

INSTRUCTION MANUAL

R.C. SYSTEMS CO. INC.

**MODEL ST-96 WIRELESS REPEATER
(With RF Wireless Interface)**

(Revision 1.1; Firmware 1.00 and later)



Warning: Read & understand contents of this manual prior to operation. Failure to do so could result in serious injury or death.

Users are responsible for correct translations of this manual into their native language

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SECTION 1 – SAFETY INFORMATION

1.1 Safety Information – Read Before Installation & Applying Power

IMPORTANT

Users should have a detailed understanding of ST-96 operating and maintenance procedures. Use the ST-96 only as specified in this manual or detection of gases and the resulting protection provided may be impaired. Read the following **WARNINGS** prior to use.

WARNINGS

- Calibrate gas monitors that communicate to the ST-96 with a known value at start-up and check on a regular schedule, at least every 90 days.
- Do not use the ST-96 if its enclosure is damaged or cracked or has missing components.
- Make sure the cover, internal PCB's and antenna connections are securely in place before operation.
- Periodically test for correct operation of the system's alarm events by exposing the monitor to a known value above the High Alarm setpoint.
- Do not expose the ST-96 to electrical shock or continuous severe mechanical shock.
- Protect the ST-96 from dripping liquids and high power sprays.
- Use only for applications described within this manual.

CAUTION: FOR SAFETY REASONS THIS EQUIPMENT MUST BE OPERATED AND SERVICED BY QUALIFIED PERSONNEL ONLY. READ AND UNDERSTAND INSTRUCTION MANUAL COMPLETELY BEFORE OPERATING OR SERVICING.

ATTENTION: POUR DES RAISONS DE SÉCURITÉ, CET ÉQUIPEMENT DOIT ÊTRE UTILISÉ, ENTRETENU ET RÉPARÉ UNIQUEMENT PAR UN PERSONNEL QUALIFIÉ. ÉTUDIER LE MANUE D'INSTRUCTIONS EN ENTIER AVANT D'UTILISER, D'ENTREtenir OU DE RÉPARER L'ÉQUIPEMENT.

1.2 Contacting R. C. Systems Co. Inc.

To contact R. C. Systems Co. Inc., call, fax, email or write:
409-986-9800 FAX 409-986-9880 Email: info@rcsystemsco.com 8621 Hwy. 6 Hitchcock, TX 77563
Or visit us on the World Wide Web: www.rcsystemsco.com

SECTION 2 – GENERAL DESCRIPTION

2.1 Introduction

R.C. Systems ST-96 "Wireless Modem/Repeaters" are available in ST-96M and ST-96R models. ST-96M "Modems" convert RS-485 data to 900 MHz or 2.4 GHz FHSS Client/Server wireless networks. Each network must have one radio set as Server and all others are Clients. Hop and Destination address settings allow many different networks within the same installation.

ST-96M modems are useful if the RS-485 device is a long distance from a desirable antenna location. For example, R. C. Systems' ST-35, ST-71, ST-72 & ST-90 Controller products are available with wireless interfaces but these require the controller be close to the antenna due to losses in long coax cables. ST-96M's may be at the desired antenna location with twisted pair copper wiring back to the controller's RS-485 & power supply terminals. Modbus Slave ports may be multi-dropped to the same ST-96M.

ST-96R "Repeaters" are similar to ST-96M modems except they have 2 radios instead of an RS-485 port and one radio. ST-96R Repeaters receive and retransmit transmissions between 2 other wireless devices that are out of range of each other. The two ST-96R radios must be on different hopping networks and one may even be 900 MHz and the other 2.4 GHz.

Primary ST-96 applications are for interfacing to R. C. Systems products but other RS-485 devices may also be converted to wireless by adding ST-96M and ST-96R's. 900MHz model's transmit power is adjustable between 10mW and 1W (0-30dBm) and 2.4GHz models power is fixed at 125mW (21 dBm).

ST-96s must be continuously powered by an external 10-30VDC power source and are ideally suited for 12VDC solar power supplies.

Additional features include:

- Magnetic keypad allows operator interface without opening the enclosure.
- All user configuration is with menus accessed via the LCD / magnetic keypad operator interface without opening the enclosure.
- Modular design affords efficient installation and troubleshooting.

2.1.1 ST-96 LCD Readouts

Figure 2-1 shows ST-96 LCD screens for displaying configuration menus and status of the radios in the ST-96R Repeater and ST-96M Modem modes. The left screen in Figure 2-1 shows an ST-96R in the Repeater Mode. Each radio's configuration is displayed and the Client radio status will be **In Range** or **No Server** (indicating no Server is in range on this network). The Server radio's status appears as dashes on the Radio B portion of this screen since the status of In Range or No Server do not apply when the radio is the Server. The right screen in Figure 2-1 shows an ST-96M in the Modem Mode. ST-96M modems have only one radio always displayed as Radio A.

