# NHRC
## Repeater Controllers

# NHRC-4/MVP
# User Guide

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No part of this document should be considered to be specifications for the proper or correct operation of the NHRC-4/MVP Repeater Controller. In no way will NHRC LLC be liable for direct or indirect damages to the controller or attached equipment.

Printed in the U.S.A.

# Thank You!

Thank you for purchasing the NHRC-4/MVP Repeater Controller. This controller has been designed using the very latest state-of-the-art technology. Please review this manual carefully before putting your controller into operation.

This manual represents a very large documentation effort. Your comments are important to us. If you find an error or find any passages that are not clearly understandable we would like to hear about it. Please send your comments to ***software@nhrc.net***.

Support for the controller is available by email or telephone. Please direct software-related questions via email to ***software@nhrc.net***. Please direct hardware-related questions via email to ***hardware@nhrc.net*** . Your question(s) will be answered promptly.

Questions of a more urgent nature can be answered by telephone support. Telephone support is available Monday through Friday, from 6 PM until 10 PM, Eastern Time.

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# 1. Installation

This section of the User Guide describes the electrical interfaces used to connect the controller to:

- Power and primary repeater (the GE Custom MVP),
- Link/Remote Base radio
- Communications Specialists TS-64 CTCSS Encoder/Decoder
- *Optional* NHRC-DAD digital audio delay board(s).

It is intended for the repeater operator to use in the planning and installation of the NHRC-4/MVP Repeater Controller into a repeater system.

The controller uses an 8 pin 0.100” header for all the primary radio's signals and DC power, a 6 pin 0.100” header for the secondary radio's signals, and a 6 pin 0.100” header for an external TS-64 CTCSS encoder/decoder for the primary radio. In addition, it has two 4 pin 0.100” connectors to support optional NHRC-DAD digital audio delays for both radio ports.

Each radio port requires audio and a signal present indication (CAS) from its receiver, and supplies transmit audio and PTT to its transmitter. The controller requires 13.8 volts DC for power, which is provided on the primary radio's connector. Be very careful when wiring DC power to the controller, reverse polarity will severely damage the controller. The connector pinouts are shown in the tables below.

## *1.1 J4 Primary Radio Port Connections*

Receiver audio can typically be taken from the high side of the squelch control. This audio must be de-emphasized with the controller's de-emphasis circuit, which provides a 6dB/octave slope. Optionally, audio can be taken from later in the receiver's audio chain, where it is already de-emphasized. Care must be taken that this source of audio is not subject to adjustment by the radio's volume control. If the receiver audio has not been properly de-emphasized, either in the receiver itself or on the controller board, the repeater will have a very "tinny", unnatural sound to it. The NHRC-4/MVP repeater controller is shipped with the de-emphasis circuit populated on the printed circuit board for main repeater audio and without de-emphasis for remote base audio for "flat" audio response. To install the de-emphasis filter for the remote base audio, two 100K ohm resistors must be removed (R10 and R11), and a replaced with a 10K ohm at R11, a 93.1K ohm at R10, and a 0.0068 microfarad capacitor at C10 must be installed on the board. Consult the NHRC-4/MVP Repeater Controller (Audio) schematic as a reference for the modification.

The receiver must provide a signal present indication (also called CAS, COR, RUS) to the controller. The controller requires an "active-high" signal here. If your radio only has "active-low" signaling available, a simple inverter can be constructed with a 2N3906 and a 4.7K resistor. Connect the emitter of the transistor to a source of positive voltage, the collector to the controller's CAS terminal, and the base to the active-low signal through the 4.7K resistor.

Transmitter audio can be fed directly into the microphone input of the transmitter. VR5 is the master level control for the primary radio, used to set the audio level into the transmitter. VR6 is the master level control for the secondary radio. The transmitter's deviation limiter (sometimes called IDC) should be set such that the transmitter cannot overdeviate, regardless of input signal level. One way to adjust transmitter deviation is to set the transmitter deviation limiter wide open (unlimited), adjust the controller's master output until the transmitter is slightly overdeviating, then set the transmitter's deviation limiter to limit just below 5 KHz deviation. Then reduce the controller's master output until the transmitted audio does not sound compressed or clipped. Transmitter deviation should be adjusted with a service monitor or deviation meter.

Transmitter keying is provided by a power MOSFET (Q1/Q9) configured in an open-drain circuit. This can be used to key many transmitters directly. The MOSFET essentially provides a closure to ground for PTT. For other transmitters, the MOSFET can drive a small relay to key the radio. Although this MOSFET can handle several amps, we recommend that no more than 500 mA of current be drawn through it.

**J4 Primary Radio Port**
**("REPEATER")**

| Pin | Use |
|---|---|
| 1 | +13.8 Volts |
| 2 | CAS (active high) |
| 3 | PTT (active low) |
| 4 | Receiver Audio |
| 5 | Transmitter Audio |
| 6 | Fan/Digital output (active low) |
| 7 | Ground/Audio Return |
| 8 | Ground/Audio Return |

## *1.2 J3 Secondary Radio Port Connections*

**J3 Secondary Radio Port**
**("REMOTE BASE")**

| Pin | Use |
|---|---|
| 1 | CAS (active high) |
| 2 | PTT (active low) |
| 3 | CTCSS detect (active high) |
| 4 | Receiver Audio |
| 5 | Transmitter Audio |
| 6 | Ground/Audio Return |

## *1.3 JTS64 Primary Radio Port TS-64 Connector*

Connector JTS64 is a 6pin header that allows the easy installation of an optional Communications Specialists TS-64 for CTCSS decode and encode. Consult table JTS64 for hookup information.

The TS-64 must have the JU-2 jumper cut. If you want to be able to disable the CTCSS requirement, install a switch on the HANGUP lead, or you could wire the HANGUP lead to the J4 Fan/Digital Output pin to allow remote enable/disable of the CTCSS requirement. If you like, you can wire the TS-64's ENCODE OUT pin into your transmitter's CTCSS input to encode PL on the repeater's output.

The TS-64 is normally configured with its high-pass filter in-circuit to remove received CTCSS tones. Jumper JP2 on the controller board must be removed when the TS-64 high-pass filter is used. If the TS-64 is not installed, then jumper JP2 must be installed in order for audio to pass through the controller.

Adjust the CTCSS deviation with R20 on the TS-64 board. The ideal deviation for the CTCSS tone is 750 Hz. Consult the TS-64 INSTRUCTION SHEET for details on setting the CTCSS frequency.

**JTS64 Primary Radio Port TS-64 Connector**

| Pin | Use | to TS-64 Signal |
|---|---|---|
| 1 | +13.8 Volts | +13.8V In |
| 2 | Receiver Audio | Decoder In |
| 3 | Receiver Audio | N/C |
| 4 | Filtered Audio | High Pass Filter Out |
| 5 | CTCSS Detect | RX Mute & Decoder Out |
| 6 | Ground / Audio Return | Ground & PTT Input & Hangup |

## *1.4 J1 & J2 DAD Connectors*

The audio delay for the primary radio simply plugs in to J4. The audio delay for the secondary radio plugs in to J5. If the audio delay is not installed, a jumper between pins 2 and 3 of the port's delay connector must be installed, or the controller will not pass audio.

**J2 Primary Radio DAD**
**("DELAY ")**
**J1 Secondary Radio DAD**
**("RB DELAY ")**

| Pin | Use |
|---|---|
| 1 | +13.8 Volts to Delay Board |
| 2 | Audio to Delay Board |
| 3 | Audio from Delay Board |
| 4 | Ground/Audio Return |

## *1.5 The LED Status Indicators*

The NHRC-4/MVP repeater controller is equipped with five status LED's that aid in setup and troubleshooting. There are green LED's for each radio port (D2 and D4) that indicate that the controller has getting a valid CAS (carrier operated switch) and, if a CTCSS decoder is connected, a valid CTCSS decode signal. This LED should light when the repeater's receiver is active, and, if a CTCSS decoder is present, that the correct CTCSS tone is present. The yellow LED (D1) indicates that a DTMF signal is being decoded on the primary receiver. This LED should light for the entire duration that the DTMF signal is present on the primary receiver. The red LED's (D3 and D5) indicate transmit. These LED's will light when the each transmitter is transmitting.

The LED's can be disabled to reduce the power consumption of the controller. Remove jumper JP3 to disable the LED's.

## *1.6 Using the Digital Output*

The NHRC-4/MVP Repeater Controller has a digital output that can be used for various remote control applications or to control a fan on the repeater's transmitter. The digital output is an open-drain into a power MOSFET, which is capable of sinking quite a bit of current, but we recommend a maximum load of about 500 mA. Use a relay to drive larger loads. The open-drain output can be used to gate the HOOKSWITCH signal to a TS-64 or other CTCSS decoder. Software allows the output to be enabled, disabled, or pulsed. In fan control mode, this output will be turned on when the transmitter is turned on, and turned off a programmable amount of time after the transmitter is turned off.

