SATEL Proof-TR4/-TR9 Radio Modem

User Guide

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Salo, FINLAND 2019

RESTRICTIONS ON USE – SATEL Proof-TR4

SATEL Proof-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 Proof-TR4 is allowed to be used in the following countries, either on license free channels or on channels where the operation requires a license. 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! Users of SATEL Proof-TR4 radio transceiver modules 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.

WARNING - RF Exposure

To comply with CE, FCC and IC RF exposure compliance requirements, maximum antenna gain is 14 dBi and separation distance of at least 1 meter 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.

RESTRICTIONS ON USE – SATEL Proof-TR9

SATEL Proof-TR9 radio transceiver module has been designed to operate on 902-928 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 Proof-TR9 is allowed to be used in the following countries. More detailed information is available at the local frequency management authority.

Countries: AU, CA and US.

WARNING - RF Exposure
To satisfy FCC and ISED RF exposure requirements for mobile transmitting devices, a separation distance of 25 cm or more should be maintained between antenna of this device and persons during device operation. To ensure compliance, operations at closer than this distance is not recommended. The antenna used for this transmitter must not be co-located in conjunction with any other antenna or transmitter. FCC regulations allow up to 36 dBm equivalent isotropically radiated power (EIRP). Therefore, the sum of the transmitted power (in dBm), the cabling loss and the antenna gain cannot exceed 36 dBm.

This radio transmitter 2422A-SATELTA31 has been approved by Industry Canada to operate with the antenna types listed below with the maximum permissible gain indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Antenna type	Manufacturer	Antenna model	Maximum gain (dBi)
Omnidirectional	Oy CompleTech Ltd	CA915H	5
Directional (yagi)	Oy CompleTech Ltd	CA930Y	6

NOTE!
According to the requirements of the FCC, the integrator should make sure that the SATEL Proof-TR9 is compliant to part 15C while integrated in the host device. Output power and spurious emissions should be verified.

PRODUCT CONFORMITY

Hereby, SATEL Oy declares that radio modems are in compliance with the essential requirements (radio performance, electromagnetic compatibility and electrical safety) and other relevant provisions of Directive 2014/53/EU. Therefore the equipment is labelled with CE-marking.

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, or if the radio modem housing has been opened or tampered with.

-The radio modem 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 devices is appropriate. This also applies to the maintenance of the products.

-To prevent damage both the radio modem and any terminal devices must always be switched OFF before connecting or disconnecting the serial connection cable. It should be ascertained that different devices used have the same ground potential. Before connecting any power cables the output voltage of the power supply should be checked.

- Any radio link can susceptible to external interference and signal degradation by its nature. Because of that, the effects of possible interference mechanism and the sufficient back-up schemes must be taken into account in the system design of the critical applications.

NOTE!
When selecting a suitable location for the radio modem it must be ensured that no water can get into the radio modem under any conditions. Direct sunlight is also to be avoided. It is not recommendable to install the radio modem on a strongly vibrating surface. Suitable dampening and/or isolation materials should be used in cases where the installation surface will be subjected to vibration.

GROUNDING

SATEL Proof-TR4 / -TR9 is equipped with a grounding terminal, as shown below. It is recommended to connect a ground wire from the grounding terminal to the earth ground and that all other interconnected devices share the same electrical ground potential.

Besides the mains voltage safety, proper grounding is essential also for the error free operation of radio links and the protection against over-voltages and lightning. Although SATEL Proof-TR4 / -TR incorporates a robust internal surge protection, the surge spikes and power transients caused by lightning, ESD or other electrical systems must be discharged to earth ground.

General installation guidelines for grounding:

- Perform grounding of the system in accordance with local and national regulations.
- Check the grounding related information of other products in the system.
- Use short low impedance cables. Although DC resistance of a ground cable may be a fraction of an ohm, its impedance may be thousands of ohms on the radio frequency. Wide copper straps are the best.
- The ground connection should be connected directly to the power supply, not the ground connection of the load, in order to isolate the radio from voltage drops across the ground return for the load.
- Equipment of the radio system should be grounded in a star ground configuration. The center of the star should be usually connected directly to a good external earth ground scheme.
- The mast installations require special measures in the construction of ground electrodes and equipotential bonding – consult professional installation providers.

