24-bit RLC, RLC tx, 3-byte CMAC, VAES encryption

1.4 Physical dimensions

PCB dimensions	43±0.2 x 16±0.3 x 1±0.1 mm
Module height	8 mm
Weight	4.5 g

[1] At default configuration (wake-up cycle 100 s, transmission cycle 1000 s).
Energy storage performance degrades over life time, especially if energy storage is long time exposed to very high temperatures. High temperatures will accelerate aging. Very low temperature will temporary reduce capacity of energy store and this leads to considerable shorter dark time operation.



Drawing STM 431 J

1.5 Environmental conditions

Operating temperature	-20 °C … +60 °C
Storage temperature	-20 °C … +60 °C, recommended[2]: +10 °C…+30 °C, <60%r.h.
Shelf life (in absolute darkness)	36 months after delivery
Humidity	0% … 93% r.h., non-condensing

Deep discharge of the energy storage leads to degradation of performance. Radio modules will be delivered in transport mode to avoid this. If there is a storage time after configuration or commissioning, the radio module has to be switched back to transport mode to reduce power consumption to a minimum.

If a storage time of more than 36 months is required, the energy storage (MS414FE) has to be recharged (e.g. 2 days @ 1.000 lux) or with external 3.1 V.

The module shall not be placed on conductive materials, to prevent discharge of the internal energy storages. Even materials such as conductive foam (ESD protection) may have negative impact.

1.6 Ordering Information

Type	Ordering Code
STM 431T	**S3061-D431**

2 FUNCTIONAL DESCRIPTION

The module will be shipped in transport mode to switch off the energy store for long term shelf storage and air cargo. The mode can be changed by pressing the learn button. The procedure for enter the standard mode has not been changed to keep compatible with modules before stepcode DE.

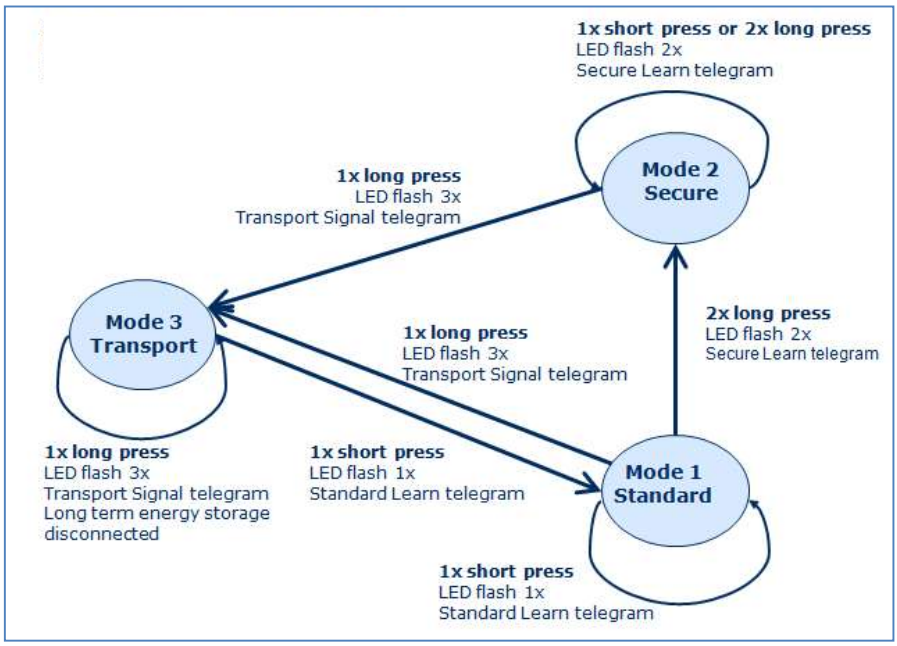
Make sure that the solar cell will get enough light for mode change and/or learn telegram.

- **Change from transport to standard mode**
  After pressing the learn button 1x short (1s) the radio module will enter Standard Mode (Mode 1). The LED will flash 1x and a standard learn telegram will be sent.

- **Change from standard to secure mode**
  After pressing the learn button 2x long (2x 5s, pause <1s) the radio module will enter Secure Mode (Mode 2). A secure learn telegram will be sent and the LED will flash 2x.

- **Change from secure or standard mode to transport mode**
  After pressing the learn button 1x long (5s) the radio module will enter Transport Mode (Mode 3). A signal telegram will be sent and the LED will flash 3x.

The following diagram illustrates all implemented mode transitions.



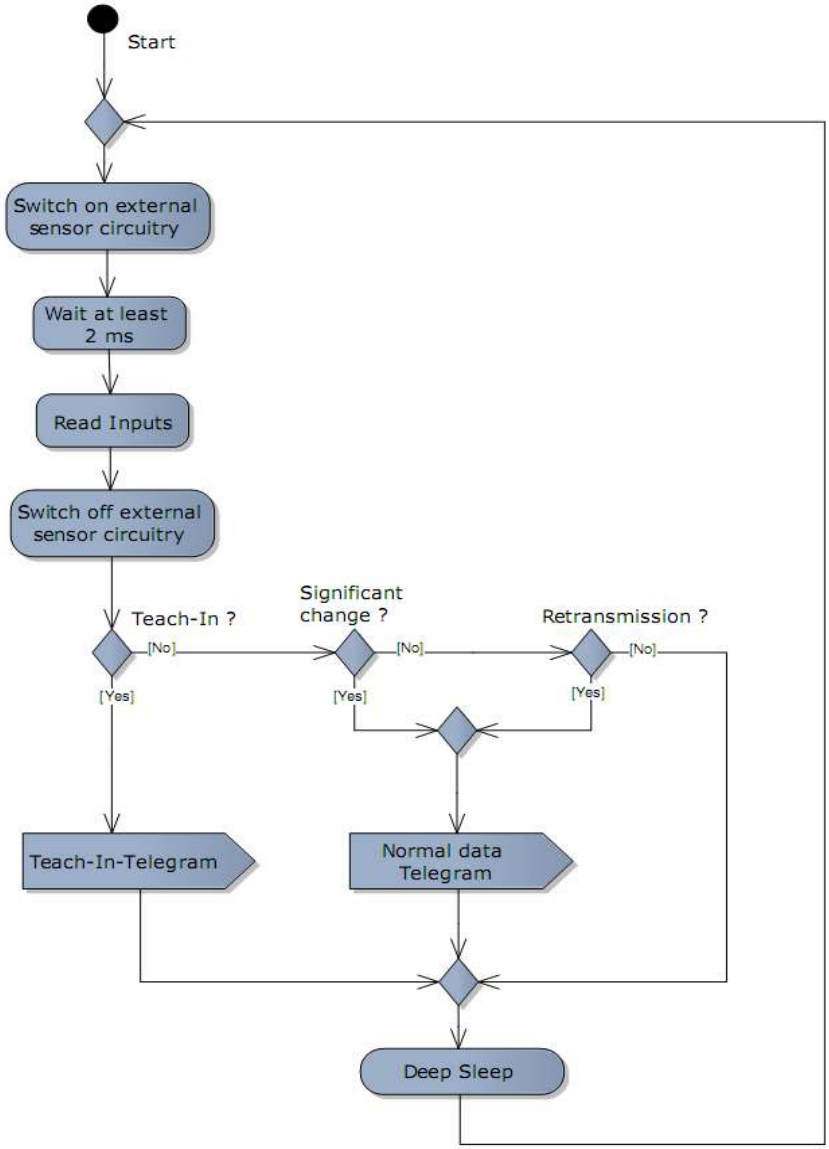
Short press: **1 s** (firmware 0.1 – 3.0 s)
Long press: **5 s** (firmware 3 – 7 s)
2x long press with very short pause of max. 1 s between
Customers can adapt the mode change options via module configuration (see 2.7):

