SPECTRUM
ELECTRONIC PRODUCTS

HRC-10 Handheld Repeater Controller

Installation & Operation Manual

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The HRC-10 production process incorporates several stages of inspection from incoming parts through final assembly. In addition, the HRC-10 is subject to thorough electrical testing and a 72 hour burn-in period before shipping.

EMI Emissions

The HRC-10 has been tested for both radiated and conducted EMI and meets the limits for a Class A computing device as defined by the FCC.

FCC Notice

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About This Manual...

This manual was organized to let you get the HRC-10 up and running in its simplest configuration in a few minutes. The first two sections of the manual provide an introduction to the basic capabilities and features of the unit and provide an overview and comparison of simplex and duplex repeater systems. Please take the time to read through these sections first. The next two sections provide an overview of the hardware and cover the basic installation and minimum setup required for a simplex repeater. At this point the unit will be functional and can be used while reading the *"DTMF Control of the HRC-10"* and *"Programming the HRC-10"* sections of the manual. These sections cover control of the HRC-10 and programming of the unit's memory locations to change timers, DTMF access codes, and the operating modes. The *"Hardware Configuration Options"* section contains details on the HRC-10 internal jumper configurations and output level adjustment. These functions are referenced in other sections of the manual. Finally, the appendices contain information on interfacing various radios to the HRC-10 including specific wiring and interface circuits.

Thank You for purchasing the HRC-10 Handheld Repeater Controller. The HRC-10 was designed using the highest quality components available and should provide years of service. The HRC-10 is the world's first and only handheld battery powered repeater controller. No larger than most handheld radios, the HRC-10 converts a handheld or mobile radio into a full featured repeater system with voice IDer, hang timer, time-out timer, and a voice mail slot. It can also be used as a "repeater-maker" to interface a repeater transmitter and receiver and as such provides the basic ID, timer, and control functions for the system. The HRC-10 was created for use by amateur and commercial radio operators and can be used to set up fixed, portable, or mobile repeater stations. It is capable of being interfaced to any radio and can be used in simplex or full duplex modes. The HRC-10 is completely programmable via DTMF commands and can be custom configured by the user for their particular application.

The following is a list and description of the HRC-10's features:

- **Simplex or Duplex Mode Operation** - Records incoming signal (up to 1 minute) and re-transmits after delay in simplex mode. Re-transmits incoming signal and provides hang and time-out timer functions in duplex mode.

- **Flexible interfacing** - Interfaces to any radio using speaker and microphone jacks. Can also be configured as a "repeater-maker" with external COS and PTT lines for repeater receiver and transmitter.

- **DTMF Control and Programming** - Can be remotely controlled and programmed using a simple DTMF command interface.

- **Voice IDer** - Identifies repeater station at programmed intervals with pre-recorded message in user's own voice. Can be reprogrammed any time over the air. IDer can be set to "active channel ID" or "continuous ID" mode.

- **Courtesy and Telemetry Tones** - Courtesy tone at end of simplex or duplex repeated transmission plus several unique tones to provide feedback for DTMF control and programming functions.

- **System Timers** - Programmable system timers for PTT hang time, receive time-out time, ID interval, and simplex repeat delay.

- **Personal Mailbox Slot** - Records message (up to 30 seconds long) in duplex or simplex repeat mode. Message can be retrieved at any time using DTMF command.

- **External Control Output** - TTL compatible output can be turned on and off using DTMF commands to allow control of external devices.

- **State-of-the-Art Speech Storage** - Uses the latest high-density Direct Analog Storage Technology (DAST™) chip by ISD to provide up to one minute of high quality, non-volatile voice record and playback.

- **Microprocessor Controlled** - Powerful single-chip microcontroller based design provides flexible control capabilities and the ability for future feature upgrades and enhancements.

- **Battery or external powered** - Unit can be powered by internal 9V battery or by external DC input. Can also be configured to recharge optional internal NiCd battery from external DC input.

- **Rugged Enclosure** - Heavy duty extruded metal enclosure provides protection for field use.

II. Simplex or Duplex - System Considerations

The question often arises; "Why use a simplex repeater instead of a duplex system?" The main advantage of a simplex repeater is that a single, inexpensive, handheld or mobile transceiver and a single antenna can be used as shown in figure 1. The simplex repeater system does not require a separate receiver and transmitter and expensive duplexers. The frequency allocation problem is also alleviated since the repeater can be set up on almost any simplex frequency without the need for using a repeater frequency "pair". These factors make the simplex repeater option attractive for emergency use, club events, portable, and temporary stations. Another use for a simplex repeater is site testing. The HRC-10 can be placed at a potential repeater site allowing the operator to hear the quality of the received signal after each transmission. The disadvantage of the simplex repeat mode is that you have to wait for the signal to repeat, but for short exchange and emergency operations this is usually acceptable and is not a problem once the user gets used to the "turn around" delay.

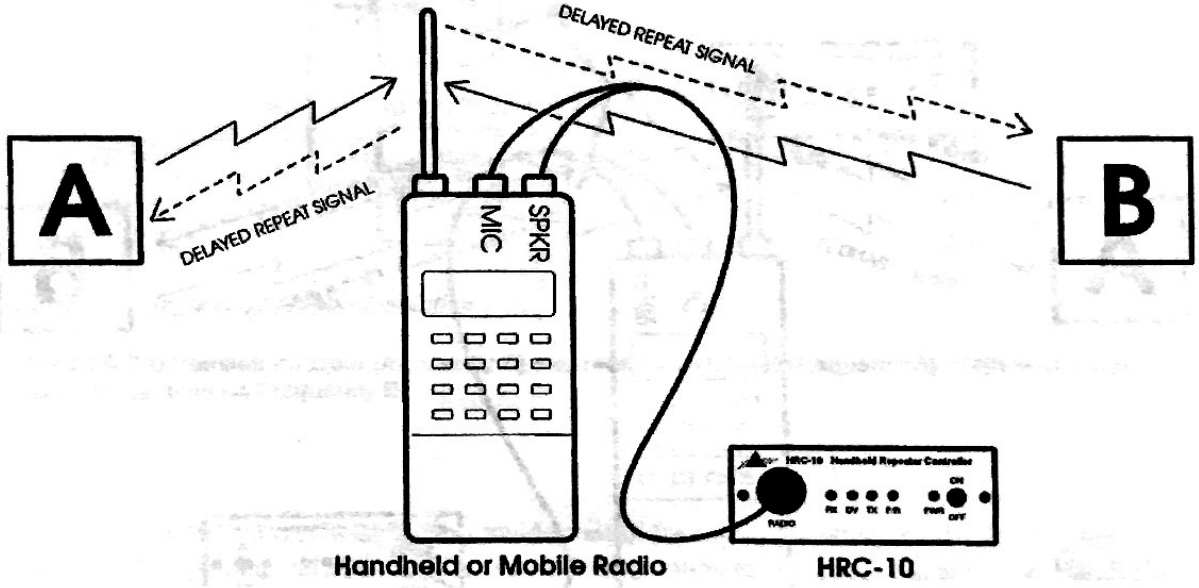


Figure 1 - Simplex Operation

Station A & B transmit and receive on same frequency. Radio connected to HRC-10 set to Simplex Mode. Delayed repeater signal heard by both stations.

The full duplex mode, on the other hand, provides "real time" communications which may be more desirable in some situations. The HRC-10 was designed to allow operation in this mode using two options - cross-band duplex or single-band duplex as shown in figures 2 and 3. The cross-band full duplex mode requires the use of a dual-band radio capable of full duplex operation or alternatively a separate VHF and UHF transceiver. When using a dual-band radio the unit should be configured for full duplex operation. The repeater input will then be on one band while the output will be on the other band. Many radios provide a cross-band linking capability which must be disabled for the HRC-10 to operate properly. The HRC-10 will not provide cross-band linking capabilities: one band is limited to receive while the other is limited to transmit. The advantage of using a dual-band radio in this mode is that a single radio can be used with separate antennas (or a dual-band antenna) for each band. Disadvantages are that more expensive dual-band radios are required to communicate through the system. The single band full duplex method requires a repeater system with separate receiver, transmitter, and antenna duplexer. The cross-band or single-band duplex system provides a more natural mode of communication but requires a more elaborate setup and a frequency "pair" allocated for repeater operation.

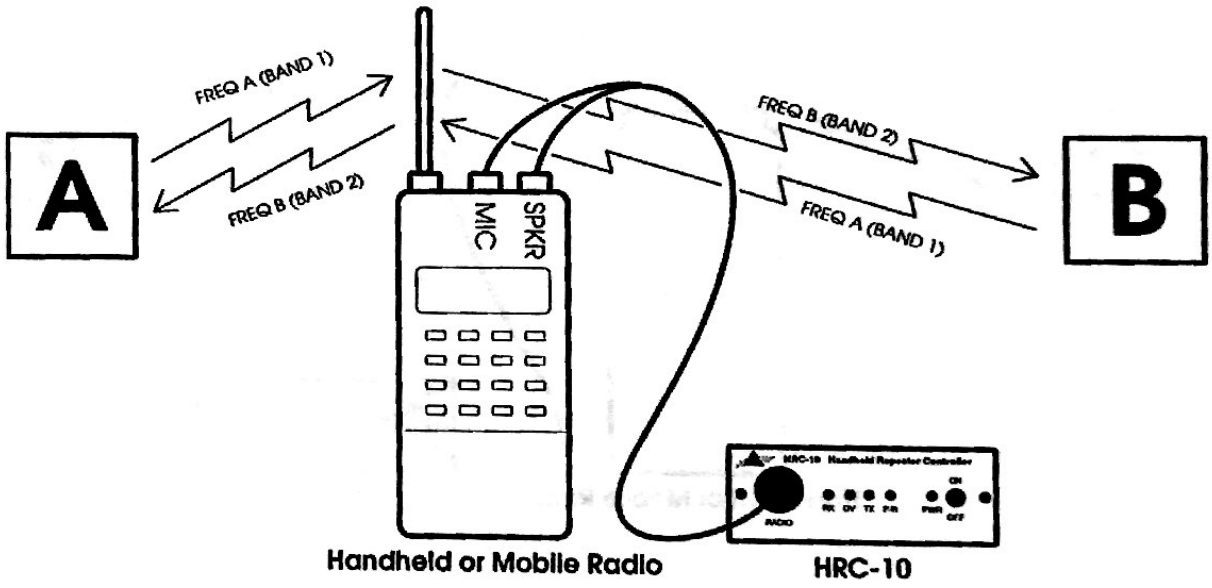


Figure 2 - Cross-Band Duplex Operation

Station A & B transmit on input frequency (Band1) and receive on output frequency (Band 2). Radio connected to HRC-10 set to Full Duplex Mode. Repeated signal heard in real-time on Frequency B (Band 2).

