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Salo, FINLAND 2010

RESTRICTIONS ON USE

SATELLINE-3ASd Epic Pro is allowed to be use in the following countries, either on licence free channels or on channels where the operation requires a licence. More detailed information is available at the local frequency management authority.

Countries*: AT, AU, BE, BG, CY, CZ, HR, DK, EE, FI, FR, DE, GR, HU, ID, IS, IE, IL, IT, LT, LV, NL, NO, OM, PL, PT, RO, RU, SI, ZA, ES, SK, SE, CH, TH, GB and US

SATELLINE-3ASd Epic Pro 35W is allowed to be use only in countries where FCC approval is valid. It does not fulfil the ETSI specification.

WARNING! Users of SATELLINE-3ASd Epic Pro radio modems 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 modem on this frequency band without a proper permit is strictly forbidden.

In addition project approvals available for IN, KZ and TW.

*codes of the countries follow the ISO 3166-1-Alpha-2 standard

WARRANTY AND SAFETY INSTRUCTIONS

Read these safety instructions carefully before using the product:

- o 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.
- o 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.
- o 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 are 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.

PRODUCT CONFORMITY

SATELLINE-3ASd Epic Pro

Hereby, SATEL Oy declares that SATELLINE-3ASd Epic Pro radio modem is in compliance with the essential requirements (radio performance, electromagnetic compatibility and electrical safety) and other relevant provisions of Directive 1999/5/EC. Therefore the equipment is labelled with the following CE-marking. The notification sign informs user that the operating frequency range of the device is not harmonised throughout the market area, and the local spectrum authority should be contacted before the usage of the radio modem.

C € 0523

 **DECLARATION of CONFORMITY**
In Accordance with
1999/5/EC Directive
of the European Parliament and of the Council of 9 March 1999 on radio equipment and telecommunications terminal equipment and the mutual recognition of their conformity

Doc No: SATEL-DC-RTTE-064
Manufacturer: SATEL Oy
Address: P.O. Box 142, (Meriniityskatu 17), FI-24101 Solo, Finland

Products:

Type	Model
SATEL-TA3	SATELLINE-3AS Epic
	SATELLINE-3AS Epic C
	SATELLINE-3AS Epic DB
	SATELLINE-3AS Epic C DB
	SATELLINE-3AS Epic NMS
SATEL-TA8	SATELLINE-3AS Epic C NMS
	SATELLINE-3ASd Epic
	SATELLINE-3ASd Epic C
	SATELLINE-3ASd Epic DB
	SATELLINE-3ASd Epic NMS
SATEL-TA4	SATELLINE-3ASd Epic C NMS
	SATELLINE-3ASd Epic Pro
	SATELLINE-3ASd Epic Pro, Sokkia

Radio Modem

Notified Body Opinion: according to: Annex IV of R&TTE Directive
Document Nr: F107700022
Issued by: Finnish Communications Regulatory Authority
Dated On: 12.09.2007
Notified Body: Nr. 0523

We, the manufacturer of the above mentioned products, hereby declare that these products conform to the essential requirements of the European Union directive 1999/5/EC. This Declaration of Conformity is based on the following documents:

Doc. No	Type of Product	Test Specification	Laboratory / Date of Issue
77819	SATEL-TA4, -TA3, -TA8	EN 300 113-2 V1.3.1	NEMKO / Espoo 20.6.2007
778215	SATELLINE-3ASd Epic	Attestation with regard to Annex I, 3.2.9.	NEMKO / Espoo 20.11.2006
90857A	SATEL-TA4	EN 301 489-1, -5	NEMKO / Espoo 31.8.2007
90857B	SATEL-TA4	Commission Directive 2004/104/EC	NEMKO / Espoo 31.8.2007
77829	SATEL-TA4	EN 60950-1	NEMKO / Espoo 11.9.2007

Solo on the 17th of September, 2007

SATEL OY


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SATELLINE-3ASd Epic Pro 35W

Hereby, SATEL Oy declares that SATELLINE-3ASd Epic Pro 35W conforms to the requirements of Code of Federal Regulations, Title 47, Part 90 (Federal Communications Commission, FCC).

DECLARATION of CONFORMITY
to CFR 47 Part 90 (FCC)

Doc No: SATEL-DC-MISC-082
Manufacturer: SATEL Oy
Address: POB 142, (Meriniitynkatu 17), 24101 Salo, Finland

Products :	Type	Model
	SATEL-TA35	SATELLINE-3ASd Epic Pro 35W

We, the manufacturer of the above mentioned products, hereby declare that these products conform to the requirements of Code of Federal Regulations, Title 47, Part 90 (Federal Communications Commission, FCC). This Declaration of Conformity is based on the following documents:

Doc. No	Type of Product	Test Specification	Laboratory / Date of Issue
129599A	SATELLINE-3ASd Epic Pro 35W	FCC Part 90	NEMKO / Espoo 17.6.2009
129599B	SATELLINE-3ASd Epic Pro 35W	FCC Part 15B	NEMKO / Espoo 17.6.2009

Salo on the 22th of October, 2009.

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 **SATEL®**
WIRELESS WORLD – LOCAL SOLUTION

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INTRODUCTION

SATEL OY is a Finnish electronics and Telecommunications Company specialising 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 organisations and private individuals.

SATEL 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.

Both the amount of data transferred, and the size of local area networks is increasing constantly. SATEL has addressed these market requirements by introducing the SATELLINE-3AS radio modem range. The **SATELLINE-3ASd Epic Pro** and **Epic Pro 35 W** can offer speeds up to 19.2 kbps and has a selectable serial interface between 300 ... 38 400 bps.

In addition to increased data transfer speed; SATELLINE-3ASd Epic Pro and Epic Pro 35 W include standard RS-232 interface.

SATELLINE-3ASd Epic Pro and 35W models include a built-in LCD display, offering the user both new features and increased flexibility. No longer do you have to rely on access to a PC or terminal device to check or alter the configuration of the unit, now this can be achieved by viewing the LCD-display and using the four (4) push buttons. The display is also a useful tool in testing the radio connection between radio modems. There is also a special software version x.xx-VAR5, where only power and channels can be chosen.

SATELLINE-3ASd Epic Pro and Epic Pro 35W facilitates the construction of large radio networks using the built-in *Message Routing* function, which is both fully transparent to the user and can be used with most system protocols.

SATELLINE-3ASd Epic Pro and Epic Pro 35W also offer option of error correction, utilising the FEC-method (Forward Error Correction). FEC can be used to minimise errors caused by noisy channels.

SATELLINE-3ASd Epic Pro and Epic Pro 35W radio modem operates in one of the 4 basic modes of operation: *Data Transfer Mode*, *Programming Mode*, *Test Mode* or *Standby Mode*.

1 SATELLINE-3ASd Epic Pro technical specifications

SATELLINE-3ASd Epic Pro (370...470 MHz) complies with the following international standards:
EN 300 113-1,-2 (RF), EN 301 489-1,-5 (EMC), EN 60950-1 (Safety) and FCC CRF47 part 90.

RADIO TRANSCEIVER

Frequency Range	370...470 MHz
Tuning Range	2 x 2 MHz
Channel Spacing	12.5 kHz / 20 kHz / 25 kHz
Number of Channels	320 / 200 / 160
Frequency Stability	< ± 1.5 kHz
Type of Emission	F1D
Communication Mode	Half-Duplex

RADIO TRANSMITTER

Carrier Power	1, 5 or 10 W / 50 ohm
Carrier Power Stability	+ 2 dB / - 3 dB
Adjacent Channel Power	according to EN 300 113-1
Spurious Radiation	according to EN 300 113-1

RADIO RECEIVER

Sensitivity	< -115 dBm (BER < 10 E-3)
Common Channel Rejection	> - 12 dB
Adjacent Channel Selectivity	> 60 dB @ 12.5 kHz, > 70 dB @ 25 kHz
Intermodulation Attenuation	> 65 dB
Spurious Radiation	< 2 nW

MODEM

Interface	RS-232
Interface Connector	Lemo compatible 8-pin, waterproof
Data Speed of Serial Interface	300 – 38400 bps
Data Speed of Radio Interface	19200 bps (25 kHz channel) 9600 bps (12.5 kHz channel)
Data format	Asynchronous RS-232

GENERAL

Operating Voltage	+11.8... +30 V _{DC}
Power Consumption (average)	1.3 VA typical (Receive) 30 VA typical (Transmit) 0.05 VA typical (when DTR is "0")
Operating Temperature Range	-25 °C... +55 °C (tests acc. to ETSI standards) -40 °C... +75 °C (absolute min / max)
Storage Temperature	-40 °C... +85 °C
Antenna Connector	TNC, 50 ohm, female
Housing	Aluminium enclosure
Size H x W x D	165 x 138 x 57 mm
Weight	1300 g
IP Classification	IP67 (NEMA 6)

2 SATELLINE-3ASd Epic Pro 35 W technical specifications

SATELLINE-3ASd Epic Pro 35W (400...470 MHz) complies with the following international standard: FCC CFR47 part 90.

RADIO TRANSCEIVER

Frequency / Tuning Range	400...470 MHz / 2 x 2 MHz
Channel Spacing	12.5 kHz / 25 kHz
Number of Channels	320 / 160
Frequency Stability	< ± 1.5 kHz
Type of Emission	F1D
Communication Mode	Half-Duplex

RADIO TRANSMITTER

Carrier Power	5, 10, 20, 25, 35 W / 50 ohm
Carrier Power Stability	+ 2 dB / - 3 dB
Adjacent Channel Power	According to EN 55022 and FCC CFR47 part 90
Spurious Radiation	According to EN 55022 and FCC CFR47 part 90
Duty Cycle*	100% (22°C / 35 °C) 40%
35W	20 min / 13 min no limit
10W	No limit / 50 min no limit

RADIO RECEIVER

Sensitivity	< -115 dBm (BER < 10 E-3)
Common Channel Rejection	> - 12 dB
Adjacent Channel Selectivity	> 60 dB @ 12.5 kHz, > 70 dB @ 25 kHz
Intermodulation Attenuation	> 65 dB
Spurious Radiation	< 2 nW

MODEM

Interface	RS-232
Interface Connector	7-pin ODU MINI –Snap Style G4 Size 0 or 8-pin LEMO HGA. 1B. 308. CLPP
Data Speed of Serial Interface	300 – 38400 bps
Data Speed of Radio Interface	19200 bps (25 kHz channel), 9600 bps (12.5 kHz channel)
Data format	Asynchronous RS-232

GENERAL

Operating Voltage	+9...+16 V _{DC} ($\geq$ +12 Vdc @ 35W output power)
Operating voltage feeding	4-pin ODU MINI -Snap Size 1
Power Consumption (average)	1.3 VA typical (Receive) 110 VA typical (Transmit) @ 35 W, min 12 Vdc 0.05 VA typical (when DTR is "0")
Operating Temperature Range	-25 °C...+55 °C -40 °C...+75 °C (absolute min / max)
Storage Temperature	-40 °C... +85°C
Antenna Connector	TNC, 50 ohm, female
Housing	Aluminium enclosure
Size H x W x D / Weight	165 x 138 x 73 mm / 1640 g
IP Classification	IP67 (NEMA 6)

* If high output power is used continuously or with a high cycle, the equipment generates excess heat. The output power is automatically decreased when necessary to prevent overheating. Typical operating times are shown in the chart with different output powers and duty cycles @ 22°C and 35 °C (see page 16).

2.1 Basic configuration and installation

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

FIXED SETTINGS DEFINED AT THE TIME OF ORDER	
Radio Frequency Range	In accordance with Customer Order and taking into account the regulations set by the local authorities, between 370–470 MHz (Epic Pro) or 400-470 MHz (Epic Pro 35W)
Channel Spacing	12.5 or 25 kHz (Epic Pro also 20 kHz)

ADJUSTABLE SETTINGS	
Radio Settings	TX power 10 W (35 W for Epic Pro 35W) / Signal threshold -112 dBm (25 kHz) or -114 dBm (12.5 kHz) / FCS OFF / Compatibility Satel 3AS / Call sign OFF (Tx output options are 1, 2, 5, 10 W (Epic Pro) and 5, 10, 20, 25, 35 W (Epic Pro 35W)).
Addressing	RX Address OFF / TX Address OFF
Serial Port 1	ON / 19200 / 8 bit data / None parity/ 1 stop bit (for 12.5 kHz the default data speed is 9600 bps)
Serial Port 2	OFF / 19200 / 8 bit data / None parity/ 1 stop bit (for 12.5 kHz the default data speed is 9600 bps)
Handshaking	CTS Clear to send / CD RSSI-threshold / RTS Ignored / Pause length 3 bytes
Additional settings	Error Correction OFF / Error check OFF / Repeater OFF / SL-Commands ON / Priority TX / Full CRC16 check OFF
Routing	OFF
Tests	OFF

The power cable (+V_b and GND) must be connected to a power supply with a proper output voltage and with a minimum output current of 5A (with 35 W version 15 A).

When creating a test connection, you can either use the *SaTerm* terminal program, (available for free from authorised SATEL dealers or directly from SATEL Customer Support) or HyperTerminal (which is included in most the Windows™ based operating system packages), or almost any other terminal program. Basic settings for the serial port of the host computer, when using a terminal program to communicate with SATEL radio modems, are as follows: "COM1, 19200 bps, 8-bit data, none parity, 1 stop bit".

If the serial port designated as COM1 in the host computer is reserved, any other free serial port in the host computer can be used (with the settings listed).

Note: If you want to change the settings of a radio modem using the *Programming Mode* of the radio modem with the help of an external terminal, the data speed of the terminal must be 9600 bps.

Basic connection between a radio modem and the serial port COM1 (RS-232) of a PC is depicted in Chapter 12.2.

3 OTHER FEATURES

SATELLINE-3ASd Epic Pro and **Epic Pro 35W** radio modems fulfil the IP67 (NEMA 6) standard. With an IP67 rating a product will be totally protected against dust and remain completely sealed when immersed in water to a depth between 15 cm and 1 meter.

SATELLINE-3ASd Epic Pro modem is equipped with a 10 W transmitter and Epic Pro 35W with high power 35 W transmitter. Both are designed for easy mobile use in demanding field conditions.

The SATELLINE-3ASd Epic Pro and Epic Pro 35W are equipped with a liquid crystal display (LCD) and a keypad, used to indicate the current operating status, as well as for changing the operating channel and power level of the radio modem.

Both models exhibit a special "Dual Band" feature. The radio transceiver of the Dual Band version offers two 2 MHz frequency bands, tuned at the factory with maximum separation of 15 MHz between the highest and the lowest frequency. The radio modem can be reprogrammed to operate at any channel within those two bands.

4 SATELLINE-3ASd EPIC PRO 35W SPECIAL FEATURES

4.1 Call Sign

Epic Pro 35W has a CALL SIGN identifier -feature required in some countries. A call sign can be formally assigned by a government agency, informally adopted by individuals or organizations, or even cryptographically encoded to disguise identity of a station.

A call sign is an FCC (in US) or other regulatory authority assigned identifier that is issued along with the license for operating a radio modem. This field is for entering your call sign. The modem automatically broadcasts the specified call sign periodically. If this field is empty, there is no call sign information.

Call sign setup can be found in PROG-menu clause 2) *Radio settings* and further in its sub clause 9) *Call sign*. Call sign has three (3) different setups. With **Call sign mode** you can set Morse code transmission ON or OFF. **Call sign ID** defines which Morse code will be transmitted. Only capital letters and numbers are allowed. If the digits are wrong kind, there will be message: *Value error*. Small letters will be converted to capital letters automatically. If **Call sign ID** field remains empty, the Call Sign transmission will not be activated. **Call sign timer** is the transmission delay of Morse codes. Minimum and default transmission time is 15 minute.

During Call sign transmission the CTS-line of the modem is not in active state. This is to inform terminal equipment that the modem is not ready to neither receive data from serial port nor forward it. The modem deletes all data (also SL commands), which has arrived to serial port during call sign transmission. Call sign transmission lasts 1-4 seconds depending on the number of digits.

Radio setup

1) TX power 5 W
2) Signal threshold -112 dBm
3) TX start delay 0ms
4) Diversity RX OFF
5) Epic power save OFF
6) Free Channel Scan RX Slave / OFF
7) View hardware info
8) Radio compatibility Satel 3AS
9) Call sign ON
Enter selection or ESC to previous menu >

Call sign

1) Call sign mode ON
2) Call sign ID 15CF62
3) Call sign timer 1 min

Enter selection or ESC to previous menu >

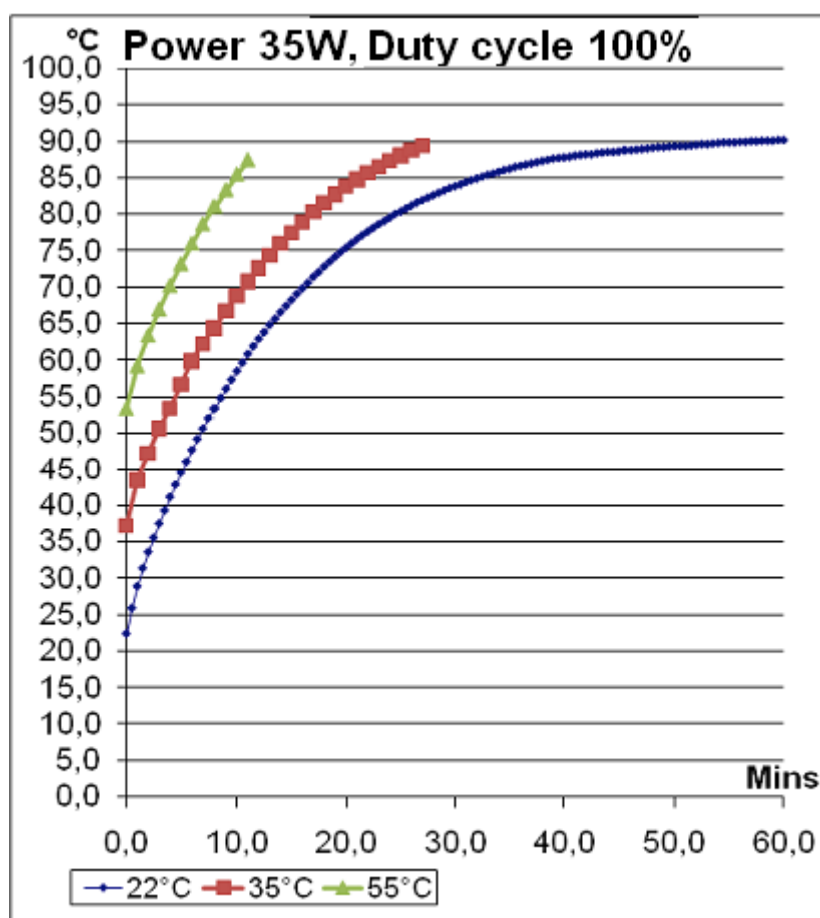
4.2 Temperature protection of RF power amplifier

RF power amplifier is protected against overheating. The power of transmitter is lowered step by step if the inner temperature exceeds certain levels as shown below.

Temperature inside a modem	Carrier power
Over 75°C	25 W
80°C	10 W
85°C	5 W
90°C	0 W (transmitter OFF)

When the ambient temperature is under 30°C and transmitter duty cycle does not exceed 40%, the temperature inside the modem does not exceed the trigger level.

The internal temperature is measured in the beginning of every transmission and at once when modem cools down. The carrier power increases with falling temperature so that at 88°C carrier power goes to 5W, at 83°C to 10W, at 78°C to 25W and at 73°C the modem operates again at the full 35W carrier power.



4.3 Protection of current

In case of bad antenna impedance matching the current consumption of the Power Amplifier may be too high. For this reason the maximum PA current is limited to 12 A. If current tends to increase over 12 A, automatic gain control circuits decrease power level of a modem until current drops under 11.5 A. New transmission starts always with max power level. The ballast can be seen in LDC-display. If display blinks, ballast is on. If it does not blink, display shows the normal power level. Power is reduced only at the 35 W power level and never more than 2 dB.

4.4 Pacific Crest and TRIMTALK compatibility

4.4.1 General

SATELLINE-3ASd Epic Pro and Epic Pro 35W radio modems support additional to the original SATEL 3AS data transfer also:

- o Pacific Crest compatible data transfer over the air, if the opponent Pacific Crest modems operate in the transparent mode/FEC ON/Scrambling ON that is the most common setup among RTK applications. The other modes are currently not supported.
- o TRIMTALK® 450s compatible data transfer over the air.