## *1.7 Adjusting the Audio Levels*

**Audio Level Adjustments**

| Potentiometer | Use |
|---|---|
| VR1 | Primary Receiver Level |
| VR2 | Secondary Receiver Level |
| VR3 | Primary Receiver Mix Level |
| VR4 | Beep Tone Mix Level |
| VR5 | Primary Transmitter Master Level |
| VR6 | Secondary Transmitter Master Level |

Preset all potentiometers to midrange. Key a radio on the primary input frequency, send some touch-tones, and adjust VR1 (the primary receiver level) until DTMF decoding is reliably indicated by yellow LED (D1).

The primary radio's transmit deviation is set with VR5 (the primary transmitter master level) on the controller board and the transmitter's deviation/modulation control. The key to properly adjusting these controls is to remember that the limiter in the transmitter is *after* VR5 but probably *before* the transmitter's deviation/modulation control. The transmitter's deviation/modulation control will set the actual *peak* deviation, and VR5 will set the level into the transmitter. You do not want excessive limiting on normal speech going through the repeater; it sounds bad and tends to "pump-up" background noise. On the other hand, some limiting is desirable. An oscilloscope connected to the audio output of a receiver tuned to the transmitter's frequency will show limiting as the audio gets "flat-topped" or clipped by the limiter. Ideally, a 4.5KHz deviation signal input to the repeater should result in a 4.5 KHz deviation output, and 5.5 KHz of input deviation should result in just under 5.0 KHz of deviation out of the repeater. A service monitor (or two), deviation meter, and/or a signal generator are necessary to do this job right.

The secondary radio's transmit deviation is set with VR6 (the secondary transmitter master level). Enable the secondary transmitter, and adjust VR6 for proper transmit deviation, similarly to VR5.

Enable the secondary receiver, and adjust VR2 for reasonable deviation on the enabled transmitters when a signal is received on the secondary receiver.

Adjust VR4 (the beep level) to set the courtesy tone and CW tone level.

VR3 is used to set the receiver audio mix level, and may not need to be adjusted from midpoint.

# 2. Operating the NHRC-4/MVP

## *2.1 Introduction*

The NHRC-4/MVP has 2 radio "ports", which are connectors that the radios connect to. There is a "primary" and a "secondary" radio port.

The "primary" radio port (J4) is where the "main" repeater connects. All DTMF commands must come from here. When the primary radio is disabled, the secondary radio is also disabled.

The "secondary" radio port (J3) is where the secondary radio connects. The secondary radio can be a remote base, link radio, or a second repeater, which when activated, is "married" to the primary repeater. The secondary radio can be disabled without any effect on the primary radio. No DTMF commands are accepted from this port.

The secondary radio can be a "Remote Base", which is a simplex radio connected to the repeater system that allows the repeater users to remotely operate on a different frequency / mode / band than the repeater.

The secondary radio can be a link radio to interconnect the repeater on the main port to a distant repeater. The link radio can be simplex or full-duplex. In the case of a full-duplex link, the main receiver and the link receiver can be repeated over both transmitters simultaneously. A simplex link will always transmit when the main receiver is active, potentially blocking any traffic that might be received over the link at that time.

The secondary port can be connected to a repeater that will "marry" or "slave" to the main repeater. Anything received on either repeater will be re-transmitted by both repeaters. This allows repeaters on two different bands to be easily and inexpensively linked.

The secondary port has several different modes of operation that apply to some or all of the applications described above. The secondary port's modes can only be selected by sending DTMF to the receiver connected to the primary radio port. These modes are:

- disabled
- alert mode
- monitor mode
- transmit mode

In disabled mode, the secondary radio port is ignored by the controller.

Alert Mode is a mode in which a different courtesy tone will be played if the receiver on the secondary port is unsquelched when the courtesy tone is requested. This is useful to indicate that traffic exists on a remote base frequency without having to hear the remote base traffic being repeated.

In monitor mode, the secondary radio's receiver audio is retransmitted over the primary repeater, but the secondary port is inhibited from transmitting. This mode is also useful for remote base operation and monitoring linked repeaters.

In transmit mode, the secondary radio's receiver audio is retransmitted by the primary radio, and the primary radio's audio is transmitted over the secondary radio. This mode is useful for remote bases, linked repeaters, and married repeaters.

A married repeater requires that the controllers "secondary port is a duplex repeater" option be set. This option changes how the PTT line to the secondary radio port operates. Normally, the secondary radio port's PTT line follows the primary radio port's CAS (receiver active) line, that is the secondary port transmits when enabled and the primary receiver is active. When the "secondary port is a duplex repeater" option is set, the secondary radio port's PTT line follows the primary radio port's PTT line, so that the courtesy tone and tail are transmitted on the married repeater.

The controller's programming is protected from unauthorized access by a 4-digit secret passcode. The controller is programmed by 8-digit DTMF commands that all begin with the 4-digit passcode. Throughout this manual, commands will be shown as ***pppp*NNNN**, where **pppp** represents the passcode, and **NNNN** is the actual command to the controller.

In order to save space in the microprocessor memory, the NHRC-4/MVP repeater controller represents all numbers in "hexadecimal" notation. Hexadecimal, or "hex" for short, is a base-16 number format that allows an 8-bit number to be represented in two digits. Hex numbers are 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, and F. Converting decimal (the normal base-10 numbers that 10-fingered humans prefer) to hex is simple. Divide the decimal number by 16 to get the 1st hex digit (10=A, 11=B, 12=C, 13=D, 14=E, 15=F), the remainder is the 2nd hex digit. For example, 60 decimal = 3 x 16 + 12 = 3C hex. Any decimal number from 0 to 255 may be represented in only 2 hex digits.

Many scientific calculators can convert between these two number systems, and the Windows 95 / 98 / 2000 calculator can, too, if the "scientific" view is selected. We provide a Web page that can generate all the programming data for the NHRC-4/MVP controller quickly and easily, see *http://www.nhrc.net/nhrc-4mvp/nhrc4prog.html*.

A 16 key DTMF pad has keys 0-9 and A-D, which map directly to their corresponding hex digits. **Use the * key for digit E and the # key for digit F.** A 16-key DTMF pad is required to program the controller.

**Note: Programming of the NHRC-4/MVP must be transmitted to the radio attached to the primary radio port.**

## *2.2 Initializing the Controller*

The controller will need to be initialized to allow you to set your secret passcode. Initializing the controller also resets all programmable settings to the factory defaults, including the CW ID message. It should not be necessary to initialize the controller again, unless you want to change the passcode. The only way to change the passcode is to initialize the controller.

To initialize the controller, remove power and install the INIT jumper (JP1). Apply power to the controller, and after a few seconds, remove the init jumper. The controller is now in the initialize mode. If you "kerchunk" the primary port's receiver now, it will send the default CW ID of "DE NHRC/4". Now transmit (into the primary receiver) your 4-digit passcode. The controller will respond by sending "OK" in CW once. The controller will store the passcode and the main repeater will be enabled.

## 2.3 Programming the Controller

All programming is done by entering 8-digit DTMF sequences. The first 4 digits are the *passcode* chosen at initialization. The next 2 digits are an *address* or a *function code*. The last 2 digits are the *data* for address or function. To enter programming information, you must key your radio, enter the 8 digits, then unkey. If the controller understands your sequence, it will respond with "OK" in CW. If there is an error in your sequence, but the passcode is good, the controller will respond with "NG". If the controller does not understand your command at all, it will not respond with anything other than a courtesy beep, and then only if the courtesy beep is enabled. If the controller is disabled, and an unrecognized command is entered, no response will be transmitted at all.

**Responses to Commands**

| Response | Meaning |
|---|---|
| "OK" | Command accepted |
| "NG" | Command address or data is bad |
| Courtesy Beep or Nothing | Command / Password not accepted |

If you enter an incorrect sequence, you can unkey before all 8 digits are entered, and the sequence will be ignored. If you enter incorrect address or data values, just re-program the location affected with the correct data.

## 2.4 Programming the Timers

The NHRC-4/MVP Repeater Controller provides several timers which control the operation of your repeater. The *Hang Timer* controls how long the repeater will continue to transmit after a received signal drops. This is often called the repeater's "tail." The tail is useful to eliminate annoying squelch crashes on users' radios. As long as a reply is transmitted before the hang timer expires, the repeater will not drop, which would cause a squelch crash in the users' radios.

The *Timeout Timer* controls the maximum duration of the retransmission of a received signal. It is more of a safety measure to protect the repeater from damage than a way to discourage long-winded users, even though it is often used that way. The NHRC-4/MVP has a separate timeout timer for each port. The timeout timer(s) can be disabled by programming a 0 length.

