

## TCM 410J – Transceiver Gateway Module

---

## TCM 410J – Transceiver Gateway Module



**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
1.00	Initial version
1.10	Added certification information and PCB Design
1.2	Changed power support information
1.3	Updated Energy consumption. Added example circuits for reset and prog_en pins. Extended PIN description. Added IOVDD and PINs circuits when using dee psleep.
2.0	Module revision update, added enhanced security mode, MSL4 -> MSL 3 and type approval updated.
2.1	Corrected Smart Ack Mailbox count and added description for repeating after POR
2.2	2019: Update of MIC/ARIB regulation
2.3	2022-04-07: Additional MIC/ARIB approval for new antennas
2.4	Added note regarding combination of SmartAck and repeating of long telegrams

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

© EnOcean GmbH  
All Rights Reserved

### 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.	Product Description .....	5
1.1	Basic functionality .....	5
1.2	Key features .....	5
1.3	Security processing .....	6
1.4	Technical data .....	6
1.5	Physical dimensions .....	7
1.6	Environmental conditions .....	7
1.7	Ordering information .....	7
2.	Functional Description .....	8
2.1	Pinout .....	8
2.2	Pin description and operational characteristics .....	9
2.2.1	GPIO supply voltage - IOVDD .....	10
2.2.2	Handling IOVDD and PINs in sleep mode .....	11
2.3	Absolute maximum ratings (non-operating) .....	12
2.4	Maximum ratings (operating) .....	12
2.5	Suggested RESET and PROG_EN circuitry .....	13
2.6	System environment .....	13
2.7	Serial Interface .....	14
2.8	Built-in Repeater .....	15
2.8.1	Persistent Repeater settings .....	16
2.9	Smart Acknowledge .....	16
2.10	Concurrent use of Smart Acknowledge and Repeater functionality .....	16
2.11	Remote Management .....	16
3.	Security Functionality .....	17
3.1	Operational modes .....	18
3.2	Reception .....	19
3.2.1	Setup of security information in the inbound secure link table .....	20
3.2.2	Resynchronisation of Learned-in Secure Devices .....	20
3.2.3	Processing of received messages with implicit RLC .....	21
3.2.4	Filtering .....	23
3.3	Transmission .....	23
3.3.1	Setup of security parameters in the outbound secure link table .....	23
3.3.2	Transmission of a teach-in telegram .....	23
3.3.3	Transmission of data messages .....	24
3.4	Storage for Rolling Codes and Keys .....	25
3.4.1	External EEPROM .....	25
3.4.2	Voltage drops .....	26
3.5	Configurations .....	27
4.	Application Information .....	28
4.1	Transmission range .....	28
4.2	Antenna options .....	29
4.2.1	Overview .....	29
4.2.2	Whip antenna .....	29
4.2.2.1	Recommendations for placement of the whip antenna .....	30
4.2.3	Helical antenna .....	31
4.2.4	Top loaded PCB spiral antenna .....	32
4.3	Power supply requirements .....	34
4.4	Layout recommendations .....	34

TCM 410J – Transceiver Module

---

4.4.1	Recommended foot pattern.....	35
4.5	Soldering information.....	38
4.6	Tape & Reel specification .....	39
5.	Japan Certification.....	40
5.1	Standard Certificate (206-000596) .....	40
5.1.1	Supported antennas based on the standard certificate .....	41
5.1.2	Required marking .....	42
5.2	Additional Certificate (215-JUK004) .....	43
5.2.1	Supported antennas based on the additional certificate .....	44
5.2.2	Required marking .....	45
6.	References .....	46

## TCM 410J – Transceiver Module

## 1. Product Description

### 1.1 Basic functionality

TCM 410J is a SMD mountable radio transmitter module enabling the realization of gateways for EnOcean 928.350 MHz radio systems.

TCM 410J provides a bi-directional radio interface and a bi-directional serial interface. Radio messages are sent transparently through the serial interface in both directions from and to an externally connected host processor or host PC.

TCM 410J allows to encrypt and sign the outgoing radio communication and to decrypt and authenticate the incoming radio communication.

TCM 410J accepts control commands from the host, for instance to configure the repeater functionality or to manage Smart Ack functions. TCM 410J can act as postmaster for up to 15 bi-directional sensors using Smart Ack technology.

The figure below illustrates the outline of TCM 410J.



### 1.2 Key features

TCM 410J provide the following key features:

- EnOcean radio transceiver gateway
- Serial interface using ESP3 (EnOcean Serial Protocol V3)
- Smart Ack controller functionality
- Configurable repeater functionality (1 Level)

### 1.3 Security processing

TCM 410J supports the following security processing features:

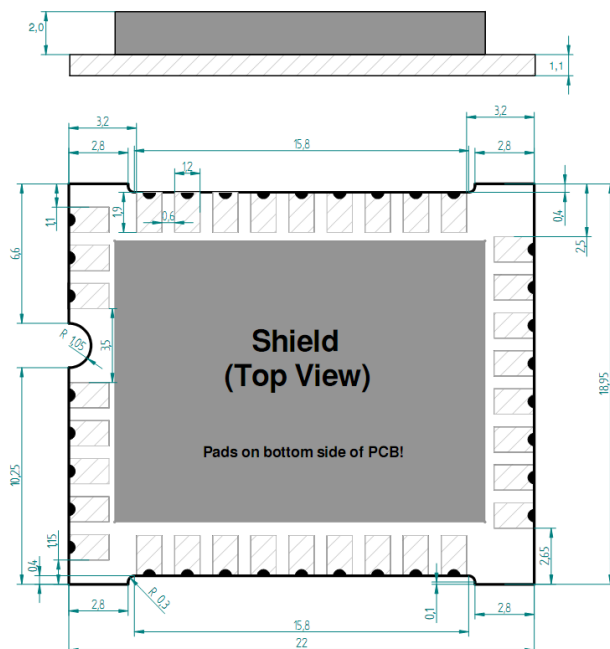
- Decryption and authentication of received telegrams
- Encryption and signing of transmitted telegrams
- Processing of Rolling Codes and Security Keys for transmission and reception
- Attack detection
- Configurable security parameters (RLC Window, etc.)
- I2C driver for communication with external EEPROM (required for security functionality)

### 1.4 Technical data

#### Features overview

<b>Antenna</b>	External whip or 50Ω antenna mountable
<b>Frequency</b>	928.350 MHz (FSK)
<b>Radio Standard</b>	EnOcean Radio Protocol 2 (FSK)
<b>Data rate/Modulation type</b>	125 kbps FSK
<b>Receiver Sensitivity (at 25°C)</b>	typ. -95 dBm
<b>Conducted Output Power</b>	typ. 0dBm
<b>Power Supply</b>	2.6...5V
<b>Serial Interface</b>	UART according to EnOcean Serial Protocol 3
<b>Current Consumption</b>	Receive mode (incl. CPU current): 27 mA Transmit mode (incl. CPU current): 22 mA
<b>Dimensions of PCB</b>	22x19x3.1 mm
<b>Operating temperature</b>	-25 to +85°C
<b>Radio Regulations</b>	ARIB STD-T108

## 1.5 Physical dimensions



Unless otherwise specified dimensions are in mm.

Tolerances:

PCB outline dimensions  $\pm 0.2$  mm

All other tolerances  $\pm 0.1$  mm

**TCM 410J (pads on bottom side of PCB!)**

<b>PCB Dimension</b>	22 x 19 x 3.1 mm
<b>Weight</b>	1.9 g

## 1.6 Environmental conditions

<b>Operating temperature</b>	-25 °C ... +85 °C
<b>Storage temperature</b>	-40 °C ... +85 °C
<b>Storage temperature in tape &amp; reel package</b>	-20 °C ... +50 °C
<b>Humidity</b>	0% ... 93% r.H., non-condensing

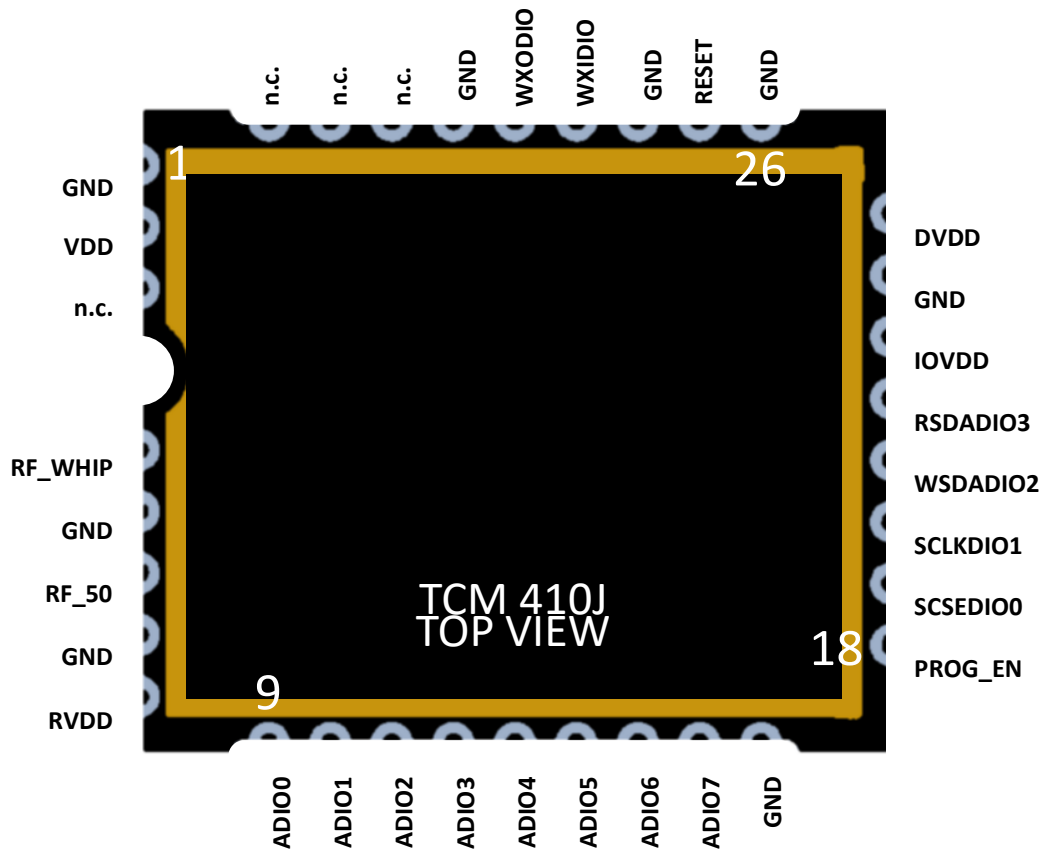
## 1.7 Ordering information

Type	Ordering Code	Frequency
TCM 410J	S3063-K410	928.35 MHz

## 2. Functional Description

### 2.1 Pinout

The figure below shows the pinout of the TCM 410J module.





