SIMREX CORPORATION

GLB
SYNTHESIZED NETLINK RADIO DATA SYSTEM
(SNRDS II)

OPERATING MANUAL

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SIMREX CORPORATION
Synthesized Netlink Radio Data System
Operating Manual
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NOTE: This product is intended for use in a commercial, industrial or business environment, and not for use by the general public or in the home.

The Synthesized Netlink Radio Data System (SNRDS) is a radio system for transferring digital data between physical locations where wire connections are impractical or too expensive. It incorporates an intelligent packet controller, a fast, frequency synthesized data radio, and supporting I/O and indicators. One SNRDS unit, a power source and antenna are required at each location requiring data communication.

SNRDS communicates with local equipment (a data terminal, host computer, or a specialized hardware device) via an RS-232 data port. A second serial port is used for outputting special messages or as an addressable serial bus to add-on modules. 1200 to 19200 baud is available on the link side (over the air).

About This Manual

These instructions are intended to enable the uninitiated to communicate via packet and to describe the SNRDS thoroughly. Most of these instructions concern the software. It's assumed that a non-intelligent computer terminal or a computer having a simple terminal emulator program is available, allowing the operator to access the SNRDS directly. Basic operation is simple, but the myriad of commands and options provided could be initially overwhelming; learn the basic commands now and review the list of commands at leisure to develop an appreciation for the capabilities provided. New commands can be studied in detail as required. Commands are highlighted in the text (in boldface type) and are often referenced in the discussions. Where a command is referenced instead of a section number, refer to the command summary in section **7. Commands**.

Character conventions used are as follows: CR is a line-feed character, usually a RETURN or ENTER key on a keyboard. LF is a line-feed, or ^J. Control characters are indicated in the text by preceding the character with "^", and are keyed in by holding the control key down while typing the character. All SNRDS commands are in boldface type. The term "connection" appears in two contexts; one refers to physical connections via electrical conductors, and the other to a "virtual" connection, which exists only in software. Confusion can be resolved by assuming that when electrical wiring is the subject, it's the former context; the latter applies when the only action involved is in typing characters to the keyboard.

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1.1. SNRDS Applications

The Synthesized Netlink Data Radio System is ideally suited to the transmission of data for a wide range of applications, such as:

Differential GPS
Public Safety
Banking
Security systems
Vehicular remote control
Utilities
Mining
Sports scoring
Telephone systems
Oceanography
Supervisory Control And Data Acquisition (SCADA) systems
Vehicle tracking
Libraries
Remote Telemetry
Environmental monitoring
Military applications
Oil & gas drilling
Construction equipment
Computer systems
Railway Communications

1.2. Description and Features

The SNRDS easily adapts to a wide range of wireless data transfer applications. In connected mode data is "packetized", or broken down to a series of transmissions, which are acknowledged as they are received., Hence, the term "Packet Radio". Connected mode handles the entire communications process automatically, but unconnected mode has advantages in many applications.

Continuous Asynchronous (CA) mode is available as an option. This is a real-time data transfer mode in which asynch bytes are transmitted immediately as they are supplied. No error checking or protocol is involved, but data is sent with an absolute minimum of delay. This mode is suited to applications such as remote control of vehicles or applications in which the protocol is handled entirely by a host computer.

Forward Error Correction is also available for connected or unconnected (not Continuous Asynchronous) modes. This option provides a great increase in the reliability of reception in the presence of impulse noise or rapid multipath fading in a mobile environment.

Within a basic communications mode there are several ways in which data is presented to be sent. In Chat mode ASCII data is typed in, then sent by using a special control character. Block mode is useful for situations where all byte values occur within the data and the host software can be customized to control the specific operations of the SNRDS. Transparent mode also allows any byte values but requires no special software in the host.

When not connected, SNRDS displays all channel activity by default, but a series of options control the display by type of field, connection status or addressing. Field types include headers, status messages, normal information and special information. If connected-only mode is activated no data is displayed unless a connection is established. A station-filtering system uses a list of addresses to control the display of received information, based on five different criteria, such as station of origin, digipeat path and the COM port to be used. This list can also control whether a connection is allowed or whether a station is to be digipeated.

Messages that are received and acknowledged are queued up in SNRDS if the host isn't ready to accept them. This action occurs either if the serial port is flow-controlled by the host or by special command. When a series of commands are to be given "queue" mode can be invoked, stopping information flow until the user is ready to receive it. Frames can be displayed one at a time or all at once. SNRDS needs only to be polled periodically to access accumulated information. If memory overflows, new data is not accepted from other stations until enough information has been accepted by the host, releasing sufficient memory space.

Any SNRDS station may be used as a relay point, or "digipeater" to forward packets from other stations, which may be too distant for a direct radio link. Up to 8 digipeaters can be included in an address field to relay packets through specified stations to the destination if the destination site can't be reached directly. Watchdog hardware on SNRDS ensures that the system runs reliably by resetting the CPU automatically in the event that CPU operation is disrupted. SNRDS also may be remotely controlled via a radio connection.

A message can be stored, to be transmitted automatically to another station each time it connects, or it can be made to transmit periodically to an independently entered address (beacon mode).

By providing access to the disk operating system (DOS) in the host software, files can be transferred to and from disk and/or to another station's disks directly. Appropriate host programming would allow such exchanges to take place as background tasks, freeing up the host computer to continue other operations transparently to the operator. Information could be directed to devices such as disk files, printers or other I/O ports.

Two protocols are supported, called MX.25 and LOP (Low Overhead Protocol). MX.25 has more features, but LOP is simpler and more efficient in many applications. The protocol may be selected by command, but when called from another station the protocol used by the caller is selected automatically.

The software provides great flexibility, with commands that can be used by the host computer to implement specialized protocols. Within the HDLC format, any kind of frame can be generated and sent by the host, and the host can screen received frames and implement custom responses.

1.3. Hardware features

SNRDS is supplied in an RF-tight aluminum housing measuring 9.775 D by 2.27 H by 4.54 W inches (24.83 x 5.77 x 11.53 cm). All interconnects are on the rear panel and all indicator LED's are on the front panel. This arrangement leaves the remaining four surfaces unobstructed.

The on-board controller provides commands for setting the operating frequencies of the receiver and transmitter, which have independent frequency synthesizers. There are no crystal ovens, so there is no warm-up delay. The CPU is supported by 64K of memory, non-volatile memory backup and panel display.

In the original RDC, a lithium battery retains the contents of memory when power is removed from SNRDS. The RDC4 has non-volatile memory for storing critical parameters.

There are two hardware "watchdogs" to ensure reliable operation. A CPU watchdog resets the program if the software should become disrupted. In addition, there's a limit timer in the transmit keying circuit to limit the length of any single transmission in case of complete controller failure.

Primary communications with the terminal or computer are carried out via an RS-232 serial port. A secondary serial port has limited functions at this time, but in future releases of software this second port will become a separate, fully addressable port such that two RS-232 devices can be connected to one radio. To keep the panel and installations simple, standard SNRDS bring out all connections except the antenna jack and power input via a single DB-25S connector. A second RF connector is available for transceivers, providing independent antenna connections to the receiver and transmitter.

Antenna switching is accomplished with PIN diodes for fast turnaround operation. In packet applications the path should "turn around", or go from receive to transmit and vice-versa, very frequently. Slow turnaround time reduces the link data throughput and increases the probability of collisions. SNRDS radios turn around in 10 milliseconds. A half-duplex version is also available, which requires no switching and has two RF panel BNC's, one for the transmitter and one for the receiver.

1.4. Software

Written in assembly language, the control program is an independent and unique GLB development. The roots of the program are based on the original GLB PK1 and PK1L controllers, which have a long history of reliable operation. Customized versions of the software can be supplied. In most applications it is found that the desired capabilities already exist, and the application can be developed and tested simply by selecting software options and setting parameters. Standard software with customized default settings can then be provided for the actual application. In the RDC4 there's an on-board EEPROM, which stores the parameter settings, addresses, filterlist entries, modes, etc. In these units the user can customize the software in the field, by making the required settings by command, then saving the settings in the EEPROM. After that, the system ignores values in EPROM on reset, using the customized values instead. When modifications require custom software modifications a quotation can be provided on the basis of programming time.

Customized versions or updates of the firmware can be provided by supplying a new EPROM, or a program image can be sent via floppy disk or directly by MODEM if facilities are available to program EPROM's.

1.5. Packet Radio Characteristics

Many SNRDS stations may share a single radio channel, each identified by an "address". Two stations enter "connected" mode, in which they ignore all other channel traffic and communicate only with each other. Data may also be transmitted in unconnected mode, where addressing controls the data path. Unconnected mode is useful where the same data is sent or updated periodically, and an occasional missed packet is not of critical importance. It is also appropriate where the host computer carries out the task of keeping track of packet re-assembly and error handling in some other way instead of using the built-in methods.

Packet radio is ideally suited to the transmission of data over a wide range of applications. In connected mode communications takes place between two specific stations via a "virtual connection". Once "connected", other channel activity is ignored. Data delivery is guaranteed via acknowledgments and a 16-bit error checking calculation (CRC) ensures that the data was received correctly. Error recover and loss of packets due to noise bursts, fades, etc. are handled by means of automatic repeats. Packet sequencing guarantees that packetized segments of files are correctly reassembled at the receiving end. For some applications special protocols may provide improved performance. For example, in polling applications it might be desirable to eliminate the overhead of connecting and disconnecting when polling each station.

Unconnected mode is available for applications where connections are either not necessary or there isn't time to make and break them. In this mode the 16-bit CRC is still used, so that flawed transmissions are not displayed. It works well for applications where information is constantly updated, so that it makes more sense to listen to the next updated transmission than to repeat a previous one. Addressing can be used to filter which transmissions to display, such as the source station address(es) or a digipeat path, and if desired data from a specific address can be sent to the secondary serial port.

Packet Protocols

A "protocol" is an agreed-upon method of forming and sending packets, just as formal procedures are used between departments in companies. There can be many protocols, but to communicate all stations must use the same one.

Protocol functions include the digital format of transmissions, methods of synchronization, breaking down transmitted data into blocks, or "packets", sending the packets with addressing and control information, packet acknowledgments and reconstruction of the data from the received packets. In addition there must be a way to

determine whether a packet has been correctly received and a mechanism to recover missing packets of data when one or more of the pieces of a file have been received with errors. Certain situations require time delays; while a protocol may specify the use of a delay, the actual values used vary with the baud rate, channel traffic density and other factors.

Special protocol functions include automatic repeating, or “digipeating” of packets by other packet stations when the destination is out of direct range of the source station, sending and interrogation of commands and status information between packet controllers, etc.

Packet radio operates by establishing a virtual connection between two stations. A connection is requested by specifying the destination address and giving a command to connect. Once the connection has been acknowledged (automatically) by the destination station all other channel activity is ignored. Data delivery is guaranteed by an checking method called a cyclic redundancy check (or CRC) on each transmission. If the error check is correct an acknowledgment (“ack”, for short) sent by the receiving station. If no ack is received within a predetermined time the original data transmission is repeated until acked or until a preset number of tries has been exceeded. Packet sequencing guarantees that packetized segments of files are correctly reassembled at the receiving end.

Amateur Radio operators developed the most popular radio protocol, known as “AX.25”. Based upon the X.25 protocol used in wired systems, it adds provisions unique to the radio environment, and in particular, its adaptation to amateur communications. Many commercial systems use AX.25, and SNRDS uses an extended proprietary version of AX.25, called “MX.25”, which remains compatible with AX.25 as long as the extensions aren’t used.

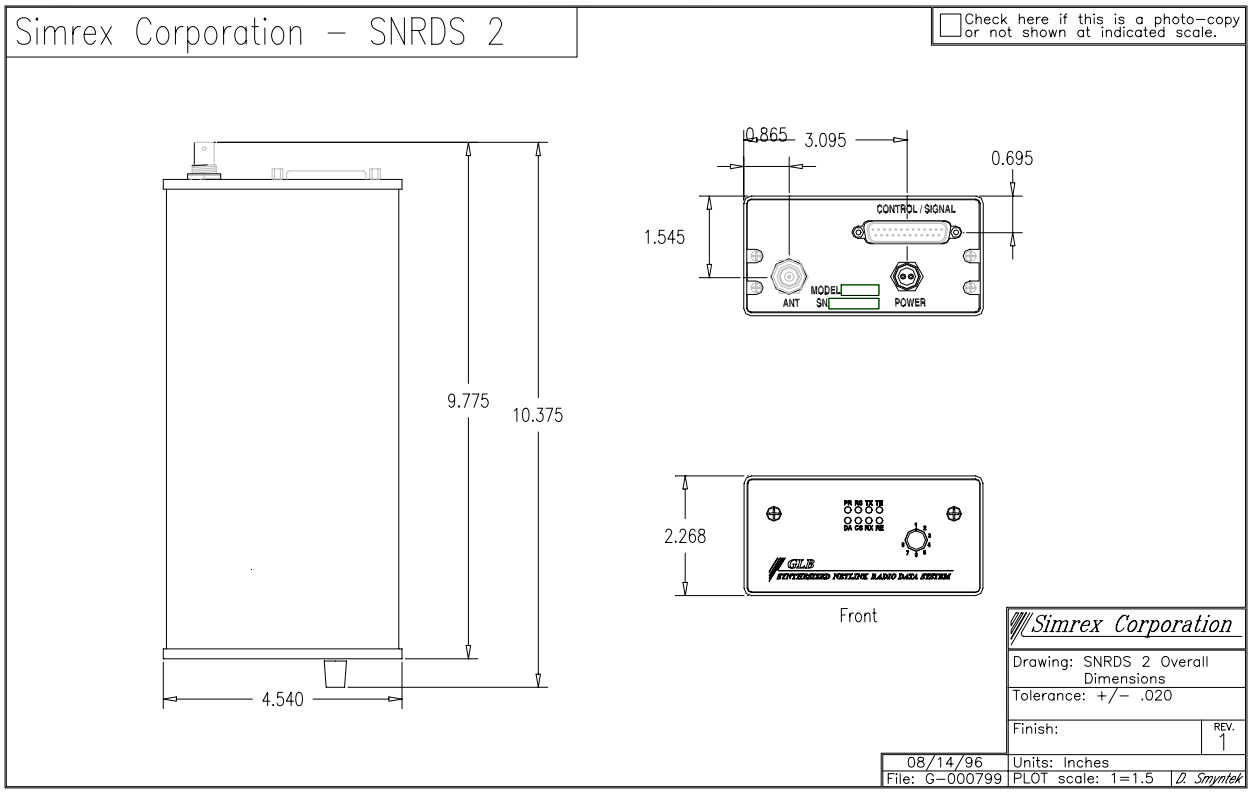
Because it takes time to send acknowledgments, the system doesn’t spend all of its time sending data. In addition, each packet carries data besides the information to be sent, called overhead. The highest throughput of MX.25 is approximately 92% of the baud rate, and for LOP it’s about 98%.

2. Installation and Connections

A SNRDS installation varies with the application, but in general it involves physical mounting, providing for an antenna and power supply, and connecting the user's equipment. For new or experimental systems the next step is to connect a terminal to each station in the system and test the radio path by making connections with the other units. Once radio paths are proven, software operating parameters can be initialized for permanent operation. In many permanent installations customized firmware avoids the need to set up parameters, addresses and modes of operation.

2.1. Physical mounting

SNRDS units may simply be placed on any horizontal surface or fastened with screws. Mounting brackets are available from Simrex. Placement should include adequate ventilation and air circulation. High humidity (condensing conditions) and temperature extremes are to be avoided, to the extent possible. Consideration should be given to access for testing and maintenance, including a clear view of the panel indicators. In cases where a terminal is normally not connected, access to the serial port is desirable for test purposes. If the mounting position makes access to the connectors difficult, extension cables leading out for easy access could be permanently attached.



2.2. Panel

The panel contains the RF and main connectors and eight indicator lamps. The PR indicator glows continuously when power is on. The TX LED is off while receiving and on continuously when the transmitter is keyed. The TE LED is lit if the transmitter synthesizer is out of lock. The RX lamp glows continuously in the presence of a RF carrier signal. The RE LED is lit if the receiver synthesizer is out of lock. The RS LED is lit when a positive RS232 state is present on pin 4. The CS LED is lit when a positive RS232 state is present on pin 5. The DA LED is not used at this time.

2.2.1. Main Connector (P1)

All non-RF connections are made with this connector, simplifying the panel and making the removal and replacement of the unit easier. A cable is normally made up to separate wires according to the various destinations of each connection. The table of pin connections is followed by a functional signal description.

PIN	DESCRIPTION	PIN	DESCRIPTION
1.	Ground	14.	Data to SNRDS (secondary port)
2.	Data from DTE to SNRDS (primary port)	15.	Transmit Clock (secondary port)
3.	Data to DTE from SNRDS (primary port)	16.	Data from SNRDS (secondary port)
4.	RTS to SNRDS from DTE (primary port)	17.	Receive Clock (secondary port)
5.	CTS from SNRDS to DTE (primary port)	18.	Transmitter Keying (active low)
6.	DSR from SNRDS to DTE	19.	RTS to SRDS (secondary port)
7.	Serial Ground	20.	DTR from DTE to SNRDS
8.	Data Carrier Detect (DCD)	21.	Bit 0 of the BCD switch
9.	Bit 1 of the BCD switch	22.	RS-232 RI
10.	/Reset	23.	Bit 2 of the BCD switch
11	Not used for RS-232	24.	Not used for RS-232
12.	Remote Command Lockout	25.	Receiver discriminator test point
13.	CTS from SNRDS (secondary port)		

2.2.2. Power Supply Requirements

SNRDS operates on +12.5 volts DC nominal. Voltage variations within specified limits have no effect on performance except for power output.

> **WARNING**: Application of reverse polarity to SNRDS could cause extensive internal damage. Be sure polarity is correct. A safe method of applying power is to connect CHASSIS ground to the power source negative first, then apply positive power to the connector. A wiring mistake during this test would short the supply but not put reverse polarity into the SNRDS. If it operates correctly this way connect the leads permanently.

A separate 2 pin connector is used to supply DC power to the SNRDS. The positive pin is on the right when viewing the power connector with the key on the bottom. The power supply is nominally 12-volts DC, negative ground. It should be regulated and have a monotonic turn-off and turn-on characteristic; that is, it should be free of “spikes” or “holes” and should shut down and come up monotonically in order to ensure orderly power-down and power-up operations. When voltage drops below 7 volts the SNRDS halts and protects the contents of memory.

2.2.3. Primary Serial Port (COM1)

Pins 2, 3, 4, 5, 6 and 7 are used for the primary serial port. These should be cabled into the corresponding pins of a DB-25S connector for connection to a terminal or computer to send data and commands and to receive incoming data. It's fully RS-232C compatible as a DCE (Data Communications Equipment). The other end of the cable connects to a DTE (Data Terminal Equipment). Connection of SNRDS to another DCE device may be made by using a null modem cable. Pins 2 and 3 carry the actual data; pin 4 is controlled by the host to control the data flow from the SNRDS. If data comes in faster than the host can process it, setting this signal false causes SNRDS to stop sending. If the host is fast and/or doesn't do much processing pin 4 may not be needed. There is a weak pullup resistor (10K) inside the SNRDS on this line. Therefore the SNRDS can send and receive data by connecting only pins 2, 3 and 7.

Pin 5 is controlled by SNRDS to control data flow from the host; the host is expected to stop sending data while this signal is false. Pin 5 may not be needed, since SNRDS can accept any reasonable input combination at maximum baud rate without overrun

Pin 6, the Data Set Ready signal, is looped back from pin 20, and indicates SNRDS is active and on line.

Pin 20 is the Data Terminal Ready signal from the host. SNRDS feeds this signal to pin 6.

Pin 22 is the RI (Ring Indicator) signal, connected to ground inside SNRDS.

For test purposes or ASCII operation X-on/X-off flow control may be used, requiring connections only to pins 1, 2, 3 and 7. Not all systems use RS-232 connections in the same manner, so some experimentation may be required.

The serial port ground on pin 7 is connected internally to chassis ground.

2.2.4. Secondary Serial Port (COM2)

This port can be assigned to input or output transmitted/received information. CA mode always uses this port, see **3.4. Continuous ASCII (CA) mode**. The software also supports data output to this port when a special source address is entered (see **SS**). A third use for COM2 is to assign it as a serial bus, used to access up to 256 individually addressable I/O devices. Such devices include parallel input/output ports, D/A and A/D converters, etc. See **FP**, **FR**, **FW**.

The signals on pins 13, 14, 16 and 19 are the same as the primary port, and the signals meet the RS-232D standards for voltage levels. Pin 17 outputs the serial clock, used for synchronization with serial bus devices.

2.2.5. Other Connections

Pin 12 is the Remote Command Lockout connection (See **AQ** and **DL** commands). When this signal is at 0 volts remote commands are accepted, and when at +5 volts remote commands are rejected. This input allows remote command access to be controlled via an external device or condition.

Pin 17 is the serial clock for the secondary serial port. This would be used for synchronous data applications.

Pin 25 is connected to the receiver discriminator output, to be used as a test point to observe received signals. It's DC coupled and non-filtered.

2.2.6. Antenna Connector (J1)

The standard RF connector is a female type BNC. Allow enough clearance so the coax cable doesn't have to make a sharp bend. Right angle adapters may help to avoid undue stresses on the cable and its connector.

SNRDS is designed for a nominal antenna impedance of 50 ohms. The selection, mounting and physical positioning of the antenna is dependent upon the distance and direction to other stations in the system, and other factors such as the noise environment and frequency of operation. Line-of-sight radio paths are desirable for reliability and are necessary to cover long distances. Directional antennas are useful to increase the distance over which communications are possible, and can be helpful in rejecting interference or noise.