SATELLINE-3ASd Epic Pro and Epic Pro 35W radio modems provide the following radio compatibility settings:

- o Option 1 for Pacific Crest 4-FSK modulation, Transparent mode/FEC ON/Scrambling ON.
- o Option 2 for Pacific Crest GMSK modulation, Transparent mode/FEC ON/Scrambling ON.
- o Option 3 for TRIMTALK GMSK modulation, Transparent mode

So far, only the transparent mode is implemented, since it is the most commonly used and recommended by the user manuals. The ARQ based protocols with ACK/NACK schemes are not preferred in RTK applications that apply one-way communication.

The implementation of Options 1, 2, 3 is based on the reference measurements and the available public data of the following radio modems manufactured by Pacific Crest Corporation: RFM96W, PDL HPB, PDL LPB. TRIMTALK is a trademark of Trimble Navigation Ltd.

4.4.2 Configuration in the Programming menu

The correct radio compatibility mode can be changed in the Programming mode submenu *Radio settings ->Radio compatibility Mode*:

```
Radio compatibility Mode
-----
1) Satel 3AS
2) Option 1 (PCC 4-FSK)
3) Option 2 (PCC GMSK)
4) Option 3 (TRIMTALK GMSK)
```

4.4.3 Configuration by using SL commands

"SL@S=" command selects the compatibility mode:

- o "SL@S=0" sets SATEL 3AS (default).
- o "SL@S=1" sets Option1 (PCC-4FSK)
- o "SL@S=2" sets Option 2 (PCC-GMSK)
- o "SL@S=3" sets Option 3 (TRIMTALK GMSK)

The modem responds with "OK" message if the requested mode is supported or "ERROR" if the mode is not allowed.

"SL@S?" enquires the active mode. The modem responds with a number:

- o "0" if the mode is SATEL 3AS
- o "1" if the mode is Option 1
- o "2" if the mode is Option 2
- o "3" if the mode is Option 3

4.4.4 Settings

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

PACIFIC CREST modems must have:

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

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

- o Addressing:
 - o 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)
 - o 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)

Note: 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:

- o Pacific Crest modems are configured via the serial port using PDLCONF Windows™ program that sends binary control messages to the serial port of the modem.
- o SATELLINE-3AS and SATELLINE-M3 radio modems are configured via the serial port using any ordinary terminal program or SATEL Configuration Manager PC-program.

The table on the next page shows the analogy of settings between Pacific Crest and SATELLINE radio modems.

The table shows the analogy of the settings between Pacific Crest and SATEL radio modems.

<i>Pacific Crest setting</i>	<i>Corresponding SATELLINE-3AS setting (status in software version 3.35)</i>
Identification: Call Sign	Epic Pro 35W (not implemented in Epic Pro)
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	The fixed link rates are: Option 2 & 3: 9600bps@25kHz / 4800bps@12.5kHz Option 1: 19200bps@12.5kHz / 9600bps@12.5kHz
Radio Link:Modulation Mode	Compatibility-> Option 1 (=PCC-4FSK) Compatibility-> Option 2 (=PCC-GMSK) Compatibility-> Option 3 (=TRIMTALK GMSK)
Radio Link:Scrambling	ON by default
Radio Link:Transmit Retries	(not implemented)
Radio Link:TX ACK Timeout	(not implemented)
Radio Link:Cdma 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 using Option 1, 2, 3 (Note: SATELLINE-3AS 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: Options 1 and 2 = Transparent w/EOT Timeout Option 3 = TRIMTALK 450s
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(in0.01s units)	(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: - Pacific Crest Local/Remote addresses are supported in the firmware versions starting from v3. 39 - Repeater function is supported only in the firmware versions starting from v3.39 - 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.	

4.4.5 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. The repeater modem passes TRIMTALK messages also to its serial port unlike for example Pacific Crest PDL modems.

Note 2. SATELLINE-3AS(d) Epic-modems do NOT support the DIVERSITY reception in TRIMTALK mode, consequently the *Diversity* setting must be OFF.

Note 3. 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.

4.4.6 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.

4.4.7 Latency

In the PCC Transparent protocol mode (Option 1 and Option 2) the whole message is first read from the serial port and after that it will be framed and transmitted over the radio.

The end of the message is detected when there is a pause in data coming from the serial port.

The symbol rates for the Pacific Crest 4FSK (Option1) are:

- o 19200 bps on 25 kHz channel
- o 9600 bps on 12.5 kHz channel

The symbol rates for the Pacific Crest GMSK (Option2) are:

- o 9600 bps on 25 kHz channel
- o 4800 bps on 12.5 kHz channel

The actual raw data rate is appr. 2/3 of the symbol rate.

4.4.7.1 Transmission delays using Option1 (Pacific Crest 4FSK) on 25 kHz channel

The table below presents the typical latency vs. the size of the message. The delays are measured from the end of transmitted data to the end of received data on the serial interface.

Number of bytes sent				
Bps	1	10	100	500
1200	77 ms	159 ms	971 ms	4590 ms
4800	48 ms	68 ms	317 ms	1438 ms
9600	43 ms	52 ms	209 ms	912 ms
19200	40 ms	45 ms	154 ms	650 ms
38400	39 ms	41 ms	127 ms	519 ms

4.4.7.2 Transmission delays using Option2 (Pacific Crest GMSK) on 25 kHz channel

The table below presents the typical latency vs. the size of the message. The delays are measured from the end of transmitted data to the end of received data on the serial interface.

Number of bytes sent				
Bps	1	10	100	500
1200	86 ms	168 ms	1042 ms	4949 ms
4800	57 ms	77 ms	390 ms	1796 ms
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

5 SERIAL INTERFACE

The radio modem is referred to as DCE (Data Communication Equipment) whereas the PC is referred to as DTE (Data Terminal Equipment). SATELLINE-3ASd Epic Pro radio modem includes a Lemo compatible 8-pin, Epic Pro 35 W includes a 7-pin ODU MINI –Snap Style G4 Size 0 (or 8 pin LEMO HGA) which contains all the connections required to establish communication between the radio modem, acting as the DCE, and the PC, acting as the DTE. More about connectors can be seen at chapter 4.2.

All EMC requirements set forth by authorities have been taken into account in the design of the radio modem. The radio modem user is thereby not required to take any special actions regarding EMC shielding (of the radio modem).

The radio modem has one serial port, **Port 1** which complies with the RS-232 standard.

5.1 RS-232 interface

RS-232 standard defines the method of serial data transfer between a computer and its peripherals. The definition includes both the interface type and signal levels. Most computers and peripherals contain one or more RS-232 type serial ports. The RS-232 standard uses transmission lines, in which each single signal line level is referenced, to a common ground level. RS-232 has been designed to be use in serial transfer of data, in situations where the distance between communicating equipment is less than 15 m. The otherwise useful RS-232 standard is applied in a multitude of slightly differing ways, (e.g. different pin configurations) and for this reason different computers and peripherals are not necessarily directly compatible with each other (see also Chapter 12.2.1 for more information on RS-232 wiring).

5.2 Connectors

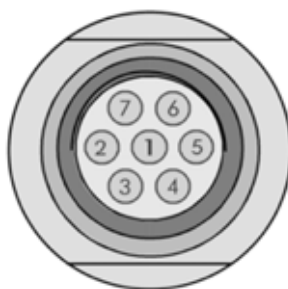
The device adopts a high standard waterproof ODU 7-pin or Lemo 8-pin data connector.
Antenna connector type is 50 ohm TNC female.

1. Data connector

a) SATELLINE-3ASd Epic Pro 35W, 7-pin model

7 pin ODU MINI-SNAP Style G4 size 0

1	PROG
2	GND
3	CTS
4	RTS
5	RXD
6	TXD
7	-



b) SATELLINE-3ASd Epic Pro and SATELLINE-3ASd Epic Pro 35W, 8-pin model

8 pin LEMO HGA. 1B. 308. CLPP

	SATELLINE-3ASd Epic Pro	SATELLINE-3ASd Epic Pro 35 W, 8-pin model
1	RTS	RTS
2	CTS	CTS
3	SGND	SGND
4	RXD	RXD
5	TXD	TXD
6	PROG	PROG
7	+VDC	Not connected
8	Not connected	Not connected

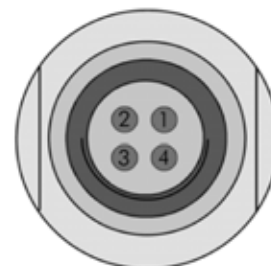


2. Power connector

SATELLINE-3ASd Epic Pro 35W

4 pin ODU MINI-SNAP Style G4 size 1

1	PWR (+)
2	PWR (+)
3	GND
4	GND



NOTE! SATELLINE-3ASd Epic Pro does not have a separate power connector. Power is fed via data connector.

6 Programming

6.1 Display

Ö	Field strength indicator. Shows how strong is the received signal. For example: -80 (dBm) Modem turns to show noise level ~7 sec. after the latest message reception.
12.1V	Battery level indicator.
CH: 1	Channel number followed by the actual frequency. For example 439.0000 (MHz). The maximum number of pre-programmed channels is 16.
Power :	Shows the output power level. The setting is LOW, MEDIUM, HIGH.
Setup	Executing commands
Noise	Shows the level of noise on the RF channel. E.g. n-110 (dBm).

6.2 Keypad ■ ● ▲ ▼

Buttons for changing settings.

Short guide:	
Setup	■
Select	■
Change	▲ ▼
Set	■
Exit	●
YES	■

6.3 Programming

Full programming is done in “programming mode”. The radio modem will switch into the programming mode by connecting the Mode pin to the ground. This is easily done by using the NARS-ST adapter cable together with the NARS-1F-4A interface adapter. Programming is explained in chapter 7.2

6.3.1 Power level change by using the LCD and keypad

1. Press ■ = Setup. Wait a moment until the display changes
2. Press ▼ and press ■ = Select.
3. ▲ ▼ will change the power level.
4. Select the power and press ■ = Set, press ● = Exit,
press ■ = YES.
The new settings are now saved to the memory.

>Change power

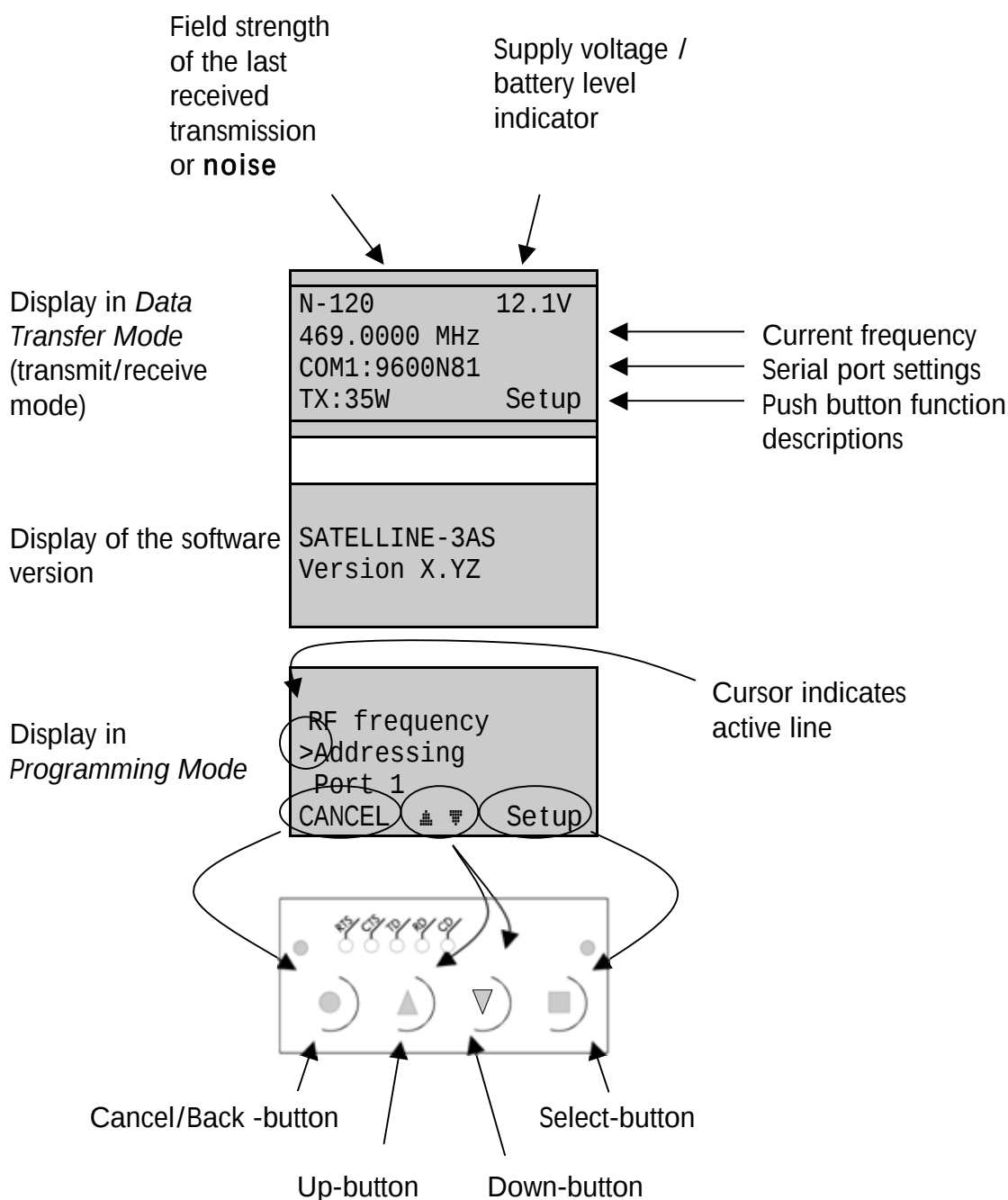
Exit

▼ Select

> Low	1W
Medium	5W
High	10W
High	35W
Change power	
Exit	▼
Select	

NOTE! If the Cancel or Exit is pressed before saving (■ = YES) there will be no changes and the previous settings will remain valid.

6.3.2 SATELLINE-3ASd Epic Pro/ Epic Pro 35W LCD DISPLAY AFTER POWER-UP



Numeric values in display differ between Epic Pro and Epic Pro 35W.

7 RF INTERFACE

The SATELLINE-3ASd Epic Pro and Epic Pro 35 W have a single TNC type connector with impedance of 50 Ω .

When ordering the radio modem, the frequency band to which the radio modem will be tuned to at the factory must be defined. The user can change the frequency of the radio modem afterwards by 2 X 2 MHz frequency bands. Of course, all local regulations set forth by the authorities must be taken into consideration.

The data speed of the radio interface depends on the chosen radio channel spacing. A channel spacing of 25 kHz enables a data speed of 19200 bps and a channel spacing of 12.5 / 20 kHz enables, correspondingly, a data speed of 9600 bps. The data speed of the radio interface is always fixed (19200 bps or 9600 bps) irrespective of the data speed of the serial interface. If the data speeds of the radio interface and the serial interface differ from each other, the radio modem will buffer the data in transfer temporarily, so no data loss will occur. The radio channel spacing is set at the factory and cannot be changed afterwards.

7.1 Transmitter

The output power of the transmitter is adjustable. The greatest allowable power depends on limits set by local authorities. It should not be exceeded under any circumstances. The output power of the transmitter should be set to the smallest possible level, which still ensures error free connections under variable conditions. High output power levels used in short connection distances can, in the worst case, cause disturbances to the overall operation of the system.

OUTPUT POWER	dBm	3ASd Epic Pro	3ASd Epic Pro 35W
1 W	+ 30	o	
2 W	+ 33	o	
5 W	+ 37	o	o
10 W	+ 40	o	o
20 W	+ 43		o
25 W	+ 44		o
35 W	+ 45		o

Possible output power settings of the SATELLINE-3ASd Epic Pro -line of radio modems.

NOTE!

Setting the radio data modem output power level to that which 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.

7.2 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) according to the table below:

	FEC OFF	FEC ON
25 kHz	-110 dBm	-113 dBm
20 kHz	-112 dBm	-115 dBm
12.5 kHz	-112 dBm	-115 dBm

Effect of settings on the receiver sensitivity

The Signal Threshold Level setting of the receiver determines a level, above which the search for the actual data transfer signal is active. It is recommended that values given in the table are used. If the Signal Threshold Level setting is set too low (the CD-LED is ON constantly), it is possible that the receiver is trying to synchronise itself with noise, in which case, the actual data transmission might remain unnoticed. Alternatively, weak data transmissions will be rejected, even though they would be otherwise acceptable.

7.3 Priority RX/TX

SATELLINE-3ASd Epic Pro and Epic Pro 35 W offer a *Priority* setting, which 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 outputs data to be transmitted (or an SL command) it will be 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.

To toggle the *Priority* setting in the programming menu, select:

1) Priority RX / TX

If the Repeater Function has been set on priority setting is automatically switched to RX mode.

7.4 **Error correction**

Another feature of the SATELLINE-3ASd Epic Pro and Epic Pro 35W is the addition of an error correction mode called the FEC method (**F**orward **E**rror **C**orrection). FEC function is switched ON (or OFF) by using the *Programming Mode*. When activated, the FEC function will cause the modems to automatically add additional error correction information, which increases the amount of transmitted data by 30 %. It is used by the receiving radio modem to correct erroneous bits - as long as the ratio of correct and erroneous bits is reasonable.

Error correction improves the reliability of data transfer via the radio interface especially in unfavourable conditions. FEC-function should be used when link distances are long and/or if there are many disturbances in the radio channels used. The use of the FEC-function will, however decrease the data transfer throughput of data by about 30 %. For a listing of exact delays introduced by using FEC-function, see Chapter 17.2.1

To switch the FEC-function ON in the *Programming Mode*, select:

1) Error correction ON

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 correctly.

7.5 **Error check**

When the error check is switched on, the radio modem will add a checksum to the transmitted data. When the data is received, the checksums are 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:

2) Error check

6) Full CRC16 check

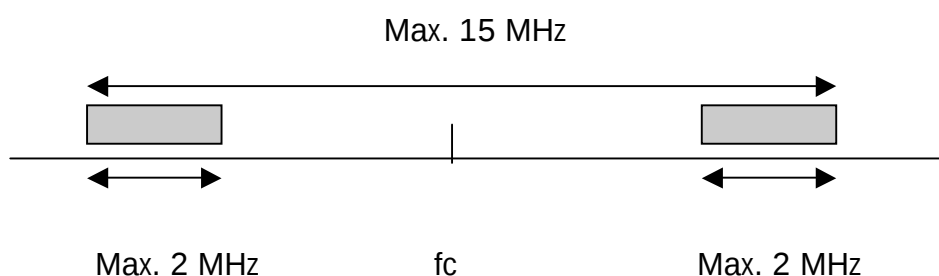
Error check checks data partially while data is received.

Full CRC16 check function 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. Notice that error check is not allowed to use when PCC-setup is activated.

7.6 Dual Band feature and Dual Channel function

SATELLINE-3ASd Epic Pro and Epic Pro 35W radio modems have a special "Dual Band" feature. The radio transceiver offers two times two MHz frequency bands, and radio modem can be reprogrammed to operate at any channel within those two bands. Frequency bands are tuned at the factory and the maximum separation between the highest and the lowest frequency is 15 MHz (see the diagram on next page).

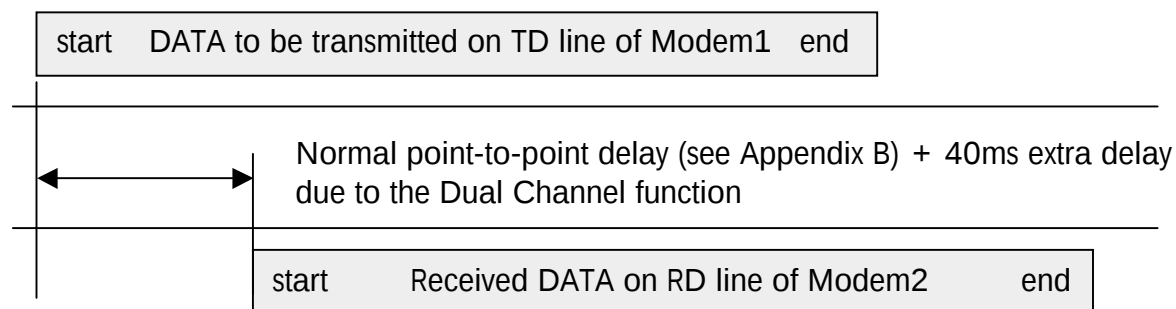
The centre frequency (f_c) is set to the middle of the two frequency bands at the factory. When using the SL-commands please note that SL&F=nnnn.nnnn is the only command for frequency change that works in all cases. (SL&+/-=nnnn command can be used only when the required value for nnnn does not exceed 9999.)



