User Manual

805U-D Radio Modem

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Thank you for your selection of the 805U radio modem. We trust it will give you many years of valuable service.

© May 2013

ATTENTION!

Incorrect termination of supply wires may
cause internal damage and will void warranty.
To ensure your 805U enjoys a long life,

double check ALL your connections with the user's manual

before turning the power on.

WARNING

1. In some countries, a radio licence is not required for the 805U telemetry modules provided the module is installed using the antenna and equipment configuration prescribed.
2. Where a radio licence is not required, operation is authorised by the relevant Authority in your country on a non-protection basis. Although all care is taken in the design of these units, there is no responsibility taken for sources of external interference. Some delay in the operation of the module may occur during periods of interference. Systems should be designed to be tolerant of these delays.
3. To avoid the risk of electrocution, the antenna, antenna cable, and all terminals of the 805U 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.
4. To avoid accidents during maintenance or adjustment of remotely controlled equipment, all equipment should be first disconnected from the 805U 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."
5. The 805U module is not suitable for use in explosive environments without additional protection.

Hazardous Location Notices:

This device complies with

Ex nL IIC. T6 -40 C <= Ta <= +70 C

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

How to Use This Manual

To receive the maximum benefit from your 805U product, please read the **Introduction**, **Installation** and **Operation** chapters of this manual thoroughly before putting the 805U to work.

Chapter Four **Configuration** details the configurations available and explains the diverse operation of the product in detail.

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

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

The foldout sheet 805U *Installation Guide* is an installation drawing appropriate for most applications.

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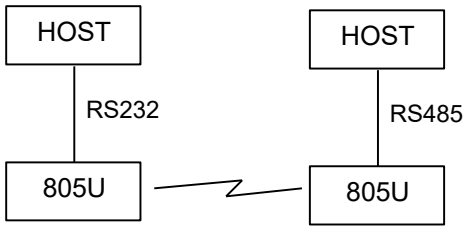
Chapter 1 INTRODUCTION

1.1 General

The 805U radio modem module has been designed to provide flexible and reliable radio modem functions, at an economical price. *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 805U 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 805U 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 805U unit can receive data from the host device and transmit this data by radio to another (or several) 805U module. The other module will recreate the serial data and output it as either a RS232 or RS485 serial signal. The 805U unit provides two-way communications - each module can accept serial data and also output serial data.

The 805U module includes power supply, microprocessor controller, serial input/output circuits and a 900MHz frequency-hopping spread-spectrum radio transceiver - no external electronics are required. The 805U radio frequency has been selected to meet the requirements of unlicensed operation for remote monitoring and control of equipment. That is, a radio licence is not required for the 805U modules in many countries. See Chapter Five **Specifications** for details. The units are configured from a PC using a "free-ware" configuration package, or from a PC terminal using Hayes commands.



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 805U unit can only connect to one serial signal - either RS232 **or** RS485. However different modules in the same system can connect to different types of serial signals. For example, RS232 data from one host device can be transmitted to a remote 805U unit and output as RS485 data to another host device.

The 805U has been designed to be flexible enough to cover a wide range of applications. The user is able to configure many different parameters such that the 805U unit will connect reliably to different types of host devices. Before the radio modem can be used, these parameters must be configured. Some of these parameters are :-

- Character type - the 805U will accept a variety of 7 or 8 data bit characters
- Serial Data Rate - between 1200 and 115200 bits/sec
- Radio Data Rate - 19200, 38400 or 76800 bits/sec
- Operating mode - transparent mode or controlled mode .

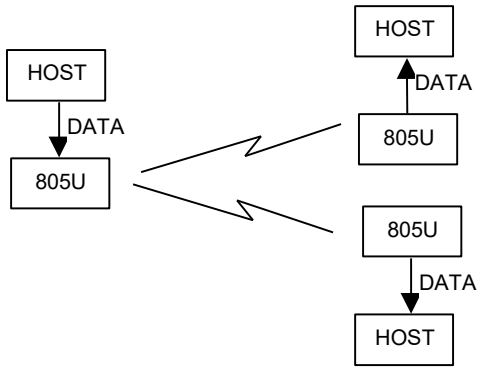
The operation of the 805U radio modem is relatively simple. As data is received at the serial port, the data is transmitted on the radio channel. Up to 530 bytes of data can be transmitted in one transmission. The radio transmission commences when the first data byte is received, and

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 530 bytes). If more than 530 bytes is input, the 805U unit will transmit the first 530 bytes, then the next 530 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 2Kbytes is provided. The RS232 connection provides CTS control to prevent the buffer overflowing. There are no data flow control signals for RS485.

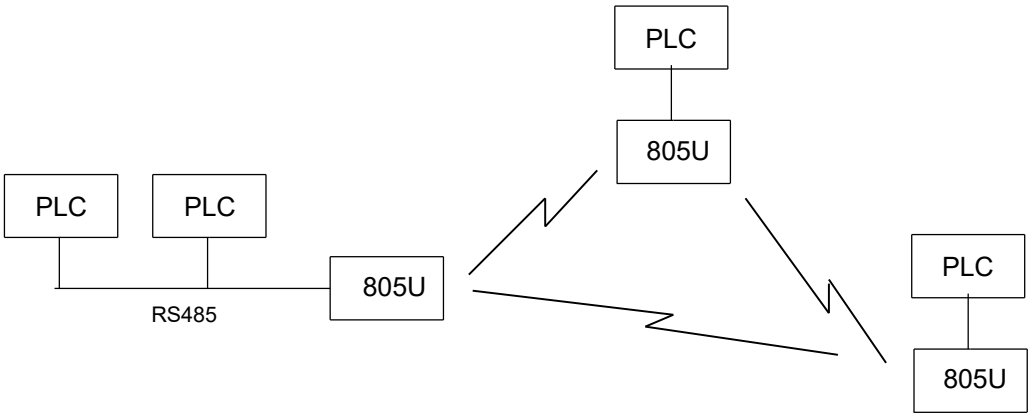
A radio channel cannot provide as secure a data channel as a wired connection. The 805U uses a radio band with a low level of natural or industrial noise, however there is a chance of interference from other users of the unlicensed radio channel. We recommend that the flow of data over the radio channel 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 805U modules. The modules may be configured by the user to operate in one of two modes. In transparent mode, it is assumed that the host devices control the flow of data. In controlled mode, the 805U units control the flow of data.

1.2 Transparent Mode



The default configuration of the 805U modem is transparent mode - the modules are set in this mode at the factory. In transparent mode, the 805U provides no control of the data transmissions (no error correction). Input data is simply transmitted by radio and every other 805U unit in that system which receives the transmission will output the data. This mode relies on the host devices to perform the "handshaking" function, and re-transmitting serial data if the data is corrupted (no "handshake"). It also relies on the host devices to include any addressing necessary in the data. In this mode, modules are not configured with a unit address. Data is "broadcast" - every other 805U in the system will receive the data and output the data to their individual host devices. The user may configure the 805U modems to add error checking to each data packet transmitted - if error checking is configured, data will not be output if it is received without a correct error-check. This feature provides additional protection against corruption of the data during the radio transmission. If error-checking is not configured, then the data received by radio will be output without checking for errors.

Transparent mode is "point-to-multipoint" communications, suitable for a host device which is able to communicate on a multi-drop "bus" type network. An example of an application is the use of radio modems to extend a PLC RS485 network. The serial messages from the PLC's already include PLC addressing and error detection/correction to control the flow of data



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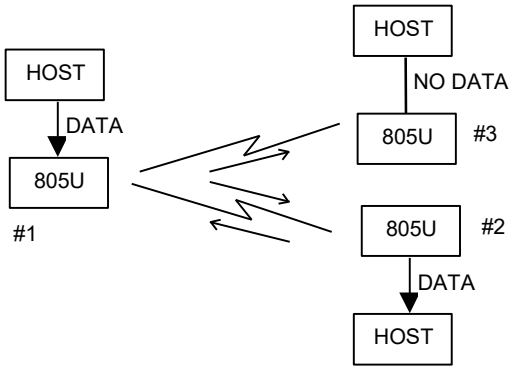
1.3 Controlled Mode



"Controlled mode" provides "point-to-point" communications similar to telephone modems. In controlled mode, the flow of data is controlled by the 805U units. Each 805U unit is configured with an address by the user, and a destination address for the data to be transmitted to. Data is transmitted addressed to the destination module, and only this module will output the serial data. The source module will add an error-check (16 bit CRC) to the data transmitted by radio. The destination module will process the error-check, and if correct, it will transmit an acknowledgment message (ACK) back to the source module. If the source module does not receive a ACK, it will re-transmit the data. The source module will attempt to transmit the data up to five times, until an acknowledgment (ACK) is received. If an acknowledgment is still not received, then the DCD signal on the RS232 port will be reset and a alarm message can be sent to the host via the serial port.

An example of an application using controlled mode would be a radio modem link between an intelligent gas analyser and a monitoring computer system. Intelligent transducers do not normally provide addressing or error checking functions - these would be provided by the 805U modules.

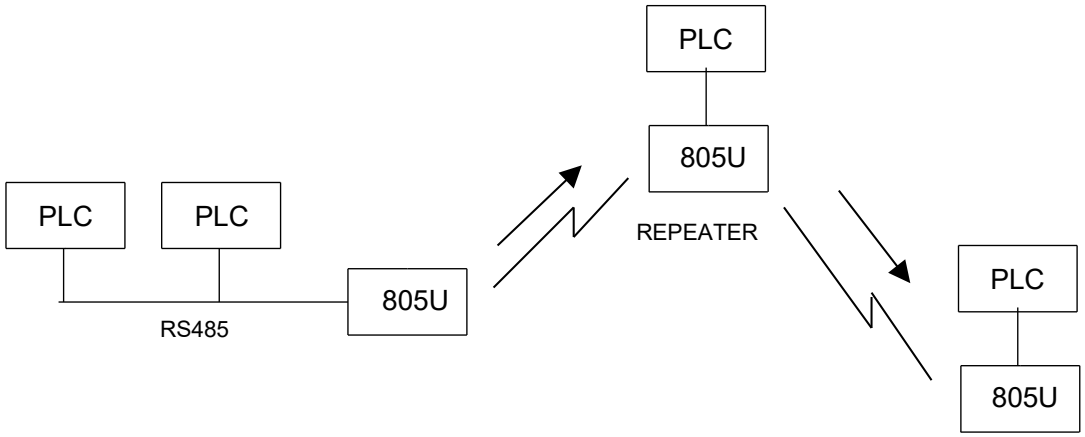
In controlled mode, the destination address may be pre-set, or set on-line by the host device using "Hayes" commands. Hayes commands are a standard set of commands used with conventional telephone modems. An example of an application that would use Hayes command to set destination addresses would be a central computer polling data loggers for periodic information.