Duplex units are available, having two BNC connectors instead of one.

2.2.7. Fuse (F1)

The fuse is a self resetting type. It is rated for 3 amps for the 5 watt units. The fuse can blow due to component failure or if reverse polarity is applied to the unit. Although a protective diode forces the fuse to blow in this case, circuit damage could still occur. 25 watt units have a 10 amp AGC fuse. This is accessible at the fuse holder in the power amp cover.

2.3. Initial Testing

There are three major components to connect; a power supply, a terminal and an antenna. It's a good idea to connect the antenna (or a dummy load) first, to avoid transmitter operation without a load. The terminal device may be either an ASCII terminal or a computer using a terminal program. Most telephone MODEM programs have a mode allowing terminal operation. When the power supply and terminal are connected to the SNRDS a preliminary test can be made. No warm-up time is required.

2.3.1. Terminal Interface

The first step is to achieve communications with the SNRDS via the serial port. The terminal (or computer with a MODEM program) should be set to send and receive 8 bits, no parity, and one stop bit (unless another combination has been specified in the order). The number of stop bits is important; if mismatched it may work fine for testing by hand typing, but fail when data is transferred at high speed.

The standard SNRDS software is Unconnected Transparent mode. To get the unit into command mode requires the typing of a special character sequence. The default character sequence is three capital letter "U" and only three within 1 second. It is very important that no characters are typed for a ¼ second before and ¼ second after the three capital letter "U". This timing is required so that you can send three capital U's in your data stream without going into command mode. It is also, very important that the serial parameters of the terminal program are set the same as the SNRDS. The serial parameters for the SNRDS can be found on the "Firmware Settings Report" that is shipped with each unit. A colon prompt (":") should be displayed by the SNRDS meaning that it is in command mode. A full sign-on message can be obtained at any time by typing RETURN by itself at the prompt.

GLB SNRDS w Vx.xx,

A letter will appear at "w" only if the SNRDS incorporates an installed option; F would signify Forward Error Correction, C would signify a CA Mode unit, etc. Lack of a letter here indicates the unit is a standard SNRDS. V stands for Version, x.xx would be replaced by the software version number.

If nothing happens or if a garbled character stream appears, repeat the procedure. A garbled sign-on may mean it's somehow missing the correct baud rate. SNRDS software is normally supplied with a fixed baud rate of 9600 baud.

NOTE: If communication can be established with the unit but the display isn't entirely correct (or if commands are not accepted correctly), see **P** commands for setting up the serial ports. Also check **ON** and **OW**.

When a sign-on comes up, try entering an **S** followed by RETURN. The terminal should display:

1 /ABCDEF 0 /------ 0/ //LDU/XE/RL/0

(the customized address replaces the "ABCDEF")

Differences in this status display may be due to customized default settings in the EPROM, or in RDC4's EEPROM. If a message similar to this is obtained proceed to the next section. Make certain the terminal being used is able to accept characters as fast as the SNRDS sends them. The SNRDS always uses CTS/RTS flow control, so if the terminal respects it overflow won't occur. Alternatively, if the terminal uses Xon/Xoff flow control, the command **OXE** will invoke that form of flow control in the SNRDS. Note that Xon/Xoff isn't suitable for non-ASCII data transfers.

2.3.2. Setting Radio Frequencies

If the frequency settings in the EPROM supplied with SNRDS have been customized, the transceiver is already set to the default frequency. If not, any frequencies stored in the EEPROM are used. Values in the EEPROM are checksummed, and if the checksum should be incorrect those values are abandoned in favor of the EPROM. The user can change values in the EEPROM at any time (See **DU** and **DO**C commands).

Frequency control software is written for flexibility on different RF sections, requiring a few preliminary entries: channel step spacing (**RS**), intermediate frequency (**RI**) and synthesizer divide modulus (**RM**). Since calculations are performed on each entry to check consistency, a channel spacing value must be present before SNRDS will allow any other entries. Note that these settings are mandated by the particular radio section being used and values are supplied in the EPROM to match the hardware for any particular SNRDS. The following examples are shown for reference only. The radio should have all of these parameters set for the frequency ordered when leaving the factory.

All frequencies are entered in kilohertz to the nearest ¼ kilohertz and the commands must be terminated with a CR (**RD**, **RM** and **RN** don't represent frequencies, so they work like other SNRDS commands). Channel selection must be consistent with channel spacing; that is, any selected frequency must be a multiple of the reference frequency selected with **RS**. It also must be within range limits or the entry is ignored and an error is indicated. For example, to set channel step spacing to 10 KHz:

rs 0-10

As usual, " 0-" is sent by the controller to show the previous value. Next, check the receiver synthesizer modulus; this is set to 64 for radios below 250 MHz and 128 at higher frequencies. Set it to 64:

rm 128-64<CR>

The receiver IF is a signed value, where a negative value indicates that the local oscillator is on the low side of the signal frequency and a positive value indicates it's on the high side. Below 160 MHz the IF in SNRDS is +21400 KHz:

```
ri 0-21400<CR>
   ^
```

This '-' isn't a minus sign; it's the usual prompt for input sent by SNRDS in response to a command

The remaining commands may be changed by the user. The first two entries set the range limits for entered frequencies, **RL** and **RU**, for Lower and Upper limit, respectively. These limits offer some measure of protection against accidental operation on unauthorized frequencies. Before any channel frequency command is accepted, the requested frequency is compared to these limits; if out of range an error is indicated and the frequency isn't accepted. Assuming the allowable limits to be 155 and 157.35 MHz:

rl 150000-155000<CR>
ru 174000-157350<CR>

Next, a receiver channel is entered:

rr 150000-155030<CR>

And a transmitter channel:

rt 150000-155030<CR>

There's one other variable involved if the receiver and transmitter operate on the same frequency: **RO**, for transmitter Offset. SNRDS transmitter synthesizers operate continuously, even in receive mode. The presence of this on-channel signal at close proximity to the receiver (inside the housing) would cause interference to received signals. To avoid this problem the transmitter is shifted to a nearby frequency just far enough to avoid interference; when the transmitter is keyed it's simultaneously shifted back to the actual transmitted frequency. The reason for this strategy is that it takes less time to shift the transmitter a small amount than to lock it from scratch each time it's keyed, resulting in faster turnaround time. **RO** accepts a signed value such as "-30" to shift the transmitter 30 KHz lower during receive operation. The best offset to use is normally preset in the EPROM default values, so this command is described mainly for reference purposes

```
ro 0--30
     ^
```

Here we really do have a minus sign!

2.3.3. Multiple channel selection

Standard SNRDS software has the option of storing and receiving multiple frequency channels. The **RC** command is added for channel selection, and optionally, a channel switch can be provided that allows panel selection of these predetermined frequencies. Frequencies are entered independently by selecting a channel, then entering them with **RR** or **RT**, in the normal way.

Default frequencies can be supplied with the order, so that a set of initial frequencies are automatically filled in on reset. The number of channels must be specified when ordered. With the switch option the maximum number of channels is 8 channels.

2.3.4. Initial Link Connection

Pick one of the SNRDS's with its associated terminal as the "local" station and the other as the "remote" station. We'll assume that the operating frequencies are set and that the software isn't customized (except for the station address). The default settings of the SNRDS are for Unconnected Transparent mode. In this mode as soon as a key is typed at the keyboard it is transmitted by the SNRDS. The receiving radio should then receive this character and display it on the terminal. The SNRDS uses hardware flow control to insure that data is not lost at the serial ports due to overrun. These are pins 4 (RTS) and 5 (CTS) on the DB25 connector. There is a weak pullup resistor (10K)

on pin 4 to +12V. This allows for a three-wire connection to the SNRDS serial port. Pins 2, 3 and 7 are all that are required for applications where hardware flow control is not used.

When bench testing use shielded loads and place the SNRDS units as far apart as possible (>10 feet) to avoid receiver overdrive. Unless the dummy load or coax is leaky a few feet should be sufficient. If antennas are used for testing, they should be separated as far as possible (>20 feet).

Weak signals are caused by poor antenna installations, less than ideal topography between the stations or simply because the stations are too far apart. It's possible, although unlikely, that test signals could be noisy if double shielded coax is used and the loads are really RF-tight. P1 pin 25 carries the receiver discriminator output signal. Connect it to an oscilloscope and observe the received signal while sending data from the other unit. Noise will be seen when no signal is being transmitted, but during transmissions a clean data waveform should be visible with little or no noise.

2.4. Technical Description

SNRDS consists of six subassemblies; A Radio Data Controller (RDC), modem, radio receiver, transmitter exciter, power amp board and a interconnect board.

2.4.1. Controller Section

The RDC consists of a 64180 microprocessor with 32K bytes of EPROM and 32K bytes of CMOS RAM, and a parallel input/output port. The 64180 has two internal asynchronous serial ports. Both the primary and secondary ports output through an RS-232 driver chip for bipolar drive levels. The parallel port is used to control the radio and MODEM sections. A lithium battery provides standby memory back-up in older RDC's. The RDC has non-volatile storage for operating parameters, and does not have the lithium cell.

2.4.2. GMSK MODEM

The purpose of the MODEM is to condition the digital data stream generated by the controller into a form that can be transmitted via the radio section, as well as to recover the transmitted signal from another station and convert it back to digital data. It modulates the transmitter to generate a frequency shift keyed signal, but conditions the state sequence of the carrier so as to limit the required base bandpass of the radio. A 3-pole low pass filter limits the transmitted bandwidth by attenuating modulation components above 5 KHz. No scramblers or de-scramblers are required. The GMSK may be operated from 4800 - 19200 baud, with some parts values changes and switch selection.

2.4.3. Receiver

The receiver has its own frequency synthesizer, controlled by a serial data stream from the controller assembly. It features four helical resonators in the front-end, an RF amplifier, a double balanced mixer, and a 21.4 MHz IF amplifier with a bandpass crystal filter. A second mixer results in an IF of 455 KHz, where a ceramic bandpass filter supplements the selectivity provided in the first IF. The limiter/discriminator output is filtered in an active low-pass filter and fed to the MODEM section.

2.4.4. Transmitter

The transmitter has its own frequency synthesizer, controlled by a serial data stream from the controller assembly. The synthesizer VCO outputs directly at the operating frequency, which is then amplified to the required system

power output level and low-pass filtered for harmonic rejection. Antenna T/R switching is implemented with PIN diodes. The receiver antenna connection plugs into the transmitter assembly, at the receiver port of the switch. Two-point modulation is used to produce DC modulation response. The upper modulation frequency limit is constrained by the modem filter. An interlock prevents transmitter keying if the synthesizer isn't locked.

2.4.5. Interconnect Assembly

All non-RF interconnections are made on this assembly. The panel indicators and their drive circuitry and the power fuse are also on this board. The system connector is RFI filtered.

2.5. Specifications

Since there are many frequency and power levels for SNRDS units the following is shown as typical for the 450-470 MHz, 4-watt unit. Detailed specifications are available upon request for any particular unit.

System	
Temperature range:	-30 to +60 degrees C, no warm-up time
Humidity:	0 to 99% RH, non-condensing
Size:	9.775L x 4.54W x 2.268H inches
Weight:	2.25 lbs.
Power requirement:	10-15 volts DC, negative ground
Current drain:	300 mA receive, 1500 mA transmit
Controller RDC2 or RDC$	
MODEM	built in, optional rates
Data rate, link side:	MODEM dependent; 1200 to 9600 baud
Data rate, serial port:	300, 600, 1200, 2400, 4800, 9600, 19200 baud
CPU Watchdog timer:	Approximately 1 second
Transmit limit timer:	approximately 15 seconds
RAM	32K bytes
EPROM	32K bytes
EEPROM	512 bytes
System turnaround time	3 ms typical receive-transmit, 5 ms transmit-receive

Radio	**MIN**	**TYP**	**MAX**	**UNITS, COMMENTS**
Frequency range available from 130 to 950 MHz. Specifications vary with frequency, shown here for the 450-470 MHz band				
Range with retuning	450	---	470	MHz
Range without retuning	5	---	---	MHz
Antenna impedance	---	50	---	Ohms nominal
Frequency stability	---	---	±2.5	PPM full temp
Synthesizer resolution		12.5		kHz
Channel spacing		25		kHz
Operating temperature	-30	---	+60	Degrees Celsius
Duty cycle			100%	
Current drain, standby	---	---	150	mA max, receive
Current drain, transmit	---	---	1	A
Conducted spurious	---	---	-57	dBm (regulatory limit)
Transmitter				
Output power	4	5	---	Watts into 50 ohms @ 13.8 Vdc
Conducted spurious/harmonics	---	---	-53	dBc keyed (regulatory limit)
Key-up time to stable data		3	5	ms
Receiver				
Sensitivity	---	-120	-119	dBm 12 dB SINAD non pre-emphasized
Spurious & Image rej	70	---	---	dB
Adjacent channel rejection	70	---	---	dB @ ±25 Khz
Intermodulation	65	70	---	dB, third order
Frequency response	DC		5000	Hz

3. Operation

In this section, control keys on the terminal are identified as "^J" for Control-J, etc. "CR" refers to a carriage return character (marked RETURN or ENTER on most keyboards). Sometimes a required input is shown in <> instead of quotes, where additional quotes could confuse matters. "LF" is short for LINE FEED (^J on keyboards lacking a LF), "Ack" is short for "Acknowledgment", and "Info" is short for "Information" (The term "data" is more general and includes data transmitted and used internally between stations to expedite protocol operation).

3.1. Saving to the EEPROM

In the course of configuring the system for the application there will be mode and parameter changes, which are stored in tables. For example the station address is usually different for each station in a network. When the system initializes, such values are checked at several levels. First, the EEPROM is checked, and if its contents show a good checksum table values are taken from it. If not, the tables in the EPROM itself are used.

All table values can be changed by command, and these changes take place in RAM memory. Therefore if the system is reset or power goes off they are lost. In order to make changes permanent the tables are stored to the EEPROM. The EEPROM contents are protected in hardware, so in order to save new information it must first be unprotected. Two commands are involved; **DU** and **DOC**.

The **DU** command is to Unprotect the EEPROM in preparation for writing, and **DOC** does the writing.. In order to minimize the chance of writing to the EEPROM accidentally, this command is canceled on any following command. Thus, the **DU** command must immediately precede the write command. It is very important that a CR is not type after either of these commands. Just type the command and do not type anything else until the colon prompt is displayed. See the command explanations for more detail.

3.2. System Planning.

Since there are a large number of modes and options, your system objectives provide the best starting point. Look over the following examples to see what approach might best achieve those objectives.

First decide whether you need connected mode. Connected operation is characterized as follows:

1.	An address must be specified and a connect request commanded before each data transfer.
2.	Data is transferred point-to-point between two stations only. Other channel activity is ignored.
3.	When transfers are complete a disconnect operation must be commanded.
4.	Data size is unlimited.
5.	Data transferred in connected mode has guaranteed integrity. Repeats are made as necessary and the data is packetized and reassembled in the correct order.

Examples of use: file transfers, where large amounts of info must be sent from one station to another, or dedicated point-to-point circuits where the stations can remain connected continuously.

Unconnected mode may be better where many stations are being polled and data fields are short, because it saves the time otherwise taken for connecting and disconnecting. It might also be better when the data being sent is volatile, that is, it's being updated repeatedly with new values. In this case it might take less time simply to send an updated version of the data, rather than to persist in repeating the original data until acked. Depending on how often it is to be updated, there may be time to send each message more than once in unconnected mode, improving the chances that each message is received. In unconnected mode:

1.	No address need be specified, but addresses can be used to limit which stations receive the messages using the filterlist (section **4.14.2. The Filterlist Mode Command**)
2.	Connect/disconnect requests aren't used.
3.	The maximum length of the data is 256 bytes per frame, but if it's longer, additional frames are automatically generated to send the excess, up to 7 frames at a time.
4.	No acknowledgments are made, so delivery isn't guaranteed.
5.	Each message is sent n times, although n is normally set to 1.

If multiple frames are needed to send the data, it's possible for one or more of them to be lost, resulting in an incomplete message.

There's an intermediate system between connected and unconnected mode, called unconnected acknowledgment mode. In this case the data is sent N times (specified in advance) to a specific station address. When received, the data is acknowledged and further repeats are halted. This method eliminates the need to connect/disconnect. If more than one frame is sent (because the message exceeds 256 bytes) there is a separate acknowledgment for each frame. It is up to the user's software to determine which frames have been acknowledged, since in this mode the controller doesn't number the frames.

Applications: GPS differential correction, SCADA systems.

3.3. Forward Error Correction

This feature may be ordered as a software option. When FEC is used, extra correction bits are sent with the data that are used to correct errors, which might have occurred during transmission. Although the extra bits incur some overhead, the probability of receiving any given frame is greatly enhanced, particularly in the presence of impulse noise or rapid fading, such as in moving vehicles.

FEC must be used in all stations of a system, since transmissions are not possible between FEC and non-FEC stations. Most modes and commands operate in the same manner with or without FEC, but a few of the commands differ.

Applications: GPS, SCADA, connected mode applications in noisy locations or fading paths.

3.4. Continuous ASCII (CA) mode

For real-time applications or in cases where no protocol is required in the SNRDS unit, and all that is required is for the controller to transfer bytes via radio as received, this mode is available as a software/hardware option. This mode operates in 2 ways. The first is the transmitter can be keyed by setting the secondary RTS true. While the transmitter is keyed bytes are sent as they are entered at the secondary serial port. The first bytes of data will be buffered until the radio has finished sending its' preamble. They're displayed at the receiver end as received. The entire transmission does not have to be received before data starts to be displayed. There is no addressing or error checking. The host system must perform those functions as required.

The second method of operation of CA mode is the transmitter is keyed automatically on the receipt of the first byte of data into the secondary serial port. This makes the SNRDS completely transparent to the user equipment since no transmitter keying signal is required. This method is more popular than the former since this method allows the radios to most closely emulate a wire in both function and timing.

CA mode has recently been modified such that garbage characters are suppressed at the beginning and end of the transmission. This change allows the user to get accurate data the first time. The user no longer has to sift through

the data to find where the good data starts and ends. This addition does not remove the possibility of erred data, but dramatically reduces the incidences of erred bytes.

CA mode uses both serial ports of the radio. Both serial ports are located on the signal DB25 connector. Special cabling is available from Simrex. The Primary serial port is always in command mode. Commands can be changed at any time, but should not be changed while data is being transferred since errors may occur. The Secondary serial port is used only for serial data transmission and reception.

Normally, CA mode operation calls for a serial port baud rate that is the same as the link (radio side) baud rate, but the rules can be bent because of the intelligence in the controller. Although the average baud rate coming into the primary serial port from the host must not exceed the link baud rate of the radio, the internal buffering allows higher speed bursts. Thus it is possible to use 19200 baud between the host and controller, even if the controller sends only 9600 baud on the link side. If bytes are sent half of the time on the average, overrun will not occur. If overrun should occur, the controller CTS signal is set false, signaling the host to wait. Similarly, at the receive end if the link rate is 9600 baud and the transfer from the controller is only 4800 baud, receive buffering prevents loss of bytes (although a delay would accumulate on received bytes that go into the queue until they can be displayed).

CA mode requires a completely different EPROM firmware and different cabling. It is not compatible with any of the packet protocol software and will not communicate with it.

There are a few important parameters that are used for CA mode.

MX This parameter controls how the transmitter is keyed. When this parameter is enabled, the transmitter is keyed by a high level on the RTS2 pin (pin 19 of the DB25). The transmitter will then unkey when there is a low level on this pin. When this parameter is disabled, the transmitter is keyed automatically upon the receipt of the first byte of data on the secondary COM port. The transmitter is then unkeyed when all of the data has been sent.

FQ This parameter controls whether the receive or transmit function has priority. When enabled, the unit will wait until the channel is clear to transmit. When disabled, the transmitter will transmit regardless of whether the unit is receiving anything at the time it is commanded to transmit. This can be useful in a system that has some low level noise on frequency and where all channel activity is controlled by a Master radio.

MF This parameter controls whether an opening and closing sequence is sent with a transmission. The opening and closing sequence are used to suppress garbage data at the beginning and end of a transmission. This is an asset when the transmitter is constantly keyed and unkeyed, but for constant keyed transmitter environments it becomes a problem. This is because a noise burst can cause the receiving unit to become confused and think that it received a closing sequence. At this point then the receiving unit would no longer output any data until a new transmission was started. Since it is a constant keyed system a new transmission is never started. With this command enabled, the receive unit does not look for opening and closing sequences, it just outputs anything that is received that is not a flag. This means that there will be garbage output on the start and end of the transmission, but since the transmitter is keyed continuously this will not be a problem.

Applications: vehicular control, SDLC-mediated systems, where the host manages the protocol.

4. Packet Operation

This section describes how to operate using the MX.25 protocol. LOP operation is very similar; the differences are discussed in section **5. LOP Packet Operation**. It's assumed that the controller is interfaced and functional. When 3 capital U's are a colon will first be displayed. Typing a CR at this point will cause a sign-on message to appear:

"GLB SNRDS-2 V1.99W3"

"V1.99W3" is the software version number, which will vary.

Whenever a ":" appears, either by itself or at the end of the sign-on message, command mode operation is indicated. It's displayed after completion of any command, as long as control remains in the command mode. If an error occurs in any command the ":" is replaced by a "?", but in either case it's ready to accept another command.

The controller comes up in the "monitor" mode, in which it displays all packet activity on the radio channel, and with MX.25 protocol selected.