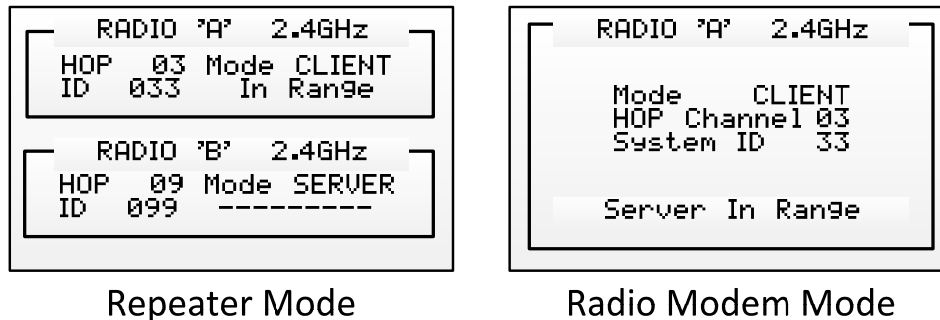


Figure 2-1: Readout Screen

2.2 Description of ST-96 & Client / Server Wireless Networks

All R. C. Systems wireless devices utilize a FHSS (Frequency Hopping Spread Spectrum) Client / Server network where multiple Clients synchronize their frequency hopping to a single Server. The wireless network's Server transmits a beacon at the beginning of every frequency hop. Client transceivers with the same **Hop Channel** and **System ID** listen for the Server beacon and upon receiving it synchronize their hopping with the Server. ST-96 radios may be user configured as either Clients or Servers.

Many wireless devices may be on the same hopping network but only one device per network may be configured as the Server. All of the Clients must receive their network's Server beacons in order to report a status of "Server In Range" and have successful communication. Therefore, if there are numerous devices the most centrally located should usually be configured as the Server.

A common ST-96R Repeater application (see Section 5) is to interface a base station's modbus Master wireless port to a group of remote modbus Slave devices that are otherwise out of range of the Master. In this case the radio on the base station's wireless network would normally be a Server to Radio A in the ST-96R. Radio B in the ST-96R must be on a different hopping network from Radio A and would typically be Server to the Slaves on its network (See Figure 5-1).

Each transceiver on a wireless network must have its **RADIO SETUP** menus configured to share the same **Hop Channel** (0-32 900MHZ, 0-42 2.4GHZ) and **System ID** (0-255) in order to communicate (see Section 4.5).

IMPORTANT! There should never be two servers with the same **Hop Channel / System ID** settings in the same coverage area because interference between the two servers will severely hinder RF communications.

Correct planning and design of wireless systems are imperative for ensuring a successful installation. It is highly recommended that a site drawing indicating location of all wireless devices, base station, line of site obstructions, and sources of RF interference be submitted when requesting a quotation.

2.2.2 #10-1252 ST-96 Power Supply PCB

ST-96 electronics consists of three PCB assemblies. The 10-0234 Power Supply PCB is mounted to the bottom of the enclosure with four 4-40 screws and connects to the upper Display / Primary Radio assembly 10-0320 (Radio 'A') with a 4 conductor cable. The Secondary Radio Assembly 10-0375 (Radio 'B' for Repeater Mode), or the 10-0376 (RS-485 Module for Radio Modem Mode) mounts to the Display/ Primary Radio assembly. Figure 2-2 shows each individual option board with the 2.4 GHz radios installed (900 MHz radios shown as dotted lines). Figure 2-3 shows an example of the boards assembled.