The *ID Timer* sets the maximum duration between transmissions of the repeater's ID message(s). (Note that the NHRC-4/MVP may transmit an ID message before the timer expires in order to avoid transmitting the ID message while a user is transmitting.)

The timer values are stored as an 8-bit value that allows a range of 0 to 255. Some of the timers require high-resolution timing of short durations, and others require lower resolution timing of longer durations. Therefore, timers values are scaled by either 1/10, 1, or 10 seconds, depending on the application.

**Timer Address and Resolution**

| Timer | Address | Resolution Seconds | Max. Value Seconds |
|---|---|---|---|
| Hang Timer | 03 | 1/10 | 25.5 |
| Primary Receiver Timeout Timer | 04 | 1 | 255 |
| Secondary Receiver Timeout Timer | 05 | 1 | 255 |
| ID Timer | 06 | 10 | 2550 |
| Fan Timer | 07 | 10 | 2550 |

Enter the 4-digit passcode, the timer address, and the timer value, scaled appropriately. For example, to program the Hang Timer for 10 seconds, enter **pppp0264**, where **pppp** is your secret passcode, 02 is the hang timer address, and 64 is the hexadecimal value for 100, which would be 10.0 seconds.

## *2.5 Programming the CW Messages*

CW messages are programmed by storing encoded CW characters into specific addresses in the controller. Use the Morse Code Character Encoding table and the Programming Memory Map to determine the data and address for the CW message characters. For example, to program "DE N1KDO/R" for the CW ID, you would use the following commands:

| DTMF Command | Address | Data | Description/Purpose |
|---|---|---|---|
| *pppp*2609 | 26 | 09 | D |
| *pppp*2702 | 27 | 02 | E |
| *pppp*2800 | 28 | 00 | space |
| *pppp*2905 | 29 | 05 | N |
| *pppp*2A3* | 2A | 3E | 1 |
| *pppp*2B0D | 2B | 0D | K |
| *pppp*2C09 | 2C | 09 | D |
| *pppp*2D0# | 2D | 0F | O |
| *pppp*2*29 | 2E | 29 | / |
| *pppp*2#0A | 2F | 0A | R |
| *pppp*30## | 30 | FF | End of message marker |

The CW ID can store a message of up to 20 characters. Do not exceed 20 characters. Be sure to include the end-of-message character (FF) at the end of each message.

## *2.6 Programming the Flag Bits*

Controller features can be enabled with the use of the Configuration Flag Bits. These bits are encoded in a single byte, which is programmed into the controller at address 01. Multiple flag bits can be selected by adding their hex weights.

For example, to set up a controller with an audio delay on each port, and configure the digital output for fan control, you would add 02, 04, and 10 to produce hex 16, which you would then program into address 01 in the controller with this command:

**pppp0131**

In addition to programming the flag bits as a group using address 01, the controller supports commands to set or clear these bits individually. Command 60 is used to clear (zero) a specified configuration bit, and command 61 is used to set (one) a specified configuration bit. For example, to set (turn on) bit 3 (to suppress DTMF muting), enter the following command: **`pppp6103`**. To clear bit 3 and enable the DTMF muting, enter this command: **`pppp6003`**. Note that the bit *number*, not it's hex weight is used for commands 60 and 61.

**Configuration Flag Bits**

| Bit | Hex Weight | Binary Value | Feature |
|---|---|---|---|
| 0 | 01 | 00000001 | secondary port is duplex repeater |
| 1 | 02 | 00000010 | audio delay on primary receiver |
| 2 | 04 | 00000100 | audio delay on secondary receiver |
| 3 | 08 | 00001000 | disable DTMF muting |
| 4 | 10 | 00010000 | digital output is fan control |
| 5 | 20 | 00100000 | main receiver has priority over link receiver* |
| 6 | 40 | 01000000 | reserved |
| 7 | 80 | 10000000 | reserved |

*Software version >= 1.4 only.

**Example Configurations**

| Flag Bits Value | Features Selected |
|---|---|
| 00 | none |
| 01 | duplex repeater on secondary port |
| 08 | no DTMF muting |
| 10 | digital output is fan control |
| 11 | duplex repeater on secondary port<br>digital output is fan control |
| 17 | duplex repeater on secondary port<br>NHRC-DAD on primary port<br>NHRC-DAD on secondary port<br>digital output is fan control |
| 36 | NHRC-DAD on primary port<br>NHRC-DAD on secondary port<br>digital output is fan control<br>main receiver has priority over link receiver* |
| 1F | duplex repeater on secondary port<br>NHRC-DAD on primary port<br>NHRC-DAD on secondary port<br>no DTMF muting digital output is fan control |

*Software version >= 1.4 only.

## *2.7 Programming the Courtesy Tones*

The NHRC-4/MVP uses up to five different courtesy tones to indicate various events:

- primary receiver
- primary receiver, the secondary transmitter enabled
- primary receiver, alert mode
- secondary receiver
- secondary receiver, secondary transmitter enabled

Each tone is individually programmable, and can be unique for that event, programmed to be the same as other events, or programmed empty to be silent.

The NHRC-4/MVP will play the appropriate courtesy tones 500 milliseconds (1/2 second) after a receiver drops. The courtesy tones all consist of four 100 millisecond (1/10 second) segments. Each segment can be no tone, low tone (a "boop", about 440 hertz), or high tone (a "beep", about 880 hertz). If all the segments are programmed as no tone, the courtesy tone will be disabled. The default courtesy tones are shown in the Default Courtesy Tones table.

**Default Courtesy Tones**

| Event | Default Tones | Binary Encoding | Hex Encoding |
|---|---|---|---|
| Primary Receiver | beep none none none | 00 00 00 01 | 01 |
| Primary Receiver Secondary Transmitter Enabled | beep none beep none | 00 01 00 01 | 11 |
| Primary Receiver Secondary Receiver Alert Mode | beep none boop none | 00 11 00 01 | 31 |
| Secondary Receiver | boop none none none | 00 00 00 11 | 03 |
| Secondary Receiver Secondary Transmitter Enabled | boop none boop none | 00 11 00 11 | 33 |

The courtesy tones are encoded as four pairs of bits, with the first segment encoded as the two least significant bits, and the fourth segment encoded as the 2 most significant bits. Each pair of bits is allowed three possible values to indicate no tone, beep, or boop. The Half Courtesy Tones table shows tones generated for valid 4-bit values and their hex representation. To use this table, first determine the tones for each of the four segments, then find the hex digit that represents the first and second pair of tones. The second pair's digit becomes the first hex digit, and the first pair's digit becomes the second hex digit. For example, to encode a courtesy tone of boop-beep-boop-none, you would find the first pair (boop-beep) in the table as the hex digit D and the second pair (boop-none) in the table as the hex digit 3, so your courtesy tone would be encoded as 3D.

**Half Courtesy Tones**

| Tones | Binary Encoding | Hex Encoding |
|---|---|---|
| none none | 00 00 | 0 |
| none beep | 01 00 | 4 |
| none boop | 11 00 | C |
| beep none | 00 01 | 1 |
| beep beep | 01 01 | 5 |
| beep boop | 01 11 | 7 |
| boop none | 00 11 | 3 |
| boop beep | 11 01 | D |
| boop boop | 11 11 | F |

## *2.8 Previewing Stored CW Messages*

Stored CW messages can be previewed with the command *40* followed with the message number you want to preview. The message numbers can be found in the Message Numbers table. For example, to preview the secondary receiver timeout message, send command:

**pppp4004**

## *2.9 Enabling/Disabling the Repeater*

The radio ports can be disabled or enabled by remote control by setting the code for the operational mode in location 00. See the Operational Modes Table for the codes that indicate the mode you want.

**Operational Modes**

| Code | Operational Mode |
|---|---|
| 00 | Primary & Secondary off |
| 01 | Primary enabled |
| 02 | Primary enabled, secondary alert mode |
| 03 | Primary enabled, secondary monitor mode |
| 04 | Primary enabled, secondary transmit mode |

For instance, to disable the repeater, send command:

**pppp0000**

To enable the repeater on the primary port, send command:

**pppp0001**

To enable the repeater on the primary port, and select monitor mode for the secondary port, send command:

**pppp0003**

## *2.10 Using the NHRC-DAD Digital Audio Delay with the NHRC-4/MVP Repeater Controller.*

The NHRC-4/MVP Repeater Controller supports the optional NHRC-DAD digital audio delay board. The NHRC-DAD allows complete muting of received DTMF tones (no leading beep before muting), and suppression of squelch crashes when the received signal drops. The NHRC-DAD has a 128 ms delay on all received audio. The NHRC-4/MVP Repeater Controller supports an NHRC-DAD on both radio ports with a software switch and a dedicated DAD connector for each port. If the DAD is not present, then a jumper must be installed between pins 2 and 3 of the DAD connector (see installation manual). If the DAD is present, then the appropriate configuration flag bit must be set.