4.1. Entering addresses

When using connected mode or unconnected ack mode it is necessary to assign a unique address to each station in the network. Addresses are also useful in unconnected mode, since the addresses can be used to control the display of information. In MX.25 protocol each packet contains the station address and the address of the destination station. Both addresses are added automatically to each packet in both unconnected and connected modes, but this information must be initially supplied by the user.

An MX.25 address consists of two parts. The first, or base address, consists of 1 to 6 characters, which may be A-Z, 0-9 or "/". The second part is a numeric value in the range 0-15. This added number, called a "Secondary Station IDentifier", or "SSID", makes it possible to operate more than one station under the same address without confusion. For example, there might be one or more digipeaters plus a primary station using the same base address. These stations may be distinguished by using a different SSID value on each address. It's customary to use 0 for the first or primary station, and an SSID of 15 is reserved as "wild" - if the correct SSID isn't known by another station the operator may use the value 15 to make an initial connection.

4.1.1. Local station address

The station address identifies the station being accessed. A default address is copied out of the EPROM at initialization. If it needs to be checked or changed, use the **SC** (Set Call) command:

SC<station address>

The existing address is then displayed:

Type: "**SC**" (the controller then displays "ABCDEF-");

If a new address is typed in response it replaces the old entry. Type a space instead, and the old one remains unchanged. Next the SSID value is displayed:

"0-".

Type another space to exit the command. Re-enter "**SC**", and this time type a new address. Enter a space or a dash after the last letter. Lower case letters are automatically promoted to upper case.

At this point the controller displays "0-", prompting for the entry of the station SSID, and showing that the value now in effect is "0". If "0" is satisfactory, type a space to retain it. If not, enter another value, followed by a space.

Repeat the command with spaces to confirm that the new address is now in place. The station address stays in place until changed or a bad checksum is found when the controller is reset. These new changes can be saved to the EEPROM by using the **DU** and **DOC** commands.

4.1.2. Entering a Destination Address

There are two methods for entering the destination address.

Method 1: The **SD** command, following the same rules as the **SC** command as explained in the previous section.
Method 2: The command "C" and the destination/path may be typed in a single line, as in the following example:

C REMOTE<CR>	calls REMOTE-0
C<CR>	connects to previously entered path

Note that an SSID of 0 is assumed if none is entered. To enter an SSID it must be prefixed with a hyphen, immediately after the address (no spaces). While typing the command backspace may be used to correct errors, and ^R to retype the line. When the <CR> is typed a connect sequence is started.

Digipeaters may also be specified with the **C** command, optionally using the letter "**V**" followed by the digipeater addresses after the destination address. See section **4.5.**, "Operation with digipeaters". Whenever new addresses are typed in conjunction with the **C** and **V** commands the stored addresses entered with **SD** and **SV**, respectively, are changed.

The destination station address and any digipeater address change only when retyped or if a connection is received from a different station. If a connection is received the destination address and digipeater addresses (called a "path") are changed to match the new station automatically.

4.2. Status Report

The command **S<CR>** produces an abbreviated "report" showing the addresses in effect, the current operating state, and what modes are currently in effect. Type:

S<CR> The response is: "1 /TEST 0 /------ 0 / //LDU/XE/RL/0"

The display line is separated into nine "fields", separated by "/"s. The first field is the link "state", and the "1" indicates that the station is currently disconnected. The second field is the station address and SSID, the third is the destination station's address and SSID (here none is entered), and the remaining fields designate various mode settings. See section **7.5.** for a complete description of the "S" command.

At this point the only concern is with the addresses and "state". The state is an internally generated number representing conditions on the link connection. The most significant thing to know is that a state of 1 means disconnected, and anything above 4 indicates a connected state. States 2-4 occur during connect/disconnect processes. Other values that occur are used mainly for diagnostic purposes.

4.3. Connected Operation

Connected operation is always used to obtain the maximum benefits from packet operation. It always involves exactly two stations. Stations in connected mode ordinarily ignore all other station activity on the radio channel, and won't respond to a connect request by any others. All information in connected mode has guaranteed delivery. In case of error in transmission packets are not accepted, and the transmission is repeated. Messages are not displayed more than once, even if they have been repeated by the sender to obtain an acknowledgment. Packets being sent are not deleted from the sender's buffer until an ack is received. If a packet is not received after a number of tries (normally 16) the connection is terminated and the message remains in the transmit buffer. If no packets have been received for more than 6 minutes (set by **SQ** command), the station becomes disconnected without making further transmissions.

Packet procedure is analogous to ordinary conversation: You say "hello", talk, then say "good-bye". In voice radio procedure you establish contact by exchanging addresses, talk, then sign off. In packet those steps would be called connect, exchange info and disconnect.

4.3.1. Connecting

The connect process is similar in all data modes, but there is some variation in how a connection is made. The first example shown is Connected Chat mode.

Type: "C BASE"<CR>

When the other station responds, "Chat" mode is entered, with the display "Connected to BASE" (where the other station's address replaces "BASE"). If any info is present in the transmit buffer at the time a connection is made, it's displayed at this point and the cursor is set to the end of it, making it possible to leave a message in the buffer to be transferred when another station connects.

4.3.2. Chat mode

Once a connection is established, information may be exchanged with the other station. Chat mode is convenient for ordinary conversation; therefore this mode is entered automatically when a connection is established (This procedure is optional; see commands **ML** and **MX**).

Chat mode is used only when the transmitted data is plain ASCII text. Anything typed is assumed to be information for transmission; thus, the letter commands used in command mode can't be used. What few commands are needed are provided by means of "control" characters. Most keyboards allow control characters to be entered by holding the "CONTROL" key down and typing a letter. A "control-B" in these instructions is given in a shorthand form using the up-arrow to designate "control", i.e., "^B" means the control key is held down while typing the letter "B".

On entry to Chat mode a BELL character is sent to the terminal, and any messages received are displayed as they come in. As soon as a character is typed the display of received packets is disabled temporarily so that the line being typed does not become disrupted with incoming info. More than one line may be typed by ending the first with a RETURN. The LF character is reserved as a "send" key. When a message to be sent is completed, type LF to transmit the message and to re-enable the display of incoming messages.

NOTE: Some keyboards lack a line feed key; a ^J is the same thing. This "send" character may be changed to another by use of the **SY** command (see Section **7.5.**). If there's any doubt what ASCII value is generated by any particular key, the **DK** command displays it.

Different terminals respond in different ways to the CR and LF characters to end a line and start a new one. The most straightforward method is for the cursor to move to the left-hand side of the screen when a CR is received and for it to move down a line (scrolling the screen up if necessary) when an LF is received. On some terminals the LF is assumed when a CR is received, thus reducing the number of characters that must be sent. In the latter case if the sender uses both CR and LF at the end of the line, lines become double spaced. In Chat mode both CR and LF are

echoed to the terminal at the end of each line, even though only CR is transmitted over the radio link. If the terminal shows the message double-spaced, the LF may be suppressed using the **MF** command (Section **7.5.**). Chat mode example: to send "Hi there.", just type

"Hi there."<CR><LF>

4.3.3. Chat Mode special characters

Special characters are used to edit the line and as commands. These include BACKSPACE to correct errors, and others as follows:

^B	send a connect request
^C	initiate a disconnect
^D	enable receive display without transmitting
^R	display one frame of received data
^T	retype the contents of the buffer
^U	delete current line of input
^X	delete contents of buffer
ESC	exit Chat mode
\	Place any next character into the message

Suppose a line has been typed but it isn't to be sent until the other station sends its next packet (to maintain the continuity of the conversation). ^D re-enables the receive display without sending the typed message; when the next message has been received the typed message is automatically returned.

A received message may be displayed during typing by using ^R. After the incoming message has been displayed the current line may be continued. If no new characters have been typed for about 40 seconds, the controller sends whatever is in the buffer and the receive display is enabled. This time value may be changed with the **OI** command. Time-out avoids accidentally blocking incoming information forever if LF is not used.]

Once typed information has been acked by the other station, it's automatically deleted from the buffer. Each time this occurs a BELL character is sent to the terminal (even if more info is being typed) to indicate that the last message was acked.

The ESC command may be used to exit from Chat mode to Command mode at any time. Manual re-entry to Chat mode is made by typing the **MS** command. Normally entry to Chat mode is automatic when a connection is established and exit occurs when the connection is terminated (see **ML** command).

Any of the reserved control characters may be sent, such as ESC by preceding them with the '\' character. The sequence "\"ESC places the ESC into the message instead of exiting Chat mode, as ESC by itself does. It follows that in order to send an actual '\' character it's necessary to type "\\". The first says "place the next character into the buffer", and the next character is '\'. See **OR**.

If there's any information in the buffer when Chat mode is entered, it's displayed as if freshly typed. When additional info is typed it appends to the old info, but the old info may be deleted or edited as desired, using the available control character controls.

4.3.4. Disconnecting

A disconnect is initiated from Chat mode with ^C. Command mode is restored automatically when the disconnect is acked (exception; see **ML** command). If command mode is entered before the disconnect (by typing ESCAPE) then the **AD** or the **D<CR>** command may be used to initiate a disconnect.

4.4. Unconnected operation

There is no provision in the connected protocols for more than two stations to communicate at a time. However, operation involving more than two stations may be accomplished in unconnected mode.

In unconnected mode transmissions are initiated by command, or when combined with transparent mode, when data is supplied. Packets can be sent once or repeated automatically N times (**SN**). Since there are no automatic acknowledgments, there is no way of knowing which (if any) of the stations on channel has received the packet. The chances that all stations receive a packet may be increased by sending it more than once. Each time it's received the data is displayed, so if it's sent more than once it may be displayed more than once.

In unconnected mode addresses are entered by command at each end of the path. By activating the **OO** command, only packets containing our address as a destination are displayed. It's possible to use different paths for communications in opposite directions.

In MX.25 if the addresses of a group are listed in the filterlist, to select each address in the monitor mode, other channel activity may be suppressed, making more than one "round table" possible on a single channel. For other options see **OM** and **MY** commands.

Information is transmitted as UI's (Unnumbered Info) frames, so there's no automatic sequencing and the receiving side simply displays what comes through, in the order received. The number of frames that can be sent at one time is limited to 7 frames per packet as in connected mode.

Even in unconnected mode certain things are done automatically. First, there need be no concern whether the channel is clear when the command to transmit is given. The channel is always checked automatically for activity before transmitting. Error checks are made on all packets, so every displayed packet is guaranteed to be accurate. It must be recognized, however, that if an error occurs the packet is not displayed at the destination at all. In a round table, it's possible that some stations may receive a message while others do not.

In Unconnected mode connect requests are ignored, since a connection could disrupt normal operation unexpectedly. If the station is to accept and respond to connect requests, Unconnected mode must be disabled (**MU**-D). This action is also taken automatically after about 6 minutes (default) with no activity, controlled by the **SQ** command, unless **SQ** is set to zero. The **MO** command makes it possible to accept connect requests while in unconnected mode.

To operate in unconnected mode set up addresses as needed, then enter **MU**E to enable unconnected mode operation. Operation may commence in command, Chat or Transparent modes. Since there's no connection involved, Chat or Transparent modes must be entered manually. For Transparent mode **MX** must be enabled first. Typing **MS** then causes the selected mode (Chat or Transparent) to be entered.

In Command or Block mode, unconnected operation involves **I**nputting the information to be sent, then sending it with the **AI** command. It may be sent as many times as necessary, but there are no status displays or acks. The **AU** command may also be used, where each sending causes transmissions to be repeated N times, where N is set with the **SN** command. Remember that **OD** must be enabled at any station receiving UI data or it won't be displayed.

Unconnected Chat mode operation differs from connected Chat mode as follows:

1.	Each time LF is entered the packet is transmitted N times, where N is set with the **SN** command, as an Unnumbered Information (or UI, see **4.15.**) frame. UI frames are limited to 256 characters.
2.	No acknowledgment is returned.
3.	Information is not automatically deleted from the transmit buffer. When finished with a message, type "^X" to clear the buffer. If it isn't purged manually, any new message is appended to the old, and both will be sent next time.

Unconnected Transparent mode compares to connected Transparent mode (see **6.1.**) as follows:

1.	Info in the transmit buffer is still sent N times, where N is set with the **SN** command.
3.	When the buffer overflows, or if the **SK** timer expires (because of a pause in the input stream), CTS is set false[1] to prevent the acceptance of further info, and the info is transmitted N times.
2.	After one more delay period CTS is set true, the information in the transmit buffer is automatically deleted and more info may be sent.

The time between transmissions is set with the **ST** command, and the number of times each info transmission is made is set with the **SN** command. **SK** controls the amount of delay time between the time data is no longer being received from the serial port and the time radio transmission begins.

4.4.1. Unconnected Ack mode

There's an extension to unconnected operation, controlled with the **MW** command. In unconnected ack mode if N UI (See **4.15.**) frames are sent automatically (**AU**, N set with **SN**), remaining transmissions stop when an acknowledgment is received. After count-out or acknowledgment the transmit buffer is cleared for another message, and in Command or Block modes a #4 status message is displayed to indicate an ack. After N repeats, if an ack has not been received the status message #3 is displayed instead. In Chat mode the message "—ack" is displayed. No status indication is shown in transparent mode. When MW is enabled it produces two effects: the generation of acks for UI transmissions at the receiving station and the acceptance of acks at the sending station. When an ack is received while in command or block mode a #4 status message is displayed. If no ack is received and the specified number of transmissions was completed, #3 is displayed.

All info frames are sent as UI's, limited to 256 bytes in length. If there are more than 256 bytes in the transmit buffer when transmission is initiated, multiple frames will be generated automatically. The number of frames sent and the number of bytes are under the control of the SH and SL commands, respectively. In transparent mode only one ack is sent for each packet (which could consist of multiple frames). If frame sequence is important, the best strategy is to limit sending to one frame per transmission and wait for each ack (or to use connected mode). In order to display UI's non-info data fields must be enabled (**OD**-E). Acknowledgments are sent as UA's (unnumbered acknowledgment).

Under Block mode, an ack is sent for each UI frame received. This allows the host system to match the count of frames sent to those received. In block mode, the receiving station (if also in unconnected ack mode) generates an identical ack for each frame received, so if one is missed the number of acks will be short of the number of frames sent. There is no sequence checking between frames, so there isn't any way to tell which frame was missed.

Unconnected ack mode works best when there are only two stations exchanging info, but it's also useful in a "star" network. In a "star" configuration all communications pass between a master "hub" station and at least two other "peripheral" stations. In many such applications information flows only from the peripheral stations to the hub. Any peripheral station may originate information at any time, using repeat transmissions until acked. The advantage in this situation is that the overhead involved in first connecting to each station is eliminated and unnecessary repeats are eliminated, speeding up the network. The only caution is that it's possible for duplicate frames to be received if the hub receives and acknowledges, but its ack is lost. If the ack isn't received the frame is sent again until an ack is received, but the hub station won't "know" it's a duplicate. In many systems (such as SCADA), duplication is not harmful, since each frame is an information update, but it would be unsuitable for file transmissions where the information length spans more than one frame unless a higher level can be used to screen any redundant parts.

[1]CTS is not set in hardware until the input queue for the serial port is 75% full, nominally 100 characters.

4.4.2. Garbage Mode

Although the accuracy of displayed packets is guaranteed, if an error occurs, however trivial, the entire message is lost. In poor radio conditions, the **SG** (Set Garbage) command may be enabled in an attempt to salvage whatever does come through. In "garbage" mode no address or error checking is done and everything received (including garbage!) is displayed. It is not possible to save this command enabled in the EEPROM. This is due to too many problems with it in the past.

> **NOTE**: In GARBAGE mode no automatic transmissions are made and connect requests are ignored, since without error checking transmissions could occur based on erroneous information. However, if a connect request is originated with **C** or **AC** garbage mode is automatically canceled and the command is executed.

4.5. Operation with digipeaters

"Digipeater" is the term for what would be called a "repeater" in voice radio. The analogy fails in that packet signals aren't repeated in real time; first they're received and stored in the digipeater, and if the error check is good they are re-transmitted. Digipeating is a simplex operation and duplexers and extra radio channels aren't needed.

MX.25 protocol includes means to designate up to eight digipeaters to relay packets to stations out of direct radio range. The digipeater can be any MX.25 station, as long as it is active and in radio range. For multiple hops it's necessary only to have a radio path between successive digipeaters. When digipeaters are used the destination station ignores the originally-sent packet, even if received, responding only to the transmission from the last digipeater address in the path. The response returns by the same path in reverse. The time delay between repeats is automatically increased for each digipeater, allowing more time for packets to be acknowledged.

The digipeat function may be disabled with the **MR** command. In command mode a status message "#9" is displayed each time a digipeat is sent. When not connected digipeated frames may be observed in Command or Block modes by enabling the **MV** command, subject to **OH** and **OO** settings. In Chat mode, if the **MV** command is enabled a message (see **4.12.1.**) accompanies each digipeat occurrence, but the digipeated frame isn't shown. There are no status displays in Transparent mode.

4.5.1. Digipeater Addressing

There are two methods to enter the digipeater addresses, or "path".

Method 1:

As shown in section 3.1, the destination and digipeater addresses may be entered as a single-line command. The characters **C** and **V** are used in the command as follows:

C REMOTE-1 **V** SITE-3 SITE-4

This command initiates a connect request to REMOTE-1 via the digipeaters SITE-3 and SITE-4. Packets go first to SITE-3, then to SITE-4, finally reaching REMOTE-1.

If preferred, "CONNECT" or "CONN" may be used in place of **C** , or **VIA** in place of **V**. The VIA entry is included only for commonality with many other packet controllers; whenever more than one address is entered the first is assumed to be the destination and the remainder are taken as a digipeater path. Thus **V** or **VIA** is optional. Note that

using this method, if any address in the path changes the entire line must be re-entered. However, method 2 allows the path to be edited, even if the original path was entered with method 1.Method 2:

The **SV** command (Set Via) operates in the same manner as **SC** or **SD**, except that each time an address-SSID is entered another prompt ("------") is shown, up to 8 times. That's the prompt to enter the next digipeater in the radio path. Up to 8 addresses may be entered, after which the command terminates automatically. The command may be terminated with fewer than 8 addresses by typing a space or CR at the next address prompt instead of another address.

4.5.2. Status Update with Digipeaters

When digipeaters are specified the status display shows three addresses instead of two. If more than one digipeater station is specified, a "#" appears next to the first digipeater address. The other digipeater addresses may be observed with the **SV** command.

4.5.3. Alternate Digipeater Addressing

There are situations where the digipeater address must be different from the normal station address. For example, for redundancy it may be desirable to install two digipeaters, capable of digipeating by the same address so that other system stations don't have to change their paths to have packets digipeated at the site. Only one of these stations would have the digipeat function enabled at a time, the other acting as a "hot" standby for it. Since it's illegal (in the protocol) to have two stations in a network with the same address, the station address must be different than the digipeater address in at least one of them.

The **DG** command allows a special digipeater address to be entered, for use by other stations in the system as a digipeater address. Each station can then keep its own independent address for making connections. A common problem in setting up a "hot" standby digipeater is that only the primary or the standby unit can be active at one time, since the standby unit must have the same digipeater address if it's to take over in a manner transparent to other stations. This command allows a common digipeat address to be assigned to both stations, yet they can be called separately by their normal connection addresses. Thus the stations may be commanded independently, activating one or the other to digipeat.

When a digipeater address is present, the station digipeats when either address is specified. If digipeating is to be allowed ONLY under the digipeater address, the **DH** command may be enabled. When a digipeater address is present and **DH** is enabled digipeat requests are ignored under the normal station address.

An important feature of using a special digipeater address is that a delay value can be specified. The **FG** command controls timing in steps of 10 ms (up to 2.55 seconds). The digipeater waits this time value after receiving a packet to digipeat before transmitting. By controlling the delay time, digipeaters can be made to concede channel priority to other stations.

4.5.4. Responding to connect requests via digipeaters

When the station is called via a digipeater path, the path is automatically stored in reverse order as if it had been typed in manually. This address is then used in all return packets.

4.5.5. Path address retention and editing

If, after having communicated via a digipeater path the station is called without digipeaters the previous digipeater addresses are retained for later use without the need for retyping. They may be reactivated by typing **SV** and

responding with spaces to each prompt. The digipeater reappears in the status display and digipeater operation commences with the next connect command. The digipeater addresses change if another station connects using a different digipeater path. Entering a long list of addresses can be tedious, hence the command system is designed to minimize typing. For example if a mistake is made on the 3rd of four addresses, the **SV** command may be re-entered. The first two addresses are skipped using the space bar, the third address may be corrected and additional spaces used to exit the command.

Any address may be deleted by entering a single "-" at the first character. The remainder of that address is automatically filled with dashes. If there are 8 addresses in place and, say, the third one is deleted the following ones are deactivated but not deleted. The next time an address is typed into that position the remaining addresses are reactivated. All addresses beyond the first "------" encountered are ignored. Thus by deleting the first address no digipeaters are used, but only the first address must be restored in order to recover the entire path.

The digipeater addresses may be deactivated without deleting ANY of the addresses, simply by stepping through the **SC** command with the space bar. They may be reactivated with **SV** by stepping through the digipeater addresses with the space bar.

4.6. Output Format and Displays

Please note the difference between what is referred to as "information" (or "info") versus "data" in this manual. Information is a subset of data and refers to the intelligence that is sent from one station to the other. The term "data" is more general and includes info and the "overhead" necessary to accomplish the task as hand. All info is sent to the serial port. Although information may be accepted by a computer program instead of a terminal and will not necessarily end up displayed on a screen, the term "display" is used here whenever data is sent to the serial port.

