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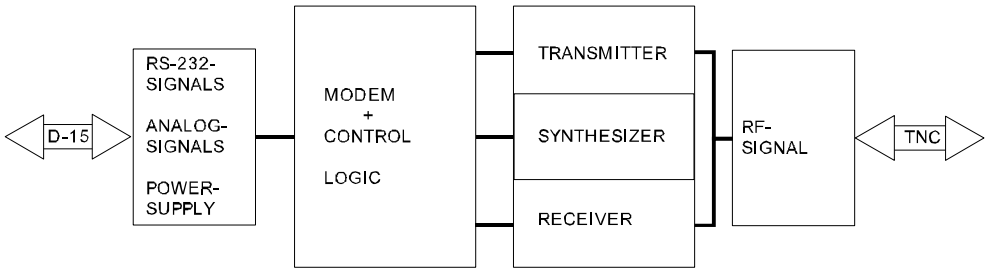
**** Due to a continuous product development SATEL OY reserves the right to change specifications without notice ****

1 SATELLINE-2ASx radio data modem

The information in this user guide concerns both SATELLINE-2ASx and SATELLINE-2ASxm2 models. In this user guide we call both models SATELLINE-2ASx. The two models are electrically identical. They only difference is in the design of the housing.

1.1 Radio data modem



The SATELLINE-2ASx radio data modem consists of a 450 MHz:n transmitter, a receiver, a synthesizer and a modem board, housed in a compact weather resistant aluminium casing. The modem has an RS-232 interface which provides the flexibility to connect it to a wide variety of data networks and terminal equipment.

The SATELLINE-2ASx operates similar to a cable although data transmission is half duplex. When planning a radio data modem installation it is important to take into account turn around delays in the radio modems and possible radio interferences. The most important RS-232 signals for operation of the radio data modem are indicated by LEDs.

Typical applications of the SATELLINE-2ASx are:

- Replacing an RS-232-cable in situations where installation of a cable is difficult, expensive or even impossible
- Data transmission to and from mobile or portable terminals
- Wireless alarm transmission
- Telemetry
- Remote control
- Transferring text to displays
- For use with Global Positioning System (GPS)
- etc.

With two SATELLINE-2ASx radio data modems it is easy to make up point to point connections. The power level of the transmitter is 0,5 W. It is possible to reach distances from 2 to 30 km depending on topographical conditions and antenna locations. On special request it is possible to manfacture transmitters with the maximum output power of 1,0 W. Country specific laws of radio communication must always be followed.

The radio data modem operates well in data networks where the same channel is used by several mobile terminals. In such systems the protocol can be either polling mode, in which the data communication is controlled through one of the radio modems or multimaster mode, in which any one of the radio modems can initiate data transmission when the radio channel is free.

Due to the incorporation of unique synthesizing techniques the SATELLINE-2ASx is also suitable for systems with several base stations using different channels. The mobile sub stations can easily change frequency for communication with the different base stations. By using this method the coverage area of the system can be enlarged without incurring extra delays due to the capacity of the radio channels.

The handshaking procedure of the SATELLINE-2ASx interface is PC compatible. Most telecommunications programs can be used with the modem in order to transmit data.This feature together with the possibility of programming of the radio data modem via the interface (see paragraph 6) make SATELLINE-2ASx a product with many application possibilities in wireless data communications.

1.2 RS-232 pin connections

D-connector Pin	Line	SD *)	Level	Operation
1	DTR	IN	RS-232	Data Terminal Ready
2	CD	OUT	RS-232	Carrier Detect
3	-			
4	-			
5	RSSI	OUT	s. NOTE	Receiving signal strength indicator
6	CTS	OUT	RS-232	Clear to send
7	GND	-	Ground	Operating voltage negative pole
8	GND	-	Ground	Operating voltage negative pole
9	RD	OUT	RS-232	Receive Data
10	DSR	OUT	RS-232	Data Set Ready
11	TD	IN	RS-232	Transmit Data
12	MODE	IN	open/gnd	Mode Selection
13	RTS	IN	RS-232	Request to Send
14	VB	-	Voltage	Operating voltage positive pole
15	VB	-	Voltage	Operating voltage positive pole

*) SD = Signal direction from the radio data modem , IN = Input and OUT = Output

Operation description of the lines pin by pin:

- DTR operates as an ON/OFF switch of the modem
- CD indicates a signal on the radio channel exceeding the level of sensitivity of the modem (it can record radio interferece signal)
- RSSI measures the received signal strength of the field of the transmitting radio (starts approximately from 1 V and goes up to 5 V). The strength of the field increases with the voltage.

- CTS indicates when the radio data modem is clear to receive data via the RS-interface
- GND is the negative pole of the operating voltage and the signal reference ground
- RD output of received data
- DSR indicates "ON" state of the modem :
- TD input of transmitted data
- MODE selection: when line 12 is open, radio data modem is in DATAMODE and ready for receiving and transmitting data. When the line is connected to ground, radio data modem is turned into PROGRAM MODE
- RTS prevents the transfer of data received by the radio modem to the RD-line (see 2.2 and 6.2.2)
- VB positive pole of the operating voltage

1.3 Technical specifications

Satelline-2ASx complies with the following international standards:
I-ETS 300 220, CEPT T/R 20-04 and CE label (m2)

TRANSCEIVER	
Frequency Range	400...470 MHz / base band 2 MHz
Channel Spacing	25 kHz
Number of Channels	16 (selectable by software via RS-232 interface)
Frequency Stability	< ± 1.5 kHz
Method of modulation	FSK
Transmitter	
Carrier Power	500 mW/ 50 ohm (+ 27 dBm)
Adjustment range	20mW... 1 W / 50 ohm (factory set)
Carrier Power Stability	+ 2 dB / - 3 dB
Frequency Deviation	± 2.5 kHz
Adjacent Channel Power	< 200 nW
Spurious Radiations	I-ETS 300 220
Receiver	
Sensitivity	< -108 dBm (BER < 10 E-4)
Co-channel rejection	> - 8 dB
Adjacent channel selectivity	> 65 dB
Intermodulation attenuation	> 65 dB
Spurious radiations	< 2 nW

DATA MODEM

Interface	RS-232	
Interface Connector	D 15 connector, female	
Data speed	1200 - 9600 bit/s	
Modulating Signal	NRZ	
Data formats	Asynchronous data	
	character length:	10 or 11 bits

GENERAL

Operating voltage	+ 10 ... + 14 Vdc	
Current consumption	When DTR is "0": 3 mA	
	When DTR is "1":	Receiving: 120 mA
		Transmitting: 600 mA
Antenna Connector	TNC, 50 ohm, female	
Size H x W x D	137 x 67 x 29 mm (m2)	
Installation plate	130 x 63 x 1 mm (m2)	
Weight	250 g (m2)	
Temperature range	-25 °C... + 55 °C	

Labelling information:

Ser.no. 96052938 Freq. Ch F 468.200 MHz

SATEL OY

Tel: +358-2-777 7800, Fax: +358-2-777 7810

- Serial number
- Frequency, preset at the factory. F= setting in programming mode. 468.200 MHz is the corresponding frequency.
- Contact information of manufacturer

2 Transmission with the Radio Modem

2.1 Transmission

The Satelline-2ASx is ready to transmit data within 400 ms after the supply voltage is switched on and the DTR line is in the "ON" state.

There are two different methods of initiating data transmission:

1. Transmission based on CTS or CD handshaking
2. Data connected directly to the TD line

1. Transmission based on CTS or CD handshaking is implemented, when the user needs to ensure that the radio channel is free and the modem is ready for transmitting data:
   - CTS line does not turn "ON" if the radio channel is occupied or if the modem is for any reason unprepared for transmission

- CD line turns "ON" if the radio channel is occupied (i.e. another transmission or a powerful interference is being effected on the same channel)

****

NOTE !

CTS does not automatically follow the CD line. CTS line is controlled by an receiving signal in the intern programming of the radio data modem (= programmable data squelch)**.** Only real received data turns the CTS "OFF". This feature enables data transmission also in interfering circumstances.

****

2. Transmission connected directly to the TD line can be used when:

- The required channel is completely free from other transmissions or overlapping transmissions are prevented
- The interval between data messages is sufficient (exceeds 60 ms with data speed of 9600 bit/s). This is required to empty the data buffer of characters from the previous transmission
- The delay between Rx/Tx is taken into account by switching from receiving to transmission (after receiving the last character a delay exceeding 10 ms before transmitting the first character when data speed is 9600 bit/s, not valid if the radio modem is in the state of immediate response (see 6.2.2**)**
- Data packets are short (less than 100 bytes)
- In transmitting long data packets (more than 100 bytes) the terminal should be set in a state using two (2) stop bits and the radio modem in a state where the total number bits of the character is one less than in the terminal. (Prevents the filling up of the buffer).

