IC TECH, INC

SCADA & Telemetry for Water, Oil and Gas

Wireless Data Products

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RM1
User Manual
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TABLE OF CONTENTS

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3

General Product Overview

The IC Tech wireless modems are micro-controller-based computers that provide functions and algorithms required for interfacing a radio and serial devices. They are designed to establish reliable, long-range, wireless data links for industrial control applications.

The *RM1* Unit is a complete Radio-Modem designed to allow installation in a user-built enclosure or system.

The Radio-Modem provides the following functions:
- · Hardware and Algorithms necessary for reliable, long-range, secure wireless data transfer.
- · RS232 or RS485 serial port for many devices such as PLCs, EFMs, Scientific Computers, Etc.
- · Digital data transceiver on Licensed UHF, VHF or License Free VHF or spreadspectrum channels.
- · LED status indicators for modem operation and troubleshooting.
- · Modbus RTU protocol for programming and operation.
- · Unique, Multi-Route Store and Forward capabilities for many protocols.

All units include the Radio/Modem along with all necessary, matched and calibrated, components to give the user complete monitoring and control, out-of the-box, without the concern of compatibility between components.

IC Tech's included Setup/Service software package is custom designed for use with all our products. This software can be used to efficiently program and troubleshoot all products as well as gather and process data from any remote ICT or Modbus compatible device automatically.

The rest of this user manual will cover the specifics of how to setup and use the products.

Initial Setup of Wireless Modem and I/O Units

<u>Getting Started Information</u>

To use all features of the RM1 you will need the following items:

1. RS-232 Straight through serial cable with Female D9 on PC end and Female or Male D9 on C14 end.
2. ICT Software toolbox v3.29 or later, (used for setting up and managing the Wireless Modem.

<u>Getting connected and powered on:</u>

Step1- load the ICT Software program onto your PC.

Step 2- start the ICT Toolbox and, on the "System Setup" tab, set it for 19200,n,8,1 (C14) for use with the Modem on the Modem port.

Step 3- connect to the PC and serial port on the RM1 with the serial cable.

Step 4- apply power, 12vdc to the "BAT" & "GND" terminals.

<u>Setting up some of the most used setup parameters:</u>

1. The IC Tech Software Toolbox is used to setup the Modem through the "Device Setup" tab.

If you experience any problems, want help or have questions, call 505-217-9250 for support.

Initial Setup of the RM1

5 Basic Setup Steps

      1. Locate and mount the unit,
      2. Locate and connect the antenna,
      3. Connect the power terminal and
      4. Set the unit ID.

The following 5 sections will describe each of the above basic steps in more detail. The remainder of this manual will describe each feature of the Radio-Modem and I/O unit in detail.

1. Locating and Mounting the Unit
The C14 Unit comes on a or 7"x4"x4" bracket with four mounting holes in the corners. This device must be mounted inside an enclosure suited for the location in which it will be installed. Try to locate the unit as far as possible from any electromagnetic devices such as transformers, computers and other electrical and electronic devices.

2. Locating and Connecting the Antenna
Caution! When locating and mounting the antenna, keep the antenna and yourself a safe distance from power lines or other dangers. Take the time to observe the installation carefully before starting!!

This is the most important step of the installation process. The antenna location will directly affect how well the unit functions over the wireless link. The antenna should be positioned as high as possible and as far as possible from any obstructions or possible interference and at least 5 to 10 feet from the Unit. If using a Yagi antenna, the radio signal radiates from an element that is different from the others and usually located one element from the rear (mounting portion) of the antenna. The antenna should be oriented with the radiating stub pointing up. The signal direction is toward the end opposite the mounting.   The RM1 has an N-Female bulkhead connector protruding through the side of the enclosure for connection to the antenna cable which should have a N-Male connector.

NOTE: The power (1 to 8 watts) radiated directly from the unit antenna can cause interference to some electronic devices if the antenna is located too close to them.

FCC NOTICE: UL or FCC Part 15 does not rate this product for EMI. This product may radiate harmful signals, which can interfere with other electronic devices.