1 DESCRIPTION OF THE PRODUCT

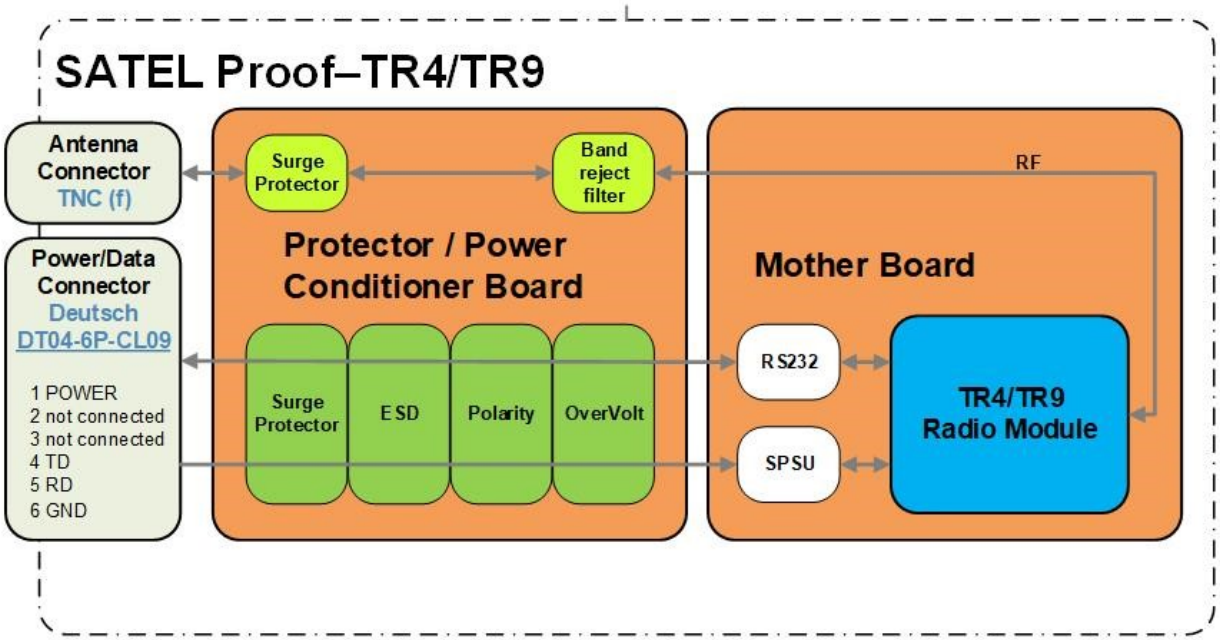
SATEL Proof-TR4/-TR9 is a UHF radio transceiver modem. It provides a transparent data link with other SATELLINE- family modems (SATELLINE-EASy, -TR1, -TR3, -TR4, -R3, -TR9, -EASy Pro, -4Pro, SATEL Compact-Proof and EASy-Proof). SATEL Proof-TR4/-TR9 can be interconnected to a data terminal or similar devices by RS-232.

SATEL Proof-TR4/-TR9 contains a 6 pin Deutsch DT connector for RS-232 and power supply, and TNC female connector for antenna.

SATEL Proof-TR4/-TR9 is intended to be used inside or outside environment and fulfills IP69K ratings (high pressure hot water). See more detailed description on chapter "Technical Specifications".

Available models and product codes:

- YM6583 SATEL Proof-TR4 with AES128 encryption support
- YM6584 SATEL Proof-TR4 without AES128 encryption support
- YM6587 SATEL Proof-TR9



2 SATEL Proof-TR4/-TR9 TECHNICAL SPECIFICATIONS

SATEL Proof-TR4 complies with the following international standards:

- EN 300 113
- EN 300 489 (EMC)
- IEC 60950 (safety)
- FCC CFR47 part90

	RECEIVER	TRANSMITTER	Note!
Frequency Range	403 ... 473 MHz		
Tuning range	70 MHz		
Minimum RF Frequency Step	6.25 kHz		
Channel Bandwidth	12.5 kHz / 25 kHz		Programmable
Frequency Stability	<1 kHz		
Maximum Receiver Input Power without Damage	+14 dBm		
Maximum Receiver Input Power without Transmission Errors	-10 dBm		FEC ON
Sensitivity	-111 dBm @ 25 kHz -117 dBm @12.5 kHz		FEC ON
Blocking	> 86 dB @ 25 kHz > 88 dB @ 12.5 kHz		FEC ON
Intermodulation Attenuation	> 61 dB @ 25 kHz > 61 @ 12.5 kHz		FEC ON
CO-Channel Rejection	> -11 dB @ 25 kHz > -10 dB @ 12.5 kHz		FEC ON
Adjacent Channel Selectivity	> 56 dB @ 25 kHz > 51 dB @ 12.5 kHz		FEC ON
Spurious Rejection	> 67 dB		FEC ON
Typical Power Consumption	RX	12 V: 1.32 W	
	TX	12 V: 5.8 W @ 1 W RF	
Transmitter Power (programmable)		0.1, 0.2, 0.5, 1 W	TX-mode, 50Ω load
Communication Mode	Half-Duplex		
Adjacent Channel Power		acc. to EN 300 113	TX-mode
Transient Adjacent Channel Power		acc. to EN 300 113	TX-mode
Carrier power stability		< ±1.5 dB	

	DATA MODEM	Note
Electrical Interface	RS-232	
Data speed of Serial Interface	1200 – 115200 bps	
Data speed of Radio Interface	4FSK FEC OFF: 19200 bps (25 kHz) 9600 bps (12.5 kHz) 4FSK FEC ON: 14400 bps (25 kHz) 7200 bps (12.5 kHz) 8FSK FEC OFF: 28800 bps (25 kHz) 14400 bps (12.5 kHz) 8FSK FEC ON: 19200 bps (25 kHz) 9600 bps (12.5 kHz) 16FSK FEC ON: 28800 bps (25 kHz) 14400 bps (12.5 kHz)	
Data Formats	Asynchronous data	
Air Interface Encryption	AES128	Programmable
Modulation	4FSK, 8FSK, 16FSK, GMSK	

Values are subject to change without a notice.