## 2.2 Pin description and operational characteristics

HW Symbol	Pin #	Function	Characteristics
GND	1, 5, 7, 17, 24, 26, 28, 31	Ground connection	Must be connected to GND; see 4.3
VDD	2	Supply voltage	2.6 V ... 5 V
RVDD	8	RF supply voltage regulator output	Leave open
DVDD	25	Digital supply voltage regulator output	1.8 V Output current: max. 5 mA
IOVDD	23	GPIO supply voltage	Must be connected to desired interface supply voltage (see 2.4) See also 2.2.1.
RESET	27	Reset input Programming I/F	Active high reset. External 10 kΩ pull-down parallel to 10nF capacitor recommended. See 0.
PROG_EN	18	Digital input, Programming I/F	HIGH (at start up): programming mode active LOW: operating mode External 10 kΩ pull-down parallel to 10nF capacitor recommended. See 0.
ADIO0	9	Not used by standard FW.	Configured as Digital In with Pull Up
ADIO1	10	Not used by standard FW.	Configured as Digital In with Pull Up
ADIO2	11	Not used by standard FW.	Configured as Digital In with Pull Up
ADIO3	12	Not used by standard FW.	Configured as Digital In with Pull Up
ADIO4	13	Not used by standard FW.	Configured as Digital In with Pull Up
ADIO5	14	Not used by standard FW.	Configured as Digital In with Pull Up
ADIO6	15	UART input – RX	See 2.7
ADIO7	16	UART output - TX Programming I/F	See 2.7
SCSEDIO0	19	Interface for external EEPROM with I2C interface Programming I/F	Digital I/O for I2C Data communication.
SCLKDIO1	20	Interface for external EEPROM with I2C interface. Programming I/F	Digital Output, Clock pin for I2C Communication
WSDADIO2	21	Not used by standard FW. Programming I/F	Configured as Digital In with Pull Up
RSDADIO3	22	Not used by standard FW. Programming I/F	Configured as Digital In with Pull Up
WXIDIO	29	Not used by standard FW.	Configured as Digital In with Pull Up
WXODIO	30	Not used by standard FW.	Configured as Digital In with Pull Up
RF_WHIP	4	RF output	Output for whip antenna
RF_50	6	RF output	50 Ohm output for external antenna
n.c.	3, 32,33, 34	Not connected	Do not connect!

### 2.2.1 GPIO supply voltage - IOVDD

For digital communication with other circuitry (peripherals) the digital I/O configured pins of the mixed-signal sensor interface (ADIO0 to ADIO7) and the pins of the serial interface (SCSEDIO0, SCLKDIO1, WSDADIO2, RSDADIO3) may be operated from supply voltages different from DVDD.

To do so, an input for supplying the interface voltage (IOVDD) is available which can be connected either to DVDD (to use the same voltage as the supply voltage) or to an external supply with a different voltage within the tolerated voltage range of IOVDD.

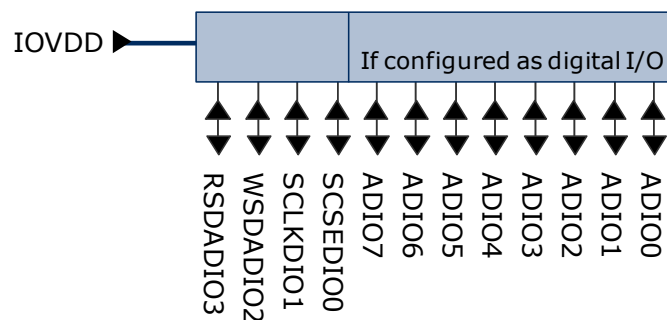


If DVDD=0 V (e.g. in any sleep mode or if  $VDD < V_{OFF}$ ) and IOVDD is supplied, then there may be unpredictable and varying current from IOVDD caused by internal floating nodes. It must be assured that current flowing into IOVDD does not exceed 10 mA while DVDD=0 V.

If DVDD=0 V and IOVDD is not supplied, then do not apply voltage to any of the above-mentioned pins. Doing so may lead to unpredictable malfunction of the device.



For I/O pins configured as analogue pins the IOVDD voltage level is not relevant! However it is important to connect IOVDD to a supply voltage as specified in 2.4.

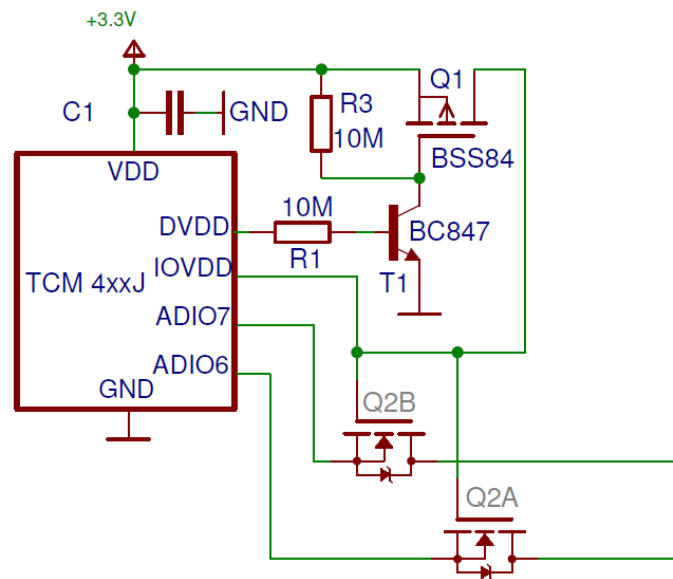


### 2.2.2 Handling IOVDD and PINs in sleep mode

TCM 410J is designed for line-powered applications communicating over a serial interface (UART). For some applications it might be desirable to put TCM 410J into sleep mode to conserve energy while the device is not used.

As discussed in chapter 2.2.1. above, it is not recommended to supply IOVDD or connect voltage to IOs if DVDD = 0 V (e.g. in any sleep mode or if  $VDD < V_{OFF}$ ). If the module is put into deep sleep mode (i.e. with the serial command CO\_WR\_SLEEP, see chapter 2.7), then it is important to cut IOVDD supply and not apply voltage on the IO pins (e.g. the UART interface).

The example below illustrates how to control IOVDD using DVDD as controlling signal.



## 2.3 Absolute maximum ratings (non-operating)

Symbol	Parameter	Min	Max	Units
VDD	Supply voltage at VDD	-0.5	5.5	V
IOVDD	GPIO supply voltage	-0.5	3.6	V
GND	Ground connection	0	0	V
VINA	Voltage at every analog input pin	-0.5	2	V
VIND1	Voltage at RESET, and every digital input pin except WXIDIO/WXODIO	-0.5	3.6	V
VIND2	Voltage at WXIDIO / WXODIO input pin	-0.5	2	V

## 2.4 Maximum ratings (operating)

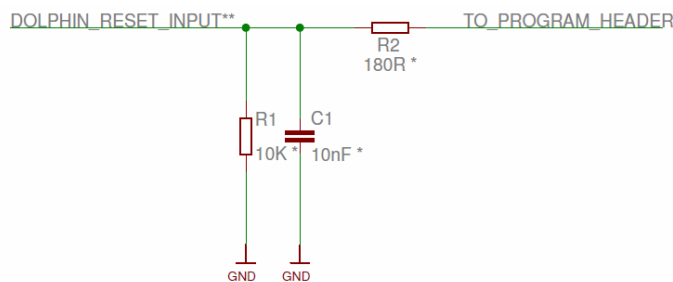
Sym-bol	Parameter	Min	Max	Units
VDD	Supply voltage at VDD	2.6	5	V
IOVDD	GPIO supply voltage (see also 2.2.1)	1.7	3.6	V
GND	Ground connection	0	0	V
VINA	Voltage at every analog input pin	0	2.0	V
VIND1	Voltage at RESET, and every digital input pin except WXIDIO / WXODIO	0	3.6	V
VIND2	Voltage at WXIDIO / WXODIO input pin	0	2.0	V
VDDR	Max. ripple at VDD		50	mVpp

## TCM 410J – Transceiver Module

## 2.5 Suggested RESET and PROG\_EN circuitry

To ensure reliable operation, it is recommended to connect both the RESET and the PROG\_EN with a 10 kΩ resistor in parallel with a 10 nF capacitor to ground. This avoids spurious signal detection in very noisy environments and in situations where an external programming header is provided.

The suggested circuit is shown below.



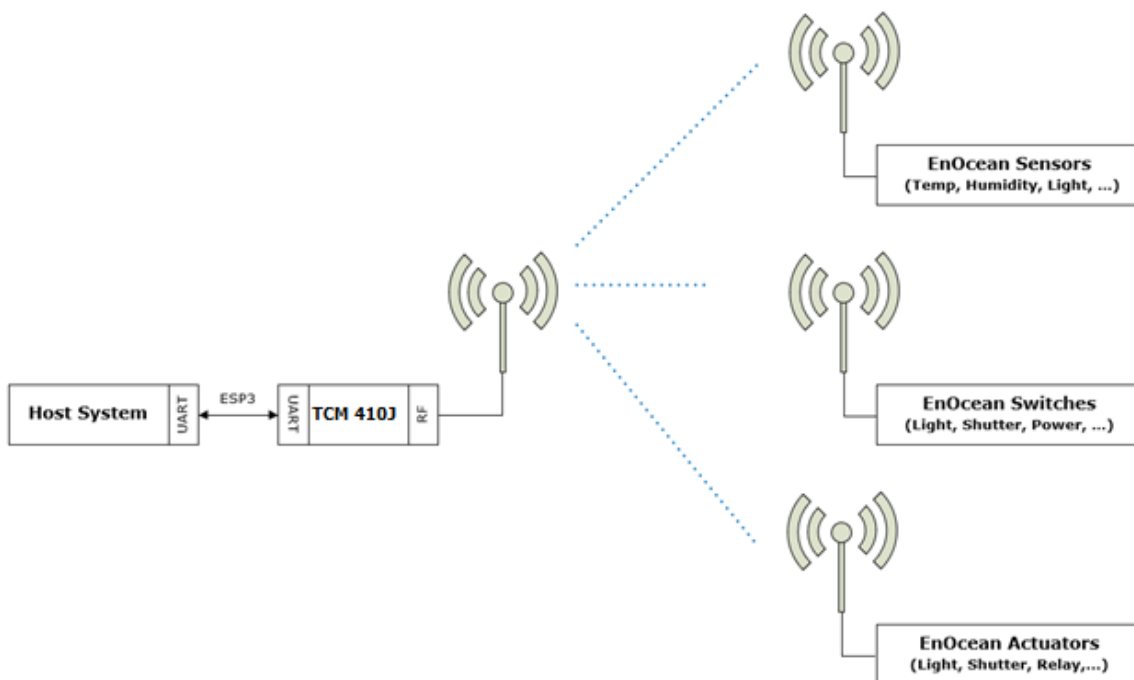
\* values may be different depending on the application

\*\* same circuit recommended for PROG\_EN Input

If the programming interfaces / reset line is not used, then the TO\_PROGRAM\_HEADER line should be connected to GND.

## 2.6 System environment

The figure below shows the integration of TCM 410J into a typical system environment.



## 2.7 Serial Interface

TCM 410J provides a bi-directional serial interface according to the EnOcean ESP3 specification. For details regarding ESP3 please refer to the ESP3 specification. The data rate on the serial interface is 56.8 kbit/s which is usually interoperable with systems running at 57.6 kbit/s.

