NHRC
REPEATER CONTROLLERS

NHRC-4/M2 Installation and Setup Guide

Hardware Version: Rev. B.

Guide Version: 2005-Aug-31

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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/M2 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/M2 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. Introduction

This manual describes how to install and set up the NHRC-4/M2 repeater controller. This manual should be used in conjunction with the NHRC-4 Operating Manual, which describes the programming and operation of the controller.

2. Installation

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

- Power and primary repeater (the GE MASTR II),
- 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/M2 Repeater Controller into a repeater system.

The controller is designed to be installed inside of a GE MASTR II mobile or station. The controller is installed onto the connectors that GE intended for the "channel guard" board. CTCSS is supported with an optional CommSpec TS-64. All of the controller's signals, for the primary and secondary radios, as well as the digital output are presented at either J908 or J909.

2.1 Primary Radio Port Connections

The NHRC-4/M2 operates using the MASTR II as the "primary" radio. The primary radio must operate in full-duplex mode. If your MASTR II is not already converted for full-duplex operation, consult the NHRC WWW MASTR II Info-site Full Duplex Conversion for duplexing information.

There are two options for interfacing the CAS and TX audio to the controller. These signals do not normally appear on the P908 plug on the system board of the MASTR II. You can either use an interface cable, or you can modify the

2.1.1 Option 1: Use an interface cable

Transmit audio and CAS appear on the controller at J1, a 3-pin header. Wire an interface cable as shown in the table below:

J1 Connections

J1 Pin #	MASTR II Signal
1	MIC HI J902 #6
2	CAS J904 #9
3	MIC LO J902 #5

2.1.2 Option 2: Modify the MASTR II System Board.

By cutting one trace and adding two wires to the MASTR II system board, the jumper described in option 1, above, can be avoided.

Add a wire that connects P908 pin 2 to J902 pin 6 (the exciter's MIC HI input). Cut the trace that leads to P908 pin 3 on the system board, and add a wire that connects P908 pin 3 to J904 pin 9 (the CAS signal from the IFAS board). Install 0 ohm resistors (jumpers) R22 and R38 on the NHRC-4/M2 board, enabling the TX audio and CAS signals on the J908 connector. Note that these jumpers may already be populated on your board. If you plan on using the local microphone on the MASTR II's control head, install a 1.5K resistor in location R38.

P908 Primary Radio Port Connections

P908 Pin #	NHRC-4/M2 Use	System Board Modification
1	Discriminator Audio	
2	Transmit Audio	Add Wire to MIC HI On Exciter (J902-6)
3	CAS	Cut existing trace to P908-3. Add Wire to CAS on IFAS (J904-9)
4	10V Regulated	
5	no connection	
6	PTT	
7	CG Encode	
	Delayed PTT	
9	Ground	

2.2 Secondary Radio Port Wiring

The controller provides the secondary radio port on the F3 through F8 frequency select leads, using the P909 connector. These leads are routed to the front panel control cable connector on the systems board. In mobile MASTR II radios, these control lines are sometimes subject to the installation of diodes and jumpers and cutting of traces to share channel elements across more than one channel selection. These diodes and jumpers must be removed, and the cut traces must be jumpered to for proper operation of the controller. Consult the MASTR II service manual for information on these jumpers.

Dissecting an old control cable makes an easy job of attaching your secondary radio to the MASTR II. In an E-chassis MASTR II, a bit of clever wiring in the systems board can allow a repeater on the "top deck" and the secondary, remote-base radio on the "bottom deck".

In base stations and repeaters, the P909 connector is unused. Individual wires must be attached to P909 to break out the secondary radio port.

P909 Secondary Radio Port Connections

P909 Pin #	NHRC-4/M2 Use	Frequency Select	J901 (control cable) Pin #
1	Secondary port CAS	F8	15
2	Secondary port PTT	F7	14
3	Secondary port CTCSS detect	F6	13
4	Secondary port receiver audio	F5	12
5	Secondary port transmitter audio	F4	11
6	Digital output	F3	10
7	no connection	F2	9
8	Unused, ground to select F1	F1	8

It is extremely important that the radio attached to the secondary radio port be provided with a common ground from the MASTR II. The "A-" lead (J901 pin 30) is a good spot. If this common ground is not provided, erratic operation or distorted audio on the secondary radio will result. Also note that the Secondary port CAS requires an active high signal. Consult the NHRC-4/M2 Remote Base Breakout Application note for instructions on converting CAS from active low if an active high signal cannot be supplied.

