NHRC-4 Repeater Controller

Installation Instructions

These instructions will guide you in the installation and adjustment of the NHRC-4 repeater controller.

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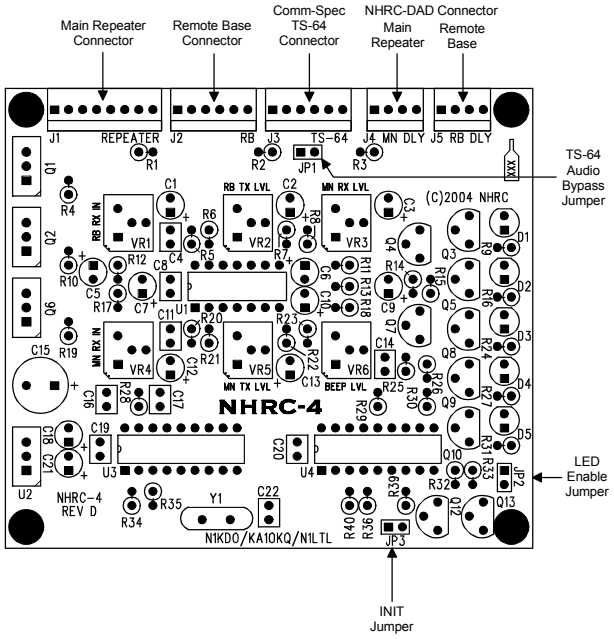

Board Layout

1. Electrical Connections

The controller uses a 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-32 or 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 it's receiver, and supplies transmit audio and PTT to it's 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.

J1 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

J2 Secondary Radio Port ("RB")

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

J3 Primary Radio Port TS-32/TS-64 Connector ("TS-64")

Pin	Use	to TS-32 Signal	to TS-64 Signal
1	+13.8 Volts	+V Power	+13.8V In
2	Receiver Audio	Decoder Input	Decoder In
3	Receiver Audio	Audio Filter Input	N/C
4	Filtered Audio	Audio Filter Output	High Pass Filter Out
5	CTCSS Detect	OUT-2	RX Mute / Decoder Out
6	Ground / Audio Return	Ground & Hangup	Ground & PTT Input & Hangup

J4 Primary Radio DAD
("MN DLY ")
J5 Secondary Radio DAD
("RB DLY ")

Pin	Use
1	+13.8 Volts to delay board
2	Audio **to** delay board
3	Audio **from** delay board
4	Ground/Audio Return

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 repeater controller is shipped without the de-emphasis circuit populated on the printed circuit board, for "flat" audio response. To install the de-emphasis filter, two 100K ohm resistors must be removed, and a 51K ohm, a 510K ohm, and a 0.0068 microfarad capacitor must be installed on the board. Consult the NHRC-4 Repeater Controller (Audio) schematic for modification instructions.

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. VR2 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 (Q2/Q6) 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 500mA of current be drawn through it.

2. The LED Status Indicators

The NHRC-4 repeater controller is equipped with five status LEDs that aid in setup and troubleshooting. There are green LEDs for each radio port 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 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 indicates transmit. These LED will light when the each transmitter is transmitting.

The LEDs can be disabled to reduce the power consumption of the controller. Remove jumper JP2 to disable the LEDs.

3. TS-32/TS-64 hookup

Connector J3 is 6-pin header that allows the easy installation of an optional Communications Specialists TS-32 or TS-64 for CTCSS decode and encode. Consult table J3 "Primary Radio Port TS-32/TS-64 Connector ("TS-64")" for hookup information.

TS-32 Notes

The TS-32 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 J1 Fan/Digital Output pin to allow remote enable/disable of the CTCSS requirement. If you like, you can wire the TS-32's ENCODE OUT pin into your transmitter's CTCSS input to encode PL on the repeater's output.

Adjust the CTCSS deviation with the R29 on the TS-32 board. The ideal deviation for the CTCSS tone is 750 Hz.

Consult the TS-32 INSTRUCTION SHEET for details on setting the CTCSS frequency.

TS-64 Notes

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.