## *2.11 Programming Example*

Programming the NHRC-4/MVP Repeater Controller can seem quite complicated at first. This section of the manual is intended as a tutorial to help you learn how to program your controller.

Let's assume we want to program a NHRC-4/MVP Repeater Controller with the following parameters:

CW ID: DE N1LTL/R FN42
Hang Time 7.5 seconds
Timeout timer 120 seconds

First, we will initialize the controller. Install JP3 and apply power to the controller to initialize. After a few seconds, remove JP3. Send DTMF **2381** to set access code to 2381. The controller will send "OK" in CW to indicate the passcode was accepted. Now the controller is initialized, and disabled.

Now we will enable the controller. Send DTMF **23810001** (passcode=2381, address=00, data=01). The controller will send "OK" in CW to indicate the command was successful.

We will now program the CW ID. Looking at the "Programming Memory Map", we can see that the first location for the CW ID is 26. The first letter of the ID is 'D', which we look up in the "Morse Code Character Encoding" table and discover that the encoding for 'D' is 09. Location 26 gets programmed with 09.

Send DTMF **23812609** to program the letter 'D' as the first character of the CW ID. The controller will send "OK" in CW if the command is accepted. If you entered the command correctly, but you don't get the "OK", your DTMF digits may not all be decoding. See the Installation Guide for your controller to readjust the audio level for the DTMF decoder.

The next character is the letter 'E', which is encoded as 02, and will be programmed into the next address, 27. Send DTMF **23812702**.

The next character is the space character, and it will be programmed into address 29. Send DTMF **23812800**. Here are the rest of the sequences to program the rest of the ID message:

**23812905** (N in address 29)
**23812A3*** (1 in address 2A)
**23812B12** (L in address 2B)
**23812C03** (T in address 2C)
**23812D12** (L in address 2D)
**23812*29** (/ in address 2E)
**23812#0A** (R in address 2F)
**23813000** (space in address 30)
**23813114** (F in address 31)
**23813205** (N in address 32)
**23813330** (4 in address 33)
**2381343C** (2 in address 34)
**238135FF** (EOM in address 35)

After the last character of the CW ID is programmed, the End-of-Message character must be programmed. In this case, the last character of the ID message was programmed into address 34, so the EOM character, which is encoded as FF, goes into address 35:
**238135##** (EOM into address 35.)

To program the hang timer, we must first determine the address of the hang timer by consulting the Programming Memory Map. The Hang Timer preset is stored in location 03. Next, we need to convert the 7.5 seconds into tenths, which would be 75 tenths of a second. Then the 75 gets converted to hex:

75 / 16 = 4 with a remainder of 11, so 75 decimal equals 4B hex.

Now program the hang timer preset by sending **2381034B**.

To program the primary receiver's timer with 120 seconds, we get the address of the primary receiver's timeout timer preset, which is 04, and then convert 120 seconds to hex:

120 / 16 = 7 with a remainder of 8, so 120 decimal equals 78 hex.

So we will program location 04 with 78: **23810478**

Any CW message can be played back at any time by "programming" location 40 with the message code you want to play. To play the CW ID, send **23814000**.

# 3. Appendices

## *3.1 Tables*

### 3.1.1 Message Contents

| Message Number | Contents | Default |
|---|---|---|
| 0 | ID Message | DE NHRC/4 |
| 1 | Primary Receiver Timeout Message | TO |
| 2 | Valid Command Confirm Message | OK |
| 3 | Invalid Command Message | NG |
| 4 | Secondary Receiver Timeout Message | RB TO |

### 3.1.2 Programming Memory Map

| Address | Default Data | Comment |
|---|---|---|
| 00 | 01 | Enable Flag:<br>00 Primary & Secondary Off<br>01 Primary Repeater Enabled<br>02 Primary Enabled, Secondary Alert Mode<br>03 Primary Enabled, Secondary Monitor Mode<br>04 Primary Enabled, Secondary Transmit Mode |
| 01 | 10 | Configuration Flags (see table) |
| 02 | 00 | Digital output control:<br>00 Off<br>01 On<br>02 ½ second On Pulse |
| 03 | 32 | Hang Timer Preset, in tenths |
| 04 | 1e | Primary Receiver Timeout Timer, in seconds |
| 05 | 1e | Secondary Receiver Timeout Timer, in seconds |
| 06 | 36 | ID Timer Preset, in 10 seconds |
| 07 | 00 | Fan Timer, in 10 seconds |
| 08 | 01 | Primary Receiver Courtesy Tone |
| 09 | 11 | Primary Receiver Courtesy Tone<br>Secondary Transmitter Enabled |
| 0a | 31 | Primary Receiver Courtesy Tone<br>Secondary Receiver Alert Mode |
| 0b | 03 | Secondary Receiver Courtesy Tone |
| 0c | 33 | Secondary Receiver Courtesy Tone<br>Secondary Transmitter Enabled |
| 0d | 00 | Reserved |
| 0e | 0f | 'O' OK Message |
| 0f | 0d | 'K' |
| 10 | ff | EOM |
| 11 | ff | EOM |
| 12 | ff | EOM |
| 13 | ff | EOM |
| 14 | 05 | 'N' NG Message |
| 15 | 0b | 'G' |
| 16 | ff | EOM |
| 17 | ff | EOM |
| 18 | ff | EOM |
| 19 | ff | EOM |

| | | |
|---|---|---|
| 1a | 03 | 'T' TO Message |
| 1b | 0f | 'O' |
| 1c | ff | EOM |
| 1d | ff | EOM |
| 1e | ff | EOM |
| 1f | ff | EOM |
| 20 | 0a | 'R' TO Message |
| 21 | 22 | 'B' |
| 22 | 00 | ' ' |
| 23 | 03 | 'T' |
| 24 | 0f | 'O' |
| 25 | ff | EOM |
| 26 | 09 | 'D' CW ID starts here |
| 27 | 02 | 'E' |
| 28 | 00 | space |
| 29 | 05 | 'N' |
| 2a | 10 | 'H' |
| 2b | 0a | 'R' |
| 2c | 15 | 'C' |
| 2d | 29 | '/' |
| 2e | 30 | '4' |
| 2f | ff | EOM |
| 30 | ff | EOM |
| 31 | ff | EOM |
| 32 | ff | EOM |
| 33 | ff | EOM |
| 34 | ff | EOM |
| 35 | ff | EOM |
| 36 | ff | EOM |
| 37 | ff | EOM |
| 38 | ff | EOM |
| 39 | ff | EOM |
| 3a | ff | EOM can fit 20 letter id |
| 3b | ff | EOM (safety) |
| 3c | n/a | Passcode Digit 1 |
| 3d | n/a | Passcode Digit 2 |
| 3e | n/a | Passcode Digit 3 |
| 3f | n/a | Passcode Digit 4 |

**Note that the entire range of 26-3B is available for your CW ID message.**
**Do not forget to terminate the message with the FF (end-of-message) character.**

### 3.1.3 Morse Code Character Encoding

| Character | Morse Code | Binary Encoding | Hex Value |
|---|---|---|---|
| sk | ...-.- | 01101000 | 68 |
| ar | .-.-. | 00101010 | 2a |
| bt | -...- | 00110001 | 31 |
| / | -..-. | 00101001 | 29 |
| 0 | ----- | 00111111 | 3f |
| 1 | .---- | 00111110 | 3e |
| 2 | ..--- | 00111100 | 3c |
| 3 | ...-- | 00111000 | 38 |
| 4 | ....- | 00110000 | 30 |
| 5 | ..... | 00100000 | 20 |
| 6 | -.... | 00100001 | 21 |
| 7 | --... | 00100011 | 23 |
| 8 | ---.. | 00100111 | 27 |
| 9 | ----. | 00101111 | 2f |
| a | .- | 00000110 | 06 |
| b | -... | 00010001 | 11 |
| c | -.-. | 00010101 | 15 |
| d | -.. | 00001001 | 09 |
| e | . | 00000010 | 02 |
| f | ..-. | 00010100 | 14 |
| g | --. | 00001011 | 0b |
| h | .... | 00010000 | 10 |
| i | .. | 00000100 | 04 |
| j | .--- | 00011110 | 1e |
| k | -.- | 00001101 | 0d |
| l | .-.. | 00010010 | 12 |
| m | -- | 00000111 | 07 |
| n | -. | 00000101 | 05 |
| o | --- | 00001111 | 0f |
| p | .--. | 00010110 | 16 |
| q | --.- | 00011011 | 1b |
| r | .-. | 00001010 | 0a |
| s | ... | 00001000 | 08 |
| t | - | 00000011 | 03 |
| u | ..- | 00001100 | 0c |
| v | ...- | 00011000 | 18 |
| w | .-- | 00001110 | 0e |
| x | -..- | 00011001 | 19 |
| y | -.-- | 00011101 | 1d |
| z | --.. | 00010011 | 13 |
| space | | 00000000 | 00 |
| EOM | | 11111111 | ff |