4.6.1. Information Fields

The basic unit of transmission in packet is the "frame", each of which contains a "header", transmitted data and its own error check. A packet may contain more than one frame, each one of which contains a header. There are different types of frames; some don't carry data at all, but are used to manage the protocol, such as connects/disconnects, acknowledgments, etc. Finally, the status of the radio link, such as whether a connection exists or data has been acknowledged, is of importance to a user or a host control program. Each of these types of data are sent to the terminal or host computer, and are referred to as "fields". In addition, there are two types of data that are sent between stations. User information is normally sent in "info" frames, which can handle large files by breaking them down into blocks, sending them with sequence numbers so the protocol can keep track of them. Other types of frames may also contain data and are lumped into one group, termed "non-info data". The latter are not sequenced, are limited to 256 bytes at a time, and may not require acknowledgment. Some info frames also carry a "Protocol IDentifier" byte (PID) which may be used in systems to identify a higher level of protocol.

The display of Information fields can't be turned off, but there are ways to control what sources are to be displayed (see section **4.15.**).

4.6.2. Header Fields

Headers consist of two parts; the address field and the control field. The address field contains the addresses of the stations in communication plus the address of any digipeater stations used. The control field tells the station what to do with the packet. MX.25 uses control fields as defined in X.25, but there are modifications and additions that optimize the protocol for radio use.

4.6.3. Status Fields

Status fields are displayed when the link state changes. Only the changed aspect of the state is sent.

If different types of fields are to be displayed they must not be allowed to contaminate the info; there must be a way of identifying each display field so the user can decide what to do with it. For example, a computer program may be sending info to a disk file, so if a status field is sent to the computer it must be identified in some way so the computer doesn't simply add it to the file.

In summary, the types of display fields include headers, info, non-info data, and status. The form of the displays and how they're distinguished varies with the mode of operation being used. The following paragraphs describe how each field is handled in Chat, Transparent and Command modes. Block mode is similar to Command mode but modified so as to expedite control by a host computer instead of a human operator. The display output is modified to reduce the number of characters sent by eliminating screen-formatting characters. Block mode is covered in greater detail in section **6.2.**.

4.6.4. Display timing

When the system is driving other equipment that might need to be keyed before the info is sent to it via the serial port and un-keyed afterwards, timing options are available. The **OG** command is used to set the keying timing and **OJ** is used to set un-keying timing. See section **7. Commands**, commands.

4.6.5. Chat mode displays

Since Chat mode is intended for human, not computer use, only information and status messages are displayed.

4.6.5.1. Headers in Chat mode

Headers are not displayed in Chat mode.

4.6.5.2. Information

In Chat mode information is sent to the terminal for direct viewing. The data may be modified for formatting of lines, adding carriage returns or line feeds as necessary. The viewing of non-info data is optional (**OD**).

4.6.5.3. Chat mode status messages

Status messages are displayed in the form of plain language messages with leading hyphens, as follows:

"- Connected to ABCDEF" means either that a call has been made from station ABCDEF or a request we made to ABCDEF has been acknowledged. Either way the station is in connected mode.

"- Disconnected" means the reverse of the above.

"- Ack" means that the contents of the transmit buffer have been sent and acknowledged by the other station. The transmit buffer is now empty. This message also contains a ^G, which sends an audible "beep" from the host terminal or computer to alert the operator that the previous message has been received by the other station. Also see "MK".

"-No ack" means there was no acknowledgment after the maximum number of retries.

"- Waiting" means the receiving station buffer is full and flow control has been invoked.

"- Holding" means that flow control has been invoked by our station to the other station.

"- Call from DEFGHI" occurs when in connected mode with a second station, the **OC** function has been enabled, and a third station sends a packet to our address. "DEFGHI" identifies the third station. If the third station sends data it is displayed on the line below the "- Call from..." message. See commands **OC** and **OE**, section **7.5.**

"- Digipeating" occurs when **MV** is enabled and a packet has been digipeated by our station.

4.6.6. Transparent mode displays

In Transparent mode only info from the remote station is displayed. Since one of the primary uses of this mode is to send data into files all other output is suppressed to avoid contamination of the files.

4.6.7. Command mode displays

When the controller is initialized it's set to display only status updates and information. The other types of fields may be displayed selectively.

4.6.7.1. Headers and tags

A typical header display:

REMOTE 0 MOBILE 0-63

A header is tagged by the "." character. The "-" within the header tags the control field value. Control fields are always displayed in hex radix. On information frames ";" is added, followed by a number representing the value of the PID field. When the frame contains data an additional tag is output at the end of the header display; ' (apostrophe character) if it's info and "/" if it's non-info data. Some of the non-info data fields (UI's, see **4.15.**) also contain a PID.

The first address shown is that of the destination station and the second is that of the source station. Any additional addresses are digipeaters, listed in order from the first to digipeat the frame to the last. An asterisk is appended to the addresses of digipeaters that have handled the frame. The destination station accepts only packets in which all digipeater addresses have been so tagged. Example:

REMOTE 0 BASE 0 SITE 0* DIGI1 0

The frame is from BASE-0, to REMOTE-0 and it has been digipeated by SITE-0. DIGI1-0 is to digipeat it next, but it hasn't done so yet. The display of headers is controlled with the **OH** command (section **7.5.**).

4.6.7.2. Information fields

In command mode info fields are identified at the end of a header with the ASCII character " ‘ ". The end of the info itself is not delimited; since command mode isn't used for computer interpretation the user can normally find the end by observing the start of other fields. If that proves difficult the other fields may be simply be disabled.

Non-info data display is controlled with the **OD** command. The tag at the end of a header for non-info fields is the character "/".

4.6.7.3. Status fields

These consist of the tag "#" and a number. The number represents the status change that has taken place:

#1	Disconnected
#2	Connected
#3	No acknowledgment received (N transmissions completed)
#4	Acknowledgment received
#5	Flow control imposed at remote station
#6	Flow control imposed by our station
#7	A retry transmission has been sent
#8	A remote command has been acknowledged
#9	Our station has digipeated a packet

Please note that these values are different from the "state" values shown in the status display (see **S<CR>** command). The latter changes only in connected mode, and indicates an absolute state while these status values occur upon a change in state.

4.7. Important constants

Certain values used to operate the protocol are preset, but they may be fine-tuned by command as conditions vary. Among these conditions are the prevailing channel activity level, the number of digipeaters in use, receiving conditions and characteristics of the radios.

A few of these are discussed here. Section **7. Commands** includes them all.

4.7.1. Preamble length

The preamble is a string of bytes sent at the beginning of every packet to allow the receiving station to synchronize to the sending station. In theory a preamble is used in synchronous operation to allow the recovered receiver clock to get into synchronization with the transmitter, an operation which normally takes place within 8 bits. In packet radio operation when a transmission is started in response to one received the transmitter must be keyed and some time must be allowed for it to reach full operation before data can be sent. At the remote station the transmitter is simultaneously being unkeyed and its carrier must decay while the receiver becomes operational. While one or the other of these delays may dominate, the effect is the same: there's a certain amount of "turn-around" delay before data can flow in the opposite direction. This delay may be provided simply by increasing the preamble length when transmitting a packet. The preamble consists of a special byte value, called a "flag", repeated as necessary. The timing is done by controlling the number of flags sent, with the **SF** command.

Most of these flags may be lost while the turnaround is taking place. A few bits are required to synchronize the clock, followed by at least one complete flag before the body of a packet can be received. These conditions are virtually assured if two complete flags are received. The rest of the flags are set to delay the onset of the packet just

enough so that data flow commences when at least two are left. At 9600 baud a flag is about .8 ms long, but at 1200 baud it's about 6.7 ms, so the flag count varies with baud rate as well as the radio hardware.

The most practical way to determine the number of flags required is to start with more than enough, then start reducing them at one end of the path until the number of packets missed begins to increase. The other station can then be set the same way, possibly yielding different values because of individual equipment differences. Always stay on the conservative side, because while a preamble that's too long wastes time, one that's too short may make communications erratic or impossible.

4.7.2. Number of retries

On power-up the controller sends each packet up to 16 times before giving up. This number may be changed with the **SN** command. More tries may be appropriate under poor conditions or on busy channels. If it runs out of tries it automatically disconnects; hence to maintain connection continuity enough tries are needed to get through every time. On the other hand, if an equipment failure is the cause all those wasted retries consume channel time. The value may be changed with the **SN** command.

4.7.3. Retry time

The default time value between retries is about 2 seconds at 1200 baud. Retry time must give the other station enough time to respond with an ack before the next repeat. If the time is too long, when a repeat is needed the data throughput is needlessly reduced. Retry time is automatically adjusted for baud rate, so the retry time for the same numeric setting is about 1/8 as long at 9600 baud as it is for 1200 baud. Retry time is also extended automatically in the presence of other channel activity, and it's automatically adjusted to account for the number of digipeaters used and the packet size. The base value of retry time is set with the **ST** command.

4.7.4. Back-off timing

The channel is always checked for other activity before any transmissions are made to avoid interference. If another transmission is detected, it enters a "backoff" wait loop. When the other transmission ends a transmission is made after a random time delay. The reason for the random delay is that there may be other stations waiting, or backing off, from the existing transmission and if all stations reacted with the same timing to the end of that transmission they would transmit simultaneously. With random timing this type of collision rarely occurs.

The backoff time delay is randomly generated, where the random time can be anything from zero to a specified maximum value. The time limit is controlled with the **SO** command. Alternatively, a fixed backoff delay may be added to the **SO** delay by setting **SP**. The backoff time is then equal to the **SP** time + **SO** time, where the latter is random. Combinations of these delays can be used to program the order in which each station in a system is to be given priority.

When digipeating there is no backoff delay, since if digipeaters are not given priority the repeats that are created have a much greater impact on channel usage than direct transmissions.

4.8. Remote Commands

Commands may be sent by remote control, using the **AQ** command. A prerequisite is that a connection must be established to the station to be commanded. In Command or Block modes such commands may be sent at any time without disrupting any info transfers in progress or changing the state of the connection. The commands received by the other station are displayed as non-info data if OD is enabled. In Command or Block mode these fields are tagged differently, so there is no confusion between them and normal info. See **7.5.**, **DL** and **AQ**.

4.9. Unattended operation

Since any MX.25-based station can be used as a digipeater, a controller may be dedicated to that purpose. Because a terminal wouldn't be needed at a remote site used as a digipeater, the primary port serial data input line is available for another connection. By holding a positive voltage on this line while resetting the controller or going through a power-down/power-up sequence, "Unattended" mode is entered. In an unattended station this signal may be tied to +5 volts permanently (If a terminal is connected, unattended mode is entered by holding a break condition to the serial port while resetting or doing a power-down/power-up sequence. Although commands can't be entered via the terminal, incoming commands may be observed).

In unattended mode all connected info received is interpreted as commands. The **AQ** (section **7.5.**) command still works, but isn't required. Commands are sent as though they were typed at a local terminal. Responses normally sent to the terminal are returned via radio to the controlling station instead.

NOTE: Remote control is limited to connected operation to prevent the unattended station from interpreting other channel activity as commands. In order to connect, the unattended station must have an address (ANY address) preprogrammed into the EPROM, since there's no terminal from which to enter an address. Once connected, it's possible to enter a new address via remote command, as will be seen.

4.9.1. Unattended commands

In addition to the normal RDC commands there are four plain English commands:

ON	activates the digipeat function
OFF	deactivates the digipeat function
FLAGS n	n is a number; sets the number of preamble characters
STATUS	displays the digipeater address, SSID, number of flags and digipeater on/off state.

Every command must be terminated with a CR. After each command a prompt (":") or error ("?") character is returned, and all input up to the point of the error is echoed. Example: if "QX" were sent the response would be "Q?". Since no command begins with 'Q', 'Q' is the character at which the error occurred.

Some of the commands are disallowed via remote commands, to avoid fatal errors. As an example, commanding it into standby mode could be fatal, since it would no longer respond to other stations, including the one that sent the command! There is no guarantee that every command is foolproof when given remotely. With good judgment commands that make sense will probably work. If in doubt test the command before leaving a remote site!

4.9.2. Remote commands, special cases

A few remote functions merit additional discussion. Changing the remote station's address is one. After a connection is made, the **SC** command may be sent, carrying the new address. The complication is that the unattended station begins using the new address immediately. The ack it returns carries the changed address in the packet header. Since the command station is still using the old address, the ack isn't accepted. This situation may be corrected by changing the destination address at the control station immediately after sending the command. If the change is made before the connection counts out operation resumes normally. If not, a new connection must be made. The new address remains in place as long as a reset doesn't occur.

Another desirable function is to change the contents of the beacon or special message at the remote site. In direct control the new message is typed into the transmit buffer, and it is stored as a beacon/special message when the **BS** command is typed. The problem is that the transmit buffer is in use at the remote site during a connection, so any command that also uses the transmit buffer overwrites the response. To overcome this problem, the **BS** command, when sent remotely, works differently. The command is followed directly by the message:

BSThis is a new beacon message.<CR>

Similarly, the action of the **BR** (Beacon Recall) function is modified. By local control **BR** copies the current message to the transmit buffer. By remote command it sends the message in response to the command as well. The message is recalled to the transmit buffer, but in unattended mode it's deleted afterwards. Since the command is ordinarily used remotely only to display the current message contents this change is appropriate.

The situation is different in the case of using **AQ** to send the command; here the transmit buffer isn't used, so operation resembles local control more closely.

AQ works with the "**I**" command, but special character entry can be confusing. Every '\' character must be doubled, because it takes two of them to insert one to the buffer while typing the AQ command line. At the other end the message becomes input to the "**I**" command, so a surviving '\' character must be present there for the special character. To place an ESC thus requires "\\"ESC instead of "\"ESC, and to place one '\' char in the destination requires "\\\\" instead of "\\".

4.10. Other Basic Commands

The commands described so far are sufficient to connect, communicate and disconnect, but at times it's convenient to operate entirely from command mode. Here are some of the commands most likely to be needed; for more details, see Section **7.5.**. These commands can't be used while in Chat or Transparent modes; type "ESC" to return from Chat mode or the sequence of "escape" characters from Transparent mode (See **6.1.**).Information may be entered and sent directly when in command mode.

"**I**" inserts information into the transmit buffer, terminated with ESC.

"**K**" clears the transmit buffer.

"**T**" "Types" the contents of the transmit buffer so you can see what you've entered or how much of a message hasn't yet been sent and acked.

"**AT**" initiates the transmission of info in the command buffer.

"**AI**" transmits info in the command buffer as a UI (see **4.15.**).

4.11. Monitoring the communications channel

It's difficult to monitor a particular communication on a busy channel because in monitor mode everything is displayed, resulting in a scramble of intermingled messages. A number of software options are offered to control the display of incoming packets. "Queue" mode makes it possible to defer all displays, and the commands **OO**, **OC** and **OE** (see section **7.5.**) control the display depending upon the connected state of the station. In addition, a station-filtering capability () is included that may be used to display only those packets having certain address or path characteristics.

4.11.1. Queue mode

Controlled by the **OQ** command, "Queue" mode prevents received data from being displayed. Instead, packets are stored or queued in memory. In this mode it is still possible for other stations to connect, leave messages in the queue and disconnect. Queued packets may be filtered by using the display controls, just as for the display of packets. Whatever remains to be sent to the terminal is stored in memory. If a station connects while in Queue mode the message "-Q-" (also see **4.12.**) is placed into the transmit buffer. It's returned to a caller in response to any info.

When memory is filled no more messages can be saved. A station connecting at that time would receive a "Wait" request and no more messages would be acknowledged until sufficient memory is unloaded. If nothing but "wait" signals are received after connecting to another station, and the "-Q-" message is returned, a full queue is indicated.

Messages are also queued if terminal flow control blocks the display. Thus a host computer program can assert flow control, do other processing, then return at a later time to examine the stored messages. Flow control is established via RTS/CTS or Xon/Xoff (see **OX** command).

The distinguishing feature of Queue mode as opposed to normal terminal flow control is that clear access is retained to the command processor. Queue mode may be invoked to halt the flow of received information to the terminal while other commands are given, for example to change an operating parameter, then to resume afterwards. Packets may be released one frame at a time (**OF**) or all at once (**OQ**D).

4.12. Beacon Operation and Special Messages

A special message, up to 256 bytes in length, may be stored to be used one of three ways:

(1) To store a message which may be needed at a later time, avoiding the need to retype it. Typing **BR** copies the contents of the stored message back into the transmit buffer. The stored message is not changed. If the same message is to be sent to a number of stations it can be recovered repeatedly and sent out as connections are made.

(2) The stored message is sent automatically to any station connecting while in Queue mode. When the controller is reset this message is initialized to the string "-Q-". Other stations connecting receive this message in response to any info they send. Thus, it behaves as a renewable message to be sent automatically to all connecting stations. This message replaces any pre-existing info in the transmit buffer.

(3) In BEACON mode the station sends a packet containing the stored message periodically. The packet is addressed in the normal fashion, except that instead of using **SD** and **SV** commands, the **BD** and **BV** (Beacon Destination, Beacon Via) are used to enter the addresses. Beacon packets are sent as non-info data, which don't require acknowledgment.

4.12.1. Special Message Entry

If the beacon isn't in use, a message may be stored by typing it into the transmit buffer for sending, then typing **BS** (Beacon Store). Once stored it remains until replaced with another, deleted (with **BK** for "Beacon Kill"), or by a reset. After the **BK** command the typed message remains in the transmit buffer, so it must be deleted (**K**) if it is not to be transmitted with the next information packet. Example (typed input is shown in quotes, the rest is from the controller; comments are at the right):

"**I**Gone to lunch. I'll be back around 1 PM<CR><ESC>"
:
"**BS**" store the message

"**K**" delete it from transmit buffer

The message may be edited by recalling it into the transmit buffer with **BR**. The contents of the transmit buffer may be edited either with the "**I**" command or by entering Chat mode temporarily (**MS**). Either of these commands is terminated with ESC.

4.13. Beacon Control

Beacon mode is activated by setting a time period with the **BT** command (Beacon Timer), where each count represents about 10 seconds. At the maximum value of 255 the repeat time is about 30 minutes, but the time values automatically increase with channel activity; on a busy channel it sends less frequently.

Beacon mode is terminated by setting the time value to zero. The beacon stops when connected; it resumes upon disconnect. The beacon time value is also shown on the status display line as the last number.

A useful function of the Beacon mode is to identify active digipeaters by having them send a periodic beacon message. The message may include the digipeater address. For a digipeater operating in the unattended mode, proceed as follows: connect to the digipeater, then set the destination address fields for the beacon using "**BD**" for the destination and "**BV**" if beacons are to be sent via a digipeater path. Use **BS** to enter a beacon message (see section **4.9.2. Remote commands, special cases**]. For example to have the beacon addressed to "QST" connect to the digipeater and send "**BD**QST 0<CR>". Then send a timing value "**BT**n<CR>" (where n is the timing value). The beacon message may be examined by sending "**BR**<CR>". If the other station isn't in unattended mode the above commands may be sent by preceding them with "**AQ**" (Section **4.8. Remote Commands**).

4.13.1. Alternate Beacon Message

Firmware can be supplied with a special message permanently programmed into the EPROM. Beacons are sent with this message by enabling it with the **BA** command.

4.14. Station filtering system

An important capability is a powerful multiple-function address filtering system, henceforth referred to as the "filterlist".

Up to 10 addresses are permitted (other numbers available as a software option), each of them assigned to any (or all) of five filters. Each filter can be designated to operate in one of two modes of operation called "REJECT" and "SELECT". Please be careful to distinguish between "filter" and "mode". The 5th filter is used to direct the flow of data to either serial port.

4.14.1. Filters and Modes

A FILTER is one of the five processes that can apply to each address. Each filter has two MODES of operation. In the commands the five filters are referenced with characters as follows:

Character	Filter	Function of filter
M	MONITOR	filters the display by originating station
V	VIA	filters the display by digipeater
D	DIGIPEAT	filters stations to be digipeated
C	CONNECT	filters stations allowed to connect

P	PORT	directs info from packet to either serial port

NOTE: If a station is referred to as being "listed", it means that its address exists in the filterlist with a particular filter enabled.

MONITOR Filter:
REJECT mode: Packets from listed stations will NOT be displayed.
SELECT mode: ONLY packets from listed stations will be displayed.

VIA Filter:
REJECT mode: Packets that specify any of the listed addresses as a digipeater will NOT be displayed.
SELECT mode: ONLY packets with a listed addresses specified as a digipeater will be displayed.

DIGIPEAT Filter:
REJECT mode: Packets originating from listed stations will NOT be digipeated.
SELECT mode: ONLY packets originating from stations whose addresses are in the list will be digipeated.

CONNECT Filter:
REJECT mode: Packets originating from listed stations WON'T connect.
SELECT mode: ONLY listed stations will connect.

PORT Filter:
REJECT mode: Info originating from UNLISTED stations goes to the secondary serial port.
SELECT mode: Info originating ONLY from listed stations goes to the secondary serial port.

4.14.2. The Filterlist Mode Command

Each filter is set to SELECT or REJECT with the command **OT**. When **OT** is typed after the prompt, a display like this appears:

MR VR DR CR PR-

"MR" indicates that the Monitor filter is in Reject mode, "VR" indicates that the Via filter is in the Reject mode, and so on for the Digipeat, Connect and Port filters. The status of these four filters is shown before any input is accepted. As usual, the "-" is an invitation for input from the keyboard. Each time a valid input is typed, the prompt line is re-displayed, showing any changes. A valid input is made when one of the letters M, V, D, C or P, followed by "R" or "S" (for REJECT and SELECT) has been typed. If MS is typed (under the **OT** command) the display would become:

MS VR CR DR PR-

The MONITOR filter is now in SELECT mode. Filter modes may be changed as often as required until the display shows the desired combinations. A CR terminates the command.

