

Scavenger Transmitter Module STM 429J / STM 420J

January 20, 2020



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
1.1	Added marking and STM 425J.
1.2	Editorial corrections.
1.3	Changed PCB / System Drawings – STM 425J and STM 429J. Added radio certificate.
1.31	Changed helical antenna picture
2.0	Update of revision with consolidation and small corrections.
3.0	Update with long term energy storage replacement, additional transport mode for shelf storage & air cargo, optimized secure mode, new drawings.
3.1	Added STM 420J.

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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 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	4
1.1	Basic functionality	4
1.2	Technical data	4
1.3	Physical dimensions	5
1.4	References	7
1.5	Environmental conditions	7
1.6	Ordering Information	8
2	FUNCTIONAL DESCRIPTION	9
2.1	Commissioning and mode change	9
2.2	Block diagram	10
2.3	Radio telegram	10
2.4	Secure radio telegram	11
2.4.1	Switching between modes	11
2.4.2	Encrypted communication – enhanced security mode	11
2.4.3	Security Teach-In – enhanced security mode	11
2.4.3.1	PSK Security Teach-in - optional	11
2.5	Signal telegram	12
2.6	Transmit timing	12
2.7	Energy consumption	13
2.7.1	Consumption in secure mode	14
3	APPLICATIONS INFORMATION	15
3.1	Antenna Details	15
3.2	Transmission range	16
3.3	Connecting an external backup battery	16
3.4	Mounting 42xJ into a housing	17
4	AGENCY CERTIFICATIONS	18
5	Label Information	19
5.1	QR Code label	19
5.1.1	Included Information:	19
5.1.2	QR-Code Specification	20

1 GENERAL DESCRIPTION

1.1 Basic functionality

The radio transmitter modules STM 42xJ from EnOcean enable the implementation of a wireless magnet contact sensor.

Powered by a solar cell, it works absolutely maintenance-free. An integrated energy store allows operation for several days even in total darkness.

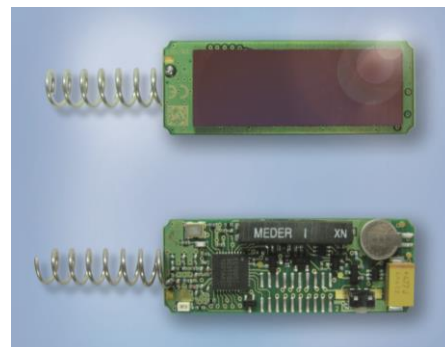
Key applications are window and door sensors.

STM 42xJ supervise an integrated reed contact and report every status change immediately (open <> closed). In addition a sign of life signal is transmitted every 20-30 minutes.

A LRN button and a TX indicator LED are pre-installed on the PCB. On STM 42xJ they are oriented upwards. When the LRN button is pressed then a special teach-in signal will be sent.

STM 42xJ operate at 928.35MHz using FSK modulation.

STM 42xJ in enhanced mode provides enhanced security features with encrypted communication.



Features with built-in firmware

- Pre-installed solar cell
- On-board energy storage and charging circuit
- **On-board LRN button (operated from above on STM 429J)**
- **On-board TX indicator LED (pointing upwards on STM 429J)**
- **On-board LRN button (operated from side on STM 420J)**
- **On-board TX indicator LED (pointing to the side on STM 420J)**
- On-board reed contact