If the connection between the radio data modems breaks in the middle of the transmission i.e. as a result of a weak field, the radio modems can be reconnected by breaking the transmission and starting a new one.

2.2 Reception

The Satelline-2ASx is ready to receive data within 400 ms after the supply voltage is switched on and the DTR line is in the "ON" state.

Equipment connected to the radio data modem receives information of incoming data by detecting changes in the state of the RD line. Start of reception can also be detected from the CTS and CD lines. (See 2.1)

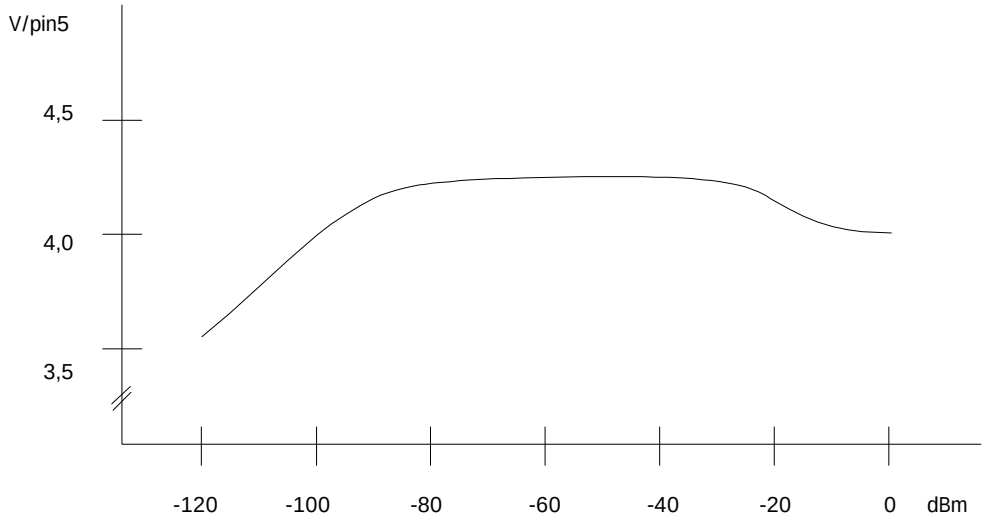
In case of interference or external equipment effecting the functions of the radio modem it can be necessary to prevent the radio modem from receiving. In simplex data transmission reception can be switched off in the transmitting part of the system. This prevents the possible external interferences preventing the transmission. (See 6.2.2)

In systems with several radio modems the reception of data can be stopped with the RTS line, by setting the "RTS line active" bit as "1" in the programming mode. (Compare with 6.2.2) When the RTS line is non active the reception of data from the RD line is interrupted. In this state the radio modem waits for new messages and the changing into transmission is unsuccesful.

2.2.1 RSSI signal

Received Signal Strength Indicator, RSSI, (D connector pin 5) announces the received field strength of the signal. This signal can be used for the approximate determination of the signal level.

In the following figure is the typical voltage level as a function of the signal level.



2.3 Delays during data transmission

When using a radio data modem, certain delays occur in data transmission and reception. (see appendix 2A and 2B).

The delays with **data speed of 9600 bit/s** are:

v Wakeup time of DTR OFF/ON	400 ms
v Rx /Tx turn around time	3...6 ms
v Rx /Tx turn around time immediately responding state (see operating mode table, bit 7)	< 0.1 ms
v Tx /Rx turn around time	10...60 ms (depends on the length of the data packet and differences in data speed between DTE and the radio data modem)
v Delay of a point-to-point connection (TD - RD delay)	18...20 ms

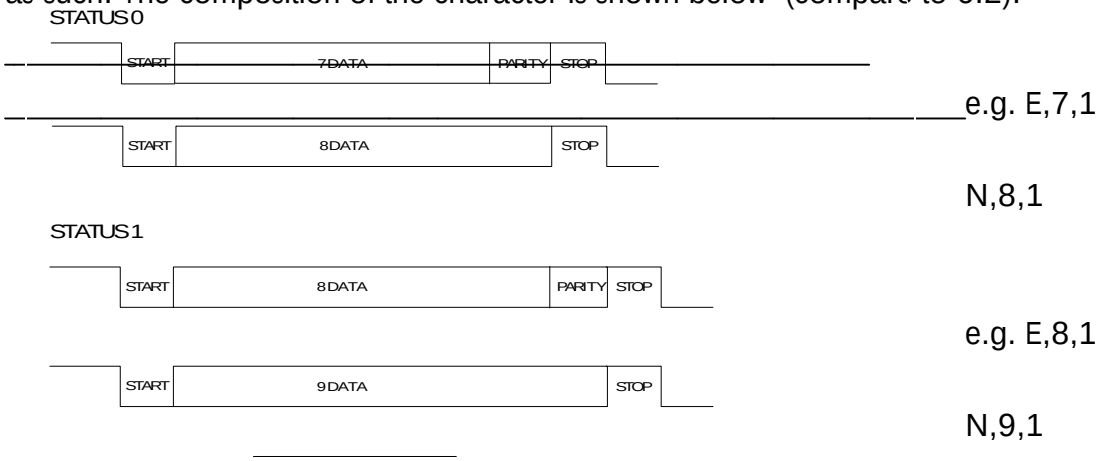
It is possible to use the radio modem in a state , where the Rx/Tx turnaround delay is close to 0. This state can be activated by programming the "immediate response" bit to position "on".

> NOTE
>
> Turn around delays and connection delays double (approx.) by halving the data speed. (The wake-up time is unchanged)

3 Asynchronous Data Transmission and Data Speed

3.1 Asynchronous character

The asynchronus data characters are in accordance with the ANSI-standard (e.g. ASCII), which according to the length of the character are divided into two groups. In STATUS 0 the character length is 10 bits including start, data, parity and stop bits and in STATUS 1 the character length is 11 bits. The radio data modem repeats the parity bit as such. The composition of the character is shown below (compare to 6.2):



3.2 Data speed

The data speeds of the SATELLINE-2ASx are 1200 - 9600 bit/s**.**

The data speeds from 1200 bit/s to 9600 bit/s are available for transmission of data with the radio modem. The data speed can be selected from the table of operating states. There is one bit for every available data speed. If more than one of the bits of data speed are selected the data speed is the slower one. If no data speed is selected it is 9600 bit/s.(compare to 6.2.2).

If the character length is incorrectly set, errors will appear in transmission. At reception they appear as "error characters" or as an incorrect operation of the modem

If the data transmission is in conflict with the selected form there will be errors in transmission. These errors will appear as false characters or inaccurate operation.

4 Relay Station Using One Radio Modem

Short data packets of maximum 106 bytes (SW version 5.06 135 bytes) can be relayed using one radio modem. The relay feature has to be set on in the programming mode. In the relay state the radio modem works as an independent unit. When a radio modem is used only as a relay station it requires a power supply and an antenna. No other equipment is needed.

A radio modem working as a relay station can also be used for transmission and reception of data. In the relay state the radio modem receives data in the same way as usual. However at the same time it memorizes the received data. After finishing the reception of data the radio modem does not turn back to the state where it observes the interface lines. It transmits directly the received and memorized data on the same channel and with the same settings as received. At transmission of data from the RS-line the functions of the radio modem do not differ from a normal radio modem.

There can be several relay stations in the same system and under the same base station. The relay stations can also be grouped in a chain, wherein the message goes via several relay stations. It is necessary to use addresses of the radio modem in a system with several relay stations.

5 Using of Address in Data Communication

5.1 General

It is possible to use addresses in both transmitting Tx and receiving Rx. The address consists of two data characters (altogether 16 bits). The addresses can either be the same in both directions or when needed the transmitting and the receiving addresses can be different.

The addresses can be selected separately in both directions. It is also possible to transfer the received address to the RS interface.

Transmission

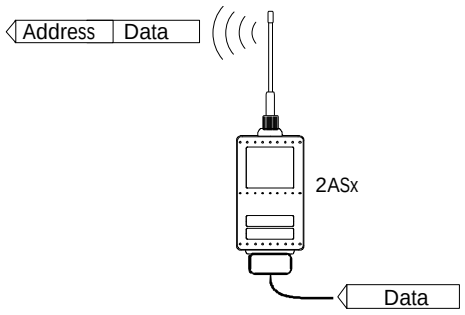


Fig 1 Address of transmission has been set ON. Radio modem will add the address to the beginning of data packet.

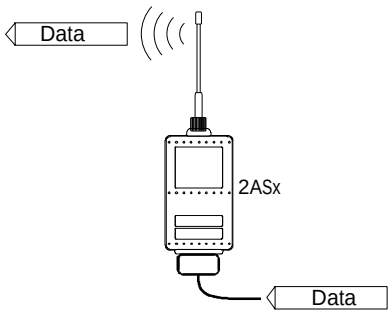


Fig 2 Address of transmission has been set OFF. Radio modem will transmit data packet without the address.