WARNING: **DO NOT APPLY VOLTAGE TO THE CTCSS DETECT INPUT!**
This input is pulled low by the CTCSS decoder when CTCSS is NOT PRESENT. It will float high when CTCSS is detected. Application of voltage to this input will destroy Q3 and render the controller inoperative. Damage of this nature is not covered by the NHRC Limited Warranty.

The TS-32 and the TS-64 both have a high-pass filter to remove the CTCSS tone from the repeated audio. By removing jumper JP1, the controller's audio can be passed through the audio filter on the TS-32/TS-64. We recommend the use of the audio filter when using the NHRC-DAD Digital Audio Delay on the Primary Repeater audio.

Note: If the audio filter is not used, then jumper JP1 must be installed in order for audio to be passed through the controller.

The Communications Specialists CTCSS boards are not supplied by NHRC. Contact Communications Specialists at 800-854-0547 directly to order these boards.

4. Installing the Audio Delay

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.

5. Using the Digital Output

The NHRC-4 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 500mA. Use a relay to drive larger loads. The open-drain output can be used to gate the HOOKSWITCH signal to a TS-32 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.

6. Adjusting the Audio Levels

Audio Level Adjustments

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

Preset all potentiometers to midrange. Key a radio on the primary input frequency, send some touch-tones, and adjust VR4 (the primary receiver level) until DTMF decoding is reliably indicated by yellow LED D5.

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* VR2 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 VR2 (the secondary transmitter master level). Enable the secondary transmitter, and adjust VR2 for proper transmit deviation, similarly to VR5.

Enable the secondary receiver, and adjust VR1 for reasonable deviation on the enabled transmitters when a signal is received on the secondary receiver.

Adjust VR6 (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.

NHRC-4 Repeater Controller

Operation Guide

Software Version 1.4

These instructions will guide you in the operation of the NHRC-4 Repeater Controller. For installation instructions, see the installation guide.

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1. Introduction

The NHRC-4 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 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 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 which 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 repeater controller represents all numbers in "hexadecimal" notation. Hexadecimal, or "hex" for short, is a base-16 number format that allows a 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 calculator can, too, if the "scientific" view is selected. We provide a WWW page that can generate all the programming data for the NHRC-4 controller quickly and easily, see *http://www.nhrc.net/nhrc4/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 that all programming of the NHRC-4 must be transmitted to the radio attached to the primary radio port.

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 nessecary 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 (JP3). 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.

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.

1. ## Programming the Timers

   The NHRC-4 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 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 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 which 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. 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:

CW Message Programming Example

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.

3. 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: **`pppp0116`**

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

*** available in software version 1.4 and greater 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 digital output is fan control
17	duplex repeater on secondary port NHRC-DAD on primary port NHRC-DAD on secondary port digital output is fan control
36	NHRC-DAD on primary port NHRC-DAD on secondary port digital output is fan control main receiver has priority over link receiver*
1F	duplex repeater on secondary port NHRC-DAD on primary port NHRC-DAD on secondary port no DTMF muting digital output is fan control

*** available in software version 1.4 and greater ONLY**

4. Programming the Courtesy Tones

The NHRC-4 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 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 Secondard 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

5. 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`**

4. Operating

1. 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. Using the NHRC-DAD Digital Audio Delay with the NHRC-4 Repeater Controller.

The NHRC-4 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 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.

5. Programming Example

Programming the NHRC-4 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 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 INIT jumper 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)

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**.

Tables

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

Programming Memory Map

Address	Default Data	Comment
00	01	enable flag 00 Primary & Secondary off 01 Primary repeater enabled 02 Primary enabled, secondary alert mode 03 Primary enabled, secondary monitor mode 04 Primary enabled, secondary transmit mode
01	10	Configuration Flags (see table)
02	00	Digital output control 00 off 01 on 02 1/2 sec on pulse
03	32	Hang timer preset, in tenths
04	1e	Primary receiver timout timer, in seconds
05	1e	Secondary receiver timout 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 secondary transmitter enabled
0a	31	primary receiver courtesy tone secondary receiver alert mode
0b	03	secondary receiver courtesy tone
0c	33	secondary receiver courtesy tone 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	0a	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.

