Messenger Series

Nano Data Radios

Technical Reference Manual

900Mhz and 2.4GHz License Free

1W Spread Spectrum

RS-232, RS-485 and USB

Copyright Notice

Nano Data Radios

Technical Reference Manual

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In This Manual...

This manual provides the technical hardware information required for system design and installation of a Messenger Nano Data Radio.

If you have just purchased one or more of these radio modules, we hope that you are as pleased using them as we have been developing them.

If you are reading this manual looking at a future purchase, we hope that you will consider a Messenger Nano Data Radio when you have an application that needs reliable license-free wireless communications up to 20 miles.

About This Manual

It is assumed that users of the products described herein have either system integration or design ex-perience, as well as an understanding of the fundamentals of radio communications.

Throughout this manual you will encounter not only illustrations (that further elaborate on the accompanying text), but also several symbols which you should be attentive to:

Caution or Warning

Usually advises against some action which could result in undesired or detrimental consequences.

Point to Remember

Highlights a key feature, point, or step which is noteworthy. Keeping these in mind will simply or enhance device usage.

Tip

An idea or suggestion to improve efficiency or enhance usefulness.

Regulatory Requirements

To satisfy FCC RF exposure requirements for mobile transmitting devices, a separation distance of 23cm or more should be maintained between the antenna of this device and persons during device operation. To ensure compliance, operations at closer than this distance is not recommended. The antenna being used for this transmitter must not be co-located in conjunction with any other antenna or transmitter.

MAXIMUM EIRP
For unlicensed operation, FCC Regulations allow up to 36dBm Effective Isotropic Radiated Power (EIRP). Therefore, the sum of the transmitted power (in dBm), the cabling loss and the antenna gain cannot exceed 36dBm.

Support

If you have questions or need help with an application, we hope that you'll take advantage of our free technical support. Simply call us at:

(530) 888-1800

If you need to send us a fax:

(530) 888-7017

If you prefer e-mail (we do), especially if you want to send us a sample of a program or other files, you can e-mail us at:

support@iclinks.com

For additional technical information including datasheets, manuals and software, visit our web site at:

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Contents

Overview

Messenger Nano Radios provide a reliable, low-cost means of data communications in SCADA (Supervisory Control and Data Acquisition) systems for Water and Wastewater, Oil and Gas, Power Generation and Monitoring and HVAC (Heating, Ventilation, and Air Conditioning) systems. They are based upon Microhard Systems "Nano" radio modules. These data radios operate within the 902-928MHz or 2.4000-2.4835GHz ISM frequency bands, using frequency hopping spread spectrum (FHSS) technology. They provide reliable wireless asynchronous data transfer between most equipment types which employ an RS232, RS485 or USB interface. The radios have a very wide operating temperature range, are compact and easy to install and configure in various operating scenarios. Besides a data communications connection, the radios require only a DC power supply ranging from 10 to 30Vdc, and a suitable antenna.

Messenger Nanos require what is typically a very small amount of configuration as part of their installation. This requires a terminal emulation program for configuration using a PC computer. If you do not have sucha program, please contact technical support at ICL for a link to a downloadable free copy.

Performance Features

Key performance features of the Messenger Series Nanos include:

- transmission within a public, North American, license-exempt band of the radio spectrum - modems may be used without access fees or recurring charges (such as those incurred by cellular airtime)

- transparent, low latency link providing up to 230Kbps continuous throughput

- communicates with virtually all PLCs, RTUs, and serial devices through either an RS232, RS485 and USB interface

- supports point-to-point, point-to-multipoint, store and forward repeater, TDMA

- wide temperature specification

- maximum allowable transmit power (1 Watt)

- low power consumption in Sleep Mode (real-time clock wakeup)

- 32 bits of CRC, selectable retransmission and forward error correction

- separate diagnostics port - transparent remote diagnostics and online network control

- ease of installation and configuration - utilizes a subset of standard AT-style commands, similar to those used by traditional telephone line modems

Familiarization

Front Panel Features

The Messenger Nano is designed to be mounted on a standard 35mm DIN rail. All connectors and indicators are located on the front face of the module as pictured below:

MMCX Antenna Connector	An industry standard micro antenna connector. Generally, a short "pig-tail" antenna cable connects from here to larger "Type N"antenna connector to interface to the rest of the antenna system.
LED status indicators	The Messenger Nano module has four independent green LED indicators, one that is illuminated when DC power is applied, and the remainder to indicate the approximate signal strength of the last received transmission. The RSSI LEDs sequence rapidly if a link cannot be established – no link to Master.
RS-232 & RS-485 Serial Data Interface & LEDs	The RS-232 and RS-485 interface utilize an RJ-45 connector. The pinout of this connector is described in the Installation Section. A standard Ethernet cable may be used to connect between this connector and the serial ports on ICL SCADA controllers and RTUs. An additional DB-9 or DB-25 adapter may be obtained from ICL for connecting to third party serial devices using an Ethernet cable. This feature eliminates soldering or crimping in the field.
	Depending on the setting of a configuration DIP switch, the Rx and Tx LEDs either blink with incoming and outgoing data on the selected data port, or show radio link status (Rx when a valid packet has been received and Tx when the radio is actually sending data "over the air").
USB Connector	The Messenger Nanos support a USB connection in addition to the serial interface above. The USB connector is a standard "micro USB" type available locally, or from ICL.
DC Power Terminal Block	DC power for the Messenger Nano radios, from 10 to 30Vdc, is supplied via this terminal block. DC power cannot be supplied by the USB connector, since the required current draw during transmissions exceeds the USB standard.
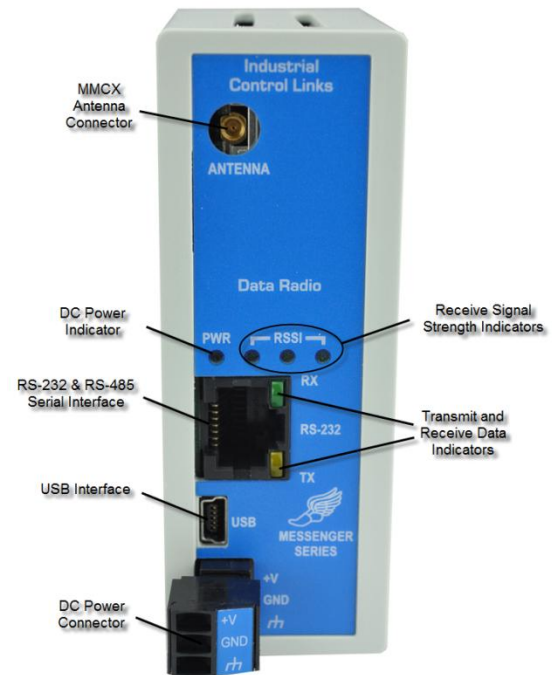
Configuration Switches

Messenger Nano radios are shipped from the factory with the following configuration:

Primary communications port uses USB, secondary (diagnostic) port is RS-232/RS-485

Transmit/Receive LED indicators show direct comm. port status, not radio transmitting status

RS-485 signals are disconnected from RJ-45 connector

If any of these settings needs to be changed, the back cover of the radio should be gently removed with the supplied screwdriver as shown below, carefully prying the cover over the latching tabs.

Do not use the tab holes to push the tabs in. This will cause them to be damaged!

This will expose four configuration DIP switches in the left hand corner as shown below.

Switch	UP (off)	DOWN (on)
1	**Data is on RS-232/485 port, USB is Diag**	Data/Cfg is on USB port, RS-232/485 is Diag
2	**Tx/Rx LEDS show data port activity**	Tx/Rx LEDs from radio for link status
3 & 4	RS-485 is not connected	**RS-485 connects to RJ-45**

Note: Factory settings shown in bold

Instructions on how to use these switches are described in the Installation Section.

Installation

This section describes the mechanical and electrical installation of Messenger Nano radios.

Mechanical Installation

Messenger Nano radios are designed to be installed in NEMA rated electrical enclosures. The cases of the radio modules have a built-in clip to snap onto a standard 7.5mm by 35mm DIN rail. The radio module has a "footprint of 1.4" x 3.7". The front edge of the terminal block sits approximately 4" off of the base plate when the module is snapped onto a DIN rail.
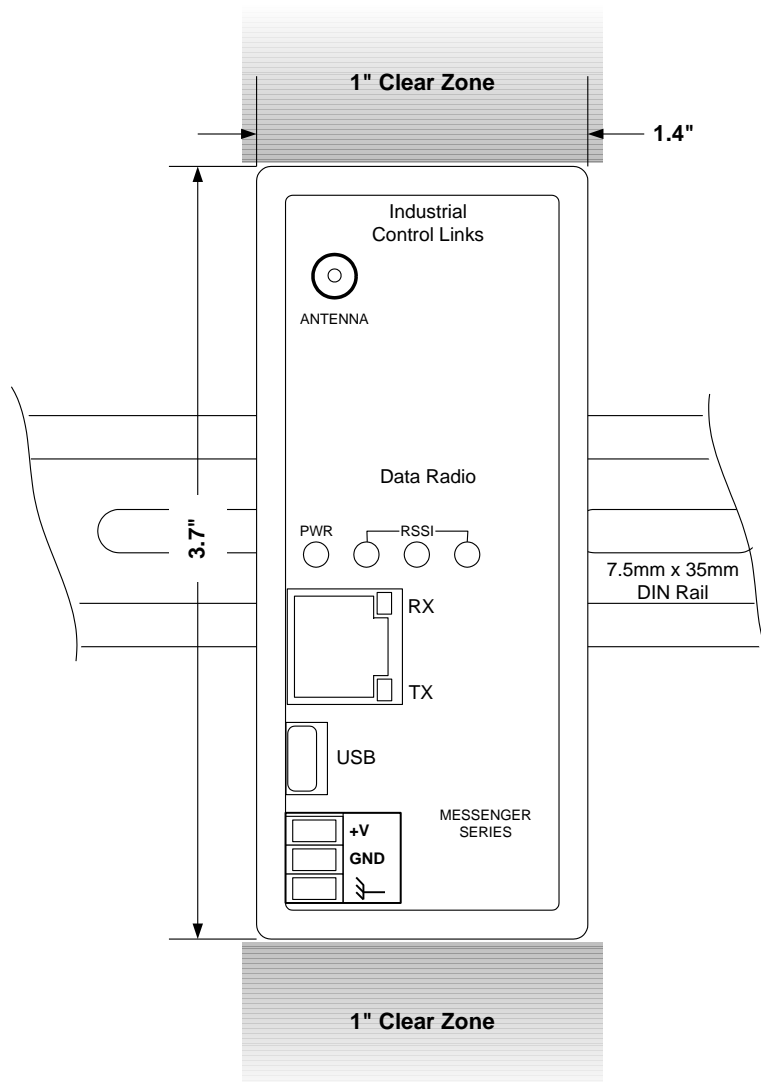
Messenger Nano radios have ventilation slots on the top and bottom of its case. To ensure proper free air circulation and maintain the full temperature rating, the space 1 inch immediately above and below the enclosure must be left clear of any other devices.