Reception

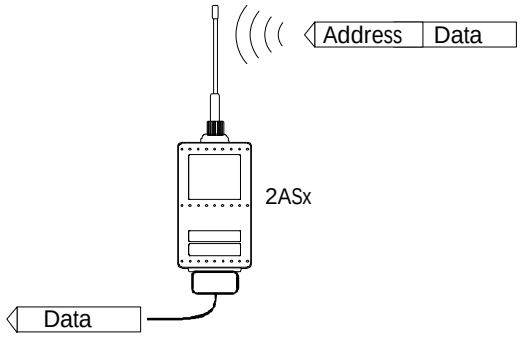


Fig 3 Address of reception has been set ON, and address of radio modem is identical to address of received data message.
Radio modem will remove the address from the beginning of data packet and will send data to RS-232 interface.
But if the 6th bit of Group II (programming mode) is on, radio modem will send also the address to interface.

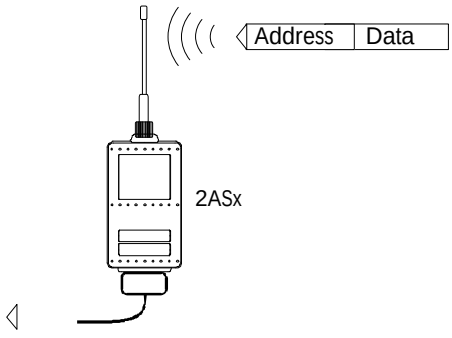


Fig 4 Address of reception has been set ON, but the address of radio modem is different from the address of the received data message. Radio modem will prevent data packet from being transferred to RS-232 interface.

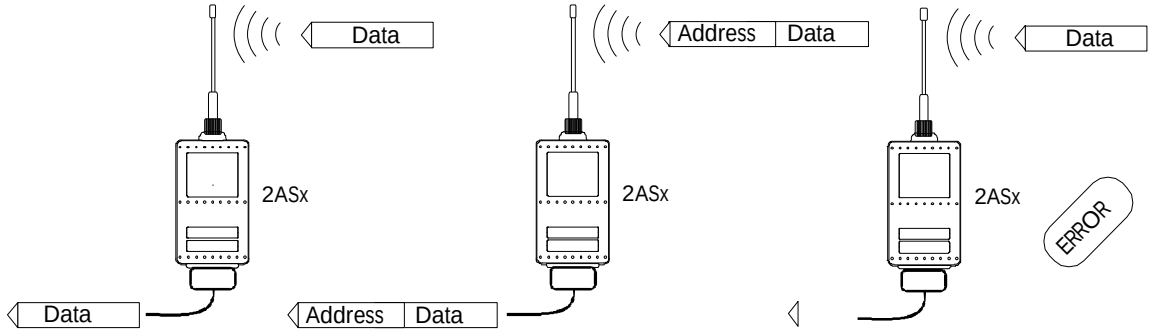


Fig 5 Address of reception has been set OFF.
Radio modem will transfer all received data to RS-232 interface.

Fig 6 Address of reception has been set OFF.
Radio modem will consider characters of the address to be a part of data and will send all characters to RS-232 interface.

Fig 7 Address of reception has been set ON but there is no address in the data packet.
Radio modem will transfer data to RS-232 interface ONLY if the first 2 characters match to its own address. Radio modem will remove those 2 characters from data.

The address consists of the first two characters of the data packet, that the radio modem adds to every sent packet and/or checks from every received packet. (compare to paragraph 6.3.1 SLAxy command, where ADD H corresponds to x and ADD L corresponds to y)

ADD H	ADD L	DATA

5.2 The connection between two points

In connecting two points it is advisable to set both the receiving and the transmitting addresses as same in both radio modems. This is the easiest way to control the addresses and the risk of interference from other systems working in the same area is minimal.

The use of address is not necessary if a special channel is reserved for the use in the area or if the terminal takes care of addressing.

5.3 A system with one base station and several sub stations

In a system with serveral sub stations it is necessary for the base station to know to which of the sub stations the message has to be sent and from which sub-station the message is received. When planning the system there are at least two different possibilities to make use of the addresses in the radio modem. It is also possible that the terminals take care of addressing and in this case the feature of the radio modem is not needed.

The address of the base station can always be changed when transmitting from one sub-station to another. In this case the base station can only listen to one sub-station at a time. In a polling system it is possible to use this arrangement because the radio modems communicate with each other in pairs.

In a system with Carrier Sense Multiple Access (CSMA) it is not possible to use the addresses at the base station as the addresses would prevent the base station to hear all the sub stations. It is useful to change the address of the base station according to the sub-station in a polling system. It is the terminal of the base station that should take care of the addition of addresses and checking of data packets.

In these applications the radio modem at the base station is left without an address and the radio modems at the sub stations are set with both the transmitting and the receiving address. The software of the base station must be able to treat the addresses given by the base station and to add to the data packet the addresses of the sub stations.

5.4 A system with one relay station

In systems with several relay, sub and base stations it is necessary to use addresses in the radio modems specially if there are more than one relay station. A system with only one relay station can be built without using the addresses. However the message will be duplicated on the communication route (the base station hears the messages from both the sub-station and the relay station).

There are at least two alternative ways to use the addresses depending on the programmability of the equipment and the number of relay stations and their position to each other.

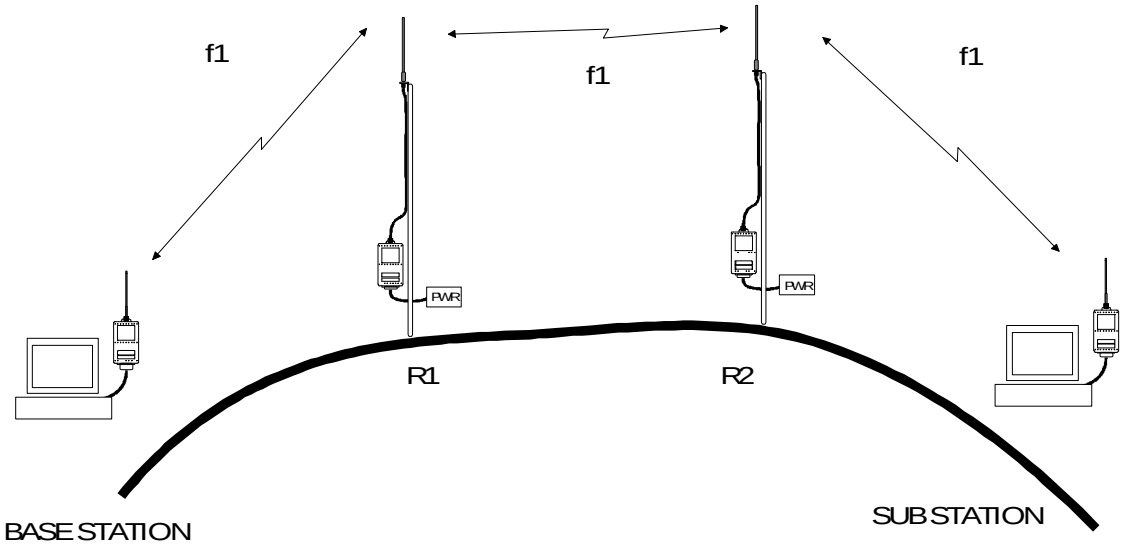
5.4.1 The alternating address of a pair of radio modems

When neither the terminal nor the substations are able to generate address fields, but they can recognize the message addressed to them, the addresses of the radio modems can be alternating. The alternation of transmitting Tx and receiving addresses Rx of the radio modem change according to the following table.

	Base station address	The address of relay station 1 and sub stations of the base station	The address of the sub-station of the relay station 1
Tx address	address 1	address 2	address 1
Rx address	address 2	address 1	address 2

In an alternating system the routing of the radio modem is set at the time of installation. The order of the address must be set according to the wished routing of the message. In systems with alternating addresses please note, that the base station and the sub-station hear their own message repeated.

5.5 A system with several relay stations



In systems with several adjacent or parallel relay stations addresses should be used. This prohibits moving around of the message and secures that only the determined radio modem receives the message.