- Transport/Standard/Secure Mode change on (default see diagram above) or
- limited to Transport & Secure Mode (details support@enocean.com) or
- limited Transport & Standard Mode (details support@enocean.com)

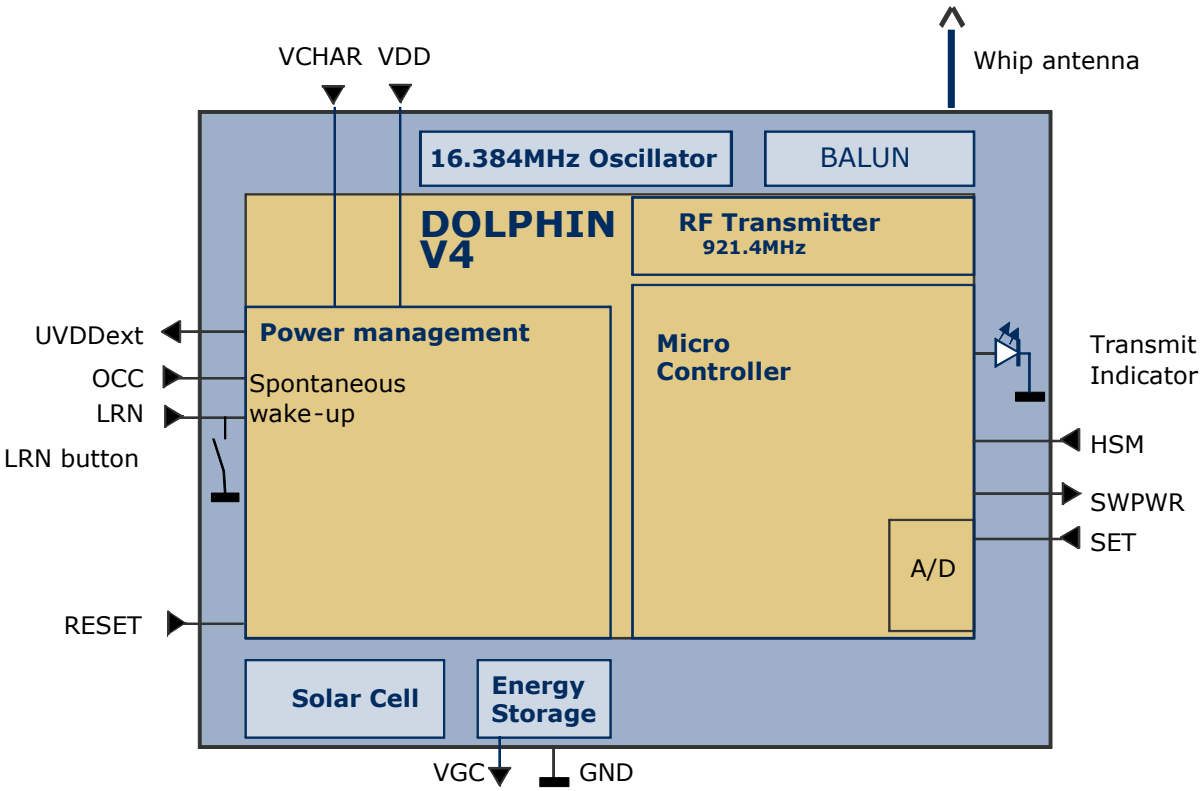
Before changing the operating mode please make sure to clear the device from all receivers which have been taught to work with this device before. Otherwise the receiver will ignore the telegrams and the application will not work.

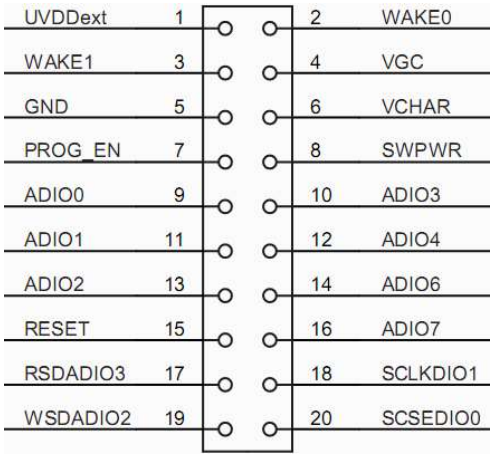
The flag for actual mode itself is stored in non-volatile memory. After power down reset the previous selected mode is active. The mode change is limited to 50 times. In normal application scenario only very few are required.

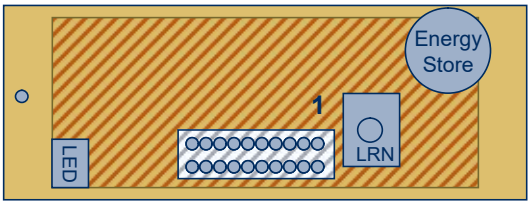
2.1 Simplified firmware flow chart for standard /secure mode



2.2 Pin out







The figure above shows the pin out of the 431T modules. The pins are named according to the naming of the Dolphin V4 core to simplify usage of the DOLPHIN API.