### *3.2 Terminology and Abbreviations*

| Term | Description |
|---|---|
| **CAS** | Carrier Activated Squelch, where receipt of a signal, with or without CTCSS tones will activate the controller. |
| **CW** | Continuous Wave signals, commonly using “Morse Code.” The term “CW” refers to the radio emission type, while “Morse Code” refers to the signaling type used. Typically, they are incorrectly used interchangeably. |
| **Digital Audio Delay (DAD)** | Digital Audio Delay (DAD) removes squelch crashes and allows DTMF tones to be fully muted. |
| **DTMF** | Also known as “Touch Tone®” codes. |
| **ID** | Identification |
| **PTT** | Push-to-Talk |

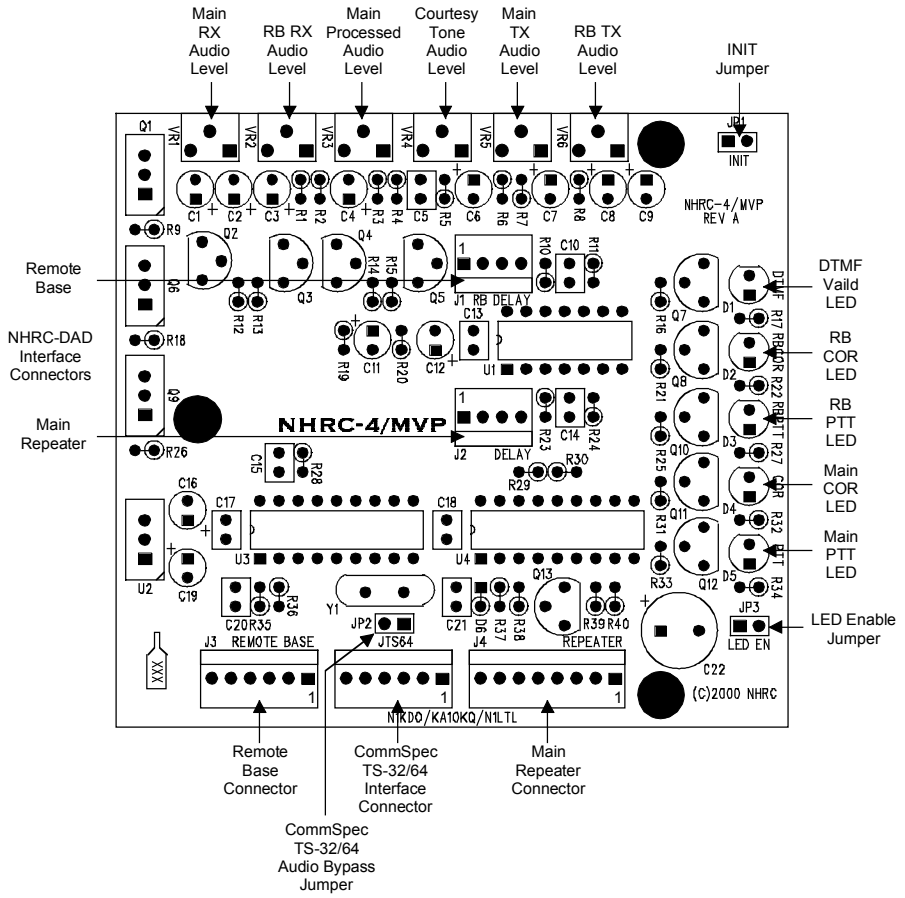
 

# 4. Circuit Board

## *4.1 Interconnections*

| Connector | Name | Purpose |
|---|---|---|
| **J1** | "RB DELAY" | Connects power and audio signals for operation of the Digital Audio Delay (NHRC-DAD) board for the **secondary** radio port. |
| **J2** | "DELAY" | Connects power and audio signals for operation of the Digital Audio Delay (NHRC-DAD) board for the **primary** radio port. |
| **J3** | "REMOTE BASE" | Connects the **secondary** repeater transmit and receive audio, PTT, and CAS signals for the radio to the controller. |
| **J4** | "REPEATER" | Connects the **primary** repeater transmit and receive audio, PTT, CAS, fan control, and power signals to the controller. |
| **JTS64** | "JTS64" | Interfaces a Communications Specialists TS-64 to the controller for CTCSS detection. |

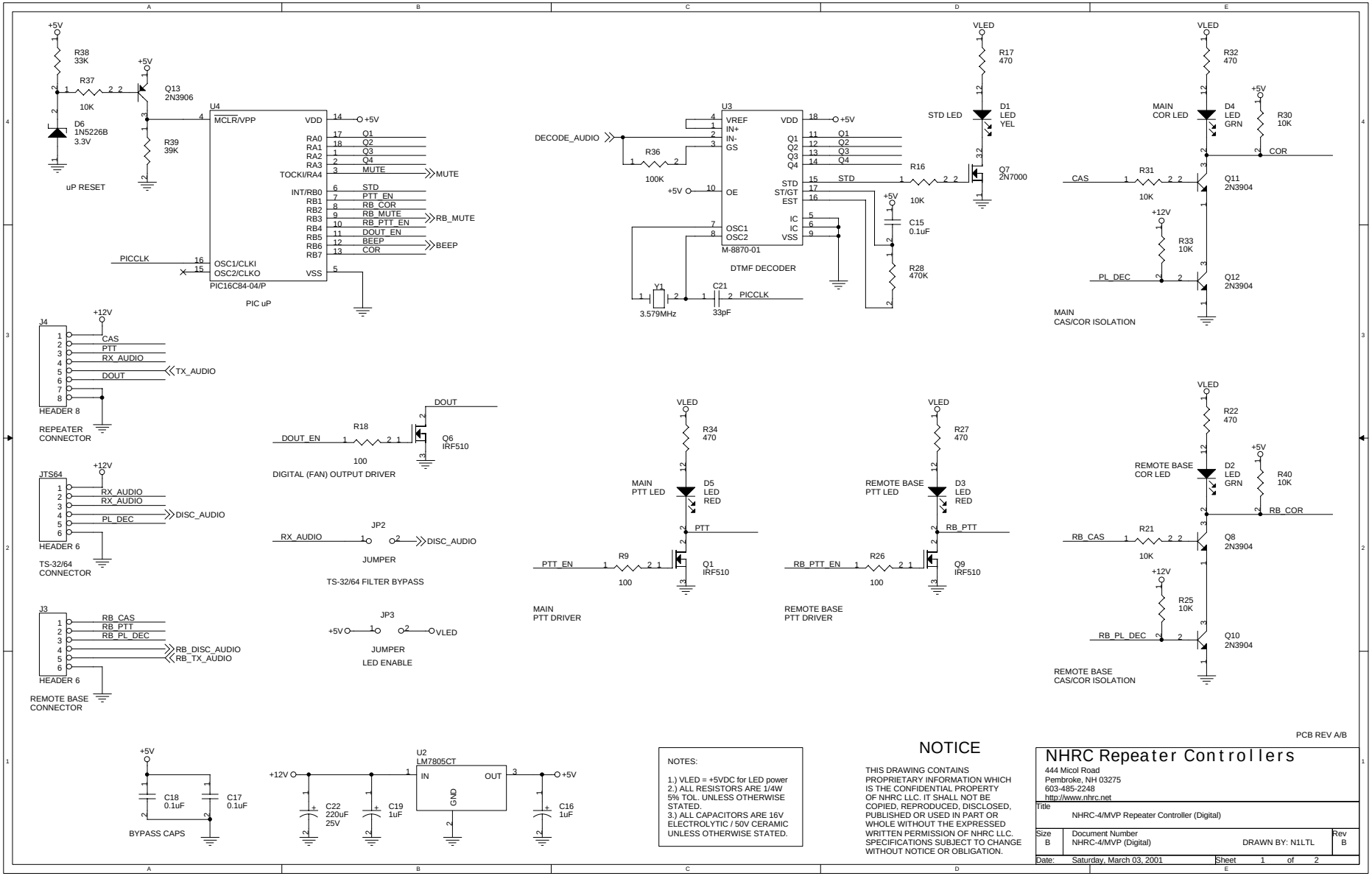
The following page is a detailed top view of the Revision "B" printed wiring board for the NHRC-4/MVP Repeater Controller.