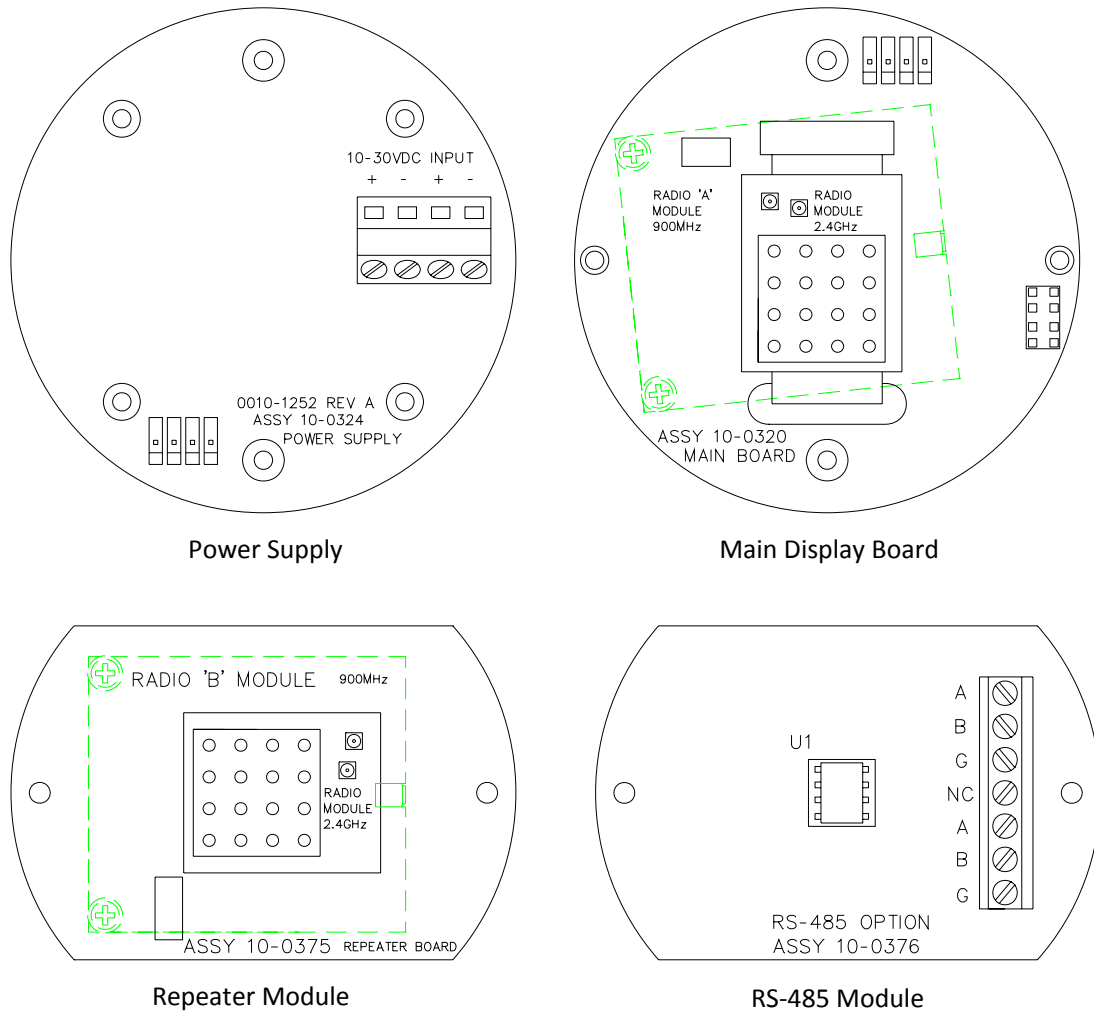


Figure 2-2: Display/Radio Assy & 10-0324 Power Supply Assy

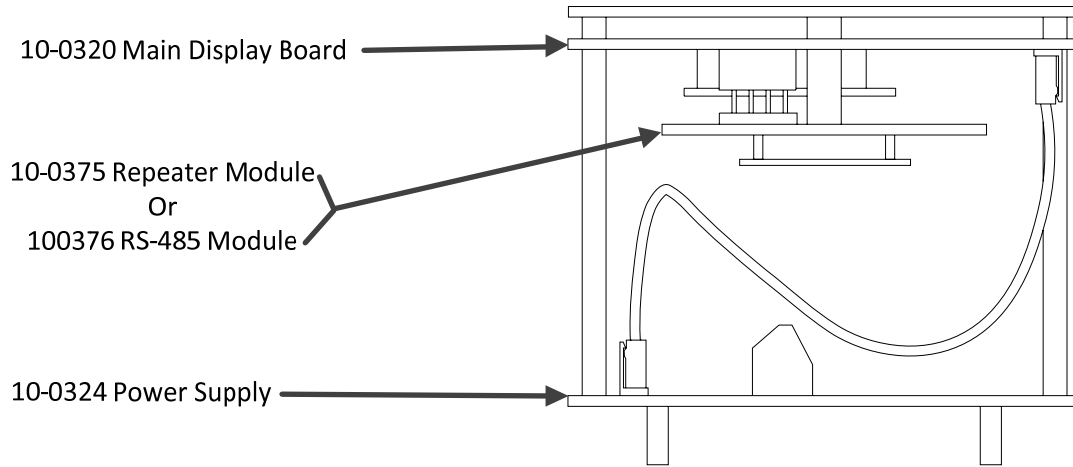


Figure 2-3: Assembled Stack

SECTION 3 – INSTALLATION INSTRUCTIONS

3.1 Ratings and Certifications

The cast aluminum enclosure is NRTL certified for Division 1 hazardous area installations for explosion-proof Class 1 Groups A,B,C,D (see Figure 3-1). **However, the 10-0295 antenna fitting with RP-SMA antenna connector and is suitable only for Division 2 classified areas.** An optional explosion-proof antenna is also available for Division 1 classified areas (order 1000-2193 for 900MHZ and 1000-2301 for 2.4GHZ). Figure 3-2 shows both antenna styles.

3.2 Location

Even though the ST-96 is designed for rugged service it should be protected from environmental damage from water, snow, shock, vibration and dirt. Minimize obstructions around the antenna.

3.3 Mounting the Enclosure

The ST-96 standard enclosure is a cast aluminum explosion-proof (NEMA 7) enclosure as shown in Figure 3-1. Modular design simplifies the installation of the ST-96 (Figure 3-2). The ST-96 antenna should typically be mounted with "line of site" access to the devices it communicates with. If a good "line of site" angle is not possible the ST-96's will usually still function properly at ranges up to 1500 feet but obstructions should be kept to a minimum.

WARNING: Qualified personnel should perform the installation according to applicable electrical codes, regulations and safety standards. Ensure correct cabling and sealing fitting practices are implemented. Install the ST-96 to a wall or bracket using the predrilled mounting flanges with I.D. 0.25 on 5.0 inch centers (Figure 3-1).

3.3.1 10-0322 Magnetic Mount Option

R. C. Systems offers square aluminum plate, with a magnet on each corner, to bolt to the back of the ST-96's instrument enclosure. The 10-0322 Magnetic Mount securely attaches the assembly to solid steel structure that is at least 6 inches wide.