The base station and sub-station terminals create a chain of addresses. The address is used in the following way in routing the message:

R1 ADD	R2 ADD	S ADD	DATA

- the message from the radio modem at the base station to the terminal that contains the addresses of the relay stations and the sub-station (R1 ADD is the address of the unit consisting of 2 characters)

R2 ADD	S ADD	DATA

- the message from the relay station 1 to relay station 2 (goes automatically only if the receiving address is programmed)

S ADD	DATA

- the message from the relay station 2 to sub-station 4 (goes automatically if only the receiving address is programmed)

DATA

- the message received from sub-station 4 (goes automatically if only the receiving address is programmed)

The address is created in the same way when the sub-station replies the base station but the routing is the other way round :

R2 ADD	R1 ADD	B ADD	DATA

6 A. Programming of Satelline-2ASx SW version 4.4x and 5.0x

6.1.A General

There are several features in radio data modem SATELLINE-2ASx that can easily be changed. The mode of the radio data modem must be changed before choosing between different features. Normally SATELLINE-2ASx is in DATA MODE, when line 12 of the D connector is open.

When line 12 is connected to ground (GND) radio data modem is turned into PROGRAM MODE.In the PROGRAM MODE the settings of the serial port are 9600 bps, N, 8,1. In this mode the features of SATELLINE-2ASx can be changed in the way described in chapter 6.2.

If the COMMAND PROGRAM MODE is activated the channel and address can be selected without moving into the PROGRAM MODE. Settings of the serial port in the command program mode are those set at the selection table. In this mode the features of SATELLINE-2ASx can be changed in the way described in chapter 6.3.

6.2.A Programming mode

Connect radio data modem to a terminal or a PC that is in terminal mode. Check that data speed is 9600 bps and the length of the ASCII code N,8,1. Switch the line 12 into ground (GND). Radio data modem provides the terminal with the following message:

Display	Comment
SATEL OY * Salo, Finland tel: +358-2-777 7800 * SATELLINE-2ASx SW Version 4.4x and 5.0x	
	Modem announces program version and the selectable settings
1) TX Address is FFFF	Transmission address
2) RX Address is FFFF	Reception address
3) Mode is 00000000 00000000	
4) Channel is 0D	
*) Available channels are F,E,D,C,B,A,9,8,7,6,5,4,3,2,1,0	Available channels
Change a new value (1-4/n) ? *1*	If change of settings is desired, give 1-4 If no changes desired, give n to get out of the programming mode

6.2.1.A Programming of address

The address can be programmed in the programming mode either in position **1** (TX address) or in position **2** (RX address).

Display	Comment
Set a new value ? 1234	Set a new address 1234 HEX

Address is given in hexadecimal form in which case the number of different address combinations exceeds 65.000. There is a selectable address in the radio data modem which can be used both at reception and transmission. In one radio data modem the address can be the same or in some special cases (e.g. in relaying) also different in transmitting and receiving. In case a communication between two radio data modems is wished to be established with addresses (=they only communicate between each other), the same address must be set in both modems e.g. "1234".

The use of an address will be cleared in the selecting table.

6.2.2.A Programming of operating mode

The operating mode can be programmed in the programming mode in position 3.

Display	Comment
Set bits one by one ? *00100001 00000000*	The setting is written bit by bit starting from bit 1.

Settings in program version V4.4 functions are as follows:

Setup bit	Function	"0"	"1"
Group I			
1.bit	RTS line active	off	on
2.bit	Command Program Mode	off	on
3.bit	data speed 9600 bps	off	on
4.bit	data speed 4800 bps	off	on
5.bit	data speed 2400 bps	off	on
6.bit	data speed 1200 bps	off	on
7.bit	immediate response	off	on
8.bit	choosing of the length of character	10 bits	11 bits
Group II			
1.bit	relay state	off	on
2.bit	receiver off	off	on
3.bit	not in use		
4.bit	not in use		
5.bit	not in use		
6.bit	transmission of the received own address into RD-line	off	on
7.bit	address of reception	off	on
8.bit	address of transmission	off	on

6.2.3.A Programming of channel

The selection of channel can be programmed in position 4.

Display	Comment
Set a new value ? *c*	Set channel "C"

Switching the radio data modem to other frequencies than specified in the instructions is strictly forbidden. The use of non-approved frequencies can lead to prosecution by local authorities. Satel is not responsible for any illegal use of its radio equipment.

6.3.A Command program mode

If the command program mode is activated channel and address can be selected directly from the serial port of the radio data modem without connecting pin 12 to ground. The change of settings is effected with the data speed and bit settings that are in current use. However the data part of the character must be 8 bits. The changes are effected with a programming packet, which is a separate packet and may not be included in the transmitted data packet and may not include extra characters. The length of the programming packet should be 5 characters and the length of pause before and after the programming packet must be of 3 characters.

6.3.1.A Programming of address

Programming of both transmitting (Tx) and receiving (Rx) addresses is effected simultaneously by the command

SLAxy

where x and y are characters consisting of 8 bits.

Programming of only receiving address is effected by the command

SLRxy

and of the transmitting address only by the command

SLTxy.

After recognizing the packet of address programming the radio modem sets the CTS signal in a non-active state and saves the new address in the memory. If the saving is succesfully completed the radio modem answers by

OK

If the saving of the address is unsuccesful the modem gives an

Error

message.

6.3.2 Programming of channel

The programming of channel is effected by the commmand

SLC0x

where x is an ASCII character 0-9 or A-F announcing the required channel number. After recognizing the packet for channel programming the radio modem sets the CTS signal in an non-active state and examines if the given channel is on the list of permitted channels. If the channel is permitted the new channel is saved in the memory and the radio is set on the required channel. If the saving is succesfully completed the radio modem answers by

OK

If the channel is not permitted or the saving is unsuccesful the modem gives an

Error

message.

7 Forming of the SL Command

By programming the radio modem with the SL command, please note that the form of the address is different than in the PROGRAM MODE. In PROGRAM MODE the address is given in hexadecimal (values between 0000 and FFFF) e.g. 2BFAh. By programming the radio modem by SL command the address consists of an address two 8 bit characters.

The radio modem requires the SL command as a continous packet. Either a file needs to be created for the command or the application software designed for the radio modem must take care of the continous transmission of the command. If there is a break in the transmission the radio modem interprets the packets as transmitted data.

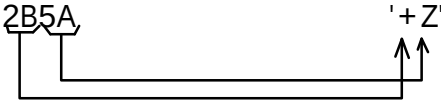
7.1 Forming of the programming packet of the address

If you want to use e.g. address 2B5A hex start by converting the hex value to characters.

This can be done by using a map of characters to convert the numbers (Appendix1). The following character map is for character set PC-8. In case you have another character set in your computer you must use a different character map or use methods given in Example 2.

EXAMPLE 1

Hex. address	*characters*	*SL -packet*
2B5A	'+Z'	'SLA+Z'



Create a file needed for the SL packet and name it e.g. AD_2B5A.TXT. The first line of your file would be :

SLA+Z

You are now able to change the address of the radio modem. Copy AD_2B5A.TXT file to the serial port. Note the settings of the serial port and the radio modem (see DOS *mode* command):

copy AD_2B5A.TXT com1

The file can be sent by using ASCII file transfer in the communications software.

As some of the characters are used for controlling devices, there is no key for them in your keyboard. It is preferable to use the following method if you are not familiar with the character set you are using.

EXAMPLE 2

Hex. address	*dec.values*	*Characters*
0AFF	10, 255	LF, DEL

1. You can use a hex editor to create the address (e.g. PCTools).
2. If you have a PC you can type some of the characters by using ALT key together with a numeric pad. Use a simple DOS editor. Press ALT key, use the numeric pad to enter the decimal value (3 numbers, e.g. 10 ® 010) and release ALT -key.

e.g.

Hex. address	*typing of the corresponding decimal values*
0AFF	ALT (down) 0 1 0 ALT (release) ALT (down) 2 5 5 ALT (release)

7.2 Forming of the programming packet of the channel

If it is necessary to switch the channel to channel A (check that A responses to the correct frequency required)

The file for switching the channel could be e.g. CHAN_A.TXT and the inhalt of the file would in this case be :

SLC0A

You are now able to change the channel of the radio modem. Copy CHAN_A.TXT file to the serial port (it is also possible to use the transfer of ASCII file in terminal programs). Note the settings of the serial port and the radio modem (see DOS *mode* command):

copy CHAN_A.TXT com1

NOTE ! THE SL COMMAND CAN NOT BE USED IN TERMINAL MODE.

YOU MUST CREATE A FILE CONTAINING THE SL COMMAND AND SEND THE FILE TO THE RADIO MODEM.

8 Multi Modem Data Systems

(Chapters 8 to 12 are general instructions applying to all radio modems manufactured by SATEL OY)

8.1 Required sequence of data characters

The data should be transferred in continuous sequences or in sequences divided into blocks. Sequences that are too short (e.g. 1 character) should not be sent because "overhead-information" (synchronization plus terminal address) takes a great deal of processing time and thus slows down the data transmission. The recommended length of a data packet is 50 - 500 characters.

