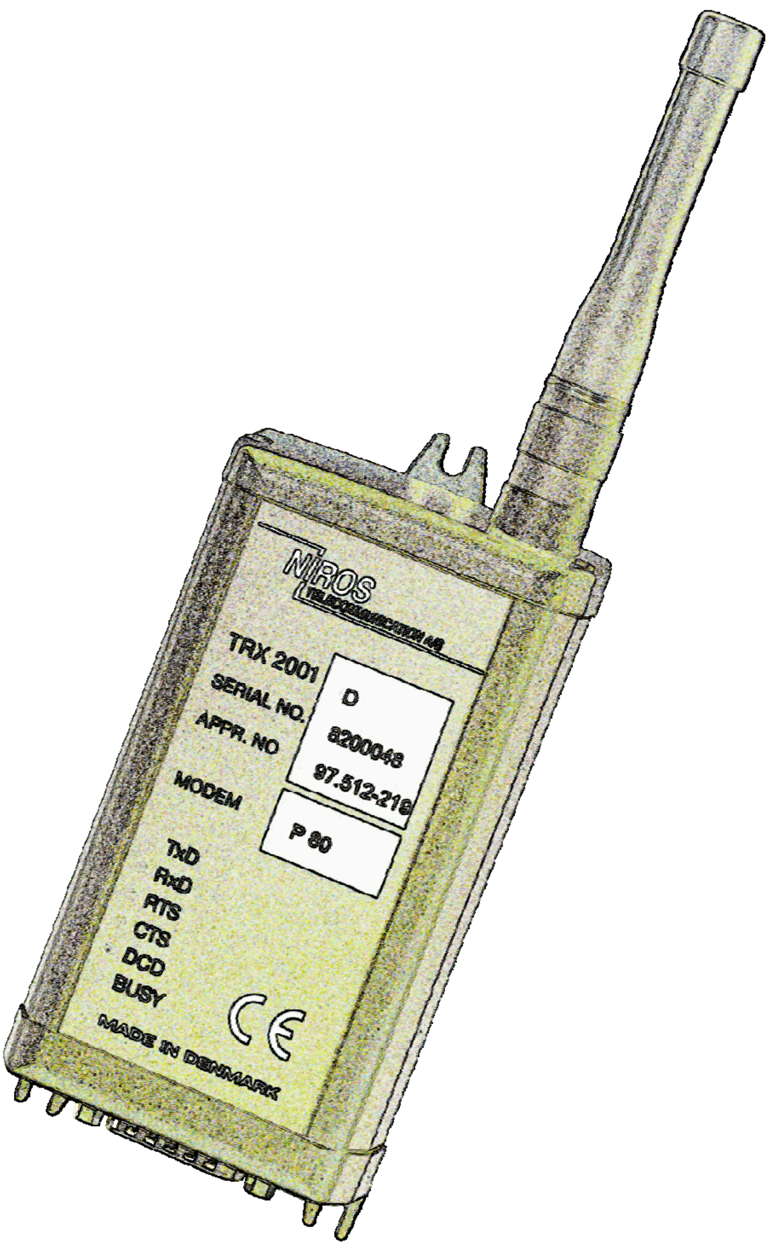
TRX2001 P82 / P83

Application Note

Version 2.01, April, 2000



NIROS
TELECOMMUNICATION A/S

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1 Introduction

This application note deals with the TRX2001 versions P82 and P83. As these two TRX2001 versions are based on a common platform, most basic and common details will be described under the sections covering P82, while the special P83 features are described in a separate section.

These pages do also serve as a “users guide” for programming the set-up parameters of the P82 and the P83, by means of the NIROS PC2001 program. This DOS-based program, including the required programming box and interface cable, is available from NIROS, too.

Note:	All data radios are delivered pre-programmed from factory and with a test report. Parameters are changed in the PC2001 program.

Note:	The text in [ ] refer to specific menu points in the PC2001 program, which is used to program the P82, P83, and the other members of the TRX2001 family. For information on how to use the PC2001 program, please refer to the user’s guide.

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2 The TRX2001 Data Radio family

The TRX2001 data radio family is available in four versions, denoted P80 to P83. As the various P8x-versions differ in transmission speed, built-in protocols, error correction ability etc., the TRX2001 provides a complete range of solutions for long range wireless data transmission, suitable for applications within energy management, traffic surveillance, environment monitoring, alarm networks etc.

All electrical connections (excl. antenna) are via a 15 pole male D-sub connector, with RS232-compatible data lines, used for programming of radio- and data parameters and for connecting peripheral equipment such as PLCs, transducers etc. during operation.

The radios are capable of simplex and semi-duplex operation, and can also be configured to operate as base stations, relay stations or repeaters. The output power is adjustable between one and five Watts.

The mechanical construction is a ruggedized, all metal construction, well screened and protected from the environment for both base station and mobile applications.

The TRX2001 series is approved according to the ETSI regulations for data and voice transmission (ETSI 300 086 and the ETS 300 113) incl. base station requirements.

The required power supply voltage for all TRX2001 data radios is +7.2 volt +-10% with negative pole grounded.