1.4 Repeater Units

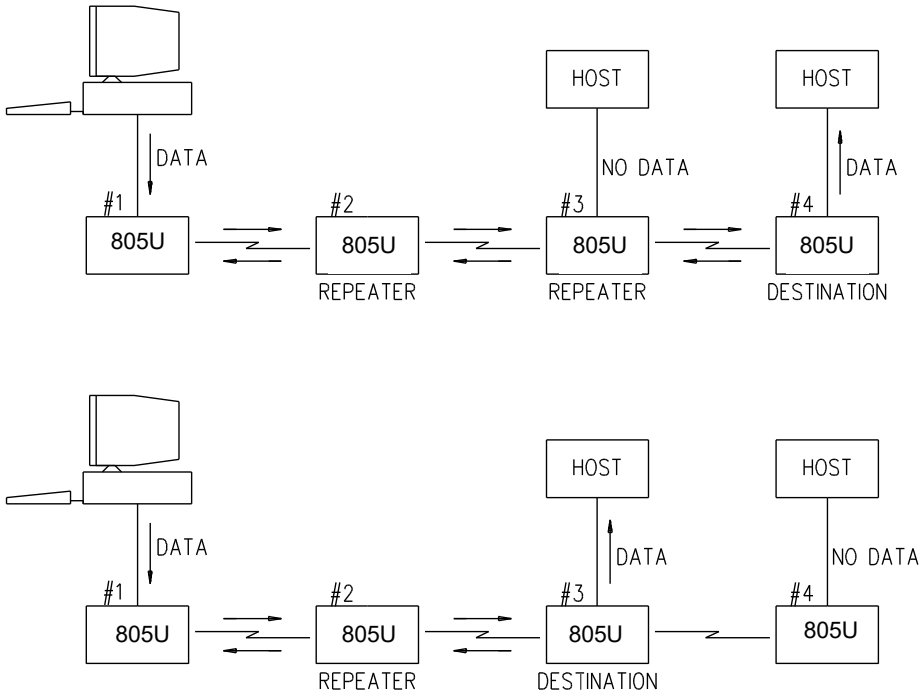
A 805U unit may be used as a repeater to re-transmit radio messages. The purpose of a repeater unit is to extend radio range.

In transparent mode, there can be an unlimited number of repeaters, however with some conditions (refer to Section 3.5).

The repeater in transparent mode will repeat every transmission it receives.



In controlled mode, up to five repeaters may be configured for any transmission path. The repeaters are configured by address.



Chapter 2 INSTALLATION

2.1 General

The 805U module is housed in an rugged aluminium case, suitable for DIN-rail mounting. Terminals will accept wires up to 2.5 sqmm in size.

Normal 110-240V mains supply should not be connected to any terminal of the 805U module. Refer to Section 2.3 **Power Supply**.

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 805U Module as a repeater.

The foldout sheet 805U ***Installation Guide*** provides an installation drawing appropriate to most applications. Further information is detailed below.

Each 805U module should be effectively earthed via the "GND" terminal on the 805U module - this is to ensure that the surge protection circuits inside the 805U module are effective.

2.2 Antenna Installation

The 805U 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 for radio data rates of 19200 bits/sec is 5 km line-of-sight . At 38400 bit/sec, the expected distance will be approx 3 km, and at 76800, the distance will be 1.5 km.

Where it is not possible to achieve reliable communications between two 805U modules, then a third 805U 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 805U 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 above ground for paths of 5 km. 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 metres of clear path before a group of trees, the trees will have less affect on the radio path.

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 power limit on the unlicensed channel - if in doubt refer to an authorized service provider.

The maximum net gain of the antenna/cable configuration permitted is 0dB.

The gains and losses of typical antennas are

Antenna	**Gain (dB)**
3dB Collinear	3
6dB Collinear	6
6 element Yagi	10
9 element Yagi	12
16 element Yagi	15
Cable type	**Loss (dB per 10 m)**
RG58	-5
RG213	-2.5
Cellfoil	-3

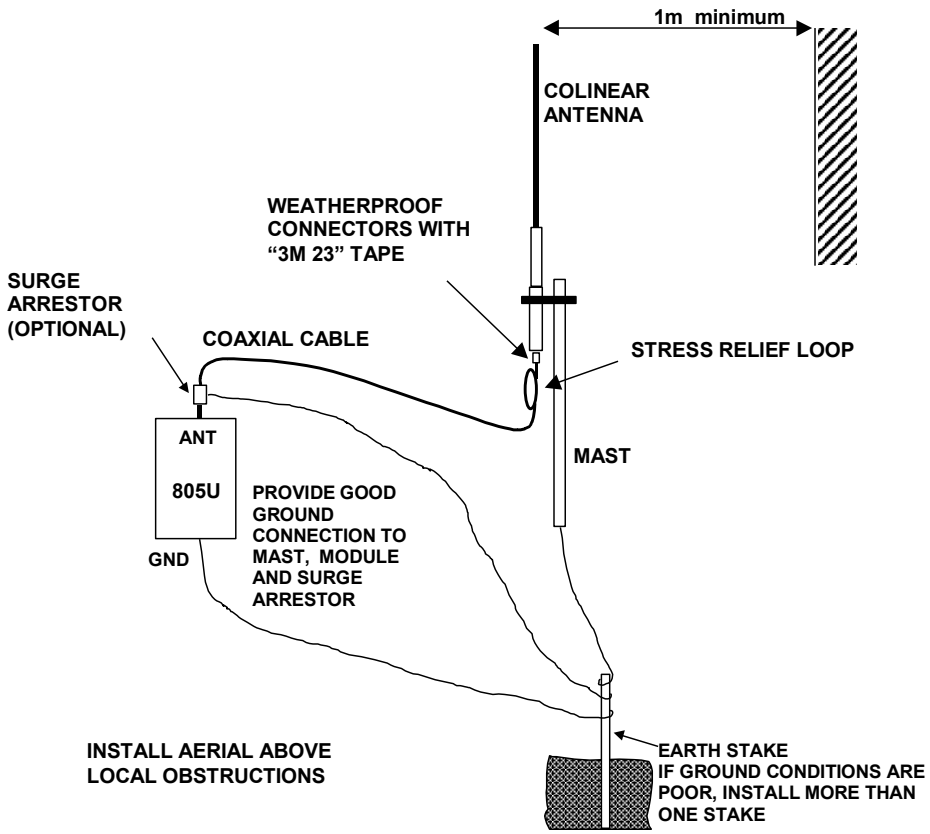
The net gain of the antenna/cable configuration is determined by adding the antenna gain and the cable loss. For example, a 6 element Yagi with 20 metres of RG58 has a net gain of 0 dB (10dB – 10dB).

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 805U 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 that 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 metres RG213 - 20 metres. 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 metres 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 metre away from a wall or mast.

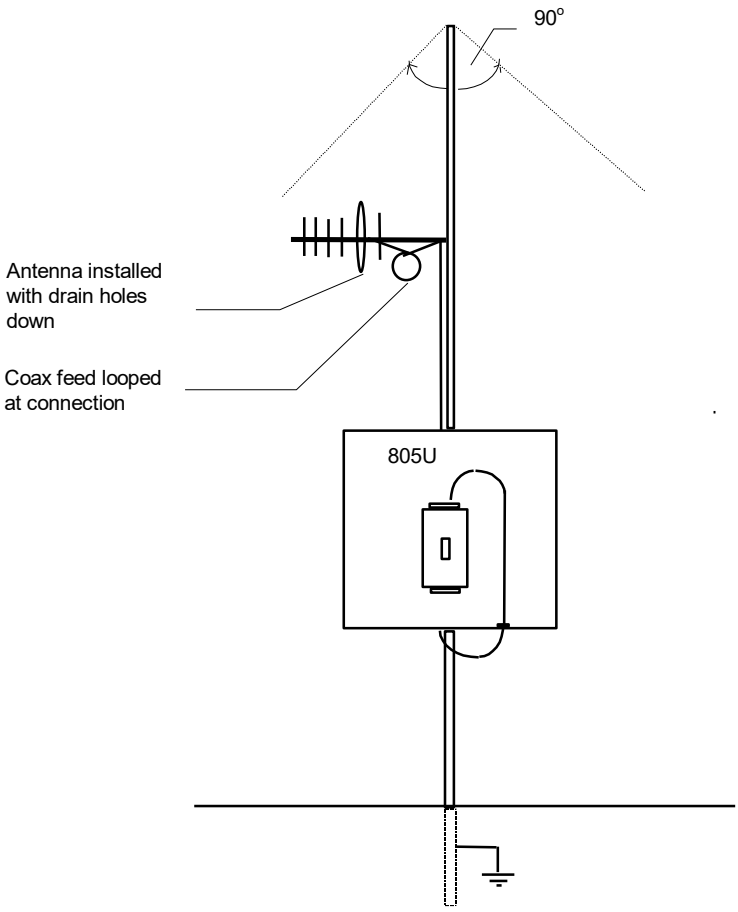


2.2.2 Yagi antennas.

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.

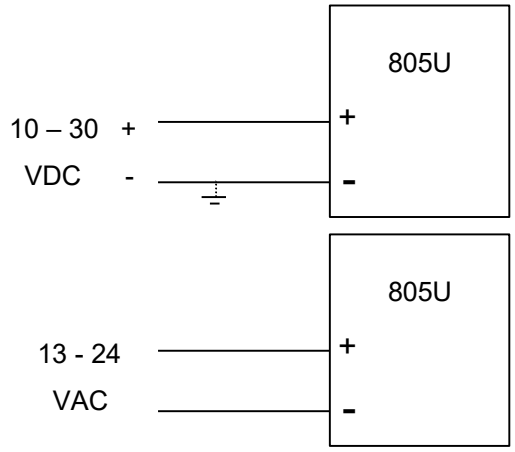
Also note that Yagi antennas normally have a drain hole on the folded element - the drain hole should be located on the bottom of the installed antenna.

2.3 Power Supply

The 805U module is powered by a 10 - 30VDC or 13 – 24VAC supply, minimum 9 Watt capacity.

For DC supplies, the negative side of the supply is connected to "COM" and may be connected to "ground". The supply negative is connected to the "GND" terminal internally. The positive side of the supply **must not be connected to earth.** The DC supply may be a floating supply or negatively grounded.

The power requirements of the 805U units is 80mA at 12VDC or 50mA at 24VDC. The power requirements in low power mode is 20mA at 12VDC.



2.4 Serial Connections

2.4.1 RS232 Serial Port

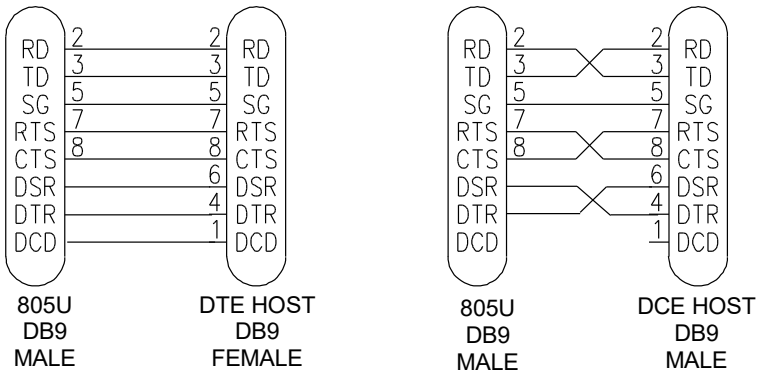
The serial port is a 9 pin DB9 female and provides for connection to a host device as well as a PC terminal for configuration, field testing and for factory testing. This port is internally shared with the RS485 - ensure that the RS485 is disconnected before attempting to use the RS232 port. Communication is via standard RS232 signals. The 805U is configured as DCE equipment with the pinout detailed below.

Hardware handshaking using the CTS/RTS lines is provided. The CTS/RTS lines may be used to reflect the status of the local unit's input buffer, or may be configured to reflect the status of CTS/RTS lines at the remote site. The 805U does not support XON/XOFF.

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

2.4.2 DB9 Connector Pinout

Pin	Name	Direction	Function
1	DCD	Out	**Data carrier detect** – - driven when link is established in controlled mode - driven always in transparent mode
2	RD	Out	**Transmit Data** – Serial Data Output
3	TD	In	**Receive Data** – 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 controlled 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		**Ring indicator** - indicates another module is attempting to connect in controlled mode.