The size of a system using one radio channel can be increased when the timeframe of transmission of one terminal is short. This must be taken into account when planning the

system. The operating range of the system can be extended by increasing both the number of base stations and the number of radio channels.

It is important that only one transmitter can be active on the same channel at the same time.

8.2 Polling

The system can be configured as a "Master-Slave" network which allows one radio modem to control the others in the system. Slave units can communicate to the Master during the time allocated to that Slave by the Master unit.

The advantage of the polling mode is that collisions (i.e. simultaneous transmissions) do not occur. The disadvantage of this method is that the transmitter of the Master is switched on half of the time in situations, where there is no data transmission from mobile to Master.

A polling protocol is not included in the transparent radio modem. It is a protocol of higher hierarchy and supplied by the system.

8.3 Multi Master

The system can also be configured as a "Multi-Master" network. In this situation any radio data modem can start transmission after first testing either by the CTS line or the CD line that the radio channel is free.

The advantage of this system is that the transmitter is ON only during data transmission. The disadvantage is that if all the mobile stations do not "hear" each another collisions may occur.

A multi master protocol is not included in the transparent radio modem. It is a protocol of higher hierarchy and supplied by the system.

9 Planning a Radio Modem Network

9.1 Factors affecting quality and distance of the radio connection

- power of radio transmitter
- sensitivity of radio receiver
- tolerance of spurious radiations of the radio modulating signal
- amplification of transmitting and receiving antennas
- antenna cable rejection
- height
- natural obstacles
- interferences caused by radio frequencies

The transmitter power of the base model of SATELLINE-2ASx is 0.5 W and sensitivity of receiver more than -108 dBm. Thus in a flat area and in free space with a 1/4 wave antenna (antenna amplifcation 1dBi) and an antenna height of 1 m communications from 3 km 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, problems caused by natural obstacles can often be solved by raising the height of antennas. 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 needs to be raised to a height of 10 to 20 m.

As the placement of the antenna at the base station is more than 10 m from the modem it is necessary to use a low loss cable (< 0.7 dB /10m) in order not to waste the antenna amplification. Problematical connections can also be solved by adding another intermediate station for relay. In systems with many base stations an RSSI-signal would assist in choosing the best receiving base station. A communications network can also be built with a combination of cables and radio data modems.

The SATELLINE-2ASx radio data modem operates in the 450 MHz band, where interference caused by human beings is insignificant. Long distance interferences need not to be taken into account even in special weather conditions.

The SATELLINE-2ASx eradicates normal levels of interference that occur. However, exceptionally high levels of interference can break through the safeguards and thus cause errors on transmssion. In mobile vehicle applications the range of operation can be increased by dividing the transmitted data into e.g. 50...500 bits blocks and by retransmitting defected blocks.

A sufficent safety margin can be obtained by testing communications using an extra 6 dB rejection at the antenna connection and with slightly less effective antennas than those to be used in the final system.

9.2 Radio field strength

A successful radio transmission depends essentially on the radio field. Where field strength is over a certain level the operational results are very good. Below this level, a few dB marginal areas may occur in which errors begin to be generated by noise and interference which will eventually lead to loss of connection.

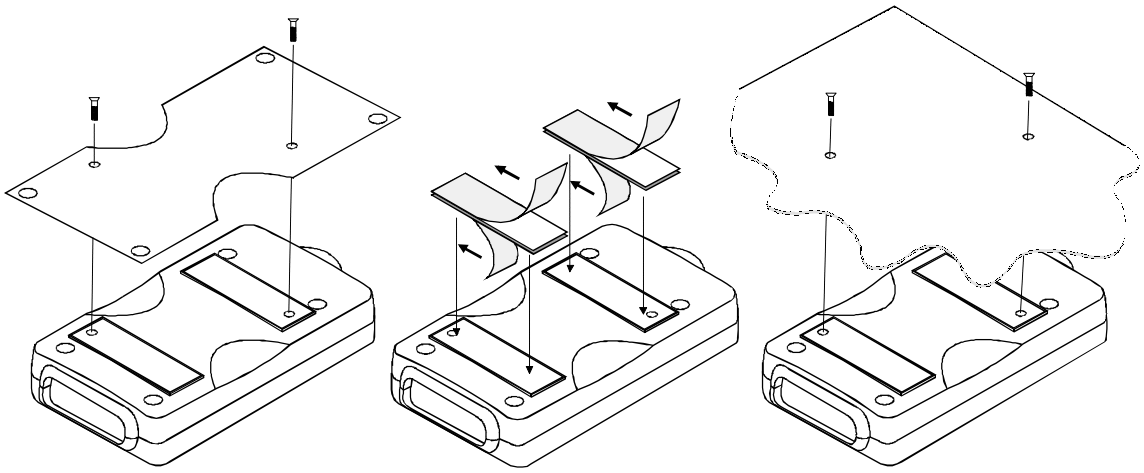
Whilst in an open space, the field strength is at its optimum level, although it will still be reduced by distance. It must also be remembered that one open space has different environmental and external factors to another, and that the affects on transmission quality must be taken into account when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

Ground, ground contours and buildings cause attenuation (loss of energy through absorbtion) and reflections 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 suffer a loss in power once they travel over a certain distance, this means that they combine with the direct radio waves and interact in either weakening or strenghtening the signal respectively. In reality attenuation can even occur at 40 dB which is very sharp and the effect on the 450 MHz frequency is about 35 cm difference.

10 Installation

The radio modem is to be installed with the installation accessories supplied with the radio modem.



1. By using the installation plate, that should be fastened on the back side of the radio modem. The installation plate can be mounted using the holes provided on installation plate .

2. By using the velcro-type tape supplied with the radio modem.

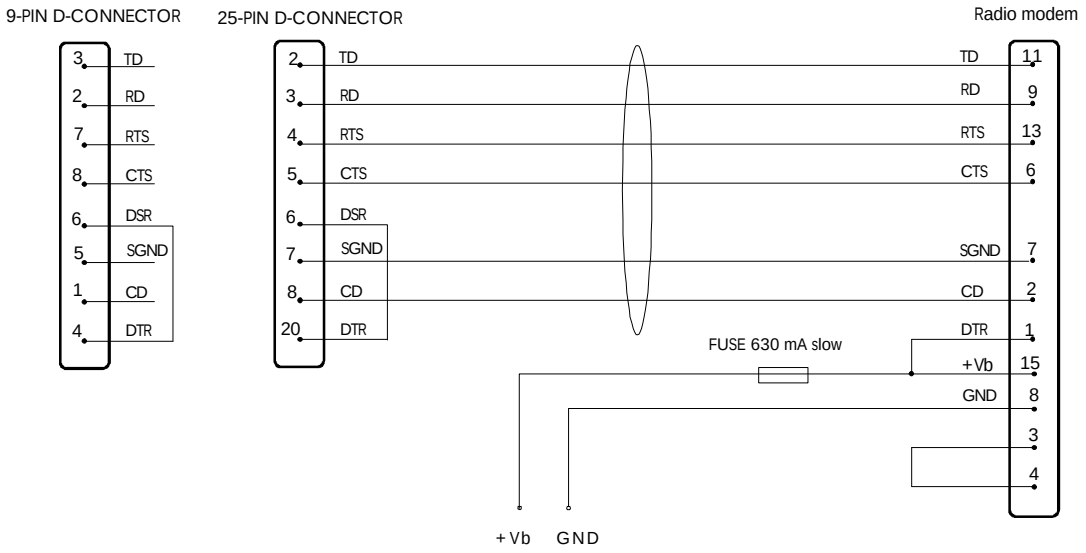
3. By mounting the radio modem directly on the customer´s equipment .

NOTE ! When choosing the place of mounting, please check that, water can not get inside the radio modem. It is not recommende to mount the radio modem on a powerfully vibrating foundation. The attachment should be lessened with help of a resilient material.