2.3 TS-32/TS-64 hookup

Connector JTS32 is a 7-pin header that allows the easy installation of an optional Communications Specialists TS-32 or TS-64 for CTCSS decode, encode, CTCSS audio filtering, and reverse-burst. (Reverse burst is only available with the TS-64.) Wire JTS32 to the TS-32/TS-64 as follows:

JTS32 Connections

JTS32 Pin #	TS-32 Signal	Description
1	+V POWER	+10 volts to CTCSS board
2	CTCSS DECODER INPUT	receiver audio to CTCSS decoder
3	TO AUDIO FILTER INPUT	receiver audio to audio filter input (separate lead for TS-64)
4	FROM AUDIO FILTER OUTPUT	filtered audio to controller
5	CTCSS DETECT	decode signal from CTCSS decoder *See important warning below!*
6	CTCSS ENCODER OUTPUT	CTCSS tone to transmitter
7	- GROUND & HANG-UP	Ground

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 Q4 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 JP3, the controller's audio can be passed through the audio filter on the TS-32/TS-64.

Note: If the audio filter is not used, then jumper JP3 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.

2.3.1 TS-64 Notes

Consult the NHRC-4/M2 TS-64 Application note for detailed connection instructions.

The TS-64 has a reverse-burst/PTT delay feature that can be used with the NHRC-4/M2. This feature is useful to eliminate the squelch crash received by the user's radio when the repeater transmitter drops. Note that the user's radios must have CTCSS decoding enabled for this to work. The NHRC-4/M2 provides support for the PTT delay through jumper JP4. JP4 pin 1 is the controller's PTT signal, and JP4 pin 2 is PTT to the MASTR II. If the reverse-burst/PTT delay feature is not used, then a jumper must be installed on JP4 so the controller can key the MASTR II.

Adjust the CTCSS deviation with R20 on the TS-64 board, with the "CG LEVEL" pot on the MASTR II exciter set to midrange. The ideal deviation for the CTCSS tone is 750 Hz.

Consult the TS-64 INSTRUCTION SHEET for details on setting the CTCSS frequency and the reverse burst.

2.3.2 TS-32 Notes

The TS-32 must have the JU-2 jumper cut. Use the OUT-2 signal from the TS-32 into the CTCSS detect of the NHRC-4/M2. If you want to be able to disable the CTCSS requirement, install a switch on the HANGUP lead. The TS-32 will supply CTCSS encode tone to the exciter through the NHRC-4/M2.

Adjust the CTCSS deviation with the R29 on the TS-32 board, with the "CG LEVEL" pot on the MASTR II exciter set to midrange. The ideal deviation for the CTCSS tone is 750 Hz.

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

3. Installing the NHRC-4/M2 into the MASTR II

The controller installs in the MASTR II where the MASTR II "Channel Guard" board normally belongs, plugged into the top of the systems board in the front of the radio. If you have not already removed the Channel Guard board, do so now by pulling it straight up and out of the radio. The NHRC-4/M2 installs with the component side of the board facing the control head cable connector. Carefully line up the P908 (left side) and P909 (right side) connectors with the pins on the system board. Push the board down firmly until the connectors are right against the system board. The controller is now installed.

3.1 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 a valid CTCSS decode signal. The appropriate green LED should light when its receiver is active, and, if a CTCSS decoder is present, 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 its respective transmitter is transmitting.

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

3.2 Installing the NHRC-DAD with the NHRC-4/M2

J2 Primary Radio DAD
J3 Secondary Radio DAD

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

The audio delay for the primary radio simply plugs in to J2. The audio delay for the secondary radio plugs in to J3. 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.

It is strongly recommended that the CTCSS filter be used, as described above, if both CTCSS encode/decode and the audio delay are used.

See the Operation Instructions section on programming the flag bits to tell the controller the delay is present.

3.3 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 500 mA. 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, to enable or disable CTCSS. 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.

3.4 Adjusting the Audio Levels

Audio Level Adjustments

Potentiometer	Use
VR1	Primary Receiver Level
VR2	Secondary Receiver Mix 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 D5.