2.3 Pin description and operational characteristics

STM 43xJ Hardware Symbol	STM 43xJ Firmware Symbol	Function	Characteristics
GND	GND	Ground connection	
VDD	VDD	Supply voltage	2.1 V – 5.0 V; Start-up voltage: 2.6 V Maximum ripple: see 2.6 Not available at pin header.
		Supply for programming I/F	Recommended supply voltage for programming 3V
VCHAR	VCHAR	Charging input	Input for an external energy harvester or a battery. See 2.12.
		Supply for programming I/F if VDD cannot be used.[3]	Recommended supply voltage for programming 3.3V – 3.6 V
VGC	VGC	Voltage Long Term storage	Connection of additional external energy storage possible. See 2.12
SWPWR (= switched DVDD of Dolphin V4)	SWPWR	DVDD supply voltage regulator output switched via transistor controlled by Dolphin V4 ADIO5 pin.	1.8 V. Output current: max. 5 mA. Supply for external circuitry, available while not in deep sleep mode. SWPWR is switched on 0.25 ms before sampling of inputs and is switched off afterwards.
UVDDext (=UVDD of Dolphin V4 with 1.8MΩ in series)	UVDDext	Ultra low power supply voltage regulator output	Not for supply of external circuitry! For use with WAKE pins only, see section 3.1. Limited to max. 1 µA output current by internal 1.8 MΩ resistor!
IOVDD (not available at pin connector)	IOVDD	GPIO supply voltage	Internal connection to Dolphin V4 DVDD (typ. 1.8 V) See 2.3.1
RESET	RESET	Reset input Programming I/F	Active high reset (1.8 V) Fixed internal 10 kΩ pull-down.
PROG_EN	PROG_EN	Programming I/F	HIGH: programming mode active LOW: operating mode Digital input, fixed internal 10 kΩ pull-down.
ADIO0	SET	Analog input	For connection of an external set point dial. See 3.3
ADIO1		Not used	Internal pull-up; do not connect
ADIO2		Not used	Internal pull-up; do not connect
ADIO3	HSM	Input for HSM 100	Internal pull-up; leave open or connect HSM 100
ADIO4		Not used	Internal pull-up; do not connect

[3] E.g. if module shall be programmed or configured via pin connector.
If a bed of nails fixture for programming is available VDD should be used instead of VCHAR.

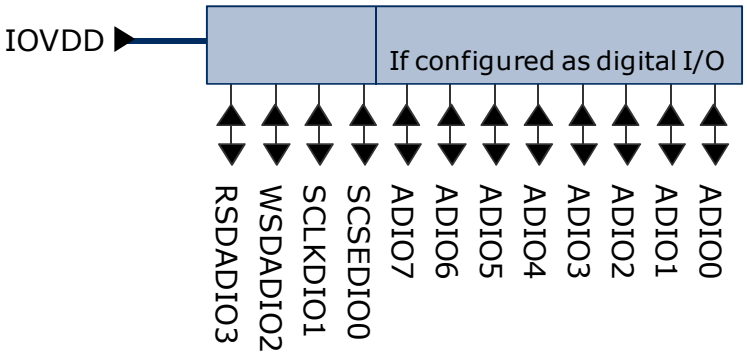
ADIO6		Not used	Internal pull-up; do not connect
ADIO7		Programming I/F	Leave open
SCSEDIO0	SDA	EEPROM pin.	SDA – I2C pin
		Programming I/F	
SCLKDIO1	SCL	EEPROM pin.	SCL – I2C pin
		Programming I/F	
WSDADIO2		Programming I/F	
RSDADIO3		Programming I/F	
WAKE0	OCC	Wake input	Input for external occupancy button. Change of logic state leads to wake-up and transmission of a telegram if correct EEP selected. Must be connected to UVDDext or GND! At time of delivery WAKE0 is connected to UVDDext via a jumper at the connector. See also 3.1.
WAKE1	LRN	LRN input	Change of logic state to LOW leads to wake-up and transmission of teach-in tele-gram. Internal pull-up to UVDD. See also 2.8.2 and 3.1.

2.3.1 GPIO supply voltage

The IOVDD pin of Dolphin V4 is internally connected to DVDD. For digital communication with other circuitry therefore a voltage of 1.8 V has to be used. While the module is in deep sleep mode the microcontroller with all its peripherals is switched off and DVDD, IOVDD, and SWPWR are not supplied.

If DVDD=0 V and IOVDD is not supplied (e.g. while in sleep mode), do not apply voltage to ADIO0 to ADIO7 and the pins of the serial interface (SCSEDIO0, SCLKDIO1, WSDADIO2, RSDADIO3). This may lead to unpredictable malfunction of the device.

For I/O pins configured as analog pins the IOVDD voltage level is not relevant! See also 2.3.2.



2.3.2 Analog and digital inputs

Parameter	Conditions / Notes	Min	Typ	Max	Units
Analog Input Mode					
Measurement range	Single ended Internal reference RVDD/2	0		RVDD	V
	Interpreted as[4]	0x00		0xFF	
Input coupling			DC		
Input impedance	Single ended against GND @ 1 kHz	10			MΩ
Input capacitance	Single ended against GND @ 1 kHz			10	pF

Parameter	Conditions / Notes	Min	Typ	Max	Units
Digital Input Mode					
Input HIGH voltage		2/3 IOVDD			V
Input LOW voltage				1/3 IOVDD	V
Pull up resistor	@IOVDD=1.7 … 1.9 V	90	132	200	kΩ

[4] For measurement of set point with external set point dial

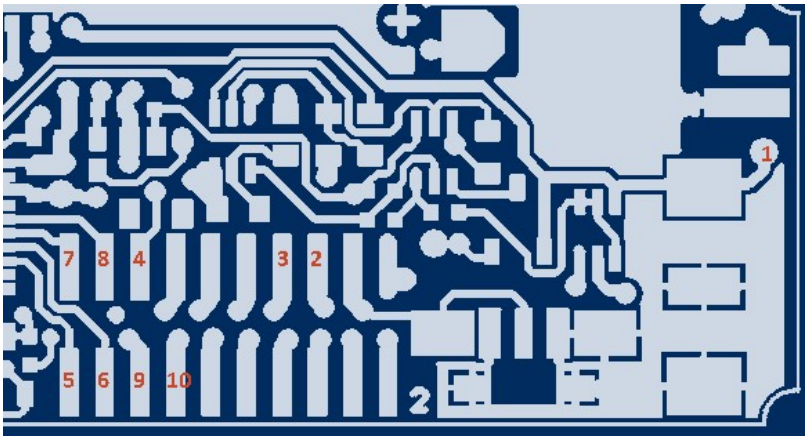
2.3.3 Temperature sensor

Parameter	Conditions / Notes	Min	Typ	Max	Units
Measurement range		0		40	°C
Accuracy	17 - 27 °C 0 - 40		0.5 1		K K

2.3.4 Programming Interface

The positions of the pads needed for programming are shown in the layout below.

