User Manual
455U-D
Radio Modem

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Thank you for your selection of the 455U-D radio modem. We trust it will give you many years of valuable service.

ATTENTION!

Incorrect termination of supply wires may

cause internal damage and will void warranty.

To ensure your 455U-D enjoys a long life,

double check ALL your connections with

the user's manual

before turning the power on.

Important Regulatory Information

FCC

Part 15 – This device has been tested and found to comply with the limits for a Class B digital device, pursuant to Part15 of the FCC rules (Code of Federal Regulations 47CFR Part 15). Operation is subject to the condition that this device does not cause harmful interference.

Part 90 – This device has been type accepted for operation by the FCC in accordance with Part90 of the FCC rules (47CFR Part 90). See the label on the unit for the specific FCC ID and any other certification designations.

Note This device should only be connected to PCs that are covered by either a FCC DoC or are FCC certified.

Industry Canada

RSS-119 - This device has been type accepted for operation by Industry Canada in accordance with RSS-119 of the Industry Canada rules. See the label on the unit for the specific Industry Canada certification number and any other certification designations.

Notice

Any changes or modifications not expressly approved by ELPRO Technologies P/L could void the user's authority to operate this equipment.

To operate this equipment legally the user must obtain a radio operating license from the government agency. This is done so the government can coordinate radio users in order to minimize interference.

How to Use This Manual

To receive the maximum benefit from your 455U-D product, please read the **Introduction**, **Installation** and **Configuration** chapters of this manual thoroughly before putting the 455U-D to work.

Chapter Four **Specifications** details the features of the product and lists the standards to which the product is approved.

Chapter Five **Troubleshooting** will help if your system has problems and Chapter Seven specifies the **Warranty and Service** conditions.

The foldout sheet 455U-D *Installation Guide* is an installation drawing appropriate for most applications.

WARNING

1. To avoid the risk of electrocution, the antenna, antenna cable, and all terminals of the 455U-D module should be electrically protected. To provide maximum surge and lightning protection, the module should be connected to a suitable earth and the antenna, antenna cable, and the module should be installed as recommended in the Installation Guide.
2. To avoid accidents during maintenance or adjustment of remotely controlled equipment, all equipment should be first disconnected from the 455U-D module during these adjustments. Equipment should carry clear markings to indicate remote or automatic operation. eg. "This equipment is remotely controlled and may start without warning. Isolate at the switchboard before attempting adjustments."
3. The 455U-D module is not suitable for use in explosive environments without additional protection.
4. All antenna installation and servicing should be done by qualified personal only. When installing or working near the antenna it is important to ensure that the transmitter is not operating, **ensure the transmitter is disabled.**
5. The antenna can have very high RF radiating fields and must be installed so that under normal operating conditions that a person cannot approach within 2.3 metres (7.5 feet) of the antenna. See chapter 2 for antenna installation guidelines.

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Chapter One INTRODUCTION

1.1 General

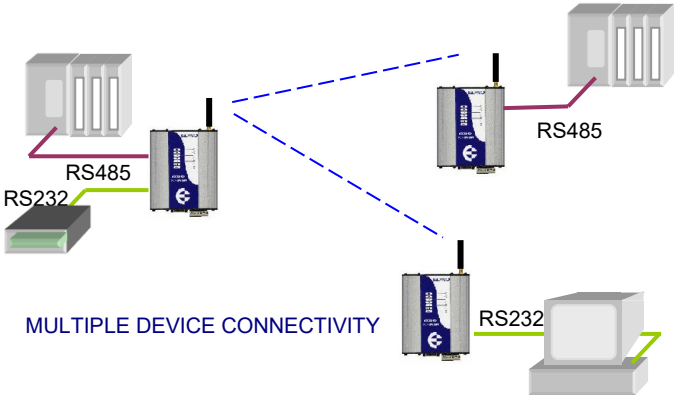
The 455U-D radio modem provides reliable radio modem operation with advanced communication control and diagnostics functions. *Radio modems* transmit serial data over a long distance via radio. The serial data is not changed - the output data is the same as the input data. Although the 455U-D is intended to be simple in its application, it also provides many sophisticated features. This manual should be read carefully to ensure that the modules are configured and installed to give reliable performance.

Each 455U-D module will connect to a host device by RS232 or RS485 serial connection. Examples of host devices are PLC's, data loggers, intelligent transducers and computers. The 455U-D unit can receive data from the host device and transmit this data by radio to another (or several) 455U-D module. The other module will recreate the serial data and output it as either a RS232 or RS485 serial signal. The 455U-D unit provides two-way communications - each module can accept serial data and also output serial data.

The 455U-D module has two data ports (one RS232 and one RS485) and can connect to two host devices independently. The 455U-D also has another RS232 port (via a RJ45 connector) which can be used only for configuration or access to diagnostics information - the RS232 data port can also be used for configuration and diagnostics.

> *RS232 is an electrical standard format for a full duplex point-to-point serial connection. RS485 is an electrical standard format for a half-duplex multidrop serial connection. Up to 32 devices can communicate on a common RS485 serial bus.*

Each 455U-D can simultaneously connect to signals from both RS232 and RS485. In addition, RS232 data from one host device can be transmitted to a remote 455U-D unit and output as RS485 data to another host device.



The unit includes a fixed frequency radio transceiver. A range of models support operation in the following bands: 58 to 72MHz; 148 to 174MHz; 220 to 235 MHz; and seven 20MHz radio bands in the range of 360 to 512MHz. The user can configure the frequency within the radio band (refer to Diagnostics section).

The 455U-D is available with a high power radio (0.5 – 5W) suitable for licensed narrow-width channels (12.5, 20 or 25KHz). The models operating in the 360 to 512MHz range are also available with a lower power radio (10 – 500mW) suitable for license-free narrow-width channels, in countries where these are available.

The operating parameters of the 455U-D are configured from a PC using a Microsoft Windows configuration package provided free with the module, or from a PC terminal using Hayes commands.

Ordering Information

455U - *Type – Radio Type – RF Power – Channel – Band – Frequency*

Type	**D**	Data modem, full functionality		
	B	Data modem, Bell 202 or V23 messaging		
	A	External modem, 600 ohm audio input		
	C	Data modem compatible with ELPRO 405U *only 400MHz models		
Radio Type	**L**	10 – 500mW	**H**	0.5 – 5W
Power	Actual power requested - for example, 100mW or 2W			
Channel	**N**	12.5 KHz	**W**	20/25 KHz
Band	**60**	58 – 72MHz	**150**	148 – 174 MHz
	220	220 – 235 Mhz (**note**: 220 model is wide band only)		
	390	380 – 400 MHz	**410**	400 – 420 MHz
	430	420 – 440 MHz	**440**	430 – 450 MHz
	460	450 – 470 MHz	**480**	470 – 490 MHz
	500	490 – 512 MHz		
Frequency	Actual frequency requested in MHz - for example, 471.0725 For different transmit and receive frequencies, enter Rxxxxx/Txxxxxx, for example, R460.5000/T472.3000			

1.1.1 Basic Operation

The operation of the 455U-D radio modem is relatively simple. As data is received at the serial port, the data is transmitted on the radio channel. Up to 1020 bytes of data can be transmitted in one transmission. The radio transmission commences when the first data byte is received, and ends when there are no more data bytes in the input buffer, or when the number of bytes transmitted equals the maximum message length (user configurable - default 1020 bytes). If more than 1020 bytes is input, the 455U-D unit will transmit the first 1020 bytes, then the next 1020 bytes, and so on until all of the data has been transmitted.

Because the radio data rate could be less than the input serial data rate, an input memory buffer of up to 8Kbytes is provided. The RS232 connection provides CTS control to prevent the buffer overflowing. There are no data flow control signals for RS485.

1.1.2 Operating Modes

A radio channel cannot provide as secure a data channel as a wired connection. The 455U-D uses a radio band with a low level of natural or industrial noise, however there is a chance of interference from other users on the radio channel. We recommend that the flow of data over the radio channel is controlled by using error detection and "handshaking" - that is, returning an acknowledgment transmission if a data packet is received on the radio channel without error. This function can be performed by either the host devices or the 455U-D modules.

The modules may be configured by the user to operate in one of two modes. In Unacknowledged mode, it is assumed that the host devices control the flow of data - the 455U-D does not provide handshaking. In Acknowledged mode, the 455U-D units provide handshaking to control the flow of data.

The RS485 port always operates in Unacknowledged mode.

1.1.3 Repeater Functionality

A 455U-D unit can act as a repeater for other units. A repeater receives a radio message from one unit and re-transmits it on to another unit.

Up to seven repeater addresses can be configured in a radio link.

If transmitting to the wildcard 0 address in Unacknowledged mode (that is, a broadcast transmission), then the repeater unit can be configured to also output the data to its own host device.

1.1.4 Hot Redundant Standby

Two 455U-D units can be installed together in a Dual Redundant relationship - an active unit with a hot redundant standby. One unit is configured as a "primary" unit and the other the "secondary". The secondary unit acts as a standby for the primary.

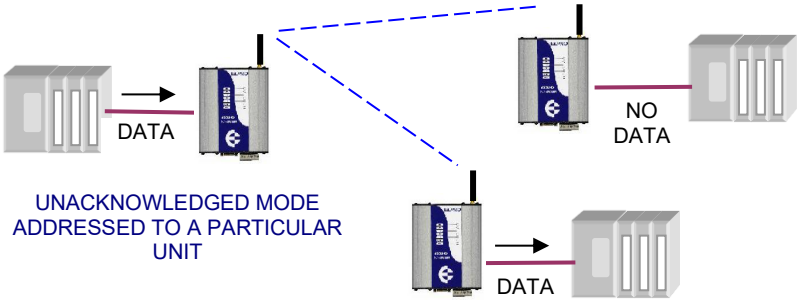
Under normal operation, the primary unit is active and the standby is inactive. If the internal diagnostics in the primary detects a fault or an operating problem, the primary stops normal operation and the secondary becomes active. The inactive unit is powered and operational, however communications out of the unit via the radio transmitter and RS485 port is disabled.

Both units have the same configuration apart from primary/secondary selection.

1.2 Unacknowledged Mode

The default configuration of the 455U-D modem is unacknowledged mode - the modules are set in this mode at the factory.

In unacknowledged mode, units do not provide handshaking functions to control the flow of data. Messages are not acknowledged, and are sent on a "Best attempt" basis. It is up to the host equipment to determine if data is lost or corrupted.



To improve reliability in this mode, units may be configured to send each message multiple times (configured in S-Register S29). The receiving unit will detect repeat messages and only send the data out the serial port once.

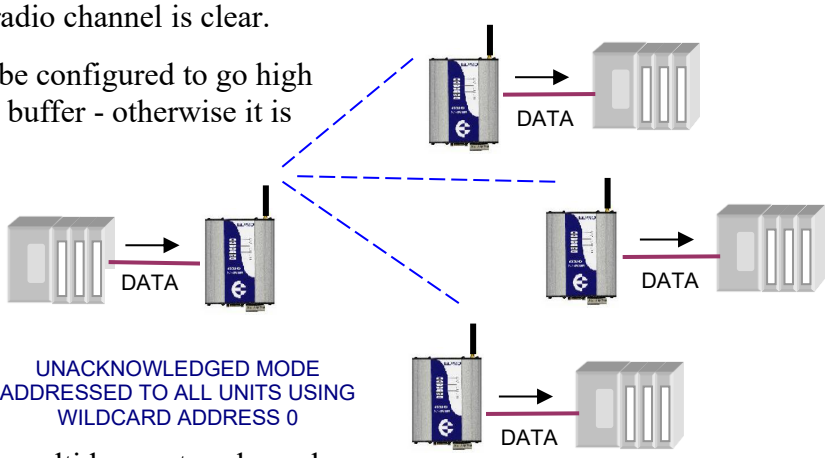
Each modem is configured with a separate unit address. In Unacknowledged mode, messages may be sent

- to a particular modem by using the remote unit's address, or
- to all modems in the system, as a broadcast message by using the wildcard address 0. The wildcard address is used to send a message to a group of modems.

Data received at the serial port is transmitted out of the radio port, addressed to the configured destination 455U-D module, or to all modules by using address 0. Data received from the radio with the correct addressing is transmitted out of one of the serial ports (RS232 or RS485).

Prior to transmitting, units will listen to the radio channel to ensure that it is clear - units will hold off from transmitting until the radio channel is clear.

At the RS232 port, the CTS pin can be configured to go high while there is space in the input data buffer - otherwise it is always high.

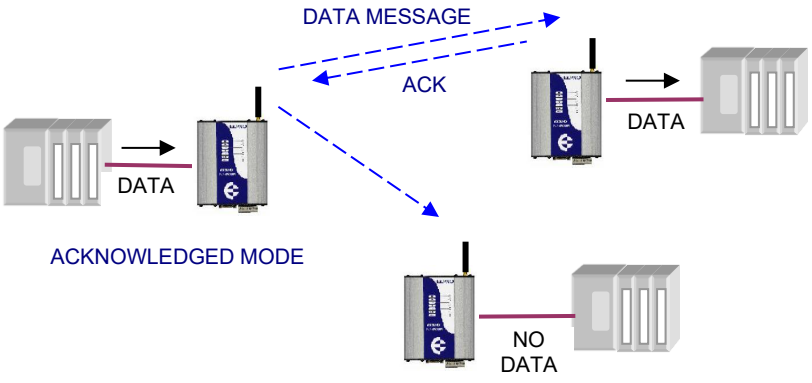


Host devices should provide a suitable protocol to ensure that error checking, handshaking and implementation of an appropriate re-transmission scheme is provided. This mode of operation is particularly suited to devices designed to operate over a multidrop network, such as PLC systems designed for operation over a RS-485 network.

If error checking is not configured at the receiving unit, data will start to be output immediately after the first byte of data has been received. If error checking is configured, data will be output approx 1mSec after the end of the message. For example, a message with 20 bytes of data transmitted at 19200 bits/sec will begin to be output approx 23 msec after the data is input, if there is no error checking, or 31 msec after the data is input if error checking is configured - this assumes the minimum lead-in time of 20 msec is configured.

1.3 Acknowledged Mode

In Acknowledged mode, data is transferred between the RS-232 ports of two modules (that is, a point to point link). One of the modules is configured as a "master" (or initiator) unit and the other as a "slave" (or responder) unit. There can be many slave units in the system; however the master unit will only link to one slave at any one time.



Note that Acknowledged mode only applies to the RS-232 port. The RS-485 port always operates in Unacknowledged mode.

To establish a link, the master unit transmits a special "connect" message. This initial message does not include any data. If the addressed slave unit receives the connect message, and is not already connected to another 455U-D unit, it will return an acknowledgment message. Both units will activate their DCD LED, and also activate their DCD output signal (if configured).

If the master unit does not receive the acknowledgment, the DCD output will reset. When the connection is made (DCD set), the 455U-D units can transmit data to each other.

A master can be configured to connect to a pre-configured slave address in two ways:

- on power up - the master will only connect to one fixed slave address and if the connection link fails, the master will continuously try to make a new connection, or
- it can be "commanded" by its host device using AT commands - the host device can control the master 455U-D to "dial" a slave address, connect, transfer data, and then disconnect (or "hang up"), and connect to a different slave address.

Once the communications channel has been established, the 455U-D unit will accept input data and send radio messages with data. When a 455U-D unit receives a radio message, it will check the system address and destination address, and also the error-check (optional). If these are correct, it will return a ACK (acknowledgment) message to the source unit. If the system address or destination address is not correct, or if the error-check is not correct, then no return message is sent.

There can also be up to five intermediate repeaters in the link. Each 455U-D unit is configured with a unit address - only the unit with an address matching the destination address of the radio message will process the message and output the serial data.

Establishing a Communications Link

Master Unit		**Slave Unit**
• Listen to ensure channel is clear • If clear, transmit "connect" message • Radio TX LED flashes	---------->	• Receives message • Radio RX LED flashes • Check system and destination address • If OK, set DCD LED and output
		• If message OK, transmit back an ACK message.
• Radio RX LED flashes	<----------	Radio TX LED flashes
• Acknowledgment received okay communication link established • Set DCD LED and output		

If the source unit does not receive an ACK message, it will re-transmit the same message. It will attempt to transmit the message the configured number of times (S-Register S30). If the unit still does not receive an ACK message after the configured number of attempts, it will reset the LINK LED, and reset the DCD output on the DB9 RS232 port and reset the DIO output (if configured).

During normal operation, if there has been no radio activity for a period (called the "link check" period), the master unit will transmit a "check" message to check the radio path. The link check period is user-configurable (S-Register S6). If the slave doesn't receive any

messages within the configured link check timeout (Configuration Setting \T), it will drop the radio link, and turn off the LINK LED, and reset the DIO and DCD signals (if configured).

Successful Communications

Source Module		Destination Module
• Serial data is received • Serial LED flashes		
• Listen to ensure channel is clear • If clear, transmit message • Radio TX LED flashes	---------->	• Receive message • Radio RX LED flashes • Check system and destination address • If OK, check error-check
• Radio RX LED flashes	<----------	• If message okay, transmit back an ACK message. • Radio TX LED flashes
• Acknowledgment received okay - communication complete		• Serial data is output • Serial LED flashes

Unsuccessful Communications

Source Module		Destination Module
• Listen to ensure channel is clear • If clear, transmit message • TX LED flashes	---------->	• Receives message • RX LED flashes • Check system and destination address • If incorrect, transmit no message and no serial output.
• No ACK received • Retry multiple times (Configure With S-Register S30)	---------->	
• If no ACK message received after all attempts • "NO CARRIER" message sent to host • DCD signal and DCD LED reset		

1.4 Security Encryption

Some applications require that the system be made secure from eavesdropping and hacking. To provide for these applications, the modem supports AES-128 data encryption.

The modem may be configured to transmit messages with or without encryption, accept messages without encryption, or to require that received messages are encrypted.

Messages sent with encryption have an additional 16 bytes of data added to the start of the radio message (the initialization vector).

1.5 Serial and Radio Data

The 455U-D module provides a full-duplex RS232 serial port and half-duplex RS485 serial port. The radio communications is half-duplex. Many applications use full duplex RS232 communications but do not require full duplex - the protocol used operates at half-duplex and will operate with the 455U-D without problems. If an application really requires full duplex communications, then the 455U-D should not be used.

Data input at the serial port is placed into the input buffer. This buffer will store up to 8Kbytes of data, and CTS/RTS control can be configured on the RS232 port to prevent overflow.

When the 455U-D unit detects data in the input buffer, it initiates a radio message. The radio message will end when the number of transmitted bytes reaches the maximum message length (configurable by the user), or if the input buffer becomes empty.

If the configured serial data rate is the same or more than the radio data rate, then data is transmitted as soon as it enters the input buffer - data "streams" from the input buffer to the radio port. If the serial rate is less than the radio rate, then the transmission will be delayed for a period to allow sufficient data to build up in the input buffer to avoid the radio emptying the input buffer before a complete serial message has been input. This delay is configurable separately for the RS232 and RS485 serial ports. Alternatively a Transmitter Hold up time can be configured (S-Register S27) to keep the transmitter keyed up between characters.

The radio transmission will stop when the input buffer is empty or when the radio has transmitted the maximum number of bytes (user configurable - maximum 1020 bytes). If there is still data in the input buffer, the 455U-D will start another radio transmission.

An error-check can be added to each radio message - this is a user-configurable selection. If error checking is configured, then a 16 bit CRC error-check is added to the end of the transmitted data packet. The receiving module will receive the full data packet and check the CRC before outputting the data.

The maximum size of the data packet is configurable by the user (maximum is 1020 bytes). If less data than the maximum size is input to the 455U-D, then the 455U-D will transmit the actual data input. If more data is input than the maximum size, then the 455U-D will transmit multiple packets until all of the data is transmitted.

Because of radio start-up delays, the effective radio data rate will be lower than the transmitted data rate. If you are sending large blocks of data, and the serial rate is equal or more than the radio rate, we recommend that you use CTS/RTS flow control to prevent the input buffer from overflowing.

1.5.1 PLC-Mode

The 455U-D will operate most efficiently when the serial data rate is higher or the same as the radio data rate. If the serial data rate is less than the radio rate, there is a risk that the radio will empty the input buffer too quickly, resulting in a single input message being broken into

more than one output messages. Many host protocols such as those used by PLC's, will not accept a message being broken into sections with delays between the sub-sections.

To avoid this occurring, the 455U-D will automatically delay the radio transmission starting if the serial rate is less than the radio rate. This is called "PLC Mode". The radio will not start transmitting until a certain number of bytes have been input into the input buffer. The 455U-D calculates the number of starting bytes depending on the values of the configured serial and radio rates. The number of bytes to start transmitting is stored in register S18 (S20 for RS485)) - when a configuration is entered whereby the serial rate is less than the radio rate, the 455U configuration software will automatically enter an appropriate value in S18. The user can change this value. If the serial rate is the same as the radio rate, or more, than there is no delay.

There is an automatic protection - if a certain time has elapsed and the number of starting bytes has not been input, then the radio will start transmitting. This is an override protection. The 455U-D will automatically calculate the override time based on the configured serial rate and S18 (the number of bytes required to start). The override time is stored in register S19 (S21 for RS485) - this value can also be changed by the user.

In applications where the extra delay introduced by buffering data at the sending modem is unacceptable, an alternative is to configure a "Transmitter Hold up" time (S-Register S27). This keeps the transmission keyed up between data characters.

1.5.2 Character Type

The 455U-D may be configured by the user to recognize the following types of characters - 7 or 8 data bits, even or odd or no parity, 1 or 2 stop bits.

Data	Parity	Stop
7	Even	1
		2
	Odd	1
		2
	None	2
8	Even	1
	Odd	1
	None	1
		2

Most applications will require the character type to be the same at each 455U-D modem in the system. Nevertheless, the character type may be configured to be different at different 455U-D modems. Data is transmitted by radio as an eight-bit byte without stop or start bits. If the input data is 7 data bits, then the byte transmitted by radio comprises the 7 bits plus a zero bit. Input characters with 8 bits are transmitted as just the 8 data bits, with no parity. Because the data is transmitted without parity, the user may configure CRC error checking to be added to each transmitted data packet. Data is output at the destination module based on the character type configured at that module - that is, the start/stop bits and parity is added to the radio data.

1.5.3 Serial Data Rate

The communications baud rates supported on both the RS232 serial port and the RS485 serial port are 600, 1200, 2400, 4800, 9600, 14400, 19200, 28800, 31250, 38400, 57600, 76800, 93750, 115200 and 187500 baud - the user selects one of these rates during the configuration of the modem.

The RS232 and RS485 ports may be configured with separate data rates.

1.5.4 Radio Data Rate

The data is transmitted by radio as direct modulated synchronous data at 1200, 2400, 4800 9600, or 19200 bits/second - (19200 baud only operates with 25KHz channel widths). The user must configure the radio data rate at each 455U-D module. The configured radio data rates must be the same for each module in a system.