The typical current consumption is:

Power-down mode:	7.2 volt	0 mA
RX-mode:	7.2 volt	90 mA
TX-mode, 1 watt:	7.2 volt	0.9 Amp.
TX-mode, 5 watt:	7.2 volt	2.3 Amp.

Note: Power saving modes are also available. Contact NIROS for information.

External power regulators are required for 12/24 volt DC. Low-cost solutions are available from NIROS in linear and in switched mode models.

3 P82 functional description

The data radio TRX2001-P82 is a complete 4800/9600 Bit/second wireless two way data transceiver. It is designed to be used on a UHF land mobile simplex or semi-duplex radio channel (12.5 or 25 kHz), and fulfils the latest ETSI standards.

The internal modem utilises GMSK-modulation and parts of the Mobitex protocol as basis for the air protocol between two or more P82/P83s.

The maximum air data rate is 9600 bits/s, whereas line baud rate goes up to 19200. As described in this application note, a complex error correction scheme is used, and the flexibility in handshaking, transmission forms, addressing etc. has resulted in a data radio suitable for numerous applications and easy installation.

3.1 The applied version of the Mobitex protocol

Each byte to be transmitted is automatically embedded in a predefined block of total 240 bits, of which 96 bits are used for FEC, CRC and other Mobitex features. One block can consist of up to 17 bytes (or characters) to be transmitted. If the less than 17 bytes are received at the RS232 of the transmitter, the remaining number up to 17 are filled up with blank characters.

3.2 Transmission procedure

1. First data byte reaches the P82 via RS232, and is stored in the line buffer (size: 16kb). If “variable TX address” is selected, the characters to be transmitted have to be proceeded by the TX information (see later section).

2. Initialisation of the transmission including preamble frame-synchronisation etc. takes place.

3. The transmission itself takes place block by block, until the RS232 data stream is paused/interrupted corresponding to the length of 1.5 – 2 characters (i.e. 11 – 16 bit), which is interpreted as “End of File”.

4. At the receiving end, data is unpacked, addressing information is checked/removed, error checked (CRC) and corrected (FEC) if required, before raw date is being transferred to the internal output buffer of the receiving P82.

Thereafter, data can be transferred to the RS232 port of the receiving P82 in two ways:

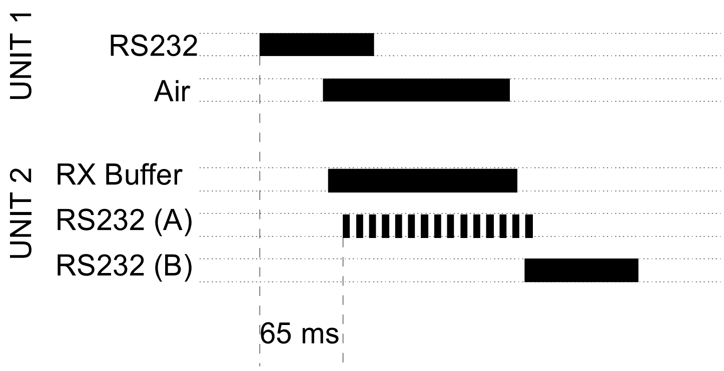
A) Each block of 17 characters is transferred to the RS232 port, as soon as they have been error checked etc.

or

B) All characters are stored in the output buffer of the receiving P82, and thereafter transferred to the RS232 port as one string when all data have been received.

In situation A), the first data byte becomes available shortly after having been transmitted from its originator, while B) ensures that the output of the data string has the same continuity as the one originally fed into the transmitting data radio.

This is also shown in the sketch below, with the two RS232 output possibilities:



Note: In the PC2001 program, transparency can in the [Modem settings] menu be set to “No” (situation A) or to “Yes” (situation B) according to your requirements.

Note: The radio protocol inside the P82 ensures that signals coming out on the RD line are without errors. In many cases transmission errors has even been corrected, but it does not detect missing telegrams. There is no ping-pong handshake on the radio link involved in the internal transmission protocol of the P82. However, a special SW, custom-designed by the user for this purpose – and with a number of additional features - will probably be part of any professional application of this data radio anyway.

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4 P82: Setting up the modem [*MODEM SETUP]*:

In the various options for configure the P82 data radio are to be found in the Modem Setup menu. This menu comprises a number of sub-menus, which are described below:

4.1 [Modem settings]

This part deals with the basic set-up of the modem itself, both the line communication (RS232) and the transfer of data over the air.

4.1.1 UART-settings.

The serial interface of the RS232 interface / UART settings of P82 can be configured to your existing interface parameters in terms of baud-rate (up to 19200), data-bits (7 or 8), parity (odd, even, or none) and handshaking (hardware or none).

Note: The RS232 parameters can be individually configured for each data radio in the network if required.

Furthermore, please note, that if “none” is selected for handshaking, the data radio will not utilise the traditional handshake signals such as waiting for a RTS signal before receiving a telegram over the interface, or activate the CTS pin before providing received data to the RS232 etc.

This "**H**and-**S**hake-**F**ree” (HSF) mode was already introduced in the well-known NIROS TRX101/P71 data radio in order to enable users to apply NIROS data radios where the connected equipment did not comply with the traditional handshaking signals.