Morse Code Character Encoding

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

NHRC-4 Repeater Controller Kit
Assembly Guide

1. Organize your parts as per the Bill of Materials. All resistors in this kit are mounted vertically on the PCB. You may want to form the resistor leads ahead of time. Simply bend the resistor lead over. (*Hint:* Try to keep the color code bands consistent top to bottom throughout the board, oriented such that the tolerance bands of the resistors all face in the same direction) You will be working from your parts list and matching components from the parts list to their appropriate location on the PCB. You can use the "Board Layout" image located on page 1 of your Installation Guide as a reference for parts placement.

2. Install the capacitors into the PCB. Be careful to install the polarized caps correctly. The square pad always goes to the positive (+) lead of the capacitor. Capacitors such as the 0.1uF bypass caps are non-polarized and do not have a square pad. They may be inserted either way. (*Note:* Double check your work, tantalum capacitors may explode upon power up if they are inserted backwards. Be careful not to mix up C22 (100pF) with any of your bypass caps, they look similar.)

3. Install the resistors. The PCB silkscreen has a circle around the pad that the resistor body will sit above and a line from the circle indicates where the other lead goes. Be careful to match the reference designator to the proper component location. If in doubt find the component in the schematic and use an ohmmeter to identify the component location in question. Some reference designators may be crowded among other reference designators and may have a line drawn to the proper component location. (*Note:* Pay special attention to the placement of resistors R5, R6, R20 & R21. Resistor R5 is located next to C4 and R20 is located next to C11.)

4. Install the voltage regulator, U2 and power MOSFETs Q1, Q2 & Q6. All of these components are installed with the heat sink surface facing out from the board. (*Note*: These parts should not require mounting to a heat sink.)

5. Install the LEDs. D1 & D3 should be red, D2 & D4 should be green and D5 should be yellow. Install the LEDs with the flat side (cathode) as shown on the silkscreen, the anode will be inserted in to the square hole. (*Note:* You may optionally use any colors you prefer in any of these locations.)

6. Install the other transistors and FETs. Q3, Q5, Q8 & Q9 are 2N3904, Q4 & Q7 are MPF102 JFETs and Q10, Q12 & Q13 are 2N7000 MOSFETs. (*Note:* All of the transistors and FETs are installed so that the flat side of these parts face the edge of the PCB with the LEDs.)

7. Install the crystal, Y1.

8. Install pots, VR1, VR3, VR4 & VR6 which are 10K (marked "103") and VR2 & VR5 which are 500K (marked "504").

9. Install connectors J1, J2, J3, J4 & J5, and 2 pin headers JP1, JP2 & JP3.

10. Install the chip sockets. (*Note:* Install them so that designator for pin 1 is per the notch shown on this chip socket on the silkscreen.) **Do not install your chips at this time**. You will need to do some power up checks first.

