

## TCM 515 – ENOCEAN TRANSCEIVER GATEWAY MODULE

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### TCM 515 EnOcean Transceiver Gateway Module

22.06.2017



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

TCM 515 – ENOCEAN TRANSCEIVER GATEWAY MODULE

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**REVISION HISTORY**

The following major modifications and improvements have been made to this document:

Version	Author	Reviewer	Date	Major Changes
1.0	MKA	MK, CB	12.05.2017	First public release
1.1	MKA	MKA	22.05.2017	Added detailed antenna information
1.2	MKA	MH, MK	22.06.2017	Added receiver class due to RED requirement

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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>.

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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.

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### 1 GENERAL DESCRIPTION

#### 1.1 Basic functionality

TCM515 is a transceiver module limited to OEM installation ONLY.

TCM 515 enables the realization of line-powered actuators, controllers and gateways communicating based on EnOcean Radio Protocol version 1 (ERP1, 868 MHz ASK) and EnOcean Radio Protocol version 2 (ERP2, 902 MHz FSK, 928MHz FSK).

It provides a transparent radio link between EnOcean radio devices and an external host connected via UART interface using the standardized EnOcean Serial Protocol V3 (ESP3) communication protocol.

TCM 515 receives and transmits radio telegrams based on a 50 Ohm or whip antenna connected to the host PCB. It forwards received radio telegrams to an external host processor or host PC via the ESP3 interface. Messages received from an external host via the ESP3 interface will be transmitted by TCM 515 as EnOcean radio telegrams according to the chosen frequency.

TCM 515 is implemented as 31 pin reflow-solderable module with optimized form factor for size constrained applications. It is not pin compatible with existing TCM 310 products.

Figure 1 below shows TCM 515.



**Figure 1 – TCM 515 outline**

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## 1.2 Technical data

<b>Antenna</b>	50 Ohm whip antenna (connected at host board)
<b>Supported Radio Frequencies</b>	868.3 MHz ASK / 902.875 MHz FSK
<b>Data Rate</b>	125 kbps
<b>Receiver Sensitivity (See Note 1)</b>	868.3 MHz ASK: -93 dBm 902.875 MHz FSK: -98 dBm
<b>Receiver Category</b>	EN 300 220 Class 2
<b>Transmit Power</b>	868.3 MHz ASK: +10 dBm 902.875 MHz FSK: +1 dBm
<b>Supply Voltage (typ)</b>	2.0 V ... 3.6 V
<b>Supply Current (at 2.0V)</b>	25 mA
<b>Supply Current Sleep Mode (at 2.0V)</b>	5 uA
<b>Start-up time (power up to RX ready)</b>	5 ms
<b>Serial Host Interface</b>	UART according to ESP3 Standard (TURBO option)

Note 1: Sensitivity figures based on 0.1% telegram error rate for the combination of 3 received sub-telegrams and is measured at 25°C

## 1.3 Physical dimensions

<b>Module Dimensions</b>	19.0 mm x 14.7 mm x 3.0 mm (all +- 0.3 mm)
<b>Module Weight</b>	1 g

## 1.4 Environmental conditions

<b>Operating Temperature</b>	-40°C ... 85°C
<b>Storage Temperature</b>	-40°C ... 85°C
<b>Humidity</b>	0% to 95% r.h. (non-condensing)

## 1.5 Packaging information

<b>Packaging Unit / Method</b>	250 units / Tape and reel
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## 1.6 Ordering information

Type	Ordering Code
TCM 515	S3003-K515
TCM 515U	S3053-K515

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## 2 FUNCTIONAL INFORMATION

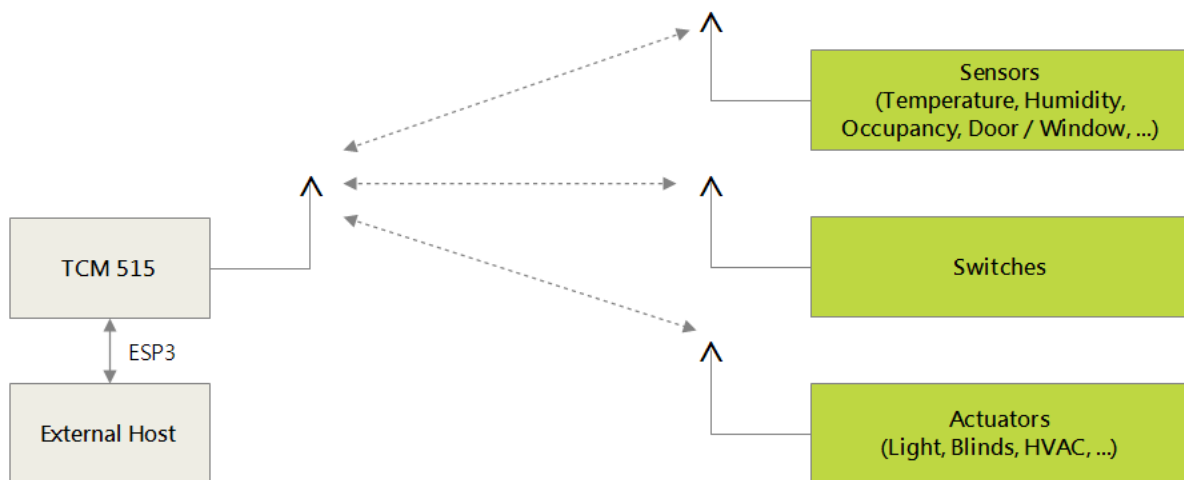
### 2.1 High level functionality

TCM 515 is a fully integrated radio transceiver for EnOcean ERP1 (868 MHz ASK) or ERP2 (902 MHz FSK and in the future also 928 MHz FSK) systems.

TCM 515 is used to exchange (send and / or receive) radio telegrams with external sensors, switches or actuators.

TCM 515 is connected to an external host which for instance could be a microprocessor, a controller or a gateway.

Figure 2 below shows the integration of TCM 515 into a typical system environment.



**Figure 2 – TCM 515 system environment**

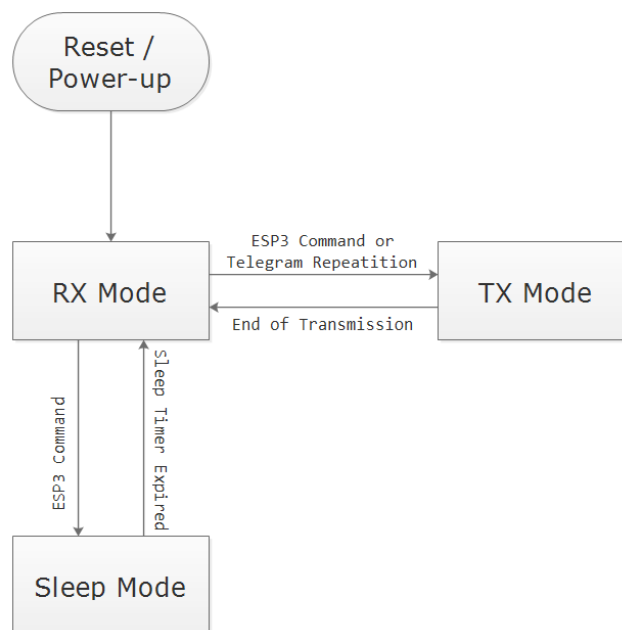
## TCM 515 – ENOCEAN TRANSCEIVER GATEWAY MODULE

## 2.2 Functional modes

TCM 515 implements the following functional modes:

- Telegram Reception
- Telegram Transmission
- Low Power Sleep

The transition between these functional modes is shown in Figure 3 below



**Figure 3 – TCM 515 functional modes**

The following chapters describe these functional modes in more detail.



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### 2.2.1 Telegram reception

In receive mode, TCM 515 processes received radio telegrams and verifies correct frame structure and check sum.

Received telegrams can be filtered according to a filter list that can be setup via dedicated ESP3 commands (see chapter 3 for the list of supported ESP3 commands).