Electrical Installation

Power connections to the Messenger Nano radios are made via removable terminal blocks. Please ensure that the following requirements are made during installation, especially in hazardous environments.

Use of Equipment in Hazardous Locations

This equipment is suitable for use in Class I, Division 2, Groups A, B, C, and D or non-hazardous locations only.

WARNING – EXPLOSION HAZARD –   Do not disconnect equipment unless power has been removed or the area is known to be non-hazardous.

WARNING – EXPLOSION HAZARD –   Substitution of any components may impair suitability for Class I, Division 2.

WARNING – EXPLOSION HAZARD –   The area must be known to be non-hazardous before servicing/replacing the unit and before installing.

Special Notice for USB Port Usage in Hazardous Locations

The following information is provided in regards to USB port connector used in this product.

WARNING –   Micro USB ports do not meet the retention requirements for Hazardous locations.

RECOMMENDATION –   It is recommended to only use the RS-232/RS-485 RJ-45 connector in hazardous environments.

Wiring Practices

- Terminal block screws must be tightened to 5 lb-in.
- For terminal block wiring, use stranded conductors from #14 to #26 AWG, or solid conductors from #12 to #26AWG consisting of either copper or copper-clad aluminum (if allowed by local electrical codes)
- Wires must be rated for 240V, 90ºC and suitably current rated. CAUTION: Use supply wires suitable for 15ºC above surrounding ambient.
- Wire insulation must be a minimum of 0.9mm (0.031") thick if subjected to movement, flexing or handling during use or maintenance.
- Wires shall be routed away from sharp edges, screw threads, burrs, fins, moving parts, drawers, and the like. Clamps and guides, if used, shall be provided with smooth, well-rounded edges.
- Wiring that is subject to flexing during servicing such as that from a stationary part to a part mounted on a hinged door shall be provided with additional insulation at any point where flexed.
- Additional insulation, if used, shall be insulating tubing, or a wrapping of not less than two layers of insulating tape. All must be minimum of 90ºC and 240V, but at least 15ºC above surrounding ambient.
- All splices and connections must be mechanically secure and provide electrical continuity. Conductors are also not to be grouped.

Power Wiring

DC Power

Messenger Nano radios require DC power, from 10Vdc to 30Vdc. Input power is applied to the positive (+V) and negative (GND) terminals at the top end of the terminal block. When the input voltage is below the minimum recommended level, or reverse polarity power is applied, the radio module will turn OFF. An external 1A fast-blow fuse is recommended on the input to the radio module. The power should be protected from surges and transients that might exceed the 30Vdc rating of the radio module.
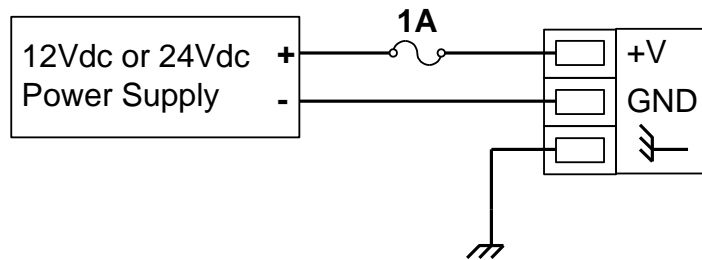
The actual current draw from the DC power supply will vary depending on the transmit activity of the module and the input voltage. Also, since the module uses switching regulators, the input current goes down as input vo9ltage goes up, and vice-versa. Also, the power required during transmissions is significantly higher than when the module is receiving. The transmit power of the module can be reduced (by configuration command) in power sensitive systems if a full 1 watt transmit power is not required. Even cutting the output power in half only reduces the signal strength by 3dB, an amount usually well within the margins designed into most systems. Also, higher gain antennas can frequently be used to offset reduced output power. The table below provides typical power usage information to help with system designs. Note that the 900MHz and 24.GHz models have slightly different current draws.

Messenger Nano 900Mhz Power Consumption

V+	Receive Current	Transmit Current@1 watt(avg)	Transmit Current@ 1 watt (peak)
12Vdc	80 to 110 mA	400mA	540mA
24Vdc	40mA	210mA	270mA

Messenger Nano 2.4Ghz Power Consumption

V+	Receive Current	Transmit Current@1 watt(avg)	Transmit Current@ 1 watt (peak)
12Vdc	70 to 90 mA	230mA	450mA
24Vdc	36mA to 45mA	120mA	240mA

System Grounding

In most applications, it's desirable to ground the system by connecting the system power supply common, to the chassis or panel ground. The negative (GND) side of the DC power input terminal as well as all I/O point terminals labeled GND are connected to chassis ground.

Communications Installation

Messenger Nano radios have two communications interfaces; one RS-232/RS-485 port and one USB port. Either one can be the main data and configuration port, while the other can be used with special diagnostic software from Microhard Systems. The Messenger Nano radios are shipped from the factory with the following configuration:

Primary communications port uses USB, secondary (diagnostic) port is RS-232/RS-485

Transmit/Receive LED indicators show direct comm. port status, not radio transmitting status

RS-485 signals are disconnected from RJ-45 connector

If any of these settings needs to be changed, the back cover of the radio should be gently removed with the supplied screwdriver as shown below, carefully prying the cover over the latching tabs.

Do not use the tab holes to push the tabs in. This will cause them to be damaged!

This will expose four configuration DIP switches in the left hand corner as shown below.

Switch	UP (off)	DOWN (on)
1	**Data is on RS-232/485 port, USB is Diag**	Data/Cfg is on USB port, RS-232/485 is Diag
2	**Tx/Rx LEDS show data port activity**	Tx/Rx LEDs from radio for link status
3 & 4	RS-485 is not connected	**RS-485 connects to RJ-45**

Note: Factory settings shown in bold

RS-232 and RS-485 Serial Wiring Connections

The most common serial communications standards in SCADA and industrial control systems are still RS-232 for short point-to-point connections and RS-485 for longer point-to-point and networked communications. Sprite I/O modules support both standards when ordered with the serial Port option.

The physical RS-232 serial port connection utilizes a standard RJ-45 connector similar to Ethernet connectors. Since Ethernet connections are isolated, no damage will occur if an Ethernet connector is accidently plugged into a serial port on the I/O module, or vice-versa.

The connector for the RS-232/RS-485 Serial Port has two LED indicators in the upper and lower left hand corners. The AMBER LED in the upper left hand corner is the "transmit Data" status LED. It illuminates when a message is being sent to an RS-232 or RS-485 device. The GREN LED in the lower left hand corner is the "Receive Data" status LED. It illuminates whenever a message is being received from an RS-232 or RS-485 device.

The wiring of the Messenger Nano radio RS-232 connector is based upon the EIA/TIA-561 standard. Using standard RJ-45 connectors enables low-cost Ethernet patch cables to be used as high-quality RS-RS-232 cables. RS-232 cables require RJ-45 to DB-9 (male or female) adapters while RS-485 cables. Ethernet patch cables are readily available in a variety of lengths, allowing for a allowing a variety of serial communications cable lengths to be "built up" without field without any soldering.

Messenger Nano radio modules support the following RS-232 and RS-485 serial communications signals:

RJ-45 (8-pin) connections	Sprite DTE Function	DB-9S RS-232 connections
1	RS-485 +	-
2	RS-485 -	-
3	-	-
4	GND	
5	RxD (out)	2
6	TxD (in)	3
7	-	-
8		
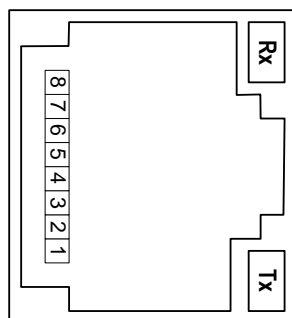
1: RS485+
2: RS-485-
3:
4: GND
5: RxD (out)
6: TxD (in)
7:
8:

RS-232 Serial Communications

RS-232 is still the most common hardwired communications interface for point-to-point links spanning distances of up to 100 ft. An RS-232 interface on the Messenger Nano radio module is typically used to connect the I/O module to a DTE (Data Communications Equipment) such as PCs and PLCs. The cable going to a DTE device normally has a 9-pin D female connector as shown below as shown below. Cables and prewired RS-232 adapters are available from ICL.
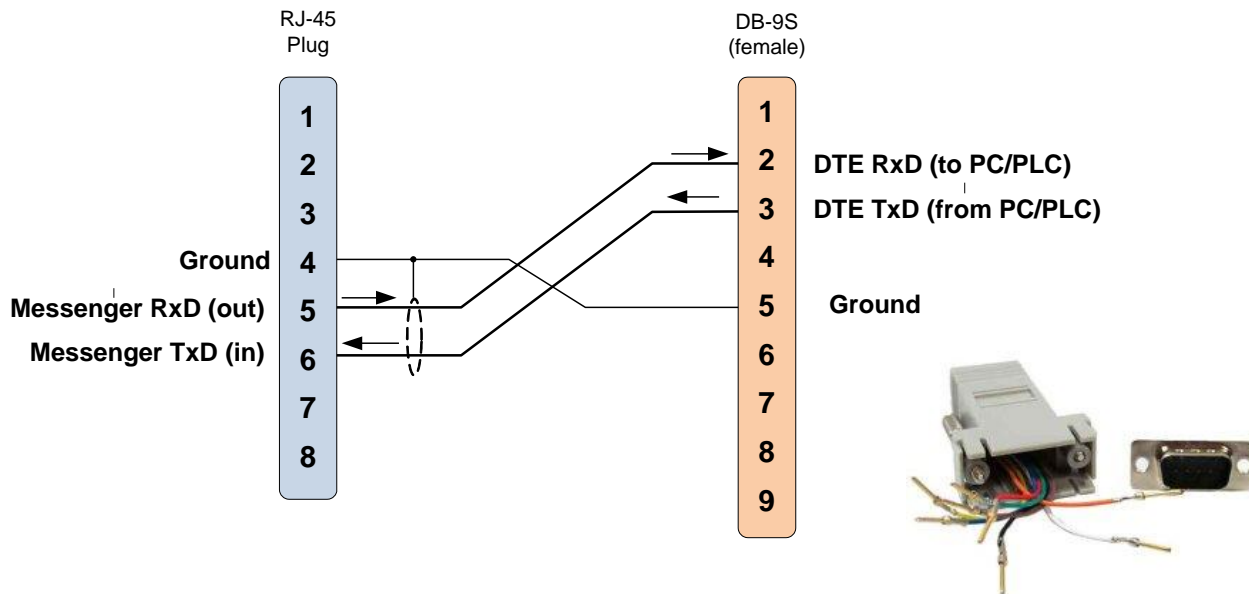
RS-232 Serial Communications Switch Settings