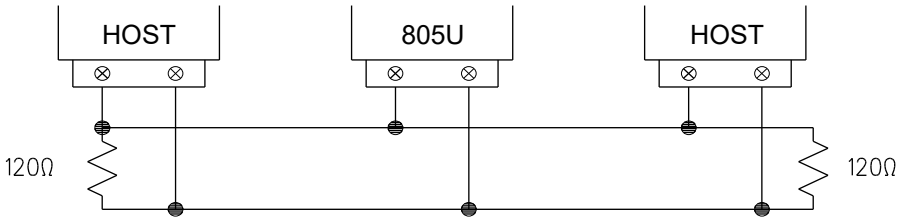


2.4.3 RS485 Serial Port

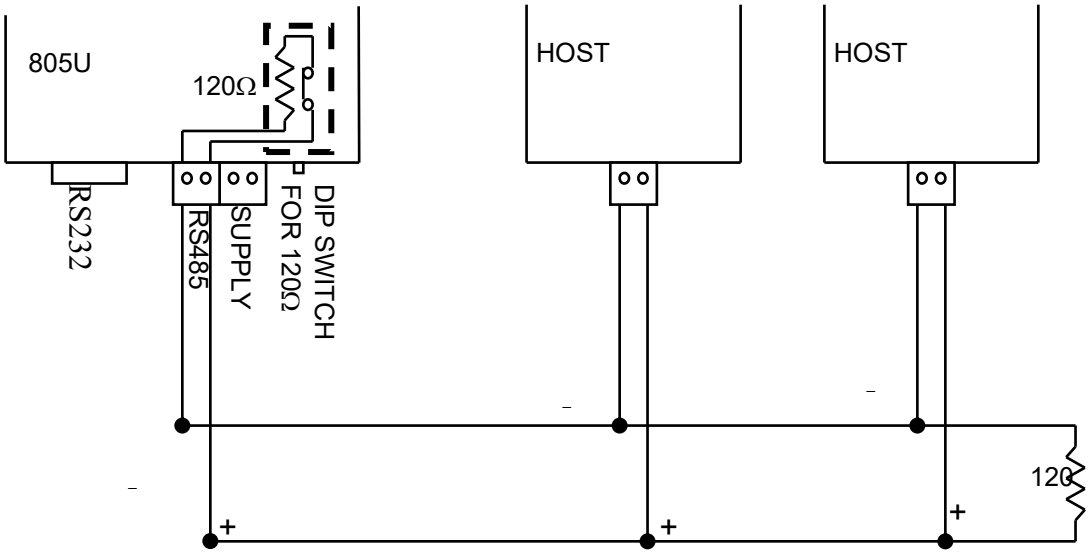
The RS485 port provides for communication between the 805U unit and its host device using a multi-drop cable. Up to 32 devices may be connected in each multi-drop network. Note that the RS485 port is shared internally with the RS232 port - make sure that the RS232 port is disconnected before using the RS485 port.

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 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.



RS485 CONNECTIONS



RS485 CONNECTION USING TERMINATING RESISTOR

Chapter 3 OPERATION

3.1 Power-up and Normal Operation

When power is initially connected to the 805U 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	On	Normal Operation
Radio RX	GREEN flash RED flash	Radio receiving data Weak radio signal
Radio TX	Flash	Radio Transmitting
Serial RX	GREEN flash RED flash	Serial Port Receiving CTS low
Serial TX	GREEN flash	Serial Port Transmitting
DCD	On	Transparent mode - always on Controlled mode - on when communications link is established
DCD	Off	Communications failure or link not established

Other conditions indicating a fault are described in Chapter Six **Troubleshooting**.

3.2 Serial and Radio Data

The 805U module provides a full-duplex RS232 serial port and half-duplex RS485 serial port - only one serial port can be used at any one time. The radio communications is half-duplex - this means that the 805U operates at 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 805U without problems. If an application really requires full duplex communications, then the 805U should not be used.

Data input at the serial port is placed into the input buffer. This buffer will store 2Kbytes of data, and CTS/RTS control can be configured on the RS232 port to prevent overflow.

When the 805U 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. The 805U will calculate the amount of delay depending on the difference between the serial and radio rates.

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 530 bytes). If there is still data in the input buffer, the 805U will start another radio transmission.

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 530 bytes). If less data than the maximum size is input to the 805U, then the 805U will transmit the actual data input. If more data is input than the maximum size, then the 805U 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.

3.2.1 Character Type

The 805U 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.

Most applications will require the character type to be the same at each 805U modem in the system. Nevertheless, the character type may be configured to be different at different 805U 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.

3.2.2 Serial Data Rate

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

3.2.3 Radio Data Rate

The data is transmitted by radio as direct modulated synchronous data at 19200, 38400 or 76800 bits/second. The user must configure the radio data rate at each 805U module. The configured radio data rates must be the same for each module in a system.

At 19200 and 38400 bits/sec, the 805U adds forward error correction in the transmitted data. This is added automatically and is different to the configurable CRC error-check.. The radio range at 19200 baud is better than 38400 or 76800. The expected range at 38400 is 60% of maximum and at 76800 is 30%.

The radio message includes the following :-

- A 5 - 10 msec leading sequence of alternating 1's and 0's provides the receiving unit with time to capture and lock onto the incoming signal.
- A system address is superimposed on each message to provide discrimination between different 805U systems on the same radio channel. Each 805U unit in the same system must be configured with the same system address - refer Section 4, Configuration. Although other 805U modules may hear the radio transmissions, because they have a different system address, the radio transmission is ignored and no serial data is output.
- In transparent mode, a group address is included, and in controlled mode, unit addressing is included.

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

Up to 530 bytes of data may be transmitted in a message - the maximum message size is configurable between 10 and 530 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).

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 805U units in a system.

- After each message is transmitted, a 805U 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.

3.3 Addressing

A 805U 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. We recommend that you select a random number for the system address.

In transparent mode, each module is also configured with a "group" address. A system may comprise several groups or sub-systems. Only modules with the same system and group address will communicate directly with each other - but modules with different group addresses can communicate via a repeater. The group address is used for repeater operation in transparent mode. The group address is not used in controlled mode.

A 805U can also be configured with a "unit" address - this gives the module a unique identification. The unit address feature is not used in transparent mode, but it is used in controlled mode.

3.4 Transparent Mode

In transparent mode, radio messages are transmitted without unit addressing. Units do not provide handshaking functions to control the flow of data. Every unit which receives the radio message, and has the correct system and group addresses, will output the data. Transparent mode operation is effectively a broadcast system.

Data received at the serial port is transmitted out of the radio port. Data received from the radio is transmitted out of the serial port. 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.

The time taken to transmit a message is :-

lead-in	system/group addr	data	error check (if configured)
5 msec	2 bytes 1 ms @19.2Kb	0.5ms per byte @ 19.2Kb	2 bytes 1ms @ 19.2Kb

If error checking is not configured at the receiving unit, data will start to be output approximately 1 msec after the system address has been received. If error checking is configured, data will be output approx 2msec 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 12msec after the data is input, if there is no error checking, or 24msec after the data is input if error checking is configured.

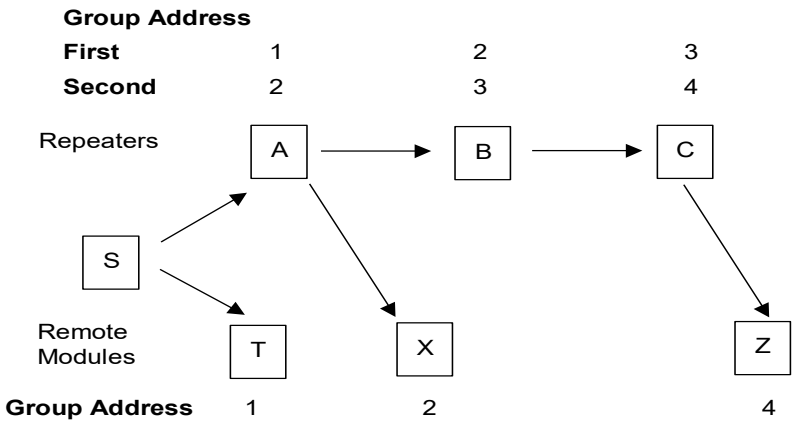
3.5 Transparent Mode Repeaters

A module can be configured as a transparent mode repeater. In this mode, the module will operate as a normal transparent mode module, plus it will also re-transmit any radio messages that it receives. However it will change the group address in the re-transmitted message. The transparent mode repeater is configured with two group addresses. When it receives a radio message with one of these group addresses, it will re-transmit the message using the other group address (assuming that the system address is correct).

One of the group addresses will be its normal or “first” group address. If a transparent mode repeater receives a message on its first group address, it will output the data on its serial port, and will also re-transmit the message using its second group address. That is, the re-transmitted message will now have the second group address. Only 805U modules configured with the second group address will accept the re-transmitted message.

If a transparent mode repeater receives a message on its second group address, it will re-transmit the message on its first group address, but it will **not** output the data on its serial port.

Here is an example :

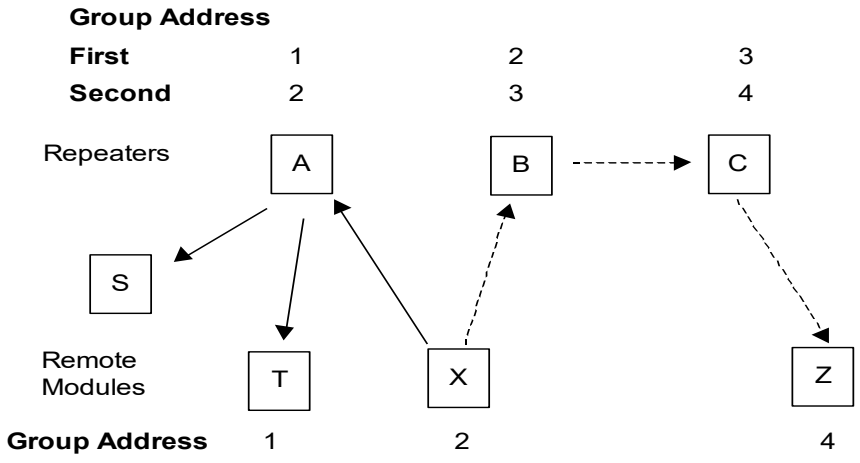


Module A, B and C are configured as transparent repeaters. Module A is configured with group addresses 1 & 2, module B with group addresses 2 & 3 and module C with group addresses 3 & 4.

Module S and T are configured with group address 1 (only one group address as it is not configured as a repeater). When S transmits a message, T and A will receive it and output the data. If module X can hear the message, it will not output it as module X is configured with group address 2.

Repeater A will re-transmit the radio message, but on group address 2. Module S and T will receive the re-transmitted message, but will not output the message as the group address is now wrong. Module X will receive the message and will output the message as the group address is now correct.

Repeater B will also receive the re-transmitted message from A, and will output the data as well as re-transmit on group address 3. The only other module which is also on group address 3 is repeater C. It will accept the message and re-transmit it on group address 4 - to module Z. Note that when a message is transmitted from a remote module, the repeaters will only transmit a message in one direction. For example :



When X transmits a message, repeater A will receive the message on group address 2. Repeater A will not output the data as the group address is not the repeater's first group address. Repeater A will re-transmit on group address 1 to modules S and T. But repeater B will not accept the re-transmitted message on group address 1.

If repeater B is able to hear the original message from module X (on group address 2), then it will re-transmit it on. But if it cannot, then the message will not be transmitted on to Z.

3.6 Controlled Mode

In controlled mode, data is only transferred between two modules (that is, a point to point link). One of the modules is configured as a "master" unit and the other as a "slave" unit. There can

also be up to five intermediate repeaters in the link. Each 805U 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.