Direction	Nominal serial data rate	Tolerance
TX (sent by module)	56888 bit/s (=57600 bit/s - 1.23%)	< 50 ppm
RX (received by module)	56888 bit/s	< 5%

The following ESP3 commands are supported:

- Type 10 : Radio Packet
- Type 2: Responses
- Type 4: Event
  - SA\_CONFIRM\_LEARN to confirm/discard learn in/out
  - CO\_READY to indicate wake up from deep sleep initiated by CO\_WR\_SLEEP
- Type 4: Event related to security processing  
CO\_EVENT\_SECUREDEVICES
- Type 5: Common commands
  - CO\_WR\_SLEEP to enter energy saving mode (deep sleep mode)
  - CO\_WR\_RESET to reset the device
  - CO\_RD\_VERSION to read SW/HW versions, chip ID etc.
  - CO\_WR\_IDBASE to write ID range base number
  - CO\_RD\_IDBASE to read ID range base number
  - CO\_WR\_REPEATER to configure repeater functionality
  - CO\_RD\_REPEATER to read repeater state
  - CO\_WR\_FILTER\_ADD to add filter to filter list (up to 10 filters are supported)
  - CO\_WR\_FILTER\_DEL to delete filter from filter list
  - CO\_WR\_FILTER\_DEL\_ALL to delete all filter
  - CO\_WR\_FILTER\_ENABLE to enable/disable supplied filters
  - CO\_RD\_FILTER to read supplied filters
  - CO\_WR\_WAIT\_MATURITY to wait maturity time before returning radio telegrams
- Type 5: Common commands related to security processing
  - CO\_WR\_LEARNMODE
  - CO\_RD\_LEARNMODE
  - CO\_WR\_SECUREDEVICE\_ADD
  - CO\_WR\_SECUREDEVICE\_DEL
  - CO\_RD\_SECUREDEVICE\_COUNT
  - CO\_RD\_SECUREDEVICE\_BY\_INDEX
  - CO\_RD\_SECUREDEVICE\_BY\_ID
  - CO\_WR\_SECUREDEVICE\_SENDTEACHIN
  - CO\_WR\_SECUREDEVICE\_ADD\_PSK
  - CO\_WR\_TEMPORARY\_RLC\_WINDOW

## TCM 410J – Transceiver Module

- Type 6: Smart Acknowledge commands
  - SA\_WR\_LEARNMODE to set/reset Smart Acknowledge learn mode
  - SA\_RD\_LEARNMODE to get learn mode
  - SA\_WR\_LEARNCONFIRM to add or delete a mailbox of a client
  - SA\_WR\_RESET to send a reset command to a client
  - SA\_RD\_LEARNEDCLIENTS to get learned mailboxes/clients
  - SA\_WR\_POSTMASTER to activate/deactivate postmaster functionality
- Type 7: Remote Management
  - Messages up to 256 Bytes



All configuration values set via ESP3 commands are held in RAM and will therefore be lost after RESET or after a deep sleep phase. Only Smart Ack mailboxes are stored in FLASH and are available also after RESET or a deep sleep phase.



After sending a CO\_WR\_RESET command, the device will send a CO\_READY event indicating Wake-up Reason 06: "A memory request from the CPU core does not correspond to any valid memory location." This is caused by the reset which is issued after receiving CO\_WR\_RESET and is not a SW/HW malfunction.

## 2.8 Built-in Repeater

TCM 410J provides the option to activate a one-level repeater for EnOcean radio telegrams. If a received telegram is valid and original (not yet repeated), then the telegram is repeated after a random delay. Configuration of the repeater is done via the ESP3 command CO\_WR\_REPEATER.

Group	Offset	Size	Field	Value hex	Description
-	0	1	Sync. Byte	0x55	
Header	1	2	Data Length	0x0003	3 bytes
	3	1	Optional Length	0x00	0 byte
	4	1	Packet Type	0x05	COMMON_COMMAND = 5
-	5	1	CRC8H	0xnn	
Data	6	1	COMMAND Code	0x09	CO_WR_REPEATER = 09
	7	1	REP_ENABLE	0x00...0x02	Repeater 0x00: OFF 0x01: Repeat all telegrams 0x02: Repeat telegrams according to filter list
	8	1	REP_LEVEL	0x00...0x02	0x00: Repeater OFF 0x01: 1-level repeater
Optional Data	9	1	STORAGE_TYPE	0x00 – 0x01	No Optional Data: Volatile memory 0x00: Volatile memory 0x01: Non-volatile memory
-	10	1	CRC8D	0xnn	

For detailed recommendations regarding the usage of repeaters please refer to our application note [EnOcean Wireless Systems - Installation Notes \(PDF\), 09/2010](#).

### 2.8.1 Persistent Repeater settings

TCM 410J supports storage of the Repeater settings either in volatile memory (lost upon power cycle) or in non-volatile memory (maintained upon power cycle). The selection between these two options is made using the STORAGE\_TYPE field of the CO\_WR\_REPEATER command shown above.

## 2.9 Smart Acknowledge

TCM 410J provides a postmaster function with 10 mailboxes for sensors using Smart Ack technology.



When teaching-in a device using Smart Acknowledge please take care to switch off all TCM 4xyJ devices which are not continuously powered. Otherwise, these TCM 4xyJ modules could be declared postmaster. As soon as the power supply is switched off, a postmaster would be missing and Smart Acknowledge would not work any longer!

### 2.10 Concurrent use of Smart Acknowledge and Repeater functionality

Use of Smart Acknowledge functionality will limit the maximum data size of repeated telegrams to 14 byte. If repeating of longer telegrams is required, then Smart Acknowledge functionality has disabled by using the SA\_WR\_POSTMASTER command shown below setting Mailbox count to 0.

Group	Offset	Size	Field	Value hex	Description
-	0	1	Sync. Byte	0x55	
Header	1	2	Data Length	0x0002	2 bytes
	3	1	Optional Length	0x00	0 byte
	4	1	Packet Type	0x06	SMART_ACK_COMMAND = 6
-	5	1	CRC8H	0xnn	
Data	6	1	SMART_ACK Code	0x08	SA_WR_POSTMASTER = 8
	7	1	Mailbox count	0xnn	Amount of mailboxes available, 0 = disable post master functionality; Maximum 28 mailboxes can be created. This upper limit is for each firmware restricted and may be smaller.
-	8	1	CRC8D	0xnn	

### 2.11 Remote Management

TCM 410J provides a transparent radio channel also for remote management messages with a message length of up to 256 bytes. This enables an external micro controller connected to TCM 410J to handle remote management request from external devices or to control other devices via remote management.



### 3. Security Functionality

TCM 410J supports the following security features defined by the Security Level Format:

- Encryption / Decryption modes
  - No data encryption
  - VAES 128
  - AES – CBC
- Rolling Code (RLC) modes
  - No RLC
  - 2 byte RLC
  - 3 byte RLC
- Authentication / Signing (CMAC) modes
  - No CMAC
  - 3 byte CMAC
  - 4 byte CMAC
- Teach-in modes
  - Standard teach-in (plaintext content)
  - Teach-in content protected by PSK (content protected using pre-shared key)

TCM 410J supported the following security functions:

- Decryption of received telegrams
- Authentication (CMAC validation) of received telegrams
- Encryption of transmitted telegrams
- Signing (CMAC calculation) of transmitted telegrams
- Handling of rolling codes (RLC) and security keys.

For details on the security functionality, please consult the EnOcean Alliance Security Specification using Reference [1].

Use of these secure features require the use of an external EEPROM as described in Chapter 3.4.

### 3.1 Operational modes

TCM 410J provides the following functional modes for security processing:

- Teach-in mode (inbound / outbound)  
This mode is used to setup the parameters required for the security processing
- Operational mode  
This is the normal operation mode where secure telegrams are processed according to the parameters that are setup in teach-in mode

For inbound (reception) and outbound (transmission) communication, TCM 410J is maintaining a secure link table with individual entries containing the required parameters for secure communication with one specific remote device. Each such entry contains information on the security key, the rolling code (RLC) and the Security Level Format (SLF) to be used for communication with the remote device.

The secure link table is managed using the following commands:

- CO\_WR\_SECUREDEVICE\_ADD
- CO\_WR\_SECUREDEVICE\_DEL
- CO\_RD\_SECUREDEVICE\_BY\_INDEX
- CO\_RD\_NUMSECUREDEVICES
- CO\_RD\_SECUREDEVICE\_BY\_ID

The direction (inbound / outbound) must be specified.

The entries in the inbound table (used for the processing of received messages) can be referenced by one of the following two options:

- Table index (entry number)
- Device ID (EURID) of the device from which the message is received

The entries in the outbound table (used for the processing of transmitted messages) can be referenced by one of the following options:

- Table index (entry number)
- Device ID (EURID) of the device to which the message is transmitted (for the case of an addressed message)
- Device ID (EURID) or Base ID of the TCM 410J module that is transmitting the message for the case of a broadcast (non-addressed) transmission

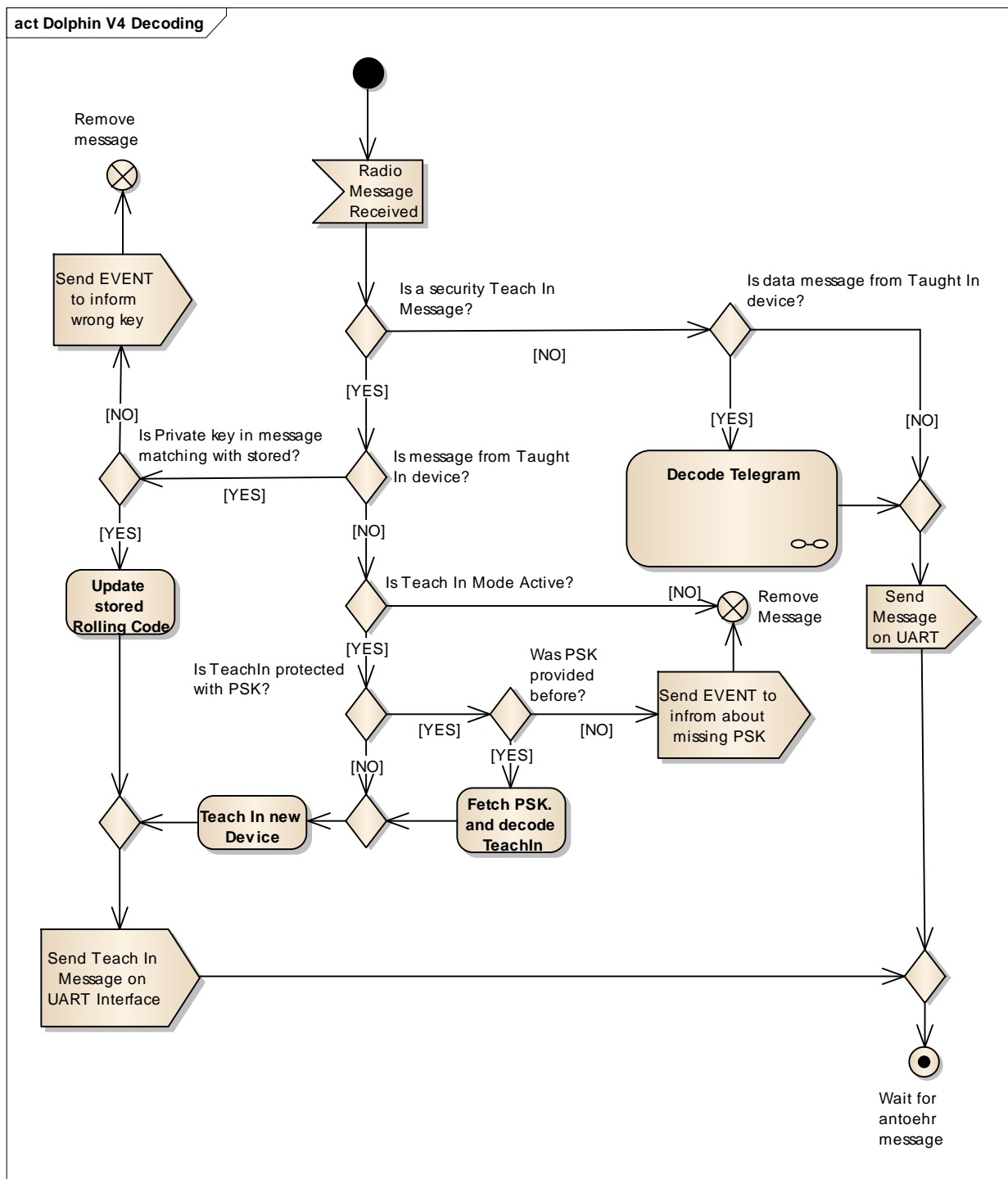
Please select the correct ID based on your use case when adding devices to the outbound table with the serial command CO\_WR\_SECUREDEVICE\_ADD.