3. Turning the Power On
Power is supplied to the unit by inserting the terminal block, with power connected, into the appropriate terminal receptacle. On the RM1 units, 12 Volt battery power connects to the two far-right terminals.

If it becomes necessary to disconnect the battery wires from the terminal block, disconnect the plug-on spade terminals from the battery first!! No Fuse protection is provided from the battery to the terminal block!!!

See the section "Power Control Circuits" for further information on battery and power source connections.

4. Setting the Unit ID

The included Setup/Service software allows ID setup quickly and simply. After installing the software on a suitable computer (see software disk or manual), connect a straight (not null) serial cable from the computers serial port to the Unit serial port. Program the unit ID according to the instructions in the "Unit Adjustments/Setup" section of this manual.

See the section "Unit Adjustments- Address" for further information and suggestions on ID setup.

Modem LEDs

The LEDs on the modem serve two purposes:

       First they indicate normal operation of the modem by displaying activity on the serial and radio ports during normal use.

       Second, they are used to indicate problems within the unit. Problems that occur during power up or

       normal operation are indicated.

       The following describes each Modem LED and its functions in normal and trouble operation:

PWR: The Power LED indicates operation of the 5-volt regulator. If it is not on, power is probably not applied to the unit, the LEDs have been turned OFF by the user or the 5-volt regulator has malfunctioned.

CD: The Carrier Detect LED indicates a clear or busy radio channel. When on, the radio channel is in use.
When off, the radio channel is available.

RXD: The Receive Data LED indicates valid data is being received at the radio port. If the Modem is receiving data from another modem, this LED will NOT come on until the data received has been verified through all error tests. Once the data packet passes all tests, the LED will come on.

TXD: The Transmit Data LED indicates data is being sent to the radio from the modem. After the radio has been 'keyed' for the specified key-up delay time, the TXD LED will light to indicate data is being sent to the radio after the delay period has expired.

ERR: The error LED has two basic functions as follow:

      First, the Error LED is indicates when one of six possible receive data error conditions exist:
          1. RF Synchronization error
          2. RF Start/Stop bit error
          3. RF LRC error
          4. RF CRC error
          5. Serial Buffer overflow error
          6. Serial CRC error

If, one of these errors is detected, this LED will light and stay on until a valid data packet is received.

The actual type and number of occurrences of a particular error will be saved in the appropriate Modbus error count Register 23 thru 25. (See Technical Manual for exact register locations and description).

SRX: The Serial Receive LED indicates the serial port, RS232 or RS485, is receiving data from an attached device.

STX: The Serial Transmit LED indicates data is being sent to the RS232 or RS485 port.

LED Control (On/Off)
The DCD, STX, TXD, SRX and ERR LEDs, under Modem Processor control, can be enabled/disabled via the ICT Software Toolbox setting for "LED Control" on the "Device Setup" tab.

NOTE: When the above Modem LED's are disabled (OFF) no activity will be indicated relating to Radio functions of the Modem. The STX and SRX LED's will continue to operate.

Power Control Circuits

Battery Input Terminal
The terminal connections on the far right end are used to connect battery power to the unit. The "BAT" terminal is for a 12-volt battery. The Unit uses negative ground.

Current Consumption
The Radio current consumption is typically less than 20 milliamps in the standby/monitoring mode.

Power-On Message

The Modem generates a message to the local serial port on power up. This message can be viewed using any terminal package such as ProComm or Windows HyperTerminal. The following is an example message:

> RESET v8.00.01 IC0560
> Radio Port Rate----- 4800
> Serial Port Rate------19200, N,8,1

1. The first line indicates a power-on reset was initiated followed by the firmware revision number and the unit serial number.
2. The second line is the RF or Radio Port data rate. 4800 baud is the factory default.
3. The third line is the serial port baud, parity, data and stop bit settings. 9600,N, 8,1 is the factory default.

Protocol

The Modem adheres to the Modbus RTU protocol format to allow set up with other systems and software. Functions and Error messages follow the standard as described in the Modbus protocol manual.

The Modbus protocol has proven to be the simplest and most effective 'standard' protocol currently used in industry to achieve communications most reliably with radio.