Dual Channel function

By setting the "Dual Channel" function on, the SATELLINE-3ASd Epic Pro and Epic Pro 35W radio modem can transmit and receive data on separate channels. The radio modem is initially at the receive channel. Data flow on the TD line starts automatically the frequency shifts to the transmit channel. The delay caused by the frequency shift before the actual data transmission sequence is 40 ms, and the same is needed for the return to the receive channel after transmission.

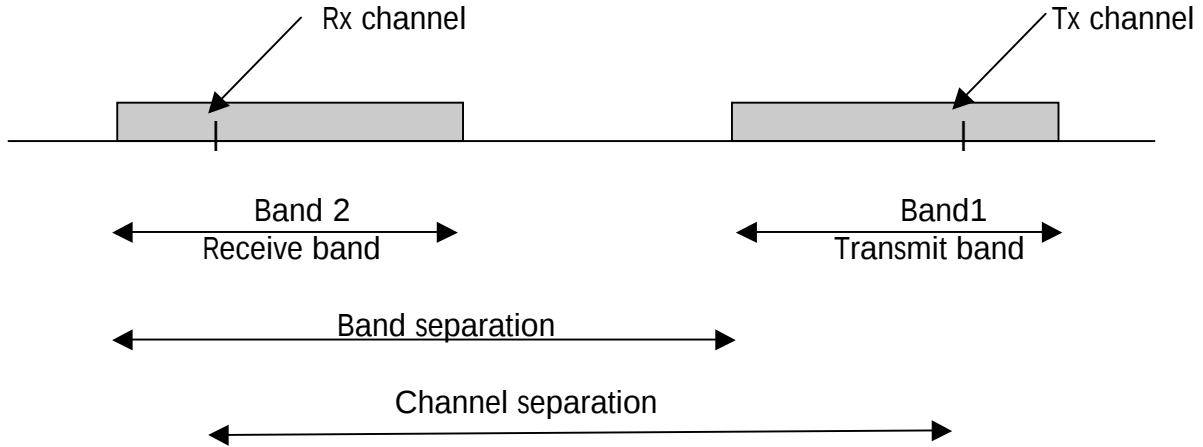
The extra delay from a modem to another is shown below:



The table below specifies the use of the frequency bands vs. Dual Channel settings.

	Band 1 (Active channel)	Band 2
Dual Channel selected	Transmit Channel	Receive Channel
Reverse Dual Channel selected	Receive Channel	Transmit Channel

The separation between transmit and receive frequencies is equal to the separation between the lower limits of the specified frequency bands (Lower limit band 1 and Lower limit band 2). Frequency bands are set in such a way that the other band covers the receive frequencies and the other includes the transmit frequencies. See below.



With the help of SL commands the modem can be set to Single, Dual or Reverse Dual Channel mode (Single Channel = normal one channel mode, default). The dual channel settings can be changed also by the SL command, see chapter 11.2.

7.7 Free Channel Scan (FCS) function

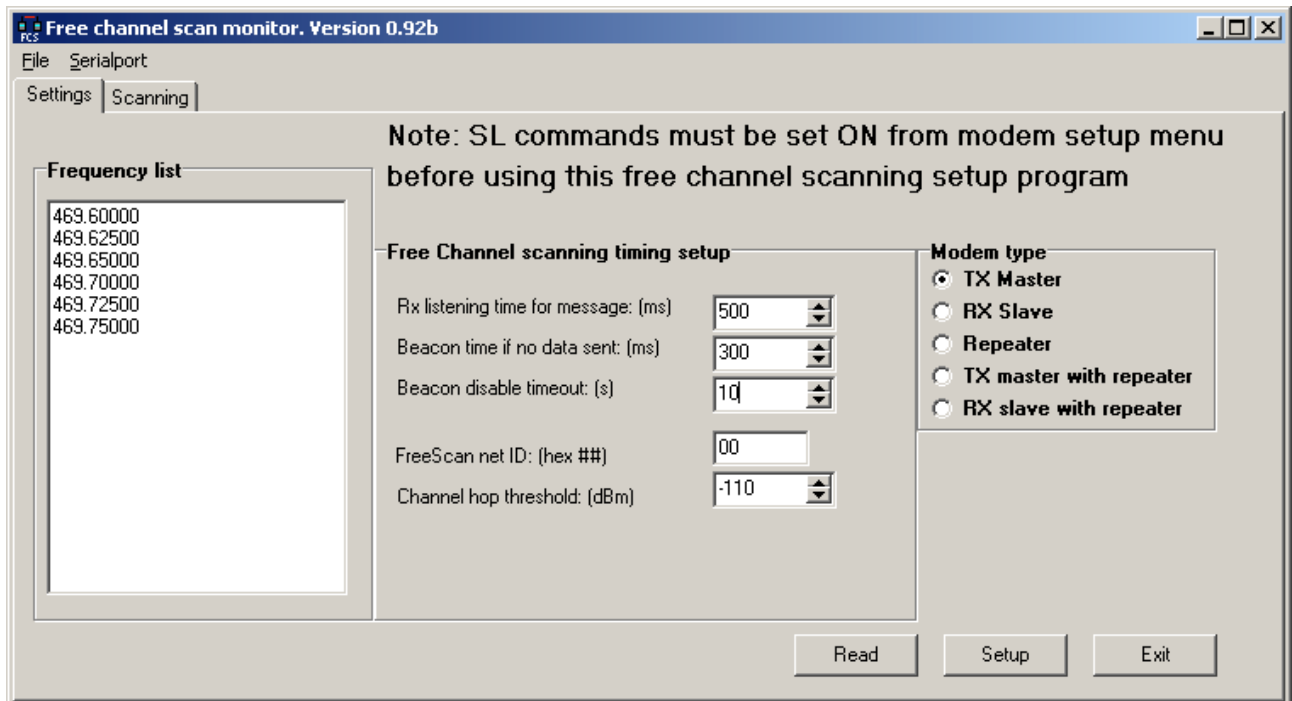
Free Channel Scan (FCS) is designed for one-way transmission between one transmitter and one or more receivers when there are at least two different radio frequencies available. The transmitter monitors the noise level of the channels between the transmissions and finds the best transmission channel. The receivers scan and follow the frequency of that particular transmitter consequently.

The feature is beneficial e.g. for the applications in land surveying or when license free channels are used and there could be other transmitters using the same channels.

The FCS function is supported starting from the software version 3.07.

To make the use easier SATEL provides the FCS terminal software for your PC. By using the program it is easy to configure the radio modems to use the FCS function. There is also a scanning tool for measuring the power level of the selected radio channels. A more detailed description of FCS function and FCS terminal software is available from the manufacturer or from the nearest distributor.

A screen snapshot of the FCS terminal software below:



8 USER INTERFACE

8.1 LED-indicators

There are five (5) LED indicators on the front panel of the radio modem, and they give an indication of the status of the serial port and the radio interface:

LED	Indication	OFF	Red	Orange	Green
RTS	RTS-line status	Inactive	Active		
CTS	CTS-line status	Inactive	Active		
TD	TD-line status	No data	Data		Test Tx active
RD	RD-line status	No data	Data		
CD	Radio status	No signal	Transmission	Noise	Reception

Description of the LED-indicators:

- RTS* indicates the status of pin 4 (7-pin version) or 1 (8-pin version).
- CTS* indicates the status of pin 3 (7-pin version) or 2 (8-pin version).
- TD* indicates that the radio modem is receiving data via serial port.
- RD* indicates that the radio modem is sending data via serial port.
- CD* indicates the status of the radio interface. The status of the CD-signal on the serial interface may differ from the status of the LED-indicator.

8.2 Programming Mode

The settings of 3ASd Epic Pro and Epic Pro 35W are fully configurable in *Programming Mode* by using a suitable terminal program. The most recommendable set-up is NARS-ST/NARS-35W (depending on the number of pins – 7 or 8 – in serial interface connector), NARS-1F-4A interface adapter, CRS-9 cable, a power supply and the *SaTerm* terminal program. NARS-1F-4A contains a switch to enable easy shifting into the *Programming Mode*. Other suitable terminal programs and cables may also be used (NARS-1F will do for accessing programming menu, but this is not suitable for data transfer tests with Epic Pro).

The radio modem will shift into the *Programming Mode* by connecting the pins (in 7-pin ODU Mini-Snap to pin 1, in 8-pin LEMO HGA to pin 6) to ground (GND). When using the NARS-1F-4A, this can be accomplished by moving the slide switch downwards.

In the *Programming Mode*, the radio modem will use serial port **PORT1**, with settings 9600 bps, N, 8,1 (data transfer speed 9600 bps, no parity, 8 data bits and 1 stop bit). For more detailed instructions for changing each setting, see Chapter 7.2.1.

8.2.1 **Changing the settings (Example: Epic Pro 35W)**

- o Connect cables (RS-232 cable to PC COM-port, power supply cable to power supply).
- o Switch on the PC and start *SaTerm* program (or other terminal program).
- o Open a terminal window and then choose "Pr" (in case you are using some other terminal program, set the serial port parameters of the program as follows: 9600 bits/s, 8 data bits, no parity, 1 stop bit, which is always the default in *Programming Mode*).
- o Connect PROG-pin to ground (if using the NARS-1F-4A adapter, slide the switch downwards), the radio modem shifts now into the *Programming Mode*. The screen should look similar to the one shown in the picture below.
- o Make desired changes to the settings.
- o Save changes by pressing "E" in the main menu. If you don't want to save changes, press "Q".
- o Disconnect PROG-pin from ground (if using the NARS-1F-4A adapter, slide the switch upwards), the radio modem should now return to the *Data Transfer Mode*.

```
***** SATELLINE-3ASd 3069 EPIC 35W *****
SW version 3.35b / HW: EPCc/TC4q + RA13H4047M
-----
Current settings
-----
1) Radio frequency    469.00000 MHz ( CF 469.00000 MHz, spacing 25 kHz )
2) Radio settings    TX power 5 W / Signal threshold -112 dBm / FCS OFF /
                    TX start delay 0ms / Diversity RX OFF /
                    Compatibility Satel 3AS / Call sign OFF
3) Addressing        RX address OFF / TX address OFF /
                    RX address to RS port OFF / TX address autoswitch OFF
4) Serial port 1     ON / 19200 bit/s / 8 bit data / None parity /
                    1 stop bit
5) Serial port 2     OFF / 9600 bit/s / 8 bit data / None parity /
                    1 stop bit ( RS-232 )
6) Handshaking       CTS Clear to send / CD RSSI-threshold /
                    RTS Ignored / Pause length 3 bytes
7) Additional setup  Error correction ON / Error check OFF / Repeater OFF /
                    SL-commands ON / Priority TX / Full CRC16 check OFF
8) Routing           OFF
9) Tests             OFF
A) Restore factory settings
E) EXIT and save settings
Q) QUIT without saving

Enter selection >
```

See Chapter 11 for more details of Programming.

8.2.2 Restoring factory settings

Selecting menu selection “A” may restore factory settings.

Enter selection >A
Restore factory settings ----- Do you want to restore factory settings? (Y/N)>

Factory settings are restored by selecting "Y" (YES). By pressing any other button current settings will remain active. The modem will ask this question twice to make ensure that this is a valid command.

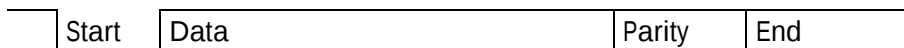
9 TRANSPARENT DATA TRANSMISSION

9.1 Serial interface, data format

The **SATELLINE-3ASd Epic Pro** and **Epic Pro 35 W** radio modem serial interface uses an asynchronous data format. No external synchronising signal is needed, since necessary timing information is acquired from the start and stop bits transmitted before and after each data field bits (byte).

The data transfer speed of the serial interfaces can be set to 300 ... 38400 bps (**bits per second**). The length of the data field must be 7, 8 or 9 bits. When using a data field length of 7 or 8 bits, a parity bit may also be used.

One character to be transmitted will thus contain a start bit; the data bits (which define the specific character in question); an optional parity bit and one or two stop bits. The overall length of one character is therefore 10, 11 or 12 bits. This should be taken into account when calculating the data throughput capability of a system. In other words, the number of start, stop and parity bits must be considered. A useful rule of thumb is that at a data transfer speed of 9600 bps, the transmission of one character will require roughly one millisecond (1 ms).



Asynchronous character data format

Example: With an 8-bit data character length and taking, for example, a decimal value of "204", (which corresponds to a binary value of "11001100") and with a start bit value of "0", parity bit set to either "NO" (NONE), "0" or "1" and with a stop bit value of "1", the possible combinations are listed in the table below:

DATA FORMAT	CHARACTER	CHARACTER LENGTH
8 bit, no parity, 1 stop bit	0110011001	10 bit
8 bit, even parity, 1 stop bit	01100110001	11 bit
8 bit, odd parity, 1 stop bit	01100110011	11 bit
8 bit, no parity, 2 stop bits	01100110011	11 bit
8 bit, even parity, 2 stop bits	011001100011	12 bit
8 bit, odd parity, 2 stop bits	011001100111	12 bit

If the settings of data speed, character length, parity or the number of stop bits differ between the radio modem and the terminal, errors will be introduced into the transferred data. The serial port settings of each individual radio modem in a system can all be different apart from the data length setting (7, 8 or 9 bits), which must always be the same in each individual radio data modem. In other words, the serial port used, the data transfer speed, parity and number of stop bits; can be different in different parts of a same system.

9.2 **Handshake lines**

When using the RS-232 serial interface, handshake signals can be used to control data transfer. Handshake signals are used, for example, by the radio modem to inform the terminal that the radio channel is busy, and that it cannot initiate transmission. The terminal can also control the radio modem via RTS-line.

Line	Direction
CTS	To terminal
RTS	To modem
CD	To terminal

A common way of using handshaking signals is to monitor the CTS-line and ignore the others. Usually the terminal is fast enough to handle the data received by the radio modem, so the use of RTS-line is not necessary.

Handshaking is not needed if the system protocol is designed to prevent collisions (data contention) by the use of polling, or if there is little traffic and also if there is no harm from occasional data contention situations (several radio modems try to transmit at the same time).

9.2.1 **CTS-line**

The options for CTS-line are:

1) **Clear To Send**

CTS is active when the radio modem is ready to accept data for new transmission. CTS will shift into inactive state during data reception and transmission.

2) **TX buffer state**

CTS will shift into inactive state only if the radio modem's TX buffer is in danger of overflowing. This typically happens when the serial interface data transfer speed is greater than the radio interface transfer speed and the size of transmitted messages is large.

CTS is connected to pin 3 in 7-pin version, and to pin 2 in 8-pin version.

9.2.2 **CD-line**

The options for CD-line are:

1) **RSSI-threshold**

CD is active whenever a signal with a level exceeding the level required for reception exists on the radio channel. It doesn't make any difference if the signal is an actual data transmission, a signal of a radio transmitter not belonging to the system, or even an interference signal caused for example, by a computer or a peripheral device. CD is also active when the radio modem in question is transmitting.

2) **Data on channel**

CD will switch to active state only after recognition of a valid data transmission. CD will not react to interference signals.

3) **Always ON**

CD is always in the active state. This option can be used with terminal equipment, which use the CD-line as an indicator of an active connection (the radio modem can transmit and receive at any time).

9.2.3 RTS-line

The options for RTS-line are:

1) **Ignored**

RTS-line status is ignored.

2) **Flow control**

The radio modem transmits data to the terminal device only when the RTS-line is active. Non-active state of the RTS-line will force the radio modem to buffer the received data. This option is used if the terminal device is too slow to handle data received from the radio modem.

3) **Reception control**

RTS-line controls the reception process of the radio modem. An active RTS-line enables reception (as normal). Non-active RTS-line will interrupt reception process immediately, even if the radio modem is receiving a data packet. This option is used to force the radio modem into WAIT State for an immediate channel change.

9.3 Timing and delays during data transmission

When using a radio modem for data transmission, certain delays will be formed through the use of a radio interface and from the radio modem circuitry itself. These delays exist when the radio modem switches from *Standby Mode* to *Data Transfer Mode* and during reception and transmission of data. For detailed delay values in each case see Appendix B and PCC compatibility.

9.3.1 Data buffering in the radio data modem

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 case, 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.

9.3.2 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:

- o 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.
- o SL-command recognition - For a SL-command to be valid, a pause must be detected before the actual "SL..." character string.
- o 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 RF 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:

- o 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).
- o The maximum absolute time is always 170 ms independent from the value of the Pause length given in the set-up.
- o 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.

9.3.3 TX delay

The radio modem can be configured to delay the beginning of a radio transmission by 1...65000 ms. This 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. Although the priority setting is "RX" (see chapter 3.3), radio modem is prevented to change over to receiving mode during the period of the TX delay. If this function is not needed, the delay time should be set to 0 ms.

9.4 Tests

The radio modem can be switched to the *Test Mode*, where it will send a test packet on the radio channel. The test packet is a normal data transmission, which can be used, for example, when directing antennas during system installation.

When the test packet transmission has been switched on and saved by using the *Programming Mode*, the transmitting radio modem needs only a power supply and an antenna.

If the channel spacing of the radio modems is 25 kHz, it is recommended to use 38400 bps as a serial data speed of the receiving radio modem. In the case of 12.5 / 20 kHz channel spacing the data speed of 19200 bps is recommended.

There are two *Test Modes*:

Short data block test

In this test mode the radio modem sends a short test string, which is preceded by a consecutive number, and it ends to the line feed character. The short data block is repeated continuously after 1 s break.

Short data block test is suitable for running data communication tests. Error-free reception of data can be monitored using a suitable terminal program.

Example of a short data blocks:

```
00 This is a testline of SATELLINE-3AS radio modem
01 This is a testline of SATELLINE-3AS radio modem
02 This is a testline of SATELLINE-3AS radio modem
```

Long data block test

Long data block consists of character strings, which are repeated without breaks 50 s time period. After 10 s break the test transmission is started again.

Long block data test can be used for measuring Tx output power, standing wave ratio (SWR) of the antenna system or received signal strength at Rx stations.

Example of a long data blocks:

This is a long testline of SATELLINE-3AS radio modem
This is a long testline of SATELLINE-3AS radio modem
This is a long testline of SATELLINE-3AS radio modem

The strength of the received signal can be monitored using the LCD-display of the receiving radio modem.

NOTE 1! Green TD led indicates active test mode.

NOTE 2! Normal data transfer is not available while the Test mode is active. Remember to switch it OFF before starting the normal data transfer.

NOTE 3! Message Routing and FCS mode must be disabled in prior to set ON the Test mode.

10 REPEATER MODE AND ADDRESSING

Repeaters and addressing may be used to extend the coverage area of a radio modem network and to direct messages to selected radio modems in the network. In large systems, with several repeaters and formed repeater chains, it is often practical to use routing instead of plain addresses. For more information on routing, see Chapter 10.

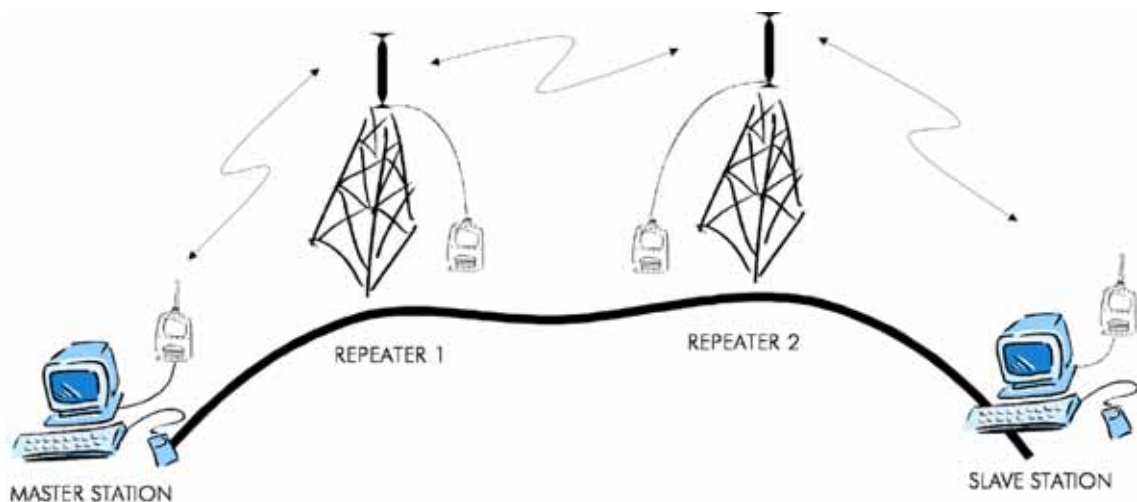
10.1 Repeater

In circumstances where it is necessary to extend the coverage area of a radio modem network, SATELLINE-3ASd Epic Pro and Epic Pro 35W radio modems can be used as repeater stations.

