

**SATEL-TR4+**

**TRANSCEIVER MODULE**

**INTEGRATION GUIDE**

**Version 1.7**

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Salo, FINLAND 2020

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## RESTRICTIONS ON USE – SATEL-TR4+

**SATEL-TR4+** radio transceiver module has been designed to operate on 403-473 MHz, the exact use of which differs from one region and/or country to another. The user of a radio transceiver module must take care that the said device is not operated without the permission of the local authorities on frequencies other than those specifically reserved and intended for use without a specific permit.

**SATEL-TR4+** is allowed to be used in the following countries. More detailed information is available at the local frequency management authority.

Countries: AE, AT, AU, BE, BG, BR, CA, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, HR, IE, IS, IT, JP, KR, LT, LU, LV, MT, NL, NO, PL, PT, RU, RO, SE, SI, SK, TR, US

**WARNING – RF Exposure!** To comply with RF exposure compliance requirements in Europe, USA and Canada maximum antenna gain is 14dBi and a separation distance listed in a table below must be maintained between the antenna of this device and all persons. This device must not be co-located or operating in conjunction with any other antenna or transmitter.

Antenna Gain [dBi]	Separation distance [cm]
0	23
4	36
6	45
8	56
10	71
12	89
14	112

**WARNING!** Users of SATEL-TR4+ radio transceiver module in North America should be aware, that due to the allocation of the frequency band 406.0 – 406.1 MHz for government use only, the use of radio transceiver module on this frequency band without a proper permit is strictly forbidden.

### Host product labeling requirements

SATEL-TR4+ is intended to be integrated into a host device. Therefore, the SATEL-TR4+ product related FCC ID and IC ID must be visible in the host device chassis:

**FCC ID: MRBSATEL-TA40**  
**IC: 2422A-SATELTA40**

**NOTE!**

According to the requirements of the FCC, the integrator should make sure that the SATEL-TR4+ is compliant to part 90 while integrated in the host device. Output power and spurious emissions should be verified.

**NOTE!**

This device complies with Part 15 of the FCC Rules. Operation is subject to the condition that this device does not cause harmful interference

## PRODUCT CONFORMITY

Under the sole responsibility of manufacturer SATEL Oy declares that SATEL-TR4+ radio transceiver module is in compliance with the essential requirements (radio performance, electromagnetic compatibility and electrical safety) and other relevant provisions of Directives 2014/53/EU and 2011/65/EU and Council recommendation 1999/519/EC. Therefore, the equipment is labeled with the following CE-marking. The operating frequency range of the device is not harmonized throughout the market area, and the local spectrum authority should be contacted before the usage of the radio module.



## **WARRANTY AND SAFETY INSTRUCTIONS**

Read these safety instructions carefully before using the product:

- Warranty will be void, if the product is used in any way that is in contradiction with the instructions given in this manual
- The radio transceiver module is only to be operated at frequencies allocated by local authorities, and without exceeding the given maximum allowed output power ratings. SATEL and its distributors are not responsible, if any products manufactured by it are used in unlawful ways.
- The devices mentioned in this manual are to be used only according to the instructions described in this manual. Faultless and safe operation of the devices can be guaranteed only if the transport, storage, operation and handling of the device are appropriate. This also applies to the maintenance of the products.

## HOST INTEGRATION

To ensure compliance with all non-transmitter functions the host manufacturer is responsible for ensuring compliance with the module(s) installed and fully operational. For example, if a host was previously authorized as an unintentional radiator under the Declaration of Conformity procedure without a transmitter certified module and a module is added, the host manufacturer is responsible for ensuring that after the module is installed and operational the host continues to be compliant with the Part 15B unintentional radiator requirements. This module is certified for Fixed and Mobile Applications only, for portable applications you will require a new certification.

This device has been modularly approved. Model name, FCC and Industry Canada identifiers of this product must appear on the outside label of the end-user equipment.

Host labelling example:

<b>Model Name:</b>	<b>SATEL-TA40</b>
<b>Contains</b>	<b>FCC ID: MRBSATEL-TA40</b>
	<b>IC: 2422A-SATELTA40</b>
<b>This device complies with part 15 of the FCC rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired</b>	

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## 1 INTRODUCTION

SATEL Oy is a Finnish electronics and Telecommunications company specializing in the design and manufacture of wireless data communication products. SATEL designs, manufactures and sells radio modems intended for use in applications ranging from data transfer to alarm relay systems. End users of SATEL products include both public organizations and private individuals.

SATEL Oy is the leading European manufacturer of radio modems. SATEL radio modems have been certified in most European countries and also in many non-European countries.

This document is the integration guide for the SATEL-TR4+ radio transceiver module. It is intended to describe how to use the module and how to integrate it into a host device.

### 1.1 **Terms and abbreviations**

Abbreviation	Description
CTS	Clear To Send, handshaking signal used in asynchronous communication.
DTE	Data Terminal Equipment (typically computer, terminal...)
ESD	Electrostatic discharge
RD	Receive Data
TD	Transmit Data
RTS	Ready To Send, handshaking signal used in asynchronous communication.
RAM	Random Access Memory
LDO	Low dropout regulator
UHF	Ultra High Frequency
RF	Radio Frequency
CPU	Central processing unit

### 1.2 **Description of the product**

The SATEL-TR4+ is UHF radio transceiver module, which transmits and receives data from the UHF frequency band. The module is designed to be as compact and power efficient as possible. They have been developed to be especially suitable for integration into battery powered and space constrained host applications benefiting from UHF communications.

The module transmits and receives data via the Air interface, modulates and demodulates, encodes and decodes the data and sends the received data payload to the DTE port. The DTE interface is used to provide power and communicate with the module.

## 2 TECHNICAL SPECIFICATIONS

### 2.1 Absolute maximum ratings

Absolute maximum ratings for voltages on different pins are listed in the following table. Exceeding these values will cause permanent damage to the module.

Parameter	Min	Max
Voltage at VCC_IN	0 V	+6 V
Voltage at ENA_MOD	0 V	+6 V
Voltage at VCC_IO	0 V	3.75 V
Voltage at digital inputs (except ENA_MOD)	0 V	3.75 V
Voltage at digital outputs	0 V	3.75 V

Note. All voltages are referenced to GND.

### 2.2 DC electrical specifications

Recommended operating conditions:

Parameter	Condition	Min	Max	Units
VCC_IN		+3.8	+5.5	V
ENA_MOD, Vlow		0	0.2	V
ENA_MOD, Vhigh		1.2	VCC_IN	V
VCC_IO		1.8	3.3	V
Logic input, Vlow	1.8 V < VCC_IO < 3.3V	0	0.3	V
Logic input, Vhigh	1.8 V < VCC_IO < 3.3V	0.9 * VCC_IO	VCCIO	V
Logic output, Vlow	1.8 V < VCC_IO < 3.3V	0	0.5	V
Logic output, Vhigh	1.8 V < VCC_IO < 3.3V	0.6 * VCC_IO	VCCIO	V
Logic output, max current	All logic output except STAT pin.	-	4	mA
Logic output, max current, STAT pin		-	12	mA

## 2.3 Specifications, SATEL-TR4+

SATEL-TR4+ complies with the following international standards:

EN 300 113 V2.2.1 (4FSK FEC ON and 8FSK FEC ON)

EN 301 489-1

IEC 62368-1

	RECEIVER	TRANSMITTER	Note!
Frequency Range	403-473 MHz		
Tuning range	70 MHz		
Minimum RF Frequency Step	6.25 kHz		
Channel Bandwidth	12.5 kHz, 20 kHz, 25 kHz		
Frequency Stability	±0.5 ppm		-40°C...+85°C (Reference to +25°C)
Maximum Receiver Input Power without Damage	+3 dBm		
Maximum Receiver Input Power without Transmission Errors	-10 dBm		4FSK, 25 kHz, FEC ON
Sensitivity <sup>1</sup> BER = 10 <sup>-2</sup>	typ. -113 dBm		4FSK, 25 kHz, FEC ON
	typ. -115 dBm		4FSK, 12.5 kHz, FEC ON
	typ. -111 dBm		8FSK, 25 kHz, FEC ON
	typ. -112 dBm		8FSK, 12.5 kHz, FEC ON
	typ. -102 dBm		16FSK, 25 kHz, FEC ON
	typ. -104 dBm		16FSK, 12.5 kHz, FEC ON
Blocking <sup>1</sup> BER = 10 <sup>-2</sup>	typ. -17 dBm		4FSK, 25 kHz, FEC ON
	typ. -20 dBm		4FSK, 12.5 kHz, FEC ON
	typ. -18 dBm		8FSK, 25 kHz, FEC ON
	typ. -17 dBm		8FSK, 12.5 kHz, FEC ON
	typ. -29 dBm		16FSK, 25 kHz, FEC ON
	typ. -25 dBm		16FSK, 12.5 kHz, FEC ON
Intermodulation Response Rejection <sup>1</sup> BER = 10 <sup>-2</sup>	typ. -35 dBm		4FSK, 25 kHz, FEC ON
	typ. -37 dBm		4FSK, 12.5 kHz, FEC ON
	typ. -36 dBm		8FSK, 25 kHz, FEC ON
	typ. -36 dBm		8FSK, 12.5 kHz, FEC ON
	typ. -44 dBm		16FSK, 25 kHz, FEC ON
	typ. -41 dBm		16FSK, 12.5 kHz, FEC ON
CO-Channel Rejection <sup>1</sup>	typ. 8 dB		4FSK, 25 kHz, FEC ON