1.2 Technical data

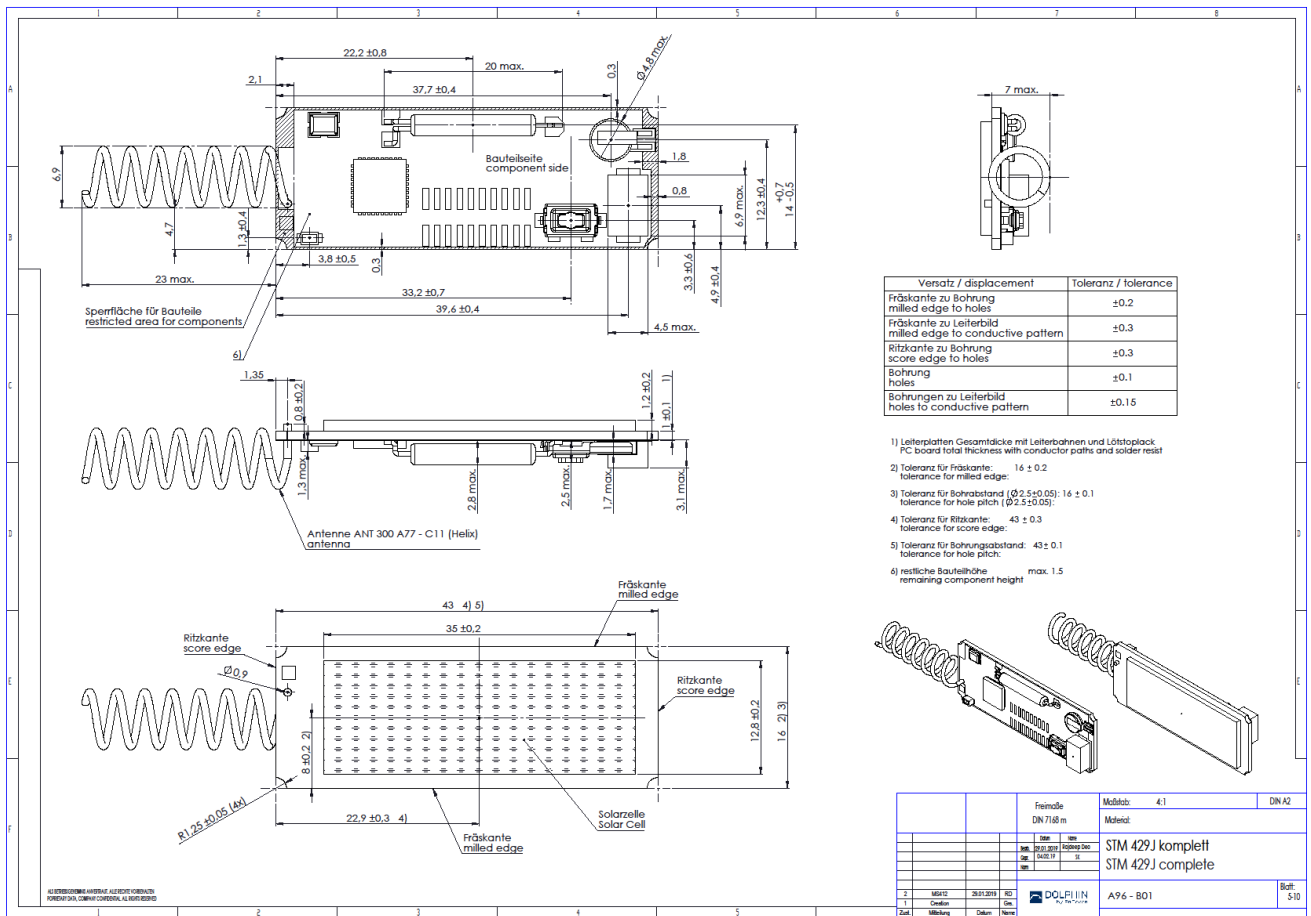
Antenna	Pre-installed helical antenna installed
Frequency	928.35MHz
Data rate/Modulation type	125 kbps / FSK
Radiated Output Power	Typ. 0dBm
Power Supply	Pre-installed solar cell Illumination 50-100000 lux
Operation time in darkness @ 25°C	min. 10 days, if energy storage fully charged ¹
Operation start up time with empty energy store	typ. < 2.5 min @ 400 lux / 25°C incandescent or fluorescent light
Reed contact	1x internal, Meder MK23-90-BV14496 or MK01-I
Radio Regulations	ARIB STD-T108
Security Level Format	24-bit RLC, RLC tx, 3-byte CMAC, VAES encryption

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.