SATEL Proof-TR9 complies with the following international standards:
FCC Parts 15.209 and 15.247 of Title 47
IC RSS-247, ICC RSS-Gen
AS/NZS 4268:2012, AS/NZS 4771:2000

	RECEIVER	TRANSMITTER
Frequency Range	902-928 MHz	
Spreading Method	Frequency Hopping	
Occupied Bandwidth	230 kHz	
Frequency Stability	<1 kHz	
Maximum Receiver Input Power without Transmission Errors	-3 dBm	
Sensitivity	typ. -109 dBm for BER 10^{-4}	
Transmitter Power		0.01, 0.02, 0.5, 0.1, 0.2, 0.5, 1 W
Carrier power stability		< ±1.5 dB
Electrical Interface	RS-232	
Data Speed of Radio Interface	115200 bps	
Modulation Method	2-GFSK	
Hopping Bands	7, user selectable	
Hopping Patterns	15 per band, 105 total, user selectable	
Hopping Channels	50-112, user selectable	
Frequency Zones	16 Zones, 7 Channels per Zone	
Data speed of Serial interface	9600 – 115200 bps	

	GENERAL FOR BOTH TR4 and TR9	Note
Operating Voltage	+6 … +30 Vdc +/- 10% Vdc	External DC supply
Temperature Ranges	-30 °C … +65 °C	Operational
	-40 °C … +75 °C	Absolute min / max
	-25 °C … +55 °C	Complies with standards
	-40 °C … +85 °C	Storage
Antenna Connector	50 Ω, TNC female	
Interface Connector	Deutsch DT04-6P-CL09	
Housing	Shielded / bare PCB inside a metal housing	
Size L x W x H	176 x 95 x 42 mm	
IP rating	IP69K	high pressure
Mechanical Properties	IEC60068-2-32, ISO9022-36-08, ISO9022-31-06, ISO9022-33-06	
Weight	<500 g	

	OTHER MEASURES	Note
ESD-failure threshold	8 kV contact, 15 kV air discharge	
Immunity test	10 V/m	

Values are subject to change without a notice.

3 CONFIGURATION

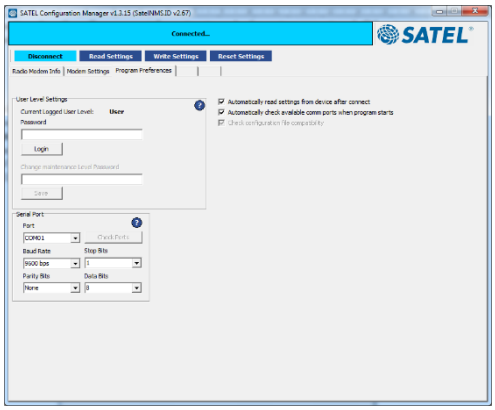
3.1 Configuration

The configuration of SATEL Proof–TR4/-TR9 radio modem can be modified by connecting the modem to the PC and using SATEL Configuration Manager (CM) or by using external SL commands. Programming is done using RS-232 port. The RS-232 serial port settings must match between SATEL Proof–TR4/-TR9 and terminal port. Download the supporting software from https://www.satel.com/support-and-services/downloads/

3.1.1 Configuration Manager

Configuration manager program makes it possible to edit the modem settings and update the firmware.

QuickStart



Preliminary settings:

1. Save the SATEL Configuration Manager files in the same directory.
2. Connect the modem to the PC using a proper interface cable.
3. Connect power to the modem. Before connecting, check that you have correct supply voltage.
4. Open the SATEL Configuration Manager program. Check from the "Program Preferences" tab, that you have selected correct COM-port number and that the serial port settings match to the modem. Default settings are 115200 bps, 8 bit, no parity, 1 stop bit.
5. To establish connection between the modem and the PC, click the blue Connect tab. To get the radio modem info, click blue Read Settings tab.
6. Check the settings and modify if needed.
7. Store settings to a modem using "Write settings" –button.

More information about Configuration Manager can be found from user guide.

3.1.2 Changing parameters using the SL COMMANDS

The controlling terminal device can change the configuration settings of a radio modem. 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. The terminal device is either a PC or a programmable logic (PLC) together with suitable (terminal) program. SL commands must be enabled using *Programming Mode* before they can be used.

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

The radio modem 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.

In case you need more information on the time delays related to the use of SL commands, please contact the manufacturer.

SL commands are described in separate documentation.

In order to get information of the latest and/or special SL commands please contact SATEL.

4 MODEM SETTINGS

4.1 Default settings of SATEL Proof-TR4

The radio modem is delivered with the following default settings (unless otherwise specifically ordered):

DEFAULT VALUES OF THE ADJUSTABLE SETTINGS (the user can change these settings later on)		
Setting	Default value	Range
Radio frequency		
Operating TX frequency	438.000 MHz	Range: 403-473 MHz
Operating RX frequency	438.000 MHz	Range: 403-473 MHz
Reference Frequency	438.000 MHz	Range: 403-473 MHz
Channel Spacing	25 kHz	Range: 12.5 kHz or 25 kHz
Radio settings		
TX Power	1000 mW	Range: 100, 200, 500 or 1000 mW
Signal threshold	-115 dBm	- 80 … -118 dBm
TX-Start Delay	0 ms	0-65535 ms
Radio Compatibility *(Available set depends on the factory configuration)*	SATELLINE 3AS	SATELLINE 3AS PacCrest-4FSK PacCrest-GMSK TrimTalk450s(P) TrimTalk450s(T) PacCrest-FST SATEL 8FSK-1 SATEL 8FSK-2 SATEL 16FSK-1
Addressing		
RX Address	OFF	ON/OFF
TX Address	OFF	ON/OFF
Serial port		
Data speed	115200 bps	1200 – 115200 bps
Data bits	8	8
Parity bits	None	None, Even, Odd.
Stop bits	1	1

Handshaking		Handshaking lines apply to the DATA-port.
Pause length	3 bytes	3….255
Additional setup		
Error correction, FEC	OFF	ON/OFF
Error check	OFF	OFF, CRC8Partial, CRC8Full, CRC16Full
Repeater Mode	OFF	ON/OFF
SL-commands	ON	ON/OFF
TX Delay	0	0 …. 65535 ms
Over-the-Air-Encryption	OFF	ON/OFF
Use Channel List	OFF	ON/OFF
Power Save Mode	OFF	ON/OFF
Add RSSI to Data	OFF	ON/OFF