To establish a link, the master will transmit a special "connect" message. This initial message will not include any data. If the "slave" unit receives the initial message, and is not already connected to another 805U unit, it will return an acknowledgment message. Both units will activate their DCD LED, and also activate their DCD output signal. If the master unit does not receive the acknowledgment, the DCD output will reset. When the connection is made (DCD set), the 805U units can transmit data to each other.

Once the communications channel has been established, the 805U unit will accept input data and send radio messages with data. When a 805U 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 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.

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
• Radio RX LED flashes	<----------	• If message OK, transmit back an ACK message. • 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 up to five times. If the unit still does not receive an ACK message after five attempts, it will reset the DCD LED, and reset the DCD output.

During normal operation, if there has been no radio activity for a period (called the "link check" period), the "master" unit will transmit the "connect" message to check the radio path. The link check period is a time configured by the user.

Successful Communications

Source Module	**Destination Module**

• Serial data is received • Serial RX 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 TX 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 up to four times	---------->	
• If no ACK message received after five attempts • "NO CARRIER" message sent to host • DCD signal and DCD LED reset		

The time taken to transmit a message is :-

|----------HEADER----------|----------DATA----------|----------|

lead-in 10msec	system address	unit addr	repeater addrs's	dest. addr	zero byte	data	error check
No. of bytes	2	1	0 - 5	1	1	no. of data bytes	2

The time for each byte is 0.5msec @19200 bits/sec. If error checking is not configured at the receiving unit, data will start to be output approx 1msec after the "zero" byte has been received. If error checking is configured, data will be output approx 2msec after the end of the message. For example, a message with 20 bytes of data transmitted at 19200 bits/sec with no repeaters, will be output approx 24msec after the data is input, assuming that error checking is configured.

There are several configurations for controlled mode:

3.6.1 Auto-Connect Controlled Mode

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 a connect message to check the communications link.

The connection will be broken if a communication failure occurs, or if one of the hosts 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 five repeater addresses may be configured as part of the auto-connect address. That is, up to 5 intermediate modules can act as repeaters between the master and slave modules.

3.6.2 Low Power Auto-Connect Mode

For special installations, the 805U may be operated in a low power condition where it switches off its receiver - power consumption is reduced to approx 30% of normal. The low power condition will occur if the 805U is configured for auto-connect mode AND if the low power mode feature is configured. The DTR signal on the RS232 port will control switching between low power and normal operation. When DTR is “low”, the module will change to low power operation, reset any connected link and switch off its receiver. When DTR goes “high”, the module will revert to normal operation and will auto-connect to its slave address.

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 805U unit. The 805U unit will then operate normally until the DTR signal is reset by the host device.

3.6.3 Single-Connect Controlled Mode

Single-connect is similar to a dial-up modem. In this mode, the module will only make one attempt to connect to a destination address. A host device will issue a connect AT 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 DCD status is set. If the destination module does not respond, then 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 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 five repeater addresses may be configured as part of the remote address. That is, up to 5 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, the DTR signal will force a hang-up (DCD reset) if the host device resets the DTR signal.

3.6.4 Fast Operation Controlled Mode

Not used.

3.6.5 CTS/RTS Flow Control

Flow control is a configurable parameter. On the RS232 port, if CTS/RTS is enabled, the CTS signal will be active when the input data buffer is not full. Note that CTS/RTS is disabled in the default configuration - if this feature is required, it must be enabled (refer Configuration Chapter 4). If CTS/RTS is not enabled, then data will be lost after the input buffer (2KB) is full.

3.6.6 Intermediate Repeaters

Where intermediate repeaters are configured, each repeater will re-transmit the message onto the next address. When the destination address is reached, the destination module will return an acknowledgment (ACK) with the reverse address structure as the received message.

If error-checking is selected, then the destination module will only return a ACK if the error check is valid. If the error check is not valid, then no ACK message is returned. If the error-checking function is not selected, then the destination module will return an ACK every time it receives a message. Each repeater will re-transmit the ACK message until it is received by the source module.

The source module will calculate a waiting time for the acknowledgment - this time is based on the radio baud rate, the message length (number of bytes) and the number of repeaters. If the source module does not receive an ACK, it will transmit the same message again. The 805U will transmit the message up to five times. If it does not receive an ACK after the 5th attempt, it will assume communications failure and reset its DCD status. The unsuccessful message will not be re-transmitted and will be lost.

Repeater Communications Successful

Unit A		**Unit B**		**Unit C**		**Unit D**
Source		*Repeater*		*Repeater*		*Destination*
• Transmit message	--->	• Receive message				
		• Re-transmit message	--->	• Receive message		
				• Re-transmit message	--->	• Receive message
Receive ACK					<---	• Transmit ACK
		• Receive ACK	<---	• Receive ACK		• Output data
	<---	• Re-transmit ACK		• Re-transmit ACK		

Repeater units may also act as destination addresses for some transmissions and output data to a host device.

3.7 What Operating Mode to Use?

3.7.1 Transparent or Controlled Mode?

Transparent mode provides simpler operation as the units do not acknowledge transmissions received. However reliable operation in transparent 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 transparent mode.

Controlled mode is suitable for point-to-point links. For multi-point networks, a "master" host device must control connecting and disconnecting to remote units.

It is possible to configure different units in the same system with different operating modes, however the system will not operate. A 805U unit configured in one mode will not process a message received from a unit in the alternate mode.

3.7.2 Error Check?

Error-checking may be configured in both transparent and controlled mode. When the error-check is configured, two additional bytes are attached to the end of each message. These bytes are used to detect any corruption of the data when it is received at another 805U unit.

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

We recommend that units in the same system have the same error-check configuration, however it is possible for users to configure the units differently. If a unit without error-check configured receives a message which includes an error-check, then the unit will treat the additional two bytes as data and output them to the host device. If a unit with error-check configured, receives a message without an error-check, it will treat the last two data bytes as the error check - the error-check will always be incorrect and no data will be output.

Error-check is strongly recommended for controlled mode operation. If error-check is not configured, then a 805U 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. If it is incorrect, an error message (NACK) is returned to the source address.

3.8 Serial / Radio Rates

The 805U will operate most efficiently when the serial and radio data are configured to the same value. If the serial data rate is less than the radio rate, there is a risk that the radio will empty the input buffer to 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.

To avoid this occurring, the 805U will automatically delay the radio transmission starting. 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 805U 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 (refer section 4 "Configuration") - when a configuration is entered whereby the serial rate is less than the radio rate, the 805U 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 805U 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 - this value can also be changed by the user.

3.9 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 805U 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 6.

Interference will only cause a problem if the amplitude of the interference is comparable to the radio signal from the 805U 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 transparent mode, try controlled mode.
- If configured for a radio data rate of 76800 or 38400 bits/sec, reduce the rate to 19200 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.

Chapter 4 CONFIGURATION

4.1 Before Configuring

Configuration comprises selecting parameter values for the operation of the 805U unit. Four pre-set configurations may be achieved using the four DIP switches. These configurations cover most applications - refer section 4.7.

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

- Addressing - system address, group address, unit address.
- Character type. You need to find out the character type of the host devices connected to the 805U 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. Remember that the radio range for 76800 and 38400 bits/sec will not be as good as that for 19200. We recommend that you use 19200 bits/sec unless your application requires the faster data rate.
- Operating mode . You need to decide which operating mode you wish to use. Modes are transparent or controlled (auto-connect, single-connect, low power mode), error-checked or no-error-check,. These modes are discussed in more detail in following sections.

The other configuration parameters do not need to be selected, and are provided as a means of "fine tuning" the operation of the 805U 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 four DIP switches located in the end-plate of the module. It is not possible to select addressing using these switches, so these switches are normally used as a quick way to try other configuration modes or data rates.

4.2 Addressing

A 805U network comprises modules with the same "system" address. The system address is a 8 bit value (values 0 to 255). Only modules with the same system address will communicate with each other. 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.

In transparent mode, a group address also needs to be configured. The group address is also a 8 bit value (values 0 to 255). This is not required in controlled mode.

In controlled mode, each module is also configured with a unit address between 0 and 127 - there can be up to 128 modules in the one controlled mode system.

In transparent mode, the unit address is used as the second group address for transparent repeaters. For modules not configured as a repeater, the unit address is ignored. For repeaters, if a message is received with the correct system address, and the first group address, the data is output to the serial port, and the message is re-transmitted but with the second group address inserted.

If a repeater receives a message with the correct group address, but with the second system address (corresponding to the configured unit address), then the data is not output to the serial port, but the message is re-transmitted, but with the first or normal group address inserted.

4.3 Default Configuration

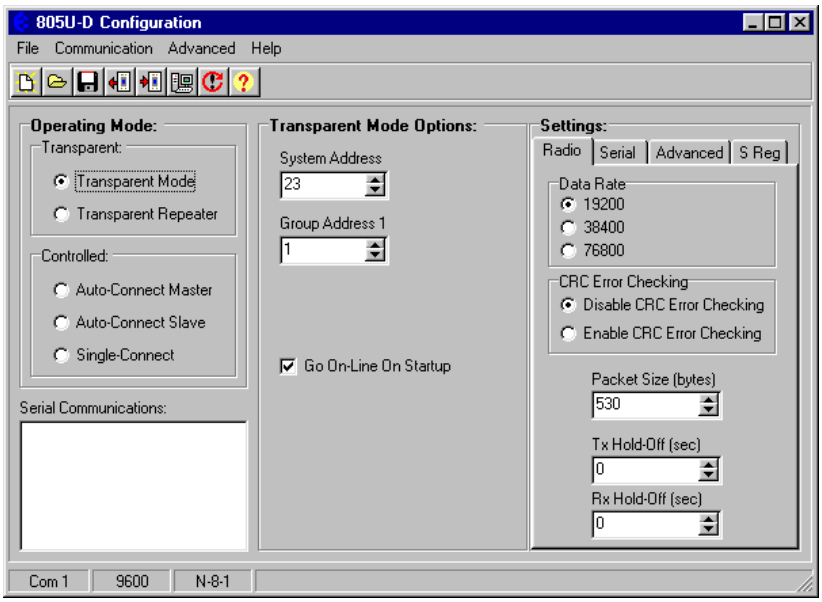
The default configuration of the 805U is transparent mode, no error check, no CTS/RTS flow control, serial rate 9600, radio rate 19200, character type 8/n/1. The system address will be set in the factory according to the module serial number.

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

4.4 Configuration Program

The configuration program is Cfg_805UD. This program will run under Windows 95, 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 805U module. You can also read the configuration from a module to edit.

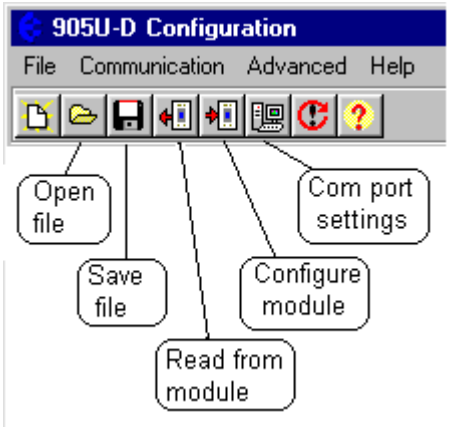
The opening screen will show default settings with a random number for the system address.



Reading and Configuring a module

You will need a connection cable between the PC and the 805U. The cable 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.

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.



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 switches in the module end plate (see section 4.7 of this manual). Note that when you do this, you will lose all of the configuration in the module.

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

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 ".05D". For example, "PLC57.05D".

