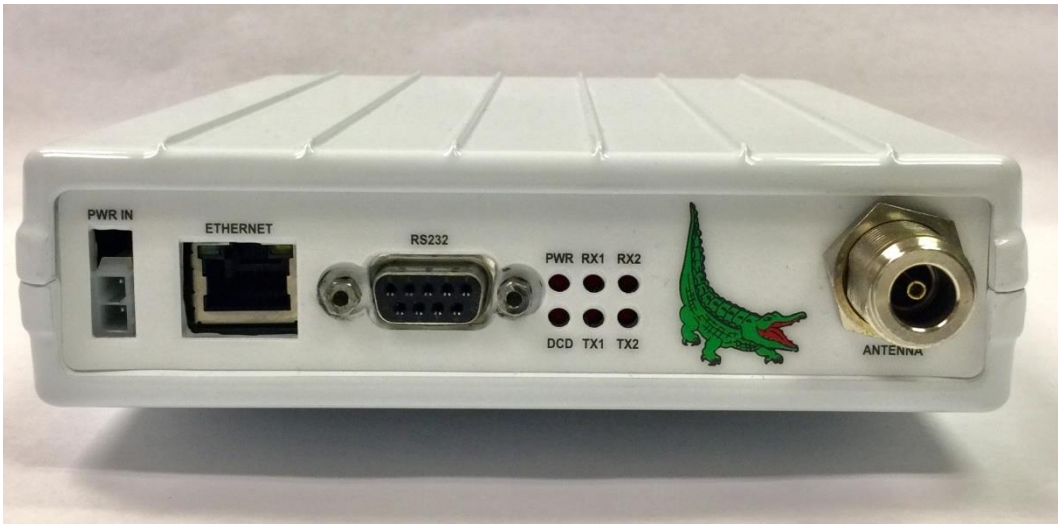
Model 2888E MAS Ethernet/RS-232 UHF Radio Transceiver Technical Manual



Alligator Communications, Inc

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Introduction

Thank you for purchasing the Alligator Model 2888E UHF Radio Transceiver. We are here to assist you personally should any questions arise in the installation or operation of this product. Please feel free to call us. We look forward to your feedback and will strive to make our product as compliant with your specific needs as possible.

1.1 General Description

The Alligator Communications Model 2888E is a microprocessor-controlled data radio transceiver designed to operate in accordance with FCC rules, Part 101, and in Canada under RSS-116 Issue 6. The 2888E data radio is frequency synthesized and programmable to individual transmitter and receiver frequencies in the 928-952 MHz frequency band. The transceiver is a fixed channel, half-duplex radio available with a channel bandwidth of 12.5 kHz. It interfaces with both Ethernet and RS-232. Internal fail-safe transmitter time out timer limits transmitter duration to 60 seconds maximum.

1.2 Applications

The 2888E data radio is designed for point-to-multipoint or point-to-point licensed operations in the 900 MHz band. Some of the most common applications are:

- Electric Utility Substation SCADA
- Pipeline Flow Monitors
- Energy Distribution & Metering Applications
- Gas or Petroleum Production Well Head Control and Monitoring
- Water Distribution and Waste Water Collection Control and Monitoring
- Petroleum Production, Transmission, Storage and Distribution

1.3 Technical Specifications

GENERAL	
Frequency Agility	928.00000 – 952.99999 MHz, 1 Hz steps
Channel Spacing	Available in 12.5 and 25.0 kHz Bandwidths
Data Rates	1200 to 9600 bps
Input Voltage	13.8 Vdc Nominal (11-14 Vdc)
Current Consumption	
Receive Mode	100 mA
Transmit Mode (5.00 Watts)	< 1.7 A
CONNECTORS	
Antenna	Type N Female
Data	Ethernet: RJ-45 RS-232: DB-9
Power	2-Pin Captive Rectangular
Diagnostics	Shared with Ethernet data connector
ENVIRONMENT	
Operating Temperature	-30°C to +60°C
Humidity	95% @ +40°C
Dimensions	6.5”W x 1.5”H x 5.5”D
Weight	2 Pounds

TRANSMITTER

RF Power	5.0 Watts (+37 dBm)
Impedance	50 Ohms
Duty Cycle	50%
Transmitter Attack Time	Less than 1 msec
Frequency Stability	± 1 ppm, -30°C to +60°C
Modulation Deviation	± 2.4kHz
Spurious and Harmonic Emissions	-65 dB
TX Timeout Timer (Programmable)	60 Seconds (typical)

RECEIVER

Type	Direct Conversion
Frequency Stability	± 1 ppm, -30°C to +60°C
Sensitivity	-117 dBm minimum discernable signal
10^{-6} BER Threshold	-110 dBm
Selectivity	-60 dB Minimum at Adjacent Channel
Inter-modulation	-75 dB (EIA)
Spurious/Image Rejection:	-80 dB

FCC INFORMATION

FCC Rules	Part 101
FCC Identifier	JIL2888E
FCC Emission Designator	11K2F1D

1.4 Warranty

Alligator Communications, Inc., warrants each of the instruments of its manufacture to meet the specifications when delivered to the BUYER; and to be free from defects in material and workmanship. Alligator Communications will repair or replace, at its expense, for a period of one year from the date of delivery of equipment, any parts that are defective from faulty material or poor workmanship. This Warranty does not cover equipment which has been misused and/or altered by the user.

Instruments found to be defective during the warranty period shall be returned to the factory with transportation charges prepaid by the BUYER. It is expressly agreed that replacement and repair shall be the sole remedy of the SELLER with respect to any defective equipment and parts thereof and shall be in lieu of any other remedy available by applicable law. All returns to the factory must be authorized by the SELLER, prior to such returns. Upon examination by the factory, if any instrument is found to be defective, the unit will be repaired and returned to the BUYER, with transportation charges prepaid by the SELLER. This warranty does not apply to equipment which, in the opinion of the SELLER, has been altered or misused.

NO OTHER WARRANTY IS EXPRESSED OR IMPLIED. ALLIGATOR COMMUNICATIONS IS NOT LIABLE FOR CONSEQUENTIAL DAMAGES.

1.5 Claims for damage in shipment

The instrument should be inspected and tested as soon as it is received. If the instrument is damaged in any way or fails to operate properly, a claim should immediately be filed with the freight carrier, or, if insured separately, with the insurance company.