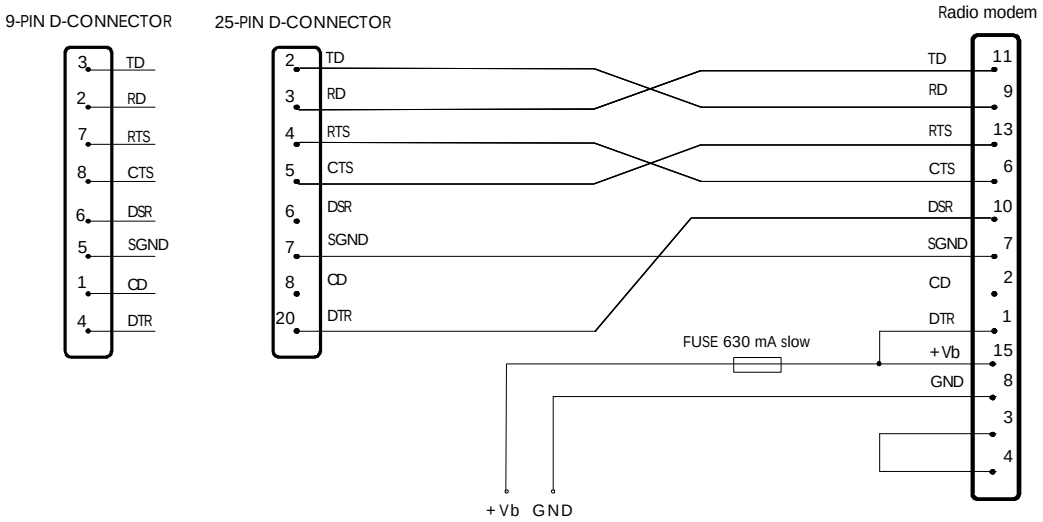
The radio modem fulfils specifications according to CEPT (T/R 20-04) regarding temperature range -25 °C...+55 °C. The radio modem operates also outside this temperature range but does not necessarily fulfil all specified specifications.

10.1 RS-232 Interface

The radio modem is connected to terminal via RS-232 interface. A typical connection where all handshaking lines are used is according to the figure below.



In some systems the radio modem is connected to another data transmission equipment (modem). The lines should in this case be connected accross according to the picture below.



10.2 Supply of current

The nominal voltage of SATELLINE radio modems is 12 V. The range of voltage is 10 - 14 V. Variations in the voltage below 1V are allowed as the radio modem is changing from one mode to another. The operating voltage of the positive pole of the D 15 connector is connected to the pins of the D connector and to the negative poles 7 and 8. The DTR line in position "1" can be used as an ON/OFF switch. In this case the logical state "1" (+5...+12 V) corresponds to ON and "0" (0 V...-12 V) to OFF.

The current consumption of SATELLINE-1ASl ja -1AS varies between 50 ... 250 mA and of SATELLINE-2AS and -2ASx between 100 ... 600 mA. In systems where models SATELLINE-1ASl or -1AS have been changed to models SATELLINE-2AS tai -2ASx , current supply has to be checked. Especially in portable applications the DTR line of the radio modem should be switched to position "0" when possible. In this case the current consumption is approx. 0.2 mA (SATELLINE-1AS and -1ASl) or 3 mA (SATELLINE-2AS and -2ASx).

NOTE POWER SUPPLY !

Even if the nominal output current of the power supply does not exceed it might temporarily be unstable as the current consumption changes e.g. at starting the power amplifier. The outputs of power supplies are often supplied with sufficient output capacitance. The output capacitance of self built power supplies with regulators or switched-mode power supplies might be insufficient or totally lacking.

Even if the nominal output current is considerably higher than the current consumption of the radio modem, the voltage varies several voltages according to the changes of the current consumption of the radio modem. This kind of function of the power supply weakens the function of the radio modem or prohibits it totally.

Supply current should be controlled in situations where the distance is short or the radio field strength is sufficient but the connection does not work or the number of faulty packets is big. Quick changes in voltage can not be measured with a multimeter as they often last for only approx. 0.5 ms. Therefore possible situations with undervoltage should be surveyed with an oscilloscope. To ensure a reliable operation of the radio modem the acceptable variation is below 1 V from the stable level and continuous oscillation below 50 mV.

NOTE! Whenever connecting RS-232 interface cables to equipment, the equipment MUST FIRST BE SWITCHED OFF.

10.3 Mounting the antenna

In great distances or in otherwise severe conditions the operation of radio communication is dependent on antennas and their mounting. In antennas, antenna cables and terminal adaptors there should always be a gold plated connector. Since connectors of poor quality oxidate and increase the attenuation in the course of time appropriate connectors and proper tools must always be used in mounting. One should also check that both the antenna and possible fitting elements resist well weather and environmental contamination.

The metal-free zone around small antennas should be at least 1/2 m and big antennas >5 m. The metal-free zone should be > 10 m around a relay antenna combination. This means that if a large network of radio modems is to be installed the best place for the antenna is at the highest point of the building or even to use a radio mast. If a mast is used, the antenna can be installed using a side-installation up to 2 ...3 m away from the mast itself.

When mounting the antenna pay also attention to possible sources of interference such as:

- mobile phone network base stations
- local telephone network base stations
- television transmitters
- radio links
- other radio modem networks
- PC equipment (about a radius of 5 m from the antenna)

When ordering antennas please note that the antennas have been tuned to a certain frequency range. Simple antennas and those made of stacked yagis are relatively wide band. The frequency range of the antenna becomes narrower the more elements there are in a yagi.

Keeping in mind the testing and service of the system it is generally useful to use rather a long antenna cable in order to avoid the installation of radio modems near the antenna into a place possibly difficult to access.

The antenna cable should be chosen according to the lenght bearing in mind the following recommendations:

Length	Type	Attenuation
< 5 m	RG58	3.0 dB/10 m/450 MHz
5 ... 20 m	RG213	1.5 dB/10 m/450 MHz
> 20 m	Nokia RFX 1/2"-50	0.5 dB/10 m/450 MHz
> 20 m	AirCom+	0.8 dB/10 m/450 MHz *)

*) AirCom+ cable is partly air insulated, thus an absolutely air tight connection between the cable and the connector is required.

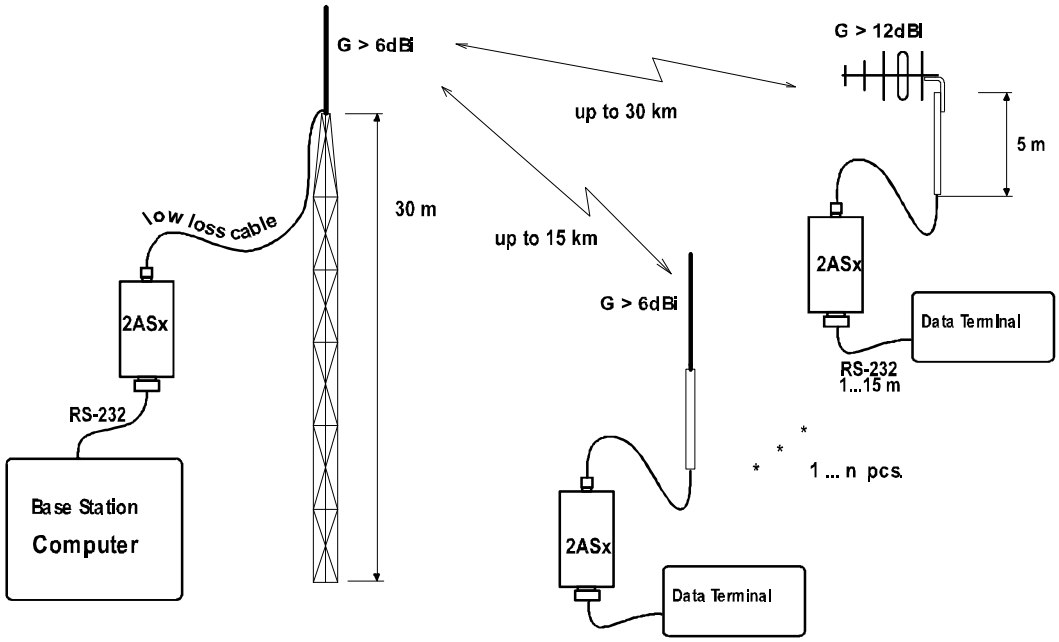
In great distances when the antennas are in optical positions a 6 dB power marginal is adequate. Since the connection is built on the reflection and/or the knife-edge diffraction the path loss can vary even 20 dB depending on the weather conditions. In this case a short test can give a too positive result 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 an attenuating 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 process.

Vertical polarized systems (antenna elements are in vertical position) are often used in radio systems. In a system between a base station and sub-stations the vertical polarization is generally recommendable. The antenna of the radio modem can not be mounted on the same level with the other sub-station antennas in the same building. The best way to distinguish from the other antennas situated in neighbourhood is by mounting the antennas as far 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.

A horizontal polarization can be used in data transmission between two points. With the polarization attenuation more distinction is obtained in the vertical polarization interference. 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 polarized antennas there must be a good attenuation of the back lobe. In addtion to this the interfering radiator should be situated behind the antenna.

When the system does not demand the use of an omnidirectional antenna it is recommendable to use directional antennas e.g. two-element yagis in firm external installations. As the antenna amplification increases the setting of the direction of the antenna demands for a greater care.

The base stations in high places should be supplied with 4...6 degree band-pass filters. Please note that the higher the antenna the larger the broadcast area. The disadvantages with a too high antenna installation at the base station are that interferences from a larger area affect the base station and that the base station occupies the channel of a too large area.



Example of an antenna installation: By use of amplifying antennas and by installing antennas in a high location, long distances can be reached with SATELLINE-2ASx.