An in-depth discussion of the Modbus protocol can be found in the Modbus protocol manual part number PI-MBUS-300 available from Modicon or Group Schneider Automation at www.modicon.com.

A brief description of each function supported by the products follows.
(See the Technical Manual for details on each function and register).

· Function 03 is used to retrieve data from multiple registers.
· Function 16 is used to write data to multiple registers.

Radio Port

The Modem radio port is designed to interface to the standard Digital Radio included with the Unit. Key-up delays, Receive turn-around times, Noise output frequency and levels, Modulation input and output circuit capacitances and wave shaping are all critical to the proper operation of high-speed data. These are taken into account through the Radio and Modem's internal algorithms and hardware designs.

Baud Rate Setting
The Software Toolbox setting for "Radio Port Baud Rate" allows changing the data rate the Radio Modem will operate at over the air. Settings from 4800 bits per second (bps) to 7200 bps will work on the standard narrowband radios supplied. The faster baud rates will not work as effectively in fringe areas as the slower rates. The signal level must be about 3db stronger for each faster rate to work as good as the next slower rate.

For example, a system working at –115dbm and 4800bps would need a signal of –112dbm to work the same at 5800bps. To go from 4800bps to 6400bps, the signal would need to go from –115dbm to –109dbm. The baud rate must match on all modems within a system. Different baud rates can be used on the same radio channel to allow multiple systems with the same IDs to operate.

For example, a system using modems at 4800bps cannot decode data from a system at 5800bps. Effectively, the two systems can run on the same radio channel, using the same IDs and they won't interfere with each other.

NOTE: Two radio modems cannot be on the air at the same time on the same radio channel in the above baud rate example.

Radio Key up Delay Setting
The Software Toolbox setting for "Radio Key up Delay" allows the user to alter the amount of time the radio push-to-talk is activated to allow the radio to "warm up" before data is actually sent to the radio. This allows the radio time to stabilize before data is put on the radio carrier.

Serial Ports

The Modem Com0 port:
- Allows direct interface to the Modem only via RS-232
- Defaults to 9600bps, No parity, 8 data bits, 1 stop bit (to match Com 1 since they are physically tied together for Modem to Modbus I/O communications).
- Is programmable via Modbus or using ICT software for other settings.

The maximum cable distance for RS-232 is typically 50 feet.

Com Port Connections
I/O Com0 and Modem Com0 (C14) RS-232 Pin Connections (Standard DCE pin out)

       DCE (Com 0, Com 2)   DTE (Computer)
       Pin 2 = TXD (Transmit data) >>>>> >>> RXD (Receive data)
       Pin 3 = RXD (Receive data) <<<<<<<<< TXD (Transmit data)
       Pin 5 = Ground <-----------------------------> Ground

       The RS-232 port will allow communication with the Modem only.

Serial Data Rate and Modem Timing
The Modem Com0 port operates at user selectable rates of 1200 to 115,200 baud, None, Even or Odd Parity and 1 or 2 stop bits. When data begins entering the port, the modem goes into a timing loop to wait a minimum of 3 to 4 byte times (3 to 4 milliseconds @9600 bps) for the next byte.

When data input stops (a break of 3 to 4 byte times) a timeout occurs and the packet is processed locally for response (ID matches and Modem is in Active mode) or is sent to the radio for transmission (ID does not match or the Modem is in Silent mode).

Modem Flow Control and Buffer
Automatic/Internal flow control is built-in to the IC Tech modem. The standard 152-byte buffer captures the incoming data and times out automatically when it calculates the data input has stopped. The modem then starts a timer that counts down a user-set delay to allow the radio time to "key up". After the delay expires, the modem automatically sends the data from its internal buffer to the radio.

1pair wire line and communicating @9600 bps. Shorter distances will allow faster data rates.

Serial Port Options

Silent Feature

The Modem has a feature to allow data to pass through to the serial port regardless of the protocol or ID. The Silent Feature, when enabled, will cause the Modem to ignore all data coming into its radio port except for Store and Forward data. When Silent is Enabled, any data received by the Modem will be sent to the serial port immediately if it is one of two situations:

1. The final forward of a store and forward packet or
2. A direct data packet (no store and forwards).
The included Setup/Service software allows this feature to be enabled/disabled. This feature can also be enabled/disabled, as all features in the Unit, using standard Modbus protocol functions. (See the Appendix A for specific information on using the Modbus programming capability.)