WE PLEDGE OUR IMMEDIATE AND FULLEST COOPERATION TO ALL USERS OF OUR ELECTRONIC EQUIPMENT.

PLEASE ADVISE US IF WE CAN ASSIST IN ANY MANNER:

Alligator Communications, Inc.

3561 Homestead Road #345

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Website: www.alligatorcom.com

1.6 Information to the user, as required by FCC section 15.21

Changes or modifications not expressly approved in writing by Alligator Communications, Inc. may void the user's authority to operate this equipment.

In accordance with FCC Rules Section 15.21, the user of this equipment is advised that changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

1.7 RF exposure information

FCC Rule Section §1.11307 and Industry Canada RSS-102 regulations contain limits on human RF exposure from transmitters. To meet these requirements, during operation, the antenna of this device must be kept at a minimum distance of 112 cm from all persons.

2.0 Radio Configuration and Operational Check

2.1 General Discussion

Prior to customer installation and electrical connection of the customer's terminal equipment to the 2888E radio, it is recommended that the installing technician conduct a brief operational checkout of the 2888E radio and confirm that all operating parameters are set as desired.

This initial checkout and possible reprogramming/customization are generally performed on the maintenance shop test bench before the radio is installed and commissioned in a link application.

Software tools that may be helpful for configuration, operation, and maintenance include:

- WireShark
- PuTTY
- Alligator Packet Error Rate Tester
- terraterm
- ttermpro

The following parts of this section provide guidance in this checkout process and illustrate alternate configurations and paths to perform the initial checkout.

2.2 Operational Bench Test

To ensure that the 2888E radio is functional prior to installation at the desired site, it is highly recommended that the following tests be performed in sequence: (Please refer to 2.2.3 Initial Checkout.)

2.2.1 Antenna Connector

The 2888E radio antenna port (RF Connector) is a coaxial, female, Type N connector. This connector mates with a male cable connector, Type N such as Amphenol 3900, Andrew L44N, or MIL Type UG-21. Under most circumstances, bench tests are conducted with a service monitor (manufactured by IFR Inc., Marconi Instruments Ltd., Hewlett-Packard, Motorola, etc.).

CAUTION
The transmitter should not be keyed on or placed in the transmit mode (dt=1) without a load connected to the antenna port to prevent damage to the 2888E radio Power Amplifier due to long periods (more than 10 minutes) of severely high SWR. An antenna, service monitor, or dummy load should be attached to the antenna port. The 2888 radio power output is approximately 5.0 Watts maximum, so if a service monitor is connected to the antenna port, ensure that the service monitor's input port can handle at least a 10 Watt input to avoid damaging the service monitor.

2.2.2 Power Connector

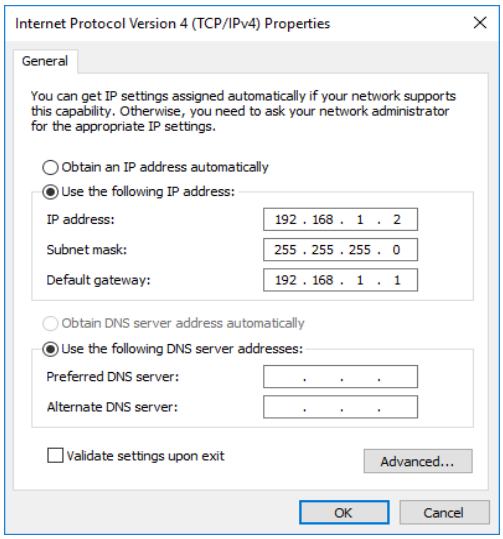
The DC power input connector to the 2888E radio is a rectangular two-pin locking connector. The radio unit is normally powered upon connection to a DC power source of +11 to +14 Vdc, +13.8 Vdc (nominal), +24 Vdc (optional). The red conductor is positive; the black conductor is negative and is internally grounded to the chassis.

2.2.3 Initial Checkout

Alligator wireless data transport products are factory-configured according to customer configuration information received prior to shipment from the factory; thereby, customer field configuration requirements are minimized.

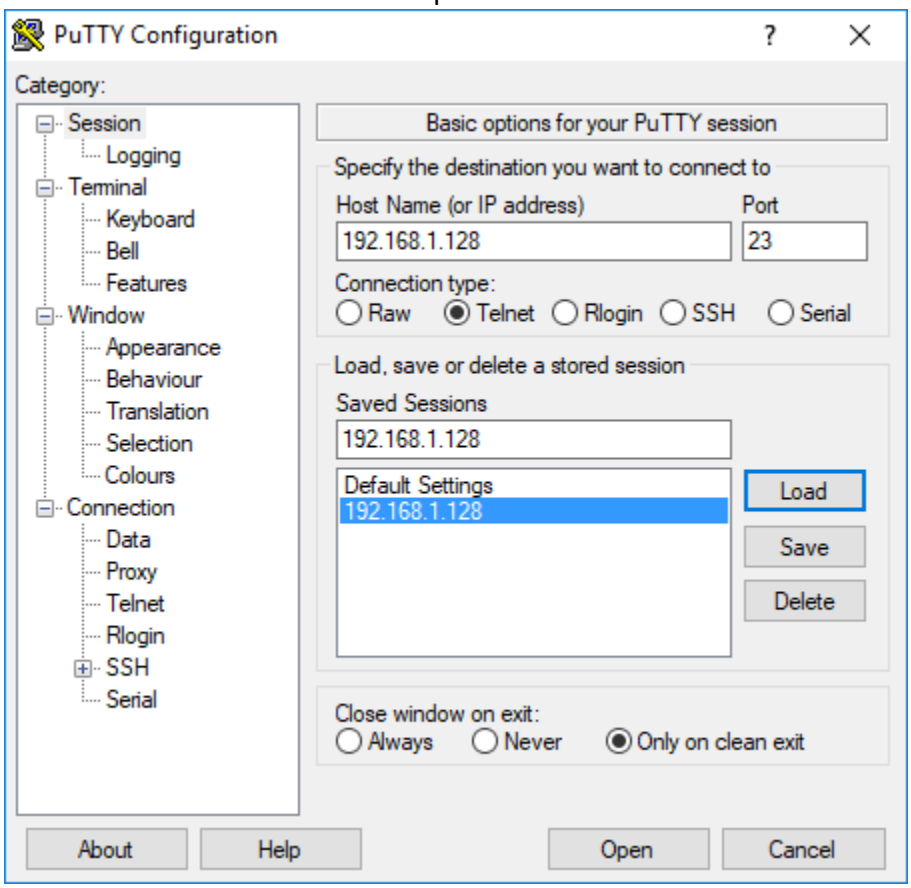
To verify that 2888E radio parameters are correct, we recommend the following minimal tests be conducted with regards to the transmitter and receiver settings of the 2888E radio:

1. Connect a 50 Ohm dummy load to the antenna Type N connector. The dummy load must have a power rating of at least 5 Watts. Always ensure that a load or antenna is connected to the Type N connector before DC power is applied.
2. Connect a spectrum analyzer to the dummy load through a power attenuator (20 dB recommended).
3. Connect a computer to the 2888E using a CAT5 Ethernet cable between Ethernet connectors. Alternatively, you may use two CAT5 cables, each connected to a multiport Ethernet router switch. Do not use an Ethernet hub because they may be a source of errors.
4. Connect a 12Vdc power source to the power input, +12V on red, GND on black. Observe all LEDs activate at power-up to verify LED functionality. The PWR LED should remain on.
5. Configure your computer for an IP address in the 192.168.1.X space (but do not use 192.168.1.1 or 192.168.1.128). This can be changed later, but is necessary for initial Telnet communication with the 2888E. For example, use 192.168.1.2.

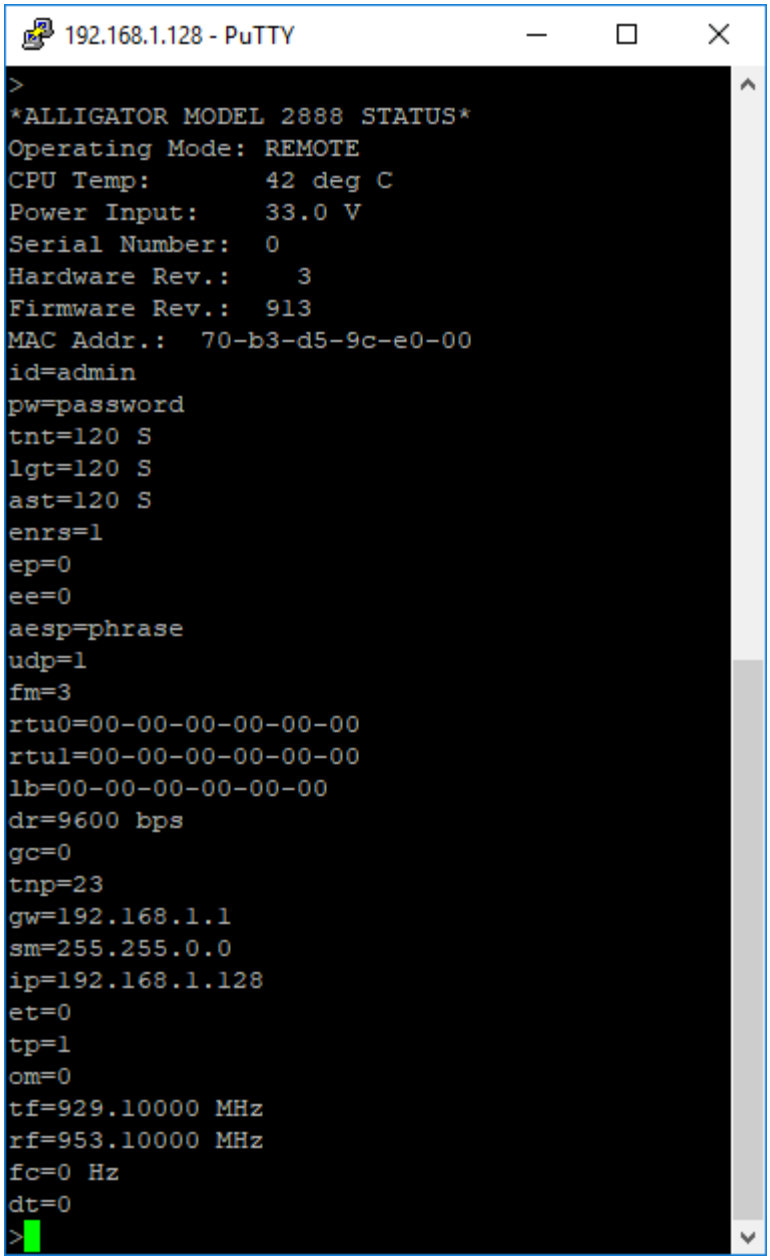


6. Download a Telnet client program for use on your laptop such as puTTY. Configure puTTY to communicate to 2888E on its IP address. The normal default IP address and port for the 2888E are 192.168.1.128 port 23.

Below shows a typical puTTY configuration for communicating with the 2888E on IP default address 192.168.1.128 port 23. Be sure to have your computer IP address set in the subnet range. puTTY should have Terminal set for local echo on. For example, below the computer has an IP address of 192.168.1.2 and communicates via Telnet to the 2888E on the default IP address 192.168.1.128 port 23.



7. Open a Telnet session with the 2888E. You should get a menu showing the current 2888E status and configuration (Fig. 2). You may end a Telnet session at any time by entering q. The menu can be re-displayed by either entering <CR> or <ESCAPE>.



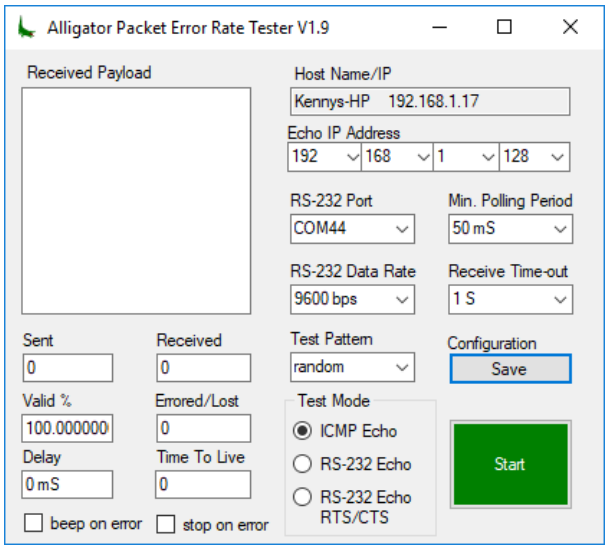
8. Set the desired transmitter frequency. For example, tf=950.0<CR>.
9. Set the desired receiver frequency. For example, rf=940.0<CR>.
10. Set the desired transmit power. For example, tp=1<CR>.
11. Use the dt=1<CR> command to activate the transmitter carrier in CW mode to confirm frequency and RF level on a spectrum analyzer. You will have 120 seconds before the anti-streaming timer expires and deactivates the CW carrier in order to protect the

power amplifier from overheating. Typing <ESCAPE> or <ENTER> will deactivate the CW carrier.