To open an archived file, select the "Read" icon on the toolbar.

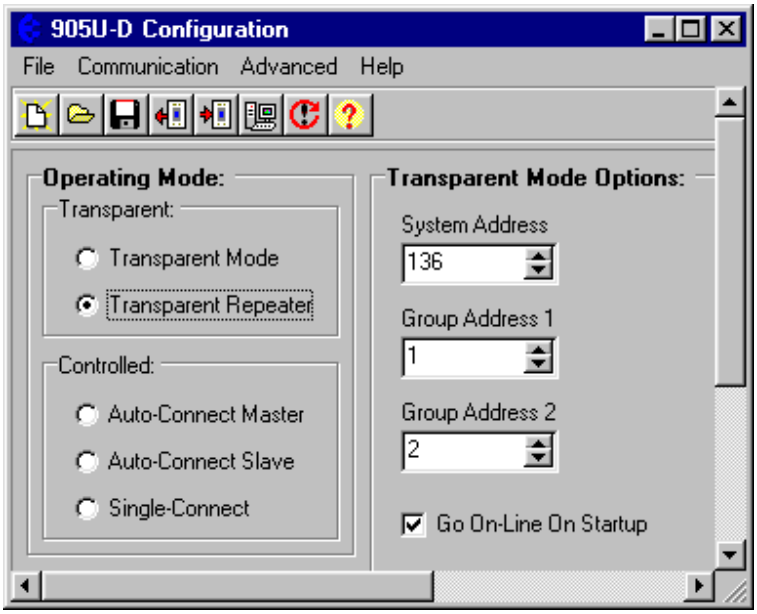
Modifying an existing configuration

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.

4.4.1 Transparent Mode

The default setting of the program is transparent mode. 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. Also select the group address - only modules with the same group address will communicate with each other.The "Go On-line On Startup" box will normally be selected for transparent mode. If you deselect this, then the module will start-up in command mode, and will not operate until the host device sends it a AT command to go on-line.

Transparent Repeater



When you select a transparent repeater, the program will ask you to enter a second group address. The repeater will re-transmit messages from the first group to the second group - and from the second group to the first group.

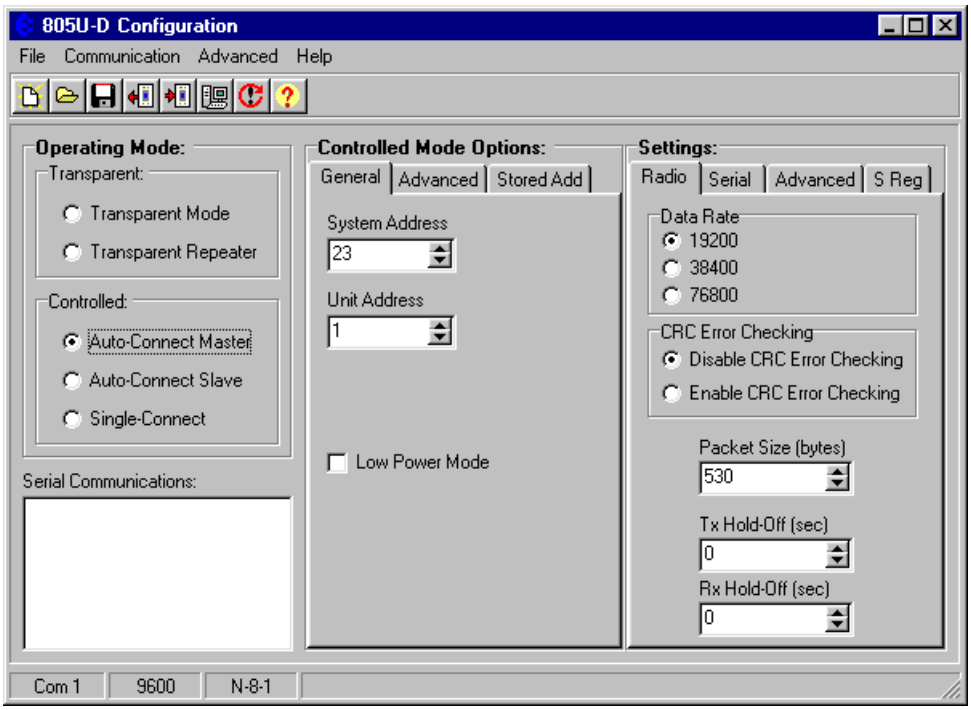
A transparent repeater will transmit data from its host device (if there is a host connected) using the first group address, and will only output data to its host device if the received message has the first group address. If the transparent repeater receives a message from the second group, it will re-transmit the message but it will not output the data.

4.4.2 Controlled Mode

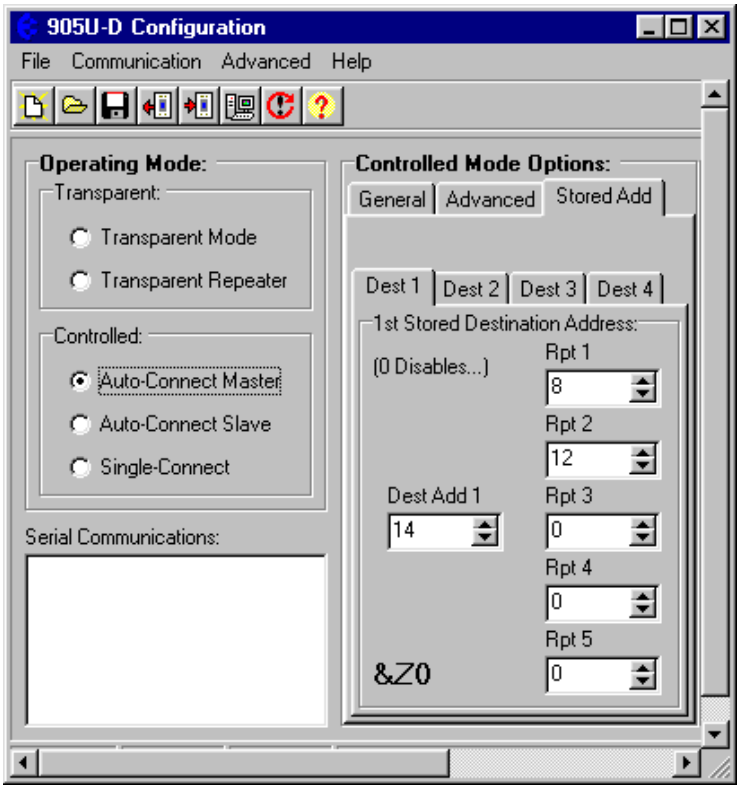
If you select any of the controlled mode options, you will be asked to select a unit address for the module. This should be a unique address for that module (0 – 127).

Auto-Connect Master

In auto-connect mode, the “master” will automatically attempt to connect to the slave address. Once connected, the link can transfer data in either direction, with error-checking, acknowledgement messages, and automatic re-transmissions if necessary. If the link connection fails (indicated by the DCD led), then the master unit will automatically try to reconnect to the slave.



At the master unit, you need to enter the address of the slave. Select the "Stored Add" page and "Dest1". The address of the slave is entered into "Dest Add 1" and up to five repeater addresses may be entered. Repeater modules may be configured in any controlled mode option, but they must have the same system address. The repeater addresses are entered in order from the master - that is, "Rpt 1" is the first repeater after the master.



You can enter address structures for four slaves - "Dest 1" to "Dest 4". However the host must use AT command to select which slave is required. Without the use of AT commands, the master will only attempt to connect to the address configured in "Dest 1".

Auto-Connect Slave

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

Single-Connect

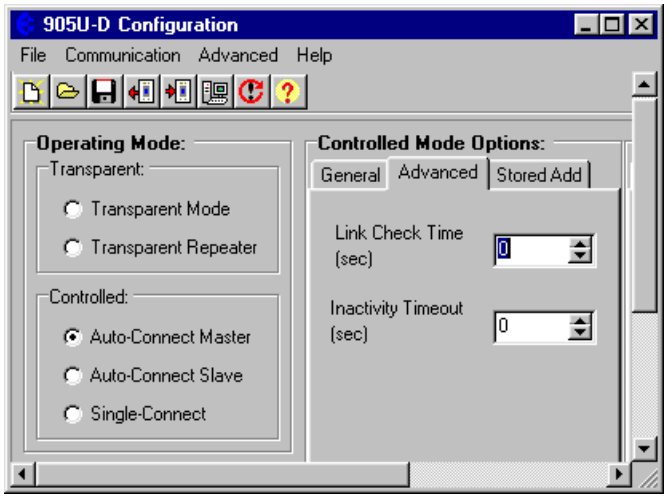
In single-connect controlled mode, the host devices use AT commands to select destination addresses to connect to. Normally the only configuration required is a unit address.

Low Power Mode

If "Low Power Mode" is selected, the module will disconnect the communications link and shutdown its receiver circuits if the RS232 DTR signal goes to a low or reset state. When the DTR signal becomes high or active, then the module will revert to normal operation.

Controlled Mode Options

For each controlled mode, there are some options. In the "Advanced" page, there are some timing parameters.



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. If there is still no ACK, then the master will reset the link (DCD reset).

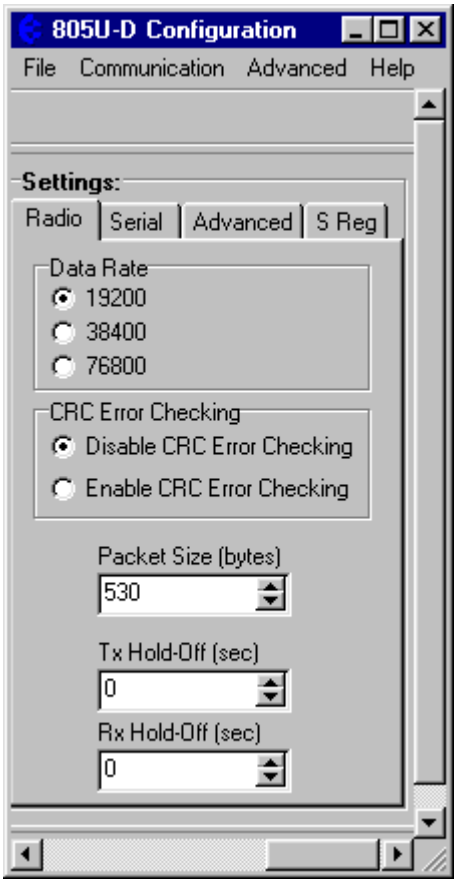
If you enter an "Inactivity Timeout" value, then the 805U will automatically reset the link if there has been no data transmissions within this time. If you use the link check feature, you should enter an "Inactivity Timeout" value to reset the link at the slave unit.

It is a good idea to use these timers as it provides a higher level of security for the controlled mode system (except for "fast operation" systems). Normally a link check time will be entered at the master unit (for example, 10 seconds), and a 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.

4.4.3 Other Parameters

Radio Data Rate



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. If you select a rate which is faster than the serial rate, the 805U will automatically set transmission delay parameters in registers S18 and S19 (refer section 3.8). To disable this, deselect the "PLC Mode" box in the Serial configuration window.

Note that modules will only communicate with each other if they have the same radio data rate.

CRC Error Checking

It is normal for error checking to be disabled for transparent mode and enabled for controlled. However you can select either for either mode. Refer to section 3 of this manual for a description on the operation of error-checking.

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 805U, then the module will transmit more than one message.