11 Equipment

11.1 The connection of antennas to radio modems

Recommended antenna types are as follows:

11.1.1 Hand portable equipment

- 1/4 wave antenna (wave length on 450 MHz is about 70 cm)
- Helix antenna

The antennas are mounted directly on to the antenna connector (TNC) at the top of the radio modem.

11.1.2 Equipment installed in vehicles

- 1/4-wave antenna
- 1/2 wave antenna

Ideally the antenna should be installed vertically and it should have at least 0.5 m of open space surrounding it. In a small system 1/4 wave antenna is adequate. There should be a ground plane below the antenna (truck bonnet or roof). In weak conditions a 1/2 wave antenna is the most suitable. It can be mounted at the top of a pipe, as this provides it with as much open space as possible. In places where the antenna cannot be connected

directly to the TNC a 50 ohm coaxial cable must be used to provide the link between the TNC and the antenna.

11.1.3 Base station

- v omnidirectional (1/4, 1/2 or 5/8 wave antenna)
- v directional (yagi or corner reflecting antenna)

The antenna should be installed in an upright position. The exact location of the antenna depends on a number of factors from system size to physical fround countours. As a general rule, the antenna for a base station should be located at the highest point in the most central location of the system.

Alternatively the base station antenna can be situated inside the building, providing that the walls of the building do not contain metal.

11.2 Cables

11.2.1 RF cables

If the antenna cable is shorter than 5 m a good quality 50 ohm RF cable can be used (e.g. RG58). If a longer cable is required, it need to be a low loss RF cable. As a standard cable we supply 50 ohm RG58 cable in lengths of 1 m (CRF-1) and 5 m (CRF-5).

NOTE ! Please check, that the contact area of cable connectors is gold plated and that the connectors used are reliable. Ageing connectors of poor quality oxidate easily and cause malfunction of the system.

11.2.2 Interface cables

When planning the location of the radio modem, it must be observed that the maximum length of an RS-232 cable is 15 m. The cable must be shielded. The maximum length of the power supply cable is 2 m. As standard cables we supply cables with either a 25 pin connector CRS-1 F or CRS-1 M (F=female, M=male) or with a 9 pin connector CRS-2 F or CRS-2 M. The length of the cables are 2 m and they contain both interface and power supply cables.

There is also an interface adapter ARS-1F with a programming switch and power supply cables available for the SATELLINE-2ASx radio modem. The interface adapter matches the connector of the modem to a 9 pin (female) D connector. In addition there is a straight cable with 9 pin connector, CRS-9.

NOTE ! Please check, that the contact area of cable connectors is gold plated and that the connectors used are reliable. Ageing connectors of poor quality oxidate easily and cause malfunction of the system.

12 Check List

When installing and configuring a radio data modem following points should be considered:

1. Before connecting the RS-232 interface to equipment always check that the operating voltage is switched off.
2. Consider the exact location of the equipment for optimum results
   - Place the antenna in a free space as far as possible from any source of interference
   - do not place the modem on a strongly vibrating surface
   - do not place the modem in direct sun light or high humidity
3. The capacity and stability of the power supply must be secured so that the current required by the transmitter is sufficient for creating a reliale connection.
4. The antenna is installated according to given instructions.
5. The settings of the radio modem correspond those of the terminal and all radio modems of the system have the same settings and are compatible to each other.
6. The radio modems are on the same channel.

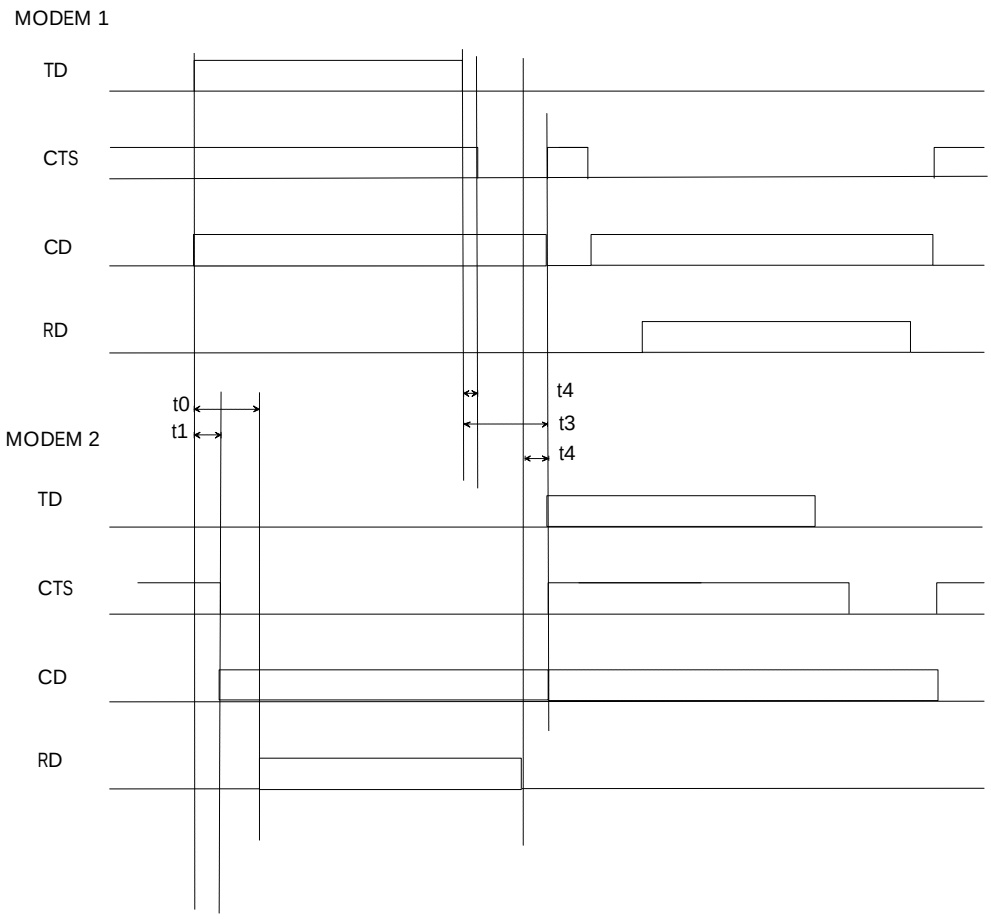
Appendix 1 Character Map

ASCII CHARACTER TABLE

D	H	C	D	H	C	D	H	C	D	H	C	D	H	C	D	H	C
000	00		043	2B	+	086	56	V	129	81	ü	172	AC	¼	215	D7	Î
001	01	☺	044	2C	,	087	57	W	130	82	é	173	AD	¡	216	D8	Ï
002	02	☻	045	2D	-	088	58	X	131	83	â	174	AE	«	217	D9	┘
003	03	♥	046	2E	.	089	59	Y	132	84	ä	175	AF	»	218	DA	┌
004	04	♦	047	2F	/	090	5A	Z	133	85	à	176	B0	░	219	DB	█
005	05	♣	048	30	0	091	5B	[	134	86	å	177	B1	▒	220	DC	▄
006	06	♠	049	31	1	092	5C	\	135	87	ç	178	B2	▓	221	DD	¦
007	07	•	050	32	2	093	5D	]	136	88	ê	179	B3	│	222	DE	Ì
008	08	◘	051	33	3	094	5E	^	137	89	ë	180	B4	┤	223	DF	▀
009	09		052	34	4	095	5F	_	138	8A	è	181	B5	Á	224	E0	Ó
010	0A		053	35	5	096	60	`	139	8B	ï	182	B6	Â	225	E1	ß
011	0B	♂	054	36	6	097	61	a	140	8C	î	183	B7	À	226	E2	Ô
012	0C	♀	055	37	7	098	62	b	141	8D	ì	184	B8	©	227	E3	Ò
013	0D	♪	056	38	8	099	63	c	142	8E	Ä	185	B9	╣	228	E4	õ
014	0E	♫	057	39	9	100	64	d	143	8F	Å	186	BA	║	229	E5	Õ
015	0F	☼	058	3A	:	101	65	e	144	90	É	187	BB	╗	230	E6	µ
016	10	►	059	3B	;	102	66	f	145	91	æ	188	BC	╝	231	E7	Þ
017	11	◄	060	3C	<	103	67	g	146	92	Æ	189	BD	¢	232	E8	Þ
018	12	↕	061	3D	=	104	68	h	147	93	ô	190	BE	¥	233	E9	Ú
019	13	‼	062	3E	>	105	69	i	148	94	ö	191	BF	┐	234	EA	Û
020	14	¶	063	3F	?	106	6A	j	149	95	ò	192	C0	└	235	EB	Ù
021	15	§	064	40	@	107	6B	k	150	96	û	193	C1	┴	236	EC	ý
022	16	▬	065	41	A	108	6C	l	151	97	ù	194	C2	┬	237	ED	Ý
023	17	↨	066	42	B	109	6D	m	152	98	ÿ	195	C3	├	238	EE	¯
024	18	↑	067	43	C	110	6E	n	153	99	Ö	196	C4	─	239	EF	´
025	19	↓	068	44	D	111	6F	o	154	9A	Ü	197	C5	┼	240	F0	-
026	1A	→	069	45	E	112	70	p	155	9B	ø	198	C6	ã	241	F1	±
027	1B	←	070	46	F	113	71	q	156	9C	£	199	C7	Ã	242	F2	=
028	1C	∟	071	47	G	114	72	r	157	9D	Ø	200	C8	╚	243	F3	¾
029	1D	↔	072	48	H	115	73	s	158	9E	×	201	C9	╔	244	F4	¶
030	1E	▲	073	49	I	116	74	t	159	9F	ƒ	202	CA	╩	245	F5	§
031	1F	▼	074	4A	J	117	75	u	160	A0	á	203	CB	╦	246	F6	÷
032	20		075	4B	K	118	76	v	161	A1	í	204	CC	╠	247	F7	¸
033	21	!	076	4C	L	119	77	w	162	A2	ó	205	CD	═	248	F8	°
034	22	"	077	4D	M	120	78	x	163	A3	ú	206	CE	╬	249	F9	¨
035	23	#	078	4E	N	121	79	y	164	A4	ñ	207	CF	¤	250	FA	·
036	24	$	079	4F	O	122	7A	z	165	A5	Ñ	208	D0	ð	251	FB	¹
037	25	%	080	50	P	123	7B	{	166	A6	ª	209	D1	Ð	252	FC	³
038	26	&	081	51	Q	124	7C	¦	167	A7	º	210	D2	Ê	253	FD	²
039	27	'	082	52	R	125	7D	}	168	A8	¿	211	D3	Ë	254	FE	■
040	28	(	083	53	S	126	7E	~	169	A9	®	212	D4	È	255	FF	
041	29	)	084	54	T	127	7F	⌂	170	AA	¬	213	D5	ı			
042	2A	*	085	55	U	128	80	Ç	171	AB	½	214	D6	Í			