An example of how the Silent Feature might be used:

If the ID (Address) of a Modem unit needed to be the same as the ID of a PLC attached to the Modem serial port (This might occur if more than 255 units exist in a system and there is a shortage of ID's.) then the Silent Feature would be enabled to allow Modbus messages to pass through to the attached PLC. The Silent Feature can be enabled and disabled during routine system polling so the unit could be polled for data in one poll and the attached PLC could be polled in the next poll after enabling the Silent Feature in the Modem.

Sending a Modbus function 05 to register 9900 will set or clear (depending on Force Data Hi value) the Silent feature in Ram only. This allows the feature to be switched on and off frequently so the Unit can be polled and then disabled to poll the attached unit often.

Sending a Modbus function 05 to register 9901 will set or clear the Silent feature in the EEPROM for non-volatile storage of the Silent feature.

Transparent Operation

Transparent serial port operation offers the user the ability to send data through a Modem unit to a device attached to the Modem serial port (RS-232/RS-485) for wireless communications. This allows the user to extend the I/O and functionality of the Modem to PLC's, Data Loggers, Gas Flow Computers and other devices using serial communication ports.

The transparency of the serial port is based on the following considerations:

• The Address byte (ID) must NOT match the ID of the Modem the data is being sent to.
• If the ID does match, the Silent feature must be enabled.
• The data buffer holds 136 of data. Xon/Xoff (ASCII data) or RTS/CTS (ASCII or Binary data) control must be supported by the attached device to send more than 384 (optional 384/1792) bytes.
• Protocol conflicts. Users 'transparent' data matches Modbus protocol and local or remote Modem address. The Modem will packetize, generate error checking and transport most data without problems as long as the above conditions do not exist or are controlled through proper setup of the Modem.

Store and Forward

<u>Description</u>
        The Store and Forward feature is setup using the included ICT "Setup/Service" software. Three basic Store and Forward (SnF) methods exist. Refer to Screen 1 (below) under the "Store and Forward Method" drop down selection box.
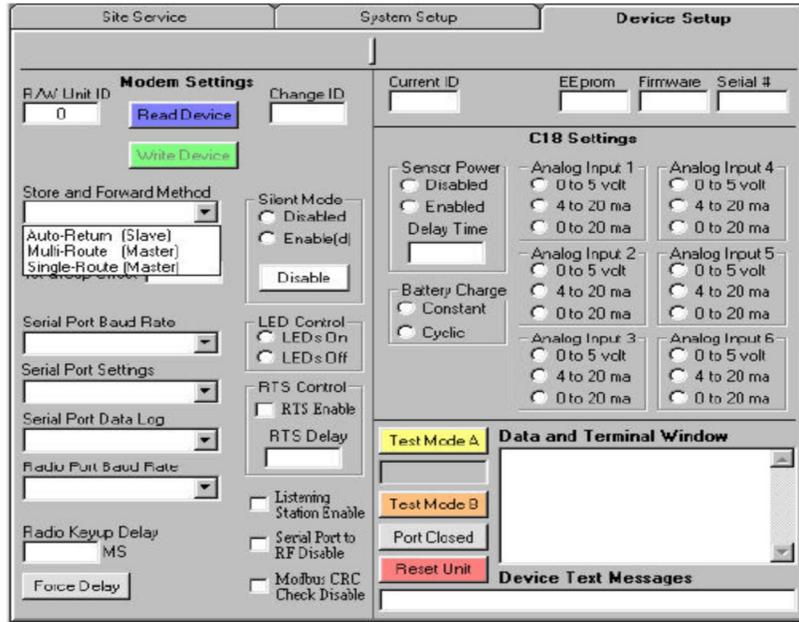
SCREEN 1

The **first** method is referred to as the "Auto-Return (Slave)". This method is the default and is typically used in remote slaves. This method allows the slave to automatically return a data packet by the route from which it came. The slave examines the data packet routing info (added to the user data by the originating modem) to determine what the route was the data packet was sent from. The slave then uses this data to assemble a return route, which is identical to the originating route except reversed to accomplish a path back to the originating unit.