To use the RJ-45 (RS-232/RS-485 serial) connector as the main data and configuration port, set the 1st DIP switch UP (off). To use this port with special diagnostic software from Microhard Systems, set this DIP switch DOWN (on).

If you are using an Ethernet cable with all of the wires running through it, you should ensure that the RS-485 signals on the RJ-45 connector are disabled. To do so, set DIP switches 3 and 4 to UP.

RS-485 Serial Communications

RS-485 is a 2-wire communications interface designed to span distances of up to 5,000 ft. and support multi-drop networked operation. The RS-485 interface in Messenger Nano radio modules are typically used for connections to PLCs, HMIs, and I/O expansion modules (such as other Sentry, Ascent, MicroBrick and PicoBrick Distributed I/O modules). Many types of industrial equipment also have RS-485 interfaces and can be used in combination with the Messenger Nano radio module. Up to 32 devices can share an RS-485 network.

Traditionally, RS-485 networks use a 100Ω resistor termination at each end of the network. This technique does not work well with certain protocols such as Modbus that do not have a lead-in message header to eliminate garbage on the beginning of a message. ICL controllers and I/O modules have series termination resistors that eliminate this problem. In most cases on longer networks, separate termination is not required. If termination is used, it should be AC coupled. Call ICL technical support for additional information if you think that you need additional network termination.

The following shows how and RS-485 circuit is wired to the radio. RS-485 cables are available from ICL.
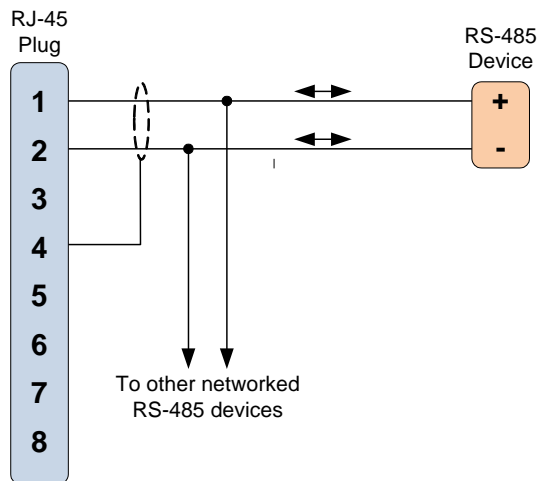
RS-485 Serial Communications Switch Settings

To use the RJ-45 (RS-232/RS-485 serial) connector as the main data and configuration port, set the 1st DIP switch UP (off). To use this port with special diagnostic software from Microhard Systems, set this DIP switch DOWN (on).

To enable the RS-485 signal on the RJ-45 connector, set DIP switches 3 and 4 to DOWN (this is the factory default setting).

> Be sure that the S142 Register (Serial Channel Mode) is set to "1" for RS-485 operation (this is the factory setting).

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USB Communications

In the last few years, USB ports have replaced serial ports in modern equipment. In fact , in many computers these days, laptaps and desktops, there are ONLY USB ports; no serial ports! The Messenger Nano radio modules have a USB interface that can be used either as the main data and configuration port, or as a special diagnostic port (with software from Datahard Systems). The USB port emulates a serial port, so it is still necessary to set a baud rate that matches the radios port baud rate. For configuration, this is 9600 baud. In actual operation, the baud rate is user settable. Unless extremely high speed is needed, we generally recommend that the port baud rate be set to 9600 for data operation as well. This is the standadr factory setting.

USB Communications Switch Settings

To use the USB connector as the main data and configuration port, set the 1st DIP switch DOWN (on). To use this port with special diagnostic software from Microhard Systems, set this DIP switch UP (off).

Configuration

Command Mode

In this mode:

- the Nano module is offline (data is not passing through the unit via its local data lines or RF communications)
- Only the power LED will be lit
- the Nano's configuration options (registers) may be viewed and modified

To Enter Command Mode

- with the Nano 'online', connect a communications cable to the main data port (USB or RS-232/RS-485) as selected above
- launch a terminal communications program (e.g. HyperTerminal) and configure for the Nano's established serial baud rate parameters (PC & modem must match). The factory setting is 9600 baud. If you need a terminal communications program, please contact ICL technical support.
- pause 1 second, type '+++', pause 1 second: the monitor should show the module response of 'NO CARRIER   OK'
- the Messenger Nano radio is now in Command Mode

Data Mode

This is the normal operational state of all deployed Messenger Nano radios. In this mode the module is prepared to exchange data as per its configuration settings. Available LED indications can provide an indication of the data exchange (TX and RX LEDs).

To enter DATA mode from COMMAND mode, enter the command: *ATA [Enter]*

Tx and RX LED Switch Settings

The Tx and RX LEDs on the RJ-45 connector provide a visual indication of data transfers. The LEDs can be set to either directly monitor the transmit and receive data going in an out of the modem for any of the RS-232, RS-485, or USB port, or connected to the radio which shows the data transfer status over the air. The LED functionality is determined by the setting of DIP switch #2. The factory setting is UP (show port activity).

Switch	UP (off)	DOWN (on)
2	**Tx/Rx LEDS show data port activity**	Tx/Rx LEDs from radio for link status

Messenger Nano radios have many different configurable operating modes. The Point-to-Multipoint (PMP) mode is generally appropriate for most SCADA applications. If you are interested in learning about the other operating modes (TDMA, Point-to-Point, etc.), please contact ICL Technical support.

Point-to-Multipoint Radio Network "Roles"

In Point-to-Multipoint mode, one radio serves as a "Master" and the rest of the radios operate as "Slaves" or "Repeaters".

Master

One per network, the source of synchronization for the system. The Master controls the flow of data through the system; all data passes to or through it.

Repeater

Required only if necessary to establish a radio path between a Master and Slave(s); stores and forwards the data sent to it. Synchronizes to Master and provides synchronization to 'downstream' units.

If a local device is attached to a Repeater's serial data port, the Repeater will also behave as a Slave (aka Repeater/Slave).

Adding one or more Repeaters within a network will HALVE the throughput; the throughput is halved only once, i.e. it does not decrease with the addition of more Repeaters.

If there is a 'path' requirement to provide Repeater functionality, but throughput is critical, this may be accomplished by placing two modems at the Repeater site in a 'back-to-back' configuration. One modem would be configured as a Slave in the 'upstream' network; the other a Master (or Slave) in the 'downstream' network. Local connection between the modems would be accomplished with a 'null modem' cable. Each modem would require its own antenna; careful consideration should be given with respect to antenna placement and modem configuration.

Slave

Endpoint/node within a network to which a local device is attached. Communicates with Master either directly or through one or more Repeaters

Setting up radios for a Point-to-Multipoint (PMP) Network

In a point-to-multipoint network, a path is created to transfer data between the Master modem and numerous remote modems. The remote modems may simply be Slaves with which the Master communicates directly, and/or Slaves which communicate via Repeaters. Some or all of the Repeaters may also act as Slaves in this type of Network, i.e. the Repeaters are not only storing and forwarding data, but are also acting as Slaves. Such Repeaters may be referred to as 'Repeater/Slaves'.

To simply initial configuration of the radios and provide a good starting point for custom configurations, as set of "AT" commands are provided to configure the radios as any one of the three PMP modes in factory default configurations:

Master	&F1 (ie: "AT&F1")
Slave	&F2 (ie: "AT&F2")
Repeater	&F3 (ie: "AT&F3")

n920 - HyperTerminal
File Edit View Call Transfer Help

```
AT&F1
OK

AT&V
NANO920A Microhard Systems, Inc.
v4.40 Apr 30 2008 11:21:00
S/N: 014-1010167

E1  DCD &C1  DTR &D0  Handshaking &K0  DSR &S1
Operating Mode          S101=0       Serial Baud Rate        S102=7
Wireless Link Rate      S103=2       Network Address         S104=1234567890
Static Mask             S107=****    Output Power(dBm)       S108=30
Hop Interval            S109=9       Data Format             S110=1
Packet Max Size         S112=256     Packet Retransmissions  S113=5
Repeat Interval         S115=3       Character Timeout       S116=10
Average RSSI(dBm)       S123=-120    Network Type            S133=0
Destination Address     S140=65535   Repeaters Y/N           S141=0
Serial Channel Mode     S142=0       Protocol Type           S217=0
Sniff timeout, hops     S237=10      Sleep mode              S143=0
Sleep time, sec         S144=60      Wake time, sec          S145=10
LEDs brightness, %      S149=100     Sync Mode               S150=0
Fast Sync Timeout,hops  S151=100     Address Tag             S153=0
FEC Mode                S158=0       Sniff Search Sleep      S169=60
Sniff Search Wake       S170=30      Ch Access Mode          S244=0
Sync timeout            S248=512     M hop alloc timeout     S251=10
OK
```
Connected 1:11:38   ANSIW   9600 8-N-1   SCROLL CAPS NUM Capture Print echo