12. You may run other optional tests to verify radio functionality:
    a. Connect two 2888E radios together using suitable attenuators and coaxial cable. If the units are physically close, the radios may radiate enough signal for test purposes with only a suitable RF load connected to each. Configure one radio to transmit CW (dt=1<CR>) and the other to receive CW (dt=2<CR>). The receiver displays the received signal strength in dBm.
    b. Connect two 2888E radios together using suitable attenuators and coaxial cable. If the units are physically close, the radios may radiate enough signal for test purposes with only a suitable RF load connected to each. Configure one radio to be a master (om=1<CR>) to send test packets (dt=3) and the other to be a remote (om=0) to receive test packets (dt=4<CR>. The receiver will monitor the number of good and bad test packets received in this one-way test.
    c. Connect two 2888E radios together using suitable attenuators (totaling 90 db attenuation) and coaxial cable. If the units are physically close, the radios may radiate enough signal for test purposes with only a suitable RF load connected to each. Configure one radio to be a master (om=1<CR>) to send a round-trip test packet (dt=5) to the remote radio. The master 2888E radio must also be given the 2888E MAC address of the remote radio. To enter the remote loopback MAC address, enter:

    lb=##-##-##-##-##-##

    The remote radio om=0<CR> will automatically echo back packets when in the dt=0<CR> configuration.
13. Alligator provides a software testing tool to do end-to-end testing such as the Alligator Packet Error Rate Tester. For example, Alligator provides software tools for simulating a host sending random data messages to keep track of errors that are not echoed back properly by an RTU simulator tool.



3.0 Field Configuration and Verification

Before field installation of the 2888E, it is crucial that bench configuration and testing be done using cables and RF attenuators to duplicate the deployed system or subsystem. This adds confidence that the configuration has been done properly and streamlines field installation.

Each remote configured 2888E must be tested with a master configured 2888E to verify proper operation. This places deployed radios in final configuration so no additional programming is necessary when final field installation is performed. This is highly recommended for a smooth system deployment.

3.1 Field Configuration Bench Test

1. Update the 2888E IP address to the desired field IP address. Each 2888E must be assigned to a **unique IP address in the subnet of the access point router.** For example, ip=10.0.0.5<CR>. **Once this instruction is entered, the Telnet connection is lost and must be re-established on the new IP address.**
2. Re-establish Telnet communications on the new IP address. Typically use a second lap-top with its **IP address configured to the desired IP subnet range** and with a copy of puTTY that can start a Telnet session with the 2888E on the newly assigned IP address.
3. Assign the access point router gateway IP address. For example, gw=10.0.0.1<CR>.
4. Assign the subnet mask. For example, sm=255.255.255.0 .
5. If desired, assign a different Telnet port from the default port 23. For example, tnp=50000<CR>. If you change the Telnet port, you lose the session and must reconnect on the newly assigned port number with puTTY.
6. Assign a group code if desired to identify a unique group of radios. This blocks accidental communications with other 2888E radios. For example, gc=3<CR>.
7. Decide if the 2888E is a master, polling master or remote. There is only one master 2888E radio in a point-to-point or point-to-multipoint radio network. For a master, configure with the command om=1<CR>. For a remote, configure with the command om=0<CR>. The primary difference between a master and remote is that a master passes host polls and other unsolicited messages. The remote radio passes responses from the polled RTU. Occasionally the RTU generates unsolicited transmissions to the remote radio. This causes no disturbance to the polling process. The remote radio buffers the packet(s) until a clear time to send back to the host. Note that both the master radio and remote radios are transparent to the protocols encapsulated in the Ethernet packets or RS-232 serial data.
8. If using RS-232, select the terminal data rate. The data rate can be selected from 1200, 2400, 4800, or 9600 bps. For example, dr=9600<CR> selects 9600 bps. Note that in RS-232 systems, the Ethernet connector is still used for Telnet control of the 2888E. The 2888E can handle RS-232 and Ethernet concurrently.
9. The 2888E has various filtering modes to limit Ethernet access to the radio network at both the master and remotes ends of the radio link. This aids in preventing flooding the radio network with unwanted packets. The 2888E shipping default is fm=3<CR>. This mode forwards all packets (known as promiscuous packet forwarding mode). This mode

is only recommended for small systems and testing. The recommended mode is fm=1<CR> (host mode filtering). In this mode a master radio filters out all other traffic and will only forward packets with a tabulated host source MAC address. Up to 16 addresses can be stored in the 2888E master radio. For additional flooding protection, additional filtering can be configured to perform RTU MAC filtering also. The host 2888E radio can maintain a table of up to 512 RTU MAC addresses. Each remote 2888E radio can maintain a table of up to 2 RTU MAC addresses. Refer to the command summary for entering and reading RTU and host MAC addresses.

10. When using host filtering only (fm=1) on the master radio, determine the host MAC Ethernet address and enter it in the host table using the command: host[n]=##-##-##-##-##-##<CR>, where n is a lower case hexadecimal number 0,1,2,3,4,5,6,7,8,9,a,b,c,d,e, or f.

    Up to 16 host MAC addresses may be stored in the host table memory. Each MAC address contains 6 bytes, in lower case hexadecimal, with hyphen separators between individual bytes. Enter hosttable<CR> to display the host table.
11. When using both Host and RTU filtering (fm=0), the master 2888E radio must contain a list of all Host MAC addresses up to 16 and RTU MAC addresses (up to 512). Enter an RTU address using the following command: rtu[abc]=##-##-##-##-##-##<CR>, where abc is a lower case hexadecimal number from 000 to 1ff (0 to 511 decimal). Enter rtutable<CR> to display the RTU table on a 2888E radio configured as a master (om=1).