No software setup is required to use this method. The software heading for this method is on the "Device Setup" tab and is under the "Store and Forward Method" drop down box. It is the selection named "Auto-Return (Slave)".

The **second** SnF method is referred to as "Multi-Route (Master)". This method, when selected and setup at the originating modem, will cause the originating modem to add SnF header information onto the user data packet which will tell other modems how to route the data packet to reach a destination. .

The distinct advantage to "Multi-Route" SnF is that each destination unit in the system can have a unique and different route as well as a different number of SnFs (up to 4) to be reached.

The **third** method is called "Single-Route (Master)". This method allows other protocols or any non-supported data types to pass through the modem system without regard to protocol or data format. The disadvantage to this method as compared to the "Multi-Route" method is that all data must pass through the same repeating modem(s). Up to four modems can be used to SnF all data but all destination

13

units must be within range of the last repeating modem.

The advantages with any SnF scheme are:
       · Setup is fast and simple and only needs to be done at the "Host" modem.
       · Data flows on rapidly on one simplex channel instead of 2 duplex frequencies.
       · Data is regenerated as a new packet with each SnF so no degradation of data occurs.
       · All modems have this feature built-in so no special units are required.

Multi-Route Store and Forward Enable
The software has one selection box on the "Device Setup" tab and 1 section on the "System Setup" tab to allow SnF setup for this method. Follow the next steps to setup this method.

    1. Select the "Device Setup" tab. Make sure the number 0 appears in the "R/W Unit ID" box in the upper left corner.
    2. Click on the blue "Read Device" button. Assuming the modem is connected to the PC properly, all data boxes on the "Device Setup" screen should fill with data.
    3. Go to the drop down box labeled "Store and Forward Method" and select "Multi Route (Master)".
    4. Click the green "Write Device" button. The modem should go through a reset and respond to the software text messages window.
    This completes enabling the "Multi-Route" Store and Forward feature.
    Multi-Route allows two ways to communicate with a remote device:

1. Direct Communications:
If a unit is to be communicated with directly simply do NOT setup a route for the destination unit which will be communicated with directly. Even though SnF was enabled on the "Device Setup" tab, the modem will not setup a route for an ID if nothing exists in the setup table. This allows using Multi-Route SnF for Direct communications without disabling the SnF feature for those units that need SnF.

2. SnF Communications
If a unit is to be communicated with by SnF follow the next steps:
    1. Enter the ID of the originating modem in the box labeled "SnF Origin" (the modem connected to the PC or the one messages will originate from).
    2. Enter the ID(s) of modems along the route (up to 4) beginning with the box labeled "SnF 1" through "SnF 4". This is the path the data will take to reach the destination unit.

    3. Enter the ID of the slave to be reached in the "SnF Dest" box. This ID can be the ID of a modem in the system or the ID of a device attached to a modem.
    Any Modbus device (or other specified protocol) can be routed to using this SnF method.

Single-Route Store and Forward Enable
Follow the same steps as shown on the previous setup for "Multi-Route Store and Forward Enable" except for Step 3.

At step 3, select "Single Route (Master)" as the Method.

Single-Route Store and Forward Route Setup
As with Multi-Route SnF Route Setup, go to the tab labeled "System Setup". Follow steps 1 and 2 for Multi-Route route "SnF Communications" setup.
    At step 3 : Enter the number 1 in the box labeled "SnF Dest".

No other route needs to be setup. Unit Ids are not used for this method so this is all that needs to be done. The modem will always go to the SnF Destination unit 1 to find the route for all data packets as long as SnF is enabled.

All units in the system must be communicated with using Store and Forward. Direct communication

is not allowed in this method since the modem always defaults to "look up" the route for all data packets in the location for unit ID 1.

Address (Unit ID)

Each Modem must have a unique address (ID) before using it over the wireless link. The ID is the only method for communicating with each remote unit on an individual basis.