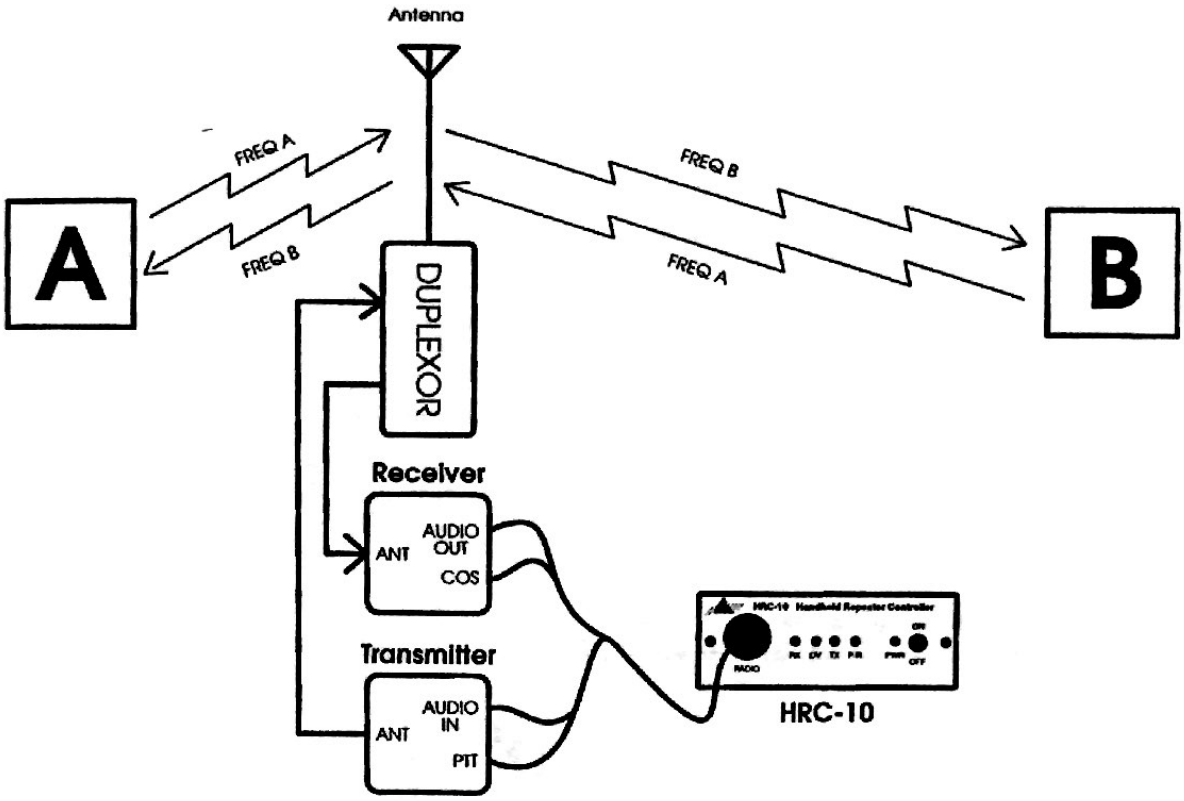


Figure 3 - Single Band Duplex Operation

Station A & B transmit on input (frequency A) and receive on output (frequencyB). Repeated signal heard in real-time on Frequency B.

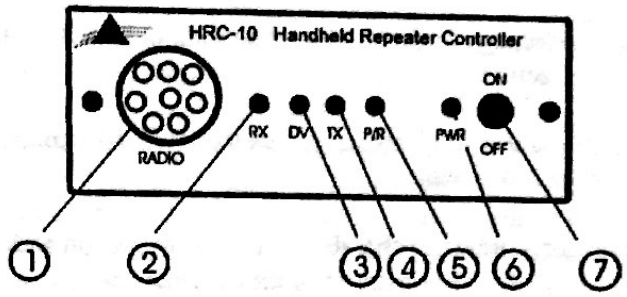
The HRC-10 was designed to provide control for any of the above modes leaving the choice to the operator and allowing the system configuration to be changed at any time. Handheld radios can be interfaced to the HRC-10 using just the microphone and speaker jacks. Mobile radios can be interfaced using the optional PTT output from the HRC-10 to key the radio. As a third option, a repeater system consisting of a separate receiver and transmitter can be interfaced to the HRC-10 using the optional COS input and PTT output from the HRC-10.

The user needs to take these issues into account and also consider the hardware required and associated costs when choosing which mode to use. The flexibility of the HRC-10 allows the mode to be easily changed. Some transceivers will even allow the unit to be changed from one mode to the other over the air.

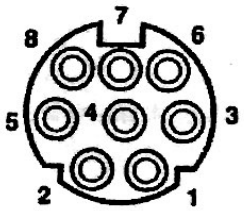
NOTE: *When setting up a simplex or duplex repeater, choose the repeater frequencies carefully. Check with your local spectrum allocation committee before placing such a system on the air to ensure that it will not interfere with other systems. In many areas the spectrum is quite crowded and this selection may have to be made carefully. Since the simplex repeat mode is a relatively new concept, acceptance of this mode will depend on the utility it provides for local operators and interference with other services should be avoided. Check FCC Part 97 for all applicable rules and regulations.*

III. Front Panel Connector, Indicators, and Controls

The front panel of the HRC-10 has a connector to interface the unit to the radio, LED's to monitor system status, and a power switch. A view of the front panel of the HRC-10 and description of each item is provided below:



① - "Radio" Connector - 8 pin mini DIN type connector for interfacing signals to and from the radio and to provide external power to the HRC-10. A pictorial showing the connector pin-out is provided below:



A cable is supplied with the unit which must be terminated with the proper connectors to interface to the radio. The electrical functions of each pin and the corresponding wire color of the supplied cable are as follows:

Connector	Cable Wire Color
Pin 1 - Audio Input	Brown
Pin 2 - Optional COS Input	Red
Pin 3 - Audio Output	Orange
Pin 4 - Optional PTT Output	Yellow
Pin 5 - Control Output Line	Green
Pin 6 - No Connection	Blue
Pin 7 - External DC Input	Violet
Pin 8 - Power Ground	Black
Case - Signal Ground	Uninsulated (Shield)

⓬ - RX - "Receive" indicator - indicates that a signal is being received on the transceiver connected to the HRC-10. The LED will indicate either the status of the Digital Voice Operated Squelch (DVOS™) circuit (audio activated) or the COS input (logic level activated) depending on how the unit's internal jumper is configured.

⓭ - DV indicator - "Data Valid" indicator - indicates a valid DTMF tone is being received and decoded by the HRC-10.

⓮ - PTT - "Push to Talk" indicator - indicates that the HRC-10 is in the transmit mode and the PTT line to the transceiver is active.

⓯ - P/R - "Playback/Record" indicator - indicates that the HRC-10's speech recorder chip is in either the playback or record mode.

⓰ - PWR - "Power" indicator - indicates that the HRC-10 power is on and that the battery condition is ok. Will flash intermittently or remain out if the internal battery is low.

⓱ - On/Off switch - turns power to the unit on or off.

IV. Installation

The HRC-10 has been designed to be easily interfaced to most radios using only the speaker and microphone connectors. The unit comes factory configured to operate in simplex repeat mode using speaker audio and microphone line keying which allows interfacing to most handheld radios. Mobile radios and standard repeater receivers and transmitters will require using the optional PTT (Push to Talk) and/or COS (Carrier Operated Squelch) signals. If your particular system requires these signals refer to the *"Hardware Configuration Options"* section of this manual for details on how to configure the HRC-10 before proceeding.

The audio input to the HRC-10 is internally terminated by an 8 ohm resistor to provide a load for the radio's output amplifier. The unit accepts a nominal 1 volt pk-pk signal. The audio input can also be configured to provide a high-impedance load so it may be driven from a line level audio source such as a repeater receiver. In either case the input gain is fixed. Setting the proper level is accomplished by transmitting DTMF tones to the unit from another radio and adjusting the receiver audio gain while observing the "DV" LED on the unit to ensure that all tones are being decoded.

The audio output level is factory adjusted to provide a nominal 50mV microphone level output. If the output level sounds distorted or is too low once the input has been properly adjusted, the "Output Level" potentiometer will need to be adjusted. See the *"Hardware Configuration Options"* section of this manual for details on configuring and adjusting the audio section should this be necessary.

The following steps should be performed to interface the HRC-10 to the radio:

1. Hardware Connections

a. Attach the proper connectors for the particular radio that will be interfaced to the unit to the supplied cable. See Appendix B and C for details on radio interfacing and connection diagrams for popular handheld and mobile radios. **Be sure to insulate any unused wires with heatshrink or electrical tape to prevent them from shorting together.**

b. Remove the rear battery compartment panel of the HRC-10 and install a 9V battery. A standard or rechargeable type battery can be used. If a rechargeable battery is used the unit can be configured to provide a charging current for the cell when powered from an external DC source. See *the "Hardware Configuration Options"* section of this manual to change this. **NEVER try to recharge a standard battery as damage to the battery and/or HRC-10 may result!!!**

c. Turn on the unit to verify that the battery is OK. The HRC-10 has a battery power detect circuit which drives the front panel "PWR" LED. If this LED fails to light or flashes intermittently during operation, replace the battery or power the unit via the radio interface cable. When the unit is configured for standard 9V batteries, the internal battery is bypassed while the unit is powered from the radio interface cable.

d. Turn on the radio and connect the speaker audio input connector and microphone audio output connector of the interface cable to the radio. Plug the other end of the cable into the HRC-10.