n920 - HyperTerminal
File Edit View Call Transfer Help

```
AT&F2
OK
AT&V
NANO920A Microhard Systems, Inc.
v4.40 Apr 30 2008 11:21:00
S/N: 014-1010167

E1  DCD &C1  DTR &D0  Handshaking &K0  DSR &S1
Operating Mode          S101=2       Serial Baud Rate        S102=7
Wireless Link Rate      S103=2       Network Address         S104=1234567890
Unit Address            S105=2       Static Mask             S107=****
Output Power(dBm)       S108=30      Hop Interval            S109=9
Data Format             S110=1       Packet Max Size         S112=256
Packet Retransmissions  S113=5       Repeat Interval         S115=3
Character Timeout       S116=10      Roaming                 S118=1
Average RSSI(dBm)       S123=-120    Network Type            S133=0
Destination Address     S140=1       Serial Channel Mode     S142=0
Protocol Type           S217=0       Sniff timeout, hops     S237=10
Sleep mode              S143=0       Sleep time, sec         S144=60
Wake time, sec          S145=10      LEDs brightness, %      S149=100
Sync Mode               S150=0       Fast Sync Timeout,hops  S151=100
Address Tag             S153=0       FEC Mode                S158=0
Sniff Search Sleep      S169=60      Sniff Search Wake       S170=30
Ch Access Mode          S244=0       Sync timeout            S248=512
M hop alloc timeout     S251=10
OK
```
Connected 1:19:55   ANSIW   9600 8-N-1   SCROLL CAPS NUM Capture Print echo

Factory **Master** Configuration   Factory **Slave** Configuration

Insofar as the factory defaults are concerned, the difference between the PMP Master and PMP Slave (above) are simply the Operating Mode (S101), Unit Address (S105), and the Destination Address (S140).

With the exception of the Master modem, all modems in a PMP network have a Destination Address of 1 - the UA of Master modem - to which all data is destined.

The settings for a factory default PMP Repeater are unique only with respect to S101 (1) and S105 (3).

Each radio must have a unique Unit Address. Make sure that if you are configuring multiple Slaves, that each Slave is set to it's own unique address. This means that if you are using the "AT&F2" (set to Slave factory defaults command), you will then have to set a unique address using the "ATS105" command. The factory default address is 2 for a Slave and 1 for the Master.

When setting up a network with one or more repeaters, the Masters S141 register must be changed from 0 to 1 (Repeaters Y/N), and Slave S118 must be modified to be the Unit Address (UA) of the Repeater (3), otherwise the Slave will synchronize directly to the Master, bypassing the Repeater.

If changes were made to the modem's configuration and it is intended that those changes be saved to non-volatile memory, do so with the AT command 'AT&W' prior to placing the modem online.

After a radios configuration has been set (and saved with an "AT&W" command), you can place it on-line for operation with an "ATO" (O, not zero) command. If you pause long enough without typing a command, the radio will automatically revert to on-line. You can also cycle power.

AT Commands

Appendix B is a quick reference for the available AT commands; in this sub-section are details regarding the most commonly used.

To invoke an AT command, enter Command Mode, then type **AT *<command>* [Enter]**.

> If changes were made to the modem's configuration and it is intended that those changes be saved to non-volatile memory, do so with the AT command '&W' prior to placing the modem online.

A   Answer

Upon completion of tasks being done with the modem in Command Mode, invoking this command will place the modem back 'online' (into Data Mode).

Dxxxxx, DTxxxxx, DPxxxxx Dial

Identical commands which change the modem's unit address to *xxxxx* and then put the modem into Data Mode.

g, G Spectrum Analyzer

This is a very useful feature of the Nano. ATg or ATG will provide a display of signal levels received within the operating environment and frequency range of the modem under test. ATg averages 256 samples, ATG 16,000.

Invoking the ATg command causes the Nano to sweep the operating band and provide a display of both the mean and peak signal levels, in dBm, found on each channel.

The 'graphical' display is limited from –110dBm to –53dBm, and is in 1dB increments. Ignore the leftmost asterisk in calculations (as below).

How to interpret the display (example):

> ...
> ch 78 -137dBm *   No signal was measured on channel 78.
> ch 80 -105dBm ******...   Mean signal level: -(110-5 (asterisks)) = -105dBm
> ...   Peak signal level: -(110-5 (asterisks) -3 (dots)) = -102dBm

For the 900Mhz version, Channel 1 is at 902.4MHz, with subsequent channels in 280kHz increments. Therefore, to calculate the frequency of channel *n*:   Freq channel *n* = 902.4+ ((*n-1*) x 0.280)MHz.

For the 2.4GHz version, channel 1 is at 2401.6 MHz.

Also displayed is the average received signal strength for 5 channels above the ISM bands. This area of the spectrum is used by paging networks.

In   Identification

The I command returns information about the Nano.

1	Product Code
2	Issue ROM Check (OK or ERROR)
3	Product Identification (Firmware Version)
4	Firmware Date
5	Firmware Copyright
6	Firmware Time
7	Serial Number
255	Factory-Configured Options listing

N   Advanced Spectrum Analyzer

The Advanced Spectrum Analyzer feature provides for a very detailed analysis of a particular area of the radio frequency spectrum within which the Nano operates.

The specific start (of scan) and stop frequencies, along with step (increment) size and dwell (on frequency) time are user-definable.

Following is the format for the ATN command:

In Command Mode

ATN F_{start} F_{stop} S D*[Enter]*

where

F_{start} = start frequency in MHz (including 0-6 decimal places)

F_{stop} = stop frequency in MHz (including 0-6 decimal places)

S = step increment in kHz (from 1-1000)

D = dwell time in ms (from 1-1000)

Example:

ATN 905.250 908.500750 25 100

Note: Be sure to enter spaces as shown in the format detailed above.

O   Online Mode

Upon completion of tasks being done with the modem in Command Mode, invoking this command will place the modem back 'online' (into Data Mode).

&F*n* Load Factory Default Configuration

See the previous section for detailed information on the various factory default options.

 If the module being configured does not support Slow Mode, do not load a Slow Mode factory default configuration.

Values

1 PMP Master

2 PMP Slave

3 PMP Repeater

4 Slow Mode PMP Master

5 Slow Mode PMP Slave

6 PTP Master

7 PTP Slave

8 Slow Mode PTP Master

9 Slow Mode PTP Slave

&H0   Frequency Restriction

 By default, the Nano will hop on frequencies across the entire 900MHz and 2.4GHz ISM bands. For some applications or within certain operating environments, it may be desired to prohibit the modem from operating on specific frequencies or range(s) of frequencies. The modem will not allow 'too many' frequencies to be restricted; it requires a certain amount of bandwidth within which to operate to comply with regulations.

Following is an example of entering Frequency Restrictions on a Nano modem.

First, the AT&H0 command is invoked:

The modem responds with a prompt for the Unit Address.

 (Enter the Unit Address for the Master (1) and all Repeaters in the network into each modem in the network.)


```
COM4 9600 8N1 - HyperTerminal
File  Edit  View  Call  Transfer  Help

AT&H0

  UA                    Restricted bands (MHz)
----------------------------------------------------

Enter unit address to restrict (1 - 65534) : _

Connected 1:45:29    VT100J    9600 8-N-1    SCROLL    CAPS    NUM    Capture    Print e
```
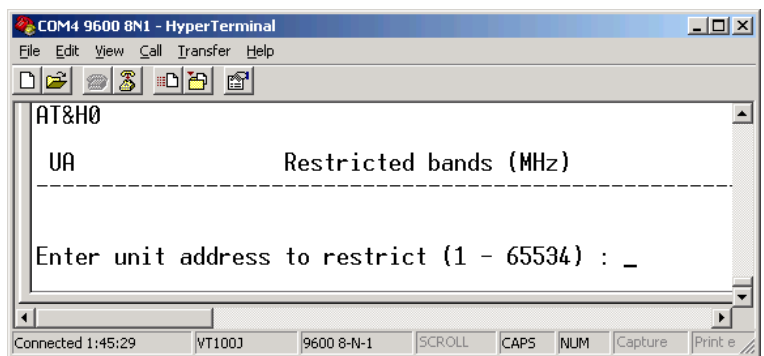
All modems in the network must have the same frequency restriction configured within them.

Use the ATg or ATG feature to help identify the frequency/range of possible interfering signals within the 902-928MHz ISM band, and then use the AT&H0 feature to configure the modem to avoid them.

Having entered '1', the modem prompts for the first restricted frequency to be entered.

```
Enter unit address to restrict (1 - 65534) : 1

     1


Band 1
Start :          [xxx.xxx] MHz:
```

905.500 was entered as the 'start' and 'end' of Band 1; this will restrict the frequency of 905.500MHz. The range of 909.250 to 912.700MHz was defined as the second (Band 2) restriction. When prompted to enter Band 3, the [Esc] key was entered to escape the entry process and the summary at left/bottom was displayed. Pressing [Esc] again saves and exits the process. To modify an existing restriction, simply overwrite it. To remove a restriction, overwrite it with 000.000.

```
Band 1
Start :          [xxx.xxx] MHz: 905.500
End :            [xxx.xxx] MHz: 905.500

Band 2
Start :          [xxx.xxx] MHz: 909.250
End :            [xxx.xxx] MHz: 912.700

Band 3
Start :          [xxx.xxx] MHz:

  UA              Restricted bands (MHz)
--------------------------------------------------
   1   905.500 909.250
       905.500 912.700
--------------------------------------------------


Enter unit address to restrict (1 - 65534) : _
```
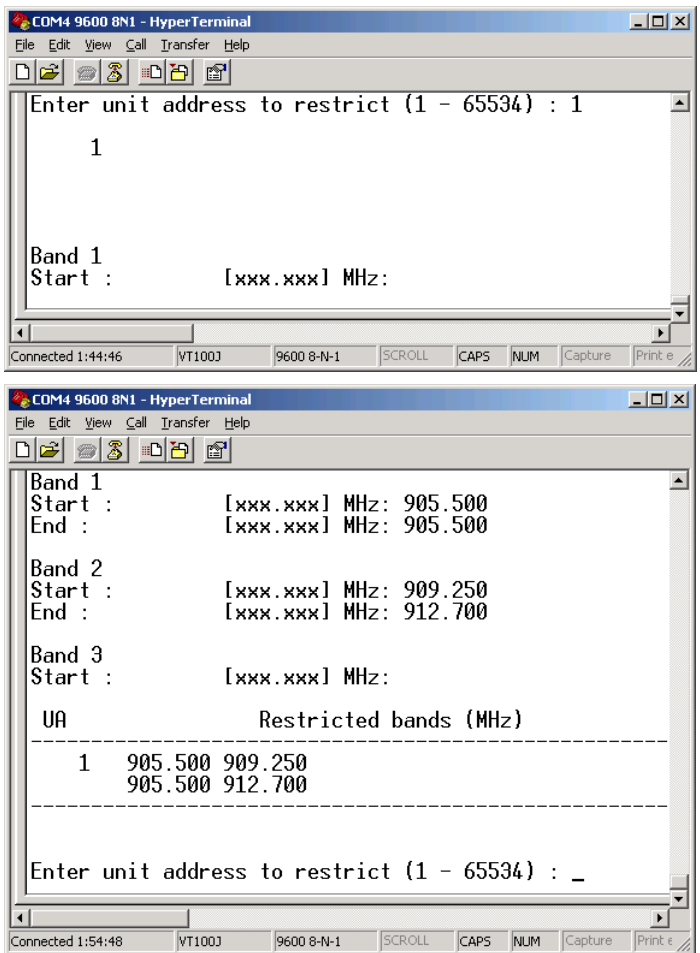
&H1   Repeater Registration