BER = $10^{-2}$	typ. 8 dB		4FSK, 12.5 kHz, FEC ON
	typ. 10 dB		8FSK, 25 kHz, FEC ON
	typ. 11 dB		8FSK, 12.5 kHz, FEC ON
	typ. 21 dB		16FSK, 25 kHz, FEC ON
	typ. 20 dB		16FSK, 12.5 kHz, FEC ON
Adjacent Channel Selectivity <sup>1</sup> BER = $10^{-2}$	typ. -33 dBm		4FSK, 25 kHz, FEC ON
	typ. -36 dBm		4FSK, 12.5 kHz, FEC ON
	typ. -34 dBm		8FSK, 25 kHz, FEC ON
	typ. -34 dBm		8FSK, 12.5 kHz, FEC ON
	typ. -43 dBm		16FSK, 25 kHz, FEC ON
	typ. -40 dBm		16FSK, 12.5 kHz, FEC ON
Spurious Rejection	typ. -35 dBm		4/8/16FSK, 12.5 and 25 kHz, FEC ON
Transmitter Power		0.01, 0.02, 0.05, 0.1, 0.2, 0.5, 1 W	
Communication Mode	Half-Duplex		
Frequency Change Time	typ. 20 ms		Time required for switching from one RF frequency to another
TX to RX time RX to TX time	TBD		
Adjacent Channel Power		<-60 dBc	TX-mode, 12.5 and 25 kHz. Acc. to EN 300 113 v2.2.1
Carrier power stability		<±1.5 dB	During transmission.

<sup>1</sup> According to EN 300 113 V2.2.1 measurement setup.

<sup>2</sup> Measured under normal ambient conditions,  $T_A = 25^\circ\text{C}$ . When the device is used in different environment, the results may change significantly. It is recommended to use external ESD protection in demanding conditions.

	DATA MODULE	
Electrical Interface	CMOS-UART Inputs and outputs referred to IO Voltage processed by user (1.8-3.3V) RTS, CTS, RX, TX, +VCC, GND	
Interface Connector	1.27 mm pitch socket	Samtec 20-pin through hole, CLP-110-02-L-D-K-TR
Data speed of Serial interface	1200 – 115200 bps	
Data speed of Radio Air Interface	4FSK FEC OFF / ON: 19200 / 14400 bps (25 kHz) 9600 / 7200 bps (12.5 kHz)	

	<u>8FSK FEC OFF / ON:</u> 28800 / 19200 bps (25 kHz) 14400 / 9600 bps (12.5 kHz) <u>16FSK FEC ON:</u> 28800 bps (25 kHz) 14400 bps (12.5 kHz)	
Air Interface Encryption	AES128, AES256 (DRM option)	
Data Format	Asynchronous data	
Modulation	4-, 8-, 16FSK	

	GENERAL	
Operating voltage	+3.8....+5.5V	
Typical Power Consumption 403...473 MHz	Sync search typ. 890 mW	RX-mode
	Receiving data typ. 860 mW	RX-mode
	SLEEP1: typ. 300 mW	RX-mode Wake-up time typically 33 ms
	typ. 4.8 W @ 1 W RF out	TX-mode, Continuous, 50 Ω, CHBW 25.0 kHz
	typ. 3.8 W @ 0.5 W RF out	
	typ. 2.9 W @ 0.2 W RF out	
	typ. 2.3 W @ 0.1 W RF out	
Inrush Current, DC voltage turned ON	< typ. 17 A, duration < typ. 9 µs	
Temperature Range	-20 °C ...+55 °C	Type Approval conditions
Temperature Ranges	-30 °C ...+70 °C	Functional
	-40 °C ...+85 °C	Storage
Vibration	≤ TBD	
ESD <sup>2</sup>	± 10 kV	Antenna connector. Acc. to EN61000-4-2; 150pF/330Ω
	± 8 kV	DTE connector. Acc. to EN61000-4-2; 150pF/330Ω
Antenna Connector	50 Ω, HIROSE U.FL compatible	I-PEX 20279-001 -E-01
Construction	PWB with sheet metal EMI shields	
Size L x W x T	57 x 36 x 6.9 mm	See Appendix 10.1
Weight	20 g	

Test condition  $V_{CC} = 4.0 \text{ V}$  and  $T_A = 25 \text{ °C}$

### 3 TIME PARAMETERS FOR STARTUP AND SHUTDOWN SEQUENCES

The following table shows the recommend times for startup and shutdown sequences.

Parameter	Recom. Time <sup>†</sup>	Explanation
$t_{vccin-ena}$	>2 ms	VCC_IN must be high before ENA_MOD is high
$t_{enamod-io}$	>2 ms	ENA_MOD must be high before VCC_IO is high
$t_{enamod-cts}$	$100 \text{ ms} < t_{enamod-cts} < 500 \text{ ms}$	CTS ready settling time
$t_{vccio-cts}$	>2 ms	VCC_IO must be high before CTS is ready
$t_{vccio-gpio}$	>2 ms	VCC_IO must be high before GPIO PINS are active
$t_{gpio-cts}$	>0 ms	GPIOs must be active before CTS is ready
$t_{enamod-gpio}$	>80 ms	Input pins must be low after ENA MOD is low
$t_{gpio-vccio}$	>0 ms	GPIOs must be low before VCC_IO is low
$t_{vccio-vccin}$	>0 ms	VCC_IO must be low before VCC is low

#### 3.1 Startup sequence

The following diagram will describe the startup sequence.

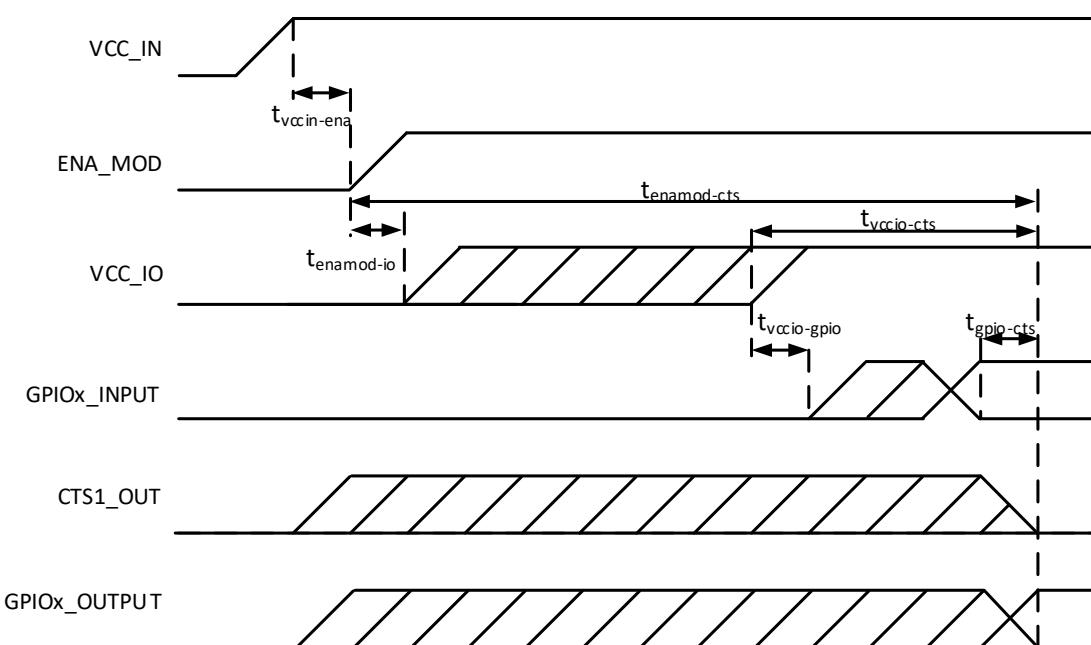
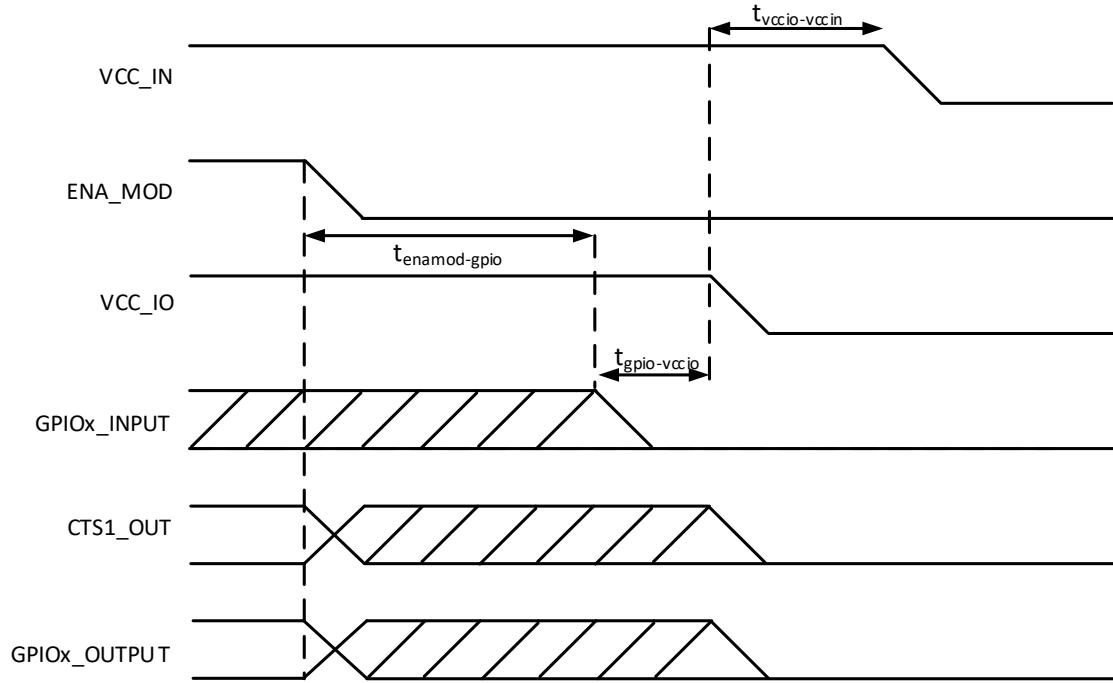