2. Audio Level Adjustment

a. Set the radio up for simplex operation on the desired frequency. Set the volume control to about one-half of maximum level. This will be the optimum input level for most handheld radios. For mobile radios, the optimum level will be from one-quarter to one-half of the maximum volume setting.

b. Using another radio tuned to the same frequency as the one connected to the HRC-10, transmit a signal to the unit. The front panel RX LED should light almost immediately. Upon unkeying the radio there will be a short delay before the LED goes off. After the radio is unkeyed the HRC-10 should re-transmit the received signal after a 2 second delay. This is indicated by the PTT LED and P/R LED being lit. The repeated audio and courtesy tone followed by the factory set "ID greeting" should be heard on the test radio. The HRC-10 contains a Digital Voice Operated Squelch (DVOS™) circuit which detects the audio from the radio even with no voice modulation present. The volume of the radio needs to be set to a sufficiently high level so as to reduce the turn on delay of the RX LED. If the separate COS signal is being used there will be no turn on and turn off delay of the RX LED. See the *"Hardware Configuration Options"* section of this manual for more details.

c. Transmit on the test radio and press a couple of the DTMF keys on the radio. After unkeying the radio, the HRC-10 will not re-transmit the received signal but will send two short tones to indicate that DTMF tones have been detected. A short, low tone will then follow to indicate that an invalid access code was entered. The DV LED should light for each key being pressed. If the level of the radio is either too high or too low, detection of tones may not work properly. To determine the proper level, depress a DTMF key while transmitting and raise the receiver volume up and down while observing the "DV" LED to determine over what range the tone is detected. Then set the radio to the midpoint of this range and test each tone once again to make sure it is being detected.

The HRC-10 is now ready for operation as a simplex repeater system. The next section of the manual gives a detailed overview of the operational features of the controller. The unit also has many DTMF control and programming commands that are covered in detail in sections VI and VII of this manual. You should now take the time to read these sections to familiarize yourself with these details before proceeding. One of the first operations you will wish to perform is to record an ID message in place of the factory set "ID greeting" you just heard. You may also want to configure the unit for duplex operation and change the timer values to suit your needs. Finally, once you are familiar with how to use the DTMF commands, the access codes can be changed to provide secure access to the control codes of the controller.

V. Basic Controller Operation

The HRC-10 contains a microprocessor which is programmed to provide many unique features to enhance both the simplex and duplex mode of operation. The following is a description of the HRC-10 features and details on each operational mode. For details on controlling and programming the individual features refer to the next two sections of this manual.

Voice IDer

The HRC-10 Voice IDer provides a natural sounding ID message for the system in the owner's own voice. The ID message can be recorded at any time and can be up to 6 seconds in length. The ID message is stored in the internal speech recorder IC and is non-volatile.

The IDer can be set for two modes of operation: "active channel ID" or "continuous ID" mode. In the "active channel ID" mode the unit will ID after the first received transmission and will then repeat at the ID timer interval provided there is activity on the channel. If no activity is detected between two subsequent ID periods, the ID will be suspended until there is again activity on the channel. In the "continuous ID mode" the unit will ID after the first received transmission and will then repeat indefinitely at the ID interval. The IDer will always wait for a transmitting station to complete its transmission before the ID message is sent.

The ID message is recorded by entering a DTMF access code for the "Program ID Message" function and then unkeying the radio. Once the controller responds with a "DTMF Acknowledge" tone, the next transmission will then be recorded in the HRC-10's ID message slot. As soon as the radio is unkeyed the ID message will play back for review. The ID message can also be played at any time by entering the "Play ID Message" DTMF control code.

Telemetry Tones

The HRC-10 sends telemetry tones during certain conditions to provide feedback to the user. The tones are made up of a combination of high, medium, and low frequency tones. The telemetry tones are as follows:

Courtesy tone - a single 250 Hz tone is sent at the end of a repeated transmission.

"DTMF Acknowledge" tone - two short 250 Hz tones are sent to acknowledge that DTMF tones have been detected.

"DTMF Command Error" tone - a single 100 Hz tone after a "DTMF Acknowledge" tone indicates an invalid access code was entered.

"New Mail" tone - a single 500 Hz tone is sent to indicate that a voice mail message has been programmed. The tone is also appended to the end of the courtesy beep to indicate to the user that new mail is present. This tone will be sent after the "record voice mail" command if attempting to write over the mail message before it has been listened to.

Telemetry Tones (cont.)

"Memory Program" tone - two short 500 Hz tones are sent after the unit receives the "Program Memory" access code to verify that the memory program mode has been activated.

"Memory Write" tone - a 500 Hz and 100 Hz tone are sent in succession to indicate that a memory location has been successfully changed.

"Memory Program Error" tone - a single 100 Hz tone at any time during a memory program operation indicates that an improper entry or programming sequence error was made.

Simplex Repeat Mode

In the simplex repeat mode the HRC-10 will record an incoming signal in the internal speech recorder IC. After the transmitting station unkeys, the HRC-10 will re-transmit the received signal. A courtesy tone is added to the end of the repeated transmission to indicate that the signal has been repeated and is not being heard direct. If DTMF tones are received, the transmission will not be repeated. The internal speech memory of the HRC-10 is limited to one minute total. The length of the simplex repeat function can be set to approximately 30, 45, or 60 seconds. The actual length of the message are these values minus the ID slot time. The rest of the speech memory is available for use by the private voice mail slot function. Fig 4 below shows the signal timing of the simplex repeat mode with factory default timer settings.

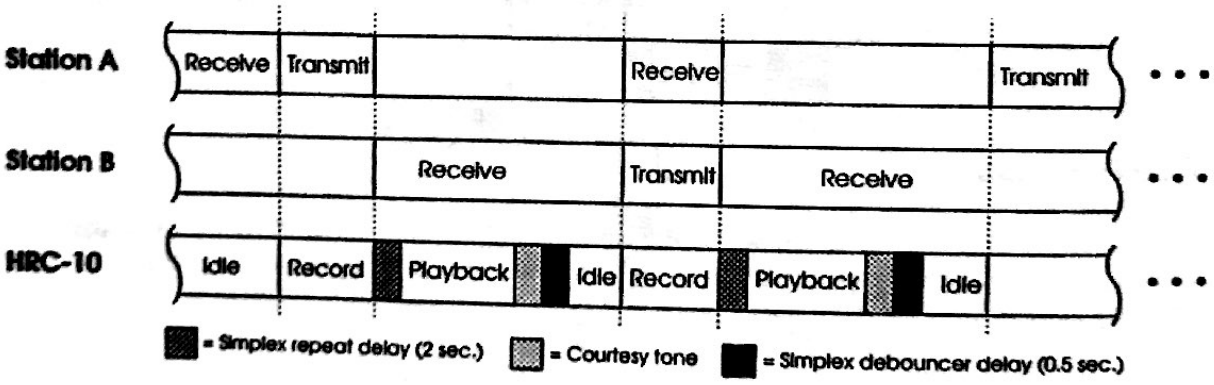


Figure 4- Simplex Repeat Diagram

Note that the diagram shows ideal timing. If a signal is received during the simplex repeat delay period the HRC-10 will not playback the recorded signal. If a signal is received during the simplex debouncer delay period it will not be recorded until the end of this delay period.

After the message is recorded the controller will wait for this delay period before repeating the received signal. If another signal is received during this period, the HRC-10 will automatically cancel the repeat of the last message received. This allows a simplex station to respond directly to the calling station if in range. The simplex repeat delay is factory set for 2 seconds but can be changed if desired.

Duplex Repeat Mode

In the duplex repeat mode the HRC-10 re-transmits the received signal as it is being received. As in the simplex mode, a courtesy tone is added to the end of each repeated transmission. If DTMF tones are received, the repeat audio will be muted. The HRC-10 also provides a PTT "hang" timer and repeater "time out" timer in this mode. After the courtesy tone is sent the repeater PTT will remain active until the hang timer expires. The time-out timer limits the length of the repeater transmission and is reset as soon as the transmitting station unkeys. A warning tone is sent before the repeater drops the PTT line to alert other users that the repeater has been timed out. The hang timer and time out timer are factory set to 4 seconds and 3 minutes respectively but can be changed if desired.

Receive Debounce Timer

The HRC-10 includes a software receive debounce timer that can be used in either the simplex or duplex repeat modes. This feature adds a delay after the PTT line is dropped which prevents the receive signal from activating the controller until the timer has expired. In the simplex mode this delays the recording of the received signal, while in the duplex mode it delays the PTT signal to the transmitter. The receive debounce timer allows the controller to be used with radios that emit a squelch burst after the PTT line is dropped which can cause intermittent or repeated keying of the transmitter. The receive debounce timer is factory set to 1.0 seconds but can be set for any time from 0 to 2.0 seconds.

Private Mail Slot

The HRC-10 can save a single voice mail message which can be retrieved at any time using a DTMF command. The message length is limited to either 15 or 30 seconds depending on the "voice mail configuration" mode setting. The message length can also be set to 0 seconds which will allocate all the speech storage time to the simplex repeat feature. In this case the voice mail slot DTMF commands will not be available to the user.

A mail message is recorded by entering the "Record Voice Mail" command. Once the controller responds with a "DTMF Acknowledge" tone, the next transmission will be recorded in the private voice mail slot. While recording the message, the controller will either unkey if in the simplex repeat mode, or stay in transmit if in the duplex repeat mode. The controller will then respond with a "new mail" tone to indicate that the message has been recorded. This tone will also be appended to the end of the courtesy tone to indicate to the user that a new voice mail message is present. The message can then be played by entering the "play voice mail" DTMF command. Once the message is played, it can be saved to prevent another message from being written over it by entering the "Save Voice Mail" DTMF command. If the slot is full it will not allow another message to be recorded until the stored message has been played at least once.