1.3 Physical dimensions

PCB dimensions	43±0.2 x 16±0.3 x 1±0.1 mm
Module height	6 mm
Weight	5.2 g



Drawing STM 429J

1.4 References

- [1] Security of EnOcean Radio Networks - <https://www.enocean-alliance.org/what-is-enocean/specifications/>
- [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 - <https://www.enocean.com/en/support/application-notes/>
- [5] AN510 Adding Security to EnOcean Receivers - <https://www.enocean.com/en/support/application-notes/>
- [6] AN511 Advanced security in self-powered wireless applications - <https://www.enocean.com/en/support/application-notes/>
- [7] Microchip EEPROM Memory - www.microchip.com/serialeeprom/
- [8] EnOcean Equipment Profiles - <https://www.enocean-alliance.org/what-is-enocean/specifications/>

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 ³
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 420J	S3061-D420
STM 429J	S3061-D429

2 FUNCTIONAL DESCRIPTION

2.1 Commissioning and mode change

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.

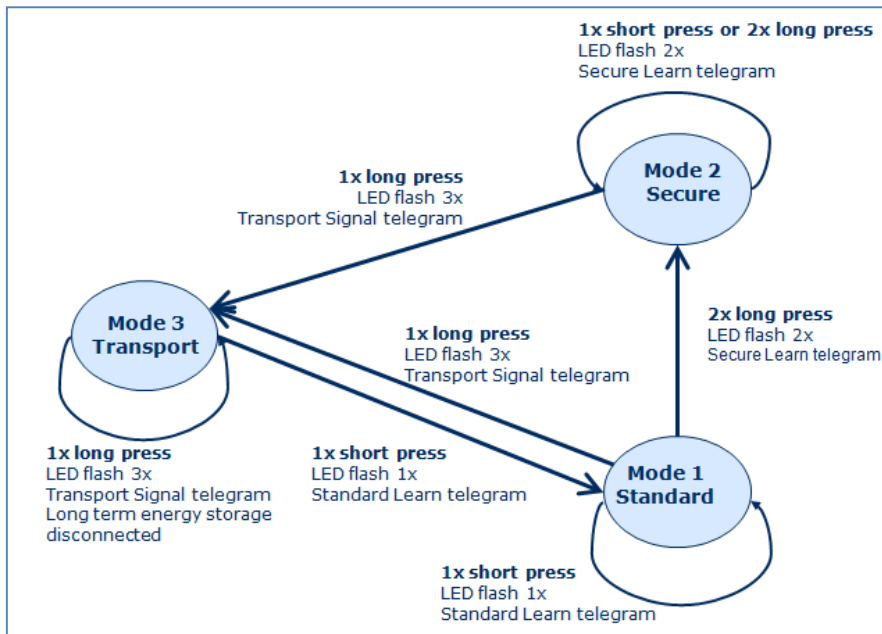
- **Change from standard to secure mode**

After pressing learn button 2x long (2x 5s, pause <1s) the radio module will enter Secure Mode (Mode 2). The LED will flash 2x and a secure learn telegram will be sent.