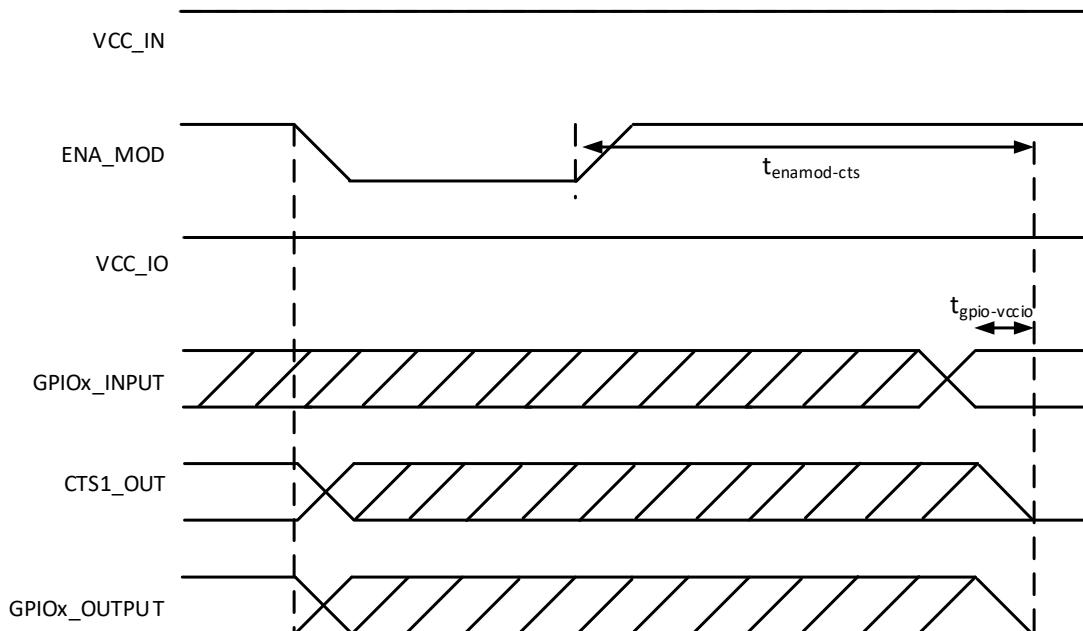
Figure 3.1 Startup sequence.

### 3.2 Shutdown and ENA sequences

The following diagrams will describe the shutdown and ENA sequences.



**Figure 3.2** Shutdown sequence.

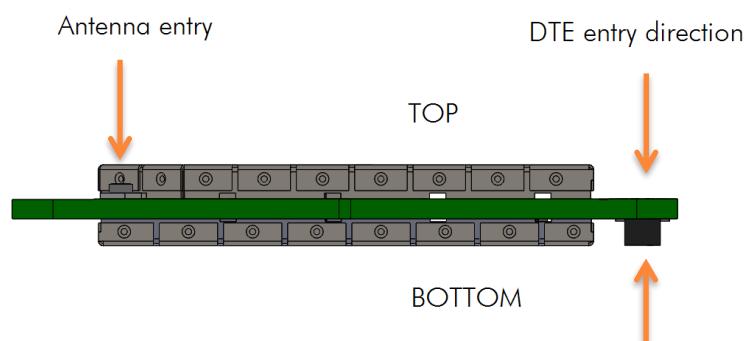


**Figure 3.3** ENA sequence.

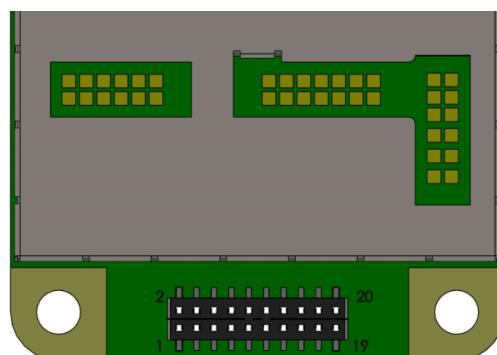
## 4 ELECTRICAL INTERCONNECTION

### 4.1 DTE connector

The DTE connector is a 20-pin pass-through connector. Connector is female two row 1.27 mm pitch. This connector allows the pin to enter the connector from the bottom side and protrude thru the module PCB to the top side, allowing flexible mounting heights with various pin lengths. Alternative DTE connector assembly variants available. DTE connector assembled either BOTTOM or TOP side of the module.



**Figure 4.1** The side view of the module with connection directions.



**Figure 4.2** Pin numbering of 1.27 mm pitch DTE connector. View from bottom side of unit.

## 4.2 Pin order of the DTE connector

Direction **IN** is data from DTE (Data Terminal Equipment) to the radio transceiver module.

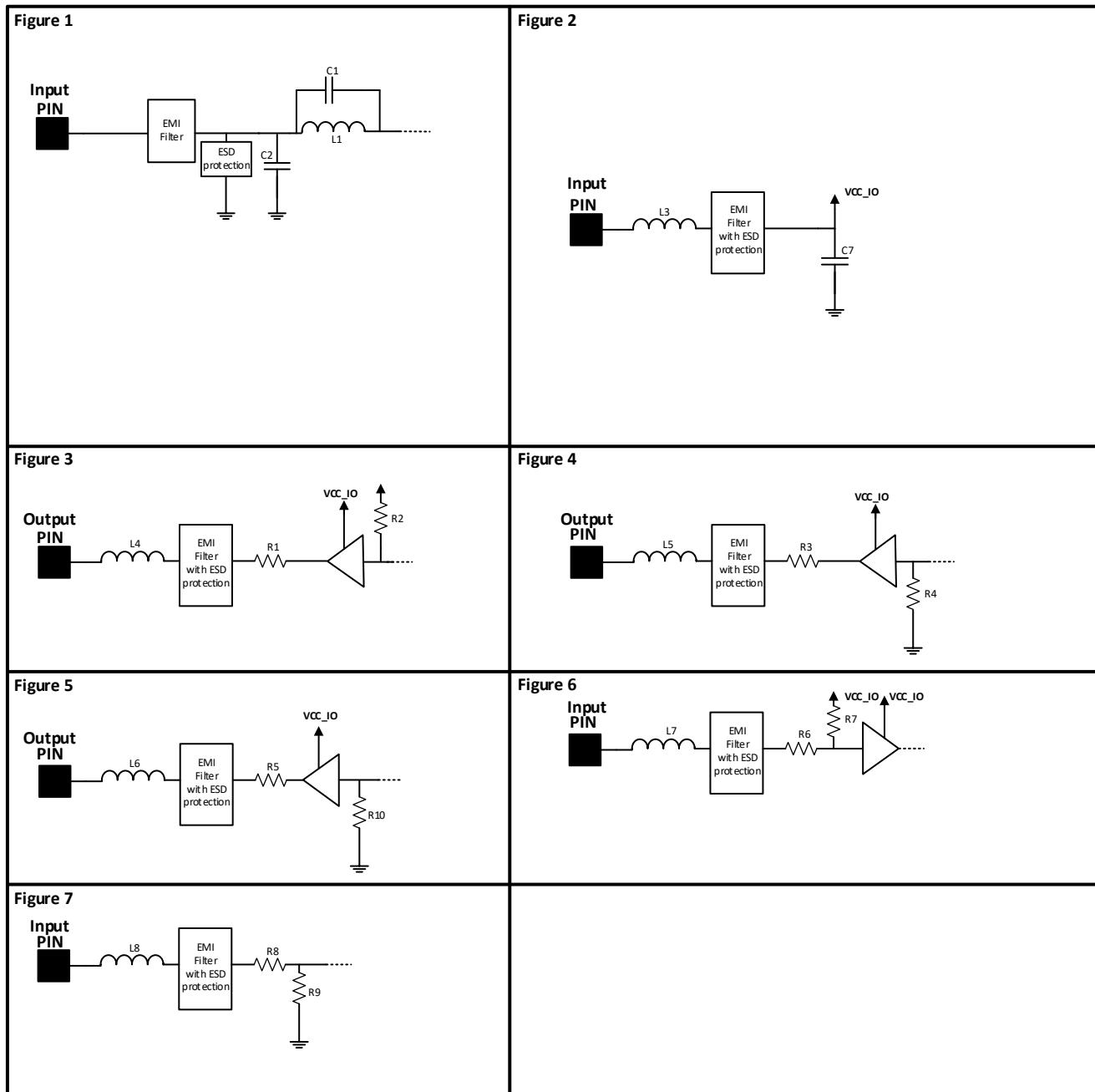
Direction **OUT** is data from the radio module to the DTE.