The Modem architecture allows for automatic master/slave operation. Every Unit can be used as a sending and receiving Unit in a system. Peer to peer operation is supported automatically.

Screen 4 shows the "Device Setup" tab of the included "Setup/Service Software". Setting the ID to 1 of 254 different values is done in the box labeled "Change ID".

ID 0 should not be used for any remote unit since this ID can only be communicated with via the wire line serial connection. If ID 0 is used, it should only be used on a unit such as a host unit in a system.

All remote units must have a unique ID other than 0 (1 to 254). No unit within a system can have the same ID (or Address). ID 1 is the default ID of a new unit. ID 255 is reserved for multi-group support.

Values from 2 to 254 should be used for remote units. Any unit having the same ID as another will cause collisions when communicating over the wireless link. All Units default to an ID of 1 when new or un-programmed. With a default ID of 1, a unit can be programmed over the wireless port.

Address Considerations

ID 1 should be left unused in a system so a new unit can be accessed by wireless if installed accidentally in an un-programmed state. All features can be programmed over the radio network if the ID of each unit differs and does not = 0.

ID 255 should be left unused in a system unless address extension is used. Then ID 255 will cause the receiving unit to look for an extended address. (NOTE- This feature is not implemented in the firmware revision described in this manual but will be in future revisions.)

Repeating (SnF) units are normally assigned Slave IDs beginning at 254 and working down. Remote units are normally assigned IDs beginning at 2 and going up. This will leave room to expand in both directions.

Carrier Detect

Carrier Detect allows the modem to know when the radio channel is busy so it will not transmit. If the modem is about to send data, it will first check the carrier detect status for busy or clear. If clear, it will transmit immediately. If channel busy is detected, the unit will go into a loop, for up to 3 seconds, to look for a "channel clear" condition. When the channel clears, the unit will transmit the data packet.

If the channel does not clear within 3 seconds the modem will terminate the data packet and the software must retry to send a new packet.

Default Setup

All Units default to the following factory settings when new or when Switch One (SW1 on the lower right side of the modem PCB) is closed before and during power up:

> · Unit ID = 001
> · RF Data Rate = 4800 bps
> · RF Key up Delay = 60 milliseconds
> · Serial Port Settings = 9600 Baud, No Parity, 8 Data Bits, 1 Stop Bit (9600,N, 8,1)
> · Silent Mode = Disabled

Closing switch one on the modem is a good method to temporarily restore default settings on a unit that is programmed to an unknown state. To verify the default mode is entered successfully, the RXD and TXD LEDs will stay lit after initialization (power up) of the unit.

Reset to Factory defaults

Use the red "Reset Unit" button on the bottom of the "Device Setup" tab of the setup/service software. To do this, the unit must first be read using the "Read Device" button. This method will reset the entire memory and

setup and will reboot the unit.

If the unit is in an unknown condition and cannot be communicated with directly, then use the above step, "Default Setup", to put the unit in a temporary known state. Then read the unit by clicking the blue "Read Device" button (make sure 0 is in the "R/W Unit ID" box), then reset the unit by clicking the red "Reset Unit" button.

<u>Rebooting the Unit</u>
If local to the unit, simply remove the power terminal and replace.

Test Modes

Test Mode A

Test Mode A is used to check and align the radio transmitter. The first test mode can be initiated with the following three methods:

      1. Pressing and releasing SW1 on the modem PCB (C44P).

      2. In the Setup/Service Software, "Device Setup" tab, "R/W Unit ID" box, enter the ID of the modem to test, then click the yellow "Test Mode A" button.

      3. A standard Modbus Function 05 command to Register 0x9916.

Any of the above three methods will cause the transmitter to turn on and transmit a tone (the tone frequency will vary depending on the RF Baud rate- 4800bps = 2400Hz, 5800bps = 2900 etc.) for approximately 10 seconds, followed by steady 101010 data for approximately 10 seconds.