- **Change from secure or standard mode to transport mode**

After pressing 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

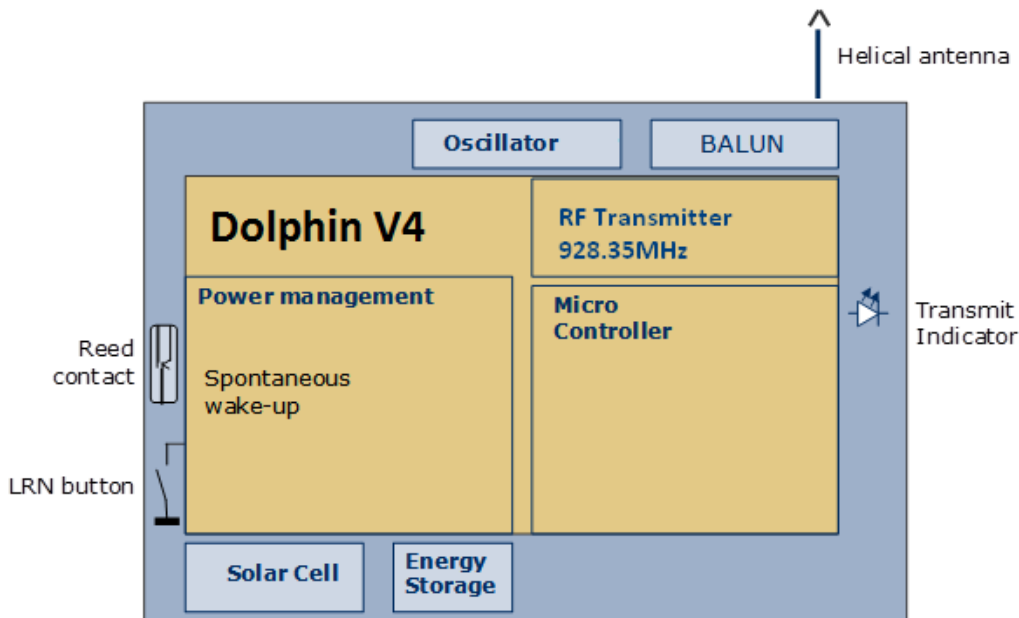


Before changing the operating mode please make sure to clear the device from all receivers which have been taught to work with this device before. Otherwise the receiver will ignore the telegrams and the application will not work.



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.

2.2 Block diagram



A change of the reed contact status or pushing the LRN button will wake the transmitter unit to send a radio telegram immediately (reed contact position, LRN push button status, unique 32-bit sensor ID - at profile teach-in 48 bit ID, checksum). In addition a redundant retransmission signal is sent to announce the contact status even in case of no input signal changes. This signal transmitted every 20-30 min, affected at random. The transmit indicator LED flashes briefly at every radio transmission. Between the wake-up phases, the device is in sleep mode for minimum power consumption.

2.3 Radio telegram

42xJ transmits a radio telegram according to EnOcean Equipment Profile EEP D5-00-01 as defined in the EnOcean Equipment Profiles specification.

2.4 Secure radio telegram

The STM 42xJ 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.

2.4.1 Switching between modes

Please refer to chapter 2.1.

2.4.2 Encrypted communication – enhanced security mode

In Enhanced mode the data link (DL) content is always protected with advanced security features. Normal operation DL and also Teach-in DL are protected in the same way. The security features used are defined by the Security Level format - SLF. This parameter is set by default to the highest possible level:

- 24-bit RLC,
- 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 for details.

2.4.3 Security Teach-In – enhanced security mode

To enable security communication the STM 42xJ 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 LRN button 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 once pressing 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.

2.4.3.1 PSK Security Teach-in - optional

The Security Teach-in telegram carries the information of KEY and RLC. This information is either sent as 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 trough a user interface or semi-automated by a code reader.

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

PSK feature is disabled by default. To enable PSK feature the execute configuration in Dolphin Suite with special adapter.

2.5 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/>)

2.6 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 0.9 ms (normal) or 1.7 ms (secured).

See EnOcean Radio Protocol 2 for detailed timings.

2.7 Energy consumption

Following diagram illustrates a complete cycle in standard mode which starts with controller active phase (setup, measurement etc.) immediately followed by a telegram transmit. After short sleep phase the controller will get active two times and send two telegrams.

Prerequisites for example calculation:

- Internal energy storage MS412FE with usable capacity of about 0.7 mAh
<https://www.sii.co.jp/en/me/datasheets/ms-rechargeable/ms412fe-5/>
(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 wake-up and transmit cycle standard mode: 100 µAs
- Power consumption wake-up and transmit cycle secure mode: 140 µAs
- 10 reed contact changes per day (e.g. 5x window open/close)
- Average leak current of STM 42xJ at 25°C: 0.5 uA
- Wake-up cycle 20 - 25 min (average 1.500 s) for status telegram
- 8 h light per day (24 h) light @ 200 lux and 25°C

Example calculation of the energy consumption with following parameters:

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

- Current consumption for status telegrams and sleep:
 $100 \text{ uAs} / 1,500 \text{ s} + 0.5 \text{ uA} = 0.57 \text{ uA}$
- Power consumption for 10 reed contact changes incl. additional transmits per day:
 $100 \text{ uAs} / (60 \times 60 \times 24 \text{ s}) = 1.2 \text{ nA} = 0.0012 \text{ uA}$
- Average current consumption: 0.57 uA
- Average solar power harvested: $5 \text{ uA} / (8 \text{ h} / 24 \text{ h}) = 1.67 \text{ uA}$
- Time to fully charge energy storage (2.4 to 3.0 V) at stable temperature:
 $0.7 \text{ mAh} / (1.67 \text{ uA} - 0.57 \text{ uA}) = 636 \text{ h} = 27 \text{ days}$
- Average operation time in darkness when fully charged (3.0 V to 2.4 V):
 $0.7 \text{ mAh} / 0.57 \text{ uA} = 1,228 \text{ h} = 51 \text{ day}$