The equivalent I/O schematic figures are shown in the next chapter.

Pin No.	Equivalent I/O Schematic	Signal name	Type	Direction	Pin State	Description
1,2	Figure 1	VCC_IN	POWER	IN	External Voltage	DC input
3,4	-	GND	GND	-	External Ground	Ground reference for power and signals
5	Figure 2	VCC_IO	POWER	IN	External Voltage	Device IO driver input
6	Figure 7	ENA_MOD	IO	IN	Internal Pull Down	Module ENA pin
7	Figure 3	RD1	CMOS	OUT	Output Driver	Receive data, active low.
8	Figure 3	CTS1	CMOS	OUT	Output Driver	Clear To Send, active low.
9	Figure 6	TD1	CMOS	IN	Internal Pull Up	Transmit Data, active low.
10	Figure 6	RTS1	CMOS	IN	Internal Pull Up	Ready to send, active low.
11	Figure 4	GPIO1	CMOS	OUT	Internal Pull Down	Reserved for future use.
12	Figure 4	GPIO2	CMOS	OUT	Internal Pull Down	Reserved for future use.
13	Figure 6	GPIO3	CMOS	IN	Internal Pull Up	Reserved for future use.
14	Figure 6	GPIO4	CMOS	IN	Internal Pull Up	Reserved for future use.
15	Figure 5	STAT	CMOS	OUT	Output Driver	Various sequences (section 4.6).
16	Figure 6	GPIO5	CMOS	IN	Internal Pull Up	Reserved for future use.
17	Figure 6	SERVICE	CMOS	IN	Internal Pull Up	Input for service access, active low. See separate section of the manual (section 4.5).
18	Figure 4	GPIO6	CMOS	OUT	Internal Pull Down	Reserved for future use.
19	Figure 4	GPIO7	CMOS	OUT	Internal Pull Down	Reserved for future use.
20	Figure 4	GPIO8	CMOS	OUT	Internal Pull Down	Reserved for future use.

### 4.3 Equivalent I/O Schematics

The module input-output equivalent circuits are shown in the figure and the component values in the table below.



**Figure 4.3** The module input-output equivalent circuits.

Component values of the equivalent schematics:

Component	Value	Note
C1	6.8 pF	
C2	1 uF	
L1	220 nH	
L3	1000 $\Omega$ +- 25%	Measured Impedance at 100MHz
C7	100 nF	
L4	1000 $\Omega$ +- 25%	Measured Impedance at 100MHz
R1	330 $\Omega$	
R2	100 k $\Omega$	
L5	1000 $\Omega$ +- 25%	Measured Impedance at 100 MHz
R3	330 $\Omega$	
R4	100 k $\Omega$	
L6	1000 $\Omega$ +- 25%	Measured Impedance at 100 MHz
R5	330 $\Omega$	
L7	1000 $\Omega$ +- 25%	Measured Impedance at 100 MHz
R6	330 $\Omega$	
R7	100 k $\Omega$	
L8	1000 $\Omega$ +- 25%	Measured Impedance at 100MHz
R8	1 k $\Omega$	
R9	>1 M $\Omega$	
R10	100 k $\Omega$	

#### 4.4 RF interface

The antenna interface is a 50  $\Omega$  coaxial connector. Matching networks are not included on the module and should be placed in the host application if the antenna is not 50  $\Omega$ . The HIROSE U.FL compatible connector is located on the TOP side of the board.

NOTE! The used connector has gold plated contacts - whereas a standard HIROSE U-FL has silver plated contacts.

If silver - gold joints are not allowed in your product, use gold plated cable-connector to mate to this device.

**NOTE!**

Setting the transmitter output power to such a level that exceeds the regulations set forth by local authorities is strictly forbidden. The setting and/or using of non-approved power levels may lead to prosecution. SATEL and its distributors are not responsible for any illegal use of its radio equipment, and are not responsible in any way of any claims or penalties arising from the operation of its radio equipment in ways contradictory to local regulations and/or requirements and/or laws.

## **4.5 VCC\_IO pin**

VCC\_IO pin determines the voltage level of UART signals and the voltage level of GPIO output signals. VCC\_IO level also determines GPIO LOW/HIGH levels on each GPIO and UART input pins.

## **4.6 Service pin**

The SERVICE pin is used to set the UART1 into a known state. Pulling this pin LOW will activate the service mode and set the UART1 into 38400, 8, N, 1. This is intended for service access of the module, to have a known serial port setting in order to provide easy access to module settings.

The pin does not affect any permanent settings, nor does it change the mode of the module. It is recommended to pull high or pull up by resistor to VCC\_IO to return serial port 1 into the configured state. When service pin is LOW the SL Commands are temporary forced to be ON

## **4.7 Stat pin**

The STAT-pin indicates the status of the device. It can be used to drive or sink a LED current using a proper series resistor. STAT-pin drive or sink capability is +/-10mA at 3.3 V. It is recommended to use VCC\_IO for LED current.

Notice that if STAT-pin is used to sink LED current, LED behavior is opposite to driving scheme. The behavior of the STAT pin is described down below.

<b>Blink cycle</b>	<b>Mode</b>
“1” - statically	Module is operational “searching for a new frame”
“0” for the endurance of the received frame.	“0” when module is receiving data from air interface. In practical cases will toggle at the frequency of the data packets on the air interface.
“0” statically	Module is in sleep1 mode
The pin is toggled in transmission interval	Module is sending data Over the Air
Pin is toggled in 1 s interval	Module has the connection to Configuration Manager program.

Pin is toggled in 500 ms interval	SL command mode set to <b>OFF</b> and SL commands enabled using “+++” sequence, section 7.2.
Pin is toggled in 250 ms interval	Module has detected a fault, fault codes can be read via Configuration Manager program.

## 4.8 **VCC pins**

VCC pins are to feed operating voltage to the module. Limit for this voltage is mentioned in chapter 2.2 DC electrical specifications. User must take into consideration surge current and current consumption issues before using these pins. Also, the user must be aware for any voltage drop on the feeding path.

## 4.9 **UART pins**

Pins 7, 8, 9, 10 are used for UART serial transmission between the module and the terminal. The UART signal level corresponds to the level in VCC\_IO pin. VCC\_IO pin must be fed with a correct voltage level to match the terminal device.

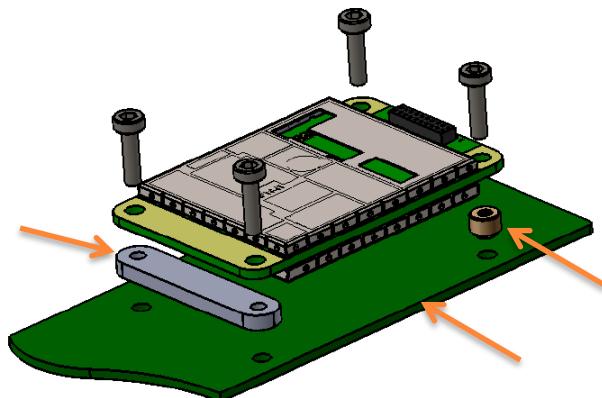
## 4.10 **GPIO pins**

GPIO pins are reserved pins for future use or special applications or special features. Unused pins should be left unconnected.

## 5 MECHANICAL CONSIDERATIONS

### 5.1 Fixing device to host

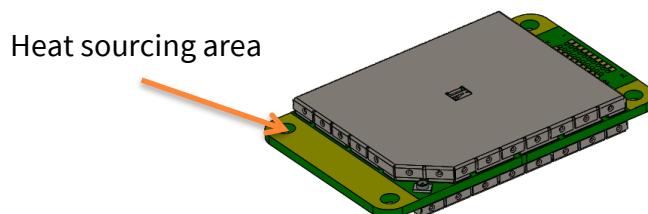
The radio transceiver module can be mounted on to the host application by using spacers and screws. It is highly recommended to use conducting metal spacers and screws to create proper electrical conductivity between the module and the host application. Recommended materials for spacers include brass or aluminum and steel screws. User must take care that there is no excessive mechanical stress created to the DTE connector while inserting and attaching the module. Recommended maximum screw size is M3, minimum spacer height between the module and the host application is 3 mm.