TCM 515 fully integrates security handling for radio telegrams. It contains a security link table that stores for each device that has been learned in the security key and the sequence counter value of the most recently received radio telegram. Received radio telegrams can therefore be automatically decrypted and authenticated.

Processed radio telegrams will then be forwarded to the external host via the ESP3 interface.

### 2.2.2 Telegram transmission

In transmit mode, TCM 515 receives radio telegrams for transmission from the external host via its ESP3 interface. TCM 515 will apply the required security processing and properly format the radio telegram frame including checksum. It will then transmit the telegram as a series of redundant telegrams.

### 2.2.3 Telegram repeating

TCM 515 can act as repeater for all or selected radio telegrams. The repeating functionality is configured via ESP3 interface.

If TCM 515 is configured to act as repeater and it receives a radio telegram that it has to repeat then TCM 515 will automatically transition from receive to transmit state to re-transmit (repeat) this telegram. After successful transmission, it will automatically transition back to receive mode.

See chapter 6.3 for a description of the repeater functionality.

### 2.2.4 Low power sleep mode

TCM 515 can be set into a low power sleep mode for a defined period of time by means of an ESP3 command. After expiry of the requested sleep period, TCM 515 will automatically wake-up and transition back to receive mode.

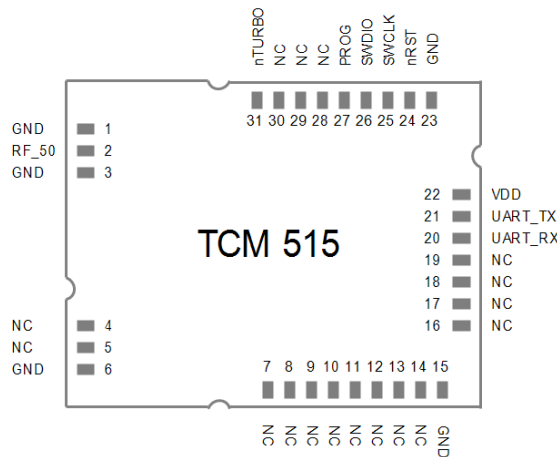
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**2.3 Device Interface**

TCM 515 implements a 31 pin reflow-solderable interface. Solder mask data is available on request from EnOcean.

**2.3.1 Pin-out**

The pin assignment (as seen from the top of the device) is shown in Figure 4 below. Solder mask and mechanical data is available from EnOcean.



**Figure 4 – TCM 515 device interface**

Table 1 below summarizes the signal assignment.

PIN	NAME	PIN	NAME	PIN	NAME
1	GND	12	NC	23	GND
2	RF_50 (50Ω antenna)	13	NC	24	nRST (Reset, active low)
3	GND	14	NC	25	SWCLK (Debug)
4	NC	15	GND	26	SWDIO (Debug)
5	NC	16	NC	27	PROG (SW Update, for future variants)
6	GND	17	NC	28	NC
7	NC	18	NC	29	NC
8	NC	19	NC	30	NC
9	NC	20	UART_RX (Input)	31	nTURBO (UART speed, active low)
10	NC	21	UART_TX (Output)		
11	NC	22	VDD		

**Table 1 - TCM 515 pin assignment**

Signals marked with “NC” are reserved for production test and future device variants and must not be connected in the design.

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### 2.3.2 Power supply

TCM 515 is supplied by the VDD and GND Pins and supports a supply voltage range from 2.0V to 3.6V. For best radio performance it is very important to minimize noise on the supply voltage lines. Please see chapter 9.4.

### 2.3.3 Antenna

TCM 515 receives and transmits data based on a 50Ω whip antenna connected to its RF\_50 input (Pin 2). Please see chapter 10.

### 2.3.4 UART interface

TCM 515 communicates with the external host using the standard ESP3 serial (UART) interface based on the signals UART\_TX (Pin 21, direction from TCM 515 to external host) and UART\_RX (Pin 20, direction from external host to TCM 515).

The default interface speed of the ESP3 interface is 57600 bit per second and data is transmitted using 8 data bits, 1 STOP bit and no parity (8N1).

It is possible to select faster communication speeds during operation using the ESP3 CO\_SET\_BAUDRATE command (see chapter 3). The following interface speeds are supported by TCM 515:

- 57600 bit per second
- 460800 bit per second

Additionally, it is possible to change the default ESP3 interface speed at power up from 57.600 Bit per second to 460.800 Bit per second by connecting the nTURBO input (Pin 31, active low) to Ground.

Subsequent modification of the interface speed during operation using the CO\_SET\_BAUDRATE command is always possible irrespective of the state of the TURBO input pin.

In all cases, care should be taken not to select a UART interface speed which cannot be supported by the connected host processor as this would prevent subsequent communication.

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### 2.3.5 Reset

TCM 515 can be reset by pulling the nRST pin (Pin 24, active low) to Ground. Please see chapter 9.5 for reset circuit recommendations.

### 2.3.6 Debug interface

TCM 515 provides a two pin debug interface (Pin 25 – SWCLK, Pin 26 – SWDIO) according to the Serial Wire Debug (SWD) standard. Please see chapter 9.6 for the typical connection to a 10 pin SWD debug connector.

### 2.3.7 Firmware update (PROG)

The following information is provided as advance notice to customers. This functionality is not supported by the current TCM 515 product, but considered for future product variants. The implementation of this feature is subject to change without notice.

The option to update the device firmware in the field from the host processor using the UART interface together with a dedicated programming pin (PROG) and the reset pin (nRST) is under evaluation. If implemented, the firmware update mechanism would be triggered by the following sequence:

1. Assert (pull high) the PROG input
2. Assert (pull low) the nRST input
3. Release (pull high) the nRST input

At this point, an integrated bootloader will check for a firmware update available via the UART interface and download this. The following UART settings are planned to be used:

- 115200 baud per second
- 8 data bits
- 1 stop bit

After the download has been completed, the PROG pin should again either be released (pulled low or disconnected).

Execution of the updated SW can then be started by asserting and releasing the nRST input as described above.

For current designs without firmware update functionality, the PROG pin can be left disconnected.

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### 3 ESP3 interface

TCM 515 provides an external interface according to the EnOcean Serial Protocol, version 3 (ESP3). This interface is used both to exchange telegrams and command / status messages with an external host. Please refer to the ESP3 specification: <https://www.enocean.com/esp>

#### 3.1 Supported ESP3 commands

TCM 515 provides a bi-directional serial interface which conforms to the EnOcean ESP3 specification. For details regarding ESP3 please refer to the ESP3 specification. The following ESP3 commands are supported by TCM 515:

- Type 1: ERP1 Radio Telegram
- Type 10: ERP2 Radio Telegram (TCM 515U only)
- Type 11: Configuration commands (TCM 515U only)
  - CFG\_WR\_ESP3\_MODE
  - CFG\_RD\_ESP3\_MODE
- 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
  - CO\_DUTYCYCLE\_LIMIT to inform about a current limitation due to duty cycle
- Type 5 Common commands
  - CO\_WR\_RESET to reset the device
  - CO\_WR\_STARTUP\_DELAY to specify the delay from reset to start-up
  - CO\_WR\_SLEEP to put the device into low power sleep mode
  - 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 or to selective repeating
  - CO\_WR\_FILTER\_DEL to delete filter from filter list or from selective repeating
  - 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\_LEARNMODE to enable / disable learn mode
  - CO\_RD\_LEARNMODE to read the status of the learn mode
  - CO\_WR\_WAIT\_MATURITY to wait until the end of the maturity time before transmitting radio telegrams
  - CO\_RD\_DUTYCYCLE\_LIMIT to read status of current duty cycle limitations (for 868 MHz EU version)
  - CO\_GET\_FREQUENCY\_INFO to read the operating frequency of the device
  - CO\_RD\_RORGS\_COUNT to read the number of entries in the RORG table
  - CO\_RD\_RORGS\_BY\_ID to read the RORG's supported by a specific device ID
  - CO\_WR\_RORG\_ADD to write the RORG's supported by a specific device ID
  - CO\_WR\_RORG\_DELETE to delete a specific RORG (specified by its index)
  - CO\_WR\_RORGS\_CLEAR to clear all RORG's from the RORG table
  - CO\_SET\_BAUDRATE to set the baudrate of the ESP3 interface

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- Type 5 Common commands (for security handling)
  - 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\_CLEAR\_LIST
  
- Type 6 Smart Acknowledge commands (postmaster / mailbox functions)
  - 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 post master functionality
  
- Type 7 Remote Management
  - Messages with up to 255 byte of payload

Note that all configuration values set via ESP3 commands are held in RAM and will therefore be lost after RESET or after power down.