The 455U-D uses four-level frequency modulation for the highest data rates - 9600 b/s for 12.5 KHz channels and 19200 b/s for 25 KHz channels. The other rates use two level frequency modulation. Two level modulation results in less data errors, resulting in more reliable operation. It is recommended that radio rates of 4800 (12.5 KHz) or 9600 (25 KHz) be used unless the application requires the higher data rates.

1.5.5 Radio Message

The radio message includes the following:-

- A 40 msec leading sequence of alternating 1's and 0's provides the receiving unit with time to capture and lock onto the incoming signal (the lead-in time can be configured to be longer for systems using talk-through repeaters).
- A system address is superimposed on each message to provide discrimination between different 455U-D systems on the same radio channel. Each 455U-D unit in the same system must be configured with the same system address - refer Configuration section. Although other 455U-D modules may hear the radio transmissions, because they have a different system address, the radio transmission is ignored and no serial data is output.
- Addressing for the sending unit, any repeater units, and the final destination unit indicates where the message is to be sent and how to get there.

An error-check (16 bit CRC) and security encryption (AES128) may be configured by the user.

Up to 1020 bytes of data may be transmitted in a message - the maximum message size is configurable between 1 and 1020 bytes. The data consists of a sequence of 8 bit bytes. Start, stop and parity bits are not transmitted, but they are re-generated at the receiving unit (if configured).

The time taken to transmit a message is :-

Section	Item	Number	Time (At 9600 Baud)
PEAMBLE	Lead-in	40 msec Default (Configurable)	40 msec
HEADER	System Address	2 Bytes	2.08 msec
	Header Control	2 Bytes	2.08 msec
	Source Address	1 Byte	1.04 msec
	Destination Address	1 Byte	1.04 msec
	Intermediate Address	1 Byte per address	1.04 msec for each address
	Header Error Check	1 Byte	1.04 msec
ENCRYPTION	Initialisation Vector	16 Bytes (if enabled)	16.64 msec (If configured)
DATA	Message Data	Data Bytes	1.04 msec x no of data bytes
CHECK	CRC Error Check	2 bytes (if enabled)	2.08 msec (If CRC configured).

The time for each byte is 1.04msec @9600 bits/sec, 2.08 msec at 4800 bits/sec, and 4.16 msec at 2400 bits/sec.. If error checking is not configured at the receiving unit, data will start to be output immediately after the first data byte has been received. If error checking is configured, data will be output approx 1msec after the end of the message. For example, a message with 20 bytes of data transmitted at 9600 bits/sec with no repeaters, will start to be output approx 71msec after the data is input, if error checking is configured, and will start to be output approx 47 msec after the data is input if no error checking is configured.

A “transmit delay” time and a “receive delay” time may also be configured. These parameters may be used to fine tune and give priority to different 455U-D units in a system.

- After each message is transmitted, a 455U-D unit will not transmit another message during the transmit delay time. This could be used to allow a reply message to be received before the next message is sent.
- After a message is received, a message will not be transmitted during the receive delay time. This could be used to delay a reply message until other messages have been sent.

1.6 Addressing

A 455U-D network comprises modules with the same "system" address. Only modules with the same system address will communicate with each other. This feature allows more than one system to operate in the same area on the same radio channel.

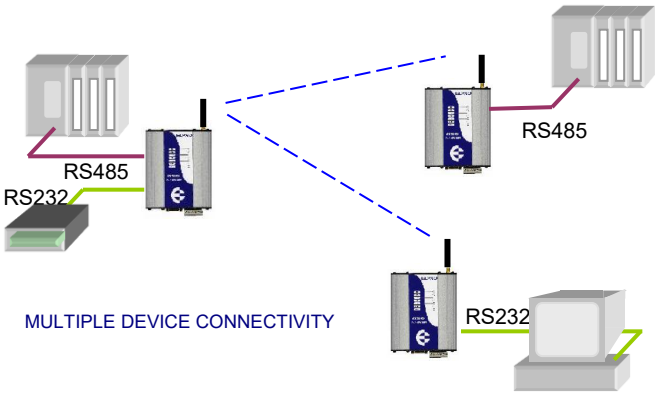
A 455U-D must also be configured with a “unit” address - this gives the module a unique identification. The unit address is used to identify the two data ports on each 455U-D. The RS232 port is accessed by addressing the configured unit address. The RS485 port is accessed by addressing the configured unit address +128. So, to access the RS232 port on unit 7, use address 7. To access the RS485 port on this unit, use address 135 (128+7).

Addresses 0 and 128 are reserved as “wildcard” addresses. Sending a message to address 0 results in all modules accepting the message. Address 0 refers to every RS232 port in the system. Address 128 is the wildcard address for every RS485 port in the system.

1.6.1 Multiple Device Connectivity (MDC)

Because each serial port is individually addressed, the 455U-D is able to connect to two serial devices and manage two independent wireless links. This is called Multiple Device Connectivity, or MDC functionality.

Some of the features if MDC are:



- Each serial port is configured individually however with the same system address.
- The device connected to the RS485 port can link to the RS485 port or the RS232 port on another 455U-D - the same applies to the RS232 device. However if a wild-card address is used (0 or 128), then all remote serial ports must be the same - that is, all R485 or all RS232.
- The RS485 port always operates in Unacknowledged mode. The RS232 port can be in Unacknowledged or Acknowledged mode. The DCD status indication will relate to the RS232 port.
- Each wireless link can include repeater addresses.
- Because both communications channels use the same radio channel, activity on one port may impact communications on the other port, by introducing delays in message transmission.

1.7 Optimum Path Routing

Optimum Path Routing (OPR) is an advanced feature providing fast and efficient radio networking. OPR is a protocol-specific feature using the link layer of a variety of host protocols, allowing routing of messages for up to 64 different host addresses.

Supported host protocols are:

- DF1 (half duplex master and slave),
- Modbus (Master and Slave) - RTU and ASCII formats,
- Profibus (Peer-to-Peer) and
- DNP3 (peer-to-peer).

Under OPR, a “path” is configured for each host protocol address, comprising the 455U destination address and any 455U repeater addresses in the path. When the 455U unit receives a data message from its host, the 455U will interrogate the message for the host destination address and use the pre-configured OPR path to send the radio message.

For more information, refer to section 3 of this Manual.

1.8 Duty Cycle Limiting

Some licenses require that the modem limits its communications so that it is transmitting for no more than a maximum proportion of the available time. This applies to European 500mW 380-520MHz unlicensed bands, where the modem must limit its duty cycle to 10%.

Duty cycle limit is set to 100% except for modems which are configured for the European limited duty cycle bands.

To change the duty cycle limit, use the AT#D command. (AT#D100 for 100%).

Duty cycle limiting must be calculated over a time no greater than one hour. You might prefer to calculate the duty cycle limit over a shorter time. The AT#T command sets the time in minutes to use to calculate the duty cycle.

1.9 What Operating Mode to Use ?

1.9.1 Unacknowledged or Acknowledged mode?

Unacknowledged mode provides simpler operation as the units do not acknowledge transmissions received. However confirmed operation in unacknowledged mode will only occur if the host devices check the messages and return acknowledgments. Generally, if a device is able to operate on a RS485 multi-drop serial link, it is suitable for unacknowledged mode.

The RS-485 port only operates in Unacknowledged mode. It is possible for the RS-485 port to be operating at the same time as the RS-232 port is sending data to another location, using either Acknowledged or Unacknowledged mode (MDC).

RS-232 links can also be made in Unacknowledged mode - the 455U units can effectively provide a “multi-drop” network for RS232 devices, provided the devices use a communications protocol that includes addressing and message acknowledgments.

Normally Unacknowledged mode would be used with PLC’s and similar devices.

Acknowledged mode is suitable for point-to-point RS-232 links where the host devices do not provide addressing or message acknowledgment. Multi-point networks are possible in Acknowledged mode, however a “master” host device must control connecting and disconnecting to remote units using AT commands.

It is possible to configure different units in the same system with different operating modes, however this requires care. A 455U-D unit configured in one mode can act as a repeater for messages sent between two 455U-D units configured in the other mode, and it is always possible to send Unacknowledged mode messages to the RS-485 port on a module regardless of the configuration of the RS-232 port.

1.9.2 Error Check ?

Error-checking may be configured in both Unacknowledged and Acknowledged mode. When the error-check is configured, a 16-bit CRC (Cyclic Redundancy Check) attached to the end of each message. This check is used to detect any corruption of the data when it is received at another 455U-D unit.

Error checking is individually selected for the RS232 port and the RS485 port.

When a unit receives a radio message with error-check, it will not output data until it has received the whole message and ensured that the error-check is correct. If the unit does not have error-check configured, then it will output data as it is received, streaming from the radio out the serial port. Hence operation of the units is faster if error-check is not configured.

Usually units in the same system will have the same error-check configuration; however it is possible for users to configure the units differently. Each message sent indicates within the message header whether it uses error-checking or not, so a single modem can receive messages with and without error checking without requiring changes to the configuration.

Error-check is strongly recommended for Acknowledged mode operation. If error-check is not configured, then a 455U-D unit will transmit an acknowledgment message (ACK) whenever it receives a radio message, **without** checking for errors. If error-check is configured, the unit will only transmit an ACK message if the error-check is correct.

When using OPR with Modbus RTU or DNP3 protocols, error check should be disabled as these incorporate their own error check within the data frame.

When using OPR with Modbus ASCII protocol, error check should be enabled as this protocol only incorporates a weak LRC error check.

When using OPR with DF1 protocol, Error check must be enabled if the DF1 protocol is configured for Block Character Check (BCC). Error check must be disabled if the DF1 protocol is configured for Cyclic Redundancy Check (CRC). Best performance is found when DF1 is configured to use CRC, and Error check is disabled on the 455U-D.

Chapter Two INSTALLATION

2.1 General

The 455U-D module is housed in a rugged aluminum case suitable for DIN-rail mounting. Terminals will accept wires up to 2.5 sqmm (12 gauge) in size.

Normal 110-240V AC supply should not be connected to any terminal of the 455U-D module. Refer to Section 2.3 **Power Supply**.

To operate this equipment legally the user must operate on a designated license-free radio channel and within the operating parameters of the license-free channel, or obtain a radio operating license from the responsible government agency. This is done so the government can coordinate radio users in order to minimize interference.

Before installing a new system, it is preferable to bench test the complete system. Configuration problems are easier to recognize when the system units are adjacent. Following installation, the most common problem is poor communications caused by incorrectly installed antennas, or radio interference on the same channel, or the radio path being inadequate. If the radio path is a problem (ie path too long, or obstructions in the way) then higher performance antennas or a higher mounting point for the antenna may rectify the problem. Alternately, use an intermediate 455U-D Module as a repeater.

The foldout sheet 455U-D ***Installation Guide*** provides an installation drawing appropriate to most applications. Further information is detailed below.

Each 455U-D module should be effectively earthed via the "GND" terminal on the 455U-D module - this is to ensure that the surge protection circuits inside the 455U-D module are effective.

2.2 Antenna Installation

The 455U-D module will operate reliably over large distances. The distance which may be reliably achieved will vary with each application - depending on the type and location of antennas, the degree of radio interference, and obstructions (such as hills or trees) to the radio path. The expected range depends on the configured radio data rate and radio bandwidth.

Data Rate	*Radio Bandwidth*	*Expected Range*
4800 baud	12.5kHz	60 km (40 miles)
9600 baud	12.5kHz	30 km (20 miles)
9600 baud	25kHz	60 km (40 miles)
19,200 baud	25kHz	30 km (20 miles)

Where it is not possible to achieve reliable communications between two 455U-D modules, then a third 455U-D module may be used to receive the message and re-transmit it. This module is referred to as a repeater.

An antenna must be connected to each 455U-D module using the female SMA connector at the top of the module.

To achieve the maximum transmission distance, the antennas should be raised above intermediate obstructions such that the radio path is true "line of sight". Because of the curvature of the earth, the antennas will need to be elevated at least 5 metres (15 feet) above ground for paths of 5 km (3 miles). For short distances, the modules will operate reliably with some obstruction of the radio path. Obstructions which are close to either antenna will have more of a blocking effect than obstructions in the middle of the radio path. For example, a group of trees around the antenna is a large obstruction, and the antenna should be raised above the trees. However if there is at least 100 meters (300 feet) of clear path before a group of trees, the trees will have less effect on the radio path. To help in planning radio systems, ELPRO provides a free utility for estimating path performance.

The modules provide test diagnostics to test the radio path and display radio signal strength.

An antenna should be connected to the module via 50 ohm coaxial cable (eg RG58, Cellfoil or RG213) terminated with a male SMA connector. The higher the antenna is mounted, the greater the transmission range will be, however as the length of coaxial cable increases so do cable losses. For use on unlicensed frequency channels, there are several types of antennas suitable for use. It is important antennas are chosen carefully to avoid contravening the maximum allowed power limit on the on the radio channel - if in doubt refer to a authorized ELPRO distributor in your country or email ELPRO on support@elprotech.com.

The gains and losses of some typical antennas and cable types are

Antenna	**450MHz Gain (dB)**	**150/220MHz Gain (dB)**	**60MHz Gain (dB)**
Dipole with integral cable	0	0	0
3dBd Collinear	5	5 (only 150MHz)	N/A
6dBd Collinear	8	N/A	N/A
6 element Yagi	9	N/A	N/A
9 element Yagi	12	N/A	N/A
16 element Yagi	15	N/A	N/A
Cable type	**Loss @ 450MHz (dB per 10 m)**	**Loss @ 150/220MHz (dB per 10 m)**	
RG58	-4.5	-2.4 (-2.8)	-1.3
RG213	-1.65	-0.9 (-1.1)	-0.5
Cellfoil	-2.25	-1.4 (-1.7)	-0.9

The net gain of the antenna/cable configuration is determined by adding the antenna gain and the cable loss. For example, at 450MHz a 6dBd Collinear with 20 metres of RG58 has a net loss of 1 dB (8dB – ((20/10) x 4.5) dB) = 8dB – 9dB = -1dB

Another important consideration when installing the antenna system is RF exposure. The antenna can radiate a large amount of RF energy. It is important to ensure that a person cannot approach the antennas within the recommended minimum safe distances in the table

below.

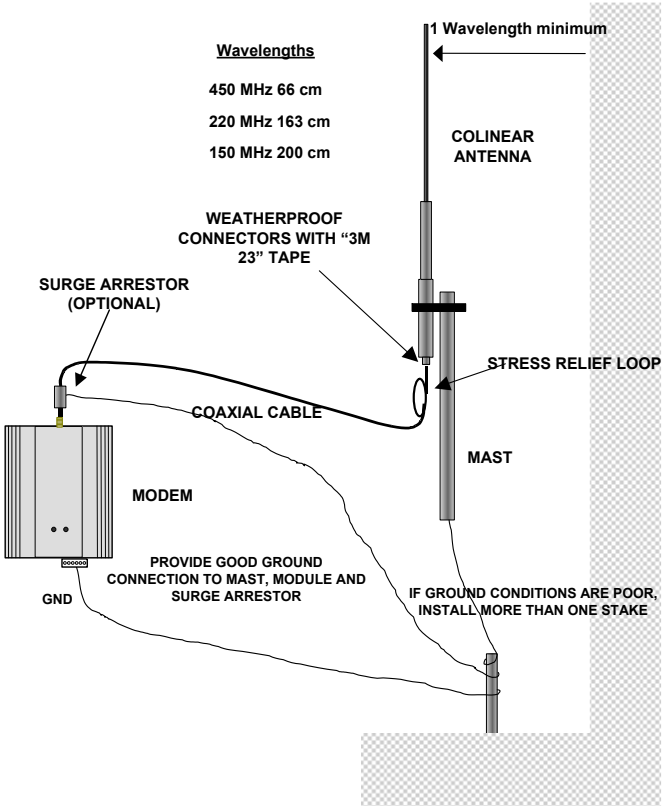
Antenna Type	Minimum safe distance (450MHz)	Minimum safe distance (60/150/220MHz)
Dipole	0.4 metres	0.2 metres
3dBd Collinear	0.7 metres	0.4 metres
6dBd Collinear	0.9 metres	N/A
6 element Yagi	1.2 metres	N/A
9 element Yagi	1.5 metres	N/A
16 element Yagi	2.3 metres	N/A

Connections between the antenna and coaxial cable should be carefully taped to prevent ingress of moisture. Moisture ingress in the coaxial cable is a common cause for problems with radio systems, as it greatly increases the radio losses. We recommend that the connection be taped with a layer of PVC insulating tape, then a layer of vulcanizing tape such as "3M 23 tape", with a final layer of PVC insulating tape.

Where antennas are mounted on elevated masts, the masts should be effectively earthed to avoid lightning surges. Although the 455U-D module is fitted with surge protection, additional surge suppression devices are recommended if lightning surge problems are experienced. If the antenna is not already shielded from lightning strike by an adjacent earthed structure, a lightning rod may be installed above the antenna to provide shielding.

2.2.1 3dB/6dB Collinear antenna.

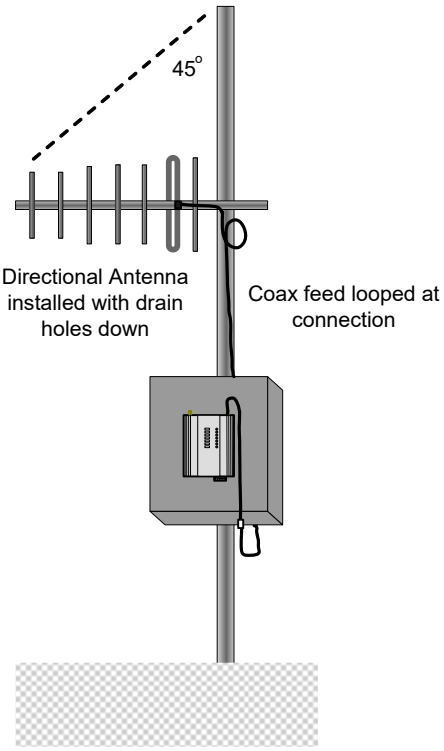
A collinear antenna transmits the same amount of radio power in all directions - as such they are easy to install and use. For marginal radio paths, the following lengths are the recommended maximum for the coaxial cable to the antenna. RG58 -10 meters, RG213 - 20 meters. Note that this applies to marginal paths only - if the radio path has a strong radio signal, then longer lengths of cable (and hence more cable loss) can be tolerated. If more than 20 meters of cable is required for a marginal path installation, then a low loss cable such as 10D-FB, or a higher gain antenna should be used. Collinear antennas should be mounted vertically, at least 1 meter away from a wall or mast.



2.2.2 Yagi antennas.

A Yagi antenna provides high gain in the forward direction, but lower gain in other directions. This may be used to compensate for coaxial cable loss for installations with marginal radio path.

The Yagi gain also acts on the receiver, so adding Yagi antennas at both ends of a link provides a double improvement.



Yagi antennas are directional. That is, they have positive gain to the front of the antenna, but negative gain in other directions. Hence Yagi antennas should be installed with the central beam horizontal and must be pointed exactly in the direction of transmission to benefit from the gain of the antenna. The Yagi antennas may be installed with the elements in a vertical plane (vertically polarized) or in a horizontal plane (horizontally polarized). For a two station installation, with both modules using Yagi antennas, horizontal polarization is recommended. If there are more than two stations transmitting to a common station, then the Yagi antennas should have vertical polarization, and the common (or "central" station should have a collinear (non-directional) antenna.

Also note that Yagi antennas normally have a drain hole on the folded element - the drain hole should be located on the bottom of the installed antenna.

2.3 Power Supply

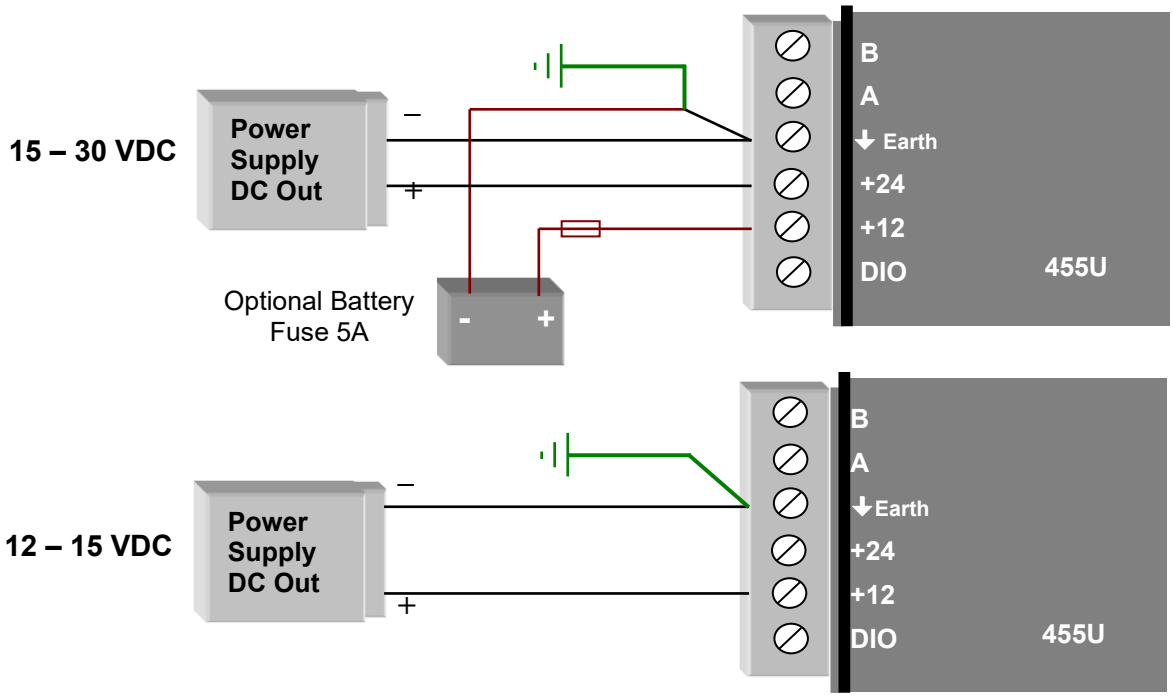
The 455U-D has a 15-28VDC "normal" supply and a 12 - 15VDC alternate supply. The supply requires a minimum capacity of 24 Watt for the high power radio version (0.5-5W) or 6W for the low radio power version (10 – 500mW).

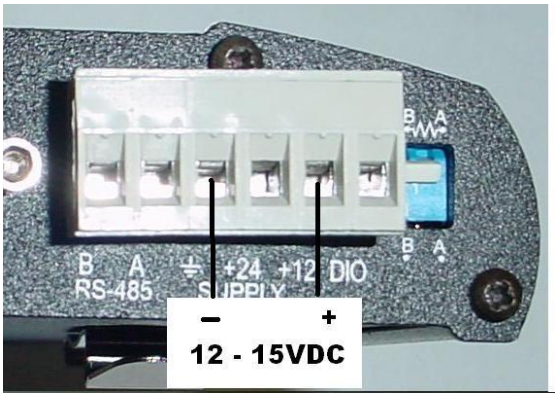
If the normal 24V supply is used, the 455U will provide battery charging for a 12V sealed lead-acid backup battery connected to the 12V terminals. The internal battery charger will provide a float charge voltage of 13.8VDC with current limit set to 0.8A (minimum supply voltage 15V).