4.14.3. Address entries

Let's assume that all filters are set to the REJECT mode and we're ready to enter addresses. An address is entered with the **OA** command, after which the following display appears:

MD VD DD CD PD-

These indications tell us which of the four filters have been selected for this address. In this case all four filters are disabled, and although this address has been typed in, no action will be taken on it. If the MONITOR filter had been enabled, "ME" would have appeared in the place of MD for this address. Filters are selected here in the same way as modes are selected in the **OT** command. Suppose we do not want this station to be displayed in the monitor mode; we can type "ME", to Enable Monitor mode. If the space bar is pressed the command moves on to the next address, leaving the modes set up as they were last displayed. This menu, with the option to select any filter or combination of filters, is repeated for each address in the list.

In the following examples, lower-case letters indicate keys typed by the operator, and upper-case represents the controller's response. Note that command characters may be typed in either upper or lower case.

Example 1:

:oa ------able 0- MD VD DD CD PD-

"**oa**" was typed and a space entry was shown ("-------"). Then the address "able" was entered, followed by a space. The controller then displayed the default SSID, "0". A space was typed, retaining that zero value as the SSID.

Now the controller responds with "MD VD DD CD PD-". The settings for "M", "V", "D", "C" or "P" may be altered as required, or a space may be typed to advance to the next address in the list. If a space is typed at this point the address remains in the list, but it isn't used. If the following is typed:

dD-e
MD VD DE CD PD-

this address becomes assigned to the DIGIPEAT Filter, and packets originating from ABLE will NOT be digipeated, since the digipeat filter is in the Reject mode. If this entry is not satisfactory, continue with:

dE-d
MD VD DD CD PD-cD-e
MD VD DD CE PD-

"dd" disables the erroneous DIGIPEAT function and "ce" enables the CONNECT function. With this setting any attempt by ABLE to connect to this station is ignored, but ABLE is still displayed and digipeated. The command can be terminated by typing a CR, or continued by typing a space, advancing the command to the next address:<space>

The controller is now waiting for the entry of another address. As in the **SV** command it continues to request addresses until the list is filled. If a space is typed in response to an empty entry the command is terminated. An address is deleted by typing a dash. Any addresses following it are moved in to close gaps between addresses.

Example 2:

Certain actions are to apply to three addresses. The station MOBILE is not to be displayed while monitoring; digipeat requests by TEST are to be rejected, and LINE1 is not to be either displayed or digipeated. First the Monitor and Digipeat filters are placed in the Reject modes using the **OT** command:

:ot MS VR DS CR PR-mS-r
MR VR DS CR PR-dS-r
MR VR DR CR PR-<CR>

The Monitor filter was found in Select mode, but since this station is to be rejected instead, it's changed to Reject mode. The Digipeat filter was also found in Select mode, so in the second line it was changed to Reject mode. The

Via, Connect and Port filters won't matter because we aren't planning to activate any addresses using them, so the command was terminated with a CR. Next, the "OA" command is used to enter addresses:

:oa------mobile 0- MD VD DD CD PD-mD-e
ME VD DD CD PD-<space>
------test 0- ME VD DD CD PD-mE-d
MD VD DD CD PD-dD-e
MD VD DD CD PD-<space>
------line1 0-MD VD DD CD PD-dD-e
MD VD DE CD PD-mD-e
ME VD DE CD PD-<space>
------ 0-<spaces>

On the first line "MOBILE" was inserted, with a space at the SSID to accept the default value, 0. "me" was typed in response to the "-" prompt, enabling the Monitor filter. When the filters were re-displayed in line two, a space advanced the command to the next address entry. In line three TEST-0 was inserted, and "md" removed it from the Monitor filter. In line 4 "de" was typed to activate the Digipeat filter on this address. Since the Digipeat filter is set to Reject, TEST-0 will not be digipeated.

On line 6 LINE1 is entered and "de" and "me" were specified. The command was terminated by typing spaces to the next display of filter status, the next address and SSID. Alternatively, it could have been terminated by typing a CR after "me".

The results of this example are: MOBILE packets won't be displayed while monitoring the channel, and TEST packets won't be digipeated by this station.

4.14.4. Remote control of the filterlist

One of the ways to use the filterlist is to prevent unwanted stations from using an unattended digipeater. In order to make filterlist entries remotely or to edit the list of addresses care must be taken to insert space and CR characters in the right places. For more than about three entries it might be best to create the command in an editor, edit it until satisfied, then save it in a file. The corrected file is then sent to the digipeater.

Suppose one address is to be entered and NOT to be digipeated. The following string should be sent after connecting to the remote station:

aqoaDOZER 0 de<CR>

The address follows the "**oa**" immediately. Note the space after the address preceding the SSID; it's needed to step the command to the SSID entry. One space is always sufficient to terminate the base address, even if it's shorter than 5 characters, since the first space causes the correct number of spaces to be filled in automatically. A space is needed after the SSID to advance the command to the filter enable entry. After the digipeat filter is enabled ("de") a CR terminates the command. If a space had replaced the CR the command would be ready for another address.

To edit the list a space is inserted for each item to be bypassed. For example, the following string would add another address to the previous entry:

```
aqoa   PUMP1 1 de<CR>
    ^^^      ^ ^     ("^" shows the position of space characters)
```

Since there already was one entry in the remote station's filterlist (REMOTE-0) 3 spaces were inserted after **aqoa**; to step the command past the first address, SSID and filter enable entries. Thus the new address was entered as the

second address in the list. If this sequence had been typed directly instead of via remote command, it would have looked like this:

aqoaREMOTE<space>-0<space> MD VD DE CD PD-<space>
-------pump1<space>0-1<space> MD VD DD CD PD-dD-e<CR>

A sure way to figure out what to send, guaranteed to work, is simply to enter the command directly, using the prompts as guides. Mark down each character typed for a successful result, then send that string to the remote station. To modify an existing list at a remote station it's easier and surer to create a new character list for the entire entry and re-send it, rather than attempt to edit remotely. Unchanged entries will simply be re-entered, doing no harm. Finally, if more than one filter is to be enabled (such as making a station ineligible to digipeat and connect) all commands can be typed together:

aqoaREMOTE 0 dece<CR>

The digipeater echoes its interpretation of a command sequence, acting as a trace. By examining the response syntax problems can be diagnosed.

4.14.5. Additional Notes on the Filterlist

The filterlist address SSID entries can be made 'wild' in two ways: An incoming address with SSID 15 is a wild match against any matching base address in the list, and if the SSID in the list is specified as 16, that item becomes a match to any incoming SSID having the matching base address. An SSID of 15 in the list is not wild; instead, it specifies that the incoming address MUST be 15 for a match to occur.

If a transmission is made via multiple digipeaters and the V (via) option is enabled, the only transmissions displayed are the ones from the digipeater address listed. All of the other digipeater transmissions in the path are ignored, even if they're strong enough to be received. This includes the final digipeater in the path, too. Thus, if a packet is transmitted via stations A, B, C and D, and station C is in the VIA list, selected, the only one displayed would be the transmission from C.A little reflection shows why modes need never be mixed for any of the five filters. If SELECT is chosen, and a few stations in the list are to be selected, the REJECT mode becomes irrelevant, since all other stations are rejected anyway. Conversely, if REJECT is chosen all unlisted stations are automatically selected. For this reason the entire list is used either as stations to be rejected or stations to be selected.

If a long list of addresses has been entered and it is decided to delete, say the second address, instead of typing a "-" to delete it, all four filters under that address could simply be disabled. This tells the controller to take no action on that address. The address remains available if later it is decided to reactivate it, making it unnecessary to retype it. If that slot is needed later a new address can always be typed in to replace the old one.

What should happen if, say, the MONITOR filter in SELECT mode is enabled and no addresses are assigned to it? Logically, this would be tantamount to turning off the monitoring function altogether, since no addresses are there to be selected. The controller detects this situation, acting as though the MONITOR SELECT filter had not been activated. This precaution may avoid accidental apparent loss of operation! The program avoids wasting time on null entries and such logical discrepancies.

The **V**IA option can add a considerable amount of work for the CPU to the processing of monitored frames, since all VIA addresses have to be compared against all addresses in the list (up to 80 addresses to compare for a 10-entry list). The CPU stops the search when it has gone far enough to ensure that there can be no additional "hits", avoiding unnecessary processing. Thus the added CPU overhead is no more than what is necessary to carry out the required instructions.

Except for the PORT filter, the filterlist has no effect while connected, since all other activity is suppressed anyway (unless **OE** is activated). The suppression of addresses with MONITOR, VIA or DIGIPEAT does not affect the

ability of stations to connect, and once connected their packets are not suppressed. For additional control, **OO** or the filterlist CONNECT filter may be used.

4.15. Unnumbered Information Frames

Unnumbered frames (UIs) are used in either connected or unconnected mode. A message that has been typed into the buffer for transmission may be sent as a UI by typing the **AI** command. For example, a file transfer could be interrupted, a UI intended as a comment to the receiving operator could be sent, and the file transfer could be continued. The program controlling the file transfer at the receiving end can distinguish info data from non-info data by interpreting the tags sent with each type output field. Such comments could then be displayed on the screen and not interfere with file data.

UI's can be suppressed from display with the **OD**(D/E) command.
UI's may be sent n times (set with **SN**) by using the **AU** command instead of AI.

5. LOP Packet Operation

Operation in LOP and MX.25 are basically similar, so this section deals mainly in the differences, using similar headings. Protocol selection is commanded by the **SX** command. If a connect request is received in either protocol while disconnected, the protocol is changed if necessary, and the connection is made in the protocol used in the request. In monitor mode the controller receives, interprets and displays packets in either protocol correctly without changing modes.

The main advantage of LOP over MX.25 is in the reduction of overhead. In systems having a limited number of stations (called "nodes" in LOP) LOP offers faster responses and improved ability to get through in poor receiving conditions.

Headers, which must be sent with each frame, are 15 bytes long in MX.25 and only 2 bytes long in LOP. Thus at 1200 baud the minimum transmission time (including opening/closing flags and FCS check) for an acknowledgment is 15.8 ms in MX.25 vs. 3.3 ms in LOP. However, MX.25 can distinguish literally billions of addresses, while LOP is limited to 255. In small systems this is not a limitation. However, LOP does retain the ability to identify and call stations by an alphanumeric address, up to 6 characters in length. The address is used as an address only on connections and disconnects; during data transfer only a single-byte token, or "node number" is exchanged. Both the node number and addresses are pre-assigned to each station in the network, and each must be different. There is no SSID in LOP.

5.1. Entering addresses in LOP

Base addresses entered under MX.25 (3.1) also apply to LOP, so once an address is entered under either protocol there's no need to re-enter it in the other. Under LOP the address entry is the same, but since there's no SSID in LOP there's no prompt for one after the base address is typed. However, each station must have a node number assigned.

The use of a node number instead of an address is analogous to that of a nickname in casual conversation; after the formal introduction conversation is facilitated by using a short mutually-understood substitute for a full name. In subsequent exchanges only the node number of the sending station is sent in the packet headers.

If the LOP node is pre-programmed into the EPROM it becomes active automatically when LOP protocol is selected. To check, enter or change the node number, use the "SA" command. Node number 255 is reserved as a "wild" number, analogous to SSID 15 in MX.25. If 255 is in place it is equivalent to no node number; connect requests are not executed and LOP connect requests are ignored. For MX.25 protocol there's an associated SSID storage location, which is undisturbed when entering an address in LOP. Be sure to check it when switching back to MX.25 protocol.

5.2. Status Report in LOP

After initialization and with LOP protocol selected (with the **SX** command), the status report looks like this:

"33 /TEST /------ $/ //LDU/E/RL/0"

Compare this display with the corresponding MX.25 display in Section **4.2. Status Report**.

The first field is the assigned node number (as opposed to the "state" in MX.25) and the "$" in the 3rd field indicates that the station is not connected. In the 7th field the "X" is missing, which otherwise would indicate the selection of MX.25 protocol. When a connection is established the "$" is replaced by the node number of that station.

5.3. Unconnected Operation

Since there's no "UI" defined in LOP, unconnected operation uses numbered (always #0) information frames. The filterlist is not consulted in LOP, since full addressing is not present on every frame. The alternative is to use the **OA** command to enter up to two acceptable node numbers, and to have all stations in the round table use one of these node numbers for the duration of the communication. See also **5.4.**

.5.4. Digipeaters in LOP

There is no provision for digipeater operation in LOP analogous to the one in MX.25 at the present state of development. An error ("?") is returned if the **SV** command is given. Even in LOP mode, MX.25 digipeat requests are serviced, unless a connection is established in LOP. Once disconnected, normal digipeater operation is restored for MX.25.

5.5. Channel Monitoring in LOP

In monitor mode under LOP, the output of duplicate packets is suppressed to reduce storage space in memory and to reduce screen clutter on repeated packets.

Since there's limited addressing information in LOP the filterlist function is not applicable. Instead, the **OA** function for selective monitoring works for one or two stations in LOP. Instead of reading addresses, node numbers are accepted. Note that to delete an address in LOP the value is changed to 255, not zero. A second address number is requested if the first one is entered. Node numbers entered are treated exactly as the address for this function in MX.25. Node numbers entered under LOP operate independently of the addresses in the MX.25 filterlist. In monitor mode up to two stations may be selected to monitor in LOP and up to ten in MX.25, independently.

5.6. Beacon Mode in LOP

Beacon mode packets are sent as numbered information frames with the station node number and no address. If the beacon is to carry station identification it must be included in the beacon message.

5.7. Output Formatting and Displays for LOP

In connect and disconnect sequences the addresses of the stations involved are sent as information fields in connect/disconnect packets, rather than including them in the headers. These address fields are treated as "non-info data", since they're not information to be transmitted from user to user but only information used to establish communication. Thus these fields are displayed with the same "tag" ("/") as unnumbered info in MX.25, and their display can be enabled or disabled with the same command, **OD**. A typical LOP header display is:

".77-17"

The "." indicates that a header follows; "77" is the node number of the originator, in the selected radix (**SR**). The "-" indicates the control field follows, and here the control field is a "17. The control field is always in hex radix. There is no PID field in LOP.

5.8. Unattended Operation in LOP

Unattended mode may be accessed in either protocol.

6. Host Computer Software Interfacing

Although software can handle operator-to-operator communication with a simple terminal program in the host computer, computer-to-computer communication and file transfers are best handled with custom software in the host computer.

Of the four basic communication modes, Transparent and Block modes are best suited for operation in conjunction with a computer host. Transparent mode is the simplest to use, but Block mode is far more robust. Connected operation is best in applications requiring guaranteed data delivery, but in other cases unconnected mode is a better choice. For example, if short data transmissions are sent periodically as updates to some real-time value change, a missed packet is not disastrous, since the next update will soon follow. In polled systems use of unconnected mode reduces the overhead of connecting and disconnecting. Which stations are to receive data is controlled by changing the destination address, and all stations can be programmed to accept only data addressed to them.

If connected mode is to be used a destination address must be supplied, and a connect request command must precede any communication. At the end of data transfer a disconnect request must be sent before communication to another station is possible. These requirements are particularly awkward in transparent mode without operator intervention or special programming. However, if all communications are between two specific stations the addresses can be entered before activating the system, and a permanent connection can be specified (**AP**).

It's also possible to use different modes at different stations in the system.

For example a central polling point could use block mode to establish connections with remote stations in transparent mode, sparing the remotes the problem of giving commands.

Differences between connected and unconnected modes are discussed in section **4.4.**

6.1. Connected Transparent Mode

Before any data transfer can take place a destination address must be specified by the user, followed by a connect request. In transparent mode the easiest way to do this is to make the host operate as a simple terminal until a connect request has been issued with the **C** command. Alternatively, the host software could provide a "shell" that communicates with the operator in its own syntax, and generates the **C** command as required. The danger in using transparent mode in this manner is that there is no way for the host to find out what the connected (or even command) status is. For example, should a connect request be initiated, how long does the host wait before sending file info? The time to connect could vary from milliseconds to many seconds, depending upon channel activity and baud rate. There's also the possibility that the address given is incorrect or that station isn't on the air, in which case no connected condition is possible, and there's no way to be sure whether a connection has been made.

Similarly the transparent mode exit sequence requires a delay, the sending of three "exit" characters (defaulted to ^C), and a second delay. These operations cause delays in program operation. Because of these difficulties transparent mode is used to greatest advantage when a simple terminal program is to be used, operated manually. The main advantage is that a simple terminal program with file transfer capability is sufficient. Almost any telephone MODEM communications package may be used, skipping any auto-dialing feature.

Since only one mode of operation is possible at a time, the commands **MS** and **ML** are shared between Chat and Transparent modes. **MS** is the command to enter Chat mode directly and **ML**, when enabled, causes an automatic entry into Chat mode whenever a connection is made, and conversely to exit Chat automatically upon disconnect.

When **MX** is enabled **MS** and **ML** apply to Transparent mode instead of Chat mode. **MS** commands it directly to the transparent mode. If **ML** is enabled transparent mode is entered automatically upon connection, and command mode is entered upon disconnect.

During Connected Transparent mode operation:

1.	There's no console echo.
2.	All bytes from the terminal are transmitted.
3.	Commands are not accepted.
4.	Only received info is sent to the host system (no headers, etc.).
5.	Transfer occurs only when connected while in connected mode. In unconnected mode transfer occurs at any time info is provided.

Data is transmitted as sent. Any continuous stream of bytes is loaded into the transmit buffer until there's a 1-second pause (See **SK**). Then the CTS line is set false and the contents of the buffer are transmitted. If the host sends more info than the controller buffer can accommodate, the CTS line is set false and the info is transmitted without delay. When the info is acked the buffer is cleared and the CTS line is set true, allowing the host to resume sending info.

To exit transparent mode, wait until the buffer is empty (transmission stops and CTS becomes true) plus at least one more second, and type three ^C's. In about one second (with no additional input) Command mode is entered, accompanied by a prompt ":". If **ML** is enabled transparent mode is exited automatically upon disconnect. Although there's no way to command a disconnect while in transparent mode, it may originate from the other station, it may occur due to "count-out" (exceeding the allotted number of retries without ack) or it could occur when the connection timer expires.

The transparent mode exit character (^C) may be changed by using the **ME** command. The one-second time interval may be changed with the **SK** command, where each count is approximately 10 milliseconds.

NOTE: Transparent mode requires the host computer to observe the CTS line. When the controller sets CTS false the host should stop sending. If it doesn't, following info could be lost, or parts of one message might be found attached to subsequent messages. For ASCII data Xon-Xoff protocol is supported; see **OX**.

6.2. Block Mode

"Block" mode provides a simple protocol for interchanges with the host. In this mode info is completely "data-transparent"; that is, all bytes are sent as-is. Byte counts are used to delimit data fields. To facilitate host program interpretation, all data fields are tagged. Block mode is initiated with the **OB** command.

In Block mode info transfers between the controller and the host computer are made by means of byte counts. Since the info fields are delimited by a countdown, this mode is also transparent to byte values in the info. Special host software is required to take full advantage of this mode, but operation can be made fully automatic and robust, without expert human operators.

Block mode is similar to command mode in that there is continuous access to the command processor. Characters needed in command mode to format controller responses on the terminal screen, such as CR, LF and most space characters, are suppressed in Block mode to speed the interface interaction. The other major difference between Block and command modes is in the handling of the "I" command and the outputting of information fields. It's helpful to disable the terminal echo (**SE**-D), to reduce the number of unnecessary characters sent to the host. Status updates (**OU**) are usually enabled in block mode.

6.2.1. Block Mode display tags

Each data field sent to the host is preceded by a unique token (or "tag") character for identification. For example, to poll for info fields the RS-232 output needs only to be tested for an apostrophe character. In Block mode the byte following is a binary count of the number of bytes of data. Used as a counter by the host, this number is

decremented with each byte taken. When it's zero the input operation is terminated. Note that field tags are displayed whether or not headers are enabled (**OH**), whereas in Command mode tags are only sent if header display is on. Table I shows a summary of tags.

Table I. Tag characters and corresponding data fields.

:	prompt	The controller is receptive to a command.
?	error prompt	same as above but previous command returned an error
;	address	address field follows, up to the next token ("-").
‘	info received	a 1-byte count (n) is followed by n bytes of data.
/	non-info data	a 1-byte count (n) is followed by n bytes of data
#	Status value	a numeric value 1-9 indicating a link event.
These tags appear within headers:		
;	PID	follows a control field for MX.25 info frames only
.	control byte	After address field; a hex numeric value

A program written for the host may use these tags to interpret each type of field. The tokens make it possible to interpret and direct or act on each field as appropriate.

6.2.2. Information field output

Information is tagged with "’" character, followed by a 1-byte binary count. After a "’" tag is detected, the next byte is taken as a counter, and as each information byte is taken the count is decremented. When the count becomes zero the host resumes testing controller output for other tokens. A single byte count is sufficient because no information field length is permitted to exceed 256 bytes in any given frame, and only one frame is output at a time. A 0 count is interpreted as 256.

Non-info data is treated in the same manner, except the host may direct it to a different destination within the computer. An example of how this could be used is that a comment sent by the sending operator via a UI may be sent to the terminal screen, even though the program is in the middle of a file transfer, without disrupting the file info flow.