## 4 Security functionality

TCM 515 implements the security handling functions as specified in the EnOcean security specification: <https://www.enocean.com/security-specification>

TCM 515 can receive and decrypt messages from the following supported products:

- PTM 215
- PTM 335
- STM 320 / STM 329 / STM 250 (or similar with same profile)
- STM 330 / STM 331 (or similar with same profile)

TCM 515 implements the following security functions:

- Message decryption using VAES 128
- Message encryption using VAES 128
- Management of 2/3 byte sequence counter
- CMAC (3 / 4 bytes length) validation based on sequence counter (2 / 3 bytes length) and telegram content
- CMAC (3 / 4 bytes length) generation based on sequence counter (2 / 3 bytes length) and telegram content

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### 5 Teach-in of remote devices

Teach-in is the process by which a remote device wants to setup communication with TCM 515. To do so, the remote device communicates to TCM 515 all parameters required to establish communication within a specially formatted telegram (teach-in telegram).

These parameters include:

- **Device source address (always)**  
This address uniquely identifies the remote device and can be used to filter incoming radio telegrams (to accept only radio telegrams from devices having specific source addresses)
- **EnOcean Equipment Profile (EEP, depending on device type)**  
The EEP identifies the way in which the telegram data is encoded. Knowing the EEP used by a remote device allows the host which is connected to TCM 515 to properly decode the telegram data into actual measurement values such as temperature, humidity, etc.
- **Security key (if using high security mode)**  
The 128 bit AES security key is used in high security mode to encode and / or authenticate radio telegrams
- **Current sequence counter value (if using high security mode)**  
The sequence counter is a continuously incrementing counter used to ensure that the payload of any two radio telegrams will be different. This is important to avoid replay attacks by which a previously transmitted radio telegram is re-transmitted. The receiver has to track the sequence counter value for each device communicating with it and will only accept radio telegrams with sequence counter values higher than that of the last received telegram.
- **Security options (if using high security mode)**  
The security options specify type and size of parameters used for the encryption and authentication functionality

For details about the security implementation, please refer to the Security of EnOcean Radio Networks specification.

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### 5.1 Entering and exiting teach-in mode

In order to accept teach-in requests from remote devices, TCM 515 must be put into teach-in mode via the ESP3 interface by using the `CO_WR_LEARNMODE` command.

After a successful teach-in process, the whole teach-in message is forwarded as `RADIO_MESSAGE` (PACKET TYPE 0x09) to the external host via the ESP3 interface.

If TCM 515 is not in teach-in mode then teach-in requests from unknown devices are ignored.

If TCM 515 receives a teach-in message from a known (previously taught-in) device operating in high security mode then the sequence counter information in the TCM 515 secure link table is updated. This approach is used in case sequence counters of receiver and sender become desynchronized.



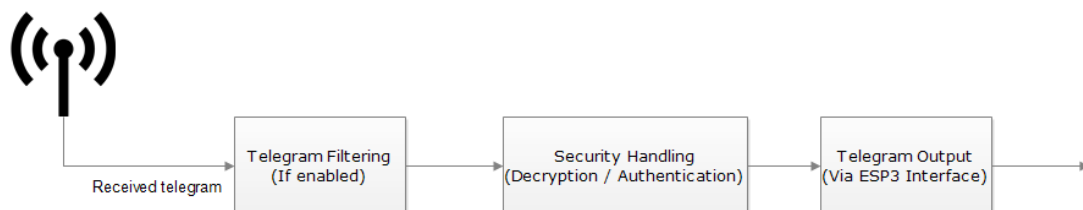
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## 6 Telegram reception flow

TCM 515 performs the following functions for each received radio telegram:

- **Telegram filtering**  
Received telegrams can be classified according to user-defined characteristics and only telegrams matching these characteristics will be processed
- **Security handling**  
Telegrams from taught-in devices operating in high security mode can be automatically decrypted and authenticated
- **Telegram output**  
Processed telegrams will be forwarded to the external host via the ESP3 interface

Figure 5 below shows the handling for received telegrams.



**Figure 5 – Telegram Reception Flow**

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### 6.1 Telegram filtering

Telegram filtering is the process by which only radio telegrams that match specific user-defined parameters will be forwarded to the external host. This mechanism is used to limit the amount of telegram processing required at the external host.

The following parameters can be used as filter:

- **Source ID**  
Only radio telegrams originating from a specific sender (identified by its EnOcean Universal Radio ID = EURID) will be processed.  
This filter type can be used for instance in actuators which only accept input from devices (e.g. switches) that have been learned in.
- **Destination ID**  
Only radio telegrams addressed to a specific receiver (as identified by its EURID) will be processed.  
This filter type can be used by a receiver to accept only radio telegrams intended for itself.
- **Telegram Type (RORG)**  
Only radio telegrams of a specific type (RPS, 1BS, 4BS or VLD) will be processed.  
This filter type can be used for instance if an actuator should react only on switch (RPS) telegrams.
- **Received signal strength (RSSI)**  
Only radio telegrams above or below a specific signal strength will be processed.  
The first case – above - can for instance be used during learn-in if an actuator should only accept teach-in telegrams from devices close to the receiver.  
The second case – below - can be used in repeaters where only weak signals (with low RSSI) should be repeated in order to limit radio congestion.

Note that more than one filter can be defined, e.g. it is possible to setup filter rules such that telegrams originating from several source ID will be processed.

Telegram filtering is configured using the following ESP3 commands:

- `CO_WR_FILTER_ADD` to add filter to filter list or to selective repeating
- `CO_WR_FILTER_DEL` to delete filter from filter list or from selective repeating
- `CO_WR_FILTER_DEL_ALL` to delete all filter
- `CO_WR_FILTER_ENABLE` to enable/disable supplied filters
- `CO_RD_FILTER` to read the currently active filters

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### 6.2 Security handling

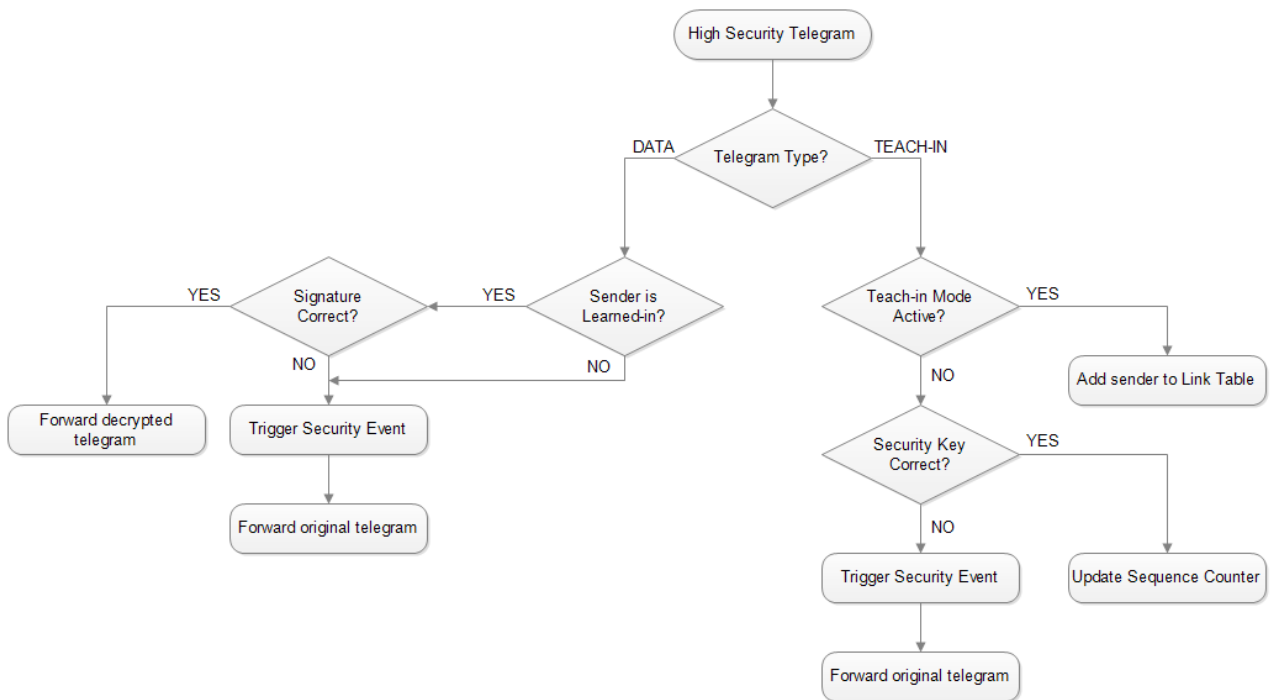
TCM 515 implements all required functionality to process high security telegrams.