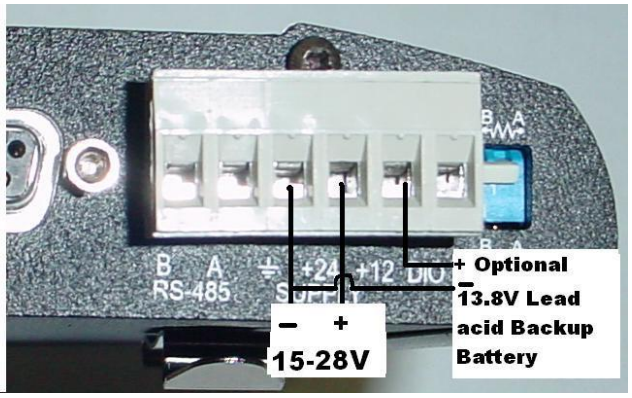
Alternately the 455U can be supplied through the "12V" terminals using a 12-15V supply.

For DC supplies, the negative side of the supply is connected to earth ("Earth" terminal). The supply negative is connected to the module case internally. The positive side of the supply **must not be connected to earth.** The DC supply may be a floating supply or negatively earthed.

The power requirements of the 455U-D units at 12VDC is 110mA (quiescent) and 2A when transmitting (5 Watt), or 450mA for 500mW.


15 – 30 VDC
Power Supply DC Out
–
+
Optional Battery Fuse 5A
-
+
B
A
Earth
+24
+12
DIO
455U
12 – 15 VDC
Power Supply DC Out
–
+
B
A
Earth
+24
+12
DIO
455U


B A ⏚ +24 +12 DIO
RS-485
SUPPLY
– +
12 - 15VDC


B A ⏚ +24 +12 DIO
RS-485
– +
15-28V
+ Optional
13.8V Lead acid Backup Battery

2.4 Serial Connections

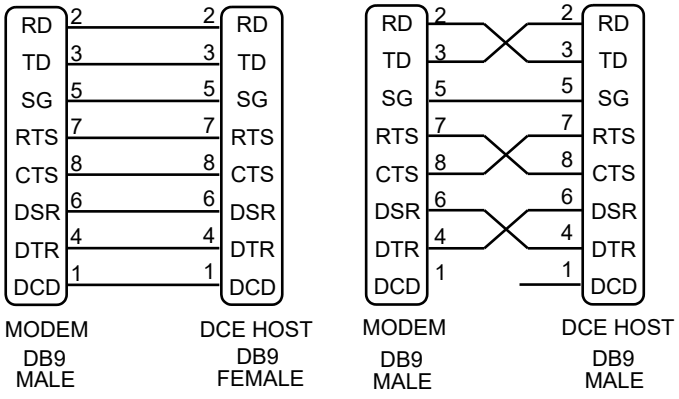
2.4.1 RS232 Serial Port

The serial port is a 9 pin DB9 female and provides for connection to a host device as well as a PC terminal for configuration, field testing and for factory testing. Communication is via standard RS232 signals. The 455U-D is configured as DCE equipment with the pinout detailed below. Hardware handshaking using the CTS/RTS lines is provided. The CTS/RTS lines can be configured to reflect the status of the local unit's input buffer. The 455U-D supports XON/XOFF flow control.

Example cable drawings for connection to a DTE host (a PC) or another DCE host (or modem) is detailed below.

DB9 Connector Pinout

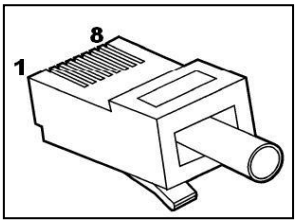
Pin	Name	Direction	Function
1	DCD	Out	**Data carrier detect** – - driven when link is established in Acknowledged mode - driven when module is online in unacknowledged mode
2	RD	Out	**Transmit Data from modem** – Serial Data Output
3	TD	In	**Receive Data into modem** – Serial Data Input
4	DTR	In	**Data Terminal Ready** - DTR can be configured to initiate low power mode, or to force a link disconnection ("hang up" in Acknowledged mode.
5	SG		**Signal Ground**
6	DSR	Out	**Data Set Ready** - always high when unit is powered on.
7	RTS	In	**Request to Send -** hardware flow control configurable
8	CTS	Out	**Clear to send -** hardware flow control configurable
9	RI	Out	**Ring indicator** - indicates another module is attempting to connect in Acknowledged mode.



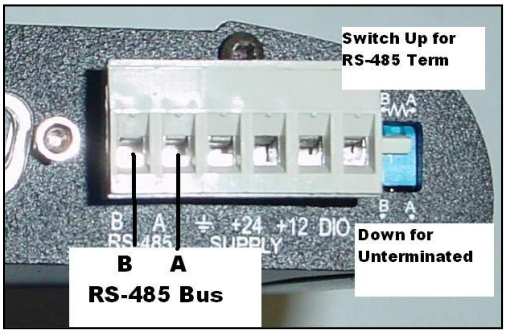
2.4.2 RS232 Configuration Port

The serial port is a 9 pin DB9 female and provides configuration and diagnostics of both the local module and of other modules in the system wile the primary RS232 port is active. This port is wired as a DCE according to EIA-561. The following table describes the connections required to connect to a PC serial port. The highlighted entries in this table are those essential for operation of the Configuration port.

RJ-45 Pins	Modem Function	EIA-561 Signal Name
1	None	Ring Indicator
2	None	Data Carrier Detect
3	**Input**	**Data Terminal Ready**
4	**Common**	**Signal Common**
5	**Output**	**Receive Data (from Modem)**
6	**Input**	**Transmit Data (to Modem)**
7	None	Clear to Send
8	None	Request to Send

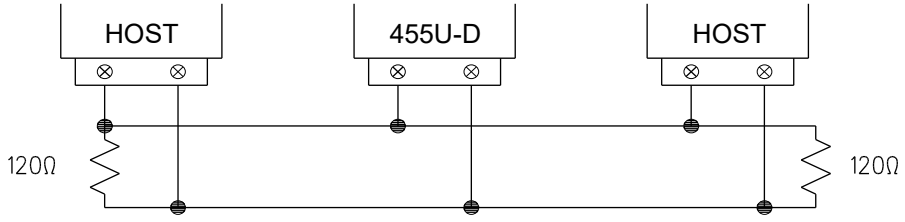


2.4.3 RS485 Serial Port



The RS485 port provides for communication between the 455U-D unit and its host device using a multi-drop cable. Up to 32 devices may be connected in each multi-drop network.

As the RS485 communication medium is shared, only one of the units on the RS485 cable may send data at any one time. Thus communication protocols based on the RS-485 standard require some type of arbitration. RS485 is a balanced, differential standard but it is recommended that shielded, twisted pair cable be used to interconnect modules to reduce potential RFI. It is important to maintain the polarity of the two RS485 wires. An RS485 network should be wired as indicated in the diagram below and



RS485 CONNECTIONS

terminated at each end of the network with a 120 ohm resistor. On-board 120 ohm resistors are provided and may be engaged by operating the single DIP switch in the end plate next to

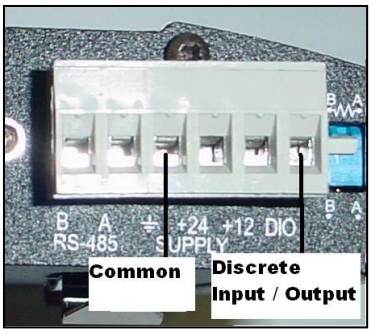
the RS485 terminals. The DIP switch should be in the "1" or "on" position to connect the resistor. If the module is not at one end of the RS485 cable, the switch should be off.

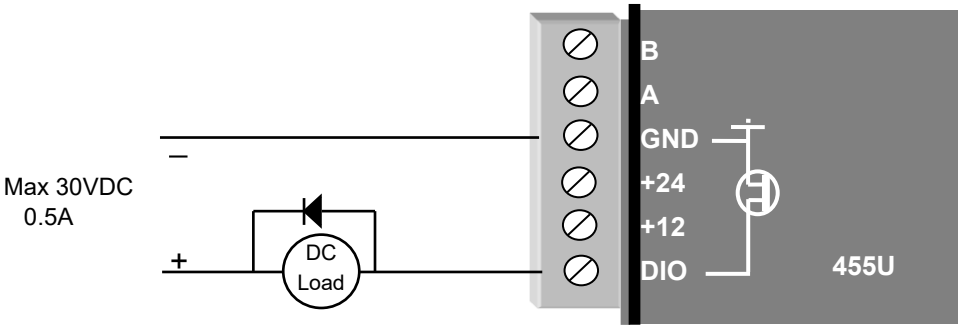
2.5 Discrete I/O Point

The 455U-D provides a single connection which can be used as a discrete input for alarms, or a discrete output, to control remote equipment,

2.5.1 Using the Discrete I/O as an Output

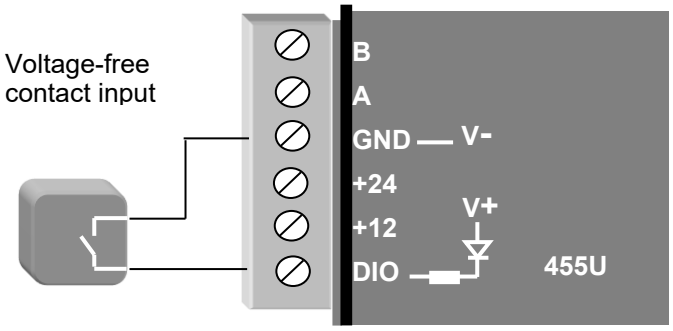
When using the DIO pin as an output, it acts as an NPN transistor to common. It can be wired to an indicator or alarm (max 30VDC, 500mA) or to a relay to remotely operate equipment. The output is controlled using the AT#O command (AT#O0 turns off, AT#O1 turns on).





2.5.2 Using the Discrete I/O point as an Input

When using the DIO pin as an input, it is activated by connecting the DIO pin to COMMON, This can be done using a voltage free contact (Relay or Switch) or a NPN transistor to common. To read the status of the Input, ensure the output function is disabled (AT#O0) and read S-Register S33.



Note: The DIO channel is not available when the 455U unit is part of a Dual Redundant pair.

Chapter Three CONFIGURATION

3.1 Before Configuring

Configuration comprises selecting parameter values for the operation of the 455U-D unit.

Before you start configuration, parameter settings must be decided. The main parameters are:-

- Addressing - system address and unit address.
- Character type. You need to find out the character type of the host devices connected to the 455U-D units. The most common character type is 8 data bits, no parity, 1 start bit and 1 stop bit.
- Serial Data Rate. You need to find out the serial data rate used by the host devices. It is possible to have different serial rates configured at different modules in the same system.
- Radio Data Rate. You need to decide what radio data rate you wish to use. It does not have to be the same as the serial data rate. We recommend that you use 4800 bits/sec for 12.5KHz channel width or 9600 bits/sec for 25KHz channel - unless your application requires the faster data rate to operate reliably. The radio range for the top data rate (9600/19200 bits/sec) will not be as good as that for 4800/9600.
- Operating mode. You need to decide which operating mode you wish to use. Modes are Unacknowledged or Acknowledged, error-checked or no-error-check. These modes are discussed in Chapter 1 and in more detail in following sections.

The other configuration parameters usually do not need to be changed, and are provided as a means of "fine tuning" the operation of the 455U-D units.

Configuration may be achieved by three different methods:

1. Using a Windows configuration program run on a PC. This is the most common way of configuring.
2. Using Hayes AT commands. This method can be performed manually by the user from a PC terminal (for example, Hyperterminal), or can be performed automatically by the host device.
3. Using the single DIP switch located in the end-plate of the module. This restores the module to a factory default configuration which is suitable for a point-to-point unacknowledged mode link.

3.1.1 Addressing

A 455U-D network comprises modules with the same “system” address. The system address is a 16 bit value, 0 to 65 535 (two 16-bit registers, each with values 0 to 255). Only modules with the same system address will communicate with each other. This feature allows more than one system to operate in the same area on the same radio channel. If you are adding another module to an existing system, use the same value as the existing modules. If you are starting a new system, select random values and use the same value for each module.

Each module is also configured with a unit address between 1 and 127 - this gives the module a unique identification.

The two data ports on the 455U-D can be addressed based on the unit address. The RS232 port is accessed using the unit address, and the RS485 port is accessed using the configured unit address +128. So, to access the RS232 port on unit 7, use address 7. To access the RS485 port on this unit, use address 135 (128+7).

Addresses 0 and 128 are reserved as "wildcard" addresses. Sending a message to address 0 results in all modules accepting the message and outputting via the RS232 ports. Address 128 is the wildcard address for every RS485 port in the system.

Every modem can also act as a repeater unit for other modems in the system. If the modem is expected to repeat messages to the wildcard address, the repeater mode should be selected to "wild card" in the configuration.

3.1.2 Command Mode

The 455U can be either in "Command mode" or "Online". Command mode is a mode in which the 455U stops its normal operations and is waiting to accept AT commands from the host device. AT commands are a standard set of modem commands use to configure or control the modem's operations.

The 455U can be configured to power up in either command mode or online - online is the default setting.

3.2 Default Configuration

The default configuration of the 455U-D is Unacknowledged mode, no error check, no CTS/RTS flow control, serial rate 19200, radio rate 4800, character type 8/n/1. The system address will be set in the factory according to the module serial number.

The module may be forced to factory default setting by using any of the three configuration methods.

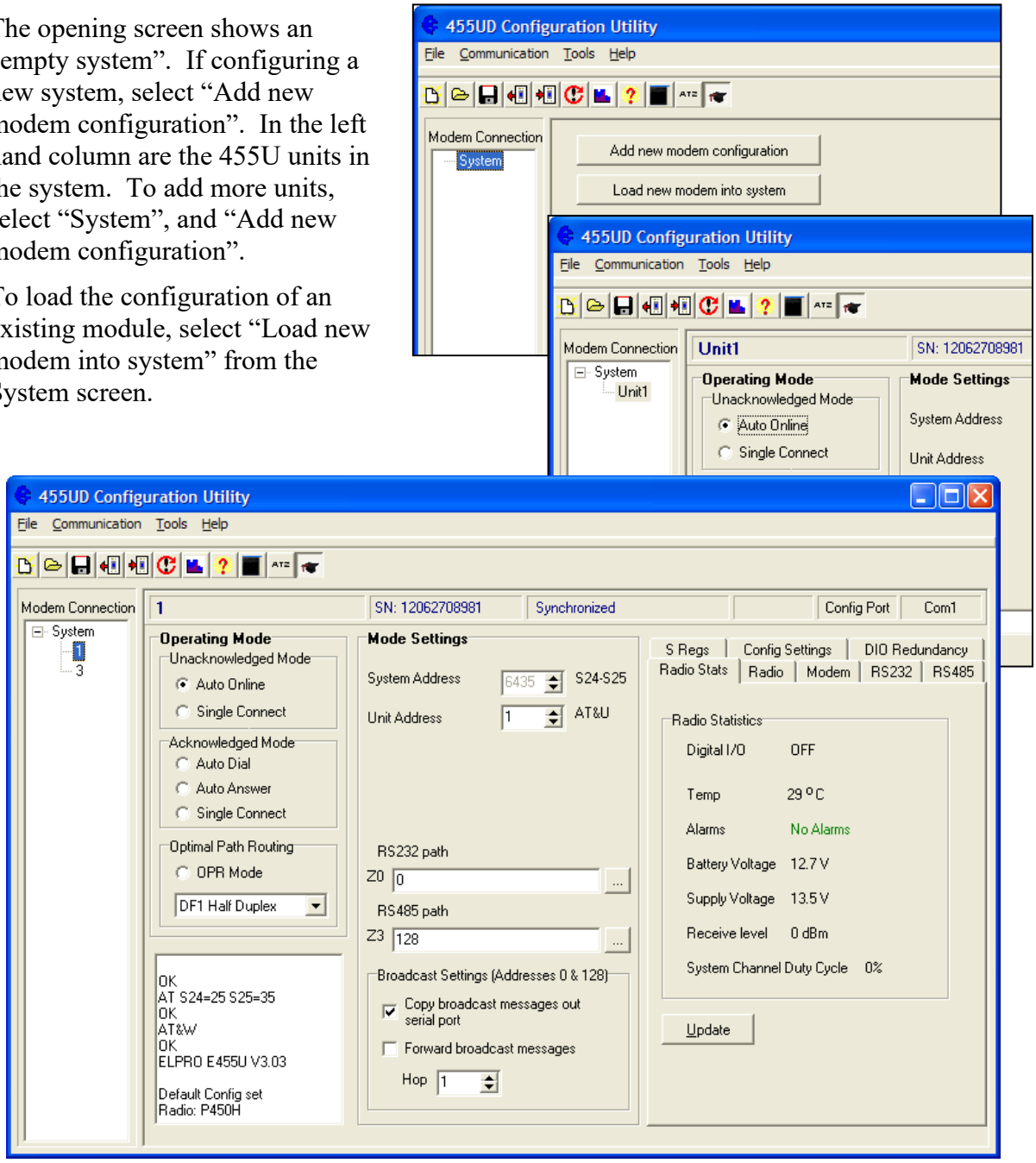
3.3 Configuration Program

The configuration program is Cfg_455U-D. This program will run under Windows XP, 98, NT, or 2000. The program may be obtained from the Product CD which came with your purchase, or can be downloaded from our web page (www.elprotech.com). When you use this program, you create a configuration in the PC and then load or program the configuration into the 455U-D module. You can also read the configuration from a module to edit.

The configuration program groups all of the configuration details of the units in one system together in one configuration file.

The opening screen shows an "empty system". If configuring a new system, select "Add new modem configuration". In the left hand column are the 455U units in the system. To add more units, select "System", and "Add new modem configuration".

To load the configuration of an existing module, select "Load new modem into system" from the System screen.



3.3.1 Reading and Configuring a module

You will need a connection cable between the PC and the 455U-D. The cable may connect to either the DB9 port or the RJ45 configuration port. Connecting to the RJ45 configuration port allows the modem to be configured while the DB9 port remains connected to the functioning host system. Connecting to the RJ45 port also allows configuration of remote modems in the system.

The cable to connect to the DB9 should have straight-through connections as per section 2.4.1 of this manual. If your PC only has USB serial connections with no RS232 port, you will need to purchase a USB to RS232 converter cable.

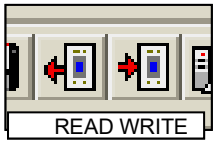
The cable to connect to the RJ45 Config port should be wired as described in section 2.4.2 of this manual.

Select the communications port that you will be using on the PC - make sure that no other program is using this com port. The program default is COM1 - if you are using a different com port, select the "Com Port Settings" icon from the toolbar and select the com port.

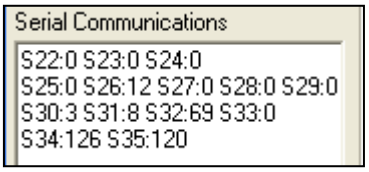
If connecting to the DB9 port, Make sure that the serial data rate and character type is the same as that already configured in the module. If you are configuring a new module, then this will be the case. If you are configuring a module which has already been in service, and you do not know this information, then you will need to force the module to factory default settings using the DIP switch in the module end plate (see section 3.10 of this manual).

If connecting to the RJ45 port, the serial data rate is fixed at 9600 baud. The character type is 8 data, No parity, 1 stop bit.

To read the configuration in a module, connect the cable and select the "Read" icon on the toolbar. To configure a module, select the "Write" icon on the toolbar.



When you read or configure a program, you will see the communication messages between the program and the module in the "Serial Communications" box in the bottom left hand corner of the program. The communication messages are Hayes AT commands being generated or read by the program.



3.3.2 Saving and Opening a configuration file

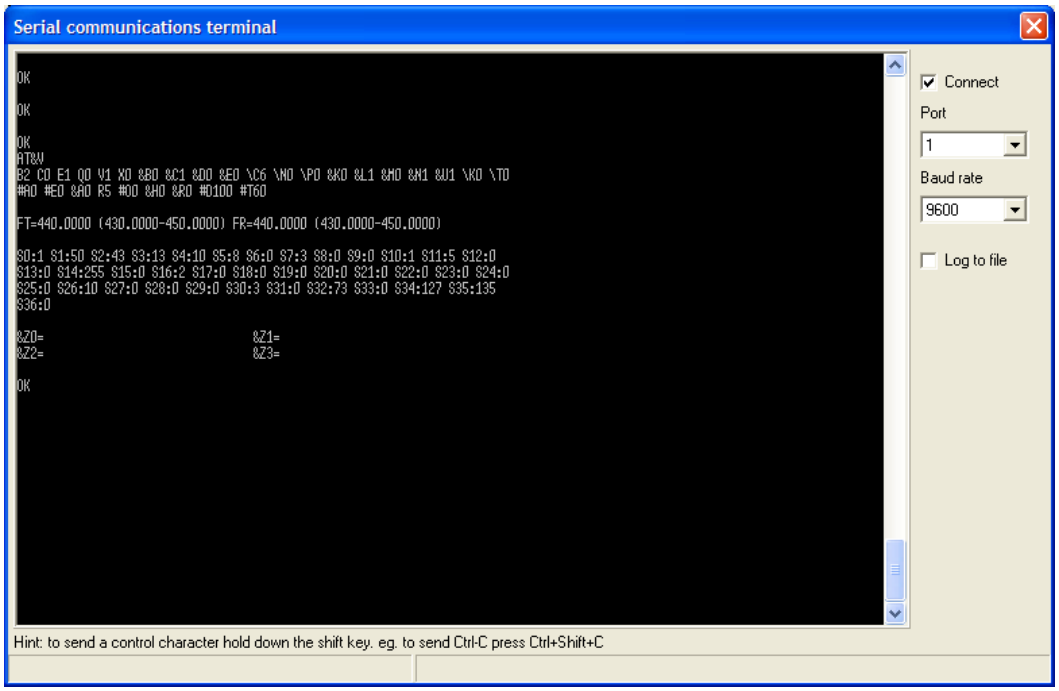
Configuration details may be saved to disk or read from disk. To save a configuration file, select the "Save" icon on the toolbar. The program will ask you for a filename and will give a file extension of ".55D". For example, "PLC57.55D". To open an archived file, select the "Open" icon on the toolbar.

3.3.3 Modifying an existing configuration

If you read a configuration from a module or a saved file, the program will display the configuration parameters. You can change these parameters and then program the module and/or save the file.

3.3.4 Serial Communications terminal

From the Tool bar at the top of the page you can also select a basic serial communications terminal similar to Windows Hyperterminal for basic command line interface with the modem, e.g. will allow manual typing of Hayes AT commands.



3.3.5 Reset and Advanced mode

The Tool bar also has a Reset button that will send a Reset command to the modem (same as the ATZ Hayes command on the Terminal)

Also the last button toggles between normal and advanced viewing modes.

This operation turns off the ability to display some of the advanced feature tabs of the software (S Reg, Config settings, radio, modem) and some of the Broadcast settings under Mode Settings.