When using command CO\_RD\_SECUREDEVICE\_BY\_INDEX then please notice that the inbound and the outbound table use separate indexes which both start at 0.

## TCM 410J – Transceiver Module

### 3.2 Reception

In Figure 1 the processing of received radio messages is shown. Also, the teach-in mode and resynchronisation features are shown.



**Figure 1 - Reception functionality**

### 3.2.1 Setup of security information in the inbound secure link table

For the processing of received messages, it is required to receive the security information of the transmitting device in a teach-in message. TCM 410J must be put into LRN Mode using the ESP3 command `CO_WR_LEARNMODE` to accept the teach-in message. Otherwise (if not in LRN mode), the teach-in message is ignored.

If a PSK (pre-shared key) is used to protect the content of the teach-in message, then the PSK must be setup using the ESP3 command `CO_WR_SECUREDEVICE_ADD_PSK` before the teach-in message is received.

After a successful teach-in process the whole teach-in message is provided to the host as one serial message of Packet Type 10.

Once the security information of a transmitting device has been setup, TCM 410J can automatically decode secure messages from this device.

Other received telegrams (for which no security parameters have been setup) will be forwarded without processing to the host via the ESP3 interface as serial message of Packet Type 10.

### 3.2.2 Resynchronisation of Learned-in Secure Devices

During normal operating mode (not teach-in mode) teach-in requests from unknown devices are ignored.

If a learned-in device sends a teach-in request and the security key is correct, then the RLC code information is updated. This is addressing the case where the receiver and sender's RLC become desynchronized.

If a learned-in device sends a teach-in request and the security key is not correct, then TCM 410J will inform the host about a potential security issue using the ESP3 event `CO_EVENT_SECUREDEVICES`

### 3.2.3 Processing of received messages with implicit RLC

If a remote device does not transmit the Rolling Code (RLC) as part of the secure message (implicit RLC, legacy feature that is not recommended for new designs), then TCM 410J has to track the most recently received RLC.

Under special circumstances (for instance power-down or being outside of radio range), it is possible that TCM 410J might not receive all messages from the remote device and therefore its tracked RLC is lower than the one that is used by the remote device.

TCM 410J provides the following functionality for this case:

- Temporary RLC window extension

TCM 410J will by default try up to 128 Rolling Code values to address this case. If this is insufficient (for instance due to an extended power down), then the number of Rolling Code (RLC) that will be tried can be extended for the next received telegram from each device setup in the secure link table.

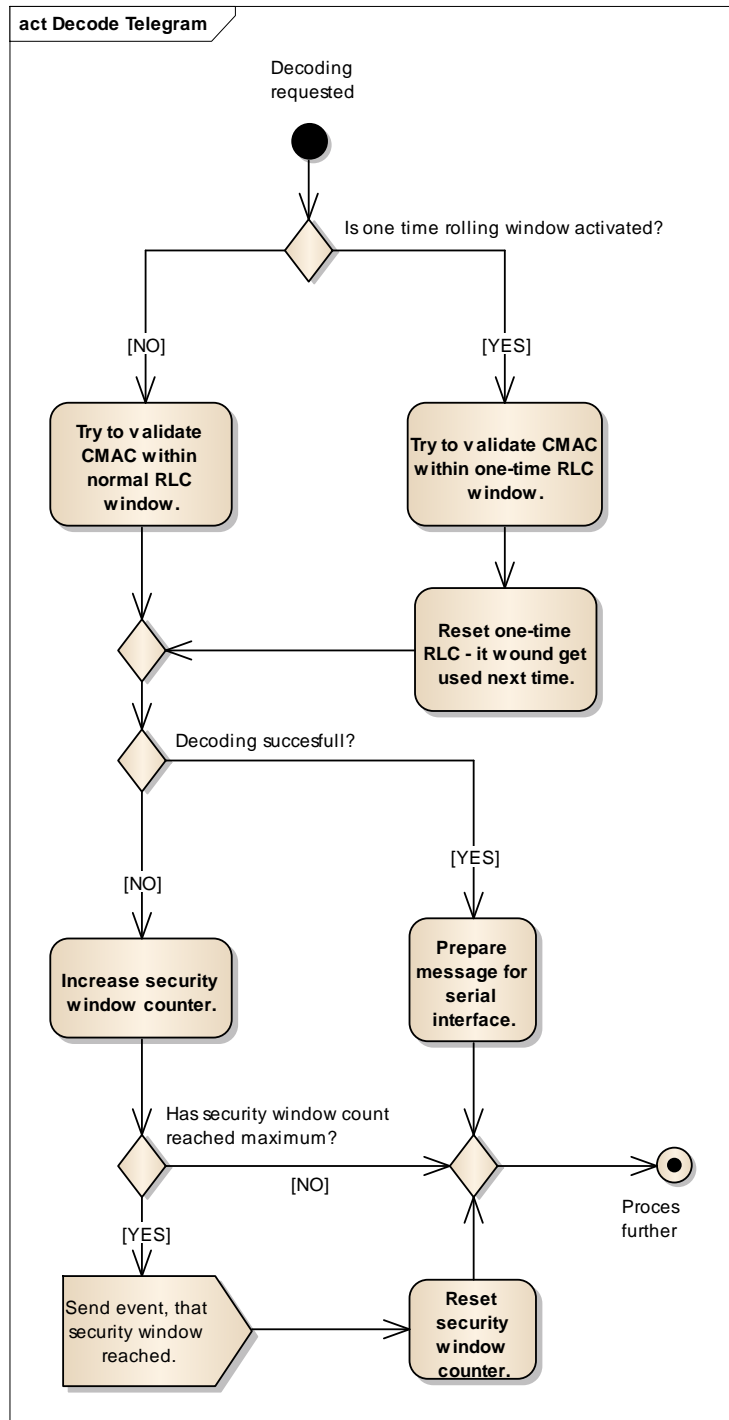
The extended Rolling Code search window can be enabled or disabled using the ESP3 command `CO_WR_TEMPORARY_RLC_WINDOW` as described in Reference [2].

- Security RLC window counter (Amount of failed CMAC validation attempts)

This value defines the count of the wrong CMAC validation attempts, before TCM 410J sends the ESP3 Event `CO_EVENT_SECUREDEVICES` to the connected host to signalize that the RLC might not be synchronized anymore.

Figure 2 shows the processing of received messages with implicit RLC.

## TCM 410J – Transceiver Module



**Figure 2 – Security processing of received messages with implicit RLC**

### 3.2.4 Filtering

TCM 410J allows filtering received messages according to certain parameters to limit the amount of received telegrams that are forwarded to the external host. The filtering functionality is independent from the security processing.

To filter received messages, use the ESP3 command `CO_WR_FILTER_ADD` to setup the corresponding filter rules. See Reference [2] for the command syntax. Note that filter rules are stored in volatile memory and therefore have to be reinitialized after a power cycle or reset.

## 3.3 Transmission

### 3.3.1 Setup of security parameters in the outbound secure link table

For the transmission of secure messages by TCM 410J, it is required to setup the security parameters (SLF format, KEY and RLC) which shall be used. These parameters are setup using the ESP3 command `CO_WR_SECUREDEVICE_ADD` as described in Reference [2].

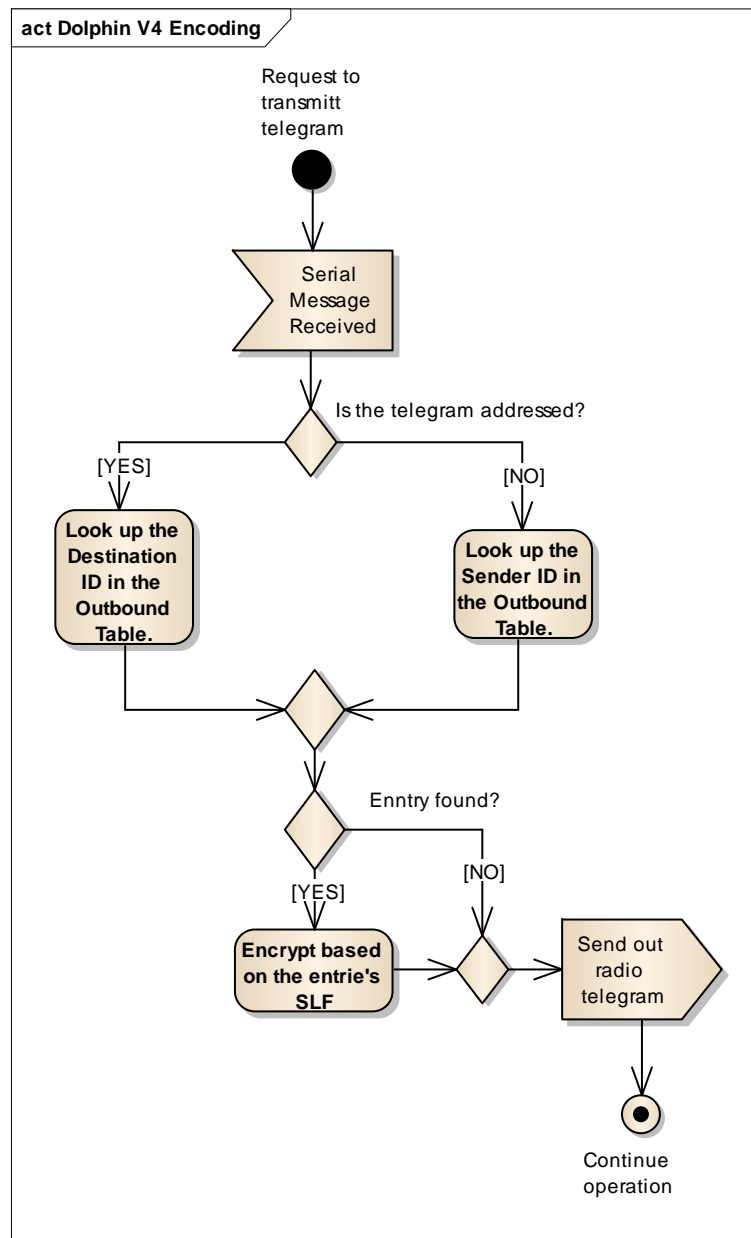
### 3.3.2 Transmission of a teach-in telegram

To enable the remote device to process secure messages from TCM 410J, it is required to transmit a teach-in telegram informing the remote device about the security parameters that will be used.