When more than one Repeater exists in a network, the Unit Address of each Repeater should be registered within **every modem** in the network. The reason for doing this is to enable the modems to create hopping patterns which will be orthogonal to each other, thereby minimizing possible interference between network segments.

Upon entering the AT&H1 command, the modem prompts as follows:

> **A** to add a Repeater (this is done by entering the Unit Address of the Repeater)
> **R** to remove a Repeater
> **C** to clear all registered Repeaters.

Pressing the [Esc] key saves and exits the process.

&V View Configuration

Displays S Register names and current values.

&W Write Configuration to Memory

Stores active configuration into the modem's non-volatile memory.

Settings (S) Registers

The majority of modem configuration is done via the Settings (S) Registers.

The previous section provides information on the available factory default settings as related to operating modes and network topologies; this section examines each S register in detail. Appendix C is a quick reference for the S register options.

> In the following descriptions, default settings (where applicable) are in boldface.
> In Command Mode,
> query format: ATS*<S register #>?* [Enter]
> change format : ATS<S register #>=<value> [Enter]

S0   Auto Answer

This register determines in which mode the modem will be upon power-up. If selected to power-up in Command Mode, the modem will be offline from the wireless network, and ready to be configured upon power-up. The typical mode of operation is for the modem to power-up in Data mode: ready to participate in data transfer over the wireless network.

Values

0	up in Command Mode
1	**up in Data Mode**

S2   Escape Code

 Escape character. If >127, escape feature is disabled. Modification of this register may be necessary when connecting the modem to a telephone modem where the +++ character string may result in undesired consequences.

 Values

any ASCII value
+ (decimal 43)

> Modification of S2 may be required when operating the Nano module via a telephone modem connection interface.

S101   Operating Mode

The operating mode defines the role of a modem. A Nano Series modem may be configured for any role required within a radio network. This is convenient for reasons of familiarity with any/all units, as well as for hardware sparing purposes. The default operating mode is dependent on which factory default option is selected.

MASTER: Only one per network. In all network types (see S133) data either originates at, is destined to, or 'passes through' the Master.

REPEATER: May act simply as a 'Repeater' to store and forward data to/from an upstream unit to/from a downstream unit (e.g. when there is a long distance between the latter units), or, may act as a Repeater/Slave in which case the above function is performed AND the unit may also exchange data as a Slave within the network.
If 1 or more repeaters are to be in a network: see Section 6.2, S141.
If 2 or more repeaters are to be in a network: see Section 6.1, AT command &H1.

SLAVE: Interfaces with remote devices and communicates with Master either directly or via Repeater(s). Communications between 2 or more Slaves is possible - through the Master - see S133 and Section 5.3, 5.4.

Note re nomenclature:

 A 'Remote' (non-Master) modem is either a Repeater or a Slave. If a Repeater is not being used as a Repeater/Slave (i.e. there is no device attached to its local data port), leave its handshaking OFF (&K0) and set the serial baud rate (S102) to 115200bps.

Values

0	Master
1	Repeater
2	Slave

S102   Serial Baud Rate

The serial baud rate is the rate at which the modem is to communicate with the attached local serial device.

Values (bps)

0	230400	8	7200
1	115200	9	4800
2	57600	9	4800
3	38400	10	3600
4	28800	11	2400
5	19200	12	1200
6	14400	13	600
7	9600	14	300

Note: Most PC's do not readily support serial communications greater than 115200bps.

S103   Wireless Link Rate

This register determines the rate at which RF communications will occur over a given network. All modems within a particular network must be configured with the same wireless link rate. Faster link rates result in greater throughput, however, for each 'step' increase in link rate, there is an approximately 1dB reduction in sensitivity.

Values(bps)

1	115200
2	**172800**
3	230400

Please do not use any values other than those listed

S104   Network Address

All modems in a given network must have the same Network Address. This unique network address is not only a security feature for a particular network, but also allows other networks - with their own unique network address - to operate in the same area without the possibility of undesired data exchange between networks.

Values (0 - 4,000,000,000)

1234567890

Change the default value for the Network Address to something unique for your network. Do this for an added measure of security and to differentiate your network from others which may be operating nearby.

S105   Unit Address

The unit address is, and must be, a unique identifier of each modem in a network. The address value is 16-bits in length.

The Master has by default, and must retain, a unit address of 1; 65535 is the broadcast address.

Values

2-65534

S107   Static Mask

This mask is applied to the transmitted data, and removed from the received data. It is an added form of security for a network.

Change S107 to something unique for your network.

Values (up to 16 char)

default (the word itself)

S108   Output Power

This setting establishes the transmit power level which will be presented to the antenna connector at the rear of the modem.

Unless required S108 should be set not for maximum, but rather for the minimum value required to maintain an adequate system fade margin.

Values (dBm (mw))

20 (100)
21 (125)
22 (160)
23 (200)
24 (250)
25 (320)
26 (400)
27 (500)
28 (630)
29 (800)
30 **(1000)**

FCC regulations allow for up to 36dBi effective isotropic radiated power (EIRP). The sum (in dBm) of the transmitted power, the cabling loss, and the antenna gain cannot exceed 36dBi.

S109   Hop Interval

This register is effective only on the Master and is responsible for establishing the rate at which all modems within a particular network change frequency (hop - from frequency to frequency).

Long hop intervals typically result in the greatest data throughput, however shorter hop intervals may decrease latency, particularly of smaller packets of data.

The default setting of 20ms is satisfactory for most applications. If adjustment of S109 is being considered, also consider the serial baud rate, wireless link rate, and maximum packet size (S102, S103, and S112).

S109	time (ms)	S109	time (ms)
0	1.5	10	30
1	2.0	11	40
2	2.5	12	50
3	3.0	13	60
4	4.0	14	70
5	5.0	15	80
6	7.0	16	90
7	10	17	100
8	15	18	125
9	**20**	19	150

Hope Interval (S109) Standard Values

S109	time (ms)	S109	time (ms)	S109	time (ms)
20	4.5	32	12	44	18.5
21	5.5	33	12.5	45	19
22	6.0	34	13	46	19.5
23	6.5	35	13.5	47	21
24	7.5	36	14	48	22
25	8.0	37	14.5	49	23
26	8.5	38	15.5	50	24
27	9.0	39	16	51	25
28	9.5	40	16.5	52	26
29	10.5	41	17	53	27
30	11	42	17.5	54	28
31	11.5	43	18	55	29

Hope Interval (S109) Extended Values

Hop Interval S109 should only be changed if recommended by Microhard or ICL Support and/or for specific applications!

S110   Data Format

This register determines the format of the data on the serial port. The default is 8 data bits, No parity, and 1 Stop bit.

Values

1	**8N1**
2	8N2
3	8E1
4	8O1
5	7N1
6	7N2
7	7E1
8	7O1
9	7E2
10	7O2

S112   Packet Max Size

Determines that maximum number of bytes from the connected device that should be encapsulated into a packet. Large packet sizes may produce the best data throughput; however, a smaller packet is less likely to become corrupted and, if it does, is retransmitted with a lesser impact on network traffic. The default setting of 255 bytes is suited to most applications.

Values (bytes)

1-256
255

S113   Packet Retransmissions

This register determines the maximum amount of times that a packet will be retransmitted (in addition to the initial transmission), noting the following specific behaviors in various network topologies:

Values

0-255
5

PMP: Master will retransmit each data packet the exact number of times specified in its S113; Slave will retransmit only if necessary, and then only until a given packet is acknowledged or the value of the Slave's S113 is reached.

PTP: Modem will retransmit to its counterpart only if necessary, and to a maximum of the value in S113.

In a PMP system, set S113 to the minimum value required as, effectively, the data throughput from Master to Remote is divided by 1 plus the number stored in S113.

S115   Repeat Interval

S115 determines the number of slots which are available within a window of opportunity for Remote units to submit channel requests to the Master modem.

Values (Hop Intervals)

1-255
3

For a large number of remotes, the value of S115 should be set relatively high: Remotes will randomly contend for the ability to access the channel request slots.

For a small number of Remotes, it is advisable to keep S115 closer to the default value so as to not 'waste bandwidth' by maintaining a relatively large window housing a greater-than-necessary number of channel reservation request slots.

In a TDMA-type system, S115 may be set to 1 as the Remotes are not able to request a transmission channel: the Master polls each Remote for data.

S116   Character Timeout

This 'timer' looks for gaps in the data being received from the local attached device. The timer is activated after the Minimum Packet Size (S111, default 1 Byte) has been accumulated in the modem, after, if the timer detects a gap in the data exceeding the Character Timeout value, the modem will transmit the data.