1. When using remote RTU filtering (fm=2), the remote 2888E radio (om=0) contains a list of up to 2 RTU MAC addresses. These addresses correspond to the RTUs connected to that particular remote 2888E radio. The first RTU MAC address is entered with the following command: rtu0=##-##-##-##-##-##<CR>. The second (if any) RTU MAC address is entered with the following command: rtu1=##-##-##-##-##-##<CR>. These two MAC addresses are displayed in the regular status menu on a 2888E radio configured as a remote (om=0).
2. Access to the 2888E can be restricted to personnel knowing an id and password. To enable this password protection, enter the following command: ep=1<CR>. The id is set using: id=### . . . ###<CR>, where the id is up to 16 characters and is case sensitive. The password is set using: pw=### . . . ###<CR>, where the password is up to 16 characters and is case sensitive. The default id is *admin* and the default password is *password*. Once a session is completed, the user logs out using the logout command: lo<CR>.

   Should the user forget to log out, it will automatically log out due to user keyboard inactivity after the lgt time. Should the password and/or id be forgotten, the factory default can be restored by removing the 2888E cover and pressing the push button. (See Fig. 3) The push-button also restores the original defaults for the IP address, subnet mask, and gateway. To disable password protection, either press the push button or enter ep=0<CR>.

3. The 2888E can operate using the AES256 encryption standard with the following commands:
   ee=0<CR> no encryption
   ee=1<CR> AES256 encryption

   No encryption results in the least number of extra characters appended to a message. This minimizes transmission latency. Encryption will pad extra randomized characters to create standardized message segment lengths of 128 bits. The pad characters are removed at the receiver.

   The AES256 standard uses a 256-bit key. The key is generated from a user-generated phrase. This phrase can be up to 32 case sensitive characters. It is entered with the command: aesp=### . . . ###<CR>. The phrase is converted into a 256-bit key using the SHA256 secure hashing algorithm. This key is used by the AES256 encryption and decryption algorithms.
4. Should it be necessary, the transmitter can be prohibited from turning on with the command: et=0<CR>. To re-enable the transmitter: et=1<CR>. In order for the radio to work, et must set to 1.4.0 Front Panel Indicators

The six front panel LEDs are defined in Table 1:

LED	Description
PWR	On when 12 Vdc power is applied.
RXD1	On when receive data is active.
RXD2	On when diagnostic receive data is active.
DCD	On when receive data preamble is detected.
TXD1	On when transmit data is active.
TXD2	On when diagnostic transmit data is active.

Table 1 LED Definition

The LEDs show the status of both Ethernet and RS-232 serial data. Diagnostic data occurs during Telnet sessions.

5.0 User Configuration and Diagnostic Menu

The 2888E uses a simple command-line interface for configuring and monitoring key parameters and metrics. Access is via IP Telnet. The 2888E is set to an IP address of 192.168.1.xxx at time of shipment. xxx are the last 3 digits of the radios serial number. The access is either local, using the Ethernet RJ-45 connector or remote through the radio system. The command-line interface facilitates writing scripts for automated configuration.

Should it ever be necessary, an internal push-button resets the IP address to the default of IP address of 192.168.1.128 and default Telnet port to 23. The push-button also resets the password, encryption phrase, and takes the unit out of password mode. The remaining parameters are unchanged. (See Fig. 3)

5.1 Transmitter Frequency

The transmitter frequency is set in MHz with up to 9 significant figures. The allowed frequency range is from 920 to 960 MHz. The full format is:

tf=###.######<CR>

The decimal point is optional. Trailing zeros are optional.

Examples: 950<CR> 950.0<CR> 950.1<CR> 950.12<CR> 950123456<CR>

5.2 Receiver Frequency

The receiver frequency is set in MHz with up to 9 significant figures. The allowed frequency range is from 920 to 960 MHz. The full format is:

rf=###.######<CR>

The decimal point is optional. Trailing zeros are optional.

Examples: 950<CR> 950.0<CR> 950.1<CR> 950.12<CR> 950123456<CR>

5.3 Frequency Calibration

The 2888E frequency reference is a precision TCXO (Temperature Compensated Crystal Oscillator) that is factory tuned to ±1 ppm accuracy. **Do not change the factory setting of this parameter without the proper test equipment.** Should it ever be necessary to adjust the compensation, the following command permits trimming the PLL multiplier that directly affects the TX and RX frequencies in steps of 1 Hz:

fc=xxxx<CR>

Examples: 100<CR> -100<CR> 10<CR> -10<CR>

Normally calibration is performed by transmitting a CW carrier (dt=1) and monitoring the output frequency on a calibrated frequency counter.

5.4 Transmit Power

The 2888E transmitter output power has three power settings:

1 Low (1 W)
2 Medium (2 W)
3 High (5 W)

tp=x<CR>

Examples: tp=1<CR> tp=2<CR> tp=3<CR>

5.5 Operational Mode

The 2888E has two operational modes:

0 Remote
1 Master

Systems can be configured for single- or dual-frequency. No advantage in latency is gained by using two-channel frequencies.

Standard systems use 1 master (om=1) and up to 512 remotes (om=0). This type of system has less latency than a store-and-forward system. It requires that the master have line-of-sight to all remote radios.

If additional channel frequencies are available, back-to-back 2888E radios act as store and forward with a CAT5 connecting cable and crossed RS-232 three-conductor cable.

om=x<CR>

Examples: om=0<CR> om=1<CR>

5.6 Group Code

To prevent confusion of two or more separate 2888E systems, there are 16 unique group codes to distinguish 2888E groups, ranging from 0 to 15. The default group code is 0.

gc=##<CR>

Examples: gc=0<CR> gc=1<CR> gc=15<CR>

5.7 IP Address

Each 2888E radio must be assigned a unique IP address within its LAN subnet group. This permits both local and remote access of radio configuration and status information. It must be changed before field deployment. The IP address assigned to the radio is for diagnostic purposes to control and monitor the 2888E locally or remotely. The IP address is set by the factory to be 192.128.1.xxx where xxx is the last 3 digits of the serial number. If the reset button is pressed, the IP address will default to 192.168.1.128.

ip=###.###.###.###<CR>

Examples: ip=10.0.0.100<CR> ip=172.16.10.100 ip=192.168.1.10<CR>

If the IP address is changed to a new subnet, **make certain that the computer is also changed** to the new subnet.