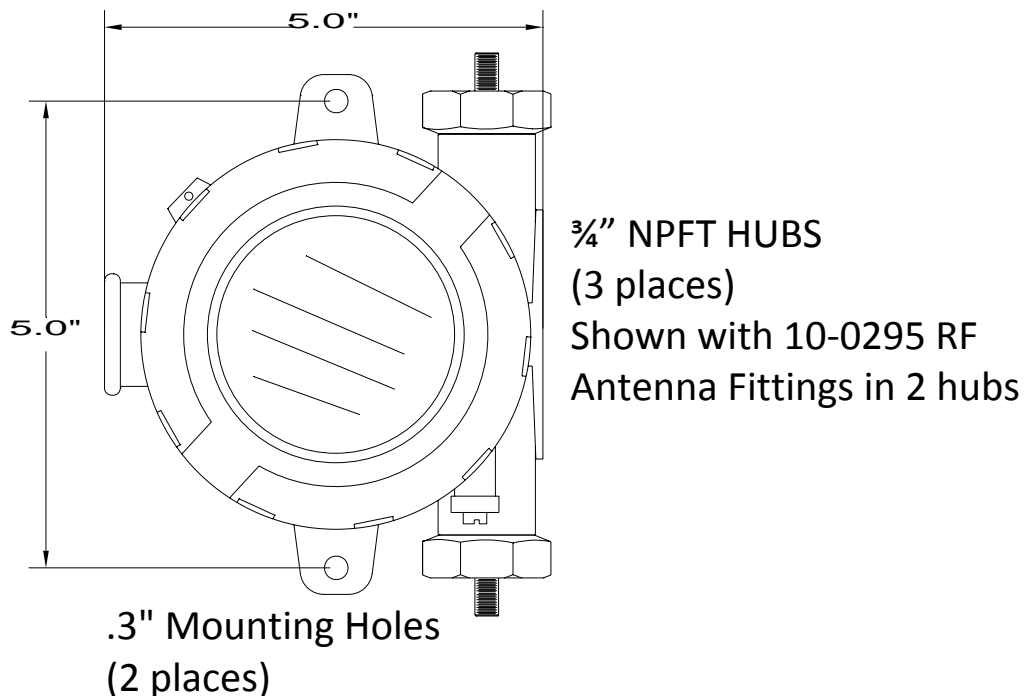


Figure 3-1: ST-96 Explosion-Proof Housing

3.4 Specifications

Power Supply:

10-30 VDC @ 2 watts max.

Performance

2.4 GHz Frequency Range = 2400 - 2483.5 MHz with 42 hops
2.4 GHz Conducted Transmit Power is 125mW / 21dBm
2.4 GHz Indoor/Urban Range = up to 1500 feet with 7dBi collinear antenna
2.4 GHz Outdoor RF LOS Range = up to 2 miles with high-gain antenna
2.4 GHz Receiver Sensitivity = -98 dBm

900 MHz Frequency Range = 902 - 928 MHz with 50 hops
900 MHz Conducted Transmit Power (selectable) = 10mW-1W / 0-30 dBm
900 MHz Indoor/Urban Range = up to 3000 feet with 2dBi dipole antenna
900 MHz Outdoor RF LOS Range = up to 5 miles with high-gain antenna
900 MHz Receiver Sensitivity = -100 dBm

Memory:

Non-volatile E2 memory retains configuration values in the event of power outages.

Ambient Temperature Range

-40 – 60 degrees C.

Housing and Area Classification

NEMA 4X / NEMA 7 instrument enclosure is suitable for
Class 1, Division 1, Gr. A,B,C,D

Area Classification should be Division 2 or non-hazardous when ST-96 housing is equipped with 10-0295 Antenna Fittings

Division 1 Area Classifications require "Explosion-Proof" 1000-2301 or 1000-2193 Antenna options (add "XP" suffix when ordering)

ST-96 Models

ST-96M/2400 Modem has one RS-485 port and one 2.4 GHz radio
ST-96R/2400 Repeater has two 2.4GHz radios
ST-96M/900 Modem has one RS-485 port and one 900 MHz radio
ST-96R/900 Repeater has two 900 MHz radios

3.5 Antenna Transmission Range

The distance radio signals can travel is dependent upon several factors including antenna design, transmitter power and Freespace losses. In order for a wireless link to work, the available system operating margin (**TX power - RX Sensitivity + Antenna gains**) must exceed the Freespace loss and all other losses in the system. For best RF line-of-site, the combined height of both antennas must exceed the Fresnel zone diameter (see below).

<u>Dist. between ant's</u>	<u>Fresnel zone diameter</u>	<u>Freespace loss (dB)</u>
1000 ft (300 m)	16 ft (4.9 m)	81
1 Mile (1.6 km)	32 ft (9.7 m)	96
5 miles (8 km)	68 ft (20.7 m)	110
10 miles (16 km)	95 ft (29 m)	116

Example:

The RF radio modem has the following parameters:

- Maximum RF TX power setting = 30 dBm (1 Watt)
- RF RX sensitivity = -100 dBm (this is a constant)
- Antenna gain (standard equipped dipole) = 2.1dBi x 2 = 4.2dBi

So the system operating margin is $30 - (-100) + 4.2 = 134.2$ dBm. This is enough to transmit 10 miles if freespace was the only loss in the system. For this to be the case, the antennas must be mounted with a combined height greater than 95ft above all obstructions (including the ground) to keep the fresnel zone clear. In practice however, there are many losses in the system besides just freespace and it is recommended there be at least 20dB extra system operating margin.

RF “Rules of Thumb”

- Doubling the range with good RF “Line of Site” (LOS) requires an increase of 6 dB.
- Doubling the range without good RF LOS requires an increase of 12 dB.

3.5.1 Antenna Selection & Location

A site survey using an RF spectrum analyzer and test radios is highly recommended.

The location of the antenna is very important. Ensure the area surrounding the proposed location is clear of objects such as other antennas, trees or power lines which may affect the antenna’s performance and efficiency. It is also vital that you ensure the support structure and mounting arrangement is adequate to support the antenna under all anticipated environmental conditions. The choice of appropriate mounting hardware is also important for both minimizing corrosion and maintaining site intermodulation performance.

Most 900MHZ installations utilize locally mounted 1000-2189 dipole antennas as shown in Figure 3-2. An option is available for a 6 foot riser to increase the height of the antenna 6 feet above the ST-96. Minimize obstructions between the ST-96 and the devices it communicate with.