However, as the only signal lines needed at the RS232 are data in and data out, in other words utilising the TD and RD pins (please refer to the pin connection list), precautions for possible data collision should be carried out in a different manner.

4.1.2 Air speed

The transmissions speed between the data radios can be selected up to 9600 bit/sec at 25 kHz channel spacing (4800 bit/sec at 12,5 kHz)

4.1.3 Transparency

Please refer to the description on the transmission procedure in section 3.2.

4.1.4 Variable TX ID – P82 only

When transmitting a telegram from a P82, the receiver can either be fixed for each telegram or variable (new TX address at each transmission). During operation, it is not possible to change between fixed and variable, but only the option selected when programming the radio will be valid.

The fixed TX address is defined in the [ID-information] menu, while the variable TX address requires a four digit hex address (two bytes) proceeding each block to be transmitted (see also next section on addressing).

5 P82/3 Addressing [ID information]

Addressing, meaning to establish contact between two or more P82s, is a part of the telegram format. Each telegram will have the TX address of the intended telegram receiver(s) included in its preamble/frame-sync., and only receivers with the matching pre-programmed RX-address will accept the data and deliver it from its internal buffer to the RS232 data output line.

For each P82, a total of 65536 different RX addresses are available. Each receiver can respond to up to 4 addresses, enabling the user to transmit data between P82s:

- As an individual calls: a point-to-point transmission of a telegram, involving one TX and one RX terminal. Polling consist of a number of individual calls to selected radios, following a predetermined pattern.
- As a group calls: By providing a number of radios with the same RX-address, all these radios will accept the incoming telegram simultaneously.
- As a general calls: As group call, but here the group consists of all RX radios in the network.

Note: Although the ID addresses in the PC2001 program can be keyed in as decimal numbers, the corresponding hexadecimal value has to be used in the users software when having selected variable TX-address (P82) or changing TX/RX ID's in P83

Consequently, when variable TX Address has been selected, the individual address has to be added to each block of data delivered as data input (TD). In other words: the first two bytes in each telegram are regarded as TX-address and used as such in the transmitting data radio.

6 P82: [Channel Definition]

The TRX2001 series utilises "one way at a time" transmission on the radio channel. This is different from a normal telephone line modem, which is most often able to transmit data in both directions simultaneously (duplex).

In the P82, one channel is available. The TX/RX frequencies can be the same (simplex channel) or two different frequencies (semi-duplex channel).

In the P83, 100 channels are available.

The PA level can either be set to "High" (5W), "Low" (1W) or "User". If "User" is selected, the output level can be chosen in the "User PA Level" entry field from the 32 predefined steps.

7 P82/P83: Repeaters and relaystation

The data telegram format is well suited for designing systems which includes re-transmission over repeater stations designed as digital repeaters and using one or two P82 units. The P83 can be configured to work as both data- and voice repeater in a "back-to-back" setup. The P83 can also be "ordered" to relay a datastring to another unit.

Note: The GMSK-modulation requires special circuits for demodulation and modulation so it is not possible to use an existing (non-P83) repeater station, designed for speech-signals.

The activation of a repeater station requires special considerations and may be subject to national regulations.

8 P83 - Introduction

The P83 is the latest version in the TRX2001 series, and was introduced in November 1999. Basically, it is an enhanced version of the P82, and thus a number of sections of this part of the P82/P83 application note will be referring directly to the P82 part.

Three major features differentiate the P83 from the P82, and these are:

Local commands: A number of commands which only have effect at the local radio.

Remote commands: A number of commands which are transmitted over the air to receiving radios perform certain changes at these remote radios.

Aloha signalling: By means of a time slot procedure the P83 is able to perform advanced polling procedures etc.

These new features will be dealt with in the next few chapters.

9 The P83 command set

With the P83, it has become possible to control P83s both locally by the RS232 interface or remotely (by sending the commands over the air to selected radios).

All commands are initiated by a "back-slash" (\), followed by an "A", "B", or "C" and three underscores, resulting in the following pattern:

\A___	Initiates a local command
\B___	Initiates a remote command
\C___	Initiates an Aloha command

In the next two sections the various local and remote commands are listed, while the Aloha commands are part of the section 10 on Aloha signalling in general.

9.1 P83 local commands

These commands will not be transmitted over the air, but only received at the P83 connected to the RS232 interface were the commands are provided. In the set-up, the ability to accept local commands can be enabled or disabled. In a master configuration it will normally be enabled whereas in slaves it will be disabled. When enabled, all communication to he P83 have to be in command form. It means that even raw data have to be proceeded by a command indicating that data are to be transmitted and how many bytes. When RS232 command mode are enabled, it is mandatory with hardware handshake on the RS232 line. The commands available are:

\A___Txx	Change TX ID to xx
\A___txx	Change TX ID to xx and store to eeprom as default
\A___RT	Restore TX ID from eeprom
\A___Cx	Change channel to x
\A___cx	Change channel to x and store in eeprom as start-up channel
\A___RC	Restore start-up channel from eeprom
\A___D	Force power setting to default
\A___L	Force power setting to low
\A___H	Force power setting to high
\A___Sxxyyzztt	Change RX ID addresses 1,2,3 and 4.
\A___sxxyyzztt	Change RX ID addresses and store to eeprom as default
\A___G	Read RX ID addresses
\A___V	Read software version
\A___Q	Read measured signal/noise ratio of last reception
\A___RS	Reset radio modem
\A___Mxx	Set max. no of data allowed in one transmission
\A___Nxx	Set time-out for RS232 time-out
\A___F48	Set air-speed to 4800 b/s
\A___F96	Set air-speed to 9600 b/s
\A___Exx	Transmit xx number of data bytes
\A___aOn	Turn audio mode ON
\A___aOf	Turn audio mode OFF
\A___Bon	Turn Buffer-up mode ON
\A___Bof	Turn Buffer-up mode OFF

9.2 Remote Commands:

These commands will be transmitted to the receiving P83 data radio, and perform changes at these remote radios:

\B___Txx	Change TX ID to xx
\B___RT	Restore TX ID from eeprom
\B___Cx	Change channel to x
\B___RC	Restore start-up channel from eeprom
\B___D	Force power setting to default
\B___L	Force power setting to low
\B___H	Force power setting to high
\B___RS	Reset radio modem
\B___RIxx……	Relay message to xx (will only work when RX ID1 is called)
\B___Rd	Read buffered data (will only work when RX ID1 is called)
\B___aOn	Turn audio mode ON
\B___aOf	Turn audio mode OFF
\B___Bon	Turn buffer-up mode ON
\B___Bof	Turn buffer-up mode OFF
\B___xAxxyy	Change TXID in repeater xx to yy
\B___rAxx	Restore TXID in repeater xx

10 Aloha signalling

The principle behind Aloha signalling is based on one or more P83(s) acting as base stations (or “masters”), which – by means of a time slot procedure – control an automatic procedure of collecting data of the remote “slave”-P83s within transmission range. No matter whether the P83 slaves are fixed or mobile, the use of the Aloha procedure can be used to optimise the efficiency of the radio channel(s) and ensures a reliable and easy way of collecting wireless data.

There are two commands available in connection with the aloha scheme:

\C___Ax/y/z	Initiate aloha request
\C___Bx…..	Reply to request with additional 15 chars

Basically, an Aloha sequence consist of the following parts:

1. A master sends out an Aloha, consisting of a number of time slots, in which the receiving slave can answer.

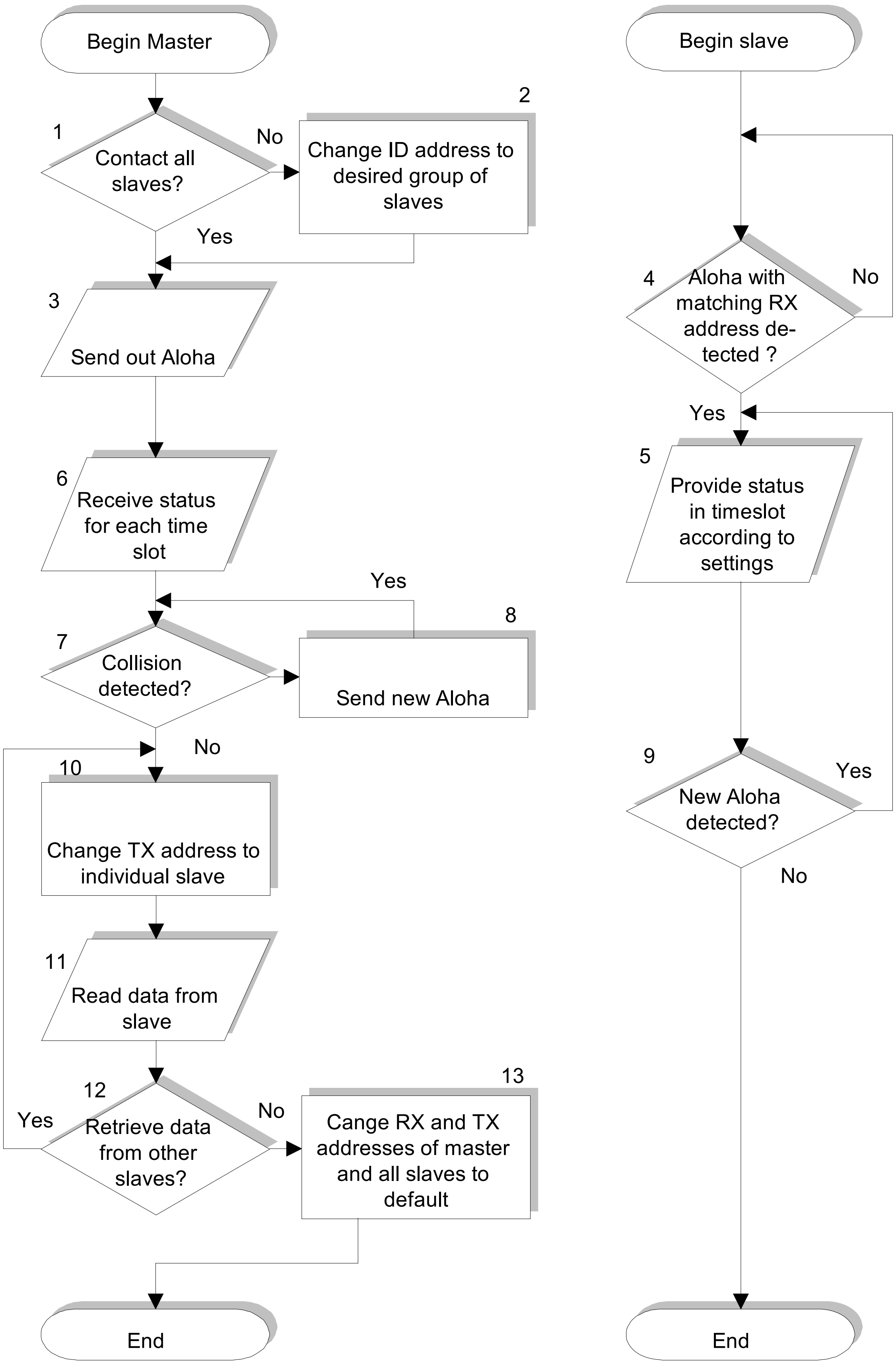
2. Each slave responds in a time slot if it is within transmission range, and if data has to be transmitted to the master.