4.2 Default settings of SATEL Proof-TR9

The radio modem is delivered with the following default settings (unless otherwise specifically ordered):

DEFAULT VALUES OF THE ADJUSTABLE SETTINGS (the user can change these settings later on)		
Operation Mode	Default value	Note
Point-to-Multipoint Slave	3	
Set Baud Rate		
Baud Rate	115200	
Data Parity	0	
Modbus RTU	0	
RS232/485	0	
Setup Port	3	
TurnOffDelay/OnDelay	0/0	
FlowControl	0	
Radio Parameters		
FreqKey	5	
Hop Table Version	0	
Hop Table Size	112	
Hop Freq Offset	0	
Frequency Zone	All 1s (Enabled)	
Max Packet Size	8	
Min Packet Size	9	
Xmit Rate	1	
RF Date Rate	3	
RF Xmit Power	1000	
Slave Security	0	
RTS to CTS	0	
Retry Timeout	255	
Low Power Mode	0	

High Noise	0	
MCU Speed	0	
Remote LED	0	
Multipoint Parameters		
Number of Repeaters	1	
Master Packet Repeat	3	
Max Slave Retry	9	
Retry Odds	9	
DTR Connect	0	
Repeater Frequency	0	
Network ID	255	
Multimaster Sync	0	
Slave/Repeater	0	
Subnet ID	"Disabled"	

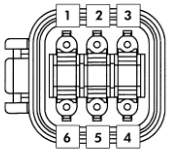
5 ANTENNA CONNECTOR

All models have a single TNC female type antenna connector with impedance of 50 Ohm.

The antenna should always be connected when the power is on.

6 DEUTSCH CONNECTOR

pin	direction	Deutsch DT04-6P-CL09
1	input	+DC power supply*)
2	-	**)
3	-	**)
4	input	TD, Port 1
5	output	RD, Port 1
6	-	GND



Note*) Power supply input should be used with a FUSE = 1A slow

Note**) Reserved for future needs.

Power supply

SATEL Proof-TR4/-TR9 is available in one operating voltage range. The radio modem must be connected to a power supply with an adequate current output.

A proper fuse should be connected in between the radio modem and the power supply:

Operating voltage range	+6 … +30 V
Current rating of the fuse	1 A slow

7 SERIAL PORTS

The radio modem is referred to as DCE (Data Communication Equipment) whereas the device connected to it, typically a PLC or a PC, is referred to as DTE (Data Terminal Equipment).

In order to transfer data, the physical interface between DCE and DTE must be compatible and properly configured. This chapter describes shortly the basics of the physical interface options, the related settings and the operation of the serial interface.

Before connecting DTE (Data Terminal Equipment) to the radio modem, make sure that the configuration matches the physical interface (electrical characteristics, timing, direction and interpretation of signals).

7.1 Pause length

The modem recognises a pause on the serial line (a pause is defined as a time with no status changes on the RS-232 interface TD-line). The pause detection is used as criteria for:
End of radio transmission - When the transmit buffer is empty and a pause is detected, the modem stops the transmission and will then change the radio to the receive mode.
SL command recognition - For a SL command to be valid, a pause must be detected before the actual command character string.
User address recognition - In order for the start character to be detected, a pause must precede it in transmission.

Traditionally, in asynchronous data communication, pauses have been used to separate serial messages from each other. However, the use of non-real-time operating systems (frequently used on PC-type hardware) often adds random pauses, which may result in the user data splitting into two or more separate radio transmissions. This may cause problems especially in the systems including repeater stations.

In order to match the operation of the radio modem to the user data, the Pause length parameter can be adjusted on the programming menu. It may have any value between 3 and 255 characters. The default value is 3 characters.

Notes:
The absolute time of Pause length is depending on the serial port settings. For example, 1 character is ~1.04 ms at 9600 bps / 8N1 (10 bits).
The maximum absolute time is always 170 ms independent from the value of the Pause length given in the set-up.
An increase in the Pause length increases the round trip delay of the radio link correspondingly; this is due to the fact that the radio channel is occupied for the time of the Pause length after each transmission (the time it takes to detect a pause). If this is not acceptable, the TX delay setting may also be useful in special cases.

7.2 Data buffering

Whenever the radio modem is in *Data Transfer Mode* it monitors both the radio channel and the serial interface. When the terminal device starts data transmission the radio modem switches to transmission mode. At the beginning of each transmission a synchronisation signal is transmitted and this signal is detected by another radio modem, which then switches into receive mode. During the transmission of the synchronisation signal the radio modem buffers data into its memory. Transmission ends when a pause is detected in the data sent by the terminal device, and after all buffered data has been transmitted. When the serial interface speed is the same or slower than the speed of the radio interface, the internal transmit buffer memory cannot overflow. However, when the serial interface speed exceeds the speed of the radio interface, data will eventually fill transmit buffer memory. In this instance, it will take a moment after the terminal device has stopped transmission of data for the radio modem to empty the buffer and before the transmitter switches off. The maximum size of transmit buffer memory is one kilobyte (1 kB). If the terminal device does not follow the status of the CTS-line and transmits too much data to the radio modem, the buffer will be emptied and the transmission is restarted.

In the receive mode, the buffer works principally in the above described way thus evening out differences in data transfer speeds. If the terminal device transmits data to a radio modem in receive mode, the data will go into transmit buffer memory. Transmission will start immediately when the radio channel is available.