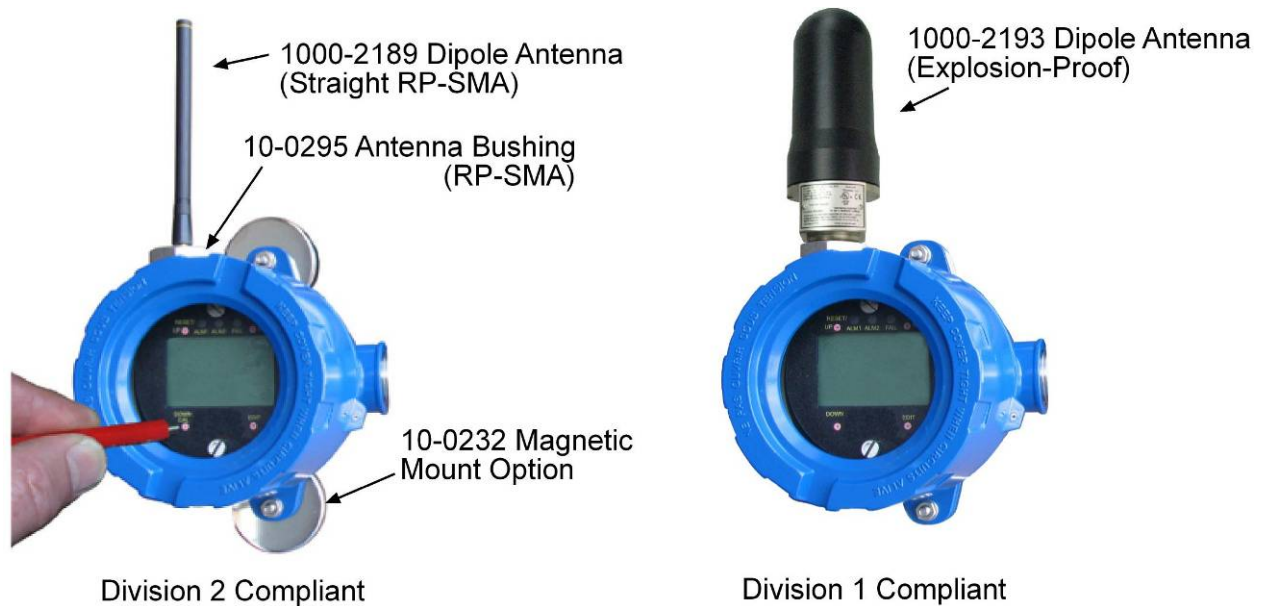


Figure 3-2: Local Antennas (900MHZ Shown)

3.5.2 Water Proofing Antenna Connections

Waterproof all outdoor coax connectors using a three layer sealing process of initial layer of adhesive PVC tape, followed by a second layer of self-vulcanizing weatherproofing tape such as 3M 23 (order # 1000-2314), with a final layer of adhesive PVC tape (see Figure 3-3).

1. Attach antenna to RP-SMA fitting
2. Wrap 20-24" strip PVC electrical tape onto hub, nut & base of antenna
3. Wrap 20-24" strip 3M 23 tape (order # 1000-2314) onto PVC tape
4. Wrap 24-28" strip PVC electrical tape over all



Figure 3-3: Water Proofing Antenna Connections

3.5.3 System Grounding

Direct grounding of the ST-96 enclosure via a good electrical connection to a well designed grounding system is essential. This will protect your system, reduce damage that can occur during lightning strikes, and reduce noise.

SECTION 4 – REPEATER MODE SETUP MENU CONFIGURATION

4.1 Menus Database Configuration

All ST-96 configuration variables are stored in its non-volatile menu database. Upon installation, many menu items will contain default values from the factory and require changes to better match a user's particular application. ST-96 menus may be configured from the magnetic keypad in just a few minutes per radio transceiver. The configuration menu tree is shown in Figure 4-1 and each menu's description follows.

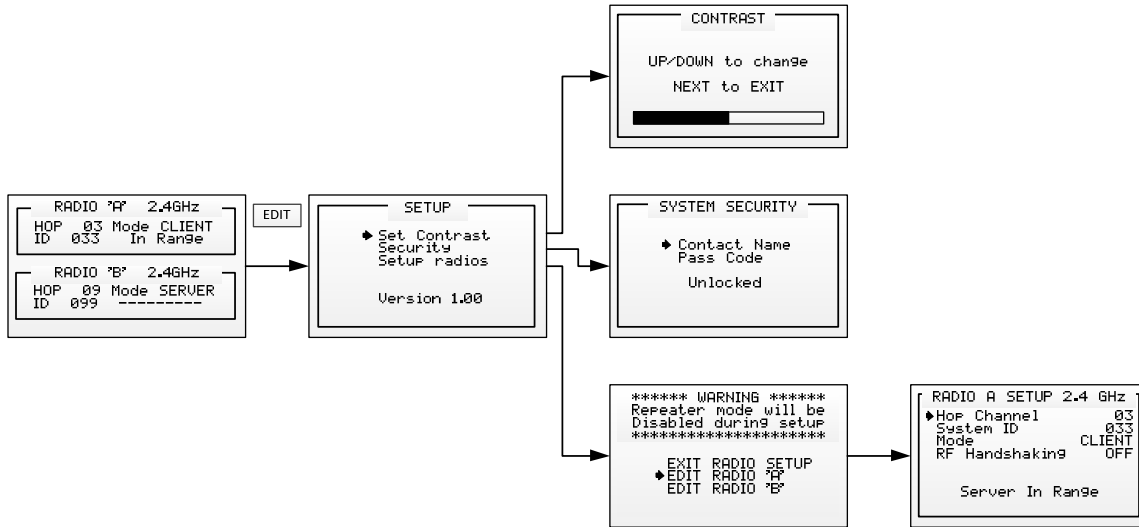


Figure 4-1: Configuration Menu Tree

4.2 SYSTEM SETUP Using the Magnetic Wand

Passing the magnetic wand over the EDIT key, from the main display screen, displays the **SYSTEM SETUP** screen as shown below in Figure 4-2. The UP / DOWN keys maneuver the pointer while EDIT enters sub-levels of menu items. All **SYSTEM SETUP** menu items have at least one page of sub-menus. Edit menu items by pointing to the item, press the EDIT key to display the cursor, press UP / DOWN to change that character, press NEXT to move the cursor, then press EDIT again to load the new item and remove the cursor. Press NEXT to reverse out of the sub-menu.