5.8 Telnet Port

The 2888E Telnet port can be reassigned from the default of 23 to any port up to 65535. This adds additional security to the system.

tnp=#####<CR>

Examples: tnp=23<CR> tnp=1000<CR> tnp=65535<CR>

5.9 Gateway Address

The 2888E must be given the gateway router IP address within its LAN subnet group. Normally it is the first IP subnet address ending in 1.

gw=###.###.###.###<CR>

Examples: gw=10.0.0.1<CR> gw=172.16.10.1 gw=192.168.1.1<CR>

5.10 Subnet Mask

The 2888E must be given a subnet mask. The default is 255.255.0.0

sm=###.###.###.###<CR>

Examples: sm=255.255.0.0<CR> sm=255.255.255.0

5.11 RS-232 Data Rate

The 2888E has a DB9 connector to permit using an RS-232 interface. The asynchronous data format is one start bit, eight data bits, and one stop bit with no parity. The data rate can be set to one of five possible rates: 1200 bps, 2400 bps, 4800 bps, 9600 bps (default), and 19200 bps.

dr=####<CR>

Examples: dr=1200<CR> dr=2400<CR> dr=4800<CR> dr=9600<CR> dr=19200<CR>

5.12 Anti-streaming Timer

The transmitter key on time is timed to prevent disrupting the channel and to protect the power amplifier from overheating. The maximum on-time is the anti-streaming time defined in seconds. The default is 120 seconds. This is most often invoked when performing testing with a CW carrier that is activated remotely.

ast=####<CR>

Examples: ast=120<CR> ast=9999<CR>

5.13 Telnet Session Activity Timer

The 2888E times activity when engaged in Telnet communications. If there is inactivity for more than the specified time duration in seconds, the Telnet session is automatically terminated. The default Telnet session activity timer default is 120 seconds.

tnt=####<CR>

Examples: tnt=300<CR> tnt=9999<CR>

5.14 Log-in Session Activity Timer

The 2888E times activity when using password access (pw=1). If there is inactivity for more than the specified time duration in seconds, the log-in session is automatically terminated. The default log-in session activity timer default is 120 seconds.

lgt=####<CR>

Examples: lgt=300<CR> lgt=9999<CR>

5.15 Enable Transmitter

The 2888E transmitter can be enabled for normal operation or forced to be disabled by this command.

et=#<CR> 0 = disable transmitter 1 = enable normal transmitter operation

Examples: et=0<CR> et=1<CR>

5.16 Enable Encryption

The 2888E can encrypt data for additional data security. This command selects encryption.

ee=#<CR> 0 = disable encryption 1 = enable AES256 encryption

Examples: ee=0<CR> ee=1<CR>

5.17 Enable Password Entry

The 2888E can restrict access by forcing an id and password before access is granted.

ep=#<CR> 0 = disable password entry 1 = enable password entry

Examples: ep=0<CR> ep=1<CR>

5.18 ID (Identification Number)

When password entry is enabled (ep=1), this ID must match to gain access to the 2888E. The ID is case sensitive and can be any set of up to 16 characters, including letters, numbers, and punctuation marks. The default id is “admin”.

id=###. . .###<CR>

Examples: id=<CR> id=admin<CR>

5.19 Password

When password entry is enabled (ep=1), this password must match to gain access to the 2888E. The password is case sensitive and can be any set of up to 16 characters, including letters, numbers, and punctuation marks. The default password is password.

pw=###. . .###<CR>

Examples: pw=<CR> id=password<CR>

5.20 ES Encryption Phrase

When encryption is enabled (ee=1), a case sensitive phrase of up to 32 characters including letters, numbers, and punctuation marks is hashed to a 256-bit AES256 encryption key using the SHA256 secure hashing algorithm. This key is used encrypt and decrypt 128-bit message fragments used in the AES256 encryption standard.

aesp=###. . .###<CR>

Examples: aesp=<CR> aesp=mydoghasfleas<CR>

5.21 Log Out

When password entry is enabled (ep=1) after a session is complete, the user logs out using the command:

lo<CR> (lower case L lower case O)

If the lo<CR> is not entered, then the session timer will automatically perform the log out after timing out.

5.22 Quit Telnet

To quit a Telnet session:

q<CR>

5.23 Filter Mode

The 2888E forwards **all RS-232 transmissions**; however, Ethernet packets are forwarded more selectively to avoid RF network flooding. There are four filter modes:

fm=0 RTU and Host filter (MAC addresses of source and destination must be in tables)
fm=1 Host filter (source MAC address in table at master, destination MAC address in table at remote)
fm=2 RTU filter (destination MAC address in table at master, source MAC address in table at remote)
fm=3 No filtering

The factory default for all radios is fm=3 (no filtering), but it is highly recommended that it be changed for a master radio to fm=1 (host filtering) to prevent other Ethernet traffic coming into the master at the host end to cause channel flooding. Host filtering is easily done by entering the host MAC address (up to 16 addresses) in the master, because many Ethernet devices may be connected to the master radio. At the master with fm=1, only host sources that are in the Host MAC address table are forwarded. This greatly reduces the probability of network flooding since the host primarily conducts traffic with RTUs. It is encouraged that hosts use a separate Ethernet interface (different MAC address) to conduct traffic with non-RTU devices.

Also at the master radio additional filtering can be used to allow only traffic for a selective number of RTUs to be polled by setting fm=0. The master's RTU MAC Address Table (up to 512 RTU addresses) must be populated, (See 5.26.) and the master's Host MAC Address Table (up to 16 addresses) must also be populated (See 5.27.) In this mode both the host source MAC and the RTU destination MAC addresses must be in the tables for a packet to forward. This totally prevents flooding the system with unwanted packets.

At the remote, only fm=2 and fm=3 are normally used. If the remote radio is connected to only one device, then fm=3 (no filtering) should be used. If the remote radio is connected to more than one device through a switch or bridge for multiple Ethernet ports, then fm=2 should be set, and the Remote RTU MAC Addresses should be entered in the Remote RTU MAC Address Table (See 5.24 and 5.25.)

The master radio can store up to 512 remote RTU MAC addresses. The remote radios can store up to two RTU MAC addresses associated with the RTUs connected to that remote radio.