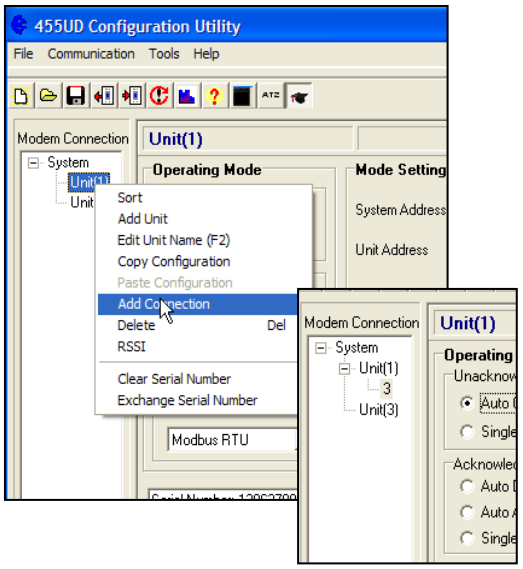
3.4 Remote Configuration and Diagnostics

Most of the configuration features of the 455U-D modem can be accessed remotely over the radio network. Remote configuration is accessed by connecting to the RJ-45 configuration port on the local modem, and using either the configuration software or AT commands. Refer to section 3.3.1 for information on setting up the PC Com port.

Before attempting to use this function, ensure that remote configuration and diagnostics is enabled at the remote modem. This selection is found under the "Modem" tab in the configuration package or use Hayes command AT#A1. If a password is configured at the remote site, ensure that this is known.

To access the configuration and diagnostics of a remote modem, first make a "connection" from the local 455U-D unit to the other unit. Right-click on the unit in the left-hand menu of the Configuration program - in the diagram, Unit 1 is the local modem.

Select "Add Connection" and then enter the address of the destination unit, including any repeaters.

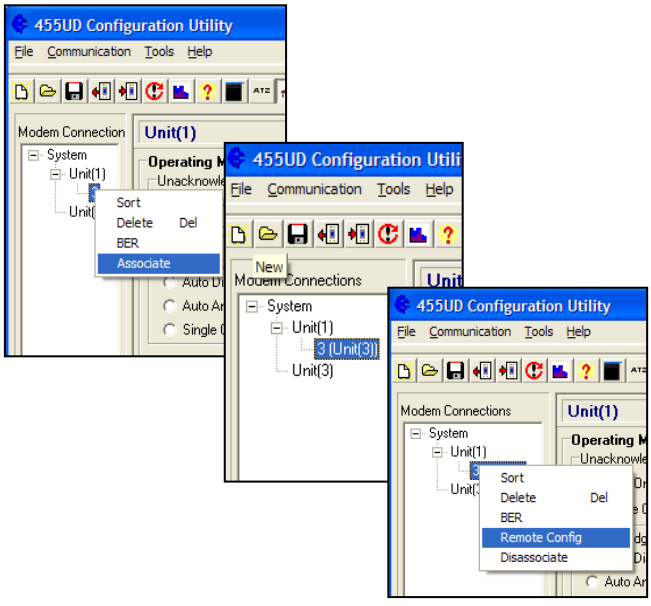


In this example, the destination address is 3.

After creating a connection, you need to create an "Association" with this module. Right-click the Connection on the left-hand menu and select "Associate" - the modules which have been entered into the system file are shown. Select the module which relates to this remote connection. In this example, connection "3" is associated with "Unit 3".

Once the Association is made, right-click the Associated connection and select "Remote configuration". Make sure that you are connected to the second RS232 port (RJ45 connection).

If the remote modem is configured to request a password (AT#P command) the password will be requested at this point.



Using AT commands:

Connection to the remote modem is accessed using the ATD command on the local RJ-45 configuration port:

ATDxxx	Remote Configuration and Diagnostics Access (RJ45 port only)
ATD3	Access remote diagnostics on station address 3
ATD3,4,5	Access remote diagnostics on station address 5 using stations 3 and 4 as intermediate repeater stations.

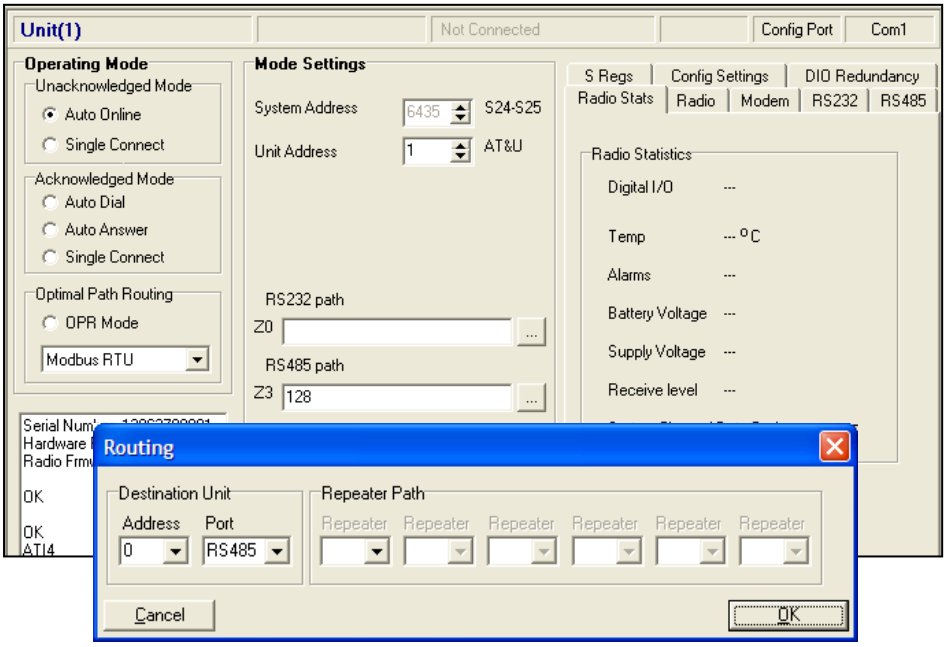
3.5 Unacknowledged Mode

The default setting of the program is Unacknowledged mode (refer section 1). Select the system address or use the random value already selected - if the module is to become part of an existing system then you must select the same system address as the existing modules.

Select a unit address for the module. Giving each module a unique unit address allows the modules to be accessed over the radio using remote configuration and diagnostics

3.5.1 RS-485 Port

The RS-485 port always operates in unacknowledged mode and starts up online. If you are using the Configuration software, click on the "RS485 path" box - a destination selection panel will appear.



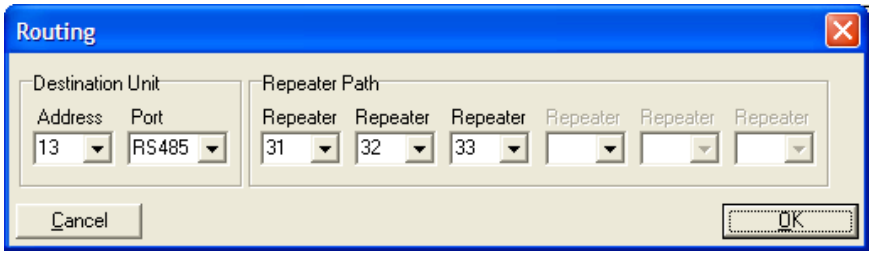
In the left-hand part of the box, select the destination Address and port type - RS232 or RS485. If there are repeater addresses, select them in sequence from the right-hand box. When you click OK, the remote port address and any repeater addresses is automatically entered into the RS485 path box.

You can use the wildcard address 0 if you wish to broadcast messages to all remote units.

You can have up to six repeater addresses. If you are using repeaters, then the right-hand box is where the repeater paths are entered. If there is only one repeater, then the repeater address is entered into the first box under the Repeater Paths, if two repeaters, then the two repeaters

are entered into the repeater path boxes with the first repeater in the most left-hand box… and so on for multiple repeaters.

For example, if you want to set up a link to remote unit 13 via units 31, 32, 33 (in this order) then you would select:



If you want to use repeaters in broadcast transmissions, refer to the section on *Broadcast Repeaters.*

If configuring with AT commands:

- The destination address for the RS485 port is in auto dial location 3 (AT&Z3).

3.5.2 RS-232 Port

The RS232 port can be configured for “auto connect” or “single connect”.

Auto connect means that the 455U-D will start up online. This will be indicated by the LINK LED going green.

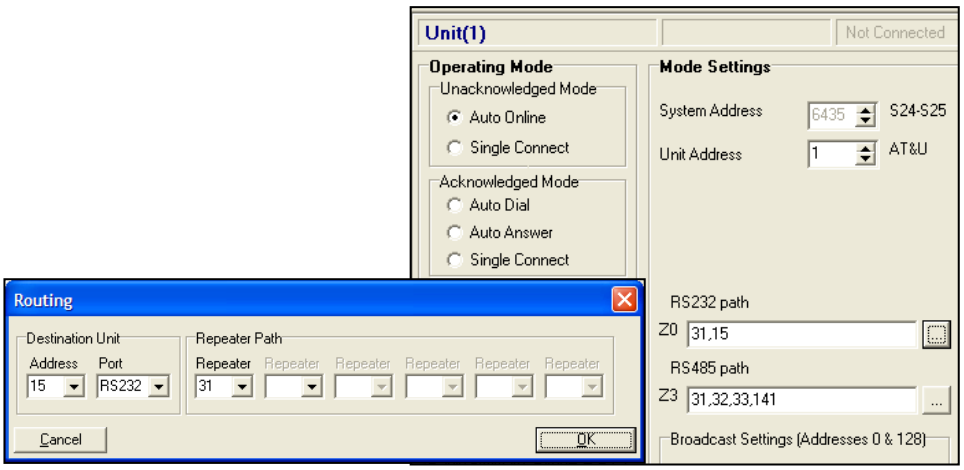
Single connect means that the unit will start up in command mode, and will not go online until it receives the correct AT command.

In Unacknowledged mode, the normal setting is auto connect. If single connect is selected, then the destination address is normally controlled by the host device using AT commands.

> *Note that the auto connect or single connect setting has no effect on the RS485 port - it is always auto connect.*

You can enter the destination address for the RS232 port in the same way as described above for the RS485 port.

In this example, the destination port is the RS232 port on unit 15, via repeater 31.



If using AT commands:

- Auto connect is set by selecting Unacknowledged mode (AT&M0) and fixed line mode (AT&L1) and by configuring a destination address into auto dial location 0 (AT&Z0).
- Single connect is set by selecting Unacknowledged mode (AT&M0) and deselecting fixed line mode (AT&L0). In this mode, the modem will go to command mode as soon as it is powered up. The RS232 port will print the message "OK" and wait for commands. The host software chooses which remote module to configure by issuing a dial command (ATD). As soon as the Dial command is issued, the modem will issue a "Connect" message and go on-line. This will be indicated by the LINK LED going green. All messages received at the RS-232 serial port are sent to the dialed address. Use the wildcard address (0 or 128) to send messages to multiple units in the system.

3.5.3 Unacknowledged mode Repeaters

Every 455U-D module automatically acts as a repeater by including its address in the address list.

For example, if unit 31 receives a message with address <31,15>, it will repeat the message onto unit 15. Unit 31 will not output the message on its serial port unless it is configured to do so.

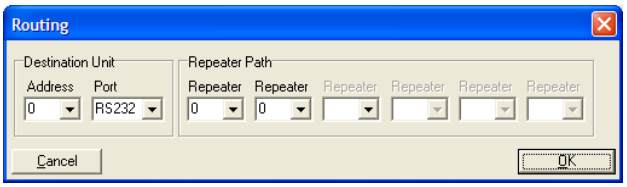
If you are using repeaters for broadcast messages, care must be taken.

3.5.4 Broadcast Network

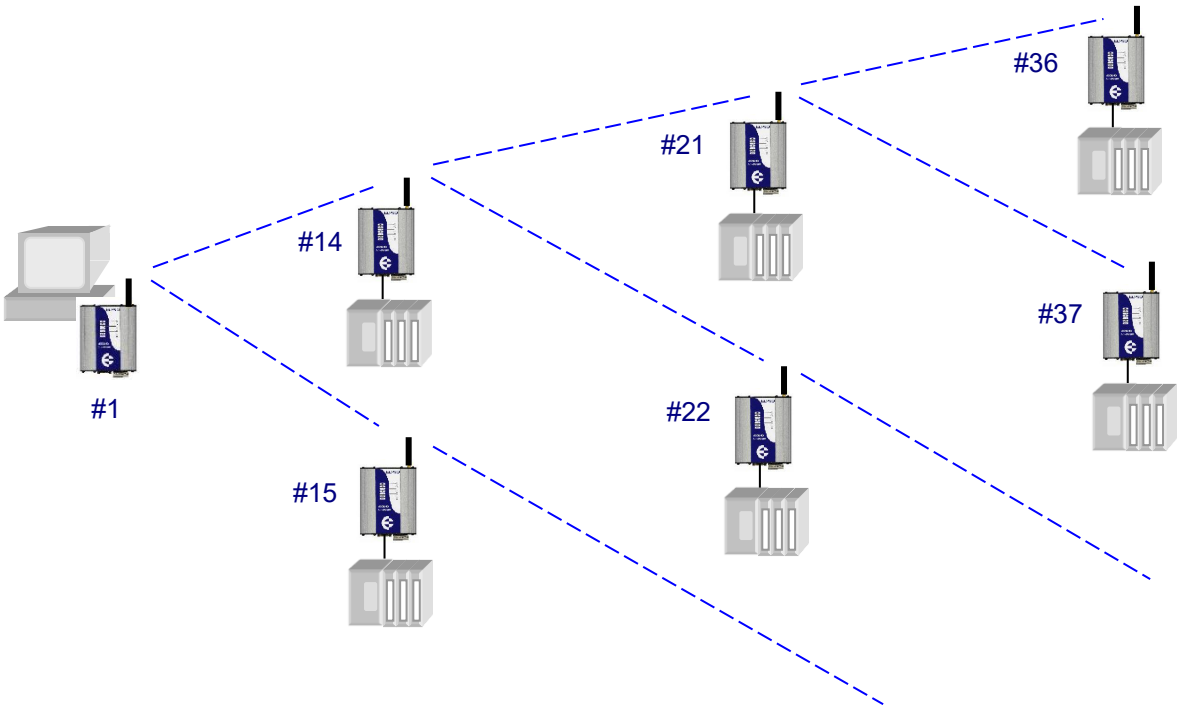
You may want a multi-hop network to broadcast messages. This takes some care at the repeater nodes to ensure that individual repeaters do not repeat messages that they have already repeated, and also to avoid an "end-node" receiving the same message multiple times.

Note - Before deciding to implement a multi-hop broadcast network, check the section below on Optimum Path Routing. If your communication uses Modbus, DF1, or DNP3 protocols, OPR may be a better way to implement your network.

You can set up a broadcast network by using address strings of the form <0,0,0> etc. That is, the destination address is the wildcard 0 and the repeater addresses are the wildcard 0.



Consider the following network:



This network has a maximum of three "hops" - to reach the most remote units, there needs to be three transmissions or hops. Unit 1 needs to transmit with address <0,0,0> - that is, three hops.

3.5.5 Addressed Network

Alternatively the messages can be directed through fixed addresses – using the same network as used in the broadcast above

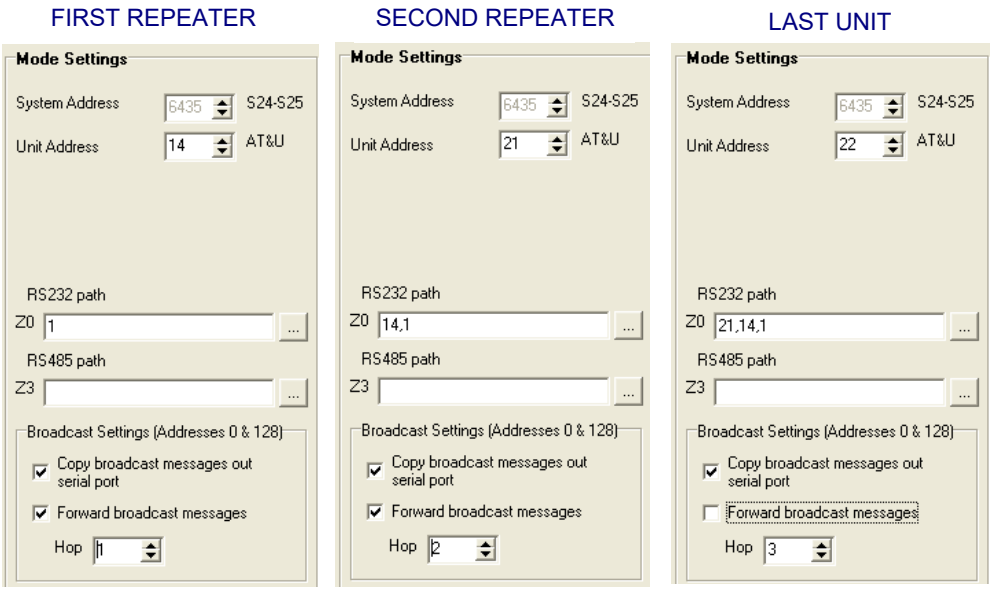
The first ring of repeaters (units 14 and 15) need to be configured as below:

The "Forward Broadcast Messages" box is selected to allow these units to repeat the broadcast messages on.

The "Copy broadcast messages out serial port" box is selected to pass any broadcast radio messages it receives to the device connected on the serial port.

The "Hops" box indicates the number of hops that the message has to go through before this unit will repeat the broadcast message. This is to prevent units repeating messages in the wrong sequence. In this case, "Hops" is set to 1 - repeater after the first hop.

Note that the address path for return messages is <1>.



The second ring of repeaters (units 21 and 22) need to be configured as above:

The "Forward Broadcast Messages" and the "Copy broadcast messages out serial port" boxes are both ticked so the message will be repeated and sent to the serial port.

The "Hops" box is set to 2 - repeater after the second hop. If unit 21 hears a weak message from unit 1 on the first hop, it will not repeat it.

Note that the address path for return messages is <14,1>.

The last ring of units (units 36 and 37) need to be configured as above:

The "Forward Broadcast Messages" box is NOT selected as these units are not required to act as repeaters.

The "Copy broadcast messages out serial port" box is selected to pass any broadcast radio messages it receives to its host device connected to the serial port.

The "Hops" box is set to 3 - this means that it will only accept messages on the third hop.

If it hears a weak message transmitted from unit 1 or 14, it will ignore it.

Note that the address path for return messages is <21,14,1>.

3.5.6 Multiple Transmissions

Units in Unacknowledged mode may be configured to send each message multiple times. The number of transmissions is configured in S-Register S29. The receiving unit will detect repeat messages and only send the data out the serial port once.

3.6 Radio and Serial Configuration

3.6.1 Radio Data Rate

Select the "Radio" tab and select the radio data rate which you want to use. Note that modules will only communicate with each other if they have the same radio data rate.

3.6.2 Serial Port Settings

Select the "RS232" or "RS485" tabs. The serial port settings should be selected to match the host device. Different port settings may be selected for different modules in the same system.

Serial data rate can be selected between 600 and 187,500 baud. If the serial rate is less than the radio data rate, the 455U-D will automatically set transmission delay parameters in registers S18 and S19 (refer section 1.5.1). To disable this, set the S18 and S19 values to zero in the RS232 Serial configuration window. For the RS485 port, registers S20 and S21 are used.

The number of Data Bits can be selected as 7 or 8. The number of stop bits can be 1 or 2. Parity can be none, even or odd.

PLC-Mode

Refer to Section 1 of this manual for an explanation of PLC-Mode. This mode is a enabled by default however may be disabled individually for the RS485 and RS232 ports.

If the radio or serial rate is changed, select "Recalculate Threshold and Timeout" under the RS232 or RS485 window.

Flow Control

"Flow control" affects the use of the CTS and RTS signals on the RS232 port. These signals can be used to prevent overflow of the input buffer or output buffer of the 455U-D. The settings should be selected to match the host device. The options for this setting are :

- "None" - The RTS signal from the host is ignored and the 455U-D sets the CTS signal always on.
- "CTS/RTS" - input buffer flow control - the 455U-D will reset the CTS signal when its input buffer is full
- "XON / XOFF" the modem uses the XON and XOFF symbols to control flow of data. This protocol should not be used with raw binary data, as the raw data may contain the

XON and XOFF characters. This flow control method is only suitable for use with ASCII data.

3.6.3 Other Settings

Select the "Modem" tab:

CRC Error Checking for transmitted messages

It is normal for error checking to be disabled for Unacknowledged mode and enabled for Acknowledged. However you can select either for either mode, and separately select for the RS-232 port and the RS485 port. The modem is always able to receive messages both with and without error checking, so different modems in the system may be configured with different error checking options.

Security Encryption

Data Encryption may be set to:

- "Disabled" setting allows the modem to receive both encrypted and unencrypted messages, but the modem will only transmit unencrypted messages.
- "Enabled on TX" causes the modem to transmit encrypted messages and to receive both encrypted and unencrypted messages.
- "Forced on RX" causes the modem to transmit encrypted messages and only accept messages which are encrypted.

Note that the encryption keys must be set up in each modem to the same values to allow the modem to decrypt encrypted data correctly. If incorrect encryption keys are entered, the data will be forwarded out the correct port, but will not be correctly decrypted at the receiver. To set the security key, connect to the modem locally and use the configuration software, or using AT commands, enter the command AT#S. Note that the security key can not be changed remotely.

DTR Control

The DTR signal on the RS232 port can be used for different functions.

- "Ignore DTR" - the DTR signal does not perform any function
- "Command Mode" - if the host resets DTR, the 455U-D will go into command mode - when DTR is activated, the module will revert to on-line mode
- "Command Mode, Disconnect" - as above except that the module will also force a disconnection of the communications link
- "Low Power, Disconnect" - when the host resets DTR, the module will disconnect the link and go to low power mode. If you select the "Low Power" option in the Acknowledged mode page, this selection of DTR will be automatically made - refer to the "Low Power Mode" section of this manual.

DCD Control

The DCD signal on the RS232 port can be used to give an indication of communications link status in Acknowledged mode. Note that the link is always connected in unacknowledged

mode.

- "Always On" - the 455U-D sets the DCD to be always on
- "Only High When Connected" - the DCD signal will be on when the link is connected and off when the link is reset
- "Pulse Low on Disconnect" - the DCD signal will be normally on but will switch off momentarily (for 0.5 sec) when the link is reset.

Packet Size (bytes)

This selects the maximum number of bytes which will be transmitted in one message. If more than this number of bytes is input into the 455U-D, then the module will transmit more than one message.

The default value is 1020 bytes which is the largest packet value. If you are operating in a noisy radio environment, then the system may be more reliable if you reduce the maximum packet size and transmit a larger number of small messages rather than a lesser number of large messages.

Packet size is configured via S-Register S14. The value in S14 is multiplied by four to get the maximum packet size.

Transmit and Receive Hold-off delay times

A "transmit delay" time and a "receive delay" time can be configured. These parameters may be used to fine tune and give priority to different 455U-D units in a system.