## 5. Schematics

The following two pages the schematic diagram for the Revision “B” Version of the NHRC-4/MVP Repeater Controller.


+5V
R38
33K
R37
10K
Q13
2N3906
D6
1N5226B
3.3V
R39
39K
uP RESET
U4
MCLR/VPP
VDD
RA0
RA1
RA2
RA3
TOCKI/RA4
INT/RB0
RB1
RB2
RB3
RB4
RB5
RB6
RB7
OSC1/CLKI
OSC2/CLKO
VSS
Q1
Q2
Q3
Q4
MUTE
STD
PTT_EN
RB_COR
RB_MUTE
RB_PTT_EN
DOUT_EN
BEEP
COR
PICCLK
PIC16C84-04/P
PIC uP
U3
VREF
IN+
IN-
GS
OE
OSC1
OSC2
IC
ST/GT
EST
M-8870-01
DTMF DECODER
DECODE_AUDIO
R36
100K
Y1
3.579MHz
C21
33pF
C15
0.1uF
R28
470K
VLED
R17
470
STD LED
D1
LED
YEL
R16
Q7
2N7000
R32
470
MAIN
COR LED
D4
LED
GRN
R30
10K
R31
10K
Q11
2N3904
R33
10K
Q12
2N3904
PL_DEC
MAIN
CAS/COR ISOLATION
J4
CAS
PTT
RX_AUDIO
DOUT
TX_AUDIO
HEADER 8
REPEATER
CONNECTOR
R18
100
Q6
IRF510
DIGITAL (FAN) OUTPUT DRIVER
JTS64
RX_AUDIO
PL_DEC
DISC_AUDIO
HEADER 6
TS-32/64
CONNECTOR
JP2
JUMPER
TS-32/64 FILTER BYPASS
R34
470
MAIN
PTT LED
D5
LED
RED
R9
100
Q1
IRF510
MAIN
PTT DRIVER
R27
470
REMOTE BASE
PTT LED
D3
LED
RED
R26
100
Q9
IRF510
REMOTE BASE
PTT DRIVER
R22
470
REMOTE BASE
COR LED
D2
LED
GRN
R40
10K
R21
10K
Q8
2N3904
R25
10K
Q10
2N3904
RB_CAS
RB_PL_DEC
REMOTE BASE
CAS/COR ISOLATION
J3
RB_CAS
RB_PTT
RB_PL_DEC
RB_DISC_AUDIO
RB_TX_AUDIO
HEADER 6
REMOTE BASE
CONNECTOR
JP3
JUMPER
LED ENABLE
C18
0.1uF
C17
0.1uF
BYPASS CAPS
U2
LM7805CT
IN
OUT
GND
C22
220uF
25V
C19
1uF
C16
1uF
NOTES:
1.) VLED = +5VDC for LED power
2.) ALL RESISTORS ARE 1/4W
5% TOL. UNLESS OTHERWISE
STATED.
3.) ALL CAPACITORS ARE 16V
ELECTROLYTIC / 50V CERAMIC
UNLESS OTHERWISE STATED.
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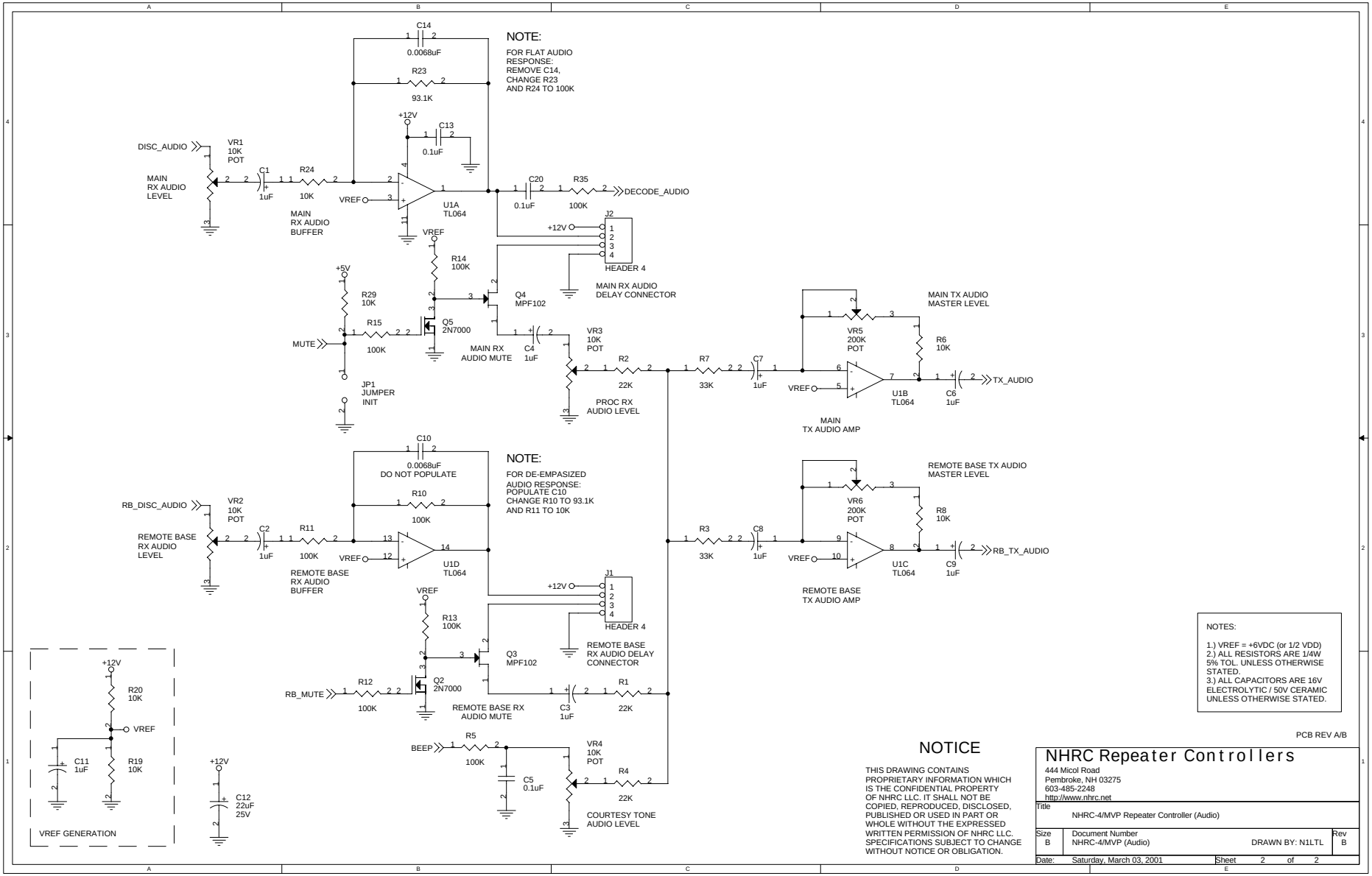
NHRC Repeater Controllers
444 Micol Road
Pembroke, NH 03275
603-485-2248
http://www.nhrc.net
Title
NHRC-4/MVP Repeater Controller (Digital)
Size
B
Document Number
NHRC-4/MVP (Digital)
DRAWN BY: N1LTL
Rev
B
Date:
Saturday, March 03, 2001
Sheet
1
of
2


NOTE:
FOR FLAT AUDIO RESPONSE: REMOVE C14, CHANGE R23 AND R24 TO 100K
C14
0.0068uF
R23
93.1K
+12V
C13
0.1uF
DISC_AUDIO
VR1
10K
POT
MAIN RX AUDIO LEVEL
C1
1uF
R24
10K
MAIN RX AUDIO BUFFER
VREF
U1A
TL064
C20
0.1uF
R35
100K
DECODE_AUDIO
J2
HEADER 4
+12V
VREF
R14
100K
+5V
R29
10K
R15
100K
MUTE
JP1
JUMPER
INIT
Q4
MPF102
Q5
2N7000
MAIN RX AUDIO DELAY CONNECTOR
MAIN RX AUDIO MUTE
C4
1uF
VR3
10K
POT
R2
22K
PROC RX AUDIO LEVEL
R7
33K
C7
1uF
MAIN TX AUDIO MASTER LEVEL
VR5
200K
POT
R6
10K
VREF
U1B
TL064
C6
1uF
TX_AUDIO
MAIN TX AUDIO AMP
NOTE:
FOR DE-EMPASIZED AUDIO RESPONSE: POPULATE C10 CHANGE R10 TO 93.1K AND R11 TO 10K
C10
0.0068uF
DO NOT POPULATE
R10
100K
RB_DISC_AUDIO
VR2
10K
POT
REMOTE BASE RX AUDIO LEVEL
C2
1uF
R11
100K
REMOTE BASE RX AUDIO BUFFER
VREF
U1D
TL064
J1
HEADER 4
+12V
VREF
R13
100K
Q3
MPF102
REMOTE BASE RX AUDIO DELAY CONNECTOR
RB_MUTE
R12
100K
Q2
2N7000
REMOTE BASE RX AUDIO MUTE
C3
1uF
R1
22K
R3
33K
C8
1uF
REMOTE BASE TX AUDIO MASTER LEVEL
VR6
200K
POT
R8
10K
VREF
U1C
TL064
C9
1uF
RB_TX_AUDIO
REMOTE BASE TX AUDIO AMP
BEEP
R5
100K
C5
0.1uF
VR4
10K
POT
R4
22K
COURTESY TONE AUDIO LEVEL
+12V
R20
10K
VREF
C11
1uF
R19
10K
VREF GENERATION
+12V
C12
22uF
25V
NOTES:
1.) VREF = +6VDC (or 1/2 VDD)
2.) ALL RESISTORS ARE 1/4W 5% TOL. UNLESS OTHERWISE STATED.
3.) ALL CAPACITORS ARE 16V ELECTROLYTIC / 50V CERAMIC UNLESS OTHERWISE STATED.
PCB REV A/B
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Size
B
Document Number
NHRC-4/MVP (Audio)
DRAWN BY: N1LTL
Rev
B
Date:
Saturday, March 03, 2001
Sheet
2
of
2