The maximum size of a repeated data packet is 1kB (kilobyte). The *Repeater Function* is switched on using the *Programming Mode*. In the repeater mode the radio modem will function as a totally independent unit, which means that only a power supply and a suitable antenna are needed. Other devices are not necessary.

A radio modem acting as a repeater can also be used to receive and transmit data. In repeater mode the radio modem will transmit the received data to the serial interface in a normal fashion. The difference being that the received data will be buffered into the buffer memory. After reception the radio modem will re-transmit the buffered data using the same radio channel as in reception. Data received through the serial interface a radio modem in repeater mode will transmit normally.

The same network may include several repeaters, which operate under the same base station. Repeaters may also be chained; in which case a message is transmitted through several repeaters. In systems with more than one serial or parallel-chained repeater, addressing or routing protocol must be used to prevent a message ending up in a loop formed by repeaters, and to ensure that the message finally reaches only the intended radio modem.



10.2 Addressing

Addresses can be used to route a data message to the desired destination or to separate two parallel networks from each other. In networks with repeaters it is usually necessary to use addresses to prevent data messages from ending up in loops formed by repeaters. In case of setting the "Message Routing" function in use, Tx / Rx addresses are ignored by the modem software.

SATELLINE-3ASd Epic Pro and Epic Pro 35W radio modem allows the use of individual addresses both for reception and transmission. Addresses can be switched on separately, or simultaneously, in both data transfer directions.

The radio modem contains two transmission and two reception addresses, which are known as the primary address and secondary address. The primary address is used whenever data from the serial interface is transmitted. At the receiving end, the radio modem will receive using either of the two receive addresses.

Secondary transmit address is only used in repeater applications.

Radio modems configured to function as repeaters, will repeat data messages using either the primary or secondary address, depending upon which address was used during the reception of the data message.

If only one address pair is needed in a network, both addresses must be set the same (TX1 = TX2 and RX1 = RX2).

It is also possible to transfer the received address onto the serial interface.

The address is composed of two characters totalling 16 bits, resulting in over 65,000 different address combinations. The address is attached to the beginning of each data packet sent by the radio modem. When a radio modem receives a data packet whilst using addressing mode, the radio modem will check the first two characters of each received data packet to ensure that the packet in question was intended for the correct radio modem.

ADD H	ADD L	DATA
-------	-------	------

Address may be selected between 0000h...FFFFh (h = hexadecimal, corresponding decimal numbers are 0-65535).

Example: address 1234h (4660 in decimal format), where 12h is ADD H and 34h is ADD L.

Example: address ABFFh (44031 in decimal format), where ABh is ADD H and FFh is ADD L.

Transmission:



Transmission address has been set OFF. Radio modem will transmit the data packet as such.



Transmission addressing has been set ON. The radio modem will add the primary TX address to the beginning of the data packet.

Reception:



Reception addressing has been set ON and either the primary or secondary RX address of the radio modem is identical to the address of the received data packet.

The radio modem will remove the address and send the actual data to the RS-232 interface.

However, if the "RX Address to RD-line" setting is on, the radio modem does not remove the address.



Reception addressing has been set ON, but both the primary and secondary RX addresses of the radio modem are different from the address of the received data packet.

Data does not appear on the RS-232 - interface.



Reception addressing has been set OFF.

The radio modem will transfer all received data to the RS-232 - interface.

Reception addressing has been set OFF.

The radio modem will consider the characters of the address as a part of the data and will send all the characters to the RS-232 interface.

Reception addressing has been set ON but there is no address in the data packet.

Data will appear on the RS-232 interface ONLY if the first 2 characters of the data match either of its own RX address. The radio modem will remove those 2 characters of data.

10.2.1 Connection between two points

When forming a connection between two points it is recommended that both the reception and transmission addresses are identical in both radio modems. This is the easiest way to control addresses and the risk caused by interference from other systems operating in the same area is minimal.

Example: by setting all addresses of both radio modems to a value '1234', they will accept only those messages which contain this address, and they will use this same value when transmitting data.

If the channel is reserved for use only by the said network, or if the terminal devices are responsible for addressing, it is not necessary to use addressing in the radio modems.

10.2.2 System of one base station and several substations

In systems with several substations, the base station must know to which substation each message is intended, and from which substation each received message originates. Usually terminal devices handle addressing completely, but it is also possible to use the addressing functionality of the radio modems.

For example, if the substation terminal devices are not able to check and form addresses by themselves, addressing may be achieved with the help of the addresses of the radio modems attached to these terminal devices. The base station may, in such a case, define the destination of a message by adding the address of the corresponding radio modem into the beginning of the data packet. The substation radio modem(s) will check the address and the corresponding radio modem will identify and remove the address characters. In a similar way, when transmitting to the base station the substation will add its address characters into the beginning of the data packet, thus defining the origin of the sent data packet. In the base station radio modem, addresses have been switched OFF, so that they are transmitted as is to the base station terminal device for further processing.

10.3 Using repeaters and addresses in the same system

In systems with several repeaters, a substation and a base-station, addresses must be used in radio modems. It is possible to realise also a system with only one repeater without addressing. In such a case, the base station may however hear the message both from the substation and from the repeater, in other words the message is duplicated as it moves along the route.

There are at least two ways of realising such a system depending on the capabilities of the terminal devices in question and on the number of repeaters to be used and on their relative positions to each other.

10.3.1 System with several repeaters

In systems with several serial or parallel-chained repeaters, addressing must be used to prevent messages from ending up in loops otherwise formed by repeaters, and to ensure that only the desired (addressed) radio modem receives the data intended for it.

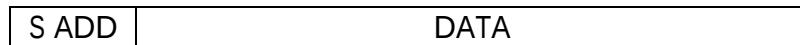
All radio modems in the network must be set to a state, in which the RX-addressing is switched ON and TX-addressing is switched OFF. Base-station and all substations add an address string in the beginning of the data to be transmitted. In the relaying of the message addressing is used in the following way:

R1 ADD	R2 ADD	S ADD	DATA
--------	--------	-------	------

- The above is the data received from the base station terminal device, containing repeater addresses (R1 ADD, R2 ADD) and the substation address (S ADD). Two characters define each address.

R2 ADD	S ADD	DATA
--------	-------	------

- The above is the same message after being relayed from repeater 1 to repeater 2.

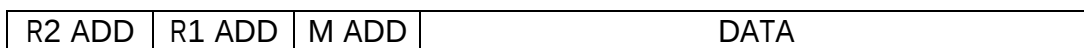


- The above is the same message after being relayed from the last repeater in the chain (repeater 2) to the substation.



- The above is the same message being relayed via the serial interface of the substation radio modem to the terminal device.

In a situation where the substation transmits data towards the base-station the address is formed in a similar way, but the order of the addresses is reversed:



-In the above, R2 ADD is address of repeater 2, R1 ADD is address of repeater 1 and M ADD is the address of the base-station.

10.3.2 Repeater chain using address pairs

In a situation where the terminal devices and substations cannot form address fields, but are able to recognise messages addressed to them, alternating address pairs may be used. Transmit address (TX) and receive address (RX) alternate in the order shown in the table below.

Address type	Base-station address	Repeater 1 and the addresses of the substations of the base-station	Repeater 1 substations addresses
TX-address	Address 1	Address 2	Address 1
RX-address	Address 2	Address 1	Address 2

In a network where alternating addresses are utilised, the exact route that is used to relay a message to a certain radio modem is fixed at the time of installation and configuring the system. The order of the addresses must be the same as the order of the route that is used to relay the message to the said radio modem. It should be noted however, that in networks where alternating addresses are used the base-station and substations will hear their own messages repeated.

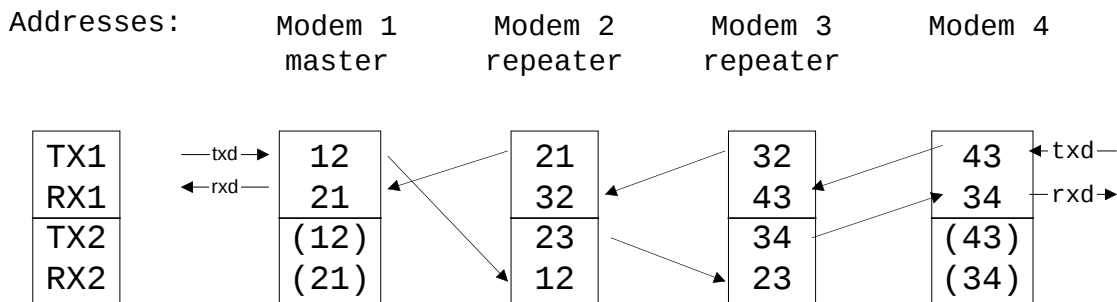
10.3.3 Repeater chain using dual addressing

If the terminal devices cannot add address chains to the beginning of the data packets, a network with several repeaters may still be realised by using dual addressing. In dual addressing each link (see arrows below in figure) is given a unique address, which will prevent duplication of messages and endless loops in the network. The terminal devices need not add anything to the data.

Usually the primary transmit address is used in transmission (TX1). The secondary transmit address (TX2) is used only if the *Repeater Mode* is used and the packet to be repeated was received using the secondary reception address (RX2).

In the following example two repeaters are used. It should be noted that each link (arrow) might be uniquely defined with the help of radio modem numbers and data transfer directions. The *Repeater Mode* should be switched ON only in the radio modems acting as repeaters to prevent the packets from remaining in endless loops in the network.

Repeaters may also act as ordinary substations; in that case the terminal device must wait until the message has reached the end of the repeater chain before sending data.



10.3.4 Redundant repeater chain

Reliability of a radio data communication system can be improved significantly by designing redundant equipment setup for master and repeater stations. The two repeater chains are separated by proper dual addressing setup. Slave stations need to be able to communicate with the master through the both repeater chains. By using the "TX address auto switch" function, the slave station modem directs the reply message to the repeater chain from which the request has been received.

If "TX address auto switch" has been set ON (see chapter 9.1.3), radio modem checks out the RX address of the received message. When one of the RX addresses is recognised, all the messages coming in from the serial interface will be sent to the air with matching TX address. The use of "TX address auto switch" function is not recommended if Repeater Function is set ON.

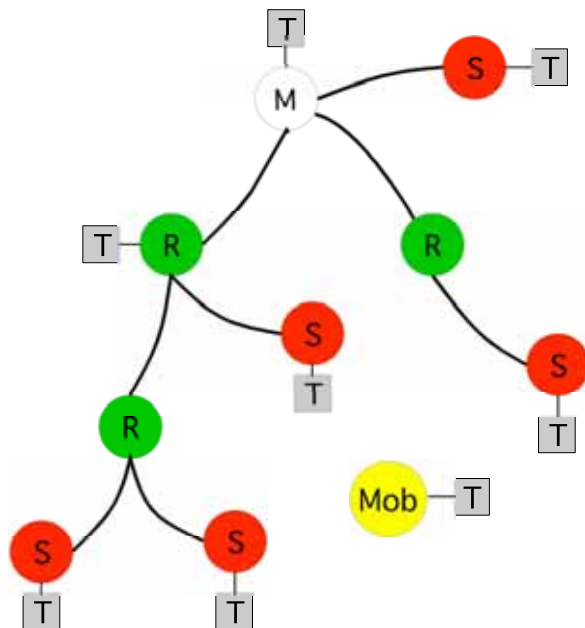
11 MESSAGE ROUTING

11.1 Introduction to Message Routing

Message Routing is an exciting feature in SATELLINE-3ASd Epic Pro and Epic Pro 35W. This feature allows messages from terminal devices to be automatically routed over the radio modem network to a specified recipient terminal.

In brief, the *Message Routing* works as follows:

- o First, a radio modem reads any message coming from the terminal(s) attached to it.
- o The radio modem detects the terminal address of the recipient, by seeking a pre-set position inside the message for the address.
- o The radio modem checks its internal route table to see, if there is route information corresponding the address it has just found.
- o The radio modem transmits a radio frame, which includes
 - o the network id (see later)
 - o the route information
 - o the original user message encapsulated
 - o redundant information such as checksums for error checking etc.
- o The radio modems along the route relay the frame over the network to the radio modem at the destination.
- o The radio modem at the destination first checks the validity of the received radio frame, then extracts the original user message, and finally outputs it the terminal device attached to it.



The figure left illustrates a possible structure of a radio modem network.

M = Master station (Central station)

R = Repeater station

S = Slave station

T = Terminal device

Mob = Mobile terminal

Terminals are usually PLC devices that send and receive messages according to a specific user protocol.

Note: The term *repeater* used in the context of the *Message Routing* should not be mixed with the *Repeater Mode*, which is a feature independent from the *Message Routing*.

11.1.1 Features of Message Routing

The *Message Routing* feature of the SATELLINE-3ASd Epic Pro and Epic Pro 35W is designed to be a fast and transparent to fit real time systems. The features include:

- o Transparent to user protocols.
- o Easy construction of a network containing several repeaters.
- o Any radio modem may operate as a repeater, i.e. dedicated repeaters are not usually needed thus cutting down on costs.
- o Large areas of coverage may be implemented by using only one radio channel.
- o The use of mobile substations is also possible to some extent.
- o The system will be fully deterministic i.e. the transmission delays are predictable. Because of that, the principle of *Message Routing* is connectionless.
- o Added redundancy, as a failing radio modem can be, in certain cases, bypassed with another radio modem positioned in the same coverage area.
- o *Message Routing* is intended mainly for the protocols based on polling scheme and a single master station.

11.1.2 Limitations of Message Routing

- o It is assumed that the position of the address field in the user messages is fixed. However some special protocols are supported:
 - o IEC 60870-5-101 is a protocol commonly used in control applications of power lines.
 - o RP570 protocol
- o The message cannot end to the address; there must be at least one character after the address.
- o It is assumed that there is only one message at a time inside the network simultaneous messages could cause collisions.
- o The max number of the routes depends on the actual hardware and the software version.
- o Operation of the Tx / Rx addresses is automatically blocked in the case of switching the "Message Routing" function on.

11.1.3 Getting started with Message Routing

The design of any radio modem system requires very precise planning. Once the choices between devices, their location, installation, maintenance etc. are clear, the *Message Routing* for the system can be implemented.

Planning your Message Routing System

1. Decide which mode of the *Message Routing* suits the system - *Source Mode* or *Virtual Mode*. See the following paragraphs for details.
2. Design a layout of the system describing the settings such as protocol, addresses of the terminal equipment, radio frequencies and so on.
3. Configure the radio modems accordingly. There are two ways to configure the parameters related to the *Message Routing*:
 - a) *SaTerm* PC-program
 - b) Manual configuration in the setup menu.

In either case, please check the chapter on *Settings* before changing the setup of the radio modems.

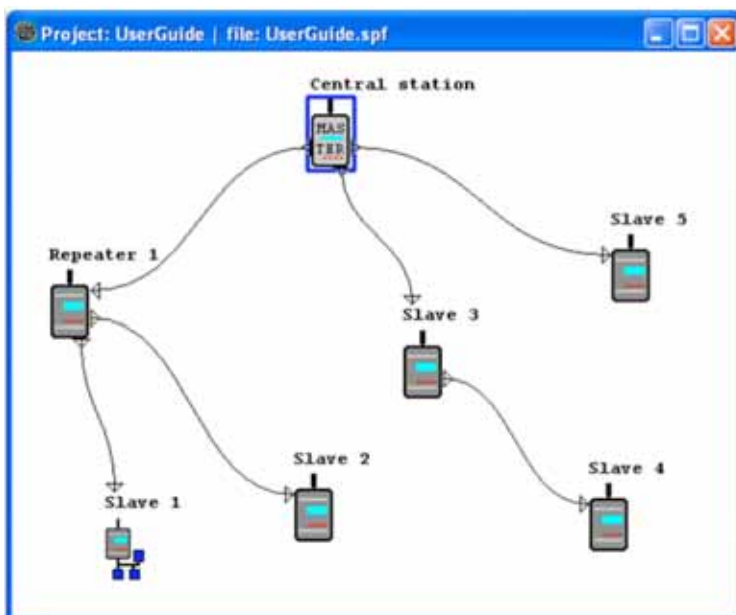
Finally, when all the radio modems have correct settings, they are ready for further installation.

11.1.4 SaTerm and the configuration of the Message Routing

SaTerm is a PC based program that allows the user to design their required network simply and quickly using a graphical interface to literally draw the network plan on the screen.

- o Firstly, a picture of the network is created to show all the radio modems and the intended route that the data is to take.
- o Secondly, the required settings are defined in the drawing.
- o Finally, the setup of each actual radio modem can be uploaded by connecting the actual radio modems one by one to the COM port, switching them to the programming mode, and clicking the transmit button of *SaTerm*.

Please check the user manual of *SaTerm* for more details.



The figure shows a typical snapshot taken from a *SaTerm* screen.

11.1.5 Manual configuration of the Message Routing

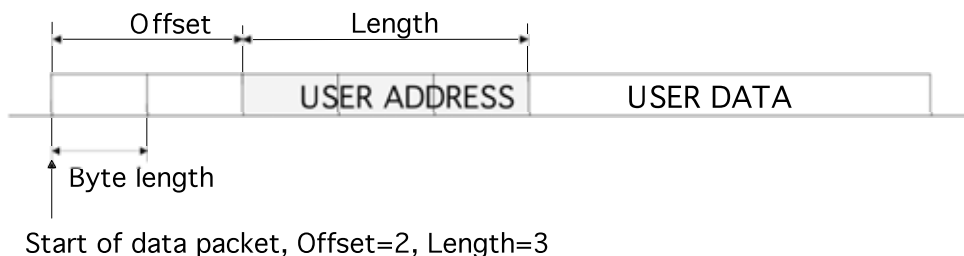
The radio modems can be configured manually via the programming menu. However, this is recommended only if the structure of the network is very simple, or if it is desirable to define such special functions that are not possible to draw using the graphical interface of *SaTerm*. Examples of such cases are for example non tree-structured networks, or the use of same repeaters in several overlapping networks. The operation of the *Message Routing* must be clearly understood before configuring the radio modems manually.

11.1.6 Configuration of the protocol in Message Routing

A radio modem will detect the presence of an address used by inspecting the protocol from the message received via the serial interface. On the basis of this user address, all necessary information needed to relay the message to destination is fetched from an internal routing table inside a radio modem. The user protocol is not interpreted; instead, the user address is searched according to its location in the message. The beginning of the packet is located by a preceding pause in the byte stream. Message Routing can therefore be applied to most protocols with fixed address field position.

The position and length of the address is defined by two settings: *Offset* and *Length*.

- o Offset defines the number of bytes (0...15) preceding the address.
- o Length is the length of the address in the user protocol expressed in bytes (1...4).



A transmitting radio modem adds a routing header and a tail to the user message. Consequently, a radio modem that receives the message removes the header and tail - so the Message Routing scheme is transparent to the user protocol.

11.2 Operating modes of Message Routing

The *Message Routing* has two different operating modes:

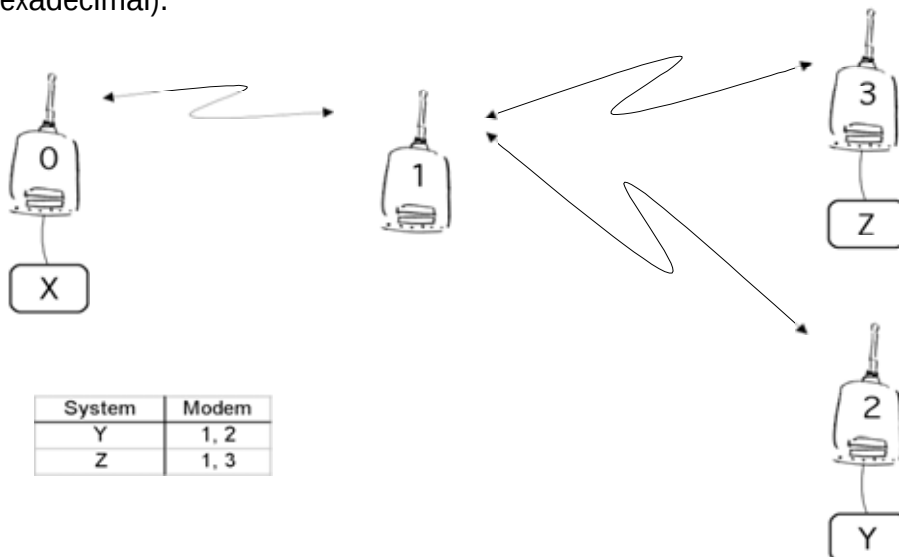
- o *Source Mode Routing*
- o *Virtual Mode Routing*

The most important differences between the two modes are shown in the table below.