- Transmit delay - S16. After each message is transmitted, a 455U-D unit will not transmit another message during the transmit delay time. This could be used to allow a reply message to be received before the next message is sent.
- Delay time - S17. After a message is received, a message will not be transmitted during the receive delay time. This could be used to delay a reply message until other messages have been sent.

3.7 Acknowledged Mode

Refer to section 1.3. There are several configurations for Acknowledged mode:

3.7.1 Auto Dial (Auto-Connect Master)

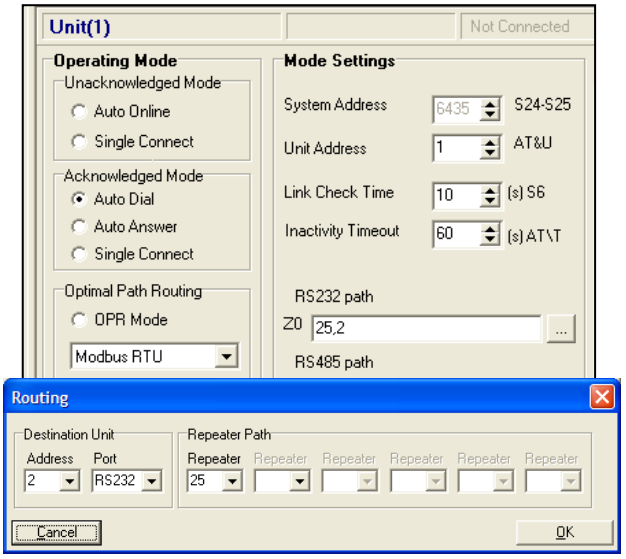
Auto-connect mode is similar to "fixed line" modem operation. The master unit wants to connect to only one slave address. Normally the slave address is preconfigured. On power up, the master unit continuously tries to connect to the slave address. The slave unit, on power up, does not try to connect but waits for a connect message. Once a connection is made, the DCD status at both ends is set and data can be transferred in either direction.

If there is no data transfer within the preconfigured "link check" time, the master will send an empty data message to check the communications link.

The connection will be broken if a communication failure occurs, or if the local or remote host's issues a "disconnect" AT command (although this would be unusual for this mode). When the master is disconnected, it will continuously try to connect to its auto-connect address.

Up to six repeater addresses may be configured as part of the auto-connect address. That is, up to 6 intermediate modules can act as repeaters between the master and slave modules.

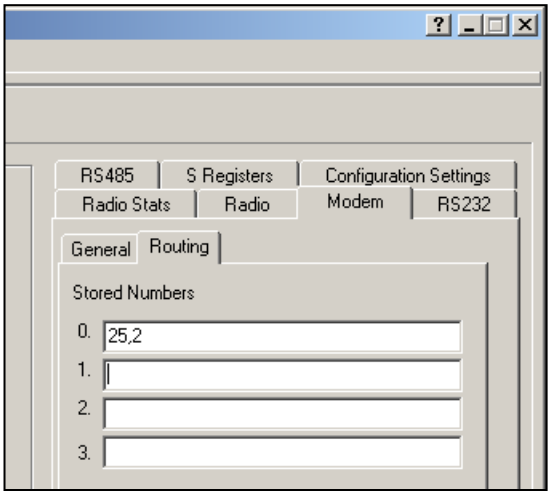
At the master unit, you need to enter the address of the slave. Select the "RS232 Path" section. Up to six repeater addresses may be entered. Repeater modules may be configured in either Acknowledged or unacknowledged mode, but they must have the same system address.



The repeater addresses are entered in order from the master - that is, the leftmost address is the first repeater after the master.

If you enter a "Link Check Time", then the master unit will send a "check message" if the check time has elapsed without any data transmissions. For example, if you enter 10 seconds, then if there is a 10 second period without a data transmission, then the master module will transmit a check message. If the slave does not acknowledge, then the master will transmit the check message up to five times (Configurable via S-30). If there is still no ACK, then the master will reset the link (DCD reset). A value of zero disables this function.

You can enter address structures for four slaves – addresses "Z0" to "Z3". However the host must use AT commands to select which slave is required. Without the use of AT commands, the master will only attempt to connect to the address configured in "Z0".

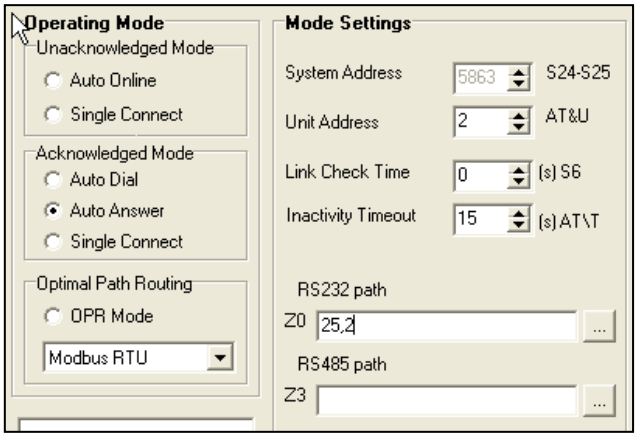


The Z0 to Z3 addresses can be configured by selecting the "Modem" tag and then the "Routing" tab.

Z3 stores the address that RS-485 messages are sent to.

3.7.2 Auto Answer (Auto-Connect Slave)

The only configuration required for an auto-connect slave module is to enter its unit address.



Its address path will be automatically taken from the Connect message from the master unit.

If you enter an "Inactivity Timeout" value, then the 455U-D will automatically reset the link if there has been no data transmission within this time. If you use the link check feature at the master unit, you should enter an "Inactivity Timeout" value to reset the link at the slave unit.

It is a good idea to use these timers as it provides a higher level of security for the Acknowledged mode system. Normally a link check time will be entered at the master unit (for example, 10 seconds), and an inactivity timeout will be entered at the slave unit (for example, 15 seconds). It is important that the inactivity timeout is greater than the link check time.

A value of zero disables these parameters.

3.7.3 Single-Connect Acknowledged mode

Single-connect is similar to a dial-up telephone modem. In this mode, the module will attempt to connect to a destination address once. A host device will issue a connect "dial" (ATD) command, and the module will send a connect message to the destination address. If the destination module responds, then the link is connected and the unit goes online. The DCD status is set (LINK LED comes on, DCD signal and DIO signal turn on if configured). If the destination module does not respond, then the initiating modem will re-try (up to the number configured in S-Register S7). If there is no response, the link is not established and no data can be transferred. The module will not attempt to reconnect again until it receives another connect command from its host.

The link is normally disconnected by the host issuing a disconnect or "hang-up ATH command. In this mode, it is normal for a host to connect and disconnect to several slave modules using AT commands. A common example is a PC polling several analyzers or dataloggers. The PC connects to a remote station one at a time, transfers data, disconnects and connects to the next station.

Up to six repeater addresses may be configured as part of the remote address. That is, up to 6 intermediate modules can act as repeaters between the master and slave modules.

The RS232 DTR signal can be configured to act as a disconnect signal. If so configured (AT&D), the DTR signal will force a hang-up (DCD reset) if the host device resets the DTR signal.

In single-connect Acknowledged mode, the host devices use AT commands to select destination addresses to connect to. Normally only a unit address is required.

3.8 Dual Redundancy

Two 455U-D modems can be setup to act as a dual-redundant pair. One unit configured as a Primary which is normally active, and the Secondary unit inactive. If the Primary detects an internal fault or operating problem, it will become inactive and the Secondary becomes active.

Dual Redundant Standby mode is implemented in Firmware versions 3.00 and later.

The trigger conditions for a change-over are:

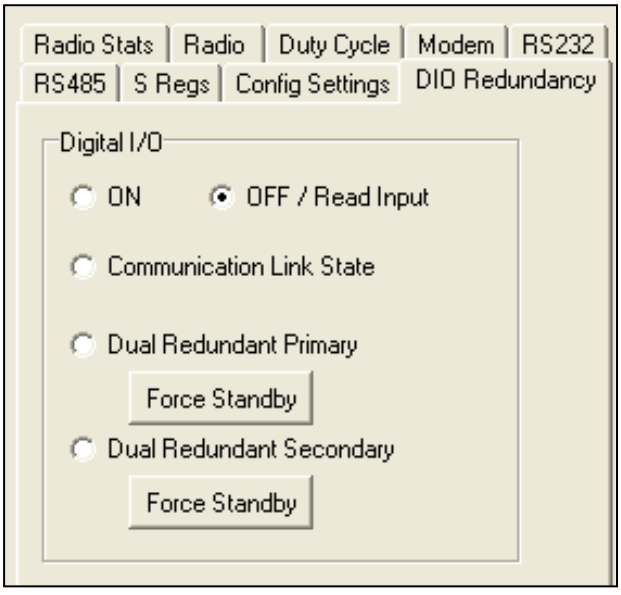
- Complete failure of the active 455U - power failure, CPU failure;
- Loss of radio communications - radio "comms-fail";
- Fault detected by internal diagnostics - over-temperature, antenna fault (high SWR), frequency failed-to-lock, or transmitter PTT timeout;
- Operator request via configuration.

To prevent change-over during short term transient fault conditions, the trigger condition must be present for a period of time before the change-over occurs. This period is configurable and can be entered via the "Change Over Delay Time" found on the "DIO Redundancy" tab or the "Dual Redundant Timeout" - S reg #11.

Note: minimum Changeover Delay time is 5 seconds.

If the primary unit changes over to the secondary unit, the secondary unit remains as the active unit until it detects a fault, or until it is forced to change by manual configuration.

The inactive unit continues to operate, and can receive messages via the radio and data ports. However it is disabled from transmitting messages on the radio and RS485 ports - it can transmit messages on the RS232 port.



Both the primary and standby units should have the same configuration except for the Redundancy setting. The redundancy setting can be configured from the "DIO Redundancy" tab, which also displays the current redundancy status.

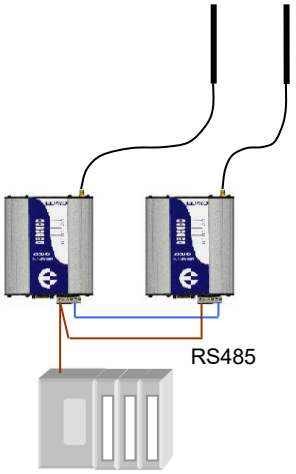
If configuraing using Hayes commands the Dual Redundancy is set via the AT#O command ("Control digital I/O function").

- Force a changeover from primary to secondary, use command AT#O5.
- Force a changeover from secondary to primary, use the command AT#O6.
- Status of the Dual Redundant system is displayed in register S33.

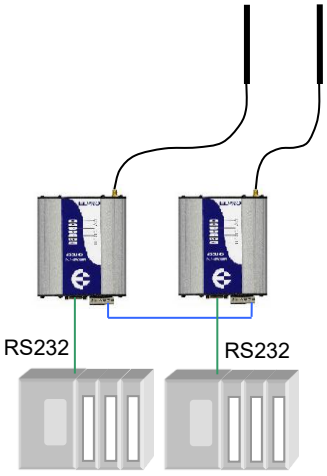
S33 Value	Dual Redundant State
2	Active Primary
3	Active Secondary
4	Active Primary – no secondary detected
5	Inactive Primary
6	Inactive Secondary

3.8.1 Single Host Device

If the 455U redundant pair are connected to a single host device, they should be connected via RS485 - both 455U units will hear all data messages, but only the active 455U unit will send messages.



REDUNDANT PAIR WITH SINGLE HOST USING RS485



REDUNDANT PAIR WITH REDUNDANT HOSTS USING RS232

3.8.2 Redundant Host Pair

If the host device is duplicated as a redundant pair, with an individual host connected to an individual 455U, then RS232 should be used - the 455U will receive and send serial messages, however only the active 455U will transmit via the radio.

3.8.3 Dual Redundanct Control Connection

The DIO channels on the two units are connected - this connection forms the Dual Redundant Control Connection.

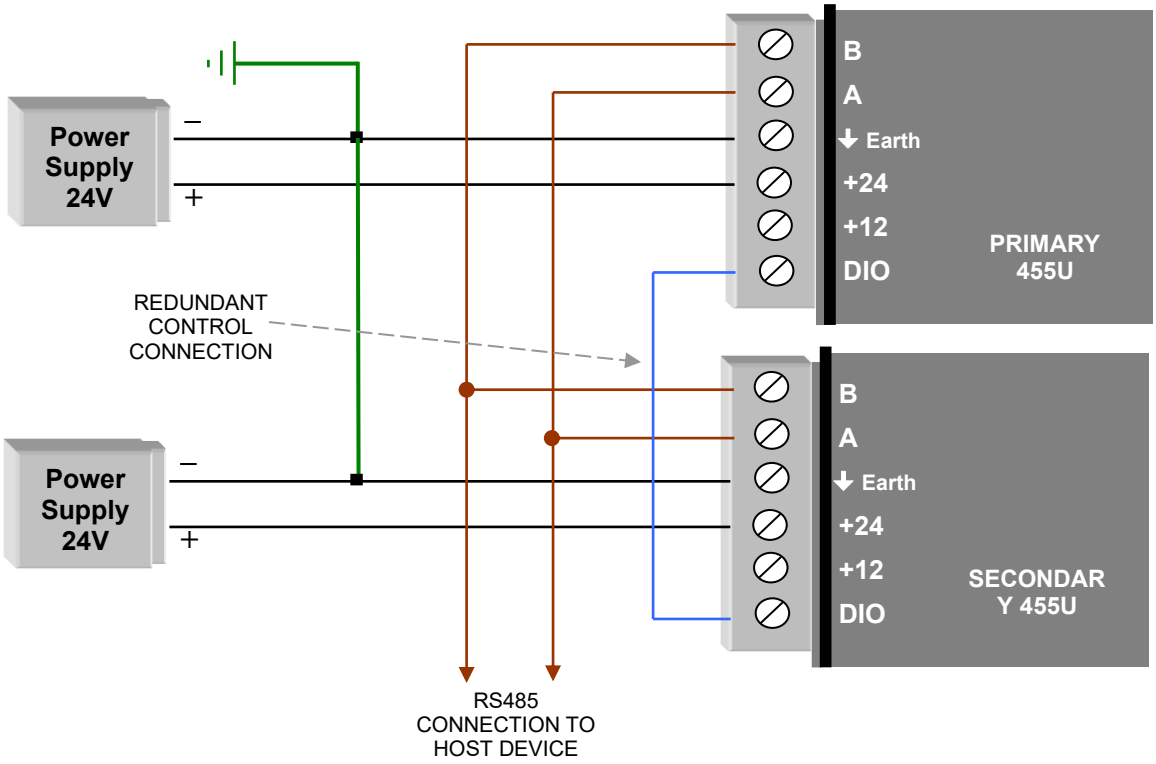
Note: The DIO channel is not available for any other purpose when the 455U unit is connected to a redundant module.

If the Dual Redundant Control Connection becomes disconnected, then the two units will remain in their previous active/in-active state.

Redundant units should be connected to separate power supplies and **must be connected to separate antennas and coaxial cables.**

Although only one antenna will transmit at any one time, care must be taken with the installation of the two antennas to avoid one antenna affecting the radiation pattern of the other. The antennas should be installed at least 2 meters (6 feet) apart.

TYPICAL REDUNDANT WIRING INSTALLATION



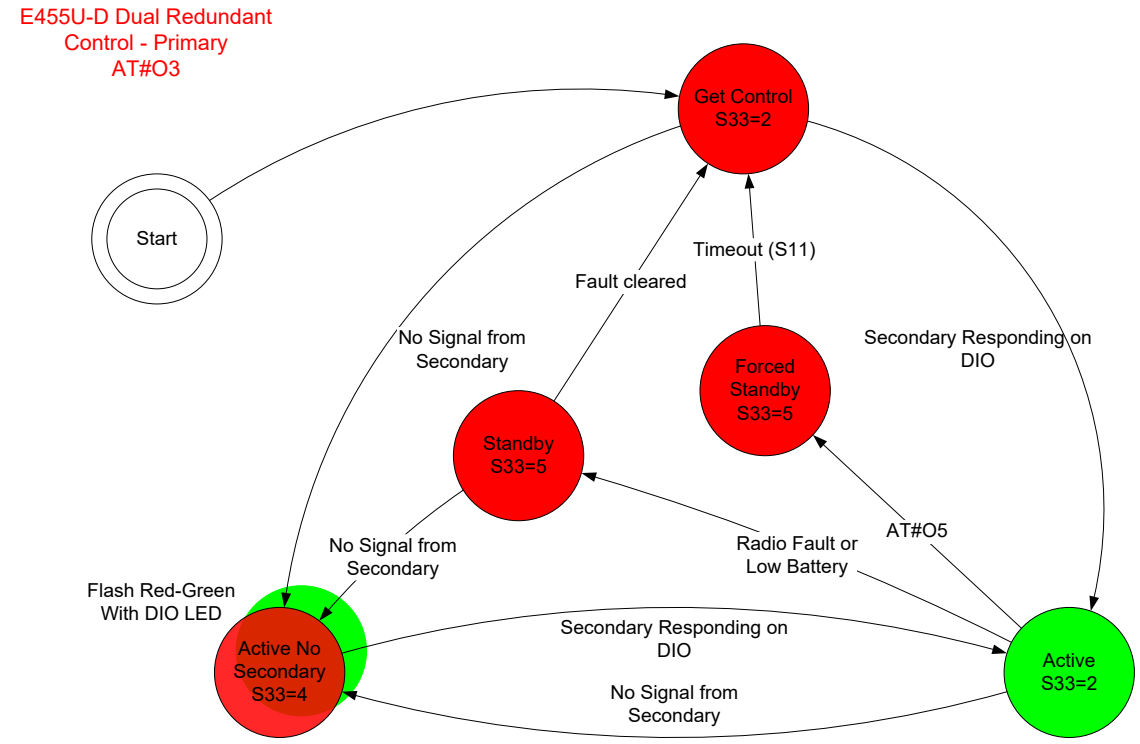
3.8.4 Dual Redundant Indications

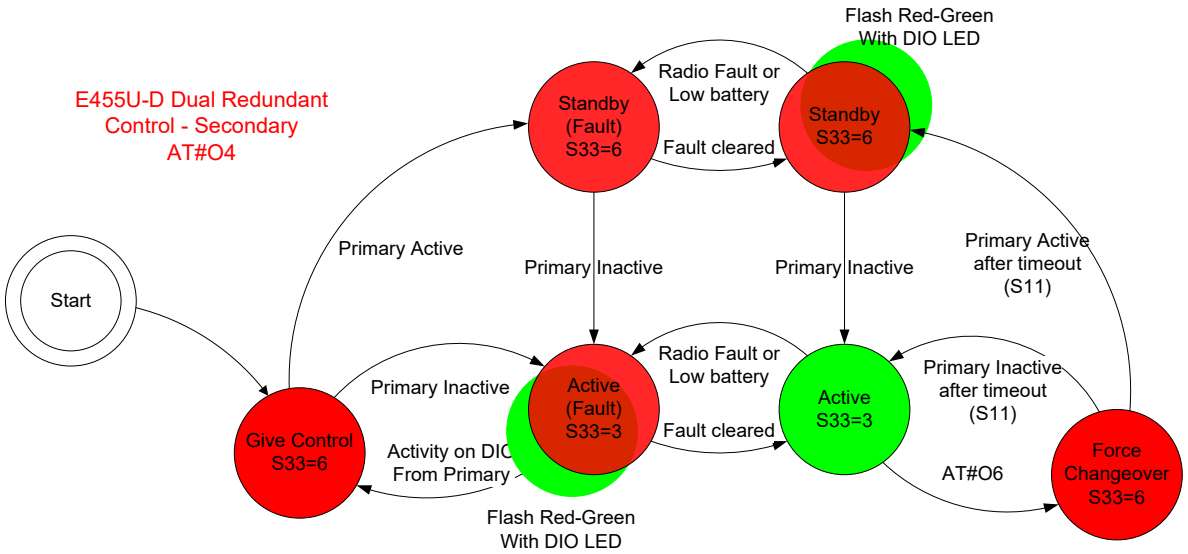
To check the state of the Dual redundant system, you can:

- Observe the DIO LEDs on the two modules. These LEDs should be flashing together. Refer to the following table to diagnose the flashing LEDs (Firmware version 3.03 and later)

Primary OK LED	Primary DIO LED	Secondary OK LED	Secondary DIO LED	System Status
Green	Flash ½ Sec Off, 1½ sec On	Flash ½ Sec Red, 1½ sec Green	Flash ½ Sec Off, 1½ sec On	Normal Operation. Primary is active. Secondary is ready to take over
Flash 1 sec Red, 1 sec Green	Flash 1 sec On, 1 sec Off	Red	Flash 1 sec On, 1 sec Off	Secondary Fault. Primary is active. Secondary may be able to take over if primary fails completely
Flash 1 sec Red, 1 sec Green	Flash 1 sec On, 1 sec Off	Fast Flash 0.4 sec Red, 0.1 sec green	Off	Secondary Low voltage shutdown. Primary is active. Secondary cannot take over if Primary fails.
Flash 1 sec Red, 1 sec Green	Flash 1 sec On, 1 sec Off	Red	Off	Secondary Module Failure. Primary is active. Secondary cannot take over if Primary fails.
Flash 1 sec Red, 1 sec Green	Flash 1 sec On, 1 sec Off	Off	Off	Secondary No Power. Primary is active
Red	Flash 2 sec Off, ½ sec On	Green	Flash 2 sec Off, ½ sec On	Primary Fault. Secondary is active. Primary may be able to take over if Secondary fails completely.
Red	Flash 2 sec Off, ½ sec On	Flash 2 sec Red, ½ sec Green	Flash 2 sec Off, ½ sec On	Primary Fault and Secondary Fault. Secondary is active. Primary may be able to take over if secondary fails completely.
Fast Flash 0.4 sec Red, 0.1 sec green	Off	Green	Flash 2 sec Off, ½ sec On	Primary Low voltage Shutdown. Secondary is active. Primary cannot take over if Secondary fails.
Fast Flash 0.4 sec Red, 0.1 sec green	Off	Flash 2 sec Red, 1/2 sec Green	Flash 2 sec Off, ½ sec On	Primary Low Voltage Shutdown and Secondary Fault. Secondary is active. Primary cannot take over
Red	Off	Green	Flash 2 sec Off, ½ sec On	Primary Module Failure. Secondary is active
Red	Off	Flash 2 sec Red, ½ sec Green	Flash 2 sec Off, ½ sec On	Primary Module Failure and Secondary Fault. Secondary is active.
Off	Off	Green	Flash 2 sec Off, ½ sec On	Primary No Power. Secondary is active
Off	Off	Flash 2 sec Red, ½ sec Green	Flash 2 sec Off, ½ sec On	Primary No Power and Secondary Fault. Secondary is active.
Other				Incorrect Configuration or Wiring error

The following diagram shows the states of the dual redundant system, the relationship to the AT#O commands, the OK LED state, and S-registers S33 and S11 (Firmware versions 3.03 and later).