## 6. Parts List

The following is the bill of materials for revision "B" of the NHRC-4/MVP Repeater Controller.

| Item | Qty. | Ref. | Schematic Value | | Description | Mfg. | Mfg. P/N | Notes |
|---|---|---|---|---|---|---|---|---|
| 1 | 11 | C1 | 1uF | | 1uF 16V Tantalum Cap | Panasonic | ECS-F1CE105K | or equivalent |
| | | C2 | 1uF | | 1uF 16V Tantalum Cap | Panasonic | ECS-F1CE105K | or equivalent |
| | | C3 | 1uF | | 1uF 16V Tantalum Cap | Panasonic | ECS-F1CE105K | or equivalent |
| | | C4 | 1uF | | 1uF 16V Tantalum Cap | Panasonic | ECS-F1CE105K | or equivalent |
| | | C6 | 1uF | | 1uF 16V Tantalum Cap | Panasonic | ECS-F1CE105K | or equivalent |
| | | C7 | 1uF | | 1uF 16V Tantalum Cap | Panasonic | ECS-F1CE105K | or equivalent |
| | | C8 | 1uF | | 1uF 16V Tantalum Cap | Panasonic | ECS-F1CE105K | or equivalent |
| | | C9 | 1uF | | 1uF 16V Tantalum Cap | Panasonic | ECS-F1CE105K | or equivalent |
| | | C11 | 1uF | | 1uF 16V Tantalum Cap | Panasonic | ECS-F1CE105K | or equivalent |
| | | C16 | 1uF | | 1uF 16V Tantalum Cap | Panasonic | ECS-F1CE105K | or equivalent |
| | | C19 | 1uF | | 1uF 16V Tantalum Cap | Panasonic | ECS-F1CE105K | or equivalent |
| 2 | 6 | C5 | 0.1uF | | 0.1uF 50V Z5U Ceramic Radial Cap | Panasonic | ECU-S1H104MEA | or equivalent |
| | | C13 | 0.1uF | | 0.1uF 50V Z5U Ceramic Radial Cap | Panasonic | ECU-S1H104MEA | or equivalent |
| | | C15 | 0.1uF | | 0.1uF 50V Z5U Ceramic Radial Cap | Panasonic | ECU-S1H104MEA | or equivalent |
| | | C17 | 0.1uF | | 0.1uF 50V Z5U Ceramic Radial Cap | Panasonic | ECU-S1H104MEA | or equivalent |
| | | C18 | 0.1uF | | 0.1uF 50V Z5U Ceramic Radial Cap | Panasonic | ECU-S1H104MEA | or equivalent |
| | | C20 | 0.1uF | | 0.1uF 50V Z5U Ceramic Radial Cap | Panasonic | ECU-S1H104MEA | or equivalent |
| 3 | 2 | C14 | 0.0068uF | | 0.0068uF 50V X7R Ceramic Radial Cap | Panasonic | ECU-S1H682KBA | or equivalent |
| | | C10 | 0.0068uF | | 0.0068uF 50V X7R Ceramic Radial Cap | Panasonic | ECU-S1H682KBA | Do Not Populate |
| 4 | 1 | C12 | 22uF | 25V | 22uF 25V Aluminum Radial Electrolytic Cap | Panasonic | ECA-1EM220 | or equivalent |
| 5 | 1 | C21 | 33pF | | 33pF 100V C0G Ceramic Radial Cap | Panasonic | ECU-S2A330JCA | or equivalent |
| 6 | 1 | C22 | 220uF | 25V | 220uF 25V Aluminum Radial Electrolytic Cap | Panasonic | ECA-1EM221 | or equivalent |
| 7 | 1 | D1 | LED | YEL | Yellow T1¾ LED | Lite-On | LTL-4253 | or equivalent |
| 8 | 2 | D2 | LED | GRN | Green T1¾ LED | Lite-On | LTL-4233 | or equivalent |
| | | D4 | LED | GRN | Green T1¾ LED | Lite-On | LTL-4233 | or equivalent |
| 9 | 2 | D5 | LED | RED | Red T1¾ LED | Lite-On | LTL-4203 | or equivalent |
| | | D3 | LED | RED | Red T1¾ LED | Lite-On | LTL-4203 | or equivalent |
| 10 | 1 | D6 | 1N5226B | 3.3V | 3.3V 5% 500mW Zener Diode | Diodes Inc. | 1N5226B | or equivalent |
| 11 | 3 | JP1 | JUMPER | | 2 Circuit Header, .100" Straight | Molex | 22-03-2021 | or equivalent |
| | | JP2 | JUMPER | | 2 Circuit Header, .100" Straight | Molex | 22-03-2021 | or equivalent |
| | | JP3 | JUMPER | | 2 Circuit Header, .100" Straight | Molex | 22-03-2021 | or equivalent |
| 12 | 2 | JTS64 | HEADER 6 | | 6 Circuit Header, .100" Straight w/ lock | Molex | 22-23-2061 | or equivalent |
| | | J3 | HEADER 6 | | 6 Circuit Header, .100" Straight w/ lock | Molex | 22-23-2061 | or equivalent |
| 13 | 2 | J1 | HEADER 4 | | 4 Circuit Header, .100" Straight w/ lock | Molex | 22-23-2041 | or equivalent |
| | | J2 | HEADER 4 | | 4 Circuit Header, .100" Straight w/ lock | Molex | 22-23-2041 | or equivalent |
| 14 | 1 | J4 | HEADER 8 | | 8 Circuit Header, .100" Straight w/ lock | Molex | 22-23-2081 | or equivalent |
| 15 | 3 | Q1 | IRF510 | | N Channel HEXFET | IRF | IRF510 | or equivalent |
| | | Q6 | IRF510 | | N Channel HEXFET | IRF | IRF510 | or equivalent |
| | | Q9 | IRF510 | | N Channel HEXFET | IRF | IRF510 | or equivalent |
| 16 | 3 | Q2 | 2N7000 | | N Channel MOSFET | Fairchild | 2N7000 | or equivalent |
| | | Q5 | 2N7000 | | N Channel MOSFET | Fairchild | 2N7000 | or equivalent |
| | | Q7 | 2N7000 | | N Channel MOSFET | Fairchild | 2N7000 | or equivalent |
| 17 | 2 | Q4 | MPF102 | | N Channel JFET | Fairchild | MPF102 | or equivalent |
| | | Q3 | MPF102 | | N Channel JFET | Fairchild | MPF102 | or equivalent |
| 18 | 4 | Q8 | 2N3904 | | NPN Transistor | Fairchild | 2N3904 | or equivalent |
| | | Q10 | 2N3904 | | NPN Transistor | Fairchild | 2N3904 | or equivalent |
| | | Q11 | 2N3904 | | NPN Transistor | Fairchild | 2N3904 | or equivalent |
| | | Q12 | 2N3904 | | NPN Transistor | Fairchild | 2N3904 | or equivalent |
| 19 | 1 | Q13 | 2N3906 | | PNP Transistor | Fairchild | 2N3906 | or equivalent |
| 20 | 3 | R1 | 22K | | 22K ¼W 5% Carbon Film Resistor | Yaego | CFR-25JB-22K | or equivalent |
| | | R2 | 22K | | 22K ¼W 5% Carbon Film Resistor | Yaego | CFR-25JB-22K | or equivalent |
| | | R4 | 22K | | 22K ¼W 5% Carbon Film Resistor | Yaego | CFR-25JB-22K | or equivalent |
| 21 | 3 | R3 | 33K | | 33K ¼W 5% Carbon Film Resistor | Yaego | CFR-25JB-33K | or equivalent |
| | | R7 | 33K | | 33K ¼W 5% Carbon Film Resistor | Yaego | CFR-25JB-33K | or equivalent |
| | | R38 | 33K | | 33K ¼W 5% Carbon Film Resistor | Yaego | CFR-25JB-33K | or equivalent |