Note: If VR1 is set too high, a crackling noise may be heard in the transmitted audio during the hang time. Reduce the level set by VR1 until this noise goes away. Any repeated audio level reduction caused by adjusting VR1 can be compensated for by adjusting VR3 (primary receiver level) or VR5 (primary transmitter output level.)

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 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 VR6 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 primary receiver's audio mix level, and may not need to be adjusted from midpoint.

4. Appendices

4.1 Terminology and Abbreviations

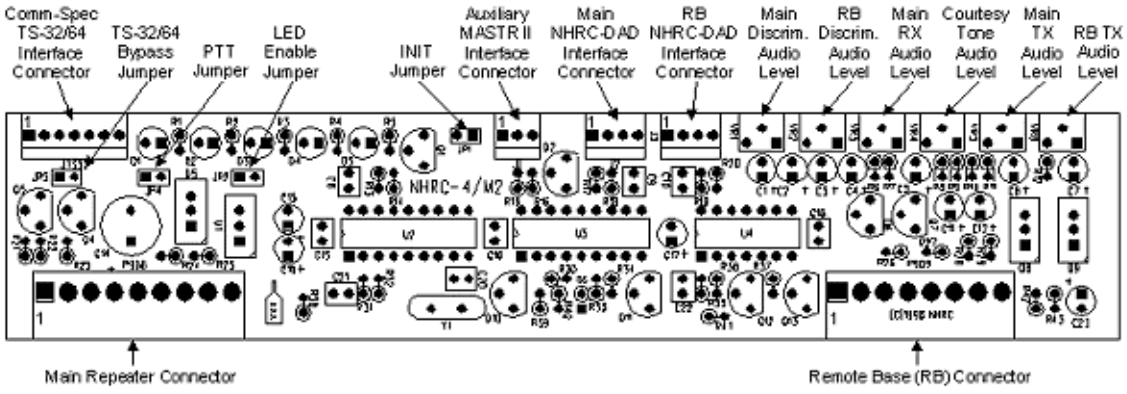
Term	Description
CAS	Carrier Activated Squelch, where receipt of a signal, with or without CTCSS tones will activate the controller.
CW	Continuous Wave signals, commonly using “Morse Code.” The term “CW” refers to the radio emission type, while “Morse Code” refers to the signaling type used. Typically, 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

5. Circuit Board

5.1 Interconnections

Connector	Name	Purpose
P908	"REPEATER"	Connects the **primary** repeater transmit and receive audio, PTT, CAS, fan control, and power signals to the controller.
P909	"REMOTE BASE"	Connects the **secondary** repeater transmit and receive audio, PTT, and CAS signals for the radio to the controller.
J1	"AUX"	Supplies MIC HI and CAS signals for unmodified MASTR Iis (with no system board modifications for the NHRC-4/M2)
J2	"DELAY"	Connects power and audio signals for operation of the Digital Audio Delay (NHRC-DAD) board for the **primary** radio port.
J3	"RB DELAY"	Connects power and audio signals for operation of the Digital Audio Delay (NHRC-DAD) board for the **secondary** radio port.
JTS64	"JTS64"	Interfaces a Communications Specialists TS-64 to the controller for CTCSS detection.