External Output Control Line

The HRC-10 has an external output control line that can be interfaced to external devices. The line can be set either high or low by executing the appropriate DTMF command. Possible uses for the control line include control of radio functions, antenna switching, or to enable or disable an external CTCSS decoder.

The control line output is an active-low 5 volt CMOS/TTL compatible signal and can be directly connected to devices that accept these voltage levels. For other types of devices the output can drive an external relay circuit as shown in Figure 6 of Appendix C.

VI. DTMF Control of the HRC-10

The HRC-10 can be remotely controlled using a simple DTMF command interface. When DTMF tones are entered over the air and the radio is unkeyed, the controller will respond by sending a "DTMF Acknowledge" tone. Then the DTMF entry is checked against a list of access codes. If a match is found, the corresponding function will be executed. Otherwise the "DTMF Command Error" tone will be sent. All access codes for the controller are pre-set to the factory default values listed below but can be changed to any 1-4 digit access code (see the *"Programming the HRC-10"* section for details). Control functions can be executed any time the controller is in normal operation.

DTMF Control Functions:

Access Code:	10
Function:	Record ID message
Description:	Records a new ID message in the ID message slot.
Access Code:	11
Function:	Play ID message
Description:	Plays the controller ID voice message. The ID timer will be reset upon execution of this command.
Access Code:	20
Function:	Disable repeater
Description:	Disables the repeat function. No signal will be re-transmitted in simplex or duplex mode. All DTMF commands will still be recognized but the controller will only send the "DTMF Acknowledge" tone in response to valid access codes. If the IDer is set to the "Continuous ID" mode the controller will continue to ID.
Access Code:	21
Function:	Enable repeater
Description:	Enables the repeat function when used after executing the "Disable Repeater" control function.
Access Code:	30
Function:	Record voice mail
Description:	Allows the user to record a message in the mailbox slot. Controller will respond with a "New Mail" tone to acknowledge that the message was recorded.

DTMF Control Functions (cont.):

Access Code: 31
Function: Play voice mail
Description: Plays the last message recorded in the private voice mail slot. The "New Mail" tone will be removed from the end of the courtesy tone once the message has been played.

Access Code: 32
Function: Save voice mail
Description: Saves the last voice mail message entered in the private voice mail slot. The "New Mail" tone will be added to the end of the courtesy tone once the message is saved.

Access Code: 40
Function: Output control line off
Description: Turns off the output control line. The active-low control line output is set to a "1" logic level (~5 volts DC)

Access Code: 41
Function: Output control line on
Description: Turns on the output control line. The active-low control line output is set to a "0" logic level (~0 volts DC)

VII. Programming the HRC-10

The HRC-10 can be remotely programmed by the owner at any time over the air. Operating parameters are stored in a non-volatile electrically erasable memory IC EEPROM in the HRC-10. These parameters can be modified at any time to custom configure the controller for specific applications. Parameters that can be modified include the timer settings, operating mode of the controller (simplex/duplex), IDer mode (active/continuous), and mail slot configuration (record time). In addition, the access codes for the DTMF functions of the controller can be reprogrammed to any 1-4 digit code consisting of a combination of DTMF numbers and characters except for the "#" character, which is reserved for use as a delimiter when entering address and data parameters.

In order to program the controller's memory locations, a special "Program Memory" access code must first be entered. This code is unique to each HRC-10 thereby limiting programming of the memory locations to the owner and control operator. The access code is factory set to 1234 but may be changed by the user to any 1 through 4 digit code by programming the "Program Memory" access code location (see table of memory locations). Programming the controller's memory permanently changes the current operating parameters of the controller so a record of these changes should be made. A worksheet is provided at the end of this manual which should be updated whenever a change is made. In the event that a certain parameter is forgotten or the controller does not operate properly due to a changed parameter, the memory contents may be reset to the factory default values by performing a "hardware reset" operation. This will reset all memory locations listed in the table to their original default values. A hardware reset is performed by cycling the power switch off and on as follows:

- Turn on the power switch and wait a few seconds.
- Turn the unit off and on again three times, waiting 1 second after turning the unit on before turning it off again. After the third time, leave the unit on.

  Note: During the power on cycle the P/R LED will flash momentarily while it is checking the number of cycles.
- The HRC-10 will reset itself approximately one second after the third cycle. The PTT LED will light and the controller will transmit a "Memory Write" acknowledge tone to indicate that the reset has been performed.

In addition, three DTMF functions are provided for to allow certain parameters to be reset over the air. The "Reset Timer Values" command resets only the timers listed in table 1 and the "Reset DTMF Access Codes" command resets the DTMF function across codes (NOT the program memory access code which is only affected by a hardware reset). A "Software Reset" performs a reboot of the controller program and does not affect any memory locations. All three of these codes are executed by first entering the "Program Memory" access code and then entering the appropriate reset code.

Memory Programming Functions:

Access Code: 1234 (default)
Function: Program Memory
Description: Enters the memory programming mode. The controller will prompt the user for the memory location and data after this code is entered. See the table on the next page for memory location assignments and data parameters.

Access Code: 100 *(can only be entered after "Program Memory" Location access code)*
Function: Reset Timer Values
Description: Resets all timers to their factory default values. The controller will respond with a "Memory Write" tone after the operation is completed.

Access Code: 200 *(can only be entered after "Program Memory" Location access code)*
Function: Reset DTMF Access Codes
Description: Resets all DTMF access codes to their factory default values. The controller will respond with a "Memory Write" tone after the operation is completed.

Access Code: 400
Function: Software Reset
Description: Performs a software reset of the controller program. This is the equivalent of a power-on reset. The controller will respond with 3 "DTMF Acknowledge" tones before resetting itself.

The controller memory locations, parameters, data format, and corresponding default values are as follows:

Timer and Mode Settings:

Location	Parameter	Data Format	Default Value
00	Simplex Repeat Delay	0.1 second increments	20 (2 seconds)
01	ID Timer Interval	1.0 second increments	540 (9 minutes)
02	Duplex Mode Hang Time	0.1 second increments	40 (4 seconds)
03	Time-out Timer	1.0 second increments	180 (3 minutes)
04	Receive Debounce Timer	0.1 second increments	10 (1 second)
10	Repeat Mode	(0=simplex, 1=duplex)	0
11	IDer Mode	(0=active channel, 1=continuous)	0
12	Voice Mail Configuration	(0=none, 1=15 secs, 2=30 secs)	1

DTMF Access Codes:

Location	DTMF Control Function	Default Access Code
20	"Record ID Message" Function Access Code	10
21	"Play ID Message" Function Access Code	11
22	"Disable Repeater" Function Access Code	20
23	"Enable Repeater" Function Access Code	21
24	"Record Voice Mail" Function Access Code	30
25	"Play Voice Mail" Function Access Code	31
26	"Save Voice Mail" Function Access Code	32
27	"Control Output Off" Function Access Code	40
28	"Control Output On" Function Access Code	41
40	"Program Memory" Access Code	1234

The procedure for programming a memory location is as follows:

1. Enter the "Program Memory" access code and unkey the radio. The controller will respond with a "DTMF Acknowledge" tone followed by a "Memory Program" acknowledge tone.

2. Enter the number of the memory location that you wish to program, a "#" character, and the value that you wish to program into the memory slot. After unkeying the radio the controller will respond with a "Memory Write" acknowledge tone.

Programming of the memory location is now complete. Be sure to test the particular parameter that you have changed before proceeding. If no memory address or data is entered during the memory programming operation, the controller will respond with a "DTMF Error" Tone and abort the process. When programming the memory locations with the simplex repeat debouncer set to values other than 0, be sure to wait for the "Memory Program" tone before proceeding.

Programming Examples:

Program simplex repeat delay to 2.5 seconds:

- Enter "Program Memory" code, unkey the radio and wait for the "Memory Program" acknowledge tone.
- Enter "0#25", unkey the radio, and wait for the "Memory Write" acknowledge tone.

Program "Play ID Message" DTMF code to "*5":

- Enter "Program Memory" code, unkey the radio and wait for the "Memory Program" acknowledge tone.
- Enter "21#*5", unkey the radio, and wait for the "Memory Write" acknowledge tone.

Programming Hints

- Before programming the controller make sure that the signal into the controller is full quieting and that the "DV" LED lights for each tone depressed on the radio keypad.

- Always wait for the "Memory Program" acknowledge tone before proceeding. This may be delayed by the amount of the simplex repeat debouncer delay.

- Do not try to rapidly program memory locations. Keep track of any parameter that you are changing since careless programming may result in improper operation of the controller.

- Make sure that the required parameter has been programmed correctly before changing anything else. If the programmed parameter has not changed, try the operation again.

- If the "RX" LED flashes between entries (due to noise on channel or other stations keying up) the controller will respond with a DTMF error. It may help to advance the squelch control or change frequencies and try again.

- If the controller has been left in duplex mode and it is connected to a simplex radio it will immediately key the radio upon receipt of a signal preventing communication and programming of the controller. If this happens, remove the microphone and/or PTT connection to the radio. Then enter the "Program Memory" code. Once the PTT light goes out enter "10#0" (the address and data necessary to set the controller in simplex mode) and unkey. Verify that the controller is now in simplex mode (P/R should light on receipt of signals). Reconnect the microphone and/or PTT line to operate in simplex repeat mode.

- If at any time during or after programming a parameter the controller behaves improperly, cycle the power off and on and enter the "Reset Timer Values" command. A "Software Reset" command may also need to be entered first if programming the controller remotely. If either of these fails to restore the controller to normal operation, a "Hardware Reset" should be performed.

- If a DTMF access code is not recognized try and reprogram it again. Remember that the voice mail commands will not work if the mail slot length is set to 0. Also, a "#" character cannot be used in an access code. If DTMF access codes are still not recognized, try the "Reset DTMF Access Codes" command.