Number	Symbol
1	VDD
2	GND
3	PROG_EN
4	RESET
5	SCSEDIO0
6	SCLKDIO1
7	WSDADIO2
8	RSDADIO3
9	ADIO7
10	ADIO6 Only if in addition to programming I/F a serial interface is needed



Top layer

If VDD is not accessible, e.g. because the module shall be programmed via the pin connector, please use VCHAR instead of VDD (see 2.12).

2.4 Absolute maximum ratings (non operating)

Symbol	Parameter	Min	Max	Units
VDD	Supply voltage at VDD	-0.5	5.5	V
VGC	Voltage long term storage	2.0	3.3	V
VCHAR	Supply voltage from external energy harvester	0	6	V
ICHAR	Supply current from external energy harvester		45	mA
GND	Ground connection	0	0	V
VINA	Voltage at every analog input pin	-0.5	2	V
VIND	Voltage at RESET, WAKE0/1, and every digital input	-0.5	3.6	V

2.5 Maximum ratings (operating)

Symbol	Parameter	Min	Max	Units
VDD	Supply voltage at VDD and VDDLIM	2.1	5.0	V
VGC	Voltage long term storage	2.0	3.3	V
VCHAR	Supply voltage from external energy harvester	0	6	V
ICHAR	Supply current from external energy harvester VCHAR<4 V 4 V<VCHAR<6 V		Limited internally 45	mA
GND	Ground connection	0	0	V
VINA	Voltage at every analog input pin	0	2.0	V
VIND	Voltage at RESET, WAKE0/1, and every digital input	0	3.6	V

2.6 Power management and voltage regulators

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

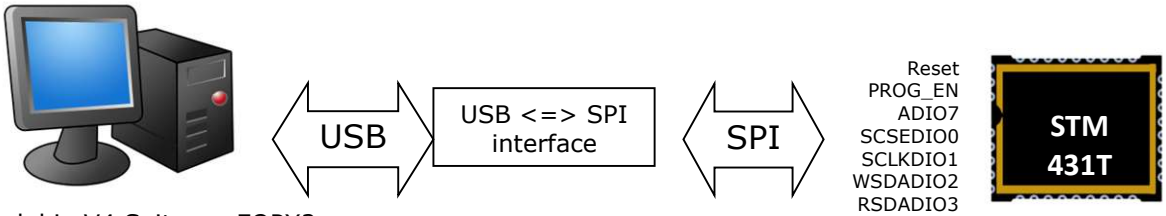
Threshold detector

STM 431T provide an internal ultra low power ON/OFF threshold detector. If VDD > VON, it turns on the ultra low power regulator (UVDD), the watchdog timer and the WAKE# pins circuitry. If VDD ≤ VOFF it initiates the automatic shut down of STM 431T. For details of this mechanism please refer to the Dolphin V4 Core Description documentation.

2.7 Configuration via programming interface

Via the programming interface the configuration area can be modified. This provides a lot more configuration options. These settings are read after RESET or power-on reset only and not at every wake-up.

The interface is shown in the figure below:



Dolphin V4 Suite, or EOPX2

EnOcean provides EOPX2 (EnOcean Programmer, a command line program) and Dolphin Suite (Windows application for chip configuration, programming, and testing) and the USB/SPI programmer device as part of the EDK 350 developer´s kit

In Dolphin Suite two configuration tabs for the STM 431T are available. The profile (GP / EEP) parameters and the module specific security parameters.

Based on Step code a newer version can be avaivable.

In standard case the user only needs to change the profile parameters = communication profile.

All security parameters of STM 431T are initialized in production. The module specific parameters, key, PSK and RLC are also initialised during production to a random value. If the module is used with standard Firmware no additional configuration at the security parameters is required. However we provide the security configuration of the keys as option for developers.

2.7.1 EEP Configuration

Parameter	Configuration via programming interface
Wake up cycle	Value can be set from 1 s to 65534 s – DEFAULT: 100s
Redundant Retransmission cycle	Min…Max values for random interval If Min=Max -> random switched off – DEFAULT MIN: 7, MAX: 14
Threshold values for Temperature, Set point	The values are: Temperature: default: 0.5 K (raw value 3), unit is ~0.16 K, max 10 K (raw value 62). Set point Temperature: default: 10 A/D digits. (max is 254) 255 – for any values – means ignore any change.
Edge of wake 0 pin change causing a telegram transmission	Every change of a wake pin triggers a wake-up. For Wake0 pin it can be configured individually if a telegram shall be sent on rising, falling, both edges or none.
Manufacturer ID and EEP (EnOcean Equipment Profile)	Information about manufacturer and type of device. This feature is needed for "automatic" interoperability of sensors and actuators or bus systems. Information how to set these parameters requires an agreement with EnOcean. Unique manufacturer IDs are distributed by the

	EnOcean Alliance.

2.7.2 Security Configuration

Parameter	Configuration via programming interface
Mode	There are three options available: Transport / Secure / Normal Transport / Secure Transport / Normal
External EEPROM Present	Default is set to yes. If set to no, then the module will not store the RLC. The Security level format must be specified not to use RLC, otherwise the RLC will restart after a power down.
Initialisation of external EEPROM.	One time option, must be performed at first start up. Default Yes.
Pre-shared key usage	Default: disabled.
Private Key	AES 128 key which is used for data encryption. Please refer to the Security specification for details on the Security level format.
Subkey 1	Subkey derivated from private key.
Subkey 2	Subkey derivated from private key.
Pre-shared Key	Pre-shared key used for PSK protected teach in.
Set initial RLC	Initial value of the RLC.

2.8 Radio telegram

2.8.1 Normal operation – standard and enhanced security mode

In normal operation 431T transmit telegram data according to the selected EEP or GP. (EnOcean Equipment Profile). In case of STM 431T is in enhanced security mode this telegram is encrypted.
For details please refer to the EnOcean Equipment Profiles specification.

2.8.2 Teach-in telegram - standard and enhanced security mode

In case of a wake-up via WAKE1 pin (LRN input) the module transmits a teach-in telegram.

- If the manufacturer code is not set, the module transmits a normal telegram according to 2.8.1 with the difference that DI_3=0.
- If a manufacturer code is set, this teach-in telegram contains special information as described below.

With this special teach-in telegram it is possible to identify the manufacturer of a device and the function and type of a device. The following EnOcean Equipment Profiles are supported by STM 431T. They have to be selected according to the availability of external occupancy button and set point control by the method described in 2.7:

- A5-02-05 Temperature sensor 0-40 °C (default)
- A5-10-03 Temperature sensor 0-40 °C, set point control
- A5-10-05 Temperature sensor 0-40 °C, set point, and occupancy control

If a HSM 100 module is plugged onto the connector in addition the following EEPs are supported:

- A5-04-01 Temperature and humidity sensor 0-40 °C and 0-100% r.h.
- A5-10-10 Temperature and humidity sensor 0-40 °C and 0-100% r.h., set point control, and occupancy control
- A5-10-12 Temperature and humidity sensor 0-40 °C and 0-100% r.h., set point control

For details please refer to the EnOcean Equipment Profiles specification.