Values

1/4 Characters
0-254
10

The Nano will accumulate data in its buffers until either (a) Maximum Packet size (S112) has been accumulated, or (b) Minimum Packet Size (S111) has been accumulated AND the Character timeout has expired—whichever occurs first.

If S116 is set to 0, the modem will buffer exactly the Minimum Packet size and then transmit that data.

S118 Roaming

This feature allows a Remote unit to synchronize with a specified 'upstream' unit (either Master or Repeater). The options are as follows:

> **S118=65535:** With this value in its S118 register, a Remote will synchronize with an upstream unit which has the same network address (S104) and static mask (S107) as the Remote. Should that upstream unit fail, this Remote will attempt to synchronize with another 'upstream' unit within the same network. This ability is particularly well-suited to mobile applications.
>
> **S118=1-254:** In most static (fixed) networks, where there are no Repeaters, the default value of 1 is maintained: All Slaves synchronize to the Master (whose unit address is 1).

In networks where Repeaters are present, the value of a Remote's S118 corresponds to the particular upstream modem with which a particular Remote is intended to communicate, e.g. Slave UA (S105)=3 may have an S118=2, where the modem with UA 2 is a Repeater between the Slave and the Master; the Repeater will have an S118=1.

S118 dictates which modem (by Unit Address (UA)) a Remote unit will 'look' or 'attach to' for its upstream signal path.

Values

> 65535 full roaming
> 1-254 specific (fixed) unit address with which to associate
> **1**

> **When bench testing 3 modems for a Master-Repeater-Slave link, be sure to set the Slave's S118 to the UA of the Repeater, and the Repeater's S118 to the UA (1) of the Master.**
>
> **This will ensure that data is routed from the Slave through the Repeater to the Master; otherwise, if the Slave's S118 is left at the default value of 1, the Slave will communicate directly with the Master, bypassing the Repeater altogether**

S119 Quick Enter to Command Mode

If this register is set to 1, a delay of 5 seconds is introduced at power-up before the modem will go into Data Mode. If, during these 5 seconds, the user enters 'mhx' the modem will instead go into Command Mode and reply with 'OK'. The terminal baud rate must be set to 9600bps. If an incorrect character is entered, the modem will immediately go into Data mode.

Values

> 0 **disabled**
> enabled

The default setting is 0: The modem will promptly go into Data Mode upon power-up.

S123   Average RSSI

This register displays (it is not a 'setting') the average signal strength received over the previous 4 hop intervals. The value in this register is also reflected in status lines RSSI1, 2, and 3, which connect to the modem's front panel RSSI LEDs.

Values (dBm)

-110 to –55dBm (max reading)

A Master modem's RSSI LEDs will not illuminate to any degree until such time as it has received valid packets from a 'downstream' unit. Also, should the downstream unit(s) fail, a Master will maintain the last RSSI reading display.

S130   No Sync Intake

Defines if the modem will accept data if the remote has become unsynchronized from the Master. If set to 0, this function will be disabled and any data received will be ignored. If set to 1, the modem will accept data and buffer it until the unit is synchronized.

S133   Network Type

Defines the type of network (see Section 5.0 for a detailed description of network topologies).

In a point-to-multipoint (PMP) network, the Master broadcasts data to all units, and all remote units send their data (ultimately) to the Master.

Values

0	Point-to-Multipoint
1	Point-to-Point
2	Peer-to-Peer or Everyone-to-Everyone

A point-to-point (PTP) network involves a Master and a Slave (with 0 or more Repeaters in-between).

Peer-to-Peer involves either communication between 2 (typically remote) units (P2P) or between all units (everyone-to-everyone - E2E).

ALL modems in a network must have the SAME value for Network Type

S140   Destination Address

As the name implies, this register specifies the ultimate destination for a modem's data.

Different network topologies dictate the configuration of S140:

PMP	: Master S140=65535, Remote S140=1
PTP	: Master S140=UA of Remote, Remote S140=1
P2P	: Master S140=65535, S140 of each (of 2 / pair) Remote modem is the UA of the other
E2E	: S140 of all modems=65535 (broadcast)

With one or more Repeaters in the system, a network's throughput is divided in half. Exercising the option of back-to-back 'Repeaters' - which requires 2 modems at a 'Repeater' site - eliminates the division of bandwidth.

If there is more than one Repeater in a network, the Repeaters should be 'registered'. See AT&H1 Repeater Registration for how to accomplish this.

S141   Repeaters Y/N

This register informs - and applies only to - the Master as to the presence of any Repeater(s) in the network.

Values

0	**no repeater**
1	1 or more repeaters

S142   Serial Channel Mode

This register defines the physical serial interface which will be used for data communications.

Values

0	RS-232 interface
1	half-duplex RS-485
2	full-duplex RS-485

Note: When placed into Command Mode, the module will communicate via the RS-232 interface at 9600bps, 8N1.

S143   Sleep Mode

This register applies only to Remote (i.e. not Master) modems, and determines if the Remote should remain active continuously (S143=0, default), or enter a timer-based sleep mode.

Sleep Mode   1

When status register S143 is set to a value of 1, the unit will use the registers S144 and S145 to determine how long a unit will remain awake when idle, or if the unit has gone to sleep, how long it will sleep for.

In this mode, data will be monitored on the **serial port** and the **RF link**. If no data is being transmitted or received after an amount of time specified by S145 (Wake Time), the unit will begin to sleep for the amount of time determined by register S144 (Sleep Time).

If data is detected on the local serial port, the unit will immediately wake up.

Sleep Mode 2

This mode is similar to Sleep mode 1, except , data will be monitored **only on the serial port**. If no data is being transmitted or received after an amount of time specified by S145 (Wake Time), the unit will begin to sleep for the amount of time determined by register S144 (Sleep Time).

Sniff Mode 1

When status register S143 is set to a value of 3, the unit will monitor all data from the **serial** and **RF link**. Upon wake up, the unit will begin to try to find a master or repeater to synchronize to. The amount of time the unit tries to find a master is determined by the number of hops, rather than time. (Time can be calculated by multiplying the number of hops in S237 and the hop interval specified in register S109).

If a master is found, the unit will stay awake for at least the time specified by register S145 (Wake Time). If there is data to transmit, the unit will stay awake until all data has been transmitted. If a master or repeater is not found, the unit will go to sleep for S144 (Sleep Time) seconds. The sniffing cycle is very brief.

 If data is detected on the local serial port, the unit will immediately wake up.

Sniff Mode 2

When status register S143 is set to a value of 4, the unit works the same way as sniff mode 1, except, the unit will monitor all data from only the **serial port**.

Sniff Mode 3

When status register S143 is set to a value of 5, the unit works the same way as sniff mode 1 and will monitor all data from both the **serial** and **RF link**. The difference is, if no master is found, all data will be discarded.

Values

0	**active (no sleep)**
1	sleep mode 1
2	sleep mode 2
3	sniff mode 1
4	sniff mode 2
5	sniff mode 3

The most effective way to put an entire network into sleep/sniff mode is by turning off, or putting into command mode, the Master modem.

S144   Sleep Time

This register applies only to Remote modems and is only effective when S143>0.

Defines sleep duration for up to approximately 18 hours.

Two conditions will awaken a Remote:

       1. sleep duration time has expired, or

       2. incoming data on local data port.

When a sniff mode is selected (S143), the modem will start its sniff cycle when the Sleep Time expires or will wake up completely when there is data on its local data port.

Values (seconds)

2-65535
60

S145   Wake Time

Applies only to Remote modems and effective only when S143>0.

This register determines how long a modem will stay awake after the local data port and radio links become idle. When the modem is idle for the amount of time specified in S145, it will go to sleep; it will go to sleep immediately if 'upstream' unit is offline or goes into sleep/sniff mode.

Values (seconds)

```
0-65535
10
```

S149   LED Brightness

This is a power saving feature which controls the current available to LEDs such that they operate with from 0% (off) to 100% available brightness.

It is recommend to set S149 to 100 for testing in a shop environment, and then reduce the value as required when deploying in the field where power consumption may be of concern.

Values (percent - %)

```
0-100
100
```

S150   Mode

This setting applies only to the Master modem. S150 dictates which sync mode the Master will use when it initially goes online. Quick sync mode results in the Master hopping very quickly, which will enable a downstream unit to become synchronized faster.

A setting of 1 applies only in a point-to-point (PTP) configuration: the Master will stay in quick sync mode until such time as it receives an acknowledgement from its associated Slave, it will then remain hopping quickly for the number of hop intervals (8-255) defined by S152 (Fast Sync Hold on Ack), after which time it will go into normal sync mode.

A value of 2 results in the Master going into quick sync mode when it initially comes online and then remaining in that mode for the duration specified in S151 (fast sync timeout) and then return to normal sync mode.

Values

```
0       normal sync
1       quick sync mode, wait for acknowledgement
2       quick sync mode, wait for timeout
```

S151   Fast Sync Timeout

This register settings applies only to a Master modem. Effective only when S150=2. It defines how long, in milliseconds, a Master modem will stay in fast sync mode after it initially goes online.

Values (milliseconds –mS)

100-65000
200

S153   Address Tag

If enabled, the modem prepends 4 extra bytes to the data: first byte = 0x00, second = 0xFF, third = source unit address (high byte), fourth = source unit address (low byte).

Value

0	**disable**
1	enable

S158   FEC (Forward Error Correction) Mode

A number of FEC schemes are available with different coding rates.

FEC consumes some bandwidth: depending on which coding rate is chosen, a number of coding bits are transmitted along with the 'data' bits.

In 'noisy' or long-range communications environments, FEC may effectively increase throughput by decreasing the amount of packet retransmissions which would otherwise be required.

Communications range may also be extended with the use of FEC: at a certain distance where data would otherwise be unacceptably corrupted, employing FEC may be all that is required to maintain the integrity of that data at that distance.