**Figure 5.1** Example of module attachment to application PCB.

### 5.2 Heat transfer

Since the module creates heat while operating, it must take into consideration to maximize the heat transfer from the module to an external heat sink. Proper heat sinking methods could be copper plated PCB, metal housing or a heat sink piece. The most recommended solution is to use a metal conductor to transfer heat from the module to an external heat sink which dimensions and location is adequate for a proper performance. To source the heat from the module is the plain area next to the antenna connector shown in a figure 5.2. Heat can be conducted from either side. To further improve the heat conductivity and reducing the heat transfer barriers, proper heat conducting paste or heat conducting tape should be used.



**Figure 5.2** Heat sourcing area, both sides.

## 6 OPERATING MODES

The radio transceiver module has the following modes of operation:

MODE	FUNCTION	DESCRIPTION
Ready to receive from RF	Search for sync	Module is searching for the start of a radio transmission from the RF signal.
	Receive data	The module has found a valid radio transmission and is receiving data.
TX	Transmit	The module transmits
Safe mode		Mode is entered when a fault has been detected and the device has been Rebooted. In safe mode fault codes can be read from the module (section 6.1).
Sleep mode	Sleep1	Will turn the module into a state where it will hold parts of the radio on, wakeup will take approx. 30 ms
Power mode	Save	Automatic sleep/wake-up procedure where module sleeping time is dynamically adjusted to received data packets. Decreases the power consumption of complete receiving cycle approx. 30%.

### 6.1 Safe mode

When a fault has been detected by the Firmware, the module is set to Safe mode. In this mode the module toggle's the STAT pin in 250 ms interval indicating an Error and reboots the device after 5 s. Transmitting/Receiving is prohibited during malfunction. When connecting to the device with SATEL Configuration Manager the Error code is shown in pop up box. If the device does not recover after multiple reboots, please contact SATEL Oy.

SATEL Configuration Manager can be downloaded from website <https://www.satel.com/support-and-services/downloads/> The version 1.12.1 or newer is compatible with SATEL-TR4+ radio transceiver module.

### 6.2 Power up / power down scenarios

The transceiver module can be set in four (4) states, “ON”, “OFF”, “Sleep1” and “Power Save”. When power is applied to the module, the module switches to ON state when voltage in ENA\_MOD is set to HIGH.

The module can be shut down by driving ENA\_MOD line to LOW state. In the “OFF” state current consumption is only that of leakage current from an LDO, section 2.3. In this state all non-essential parts off the module are powered down and all settings/state information that are not stored in nonvolatile memory are reset.

## 6.3 **Sleep Mode**

When being in sleep mode, the radio part of the module is switched OFF while the serial interface communication related parts remain powered ON. The module will be automatically woken up after the CPU senses a state change in the TD1 pin. *Example:* The module is in Sleep1- mode. The module is woken up by sending a character or characters into the TD1 pin after which the module responses “OK”. After “OK” the module is ready for normal communication.

To turn the module ON from Sleep1 mode:

- 1) Issue a state change to TD1 (toggle pin (minimum pulse duration time 10  $\mu$ s) or issue a byte on the UART (for example 0x00))
- 2) Wait for “OK” -response from the module. The wake-up time is approx. 30 ms.
- 3) Start communicating normally

Module will remain powered ON until a new sleep command is issued.

## 6.4 **Power Save Mode**

The Power save mode performs an automatic, self-adjusting receiver wake-up/sleep cycle. It is designed for applications which base on one-way communication with relatively constant TX interval and, in which the data packet separation is > 200 ms.

When enabled, the unit makes the *transmission interval study* basing on four (4) successfully received data packets. The shortest time between transmitted packets is measured ( $t_{min}$ ). Measured value is updated after each successfully received data packet, so that possible changes in the message length becomes noted.

Ensuring that the complete messages will be received even if there occur little variation in transmission interval, some safety margin ( $t_{marg}$ ) is left into Ready to receive from RF mode time.

Safety margin is calculated by dividing the shortest time between transmitted packets ( $t_{min}$ , in ms) with 8 and by adding 60 ms to this result:

$$t_{marg} = \frac{t_{min}}{8} + 60 \text{ ms}$$

The length of the whole sleeping period ( $t_{sleep}$ ) is calculated by decreasing the shortest time between transmitted packets ( $t_{min}$ ) with safety margin ( $t_{marg}$ ) and transmission time of the original message ( $t_{TX}$ ):

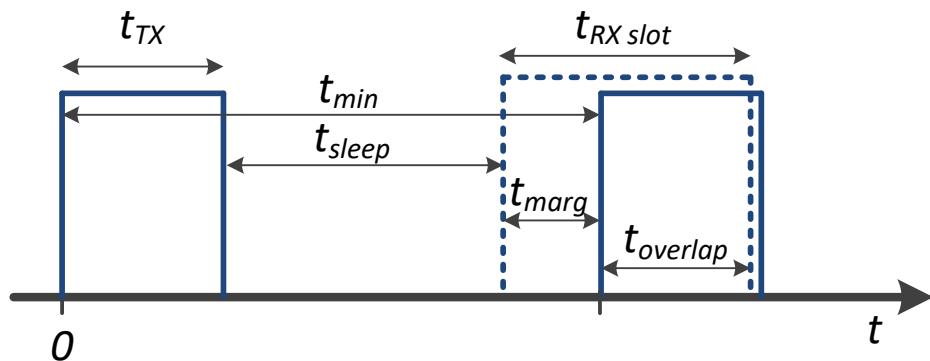
$$t_{sleep} = t_{min} - t_{marg} - t_{TX}$$

Transmission interval study is started over always after 100 successful sleep/wake-up cycles and, if the expected receiving slot ( $t_{RX\ slot}$ ) with enhanced overlap margin ( $t_{overlap}$ ) has been missed. In latter case the package is considered to be lost.

$$t_{overlap} = t_{marg} + 100\ ms$$

$$t_{RX\ slot, min} = t_{min} - t_{marg}$$

$$t_{RX\ slot, max} = t_{min} + t_{overlap}$$



**Figure 6.1** Power save mode timing factors.

E.g. In system with TX interval of 1 s, and with 300 ms (approx. 300B @ 9600 bps) transmission time:

$$t_{min} = 1000\ ms$$

$$t_{TX} = 300\ ms$$

$$t_{marg} = 125\ ms + 60\ ms = 185\ ms$$

$$t_{sleep} = 1000\ ms - (125\ ms + 60\ ms) - 300\ ms = 515\ ms$$

$$t_{RX\ slot, min} = 1000\ ms - 185\ ms = 815\ ms$$

$$t_{RX\ slot, max} = 1000\ ms + 285\ ms = 1285\ ms$$

## 6.5 Restart

After startup the module can be restarted by issuing a SL command, upon which the module will shut down all circuitry, and Reboot the CPU (see SL command list).

## 7 CHANGING PARAMETERS USING SL COMMANDS

The controlling terminal device can change the configuration settings of the module. This is accomplished with the help of SL commands. SL commands can be used to change e.g. the frequency or addresses. It is also possible to ask the radio transceiver module to show current settings which are in use.

### 7.1 SL Commands

The controlling terminal device can change the configuration settings of a radio. This is accomplished with the help of SL commands, which can be used during data transfer. SL commands can be used to change e.g. the frequency or addresses. It is also possible to interrogate a radio modem in order to gain information concerning current settings that are in use. SL command -setting must be enabled before they can be used.

An SL command is a continuous string of characters, which is separated from other data by pauses which are equal or greater than time defined by Pause length parameter (default=3 characters) in the set-up. No extra characters are allowed at the end of an SL command.

Serial interface settings are the same as in data transfer. SL command is properly recognised also in the case when the command string is terminated by <CR> (=ASCII character no. 13, Carriage Return, 0x0d) or <CR><LF> (<LF> = ASCII char. no. 10, Line Feed, 0x0a). If multiple SL commands are sent to the module, the next command can be given after receiving the response ("OK" or "ERROR") of the proceeding command. In addition, it is recommended to implement a timeout to the terminal software for recovering the case when no response is received from the radio module.

The transceiver module will acknowledge all commands by returning an "**OK**" (command carried out or accepted) or the requested value, or an "**ERROR**" (command not carried out or interpreted as erroneous) message.

It is possible to use SL commands in Port 2 (TD2 signal in GPIO3 (Pin13) and RD2 signal in GPIO1 (Pin11)) when Port2 Function has been configured as Diagnostics. SL commands can be used even in parallel with Port1 – in that case the response appears in the same port where the SL command came from.

Port2 is configured on Serial Interface sheet of Configuration Manager software (starting from version 1.8.0) by selecting the Port2 Function:

- OFF (=Port 2 not in use)
- Diagnostics (=SL commands ON in this case)

CR/LF characters are added to end the response messages (unless they are already present) in order to make parsing easier. Settings can be toggled, SL Commands ON/OFF, CR/LF ON/OFF.