Property	<i>Source Mode Routing</i>	<i>Virtual Mode Routing</i>
Summary	Slower, more functions	Faster, less functions
Radio interference tolerance	Yes, over hop function	No
Support for mobile stations	Yes	No
Addition of substations to a network	Only master station needs to be reconfigured	Master station and consecutive repeaters need to be reconfigured
Changing routes	Only master station needs to be reconfigured	All radio modems need to be reconfigured
Maximum length of route	16 hops	No limit
Over hop function	Yes	No
Network ID	Yes	Yes
Storing of routing information	Centralised	Dispersed
Message Routing overhead (bytes)	$10 + 2 \times \text{number of hops}$	9
Maximum length of user protocol message (bytes)	1kB – Message Routing overhead	1kB – Message Routing overhead

Other issues common to the both modes:

- o The maximum number of terminals depends on the radio network structure and the number of routes.
- o Multiple terminal addresses may be attached to a radio modem.
- o The maximum length of a terminal address (in the user's protocol) is four bytes (FFFFFFFF in hexadecimal).
- o The maximum length of the address of a radio modem is two bytes (FFFF in hexadecimal).



11.3 Detailed description of Message Routing

11.3.1 Source Mode Routing

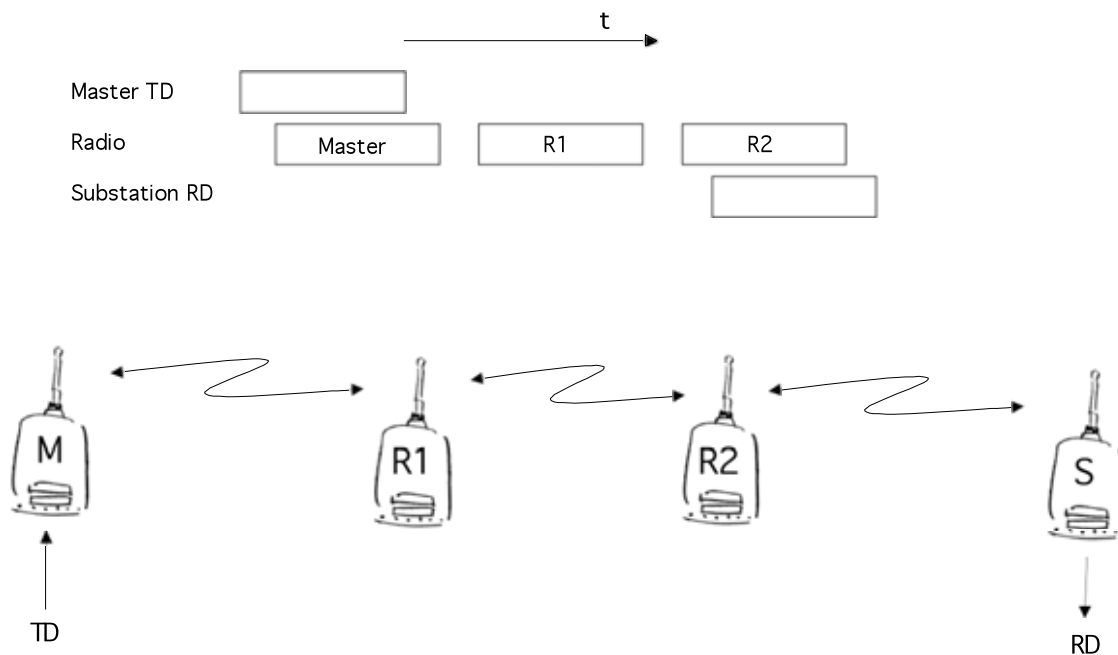
The above figure represents a network containing four (4) radio modems. Each radio modem is given a unique address (0...3). A terminal device has been attached to the three of the four radio modems and they communicate with each other using terminal addresses X, Y and Z, respectively. Radio modem 0 and terminal device X together constitute the base station of the network and all routing information of the network has been programmed into this base station.

When the terminal device X transmits a packet to (e.g.) terminal Y, radio modem 0 will detect the address Y from the data received through the serial port. From the routing table a route 1,2 can be found to which the radio modem also adds its own address to define the route for return data. Radio modem 1 repeats the packet and radio modem 2 removes the address information from the received data packet thereby transferring only the original data to the serial interface. The address information received together with the packet is reversed (2, 1, 0) and saved to be use in the transmission of subsequent reply packets.

11.3.2 Virtual Mode Routing

Please contact SATEL for more information of Virtual Mode Routing.

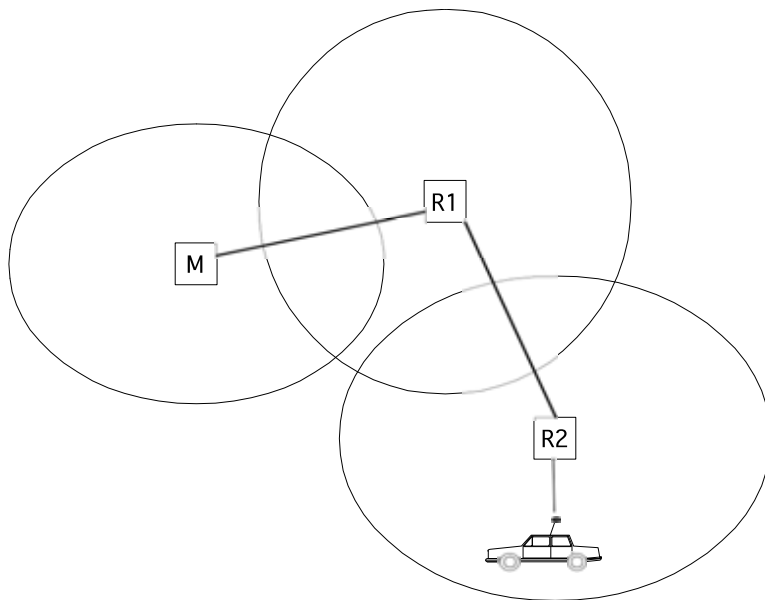
11.3.3 Overhop function in Source Mode Routing



When using repeaters, the same packet is sent via a (radio) channel several times. A radio modem situated in the repeater chain will often hear other radio modems in addition to the immediate neighbouring radio modems. With *Source Mode Routing* the complete address information is sent together with the packets enabling the use of these secondary routes. Usually repeaters have better antennas (and/or antennas placed higher) than normal substations, which means that the distance between two repeaters can be much longer than the distance between a repeater and a substation.

Connections to other than the neighbouring stations of the repeater are not necessarily reliable under all possible (radio) conditions, but they can often be used to keep the network up and running at least partially should a repeater somewhere in the middle of the chain fail. In addition to this, the likelihood of a transmission error decreases if it is possible to listen to more than one transmission since; in this case, it is more likely that at least one of them will be received error-free. It is also possible, that the radio connection is asymmetrical due to the greater output power of a repeater or due to local interference; in which case, data can in fact travel in opposite directions using different routes.

When a repeater receives a message that contains its address but not as the first address in the address field, the packet is stored in a buffer. If the relayed message from the repeater, and the modem having sent the message originally, is not received (due for example, because of radio modem failure or if it has an erroneous checksum), the packet already buffered into the memory is re-sent without any change to the timing (no additional delays are introduced). Because of this, relatively short hop distances can be used, without the likelihood of errors being increasing due to the added number of repeats. A possible error in one of the repeaters does not necessarily cause a total breakdown of traffic.



The over hop function allows for the use of mobile substations. In the example above, a mobile substation is first located in the coverage area of repeater R2. The route is defined as M, R1, R2 and vehicle. When the vehicle moves to the coverage area of repeater R1, the radio modem

picks the packet already from the transmission of R1. This is then transferred to the serial port using an additional delay, so that the timing does not differ from the first situation where the radio modem of the vehicle was in the coverage area of repeater R2. In this way a collision of the reply transmission and the transmission by repeater R2 is prevented. When the mobile station is transmitting, it is enough that at least one radio modem defined to be a part of the route receives the transmission.

11.3.4 Network ID

The Network ID is a string of up to eight characters, which is used to prevent the reception of the messages coming from an external system. The radio modems operating in the same system using *Message Routing* must have the same Network ID. Only the messages that have a matching Network ID are received.

12 SETTINGS

The configuration of SATELLINE-3ASd Epic Pro radio modems can be easily changed. Simply by connecting pin 1 (7-pin. version) or 6 (8-pin. version) to ground (GND) the radio modem will switch into *Programming Mode*.

SATELLINE-3ASd Epic Pro and Epic Pro 35W model contains push buttons and a LCD-display, which can be used to modify configuration settings without the help of an external terminal device. The radio modem will switch into *Programming Mode* by pressing the "SETUP"(■) button.

If the SL-command function has been activated active radio channel and addresses can be changed without switching the radio modem into *Programming Mode*. Serial port settings will remain as those defined previously when the radio modem was in *Programming Mode*.

12.1 Changing parameters using a terminal device

PORT 1 of the radio modem is connected to a terminal device or a PC, which is in terminal emulation state. (This can be accomplished by using a suitable program such as the *SaTerm* program or the Windows™ Hyper Terminal program). Check the wiring of the serial port connection cable. Terminal device serial port settings must be set to 9600 bps, N, 8, 1 (data transfer speed 9600 bps, no parity, data length 8 bits and one (1) stop bit). MODE-pin is then connected to ground (GND). Following this the radio modem will transmit the following message to the terminal (certain configuration settings might differ from the ones shown):

NOTE! Serial Port 2 is not supported.

```
***** SATELLINE-3ASd 3069 EPIC 35W *****
SW version 3.35b / HW: EPCc/TC4q + RA13H4047M
-----
1) Radio frequency  469.00000 MHz ( CF 469.00000 MHz, spacing 25 kHz )
2) Radio settings   TX power 5 W / Signal threshold -112 dBm / FCS OFF /
                   TX start delay 0ms / Diversity RX OFF /
                   Compatibility Satel 3AS / Call sign OFF
3) Addressing       RX address OFF / TX address OFF /
                   RX address to RS port OFF / TX address autoswitch OFF
4) Serial port 1    ON / 19200 bit/s / 8 bit data / None parity /
                   1 stop bit
5) Serial port 2    OFF / 9600 bit/s / 8 bit data / None parity /
                   1 stop bit ( RS-232 )
6) Handshaking      CTS Clear to send / CD RSSI-threshold /
                   RTS Ignored / Pause length 3 bytes
7) Additional setup Error correction ON / Error check OFF / Repeater OFF /
                   SL-commands ON / Priority TX / Full CRC16 check OFF
8) Routing          OFF
9) Tests            OFF
A) Restore factory settings
E) EXIT and save settings
Q) QUIT without saving
Enter selection >
```

12.1.1 Changing frequency (active radio channel frequency)

The frequency of the active radio channel can be changed by selecting main menu selection "1". In the example below the frequency is changed (469.0000 MHz -> 470.0000 MHz).

Enter selection >1
<pre>Radio frequency setup ----- Active channel 469.0000 MHz Lower limit band 1 468.0000 MHz Upper limit band 1 470.0000 MHz Lower limit band 2 468.0000 MHz Upper limit band 2 470.0000 MHz Channel spacing 25 kHz Enter new frequency (MHz) or ESC to previous > 470.0000</pre>

A list of frequency values will appear on the screen updated with the new active radio channel frequency value:

<pre>Radio frequency setup ----- Active channel 470.0000 MHz Lower limit band 1 468.0000 MHz Upper limit band 1 470.0000 MHz Lower limit band 2 468.0000 MHz Upper limit band 2 470.0000 MHz Channel spacing 25 kHz Enter new frequency (MHz) or ESC to previous >ESC</pre>
--

Maximum adjustment range of the active radio channel frequency is ± 1 MHz counting from the factory set centre frequency. Because of possible deviations in each country and/or region concerning the authorised use of the frequency spectrum local authorities may limit this adjustment range. SATELLINE-3ASd Epic Pro and Epic Pro 35W radio modems can be supplied with the adjustment range divided into two bands (**Band 1** and **Band 2**), and this feature can be utilised in case it is required to limit the arbitrary adjustment of the active radio channel accidentally to a forbidden value. The centre frequency and the frequency band limiting values are factory set and the user cannot change them. The active channel is selected by entering a numerical value.

NOTE !

Adjustment of the active radio channel of the radio modem to frequencies other than those allocated and/or allowed by local authorities is strictly forbidden. Use or intended use of forbidden frequencies may lead to prosecution and penalties. SATEL is not responsible for any illegal use practiced with any devices manufactured and/or sold by SATEL and is not liable to pay any damages or compensation caused by such illegal use.

12.1.2 Changing radio settings

Radio settings which consist of transmitter output power and receiver sensitivity can be configured by selecting main menu selection "2". In the following example both the transmitter output power (35 W -> 10 W) and the signal threshold level (-112 dBm->-110 dBm) are changed. Please note with SATELLINE-3ASd Epic Pro the output power alternatives are as follows: 1, 2, 5 and 10 W. Selection "4" (Diversity RX) is possible to set ON only with Epic Pro modems.

Enter selection >2	
Radio setup ----- 1) TX power 35 W 2) Signal threshold -112 dBm 3) TX start delay 0ms 4) Diversity RX OFF 5) Free Channel Scan RX Slave / OFF 6) View hardware info 7) Radio compatibility Satel 3AS 8) Call sign OFF	
Enter selection or ESC to previous menu >1	
	TX power setup ----- 1) 5 W 2) 10 W 3) 20 W 4) 25 W 5) 35 W Enter selection or ESC to previous menu >2
Enter selection or ESC to previous menu >2	
	Signal threshold setup ----- Signal threshold -112 dBm Enter new value (80 - 118) or ESC to previous menu > -110
Enter selection or ESC to previous menu >3	

	Set TX start delay setup ----- TX start delay 0 ms Enter new value (0 - 65535 ms) or ESC to previous menu > 100 Radio setup ----- <table border="0"> <tr><td>1) TX power</td><td>10 W</td></tr> <tr><td>2) Signal threshold</td><td>-110 dBm</td></tr> <tr><td>3) TX start delay</td><td>100 ms</td></tr> <tr><td>4) Diversity RX</td><td>OFF</td></tr> <tr><td>5) Free channel scan</td><td>RX Slave / OFF</td></tr> <tr><td>6) View hardware info</td><td></td></tr> <tr><td>7) Radio compatibility Satel 3AS</td><td></td></tr> <tr><td>8) Call sign</td><td>OFF</td></tr> </table> Enter selection or ESC to previous menu >ESC	1) TX power	10 W	2) Signal threshold	-110 dBm	3) TX start delay	100 ms	4) Diversity RX	OFF	5) Free channel scan	RX Slave / OFF	6) View hardware info		7) Radio compatibility Satel 3AS		8) Call sign	OFF
1) TX power	10 W																
2) Signal threshold	-110 dBm																
3) TX start delay	100 ms																
4) Diversity RX	OFF																
5) Free channel scan	RX Slave / OFF																
6) View hardware info																	
7) Radio compatibility Satel 3AS																	
8) Call sign	OFF																

The maximum useable sensitivity of the receiver is determined by the channel spacing (=radio interface data transfer speed) and also by error correction (utilised or not). For further information see Chapters 1.1, 5.5.2, 6.2 and 13.1.

In environments with high levels of interference, and when connection distances are short, it is often beneficial to use a "Signal threshold level" value, which is approximately 10 – 20 dBm above the maximum sensitivity level. This will prevent unnecessary receive attempts caused by noise.

NOTE !

The setting of the transmitter output power of the radio modem to levels in contradiction with transmitter power levels regulated by local or other governmental authorities is strictly forbidden. Use or intended use of forbidden transmitter power levels may lead to prosecution and penalties. SATEL is not responsible for any illegal use practised with any devices manufactured and/or sold by SATEL and is not liable to pay any damages or compensation caused by such illegal use.

Free channel scan settings can be set by choosing the 6) Free channel scan from the menu. The options are as follows:

```
Free channel scan settings
-----
1) Free channel scan mode  OFF
2) Type of modem          RX Slave
3) FCS net ID             0000
4) Rx listen timeout      500ms
5) Channel hop threshold  -110 dBm
6) Beacon interval        1000 ms
7) Beacon disable timeout  0
8) Add new frequency to list
9) Show free scan frequency list
A) Clear frequency list

Enter selection or ESC to previous menu >
```

The hardware information can be seen by selecting 7) View hardware information from radio setup settings. The menu is as follows:

```
Current hardware info
-----
Product version:      xxxx
Logicboard name:      xxxx
Logicboard version:   xxxx
Radioboard name:      Default
Radioboard version:   Default
```

12.1.3 Changing primary and secondary addressing settings

Addressing can be switched ON or OFF with the help of main menu selection "3". In the following example a primary RX-address (receiver address) is switched ON and the corresponding hexadecimal address value is modified ("0000" -> "0020"). The current values of the parameters are displayed and changed in toggle-type fashion by selecting the appropriate parameter selection number from the list displayed. The next menu level will then enable the modification of the values (within allowed limits). Modification of all other primary and secondary transmitter and receiver addresses is done in similar way.

Enter selection >3

Addressing setup
Toggle ON/OFF values. Current value shown.

-
- | | |
|--------------------------------|-----|
| 1) RX address | OFF |
| 2) TX address | OFF |
| 3) RX address to RS port | OFF |
| 4) Change primary RX address | |
| 5) Change primary TX address | |
| 6) Change secondary RX address | |
| 7) Change secondary TX address | |
| 8) TX address autoswitch | OFF |

Enter selection or ESC to previous menu >1

Addressing setup
Toggle ON/OFF values. Current value shown.

-
- | | |
|--------------------------------|--------------|
| 1) RX address | ON 0000/0000 |
| 2) TX address | OFF |
| 3) RX address to RS port | OFF |
| 4) Change primary RX address | |
| 5) Change primary TX address | |
| 6) Change secondary RX address | |
| 7) Change secondary TX address | |
| 8) TX address autoswitch | OFF |

Enter selection or ESC to previous menu >4

RX address setup

RX Address ON 0000/0000

Enter new address (HEX) or ESC to previous menu >0020

The new value is displayed in the menu:

RX address setup

RX Address ON 0020/0000

Enter new address (HEX) or ESC to previous menu >ESC

The address is given in hexadecimal format with four digits and the number of different addresses is thus over 65 000.

12.1.4 Modification of handshaking functions

Handshaking related configuration settings can be modified by selecting the options from the main menu "6". In the following example characteristics of the CTS-line (CLEAR TO SEND -> TX BUFFER STATE), CD-line (RSSI-THRESHOLD -> DATA ON CHANNEL) and RTS-line (IGNORED -> FLOW CONTROL) are changed.