8 RF INTERFACE - SATEL PROOF-TR4

All modem types have a single TNC female type antenna connector with impedance of 50 Ohm.

SATEL Proof-TR4 (403 – 473 MHz) offers the radio settings for user to select:

- Channel spacing: 25 kHz or 12.5 kHz
- Frequency can be any 6250 Hz divisible frequency between 403…473 MHz in case the Channel Spacing is 25 kHz or 12.5 kHz
  (for example 403.000 MHz, 403.006250 MHz, 403.012500 MHz)

The data speed of the radio interface depends on the radio channel spacing:

- 25 kHz channel => 19200 bps
- 12.5 channel => 9600 bps

The data speed over-the-air is irrespective of the data speed of the serial interface. If the two differ from each other, the radio modem will buffer the data (max 1 kB) temporarily.

Please note that any communication link introduces an extra time delay called latency that affects the system performance. It is the minimum time experienced by the data between the moment when the data appears at the serial interface of the transmitting modem and the receiving modem.

8.1 Transmitter

The output power of the transmitter is adjustable (see the table below for available values). The greatest allowable power depends on limits set by local authorities, which should not be exceeded under any circumstances. The output power of the transmitter should be set to the smallest possible level such that it still ensures error free connection under variable conditions. Excessively high output power levels used in short link spans can cause interferences and affect to the overall operation of the system.

Transmitter output power levels		
Output power (mW)	Output power (dBm)	403-473 MHz
100 mW	+20 dBm	✓
200 mW	+23 dBm	✓
500 mW	+27 dBm	✓
1000 mW	+30 dBm	✓

The antenna (or a 50 Ohm attenuator) should be always connected to the antenna connector while the transmitter is being used in order to guarantee the maximum lifetime of the transmitter.

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.

8.2 Receiver

The sensitivity of the receiver depends on the channel spacing of the radio modem (=data speed of the radio interface) and on the mode of the FEC (error correction).

Receiver sensitivity			
Frequency range	Channel Spacing	FEC OFF	FEC ON
403 – 473 MHz	25 kHz	-108 dBm	-111 dBm
	12.5 kHz	-111 dBm	-114 dBm

The radio modem measures the received signal strength (RSSI) of the receiver constantly. The Signal Threshold setting determines the received signal level above which the search for the radio messages is active. It is recommended that values given in the table above are used as a basis. If the threshold is set too low, it is possible that the receiver is trying to synchronise itself with noise. In such a case the actual data transmission might remain unnoticed. If the threshold is set too high, the weak data transmissions will be rejected although they could be otherwise receivable. Signal threshold should only be changed for a reason - for example in the following cases:
Continuous interference is present and the desired signal is strong. In this case the signal threshold can be increased to prevent the modem from synchronising to the interfering signal(s) and /or possible noise.
Maximum sensitivity should be achieved and the desired signal is very weak. In this case the sensitivity could increase by decreasing Signal threshold. This type of situation is usually a sign of a poorly constructed radio network / contact. Bit errors and momentary loss of signals can be expected in this kind of a situation. Some data might be successfully transferred.

The RSSI can be requested also locally by using a special SL command (SL@R?). The RSSI value is available 7s after the receiving the message. After that the value is returned to zero.

8.3 Priority RX/TX

Priority setting selects the priority between reception and transmission. The setting can be changed in Programming Mode. By default, transmission has higher priority than reception i.e. the default value is Priority TX.

Priority TX means that a terminal device attached to a radio modem decides the timing of the transmission. The transmitter is immediately switched on when the terminal device starts to output data. Should reception be in progress, the radio modem will stop it and change to a transmit state. There is no need to use any handshaking for the control of timing.

Priority RX means, that a radio modem tries to receive all data currently in the air. If a terminal device outputs data to be transmitted (or an SL command) it will buffered. The radio modem will wait until the reception has stopped before transmitting the buffered data. This will result in timing slacks to the system, but decreases the number of collisions on the air; this is particularly useful in systems based on multiple random accesses.

8.4 Forward Error Correction (FEC)

FEC improves the reliability of data transfer over the radio by adding additional correction information to the radio messages. Based on that information, the receiving radio modem will be able to correct erroneous bits provided the ratio of erroneous and correct bits is reasonable. However, the use of FEC decreases the data throughput, because the amount of transmitted data increases about 30 % (see Appendix B). FEC should be used on long distance links and/or if the radio channel is "noisy" in other words suffering from interfering signals.

NOTE! All radio modems, which are to communicate with each other, must have the same setting for FEC (ON or OFF). If the transmitting radio modem and the receiving radio modem has different settings, data will not be received.

8.5 Error checking

When the error checking is switched on, the radio modem will add a checksum to the transmitted data. When the data is received, the checksum is verified before data is forwarded to the serial port. There are two different options for error checking that can be accessed in the Additional setup menu in the Programming Mode:

Error check checks data only partially while data is received.

Full CRC16 check adds two checksum characters at the end of the user data message. At the reception end the receiver receives first the whole package and if the checksum matches the data message is forwarded to the serial port. If Full CRC16 check is selected it must be set ON for all radio modems in the same network. Otherwise the checksum characters appear at the end of user message on the serial port.

8.6 TX delay

The radio modem can be configured to delay the beginning of a radio transmission by 1...65000 ms. The function can be used to prevent packet contention in a system, where all substations would otherwise answer a poll of a base-station simultaneously. During this delay data sent to the radio modem is buffered. Even when the priority setting is "RX", the radio modem is prevented to change over to the receiving mode during the period of the TX delay. If TX delay is not needed, its value should be set to 0 ms.