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, each 10 K increase from 25°C will half expected life time. 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

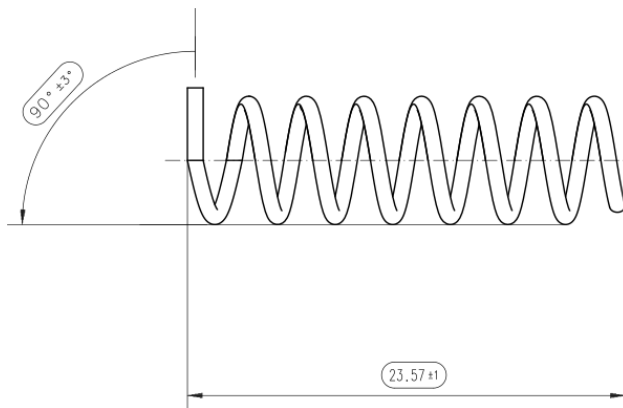
2.7.1 Consumption in secure mode

Enhanced security mode requires more energy due to encryption algorithm computing time and extended telegram length because of CMAC. 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.

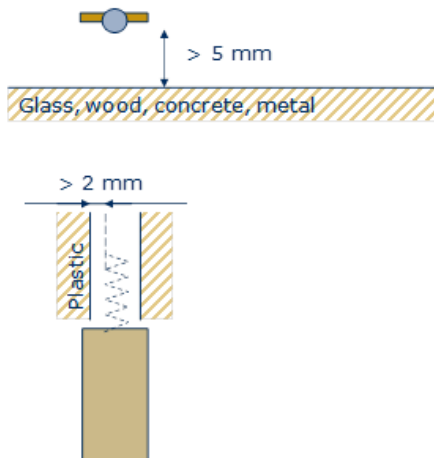
3 APPLICATIONS INFORMATION

3.1 Antenna Details

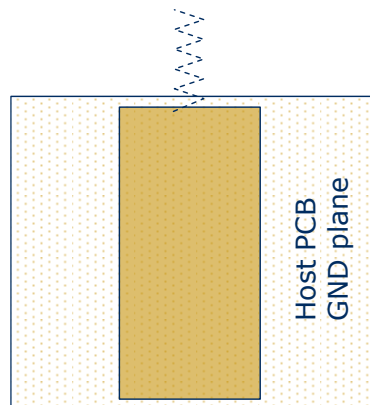


Antenna location recommendation

42xJ without host PCB



42xJ with host PCB



3.2 Transmission range

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

The following figures for expected transmission range are considered 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:

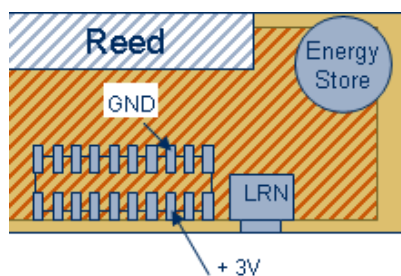
- Switch mounted on metal surfaces (up to 30% loss of transmission range)
- Hollow lightweight walls filled with insulating wool on metal foil
- False ceilings with panels of metal or carbon fiber
- Lead glass or glass with metal coating, steel furniture

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.

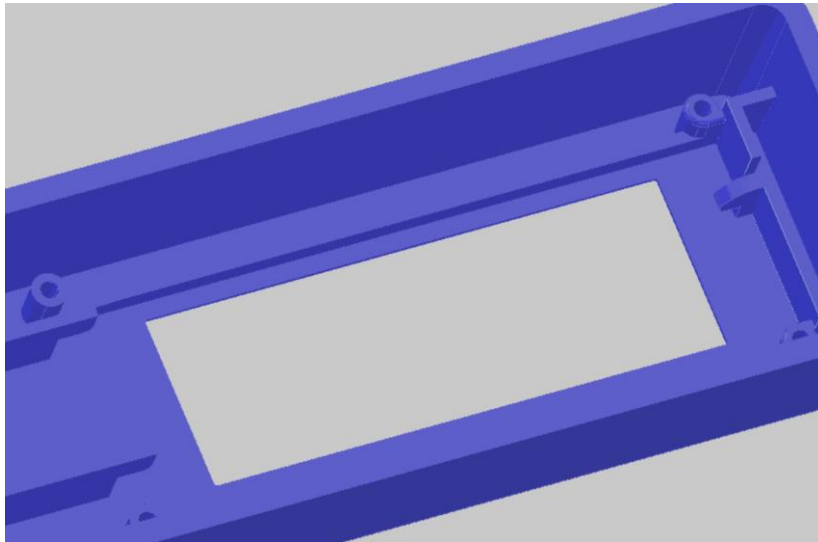
3.3 Connecting an external backup battery