6.2.3. Flow Control

If the host becomes busy RTS may be set false to control data flow. Alternatively, the **OQ** command causes entry to Queue mode, which has the same effect, except resumption of data flow requires an explicit command "**OQ**D" instead of a hardware level change. If in Queue mode and any received frames are present in the queue the command prompt characters (: or ?) are sent with bit 7 set. This bit is 0 when the queue is empty. It's the programmer's responsibility to off-load accumulated data before memory is filled. If memory capacity is exceeded additional packets from other stations will be refused with "wait" acknowledgments.

6.2.4. Sending information

The **I** command is used to send info from the host for transmission, and is followed by a 2-byte binary count, least significant first, which is followed by the info. If the count is greater than the number of bytes assigned to the buffer "?" is returned immediately after the count is read, and info isn't accepted. If more characters are sent than the given count, the extra bytes would be interpreted as commands.

6.2.5. Example of a Block mode transfer to station

1.	Host:	"**C** ABCD 0<CR>"	call station ABCD
2.	controller:	"#02" (a return of #01 would have indicated error - failed connection)	connect was acked
3.	Host:	"**I**<n><m><mn bytes of info>"	send mn bytes of data
4.	Host:	"**AT**"	initiate sending of packet
5.	controller:	"#04" (loop to step 3 until all info is sent)	ack received
6.	Host:	"**AD**" (or "D<CR>")	disconnect
7.	controller:	"#01"	disconnect acked

Consecutive commands may be concatenated. For example, steps 3 and 4 could be combined into a continuous command stream. There's a delay between the sending of a command and the return of a status indicator. Since it may take several timed retries, the host should be prepared to wait for many seconds before abandoning the operation. If a "count-out" occurs (the number of times specified has been exceed without a response) two status messages are generated; #03 to indicate count-out, and #01 to indicate disconnected status. If #01 shows up alone either a disconnect has been sent from the other station or link time-out has occurred due to lack of activity.

In step 5 there may be other indications besides #01, #03 or #04. #05 would indicate that the other station is "busy"; normally meaning that memory is full. This condition could be temporary or a long-standing one. If the queue is backed up and it isn't being unloaded, the condition could be permanent, and the connection must be ended. If the other station is in Queue mode, when the first info is sent it responds with the message "-Q-" as an information frame. The host can receive this and note that the other station isn't off-loading data, then act accordingly when #5 is received. If "-Q-" isn't received the busy condition is likely to clear and data transfer can resume. When the other station is ready for more info, #04 appears.

If a connection is lost due to count-out in the middle of a transfer all is not necessarily lost. Information not sent is retained in the transmit buffer, allowing a resumed connection to continue where the transfer left off. However, there is a chance that some info could be received twice, depending upon the conditions leading to the loss of connection. For this reason, it's a good idea for both hosts to keep track of byte counts and perhaps even checksums on the transferred data, then compare results at the end of the transfer. Alternatively, re-send entire files if they have been interrupted by a disconnect.

Step 7 may appear trivial, but if the other station fails to receive the disconnect it may be left with a "hanging" connection. In this condition it wouldn't be able to accept connections from other stations until its connection timer runs out (about 6 minutes). An error response (#3) at step 7 indicates the disconnect wasn't acked, and it should at least generate a system error for handling at higher levels of protocol (such as notifying the operator).

6.3. Numeric Radix

With the exception of the Block mode byte counts and certain special commands such as time/date entry, all numeric values reflect the radix and leading zero settings, giving the programmer a choice. It may be easier to parse the numeric fields with leading zeros enabled, because it makes all numbers the same length; one digit in binary, two in hex, and three in decimal or octal. The Block mode byte-count values are ALWAYS in binary. Note that binary radix doesn't use a string of ASCII 1's and 0's; numbers are sent as binary byte values.

6.4. Special Packets and Protocols

The "M" commands may be used to generate packets having any desired address, control field and data. The purpose of these "Manual" commands is to allow the host computer to generate individual transmissions, and to

take over the link level protocol. Entering unconnected operation with the **MU** command enabled suppresses automatic link protocol operation. Addresses (call signs or LOP node number) are set up in the usual manner, but the control field is set up directly (using the "MC" command). Data is optionally placed into the transmit buffer. The command **MT** causes a packet to be sent, using these parameters.

If the control field is of the "info" type (bit 0=0) multiple frames are created automatically, consistent with data length and the limits given with the **SL** and **SH** commands. When using the "M" commands it's important to keep info length smaller than or equal to the number of bytes that can be sent in one packet or it won't all be sent. If the data length is greater than the length value (**SL**), the first frame is sent having length (**SL**). If (**SH**) is greater than 1, additional frames of maximum (**SL**) length are sent, up to (**SH**) frames. Any additional data remaining at this point is ignored. The maximum number of frames permitted is 7 (maximum data count, 1792), and the sequence number in the control field is incremented with each frame, starting with the specified control field value. With other frame types the maximum data length is 256, and multiple frames are not generated.

Whereas connected mode automatically clears info from the transmit buffer as it is acked, in unconnected mode (since there are no acks) old info must be deleted from the buffer (**K** command) before new info is sent. If this step is neglected the new info becomes appended to the old and the next transmission restarts again with the old info.

6.5. Memory Allocation

About 2K bytes of RAM are used above the program itself for storage and stacks. 1792 bytes are reserved on initialization for the transmit buffer. The rest of contiguous memory is available for receive buffering, data queuing and the formatting of packets for transmission. The **SM** command may be used to re-allocate the division of memory between the transmit buffer and receive space. Note: Use this command only if the receive queue is empty and no important data is being received. The **MM** command returns the number of 256-byte blocks of free memory available for receiving and storage. Space for about 512 bytes are reserved at the end of the receive buffer for receiving new packets and formatting responses so that protocol can still operate despite a full queue.

6.6. Polling for Messages

Often the host computer is being used for other purposes when a packet call is received. Since, in Queue mode, bit 7 of the prompt character indicates the presence of data, the controller may be polled by sending LF and testing the prompt without actually downloading the data. An alternative action could be programmed into the host, such as sending a BELL character to the console.

6.7. Downloading Capability

The firmware includes the capability for downloading new programs. Special software, written in assembly code for the 64180 processor may be loaded into the upper part of the available RAM and the memory map switched around to execute that program at address 0. The remaining RAM (it may vary with the software version) is available to the new program. The program is loaded with the command **F#L** followed by a 2-byte length, least-significant byte first. The program having that exact length is then sent from the terminal, followed by a 2-byte checksum. The checksum consists of the twos complement of the sum of all bytes following the byte count most-significant byte. Thus the sum of all the bytes plus the checksum value should be zero. If the checksum is good the program is automatically re-mapped to logical address 0000H and started. If not, the errant checksum value is displayed (in hex) and the program is not executed.

A downloaded program is re-entered even after power-down or reset operations. Unless the downloaded program includes a way to return to the EPROM code, the only way to restart the EPROM program is to violate the

checksum of the download code. If the downloaded program malfunctions without changing part of itself, or if it contains no command to return to EEPROM or method of voiding the checksum, the only exit means available is to remove battery backup power from the RAM long enough for the contents of memory to change, voiding the checksum of the downloaded program.

7. Commands

Commands are needed to transmit packets, set operating modes, control the display format and to change operating parameters. This section explains how to enter commands. Section **7.4.** is a quick-reference summary of the commands and detailed explanations for the commands, listed in alphabetical order, are in section **7.5.**.

Character conventions used in this section are as follows: CR is a carriage-return character, usually a RETURN or ENTER key. LF is a line- feed, or ^J. Control characters are indicated by preceding the character with "^", entered by holding the control key down while typing the character.

Most commands begin with two letters; the first implies a category and the next defines the command within that category. A few exceptions use one letter because of frequent usage. Most command letters were chosen for easy memorization by picking letters as abbreviations to words describing the command. For example "**T**" means "Type", "**AC**" means "Automatic Connect", etc. Since there are so many commands, some can't conform to this practice.

The controller indicates readiness for a command with a prompt ":". Each completed command results in another prompt. The prompt character is replaced by a "?" if the preceding command encountered an error. To reduce waiting time on slow terminals only the prompt is displayed after the original sign-on. If only a CR is typed the sign-on is repeated, and if only a LF is typed the prompt is re-displayed. Most commands fall into one of three categories; direct, numeric and mode-setting.

7.1. Direct Commands

Direct commands require no additional information. Example: "AT" means "Automatic Transmit" (causes the current info to be transmitted until acknowledged).

7.2. Commands with Numeric entries

These can be used to either examine or enter a new numeric value. For example, the command for entering the station address is **SA**n, meaning "Set Address to the number 'n'. The small 'n' is where the desired number is typed. If multiple arguments are required, separate them with spaces.

After the command is typed the previous value is displayed, followed by "-". A new number may then be typed in. Example:

"SA" is typed; the response is **"255-"** (the existing value);

- to leave it as is, type just "CR".
- to change it, type a new number, then "CR"

All numeric values are handled similarly unless otherwise noted.

7.3. Mode-setting Commands

Commands that set or reset operating modes are completed with either a "D" or an "E" (Disable or Enable), indicated by "(D/E)" after the command. Example:

The **OH** command controls the display of headers, listed as "**OH**(D/E)". Type **OH**; the display continues with "D-" indicating that the function is currently disabled.

- to leave the function disabled, type just "CR" or space.
- to enable the function, type "E".

Address entry is covered in Section **4.1.**

Commands not requiring a "CR" may be concatenated (run together).

7.4. Command Summary

This section is a command quick-reference. Commands are listed roughly in categories, and alpha-numerically within each category.

7.4.1. Single-Letter Commands

C[ONNECT]...	Connect request (combined **SD**, [**SV**] and **AC**).
D<CR>	Disconnect (same as **AD**).
I(ab)(data)	Input (ab) bytes of data to send (Block mode).
I(data)ESC	Input all bytes up to ESC (Command mode).
K	"Kill" contents of transmit buffer.
T	"Type" transmitter buffer contents.
V[IA]...	used with "**C**" to enter digipeater addresses.

7.4.2. Commands controlling automatic functions

AA	send info Acknowledgment (after an "**AW**").
AC	initiate a Connect request to another station.
AD	send a Disconnect request.
AH	stop repeating an unacknowledged packet (Halt).
AI	send unnumbered Info packet
AL(D/E)	Suppress duplicate frames in LOP.
AP(D/E)	makes a connection to Permanent.
AQ	Used to send a remote command to another station.
AR	Resume sending (after a Halt).
AS(D/E)	Standby mode (no receive or transmit).
AT	Transmit current packet until acknowledged.
AU	Send Unnumbered info packet N times.
AW	send a "Wait" acknowledge (RNR) to control data flow.
AX	abort current transmission.

7.4.3. Beacon Commands

BA	Alternate beacon message
BC	put beacon addresses into destination fields.
BD(address)	enter a beacon Destination address.
BK	"Kill" beacon message.
BR	Recall a beacon message.
BS	Store a beacon message.
BT	set Time value for automatic beacon.
BV(addresses)	enter beacon digipeater addresses (Via).

7.4.4. Miscellaneous Commands

DE(n)	enter scramble key
DG(address)	enter special digipeater address
DKc	display ASCII value of Keyboard character c
DL(D/E)	disable remote command lockout
DN(m)	display/modify Number of retries accumulated
DOC	save parameters and settings to EEPROM.
DU	Unprotect EEPROM for writing or erasing.
DZ(n)	set closing flag count

7.4.5. Diagnostics and Debugging

DC	key transmitter, send test signals continuously.
DD(n),(m)	dump memory contents in hex from address n to m.
DF(n),(m),(x)	fill memory with byte x from address n to m.
DH(D/E)	InHibit digipeat by our calling address.
DI	fills transmit buffer with test data for sending.
DQ	input/output to a port
DS[n]...	memory byte substitution mode, address n.
DT(n),(m)	Type memory contents in ASCII from address n to m.

7.4.6. Other Special Commands

F*	Download a program.
F#c	Restart program in EPROM (c='R') or download (c=CR)
F@(D/E)	Enable serial bus operation for COM2.
FA(D/E)	Set Automatic Transparent mode entry on power-up.
FD(YY/MM/DD/WW)	set Date
F^(D/E)	Enable automatic remote error reporting.
FG(n)	Set digipeater delay value.
FI	re-Initialize all fields to default values
FL(n)	Display local error byte
FP(n)	Set serial bus device address
FR	Read and display serial bus device data
FQ(D/E)	Enable carrier sense backoff
FT(HH:MM:SS)	set Time
FU(D/E)	Enable unattended mode entry
FX(D/E)	filter control and non-ASCII characters from display.
FW(n)	output data to serial bus device
FY(D/E)	bit monitor mode
FE(n)	Display remote error byte
GB(255)	Embedded commands control character
GK(0)	Set Unconnected Transparent mode time value

7.4.7. Manual functions

MA(n)	set Address field to value "n".
MC(n)	set Control field to value "n".
MD	unilateral Disconnect.
ME(n)	set Transparent mode Exit character.

MF(D/E)	send LF after CR to information sent in Chat mode.
MK(D/E)	enable "- Ack" message in Chat mode.
ML(D/E)	enable automatic entry into Chat or Transparent modes.
MM	display number of 256-byte Memory blocks available.
MO(D/E)	controls the ability to connect while in unconnected mode.
MR(D/E)	enable MX.25 digipeater (Repeat) operation.
MS	enter Chat or Transparent mode.
MT	Transmit packet as specified (or last packet sent).
MU(D/E)	set Unconnected mode.
MV(D/E)	enable display of digipeated packets (eaVesdrop).
MW(D/E)	unconnected ack mode
MX(D/E)	enable Transparent mode.

7.4.8. Output and Display options

OA(n)	receive packets only having address "n" in LOP
OA(addresses)	receive packets only from station(s) in MX.25
OB(D/E)	enable Block mode.
OC(D/E)	display calls from other stations while connected.
OD(D/E)	enable non-info Data display.
OE(D/E)	display other channel activity while in connected mode.
OF	output one Frame from the queue.
OH(D/E)	enable Header display.
OI(n)	set value of Chat mode timer.
OK	"Kill" the contents of the receive queue.
OL(D/E)	enable auto LF after a CR to host.
OM(D/E)	display only completed paths
ON(n)	insert "n" nulls after a CR.
OO(D/E)	enable connect-Only mode.
OP(n)	set PID value to "n".
OQ(D/E)	enable Queue mode.
OR(D/E)	enable Chat status messages.
OT MR DR VR CR PR-	set filterlist categories.
OU(D/E)	enable status Updates ("#" numbers).
OW(n)	limit display Width to "n" columns.
OX(D/E)	Xon/Xoff flow control.

7.4.9. Serial Port Setup, m=port (1 or 2)

P(m)**B**(n)	set baud rate
P(m)**N**(n)	set number of bits
P(m)**P**(n)	set parity
P(m)**S**(n)	set number of stop bits

7.4.10. Frequency control commands

RC(n)	set receiver/transmitter to channel n
RI(KHz)	set receiver IF frequency.
RL(KHz)	set Lower frequency limit.
RM(n)	set receiver prescaler Modulus (32, 64 or 128)
RN(n)	set transmitter prescaler modulus (32, 64 or 128)
RO(KHz)	set transmitter Offset.
RR(KHz)	set Receiver frequency.
RS(KHz)	set channel Spacing.

RT(KHz)	set Transmitter frequency.
RU(KHz)	set Upper frequency limit.
RX(KHz)	set Receiver and transmitter frequency.

7.4.11. Setup Commands

S(CR)	display system status.
S1	display active modes.
SA(n)	set LOP Address to "n".
SB(D/E)	set Backoff to utilize squelch input.
SC(address)	set our address.
SD(address)	set Destination address.
SE(D/E)	disable/Enable Console Echo.
SF(n)	set length of preamble to "n" bytes.
SG(D/E)	disable/Enable "garbage" mode.
SH(n)	set Highest number of frames per packet to "n".
SI	re-Initialize default modes and parameters.
SK(n)	set Transparent mode time value
SL(n)	set maximum packet Length to "n" characters
SM(n)	allocate "n" Memory blocks to transmit buffer
SN(n)	set Number of tries to "n".
SO(n)	set random backoff time base to 10n milliseconds
SP(n)	set fixed backoff delay to 2n milliseconds
SQ(n)	set value for T2 (connection timer)
SR(B,D,H or O)	set numerical Radix to Binary, Decimal, Hex or Octal
SS(address)	enter Special address
ST(n)	set retry delay Time to "n" tenths of seconds
SU(D/E)	convert output to Upper case characters
SV(address)	enter digipeater (Via) address
SX(D/E)	disable/Enable MX.25 protocol
SY(abcdefghikl)	set control characters for Chat and **I** command
SZ(D/E)	enable/Disable leading Zeros
S#(n)	set the value of the preamble character

7.5. Command Explanations

AA Send an acknowledgment of previous information packet. This command is normally done automatically, but for test purposes an acknowledgment can be repeated (see **AW**). In MX.25 this function also requests the flow status of the other station, causing it to return either a normal ack or a "wait" request.

AC Automatic connect. Initiates a call for connection to another station, using the addresses already specified. The call is repeated up to 16 times or until the other station responds. When a response is detected the return packet is displayed with a #2 status message (or "Connected to...." in Chat mode), indicating connected mode. If no response is detected a #3 message is displayed (no ack), normally accompanied by #1, meaning disconnected. If an address has not been entered for the station (or LOP node number), an error ("?") is returned. See **C<CR>** command.

AD Automatic disconnect. A disconnect request is sent and repeated up to 16 times or until an ack is received. Upon receipt of the ack a #1 message indicates the disconnected state. A #3 status indicates no response was received. See **D** command.

AH Halt. Used to prevent further repeats of a packet under automatic control. In the halted condition the status display includes an "H". It resumes sending with the **AR** command.

AI Send an unnumbered information packet (MX.25) or a normal information packet (LOP), numbered zero. Info is typed in the normal way, using the **I** command or in Chat mode. The display of UI's at the receiving end is optional, controlled by the commands **OC**, **OD** and **OE**.

AL(D/e) This function affects only the display of LOP packets. While unconnected, if enabled, duplicate frame display is suppressed. For example, if a message is repeated n times by the sender, only the first one received is displayed, and the repeats are ignored.

AP(D/e) Make connection Permanent. Prevents a disconnect from taking place. If disconnect is attempted, either automatically, by operator command or from the other station, an immediate connect request is sent to maintain the connection. Note that time-out can be avoided by setting the connection timer value (**SQ**) to zero. The connection remains as long as the other station continues to respond. This mode is needed to maintain a permanent connection with some systems that send a disconnect request when they time out. If the other station fails to respond at some point and count-out occurs, the command is disabled to avoid calling forever. To keep it trying forever, the try counter (**SN**) may be set to 0, but it'll eventually stop when the connection timer expires. To keep it going forever set **SQ** to zero, too.

AQ(command) Sends a command to a remote station. A connection with the target station must be established or the command returns an error "?". (command) is almost any command as described in this manual. Some mode changes are not accepted by remote command, nor is it allowed to send a remote control **AQ** command. The response sent by the destination station shows the interpretation of the command as though it had been typed locally. This response is sent as non-info data, hence to see it the **OD** command must be enabled. If a disallowed mode command is sent the response may show the command accepted without error, but the mode is restored after the command.

Neither the command nor its response packet has any effect on info being sent or received in the normal manner. This capability is useful for adjusting parameters at the sending end of a data dump from the receiving end as receiving conditions change. For example, the command: **AQSF**25<CR> causes the other station to set its flag count to 25. When a command is sent, a special acknowledgment is returned, displayed as the status message #8. Caution must be exercised when sending commands, since some are inappropriate for remote use. For example, if the command is to change the remote station's address, responses won't be received again unless the destination address of the local station is similarly changed [**4.9.2.**] This, of course, applies even to the acknowledgment of the command itself! Other commands may make the remote station inoperable. It's a good idea to check out the effect of any doubtful commands before sending them to a remotely sited unattended station. See sections **4.8.**, **4.9.2.**.

When the command being sent includes an ASCII string, control characters may be entered to the string without terminating the command by preceding each control character with '\'. For example, to place a special beacon message into the remotely controlled station, ending with two CR characters, type:

AQBSThis is a special beacon message\CR\CRCR

"CR" is actually typed using the corresponding key on the keyboard. Since the AQ command terminates when CR is typed it's otherwise impossible to embed CR into a message. In the example each \CR embeds CR into the message, and the final CR terminates the command. To actually place the '\' character into the string, type "\\".

AR Resume sending. See **AH**.

AS(D/e) Standby mode. Stops both receive and transmit activity.

AT Automatic Transmit. An information packet is sent, containing data from the transmit buffer. The packet is repeated N (16 by default) times or until acknowledged. If acked, further repeats are canceled, and a #4 is displayed If it counts out without being acked, #3 is shown. Ack failure also causes an automatic disconnect, indicated by #1. Data in the buffer is deleted as it's acked, hence remains in the buffer until then. On long messages the data may be broken into more than one packet, so it's possible for part of the data to be deleted while the rest is being sent. Packets are formed and sent continuously as long as data remains, unless the maximum number of tries is exceeded. With each ack N more tries become available for the next packet. The **SN** command is used to change the number of tries from 16 to anything between 1 and 256.

AU Send an Unnumbered info frame N times, where N is controlled by the **SN** command. UI's don't require acknowledgment.

AW Send a "Wait acknowledge" packet. A wait request is sent to the other station, requesting him to stop sending info temporarily. The other station enters a polling mode, checking flow status periodically until a normal ack is sent (**AA**). This procedure avoids unnecessary repeats. If the local station has been asked to wait by the other station, the status report includes the letter "X" (eXternal wait) in field 5. This "hold" condition exists until the other station sends a normal acknowledgment packet or a disconnect. A wait ack is sent automatically when memory space becomes too small. A request for more data is sent when memory again become available. If the request is sent manually it doesn't clear automatically. It clears only on disconnect or a manual ack (**AA**).