3. The master establishes contact to the answering slaves one by one, and thereby enable the data transmission to takes place.

4. The data transmission itself take place between the slave and the master.

By means of the flow-chart on the next page, the principle in an Aloha-session is explained in more details. The text below refers to the various steps in this flow chart.

Note: text in [ ] refers to the menu points in the [modem settings] menu of the PC2001 program.


Begin Master
1
Contact all slaves?
No
2
Change ID address to desired group of slaves
Yes
3
Send out Aloha
6
Receive status for each time slot
Yes
8
7
Collision detected?
Send new Aloha
No
10
Change TX address to individual slave
11
Read data from slave
12
Yes
Retrieve data from other slaves?
No
13
Cange RX and TX addresses of master and all slaves to default
End
Begin slave
4
Aloha with matching RX address de-tected ?
No
Yes
5
Provide status in timeslot according to settings
9
New Aloha detected?
Yes
No
End

Master (step 1 – 3):

Depending on the system configuration, the addressing of the slaves can be configured as described for P82s. Thus if all radios are ment to be contacted at every Aloha session, a fixed TX address can be utilised as "all call".

Before sending the Aloha request to the radios, the group of radios to address by the controller has to be selected. This group of radios is selected according the RX addresses of the slaves to be contacted, as described in section 5 in the part of this note covering P82.

The command for changing is \A___Txx, where xx is the hexadecimal value for the chosen receivers' RX address (see also P82 section on addressing). Now the Aloha request itself is send out, but will only be received at the units with the correct RX address (as in described in point 2). The Aloha contains of three parameters to be set by using the command C___Ax/y/z (x,y and z in 8 bit hex value)

where

x corresponds to the number of time slots to be used in the request.
y corresponds to the length of each time slot (number of 5 ms periods)
z correspond to the length of idle time before first timeslot (number of 5 mS periods)

Note:	Both x, y and z are a 8 bit hexadecimal number. Example: The command \C___A10/14/10 will result in an Aloha request with 16 time slots of 100 ms each (14H * 5 ms = 100 ms) and with and idle time before first timeslot of 80 mS (10H * 5 mS = 80 mS)

Slave (step 4 & 5)

Thereafter, a slave will respond to the Aloha if the TX address used by the master corresponds to one of its RX addresses. However, other conditions are:

- If [buffer data transmit] is set to YES and [Respond only if buffered data] is set to YES, the P83 will only respond to the Aloha if it actually has data in its buffer to be transmitted. If it is set to NO, the P83 will responds no matter whether data is present in its buffer or not.

- If [Auto response] is set YES, the modem will respond by itself, while if set to NO a command (\C___Bx….) over the RS232 will initiate the response to the Aloha. The response will take place in timeslot x with the additional 15 chaharacters.

When answering to an Aloha, a text is added to the answer, which consist of 15 characters.

The radio can either respond in a random time slot by setting [Auto responds] to RANDOM, or choosing a [fixed time slot] the P83 should reply in every time it receives an Aloha request.

Master (step 6 – 9)

Each receiver of the Aloha request will now be answering in a timeslot, resulting in a status on the master side for each time slot, following this pattern:

\tx/Y

where

x : Time slot number (time slots are represented in an 8 bit hexadecimal number)

Y : F = Free, meaning no data received in timeslot

A = Answer, meaning a responding P83 wants to transmit data. The A is followed by the responding P83s RXID1 (see section on addressing), and an ASCII text for this unit (see section on transmission procedure from slave).

C = Collision detected

Example: *\t01/F\t02F\t03/A0009Answer unit 9 \t04/F\t05/C means:*

time slot 01: Free
time slot 02: Free
time slot 03: Answer from RX ID 0009, followed by the user defined ASCII text ”Answer unit 9 ”
time slot 04: Free
time slot 05: Collision detected

If a collision is detected in a time slot, the master has several options:

1. Send out a new Aloha, and extending the number of time slots

2. Send out a new Aloha, and limit to a smaller number of radios by choosing an TX address with fewer matching RX addresses.

3. Contact the slaves who have successfully answered to the Aloha without being involved in a collusion (as described in next point), and thereafter send a new Aloha (does only make sense, if [buffer data transmit] has been set to YES).

etc.