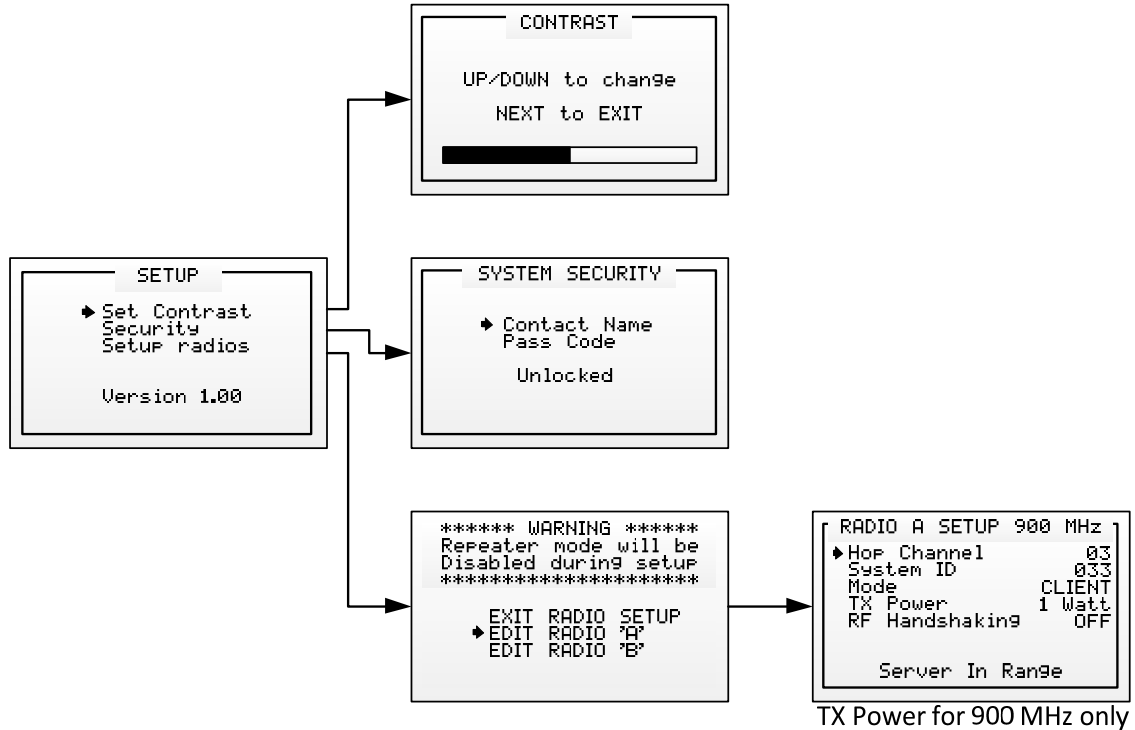


Figure 4-2: Setup Menu Entry

4.3 Contrast Menu

The **SET CONTRAST** menu shown in Figure 4-3 allows adjusting of the LCD contrast to ambient lighting conditions and user preferences.

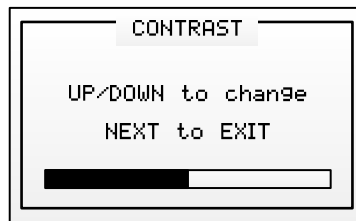


Figure 4-3: LCD Contrast Adjust Menu

4.4 Security Menu

The **SECURITY** menu in Figure 4-4 allows locking of all configuration variables by requiring a 4-digit **Pass Code** (code 0000 is reserved) prior to altering menus. **Contact Info** is a 15 character ASCII field available for displaying a phone # or name of personal in possession of the **Pass Code**.



Figure 4-4: System Security Menu

4.5 Radio Setup Menu

The **SETUP RADIOS** menu consists of five menu items as shown in Figure 4-5. This screen also confirms if the ST-96's wireless network Server is in range. If this ST-96 radio is the network's Server then only the first three menu items will be displayed and it will say **SERVER** on the **Mode** line.



TX Power for 900 MHz only

Figure 4-5: Radio Setup Menus

- **Hop Channel** may be set from 1-32 ON 900 MHz and 0-42 on the 2.4 GHz and assigns the pseudo-random radio frequency hopping pattern. A transceiver will not go **In Range** of or communicate with a transceiver operating on a different Hop Channel. Different Hop Channel designations may be used to prevent radios in one network from listening to transmissions of another. Installations with more than one Server network should also have different hop channels for each network.

IMPORTANT!! IT IS THE USERS RESPONSIBILITY TO EXPLORE WHAT FREQUENCIES ARE APPROPRIATE FOR THE FINAL LOCATION OF ANY WIRELESS SYSTEM.

- **System ID** may be set from 1-255 and is similar to a password character or network number and makes network eavesdropping more difficult. A transceiver will not go in range of or communicate with a transceiver operating on a different **System ID**.
- **Mode** may be set for CLIENT or SERVER. For a single ST-96 communicating to multiple transceivers, **Mode** is set to Server at the Master for the initial network and the secondary network Server is set at the ST-96 repeater (see Figure 5.1). If an application calls for the ST-96 plus additional ST-71 or ST-90/QUAD locations, only one may be set for Server and all others must be Clients. This single Server transmits a beacon for each of this network's Clients to synchronize to.