8.7 Separate RX/TX-frequencies

Modem can transmit (TX-frequency) and receive (RX-frequency) on separate frequencies. The switch between the frequencies introduces an extra 40 ms delay in the data transfer that must be taken account when designing the system.

8.8 Pacific Crest and TRIMTALK compatibility

SATEL Proof-TR4/-TR9 radio modem provides the following radio compatibility options:

- SATELLINE-3AS Original SATELLINE-3AS data transfer mode (Default)
- PacCrest-4FSK Transparent mode/FEC ON/Scrambling ON (Option 1)
- PacCrest-GMSK Transparent mode/FEC ON/Scrambling ON (Option 2)
- TrimTalk450s(P) Trimtalk450s GMSK Rx fitted to PacCrest transmitters (Option 3)
- TrimTalk450s(T) Trimtalk450s GMSK Rx fitted to Trimble transmitters (Option 4)
- PacCrest-FST (Option 5)

Notes:
Supported compatibility options may vary depending on the model and factory configuration.

All radio modems of a system must have identical FEC setting (ON or OFF) in SATELLINE-3AS mode.

The implementation of Radio compatibility options is based on the reference measurements and the available public data of the following radio modems manufactured by Pacific Crest Corporation: ADL, RFM96W, PDL HPB, PDL LPB. TRIMTALK is a trademark of Trimble Navigation Ltd.

8.8.1 Settings in compatibility modes

In order to use the Pacific Crest/TRIMTALK modes implemented in SATELLINE modems:

PACIFIC CREST modems must have:

- Protocol Mode
- Transparent w/EOT Timeout (when using Pacific Crest modulations)
- TrimTalk 450s (when using TRIMTALK GMSK modulation)
- Modulation Type depends on the system
- GMSK (default, always selected when using TRIMTALK 450s mode)
- 4-Level-FSK
- FEC = ON
- Scrambling = ON
- Data Security Code set to = 0 (=not used)
- Local Address= 0…254 (0 by default)
  Pacific Crest modems receive messages from SATELLINE modems that have their TX1 address matching the Local Address.

Remote address=0…255 (255 by default, that is the broadcast address to be received by all).
SATELLINE modems receive the message from a Pacific Crest radio, provided their RX1 address

matches the Remote Address of a Pacific Crest transmitter (or if the message has the broadcast address 255).

SATELLINE modems must have the following key settings:

- FEC OFF (because the FEC here means SATEL 3AS FEC, not Pacific Crest/TRIMTALK FEC)
- Error check OFF
- Full CRC16 check OFF
- Radio Compatibility Option 1 in case of Pacific Crest 4FSK
- Radio Compatibility Option 2 in case of Pacific Crest GMSK
- Radio Compatibility Option 3 in case of TRIMTALK GMSK

When TX address is selected ON, then TX1 address is used like PDL Remote address that is the destination address for the transmitted messages. Default value is 0x00FF (=255) (note the hexadecimal format of the setting).
When RX Address is selected ON, then RX1 address is used like PDL Local address. Default value is 0x0000 (=0) (note the hexadecimal format of the setting).
Addresses are NOT applicable in TRIMTALK 450s mode so SATELLINE modems must have their RX/TX addresses OFF with Option3.

The configuration tools and settings are different between SATELLINE and Pacific Crest modems: Pacific Crest modems are configured via the serial port using PDLCONF WindowsTM program that sends binary control messages to the serial port of the modem.
SATEL Proof-TR4/TR9 radio modems are configured via the serial port using any ordinary terminal program or SATEL Configuration Manager PC-program.

The table below shows the analogy of settings between Pacific Crest and SATELLINE radio modems (status in firmware version v3. 46.3).

Pacific Crest setting	**Corresponding SATELLINE setting**
Identification: Owner	not implemented
Identification: Channel Bandwidth	Channel spacing
Identification: RF Power	TX power
Radio Link: Channel Selection Type (Manual)	Radio frequency
Radio Link: Current Channel	Radio frequency
Radio Link: Link Rate	Radio compatibility mode and channel spacing determine the link rate
Radio Link:Modulation Mode	Radio compatibility
Radio Link:Scrambling	ON by default
Radio Link:Transmit Retries	not implemented
Radio Link:TX ACK Timeout	not implemented
Radio Link:Csma Monitoring	Priority (RX=ON, TX=OFF) Default: RX
Radio Link: AutoBase/AutoRover	not implemented
Radio Link:Digisquelch	Signal threshold
Radio Link:Forward Error Correction	ON by default Note: SATELLINE-EASy FEC must be OFF!
Radio Link:Local Address (0 by default)	Primary RX address (RX1) (OFF by default)

Radio Link:Remote Address (255 by default)	Primary TX address (TX1) (OFF by default)
Serial Interface:Protocol Mode	Radio compatibility
Serial Interface:BREAK to Command	not implemented
Serial Interface:Modem Enable: Yes	not applicable
Serial Interface:Soft Break Enable	not implemented
Serial Interface:EOT value (in 0.01s units)	Pause length (in serial port byte intervals)
Serial Interface:Digipeater Delay	not implemented
Serial Interface:Local Node Repeater	not implemented
Frequency Table	Radio frequency
Data Security Code (must be 0=not used)	not implemented
Potential conflicts: FEC setting applies only to the SATELLINE-3AS mode, the other radio compatibility modes have their own FEC bindings (although some previous or special firmware versions differ in the way FEC setting is handled - in case of doubt please contact technical support) Pacific Crest Local/Remote addresses are supported in the firmware versions starting from v3.46.3 Repeater function is supported only in the firmware versions starting from v3.46.3 Error check and Full CRC16 check must be OFF in SATELLINE modem FCS (Free Channel Scanning) feature is not supported by Pacific Crest radios Message Routing is not supported by Pacific Crest radios SATELLINE RX/TX addressing does not use ARQ scheme like Pacific Crest radios.	