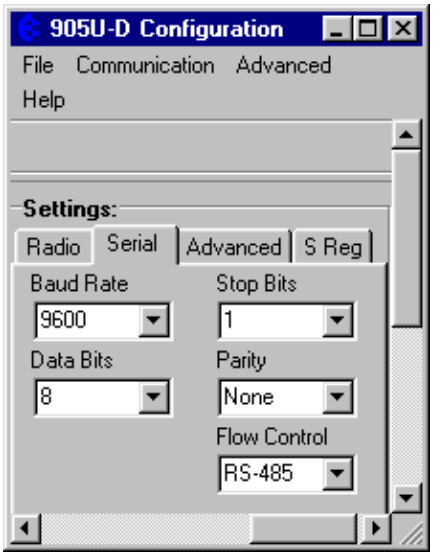
The default value is 530 bytes which is the largest packet value. If you are operating in a noisy radio environment, then the system may be more reliable if you reduce the maximum packet size and transmit a larger number of small messages rather than a lesser number of large messages.

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 805U units in a system.

- After each message is transmitted, a 805U 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.

Serial Port settings



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 1200 and 115,200 baud. If you select a rate which is slower than the radio rate, the 805U will automatically set transmission delay parameters in registers S18 and S19 (refer section 3.8).

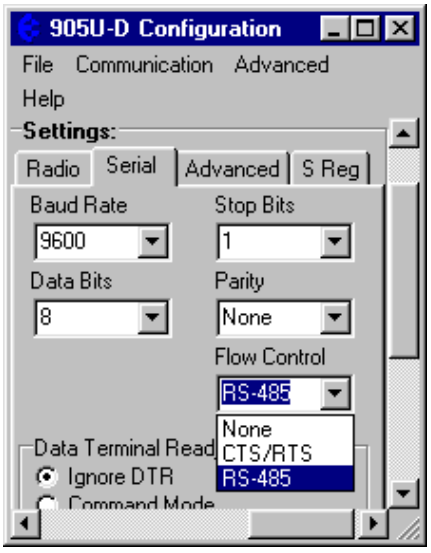
To disable this feature, deselect the "PLC Mode" box. Then there will be no delay - data bytes will be transmitted as soon as they appear in the input buffer.

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.

Flow Control

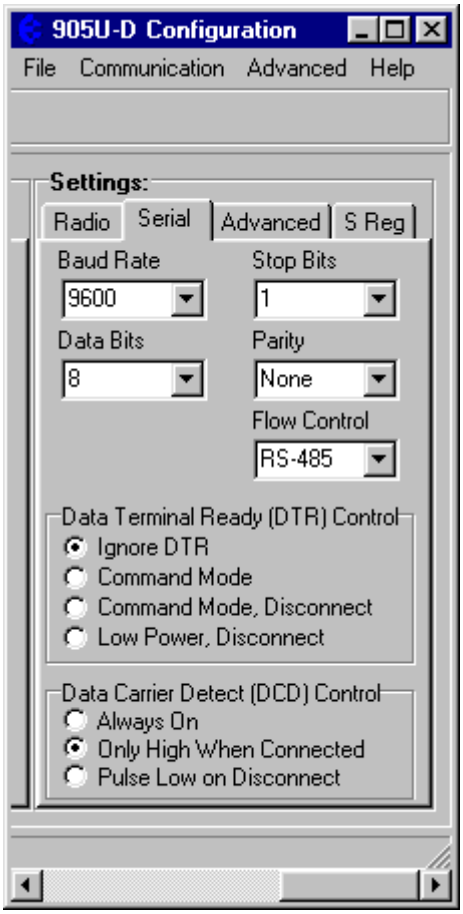
"Flow control" affects the use of the CTS and RTS signals on the RS232 port. These signals can be used to prevent overflow of the input buffer or output buffer of the 805U. The settings should be selected to match the host device. The options for this setting are :

- "None" - The RTS signal from the host is ignored and the 805U sets the CTS signal always on.
- "CTS/RTS" - input buffer flow control
  - the 805U will reset the CTS signal when its input buffer is full
  - presently there is no flow control on the output side; if the host resets the RTS signal, the 805U will still output data
- "RS-485" - must be selected if using the RS485 port; the 805U resets CTS when it is transmitting data.



If you want full duplex operation of the RS232 port, then you need to select "None" or "CTS/RTS" - in the RS485 setting (default setting), the RS232 port will operate in half duplex.

DTR Control



- The DTR signal on the RS232 port can be used for different functions in controlled mode:
- "Ignore DTR" - the DTR signal does not perform any function
- "Command Mode" - if the host resets DTR, the 805U 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 Controlled Mode page, this selection of DTR will be automatically made.

DCD Control

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

- "Always On" - the 805U 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 0.1 sec) when the link is reset.

Advanced Settings

These settings may be adjusted if the host device is using AT commands - refer to Appendix A for an explanation of the different parameters.

S Registers

These are parameter registers settable by AT commands. They do not normally need to be changed. Refer to Appendix A for an explanation of these parameters.

4.5 Hayes Commands

The 805U 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 805U unit will accept Hayes commands, it must be in "command" mode. 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 805U 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 controlled mode.

Once in configuration mode, the 805U 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 76800 baud. B selects the radio rate parameter and 2 is the value corresponding to 76800 baud.

Summary

Enter command mode	<1sec break> + + + <1 sec break>
Response from 805U	OK
Enter configuration commands	ATxy
Response from 805U	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 switches (refer section 4.3), 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 805U. The following commands are the most common.

Configuration of addressing

AT&S	System Address	Range 0-255 Default set by factory.
AT&G	Group Address	Range 0-255. Default 1.
AT&U	Unit Address	Range 0-127. Default 1. This is also the second group address for transparent repeaters.

Configuration of Data Rates and Character Type

ATB	Radio Baud Rate	The radio rate must be the same in all modules	
B0	19,200 baud (default)	B2	76,800 baud
B1	38,400 baud		
ATC	Serial Baud Rate	The serial rate can be different in different modules.	
C0	115,200 baud		
C1	1200 baud	C7	28,800 baud
C2	2400 baud	C8	31,250 baud
C3	4800 baud	C9	38,400 baud
C4	9600 baud (default)	C10	57,600 baud
C5	14,400 baud	C11	76,800 baud
C6	19,200 baud	C12	115,200 baud
AT&Bxx	Character Type (Data bits, Stop bits, Parity). "xx" is formed by adding the values below. Default is 8 data bits / 1 stop bit / no parity.		
0	7 Data Bits	0	No Parity
2	8 Data Bits	4	Zero Parity (Parity bit always zero)
0	1 Stop Bit	8	Odd Parity
1	2 Stop Bits	12	Even Parity

For example, AT&B9 will be 7 data bits, 2 stop bits, odd parity. The character type does not need to be the same for all modules in a system.

Transparent mode

If you have forced the module to factory default configuration, this configuration will not be necessary. The following commands can be used to change the configuration to transparent mode.

AT&M0&L1

Transparent repeater

AT&M1&L1

The repeater will use both a primary group address (AT&G) and a secondary group address (AT&U). Data will be output to the serial port only when received with the primary group address.

Controlled mode, auto-connect

Master module AT&E1&M2&L2

The module will start up in operating mode and will automatically try to connect to the destination address saved in AT&Z0 (this is the slave unit). The destination address needs to be entered - for example,

AT&Z0=24 will store a destination address of 24

AT&Z0=33,34,35,5 will store an address sequence, where 5 is the destination address and 33, 34 and 35 are repeater addresses. The first repeater will be 33.

The 805U master will attempt to connect to the destination address (slave). If the module cannot connect, or if communications fails, the module will continually send "connect" messages to make a connection.

Slave module AT&M2&L3&E1

The module will start up in operating mode and will automatically accept any connect message addressed to it.

Low Power Mode

Low power mode is normally used with auto-connect controlled mode, although it can also be used with other controlled modes. Before you configure the unit for auto-connect controlled mode, enter

AT&D3

This allows the DTR signal on the RS232 port to control the module. When the host resets (signal low) the DTR signal, the module will disconnect the radio link, and the module will revert to low power mode - the module will switch off its radio receiver and microprocessor. When the host activates the DTR signal, the module will start up and attempt to connect to its slave address.

Controlled mode, single-connect

AT&E1 &M2&L0 (both master and slave module)

The module starts up in command mode and waits for a command from the host device. An ATD command will initiate a connect command to another module.

For example, ATD8 to module #5 will initiate a connect command to be sent to module #8. Module #5 will respond with RINGING to its host. If #8 is not already connected to another module, it will connect (set DCD) and respond to #5. Module #8 will respond to its host with CONNECT and will automatically go to operating mode. Module #5 will respond with CONNECT to its host and will also automatically go to operating mode.

If #8 does not reply, #5 will make up to 5 attempts to connect, and will then respond to its host with NO CARRIER. If #8 is already connected to another module, then it will respond to #5 with a "busy" message and #5 will respond to its host with BUSY or NO CARRIER (this response can be configured under "responses").

If there are repeater modules, then the ATD command will have the form ATDr1,r2,r3,r4,r5,d where "d" is the destination address and "r" is a repeater address. "r1" is the repeater closest to the master unit. For example, ATD2,3,10 will try to connect to 10 via repeaters 2 and 3. Up to 5 repeater addresses may be used. A repeater can already be connected to another module - it can still act as a repeater for another link.

Once a connection is made (DCD set), any data sent will be acknowledged by the other module. The connection will be broken (DCD reset) if an ACK is not received within 5 attempts to transmit a message.

Either host may disconnect the link using the ATH command - or by using the DTR signal on the RS232 port - refer to the AT&D command in Appendix A.

When the link is disconnected for any reason, the DCD output at each module is reset and each module will respond to its host with NO CARRIER - each module will revert to command mode.

Fast Operation Mode

Not used.

Controlled Mode Link Check and Reset times

If the master module has not sent or received a radio message within a preset time, it will send a check message to make sure that the link is still active. If it does not receive a response from the slave unit, it will disconnect the link and reset DCD. The check time can be configured using the ATS6 command. For example, ATS6=10 sets the check time to 10 sec.

If the slave module does not receive a radio message within the link reset time, it will disconnect the link and reset its DCD. The link reset time can be configured using the AT\T command. For example, AT\T12 sets the link reset time to 12 seconds. The link reset time should be larger than the link check time.

Note that any module can be master or slave - the master module for a specific link is the module which initiated the connection (by ATD).

The default for both of these parameters is 0 which disables the link check and link reset function.

Configuration of Flow Control

CTS/RTS flow control can be configured. This may be desirable to ensure data is not lost if transmitting large amounts of data.

AT&K

&K0	Flow Control Disabled. CTS Always high. Module ignores host's RTS. Select for full duplex RS232 with no flow control.
&K1	not used
&K2	not used
&K3	CTS/RTS Flow Control. CTS Reflects the state of the local buffer. Module only transmits serial data when RTS is high.
&K4	(default) RS-485 Control - flow control disabled. Must be selected for RS-485 to work. CTS is high. CTS goes low when transmitting data. RTS is ignored.

Configuration of Error Checking

Error-checking is normally disabled for transparent mode, and normally enabled for controlled mode. The configurations for transparent and controlled modes above follows this convention. However you are able to override this.

AT&E CRC Error Checking

&E0	Disable CRC Error Checking (default)
&E1	Enable CRC Error Checking

View Configuration

The AT&V command will output to the terminal a listing of all configuration settings.

AT&V	Show all settings including S registers
&V0	Same as AT&V
&V1	Only show settings that are different from the defaults.

Transmit and Receive Hold-off times

Transmit holdoff ATS16=x where x is the delay time in msec (0 – 255)

For example, ATS16=200 results in a transmit holdoff delay of 200msec.