The SL commands are listed in appendix 10. In order to get information of the latest and/or special SL commands please contact SATEL.

## 7.2 **SL Command Mode**

The SL commands have always been enabled in the previous products like M3-R3. When the SL commands are enabled there are possibilities that the user data may start with the characters “SL” which is handled as the SL command. This has caused the firmware to go to the continuous SL command search mode and any data has not been sent or even an “**ERROR**” acknowledgment has been received. To avoid this kind behavior the user can disable the SL commands.

The SL commands can be disabled or enabled by using SL commands or toggling the “*SL Command mode*” parameter via the *SATEL Configuration Manager*, version v1.3.15 or newer.

By default the *SL Command mode* is set to **ON**. If the *SL Command mode* is set to **OFF** then the SL commands can be enabled or disabled by using the below described procedure. Regardless of original SL command –setting state, changing the setting state with this procedure will effect to the reception process of the radio module. SL command –setting state can be changed only via SATEL Configuration Manager in maintenance access level.

### **Note1!**

#### To enable the SL Commands\* (disables interface transmission and reception):

- Send three “+” characters via serial port so that there is at least three bytes delay between each character. The response is “**OK**”, when successfully set.  
*<+><at least three bytes pause><+><at least three bytes pause><+>*

#### To disable the SL Commands\* (enables radio interface transmission and reception):

- Send three “-” characters via serial port so that there is at least three bytes delay between each character. The response is “**OK**”, when successfully set.  
*<-><at least three bytes pause><-><at least three bytes pause><->*

\*) Regardless of the set state for the SL command mode.

### **Note2!**

The “+ + +” and “- - -” procedures are not allowed to be used, when radio is transmitting or receiving data (i.e. the application data occupies the TD or RD lines of the radio).

## 8 DEFAULT DELIVERY VALUES – SATEL-TR4+

DEFAULT VALUES OF THE ADJUSTABLE SETTINGS (the user can change these settings later on)		
Setting	Default value	Range
<b>Radio frequency</b>		
<b>Operating TX and RX frequency</b>	<b>438.000 MHz</b>	<b>403 - 473 MHz</b>
<b>Channel Spacing (equals channel width)</b>	<b>12.5 kHz</b>	<b>12.5, 20, 25 kHz</b>
<b>Transmitter Output Power</b>	<b>1 W</b>	<b>0.01, 0.02, 0.05, 0.1, 0.2, 0.5 and 1 W</b>
<b>Radio settings</b>		
<b>Radio Compatibility</b>	<b>SATEL 3AS</b>	<b>SATEL 3AS PacCrest-4FSK SATEL-8FSK-1 (FEC OFF) SATEL-8FSK-2 (FEC ON) SATEL-16FSK-1 (FEC ON)</b>
<b>Addressing</b>		
<b>RX Address</b>	<b>OFF</b>	<b>ON/OFF</b>
<b>TX Address</b>	<b>OFF</b>	<b>ON/OFF</b>
<b>Serial port</b>		
<b>Data speed</b>	<b>115200 bps</b>	<b>1200 -115200 bps</b>
<b>Data bits</b>	<b>8</b>	<b>8</b>
<b>Parity bits</b>	<b>None</b>	<b>None, Even, Odd</b>
<b>Stop bits</b>	<b>1</b>	<b>1</b>
<b>Handshaking</b>		<b>Handshaking lines apply to the DATA-port</b>
<b>CTS</b>	<b>TX Buffer State</b>	<b>Clear to send, TX Buffer State</b>
<b>RTS</b>	<b>Ignored</b>	<b>Ignored, Flow Control</b>
<b>Additional setup</b>		
<b>Error Correction, FEC</b>	<b>OFF</b>	<b>ON/OFF</b>
<b>Error check</b>	<b>OFF</b>	<b>OFF, CRC8Partial, CRC8Full, CRC16Full</b>
<b>SL Command Mode</b>	<b>ON</b>	<b>ON/OFF</b>
<b>Repeater Mode</b>	<b>OFF</b>	<b>ON/OFF</b>
<b>TX Delay</b>	<b>0</b>	<b>0 .... 65535 ms</b>
<b>Over-the-Air-Encryption</b>	<b>OFF</b>	<b>ON/OFF</b>
<b>Use Channel List</b>	<b>OFF</b>	<b>ON/OFF</b>
<b>Power Save Mode</b>	<b>OFF</b>	<b>ON/OFF</b>
<b>Add RSSI to Data</b>	<b>OFF</b>	<b>ON/OFF</b>
<b>Radio state</b>	<b>Tx/Rx</b>	<b>Tx/Rx / Rx (transceiver modules)</b>

## 9 CONSIDERATIONS

### 9.1 EMI Interferers

The module is designed to be mounted inside a host device. The module is designed to withstand EMI even beyond type approval requirements. However, a small module which is integrated closely to modern high-speed electronics is bound to receive some interference.

To make a working integration, consider the following: EMI can enter the module in four ways:

- 1) Via the antenna (radiation from enclosure enters the antenna)
- 2) Radiated disturbances to the coaxial cable
- 3) Radiation from other electronics / cabling directly to the module
- 4) Conducting through the DTE interface (power, control and data lines).

Because the module is shielded and the DTE interface is filtered, the usually worst method of disturbance is via the antenna port, which is easily overlooked in design. Keep in mind that the radio module has a sensitivity of approx. -115 dBm (depends on mode of operation and speed etc.). While the module has an approx. 10 dB S/N requirement, this constitutes, that any signal entering the radio antenna on receive frequency on a level of < -125 dBm (-115 dBm -10 dB), causes desensitization of the radio on that particular channel.

Example:

An interferer has a level of -100 dBm on the frequency 421 MHz. The radio will show an approximate sensitivity of -90 dB (-100 dBm+S/N requirement 10 dB) on 421 MHz.

Now consider that generic EMC requirements usually have pass/fail criteria of -57dBm (if normalized to the surface of the device). **So there is almost a 70dB gap between generic EMC requirements and co-existence requirements between a high sensitivity narrowband radios.**

To avoid problems of co-existence a good design should apply:

- 1) EMI shielding in enclosure – ambient air interface
- 2) careful layout
- 3) shielding of all digital high-speed parts and cables
- 4) Have a clocking plan to avoid clock frequencies causing harmonics on the UHF band of interest.

Number one is to recognize this challenge and act upon it.

SATEL R&D can help in this by participating in design review of the host device, aiming to catch problems early in the design phase.

## **9.2 Electrostatic discharge**

As the module is intended to be embedded in a host application, in a typical use case, the antenna port is the only port of the module directly interface with a surface or contact area subjected to Electrostatic Discharge (ESD). Thus, the antenna port is the only interface with high level ESD protection. The DTE port also features ESD protection diodes, but is not designed to withstand similar performance as expected from standalone units with enclosures.

Consequently, the module should be subject to ESD handling precautions that typically apply to ESD sensitive components. Proper ESD handling and packaging procedures must be applied throughout the processing, handling and operation of any application that incorporates this module.

## **9.3 Using the device in unmanned high reliability applications**

The module features software and hardware watchdogs which are incorporated inside the CPU. While we believe that this is a reliable method of keeping the module in operational condition, there are parts of the module that can't be monitored for proper operation to 100%. For example the module chip has a firmware that resides in the chips RAM. The firmware can't be read back or reloaded, without interrupting reception. Hence the module can't reload this automatically by itself without causing breaks in communication. To avoid the module from ending up in a state where for example the module chip firmware is corrupted for example by ionizing radiation, it is recommended that the controlling system implements some form of watchdog function for the module. This can be done for example if the system knows that data should be received every second, and no data has been received for a minute – then do a module restart using the ENA\_MOD pin or by issuing a restart command, or a cold boot by toggling VCC\_IN low and high again.