AX Stops further re-transmission of the current packet. This command should be used only when necessary to stop needless transmissions. In normal operation allow the retry counter to expire if the other station doesn't respond.

BA(E/e) Enable alternate beacon message. A customized message can be supplied in the EPROM, enabled with this command. When beaconing, this message is sent instead of any message entered with **BS**.

BC Copy addresses entered under **BD** and **BV** into locations normally entered with **SD** and **SV**. This command allows a destination address (plus path) to be stored as a convenience, if beacon mode isn't in use at the time. For example, after entering a destination address path with **BD**/**BV**, to call that station at any later time "**BCC**<CR>" may be typed. This is a combination of the **BC** command to reset the destination path and **C<CR>** to call that path.

BD(address) Used exactly as **SD** except that the address entered is the destination of beacon messages, or for later retrieval via the **BC** command.

BK Delete the stored beacon message. Note that this command doesn't stop the sending of beacon packets (see **BT**).

BR Copies the current beacon message into the transmit buffer, where it can be transmitted as a normal packet or examined. Any previous contents of the transmit buffer are deleted.

BS Store the contents of the transmit buffer as a new beacon message. Any previous beacon message is replaced.

BT(0) (Set the time interval for automatic beacon transmissions containing the beacon message. Each count represents approximately 10 seconds, but the time is automatically lengthened with increased channel activity. A value of 0 terminates the function, but the beacon message remains in memory. Each message is sent as an "Unnumbered Information" (UI) frame with address fields specified by the **SC**, **SD** and **SV** commands. If the station becomes connected the beacon mode operation is suspended, to resume when the connection is terminated.

BV(addresses) Used exactly as **SV** except that the addresses entered are used in the destination fields for beacon messages or for later retrieval via the **BC** command.

C <address> [**V**] <path> Single-line connect request. "<address>" is the destination station address, "**V**" indicates that additional addresses are to follow, and "<path>" is a digipeater address or a series of up to 8 digipeater addresses, separated by blanks. Be sure to include a blank between the "**C**" and the first address. When the line is completed, a CR originates a connect request to the specified station via the specified digipeater path. All addresses are assumed to have an SSID of 0 unless another SSID is designated by appending "-<SSID>" to it. For example, TEST has an SSID of 0, while TEST-5 has an SSID of 5.The command letter "**C**" is an abbreviation for "CONNECT"; and actually any word beginning with "C" is interpreted as the connect command. "**V"** is an abbreviation of "VIA", and its inclusion is optional unless the first digipeater address begins with "V".

If "V" and the subsequent <path> addresses are left off, the connect request is sent directly to <address>. If the **C** command is typed by itself, the connect request is sent to the <address> and <path> that was previously entered (the same as **AC**).

NOTE: Some of the following 'D' commands are marked with '*'. These are intended for use as diagnostic, debugging or servicing aids. Descriptions are included here for the convenience of some users. They can be dangerous in terms of program function, potential data loss or protocol malfunction. They are offered with no guarantees.

D Disconnect request, same as **AD** (In Chat mode use ^C).

DC * Keys the transmitter for MODEM Calibration, with a tone. Once started with this command, tones can be alternated by typing the space bar, and typing "D" causes a square-wave to be sent, alternating between the two tones at the current baud rate. If a hex value is typed during this square-wave test the byte value represented is sent repeatedly instead of a square wave. Typing "Q" unkeys the transmitter, turns off the tones and returns control to Command mode. When using this command note that the transmitter unkeys after about 15 seconds. This occurs because the transmit limit timer in hardware prevents continuous transmissions from occurring. To reset the timer quit the command and type it again.

DD(m),(n) *Dumps memory contents, starting at memory address m and ending at address n. Each line of the display shows the starting address of that line followed by 16 hex values.

DE(0) Data to be transmitted may be "scramblEd", by entering a value with this command at both the sending and receiving stations. Each byte of the information sent over the air is exclusive-OR'ed with the value given to produce an unreadable display, and it's recovered at the receive end by the same process. The security of this system is minimal, intended only to avoid displaying sensitive information to casual observers at other locations.

DF(m),(n),(k) *Fills memory starting at address m and ending at n with the byte value of k. This function is a diagnostic having potentially disastrous consequences.

DG<address> Enter a DiGipeater address for this station. Often it is desirable to use different addresses for connecting to a station and for digipeating through it. By entering an address here other stations may digipeat via this station by either address. See **DH**.

DH(D/e) inHibit digipeating via the normal station address. When an alternate digipeater address has been entered via the **DG** command other stations may specify either that address or the normal station address as a digipeater. When this function is enabled, packets specifying the normal station address are not digipeated, but they are digipeated via the address entered under **DG**. If no entry is present under **DG** this function has no effect.

DI *This diagnostic command fills the transmit buffer with information, consisting of the sequence of printable ASCII characters, repeating until the end of the buffer is reached. When sent, (using **MT** and a control field of 0) the result is a packet of longest possible length for test purposes.

DK(key) Displays the next Key typed and its numeric value.

DL(E/d) Enable remote control lockout. The remote command lockout input is used to prevent unauthorized use of the remote command capability (see section **4.8. Remote Commands**. An external device can be used to feed this input (+5=disable) to enable or disable the remote command capability.

DN[n] Display or modify Number of retries. n is displayed as a 16-bit hex value, followed by a hyphen. If a new hex value is typed the value of n is replaced accordingly, but if a CR is typed by itself the value of n remains unchanged. n is initialized to zero on power-up, and it's incremented every time a retry is sent (original transmissions are not counted). This function provides information helpful in choosing parameter settings such as frame size, etc., for optimum throughput.

DOC This commands is used to store the current settings in the EEPROM. Note that the EEPROM is protected against accidental writing under normal conditions. For writing it must first be unprotected with the **DU** command. The **DOC** command must follow **DU** immediately, because the EEPROM is re-protected after all other commands. **DOC** causes the Current settings in RAM to be saved.

DQ(m),(n) (RDC2 or RDC4) *Read or write input port. m specifies a 16-bit port number. If n is included, n is written to the port. If not, the contents of the port are displayed.

DS(n) *Display/Substitute memory bytes. n is the address to display, after which the memory byte at that address is displayed in hex, followed by a hyphen. Typing CR exits the command at any point. Memory contents at that address can be changed by typing a new hex value. If the new value is followed by a space the command proceeds to the next memory location. Pressing the space bar without typing a new value advances to the next location without changing the contents at the current one. Every 8 bytes a new line is started and the current address is displayed with its memory contents. Typing "," decrements the address and starts a new line showing the new address and memory contents.

DT(m),(n) *Type the contents of memory, in ASCII, starting at address m and ending at n. The display begins with the address, followed by up to 56 characters for each line. Dots replace non-printable characters and bit 7 is stripped from values exceeding 127 (7F hex) to make them printable.

DU (RDC2 only) Unprotects the EEPROM for writing. It remains unprotected only until the next command is given; thus the **DO** or **D%** commands must follow to write to the EEPROM.

DZ(1) Sets the number of closing flags at the end of a packet. Normally this is set to 1, since extra closing flags serve only to waste channel time. With some hardware there may be a transmitter data delay such that when the keying line is dropped, the data has not yet propagated out. With such a delay the end of the packet could be lost, since the transmitter is unkeyed before all has been sent. If this problem should occur, increasing the number of closing flags could be the cure, since it has the effect of delaying the keying line dropout. The delay time for each added flag corresponds to the length of a byte at the current baud rate (6.67 ms at 1200 baud or 833 us at 9600 baud). The acceptable range for this value is 1 to 254.

F@(D/e) Enable serial bus operation on COM2; when enabled, the **FP**, **FR** and **FW** commands apply. When disabled COM2 is used as a second serial port (see **SS**).

F#L<n><file><checksum> Used to download a program to the controller. n is a 16-bit binary number representing the number of bytes in the file (excluding n and the checksum), sent with the least significant byte first. <file> is the program to be downloaded, as a binary image of a 64180 program, n bytes long. The checksum is a 16-bit value, generated by summing all n bytes of the program modulo 16 and taking the two's complement. The sum of all file bytes plus the checksum (stored with the least significant byte first) must be zero. If the checksum is correct the program is loaded and executed. If not the value of the errant checksum is displayed and the command is abandoned. See section **6.7.**

F#© This command has been replaced by F#P.

F#P Restarts a downloaded program. If the checksum is bad the errant value is displayed and the command is abandoned. See section **6.7. F#R** Restarts the EEPROM program. See section **6.7.**

F*<n><file><checksum> This command has been replaced by **F#L**.

F^(D/e) Enable automatic remote error reporting. When enabled, whenever a connection is made any errors are sent to the other station automatically, updating its remote error byte. See **FE** and **FL**.

FA(D/e) Set auto Transparent on power-up mode. With this command enabled when the controller is shut off and restarted it enters Transparent mode directly, skipping sign-on and Command mode. The automatic entry is aborted if a checksum error occurs in a critical part of memory during initialization.

FD(date) Displays/sets the internal calendar. Once set, the date is maintained as long as power is on. When **FD** is typed the date is displayed in the form: "1991/6/3/0". 1991 is the year, 6 is the month (June), 2 is the day and 0 is the day of the week (Sunday). The time may be reset by typing a new value: "91 7 5 3<CR>", setting the new date to Wednesday, July 5, 1991. The current date may be requested without changing it, using the same command without the argument: "**FD**<CR>".

FE(0) Displays/modifies the remote Error byte. If certain error conditions are detected, bits indicating the nature of the problem are stored in the local error byte (see **FL**). However, when a connection exists to another station and **F^** is enabled the error byte of either station is sent to the other, where it's stored as the "remote" error value. This command displays the value, and allows it to be modified (or reset to zero). The remote Error byte is also set to zero when a connection is made (to avoid ascribing old errors to the new connection). Error conditions are set as follows:

bit 0:	parity error on primary serial port.
bit 1:	framing error on primary serial port.
bit 2:	overrun error on primary serial port.
bit 3:	parity error on secondary serial port
bit 4:	framing error on secondary serial port
bit 5:	overrun error on secondary serial port
bit 6:	unused
bit 7:	memory error.

These bits are cleared only by typing the command and entering a value of 0. If bit 7 is set the location of the error is not vital to the running of the program, but errors might occur during operation. If the errant bit is vital there is no sign-on. The CPU halts, and the watchdog circuit soon creates another reset, the cycle continuing as long as the memory problem persists. See **F^**, **FL**.

FG(0) Set digipeat delay value to N*10 milliseconds. When a digipeat is specified by the DG address, a delay value can be introduced by setting N between 1 and 250 (up to 2.5 seconds). By setting different delays on more than one digipeater to different values and using identical digipeater addresses, the same message can be made to be digipeated successively by each station without colliding.

FI Initialize all values stored in EPROM to EPROM settings, including modes, parameter values, all addresses, filterlist and (if applicable) radio frequency settings. See **SI**.

FL(0) Displays/modifies the local Error byte. If certain error conditions are detected, bits indicating the nature of the problem are stored in the local error byte. The value may be modified by entering a new one (or 0 to reset it). The bits are set in the same way as the remote error byte (see **FE**).

FP(n) This command applies when COM2 is used with data I/O devices (**F@**). Up to 256 devices can be daisy-chained to COM2 in a serial bus configuration. Each device has its own unique address, 0-255. Once this command is used to set the address of the device to be accessed, the **FR** or **FW** commands may be used to read

or write data. When an address has been set by this command, data may be written and read to/from the device any number of times. The address needs to be changed only to access a different device.

FQ(d\E) This command enables the SNRDS to backoff when the channel is busy. If the receive LED is on and a message is waiting to be transmitted by the unit, it will wait until the channel is clear before transmitting. When disabled the unit will transmit regardless if the channel is busy or not. Care must be taken when using this command as setting it to disabled can be in violation of the FCC. This is especially true for the survey customers.

FR Read data from the COM2 data device. The device is selected by first using the **FP** command. After the command is typed the value is displayed as a 16-bit unsigned decimal value. See also **F@**, **FW**.

FT(time) Displays/sets the internal clock. Once set, the time is maintained as long as power is on. When **FT** is typed the time is displayed. It may be reset by typing a new value: "09:30:00<CR>". setting the time to 09:30:00, where 09 is the hour (in 2400-hour format), 30 is the minute and 00 is the second. The current time may be requested without changing it, using the same command without the argument: "**FT**<CR>".

FU Set Unattended mode operation. Normally unattended mode is entered by holding the primary port data input high and restarting. This command may be used to enter it via software. When enabled, unattended mode is entered upon the next power-down/power-up sequence.

FW(n) Write data n to the COM2 data device. The device must be previously selected via the **FP** command, and n is a 16-bit unsigned decimal value to be written. See **F@**, **FR**.

FX(D/e) Control Character Filter. Its purpose, during monitor mode, is to avoid disrupting the display screen with spurious screen-clear, cursor-set, etc. sequences that are part of non-ASCII data files in packets being monitored. All graphic characters with bit 7 set, form-feeds, and all control characters with the exception of CR, LF and TAB are deleted. The filter has no effect on connected operation. Bell characters are also deleted, so the terminal won't be beeping on every message that passes on the channel. The filter doesn't apply when you're connected, so beeps intended for you still come through.

FY(D/e) Bit monitor mode. In this mode the four auxiliary input lines on the system connector are monitored continuously for their logic states. In connected mode, if any of the bits changes state (and a connection is not already in progress), a connect request is made to the current destination station/path. When the ack is received, the current bit status is sent to the other station. When the information is acked, a disconnect is made automatically. In unconnected mode the information is sent without making a connection. The data format is as follows:
0101 00020

The first four digits indicate the states of the four input lines in the order 4-3-2-1. A '1' indicates a 5-volt input level and a '0' indicates a zero level. The next 5 digits represent the time (in seconds) input 2 has been in its previous state. If input 2 wasn't the input that triggered the transmission it would be the time input 2 has been in the current state.

GB(255) Embedded command character. This command sets the character for using embedded commands. This is for Transparent mode only. This gives the user the ability to send single commands to the radio, while in Transparent mode by preceding the command with the GB set character. The value 255 disables the embedded commands. The valid values are from 0 to 254. To

send the character that is used for the embedded commands over the air requires that 2 bytes of that character be sent into the serial port to transmit 1 character over the air. By sending 2 of the embedded command character causes no embedded command to take place. If 2 continuous bytes of the embedded command character wish to be sent over the air, then 4 characters must be put into the serial port of the radio and so on.

GK(0) This command is identical to SK except that it is used for Unconnected mode, while SK is used for Connected mode. If the value of GK is set to zero (default) then the SK value is used for both Connected and Unconnected modes.

I(data) Insert data for transmission. In normal operation all characters following the "**I**" are inserted to the transmit buffer, where they're stored for transmission. If not connected, any previous contents are deleted. If connected, existing contents are first displayed, and additional characters may be appended. During Insert, the backspace key may be used to correct errors. One character is deleted for each occurrence (the backspace/delete character is not entered into the buffer). "^T" can be used to retype the entire buffer contents, "^U" to delete the current line and "^X" to delete the entire message. Once part of the contents of the buffer have been transmitted but as yet un-acked, it's no longer possible to backspace into it or to delete it with "^U" or "^X".

If too many characters are typed the last character in the buffer is overwritten with each additional character typed. For each overflow character a backspace is sent to the terminal. To end the insert mode, type ESC.

Special control characters may be inserted into the message by preceding them with '\'. This character means "embed the next character, whatever it is, into the string". For example, inserting an ESC character is normally impossible since ESC terminates the command. Typing "\"<ESC> embeds the ESC into the string without terminating the command. To actually place the '\' character into the string, type "\\".

I(ab)(data) This is the form of the "I" command in Block mode. The "I" must be followed by two binary bytes (a and b) representing the count of the characters to be sent. The first is the least significant and second is the most significant 8 bits of the count. If the number is too large, an error ("?") is returned. The command is terminated when the specified number of bytes has been sent. Old data is not deleted with new entries; the new data is appended. In connected mode (or unconnected ack mode) data is deleted automatically as it becomes acked. There are no reserved control characters, such as backspace, etc. All byte values are placed into the buffer for transmission.

K Delete (Kill) the contents of the transmit buffer.

MA(255) Set LOP node number for sending packets manually, range 0-254. 255 is a null value.

MC(0) Set Control field for the next manual transmission. In connected mode this value may change at any time.

MD Manual Disconnect. If a disconnect can't be completed because the other station fails to acknowledge, use this command to restore disconnected mode. This command should be viewed as an emergency measure and not to replace an automatic disconnect operation, since it could leave the remote station with a "hanging" connection.

ME(3) Set the exit character for Transparent mode (see **MX**). The argument is the numeric ASCII value for the desired character, for example 3 is a ^C. Hint: the ASCII value for any particular key can be found using the **DK** command.

MF(D/e) In Chat mode a new line is generated at the receiving station when just a CR character is sent, since LF is used as the send key. If the receiving station requires both CR and LF for a new line, activating this function causes CR LF to be transmitted when the CR is typed by itself. This command also has a special function for CA mode units. See section 3.4 for details.

MG(D/e) Transparent mode is special in two ways: 1) The method of transferring info to be transmitted into the RDC and initiating its transmission, and 2) Display and other modes are automatically set up for operation appropriate to transparent mode. An example of the latter is that header and status displays are disabled (even if commanded "enabled") automatically so that only pure info is displayed. It's set up this way to make transmissions automatic and transparent and to make it simple to use. Thus the user has no way to activate the display of any data other than received info or to alter other settings.

This command changes the nature of Transparent mode such that only special condition 1) is imposed. That is, transmission of info is transparent-like, but all display and most other options must be specified by command, and they remain in effect during Transparent mode operation. It's important to remember that all options must be correct in order to get the desired result.

In normal Transparent mode operation the following commands are automatically disabled:

standby (**AS**)	display calls, connected (**OC**)	status messages [**OU**)
debug (**DE**)	display all, connected (**OE**)	Chat messages (**OR**)
display transmitted frames (**DV**)	Unattended mode	terminal echo (**SE**)
garbage filter (**FX**)	header display (**OH**)	garbage (**SG**)
digipeater display (**MV**)	auto line feed (**OL**)	uppercase (**SU**)
block mode (**OB**)	queue (**OQ**)	

This command has a similar effect on Chat mode. Commands normally canceled upon entry to Chat mode are:

standby (**AS**)	Unattended	Transparent (MX)
queue (**OQ**)	debug (**DB**)	non-info data (**OD**)
garbage (**SG**)	transmissions (**DV**)	Block (**OB**)
SCADA (?)		

When **MG** is enabled it's the user's responsibility to set and/or disable the proper functions before entering Chat or Transparent mode.

MN(N) Sets the count for the Number of transmissions to make in unconnected mode each time new info is placed into the transmit buffer. This parameter is analogous to the **SN** value for connected mode, but for unconnected operation. The **SN** value establishes the number of times a frame is repeated while waiting for an acknowledgment. In older software **SN** was used for both connected and unconnected modes; in unconnected mode it established the number of times each info packet was repeated. Current software is compatible simply by setting **MN** to 0, which defaults the **MN** count to the **SN** value. Setting separate repeat counts for connected and unconnected mode makes it practical to communicate in both modes without changing settings. For example, if **MN** =0 and **SN**=1, for both modes each transmission would be made once. However it would be virtually impossible to connect to the station because when the count expires any connection is lost. With only

one transmission allowed a connection couldn't be maintained. By setting **MN** to 1 and **SN** to, say, 16, both the unconnected and connected modes would work.

MO(D/e) When disabled, if the station is placed into unconnected mode (**MU**-E), connect requests received are ignored. When enabled, connect requests are honored while in unconnected mode. During a connection the MU command is automatically disabled, but it's restored to its original state when disconnect occurs.

MK(d/E) Disabled, the "—Ack" message is suppressed in Chat mode.

ML(d/E) Enabled, causes automatic entry to Chat or Transparent mode on connect, and automatic return to Command mode upon disconnecting.

MM Displays the number of 256-byte blocks of memory in the receive queue.

MR(d/E) Controls the MX.25 digipeat function. If disabled the station does not repeat other packets.

MS A direct entry to Chat or Transparent mode, depending on which is currently enabled (see **MX**).

MT Manual Transmit. A custom-made packet can be transmitted by means of this command. In LOP the address is set with the **MA** command, and the control field with the **MC** command. In MX.25 a header is formed with the prevailing address entries and a control field entered via **MC**. If any information is in the transmit buffer it is sent in the "info" field of the packet regardless of the control field value. If the control field is an even number (i.e., designating an "info" packet) buffer data is broken into frames if needed and the sequence number is incremented with each frame. **MT** then causes a packet with these fields to be transmitted once. It can be repeated as often as desired by repeating the command. Be aware that any automatic transmissions made by the protocol modify the **MA** and **MC** values.

MU(D/e) Unconnected mode. Normally connect requests are recognized and acted upon. Unless this mode is enabled, if another station should connect communications would be disrupted, since when you become connected packets are no longer displayed from the unconnected station. When enabled, this mode locks out automatic connections.

MV(D/e) Enabled, packets digipeated by your station are displayed.