Enter selection >6	
Serial ports 1 and 2 Handshaking ----- 1) CTS line property Clear to send 2) CD line property RSSI-threshold 3) RTS line property Ignored 4) Pause length 3 bytes Enter selection or ESC to previous menu >1	
	Select CTS line action property ----- 1) Clear to send 2) TX buffer state Enter selection or ESC to previous menu >2
Serial port 1 and 2 Handshaking ----- 1) CTS line property TX buffer state 2) CD line property RSSI-threshold 3) RTS line property Ignored 4) Pause length 3 bytes Enter selection or ESC to previous menu >2	
	Select CD line action property ----- 1) RSSI-threshold 2) Data on channel 3) Always ON Enter selection or ESC to previous menu >2
Serial port 1 and 2 Handshaking ----- 1) CTS line property TX buffer state 2) CD line property Data on channel 3) RTS line property Ignored 4) Pause length 3 bytes Enter selection or ESC to previous menu >3	

Select RTS line action property ----- 1) Ignored 2) Flow control 3) Reception Control Enter selection or ESC to previous menu >2
Serial port 1 and 2 Handshaking ----- 1) CTS line property TX buffer state 2) CD line property Data on channel 3) RTS line property Flow control 4) Pause length 3 bytes Enter selection or ESC to previous menu >4
Pause length ----- Current Setting: 3 bytes Enter new value (3...255) to cancel > 4

Now all of the modifications of the example have been performed and the new values are displayed on the menu (see above):

***** SATELLINE-3ASd 3069 EPIC 35W ***** SW Version 3.35b / HW: EPCc/TC4q + RA13H4047M -----	
Current settings -----	
1) Radio frequency	470.0000 MHz (CF 469.0000 MHz, spacing 25 kHz)
2) Radio settings	Tx power level 10W / Signal threshold -110 dBm / FCS OFF / TX start delay 100 ms / Diversity RX OFF / Compatibility Satel 3AS / Call sign OFF
3) Addressing	RX address ON 0020/0000/ TX address OFF / RX address to RS port OFF / TX address autoswitch OFF
4) Serial port 1	ON / 19200 bit/s / 8 bit data / None parity / 1 stop bit
5) Serial port 2	OFF / 19200 bit/s / 8 bit data / None parity / 1 stop bit (RS-232)
6) Handshaking	CTS TX buffer state / CD Data on channel / RTS Flow control / Pause length 4 bytes
7) Additional setup	Error correction ON / Error check OFF / Repeater OFF / SL-commands ON / Priority TX / Full CRC16 check OFF
8) Routing	OFF
9) Tests	OFF
A) Restore factory settings	
E) EXIT and save settings	
Q) QUIT without saving	
Enter selection >	

12.1.5 Special functions

Special functions are modified by selecting from the main menu selection "7". (For further information see the relevant Chapters describing the said functions). The current values of the parameters are displayed and can be modified in toggle-type fashion by choosing the appropriate parameter selection number from the list displayed. The next menu level will then enable the modification of the values (within allowed limits).

Enter selection >7

Additional set-up
Toggle ON/OFF values. Current value shown.

1) Error correction OFF
2) Error check OFF
3) Repeater OFF
4) SL-commands OFF
5) Priority TX
6) Full CRC16 check OFF

Enter selection or ESC to previous menu >ESC

12.1.6 Modification of routing

Configuration settings defining routing can be changed by selecting main menu selection "8".

Enter selection >8	
<pre>Routing Setup ----- 1) Mode OFF 2) Protocol 3) Address 4) Net id 5) Route list 6) Route add 7) Route delete 8) Delete all routes Enter selection or ESC to previous menu >1</pre>	
	<pre>Routing mode setup ----- 1) Disabled 2) Source routing 3) Virtual routing Enter selection or ESC to previous menu >3</pre>
<pre>Routing Setup ----- 1) Mode Virtual routing 2) Protocol Userdefined 01 00 3) Address 0000 4) Net id 5) Route list 6) Route add 7) Route delete 8) Delete all routes Enter selection or ESC to previous menu >2</pre>	
	<pre>Protocol set-up ----- 1. Userdefined 2. IEC60870-5-101 3. RP570/571 Enter selection or ESC to previous menu >1</pre>

User defined address position setup ----- 1) Start position 00 2) Length 001 Enter selection or ESC to previous menu >1	
	User defined address start position setup ----- Current value: 01 Enter new start position (0-16) >02 User defined address start position setup ----- Current value: 02 Enter new start position (0-16) >ESC
User defined address position setup ----- 1) Start position 02 2) Length 01 Enter selection or ESC to previous menu >2	
	User defined address length setup ----- Current value: 01 Enter new length (1-4) >3 User defined address length setup ----- Current value: 03 Enter new length (1-4) >ESC
User defined address position setup ----- 1) Start position 02 2) Length 03 Enter selection or ESC to previous menu >ESC	

The display has now returned to the main menu of the routing settings and it can be seen that the routing mode (*Virtual Mode Routing*) as well as the protocol (USERDEFINED 02 03) have been modified.

Following this, a new address will be modified ("0009" -> "0002") and a new Network ID is defined ("testnet" -> "newname"):

<pre>Routing Setup ----- 1) Mode Virtual routing 2) Protocol Userdefined 02 03 3) Address 0000 4) Net id 5) Route list 6) Route add 7) Route delete 8) Delete all routes Enter selection or ESC to previous menu >3</pre>	
	<pre>Address setup ----- Current routing address 0009 Enter new address (HEX) or ESC to previous menu >0002 Address setup ----- Current routing address 0002 Enter new address (HEX) or ESC to previous menu >ESC</pre>
<pre>Routing Setup ----- 1) Mode Virtual routing 2) Protocol Userdefined 02 03 3) Address 0002 4) Net id 5) Route list 6) Route add 7) Route delete 8) Delete all routes Enter selection or ESC to previous menu >4</pre>	
	<pre>Net id ----- Net id current value: Enter net id (8 char) or ESC to previous menu >newname Net id ----- Net id current value: newname Enter net id (8 char) or ESC to previous menu >ESC</pre>

```
Routing Setup
-----
1) Mode           Virtual routing
2) Protocol       Userdefined 02 03
3) Address        0002
4) Net id         newname
5) Route list
6) Route add
7) Route delete
8) Delete all routes

Enter selection or ESC to previous menu >ESC
```

Selection "5" will produce a list of the routes:

```
Route list
-----
xxx
xxx
xxx

Press any key to return >
```

Selection "6" enables the addition of a route:

```
Route add
-----
Enter destination address (HEX) >
```

Selection "7" enables the removal of a route:

```
Route delete
-----
Enter destination address (HEX) >
```

Selection "8" enables erasure of ALL routing information simultaneously. The menu will then display the following text:

```
Routing Set-up
-----
1) Mode           Virtual routing
2) Protocol       Userdefined 02 03
3) Address        0009
4) Net id         newname
5) Route list
6) Route add
7) Route delete
8) Delete all routes

Enter selection or ESC to previous menu >8

Do you really want to delete all routes?
Press Y key to delete or ESC to cancel >
```

12.1.7 Activating tests

Tests can be activated by selecting main menu selection "9". For more information on tests, see Chapter 5.4. Tests are activated by setting the status of the desired test to "ON" and will remain active until the value of the selection in the menu is returned to the value "OFF".

Enter selection >9	
Tests setup -----	
1) Short block test	OFF
2) Long block test	OFF

NOTE! Message Routing and FCS mode must be disabled in prior to set ON the Test mode.

12.1.8 Restoring factory settings

Selecting main menu selection "A" can restore factory settings.

Enter selection >A	
Restore factory settings -----	
Do you want to restore factory settings? (Y/N)>	

Restoring is confirmed by pressing "Y" (Y=YES) or cancelled by pressing "N" (N=NO). Also the pressing of "ESC" button at any point in the procedure will return the display to the previous (next higher) menu level without restoring factory settings.

12.1.9 Saving modified settings into the permanent memory

All modified settings must be saved into the permanent non-volatile memory of the radio modem before switching out of the *Programming Mode*. Selecting the main menu selection "E" automatically saves the settings:

Enter selection >E	
Configuration saved! Please turn off program mode switch!	

12.1.10 Updating software

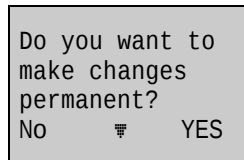
The software of SATELLINE-3ASd Epic Pro and Epic Pro 35W is stored in a flash memory. If needed, the software can be easily updated by SaTerm terminal program. Please see the user guide of SaTerm for more details.

12.1.11 Saving modified values into the internal memory

After all desired modifications have been performed; they have to be saved in order to make them permanent (until next modification). This is accomplished by choosing selection "EXIT" from the main menu. The display will then show a message (see below) asking a confirmation of the performed modifications.

By choosing "YES" all modifications are saved into the non-volatile memory inside the radio modem. By choosing "NO" all modification performed are cancelled and previous settings remaining in the non-volatile memory.

Press "YES" to save all modifications into the non-volatile memory and "NO", if modifications are to be cancelled.



12.2 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 (see chapter 5.3.2) 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 and pin 12 of the serial connector MUST NOT be connected to ground (GND). SL-command is properly recognised also in the case when the command string is terminated in <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 radio modem 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 modem.

When the power of a radio modem is switched off the configuration settings of a radio modem always return to values defined initially using the *Programming Mode*, thus resetting any settings changed using SL-commands during power on. It is however possible to save settings changed by using SL-commands and to make them the new configuration settings.

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.

In order to get information of the special product variant specific SL-commands please contact SATEL Oy.

12.2.1 Frequency

Command	Effect and description of command
SL&F=nnn.nnnnn	Set frequency to nnn.nnnnn MHz
SL&F?	Display current frequency (response 'nnn.nnnnn MHz')
SL&C?	Display centre frequency (response 'nnn.nnnnn MHz')
SL&+ = nnnn	Set frequency nnnn channels above centre frequency Frequency = Centre frequency + nnnn * Channel spacing, where value of nnnn = [0...Number of channels/2] For conventional reasons, only 2 or 4 digit inputs are valid
SL&- = nnnn	Set frequency nn channels below centre frequency Frequency = Centre frequency – nnnn * Channel spacing, where nnnn = [0...Number of channels/2] For conventional reasons, only 2 or 4 digit inputs are valid
SL&N?	Display current frequency deviation from centre frequency as channels (Frequency – Centre frequency)/Channel spacing (response '+ nn' or '-nn')
SL&W?	Display channel spacing / channel width (response 'nn.n kHz')
SL&D=x	Set operational mode of radio. Values of x are: "S" = Single channel: Rx and Tx frequencies are identical. "D" = Dual channel: Rx frequency = Tx Frequency - (lower limit of frequency band1 - lower limit of frequency band 2) "R" = Reverse dual channel: Tx frequency = Rx Frequency - (lower limit of frequency band1 - lower limit of frequency band 2) Command applies only if lower limits of frequency band 1 & 2 match Dual channel operation NOT RECOMMENDED for new systems - firmware variants with separate Rx/Tx frequencies provide better applicability
SL&D?	Get operational mode of radio. "S" = Single Channel (default) "D" = Dual Channel "R" = Reverse Dual Channel

SL!D?	Get lower limit of frequency band 1 Response "nnn.nnnnn MHz"
SL!U?	Get upper limit of frequency band 1 Response "nnn.nnnnn MHz"
SL!W?	Get lower limit of frequency band 2 Response "nnn.nnnnn MHz"
SL!Y?	Get upper limit of frequency band 2 Response "nnn.nnnnn MHz"

12.2.2 Addressing

xxxx = address in hexadecimal format (0000 ... FFFF)

Command	Effect and description of command
SL#I=xxxx	Set all addresses (RX1, RX2, TX1, TX2) to value xxxx
SL#I?	Display both primary addresses (TX1, RX1) (response 'xxxx;yyyy')
SL#T=xxxx	Set both transmit addresses (TX1, TX2) to value xxxx
SL#T?	Display primary transmit address (TX1) (response 'xxxx')
SL#R=xxxx	Set both receive addresses (RX1, RX2) to value xxxx
SL#R?	Display primary receive address (RX1) (response 'xxxx')
SL#Q=x	Set TX address ON/OFF: "0" = TX address OFF "1" = TX address ON
SL#Q?	Display status of the TX address (response '1' on, response '0' off)
SL#W=x	Set RX address on x=1, off x=0
SL#W?	Display status of the RX address (response '1' on, response '0' off)
SL#P=xxxx;yyyy	Set primary transmit address (TX1) to value xxxx and receive address (RX1) to value yyyy
SL#S=xxxx;yyyy	Set secondary transmit address (TX2) to value xxxx and receive address (RX2) to value yyyy
SL#P?	Display primary transmit address (TX1) and receive address (RX1) (response 'xxxx;yyyy')
SL#S?	Display secondary transmit address (TX2) and receive address (RX2) (response 'xxxx;yyyy')
SL#A=xxxx,yyyy, wwwwww,zzzz	Set the addresses to values TX1=xxxx TX2=yyyy RX1=wwwww RX2=zzzz
SL#A?	Display all addresses (RX1, RX2, TX1, TX2)(response 'xxxx, yyyy, wwwwww, zzzz')
SLAxx	Set all addresses (RX1, RX2, TX1, TX2) to value xx [2 binary bytes] NOT RECOMMENDED for new systems
SLHnn	Set active frequency nn [0...99] channels above center frequency Frequency = Center frequency + nn*Channel spacing For conventional reasons, only 2 digit inputs are valid NOT RECOMMENDED for new systems
SLLnn	Set active frequency nn [0...99] channels below center frequency Frequency = Center frequency – nn*Channel spacing For conventional reasons, only 2 digit inputs are valid NOT RECOMMENDED for new systems

SLRxx	Set receive addresses (RX1, RX2) to value xx [2 binary bytes] NOT RECOMMENDED for new systems
SLTxx	Set transmit addresses (TX1, TX2) to value xx [2 binary bytes] NOT RECOMMENDED for new systems

12.2.3 Radio parameters

Command	Effect and description of command
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".
SL@P=xxxxx	Set RF output power (mW) For example "SL@P=100" sets 100 mW transmitter output power. Output power is rounded if given value does not match preset power levels.
SL@P?	Requests the RF output power. Response "xxxxx mW", where xxxxx is a decimal value the output power of the transmitter.
SL@T=-xxx	Set the minimum power level of the signal to be received (= "Signal Threshold level), where xxx is a decimal value of the new intended level in dBm.
SL@T?	Get current signal threshold (dBm). "-nnn dBm" (for example "-80 dBm" or "-112 dBm")
SL@D=x	Set TX delay. Value x = 0...65535 ms
SL@D?	Display TX delay value. Response 'x ms'
SL@F?	Display the current noise level on the radio channel. Response "-xxx dBm".
SL@S=x	Command selects the compatibility mode: "SL@S=0" sets SATEL 3AS (default). "SL@S=1" sets Option1 (PCC-4FSK) "SL@S=2" sets Option 2 (PCC-GMSK) "SL@S=3" sets Option 3 (TrimTalk GMSK) The modem responds with "OK" message if the requested mode is supported, or "ERROR" if the mode is not allowed.
SL@S?	Enquires the active mode. The modem responds with a number: "0" if the mode is SATEL 3AS "1" if the mode is Option 1(PCC-4FSK) "2" if the mode is Option 2 (PCC-GMSK) "3" if the mode is Option 3 (TrimTalk GMSK)
SL@M?	Get repeater function: "0" = Repeater OFF, "1" = Repeater ON
SL@M=x	Set repeater function. Values of x are: "0" = Repeater function OFF "R" = Repeater function ON
SL%F?	Get status of Error correction (FEC) "0" = FEC OFF "1" = FEC ON
SL%F=x	Set Error correction (FEC). Value of x is: "1" Set FEC ON "0" Set FEC OFF

12.2.4 Other functions

Command	Effect and description of command
SL**>	Save current settings as permanent settings. This command must be used only seldom and under controlled conditions in order to avoid the corruption of the settings, which may happen in case the power supply fails in the middle of the memory save procedure.
SL%V?	Get firmware revision information, for example "3.39"
SL%D?	Display modem type (response 'SATELLINE-3AS')
SL%S?	Display modem serial number (response 'nnnnnnnnnn' or 'No Serial nr')
SL%C?	Get product number (or other customer info). If not specified the response is 'No version id'). For more information please contact SATEL Oy.
SL%P = 1	Activate <i>Programming mode</i> without the use of PROG pin. Note that the serial port data speed remains the same as in the data transfer mode.
SL%B?	Requests the serial data parameters, response is a,b,c,d where a = "38400", "19200", "9600", "4800", "2400", "1200", "600", or "300" (defines the baud rate) b = "8", "7" or "9" (defines the character length) c = "N", "E" or "O" (defines the parity) d = "1" or "2" (defines the number of stop bits)
SL%B = a,b,c,d	Sets the serial data parameters for data ports, where a = "38400", "19200", "9600", "4800", "2400", "1200", "600", or "300" (defines the baud rate) b = "8" (defines the character length) c = "N", "E" or "O" (defines the parity) d = "1" or "2" (defines the number of stop bits) Response is "OK" at the original baud rate.
SL + P = xx	Get the measured signal strength from the remote modem i.e. SL "ping". If a remote radio modem is pinged the response is "OK, Modem xxxx rssi -80 dBm", where xxxx=RX1/RX2 address (in case the Tx/Rx addressing is configured) or the terminal address of the modem (in case the Message Routing is ON). "OK" is first received from the current radio modem to acknowledge that the SL-ping command has been interpreted correctly. The rest of the response will take a little longer to come, depending on the length of the radio link. The remote radio modem that is to be pinged does not need to have SL-commands ON. The value of the RSSI is between -118 and -80 dBm. If the signal strength is better than -80 dBm, -80 dBm is shown. If the current radio modem is pinged, the response is "Local OK". Please note that the SL-ping message will come out from the serial line of the radio modem that is pinged and also the repeater stations using the Tx/Rx addressing. Note, SL-ping is a very short message so it may not give accurate results from the link condition. Even if the responses are good, channel interference may cause problems with longer data messages.
SL!B?	Get beacon interval (ms), (decimal number)
SL!B = n	Set beacon interval, n is decimal number (ms)

SL!C?	Get number of channels in FCS list (decimal number)
SL!C0	Clear number of channels in FCS list
SL!F?nn	Get frequency of FCS list channel nn (MHz) (Decimal number in MHz, for example "451.00000")
SL!F=nnn.nnnnn	Add new frequency to FCS list (MHz) Note: Use SL!C0 to clear list before creating an updated frequency list!
SL!I?	Get FCS Net ID, "xxxx" [0000...ffff]
SL!I=xxxx	Set FCS Net ID [0000...ffff]
SL!L?	Get channel hop threshold (dBm) i.e. RSSI trigger level for TX modem to change TX frequency Command is irrelevant in version 3.34 or later - adaptive channel hop scheme has replaced setting's function
SL!L=n	Set channel hop threshold (dBm) i.e. RSSI trigger level for TX modem to change TX frequency [-80...-118] Command is irrelevant in version 3.34 or later - adaptive channel hop scheme has replaced setting's function
SL!M?	Get FCS (Free Channel Scanning) mode "O" if FCS is OFF "M" for master (=transmitter) without repeater in system "S" for slave (=receiver) without repeater in system "E" for master with repeater in the system "R" for repeater "H" for slave with repeater in the system
SL!M=x	Set FCS mode. Values of x are: "O" if FCS is turned OFF "M" for master (=transmitter) "S" for slave (=receiver). "E" for master with repeater in the system "R" for repeater "H" for slave with repeater in the system
SL!N?nn	Show last measured noise on channel nn (dBm) Note: This command applies only to FCS Master modem For example "-112 dBm"
SL!O?	Get beacon disable timeout (seconds)
SL!O= n	Set beacon disable timeout in seconds. If it is zero then beacon is never disabled. If timeout is less than beacon timeout, modem will not send additional beacons.
SL!R?	Get RX listen timeout (ms)
SL!R=n	Set RX listen timeout (ms)
SL!S?	Get beacon time (ms) i.e. time beacon is sent after channel change
SL!S=n	Set beacon time (ms) i.e. time beacon is sent after channel change
SL!T?	Get frequency RSSI measure time for TX modem (ms)
SL!T=n	Set frequency RSSI measure time for TX modem (ms)

SL!X?	Get current transmit frequency
SL*R>	Restore settings to their factory set values
SLSOS	Save current settings as permanent settings NOT RECOMMENDED for new systems
SL!H?	Get radio HW info: "HW:nnnnnn"
SL!V?	Get modem "type" Depending on variant, for example "3AS modem"
SL%C="text string"	Sets p/n (or other customer info) if it is empty (command works only once) P/n must be stored to eeprom with command SL**> (Save settings) Otherwise it will be lost when power is turned off
SL + + ?	Get status of reception control "0" = Reception enabled "1" = Reception disabled
SL + + +	Disable reception
SL + + O	Enable reception
SL + C?	Get modem temperature in Celsius degrees For example "-31", "-2", "7" or "No sensor" if not available
SL + T?	Get status of Transmitter tests "0" = Transmitter tests are OFF "1" = Carrier test is ON "2" = Deviation test is ON
SL + T = x	Activate/Stop transmitter test. Value of x is: "0" = Stop any transmitter test "1" = Transmit Carrier test "2" = Transmit Deviation test

13 INSTALLATION

13.1 Installation of a Radio Data Modem

The radio modem should be installed with the installation accessories supplied with the radio modem.