Examples: fm=0<CR> fm=1<CR> fm=2<CR> fm=3<CR>

5.24 Remote RTU0 MAC Address

This is the RTU MAC hexadecimal address of the first RTU connected to a remote 2888E. It is stored at the remote 2888E and is used when the remote radio is in filtering mode, om= 0 or 2.

rtu0=##-##-##-##-##-##<CR> Example: rtu0=01-23-45-ab-cd-ef<CR>

5.25 Remote RTU1 MAC Address

This is the RTU1 MAC hexadecimal address of the second RTU connected to a remote 2888E. It is stored at the remote 2888E and is used when the remote radio is in filtering mode, om =0 or-2.

rtu1=##-##-##-##-##-##<CR>

Example: 01-23-de-ad-be-ef<CR>

5.26 Master RTU MAC Address Table

This is the command format for entering RTU hexadecimal addresses in the master radio RTU table. It is used when the master is in forwarding mode 0 or 2. Up to 512 RTU MAC addresses may be saved in the master RTU MAC address table. Both RTU number (000 to 1ff) and associated MAC address are in hexadecimal. The table is initially cleared to all zeros. Normally the table is filled, starting at 000 and progressing to a maximum number of 1ff. The entire table is scanned for each forwarding operation by the master radio when fm=0 or fm=2.

rtu[###]=##-##-##-##-##-##<CR>

Example: rtu[000]=01-23-45-ab-cd-ef<CR> rtu[1ff]=01-23-de-ad-be-ef<CR>

5.27 Host MAC Address Table

This is the command format for entering host hexadecimal MAC addresses in the 2888E host table. It is used when the master or remote radio is in filtering mode 0 or 1. Up to 16 host MAC addresses may be saved in the host address table. Both host number (0 to f) and associated MAC address are in hexadecimal. The table is initially cleared to all zeros. Normally the table is filled, starting at 0 and progressing to a maximum number of f. The entire table is scanned for each forwarding operation by the radio when fm=0 or fm=1.The remote radio can use the host table too so that only return traffic from the RTU to the appropriate host MAC is permitted.

host[#]=##-##-##-##-##-##<CR>

Example: host[0]=01-23-45-ab-cd-ef<CR> host[f]=01-23-de-ad-be-ef<CR>

5.29 Loopback Remote MAC Address

This is the remote radio hexadecimal MAC address placed in the master radio when performing the loopback diagnostic test (dt=5). Note that Alligator 2888E radios are currently assigned to MAC addresses starting with 70-b3-d5-9c-e.

lb=##-##-##-##-##-##<CR>

Example: lb=70-b3-d5-9c-e0-00

5.30 Diagnostic Tests

Several different diagnostic tests can be performed using the dt command:

1 TX CW
2 RX CW
3 TX 1 Way
4 RX 1 Way
5 TX 2 Way
6 Display TX Buffer
7 Display RX Buffer
8 Display TX and RX Buffers
9 Display Sub-packet Types

dt=#<CR> Note that <ESC> terminates the test, returning to dt=0.

Example: dt=1<CR> dt=5<CR>

The default at power-up is 0 (none).

5.31 Display Status Screen

The status screen is displayed by two methods:

<ESC> a single press of the escape key

<CR><CR> a double press of the carriage return (ENTER key)

5.32 Display RTU Table

The entire 512-entry RTU table is displayed:

rtutable<CR>

5.33 Display Host Table

The entire 16-entry host table is displayed:

hosttable<CR>

6.0 Theory of Operation

The 2888E concurrently operates transparently using two communication interfaces: Ethernet and RS-232 (Fig. 1). The 2888E encapsulates any protocol in a proprietary Alligator format to encrypt and forward multiple packet fragments across a UHF radio link and reassemble them seamlessly. It is most easily understood as a wire transmission with added latency due to the time taken for transmission over a 12.5 kHz channel at 9600 bps along with delays due to packet screening, assembly, and encryption.

6.1 RS-232 Communications

The RS-232 communications interface forwards all incoming serial data with no screening. It operates at one of five programmable data rates: 1200, 2400, 4800, 9600, and 19200 bps. There is no RTS or CTS data flow control required because data is forwarded based on TXD line activity. This permits a simple three-wire interface consisting of TXD, RXD, and GND.

6.2 Ethernet Communications

All Ethernet packets (UDP, TCP/IP, Ping, ARP, . . .) are recognized and can be transparently forwarded over the RF network. UDP packets can be filtered (udp=0) in certain special cases when a UDP device not intended for the radio system causes radio network flooding. The default of udp is udp=1 (not filtered)

6.2.1 Packet Forwarding

The Ethernet communications interface forwards incoming IP packets, provided that they pass a user-programmable forwarding screening test. Packet forward screening is done to minimize data traffic not intended for the radio network that could otherwise flood the system. The 2888E has four programmable forwarding modes:

fm=0	RTU and Host filter (qualified RTU and Host source/destination MAC address)
fm=1	Host filter (qualified host source/destination MAC address)
fm=2	RTU filter (qualified RTU source/destination MAC address)
fm=3	No filtering, allow all packets to be forwarded

The simplest filtering mode (fm=3) does not screen any packets. This is referred to as the IP promiscuous mode and is only used in small systems where flooding by unwanted packets is improbable. It is not recommended in systems with either the master or remote ends tied to LANs due to the flooding potential. The 2888E defaults in this mode for testing but is not recommended for field deployment.

The host screening mode (fm=1) is highly recommended for packet forwarding on the master radio. At the master radio, a host table with up to 16 entries is created by the user with a list of host MAC addresses. Only packets originating by authorized hosts on the MAC table are forwarded.

The RTU screening mode is used so that only packets destined for authorized RTU MAC addresses are forwarded. At the master radio, an RTU table with up to 512 entries is created by the user

with a list of RTU MAC addresses. Only packets destined for authorized RTUs on the MAC table are forwarded. The remote radio can also be configured for RTU filtering. This causes the remote radio to forward only packets back over the RF link when they are sourced by an authorized source RTU MAC address. This also greatly reduces the probability of system flooding.

The combined RTU and Host filtering mode provide the greatest amount of screening. Only authorized traffic has access to the radio address with both source and destination MAC address complying with the system definition. This makes system flooding nearly impossible to occur.

6.2.2 Telnet Radio Configuration and Diagnostics

The primary mission of the 2888E is to provide robust RF linkage with total protocol transparency; however, a Telnet server for local and remote radio configuration is provided in each 2888E. Thus, each 2888E is factory-assigned a unique Alligator MAC address for IP access using the Telnet protocol. The user can program the IP address, gateway address, subnet mask, and Telnet port address. This gives the radio visibility to the host and/or a separate client host for radio configuration and diagnostics. Users of RS-232 interfaces also use the Ethernet interface with a Telnet client program. The Telnet communications over the RF link shares the bandwidth of the system transparently.