## **9.4 PROPOSALS FOR MORE RELIABLE RADIO LINK**

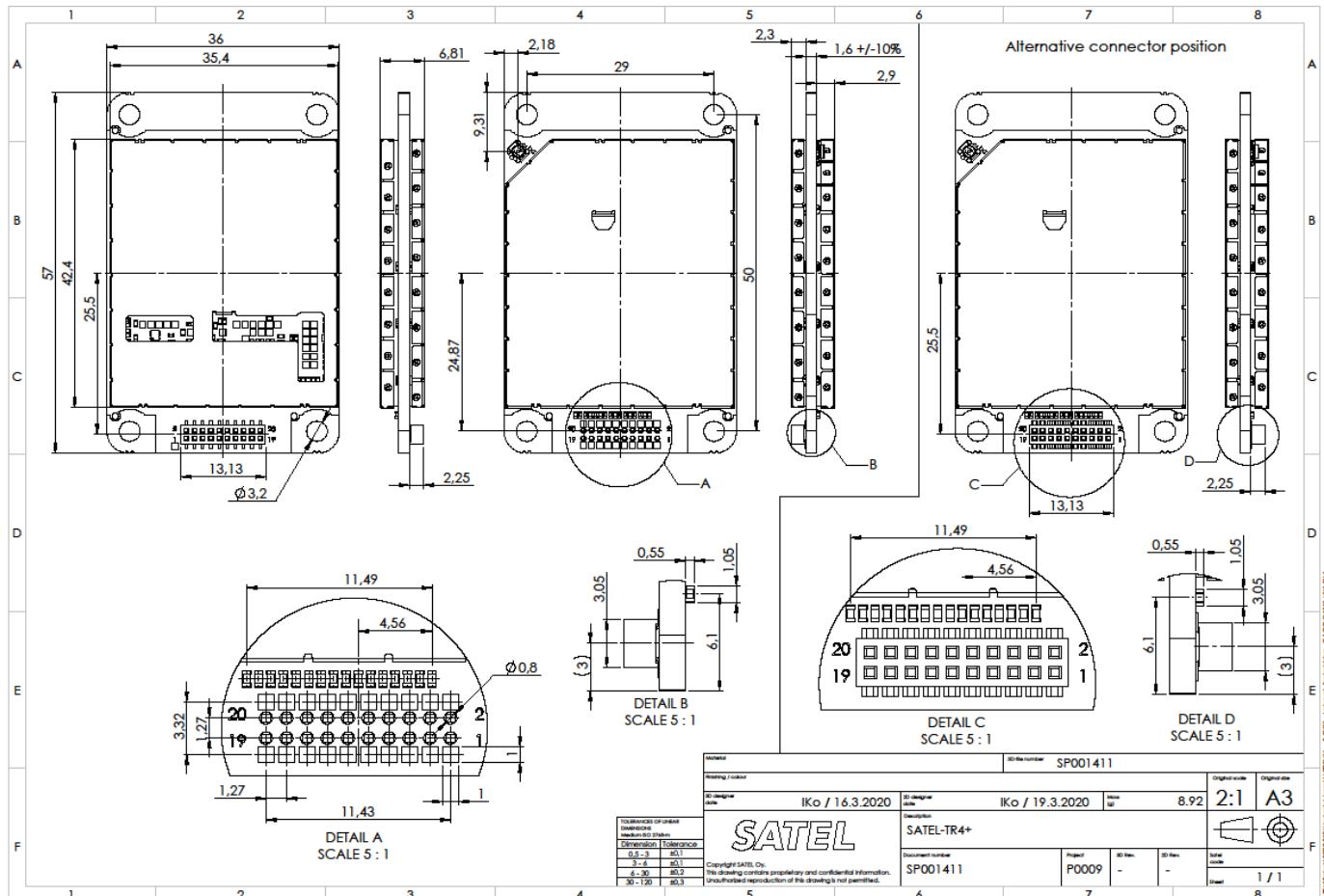
In case where the environment is challenging the following methods can be used for improving the transmission reliability:

- Forward Error Correction, FEC, is recommend to use in challenging environment like urban areas.
- Directional antennas.
- Before building the radio link(s) it is highly recommend that the radio environment is measured to find out whether the radio environment is clean enough by using a spectrum analyzer or radio module's RSSI, Received Signal Strength Indication, value.
- Co-operation with the local authority to find out the optimum free radio channel.

- If the channel is disturbed an external band-pass filter can be used for improving the filtering.
- If at the adjacent channel is TDMA, Time Domain Multiple Access, it is recommended to use time slot for receiving which is not in synchronization with the TDMA radio transmission.
- In Europe it is not recommended to use channels which are located near by the TETRA or television frequencies.

## 10 APPENDIX

### 10.1 Module dimensions



### 10.2 SL COMMANDS

Category	Command	Description	Response
Addressing	SL#A?	Show all addresses (RX1, RX2, TX1, TX2)	"xxxx,yyyy,zzzz,vvvv"
Addressing	SL#A=xxxx, yyyy, zzzz,vvvv	Set RX/TX addresses (RX1, RX2, TX1, TX2)	"OK" or "ERROR"
Addressing	SL#I?	Get primary addresses (TX1, RX1)	"xxxx;yyyy"

Addressing	SL#I=xxxx	Set all addresses (RX1, RX2, TX1, TX2) to value xxxx [0000....ffff]	"OK" or "ERROR"
Addressing	SL#P?	Get primary transmit address (TX1) and primary receive address (RX1)	"xxxx;yyyy"
Addressing	SL#P=xxxx;yyyy	Set primary transmit address (TX1) to value xxxx and primary receive address (RX1) to value yyyy [0000....ffff]	"OK" or "ERROR"
Addressing	SL#Q?	Get TX address mode	"0" = TX address OFF "1" = TX address ON
Addressing	SL#Q=x	Set TX address ON/OFF. Values of x are: "0" = TX address OFF "1" = TX address ON	"OK" or "ERROR"
Addressing	SL#R?	Get primary receive address (RX1)	"yyyy"
Addressing	SL#R=xxxx	Set receive addresses (RX1, RX2) to value xxxx [0000....ffff]	"OK" or "ERROR"
Addressing	SL#S?	Get secondary transmit address (TX2) and secondary receive address (RX2)	"xxxx;yyyy"
Addressing	SL#S=xxxx;yyyy	Set secondary transmit address (TX2) to value xxxx and secondary receive address (RX2) to value yyyy [0000....ffff]	"OK" or "ERROR"
Addressing	SL#T?	Get primary transmit address (TX1)	"xxxx"
Addressing	SL#T=xxxx	Set transmit addresses (TX1, TX2) to value xxxx [0000....ffff]	"OK" or "ERROR"
Addressing	SL#W?	Get RX address mode	"0" = RX address OFF "1" = RX address ON
Addressing	SL#W=x	Set RX address ON/OFF. Values of x are: "0" = RX address OFF "1" = RX address ON	"OK" or "ERROR"
ChannelList	SL\$A=1	Go to channel list default channel	"OK" or "ERROR"
ChannelList	SL\$C?	Get number of channels in channel list	decimal number
ChannelList	SL\$C=nn	Set number of channels in channel list. nn = 0...40, 0 clears the whole list	"OK" or "ERROR"
ChannelList	SL\$D?	Get channel list default channel number	decimal number
ChannelList	SL\$D=n	Set channel list default channel, n is channel number	"OK" or "ERROR"
ChannelList	SL\$E=1	Search free channel Modem searches for next traffic-free channel. Listening time of traffic is about 2 seconds	"OK" followed by "channel n is free" Value of n is channel number of next free channel on channel list

		Modem shows next free channel by activating command again	
ChannelList	SL\$F?	Get active channel number	decimal number
ChannelList	SL\$F=n	Set modem to channel number n in channel list	"OK" or "ERROR"
ChannelList	SL\$L?nn	Get channel info. Index nn=[0...(number of channels-1)]	Channel number, Frequency, Channel width, Tx Power For example: "CH 1, 430.150000 MHz, 25.0 kHz, 100 mW\0D"
ChannelList	SL\$L=aa,Nbbbb bb,Fccc.cccccc, Wddddd,Peeee e<CR>	I = Index field aa = 0...39 //Future reservation 0...255 N = Channel number field bbbbb = -32767...32767 F = Tx/Rx Frequency field ccc.cccccc = Tx/Rx Frequency in MHz (only numbers or "." allowed, "," is not allowed) W = Channel spacing/width field dddddd = 12.5, 20 or 25 (unit is kHz, trailing decimals are tolerated e.g. "25", "25.0", "25.00" and "25.000" are all valid) P = Transmitter power field eeeee = 0...35000 (modem rounds the value to the closest applicable) Note: 0 means "don't care" value for power. <CR> = Carriage return character	"OK" or "ERROR"
ChannelList	SL\$M?	Get status of channel list. 0 = Not in use, 1 = Channel list in use	"0" or "1"
ChannelList	SL\$M=n	Set status of channel list. 0 = Not in use, 1 = Channel list in use	"OK"
ChannelList	SL\$R?	Get listening time (seconds) of Search free channel function	decimal number
ChannelList	SL\$R=n	Set listening time (seconds) of Search free channel function	"OK" or "ERROR"
ChannelList	SL\$S=1	Set channel scanning mode When activated, modem scans channels one by one and saves RSSI readings to memory	"OK" followed by channel/RSSI info For example: "OKCH 6 -122 dBm, CH 22 -121 dBm, CH 10003 -122 dBm, "
DataPort	SL%B?	Get serial data parameters	baud rate, character length, parity, number of

			stop bits (for example "38400, 8, N, 1")
DataPort	SL%B=a,b,c,d	Set serial data port parameters. a= "115200", "57600", "38400", "19200", "9600", "4800", "2400" or "1200" (defines baud rate) b="8" (defines character length) c= "N", "O" or "E" (defines parity) d= "1" (defines number of stop bits)	"OK" or "ERROR"
DataPort	SL%L?	Get pause length	Decimal number
DataPort	SL%L=n	Set pause length	"OK" or "ERROR"
Memory	SL**>	Save current settings as permanent settings	"OK" or "ERROR"
Memory	SL*R>	Restore settings to their factory set values	"OK" or "ERROR"
ModemInfo	SL!H?	Get radio HW info	"HW:nnnnn"
ModemInfo	SL!V?	Get modem "type"	Depending on variant, for example "M3-TR3"
ModemInfo	SL%1?	Get arbitrary data stored in memory location 1	If empty data is stored, response = "Undefined", otherwise data and carriage return
ModemInfo	SL%1="data"	Set arbitrary data (max 25 characters) in memory location 1	"OK" or "ERROR"
ModemInfo	SL%2?	Get arbitrary data stored in memory location 2	If empty data is stored, response = "Undefined", otherwise data and carriage return
ModemInfo	SL%2="data"	Set arbitrary data (max 25 characters) in memory location 2	"OK" or "ERROR"
ModemInfo	SL%3?	Get arbitrary data stored in memory location 3	If empty data is stored, response = "Undefined", otherwise data and carriage return
ModemInfo	SL%3="data"	Set arbitrary data (max 25 characters) in memory location 3	"OK" or "ERROR"
ModemInfo	SL%4?	Get arbitrary data stored in memory location 4	If empty data is stored, response = "Undefined", otherwise data and carriage return
ModemInfo	SL%4="data"	Set arbitrary data (max 25 characters) in memory location 4	"OK" or "ERROR"
ModemInfo	SL%D?	Get Modem Type	Depends on model, for example "M3-TR3"
ModemInfo	SL%H?	Get logic hardware version	Hardware info
ModemInfo	SL%S?	Get Serial Number	Serial number of radio modem