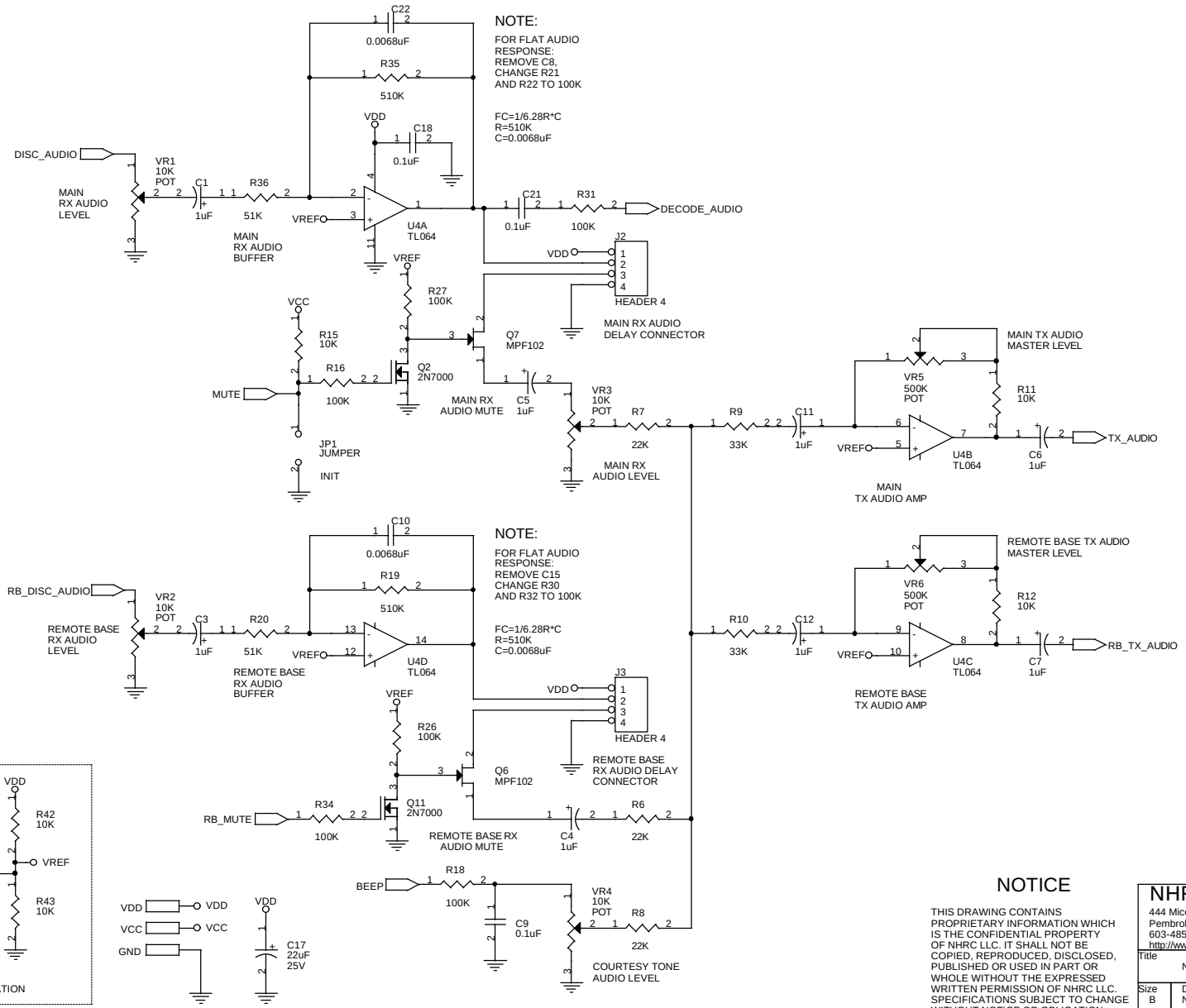
This is a detailed top view of the Revision "B" printed wiring board for the NHRC-4/M2 Repeater Controller.



6. Schematics

The following two pages the schematic diagram for the Revision “B” Version of the NHRC-4/M2 Repeater Controller.

PCB REV B



NOTES:
1.) VDD = +12VDC
2.) VCC = +5VDC
3.) VREF = +6VDC (or 1/2 VDD)
4.) ALL RESISTORS ARE 1/4W 5% TOL. UNLESS OTHERWISE STATED.
5.) ALL CAPACITORS ARE 16V ELECTROLYTIC / 50V CERAMIC UNLESS OTHERWISE STATED.