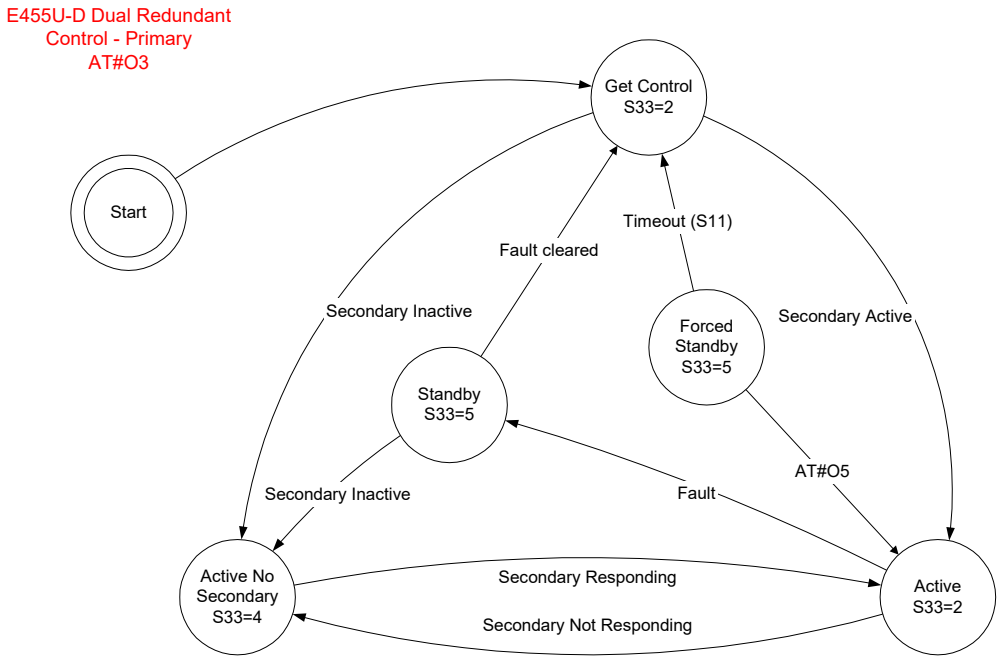


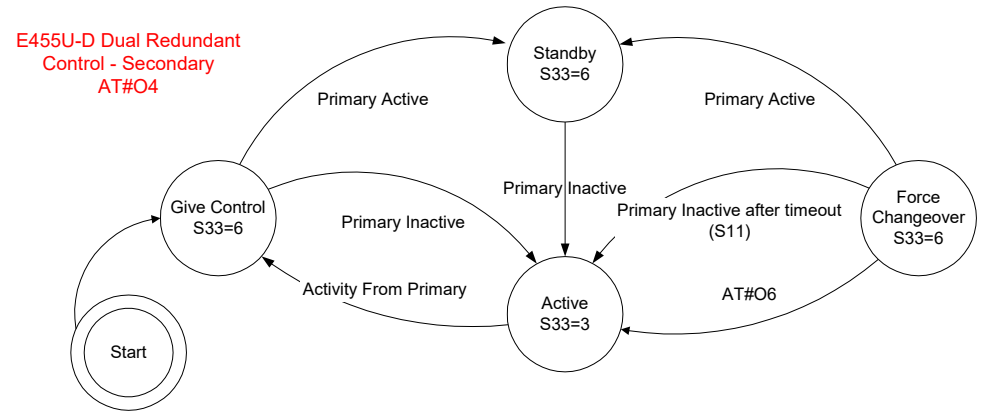
3.8.5 Firmware versions prior to 3.03

Firmware version 3.03 introduced enhanced diagnostics by flashing the OK LED in synchronisation with the DIO LEDs. For firmware versions 3.00 to 3.02, refer to the following diagrams indicating the LED diagnostics and Redundancy state diagrams.

LED Indicator	Redundancy Status
1½ sec on, ½ sec off.	Normal operation. Primary is active, Secondary is inactive but functional
1 second on, 1 second off	Secondary Fault. Primary is active, Secondary is inactive and has a fault
½ second on, 2 seconds off	Secondary is active, Primary is inactive and has a fault
Always On	Hardware fault on I/O Circuit or module fault - disconnect wire to determine which module is functional.

The following diagram shows the states of the dual redundant system and the relationship to the AT#O commands, and S-registers S33 and S11 (Firmware versions 3.00 to 3.02).



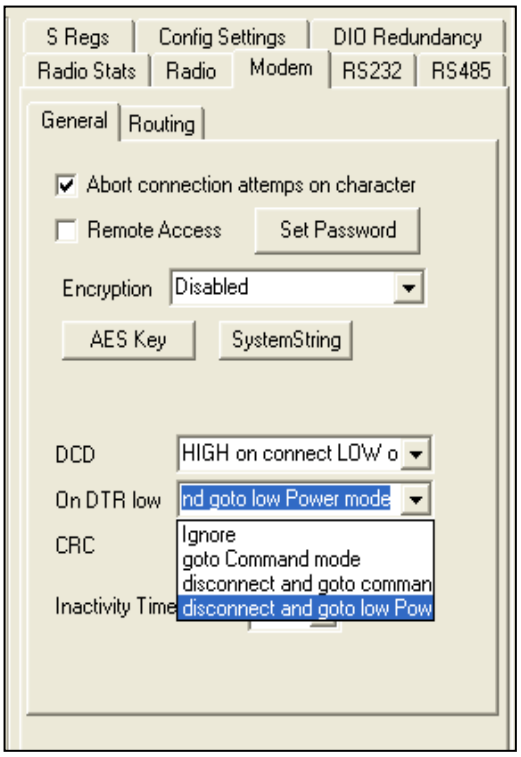


3.9 Low Power Mode

The modem can be configured for low power shutdown when the DTR signal on the data RS232 port is “reset”. In this state the supply current is reduced to approx 50% of normal load and the modem will not receive or transmit radio messages.

When in low-power shutdown mode, the OK Led flashes red-green at a 2Hz rate (red 400 msec, green 100 msec).

This is configured in the Modem/General screen, or using the AT&D Hayes command (AT&D3 to enable).



The use of this low power operation may be applicable in remote locations where there is a limited power supply such as solar panels. In this situation, the DTR signal from the host device is used to “wake-up” the 455U-D unit. The 455U-D unit will then operate normally until the DTR signal is reset by the host device.

In addition, the modem will go to low power mode if the 12V supply becomes too low. This feature is designed for battery backup use. The 455U monitors its battery supply, and if the battery voltage falls below 10.7 volts for more than 5 seconds, the modem goes to low-power shutdown state. The battery supply must rise back above 11.7 volts before the modem will exit low-power shutdown mode.

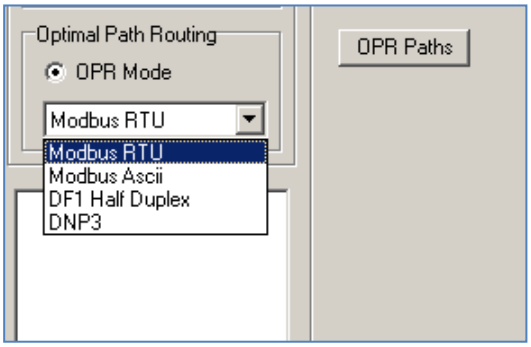
If the modem shuts down because of low voltage, asserting DTR at the RS-232 port will not cause the unit to “wake”. The unit can be forced to normal operation from low power shutdown by plugging a configuration cable to the CONFIG port (with DTR line connected).

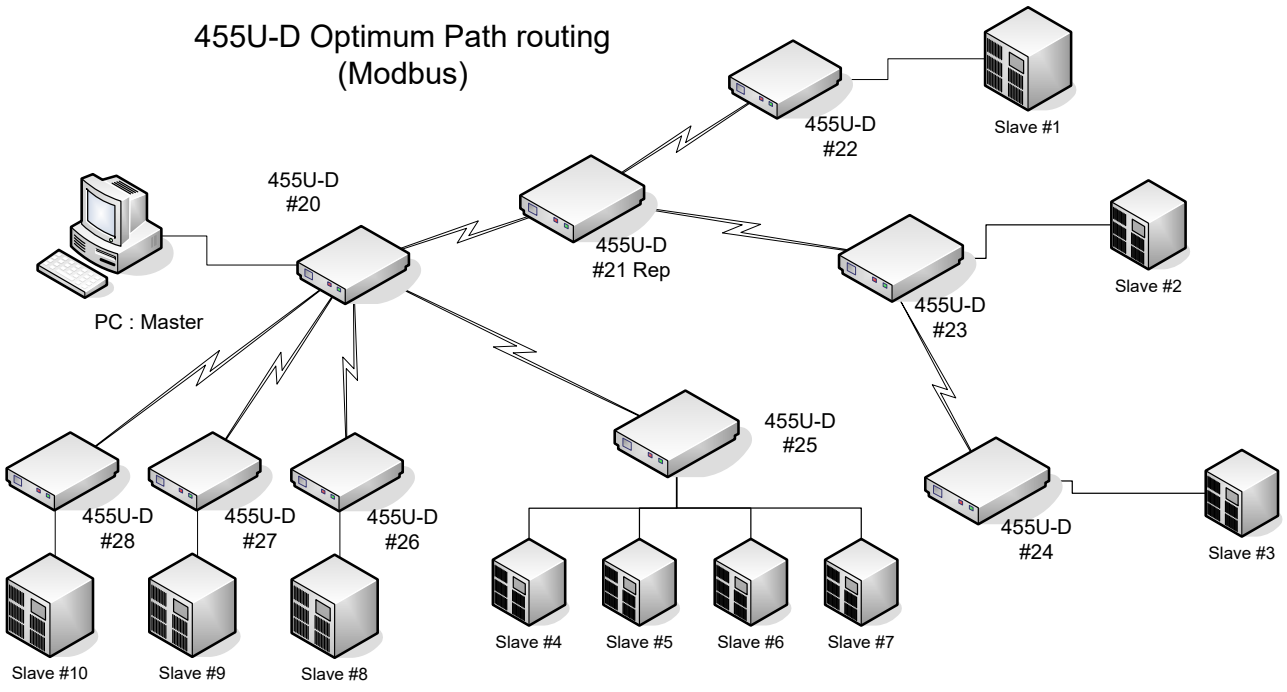
3.10 Optimum Path Routing

Optimum Path Routing (OPR) provides support for various host protocols. This mode uses knowledge of the host frame format to ensure that a full packet of information is sent over the radio in a single transmission. The host message is examined, and the destination address is extracted from the message. This is used to look-up the protocol routing paths (AT&P command configure these routing paths).

Optimum Path routing is available in firmware version 3.00 and later.

To use OPR, select "Host Protocol" under the "Operating Mode" section of the configuration screen (Modbus ASCII or RTU, DF1 or DNP3) then press the "OPR Paths" button which will bring up the Optimal Path Routing table (shown in 3.10.1 Path Configuration).





3.10.1 Path Configuration

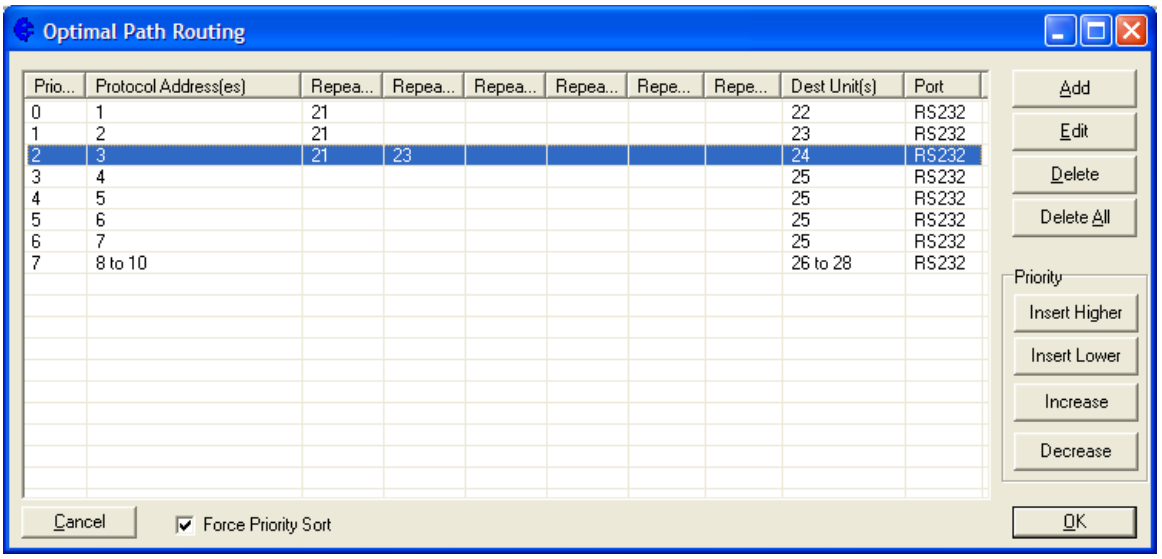
To configure the paths the "Protocol Address Range" which is the address of the Protocol device (Modbus Slave, etc), then select the radio route or the path the message needs to go to reach the destination.

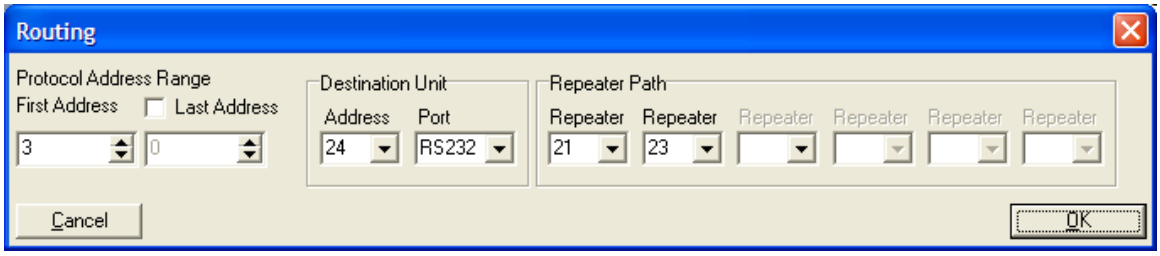
In the configuration below you will see that Modbus Slave address #1 is attached to remote radio #22 and the message needs to be sent via a repeater radio (#21), same with Modbus Slave Address #2 except it is attached to the remote radio #23.

Modbus address #3 is attached to Remote radio #24 and communicates through two repeaters (#21 & #23).

The next three Modbus Slaves are all connected to the same remote radio (#25) and each link needs a separate configuration.

Finally if you are setting up a large system and the remote radios have consecutive Protocol devices you can use the “First” and “Last” address range which will configure a number of remote devices each with an attached Protocol address.





3.10.2 Configuring for Modbus Protocol (RTU or ASCII)

With Modbus protocol, the master station does not have an address. This means that for each remote, you need to configure a path back to the master station which uses the remote’s own address as the Protocol address.

At the master station, you must configure a path to each remote station, using the address of the remote station as the protocol address.

3.10.3 Modbus RTU Protocol

When configured for Modbus RTU Protocol, the modem ignores the configured Rx Timeout value, and sets it to the correct value for the Modbus RTU protocol.

3.10.4 Modbus ASCII protocol

The correct value for serial timeout in the Modbus ASCII protocol is 1 second, however, this is normally too long. Setting the serial timeout value to 0 causes the actual serial timeout to be

1 second. Otherwise, the configured value is used. Unless your application requires the 1 second serial timeout, select PLC mode to set a good value for serial timeout.

3.10.5 DF1 protocol

The 455U works with DF1 Half Duplex protocol. Some DF1 Half Duplex frames are only sent from a slave to a master. These frames do not include a destination address. For DF1 protocol to work, the DF1 Half-Duplex master must be configured with address 0. (This is normally the case).

3.10.6 DNP3

The end of the DNP protocol frame is indicated by a period of no data transmission equal to the configured timeout for that serial port (Configured in S19 for the RS232 port and in S21 for the RS485 port).

3.11 Advanced Settings - S Registers

These are parameter registers settable by AT commands or the Configuration software to fine-tune the operation of the 455U. In most applications they do not need to be changed. Refer to Appendix C for an explanation of these parameters.

3.12 Hayes AT Commands

The 455U-D unit may be configured by a host device using Hayes AT commands. Configuration may be done "off-line" by a user (with a PC terminal as the host device) or it can be done automatically "on-line" by a host device such as PLC or SCADA. The AT commands are ASCII messages designed for use with conventional telephone modems.

Before a 455U-D unit will accept Hayes commands, it must be in "command" mode. The RJ-45 configuration port is always in command mode. The DB9 RS-232 port needs to be set to command mode if the modem is currently communicating. A host device may force the unit to command mode by sending a sequence of three "escape" characters - "+++". The default escape character is "+", however this may be changed as it is one of the configuration parameters. There must be a 1 second break of data before and after the escape sequence. The 455U-D can be configured to start up in command mode (or alternately in operating mode). It would be normal for the modem to start up in command mode when used in single-connect Acknowledged mode.

Once in configuration mode, the 455U-D unit will accept a string of Hayes commands, and the configuration changes made. The changes will not however be stored in permanent memory (EEPROM) unless the Hayes command for recording the configuration (AT&W) is sent. When the configuration changes are made, the module must be put back into its operating mode by using the "online" Hayes command, **ATO**

Commands are entered in the format ATxy, where x selects the parameter, and y the value of the parameter. For example, ATB2 sets the radio data rate to 4800 baud. B selects the radio rate parameter and 2 is the value corresponding to 4800 baud.

Summary

Enter command mode	<1sec break> + + + <1 sec break>
Response from 455U-D	OK
Enter configuration commands	ATxy
Response from 455U-D	OK
Save configuration	AT&W
Exit command mode	ATO

Note that some commands will automatically exit command mode. Several commands can be run together, for example, ATB2&WO is the same as ATB2 and AT&W and ATO

Prior to Configuration

Before configuring a module initially, force the module to its factory default configuration - either by using the DIP switch (refer section 3.10), or by using the AT&F command. If you are making a change to an existing configuration, this step is not necessary.

Appendix A details all of the Hayes commands accepted by the 455U-D. The following commands are the most common.

3.13 AT Configuration Examples

The following section describes some typical applications and the configuration of the modems involved.

3.13.1 Data Logger Network with Central Computer

In this application, the computer connects to each logger on a regular basis, and uploads information from the logger. The logger protocol does not support error checking, and the PC application software is designed to work with telephone modems. The PC software issues ATD commands to the central modem to make connection with each logger. When it has finished communicating with the logger, it issues an ATH command to terminate the connection.

Central Modem configuration

AT&M1 – Configure Acknowledged Mode

AT&E1 – Enable Error checking

AT&U1 – Set unit address to 1.

Remote Modems configuration

AT&M1 – Configure Acknowledged Mode

AT&E1 – Enable Error checking

ATS0=1 – Enable Auto Answering on first attempt.

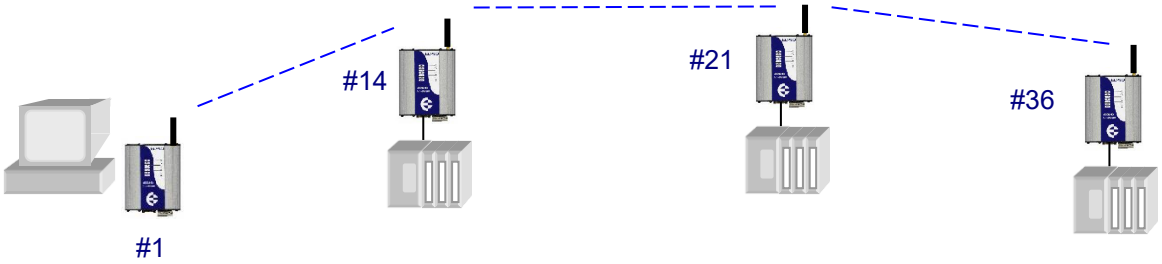
AT&U2, AT&U3, etc – Set unit address to 2, 3, 4, etc for each remote modem.

3.13.2 Unacknowledged mode with broadcast messages and repeaters.

This example demonstrates how to broadcast messages to the entire system using unacknowledged mode.

This example incorporates a single station connected to Master host device (Address 1), two repeater stations with connected slave host devices (Addresses 14 and 21), and a remote stations with a connected slave host device (Address 36).

This example uses Auto Online mode, which routes all messages according to the path set with the &Z0 command. The path set with &Z0 command is configured to broadcast to the entire system.



The host protocol is packet based, with message packets of up to 100 bytes. The master station initiates all communication, and waits for a response from the slave devices.

Master Host site Modem configuration

AT&M0 - Configure mode 0 – Unacknowledged mode.

AT&L1 – Go directly online at startup

AT&U1 - Set Modem's address to 1

AT&Z0=0,0,0 - Set all messages to go to the wildcard address, and repeat twice

Slave Repeater station address 14

AT&M0 - Configure mode 0 – Unacknowledged mode.

AT&L1 – Go directly online at startup

AT&14 - Set Modem's address to 14

AT&Z0=1 - Set all messages to go directly to master station, address 1.

AT&R3, AT&H1 - Set Broadcast Repeater mode – Repeat wildcard messages on their first hop, and send these messages out the serial port.

ATS17=4 – Set the receive hold-off. This ensures that the repeated messages from the repeaters don't clash with responses from the directly communicating device (address 15). This command sets the repeater to 200 msec hold-off.

Slave Repeater station address 21

AT&M0 - Configure mode 0 – Unacknowledged mode.

AT&L1 – Go directly online at start-up

AT&21 - Set Modem's address to 21

AT&Z0=14,1 - Set all data to go through address 14 to master station, address 1.

AT&R3, AT&H2 - Set Broadcast Repeater mode – Repeat wildcard messages on their second hop and send these messages out the serial port.

ATS17=4 – Set the receive hold-off. This ensures that the repeated messages from the repeaters don't clash with responses from the directly communicating device (address 15). This command sets the repeater to 200 msec hold-off.

Slave devices Site address 36

AT&M0 - Configure mode 0 – Unacknowledged mode.

AT&U36 - Set Modem's address to 36

AT&Z0=21,14,1 - Set all messages to go to master station, address 1 via repeaters 21 and 14..

AT&R2, AT&H3 – Send wildcard messages on their third hop out the serial port.

3.14 Switch Configuration

Factory default configuration may be restored to the modem by setting the DIL switch on the end plate to "Default" setting. This will not change the configuration settings in non-volatile memory, but will set the volatile configuration to factory default settings. This is equivalent to entering the command "AT&F" to the modem. To restore Factory defaults, perform the following

1. Set the switch to "Default" (down) position
2. Turn off module power
3. Turn module power back on
4. Return the switch to the up position

The module will now be configured for 19,200 baud communication on the RS232 DB9 port.

Chapter Four TROUBLESHOOTING

4.1 Power-up and Normal Operation

When power is initially connected to the 455U-D module, the module will perform internal diagnostics to check its functions. The following table details the status of the indicating LEDs on the front panel under **normal** operating conditions.