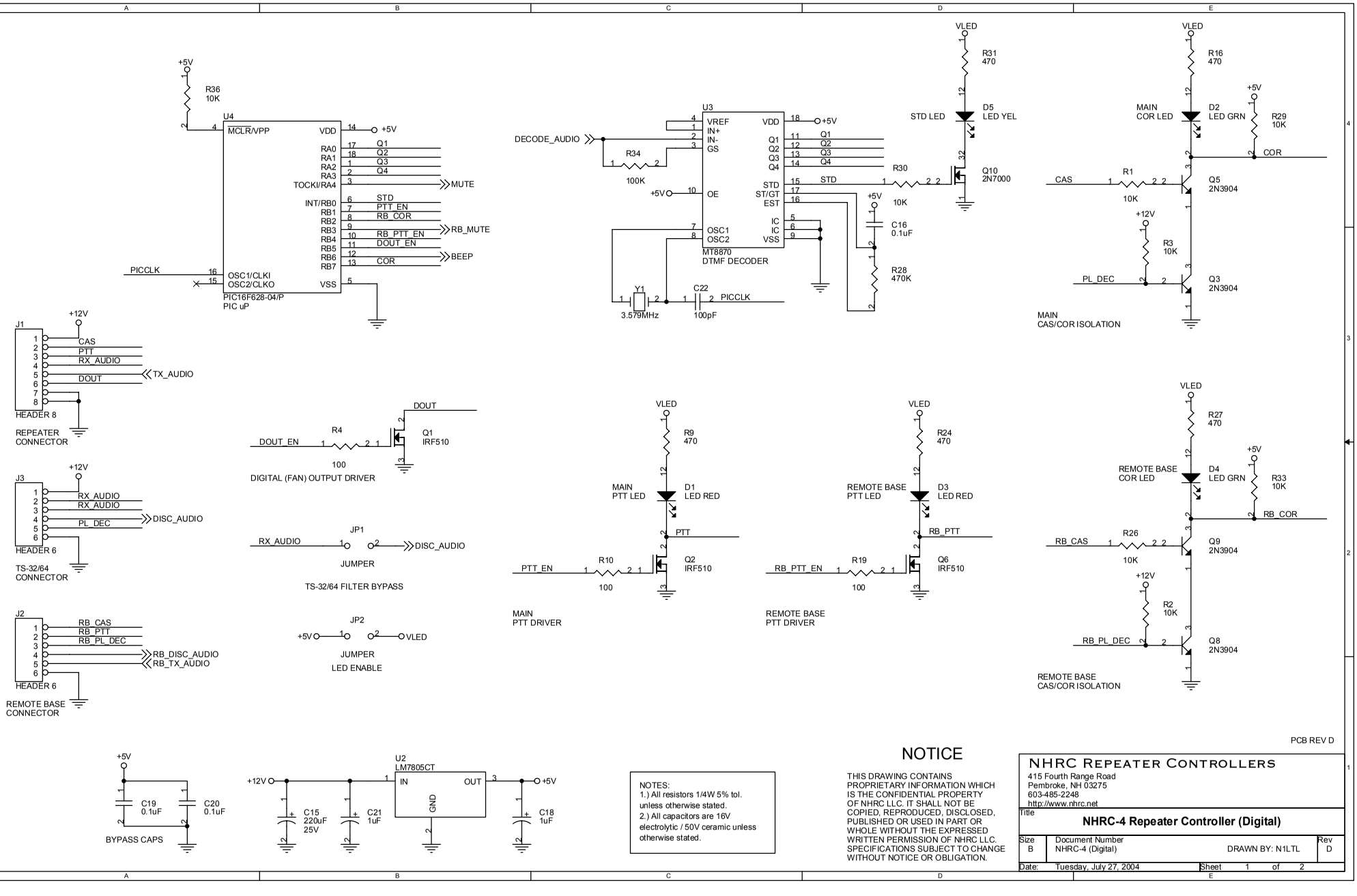
11. Solder all of your connections with rosin core solder. Use care not to overheat the PCB. (*Note:* We recommend using "63/37" rosin core solder and the use of a soldering iron, do not use a soldering gun or acid core flux solder.) Carefully trim the leads of the bottom of the PCB. Clean the PCB with alcohol to remove flux residue.

12. Double check your work. Check for any unsoldered parts, solder bridges, or improper part placement.

13. Install 2 pin shorting jumpers on headers JP1 & JP2. If you are not using the NHRC-DAD digital audio delay option, then you must install a shorting jumper on pins 2 and 3 of the delay connectors J4 & J5.

14. You are now ready to apply power to the PCB and check some voltages before installing the IC chips. See the installation instructions and operating instructions for assistance with assembly of the connections required. Apply power and check that the 5V regulator is working and that 5 volts (VCC) is being supplied where needed. Check that VREF is approximately 1/2 of your input supply voltage is at U1 pins 3, 5, 10 & 12. When you are confident that all of your voltages are OK, then you can install the IC chips into their sockets and power the PCB back up. If you encounter problems go back and recheck your work, look for unsoldered connections and solder bridges.

Look at the NHRC-4 web site (http://www.nhrc.net/nhrc-4) for more detailed trouble shooting instructions. We also offer troubleshooting support by email (hardware-support@nhrc.net). The circuit is fairly simple and most problems can be resolved quickly.