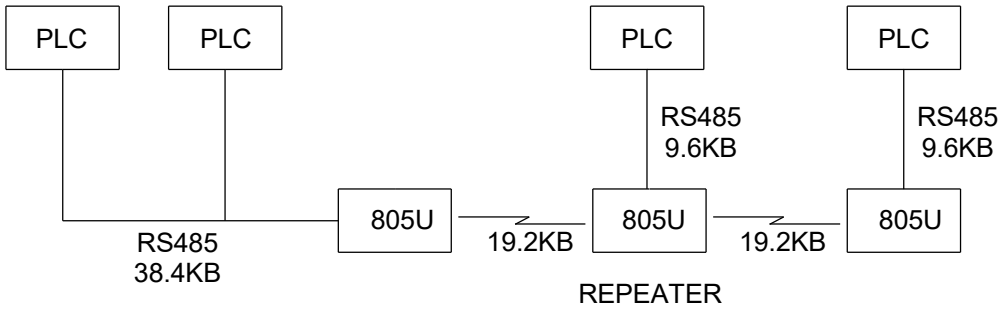
Receive holdoff ATS15=x where x is the delay time in msec (0 – 255)

For example, ATS15=80 results in a receive holdoff delay of 80msec.

4.6 Configuration Examples

Transparent Mode

Extending a PLC Network



DATA = 7 DATA BITS, 1 START, 2 STOP, EVEN PARITY

Left-hand Unit Configuration

Set the module to factory default settings:	AT&F
Set the system address to a random number:	AT&S138
Set the group address	AT&G1

The group address for the left hand side modules has been set to 1.

Set the serial data rate to 38400	ATC6
Set the radio data rate to 19200	not necessary (default)
Set the character type to 7,1,2,even	AT&B13
Exit and save the configuration	AT&W ATO

The operating mode will already be in transparent mode from the factory default settings. The other default values for the other parameters will likely be OK.

Repeater Configuration

Set the module to factory default settings:	AT&F
Set the system address to the same random number:	AT&S138
Set the group address and unit (secondary group) address	AT&G1 AT&U2

The group address for the right hand side module will be set to 2 (this corresponds to the secondary address of the repeater).

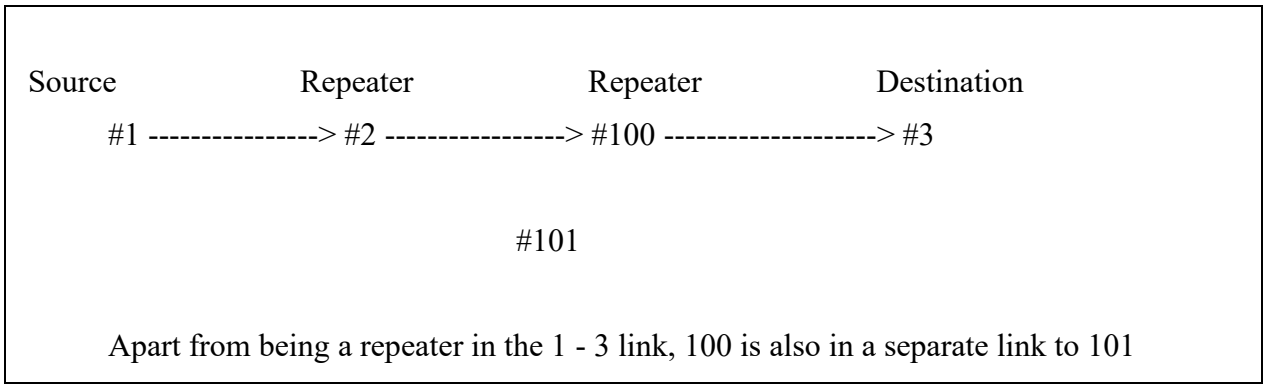
Note that the repeater will only output data to its PLC for messages received from the first 805U. It will not output data from the right-hand PLC. If you set both group addresses to 1, then the repeater will output data from both sides - this is only possible when there is only one repeater. The disadvantage of this is that both sides will hear the re-transmitted message - that is, the PLC that sent the message will receive the same message back as a re-transmitted message. This is not a problem with most PLC's, but is with a small number of brands. For these brands, use a different group address either side of the repeater.

Set the serial data rate to 9600	ATC4
Set the radio data rate to 19200	not necessary (default)
Set the character type to 7,1,2,even	AT&B13
Set the operating mode to Transparent Repeater	AT&M1&L1
Exit and save the configuration	AT&W ATO

Right-hand Unit Configuration

Set the system address to the same random number:	AT&S138
Set the group address	AT&G2
Set the serial data rate to 9600	ATC4
Set the radio data rate to 19200	not necessary (default)
Set the character type to 7,1,2,even	AT&B13
Exit and save the configuration	AT&W ATO

Controlled Mode



Auto-connect link with repeaters

Assume that default settings are used for data rates and character types. The only configuration required is addressing.

Module #1

Set the module to factory default settings:	AT&F
Set the system address to a random number:	AT&S217
Set the unit address to 1	AT&U1
Set the autodial address to 3 via 2, 100	AT&Z0=2,100,3
Set the operating mode to controlled mode, auto-connect, master	AT&M2&L2
Exit and save the configuration	AT&W ATO

Note that module #1 is the “master” unit in this link.

Module #2

Set the module to factory default settings:	AT&F	
Set the system address to the same random number:	AT&S217	
Set the unit address to 2	AT&U2	
Set the operating mode to controlled mode	AT&M2&L3	

Note that this module can be configured as any controlled mode, except for fast operation.

Exit and save the configuration	AT&W	ATO

Module #3

Set the module to factory default settings:	AT&F	
Set the system address to the same random number:	AT&S217	
Set the unit address to 3	AT&U3	
Set the operating mode to controlled mode, auto-connect, slave	AT&M2&L3	
Exit and save the configuration	AT&W	ATO

Module #100

Note that #100 is the master unit for a link between #100 and #101, It is also acting as repeater in the #1 to #3 link. The system address for #100 and #101 must be the same as the other modules so that #100 can act as a repeater.

Set the module to factory default settings:	AT&F	
Set the system address to the same random number:	AT&S217	
Set the unit address to 100	AT&U100	
Set the autodial address to 101	AT&Z0=101	
Set the operating mode to controlled mode, auto-connect, master	AT&M2&L2	
Exit and save the configuration	AT&W	ATO

The configuration for #101 is not shown as it is not part of the active link.

4.7 Switch Configuration

Some configurations can be made using the four DIL switches mounted in the end-plate of the module.

The DIL Switches are only read at power-up, and change the volatile configuration of the module. The non-volatile configuration is not changed. DIL Switch settings allow the factory configuration to be restored, testing functions, and some simple back-to back configurations. If you want the module to start up in the same way each time, you will need to leave the switches in the same setting. If you are using the switches to do temporary changes, then you should change the switches back to the zero position after powering up.

Note that these switch settings do not set the system or group addressing - this still needs to be set by Hayes Commands or the configuration program.

The four switches are located on the top end-plate, as per this diagram. If you look at the end of the module with the front of the module up, then Switch 1 is the left-most switch, and "on" or 1 is when the switch is down. The switches in the diagram have the pattern 0100.

Switch	Function	Equivalent Hayes Command at start-up.	Baud rates	
0000	Normal Operation – no change			
0100	Restore Factory Defaults.	AT&F		
1100	Perform Transmit BER Test	AT&T0 (for use with AT&T1 at other module - see section 6.2.1)	Serial	Radio
0010	Transparent Mode.	AT&M0B0C4&L1	9600	19200
1010	"	AT&M0B1C6&L1	19200	38400
0110	"	AT&M0B1C9&L1	38400	38400
1110	"	AT&M0B2C10&L1	57600	76800
0001	Controlled Mode Auto-connect master.	AT&M2&U1B0C4&E1&Z0=2 &L2	9600	19200
1001	"	AT&M2&U1B1C6&E1&Z0=2 &L2	19200	38400
0101	"	AT&M2&U1B1C9&E1&Z0=2 &L2	38400	38400
1101	"	AT&M2&U1B2C10&E1&Z0= 2&L2	57600	76800
0011	Controlled Mode Auto-connect slave.	AT&M2&U2B0C4&E1&L3	9600	19200
1011	"	AT&M2&U2B1C6&E1&L3	19200	38400
0111	"	AT&M2&U2B1C9&E1&L3	38400	38400
1111	"	AT&M2&U2B2C10&E1&L3	57600	76800

Chapter 5 SPECIFICATIONS

General		
EMC specification	EN 300 683	89/336/EEC
Radio specification	EN-300-220/1	869.4 – 869.65 MHz, 500mW
Housing	110 x 185 x 30mm DIN rail mount	Powder-coated, extruded aluminium
Terminal blocks	Removable	Suitable for 2.5sqmm conductors
LED indication	OK operation, Serial RX and TX, Radio RX and TX, DCD active	
Operating Temperature	-40 to +60 degrees C 0 – 99% RH non-condensing	Typical performance
Power Supply		
Nominal supply	10 to 30VDC 13 to 24VAC	Overvoltage and reverse voltage protected
Current Drain @ 12VDC	80 mA quiescent 20mA (low power mode)	During transmission 350mA
Current Drain @ 24VDC	50 mA quiescent 15mA (low power mode)	During transmission 250mA
Radio Transceiver		
Single channel	synthesized, fixed band 250KHz	869.4 – 869.65MHz
Transmit power	500mW	
Signal detect / RSSI	-120 to -60 dBm	
Expected line-of-sight range	5 km @ 19200 baud 3 km @ 38400 baud 1.5 km @ 76800 baud	Range may be extended by up to 5 intermediate modules as repeaters, in controlled mode
Antenna Connector	Female SMA coaxial	
Serial Ports		
RS232 Port	DB9 female DCE	RTS/CTS/DTR/DCD hardware signals provided
RS485 Port	2 pin terminal block	Typical distance 1.2 km

Data rate (bit/sec) - configurable	1200, 2400, 4800, 9600, 14400, 19200, 38400, 57600, 76800, 115200	
Byte format	7 or 8 data bits	Stop/start/parity bits configurable
System Parameters		
Operating modes	Transparent mode Controlled mode	Broadcast system Addressed communications with acknowledged
System address	Configurable 8 bit	
User Configuration		Hayes commands from host device. Or via on-board DIP switches
Diagnostics	OK and PWR leds	
	Low signal receive led CTS/RTS indication	
	RSSI measurement in dBm	BER test

Chapter 6 TROUBLESHOOTING

6.1 Diagnostics Chart

INDICATOR	CONDITION	MEANING
OK LED OFF	Continuously	• Power supply failure • CPU failure
OK LED ON	Continuously	• Normal Operation
Radio TX LED ON	Flashes briefly	• Radio transmitting
Radio RX LED ON	GREEN flash RED flash	• Radio receiving data • Weak radio signal (<-95dBm)
Serial RX LED ON	GREEN flash RED flash	• Serial Port Receiving • Input buffer near full
Serial TX LED ON	Flashes briefly	• Serial port transmitting
DCD LED ON	Continuously	• In transparent mode, always on. • In controlled mode, a radio link has been established.

The green OK LED on the front panel indicates correct operation of the unit. This LED extinguishes on failure as described above. When the OK LED extinguishes 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.

6.2 Test Functions

6.2.1 Radio Testing - AT&Tx

To aid in the checking and setup of the 805U 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). The table below outlines the functions of the various tests:

AT&T	Self Tests. Allows in-field diagnostics, and factory testing.
&T0	Transmit Bit Error Rate Test. Generates pseudo random data and sends out radio.
&T1	Receive Bit Error Rate Test. Receives data from &T0 module, and displays BER statistics.
&T2	Transmit & Receive BER Test. Used with a second module configured as a transparent repeater.
&T3	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&T3 - Received Signal Strength Display

This option provides for testing the radio path between two 805U 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, force the remote unit to generate data and read the signal level from the local terminal. The remote unit can be forced to transmit by selecting AT&T0 or by selecting 1100 on the four DIL switches and resetting the power to the module.