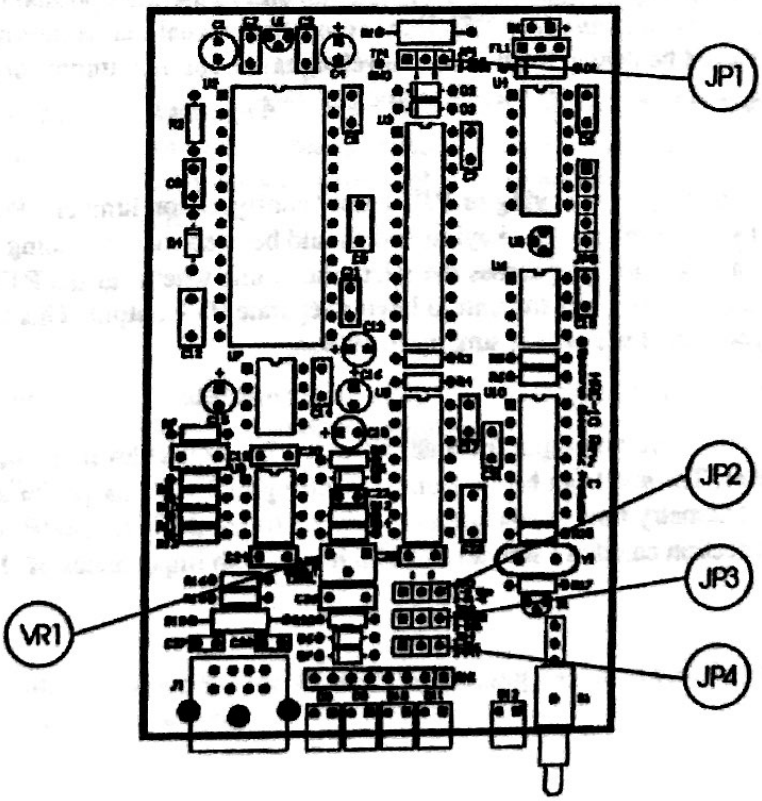
VIII - Hardware Configuration Options

The HRC-10 hardware interface circuitry has been designed to accommodate a variety of radios from handhelds and mobiles to separate receivers and transmitters with a minimum of adjustments required. In order to use the COS and PTT hardware interface options or to adjust the audio output level the unit will need to be opened as follows:

NOTE: *The HRC-10 contains static sensitive CMOS components. Whenever handling the PC board and interfacing external devices to the unit observe standard precautions for handling static sensitive devices!!!*

1. Remove the rear battery compartment cover and battery.
2. Remove the two screws located at either side of the battery compartment and remove the battery compartment.
3. Push the "ON/OFF" switch into the front panel to release the PC board and slide the PC board out of the box.

A pictorial of the PC board showing the location of components, configuration jumpers, and the audio level potentiometer is shown below:



The function of each of the configuration jumpers and output level potentiometer is as follows:

JP1 - "STD/RCHG" - Battery type configuration jumper - Position 1 configures the unit for a standard battery. Position 2 configures the unit for a NiCd rechargeable battery. When in this position the unit will provide approximately 12ma of charging current via the external DC input. The battery is charged regardless of the ON/OFF switch position. Since a simple current limit resistor charging scheme is used, the charge current to the battery is dependent on the input voltage and ranges from 8ma to 20ma for a 10-14 volt input. This scheme typically provides a full charge in 4 -12 hours and most batteries can be left in the charge mode indefinitely. **Check the charging specifications on each battery before use.**

JP2 - "8 ohm/Hi-Z" - Audio input impedance configuration jumper - Position 1 configures the input impedance for 8 ohms and should be used when driving the unit from a radio's speaker output. Position 2 configures the unit for a high impedance input and should be used when driving the unit from a line level audio source. The input impedance is approximately 2.7k ohms with the unit configured for DVOS™ operation. When the unit is configured for COS operation, the input impedance will be approximately 20k ohms.. The input level measured at the input terminals in either case should be approximately 1 volt pk-pk to ensure the proper audio level to the speech recorder and DTMF decoder circuits.

JP3 - "DVOS™/COS" - Digital Voice Operated Squelch (DVOS™) or COS configuration jumper - Position 1 configures the unit to use the output of the DVOS™ circuit as the received signal indicator. Position 2 configures the unit to use the optional COS input line input. This line is an active-low TTL level compatible signal that is internally pulled high. The input should be driven from a logic level signal (5 volt maximum) or can be pulled low using a relay contact or open collector type interface.

JP4- "MIC/PTT" - Microphone keying or PTT output configuration jumper - Position 1 configures the unit to use microphone line keying and should be used for interfacing to handheld radios. This places a 2.2k ohm load across the microphone line whenever the PTT is active to key the radio. Position 2 configures the unit to have a separate PTT output. This is an active-low open collector type output which can sink up to 100ma.

VR1 - "Output Level" - Audio output level adjustment - The output level can be adjusted using this potentiometer. The level can be set from ~0 volts up to 2 volts pk-pk for a 1 volt pk-pk input signal. The telemetry tone levels are internally set to 1/2 the level (-6dB) of the input signal. The output section can drive line level audio inputs with impedances of 10k ohms or greater.

IX. In Case of Trouble

The following are some common problems that may occur due to improper settings and/or external equipment problems:

Symptom	Possible Cause	Remedy
Intermittent or delayed key up (DVOS™ mode).	Audio input level too low.	Increase audio input level to unit. Verify that level is 1v pk-pk with scope, if possible.
Audio Distorted.	Input and/or output level set too high.	Re-adjust DTMF tone detect to mid-range and adjust output level. Monitor input and output with scope to ensure proper input level to unit and radio, if possible.
Repeat audio level low.	Output level set too low.	Adjust output level potentiometer. Monitor output of unit with scope to ensure proper level to ra dio, if possible.
All or some DTMF tones not decoding properly.	Input level set too low or high. Receiver audio frequency response not flat.	Adjust DTMF level to mid-range on receiver volume knob. Check receiver audio output response if possible, and add pre-emphasis or de-emphasis to flatten response, if necessary.
Repeater keys up repeatedly with no input when in simplex repeat mode (DVOS™ mode only).	Audio burst from radio keying DVOS™ circuit (LED will flash).	Increase simplex debouncer time.

If you still have problems with operation of the unit that can not remedied you may contact Spectrum Electronic Products for technical support.

Appendix A - About the ISD-2560 Speech Recorder Chip

The HRC-10 is designed around the ISD-2560 IC from Information Storage Devices (ISD) which uses an innovative new technology for speech record and playback. Direct Analog Storage Technology (DAST™) is used to store analog voltages in an EEPROM array which provides a full minute of high-quality audio record and playback in a single IC. The HRC-10 controller couples the ISD-2560 with a powerful single-chip microcontroller to provide the most compact and powerful repeater controller of its kind.

Like any EEPROM device, the ISD-2560 does have a limited number of write cycles which is specified by ISD to be on the order of 100,000 before any noticeable degradation of audio occurs. The useful life of the chip in the HRC-10 should exceed 5 to 10 years and has been calculated as follows:

1. The WORST CASE LIFETIME is calculated by assuming the unit records and playback signals at a 50% duty cycle (1 minute on/1 minute off) which corresponds to 30 cycles/hour x 24 hours/day = 720 cycles/day. The WORST CASE lifetime would then be 100,000/720=138 days.

2. The PRACTICAL LIFETIME is found by dividing the WORST CASE lifetime by a correction factor since in normal use one expects a much lower duty cycle. If one assumes that the repeater is used 12 hours out of the day at 10% of the WORST CASE duty cycle (i.e. 72 record and playback cycles/day) then this would correspond to 5% of the worst case figure. The chip lifetime would then be 138/.05 =2760 days or approximately 7.5 years.

At this point the audio quality would begin to degrade since failure of the storage cells will occur in a random fashion resulting in a noisy output. The chip could then be replaced once the audio quality has degraded to an unacceptable level. The above worst case analysis only applies to a write cycle (i.e. simplex repeat or voice mail); read cycles are unlimited. The non-volatile storage of data in the part has been specified by ISD to be in excess of 100 years.

Appendix B - Radio Interfacing Notes

This appendix contains information on interfacing the HRC-10 to a variety of radios. Also included are hints and circuits to help interface the unit to non-standard signals and for avoiding and curing problems associated with ground loop noise.

Non-Standard Radio Signal Interfacing

The HRC-10 has been designed to be interfaced to any radio however, in some cases, the radio may require different interface levels for COS or PTT lines. Incompatibilities may require that the logic polarity of a signal be inverted or the voltage level may need to be converted to meet the controller's specification.

The COS input to the HRC-10 requires an active-low TTL level signal, open collector input, or contact closure. Methods of inverting this signal or converting a higher or non-standard voltage level input are shown in figures 1-4 of Appendix C.

The PTT output is an active-low open collector output. Methods of inverting this signal or interfacing it to a relay to provide higher current capabilities are shown in figures 5-6 of Appendix C.

Dual-Band Full Duplex Mode Connections

On many handheld and some mobile radios it may be necessary to remove the 8 ohm termination (JP2) to obtain proper DTMF muting in full duplex mode. Configuring the unit for a high-impedance input prevents coupling the speaker audio into the microphone input and provides full DTMF muting.

Power Supply Distribution and Grounding

When powering the HRC-10 from an external power supply good power distribution and grounding practices should be followed to eliminate potential ground loop problems. In order to facilitate this, the HRC-10 has two grounds that are available on the cable: signal ground and power ground. The signal ground should always be connected to the MICROPHONE or SPEAKER return on the radio. It may also be used as a DC return in some cases with no problems. Due to the differences in individual radio internal power distribution and grounding schemes, situations may exist where ground loop noise becomes a problem. This is mostly the case where a low level microphone input is used. Due to sensitivity of these inputs even a few millivolts of ground loop induced voltage may have an effect on the audio, producing a buzzing or humming sound. If the ground loop induces even larger voltage differences, erratic operation of the controller may occur. The primary cause of the problem is that the radio case ground is used for both signal and power. This makes it impossible to run all grounds to one common point such as in a "star" configuration. In many cases ground loop problems can be difficult to track down and cure. Since each system will have its own unique interconnections it is hard to provide a universal solution to these problems. Testing was done with a variety of radios and the following is a list of possible solutions should you experience any problems:

1) Try using only the power ground as the return (disconnect signal ground). If the radio includes a separate low-level signal ground (or microphone"-" input) connect the signal ground to this. If the situation gets worse try connecting both the power and signal ground.