To transmit such teach-in telegram, the remote device first must be setup in the outbound secure link table as described above. After that, transmission of the teach-in telegram can be triggered using the ESP3 command `CO_WR_SECUREDEVICE_SENDTEACHIN` as described in Reference [2].

### 3.3.3 Transmission of data messages

After setup of the remote device in the outbound secure link table - as described above - TCM 410J will automatically process transmitted messages according to the specified parameters.



**Figure 3 – Security processing for transmitted messages**



### 3.4 Storage for Rolling Codes and Keys

To implement the security functionality described in the previous chapters, TCM 410J needs to store the following parameters for communication with each remote device:

- Security Key: 16 bytes
- Rolling Code (RLC): 2 or 3 bytes

The security key is stored internally in TCM 410J, while the RLC is stored in an external EEPROM memory. TCM 410J can support the following maximum number of remote devices:

- Reception of messages from up to 30 remote devices
- Transmission of message to up to 30 remote devices

While the security Key of a device is constant, the Rolling Code (RLC) will change with every telegram transmission and therefore has to be stored periodically in the external EEPROM. The Rolling Code is stored with the following rate:

- For transmission: RLC is by default stored for every transmitted telegram
- For reception: RLC is by default stored for every 30<sup>th</sup> received telegram

These parameters can be adjusted through Dolphin Suite if needed.

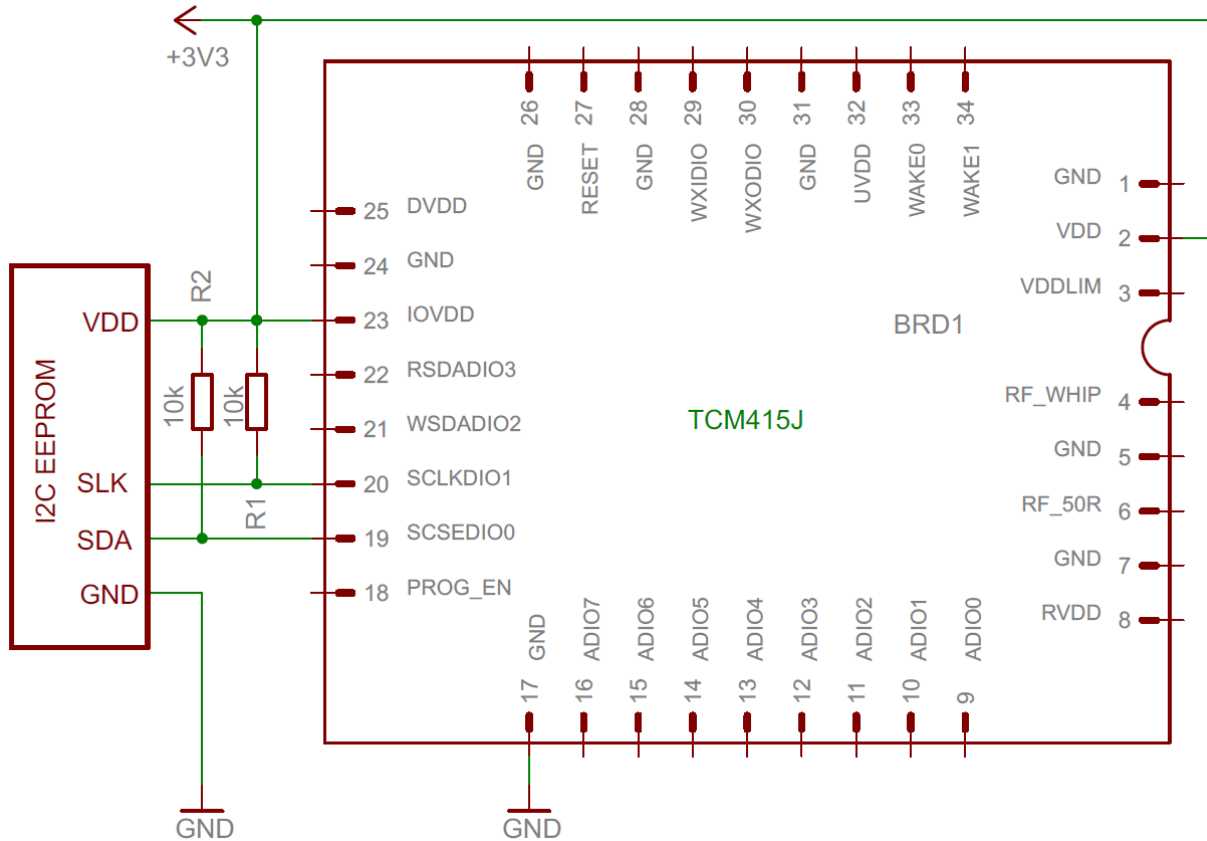
#### 3.4.1 External EEPROM

TCM 410J requires an external EEPROM to store the Rolling Code information. The following EEPROM shall be used for that purpose:

- Microchip 24AA08 (8 kilobit EEPROM)

The connection between TCM 410J and the external EEPROM has to be implemented as shown below.

## TCM 410J – Transceiver Module



**Figure 4 - Connection between TCM 410J and the external EEPROM**

### 3.4.2 Voltage drops

Power supply design has to ensure that the supply voltage provided to TCM 410J and the external EEPROM is stable. This is especially important during critical tasks such as write and erase operations of the external EEPROM memory. Any voltage drop during such operations can cause unexpected behavior.

It is therefore required to implement an external capacitor of sufficient size to maintain a current to the EEPROM of at least 100uA for at least 5 ms.

### 3.5 Configurations

The security configuration is stored in CFG Area of the Dolphin v4 ASIC used in TCM 410J. The following parameters can be changed using Dolphin v4 Suite:

- Security RC storage cycle outbound – Address in CFG: 0x23 Default value: 1

This value defines how many telegrams of one security profile will be send prior to updating the rolling code in persistent memory.

- Security RC storage cycle inbound – Address in CFG: 0x22 (Length: 1 byte), Default value: 30

This value defines how many telegrams of one security profile will be send prior to updating the rolling code in persistent memory.

- Wrong CMAC count – Security RLC window – Address in CFG: 0x20 (Length: 1 byte), Default value: 100

This value defines the count of the wrong CMAC validation attempts, before the Decoding Gateway module sends the event serial command (CO\_EVENT\_SECUREDEVICES).

- RLC window – Address in CFG: 0x1C (Length: 4 bytes), Default value: 128

This value defines how big the Rolling Code window can be. The Rolling code window defines the amount of tries where the device tries to validate the RLC from a message.

- PSK – Pre-shared key - Address in CFG: 0x1C (Length: 16 bytes), Default value: N/A – set in production

The PSK which can used for outbound security teach-in.

Please see configuration window from Dolphin v4 Suite as reference:

Security

Brute Force Limit	<input type="text" value="100"/>	Count of receiving wrong CMAC to send an CO_EVENT_SECUREDEVICES
Rolling-Code Window	<input type="text" value="128"/>	Rolling code window size
Rolling-Code In Save	<input type="text" value="30"/>	Save rolling code to EEPROM after every Nth inbound telegram
Rolling-Code Out Save	<input type="text" value="1"/>	Save rolling code to EEPROM after every Nth outbound telegram

Security Keys

Define Pre-Shared

Pre-shared Key

## 4. Application Information

### 4.1 Transmission range

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

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

- Line-of-sight connections: Typically 30 m range in corridors, up to 100 m in halls
- Plasterboard walls / dry wood: Typically 30 m range, through max. 5 walls
- Ferro concrete 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:

- Devices mounted on metal surfaces (shielding and detuning of antenna may cause heavy loss of transmission range)
- Hollow lightweight walls filled with insulating wool on metal foil
- Suspended ceilings with panels of metal or carbon fibre
- 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](http://www.enocean.com).

## 4.2 Antenna options

### 4.2.1 Overview

TCM 410J has been approved for use with a number of different antennas. The following chapters describe common options.

### 4.2.2 Whip antenna

Antenna length:	64 mm wire, connect to RF_WHIP
Minimum GND plane:	50 mm x 50 mm
Minimum distance space:	10 mm

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

For good receiver performance, great care must be taken about the space immediately around the antenna since this has a strong influence on screening and detuning the antenna.

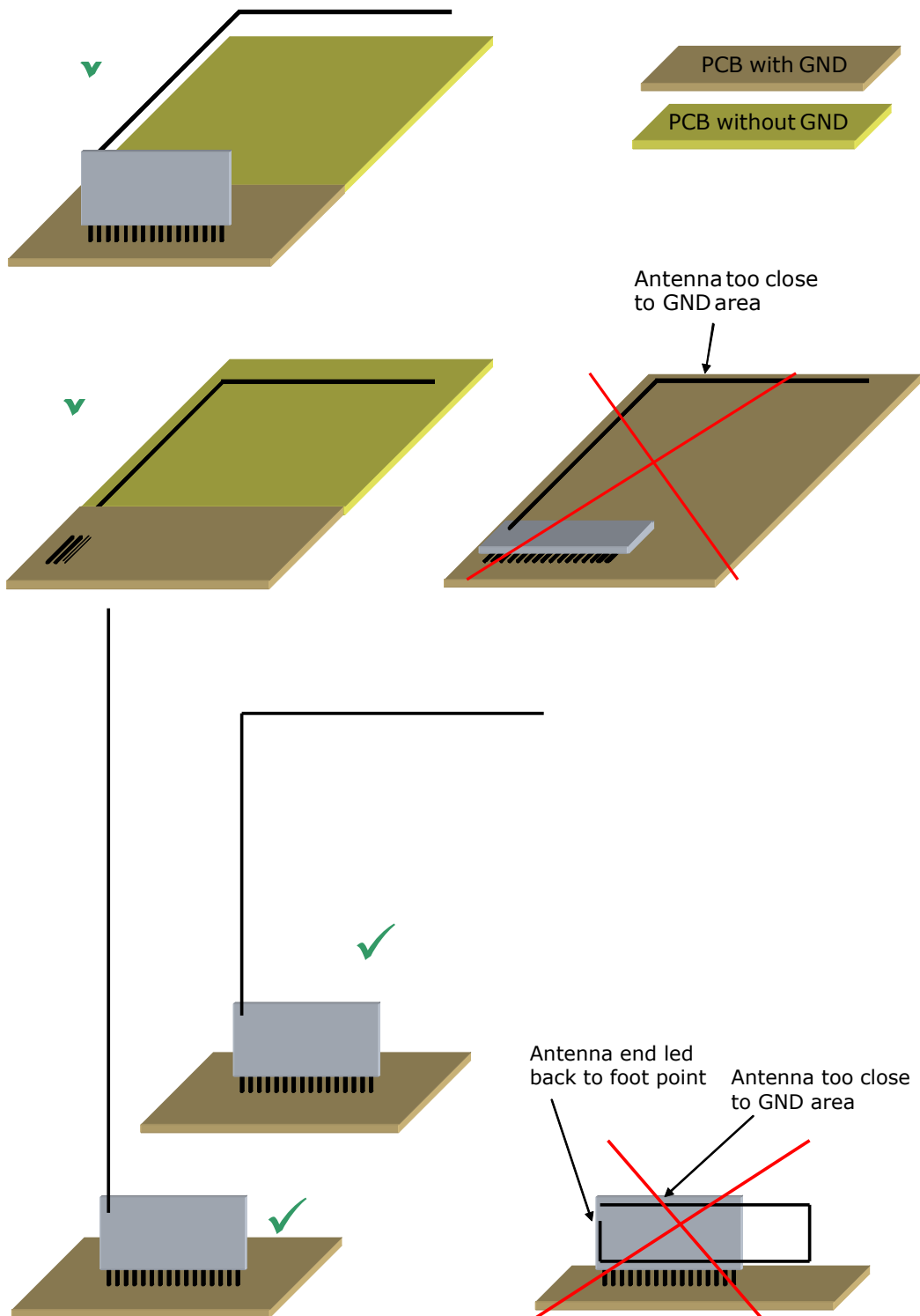
The antenna should be drawn out as far as possible and must never be cut off. Mainly the far end of the wire should be mounted as far away as possible (at least 15 mm) from all metal parts, ground planes, PCB strip lines and fast logic components such as microprocessors).