Types of FEC available within the Nano:

Hamming (7,4):	Information rate 0.5, corrects 1 out of 7 bits
Hamming (15,11):	Information rate 0.66, corrects 1 out of 15 bits
Hamming (31,24):	Information rate 0.75, corrects 1 out of 31 bits
Binary BCH (47,36):	Information rate 0.75, corrects 2 bits
Golay (23, 12, 7):	Information rate 0.5, corrects 3 bits
Reed-Solomon (15,11):	Information rate 0.687, corrects 2 nibbles

Values

0	**No FEC**
1	Hamming (7,4)
2	Hamming (15,11)
3	Hamming (31,24)
5	Binary BCH (47,36)
6	Golay (23,12,7)
7	Reed-Solomon (15,11)

S159   Encryption Mode (AES)

AES encryption is only available in models delivered as –AES. This is a factory configured option that can only be loaded and enabled at the factory at time of assembly. The use of AES encryption, and export laws governing AES, vary from country to country, contact Microhard Systems Inc. for more information.

AES (Advanced Encryption Standard) provides an extremely strong level of encryption for data for security of wireless data communication. The use of AES may cause slight degradation of system performance due to the processing requirements of the encoding/decoding process.

Up to three levels of AES are available, 128 bit, 192 bit and 256 bit. Only the specific options enabled by the factory will be available Once a level of AES is chosen using register S159, the encryption key must be entered. The same AES setting and encryption key must be entered on every modem in the network.

The size of the key is dependant of the level of AES:

128bit AES: 16 Byte Encryption Key

192bit AES: 24 Byte Encryption Key

256bit AES: 32 Byte Encryption Key

The encryption key can be entered in registers S107 or S177 as they share the same key array for encryption. S107 (Static Mask) is used to enter in up to 32 printable characters (ASCII). If using 128 or 192 bit AES, any character entered after 16 or 24 bytes respectively will be ignored. If less than the required number of characters is entered, 0's will be appended to fill the encryption key array.

To improve the strength of the key, S177 can be used to enter 16-32 bytes (dependant of the AES type) of binary non-printable characters. This register requires the appropriate number bytes to be entered. In other words, if you are using AES256, S177 requires 32 bytes of data to be entered. A binary file can be transferred to the modem using a terminal program after a ATS177= command has been invoked.

Values

0	**No encryption**
1	AES 128 bit
2	AES 192 bit
3	AES 256 bit

S177 Binary Encryption Key

When using AES encryption, S177 can be used to define the encryption key in binary. The type of AES used defines the minimum number of binary bytes that need to be entered. See S159 for more information.

Values (Binary Bytes)

16 - 32 Bytes (AES type dependant)

S217 Protocol Type

For most applications, the default value of 0 - resulting in transparent operation - will be maintained in this register. Setting this register to a value of 1 specifies MODBUS operation, in which the modem will frame the output data and comply with MODBUS specifications. S217=2 configures the modem for DF1 filtering. In this mode, the PLC's address must match the Unit Address of the modem. Data not intended for a specific PLC/Modem pairing will be blocked from passing through the modem to the attached PLC.

Values

0	transparent
1	MODBUS RTU
2	DF1 protocol, full-duplex, with address filtering

S232 Maximum Buffer in Storage

Values

1-255
200

S237 Sniff Timeout

This register applies only to Remote modems. Defines how many hops the unit will sniff for upon expiry of the Sleep Time (S144). The Sniff Timeout (sniff duration) in milliseconds is calculated as follows:

Sniff Timeout=S237 (hops) x hop interval (per S109)

Example: S237=20, S109=9 (=20ms)

Sniff Timeout = 20 (hops) x 20ms per hop = 400ms

Values (hops)

1-255
10

The longer the Sniff Timeout (duration), the more assured it is that the Remote modem will 'find' an upstream unit when it is desired to wake up the system, however more power will be consumed.

S244   Channel Request Mode

Channel Request Mode 'on' (default), allows a Remote modem which has data to send to request from the Master permission to do so. When granted, the Remote will be allowed to transmit all of its data (no other Remotes may transmit during this period), upon completion of which it will release the channel. This feature eliminates collisions which would otherwise occur if a number of Remotes were all trying to transmit at the same time.

TDMA mode is discussed in detail in Section 5.2.1. It relates to Channel Requests in that, in TDMA mode, the Master does not allow such requests from Remotes; the Master sequences through a list of Remotes, giving each one in turn an opportunity to transmit.

Values

0	**Channel Request**
1	TDMA Mode (Standard)
2	Fast TDMA
3	GPS Indexed TDMA
4	Adaptive TDMA

S248   Sync Timeout

This register defines how many hop intervals where the slave does not receive a synchronization packet from the master, before it will become unsynchronized and begins to search for a master.

Values

1-65534
512

In a 'clean' RF environment, it may be of benefit to reduce S251 to 2 or 3 as, should a Remote be unable to communicate for some reason, the 'wait' time for the Master to proceed to poll the next Slave would be reduced.

S251   Master Hop Allocation Timeout

In TDMA mode (see S244 and Section 5.2.1) this register determines how long, in hop intervals, the Master will wait for a Remote to either (a) begin to send data or (b) indicate that it has completed sending all of its data, prior to the Master sequencing to the next Remote to be given permission to transmit.

Values (hops)

1-254
10

Radio System Installation

There are a number of factors to consider when preparing to deploy a radio network, several of which have been touched-upon or detailed elsewhere within this manual.

Throughput

The Messenger Nano radio is capable of 230.4kbps asynchronous serial data throughput. The network topology has an effect on how this available throughput is 'shared' between all nodes on the network.

Distance

The physical distance between the modems dictates such things as required antenna performance and heights, and whether or not a Repeater(s) is required. When contemplating antenna types and Repeater sites, keep in mind the directivity (omnidirectional or directional) of the antennas being used, and also recall the effect of a Repeater on throughput (halved).

Terrain

Along with distance, the terrain is a very important consideration with respect to antenna height requirements. The term 'line-of-sight' (LOS) refers to being able to 'see' one location from another - a minimum requirement for a radio signal path. In addition to LOS, adequate clearance must also be provided to satisfy 'Fresnel Zone' requirements - an obstruction-free area much greater than the physical LOS, i.e. LOS is not enough to completely satisfy RF path requirements for a robust communications link.

Transmit Power

Having read thus far through the factors to be considered, it should be clear that they are all interrelated. Transmit power should be set for the minimum required to establish a reliable communications path with adequate fade margin. Required transmit power is dictated primarily by distance, antenna type (specifically the 'gain' of the antennas being used), and the receive sensitivity of the distant modem. Cable and connector losses (physical path from the modem's 'antenna connector' to the antenna) must also be taken into account.

Receive Sensitivity

The Nano Series has exceptional receive sensitivity, which can produce a number of benefits, such as: added fade margin for a given link, being able to use less expensive coaxial cable or antenna types, being able to operate at greater distances for a given distant transmitter power (perhaps negating the requirement for a Repeater site!). Distance, antenna gain, transmit power, and receive sensitivity are critical 'numbers' for radio path calculations. Fortunately, the Nano Series features the maximum available transmit power combined with exceptional receive sensitivity - two 'numbers' which will produce the most favorable path calculation results.

Fade Margin

When all radio path numbers are being considered and hardware assumptions are being made, another factor to consider is the 'fade margin' of the overall system. the fade margin is the difference between the anticipated receive signal level and the minimum acceptable receive level (receive sensitivity). Being that the Nano Series performs to exacting specifications, the overall deployment should be such that the modems may be utilized to their full potential to provide a reliable and robust communications link. A typical desired fade margin is in the order of 20dB, however oftentimes a 10dB fade margin is acceptable.

Frequency

The 900MHz and 2.4GHz frequency ranges are not effected by rain to any significant degree, and is also able to penetrate through foliage and 'around obstacles' to a certain degree. This being the case, some may choose to scrimp on the physical deployment, particularly when it comes to antenna (tower) heights. Path calculations provide results which specify 'required' antenna heights. For cost savings and in taking advantage of the characteristics of the frequency range, sometimes the height requirements are not adhered to: this may result in unreliable communications.

Power Requirements

Messenger Nano Radios may be integrated into a system which accepts a range of DC input voltages (supply current requirements must also be met). In some deployments, power consumption is critical. A number of features related to minimize power consumption are available with the Nano Radios: sleep/sniff modes, LED dimming, and the ability to operate at less transmit power given the receive sensitivity of the distant modem.

Interference

The frequency hopping spread spectrum (FHSS) operation of the Nano Series most often allows it to work well in an environment within which there may be sources of in-band interference. Frequency Restriction is a built-in feature which may be utilized to avoid specific frequencies or ranges of frequencies; the Spectrum Analyzer function may be used to identify areas of potential interference. Cavity filters are also available if required: contact Microhard Systems Inc. for further information

Installation of Antenna System Components

The installation, removal, or maintenance of any antenna system components must be undertaken only by qualified and experienced personnel.

Antennas

The two most common types of antenna are the omnidirectional ('omni') and directional (Yagi).

An omni typically has 3-6dBi gain and spreads its energy in all directions (hence the name 'omnidirectional'). The 'pattern' of the energy field is in the shape of a donut, with the antenna mounted vertically at the centre. This vertical-mounted antenna produces a signal which is vertically 'polarized'.

A Yagi has a more focused antenna pattern, which results in greater gain: commonly, 6-12dBi. The pattern of a Yagi is in the shape of a large raindrop in the direction in which the antenna is pointed. If the elements of the Yagi are perpendicular to the ground (most common orientation) the radiated signal will be vertically polarized; if parallel to the ground, the polarization is horizontal.

The network topology, application, and path calculation are all taken into consideration when selecting the various antenna types to be used in a radio network deployment.

In a long-range PTP network, Yagi antennas should be considered. There antennas will provide for the most focused 'RF connection' between the two sites.

In a PMP network where Remotes are located in all directions from the Master, the Master site will typically have an omni so that it can communicate with all Remotes; the Remotes, however, may all employ Yagi antennas 'pointed at' the Master.

Typically a Repeater site will employ an omni such that it can readily receive an RF transmission from one direction and be able to readily transmit it in another.

If an application involves Remotes which are not stationary (e.g. mobile application), all sites would likely use omni antennas so that wherever the units may be, there should be antenna pattern coverage.

A radio path survey is always recommended before installation of a new radio system. This process involves collecting the GPS coordinates of the various radio sites, entering them into a software program designed to analyze radio propagation, and analyzing the effects of terrain, antenna heights and types, frequency, power, radio sensitivity, and data rates. ICL can provide radio path surveys, as well as instruction on doing your own analysis. We recommend the "Radio Mobile" software, available at no cost over the Internet. For more information and downloading, go to http://www.cplus.org/rmw/english1.html .