Master (Step 10 - 13)

Now data has to be retrieved from the P83s having answered with an “A” in a specific time slot. This is done by having the controller to contact the slaves one by one, typically by:

1. \A___Txx	Changes TX ID of controller to desired slaves individual RX ID address (= xx)
2. \B___Tyy	Changes the TX Address of the remote slave to correspond to the RX ID of the controller
3. \B___Rd	The slave will now release and transmit all data stored in its buffer to the controller.
4. \B___RT	Restores the TX ID address of the remote slave to its default value
5. \A___RT	Restores the TX ID value of the controller to its default value

NOTE: point 1-4 have to be repeated until all data from all slaves having answered with an “A” in a time slots has been retrieved. Thereafter, the command in point 5 is provided.

11 Audio mode in TRX2001 P83

The P83 features an audio mode. This is enabled by toggling ”Audio mode” to ON in the submenu [P83 Modem setup] in the PC2001 setup program or commanding slave/master into audio mode.

The pins 5, 6 and 12 on the 15 pin connector is now the active pins in connection with audio reception and transmission. Pin 12 – labelled ”B-mode” is used as PTT key. However it is important that B-mode is inactive upon applying power. If B-mode is active when power is turned on, the modem will go into a test mode and will not act as programmed for.

Pin 5:	Received audio out – appr. 180 mV_{RMS} for 3 kHz deviation.	
Pin 6:	Microphone input - appr 250 mV_{RMS} input for 3 kHz deviation.	
Pin 12:	B-mode – receive mode	0 V
	B-mode active - transmission mode	> 5 V

12 P83 relay (repeater) function

Due to the P83s ability of handling a number of predefined commands both at local and remote stations, this version in the TRX2001 series supports a simple relay function.

In brief, the procedure is as described in the below example, where Data Radio 1 (DR1) has to transmit to DR3 via DR2 (the relay station).

1. Send the command “\A___Txx” via RS232 to DR1, where ”xx” is the 4 hexadecimal unique receiving address of the repeater DR2 (addressing etc. is defined in the P83 set-up program). Thereby, the DR1 knows that the next to be sent has to be directed to DR2.

2. Send the command “\B___Rlyy…………” via RS232 to DR1, where “yy” is the unique receiving address of DR3 and …. is the data to be transmitted. All data that shall be relayed have to be proceeded by the command.

Following this procedure, the DR2 will receive the command followed by the data itself from DR1. DR2 will then buffer the received data in its internal buffer, strip of the command, and re-send the data to the address of DR3 (denoted ”yy” in this example) without emitting the data to the RS232 port of DR2.

When the data arrives at the input buffer of DR3, all addressing information is removed, and only the telegram itself (point 3. in the above example) is submitted to the RS232 port of P83.

This procedure can involve a large number of relaystations if necessary, however, each additional relaystation will have to go through the above described procedure of buffering the data for re-transmission, which will result in a delay for each transmission.

13 P83: [MODEM SETUP]

Besides the Aloha settings, which were described in the previous section, most of the other parameters are configured as described in the P82 section on these points. However, a few extra options have been added in the P83:

13.1 [RS232 command]

This option enables/disables the command interpreter for commands given over RS232 line. In a slave application it might be wanted that commands received via RS232 are not valid, and in that case this option would have to be set to NO.

13.2 [Modem command]

This option enables/disables the command interpreter for commands received "over air". In a master application it might be desirable that remote units (or slaves) are prevented from giving the base any commands.

13.3 [Buffer data transmit]

This option is normally used in slave units, where it is desired that the slave does not transmit any data unless asked to. When option is set to YES, the unit will buffer up all data that are received via RS232 without transmitting, unless a “Read”-

command is received. When operating in buffer-up mode, the RS232 command mode have to be disabled.

14 P83: Addressing [ID information]

Addressing of the P83 is performed as described in section 5, however, it is important to remember that the first RX address (RX1) has to be unique for each radio in a system in order to utilise the Aloha facilities as well as remote read and relay functions.

15 P83: [Channel Definition]

Besides the fact, that P83 can utilise up to 100 channels instead of only one as in P82, setting up channels in the P83 is performed as in P82. Please refer to the relevant section.

16 P P82 & P83 Pin connections

Data plug: Sub-D 15 pole, Male on radio, Female on cable.

Pin:	Name:	Utilisation:
1+2	GND	Ground for data and power supply
3	CTS out	RS 232: Clear To Send.
4	RSSI out	Analogue signal strength from receiver.
5	A out	Analogue output from RX discriminator.
6	A in	Analogue input, not used in P82
7	DCD out	RS 232: RF carrier detect.
8	DTR in	RS 232: Remote on-off. n.c. or more than +5 volt = on. gnd. or neg. voltage = off.
9+10	+7.2 Volt	Power supply. Max. 2.5 Amp.
11	RTS in	RS 232: Request To Send
12	Mode in	RS 232: Activation of programming mode or use as PTT in audio mode. +5 volt or more for programming or PTT. n.c. or gnd for normal operation or receive.
13	TD in	RS 232: Data input to transmitter.
14	DSR out	RS 232: No function in P82/P83.
15	RD out	RS 232: Data output from receiver.