If Generic Profiles was selected then in teach-in mode Generic Profiles Teach-in request is transmitted. Please refer to the Generic Profiles Specification for details [8].

2.9 Secure radio telegram

The STM 431T can be operated in:

- Standard mode – no enhanced security is used. This is the common operation mode, originally available. This is also the default factory mode.
- Security mode – communication is protected by enhanced security features. This mode was added later in module evolution.

2.9.1 Switching between modes

See chapter 2 for details.

2.9.2 Encrypted communication - Enhanced security mode

In enhanced mode the data link content is always protected with advanced security features. Normal operation DL and also Teach-in DL are protected in the same way. The secu-

rity features used are defined by the Security Level format - SLF. This parameter is set by default to the highest possible level and cannot be changed (Stepcode >=DE):

- 24-bit RLC, set to 0 at production
- RLC tx,
- 3-byte CMAC,
- VAES encryption

To add security features to the communication the Normal operation DL and Teach-in DL are encapsulated into a secured telegram. The data content of the telegram is not changed. Please refer to the EnOcean Security Specification [1] for details.

2.9.3 Security Teach-In - Enhanced security mode

To enable security communication the STM 431T has to send a security teach-in telegram to the other communication partner and so inform him about the used security profile, keys and initial RLC. The security teach-in has to take place before any other communication can be executed (profile teach-in included). To trigger the transmission of the teach-in telegram WAKE1 pin (LRN input) is pressed. The security teach-in telegram is transmitted before the profile teach-in. The following profile teach-in telegram is already protected by advanced security features.

The process of sending security teach-in telegram and profile teach-in telegram is triggered by one pressing of the LRN button.

The behaviour of the LRN button in enhanced mode is following:

1. Button is pressed
2. Security teach-in is send.
3. Profile teach-in is send.

2.9.3.1 PSK Security Teach-in - Enhanced security mode - optional

The Security Teach-in telegram carries the information of KEY and RLC. This information is either send plain text (as is) or it is protected by the pre-shared key - PSK. The PSK must be in printed on the transmitting device. To use PSK teach-in, the PSK must be read by the end-user and entered into the other communication partner. For this purpose the EnOcean radio interface cannot be used. The PSK can be entered through an user interface or semi-automatized e.g. by a QR code reader.

For details on the PSK Teach-in please refer to the EnOcean Security Specification [1].

PSK feature is disabled by default. To enable PSK feature the execute configuration via programming interface. See chapter 2.7.2 for details.

2.10 Signal telegram

After pressing the LRN button for 5 seconds a signal telegram (data: 0x0E) will be sent and the module enters the transport mode. Signal telegram is used for the purpose to inform the nearby receivers this device will stop radio transmission.

For details please refer to the EnOcean Equipment Profiles specification.
(http://www.enocean-alliance.org/eep/)

2.11 Transmit timing

The setup of the transmission timing allows avoiding possible collisions with data packages of other EnOcean transmitters as well as disturbances from the environment.
Within each transmission cycle, 3 identical sub-telegrams are transmitted within 25 ms.

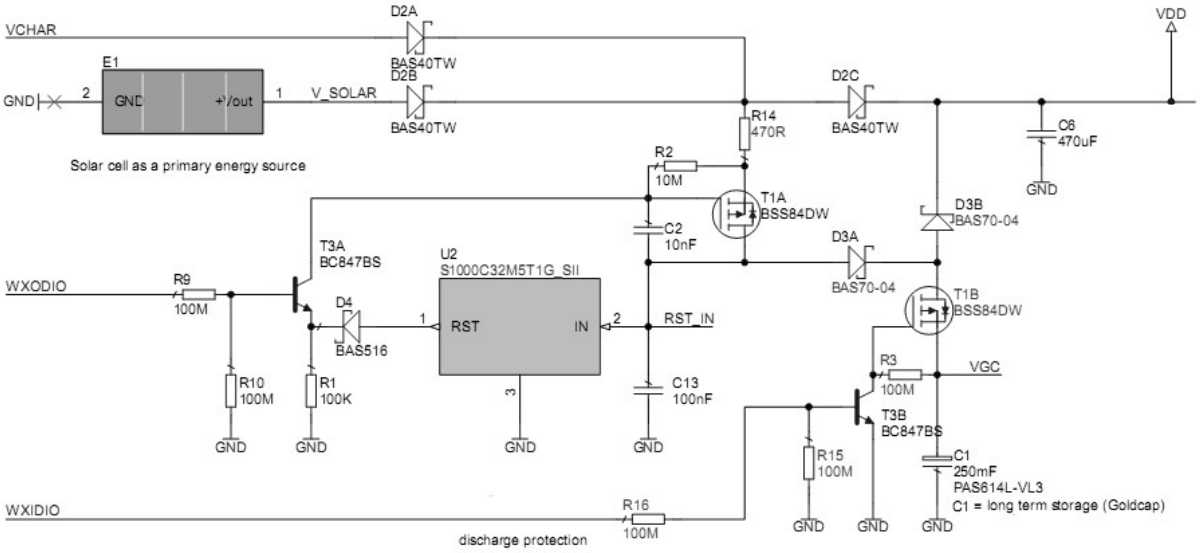
In case of case of encrypted operation only 2 sub telegrams are transmitted.

The transmission of one sub-telegram lasts approximately 1.2 ms (normal) or 2 ms (secured).

See EnOcean Radio Protocol 2 for detailed timings [9].

2.12 Charging circuitry

The figure below shows the internal charging circuit. It is controlled via the WXODIO pin of Dolphin V4 which switches according to the status of the internal threshold detector. For details please refer to the Dolphin V4 Core Description documentation. The WXIDIO pin is used to disconnect the long term energy storage element at voltages below VOFF to avoid deep discharge.



C1 is from DE step code changes to MS412FE.

An external 3 V backup battery can be connected at VCHAR.