Specifically, TCM 515 can automatically decrypt and authenticate messages originating from taught-in remote devices transmitting messages according to the EnOcean Network Security specification.

Security processing requires the receiver to know the security key and the latest rolling code counter. Therefore this is only possible for devices that have previously been taught-in.

If a high security radio telegram is received from a device that has not been taught in then TCM 515 will report a security event and forward the raw (unprocessed) telegram to the host for further analysis.

Figure 6 below illustrates the high level processing flow for received EnOcean high security radio telegrams.



**Figure 6 – TCM 515 high security telegram processing flow**

### 6.3 Reporting of security-related events

TCM 515 can report to the host the following security-related events by means of a CO\_EVENT\_SECUREDEVICES event message:

- **EVENT\_RESYNC\_WRONG\_KEY**  
Resynchronization attempt with wrong private key
- **EVENT\_TI\_CORRUPTED**  
Teach-In failed because the teach-in telegram has been corrupted.
- **EVENT\_NO\_MORE\_SPACE**  
Teach in failed, because no more space is available
- **EVENT\_BRUTE\_FORCE\_ATTACK**  
Configured count of telegrams with wrong CMAC has been received
- **EVENT\_TI\_PSK\_FAIL**  
Teach-In based on pre-shared key (PSK) failed because no PSK is set for the device

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## 7 Telegram transmission

### 7.1 Transmission flow

TCM 515 performs the following functions to transmit radio telegrams:

- Telegram input  
TCM 515 receives the radio telegram data from the external host via the ESP3 interface
- Security handling  
Telegrams from taught-in devices operating in high security mode can be automatically decrypted and authenticated
- Telegram transmission  
Processed telegrams will be transmitted

Figure 7 below shows the handling for transmitted telegrams.



**Figure 7 – Telegram Transmission Flow**

### 7.2 Built-in Repeater

TCM 515 provides the option to activate a one or two-level repeater for EnOcean radio telegrams.

- 1-level repeater: If a received telegram is a valid and original (not yet repeated), the telegram is repeated after a random delay. This delay will be chosen such that the maximum TX maturity time (as standardized in ISO 14543-3-10) of 40ms will not be exceeded.
- 2-level repeater: If a received telegram is valid and original or repeated once, the telegram is repeated after a random delay. This delay will be chosen such that the maximum TX maturity time (as standardized in ISO 14543-3-10) of 40ms will not be exceeded.

Repeated telegrams are marked as "repeated" by an increased repeater counter. Configuration of the repeater functionality is done via serial interface commands.

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When using repeaters, care must be taken to ensure that regulatory transmitter duty cycle limits (if applicable) are not exceeded.



2-level repeating function should only be activated after careful study of the radio conditions! Otherwise the system function can be compromised by collisions of telegrams.

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

TCM 515 also provides selective repeating, i.e. the option to only repeat certain telegrams with match pre-defined filter criteria. The filter criteria that can be applied for repeating are the same as the ones for telegram reception, please see chapter 6.1.

### 7.3 Duty Cycle Limit

European radio regulation mandates that the duty cycle limits of radio transmitters have to be enforced by technical means. The European (868.3 MHz) version of TCM 515 therefore implements a hardware duty cycle monitor which enforces the regulatory duty cycle limit of 1% per hour.

The functionality of this monitor is as follows:

- Each 1 hour (3600 seconds) period is sub-divided into 10 time slots of 360 seconds each. The total available transmission time (36 seconds per 3600 second period) is equally divided upon these 10 time slots, i.e. each time slot is allocated 3.6 seconds of transmission time.
- For each time slot, the total transmission time is accumulated
- The remaining available transmission time is calculated as difference between allocated and accumulated transmission time.
- If the available transmission time reaches zero (no more transmission time available) then TCM 515 will not transmit any additional messages during this time interval. TCM 515 will respond with RET\_LOCK\_SET to the host if this requests transmission of additional telegrams in this case.

The host can query the duty cycle status at any time using the ESP3 command CO\_RD\_DUTYCYCLE\_LIMIT. The response from TCM 515 will specify both the already used percentage of available transmission time within the current time slot (0% ... 100%) and the remaining time (in seconds) until the start of the next time slot.

TCM 515 – ENOCEAN TRANSCEIVER GATEWAY MODULE

## 8 Remote Management

TCM 515 provides a transparent radio channel also for remote management messages with a message length of up to 255 bytes. This enables an external micro controller connected to TCM 515 to handle remote management request from external devices or to control other devices via remote management.

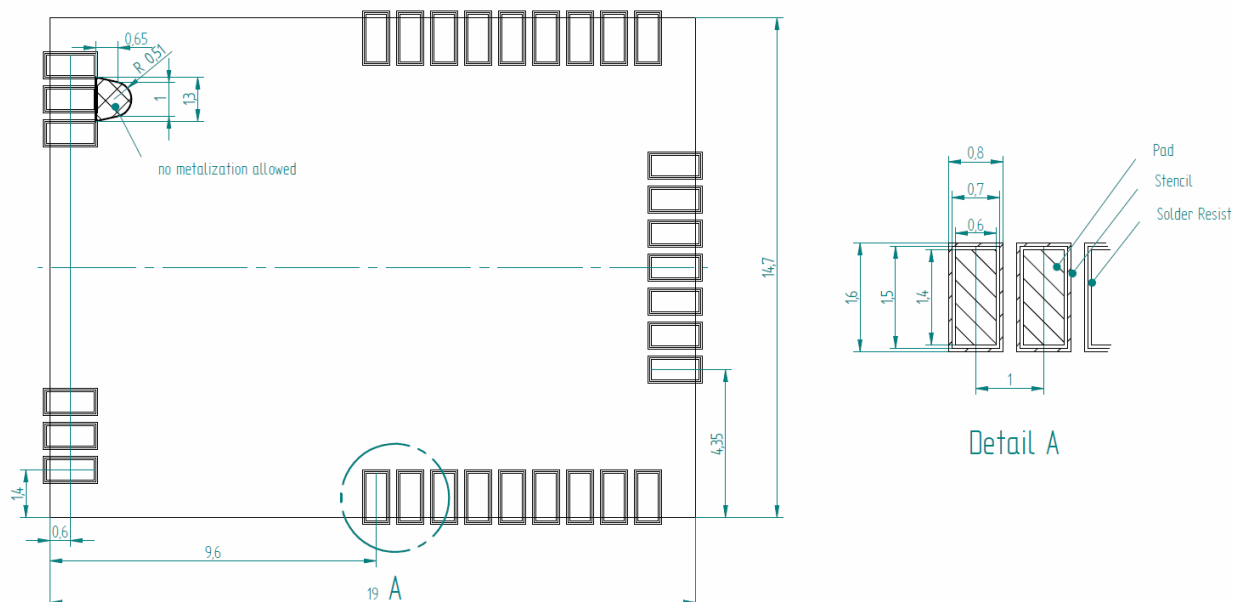
For more information on remote management please refer to the EnOcean End Equipment Profiles (EEP) 2.6 specification.