Note: The P83 utilises a number of pins for its Audio function. Please refer to section 11 for further information.

17 Use of the RSSI test point

The RSSI (**R**eceived **S**ignal **S**trength **I**ndicator) signal is a dc-voltage, which depend upon the received signal amplitude at the receiver antenna terminal.

The voltage can be measured during installation, by connecting an external digital voltmeter between ground and pin 4 of the D-connector on the TRX2001-radio.

The signal could be used to verify the signal strength in a particular position and possible local interference.

The local noise picked up by the antenna can be checked by reading the RSSI voltage both with and without the antenna attached.

An increase of less than 0.2 volt ,when the antenna is connected, indicates an acceptable level of external noise.

The coverage range can be checked, by arranging for a continuous keying of the base station, and using a mobile P83 with an attached voltmeter as a field strength meter.

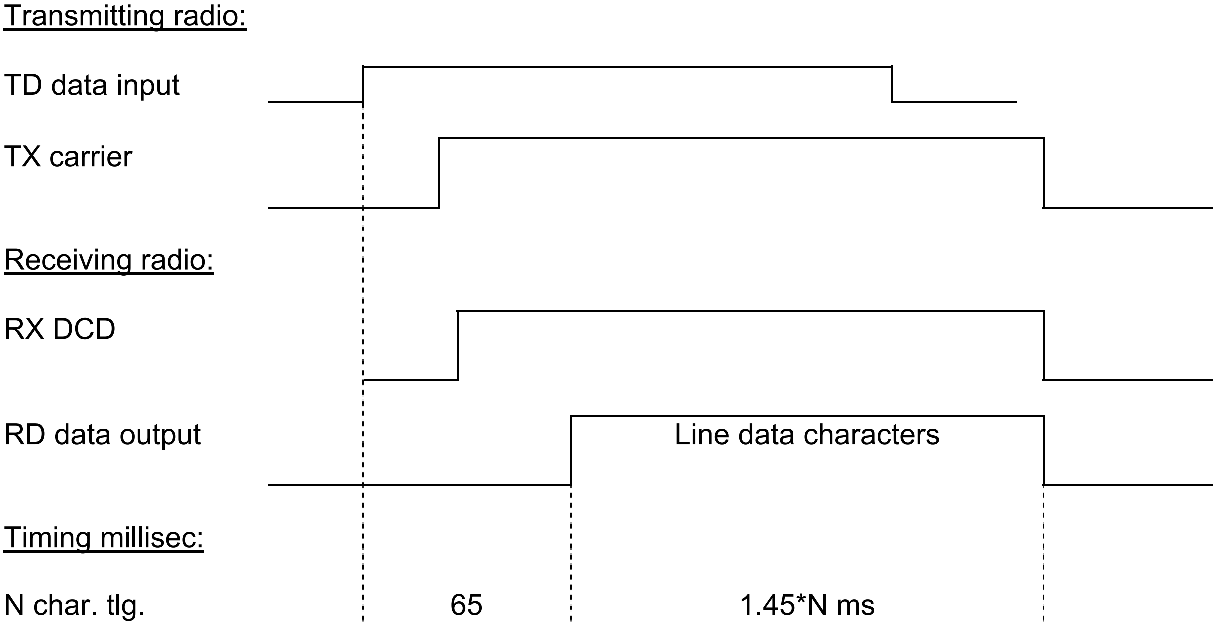
When moving the antenna around in the far end of the required coverage range, you will note that the field strength varies when the antenna is moved just a few centimetres, especially if the antenna is placed in an unfavourable low position .

Note: The average signal should, at the edge of the coverage area, not be lower than approx. -90dBm.

The following typical calibration table can be used for field strength evaluations:

Signal / dBm	**Microvolt/50 ohm**	**RSSI voltage**
no signal	0 uV.	0.83 V.
- 120 dBm	0.22 uV	1.08 V.
- 110 dBm	0.7 uV	1.64 V.
- 100 dBm	2.2 uV	2.22 V.
- 90 dBm	7 uV	2.71 V.
- 80 dBm	22 uV	3.14 V.
- 70 dBm	70 uV	3.62 V.
- 60 dBm	220 uV	3.68 V.

18 P82 & P83 signal timing diagram



Test telegram consists of N characters 9600,E,8,1

Total duration from start of input (TD) to end of output (RD):

Number of bytes:	Total duration:
16	90 ms.
128	250 ms.
512	810 ms.

Note: This timing does not apply for sending Aloha requests, repeater functions etc.

19 Main principles of data transmission on radio

Modern modems for telephone lines have made impressive progress in the last years. Unfortunately these techniques are in general not well suited for radio transmission.

They require a good stable signal with a minimum of fading, noise and interference. They also rely on adaptive techniques which requires a continuous duplex connection between the two modems in communication.

Simultaneous communication from one transmitter to a number of receivers is not possible in these protocols. The dial-up time when initiating a transfer is also very long compared to what is needed in most radio nets.

The transmission of data on land mobile radio channels requires the use of special types of modulation and error-handling techniques to utilise the radio spectrum in an efficient way. Experience has proved that a number of techniques are usable and optimal for different applications, depending on the required baud rates and transmission range and other system parameters.