+5V
R36
10K
U4
MCLR/VPP
VDD
RA0
RA1
RA2
RA3
TOCKI/RA4
INT/RB0
RB1
RB2
RB3
RB4
RB5
RB6
RB7
OSC1/CLKI
OSC2/CLKO
VSS
PIC16F628-04/P
PIC uP
PICCLK
MUTE
STD
PTT_EN
RB_COR
RB_MUTE
RB_PTT_EN
DOUT_EN
BEEP
COR
U3
VREF
IN+
IN-
GS
OE
OSC1
OSC2
VDD
Q1
Q2
Q3
Q4
STD
ST/GT
EST
IC
IC
VSS
MT8870
DTMF DECODER
DECODE_AUDIO
R34
100K
Y1
3.579MHz
C22
100pF
C16
0.1uF
R28
470K
R30
10K
Q10
2N7000
STD LED
D5
LED YEL
R31
470
VLED
J1
CAS
PTT
RX_AUDIO
DOUT
TX_AUDIO
HEADER 8
REPEATER
CONNECTOR
J3
RX_AUDIO
RX_AUDIO
PL_DEC
DISC_AUDIO
HEADER 6
TS-32/64
CONNECTOR
J2
RB_CAS
RB_PTT
RB_PL_DEC
RB_DISC_AUDIO
RB_TX_AUDIO
HEADER 6
REMOTE BASE
CONNECTOR
R4
DOUT_EN
100
Q1
IRF510
DIGITAL (FAN) OUTPUT DRIVER
JP1
RX_AUDIO
DISC_AUDIO
JUMPER
TS-32/64 FILTER BYPASS
JP2
+5V
VLED
JUMPER
LED ENABLE
R9
470
MAIN
PTT LED
D1
LED RED
PTT
R10
PTT_EN
100
Q2
IRF510
MAIN
PTT DRIVER
R24
470
REMOTE BASE
PTT LED
D3
LED RED
RB_PTT