Coaxial Cable

The following types of coaxial cable are recommended and suitable for most applications (followed by loss at 900MHz, in dB, per 100 feet):

- · LMR 195 (10.7)
- · LMR 400 (3.9)
- · LMR 600 (2.5)

For a typical application, LMR 400 may be suitable. Where a long cable run is required   - and in particular within networks where there is not a lot of margin available - a cable with lower loss should be considered.

When installing cable, care must be taken to not physically damage it (be particularly careful with respect to not kinking it at any time) and to secure it properly. Care must also be taken to affix the connectors properly - using the proper crimping tools - and to weatherproof them.

Surge Arrestors

The most effective protection against lightning-induced damage is to install two lightning surge arrestors: one at the antenna, the other at the interface with the equipment. The surge arrestor grounding system should be fully interconnected   with the transmission tower and power grounding systems to form a single, fully integrated ground circuit. Typically, both ports on surge arrestors are N-type female.

External Filter

Although the Nano Series is capable of filtering-out RF noise in most environments, there are circumstances that require external filtering. Paging towers and cellular base stations in close proximity to the Nano's antenna can desensitize the receiver. An external band-pass cavity filter eliminates this problem. The filter has two N-female connectors and should be connected inline at the interface to the RF equipment.

Appendix A: AT Command Quick Reference

The following commands may be used when the modem is in COMMAND MODE; all are to be preceded with "AT" and followed with [Enter]. An asterisk (*) indicates a default setting, where applicable.

A   **Answer**
     this command puts the modem into data mode

D*xxxxx***, DT***xxxxx***, DP***xxxxx***   Dial**
     identical commands which change the unit address to *xxxxx* and put the modem into data mode

g, G   **Spectrum Analyzer**
     Used to help determine if interfering RF signals are present.

I*n*   **Identification**
     follow ATI with either of the following '*n*':
     1   product code
     2   ROM check (OK or ERROR)
     3   firmware version
     4   firmware date
     5   firmware copyright
     6   firmware time
     7   serial number
     255   factory-configured options listing

N   **Advanced Spectrum Analyzer**
     Advanced spectrum analyzer provides for a more detailed scrutiny of the RF environment.

O   **Online Mode**
     this command puts the modem into data mode

T*x*   **Registered Slave List (TDMA)**
     ?   view list
     T*n*=*UA* -set list number *n* equal to Remote's Unit Address
     T*n*? -view list item *n*

&F*n*   **Load Factory Default Configuration**
     follow AT&F with either of the following '*n*':
     1   MASTER Point-to-Multipoint, use with &F2/&F3 modems
     2   SLAVE Point-to-Multipoint, works with &F1
     3   REPEATER Point-to-Multipoint, works with &F1/&F2
     4   SLOW MODE* MASTER Point-to-Multipoint
     5   SLOW MODE* SLAVE Point-to-Multipoint
     6   MASTER Point-to-Point, works with &F7
     7   SLAVE Point-to-Point, works with &F6

&H0   Frequency Restriction

Follow onscreen prompts to input undesired frequencies.

&H1   Repeater Registration

When more than 1 repeater exists in a network, the repeaters should be 'registered' using this command to ensure that frequencies used are orthogonal to each other (thereby minimizing potential interference).

&V   View Configuration

displays all visible S registers and their current values

&W   Write Configuration to Memory

stores active configuration into modem's non-volatile memory

S*xxx*?   Read S Register Value

where xxx is the S register's number, this command will result in displaying the current setting of that register

S*xxx=yyy*   Set S Register Value

where xxx is the S register's number, this command will place value yyy in that register

Appendix B: Settings (S) Registers

The registers described in this Appendix are ones which are normally 'visible' to the user. The values stored in these registers effect the operation of the modem. An asterisk * represents default value (if applicable).

Query format:　　　　**ATSxxx? [Enter]**　　　where xxx is S register *number* detailed below

Change format:　　　**ATSxxx=y [Enter]**　　　where xxx is S register number and y is desired value

S0　　**Auto Answer**
　　　0　　modem will power-up in command mode
　　　1　　*modem will power-up in data mode

S2　　**Escape Code**
　　　contains ASCII value of escape character
　　　*'43' is default value, which represents the ASCII character '+'
　　　values greater than 127 disable the escape feature and prevent user from returning to command mode

S101　**Operating Mode**
　　　Master
　　　Repeater
　　　Slave

S102　**Serial Port Baud Rate (bps)**
　　　0　230400
　　　1　115200
　　　2　57600
　　　3　38400
　　　4　28800
　　　5　19200
　　　6　14400
　　　7　*9600

S103　**Wireless Link Rate (bps)**
　　　1　　115200
　　　2　　*172800
　　　3　　230400

S104　**Network Address**　　0-4,000,000,000
　　　*1234567890

S105　**Unit Address**
　　　2-65534 (master is 1, broadcast is 65535)

S107　**Static Mask**　　-up to 16 characters
　　　*default

S108　**Output Power Level**　20-30dBm

*30 (1W)

S109   Hop Interval (ms)
0   1.5
1   2.0
2   2.5
3   3.0
4   4.0
5   5.0
6   7.0
7   10
8   15
*9   20
10   30

S110   Data Format (of Asynchronous serial input to modem)
1   *8N1
2   8N2
3   8E1
4   8O1
5   7N1
6   7N2

S112   Packet Max Size (bytes)   1-256
*255

S113   Packet Retransmissions   0-255
*5

S115   Repeat Interval   1-255
*3

S118   Roaming   65535-roaming enabled   1-254-fixed upstream unit
*1

S119   Quick Enter to Command Mode
0   *disabled
1   enabled

S123   RSSI Value (dBm, read only)

S133   Network Type
0   Point-to-Multipoint (PMP)
1   Point-to-Point (PP)
2   Peer-to-Peer (P2P)

S140   Destination Address   1-65535

S141   Repeater Existence
   0   *no repeater
   1   1 or more repeaters exist

S142   Serial Channel Mode
   0   *RS-232 interface
   1   half-duplex RS-485
   2   full-duplex RS-485

S143   Sleep Mode
   0   *active (no sleep)
   1   sleep mode 1, stays awake on local and air data
   2   sleep mode 2, stays awake only on local data
   3   sniff mode 1, stays awake on local and air data
   4   sniff mode 2, stays awake only on local data
   5   sniff mode 3, same as sniff mode 1 but will discard data if cannot find upstream unit

S144   Sleep Duration (seconds)   0-65535
   *60

S145   Awake Timeout (seconds)   0-65535
   *10

S149   LED Brightness (%)   0-100
   *100

S150   Quick Sync Mode
   0   *normal sync
   1   quick sync mode, wait for acknowledgement
   2   quick sync mode, wait for timeout

S151   Quick Sync Timeout (ms)   100-65534
   *200

S153   Address Tag
   0   *disable
   1   enable

S158   FEC Mode
   0   *No FEC
   1   Hamming (7,4)
   2   Hamming (15,11)
   3   Hamming (31,24)
   4   Binary BCH (47,36)
   5   Golay (23,12,7)
   6   Reed-Solomon (15,11)

S217 **Protocol Type**
    0   *transparent
    1   MODBUS RTU
    2   DF1 protocol, address filtering

S237 **Sniff Duration (hops)** 1-255
    *10

S244 **Channel Request Mode**
    0   *channel request
    1   TDMA mode

S251 **Master Hop Allocation Timeout (hops)**   1-254
    *10
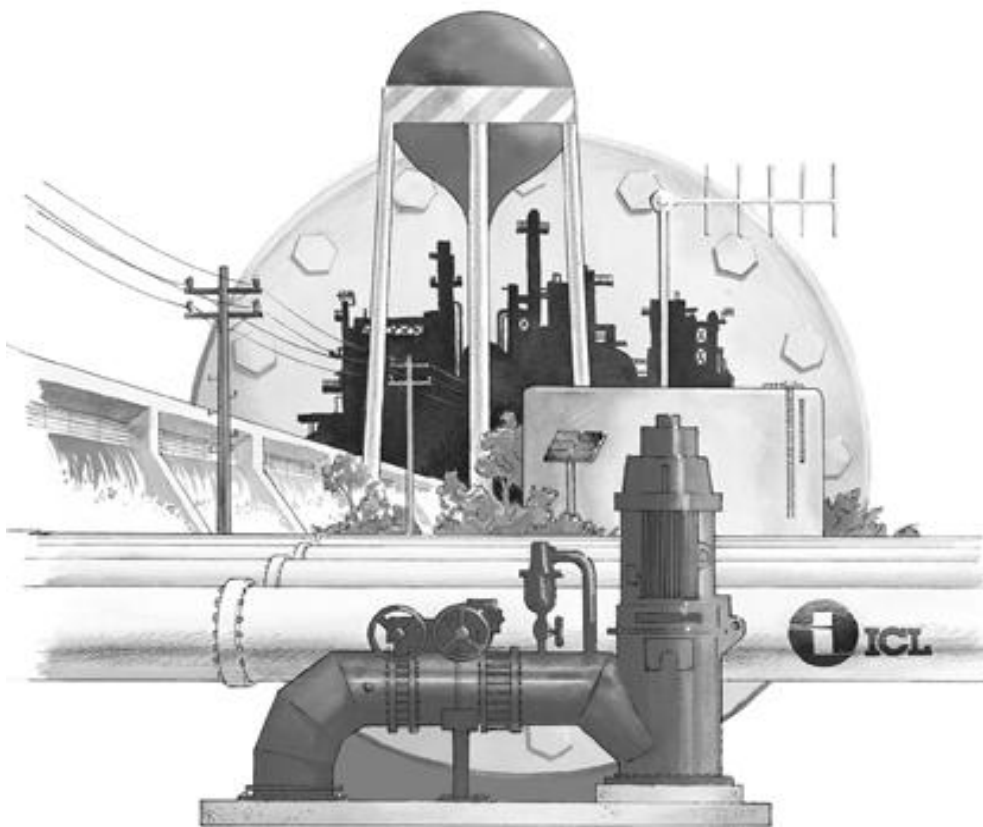
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