NOTE!

When selecting a suitable location for the radio modem it is recommended to protect it from direct sunlight. Installation on a strongly vibrating surface should be avoided. Suitable dampening and/or isolation materials should be used in cases where the installation surface will be subjected to vibration.

13.2 Connection cables

NOTE!

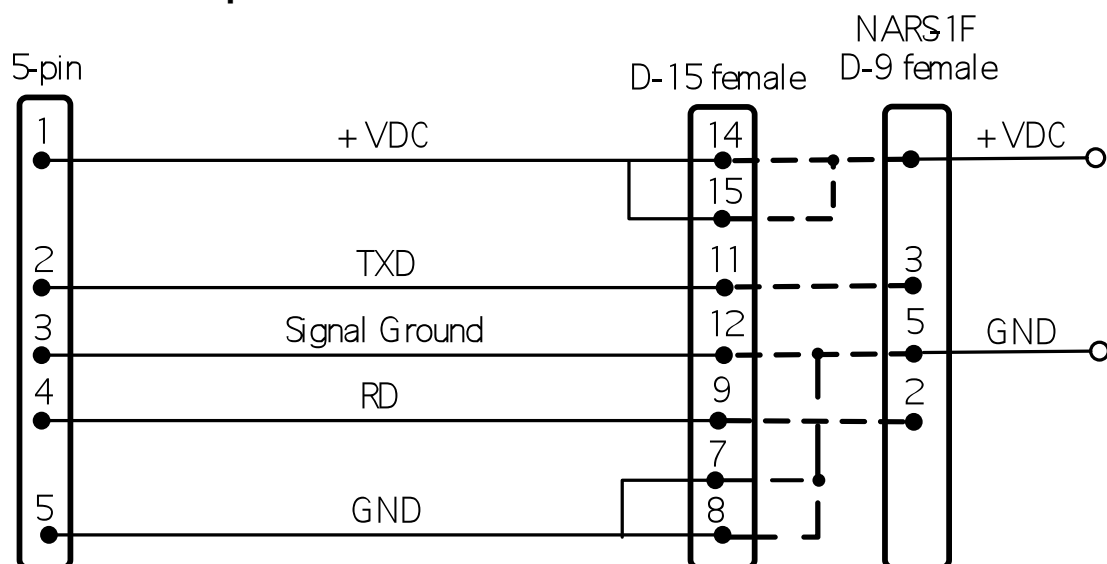
When installing the cables of the serial interface, the operating voltage of all devices must be off (POWER OFF condition).

Due to the greater current consumption of SATELLINE-3ASd Epic Pro 35W operating voltage must be connected to pins 1 AND 2, and ground to pins 3 AND 8. Correct fuse rating is in this case 15 A (SLOW FUSE).

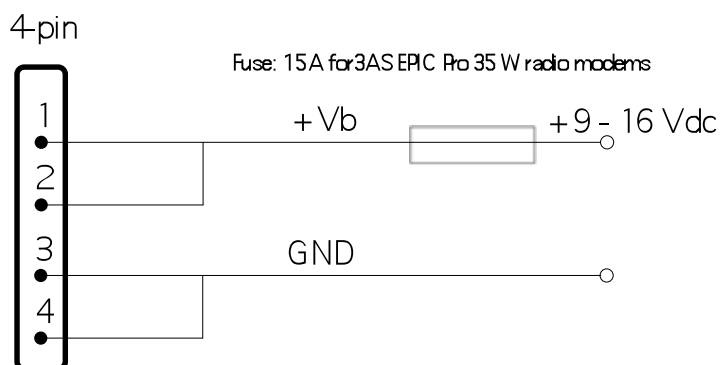
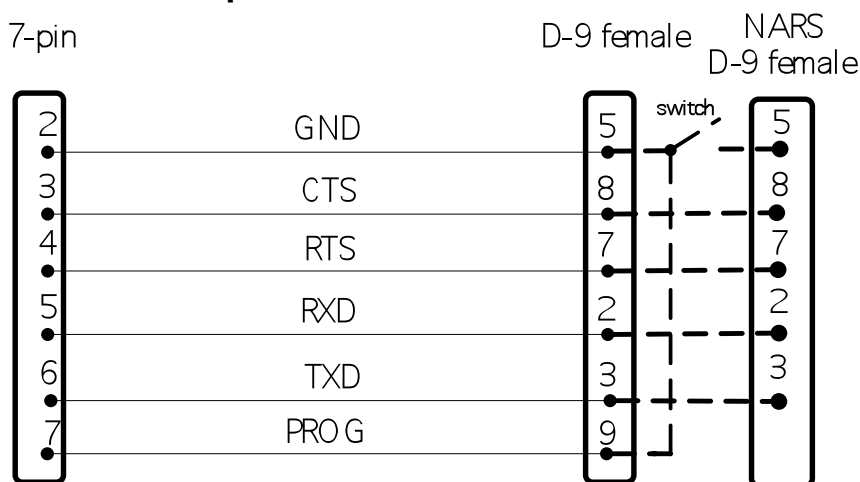
13.2.1 RS-232 wiring

Basic RS-232 connection between the radio modem (PORT1) and a typical PC (COM-port) using handshaking:

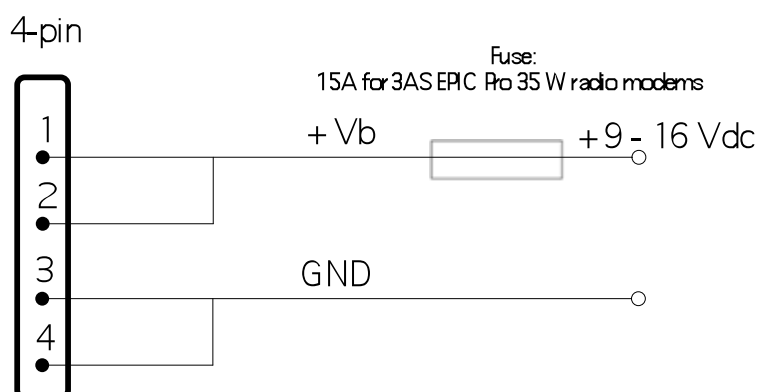
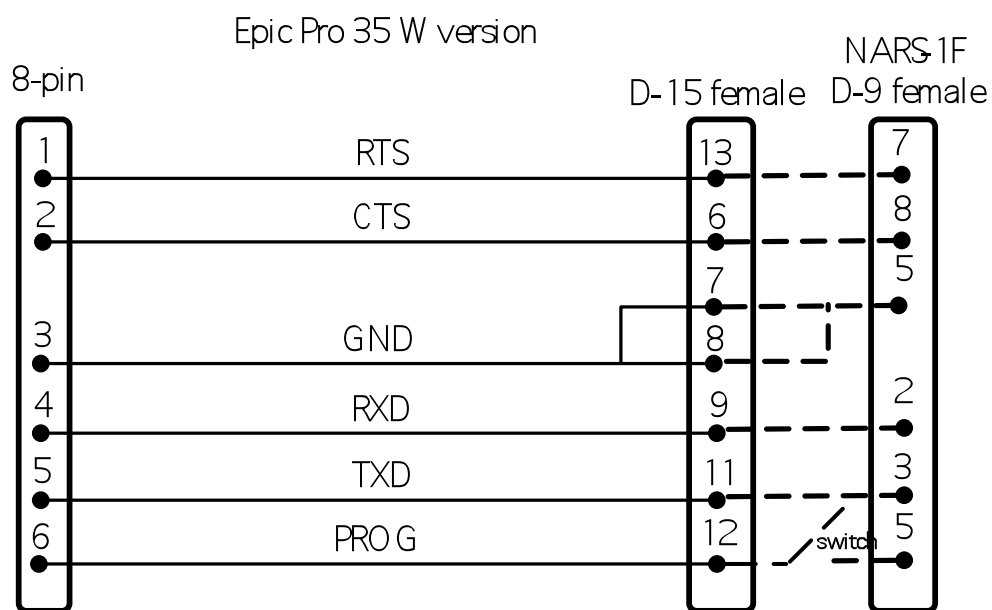
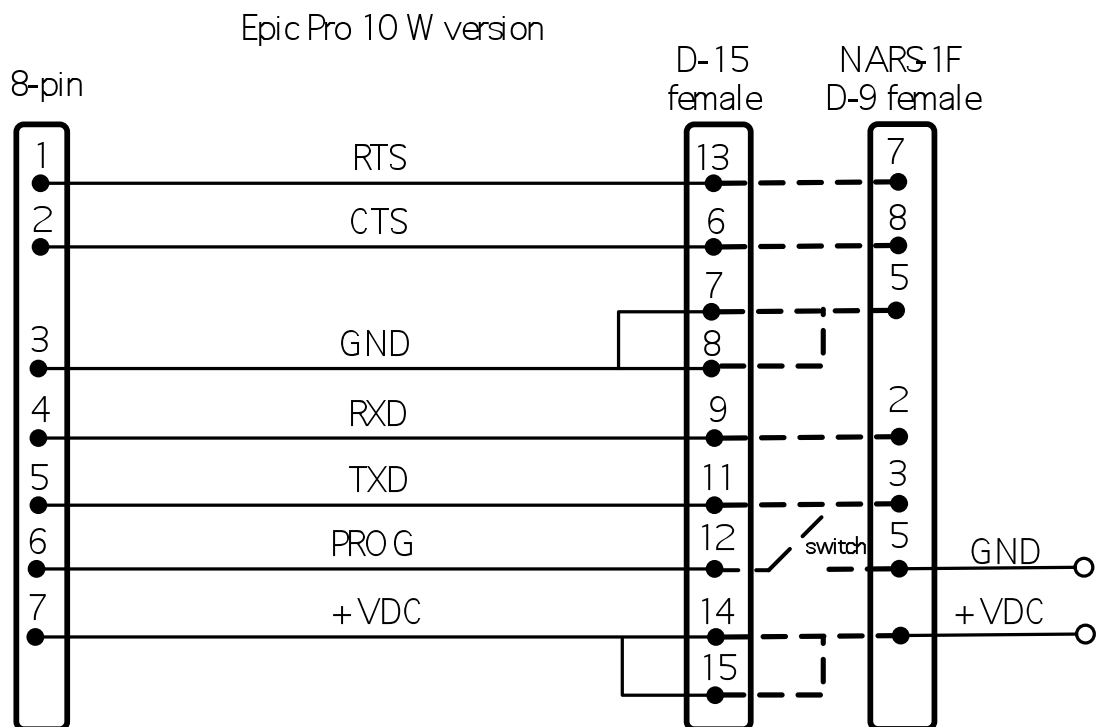
SATELLINE-3ASd Epic Pro



SATELLINE-3ASd Epic Pro 35W



NOTE! In Epic Pro 35W the voltage is limited to 16V.



13.2.2 Fuse

A proper fuse must be connected in between the radio modem and the power supply. The correct value depends on the model (see list below).

	Fuse
SATELLINE-3ASd Epic Pro	4 A slow (in 6,3 A cable), 4A in NARS
SATELLINE-3ASd Epic Pro 35W	15 A

13.2.3 Power supply

The allowed operating voltage is +11.8 ... +30 V_{DC} (**SATELLINE-3ASd Epic Pro**) and +9 ... +16 V_{DC} (**Epic Pro 35W**). The radio modem must only be connected to a power supply with an adequate current output (power rating minimum is 50W, with the Epic Pro, with Epic Pro 35W model 120W). Epic Pro 35W: the pins 1 and 2 of the 4pin Odu-connector are connected to the positive power supply line. The pins 3 and 4 are connected to negative power supply line (ground).

13.3 Antenna installation

NOTE!

Because of the great transmission power of **SATELLINE-3ASd Epic Pro 35W** radio modem, only an external antenna is allowed. A whip-antenna directly connected to the antenna connector must not be used.

13.3.1 Base stations

Omni-directional antennas ($\frac{1}{4}$ - , $\frac{1}{2}$ - or $\frac{5}{8}$ -wave antenna)
Directional antennas (yagi /multi-element antenna or corner antenna)

The antenna should be installed in a vertical position. The exact location of the antenna depends on several factors, such as the size of the overall system and the coverage area terrain contours. A rule of thumb is that the base station antenna should be located at the highest point of the coverage area and as close to the centre of the coverage area as possible. The base station antenna can also be located inside a building, if the walls of the building do not contain metal.

13.3.2 General antenna installation instructions

The reliability and the achievable coverage of useful signal strength can be severely affected by the positioning of the antenna. Antenna and cable connectors should have gold-plated pins and sockets, as use of low quality connectors can lead to eventual oxidation of the connector surfaces, which in turn may degrade the contact and cause additional attenuation. Good quality tools and materials must be used when installing radio modems, antennas and cables. The weather tolerance of the materials used must also be taken into account. Installed materials must withstand all foreseeable weather conditions (frost, excess sun, direct UV-radiation, seawater etc.). Also possible environmental pollution must be considered (acids, ozone etc.).

Antennas must be installed well away from metallic objects. In the case of small antennas this distance should be at least $\frac{1}{2}$ m. With large antennas the distance should be >5 m and in case of repeater antenna combinations >10 m.

If the system contains a large number of radio modems, the best location for an antenna is the highest point of a building and possibly an additional antenna mast. If a separate antenna mast is used, the antenna can, if necessary, be installed sideways about 2...3 m from the mast itself.

When installing an antenna possible interference sources must be considered. Such interference sources are, for example:

- o mobile telephone network base station antennas
- o public telephone network base station antennas
- o television broadcast antennas
- o radio relay antennas
- o other radio modem systems
- o PC-related devices (approximately 5 m radius from antenna)

When ordering antennas we request you to note that antennas are always tuned to a specific frequency range. Simple antennas and antennas, which have been constructed of stacked yagi-antennas, are typically rather broadband. As the number of yagi-elements increases the frequency range becomes narrower. Note this specially with 35W.

When designing and installing a system it is advisable to prepare to test the system, and also to consider serviceability of the system. In particular cabling should be planned to allow easy access and to allow for maintenance. It is often practical to use long antenna cables, so that the radio modem can be installed far enough from the antenna itself to a location that is easily accessible (see section 10).

The type of the antenna cable is dependent on the length of the antenna cable, and the following table can be used to select a suitable type:

Length	Type	Attenuation 10m/450MHz
<5m	RG58	3.0dB
0...20m	RG213	1.6dB
> 20m	ECOFLEX10	0.9dB
> 20m	AIRCOM+	0.8dB*
> 20m	ECOFLEX15	0.6dB

*) AIRCOM+ cable is partially air insulated, so the use of this cable requires that the connection between the cable and the connectors are fully airtight.

If there is a line-of-sight path between the antennas a 6 dB power marginal is usually adequate. However, if the connection is built on the reflection and/or the knife-edge diffraction the path loss can vary even 20 dB depending on the weather conditions. In this case a short test can give a too positive result of the quality of the connection. Thus the height of the antennas and topographical obstacles must be surveyed with great care. From time to time a marginal connection can be used if the data transmission protocol is well prepared for this and the data transmission that occasionally slows down does not cause any problems to the system.

Vertical polarised antennas (antenna elements are in vertical position) are often used in radio systems. In a system between a base station and substations vertical polarisation is recommended. The radio modem antenna cannot be mounted on the same level as the other substation antennas in the same building. The best way to distinguish from the other antennas situated in the neighbourhood is to mount the antennas as far a part as possible from each other on the altitude level. The best result is generally obtained when all the antennas are in the same mast. With an extra ground plane between the antennas more distinction can be obtained between the antennas in the mast.

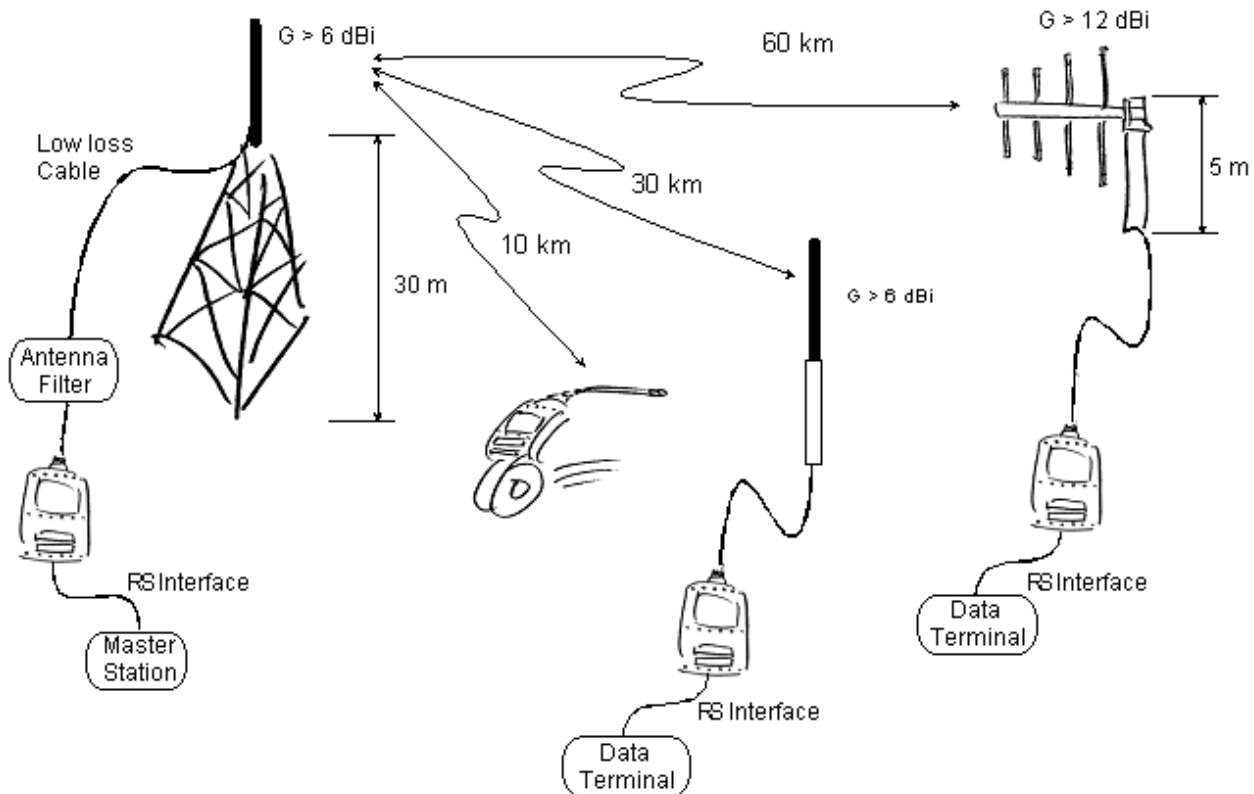
Horizontal polarisation can be used in data transmission between two points. With the polarisation attenuation more distinction is obtained to vertical polarised systems. The influence of the directional patterns of the antennas must, however, be taken into consideration. If a distinction to another interfering antenna is wanted with the horizontal polarised antennas there must be a good attenuation of the back lobe. In addition to this the interfering radiator should be situated behind the antenna.

When a system does not demand the use of an omni-directional antenna it is recommended that directional antennas are used e.g. two-element yagi is in permanent external installations. Please note that as antenna amplification increases the setting of the direction of the antenna requires more attention.

Base stations in high places should be supplied with high-Q cavity filters. Please note that the higher the base station antenna, the larger the coverage area and in turn that the risk of interference is also increased.

SATEL recommends the use of a band-pass filter with a large Q in the antenna cable of the base station.

Example of an antenna installation: by using amplifying antennas (G=Gain) and by installing the antenna high, long connection distances can be realised using the SATELLINE-3ASd Epic Pro / Epic Pro 35W radio modem. The distances in picture are to **Epic Pro 35W**.



14 DESIGNING SYSTEMS

14.1 Factors affecting the quality and distance of the radio connection

- o power of the radio transmitter
- o sensitivity of the radio receiver
- o tolerance of spurious radiation's of the radio modulating signal
- o amplification of transmitting and receiving antennas
- o antenna cable attenuation
- o antenna height
- o natural obstacles
- o interference caused by other electrical equipment

The transmitter power of the base model of SATELLINE-3ASd Epic Pro is 10 W (maximum) (Maximum power of SATELLINE-3ASd Epic Pro 35W is 35W) and the sensitivity of the receiver better than -115 dBm. Thus in a flat area and in free space with a 1/4 wave antenna (antenna amplification 1dBi) and antenna height of 1 m communication distances of 3 to 4 km can be achieved. Distances may be considerably shorter in situations where there are metallic walls or other material inhibiting the propagation of radio waves.