2.13 Energy consumption

For energy calculations following values are used:

- Internal energy storage MS412FE with usable capacity of about 0.7 mAh https://www.sii.co.jp/en/me/datasheets/ms-rechargeable/ms412fe-5/ (usable voltage range 2.4 - 3 V at 25 °C)
- Solar cell ECS 200 delivers at 200 lux about 5 µA https://www.enocean.com/de/enocean-module/details/ecs-300/
- Power consumption transmit cycle standard mode: 100 µAs
- Power consumption internal sensor measurement: cycle 30 µAs Current is proportional to illumination level (not true at very low levels!)
- Average leak current of STM 4xy at 25°C: 0.5 uA

Example calculation of the energy consumption with following parameters:

Requirements for example calculation:

- configuration: wake cycle 100 s and min. transmit every 10th wake up
- 8 h light per day (24 h) light @ 200 lux and 25°C

Current consumption (depending on amount of wake-ups due to temperature change):

- Min. current consumption with no wake-up cycle due to temperature changes: 30 uAs / 100 s + 100 uAs / 1000 s + 0.5 uA = 0.9 uA

- Maximum current consumption with max. wake-up cycles due to temperature changes :
  30 uAs / 100 s + 100 uAs / 100 s + 0.5 uA = 1.8 uA

- Average current consumption: (0.9 uA + 1.8 uA) / 2 = 1.35 uA

- Average solar power harvested: 5uA / (8 h / 24 h) = 1.67 uA

Time to fully charge energy storage (2.4 to 3.0 V) at stable temperature:
0.7 mAh / (1.67 uA – 0.9 uA) = 909 h = 38 days

Average operation time in darkness when fully charged (3.0 V to 2.4 V):
0.7 mAh / 1.35 uA = 519 h = 22 days

Remarks:

- Calculation examples and values have tolerances of about +/- 20%.
- Energy storage performance, power consumption and solar cell performance varies over temperature.
- Energy storage performance degrades over life time, especially if energy storage is long time exposed to very high temperatures. High temperatures will accelerate aging. Very low temperature will temporary reduce capacity of energy store and this leads to considerable shorter dark time operation
- Short wake-up cycles (e.g. 1 s) and transmit intervals (e.g. 1 s) significantly reduce energy storage performance, for this use case an external power supply is recommended

2.13.1 Consumption in enhanced security mode

Enhanced security mode requires more energy due to encryption algorithm computing time and extended telegram length because of CMAC and RLC. This added consumption is compensated by reducing the subtelegram count to 2. With this measure the operation in dark time is even little bit increased.

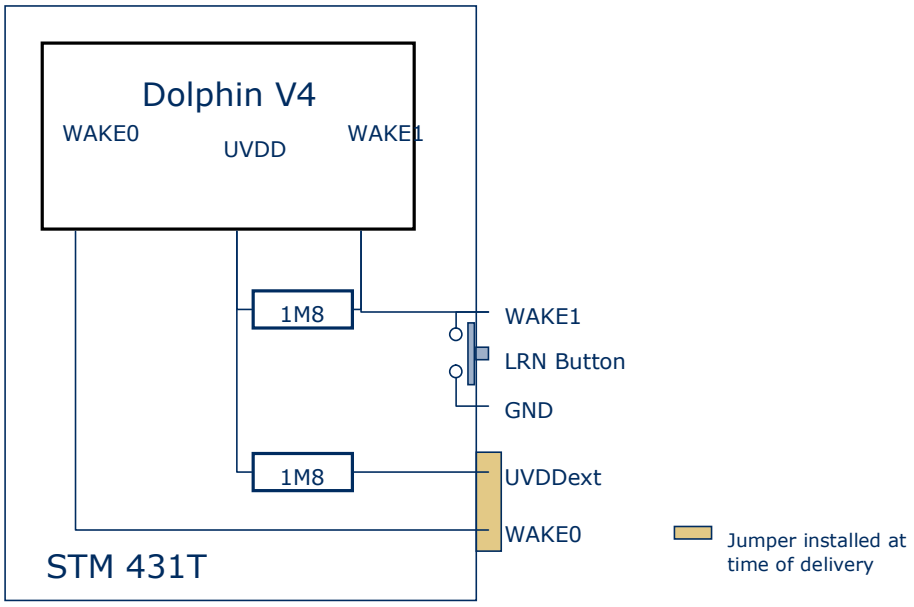
There it is to assume the operation in dark time is not reduced by using enhanced security.

3 APPLICATIONS INFORMATION

3.1 Using the WAKE pins

The logic input circuits of the WAKE0 and WAKE1 pins are supplied by UVDD and therefore also usable in "Deep Sleep Mode". Due to current minimization there is no internal pull-up or pull-down at the WAKE pins. When STM 431T is in "Deep Sleep Mode" and the logic levels of WAKE0 and / or WAKE1 is changed, STM 431T starts up.

As the there is no internal pull-up or pull-down at the WAKE0 pin, it has to be ensured by external circuitry, that the WAKE0 pin is at a defined logic level at any time. At time of delivery a jumper is connected between WAKE0 and UVDDext. WAKE1 provides an internal 1.8 MΩ pull-up. See figure below.



When the LRN button is pressed WAKE1 is pulled to GND and a teach-in telegram is transmitted. As long as the button is pressed a small current of approximately 1 µA is flowing. It is possible to connect an additional external button in parallel between WAKE1 and GND if a different position of the button in the device is required.

WAKE0 is connected to UVDDext via a jumper at time of delivery. If the module is mounted onto a host PCB the jumper has to be removed. The circuitry on the host PCB then has to ensure that WAKE0 is always in a defined position. There are two ways to use WAKE0:

- Connect WAKE0 to UVDDext and connect an external button between WAKE0 and GND. As long as the button is pressed a current of 1 µA will flow.
- Connect a 3 terminal switch and switch WAKE0 to either GND or UVDDext. In this case there is no continuous flow of current in either position of the switch.

3.2 Temperature sensor

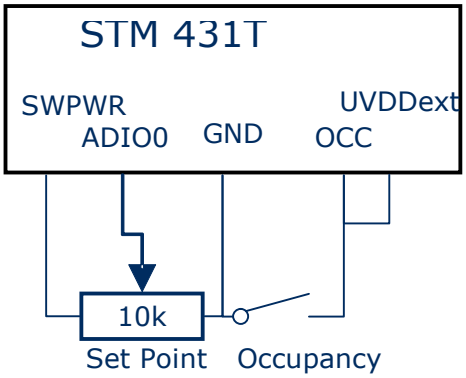
STM 431T provide an internal temperature sensor which is part of the Dolphin V4 integrated circuit and measures the chip temperature.
Therefore it is important to provide a good thermal connection of the IC to the environment by ensuring sufficient ventilation of air inside the housing. Only then the measurement will represent the ambient temperature.

Depending on the design of the housing a delay between ambient temperature changes and measured temperature value will be seen.