6.2.3 Graphics Heavy Communications

The use of communications carrying a large amount of graphics data is discouraged. Please be aware that at 9600 bps, the transmission rate is only about 1K bytes per second. Sending large graphics files can take tens of seconds. This can be done concurrently with the normal polling traffic along with Telnet diagnostic traffic but at the cost of system time latency. Nothing prohibits doing large file transfers, but be aware of the time required to push the data through a 9600 bps link.

6.2.4 Radio Programming Commands

COMMAND	DEFAULT	UNITS	DESCRIPTION
• tf=###.#####<CR>	929.1	MHz	Transmit Frequency (dec point and trailing zeros optional)
• rf=###.#####<CR>	953.1	MHz	Receive Frequency (dec point and trailing zeros optional)
• fc=####<CR>	0	Hz	Frequency Offset Calibration (-10000 to 10000)
• tp=#<CR>	1		Transmit Power 1=low 2=med 3=high
• om=#<CR>	0		Operating Mode 0=remote 1=master
• gc=##<CR>	0		Group Code (0 to 15)
• ip=###.###.###.###<CR>	192.168.1.128		Radio IP Address
• tnp=#####<CR>	23		Radio Telnet Port Number 0 to 65534
• gw=###.###.###.###<CR>	192.168.1.1		Gateway Router IP Address
• sm=###.###.###.###<CR>	255.255.0.0		Subnet Mask
• dr=####<CR> 1200, 2400, 4800, 9600	9600	bps	RS-232 Data Rate

• ast=####<CR>	120	sec	Anti-streaming time (1 to 4 digits)
• tnt=####<CR>	120	sec	Telnet session activity timer (1 to 4 digits)
• lgt=####<CR>	120	sec	Log-in session activity timer (1 to 4 digits)
• et=#<CR>	1		Enable Transmitter 0=disable 1=enable
• ec=#<CR>	0		Enable Compression (not implemented)
• ee=#<CR>	0		Enable Encryption 0=disable 1=AES256
• ep=#<CR>	0		Enable Password 0=disable 1=enable
• id=###. . .###<CR>	admin		ID word (16 character max, not displayed)
• pw=###. . .###<CR>	password		Password (16 character max, not displayed)
• aesp=###. . .###<CR>	phrase		AES Encryption Phrase (32 character max)
• udp=#<CR>	1		Enable UDP 0=disable 1=enable
• lo<CR>			Log Out
• q<CR>			Telnet Log Out
• fm=#<CR>	3		Forward Mode 0=rtu&host 1=host 2=rtu 3=all
• rtu0=##-##-##-##-##-##<CR>	00-00-00-00-00-00		RTU0 MAC Address (remote mode)
• rtu1=##-##-##-##-##-##<CR>	00-00-00-00-00-00		RTU1 MAC Address (remote mode)
• rtu[###]=##-##-##-##-##-##<CR>	00-00-00-00-00-00		RTU[n] master MAC Address Table, n hex (000 to 1FF)
• host[#]=##-##-##-##-##-##<CR>	00-00-00-00-00-00		Host[n] MAC Address Table, n hex (0 to F)
• qip[#]=###.###.###.###	0.0.0.0		qip[n] High QOS IP Address Table, n hex (0 to F)
• Escape Key or second Enter key			Print Status
• rtutable<CR>			Print Master RTU MAC Address Table
• hosttable<CR>			Print Host MAC Address Table
• lb=##-##-##-##-##-##<CR>	00-00-00-00-00-00		Loopback MAC of Remote Radio (when using dt=5)
• dt=#<CR>	0		Diagnostic Test 0=none 1=TX CW 2=RX CW 3=TX 1 way 4=RX 1 way 5=TX 2 way 6=display TX Buffer 7=display RX Buffer 8=display TX & RX Buffers 9=subpacket

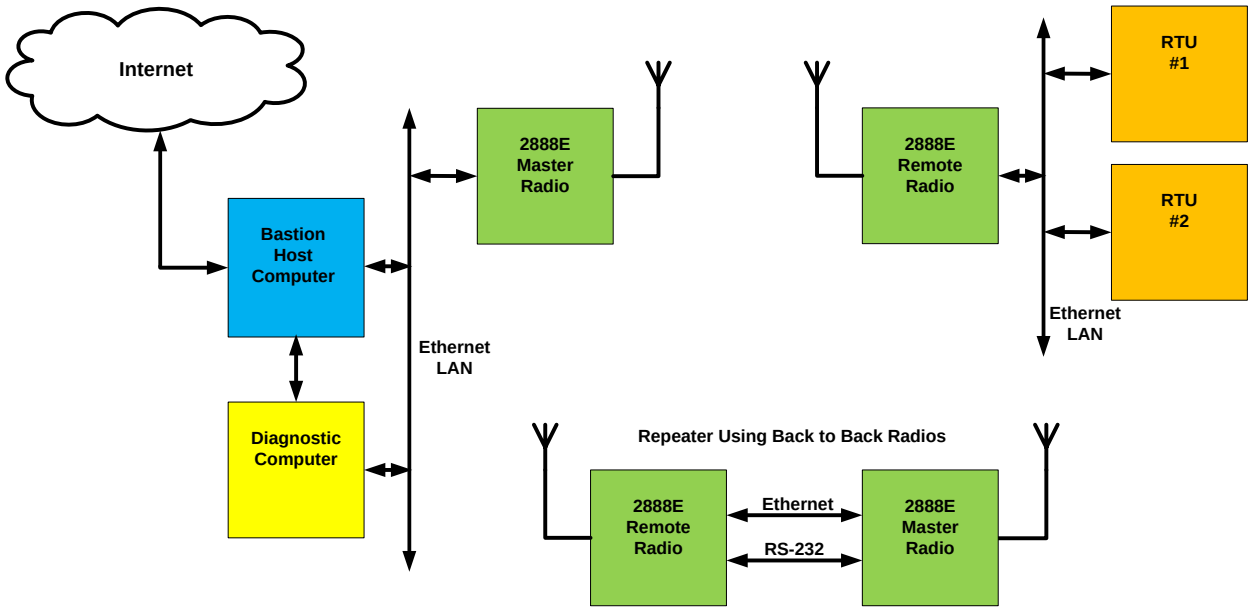


Figure 1 Typical System Block Diagram

Model 2888E Internal Reset Push Button Location