## 9 Device Integration

TCM 515 is designed for integration onto a host PCB. Detailed Gerber data of the device footprint is available from EnOcean.

### 9.1 Recommended PCB Footprint

Figure 8 below shows the recommended PCB footprint for TCM 515.



**Figure 8 – Recommended PCB footprint**

TCM 515 – ENOCEAN TRANSCEIVER GATEWAY MODULE

9.2 Device outline

Figure 9 below shows the device outline of TCM 515.

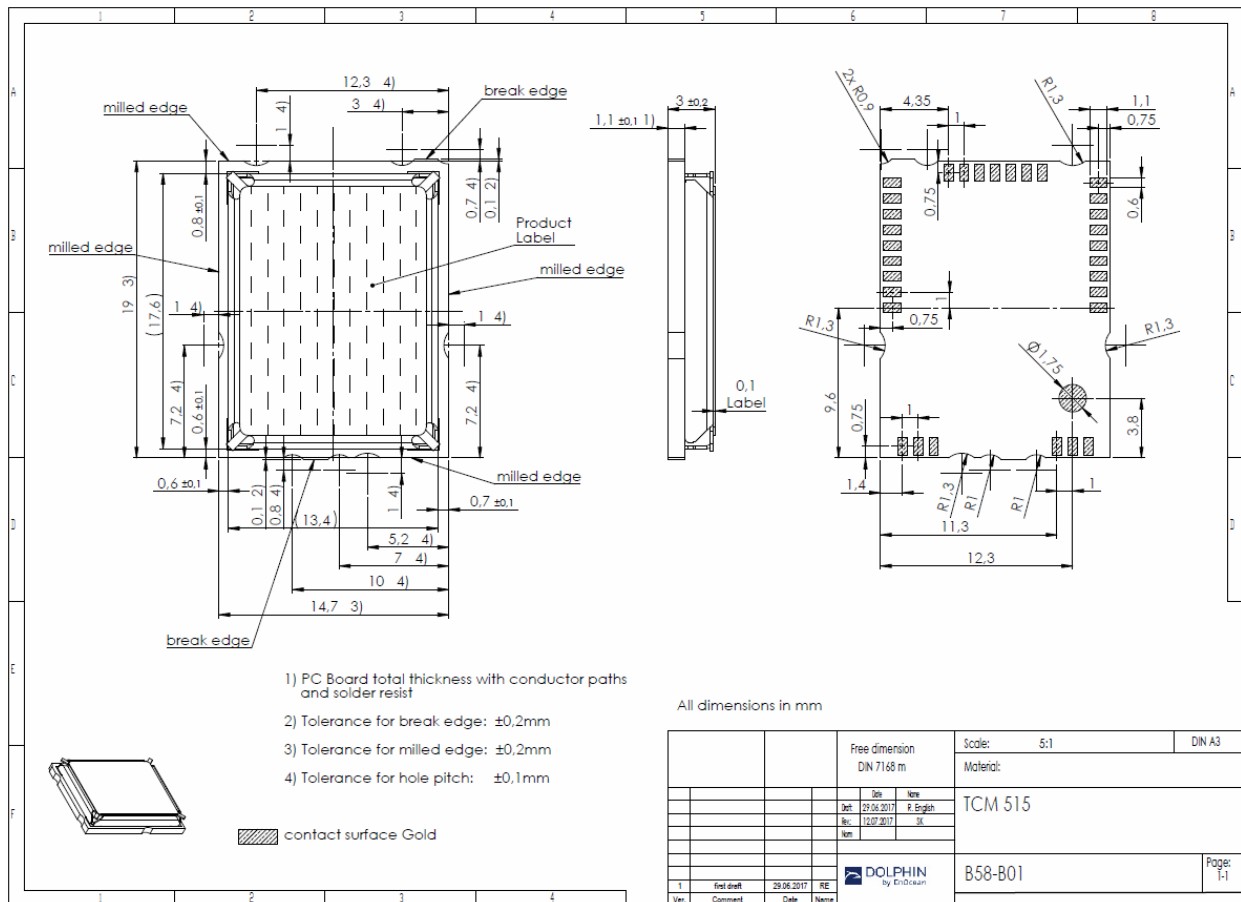


Figure 9 – Device outline



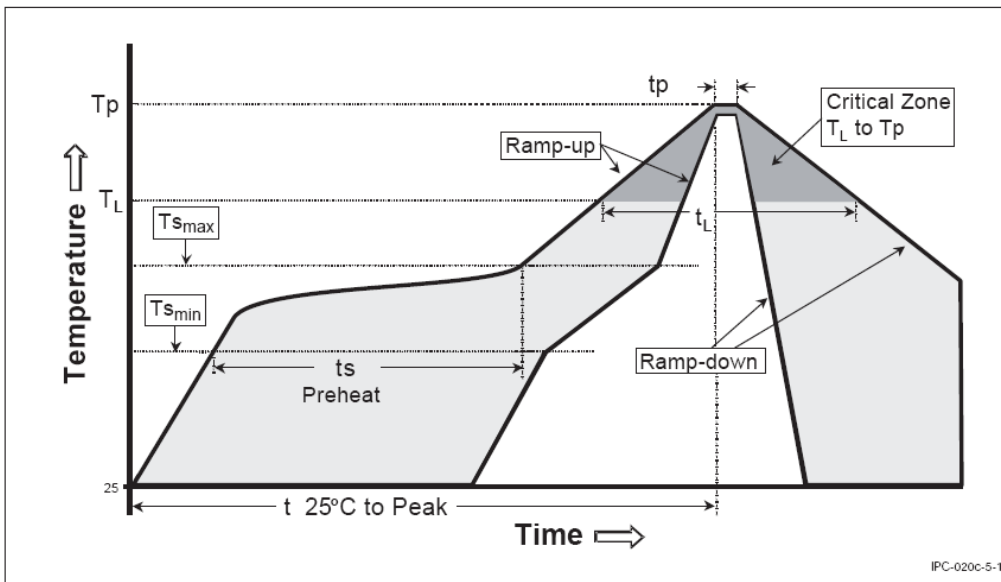
TCM 515 – ENOCEAN TRANSCEIVER GATEWAY MODULE

**9.3 Soldering information**

TCM 515 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>	
- Temperature Min ( $T_{S_{min}}$ )	150 °C
- Temperature Max ( $T_{S_{max}}$ )	200 °C
- Time ( $t_{S_{min}}$ to $t_{S_{max}}$ )	60-180 seconds
Time maintained above:	
- Temperature ( $T_L$ )	217 °C
- Time ( $t_L$ )	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.



**Figure 10 – Recommended soldering profile**

TCM 515 shall be handled according to Moisture Sensitivity Level MSL4 which means a floor time of 72 h. TCM 515 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 515 modules shall be soldered within 6 months after delivery!

## TCM 515 – ENOCEAN TRANSCEIVER GATEWAY MODULE

### 9.4 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  $\mu\text{F}$  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.

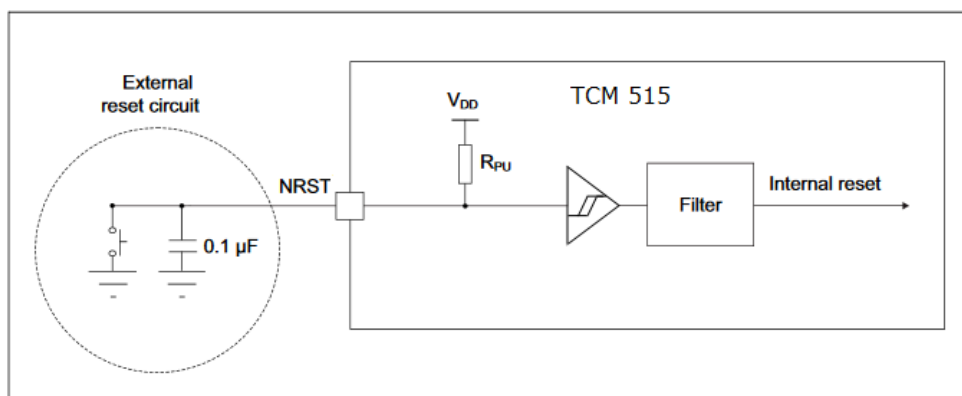
For best performance it is recommended to keep the ripple on the power supply rail below 10 mVpp.