Heating of the chip due to its current consumption is negligible as the chip only consumes 100 nA while in sleep mode.
Temperature measurement every second is not recommended as in this case effects of heating of the chip might become visible and accuracy is reduced.

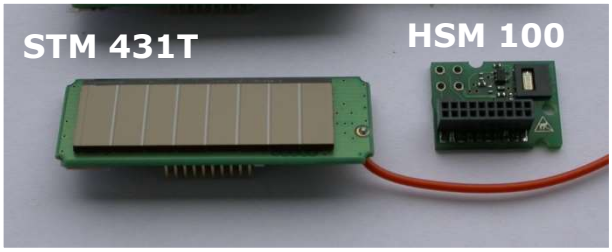
3.3 Set point control and occupancy button

In order to control the set point, an external potentiometer has to be connected as shown below. In addition this figure shows how to connect the occupancy button.



3.4 Combination with humidity sensor module HSM 100

The humidity sensor module HSM 100 extends the functionality of STM 431T temperature sensor modules.
HSM 100 contains an internal calibrated humidity sensor and can be plugged onto STM 431T modules via the 20 pin connector. For details please refer to the data sheet of HSM 100.

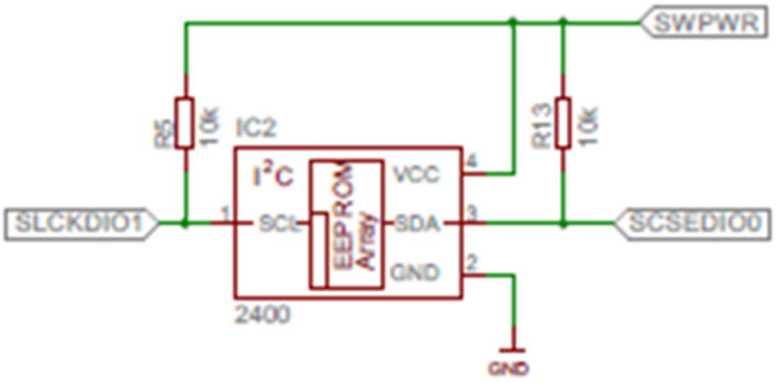


3.6 EEPROM Storage for the Rolling code

The STM 431T was developed to be used with internal memory. The EEPROM is connected to the SDA and SLK pins and it is suited on the PCB of the STM 431. The SWPWR pin controls the power supply of the EEPROM. Please consider that the SWPWR pin also provides energy to possible external sensor circuit – absolute maximum is 5 mA.

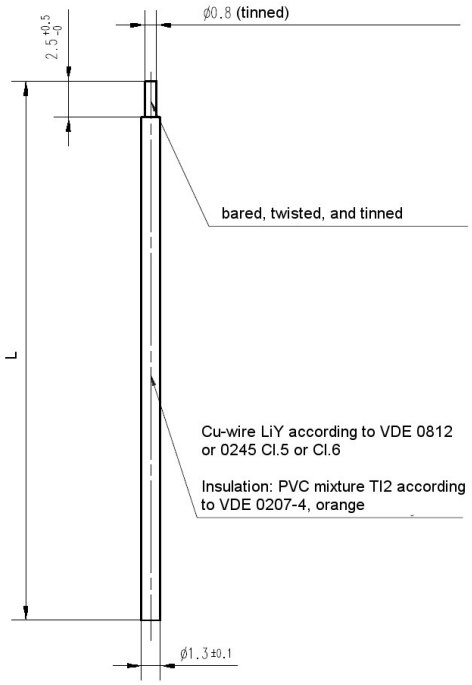
The EEPROM current is typ. 0.1 mA for 5 ms during write operation. For details please refer to the User Manual of the EEPROM [7] (24AA08).

Circuit of connected EERPOM is following:



3.7 Antenna layout

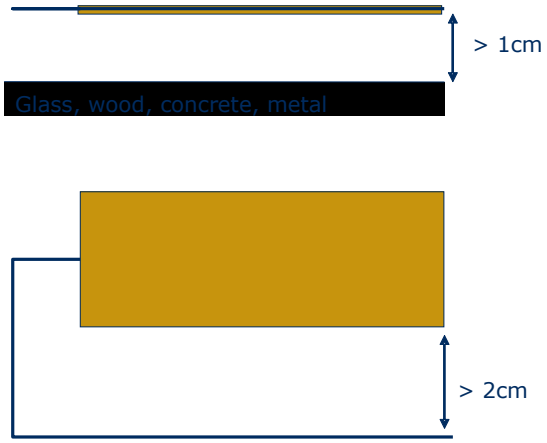
3.7.1 Whip antenna



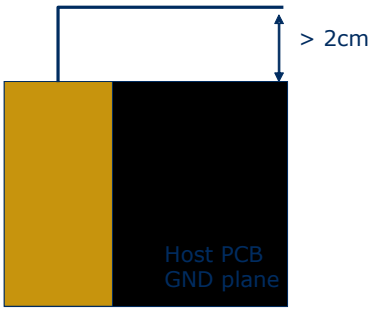
Specification of the whip antenna; L=64 mm