LED Indicator	Condition	Meaning
OK	Green	Normal Operation
	Off	Power Disconnected or Battery Over-voltage
	Red	Low Supply voltage or Internal Module fault
Radio RX	Green flash	Radio receiving data
	Red flash	Weak radio signal
Radio TX	Flash	Radio Transmitting
RS232	Yellow flash†	RS232 Serial Port Activity (Older version Hardware) †
	Orange flash	RS-232 port receiving and transmitting simultaneously
	Red flash	RS232 serial port transmitting data to host device
	Green flash	RS232 serial port receiving data from host device
RS485	Yellow flash†	RS485 Serial Port Activity (Older version Hardware) †
	Orange flash	RS-485 port receiving and transmitting
	Red flash	RS485 serial port transmitting data to host device
	Green flash	RS485 serial port receiving data from host device
DCD	Green	Modem is Online and ready to send data.
	Red	Modem is Online but Currently in Command Mode
	Off	Communications failure or data connection not established

† Hardware version 1.5 and later has extended LED functionality, providing red & green indication on the serial LEDs. Earlier hardware support single-color (yellow) serial LEDs. Check hardware version using ATI5 command.

4.2 LED indication Diagnostics Chart

INDICATOR	CONDITION	MEANING	
OK LED OFF	Continuously	• Power supply failure • Battery Supply Overvoltage	
OK LED RED	Briefly	• Module Out of buffer memory (Host device ignores CTS) • Low Supply Current during transmit (Modem resets)	
OK LED RED	Continuously – from startup	• CPU Failure • Radio module fault. • Low Supply Voltage (< 7V) • Corrupted Configuration file	
OK LED RED	Turns red after startup	• CPU Failure • Low Supply Voltage (< 7V)	
OK LED FLASHING	Flashes red/green twice per second	• Low Supply Voltage (< 10.7V) • Modem is in low power mode – DTR control.	
OK LED GREEN	Continuously	• Normal Operation	
Radio TX LED ON	Flashes briefly	• Radio transmitting	
Radio RX LED GREEN	flashes	• Radio receiving data	
Radio RX LED RED	flash	• Radio Receiving data - Weak radio signal	
		Baud Setting	Signal Strength
		B0	Less than -111 dBm
		B1	Less than -108 dBm
		B2	Less than -105 dBm
		B3	Less than -100 dBm
RS232 LED ON	Orange flash	RS-232 port receiving and transmitting simultaneously	
	Red flash	RS232 serial port transmitting data to host device	
	Green flash	RS232 serial port receiving data from host device	
	Orange flash†	RS232 Serial Port Activity (Older version Hardware) †	
RS485 LED ON	Orange flash	RS-485 port receiving and transmitting	
	Red flash	RS485 serial port transmitting data to host device	
	Green flash	RS485 serial port receiving data from host device	

	Orange flash†	RS485 Serial Port Activity (Older version Hardware) †
DCD LED OFF	Continuously	• No Radio Link established.
DCD LED GREEN	Continuously	• Modem is online & ready to transmit. • In Acknowledged mode, a radio link has been established.
DCD LED RED	Continuously	• Modem is in Command mode, but has a radio link established. • Must send "Online" command (ATO) to modem before communicating to other modems.

† Hardware version 1.5 and later has extended LED functionality, providing red & green indication on the serial LEDs. Earlier hardware support single-color (yellow) serial LEDs. Check hardware version using ATI5 command.

The green OK LED on the front panel indicates correct operation of the unit. This LED becomes red on failure as described above. When the OK LED becomes red shutdown state is indicated. On processor failure, or on failure during startup diagnostics, the unit shuts down, and remains in shutdown until the fault is rectified.

4.3 Operating Problems

Most operating problems relate to an inadequate radio path, or radio interference. Before installing a system, bench test the complete system with the 455U-D units near each other. This test eliminates the radio path or interference as a factor, and ensures that the system will operate in the way that you want. It is not necessary to connect antennas, however a small length of wire should be inserted into the middle pin of the coaxial connector - this will act as an antenna.

If the bench test does not give adequate performance, then you need to adjust the configuration parameters. We recommend that you do not install the system until you are happy with the bench test performance.

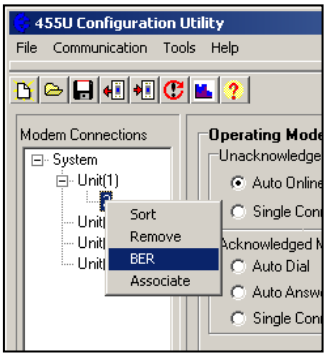
If a system gives poor performance after it is installed, check the adequacy of the radio path - refer to the Diagnostics Section 4.4.

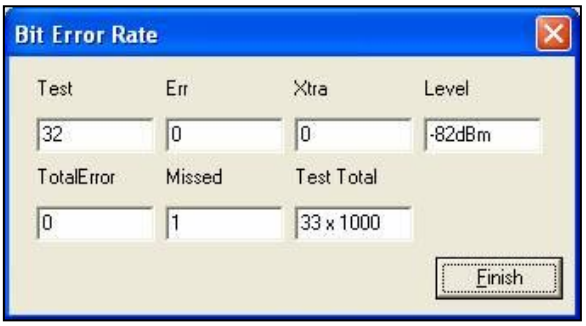
Interference will only cause a problem if the amplitude of the interference is comparable to the radio signal from the 455U-D units. If the interference level is relatively small, then it will not affect the performance of the system. If interference is causing a problem, try to improve the normal radio level by mounting the antennas higher or in a better location. This not always possible.

System performance may be improved by changing the following parameters:-

- If in unacknowledged mode, try Acknowledged mode.
- If configured for a radio data rate of 9600 bits/sec, reduce the rate to 4800 bits/sec.

- If large radio messages are being transmitted, reduce the maximum message length, and transmit the data in more messages of smaller size.





Another common problem is the response time of the host software. Some hosts operate by sending a message from one end and require a response to that message within a certain time. If this time is less than the turn-around time of the radio modem, then the system will not operate. It may be possible to lengthen the response time in the host software.

4.4 Test Functions

4.4.1 Bit Error Ratio Test (BER)

BER may be tested from the Configuration program or from a terminal using AT commands.

Using Configuration Program

To carry out a BER test, follow the instructions in section 3.4 to associate with a remote modem.

Note that host devices should have communications paused during the BER test.

Right-click on the "connection" in the left-hand menu, and select "BER". The local modem will repeatedly send pseudo-random frames, and the receiving unit will check these frames for errors. The receiving unit returns a response message indicating how many (if any) errors were found. Each test takes approx 1 second, which means the results will be updated every second.

Test	the sequence number of the last received pseudo-random data frame
Errors	the number of bit errors in the last received frame
Extra	any extra characters at the end of the frame (negative numbers indicate frame dropped out early)
Level	the RSSI level when the frame was received.
TotErr	the total errors received during this test.
TotMissed	the number of missed frames during this test
TotTest	the total number of bits sent (in 1000's)

Using AT Commands

BER may be tested by typing AT#B (Slave Address). The sending unit will repeatedly send pseudo-random frames, and the receiving unit will check these frames for errors. The receiving unit returns a response message indicating how many (if any) errors were found. The test results are displayed on the sending unit. To test Communication to slave station 13, enter AT#B13. To test slave station 14 using station 13 as a repeater, AT#B13, 14 etc.

An example of the sending unit's display is here.

Test	Errors	Extra	Level	TotErr	TotMissed	TotTest
109	0	0	-77dBm	3	0	109 kbit

Occasionally during testing, the following may be displayed:

Test	Errors	Extra	Level	TotErr	TotTest
			No Response		

This indicated that either the request to the responding device, or the response from that device, was lost during transmission. lost data frames do not contribute to the bit errors, which are calculated only on the 1,000 bit frame.

The BER test will automatically end if a test time has been entered at S8 register (refer Appendix A). If S8 has a zero value (default), the timer is inactive and the BER test will continue until manually stopped.

When using directional antennas (YAGI antennas) this feature may be used to align the antenna in the correct direction by selecting the peak signal level when moving the antenna. Begin the BER test (AT#Bxxxx), and observe the signal strength indication (Level) while adjusting the orientation of the antenna. A peak in signal level indicates optimum orientation of the antenna.

4.4.2 Other Radio Testing - AT&Tx

To aid in the checking and setup of the 455U-D unit, diagnostic functions are provided using the standard Hayes AT commands. To perform the tests, you will need a terminal (PC + hyper-terminal) set-up to match the module (same character type and serial speed). Use a RS232 cable as per section 2.4 - refer to section 3.3.1 on setting up the PC COM port.

The table below outlines the functions of the various tests:

AT&T	Radio Self Tests. Allows in-field diagnostics, and factory testing.
&T0	Stop Tone Reversals.
&T1	Tone Reversals – 200 HZ modulation
&T2	Tone Reversals – 2400 HZ modulation
&T3	Tone Reversals – No modulation
&T4	Random Tone Reversals. Generates pseudo random data and sends out radio.
&T5	RSSI Measurement. Monitors the received signal strength, and displays in dBm

Most radio tests are carried out using the AT&T2 test as this is the easiest to accomplish.

AT&T5 - Received Signal Strength Display

This option provides for testing the radio path between two 455U-D units. Although a pair of units may communicate successfully, radio communication may be affected by a range of influences, including atmospheric conditions, changing landscape, degradation of antennas or co-axial cable, low battery voltage etc. Fade margin is an indication of how far a radio path can deteriorate before reliable communication becomes unreliable.

When using this feature, the current value of the received signal strength is displayed in dBm (decibels referenced to 1 mW). This value is updated every half second. To check the radio path between two units, Use the AT#B command to check the signal strength between two modules. Next, measure the background noise by selecting the AT&T5 command and reading the value from the terminal. For reliable operation, with a safe margin for changes in the radio path, the received signal should be better than the following margins:

Radio Baud Rate	Margin above Noise	Minimum Value (dBm)
9600	10	-95
4800	10	-105

AT\S Radio Statistics

The AT\S command returns useful statistics on radio operation, which modems can be heard from a particular modem, and how good the signal strength is from each modem.

AT\S	Radio Statistics
\S	Display stats including last received signal strength from all module addresses – 1 – 127 (only modules that have been received are displayed).
	1 RSSI: -98dBm Rx: 95 Fwd: 0 Err: 72 Last: 0d03h19m18s
	Stats are: Last Received signal strength, Number of Messages Received from this address, Number of messages Forwarded from this address, and Number of received messages with errors from this address. Also indicates the time since last received a message from this address.
\Snn	Display Stats for remote number nn only

4.4.3 On-line diagnostics

Diagnostic values may be read by the 455U Configuration program or by a host device, using AT commands. These values include the radio signal strength of the last message received (ATS9?) and the reason for the communication link resetting in Acknowledged mode (ATS12?) - refer Appendix C.

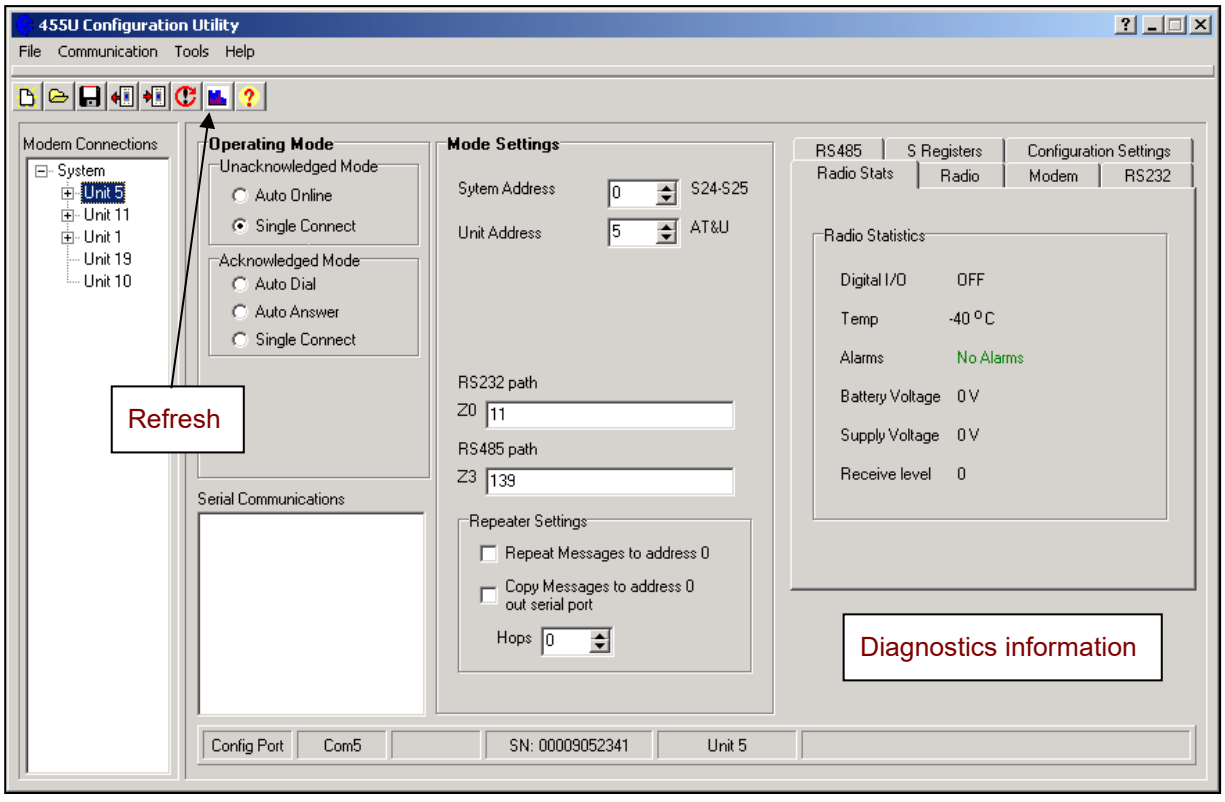
Diagnostic registers are:

S-Register	Meaning

S9	Radio signal strength of last radio message received
S12	Reason for radio link resetting in Acknowledged mode - refer App C for codes.
S31	Radio Flags, 0 for All OK, Otherwise some Radio faults. The fault code is generating by adding the following numbers: 1 indicates Radio shutdown from over-temperature 2 indicates Radio shutdown due to PTT Timeout 4 indicates radio Phase-Locked-Loop failed to lock 8 indicates SWR fault (Antenna missing or faulty)
S32	Module Temperature (Subtract 50 to get temp in deg C)
S33	State of Digital I/O point or status of Dual Redundancy system
S34	Battery Input Voltage (Units 0.1Volt)
S35	Supply Input Voltage (Units 0.1Volt) (0-25.5 Volts)

The diagnostic information can be viewed using the configuration program while the 455U-D is online, by connecting via the secondary RJ45 RS232 port.

The information is displayed under the "Radio Stats" tab on the right-hand side and the information refreshed (read from the connected module) by selecting the "Reload Radio Statistics" icon on the Toolbar.



4.5 Radio Path Testing

To carry out a radio path test, you will need two 455U modules. One module will be "fixed" and the other "mobile". Both units will need power supplies and antennas. The power supply for the mobile unit is normally a 12V battery, but make sure that the battery is fully charged - batteries with low voltage will lead to low radio power which will affect the test result.

The object of the test is to determine whether radio paths are reliable, marginal or unreliable. A reliable path will have a margin of at least 10dB above the minimum required signal level in good weather - this margin is enough to ensure that the radio path remains reliable in poor conditions, and with changes in antennas and environment over time. A marginal path will work reliably in good conditions, however may fail during poor conditions or if the landscape changes over time. A margin of 10 dB is recommended as a safe minimum.

Set up as per section 4.4.1 to carry out a BER test.

Procedure:

- Configure the modules on the bench to communicate with each other in unacknowledged mode.
- When the modules are close to each other, carry out a BER test without any antennas connected, to make sure that the modules will communicate with each other.
- Set up the fixed module in one of the test positions - this is normally at a control centre or repeater site. Fix the antenna in a temporary fashion. You will need to make an initial assessment on how high the antenna should be mounted.
- Take the mobile module to the other end of the radio path. The antenna at this end can be either held by the tester, or fixed in a temporary fashion. Note that a person's body will affect the radiation pattern of an antenna, so if the antenna is hand-held and the test is not successful, try again with the antenna fixed to a 1 metre length of plastic pipe or timber. The tester holds the length of pipe or timber with the antenna above head height.
- Test the radio path by AT#B command, or the communications test command in the configuration software
- Record these measurements for comparison later during commissioning or if the system has problems later.

If the radio path test is not successful:

1. Increasing the height of the antenna at either module, or at both modules can significantly improve the result. Sometimes moving the antenna to the side helps, if there is an obvious obstruction in the radio path.
2. Change one or both antennas to a higher gain if regulations allow.
3. Use a shorter coaxial cable between the antenna and the 455U.(this may involve moving the 455U nearer to antenna mounting), or use a different coaxial cable with lower loss.
4. If a reliable radio path is not possible because of distance or path obstructions, you will need to consider using a repeater module. The ideal repeater is another module in the system, in a good location to act as a repeater. If this is not the case, you need to consider installing a module to act specifically as a repeater.

4.6 Changing the Radio Parameters

It is possible to change the radio Transmit and receive frequency and the radio power setting from the configuration software (Select the "Radio" tab, and enter new values for TX Frequency and RX Frequency). When changing the frequency of a remote module, over the radio, take care to change the most distant module (The module that communicates through the most repeaters) first, then change the closer modules in order.

To change the transmit and receive frequency using AT commands, enter the command ATFT=xxx.xxxx (transmit) or ATFR=xxx.xxxx (receive) where xxx.xxxx is the new frequency in MHz. The frequencies must be within the allowed range. Use the AT&V command to display the current settings and the allowed range of frequency.

To change the power setting using AT commands, enter AT\Px, where x is a number from 0 to 3, with 0 corresponding to the lowest power setting (500 mW on E455U-D-5W) and 3 corresponding to the highest power setting (5W on E455U-D-5W).

Other radio parameters are available after pressing the "Advanced / Configuration" button, and entering the correct access password. These items are protected to ensure that the radio is not inadvertently mis-configured in contravention of radio licensing requirements.

4.7 Diagnostic Messages

The modem is configured to print diagnostic messages out the RS-232 Configuration port. At startup, this port displays the following messages.

Firmware Version	ELPRO E455U V3.00	Modem firmware version
Configuration Load status	Config Loaded OK	Configuration was loaded from EEPROM with no fault detected
	Default Config Set	Factory default configuration via Default Switch
	Config Load Failed	Problem with CRC check of stored configuration. OK LED will remain RED, and configuration should be re-programmed.
Radio Type	Radio: P450L	P450L radio detected (10 mW to 500 mW, 400 MHz band)
	Radio: P450H	P450H radio detected (0.5W to 5W, 400 MHz band)
	Radio: P150H	P150H radio detected (0.5W to 5W, 150 MHz band)
	Radio: Fault	No response detected from radio to version command.
	Radio: Unknown	Radio responded to version command, but version not recognized.

During normal operation, no messages will be printed on the CONFIG port, unless the modem detects an internal consistency error. In such a case, the modem could print a message indicating a line number and file, for example.

“Fail: 123 c:\RND\e455U-D\current\sources\hardware.c”

In this case, the module may be able to continue functioning, but you should take the following steps.

1. Re-start the modem, and check if the error occurs again.

2. If the error continues to occur, contact ELPRO support with the message, and information about your application

Chapter Five SPECIFICATIONS

General		
EMC specification	EN 301 489	FCC Part 15
EMC specification – Railway Specific	EN-50121-4 (60MHz band only)	
Radio specification	EN 300 113 EN 300 220	RSS-119, AS 4768.1 FCC Part 90, AS4295
Housing	140 x 114 x 30mm 5.5 x 4.5 x 1.2 inch	Powder-coated, aluminium DIN rail mount
Terminal blocks	Removable	Suitable for 2.5sqmm (12 gauge) conductors
LED indication	OK operation, Serial RX and TX, Radio RX and TX, DCD active	
Operating Temperature	-30 to +60 degrees C 0 – 99% RH non-condensing	All models.
Extended Temp range (Derated) 58-72Mhz models	-30 to +70 degrees C 0 – 99% RH non-condensing	• Max Tx Power:1W • Max Data Rate:4800 Baud • Max Duty Cycle: 50%
Power Supply		
Normal supply Battery or 12V supply	15 to 30 VDC 11 to 15VDC	Reverse current protected. Overvoltage and reverse voltage protected. Provides Battery charging features from main supply.
Current Drain @ 13.5VDC	110 mA quiescent “Low power” 30mA	During transmission 450mA (<0.5W), 800mA (1W), 1.25A (2W), 2A (5W)
Radio Transceiver		
Single channel	synthesized, fixed band 12.5, 20 or 25KHz 220 MHz band is wide only	58 – 72 MHz 148 - 520 MHz 220 – 235 MHz 380 - 520 MHz (In 20 MHz bands)

Transmit power	380 – 512MHz - Low power	10mW, 25mW, 100mW, 500mW
	380 - 512MHz - High power	500mW, 1W, 2W, 5W
	58 - 72MHz	500mW, 1W, 2W, 5W
	148 - 174MHz	100mw, 1W, 2W, and 5W
	220 - 235MHz	100mw and 5W
Receive Sens (BER 10^{-3}) 12.5KHz channel	-106 dBm -112 dBm -114 dBm -116 dBm	9600 Baud 4800 Baud 2400 Baud 1200 Baud
Signal detect / RSSI	-120 to -60 dBm	
Expected line-of-sight range Range may be extended by using repeaters (max 6).	450 MHz @ 5W 30 km @ 19200 baud (25Khz) 35 km @ 9600 baud (12.5Khz) 60 km @ 4800 baud	60/150/220 MHz @ 5W Dependant on local conditions
Lightning surge protection		Internal gas discharge arrester
Antenna Connector	Female SMA coaxial	
Data Serial Ports		
RS232 Port	DB9 female DCE	RTS/CTS/DTR/DCD hardware signals provided
RS485 Port	2 pin terminal block	Maximum distance 1.2 km
Data rate (bit/sec) - configurable	600, 1200, 2400, 4800, 9600, 14400, 19200, 28800, 31250, 38400, 57600, 76800, 93750, 115200, 187500	
Byte format	7 or 8 data bits	Stop/start/parity bits configurable
Configuration Serial Port		
RS232 Port	RJ45 – EIA561	9600 baud, 8, n, 1
Diagnostics	OK led	

	Low signal receive led CTS/RTS indication Online / Link Status RS232 activity RS485 activity Radio Transmit	
	RSSI measurement in dBm	BER test

Chapter Six WARRANTY & SERVICE

Warranty, Disclaimer and Limitation of Remedies

ELPRO products are warranted to be free from manufacturing defects for the period outlined in the ELPRO Warranty Statement.

Please visit the following link for this document.

https://elprotech.com/resourcehub-category/company-policies/

"Serviceable lifetime is not an extension of the warranty period and does not constitute a lifetime warranty."