Also measure the background noise by stopping transmission from the remote module and reading the value from the terminal. The readout will jump around as the radio hops between channels - determine the average value. For reliable operation (that is, a bit error rate of more than 1 in 300) the transmitted signal should be better than the following margins:

Radio Baud Rate	Margin above Noise	Minimum Value (dBm)
19200	10	-95
38400	15	-90
76800	20	-85

For example, for transmissions at 19200 baud, the radio signal should be at least 10dB better than the background noise level, or better than –95dBm if the noise level is less than –105dBm. If the background noise is –100dBm, then you need –90dBm of signal for reliable operation. If the background noise is –120dBm, then you need –95dBm of signal for reliable operation.

When using directional antennas (YAGI antennas) this feature may be used to align the antenna in the correct direction by selecting the peak signal when moving the antenna. Setup the remote unit to transmit, and observe the signal indication while adjusting the orientation of the antenna. A peak in signal level indicates optimum orientation of the antenna.

6.2.2 Bit Error Rate Test (BER)

BER may be tested in one direction by typing AT&T0 (BER master) at the sending unit and typing AT&T1 (BER slave) at the receiving unit. The sending unit will repeatedly send pseudo-random frames, and the receiving unit will check these frames for errors. If a terminal is connected to the sending unit, the pseudo-random data is displayed as it is transmitted. If a terminal is connected to the receiving unit, then the test results are displayed.

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

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

Test - the sequence number of the last received 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)

Occasionally during testing, the following may be displayed:

Test	**Errors**	**Extra**	**Level**	**TotErr**	**TotTest**
			Bad Header		

This indicated that the header information has been corrupted. Corrupted headers do not contribute to the bit errors, which are calculated only on the 1,000 bit frame.

BER testing may also be performed in both directions simultaneously. In this case, a remote module is set up to Transparent mode repeater operation (set Group address and Unit address both to 1) and the BER test is performed on the local module using the command AT&T2 (loopback Bit Error Test). In this case, the display is identical to the display on the BER slave unit above, but the displayed bit errors are a total for the round trip, so will be the sum of the bit errors in both directions. This test is generally the easiest to perform with one person - the remote module can be set as a repeater, and the full test can then be carried out from the other module. During this test, disconnect the serial cable to any host device at the repeater.

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.

The BER test can also be initiated by the configuration switches in the end-plate - see section 4.7.

6.2.3 On-line diagnostics

Some diagnostic values may be read 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 controlled mode (ATS12?) - refer Appendix 1.

Chapter 7 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."

Appendix A Hayes Commands

The following details all of the Hayes commands supported by the 805U. Default settings are shown by a "dot", •

Command	Function
ATA	Answer Incoming Connection message in controlled mode – the module can also be set to answer incoming connections immediately or after a certain number of attempts (see S-Register S0) - the default for S0 is 1, meaning that the module will normally automatically answer on the first connection attempt. If you want to use ATA, S0 should be set to zero or a larger number.
ATB	Set Radio Baud Rate – Radio Baud rates are 19 200, 38 400 and 76 800 baud.
B0•	19 200 baud
B1	38 400 baud
B2	76 800 baud
ATC	Serial Baud Rate selection / Automatic Baud Detection control
C0	115,200 baud
C1	1200 baud
C2	2400 baud
C3	4800 baud
C4•	9600 baud
C5	14,400 baud
C6	19,200 baud
C7	28,800 baud
C8	31,250 baud
C9	38,400 baud
C10	57,600 baud
C11	76,800 baud
C12	115,200 baud
ATD	Connection/Dialling Control. Dial a specific remote or a stored number. Used in single-connect controlled mode (master module).
ATDSn	Dial stored number "n" - see AT&Z for storing numbers
ATE	Local Echo Control. Enable / Disable Command Echo.
E0	Disable Local Echo
E1•	Enable Local Echo
ATH	Disconnect link in controlled mode. "Hang up" control.
ATI	Module Identity / Firmware version - returns the software version number.
ATO	Go to "on-line" (operating mode)
ATQ	Quiet mode (Suppress/enable response codes) see details of Response Codes later in this section.
Q0•	Enable response codes
Q1	Disable response codes
ATSn?	Read value from S-Register n - see description of S registers later in this section

ATSn=xx	Set value of S-Register n to xx
ATV	Verbal/Numeric Response Codes
V0	Numeric response codes
V1•	Verbose response codes
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 38400)
X2	X1 + BUSY Message
X3	X2 + RINGING Message
ATZ	Reset the module, and re-load the configuration stored in non-volatile memory.

AT&Bxx Character Type (Data bits, Stop bits, Parity). "xx" is formed by adding the values below.

0•	1 Stop Bit	0•	No Parity
1	2 Stop Bits	4	Zero Parity (Parity bit always zero)
0	7 Data Bits	8	Odd Parity
2•	8 Data Bits	12	Even Parity

AT&C Data Carrier Detect (DCD) Control. DCD is always on in transparent mode.

&C0	DCD Always on.
&C1•	DCD High when connected. Low otherwise.
&C2	DCD Always on, Pulses low on Disconnect (0.1 sec)
AT&D	Data Terminal Ready (DTR) Behavior. The host controls DTR. This command controls how the module reacts to the state of DTR.
&D0•	Module ignores DTR, and acts as if it is asserted.
&D1	If the host lowers DTR, the module returns to command mode, but does not disconnect.
&D2	If the host lowers DTR, the module disconnects and returns to command mode.
&D3	If the host lowers DTR, the module disconnects and goes to low power mode. Raising DTR will cause the module to dial if the leased line settings are correct (&L1).
AT&E	CRC Error Checking
&E0•	Disable CRC Error Checking
&E1	Enable CRC Error Checking
AT&F	Restore Factory Defaults. This function is also available from the external DIP Switches.

AT&G	Set module's Group Address Range 0-255. Default 0.
AT&K	Flow Control Configuration.
&K0	Flow Control Disabled. CTS Always high. Module ignores RTS.
&K1	not used
&K2	not used
&K3	CTS/RTS Flow Control. CTS Reflects the state of the local buffer. Module only transmits serial data when RTS is high.
&K4•	RS-485 Control. Must be selected for RS-485 to work. CTS is high. CTS goes low when transmitting data. RTS is ignored.
AT&L	Configuration of start-up mode, and controlled mode operation.
&L0	At power-up, the module enters command mode and waits for commands. Normal single-connect controlled mode operation.
&L1•	If set to transparent mode in AT&M, the module automatically goes online. For controlled mode, ATD automatically dials the number stored in Z0, ATA answers an incoming call.
&L2	Auto-connect mode - master. The module "dials" the number stored in &Z0 automatically. It continuously attempts to connect to that number. Use DTR with the AT&D command to control the connection.
&L3	Auto-connect mode - slave. The module continuously attempts to answer any incoming call. Use DTR with the AT&D command to control the connection.
AT&M	Operating Mode. This allows selection between transparent mode and controlled mode.
&M0•	Transparent Mode.
&M1	Transparent Repeater. All serial data is sent out the radio, with the configured system (AT&S) and group (AT&G) address. All incoming radio data with the correct system address and matching group address is sent out the serial port, and also re-transmitted out the radio port using the unit address (AT&U) setting as the group address. All incoming radio data with the configured system address and group address matching the Unit address is re-transmitted out the radio with the group address set to the group address.
&M2	Controlled Mode.
&M3	Not used.
AT&N	Abort Connection Control. Controls whether the module will abort a connection attempt in controlled mode if a character is entered.
&N0	Ignore characters entered while attempting to make a connection.
&N1•	If a key is hit or a character input while attempting to connect, abort the connection attempt and return to command mode.
AT&S	Set module's System Address Range 0-255.

AT&T	Self Tests. Allows in-field diagnostics, and factory testing.
&T0	Transmit Bit Error Rate Test. Generates pseudo random data and sends out radio.
&T1	Receive Bit Error Rate Test. Receives data from &T0 module, and records BER statistics.
&T2	Transmit & Receive BER Test. Used with a second module configured as a transparent repeater.
&T3	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.
&V0	Same as AT&V
&V1	Only show settings that are different from the defaults.
AT&U	Set module's Unit Address Range 0-127. Default 1.
AT&W	Write Current Configuration to non-volatile storage
AT&Z	Stored Numbers – Up to 4 destination addresses may be stored.
	Format: "AT&Zx=nn,nn,nn,nn". "x" = 0 to 7. "nn" = 1 to 127.
	AT&Z0 is used for auto-connect address.
AT\T	Inactivity Timeout – Units Seconds. Value 0-255. Default = 0 (disable). If there is no radio activity in controlled mode within this time, the module resets the connection. If used, should be larger than the value in S6.

S-Registers

S-Registers provide a method of storing operational parameters of the module. A radio module has different requirements to a telephone module, so functions of the S-Registers are also different. S-Registers may be examined using the command ATSn?, where n is the number of the S-Register. S-Registers may be modified using the command ATSn=xx, where n is the S-Register number, and xx is the new value for the register.

S-Registers and functions are listed below:

No.	Range	Function	Comment
S0	0-255	Number of attempts before answering connection message	Should normally be set to 1 - 0 disables auto answering of calls (ATA only).
S1	3-255	Escape Sequence Guard Time (units 20 milliseconds) default = 50	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 = "+" (ASCII code)
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	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	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). Default 0 (no time-out).
S9	0-255	Module Receive Level	Units (-)dBm - RSSI indication of last received message
S10	0-255	DTR Loss Detection Time	Units 10 milliseconds
S11	0-255	Not used	
S12	read-only	Command Mode Diagnostic	Reason module 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 module after connected.	
	S12 = 4	Activity timer timed out.	
	S12 = 5	No response to dial request to remote module.	
	S12 = 6	"BUSY" response from remote module on dial request.	
	S12 = 7	Character received from host while attempting to connect	
	S12 = 8	Hang-up from remote module.	
S13	0-3	Country code for radio (not user configurable)	0 = US/Canada 1 = Australia 2 = New Zealand 3 = Europe
S14	0-255	Max Data Packet size transmitted by radio	Max Packet size = 20 + (S14 x 2). Default 255 = 530 bytes
S15	0-7	Not Used	
S16	0-255	Transmit Hold-off Time	In msec (default = 0)
S17	0-255	Receive Hold-off Time	In msec (default = 0)
S18	0-255	Input buffer delay	Radio will not transmit until the number of characters in the input buffer = 2 x S18 value - see below
S19	0-255	Input buffer delay override	Override time in msec to override S18 delay - see below.
S20	0-255	Default system address	

S18 is calculated as S18 = (MP – (SR * (10*MP/RB + TD)) / 2 (Rounded up)

SB is serial baud Rate, (in *bits* per second)
SR is serial data Rate, (in *bytes* per second – usually 1/10th of SB)
RB is radio baud Rate, (in *bits* per second)
TD is transmit delay (0.008)
MP is the maximum packet size to be transferred
NB is the maximum number of bit times delay allowed between characters in the protocol.

S19 is calculated as S19 = 1000 * (NB/SB) (Rounded up)

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
15	CONNECT 19200		•	•	•	CONNECT is displayed for X0
17	CONNECT 38400		•	•	•	CONNECT is displayed for X0
19	CONNECT 76800		•	•	•	CONNECT is displayed for X0