Antenna layout recommendation

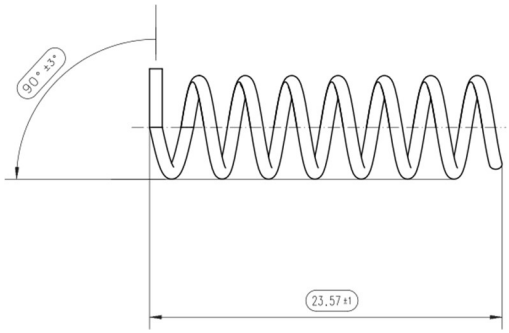
STM 43xJ without host PCB



STM 43xJ with host PCB

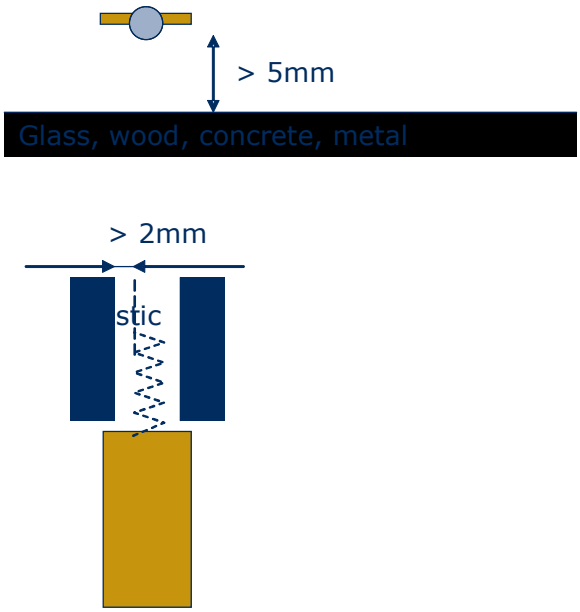


3.7.2 Helical antenna (STM 431T)

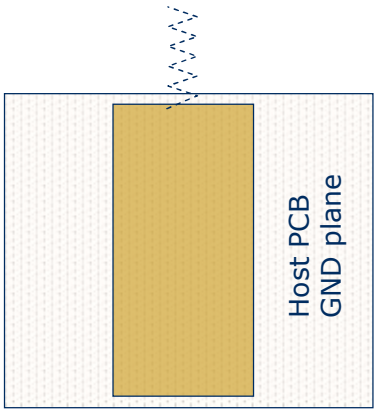


Antenna recommendation

STM 431T without host PCB

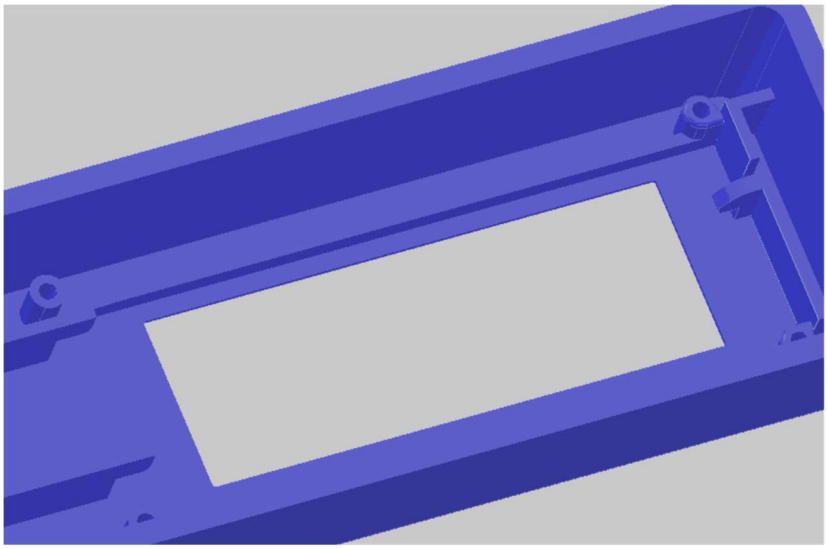


STM 431T with host PCB



3.8 Mounting STM 431T into a housing

The figure below shows an example of a housing into which the module can be mounted (with antenna pointing to the left).



To avoid damage to the solar cell or the PCB itself, please make sure not to exert shear force (side force within the plane of the solar cell) onto the solar cell!
The maximum vertical force onto the solar cell must not exceed 4 N and should be homogeneously distributed!
Bending of the PCB must be avoided!

Please make sure that the housing covers 0.5 mm at the solar cell edges.
Within 0.5 mm off the edge flaking is possible due to the cutting process.

3.9 Transmission range

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

The following figures for expected transmission range may be used as a rough guide only:

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

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

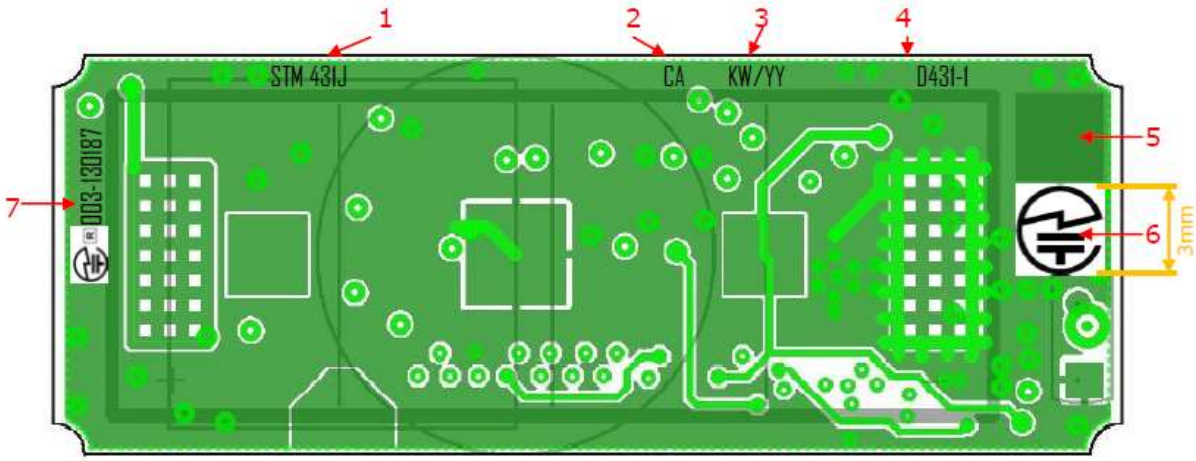
- Switch mounted on metal surfaces (up to 30% loss of transmission range)
- Hollow lightweight walls filled with insulating wool on metal foil
- False ceilings with panels of metal or carbon fiber
- Lead glass or glass with metal coating, steel furniture

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

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

4 AGENCY CERTIFICATIONS

5 Label Information



1. Product name - „STM 431T / STM 435J"
2. Step Code „xy"
3. Date Code "KW/YY": e.g. 15/13
4. Status „D431-z": e.g 1
5. DMC
6. ARIB Marking, radius 3mm
7. ARIB Marking with number (003-130187)

5.1 QR Code label

5.1.1 Included Information:

[30S00000502CB78+ ZBA2054A875E77768C7740157BDF9CF68+30PS3061-D431+2PDB08+S01123456123456]

30S00000502CB78	15 CHARS	30S<6 Byte Chip-ID>
+	1 CHAR	
13ZBA2054A…….68	33 CHARS	13Z<32 Digit Key>
+	1 CHAR	
30PS3061-D431	13CHARS	30P<Order code>
+	1 CHAR	
2PDB08	6 CHARS	2P<2 Digit Stepcode><2 Digit Status>
+	1 CHAR	
Sxxyyyyyyyyyyyy	15 CHARS	S<2 Digit Hersteller Kennung> <12 Digit DMC/Seriennummer>

5.1.2 QR-Code Specification

QR-Code Version:	4 (33x33 pixel)
Error Correction Level:	M (15% error correction)
Mode:	Alphanumeric Mode
Character Capacity:	90

Keep off are around the code:	2 Pixel (UP, Down, Left und Right)
Pixel Size:	min. 4x4 points per Pixel

600dpi x 600dpi Resolution:
1 Printpoint: 0.0423mm x 0.0423mm
1 Pixel: 0.1693mm x 0.1693mm