- **TX Power** for 900 MHz models may be set to 10mW, 200mW, 400mW and 1 watt (0-30 dBm). Since ST-96s typically have power to spare, the recommended 900 MHz TX Power setting is 1 watt. **TX Power** is fixed at 125mW on 2.4 GHz models (21 dBm).
- **Handshaking** is available in the CLIENT mode only. When set to the ON mode, an Acknowledgement is sent back to the Server after a successful reception. This can be useful to improve data integrity in systems that have single receiving stations in a network. This feature should be turned OFF when multiple receivers are on the same HOP and SYSTEM ID to avoid collisions of the acknowledgment packet.

Note: *Items changed in the setup menus do not take affect until the menu is exited and the settings are written to the radio.*

SECTION 5 – REMOTE RADIO MODEM MODE SETUP MENU CONFIGURATION

5.1 Menus Database Configuration

All ST-96 configuration variables are stored in its non-volatile menu database. Upon installation, many menu items will contain default values from the factory and require changes to better match a user's particular application. ST-96 menus may be configured from the magnetic keypad in just a few minutes. The configuration menu tree is shown in Figure 5-1 and each menu's description follows.

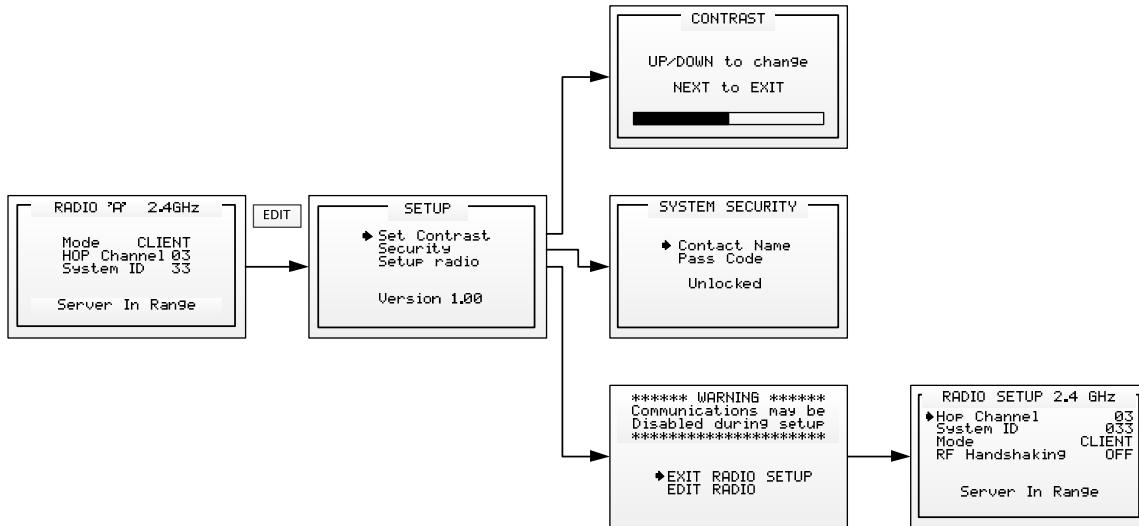


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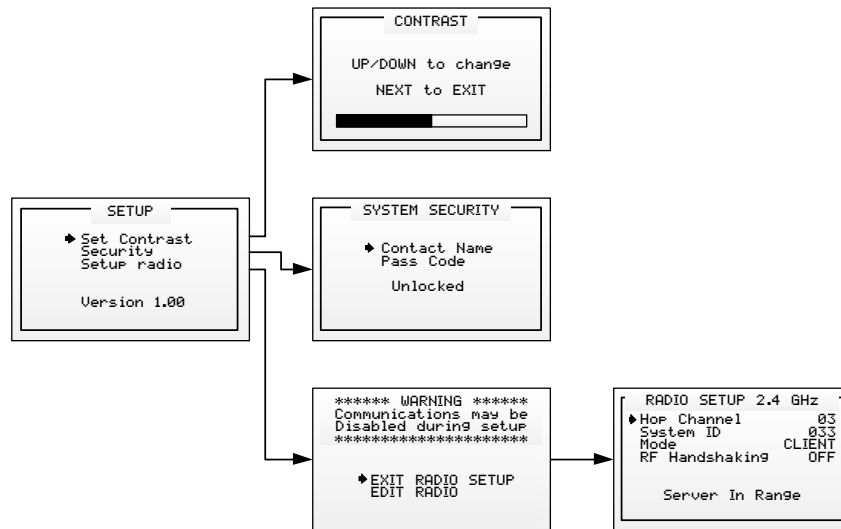


Figure 5-2: Setup Menu Entry

5.3 Contrast Menu

The **SET CONTRAST** menu shown in Figure 5-3 allows adjusting of the LCD contrast to ambient lighting conditions and user preferences.

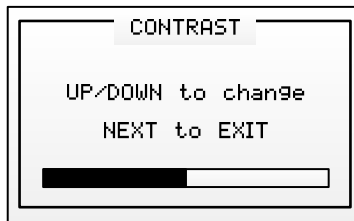


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Figure 5-4: System Security Menu

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TX Power for 900 MHz only

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- **Mode** may be set for CLIENT or SERVER. For a single ST-96 communicating to multiple transceivers, **Mode** is set to Server (see Figure 6.1). If an application calls for multiple ST-96 radio modems, only one may be set for Server and all others must be Clients. This single Server transmits a beacon for each of this network's Clients to synchronize to.