R19
RB_PTT_EN
100
Q6
IRF510
REMOTE BASE
PTT DRIVER
R16
470
MAIN
COR LED
D2
LED GRN
R29
10K
COR
CAS
R1
10K
Q5
2N3904
R3
10K
PL_DEC
Q3
2N3904
MAIN
CAS/COR ISOLATION
R27
470
REMOTE BASE
COR LED
D4
LED GRN
R33
10K
RB_COR
RB_CAS
R26
10K
Q9
2N3904
R2
10K
RB_PL_DEC
Q8
2N3904
REMOTE BASE
CAS/COR ISOLATION
C19
0.1uF
C20
0.1uF
BYPASS CAPS
U2
LM7805CT
IN
OUT
GND
C15
220uF
25V
C21
1uF
C18
1uF
NOTES:
1.) All resistors 1/4W 5% tol. unless otherwise stated.
2.) All capacitors are 16V electrolytic / 50V ceramic unless otherwise stated.
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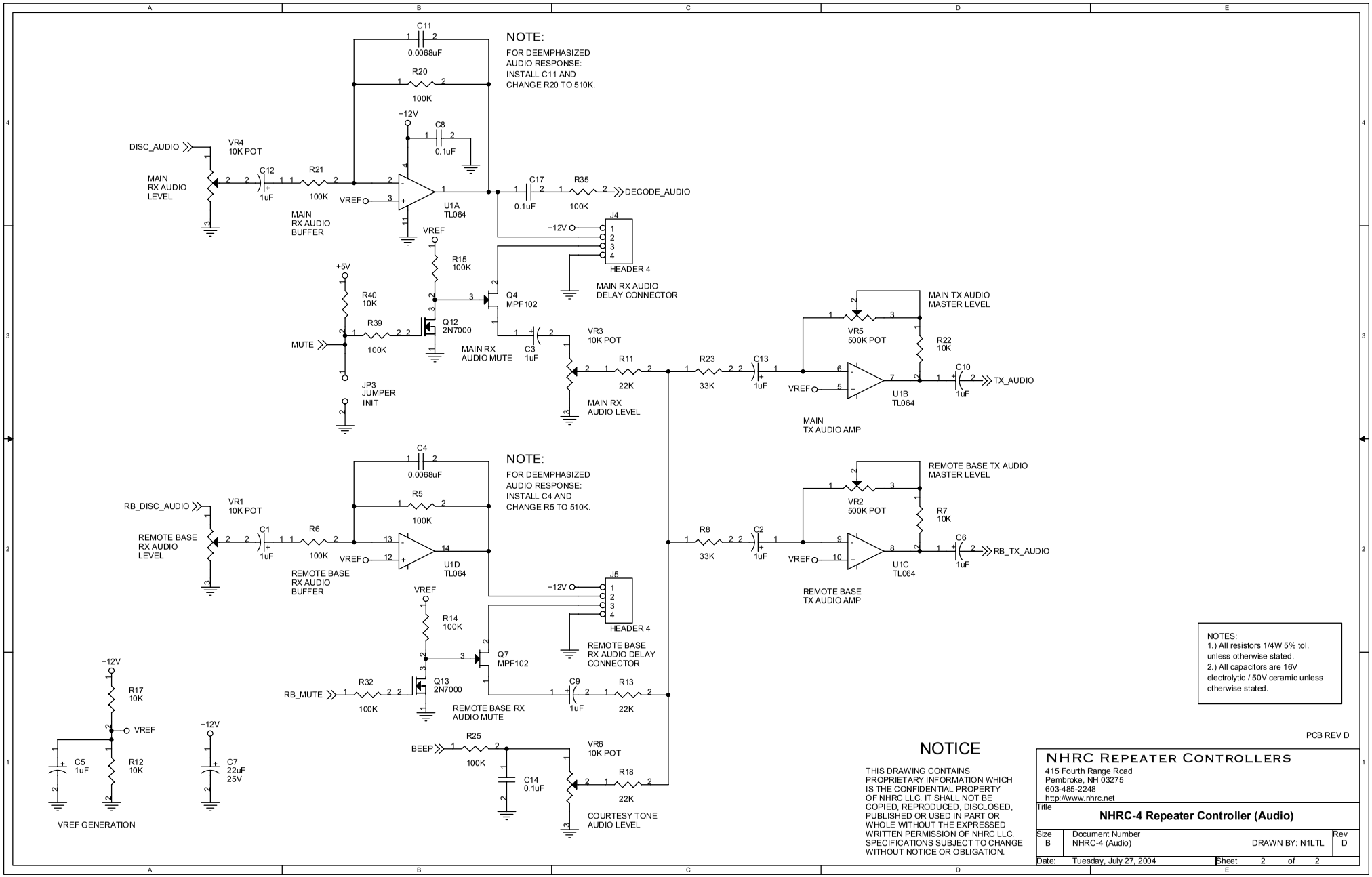
PCB REV D
NHRC REPEATER CONTROLLERS
415 Fourth Range Road
Pembroke, NH 03275
603-485-2248
http://www.nhrc.net
Title
NHRC-4 Repeater Controller (Digital)
Size B
Document Number NHRC-4 (Digital)
DRAWN BY: N1LTL
Rev D
Date: Tuesday, July 27, 2004
Sheet 1 of 2