8.8.2 Repeater function

The implemented Pacific Crest/TRIMTALK modes support also the repeater function. The repeater function is configured either by using the SL commands:

- "SL@M=R" (Repeater ON)
- "SL@M=O" (Repeater OFF)

or by selecting Repeater OFF/ON in the Additional setup-> Repeater programming menu.

Note 1. If error correction is ON (FEC ON) and TRIMTALK mode is activated by using "SL@S=3" command, the firmware automatically switches SATEL FEC OFF temporarily, and turns it back at the mode return.

8.8.3 Support for Local / Remote addresses

If the modem has TX address ON then primary TX address is handled in the same way as Remote address in Pacific Crest PDL modems. The default value is 0x00FF (255 in decimal format) i.e. the broadcast address.

If the modem has RX address ON then primary RX address is handled in the same way as PDL Local address in Pacific Crest PDL modems. The default value is 0x0000 (0 in decimal format). SATELLINE modem needs to have TX Delay 50ms or more in order to avoid messages from colliding in case it is to be placed in a Pacific Crest system that uses addressing and acknowledging scheme.

In case only broadcast messages are used (like in RTK applications) there is usually no need for TX Delay, except if the transfer delays identical to Pacific Crest modems are preferred – in such cases an appropriate value of TX Delay is 34 ms.

Note 1. SATELLINE-modems do not support Pacific Crest retransmit/acknowledge scheme. However, that has no effect in RTK applications because they utilize only broadcast messages.

8.8.4 Transmission delays

The original SATELLINE-3AS is the fastest mode – the transfer delays are presented Appendix B.

In the PacCrest-4FSK, PacCrest-GMSK and Trimtalk450s modes the whole message is first read from the serial port. The end of the message is detected when there is a pause in data. After that data is framed and transmitted over the radio. Likewise the reception is done fully before outputting the message to the serial port.

Symbol rates of the compatibility modes The actual raw data rate is appr. 2/3 of the symbol rate.		
Compatibility mode	Symbol rate on 12.5 kHz channel	Symbol rate on 25 kHz channel
PacCrest 4FSK	9600 bps	19200 bps
PacCrest GMSK	4800 bps	9600 bps
Trimtalk450s	4800 bps	9600 bps
PacCrest FST	9600 bps	19200 bps

The typical latency vs. the size of a message is shown in the tables below for each radio compatibility mode. The delays are measured from the end of transmitted data to the end of received data on the serial interface.

Pacific Crest 4FSK mode on 12.5 kHz channel - Transfer delays				
Bps	1 byte	10 bytes	100 bytes	500 bytes
9600	74 ms	82 ms	302 ms	1293 ms
19200	73 ms	77 ms	249 ms	1031 ms
38400	72 ms	74 ms	222 ms	900 ms

Pacific Crest 4FSK mode on 25 kHz channel - Transfer delays				
Bps	1 byte	10 bytes	100 bytes	500 bytes
9600	43 ms	51 ms	208 ms	911 ms
19200	41 ms	46 ms	155 ms	650 ms
38400	39 ms	43 ms	127 ms	519 ms

Pacific Crest GMSK mode on 12.5 kHz channel - Transfer delays				
Bps	1 byte	10 bytes	100 bytes	500 bytes
9600	93 ms	101 ms	445 ms	2011 ms
19200	91 ms	97 ms	393 ms	1750 ms
38400	91 ms	92 ms	366 ms	1619 ms

Pacific Crest GMSK mode on 25 kHz channel - Transfer delays				
Bps	1 byte	10 bytes	100 bytes	500 bytes
9600	52 ms	62 ms	281 ms	1272 ms
19200	50 ms	55 ms	226 ms	1009 ms
38400	48 ms	51 ms	198 ms	878 ms