- **TX Power** for 900 MHz models may be set to 10mW, 200mW, 400mW and 1 watt. Since ST-96s typically have power to spare, the recommended TX Power setting is 1 watt. **TX Power** is fixed at 50mW on 2.4 GHz models.
- **Handshaking** is available in the CLIENT mode only. When set to the ON mode, an Acknowledgement is sent back to the Server. This can be useful to improve data integrity in systems that have single receiving stations in a network. This feature should be turned OFF when multiple receivers are on the same HOP and SYSTEM ID to avoid collisions of the acknowledgment packet.

Note: *Items changed in the setup menus do not take affect until the menu is exited and the settings are written to the radio.*

SECTION 6 – NETWORK CONFIGURATION

6.1 Network Configuration

ST-96R Repeaters are equipped with two radios and should be utilized when the distance between wireless devices is too far, or to go around obstacles that prevent reliable communication. In the example in Figure 6-1, the queries from the Master (base station) are passed through the ST-96R Repeaters to the “Out of Range” Slaves. Slave responses are passed back through the ST-96R to the Master. As shown in the table, there must be separate HOP networks for each side of the ST-96R and all other collocated networks must also be configured with their own unique System IDs and HOP channels (see Section 4.5).

The Master is often the most centrally located device and is therefore configured as the Server. The drawing in Figure 6-1 indicates Servers and Clients with S for Server and C for Client. ST-96R Repeaters in Figure 6-1 are illustrated with 2 antennas and ST-96M Modems with only 1 antenna.

ST-96M Modems are useful for converting RS-485 signals to wireless signals. ST-96M’s have one radio and it may also be configured for Server or Client. Networks with multiple ST-96M Modems must also have only one Server per network.

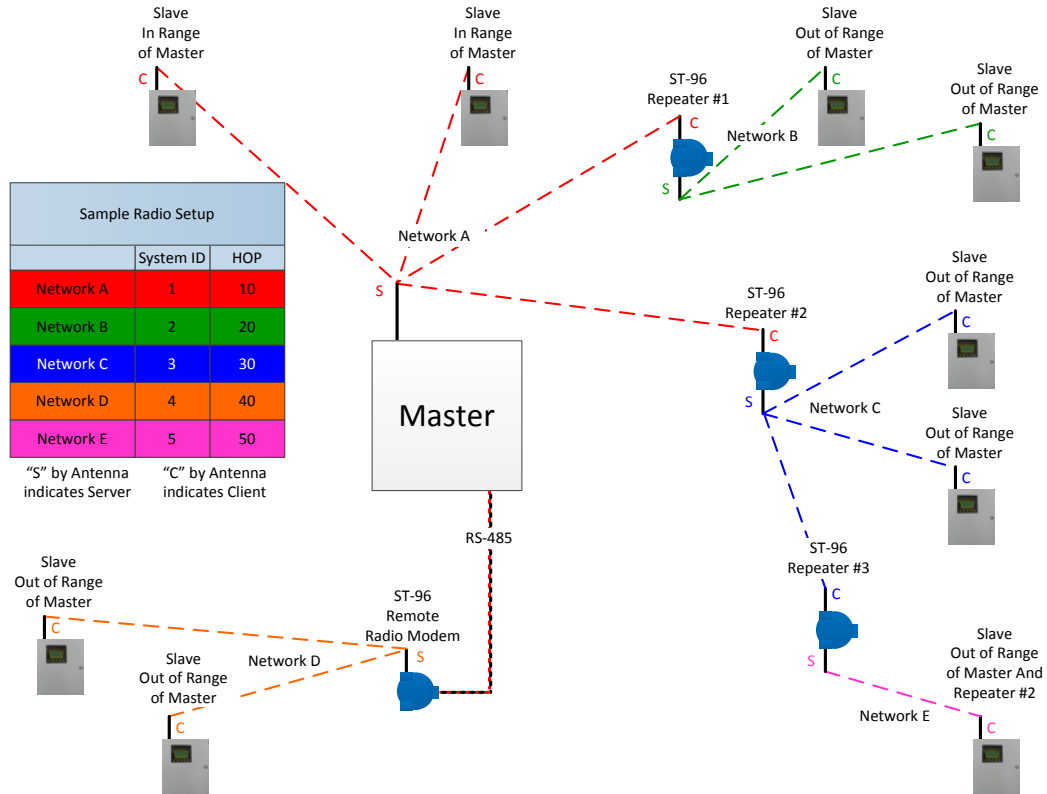


Figure 6-1: ST-96R / ST-96M Collocated Network

SECTION 7 – ORDERING INFORMATION

7.1 ST-96 MODELS

ST-96M/2400 Modem Suitable for Div 2; Includes 1, 1000-2300

ST-96R/2400 Repeater Suitable for Div 2; Includes 2, 1000-2300

ST-96M/900 Modem Suitable for Div 2; Includes 1, 1000-2189

ST-96R/900 Repeater Suitable for Div 2; Includes 2, 1000-2189

ST-96M/2400/XP Modem Suitable for Div 1; Includes 1, 1000-2301

ST-96R/2400/XP Repeater Suitable for Div 1; Includes 2, 1000-2301

ST-96M/900/XP Modem Suitable for Div 1; Includes 1, 1000-2193

ST-96R/900/XP Repeater Suitable for Div 1; Includes 2, 1000-2193

7.2 ST-96 SPARE PARTS & ACCESSORIES

10-0295 3/4" NPT to RP-SMA Antenna Fitting

1000-2300 2.4 GHz Collinear Rubber Antenna

1000-2189 900 MHz Dipole Rubber Antenna

1000-2301 2.4 GHz Dipole Explosion-Proof Antenna

1000-2193 900 MHz Dipole Explosion-Proof Antenna