NOTE:
FOR DEEMPHASIZED AUDIO RESPONSE: INSTALL C11 AND CHANGE R20 TO 510K.
C11
0.0068uF
R20
100K
+12V
C8
0.1uF
DISC_AUDIO
VR4
10K POT
MAIN RX AUDIO LEVEL
C12
1uF
R21
100K
MAIN RX AUDIO BUFFER
VREF
U1A
TL064
C17
0.1uF
R35
100K
DECODE_AUDIO
J4
HEADER 4
MAIN RX AUDIO DELAY CONNECTOR
R15
100K
+5V
R40
10K
R39
100K
Q12
2N7000
Q4
MPF102
MUTE
JP3
JUMPER
INIT
MAIN RX AUDIO MUTE
C3
1uF
VR3
10K POT
R11
22K
MAIN RX AUDIO LEVEL
R23
33K
C13
1uF
MAIN TX AUDIO MASTER LEVEL
VR5
500K POT
R22
10K
U1B
TL064
C10
1uF
TX_AUDIO
MAIN TX AUDIO AMP
NOTE:
FOR DEEMPHASIZED AUDIO RESPONSE: INSTALL C4 AND CHANGE R5 TO 510K.
C4
0.0068uF
R5
100K
RB_DISC_AUDIO
VR1
10K POT
REMOTE BASE RX AUDIO LEVEL
C1
1uF
R6
100K
REMOTE BASE RX AUDIO BUFFER
U1D
TL064
J5
HEADER 4
REMOTE BASE RX AUDIO DELAY CONNECTOR
R14
100K
Q7
MPF102
RB_MUTE
R32
100K
Q13
2N7000
REMOTE BASE RX AUDIO MUTE
C9
1uF
R13
22K
R8
33K
C2
1uF
REMOTE BASE TX AUDIO MASTER LEVEL
VR2
500K POT
R7
10K
U1C
TL064
C6
1uF
RB_TX_AUDIO
REMOTE BASE TX AUDIO AMP
+12V
R17
10K
VREF
C5
1uF
R12
10K
VREF GENERATION
+12V
C7
22uF
25V
BEEP
R25
100K
C14
0.1uF
VR6
10K POT
R18
22K
COURTESY TONE AUDIO LEVEL
NOTES:
1.) All resistors 1/4W 5% tol. unless otherwise stated.
2.) All capacitors are 16V electrolytic / 50V ceramic unless otherwise stated.
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Sheet 2 of 2