In case there is not sufficient light available for operation with solar cell an external 3 V Lithium backup battery can be connected to the module at the soldering pads shown below:



3.4 Mounting 42xJ into a housing

The figure below shows an example of a housing in which the module can be mounted (with antenna pointing to the left). Design data of the housing and the modules is available in .igs format.



To prevent damage, please make sure not to exert shear force (side force within the plane of the solar cell) onto the solar cell or the module itself!
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.

4 AGENCY CERTIFICATIONS


STM 429J have been designed and tested to fulfil the approval requirements for ARIB STD-T108 based on the built-in firmware.

When the product is placed on the Japanese market, it must carry the Specified Radio Equipment marking as shown below:



認 証 書

認証を受けた者	ローム株式会社
特定無線設備の種別	第2条第1項第8号に掲げる無線設備 特定小電力機器 13GHz未満
電波の型式、 周波数及び 空中線電力	F1D 928.35MHz 0.001W
型式又は名称	STM429J、STM425J 又は STM420J
販売業者	ローム株式会社
認証番号	003-130160
認証をした年月日	2020年2月19日
備考	No.20-0376 920MHz / テレコントロール、テレメーター、データ伝送用 P131169

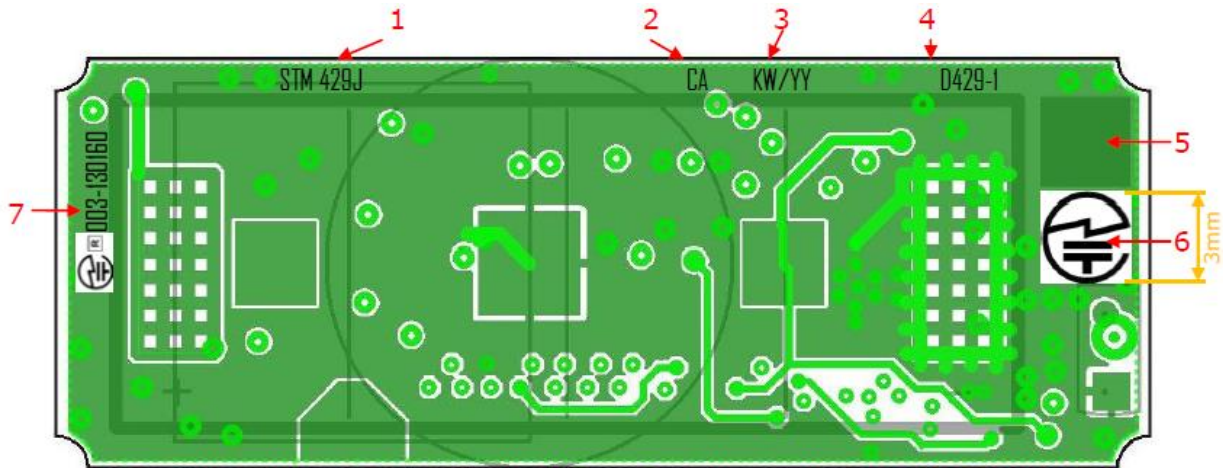
 上記のとおり、電波法第38条の24第1項の規定に基づく認証を行ったものであることを証する。

2020年2月19日

株式会社ディーエスピーリサーチ



5 Label Information



1. Product name - „STM 429J“
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 (003-130160)

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	
Sxxxxxxxxxxxxxxx	15 CHARS	S<2 Digit MAN> <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 area 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