Over long distances, increasing the height of antennas can often solve problems caused by natural obstacles. A ten-fold increase in distance can be achieved with the use of amplifying antennas. Frequent topographical variations over long distances may require that at least one of the antennas be raised to a height of 10 to 20 m.

If the antenna cable is more than 10 meters long it is necessary to use a low loss cable (< 0.7 dB /10 m) in order not to waste the antenna amplification. Adding a repeater station can also solve problematical radio connections. In systems with many base stations the RSSI-signal can be used to assist in choosing the base station with the best signal. A communications network can also be built with a combination of cables and radio data modems.

Epic Pro radio data modems operates in the 450 MHz band, where man-made interference is insignificant. Long distance interference needs not to be taken into account even in special weather conditions.

The SATELLINE-3ASd Epic Pro tolerates normal levels of interference that occur. However, exceptionally high levels of interference can break through the safeguards and thus cause errors in data transfer. In mobile vehicle applications the range of operation can be increased by dividing the transmitted data into e.g. 50...500 byte long blocks and by re-transmitting the defected blocks.

A sufficient safety margin can be obtained by testing the communication path using extra 6 dB attenuation at the antenna connection and with slightly less effective antennas than those to be used in the final system.

14.2 Radio field strength

Radio signal strength must be good enough for successful data transfer. Where field strength is above a certain level, the operational results are very good. Below this level, a few dB marginal areas occur in which errors begin to be generated by noise and interference that will eventually lead to loss of connection.

The field strength is at its optimum level in open space, although increasing distance will still reduce it. It must also be remembered that one open space has different environmental and external factors to another, and that the effects on transmission quality must be taken into account when planning the system.

Ground, ground contours and buildings cause attenuation (loss of energy through absorption) and reflection of radio waves. Buildings reflect radio waves and therefore the affects of attenuation are not as acute when transmission is over a short distance.

However, the reflected waves will often be a bit delayed, and when they combine with the direct radio waves they interact in either a weakening or a strengthening way. This causes the fading effect in mobile systems. In reality very sharp signal drops spaced about 35 cm apart may occur. The attenuation may even reach 40 dB, normally less.

15 CHECK LIST

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.
2. When considering the exact placement of a radio modem and/or its antenna, the following points must be taken into account to guarantee optimal results:
 - a) The antenna should be installed in open space as far as possible from any possible sources of interference
 - b) The radio modem should not be installed onto a strongly vibrating surface
 - c) The radio modem should be installed in such a way as to minimise exposure to direct sunlight or excessive humidity.
3. To ensure reliable operation the voltage output of the power supply used 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 settings (radio frequency, channel spacing and data field length). See Chapter 5.

16 ACCESSORIES

16.1 RS-232 adapters and adapter cables

Type	Description
NARS-1F-4A	D15 male / D9 female with 4A fuse, power supply cables and programming switch
NARS-35	7pin; for Epic Pro 35W only
NARS-ST	8 pin; for Epic Pro and Epic Pro 35W

16.2 Power cable

Type	Description
C-P-35W	0.85m cable, ODU 4-pin male / 4mm lab plugs for Epic Pro 35 W

16.3 RF-cables

Type	Description	Length	Note
CRF-1	Cable with TNC m/TNC f-connectors	1 m	RG58 (3 dB/10 m)
CRF-5F	Cable with TNC m/TNC f-connectors	5 m	RG58 (3 dB/10 m)
CRF-5M	Cable with TNC m/TNC m-connectors	5 m	RG58 (3 dB/10 m)
CRF-15	Cable with TNC f/TNC f 90-degree connector	15 cm	RG58 (3 dB/10 m)
RG213	Low loss cable	X	1.6 dB/10 m
ECOFLEX10	Low loss cable	X	0.9 dB/10 m
AIRCOM+	Low loss cable	X	0.8 dB/10 m
ECOFLEX15	Low loss cable	X	0.6 dB/10 m

Note! In the description, m= male, f= female connector type.

16.4 Antennas

Antennas for **Epic Pro**:

Type	Description
GAINFLEX 400-430	Half-wave antenna
GAINFLEX 430-470	Half-wave antenna
CA420Q	Sleeve fed quarter wave whip, 2dBi, 405–440 MHz
CA450Q	Sleeve fed quarter wave whip, 2dBi, 440-475 MHz
MINIFLEX 400-430	Helix antenna
MINIFLEX 430-470	Helix antenna

Antennas for Epic Pro 35W:

Type	Description
CA420O	Omnidirectional coaxial dipole, 2 dBi, 405-440 MHz
CA450O	Omnidirectional coaxial dipole, 2 dBi, 440-475 MHz
CA405GP+	Omnidirectional ground plane, 6 dBi, 401-409 MHz
CA410GP+	Omnidirectional ground plane, 6 dBi, 406-414 MHz
CA420GP+	Omnidirectional ground plane, 6 dBi, 416-424 MHz
CA430GP+	Omnidirectional ground plane, 6 dBi, 426-434 MHz
CA435GP+	Omnidirectional ground plane, 6 dBi, 431-439 MHz
CA440GP+	Omnidirectional ground plane, 6 dBi, 436-444 MHz
CA445GP+	Omnidirectional ground plane, 6 dBi, 441-449 MHz
CA450GP+	Omnidirectional ground plane, 6 dBi, 446-454 MHz
CA460GP+	Omnidirectional ground plane, 6 dBi, 456-464 MHz
CA470GP+	Omnidirectional ground plane, 6 dBi, 465-475 MHz
CA400Y	Directional yagi, 6 dBi, 380-410 MHz
CA420Y	Directional yagi, 6 dBi, 405-440 MHz
CA450Y	Directional yagi, 6 dBi, 440-475 MHz
CA400Y+	Directional yagi, 8 dBi, 380-410 MHz
CA420Y+	Directional yagi, 8 dBi, 405-440 MHz
CA450Y+	Directional yagi, 8 dBi, 440-475 MHz

SATEL antenna selection includes also directional and/or omni-directional antenna. These can be supplied separately on request.

16.5 Filters and lightning protectors

If a radio modem system is installed in an environment that contains high-power transmitters or sources of radio frequency interference, it is highly recommendable to insert suitable filters between each radio modem and its antenna. If a station is installed to a location exposed to lightning, it is recommended to insert a lightning protector to the feed-line outside the protected zone. SATEL Technical Support can give guidance in the selection of suitable products.

17 APPENDIX A

ASCII CHARACTER TABLE											
D	H	A	D	H	A	D	H	A	D	H	A
0	0	NUL	43	2B	+	86	56	V	129	81	
1	1	SOH	44	2C	,	87	57	W	130	82	
2	2	STX	45	2D	-	88	58	X	131	83	
3	3	ETX	46	2E	.	89	59	Y	132	84	
4	4	EOT	47	2F	/	90	5A	Z	133	85	
5	5	ENQ	48	30	0	91	5B	[	134	86	
6	6	ACK	49	31	1	92	5C	\	135	87	
7	7	BEL	50	32	2	93	5D	]	136	88	
8	8	BS	51	33	3	94	5E	^	137	89	
9	9	HT	52	34	4	95	5F	_	138	8A	
10	A	LF	53	35	5	96	60	`	139	8B	
11	B	VT	54	36	6	97	61	a	140	8C	
12	C	FF	55	37	7	98	62	b	141	8D	
13	D	CR	56	38	8	99	63	c	142	8E	
14	E	SO	57	39	9	100	64	d	143	8F	
15	F	SI	58	3A	:	101	65	e	144	90	
16	10	DLE	59	3B	;	102	66	f	145	91	
17	11	DC1	60	3C	<	103	67	g	146	92	
18	12	DC2	61	3D	=	104	68	h	147	93	
19	13	DC3	62	3E	>	105	69	i	148	94	
20	14	DC4	63	3F	?	106	6A	j	149	95	
21	15	NAK	64	40	@	107	6B	k	150	96	
22	16	SYN	65	41	A	108	6C	l	151	97	
23	17	ETB	66	42	B	109	6D	m	152	98	
24	18	CAN	67	43	C	110	6E	n	153	99	
25	19	EM	68	44	D	111	6F	o	154	9A	
26	1A	SUB	69	45	E	112	70	p	155	9B	
27	1B	ESC	70	46	F	113	71	q	156	9C	
28	1C	FS	71	47	G	114	72	r	157	9D	
29	1D	GS	72	48	H	115	73	s	158	9E	
30	1E	RS	73	49	I	116	74	t	159	9F	
31	1F	US	74	4A	J	117	75	u	160	A0	
32	20	SP	75	4B	K	118	76	v	161	A1	
33	21	!	76	4C	L	119	77	w	162	A2	
34	22	"	77	4D	M	120	78	x	163	A3	
35	23	#	78	4E	N	121	79	y	164	A4	
36	24	\$	79	4F	O	122	7A	z	165	A5	
37	25	%	80	50	P	123	7B	{	166	A6	
38	26	&	81	51	Q	124	7C		167	A7	
39	27	'	82	52	R	125	7D	}	168	A8	
40	28	(	83	53	S	126	7E	~	169	A9	
41	29	)	84	54	T	127	7F		170	AA	
42	2A	*	85	55	U	128	80		171	AB	
									172	AC	
									173	AD	
									174	AE	
									175	AF	
									176	B0	
									177	B1	
									178	B2	
									179	B3	
									180	B4	
									181	B5	
									182	B6	
									183	B7	
									184	B8	
									185	B9	
									186	BA	
									187	BB	
									188	BC	
									189	BD	
									190	BE	
									191	BF	
									192	C0	
									193	C1	
									194	C2	
									195	C3	
									196	C4	
									197	C5	
									198	C6	
									199	C7	
									200	C8	
									201	C9	
									202	CA	
									203	CB	
									204	CC	
									205	CD	
									206	CE	
									207	CF	
									208	D0	
									209	D1	
									210	D2	
									211	D3	
									212	D4	
									213	D5	
									214	D6	
									215	D7	
									216	D8	
									217	D9	
									218	DA	
									219	DB	
									220	DC	
									221	DD	
									222	DE	
									223	DF	
									224	E0	
									225	E1	
									226	E2	
									227	E3	
									228	E4	
									229	E5	
									230	E6	
									231	E7	
									232	E8	
									233	E9	
									234	EA	
									235	EB	
									236	EC	
									237	ED	
									238	EE	
									239	EF	
									240	FO	
									241	F1	
									242	F2	
									243	F3	
									244	F4	
									245	F5	
									246	F6	
									247	F7	
									248	F8	
									249	F9	
									250	FA	
									251	FB	
									252	FC	
									253	FD	
									254	FE	
									255	FF	

18 APPENDIX B

18.1 Functional delays

Function	Delay (ms)
Wakeup time from STAND-BY to ON (controlled by DTR line)	200
Serial interface, turnaround time of RS-232	0
Intercharacter delay	max. 2-3 characters
SL-Ping response time from remote modem	129

SL-Ping response time (typical) in Source Routing network:

t = SL-Ping response time from router

router.count = Count routers from master to router/slave to ping

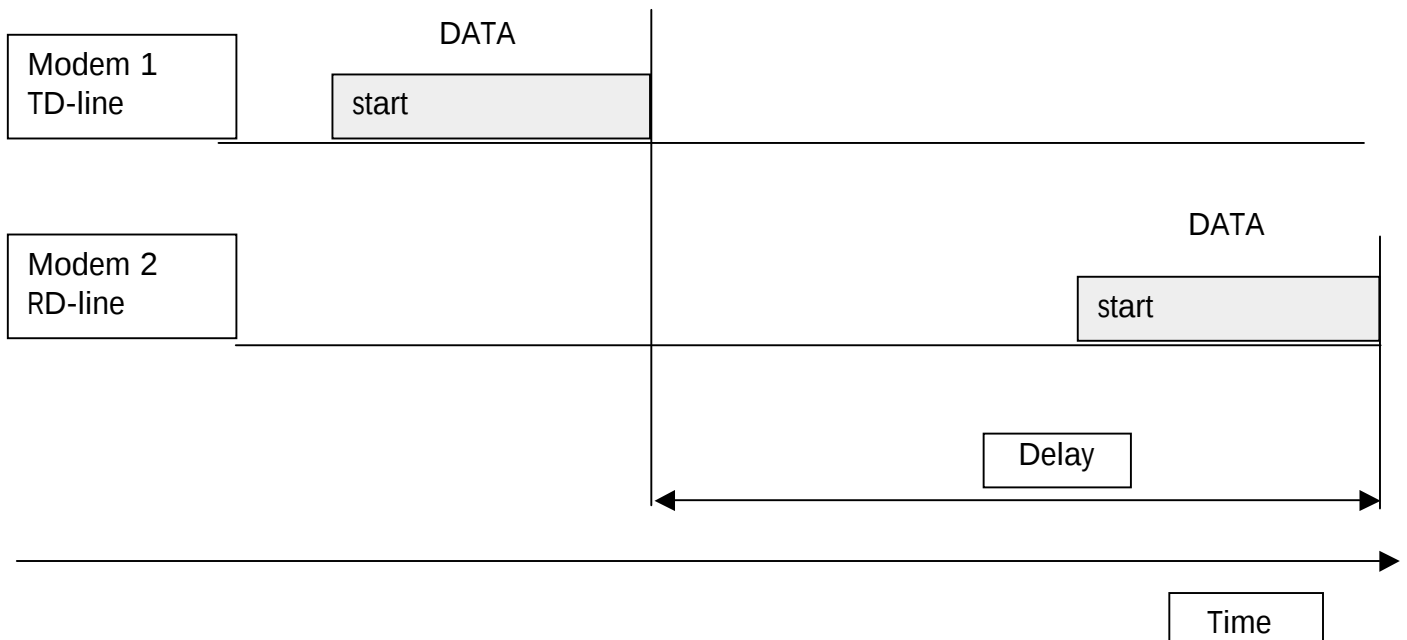
Response time from router/slave = $(t * (\text{router.count} + 1) + 1 \text{ ms})$

Example Response time from slave behind two routers

$(129 \text{ ms} * (2 + 1)) + 1 \text{ ms} = 388 \text{ ms}$

18.2 Transmission related delays

Delay from the end of transmission to the end of reception on the serial interface:



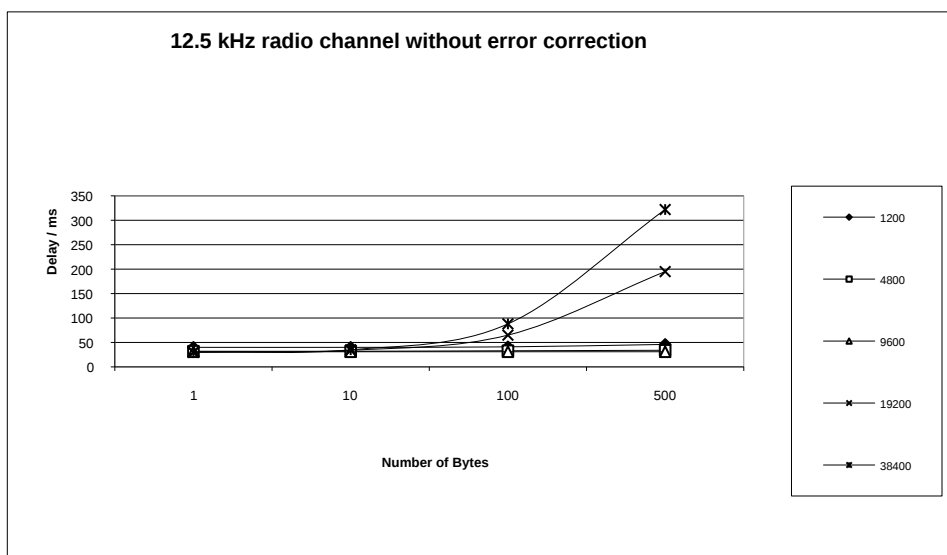
18.2.1 Transmission delays when using a 12.5 kHz radio channel

Transmission delays (ms) without FEC-function (Forward Error Correction).

Number of bytes sent

Bps	1	10	100	500
1200	38	38	38	38
4800	33	32	32	32
9600	31	31	31	31
19200	31	33	65	195
38400	31	36	88	322

Delays are in milliseconds and with a 10% margin.

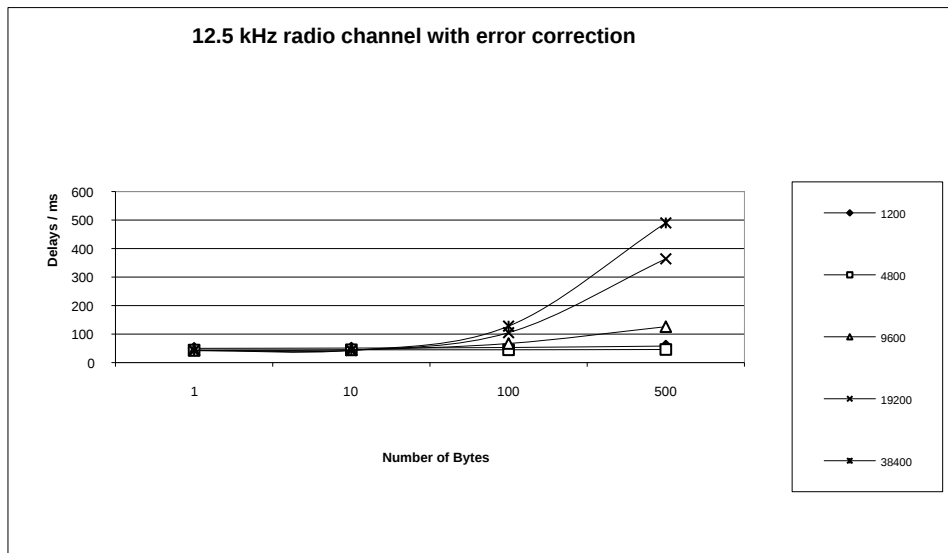


Transmission delays with FEC-function (Forward Error Correction).

Number of bytes sent

Bps	1	10	100	500
1200	50	50	51	50
4800	44	44	44	44
9600	43	43	66	126
19200	43	42	104	364
38400	47	46	132	496

Delays are in milliseconds and with a 10% margin.



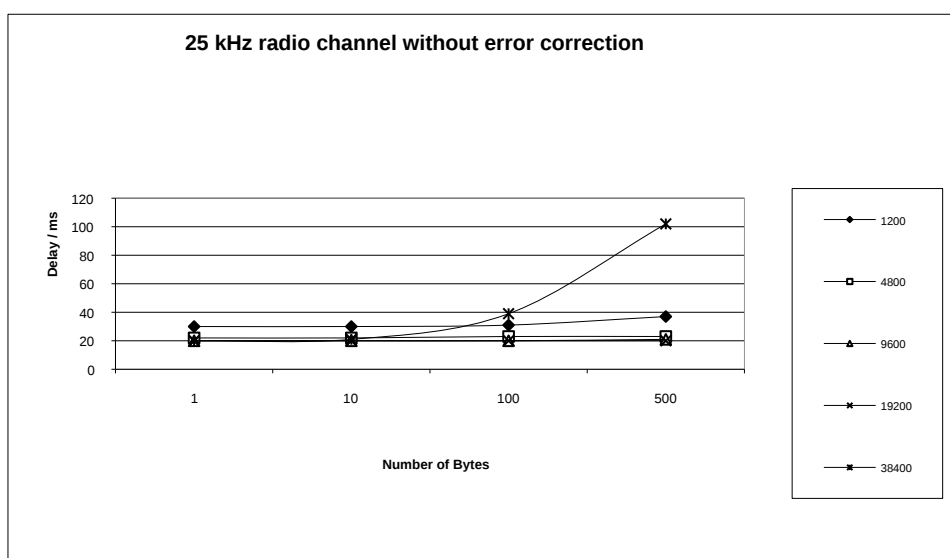
18.2.2 Transmission delays using a 25 kHz radio channel

Transmission delays without FEC-function (Forward Error Correction).

Number of bytes sent

Bps	1	10	100	500
1200	28	28	28	28
4800	22	22	22	22
9600	21	21	21	21
19200	23	23	22	23
38400	25	23	36	101

Delays are in milliseconds and with a 10% marginal.



Transmission delays with FEC-function (Forward Error Correction).

Number of bytes sent

Bps	1	10	100	500
1200	34	34	34	34
4800	28	28	28	28
9600	27	32	28	31
19200	35	31	35	64
38400	33	33	57	185

Delays are in milliseconds and with a 10% margin.