TCM 515 integrate approximately 10  $\mu\text{F}$  of capacitance for filtering the internal supply voltage bus. The power supply architecture has to be capable of supplying sufficient current to charge this capacitance during power up.

### 9.5 Suggested Reset circuit

TCM 515 can be reset by pulling the nRST pin (active low) to Ground. TCM 515 integrated a weak (50k $\Omega$ ) pull-up resistor that will maintain the internal nRST input active high (not active).

In order to avoid spurious reset events, it is recommended to filter the input signals by means of a small capacitor which is placed as close as possible to the TCM 515 nRST pin as shown in Figure 11 below.



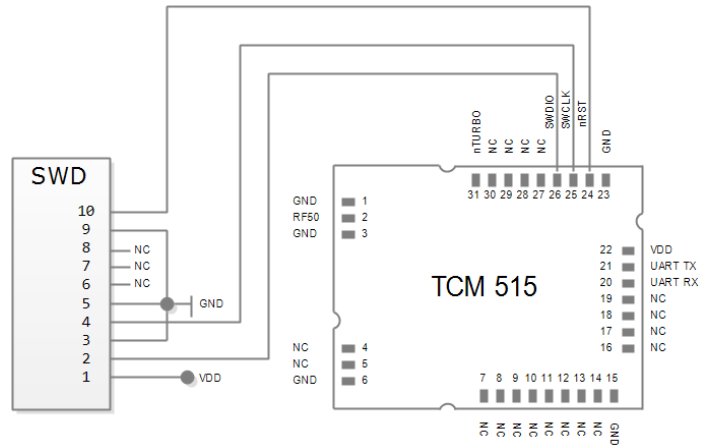
**Figure 11 – Recommended reset circuit**

The reset pulse should have a duration of at least 1 ms in order to guarantee reliable reset operation.

TCM 515 – ENOCEAN TRANSCEIVER GATEWAY MODULE

### 9.6 Debug interface

TCM 515 implements a debug interface according to the Serial Wire Debug (SWD) standard. The connection of TCM 515 to a standard 10 pin SWD connector is shown in Figure 12.



**Figure 12 – TCM 515 debug interface**

## TCM 515 – ENOCEAN TRANSCEIVER GATEWAY MODULE

## 10 Antenna options

This chapter outlines options for antenna that can be used with TCM 515. Note that this chapter is for guidance purposes only, please consult with an authorized certification body for specific information.

### 10.1 Antenna options for 868 MHz (European Union)

In order to be compliant with the Radio Equipment Directive (RED) of the European Union, an antenna needs to fulfil at least following requirements to be usable with TCM 515:

Frequency band	868.300 MHz ISM	Antenna must be suited for this band
Antenna type	Passive	Mandatory for radio approval
Impedance	~50 Ohm	Mandatory for radio approval
Maximum gain	≤ 0 dBd	Mandatory for radio approval

In addition, it is important to fulfill the following requirements in order to achieve compatibility with other EnOcean products and to ensure EMI robustness:

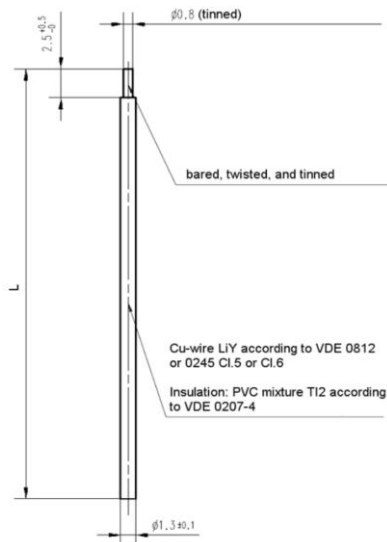
VSWR	≤ 3:1	Important for compatibility with EnOcean protocol
Return Loss	> 6 dB	Important for compatibility with EnOcean protocol
Bandwidth	≤ 20 MHz	Important if 10 V/m EMI robustness required for device

See chapter 12.1 for additional important remarks regarding RED certification.

## TCM 515 – ENOCEAN TRANSCEIVER GATEWAY MODULE

**10.1.1 Whip antenna**

TCM 515 modules have been certified for use with a whip antenna under EU (RED) regulations. Figure 13 below shows key whip antenna parameters.



**Figure 13 – Whip antenna parameters**

The whip antenna has to meet the following parameters in order to be compliant to the regulations mentioned above:

- Antenna length (L): 86 mm wire, connect to RF\_50
- Minimum GND plane: 38 mm x 18 mm
- Minimum distance space: 10 mm



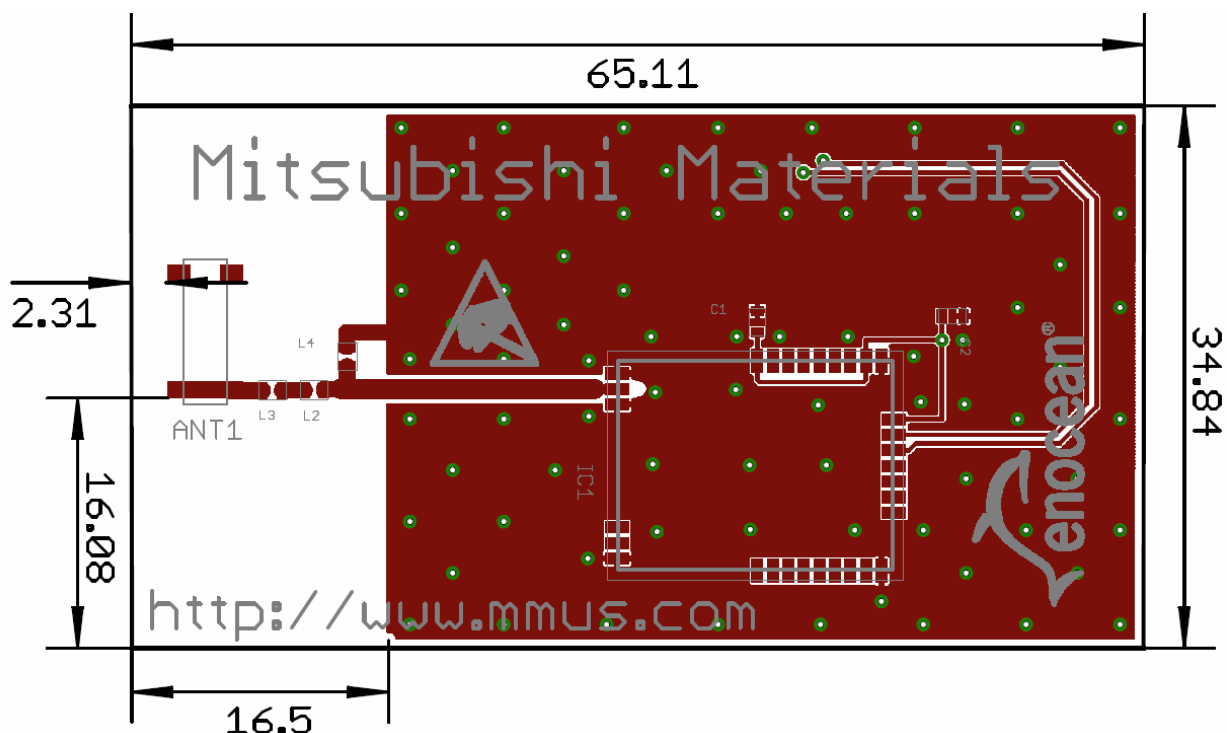
## TCM 515 – ENOCEAN TRANSCEIVER GATEWAY MODULE

**10.2.3 Chip antenna (Supplier: Mitsubishi Material, Type AM11DP-ST01T)**

TCM 515 has been certified for use with the chip antenna AM11DP-ST01T from Mitsubishi Material provided that the following layout guidelines are met:

- Dimensions may not be shortened
- Matching circuit is part of the single modular approval and may not be changed
- Matching circuits values: L2 = 33 nH; L3 = 3,9 nH, L4 = 12 nH
- Use High Q wire wound inductors, e.g. 0603 Murata LQW18A series
- Minimum top and bottom side ground plane required as shown below
- Connect ground planes using multiple via as shown in Figure 15
- Connect matching circuit to RF\_50 pin

Figure 15 below shows the reference layout that has to be used.