Do not roll up or twist the whip antenna!

Radio frequency emissions might reduce the reception performance of TCM 410J. The following recommendations should be followed:

- PCB strip lines on the user board should be designed as short as possible
- A PCB ground plane layer with sufficient ground vias is strongly recommended

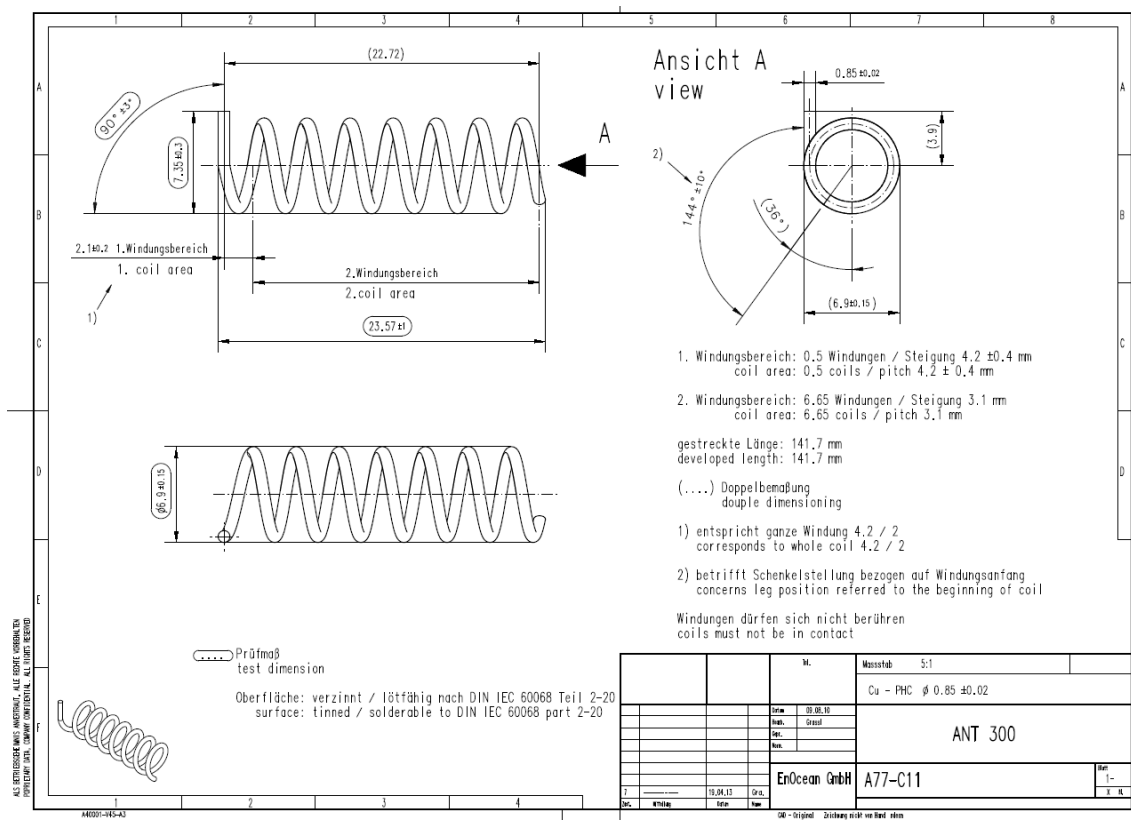
#### 4.2.2.1 Recommendations for placement of the whip antenna



TCM 410J – Transceiver Module

4.2.3 Helical antenna

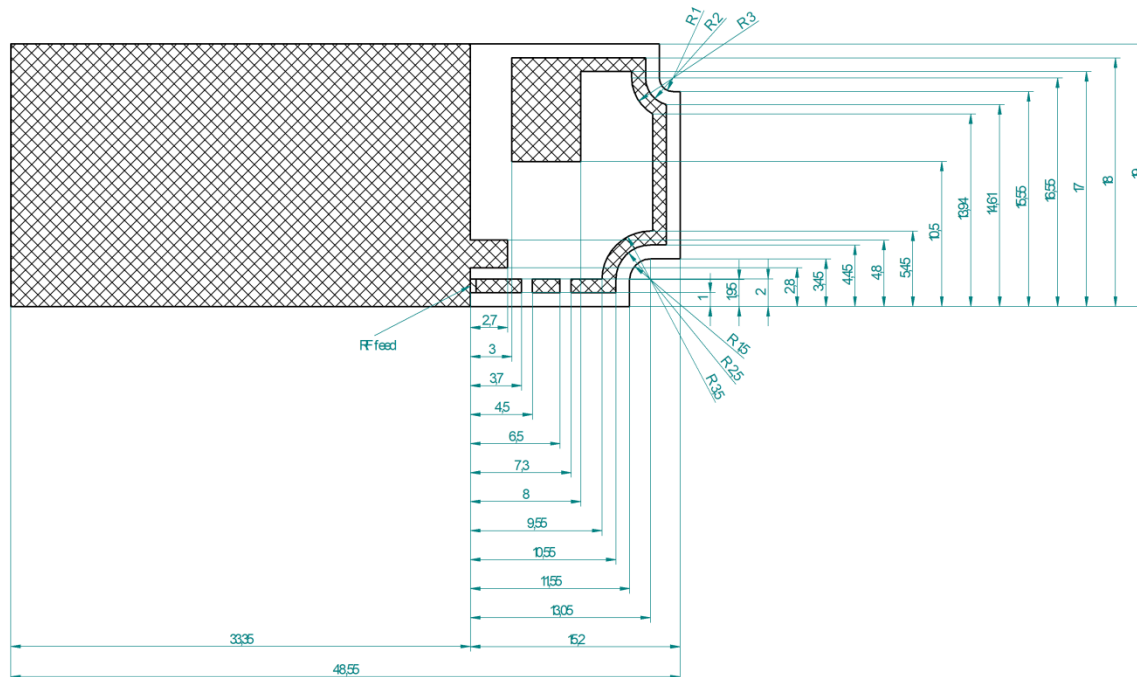
Antenna shape: According to drawing below, connect to RF\_WHIP  
Minimum GND plane: 35 mm x 30 mm  
Minimum distance space: 10 mm



## TCM 410J – Transceiver Module

#### 4.2.4 Top loaded PCB spiral antenna

The design of the antenna made on a 1mm thick, two-layer FR4 PCB. The dimensions are given in figure below. The hatched areas are double sided in layout. The large area to the left is a ground area. Components can be placed here as long as the area is not split by this nor has long cuts in it which can act as radiators itself.



### Dimensions of the PCB antenna

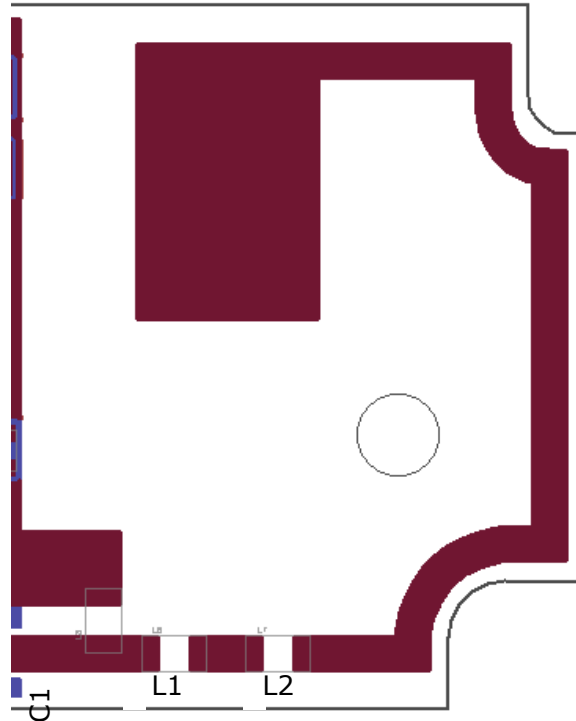
Parameter of PCB	VALUE
PCB material	FR4, 2 layer
Thickness (total)	1,27mm
Shape	Rectangular with millings
Dimension	19*48,55 mm

Layer	Thickness in $\mu\text{m}$	Exact description
Solder Mask		Solder resist
Top Layer	35	Cu, >35um after electroplating
Core	1200	
Bottom Layer	35	Cu, >35um after electroplating
Solder Mask		Solder resist
Total	1270	



## TCM 410J – Transceiver Module

The PCB antenna uses three discrete matching components. The position of these components can be seen in figure below.

**Position of matching components**

The antenna was matched to 50 $\Omega$  input impedance at the feed point. A compromise for a good matching when plugged into a laptop and when plugged to the end of a USB cable was chosen. Several environments in the proximity of the antenna were also evaluated for this compromise. The following table shows the values of the proposed components.

Component	Value
C1	3.3pF
L1	12nH
L2	12nH

0603 components should be used for the antenna matching. For the capacitor general purpose C0G capacitors with 5% tolerance are sufficient.

The inductors should be wire wound inductors from the Würth WE-KI series or the Murata LQW series.

### 4.3 Power supply requirements

In order to provide a good radio performance, great attention must be paid to the power supply and a correct layout and shielding. It is recommended to place a 22  $\mu$ F ceramic capacitor between VDD and GND close to the module (material: X5R, X7R, min 6.3 V to avoid derating effects).

In addition, an HF SMD EMI Suppression Ferrite Bead such as the Würth WE-CBF HF SMD EMI Suppression Ferrite Bead (Würth order number 742863160) shall be inserted in the power supply line.

For best performance it is recommended to keep the ripple on the power supply rail below 10 mVpp (see 2.4).



All GND pins must be connected to GND. Be careful not to create loops! The ground must be realized ideally on both sides of the PCB board with many Vias. At least there must be a short star connection. Otherwise, RF performance can be reduced!

### 4.4 Layout recommendations



The length of lines connected to I/Os should not exceed 5 cm.