MW(D/e) This function applies only when unconnected mode (**MU**) is enabled. When enabled, any UI received (with our station address) causes an unnumbered acknowledgment (UA) to be returned. The acknowledgment is sent automatically to the path/station that sent the UI. If this command is enabled at the station sending multiple UI's (**AU** in command mode), further repeats of the transmission are canceled when an UA is received. The UA is acked only if the packet is addressed to it. In Chat mode, this function causes multiple UI's to be sent instead of info frames, after which "—Ack" is displayed when a UI is received or after N transmissions. The contents of the transmit buffer are cleared automatically. There are no ack indications in transparent mode. This mode isn't recommended where info is being sent to more than one station at a time, since the first ack received cancels further transmissions. Thus the first station receiving the frame may prevent others, which might not have received the first transmission, from receiving it on a repeat. It finds good

application in a "star" station configuration where the only information passed is from the satellite stations to the hub, since unnecessary repeats are prevented and the need for making connections is eliminated (see **4.4.**). UI's are limited to one frame, not to exceed 256 bytes, and are considered non-info frames requiring **OD**E for display.

MX(D/e) When enabled, Transparent mode is substituted for Chat mode for the **MS** and **ML** commands. This mode is used for automatic transfer of non-ASCII as well as ASCII data. See section **6.1.**. This command also has a special function for CA mode units. See section 3.4 for details.

MY(d/E) With this mode enabled only frames addressed to our station are displayed, even when unconnected. See **OO**, which performs a similar function in connected mode.

OA(addresses) In MX.25, enter addresses to the filterlist and select filter modes to be used (section **4.14. Station filtering system**).

OA(n n) In LOP this command allows up to two node numbers to be entered, which then become the only LOP stations that are displayed in monitor mode.

OB(D/e) Block mode is used for communication with a computer program. Unnecessary Spaces, CR's, etc. are suppressed to keep the communications overhead to a minimum. Each frame sent to the host computer begins with an apostrophe character and a 1-byte binary number equal to the number of bytes of data to follow. Operation of the "Input" mode is also modified (see **I** command). Also see Section **6.2.**.

OC(D/e) When enabled, this command allows connection requests from other stations to be displayed, even while in the connected mode. The address of the originating station may be seen by enabling headers (**OH**), and in Chat mode, connect requests show up as a message:
"- Call from <address>"

If any info was included with the packet, it's displayed on the next line. A caller can thus send a message to be displayed by sending it as a UI (see **AI**). With this function enabled, non-info data from the connected station is also displayed. This function has no effect in Transparent mode. In Command mode information from an outside call is displayed as non-info data (even if it were sent as an info frame), and headers are displayed if enabled.

OD(d/E) Control the display of non-info data. Unnumbered information data and the information fields of LOP connect/disconnect packets are considered "non-info" data. By disabling non-info data the only data seen is data in sequenced info frames.

OE(D/e) When enabled, causes ALL received packets to be displayed, even if already connected to another station. Information frames, other than those from the connected station, are converted to unnumbered information frames (UI). Such packets are not acknowledged, and the connected state is unaffected. A connect request in Chat mode displays:

"- Call from <address>"

A "/" token is issued on UI's instead of the normal info ("'") tag, so that the host computer can direct them to the display (or other) and not into disk files during file transfers.

OF If many messages are allowed to accumulate in the Queue mode, then Queue mode is disabled, all of the messages stream out at once. Each time this command is given one frame is displayed instead.

The following two commands are useful only on stand-alone RDCs because the required output line isn't available at the radio connector on SNRDS:

OGn Used to control external equipment connected to the serial port. Each time info is available for display the aux. output bit 1 is set high. This line can be used to activate the external equipment, for example it could be cross-wired to the RTS output to control the host device. After the line goes true there's a time delay before the info is sent for display. This command sets a delay value (n) of about 1 ms per count. When set to zero the output bit activation is canceled. See OJ for timing at the end of info display.

OJ(n) Sets the amount of time (n, in milliseconds) that elapses after received info has been sent to the serial port and before the aux output bit 1 line is set low again. If n is set to zero there's no delay. This delay doesn't occur if the **OG** value is set to 0. See **OG**.

OH(d/E) Disable/Enable the display of frame headers. Headers consist of address and control field outputs that come with each frame. The control field is shown in hex radix. If headers, non-info data and status outputs are all disabled only "pure" data is displayed. Thus sentences that break into more than one packet are reconstructed as though they all came in the same packet. This command has no effect on Chat or Transparent modes. See also **4.6.2.**.

OI(8) Set Chat mode Input timer. Each count represents approximately 5 seconds.

OK Deletes the contents of the receive queue. If messages have accumulated during Queue mode operation and they are of no interest this command is used to purge them.

OL(D/e) Automatic line feeds to the display. Enabled on power-up, this function causes line feeds in received messages to be ignored, and inserts line feeds after every carriage return. If disabled, characters are sent to the terminal as received.

OM(d/E) When enabled and not connected, only frames that have traversed a complete path are displayed. Normally, all frames are displayed when there is no connection. If a frame is digipeated, it appears on the air once in the original packet and again each time it passes through a digipeater. A receiving station may be in a position to receive more than one of these transmissions, thus showing the same info more than once. Some applications don't work right when info is received in duplicate, so this command is provided to filter out every occurrence of a digipeated transmission (including the original) until it has passed through the final digipeater specified. The path has been completed at that point. Thus, each transmission is only received once, even when it is digipeated. Non-digipeated frames are not affected, since the original transmission is also the completed path, since there are no digipeaters specified.

ON(0) Output Null characters after every carriage return. Use this with slow terminals to allow time for motion to stop before characters are printed on the next line. The value range is 0 to 255.

OO(D/e) Connected-Only mode. When this mode is enabled no data is displayed unless the other station connects or Unconnected mode is on and the packet is addressed to us. Thus, extraneous channel activity doesn't clutter the screen or queue up in memory.

OP(240) Set the value of the Protocol IDentifier byte (PID) to be sent with information frames (MX.25 only).

OQ(D/e) In Queue mode messages aren't displayed until requested. All eligible messages are stored in memory instead. If memory is full and queue mode is again disabled, they're displayed immediately. See **OF**.

OR(d/E) Controls the display of Chat mode system messages. Although Chat mode isn't intended for file transfers, suppression of the internally generated messages makes it possible to use it for ASCII files. When Enabled, messages (such as "- Connected to... or "- Waiting", etc) are displayed; when Disabled the messages are suppressed, and the '\' characters are accepted at face value instead of having special significance (see **4.3.3.**).

OT(MR VR DR CR PR-) Controls the "Filterlist" modes. Allows each list to be set for Select (passing information) or Reject (not passing information) from stations designated in the "OA" command. See Section **4.14.2. The Filterlist Mode Command** for further details.

OU(d/E) Controls the output of status (#) Updates. When disabled, "#" messages are not displayed. Applies only to Command and Block modes.

OW(0) Set terminal width. Inserts an automatic CR-LF as required to limit the line length on the display. The value range is 0 to 255, and when 0 the function is disabled.

OX(d/E) X-on/X-off flow control on the primary serial port. When enabled, RS232 data to the host is controlled by ^Q and ^S characters; if data is sent too fast by the host, ^S is sent. When there's room for more a ^Q is sent to the host. Similarly, if these control characters are sent by the host, the controller stops on ^S and restarts on ^Q. Note that RTS flow control is always observed, even if this function is enabled. With RTS/CTS flow control the controller stops sending data when the primary serial port RTS line goes false and it sets the CTS line false when it is being overrun. Please note that Xon/Xoff is not suitable for non-ASCII data, since the byte values corresponding to ^S and ^Q are not sent as data. P1X(d/E) is equivalent; see P command series.

NOTE: The following commands apply to either serial port, designated by typing 1 or 2 for the (m) argument. For m=1 the command applies to the primary serial port, while m=2 applies the command to the secondary serial port. No actual change occurs after typing these commands until the PG command is given, or a power-down/power-up (not reset) sequence occurs. The original default values are replaced upon reset. The SE and OX commands, which control COM1 echo and Xon/Xoff operation, are duplicated with the general commands PmE(d/e) and PmX(d/e), respectively. SE and OX are retained for compatibility, but affect only COM1.

P(m)**B**(n) Set serial port baud rate. The baud rate, n, must be entered 300, 600, 012 (1200), 024 (2400), 048 (4800), 096 (9600) or 019 (19200).

P(m)**N**(8) Set number of bits (n=7 or 8). Observe that 8 bits is required for non-ASCII data.

P(m)**P**(n) Set parity. Parity off, n=0; odd parity, n=1; even parity, n=2.

P(m)**S**(n) Set number of stop bits (n=1 or 2).

P(m)**X**(n) Controls Xon/Xoff flow control on either port. RTS/CTS remains active.

PG Port Go command; causes the above commands to take effect immediately.

NOTE: The following commands are used in conjunction with GLB Synthesized Data Link radios for setting frequencies. Frequency entries are in kilohertz to the nearest ½ kilohertz. Channel selection must be consistent with channel spacing and range limits or the entry is ignored and an error is indicated. Channel spacing must be set to a non-zero value before any other frequency entries are accepted. Example, to set reference frequency to 12.5 KHz:

rs 0-12.5

As usual, " 0-" is sent by the controller to show the previous value.

RC<1> When multiple channels are specified as a software option, this command is used to select which of them is to control the radio at any given time. The number of available channels is specified when ordering. A panel switch option is also available.

RI(-21400) Set receiver IF frequency, a signed value. The IF must be an even multiple of the channel spacing. Low-side injection is indicated by preceding the IF frequency with a minus sign.

RL(450000) Set Lower frequency limit. In order to prevent accidental entry of illegal frequencies or out-of-range frequencies lower and upper limits are entered before actual operating frequencies. Subsequent frequency entries are checked against these limits and an error is generated if the new entry is not within them.

RM<32, 64 or 128> Set up the prescaler modulus for the associated synthesized receiver. The modulus value varies with the frequency band.

RN<32, 64 or 128> Set up the prescaler modulus for the associated synthesized transmitter. The modulus value varies with the frequency band.

RO(0) Set transmitter Offset. The transmitter synthesizer is left in the locked condition while receiving to reduce turnaround time. For simplex operation during receive periods the transmitter is offset from the receiver channel to prevent interference. This command sets the offset value, in kilohertz. If set to -25, for example, in the receive mode the transmitter frequency is set 25 KHz below the receive frequency to prevent interference to the receiver from the transmitter synthesizer. Each time the transmitter is keyed a serial stream is sent to the transmitter to move it to the correct transmit channel, and when it's unkeyed another serial stream is sent to offset it again. Observe that where the transmitter and receiver operate on different channels offsetting isn't necessary, hence RO is set to zero. When this value is set to zero no commands are sent to the radio when keying and un-keying; thus when using the output lines controlled by **DW**, set **RO**=0.

RR(450000) Set Receiver frequency.

RS(0) Set channel Spacing. This value is determined by the particular receiver or transmitter in use. Note: This value should be set to zero if the controller is not to be used with a synthesized GLB radio to avoid sending frequency commands to the auxiliary output lines.

RT(450000) Set Transmitter frequency.

RU(470000) Set Upper frequency limit. See "**RL**", above.

RX(470000) Same as RR, but the transmitter is set to the same frequency. If the receiver is set to frequency A and the transmitter is set to frequency B, typing RX and not entering a new frequency will set transmitter to the same frequency as the receiver. If a new value is typed both the receiver and transmitter are set to it.

S(CR) A request for a status report. There are eight fields, separated by "/", to be described from left to right.

(1) Link state (MX.25) or the station node number (LOP). Not to be confused with status updates, displayed with the "#" tag.

(2) The station address, (and SSID in MX.25).

(3) The destination address (and SSID in MX.25. In LOP a "$" follows if unconnected, otherwise the node number of the other station.

(4) MX.25 - digipeater address and SSID (empty in LOP). An "@" indicates that monitor mode receive is limited by "OA".

(5) A series of letters indicating the state of data flow, as follows:

B	our end Busy (memory filled)
W	our end busy via manual (**AW**).
X	waiting for the other station, who has sent a "busy" flow status.
H	waiting due to manual command (**AH**)
S	our end is in Standby - neither receiving or transmitting.

(6) A series of letters indicating output formatting modes (the presence of a letter indicates the enabled state):

B	Block mode is enabled (OB)
L	automatic Line-feed mode is enabled (OL).
O	connected-Only mode is enabled (OO).
R	Chat message suppression is enabled (OR).
H	Header display is enabled (OH)
D	non-info Data display is enabled (OD)
U	status Update mode is enabled (OU).

(7) A series of letters indicating the following modes:

U	Upper case mode. SU
G	Garbage mode is enabled. SG
X	MX.25 protocol enabled. SX
Q	Queue mode enabled. OQ
E	terminal Echo enabled. SE

(8) A series of letters indicating the following modes:

U	Unconnected mode is enabled. MU
V	digipeater eaVesdropping mode is enabled. MV
R	digipeater active. MR
L	automatic Chat/Transparent mode entry enabled. ML

F	auto LF in Chat mode is enabled. MF
X	Transparent mode is enabled. MX
!	Unattended mode is enabled (seen only via remote control).
“	data is present in the transmit buffer.

(9) A number indicating the value of the beacon timer (0 if the beacon is turned off).

S1 Mode status display. Displays a list of enabled mode commands.

SA(255) Set LOP node number, 0-254. 255 is a null value.

SB(d/E) set squelch Backoff. Backoff occurs a when a packet is ready to be sent but the channel is busy. When the communications channel is shared with voice users there’s a potential conflict with data stations. SNRDS units check for a busy channel by observing whether a data signal is present, but they normally ignore voice signals. Thus, packets could be transmitted during other voice transmissions, causing interference to the latter. When the audio option assembly is included with SNRDS, the squelch circuit can be used for detecting voice transmissions. Squelch backoff is then enabled with this command, causing SNRDS to back off when either a MODEM signal is present OR when the squelch is open. Also see **SO** and **SP**.

SC(address) Set address. Type the station address after the “scABCDEF-“ (Any previous address is displayed instead of “ABCDEF”). Terminate the body of the address with a space or dash. If the address is less than 6 characters long the remaining characters are filled with spaces. A second prompt is sent in MX.25 mode, for the numerical value of the station SSID. Example (user input is shown in boldface; the remaining characters are responses):

“SCABCDEF-**TEST2** 0-**2<CR>**”

In this example there was no previous address entry, a new address TEST2 was typed, the old value of SSID was zero, and a value of 2 was typed. A CR or SPACE response to either prompt would have left the old value in place. There is no second prompt for SSIDs in LOP mode. An address may be removed by typing a dash at the “-“ prompt.

SD(address) Set Destination address, using the same procedure as in the **SC** command, except “------“ appears instead of “ABCDEF”. Also see **C**.

SE(d/E) Control terminal Echo. When enabled, characters typed are “echoed” back to the terminal - that is, they’re sent back to be printed on the screen so what’s typed can be seen on the terminal. Some terminals echo typed characters internally, resulting in a double character echo. In such cases disable this function. Note that **P**1**E**(d/E) does the same thing, see **P** commands.

SF(32) Set number of bytes in preamble. The “preamble” is a string of bytes sent at the beginning of every packet, needed at the receive end for receive synchronization. It also allows time for the transmitter to come on and for the receiver to recover data. More length is needed for slow receivers and fewer for fast ones, between 1 and 256 bytes. It’s safe to start with a larger number and to reduce it until the number needed is found. Since unnecessarily long preambles waste time, the fewer the better for the system.

SG(D/e) Disable/Enable "garbage" mode. Disables error checking to allow all data through for channel monitoring or in disconnected mode. Useful in such cases because data integrity is not critical in casual conversation and fragments of bad packets may contain some readable text, which may be better than none. NOTE: In this mode connect requests are ignored, since erroneous transmissions could occur as a result of receiving inaccurate data. If a connect request is commanded, however, this mode is cleared and the connect request is made in the normal manner. There may be occasional real garbage displayed while connected to a receiver, due to noise.

SH(7) Set the maximum (Highest) number of frames per packet (1 to 7). As much of the data in the transmit buffer is sent as possible in a single packet (up to 7 frames of 256 characters each). This command allows the number of frames sent in one packet to be reduced.

SI Initialize modes, parameter values and serial port settings to the default values in the EPROM. See **FI**.

SK(16) Set Transparent mode time delay. Each count is approximately 10 milliseconds. This time value is used as a delay interval under each of four circumstances in Transparent mode:

1. The delay between the last-sent byte from the terminal and the start of transmission.
2. The delay required after a transmission before typing exit characters.
3. The time allowed between exit characters.
4. The time after the last exit character and the return to Command mode. See Transparent mode explanation in section **6.1.**.

SL(0) Set maximum frame length in bytes. The range is 1 to 256, where 256 is displayed as 0. Information packets can contain up to 7 "frames" of data. Each frame carries its header and error check value (FCS). When a multi-frame packet is sent, only those received correctly are acked, and all frames following the first bad one are re-transmitted instead of the entire packet. Shorter frames are more likely to get through, but under good radio conditions long frames are more efficient. If the data sent to the transmit buffer exceeds the maximum frame length the data is automatically broken into multiple frames for transmission, up to 7 at a time (see **SH**).

SM(7) Set transmit storage space in blocks of 256 bytes. Available memory is divided between the receive and transmit buffers, and this command sets the transmit buffer space, initially 1752 bytes. What's left is assigned to the receive queue. If too much is allocated the error signal ("?") is returned and the maximum amount available is used. See **MM**, **SL** and **SH**.

SN(16) Set Number of retries. Any given packet is sent up to 16 times while waiting for an ack. Range: 1 to 255. A value of 0 causes it to re-send forever.

SO(25) Set backoff delay time base. When a packet is ready for transmission, but the channel is busy, a backoff procedure is entered. When the channel becomes clear a random wait time is invoked before transmission. This action prevents, for the most part, collisions with other stations that might also have been waiting, since the odds are that the two won't have the same delay value at the same time. The maximum value of the random time delay is set with this command in steps of 10 ms, making the default value about ¼ second. See **SB**, **SP**.

SP(0) Set fixed backoff delay, a delay that is added to the delay controlled by the **SO** command. Random backoff delay is used in networks where no control is available on other channel users or there are too many to make fixed values of delay feasible. Where full configuration control is available on all stations fixed delays may be assigned to establish a priority hierarchy for channel usage. Timing is about 2 ms per count. Since the argument may be set as high as 255, maximum delay is 510 milliseconds. In order to ensure a fixed delay, **SO** must be set to zero. A random delay range is also possible, using this command to set the minimum time and **SO** to set a random time. Backoff timing then varies randomly from (**SP**) to (**SP**)+(**SO**). See also **SB**.

SQ(50) Set value of the connection timer. Steps are about 6 seconds each, so a count of 10 corresponds to about 1 minute. Setting the value to zero is equivalent to an infinite time value. When this timer expires the controller is disconnected, so that an inactive connection doesn't tie it up forever. Unconnected mode is also canceled by this time-out. Each time a transmission is received from the other station the counter is reset to the full time period. See also **AP**.

SR(b,D,h or o) Set Radix (number system) to Binary, Decimal, Hex or Octal. If numeric values are preferred in another radix, this command may be used to change it. The binary radix does not display or accept the characters "1" and "0" as it might appear; a true binary value is used for easier computer interpretation. This command doesn't affect functions using 16-bit values.

SS<address> This command allows a special address to be entered. Data from any frames received from the station having this address is displayed on the secondary serial port (and not on the primary serial port). No connection is required, and only data fields are displayed. If the SSID entered with this command is set to 15, any station having the specified base address is accepted, regardless of SSID. The filterlist monitor mode may also be used in conjunction with this function to restrict the display of stations with specific SSIDs. For example, if SENDER-15 is entered, any SENDER station is displayed, but the filterlist could further specify that only SENDER-8 and SENDER-10 are to be displayed.

ST(10) Set reTry time in tenths of seconds. The initial retry time is 1 second, but it can be set to values ranging from 0 to 25.5 seconds, corresponding to values between 0 and 255. The timing value is based upon a 1200 baud link rate, but actual timing is automatically scaled to the baud rates; at 9600 baud the retry time is 1/8 of what the same value produces at 1200 baud.

SU(D/e) Enabled, characters sent to the host are converted to upper case.

SV(------) Enter digipeater address(s) (Set Via). Used in the same manner as **SC** for the station address. For more detail see **4.5.1.**; also **C** command.

SX(d/E) Set MX.25 mode. Any packets received switch the protocol to the appropriate mode automatically. This command is needed only to originate a connection.

SY(11 values) Examine/modify control characters used in Chat and Input modes. When accessed, 11 character values are shown, one at a time. Each can be changed by typing a new value or skipped by a space. The order of characters is:

character	default value	function
ESC	(27)	Exit Chat and insert modes

CR	(13)	Carriage return (produces automatic LF in Chat)
LF	(10)	Line feed is used to command a transmission.
BS	(8)	Backspace character.
^T	(20)	Retype buffer contents.
^X	(24)	Clear buffer contents.
^U	(21)	Delete current line.
^C	(3)	Disconnect.
^B	(2)	Connect.
^R	(18)	Display one frame received.
^D	(4)	Revert to display mode without transmitting.

Take care that none of these characters are used twice. Action taken as a result of typing one of them is based upon the order of occurrence. Thus, if ESC were entered for both Exit Chat and Disconnect positions the ESC key would always exit Chat and never apply to Disconnect.

SZ(D/e) Disable/Enable leading Zeros. Without Leading zeros a “1” would be displayed as “1” in any radix except binary. With leading zeros, would be seen “001” in decimal or octal and “01” in hex. This method may be selected merely by preference, but its intended function is to make it easier for a host computer to interpret numbers. Initially leading zeros are not displayed. Not applicable to binary radix.

T Display (“Type”) whatever data is in the transmit buffer. Buffer contents are not affected.

V Used to enter digipeater addresses, see **C**.

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