2) If the system is AC powered, use a separate power supply for the radio and controller. An ideal power supply is a small DC wall supply (6-15 volts DC ONLY). Connect the power supply ground to the controller power ground ONLY. In many cases this will isolate the noise by providing a separate isolated return path other than the radio ground.

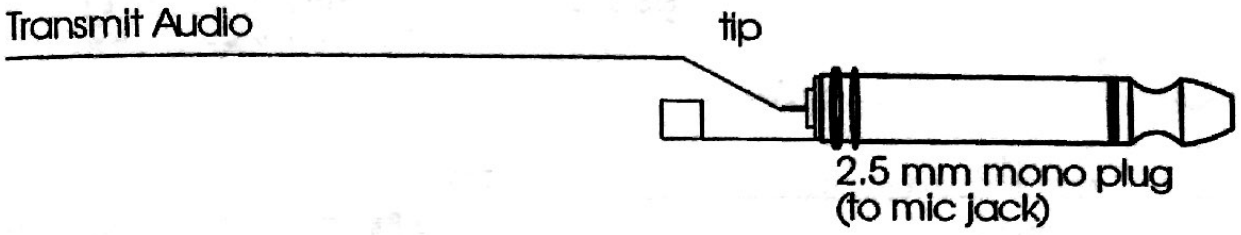
3) If the system is DC powered, use a common-mode filter before the HRC-10 power in and power ground leads as shown in figure 7 of Appendix C. This filter effectively isolates the power leads and prevents any AC ground currents from flowing at frequencies above a few hertz which should eliminate AC ground loops. Separate chokes can be used but best results will be obtained by using a common-mode choke of the type used in switch-mode power supplies. These can be obtained from many electronic distributors or contact Spectrum Electronic Products for more information.

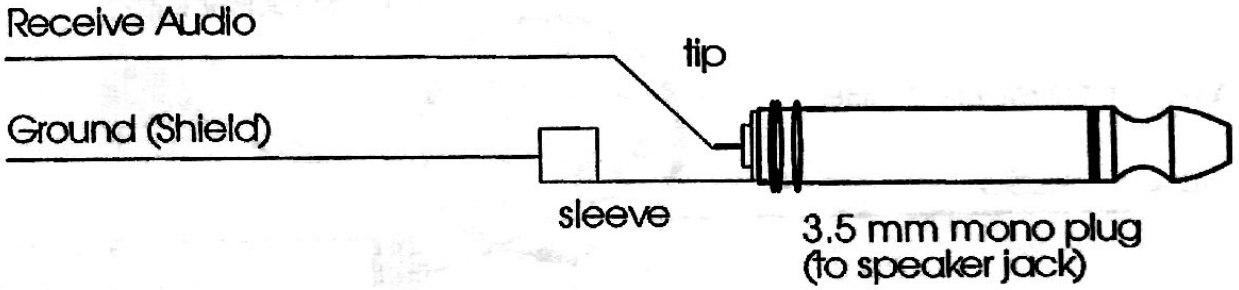
4) Use a line level input to the radio if possible. Since ground noise from the controller may be in the 2-5mV range this will effectively increase the audio signal-to-noise ratio to the point where the noise is inaudible.

Appendix C- Radio Wiring Diagrams, Interface Circuits and Schematic Diagram

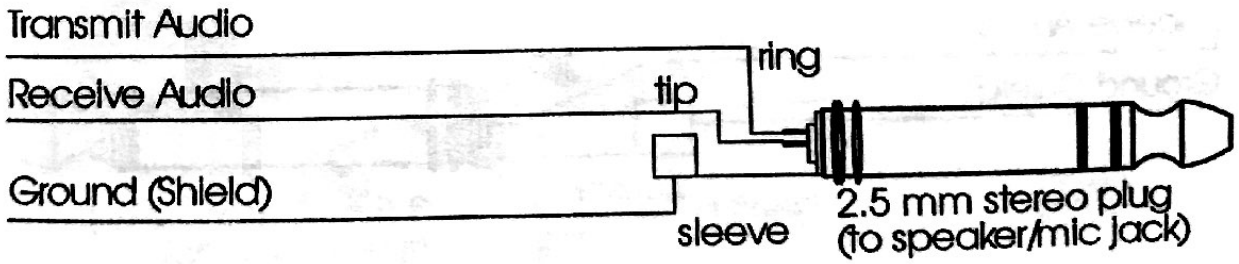
Handheld Radios

ICOM 2AT, 3AT, 4AT, H16, and U16 Style Handheld Radios *(and some newer models)*

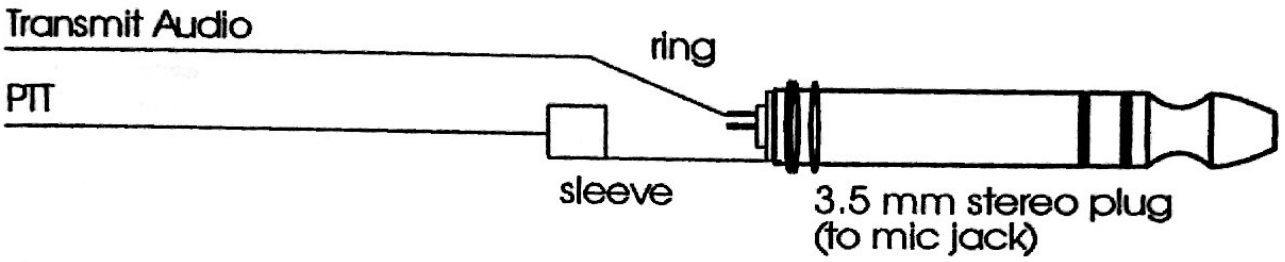


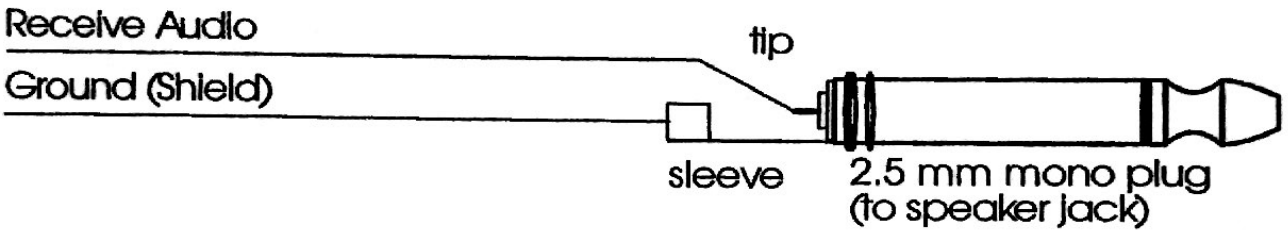


ICOM W2A Style Handheld Radio *(and some newer models)*

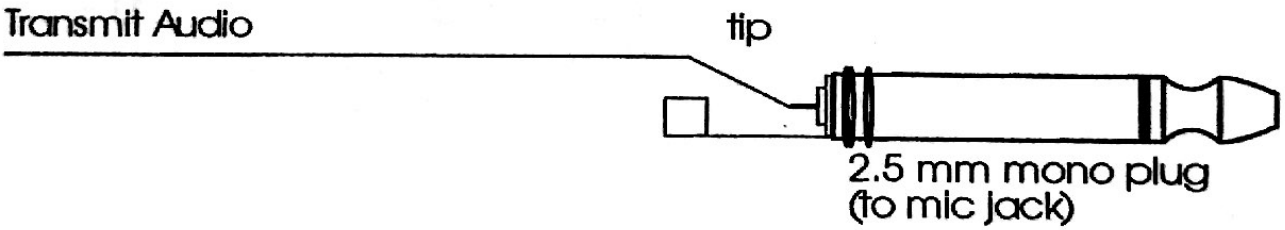


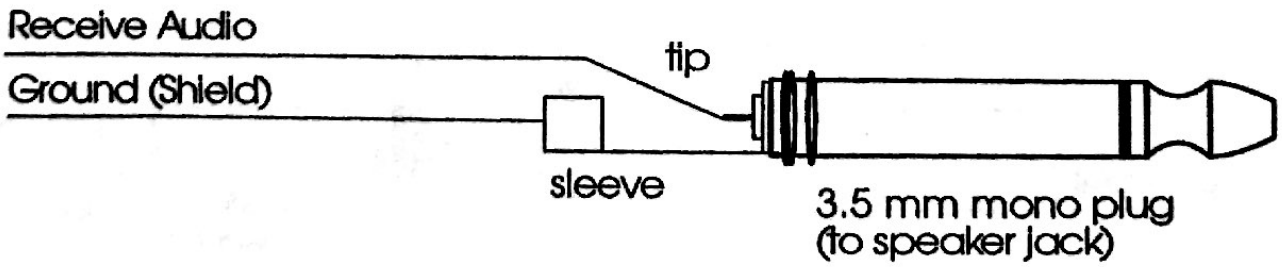
Kenwood 2600 Handheld Radio *(and some newer models)*