It is recommended to have a complete GND layer in the application PCB, at least in the area below the module and directly connected components (e.g. mid-layer of your application PCB).

Due to unisolated test points there are live signals accessible on the bottom side of the module.

Please follow the following guidance to minimize interference with your application circuit:

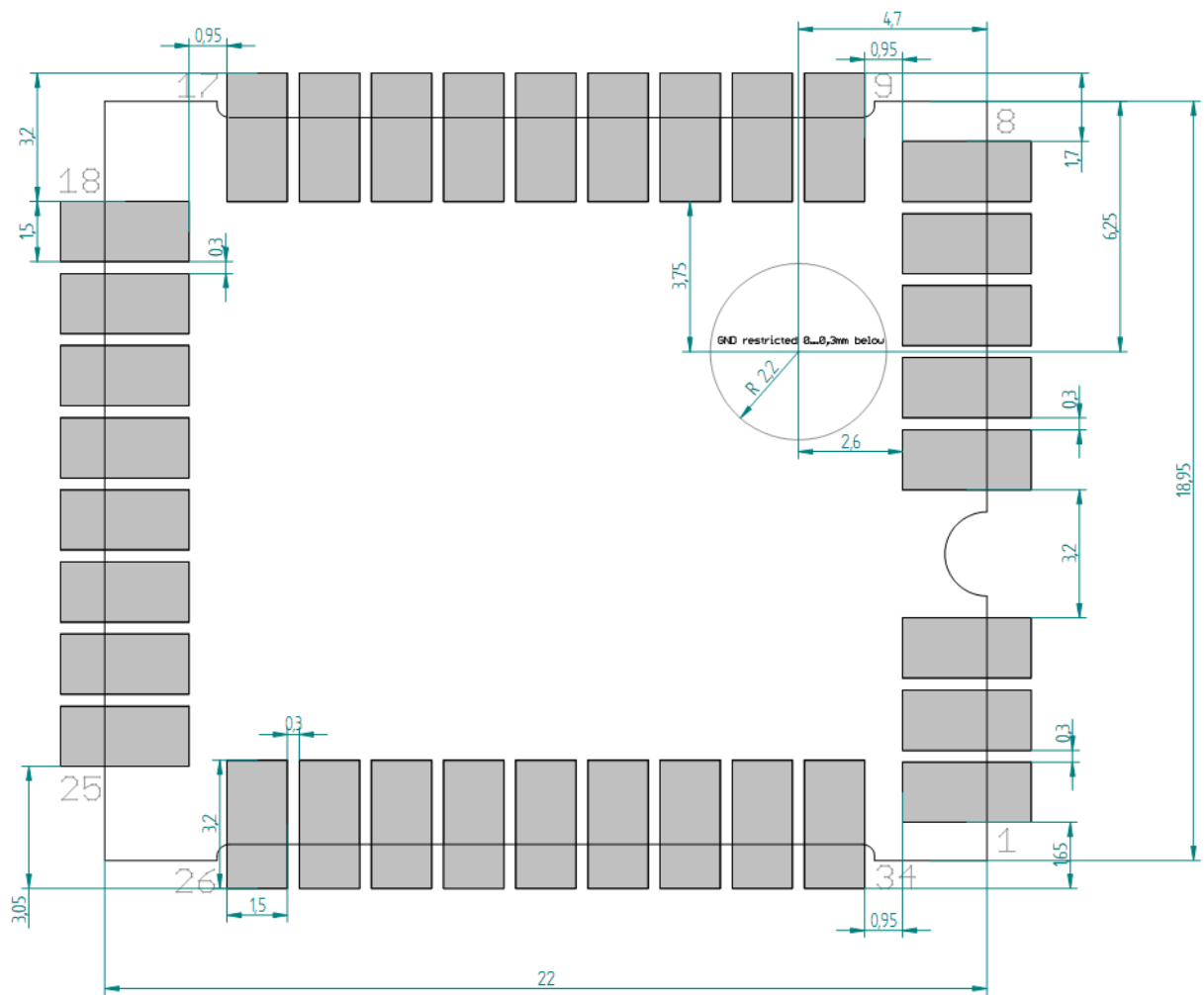
- We suggest avoiding any copper structure in the area directly underneath the module (top-layer layout of your application PCB). If this is not possible in your design, please provide coating on top of your PCB to prevent short circuits to the module. All bare metal surfaces including vias have to be covered (e.g. adequate layout of solder resist).
- It is mandatory that the area marked by the circle in the figure below is kept clear of any conductive structures in the top layer and 0.3 mm below. Otherwise, RF performance will be degraded!

Furthermore, any distortive signals (e.g. bus signals or power lines) should not be routed underneath the module. If such signals are present in your design, we suggest separating them by using a ground plane between module and these signal lines.

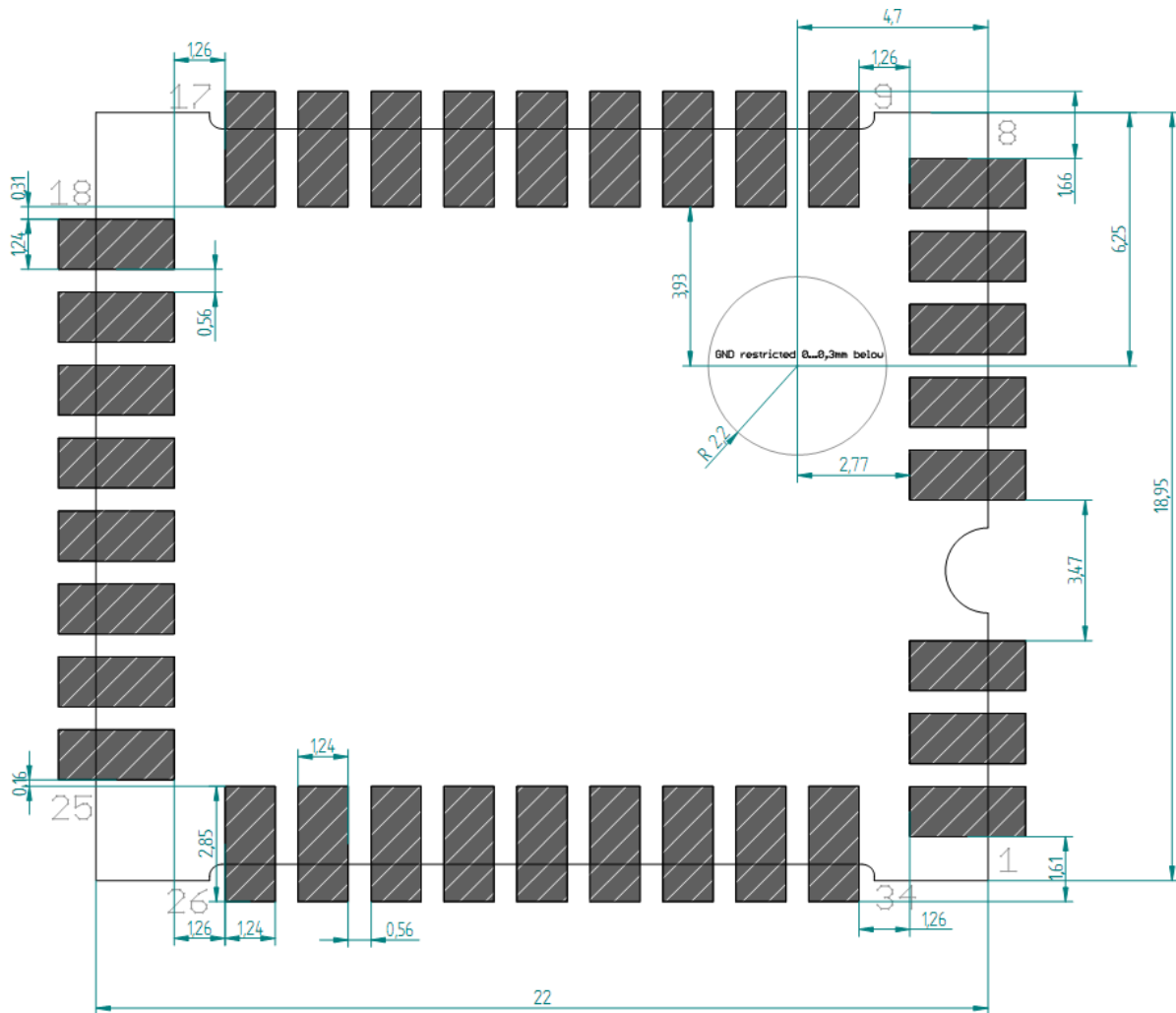
[illegible]

TCM 410J – Transceiver Module

Solder resist top layer



## TCM 410J – Transceiver Module

**Solder paste top layer**

The data above are also available as EAGLE library.

To ensure good solder quality a solder mask thickness of 150 µm is recommended.

If a 120 µm solder mask is used, then it is recommended to enlarge the solder print. The pads on the solder print should then be 0.1 mm larger than the pad dimensions of the module.

An application and production specific test regarding the amount of soldering paste should be performed to find optimum parameters.

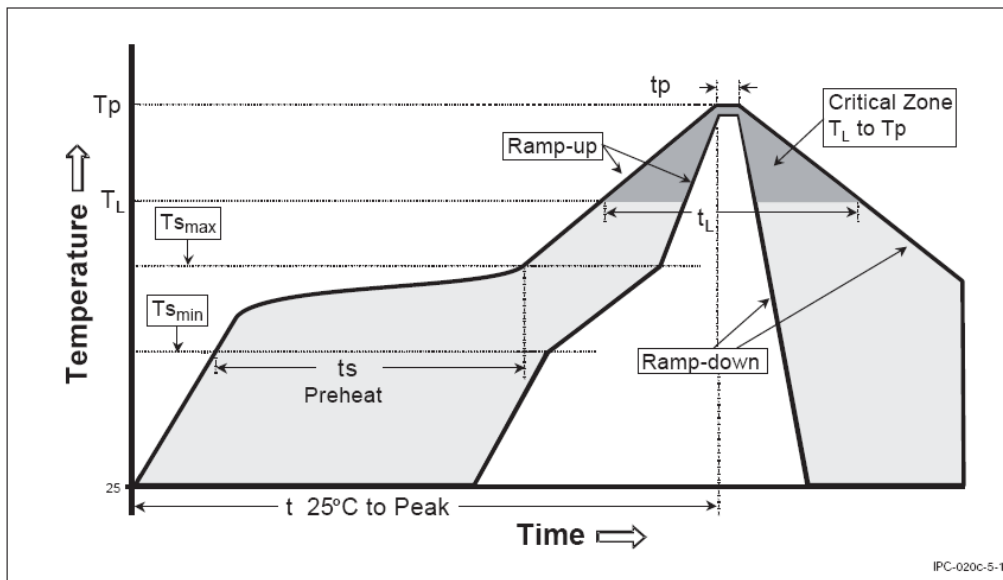
## TCM 410J – Transceiver Module

## 4.5 Soldering information

TCM 410J shall be soldered according to IPC/JEDEC J-STD-020C standard.