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Appendix A Hayes Commands

The following details all of the Hayes commands supported by the 455U-D. Default settings are shown by a "dot", •

Command	Function	
ATA	Answer Incoming Call – The modem can also be set to answer incoming calls immediately or after a certain number of attempts. (See S-Register S0)	
ATB	Set Radio Baud Rate – Radio Baud rates are 1200, 2400, 4800, 9600 and 19200 baud. Some baud rates may not be possible for some country codes. The baud rate selected depends on the radio bandwidth setting (AT\N0 or AT\N1)	
	With Narrowband radio (AT\N1 selected)	With wideband radio (AT\N0 selected)
B0	Set 1200 baud	Set 2400 baud
B1	Set 2400 baud	Set 4800 baud
B2•	Set 4800 baud	Set 9600 baud
B3	Set 9600 baud	Set 19200 baud
ATC	Serial Baud Rate selection / Automatic Baud Detection control (These commands refer to the RS-232 serial port. ATR commands refer to RS-485 port).	
C0•	Set automatic baud rate detection	
C1	Set 600 baud	
C2	Set 1200 baud	
C3	Set 2400 baud	
C4	Set 4800 baud	
C5	Set 9600 baud	
C6	Set 14,400 baud	
C7	Set 19,200 baud	
C8	Set 28,800 baud	
C9	Set 31,250 baud (Foundation Fieldbus + Profibus FMS)	
C10	Set 38,400 baud	
C11	Set 57,600 baud	
C12	Set 76,800 baud	
C13	Set 93,750 baud (For Profibus)	
C15	Set 115,200 baud	
C16	Set 187,500 baud (For Profibus)	

ATD	Connection/Dialing Control. Dial a specific remote or a stored number. This command has a different effect depending on whether it is issued from the RS-232 main serial port (connects to the remote modem's serial ports) or from the Diagnostic serial port (Connects to the remote modems diagnostic functions).
ATE	Local Echo Control. Enable/Disable Command Echo. (Only applies to DB9 port RJ-45 port always has Echo enabled)
E0	Disable Local Echo on DB9 serial port
E1•	Enable Local Echo on DB9 serial port
ATF	Set Radio Frequency
FT xxx.xxxx	Set Transmit Frequency xxx.xxxx MHz – Returns ERROR if outside radio range.
FR xxx.xxxx	Set Receive Frequency xxx.xxxx MHz – Returns ERROR if outside radio range.
ATH	Hang up/Hook control. End a call, or disable incoming calls.
ATI	Modem Identity / Firmware version
I0•	Return Modem Firmware Version - EG "ELPRO E455U V2.3"
I5•	Return Full Information on modem, including serial numbers and hardware version
ATO	Go to on-line (When connection established)
ATQ	Quiet mode (Suppress/enable response codes) RJ-45 port always has quiet mode disabled
Q0•	Enable response codes on DB9 serial port
Q1	Disable response codes on DB9 serial port
ATR	RS-485 Serial Baud Rate selection.
R1	Set 600 baud
R2	Set 1200 baud
R3	Set 2400 baud
R4	Set 4800 baud
R5•	Set 9600 baud
R6	Set 14,400 baud
R7	Set 19,200 baud
R8	Set 28,800 baud
R9	Set 31,250 baud
R10	Set 38,400 baud
R11	Set 57,600 baud

R12	Set 76,800 baud
R13	Set 93,750 baud (For Profibus)
R14	Set 115,200 baud
R15	Set 187,500 baud (For Profibus)
ATSn?	Read value from S-Register n (Refer to Appendix C)
ATSn=xx	Set value of S-Register n to xx (Refer to Appendix C)
ATV	Verbal/Numeric Response Codes (RJ-45 port always has verbal responses)
V0	Numeric response codes on RS-232 serial port
V1•	Verbose response codes on RS-232 serial port
ATX	Extended Response Codes. Allows more detailed response codes, including connection speed.
X0•	Basic response codes only
X1	X0 + Connection Baud rate codes (CONNECT 19200, CONNECT 57600)
X2	X1 + BUSY Message
X3	X2 + RINGING Message
ATZ	Reset the modem, and re-load the configuration stored in non-volatile memory.
AT#A	Remote Configuration and Diagnostics Access Mode
#A0•	Disallow Remote Access
#A1	Allow Remote Access (Password required if configured) (Use password command AT#P to change password)
AT#B	Perform BER (Bit Error Rate) test to specified address (AT#B1,2,3,4 to do BER test to site 4 via 1, 2 and 3).
AT#C	Radio Calibration Options (Can only be accessed when #R Password entered)
#C0	Calibrate Power level for Power setting 0.
#C1	Calibrate Power level for Power setting 1.
#C2	Calibrate Power level for Power setting 2.
#C3	Calibrate Power level for Power setting 3.
#C4	Calibrate Radio Frequency offset
#C5	Calibrate Radio Deviation
#C6	Calibrate Radio Modulation Balance
#C7	Calibrate Radio RSSI Using Radio TestSet
#C8	Calibrate Radio RSSI (Set default Calibration or enter actual values)
AT#E	Encryption Mode (Use security menu AT#S to change encryption key)
#E0•	Disable security encryption

#E1	Enable security encryption on transmitted messages
#E2	Enable security encryption on transmitted messages and enforce encryption on received msgs.
AT#N	Enter Module Serial Number (11 characters Max) (Requires Radio Access AT#R to change).
AT#O	Control digital I/O point
#O0	Turn digital I/O point off (And enable as an input)
#O1	Turn digital I/O point on
#O2	Digital I/O point reflects communications link
#O5	Dual Redundancy – Change from Primary to Secondary
#O6	Dual Redundancy – Change from Secondary to Primary
AT#P	Set the Remote Access Password. This password must be entered by a remote user before accessing the module over the radio (Also #A1 must be set).
AT#R	Enter Radio Access Password – Enables radio commands until next reset.
AT#S	Enter AES Security key.
AT#V	Enter Hardware Revision (7 characters Max) (Requires Radio Access AT#R to change).
AT&Axx	RS-485 Serial port Character Type (Data bits, Stop bits, Parity)
0•	8 data, No parity, 1 Stop Bit
1	8 data, No parity, 2 Stop Bits
2	7 Data Bits, Even Parity, 1 Stop bit
3	7 Data Bits, Odd Parity, 1 Stop bit
4	8 Data Bits, Even Parity, 1 Stop bit
5	8 Data Bits, Odd Parity, 1 Stop bit
AT&Bxx	RS-232 Serial port Character Type
0•	8 data, No parity, 1 Stop Bit
1	8 data, No parity, 2 Stop Bits
2	7 Data Bits, Even Parity, 1 Stop bit
3	7 Data Bits, Odd Parity, 1 Stop bit
4	8 Data Bits, Even Parity, 1 Stop bit
5	8 Data Bits, Odd Parity, 1 Stop bit
AT&C	Data Carrier Detect (DCD) Control.
&C0	DCD Always on.
&C1•	DCD High when connected (Acknowledged Mode) or when online

(Unacknowledged mode). Low otherwise.

&C2	DCD Always on, Pulses low on Disconnect (Acknowledged Mode) or on Hangup (Unacknowledged mode).
AT&D	Data Terminal Ready (DTR) Behavior. The host controls DTR. This command controls how the modem reacts to the state of DTR.
&D0•	Modem ignores DTR, and acts as if it is asserted.
&D1	If the host lowers DTR, the modem returns to command mode, but does not disconnect.
&D2	If the host lowers DTR, the modem disconnects and returns to command mode.
&D3	If the host lowers DTR, the modem disconnects and goes to low power mode. Raising DTR will cause the modem to dial if the fixed line settings are correct (&L1).
AT&E	CRC Error Checking
&E0•	Disable CRC Error Checking
&E1	Enable CRC Error Checking for RS-232 port
&E2	Enable CRC Error Checking for RS-485 port
&E3	Enable CRC Error Checking for both RS-232 and RS-485 port
AT&F	Restore Factory Defaults. This function is also available from the external DIP Switch.
AT&H	Broadcast Repeater Hops Setting – Set the number of hops for a message to activate the broadcast repeater function (AT&R).
&H0•	Don't repeat messages to the "Wildcard" address, and don't copy repeated messages out the local serial port, regardless of the AT&R setting.
&H1	Perform the action specified by the AT&R setting when the wildcard address is the first Store&Forward address, and the message has completed one hop.
&H2	Perform the action specified by the AT&R setting when the wildcard address is the second Store&Forward address, and the message has completed two hops.
&H3 .. &H6	Repeat Messages when the wildcard address is the third (.. sixth) Store&Forward address, and the message has completed three (..six) hops.
AT&K	RS-232 Serial port Flow Control Configuration. Flow control options are: none, CTS/RTS and XON/XOFF. In Acknowledged mode, flow control passes across the modem link, as the local buffers become full, then back to the remote host device as the remote modem's buffers become full. No Flow control is provided on the RS-485 port.
&K0•	Flow Control Disabled. CTS Always high. Modem ignores RTS.
&K1	CTS/RTS Flow Control. CTS follows RTS high if there is space in the local

buffer. Otherwise CTS goes low. On Serial Transmit, CTS goes high, and waits for RTS to go high before transmitting. Note: Currently not implemented (Behavior is as for &K3)

&K2 CTS/RTS Flow Control. CTS Reflects the state of the remote buffer, AND the local buffer, AND the remote RTS input. The modem only transmits serial data when RTS is high. RTS input is transferred to the remote modem. Note: Currently not implemented (Behavior is as for &K3)

&K3 CTS/RTS Flow Control. CTS Reflects the state of the local buffer. Modem only transmits serial data when RTS is high.

&K4 XON – XOFF Flow Control. Modem uses XON (Hex value 0x17) and XOFF (Hex value 0x19) to control flow of information between modem and host.

AT&L Fixed line Mode Control. Allows configuration for answer, originate, or command mode.

&L0• Normal Mode. At power-up, the modem enters command mode and waits for commands.

&L1 Fixed line mode. For Acknowledged mode, ATD automatically dials the number stored in Z0, ATA answers an incoming call. For Unacknowledged modes, the modem automatically goes online, and sends messages to the modem configured in Z0.

&L2 Fixed line Answer mode. The modem continuously attempts to answer any incoming call. Use DTR with the AT&D command to control the connection. This mode is only allowed when operating in Acknowledged mode.

AT&M Operating Mode. This allows selection between unacknowledged and, acknowledged mode.

&M0• Unacknowledged Mode. All serial data is sent to the configured destination address (In Z0 or specified in a dial command). No Acknowledgement is required, and broadcast messages are allowed by using the wildcard address “0”.

In this mode, Messages on the RS-485 port are sent the address configured in register &Z1. Messages on the RS-232 port are sent to the address dialed from the command line, or configured in the auto-dial register &Z0.

&M1 Acknowledged mode. This mode simulates telephone modems, with a single connection being made to a remote modem in the system, and each message is acknowledged before more data is sent. If no Acknowledgement is received, the message is re-transmitted.

&M2 Modbus RTU Mode.

&M3 Modbus ASCII Mode.

&M4 DF1 Protocol

&M5 DNP3 Protocol

AT&N Abort Connection Control. Controls whether the modem will abort a connection attempt if a character is entered. This item is only meaningful with the

acknowledged mode of operation.

&N0 Ignore characters entered while attempting to make a connection.

&N1• If a key is hit while attempting to connect, abort the connection attempt and return to command mode.

AT&P Protocol Routing Paths – Up to 100 paths can be stored. Routing paths are used in conjunction with host protocol specific routing, so that device addresses may be extracted from the data frame and used to direct the message. Each path consists of a destination address extracted from the protocol frame, a radio destination address and up to 6 store and forward addresses.

Format:

1. "AT&Pxx= a[-a]:{n,}f".

   "xx" = 0 to 99. "a" = 0 to 65535 (depending on protocol). "n" = 0 to 127, "f" = 0 to 255. This indicates the path to send the message. "a" is the protocol address to match. ("a-a" indicates a range of addresses) "n" indicates a repeater address in the radio network, and "f" indicates the final address (0-127 indicates RS232 port, 128-255 indicates RS485 port)

2. "AT&Px=" "x" = 0 to 99. Clear path number "x"
3. "AT&Px?". "x" = 0 to 99. Display setting for Path "x"
4. "AT&P?" or "AT&P" – Display all configured paths
5. "AT&P=" Clear all paths

These paths may apply to either the RS-232 port or the RS-485 port depending on the modem's operating mode

AT&R Repeater Functionality– Enable or disable repeating of messages to the wildcard addresses 0 and 128, and enable or disable sending messages to serial port . (Also see AT&H command).

&R0• Don't repeat messages to the "Wildcard" address, and don't copy wildcard messages out the local serial port..

&R1 Repeat Messages when the wildcard address is the next un-visited Store&Forward address in the message, and message has done the number of hops specified by the AT&H setting.

&R2 Send a copy of the message out the local serial port when the wildcard address is the next un-visited address in the message, and message has done the number of hops specified by the AT&H setting.

&R3 Do both Actions – Forward the message and send a copy of the message out the local port – when the next store & Forward address is the wildcard address and the message has done the number of hops specified in the AT&H setting.

AT&T Self Tests. Allows in-field diagnostics, and factory testing. Tests time out after the period configured in S-Register S8 (if not zero).

&T0 Stop Tone reversals (See T1 to T4 below).

&T1	Transmit tones Modulated at 200 Hz
&T2	Transmit tones Modulated at 2400 Hz
&T3	Transmit Tones Unmodulated
&T4	Transmit Random Modulated tones at current radio baud rate
&T5	RSSI Measurement. Monitors the received signal strength, and displays in dBm.
AT&V	View Current Configuration – List the value of all settings as well as S-Registers (except &P settings).
&V0	Same as AT&V
&V1	Only show settings that are different from the defaults.
&V2	Show all settings, including extra debug registers.
&V10	View configuration in non-volatile memory
&V11	As for V1, but configuration in non-volatile memory
&V12	As for V2, but configuration in non-volatile memory
AT&U	Set modem's Unit Address Range 0-127. Default 1. The Unit address is used to identify the module in the system. It should always be set to a unique number within the modems in the system. This address is also used to access to the module using the remote diagnostics protocol.
AT&W	Write Current Configuration to non-volatile storage
AT&Z	Stored Numbers – Up to 4 stored numbers, also "Auto Connect" number for leased-line mode.
	Format: "AT&Zx=nn,nn,nn,nn". "x" = 0 to 3. "nn" = 1 to 127. Z0 is used for the autoconnect number.
	Z0 contains the autoconnect number for the RS232 port (If Fixed line &L1 is selected)
	Z3 contains the destination addressing for the RS485 port.
AT\B	Generate Break signal at remote modem. (Currently not implemented)
\Bn	"n" is the break length in units of 0.1 seconds.
AT\C	Radio Frequency Increment (Can only be set when #R Password entered)
\C5	Set Radio frequency increment to 5.00 kHz.
\C6	Set Radio frequency increment to 6.25 kHz.
AT\N	Radio Bandwidth (Can only be set when #R Password entered)
\N1	Set Radio to 2400 HZ bandwidth.
\N0	Set Radio to 4800 HZ bandwidth.
AT\P	Radio Power (Can only be set when #R Password entered)
	5 Watt Radio **.500 mW Radio**

\P0	Set Radio to 500 mW	Set Radio to 10mW	
\P1	Set Radio to 1 W.	Set Radio to 25 mW	
\P2	Set Radio to 2 W	Set Radio to 100 mW	
\P3	Set Radio to 5 W.	Set Radio to 500 mW	

AT\K Break signal handling control **(Currently not implemented)**

	AT\B command from online	Host sends break on serial	Receive break from remote
\K0	Purge Buffers & send break	Enter command state & purge buffers. Don't send Break.	Purge buffers and send break to host.
\K1	As for \K0	Purge Buffers and send break	As for \K0
\K2	Send Break ahead of buffered data.	As for \K0	Transfer break to host ahead of buffered data.
\K3	As for \K2	Send break ahead of buffered data.	As for \K2
\K4	Queue Break behind buffered data.	As for \K0	Queue Break behind buffered data.
\K5	As for \K4	Queue break behind buffered data.	As for \K4

AT\S Radio Statistics

\S Display stats including last received signal strength from all module addresses – 1 – 127 (only modules that have been received are displayed).

```
1 Rssi: -98dBm Rx: 95 Fwd: 0 Err: 72 Last: 0d03h19m18s
```

Stats are: Last Received signal strength, Number of Messages Received from this address, Number of messages Forwarded from this address, and Number of received messages with errors from this address. Also indicates the time since last received a message from this address.

\Snn Display Stats for remote number nn only

AT\T Inactivity Timeout – Units Seconds. Value 0-255. 0 = Disable. If there is no activity within this time, the modem drops the connection. See also S Register S6.

Appendix B Response Codes

Response codes display the status of the module in response to user commands. The response code displayed depends on the ATV setting, the ATX setting and the ATQ setting. ATV0 selects numeric response codes. ATV1 selects verbal response codes. The ATXn command

selects extended response codes. ATQ0 disables all response messages. ATQ1 enables response messages. The following table describes the messages. A • symbol indicates that messages is displayed for the corresponding ATX setting.

Numeric Code	Verbal Message	ATX setting				Comments
		X0	X1	X2	X3	
0	OK	•	•	•	•	Valid Command Entered
1	CONNECT	•				Connection established. CONNECT *baud* is displayed for X1,X2,X3
2	RING	•	•	•	•	Module Received an incoming connection request
3	NO CARRIER	•	•	•	•	Connection with remote module lost, or not initiated.
4	ERROR	•	•	•	•	Invalid Hayes command entered.
7	BUSY			•	•	X0, X1 display NO CARRIER instead of BUSY
13	RINGING				•	X0, X1, X2 Don't display RINGING message
5	CONNECT 1200		•	•	•	CONNECT at 1200 baud
10	CONNECT 2400		•	•	•	CONNECT at 2400 baud
11	CONNECT 4800		•	•	•	CONNECT at 4800 baud
12	CONNECT 9600		•	•	•	CONNECT at 9600 baud
15	CONNECT 19200		•	•	•	CONNECT at 19200 baud

Appendix C S-Registers

The following table lists the S-Registers supported by the 455U-D modem.

No.	Range	Function	Comment
S0	0-255	Attempts before Answering Call	Should normally be set to 1. 0 disables auto answering of calls (ATA command to answer calls only).
S1	3-255	Escape Sequence Guard Time	Units 20 milliseconds. Min. Delay before and after entering the escape sequence ("+++") also Max. Delay between characters of the escape sequence.
S2	1-255	Escape Sequence Character	Normally 43 = "+"
S3	0-127	Carriage Return Character	Normally 13 = <CR>
S4	0-127	Line Feed Character	Normally 10 = <LF>
S5	0-127	Back Space Character	Normally 8 = <BS>
S6	0-255	Inactivity Timer / Link Check Timer	Units Seconds. 0 disables. How frequently to send a "Link Check" message. Usually set less than the timeout set by the AT\T command. Default 0.
S7	1-255	Number of Connection attempts (Acknowledged Mode)	How many times to attempt a connection after an ATD command. Default 5.
S8	0-255	Test Timer	Units Seconds – How long to run tests (AT&Tx)
S9	0-255	Modem Receive Level	Units (-)dBm – RSSI indication of last received message. AT&T5 command may be more useful.
S10	0-255	DTR Loss Detection Time	Units 10 milliseconds (Not Implemented)
S11	0-255	Change Over Delay Time or Dual Redundant Timeout	The trigger condition must be present for the time period for the changeover to occur. Minimum time period is 5 seconds
S12	read-only	Command Mode Diagnostic	Reason modem last returned to command mode, i.e. connection lost.
	S12 = 0	Reset (ATZ or Power Up).	
	S12 = 1	Escape sequence ("+++")	
	S12 = 2	DTR lowered.	
	S12 = 3	No ACK from remote modem after connected.	
	S12 = 4	Activity timer timed out.	
	S12 = 5	No response to dial request to remote modem.	

	S12 = 6	"BUSY" response from remote modem on dial request.	
	S12 = 7	Character received from host while attempting to connect	
	S12 = 8	Hang-up from remote modem.	
S13	0-255	Spare Function	Not Implemented
S14	0-255	Max Packet (0–1020 bytes)	Max Packet size = S14 x 4. Default 255.
S15	0-255	Break Length (Not Implemented)	Minimum time to send "BREAK" signal. Units 20 milliseconds.
S16	0-255	Transmit Hold-off (0-12.75 Sec)	How long to disable transmitting after transmitting a message (Units 50 milliseconds)
S17	0-255	Receive Hold-off (0-12.75 Sec)	How long to disable transmitting after receiving a message (Units 50 milliseconds)
S18	0-255	RS-232 Serial Rx Buffer Threshold	This register indicates the number of characters to be received into the RS-232 serial receive buffer before beginning radio transmission. (default 0)
S19	0-255	RS-232 Serial Rx Timeout	If there is data in the RS-232 serial receive buffer, and no data is received on the serial port for this time, radio transmission will begin regardless of the setting of S18. A value of zero disables the timeout, so the modem will not transmit until there are at least S18 characters in the receive buffer.
S20	0-255	RS-485 Serial Rx Buffer Threshold	This register indicates the number of characters to be received into the RS-485 serial receive buffer before beginning radio transmission.
S21	0-255	RS-485 Serial Rx Timeout	If there is data in the RS-485 serial receive buffer, and no data is received on the serial port for this time, radio transmission will begin regardless of the setting of S20. A value of zero disables the timeout, so the modem will not transmit until there are at least S20 characters in the receive buffer
S22	0-255	Default System Address – High Byte	System address is set to this value when factory defaults restored. This register is not affected by the AT&F command.
S23	0-255	Default System Address – Low Byte	System address is set to this value when factory defaults restored. This register is not affected by the AT&F command.
S24	0-255	System Address – High Byte	The 16-bit system address uniquely identifies the radio network
S25	0-255	System Address –	The 16-bit system address uniquely identifies the

		Low Byte	radio network
S26	0-255	Lead-In Tone Time	This selects the Lead-In tone period – units 4 msec. The default (10) should not normally be changed.
S27	0-255	Transmitter Hold-Up Time	Selects How long the transmitter will stay on waiting for more data before starting to send the tail (msec)
S28	0-255	Transmitter Tail Time	Selects how long the transmitter will send a "Tail" at the end of transmission. New data is ignored during the tail time
S29	0-255	Unack Retries	How many times to ret-transmit each message in unacknowledged mode. Each message is transmitted this number of times. The sequence number and source address ensure that repeat messages are ignored by the receiver.
S30	0-255	Ackmode retries	Number of times to re-try in acknowledged mode if no Acknowledge response is received.
S31	0-255	Radio Flags	This read-Only register indicates radio Tx error flags 1 => Over-temperature Shutdown 2 => PTT Timeout 4 => PLL Out of lock 8 => Antenna failure
S32	0-255	Module Temperature	This read-Only register indicates the module temperature +50 (units °C)
S33	0-1	Dual Redundancy Status	2 = Active Primary 3 = Active Secondary 4 = Active Primary – no secondary detected 5 = Inactive Primary 6 = Inactive Secondary
S34	0-255	Battery Voltage	This read-Only register indicates the voltage at the battery input (Units 0.1V)
S35	0-255	Supply Voltage	This read-Only register indicates the voltage at the Supply input (Units 0.1V)
S36		System Channel Duty Cycle %	