 

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 22 | 9 | R5 | 100K | | 100K ¼W 5% Carbon Film Resistor | Yaego | CFR-25JB-100K | or equivalent |
| | | R10 | 100K | | 100K ¼W 5% Carbon Film Resistor | Yaego | CFR-25JB-100K | or equivalent |
| | | R11 | 100K | | 100K ¼W 5% Carbon Film Resistor | Yaego | CFR-25JB-100K | or equivalent |
| | | R12 | 100K | | 100K ¼W 5% Carbon Film Resistor | Yaego | CFR-25JB-100K | or equivalent |
| | | R13 | 100K | | 100K ¼W 5% Carbon Film Resistor | Yaego | CFR-25JB-100K | or equivalent |
| | | R14 | 100K | | 100K ¼W 5% Carbon Film Resistor | Yaego | CFR-25JB-100K | or equivalent |
| | | R15 | 100K | | 100K ¼W 5% Carbon Film Resistor | Yaego | CFR-25JB-100K | or equivalent |
| | | R35 | 100K | | 100K ¼W 5% Carbon Film Resistor | Yaego | CFR-25JB-100K | or equivalent |
| | | R36 | 100K | | 100K ¼W 5% Carbon Film Resistor | Yaego | CFR-25JB-100K | or equivalent |
| 23 | 14 | R6 | 10K | | 10K ¼W 5% Carbon Film Resistor | Yaego | CFR-25JB-10K | or equivalent |
| | | R8 | 10K | | 10K ¼W 5% Carbon Film Resistor | Yaego | CFR-25JB-10K | or equivalent |
| | | R16 | 10K | | 10K ¼W 5% Carbon Film Resistor | Yaego | CFR-25JB-10K | or equivalent |
| | | R19 | 10K | | 10K ¼W 5% Carbon Film Resistor | Yaego | CFR-25JB-10K | or equivalent |
| | | R20 | 10K | | 10K ¼W 5% Carbon Film Resistor | Yaego | CFR-25JB-10K | or equivalent |
| | | R21 | 10K | | 10K ¼W 5% Carbon Film Resistor | Yaego | CFR-25JB-10K | or equivalent |
| | | R24 | 10K | | 10K ¼W 5% Carbon Film Resistor | Yaego | CFR-25JB-10K | or equivalent |
| | | R25 | 10K | | 10K ¼W 5% Carbon Film Resistor | Yaego | CFR-25JB-10K | or equivalent |
| | | R29 | 10K | | 10K ¼W 5% Carbon Film Resistor | Yaego | CFR-25JB-10K | or equivalent |
| | | R30 | 10K | | 10K ¼W 5% Carbon Film Resistor | Yaego | CFR-25JB-10K | or equivalent |
| | | R31 | 10K | | 10K ¼W 5% Carbon Film Resistor | Yaego | CFR-25JB-10K | or equivalent |
| | | R33 | 10K | | 10K ¼W 5% Carbon Film Resistor | Yaego | CFR-25JB-10K | or equivalent |
| | | R37 | 10K | | 10K ¼W 5% Carbon Film Resistor | Yaego | CFR-25JB-10K | or equivalent |
| | | R40 | 10K | | 10K ¼W 5% Carbon Film Resistor | Yaego | CFR-25JB-10K | or equivalent |
| 24 | 3 | R9 | 100 | | 100 ¼W 5% Carbon Film Resistor | Yaego | CFR-25JB-100R | or equivalent |
| | | R18 | 100 | | 100 ¼W 5% Carbon Film Resistor | Yaego | CFR-25JB-100R | or equivalent |
| | | R26 | 100 | | 100 ¼W 5% Carbon Film Resistor | Yaego | CFR-25JB-100R | or equivalent |
| 25 | 1 | R23 | 93.1K | | 93.1K ¼W 5% Metal Film Resistor | Yaego | MFR-25FBF-93K1 | or equivalent |
| 26 | 5 | R17 | 470 | | 470 ¼W 5% Carbon Film Resistor | Yaego | CFR-25JB-470R | or equivalent |
| | | R22 | 470 | | 470 ¼W 5% Carbon Film Resistor | Yaego | CFR-25JB-470R | or equivalent |
| | | R27 | 470 | | 470 ¼W 5% Carbon Film Resistor | Yaego | CFR-25JB-470R | or equivalent |
| | | R32 | 470 | | 470 ¼W 5% Carbon Film Resistor | Yaego | CFR-25JB-470R | or equivalent |
| | | R34 | 470 | | 470 ¼W 5% Carbon Film Resistor | Yaego | CFR-25JB-470R | or equivalent |
| 27 | 1 | R28 | 470K | | 470K ¼W 5% Carbon Film Resistor | Yaego | CFR-25JB-470K | or equivalent |
| 28 | 1 | R39 | 39K | | 39K ¼W 5% Carbon Film Resistor | Yaego | CFR-25JB-39K | or equivalent |
| 29 | 1 | U1 | TL064 | | Quad Op-Amp | TI | TL064CN | see note 1 |
| 30 | 1 | U2 | LM7805CT | | 5V 1.0A Voltage Regulator | Nat'l Semi | LM340T-5.0 | or equivalent |
| 31 | 1 | U3 | M-8870-01 | | DTMF Decoder | Teltone | M-8870-01 | see note 1 |
| 32 | 1 | U4 | PIC16C84-04/P | | PIC Microcontroller (Blank) | Microchip | PIC16F84-04I/P | see note 1 |
| 33 | 4 | VR1 | 10K | POT | 10K 6mm Carbon Trimpot | Panasonic | EVN-D2AA03B14 | or equivalent |
| | | VR2 | 10K | POT | 10K 6mm Carbon Trimpot | Panasonic | EVN-D2AA03B14 | or equivalent |
| | | VR3 | 10K | POT | 10K 6mm Carbon Trimpot | Panasonic | EVN-D2AA03B14 | or equivalent |
| | | VR4 | 10K | POT | 10K 6mm Carbon Trimpot | Panasonic | EVN-D2AA03B14 | or equivalent |
| 34 | 2 | VR5 | 200K | POT | 200K 6mm Carbon Trimpot | Panasonic | EVN-D2AA03B25 | or equivalent |
| | | VR6 | 200K | POT | 200K 6mm Carbon Trimpot | Panasonic | EVN-D2AA03B25 | or equivalent |
| 35 | 1 | Y1 | 3.579MHz | | 3.579545MHz Crystal | ECS | ECS-35-17-4 | or equivalent |
| | **Additional Items** | | | | | | | |
| 36 | 1 | | | | NHRC-4/MVP PCB REV B | NHRC | NHRC-4/MVP PCB REV B | |
| 37 | 2 | | | | 18 Pin DIP Socket | Mill-Max | 110-99-318-41-001 | use at U3/U4 |
| 38 | 1 | | | | 14 Pin DIP Socket | Mill-Max | 110-99-314-41-001 | use at U1 |

Notes:
1. Use sockets for U1, U3 and U4.

## 7. NHRC LLC Limited Warranty

NHRC LLC warrants that it's assembled and tested products will be free from defects in materials and workmanship for a period of NINETY DAYS from the date of shipment. During this period, NHRC LLC will repair or replace, at our option, any of our products that fail as a result of defects in materials or workmanship. NHRC LLC's liability will be limited to parts, labor, and return shipping for this period.

NHRC LLC warrants that its kit products will contain components that are free from defects in materials and workmanship for a period of THIRTY DAYS from the date of shipment. During this period, NHRC will replace any of the components in a kit ONCE. Subsequent replacement of any component any subsequent times is completely at the discretion of NHRC LLC, and may require the complete return of the kit.

In no case will NHRC LLC be liable for products damaged by improper wiring (including, but not limited to, over-voltage or application of reverse polarity), physical damage resulting from misuse and/or abuse of the product, neglect, or acts of God (lightning, floods, etc.).

Unauthorized modification of a NHRC product will void the warranty on the modified product.

In no case will NHRC LLC be liable for any direct, consequential, or incidental loss or damage resulting from the use or inability to use any of its products.

Some states or countries do not allow the limitation of incidental or consequential damages, so the paragraph above may not apply to you.

This warranty applies only to the original purchaser of the product; proof of purchase must be presented to receive warranty service.

 

NHRC

Repeater Controllers