**Figure 15 – Required layout for AM11DG-ST01**

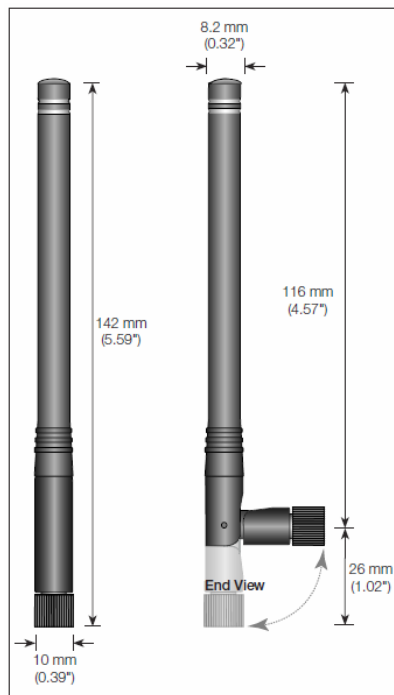
For any further questions or chip antenna quotes, please refer to Mitsubishi Materials website at [www.mmea.com](http://www.mmea.com) or email to [electroniccomponents@mmus.com](mailto:electroniccomponents@mmus.com).

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**10.2.4 Dipole antenna (ANT-916-CW-HWR-RPS)**

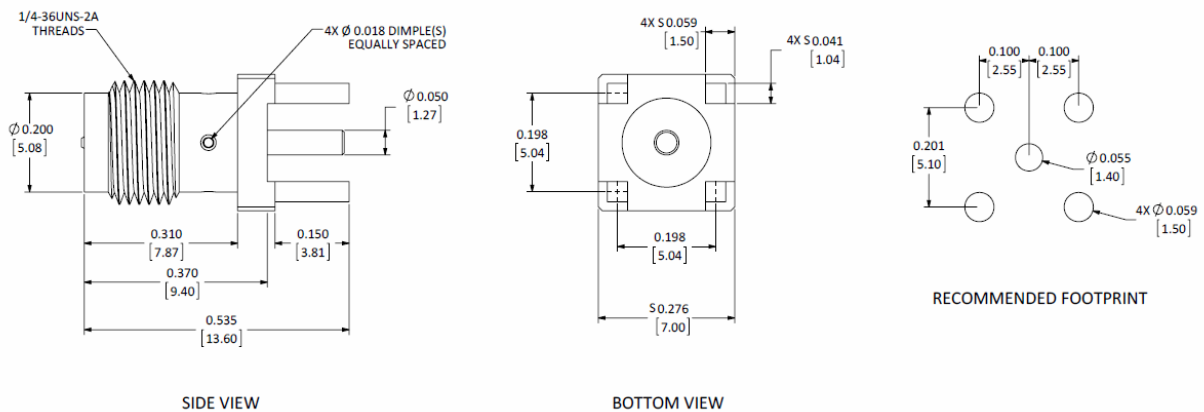
TCM 515 has been certified for use with the dipole antenna ANT-916-CW-HWR-RPS from Linx provided that a non-standard connector such as RP-SMA-Female from Linx is used.

Figure 16 below shows ANT-916-CW-HWR-RPS from Linx.



**Figure 16 – ANT-916-CW-HWR-RPS**

Figure 17 below shows RP-SMA- Female from Linx.



**Figure 17 – RP-SMA-Female**



## TCM 515 – ENOCEAN TRANSCEIVER GATEWAY MODULE

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### 11 APPLICATION INFORMATION

#### 11.1 Transmission range

The main factors that influence the system transmission range are:

- Type and location of the antennas of receiver and transmitter
- Type of terrain and degree of obstruction of the link path
- Sources of interference affecting the receiver
- “Dead spots” caused by signal reflections from nearby conductive objects.

Since the expected transmission range strongly depends on this system conditions, range tests should always be performed to determine the reliably achievable range under the given conditions.

The following figures should be treated 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  
Such 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 include:

- Switch mounting 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 fibre
- Lead glass or glass with metal coating, steel furniture

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

TCM 515 – ENOCEAN TRANSCEIVER GATEWAY MODULE

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**11.2 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 non-isolated test points there are live signals accessible on the bottom side of the module.

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).

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.

## TCM 515 – ENOCEAN TRANSCEIVER GATEWAY MODULE

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### 12 REGULATORY INFORMATION

TCM 515 has been tested according to standards for RED (European Union) certification, FCC (US) and ISED (Canada) regulations.

#### 12.1 RED (European Union)

The Radio Equipment Directive (2014/53/EU, typically referred to as RED) replaces the old R&TTE directive from 1999 as regulatory framework for radio products in the European Union. All products sold to final customers after 12th of June, 2017 have to be compliant to RED.

At the time of writing, the text of the RED legislation was available from this link:

<http://eur-lex.europa.eu/eli/dir/2014/53/oj>

Dolphin radio modules such as TCM 515 are components which are delivered to OEM manufacturers for their use in final or combined products.

It is the responsibility of the OEM manufacturer to demonstrate compliance to all applicable EU directives and standards. The attestation of conformity for TCM 515 serves as input to the declaration of conformity for the full product.

At the time of writing, guidance on the implementation of EU product rules – the so called “Blue Guide” – was available from this link:

<http://ec.europa.eu/DocsRoom/documents/18027/>

Specifically within the new RED framework, all OEM manufacturers have for instance to fulfill the following additional requirements:

- Provide product branding (on the product) clearly identifying company name or brand and product name as well as type, charge or serial number for market surveillance
- Include (with the product) documentation containing full postal address of the manufacturer as well as radio frequency band and max. transmitting power
- Include (with the product) user manual, safety information and a declaration of conformity for the final product in local language
- Provide product development and test documentation upon request

Please contact an accredited test house for detailed guidance.

The maximum transmitting power of TCM 515 using a whip antenna is +10.8 dBm.

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**12.1.1 RED Attestation of Conformity for TCM 515**

## Attestation of Conformity

We,

**PKM electronic GmbH**

confirm hereby that the product  
(description of the apparatus, system, installation to which it refers)

Transceiver Modul  
TCM 515


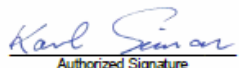
complies with

**Used Standard(s):**

<b>EN301489-3</b> :v1.6.1	Electromagnetic compatibility and Radio spectrum Matters (ERM); EMC standard for radio equipment and services; Part 3: Specific conditions for Short-Range Devices (SRD) operating on frequencies between 9 kHz and 248 GHz
<b>EN61000-3-2</b> :2014	Electromagnetic compatibility (EMC) - Part 3-2: Limits - Limits for harmonic current emissions (equipment input current up to and including 16A per phase)
<b>EN61000-3-3</b> :2013	Electromagnetic compatibility (EMC) - Part 3-3: Limits - Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current up to 16A per phase and not subject to conditional connection
<b>EN300220-2</b> :v3.1.1	Short Range Devices (SRD) operating in the frequency range 25 MHz to 1 000 MHz; Part 2: Harmonised Standard covering the essential requirements of article 3.2 of Directive 2014/53/EU for non specific radio equipment
<b>EN60950-1</b> :2006+A11:2009+A1:2010 +A12:2011+A2:2013	Information technology equipment - Safety Part 1: General requirements
<b>EN62479</b> :2010	Assessment of the compliance of low power electronic and electrical equipment with the basic restrictions related to human exposure to electromagnetic fields (10 MHz to 300 GHz)

The attestation based on a positive testing of a representative test sample. The test sample  
fulfills the requirements of the above listed standard(s).