Profile Feature	Pb-Free Assembly
Average Ramp-Up Rate ( $T_{s_{max}}$ to $T_p$ )	3° C/second max.
<b>Preheat</b> <ul style="list-style-type: none"> <li>– Temperature Min (<math>T_{s_{min}}</math>)</li> <li>– Temperature Max (<math>T_{s_{max}}</math>)</li> <li>– Time (<math>t_{s_{min}}</math> to <math>t_{s_{max}}</math>)</li> </ul>	150 °C 200 °C 60-180 seconds
Time maintained above: – Temperature ( $T_L$ ) – Time ( $t_L$ )	217 °C 60-150 seconds
Peak/Classification Temperature ( $T_p$ )	260 °C
Time within 5 °C of actual Peak Temperature ( $t_p$ )	20-40 seconds
Ramp-Down Rate	6 °C/second max.
Time 25 °C to Peak Temperature	8 minutes max.

Note 1: All temperatures refer to topside of the package, measured on the package body surface.



TCM 410J shall be handled according to Moisture Sensitivity Level MSL3 which means a floor time of 168 h. TCM 410J may be soldered only once, since one time is already consumed at production of the module itself.

Once the dry pack bag is opened, the desired quantity of units should be removed and the bag resealed within two hours. If the bag is left open longer than 30 minutes the desiccant should be replaced with dry desiccant. If devices have exceeded the specified floor life time of 72 h, they may be baked according IPC/JEDEC J-STD-033B at max. 90°C for less than 60 h.

Devices packaged in moisture-proof packaging should be stored in ambient conditions not exceeding temperatures of 40 °C or humidity levels of 90% r.H.

TCM 410J modules shall be soldered within 6 months after delivery!



## TCM 410J – Transceiver Module

## 5. Japan Certification

TCM 410J has been tested to fulfil the approval requirements for the Japanese radio certification based on EnOcean hardware and firmware combined with one the antennas listed in the approval certificates.

### 5.1 Standard Certificate (206-000596)

TCM 410J has been tested and is labelled in accordance with the following construction type certificate.



Notified Body EMC Directive 2014/30/EU  
Notified Body Directive 2014/53/EU  
RF CAB under the Japan-EC MRA  
FCB under the Canada-EC MRA  
TCB under the USA-EC MRA

RF CAB ID No. 206

Designated by the German Regulator Bundesnetzagentur to act as a  
Recognised Foreign Conformity Assessment Body in accordance with the Japan-EC MRA

#### CONSTRUCTION TYPE CONFORMITY CERTIFICATE

##### for Specified Radio Equipment

Registration No.	JU000596L
Certificate Holder	EnOcean GmbH Kolpingring 18a 82041 Oberhaching Deutschland
Product Category	Article 2, Paragraph 1, Item 8 (Y)
Product Designation	STM 400J, TCM 410J, USB 400J
Product Description	Scavenger Transceiver Module, Transceiver Module, USB Gateway
Software Release No.	--
Manufacturer	Katek GmbH Bahnhofstraße 108 83224 Grassau Germany

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



**R** 206-000596

The scope of evaluation relates to the submitted documents only.

This Certificate confirms that the listed product has demonstrated conformity with the relevant technical regulations defined in the attached Annex. It is only valid in conjunction with the Annex.

Unterleinleiter,  
2019-05-06

  
Günther Proß  
Recognised Foreign Conformity Assessment Body

EMCCons DR. RAŠEK GmbH & Co. KG • Stoernhofer Berg 15, 91364 Unterleinleiter, Germany  
Tel.: +49 9194 7263-888 • Fax: +49 9194 7263-889 • E-mail: emc.cert@emcc.de • Web: www.emcc.de



## TCM 410J – Transceiver Module

### 5.1.1 Supported antennas based on the standard certificate

TCM 410J might be used with the antenna specified in this construction type certificate.

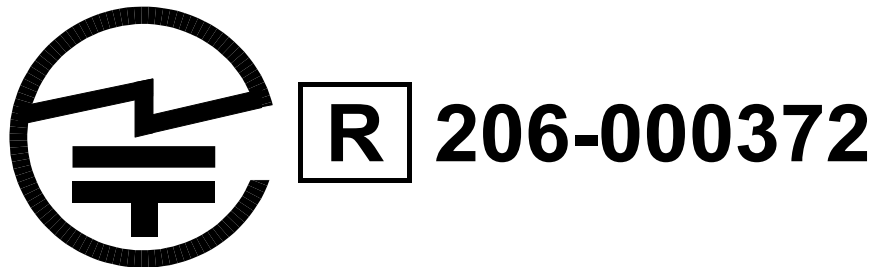
Annex to Certificate Registration No. JU000596L  
Date 2019-05-06  
Page 1 of 1

#### Technical Construction File (TCF) Details

<b>Technical Standards and Specifications</b>		
<i>The product complies with:</i>		
Ordinance Regulating Radio Equipment No. 18, 2006		
Chapter I	General Provisions	
Chapter II	Transmitting Equipment	
Chapter III	Receiving Equipment	
Chapter IV	Article 49.14	
<b>Documentation submitted for the Construction Type Certification</b>		
Test Report No.	Issue Date	Issued by
16/02-0005	2016-04-05	pkm electronic GmbH
Product documentation		
Antenna specifications		
Assembly drawings		
Bill of materials		
Block diagram		
Internal & external photographs		
Schematic diagrams		
User manual		
Quality System documentation		
ISO 9001 Certificate		
<b>Technical characteristics</b>		
Type of modulation:	FSK	
Emission designator:	F1D	
Operating frequency range:	928.35 MHz	
Rated output power density:	1 mW	
Maximum antenna gain:	3 dBi	
<b>Other information</b>		
The device is certified for operation with the following antenna(s):		
ANT 300, helical antenna, 2.15 dBi gain		
ANT 300J, helical antenna, 2.15 dBi gain		
Whip antenna, 64mm, -3.89 dBi gain		
USB 400J, top loaded PCB spiral antenna, 1.14 dBi gain		
ANT-GXM602, "758-0965", monopole antenna, 2.14 dBi gain		
2J520, "758-0961", dipole antenna, 2.14 dBi gain		
MC0114033, "758-0910", monopole antenna, 1 dBi gain		
USB 400J (mirrored), top loaded PCB spiral antenna, 1.17 dBi gain		
1019-010A, $\lambda/2$ monopole, L type, 3 dBi gain		
1019-008A, $\lambda/2$ monopole, straight type, 3 dBi gain		
ME467XSAXX, $\lambda/2$ monopole, straight type, 2 dBi gain		

### 5.1.2 Required marking

When using TCM 410J based on the Standard certificate, it is required that the product that is placed on the Japanese market carries the Specified Radio Equipment marking shown below:



If the certification label cannot be recognized from outside (e.g. installation in a host) appropriate information must be referenced in the user manual.

## TCM 410J – Transceiver Module

## 5.2 Additional Certificate (215-JUK004)

In addition to the standard certificate listed above, TCM 410J has been tested for use with the following additional antenna based on an additional construction type certificate:

- MC0114052-A-WH-SMA, "0758-0911" antenna
- GA.111.101111, "0758-0975" monopole antenna

The extended certificate applies only if the antennas listed above shall be used. In that case it is required to use a different Specified Radio Equipment marking on both the TCM 410J module and the end product. It is the responsibility of the customer to ensure that the proper Specified Radio Equipment marking is applied.



CETECOM GmbH  
RCB Identifier 215



Bundesnetzagentur

authorized by the German Federal  
Regulatory body BNetzA to act as a  
CAB (Conformity Assessment Body) in  
accordance with the MRA EU-Japan

BNetzA - CAB - 18/25 -54

### CONSTRUCTION TYPE CERTIFICATE

<b>Certificate Holder</b>	<b>EnOcean GmbH</b> Kolpingring 18a 82041 Oberhaching Germany
<b>CETECOM Registration No.</b>	21-1-0145501T01
<b>Model Name</b>	TCM 410J, STM 400J
<b>Product Description</b>	TCM 410J Radio Transceiver Module
<b>Name of Manufacturer</b>	<b>EnOcean GmbH</b> Kolpingring 18a 82041 Oberhaching Germany

*This is to certify that the above-mentioned certification by type has been granted in accordance with the provisions of Article 38-24, Paragraph 1 of the Japan Radio Law.*

This device must be  
labelled appropriately  
physically or electronically



R

215-JUK004

Place, date of issue

Essen, 2022-05-09

CETECOM GmbH

Wenping Mi

Wenping Mi / RCB

CETECOM GmbH | Im Tiefbuck 116,  
46219 Essen | info@cetecom.com | www.cetecom.com

## TCM 410J – Transceiver Module

**5.2.1 Supported antennas based on the additional certificate**

TCM 410J might be used with the antenna specified in this construction type certificate.

**Testing Lab**

**CTC advanced GmbH**  
Untertuerkheimer Strasse 6-10  
66117 Saarbruecken  
Germany  
Phone:49-681-598-0

**Antenna Information**

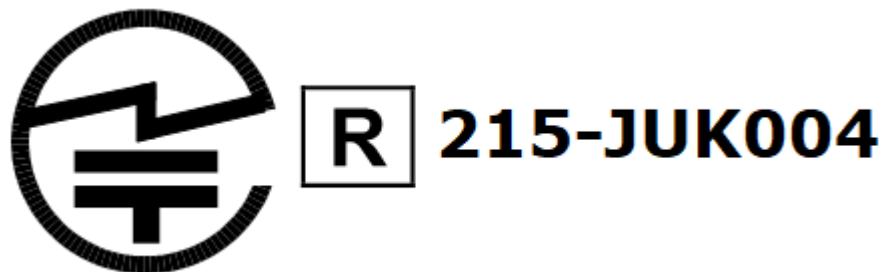
ANT 300, helical antenna, 2.15dBi gain  
AND 300J, helical antenna, 2.15dBi gain  
Whip antenna, 64mm, -3.89dBi gain  
USB400J, top loaded PCB spiral antenna, 1.14 dBi gain  
ANT-GXM602, "758-0965", monopole antenna, 2.14dBi gain  
2J520, "758-0961", monopole antenna, 2.14dBi gain  
MC0114033, "758-0910", monopole antenna, 1dBi gain  
USB 400J (mirrored), top loaded PCB spiral antenna, 1.17dBi gain  
1019-010A,  $\lambda/2$  monopole, L type, 3dBi gain  
1019-008A,  $\lambda/2$  monopole, straight type, 3dBi gain  
ME467XSAXX,  $\lambda/2$  monopole, straight type, 2dBi gain  
MC0114052-A-WH-SMA, "0758-0911", 2dBi gain  
GA.111.101111, "0758-0975", monopole antenna, 1.92 dBi gain

**Item8,Paragraph1,Article2**

Frequency Range	Emission Class	RF Power or Field Strength	Remarks
928.35 MHz - 928.35 MHz	F1D	0.001000 W	SRD

### 5.2.2 Required marking

When the product is placed on the Japanese market subject to the extended certificate (i.e. with one of the two new antennas described above), then it must carry the Specified Radio Equipment marking shown below both on the TCM 410J module and the end product:



If the certification label cannot be recognized from outside (e.g. installation in a host) appropriate information must be referenced in the user manual.

## 6. References

1. EnOcean Radio Standard Specifications  
<https://www.enocean-alliance.org/what-is-enocean/specifications/>
2. EnOcean Serial Protocol v3.0  
<https://www.enocean.com/esp>
3. EnOcean Knowledge Base  
<https://www.enocean.com/en/knowledge-base/>