The NIROS TRX2001 data radio family utilise three different types of modulation:

19.1 Indirect FFSK-modulation

Fast **F**requency **S**hift **K**eying is used in the P81. A special tone modem is used and the tones are 1200/1800 Hz for 1200 baud and 1200/2400 Hz for 2400 baud.
The tones are used for FM-modulation of the TX-carrier frequency. The highest possible baud rate is 2400 baud.
There is a coupling in the TX-modem between the tone generator and the data signal which means that tone shift always takes place at the zero crossings of the tones. This reduces the side band noise and is the reason why 2400 baud is possible.
This type of modulation is well proven for signalling in many radio telephone systems (NMT etc.) and in trunking radio systems.
The standardised protocol (MPT1327) is a package-protocol which includes error detection and is used in our P81.
The performance for long distance transmissions is very good, even at 2400 baud.
Transmission via an analogue repeater station is possible.

19.2 Direct GMSK

Gaussian **M**inimum **S**hift **K**eying is used in the P82 and P83 data radios for high speed data transmission. The digital output from the data modem is used, after the proper filtering in a Gauss-shaped phase linear filter, for direct FM-modulation of the TX frequency.

This is the recommended type of data modulation for obtaining the highest air baud rates within the bandwidth constrains of the allocated land mobile radio channel.

Many variants exist. Some are optimal for short distance (strong signals) and very high speed (19200 bits/sec).

We have chosen the standard format used in the Mobitex Wide Area Networks. This format gives a very good performance for long distance data transmission and a maximum air-data rate of 9600 bits/sec.

The telegram format is very advanced, utilising error correction (FEC), error detection (CRC), data time spread and randomising.
This utilisation of advanced coding techniques compensates to a large extent for the reduced sensitivity, which a wide band FM-radio receiver will have for physical reasons, compared to the sensitivity in a 3 kHz speech bandwidth.

The net-result of all this is that we get an effective radio receiver, almost as sensitive as the FFSK-radios, but at approx. three times the data speed. The protection against impulse noise and Raleigh-fading is excellent, too.

The effective air data rate, incl. all transmission overhead, can best be judged by checking the detailed timing diagrams for the relevant data radios.

19.3 FEC (Forward Error Correction)

Is obtained by adding 4 correction bits to each byte transmitted. This enables the receiver to correct most transmission errors.

19.4 CRC (Cyclic Redundancy Checksum)

is calculated in the transmitter and transmitted. The receiver recalculates it and will detect most transmission errors not being corrected by the FEC.

19.5 Data time spread

is done by mixing bits in a telegram in a predetermined way between bytes. Short fading or noise bursts will then most likely only destroy one bit in each byte. This can be corrected completely by the FEC.

Randomising is done by multiplying the Data bits with a pseudo random sequence before transmission. This improves bit clock synchronisation in the receiver, especially if long strings of identical bits are transmitted.

20 Transmission Protocol Considerations

The TRX2001 utilises a simplex (one way at a time) transmission on the radio channel. This is different from a normal telephone line modem, which is most often able to transmit data in both directions simultaneously (duplex).

In practice, a simultaneous transmission in both directions of long messages is not needed in most applications, and a switching simplex procedure is often usable, if switching is automatic, fast and without any loss of characters.

The hand-shake-free concept used in some of the TRX2001-versions depends on this fact, combined with large data buffers in both the transmitting and the receiving end of the circuit.

The transmission protocol ensures, that incoming line data is stored in the line input buffer, and is transmitted, as soon as the radio channel is free.

The transmission is initiated by the micro controller in the HSF-models, without any need of the RTS-signal. Transmission continues until the transmission buffer is empty.

This concept will, in many cases, work with software which is made for telephone modems or other duplex data connections.

It is, however, the responsibility of the system integrator to ensure that this is indeed the case, both under normal conditions and under different types of transmission errors.

A simple statement like "We just need a transparent data bank" is most often not enough.

Some of our TRX2001-radios have facilities for customisation to fit specific transmission protocols, but this is a very big and diffuse problem area still under development, so consultations with the design-staff at NIROS will be necessary in most cases.

21 NIROS sales policy for data radio products

All radio systems depend in their total performance on the antennas used and their placement. Nothing can compensate for bad antennas or bad antenna positions.

Theoretical calculations are of limited value due to the complex character of radio propagation under practical conditions.

It will normally be necessary to perform field strength measurements at all planned radio locations in order to verify sufficient radio coverage in an early stage of the system planning. This will clarify which type of antenna is needed and what antenna height is required.

It is a natural demand from the final system buyer to require a guarantee for a satisfactory total performance, including radio coverage. This is a complex question which is best handled by a system integrator with a solid knowledge in all aspects of the required system, including SW, HW and the application of the radio.

NIROS regard the data radios as an OEM-product, sold to qualified system houses, which are expected to be able to perform the system planning in a satisfactory way and being able to integrate the data radios as building blocks in the final user system.

NIROS will advise its customers, to the best of our ability, on all factors related to the performance and application of our data radios but we will not guarantee the functionality, or the radio coverage of a particular total system.

The normal NIROS sales conditions apply to data radios as well as to all other NIROS products.