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 <p><b>TESTED IN GERMANY</b></p>	<p>Date: 02.05.2017 Ref.-No.: 17/04-0028 <small>Based on Test report, Ref.-No.: 17/04-0028</small></p> <p><small>ACCREDITATION: DAKS D-PL-17379-01-00</small></p>	<p><b>PKM electronic GmbH</b></p>  <p>Authorized Signature</p>
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## TCM 515 – ENOCEAN TRANSCEIVER GATEWAY MODULE

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### 12.2 FCC (United States)

TCM 515U is a RF module approved for Single Modular use.

It is limited to OEM installation ONLY.

A separate approval is required for all other operating configurations, including portable configurations with respect to Part 2.1093 and different antenna configurations not covered by chapter 10.2

The module is limited to installation in mobile or fixed application.

TCM 515U has been tested against and is in compliance with FCC Part 15 Subpart B Class B. By incorporating this module into the final product, the final product may have to be tested to the FCC Part 15 Subpart B requirements. It is important to follow all notes regarding the installation and use of this module to ensure that the final product does comply with the FCC Part 15 Subpart B requirements.

To ensure compliance for all non-transmitter functions, a host product manufacturer is responsible for ensuring compliance with the module installed and fully operational. For example, if a host product was previously authorized as an unintentional radiator under the Declaration of Conformity procedure without containing a certified transmitter module, then a module is added, the host manufacturer is responsible for ensuring that the host continues to be compliant with the Part 15 subpart B unintentional radiator requirements after the module is installed and operational. Because this may depend on the details of how the module is integrated within the host, EnOcean will provide any guidance to the host manufacturer if needed for the final product for ensuring compliance with the Part 15 Subpart B requirements.

The module is optimized to operate using small amounts of energy, and may be powered by a battery. The module transmits short radio packets comprised of control signals, (in some cases the control signal may be accompanied with data) such as those used with alarm systems, door openers, remote switches, and the like.

The module does not support continuous streaming of voice, video, or any other forms of streaming data; it sends only short packets containing control signals and possibly data. The module is designed to comply with, has been tested according to 15.231(a-c), and has been found to comply with each requirement.

Thus, a finished device containing the TCM 515U radio module can be operated in the United States without additional Part 15 FCC approval (approval(s) for unintentional radiators may be required for the OEM's finished product), under EnOcean's FCC ID number if the OEM requirements are met and an OEM Modular Approval Agreement with EnOcean has been signed.

#### 12.2.1 OEM Requirements

In order to use EnOcean's FCC ID number, the OEM must ensure that the following condi-

## TCM 515 – ENOCEAN TRANSCEIVER GATEWAY MODULE

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tions are met:

- End users of products, which contain the module, must not have the ability to alter the firmware that governs the operation of the module. The agency grant is valid only when the module is incorporated into a final product by OEM integrators.
- The end-user must not be provided with instructions to remove, adjust or install the module.
- Changes or modifications not expressly approved by EnOcean could void the user's authority to operate the equipment.
- The module must be used with the approved antenna(s) as listed in chapter 10.2
- The OEM must ensure that timing requirements according to 47 CFR 15.231(a-c) are met.

- The Original Equipment Manufacturer (OEM) must ensure that FCC labeling requirements are met. This includes a clearly visible label on the outside of the final product. Attaching a label to a removable portion of the final product, such as a battery cover, is not permitted. The label must include the following text:

*Contains FCC ID: SZV-TCM515U*

*The enclosed device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (i.) this device may not cause harmful interference and (ii.) this device must accept any interference received, including interference that may cause undesired operation.*

When the device is so small or for such use that it is not practicable to place the statement above on it, the information required by this paragraph shall be placed in a prominent location in the instruction manual or pamphlet supplied to the user or, alternatively, shall be placed on the container in which the device is marketed. However, the FCC identifier or the unique identifier, as appropriate, must be displayed on the device.

The user manual for the end product must also contain the text given above.

### 12.2.2 Module Activation

The module can be triggered manually or automatically as described below.

#### Manual Activation

The radio module can be configured to transmit a short packetized control signal if triggered manually. The module can be triggered, by pressing a switch, for example.

The packet contains one (or more) control signals that is(are) intended to control something at the receiving end. The packet may also contain data. Depending on how much energy is available from the energy source, subsequent manual triggers can initiate the transmission of additional control signals. This may be necessary if prior packet(s) was (were) lost to fading or interference.

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Subsequent triggers can also be initiated as a precaution if any doubt exists that the first packet didn't arrive at the receiver. Each packet that is transmitted, regardless of whether it was the first one or a subsequent one, will only be transmitted if enough energy is available from the energy source.

### **Automatic Activation**

The radio module also can be configured to transmit a short packetized control signal if triggered automatically, by a relevant change of its inputs or in response to receiving a signal from another transmitter, for example.

Again, the packet contains a control signal that is intended to control something at the receiving end and may also contain data. As above, it is possible for the packet to get lost and never reach the receiver. However, if enough energy is available from the energy source, and the module has been configured to do so, then another packet or packets containing the control signal may be transmitted at a later time.

### **12.3 ISED (former Industry Canada) Certification**

This device complies with Industry Canada's license-exempt RSSs. Operation is subject to the following two conditions:

- (1) This device may not cause interference; and
- (2) This device must accept any interference, including interference that may cause undesired operation of the device.

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes :

- (1) l'appareil ne doit pas produire de brouillage, et
- (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

In order to use EnOcean's IC number, the OEM must ensure that the following conditions are met:

- Labeling requirements for ISED are similar to those required by the FCC. The Original Equipment Manufacturer (OEM) must ensure that ISED labeling requirements are met. A clearly visible label on the outside of a non-removable part of the final product must include the following text:

*Contains IC: 5713A-TCM515U*

*Contient le module d'émission IC: 5713A-TCM515U*

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- The OEM must sign the OEM Modular Approval Agreement with EnOcean

Pour utiliser le numéro IC EnOcean, le OEM doit s'assurer que les conditions suivantes sont remplies:

- Les exigences d'étiquetage pour ISED sont similaires à ceux exigés par la FCC. Le fabricant d'équipement d'origine (OEM) doit s'assurer que les exigences en matière d'étiquetage ISED sont réunies. Une étiquette clairement visible à l'extérieur d'une partie non amovible du produit final doit contenir le texte suivant:

*Contains IC: 5713A-STM300U*

*Contient le module d'émission IC: 5713A-TCM515U*

- L'OEM doit signer l'accord OEM Approbation modulaire avec EnOcean



TCM 515 – ENOCEAN TRANSCEIVER GATEWAY MODULE

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**12.4 Repeater Function (FCC/IC)**

The device is capable to operate as a repeater, which can receive signals from the following list of FCC/IC approved transmitters, and retransmit the signals:

■ PTM 210U	FCC ID:SZV-PTM210U	IC:5713A-PTM210U
■ PTM 330U	FCC ID:SZV-PTM330U	IC:5713A-PTM330U
■ STM 300U	FCC ID:SZV-STM300U	IC:5713A-STM300U
■ STM 320U	FCC ID:SZV-STM320U	IC:5713A-STM320U
■ STM 332U	FCC ID:SZV-STM332U	IC:5713A-STM332U
■ TCM 300U	FCC ID:SZV-STM300U	IC:5713A-STM300U
■ TCM 310U	FCC ID:SZV-STM300U	IC:5713A-STM300U
■ TCM 320U	FCC ID:SZV-TCM320U	IC:5713A-TCM320U
■ TCM 330U	FCC ID:SZV-STM300U	IC:5713A-STM300U
■ TCM 515U	FCC ID:SZV-TCM515U	IC:5713A-TCM515U