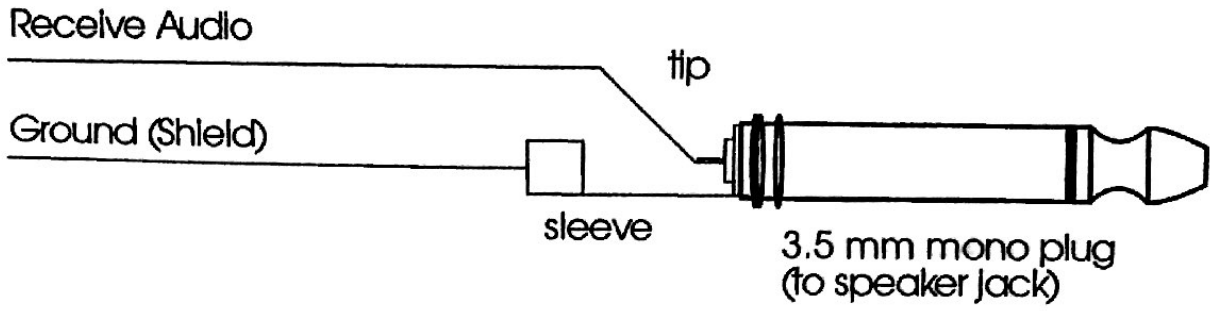
Yaesu FT-727 Handheld Radio



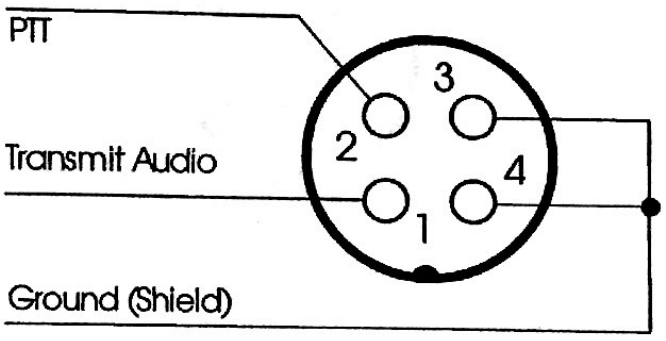


Mobile Radios

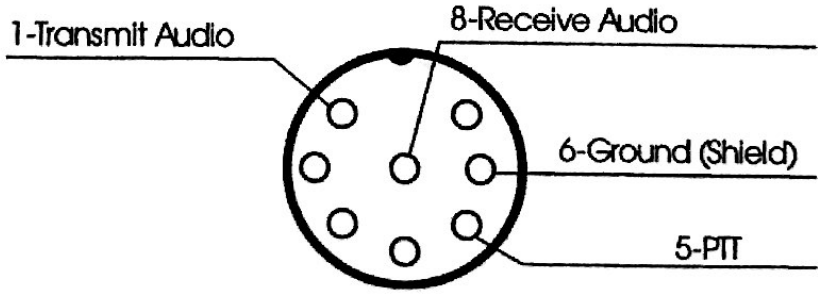
Connection for Receive Audio from Mobile Radio Speaker Jack
(if not provided at microphone connector)



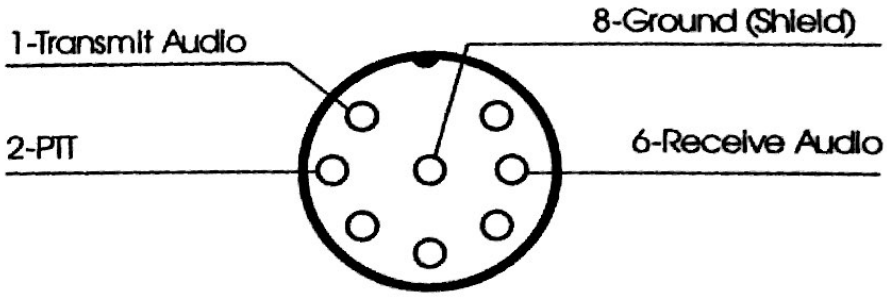
4 Pin Microphone Connector *(Older Model Radios)*



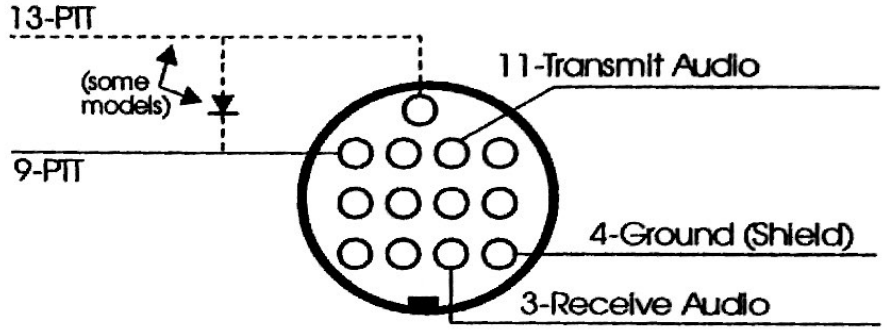
Icom 8-pin Microphone Connector



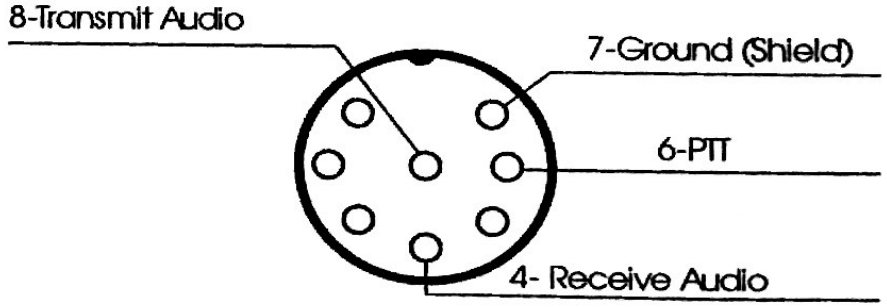
Kenwood 8-pin Microphone Connector



Kenwood 13-pin DIN Connector



Yaesu 8-pin Microphone Connector



NOTE: *All Connectors shown from wiring side (rear view)*

HRC-10 Memory Programming Worksheet

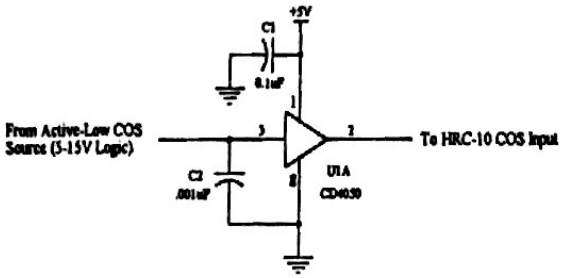
Timer and Mode Settings:

Location	Parameter	Data		
00	Simplex Repeat Delay	_____ x 0.1 seconds	=	_____ seconds
01	ID Timer Interval	_____ x 1.0 seconds	=	_____ minutes
02	Duplex Mode Hang Time	_____ x 0.1 seconds	=	_____ seconds
03	Time-out Timer	_____ x 1.0 seconds	=	_____ minutes
04	Simplex Debouncer Delay	_____ x 0.1 seconds	=	_____ second
10	Repeat Mode	_____ (0=simplex, 1=duplex)		
11	IDer Mode	_____ (0=active channel ID, 1=continuous ID)		
12	Mail Slot Configuration	_____ (0=none, 1=15 seconds, 2 =30 seconds)		

DTMF Function Access Codes:

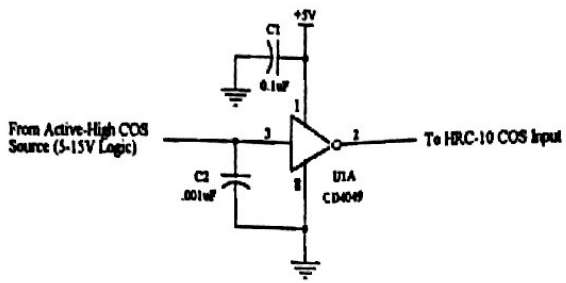
Location	DTMF Control Function	Access Code
20	"Record ID" Function Access Code	_____
21	"Play ID" Function Access Code	_____
22	"Disable Repeater" Function Access Code	_____
23	"Enable Repeater" Function Access Code	_____
24	"Save Voice Mail" Function Access Code	_____
25	"Play Voice Mail" Function Access Code	_____
26	"Save Voice Mail" Function Access Code	_____
27	"Control Output Off" Function Access Code	_____
28	"Control Output On" Function Access Code	_____
40	"Program Memory" Access Code	_____

Figure 1 - Level Conversion of Active-Low COS Signal



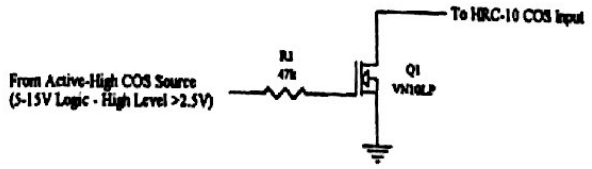
Note: Connect pins 5,7,9,11, and 15 to ground.

Figure 2 - Level Conversion of Active-High COS Signal



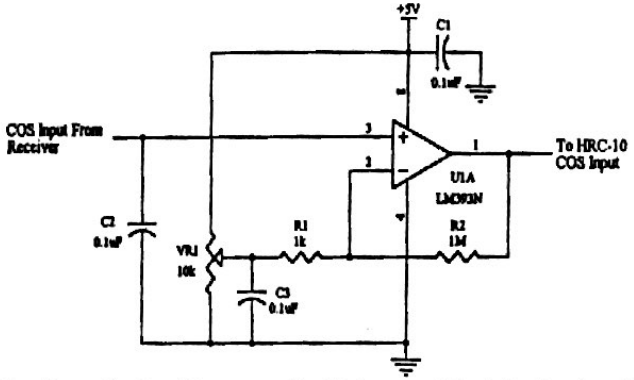
Note: Connect pins 5,7,9,11, and 15 to ground.

Figure 3 - Inverting an Active-High COS Signal



Note: Can also use 2N3904 or any general-purpose NPN switching transistor. Use 1k for R1 (to base) and ground emitter.

Figure 4 - Interfacing to Non-Standard COS Signal Voltage Levels



Note: Connect Pins 5,6, and 7 to ground. Adjust VR1 for proper COS swicthing (set wiper volage equal to mid-point of voltage swing at pin 2). May need to invert output depending on direction of COS voltage swing. Use 1k pull-up from pin 1 and circuit of figure 3 to invert. For COS voltage higher than 5V use higher supply voltage and level conversion circuit of figure 1 or figure 2.