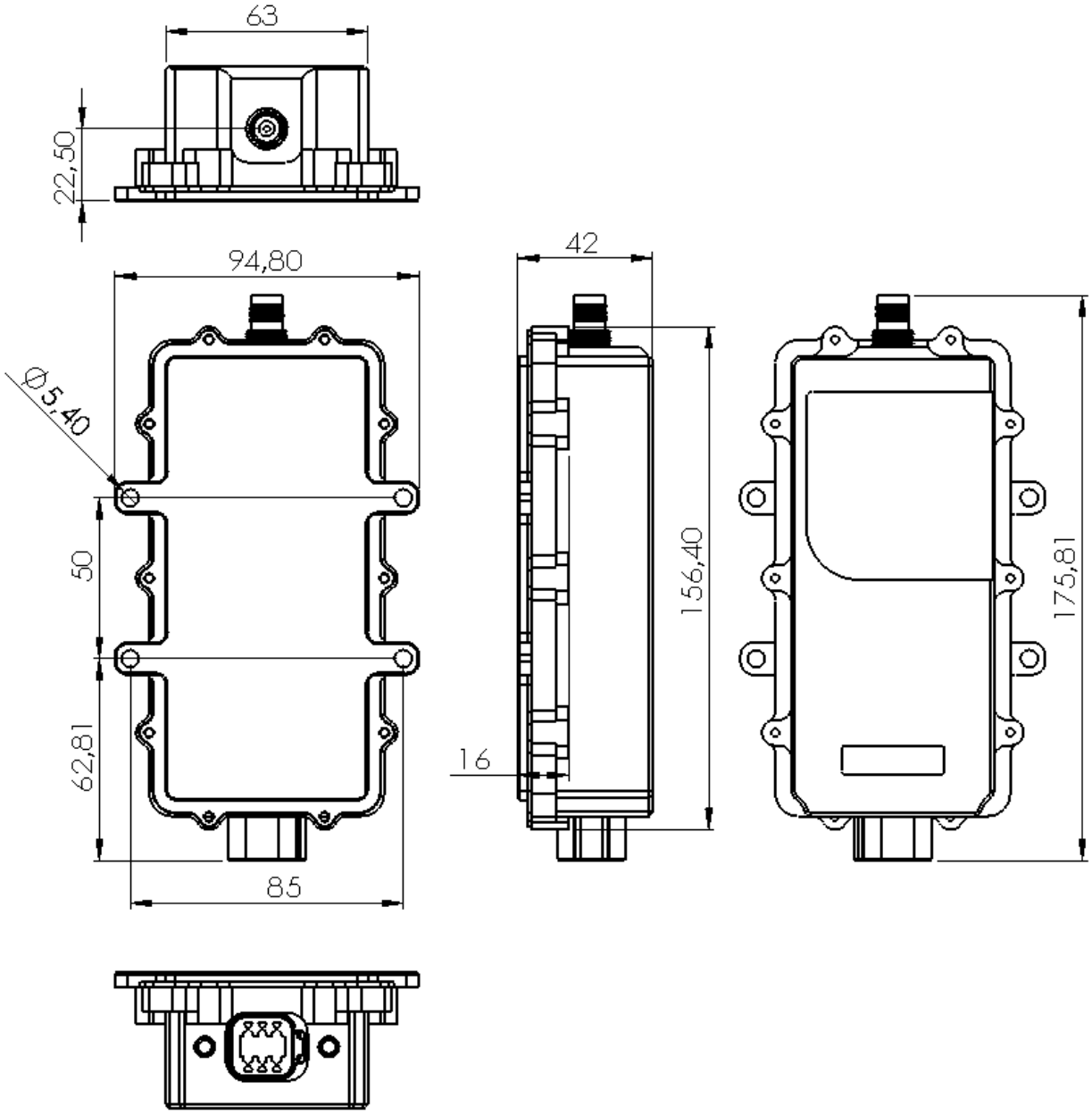
Trimtalk450s modes on 12.5 kHz channel - Transfer delays				
Bps	1 byte	10 bytes	100 bytes	500 bytes
9600	153 ms	177 ms	421 ms	1505 ms
19200	151 ms	172 ms	368 ms	1244 ms
38400	151 ms	168 ms	341 ms	1113 ms

Trimtalk450s modes on 25 kHz channel - Transfer delays				
Bps	1 byte	10 bytes	100 bytes	500 bytes
9600	82 ms	98 ms	267 ms	1017 ms
19200	80 ms	93 ms	215 ms	756 ms
38400	79 ms	89 ms	187 ms	625 ms

Radio compatibility Option 5 - Pacific Crest FST on 12.5 kHz channel				
Bps	1 byte	10 bytes	100 bytes	500 bytes
9600	47 ms	71 ms	261 ms	1145 ms
19200	45 ms	64 ms	207 ms	883 ms
38400	48 ms	65 ms	184 ms	756 ms

Radio compatibility Option 5 - Pacific Crest FST on 25 kHz channel				
Bps	1 byte	10 bytes	100 bytes	500 bytes
9600	31 ms	48 ms	190 ms	840 ms
19200	29 ms	41 ms	136 ms	578 ms
38400	28 ms	38 ms	109 ms	447 ms

9 MECHANICAL DIMENSIONS



10 INSTALLATION

SATEL Proof–TR4/-TR9 radio can be installed to any position from its 4 screw attachment points with maximum of M5 bolts/screws.

SATEL Proof–TR4/-TR9 is waterproof fulfilling IP67 and IP69K specifications. Note that the antenna must be installed properly and Deutsch DT connector cable counterpart must have a gasket installed to properly seal the connection in order to reach the IP ratings.

Avoid installations to vibrating surfaces, hot places, directly to sunlight or under water. Avoid abrasion and impacts. Protect the cables and antennas placing them away from damaging elements. Keep the antenna in open space and away from interference.

Antenna is installed either directly to the TNC connector or by using antenna cable. By using a good quality RF-cable and keeping the distance to its shortest will minimize the signal losses.

The following points must be taken into account when installing and configuring a radio modem:

1. All operating voltages of all the equipment concerned must always be switched OFF before connecting the serial interface cable.
3. To ensure reliable operation the voltage output of the power supply must be stable enough and the current capability of the power supply must be sufficient.
4. The antenna must be installed according to instructions.
5. Serial interface settings between the radio modem and the terminal unit must correspond to each other.
6. All radio modems in the same system must be configured using same radio related settings (radio frequency, channel spacing, etc).
7. Check the instructions of grounding the modem on chapter *Grounding*.

NOTE!
It is not recommended to install the radio modem on a strongly vibrating surface. Suitable dampening and/or isolation materials should be used in cases where the installation surface will be subjected to vibration.

NOTE!
Do not expose the device to solvents or fuels/oils.

11 ACCESSORIES

SATEL provides a wide selection of accessories and solutions for its radio modems.

- Antennas
- Serial data/Power cables and adapters
- RF-cables
- Filters and lightning protectors
- Power supplies
- Enclosures

Please visit www.satel.com