During the transmitter turn on time, the deviation level may be checked and adjusted. (On early modems so equipped, the "TX LEVel" potentiometer should be adjusted for proper deviation) On current DM55 units, the deviation must be adjusted inside the radio. The following deviation settings are recommended:

      For wideband 25Khz radios this is typically +/- 4.8 KHz deviation.

      For narrowband 12.5Khz radios this level is +/- 2.4 KHz deviation.

During the transmitter turn-on time the transmitter frequency and power can also be checked and adjusted. *All the above transmitter adjustments should be made by qualified technicians.*

Test Mode B

Test Mode B is used to test the radio path for data thru-put reliability. The second test mode can be initiated with the following two methods:

      1. In the Setup/Service Software, "Device Setup" tab, "R/W Unit ID" box (see previous page for "Device Setup" tab example), enter the ID of the modem that will transmit the test, then click the orange "Test Mode B" button.

      2. A standard Modbus Function 05 command to Register 0x9915.

Either of the above two methods will cause the modem to send a response message then, after a short pause, to begin transmitting 100 data packets rapidly. The test takes about 20 seconds or less (depends on system RF Baud rate).

The method to utilize this test is as follows:

      1. In the Service/Setup Software, "Site Service" tab, "Slave ID" box, enter the ID of the local (or remote) unit that will receive the test data. Press tab to go to the "Start Reg" box.

      2. In the "Start Reg" box, enter "25". Press tab to go to the "# of Regs" box.

      3. In the "# of Regs" box, enter 1. Press tab once.

      4. Click the green "Write (Func16)" button to clear Register 25 in the unit that will be receiving the data packets.

      5. Go to the "Device Setup" tab and enter the ID of the remote modem, that will be sending the data, in the "R/W Unit ID" box.

      6. Click the orange "Test Mode B" button. This will cause the remote modem to begin transmitting the test data back to the receiving unit.

      7. Wait about 20 seconds for the test to complete. The CD LED should stay lit during the entire test and the RXD and STX LEDs on the receiving modem will flicker during the test.

      8. When the 20 second time is up or the LEDs stop flickering on the receiving modem, repeat steps 1 thru 3 above (the values previously setup may still be there when the "Site Service" tab is selected).

      9. On the "Site Service" tab, click the blue "Read (Func03)" button.

      10. The data value contained in Register 25 will indicate, from 0 to 100, the percentage of data throughput achieved.

Wireless Data Features

All Modem units contain the following unique features for wireless data transfer:

- Unique Packet Synchronization firmware to insure positive data transfer.
- Data Encryption for security of data transmitted over the radio channel and to allow "sorting" of received data from noise.
- Store and Forward (Repeat) capability for extended communications range.
- Extensive Error Detection for data integrity.

Packet Synchronization

Every unit contains, in the firmware, the ability to set its receiving synchronization clock to the sending units data stream, thereby eliminating out-of-sync errors once the units have locked onto each other. This eliminates out-of-tolerance crystal clocks between units as well as aging effects on components over time.

Data Encryption

A proprietary data encryption technique, which adds no overhead to the packet size, is utilized to allow all data sent over the wireless connection to be secure. This technique also allows the modem to recover its data stream from noise and interference, which would stop most data techniques. This encryption technique also eliminates the need for error correction techniques, which typically add overhead and time to wireless data transfers.

Different encryption schemes can be set at the factory for individual systems so users of the same Modem equipment cannot interfere or have access to data from other systems.

Store and Forward

All IC Tech modems contain a unique auto-store and forward technique that allows for greater distances and flexibility in accessing difficult to reach units. The store and forward path is entered at the sending unit using the Setup/Service software. The receiving units program themselves automatically to handle and respond to the forwarded data. This allows the user to set up different paths for every unit (using Modbus, BSAP and other protocols) in the system if needed.

This also allows the user to change the path quickly if a unit in the path (such as a repeater) should fail and another path is available.

The distant unit being forwarded to will send its response back by the same route it was received thereby eliminating the need for field programming or concern for frequently changing paths.

Store and forward setup is covered in this manual for simplified setup and in the Technical Manual for specific setup details.

Error Detection

Extensive error detection methods mean your data will not be allowed to exit the serial port unless it is exactly as it was sent from the originating unit.