Appendix 2A

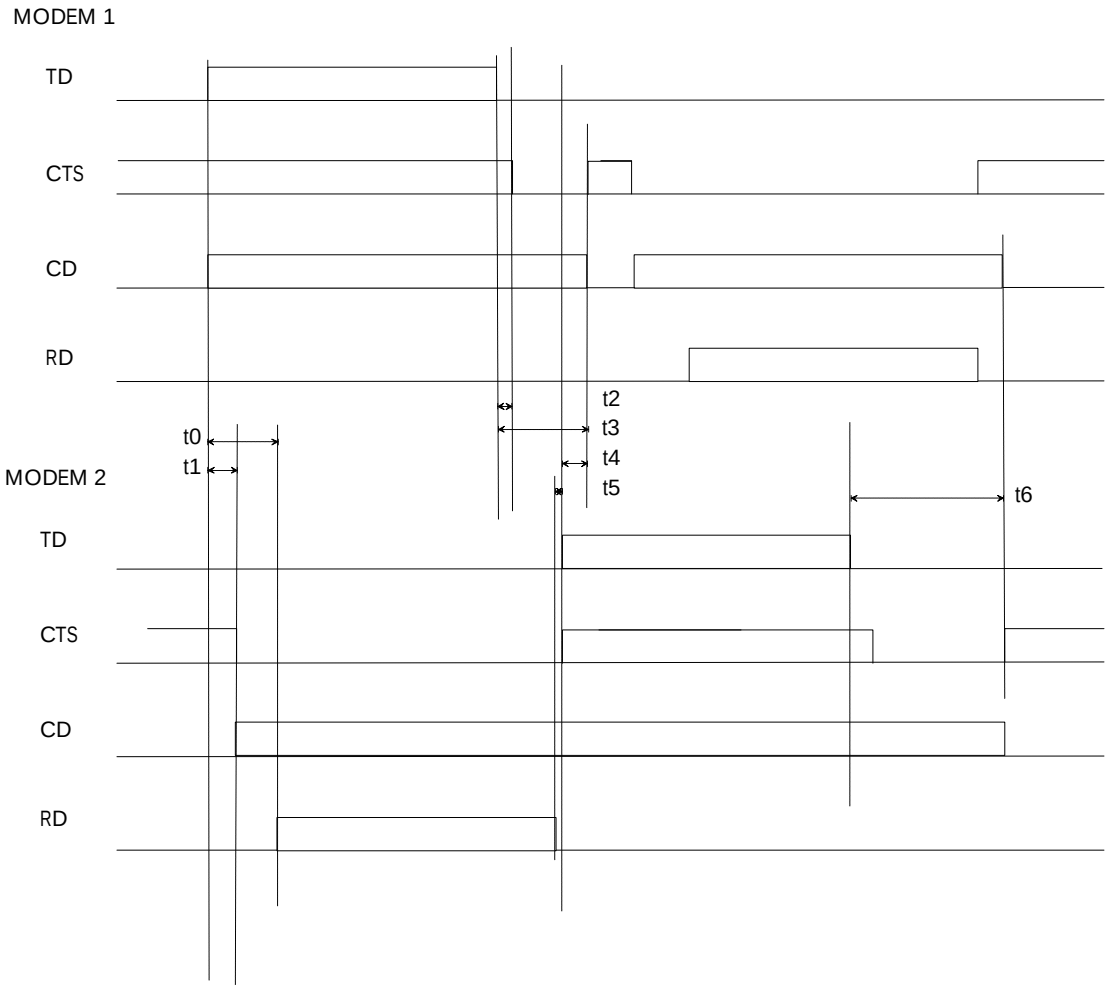
Delays and reaction time of the RS-232 interface with a data speed of 9600 bps



t0 = 17 - 20 ms (typ. 18 ms)	delay between TD and RD data
t1 = 4 - 10 ms	Tx on / Rx CD delay
t2 = 2 - 10 ms (typ. 3 ms)	Data package end delay
t3 = 10 -60 ms (typ. 30 ms)	Tx buffers emptying time
t4 = 3 - 6 ms	Rx to Tx connecting time

Appendix 2B

Delays and reaction time of the RS-232 interface with a data speed of 9600 bps and immediate response



t0 = 17 - 20 ms (typ. 18 ms)	delay between TD and RD data
t1 = 4 - 10 ms	Tx on / Rx CD delay
t2 = 2 - 10 ms (typ. 3 ms)	Data package end delay
t3 = 10 - 60 ms (typ. 30 ms)	Tx buffers emptying time
t4 = 3 - 6 ms	Rx to Tx connecting time
t5 = < 0,1 ms	Virtual Rx to TX connecting time
t6 = t3 + (t4 - x)	Tx buffer emptying time 2 (x = TD start time before t4)

Table of Selectable Radio Channels

Frequency Range (harware settings)	Channel (software settings)															
	F	**E**	**D**	**C**	**B**	**A**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
**x.200 - **x.575 MHz	**x.200	**x.225	**x.250	**x.275	**x.300	**x.325	**x.350	**x.375	**x.400	**x.425	**x.450	**x.475	**x.500	**x.525	**x.550	**x.575
**x.600 - **x.975 MHz	**x.600	**x.625	**x.650	**x.675	**x.700	**x.725	**x.750	**x.775	**x.800	**x.825	**x.850	**x.875	**x.900	**x.925	**x.950	**x.975
**y.000 - **y.375 MHz	**y.000	**y.025	**y.050	**y.075	**y.100	**y.125	**y.150	**y.175	**y.200	**y.225	**y.250	**y.275	**y.300	**y.325	**y.350	**y.375
**y.400 - **y.775 MHz	**y.400	**y.425	**y.450	**y.475	**y.500	**y.525	**y.550	**y.575	**y.600	**y.625	**y.650	**y.675	**y.700	**y.725	**y.750	**y.775
**y.800 - **z.175 MHz	**y.800	**y.825	**y.850	**y.875	**y.900	**y.925	**y.950	**y.975	**z.000	**z.025	**z.050	**z.075	**z.100	**z.125	**z.150	**z.175

y = x + 1, z = x + 2

Hardware settings are made by the manufacturer. The frequency range of the equipment is marked on the label on the back of the r adio modem.

Example: The channel of the radio modem has been set on A = 433.125 MHz as seen by switching the modem into programming mode. The frequency range of the radio modem is 433.000 - 433.375 MHz (see the 3rd row at the table above). If the new channel should be e.g. 433.275 MHz, the channel 4 should be selected.

For more information of programming the radio modem: please see chapter 6.