NHRC Repeater Controllers

NHRC-4 Repeater Controller

Bill Of Materials

PCB rev D

Item	Qty	Reference	Part	Description	Populate	Manufacturer	Manufacturer P/N	Digi-Key P/N	Notes
1	11	C1,C2,C3,C5,C6,C9,C10, C12,C13,C18,C21	1uF	1uF 16V Tantalum Cap	YES	Panasonic	ECS-F1CE105K	P2105-ND	
2	2	C11,C4	0.0068uF	0.0068uF 50V X7R Ceramic Radial Cap	NO	Panasonic	ECU-S1H682KBA	P4951-ND	*
3	1	C7	22uF	22uF 25V Aluminum Radial Electrolytic Cap	YES	Panasonic	ECA-1EM220	P5149-ND	
4	6	C8,C14,C16,C17,C19,C20	0.1uF	0.1uF 50V Z5U Ceramic Radial Cap	YES	Panasonic	ECU-S1H104MEA	P4924-ND	
5	1	C15	220uF	220uF 25V Aluminum Radial Electrolytic Cap	YES	Panasonic	ECA-1EM221	P5153-ND	
6	1	C22	100pF	100pF 100V C0G Ceramic Radial Cap	YES	Panasonic	ECU-S2A101JCA	P4849-ND	
7	2	D1,D3	LED RED	Red T1¾ LED	YES	Lite-On	LTL-4223	160-1127-ND	
8	2	D4,D2	LED GRN	Green T1¾ LED	YES	Lite-On	LTL-4233	160-1130-ND	
9	1	D5	LED YEL	Yellow T1¾ LED	YES	Lite-On	LTL-4253	160-1133-ND	
10	3	JP1,JP2,JP3	JUMPER	2 Circuit Header, .100" Straight	YES	Molex	22-03-2021	WM4000-ND	
11	1	J1	HEADER 8	8 Circuit Header, .100" Straight w/ lock	YES	Molex	22-23-2081	WM4206-ND	
12	2	J3,J2	HEADER 6	6 Circuit Header, .100" Straight w/ lock	YES	Molex	22-23-2061	WM4204-ND	
13	2	J5,J4	HEADER 4	4 Circuit Header, .100" Straight w/ lock	YES	Molex	22-23-2041	WM4202-ND	
14	3	Q1,Q2,Q6	IRF510	N Channel HEXFET 100V 5.6A	YES	International Rectifier	IRF510	IRF510-ND	
15	4	Q3,Q5,Q8,Q9	2N3904	NPN Transistor 40V 200mA	YES	Fairchild	2N3904	2N3904FS-ND	
16	2	Q4,Q7	MPF102	N Channel JFET 25V 10mA	YES	Fairchild	MPF102	MPF102-ND	
17	3	Q10,Q12,Q13	2N7000	N Channel MOSFET 60V 200mA	YES	Fairchild	2N7000	2N7000FS-ND	
18	13	R1,R2,R3,R7,R12,R17,R22, R26,R29,R30,R33,R36,R40	10K	10K ¼W 5% Carbon Film Resistor	YES	Yageo	CFR-25JB-10K	10KQBK-ND	
19	3	R4,R10,R19	100	100 ¼W 5% Carbon Film Resistor	YES	Yageo	CFR-25JB-100R	100QBK-ND	
20	11	R5,R6,R14,R15,R20,R21, R25,R32,R34,R35,R39	100K	100K ¼W 5% Carbon Film Resistor	YES	Yageo	CFR-25JB-100K	100KQBK-ND	**
21	2	R23,R8	33K	33K ¼W 5% Carbon Film Resistor	YES	Yageo	CFR-25JB-33K	33KQBK-ND	
22	5	R9,R16,R24,R27,R31	470	470 ¼W 5% Carbon Film Resistor	YES	Yageo	CFR-25JB-470R	470QBK-ND	
23	3	R11,R13,R18	22K	22K ¼W 5% Carbon Film Resistor	YES	Yageo	CFR-25JB-22K	22KQBK-ND	
24	1	R28	470K	470K ¼W 5% Carbon Film Resistor	YES	Yageo	CFR-25JB-470K	470KQBK-ND	
25	1	U1	TL064	Quad Op-Amp	YES	TI	TL064CN	296-1773-5-ND	
26	1	U2	LM7805CT	5V 1.0A Voltage Regulator	YES	Fairchild	LM7805CT	LM7805CT-ND	
27	1	U3	MT8870	DTMF Decoder	YES	Zarlink	MT8870DE		***
28	1	U4	PIC16F628-04/P	PIC Microcontroller (Blank)	YES	Microchip	PIC16F628-04/P	PIC16F628-04/P-ND	***
29	4	VR1,VR3,VR4,VR6	10K POT	10K 6mm Carbon Trimpot	YES	Panasonic	EVN-D8AA03B14	D4AA14-ND	
30	2	VR5,VR2	500K POT	500K 6mm Carbon Trimpot	YES	Panasonic	EVN-D8AA03B55	D4AA55-ND	
31	1	Y1	3.579MHz	3.579545MHz Crystal	YES	ECS	ECS-35-17-4	X079-ND	
Additional Items									
32	1			NHRC-4 PCB rev D		NHRC	NHRC-4 PCB rev D		***
33	2	R20,R5	510K	510K ¼W 5% Carbon Film Resistor		Yageo	CFR-25JB-510K	510KQBK-ND	**
34	2			18 Pin DIP Socket		Assmann	A18-LC-TT	AE8918-ND	
35	1			14 Pin DIP Socket		Assmann	A14-LC-TT	AE8914-ND	
36	1			8 Circuit Housing, .100" w/ lock and polarizer		Molex	22-01-3087	WM2006-ND	
37	2			6 Circuit Housing, .100" w/ lock and polarizer		Molex	22-01-3067	WM2004-ND	
38	2			4 Circuit Housing, .100" w/ lock and polarizer		Molex	22-01-3047	WM2002-ND	
39	28			Crimp Terminal for Molex Housing		Molex	08-50-0114	WM2200-ND	
40	5			Shorting Jumpers		3M	929950-00-I	929950-00-ND	

Notes

* Populate parts C4 and/or C11 if deemphasis is required.

** Populate 510K part for R20 and/or R5 if deemphasis is required.

*** U1, U3, U4 (Programmed) and PCB are included w/ the NHRC-4 kit.

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 it's 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 it's 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.