First, every byte of data has a start and stop bit on each end. These are checked as each byte is received. Every byte must have a correct start and stop bit or the entire packet is rejected.

Second, a Longitudinal Redundancy Check is calculated on each byte of data as it is sent and received. This value is stored and calculated during the entire data reception process for evaluation at the end of reception. If the value received does not match the value calculated, the packet is rejected.

Third, a 16-bit Cyclic Redundancy Check is performed on the entire data packet after it is received. If the CRC-16 calculated locally does not match the one received from the sending unit, the packet is rejected.

Fourth, if the packet sent is a Modbus data packet, another CRC-16 is performed on the Modbus portion of the data.

The ultimate result of the above four features means the data packets sent will be accurate (>99.9999%) and will typically (>95% on first attempt in actual field tests) get through the first time. This results in a net system throughput that is better than modems running at faster speeds. These features also insure long-term reliability in the field.

The reality is: getting through the first time at 4800 baud, is faster than getting through the second, third or fourth time at 9600 baud.

No Response Conditions- Possible Causes
- The slave never receives the message due to RF interference or failure.
- An error is detected in the data at the receiving unit.
- The message sent to the remote unit is not a valid function or the message is for an attached device that is not responding.
- The message sent is not for the IC Tech operating system. User data sent through the transparent serial port is not acknowledged by the IC Tech system.

Firmware Revision Information
v8.00.01 is a typical revision code. The first letter, v, simply indicates "version".

The **first** digit indicates hardware changes that might not function with other code revisions having a different first digit inserted into this PCB.

The **next two** digits, between the dots, indicate major revisions and compatibility issues.

The **last two** digits indicate minor revisions and bug fixes within a code version. Differences here should not mean any incompatibilities exist.

APPENDIX A

Radio Communications Timing
The following timing parameters should be noted for system planning:

First, timing for data to enter and exit the serial buffer of the radio modem is 1 millisecond per byte for a 9600bps serial port rate. This rate becomes .5 milliseconds @19,200bps, .25 milliseconds @38,400bps, .175 milliseconds @57,600bps.
Example: a 10 byte query would require 10 milliseconds @9600bps. A 260 byte response would require 260 milliseconds to enter the buffer @9600bps.

Second, add the radio key-up delay time of (normally) 60 milliseconds. 80 milliseconds should be a worst-case key-up delay.
Example: the 10 byte query above would total 70ms after key-up delay. The 260 byte response would equal 320ms after key-up delay.

Third, the over-the-air rate of 4800bps requires about 4 milliseconds per byte. This rate becomes 3.4 milliseconds @5800bps, 3ms @6400bps, 2.8ms @7200bps.
Example: the 10 byte query would require 34ms over-the-air @5800bps. Add 70ms from the first two steps and you have 104ms now. Add 10 more ms for the query to exit the serial port at the slave and you have a total of 114ms for the query to get to the slave in a direct communication.
The 260 byte response, from the slave, would require 884ms over-the-air @5800bps. Add 320ms from the first two steps and you have 1,204ms now. Add 260 more ms for the response to exit the serial port at the host and you have a total of 1,464ms for the response to get through the system in a direct communication. Add 114ms for the query and 1,464ms for the response and the total turnaround time for a direct communication is 1,578ms.

Fourth, if a store and forward is involved, the delay time is simply 3.4ms per byte in each direction @5800bps. (Buffering does not add to the delay in this case.)
Example: using the direct communication above, the query would require 34ms (10 bytes x 3.4ms per byte) going to the slave thru 1 SnF and the response would require 884ms (260 bytes x 3.4ms per byte) returning to the host. This means the total time added to the above direct transaction would be 918ms. Add the normal turnaround time, for a the direct communication, of 1,578ms plus 918ms for the SnF and you have a total of 2,496ms total turnaround with 1 SnF.

All the above examples assume there is no delay in the radio network due to carrier detect. If the modem detects a signal on the radio channel, it will hold the data in the buffer for up to 3 seconds, checking every 20ms for a clear channel to transmit, before the attempt to transmit is abandoned. In this scenario, the modem assumes the host will retry.