Figure 5 - Inverting PTT Output Level

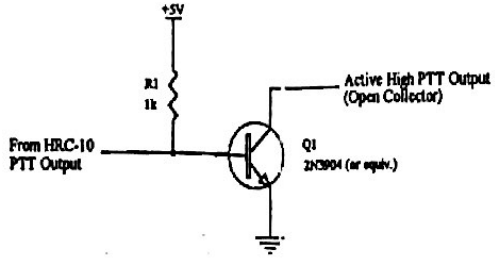
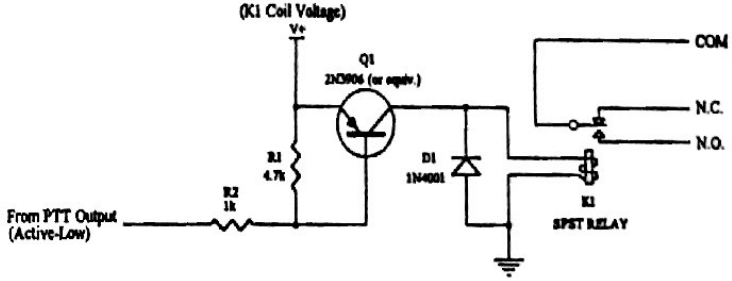
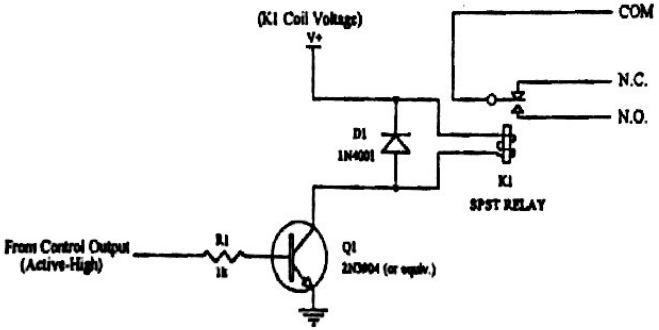


Figure 6 - High Current PTT Output



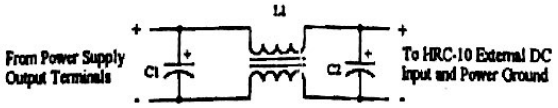
Note: Q1 general-purpose PNP (Icc rated to handle relay coil current).

Figure 7 - High Current External Control Line Interface



Note: Q1 general-purpose NPN (Icc rated to handle relay coil current).

Figure 8 - Common-Mode Power Supply Filter

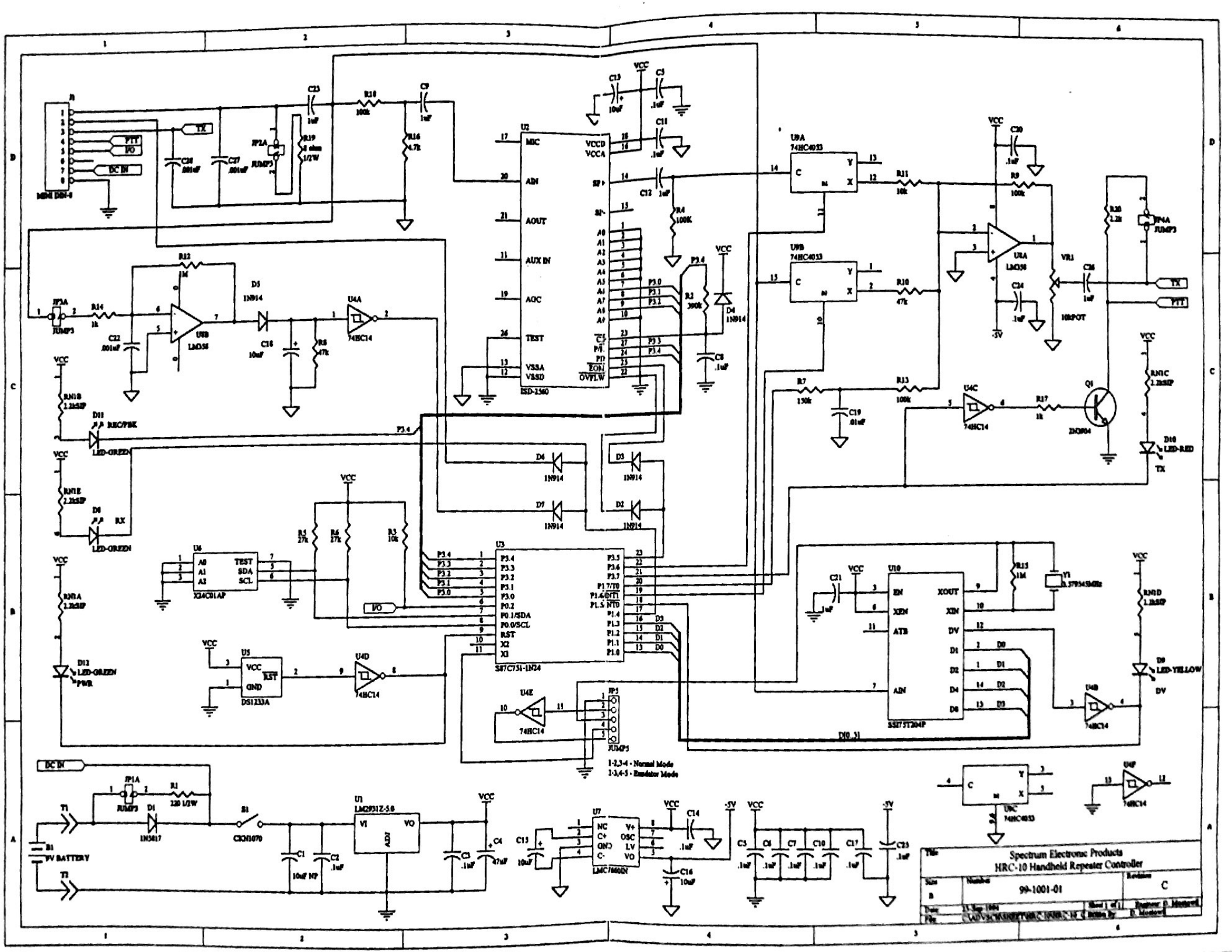


L1: 10-33mH Common-Mode Choke (Digi-key PLK1005).
C1,C2: 10-100uF 25VDC Electrolytic Capacitor.

NOTES:

1. Test all circuits before connecting them to equipment and the HRC-10.
2. All interface circuit components can be obtained from the Digi-Key Corp.. For catalog and ordering information call 1-800-344-4539.
3. All resistors 1/4 watt unless otherwise noted.

Title	Spectrum Electronic Products HRC-10 Interface Circuits	
Size: B	Number: 004-002-01	Revision: A
Date: 23-Sep-1994	Sheet of	
File: C:\ADVSCH\HRC10\HRC-10.SCH	Drawn By: D. Mostrom	


J1
MINI DIN-8
PTT
I/O
DC IN
TX
JP2A
JUMP3
R19
.5 ohm
1/2W
C25
.001uF
C27
.001uF
R10
100k
C9
1uF
R16
4.7k
U2
ISD-2560
MIC
AIN
AOUT
AUX IN
AGC
TEST
VSSA
VSSD
VCCD
VCCA
SP+
SP-
A0
A1
A2
A3
A4
A5
A6
A7
A8
A9
P3.0
P3.1
P3.2
P3.3
P3.4
P3.5
P3.6
P3.7
EOM
OVFLW
C13
10uF
C5
.1uF
C11
.1uF
C12
1uF
R4
100K
R2
390k
D4
1N914
C8
.1uF
U9A
74HC4053
U9B
74HC4053
R11
10k
R10
47k
C20
.1uF
R9
100k
U8A
LM358
R20
2.2k
JP4A
JUMP3
VR1
10KPOT
C26
1uF
C24
.1uF
TX
PTT
-5V
JP3A
JUMP3
R14
1k
R12
1M
U8B
LM358
C22
.001uF
D5
1N914
C18
10uF
R8
47k
U4A
74HC14
RN1B
2.2kSIP
D11
REC/PBK
LED-GREEN
RN1E
2.2kSIP
D6
RX
LED-GREEN
RN1A
2.2kSIP
D12
LED-GREEN
PWR
R7
150k
C19
.01uF
R13
100k
U4C
74HC14
R17
1k
Q1
2N3904
RN1C
2.2kSIP
D10
LED-RED
TX
D6
1N914
D3
1N914
D7
1N914
D2
1N914
R5
27k
R6
27k
R3
10k
U6
X24C01AP
TEST
SDA
SCL
A0
A1
A2
I/O
U3
S87C751-1N24
P3.4
P3.3
P3.2
P3.1
P3.0
P0.2
P0.1/SDA
P0.0/SCL
RST
X2
X3
P3.5
P3.6
P3.7
P1.7/T0
P1.6/INT1
P1.5 NT0
P1.4
P1.3
P1.2
P1.1
P1.0
D3
D2
D1
D0
U5
DS1233A
VCC
RST
GND
U4D
74HC14
U4E
74HC14
JP5
JUMP5
1-2,3-4 - Normal Mode
1-3,4-5 - Emulator Mode
C21
1uF
U10
S8275T2604P
EN
XEN
ATB
AIN
XOUT
XIN
DV
D1
D2
D4
D6
D0
D1
D2
D3
D[0..3]
R15
1M
Y1
3.579545MHz
U4B
74HC14
RN1D
2.2kSIP
D9
LED-YELLOW
DV
DC IN
JP1A
JUMP3
R1
220 1/2W
D1
1N5817
T1
B1
9V BATTERY
T2
S1
CKN1070
U1
LM2931Z-5.0
VI
VO
ADJ
C1
10uF NP
C2
.1uF
C3
.1uF
C4
47uF
U7
LMC7660IN
NC
C+
GND
C-
V+
OSC
LV
VO
C13
10uF
C14
.1uF
C16
10uF
C5
.1uF
C6
.1uF
C7
.1uF
C10
.1uF
C17
.1uF
C23
.1uF
U8C
74HC4053
U4F
74HC14
Title
Spectrum Electronic Products
HRC-10 Handheld Repeater Controller
Size
B
Number
99-1001-01
Revision
C
Date
Sheet 1 of 1
Drawn By:
D. Masters