ModemInfo	SL%V?	Get firmware revision information	For example "V07.22.2.3.0.2"
RadioFreq	SL!D?	Get lower limit of frequency band 1	"nnn.nnnnn MHz"
RadioFreq	SL!U?	Get upper limit of frequency band 1	"nnn.nnnnn MHz"
RadioFreq	SL!W?	Get lower limit of frequency band 2	"nnn.nnnnn MHz"
RadioFreq	SL!Y?	Get upper limit of frequency band 2	"nnn.nnnnn MHz"
RadioFreq	SL&F?	Get active frequency	"nnn.nnnnn MHz"
RadioFreq	SL&F=nnn.nnnnn n	Set active frequency to nnn.nnnnn MHz	"OK" or "ERROR"
RadioFreq	SL&FR?	Get Rx frequency	"nnn.nnnnn MHz"
RadioFreq	SL&FR=nnn.nnn nn	Set Rx frequency to nnn.nnnnn MHz	"OK" or "ERROR"
RadioFreq	SL&FT?	Get Tx frequency	"nnn.nnnnn MHz"
RadioFreq	SL&FT=nnn.nnn nn	Set Tx frequency to nnn.nnnnn MHz	"OK" or "ERROR"
RadioFreq	SL&W?	Get channel spacing/channel width	"25.0 kHz", "20kHz", "12.5 kHz"
RadioFreq	SL&W=xxxx	Set channel spacing. Value of xxxx is: "1250" for 12,5 kHz "2000" for 20 kHz "2500" for 25 kHz Before using this command, make sure that active frequency matches new channel spacing	"OK" or "ERROR"
RadioProperty	SL%F?	Get status of Error correction (FEC)	"0" = FEC OFF, "1" = FEC ON
RadioProperty	SL%F=x	Set Error correction (FEC). Value of x is: "1" Set FEC ON "0" Set FEC OFF	"OK" or "ERROR"
RadioProperty	SL%E?	Get status of Error check and Full CRC16 check modes	"0" Error check off "1" CRC8 Partial "2" CRC8 Full "3" CRC16 Full
RadioProperty	SL%E=x	Set Error check and Full CRC16 check modes. Value of x is: "0" Error check off "1" CRC8 Partial "2" CRC8 Full "3" CRC16 Full	"OK" or "ERROR"
RadioProperty	SL%R?	Get region code setting/status	0,0 = Default, 1,1 = US, 1,2 = US & Illegal radio setting combination (TX is disabled)
RadioProperty	SL@C?	Get Call sign settings	a, b, c followed by Carriage Return character, where:

			a=CallSignState (0=OFF, 1=ON) b=CallSignInterval (0...255) in minutes c=CallSignId (max 16 alphanumeric characters) For example: "1,5,MYMESSAGE" followed by Carriage Return character
RadioProperty	SL@C=a,b,c	Set Call Sign settings a=CallSignState (0=OFF, 1=ON) b=CallSignInterval (0...255) in minutes c=CallSignId (max 16 alphanumeric characters)	"OK" or "ERROR"
RadioProperty	SL@D?	Get Tx delay (ms)	For example "0 ms" or "50 ms"
RadioProperty	SL@D=n	Set Tx delay (ms), n is [0...65535]	"OK" or "ERROR"
RadioProperty	SL@E?	Get supported radio compatibility modes.	List of numbers, separated by commas, showing the supported modes: 0=Satel3AS, 1=PacCrest 4FSK, 20=SATEL-8FSK-1, 21=SATEL-8FSK-2, 22=SATEL-16FSK-1 For example: "0,1" indicates that the modem supports Satel3AS and PacCrest 4FSK protocols.
RadioProperty	SL@F?	Get noise level of radio channel	"-xxx dBm"
RadioProperty	SL@M?	Get repeater function	"O" = Repeater OFF(character O) "R" = Repeater ON
RadioProperty	SL@M=x	Set repeater function. Values of x are: "O" = Repeater function OFF(character O) "R" = Repeater function ON	"OK" or "ERROR"
RadioProperty	SL@P?	Get transmitter output power	One of these values "10mW", "20mW", "50mW", "100mW", "200mW", "500mW", "1000 mW".
RadioProperty	SL@P=nnnnn	Set RF output power (mW) For example "SL@P=100" sets 100 mW transmitter output power. Range: 10, 20, 50, 100, 200, 500, 1000	"OK" / "ERROR"

RadioProperty	SL@R?	Get RSSI (Received Signal Strength Indication) of last received message (dBm)	"-nnn dBm", nnn is a decimal value of field strength between -80 dBm and -118 dBm. Value is available 7 s after reception, after that the response is "<-118 dBm". SATELLINE-3AS Epic returns the stronger value of two transceivers.
Radio Property	SL@S?	Get radio compatibility mode	decimal number. See list on lower left
RadioProperty	SL@S=x	Set radio compatibility mode. Value of x is: 0 = SATELLINE-3AS 1 = PacCrest-4FSK 20 = SATEL-8FSK-1 (FEC OFF) 21 = SATEL-8FSK-2 (FEC ON) 22 = SATEL-16FSK-1 (FEC ON)	decimal number
Radio Property	SL&P?	Get TX/RX priority.	1 = TX priority 2 = RX priority
Radio Property	SL&P=n	Set TX/RX priority. Value of n: 1 = TX priority 2 = RX priority	OK or ERROR
Reset	SL@X=n	Reset command. Values of n are: "9" Reset modem	"OK" or "ERROR", then modem resets required blocks.
Test	SL+P=xxxx	Get measured signal strength from remote modem i.e. SL "ping" Value of xxxx [0000...ffff] defines address of remote modem	"OK" followed by RSSI info from remote modem
Operational mode	SL++?	Get status of transmission control	"0" = Transmission enabled or "1" = Transmission disabled
Operational mode	SL++	Disable radio transmission / reception	"OK" or "ERROR"
Operational mode	SL++0	Enable radio transmission / reception	"OK" or "ERROR"
Operational mode	SL%N=1	Set enabled radio states Tx/Rx	"OK" or "ERROR"
Operational mode	SL%N=0	Set enabled radio states Rx only	"OK" or "ERROR"
Operational mode	SL%N?	Get enabled radio states	0 (=Tx/Rx) or 1 (=Rx only)

Operation mode	SL+S=x	Activate sleep mode "1" turn the modem into a state where it will hold serial interface parts of the module on, wakeup will take approx. 30ms "5" Turns ON Power save mode. "6" Turns OFF Power save mode.	"OK" or "ERROR"
Operation mode	SL%Z=0	SL commands are OFF (working then only in the command mode) and CR/LF feature OFF	"OK" or "ERROR"
Operation mode	SL%Z=1	SL commands are always ON and CR/LF feature OFF	"OK" or "ERROR"
Operation mode	SL%Z=3	SL commands are always ON and CR/LF feature ON	"OK" or "ERROR"
Operation mode	SL%Z=4	SL commands are OFF (working then only in the command mode and CR/LF feature ON	"OK" or "ERROR"
Operation mode	SL%Z?	Get SL command mode	Responds with a number accordingly

## 11 VERSION HISTORY

Version history:

Version:	Date:	Remarks:
0.1	28.10.2019	First Draft.
0.2	23.03.2020	Updated mechanical drawing, section 5.3 removed and section 10.1 added.
0.3	24.03.2020	Several minor corrections and updates.
1.0	25.03.2020	First official release.
1.3	18.05.2020	Updated chapter 2.3
1.4	09.06.2020	RF Exposure information added
1.5	25.09.2020	Sleep Mode power consumption and lower carrier power values added, plus other minor corrections and updates
1.6	14.10.2020	Sleep Mode wake-up time added, Safety standard updated, SL-command list updated (transmitter power, radio compatibility options)
1.7	15.12.2020	Minor changes in SL-command list