NOTICE

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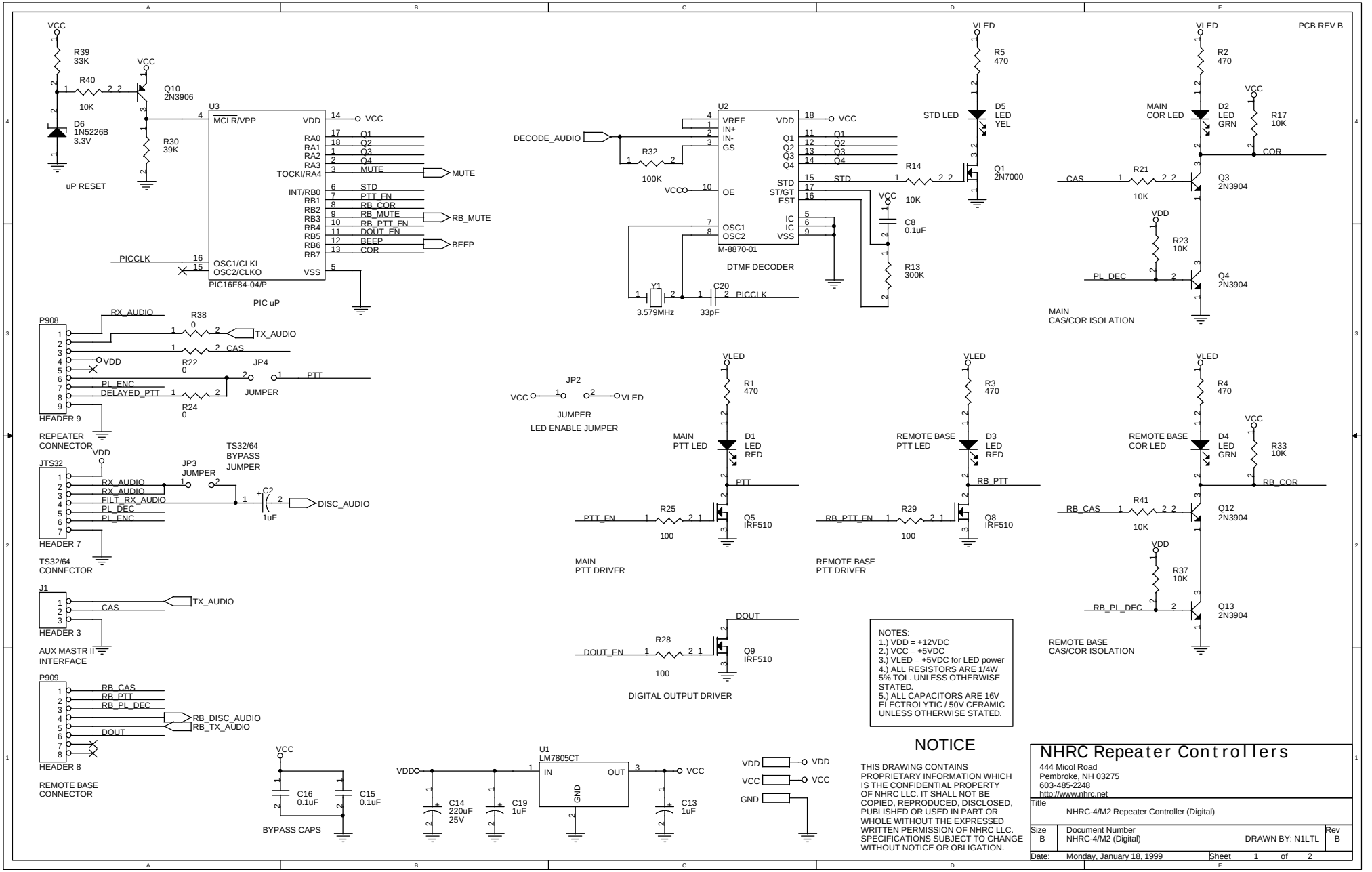
Title	NHRC-4/M2 Repeater Controller (Audio)	
Size B	Document Number NHRC-4/M2 (Audio)	Rev B
Date: Friday, November 06, 1998	DRAWN BY: N1LTL	Sheet 2 of 2


PCB REV B
uP RESET
PIC uP
PIC16F84-04/P
DTMF DECODER
M-8870-01
MAIN
CAS/COR ISOLATION
REPEATER
CONNECTOR
HEADER 9
TS32/64
CONNECTOR
HEADER 7
AUX MASTR II
INTERFACE
HEADER 3
REMOTE BASE
CONNECTOR
HEADER 8
LED ENABLE JUMPER
MAIN
PTT DRIVER
REMOTE BASE
PTT DRIVER
DIGITAL OUTPUT DRIVER
REMOTE BASE
CAS/COR ISOLATION
BYPASS CAPS
NOTES:
1.) VDD = +12VDC
2.) VCC = +5VDC
3.) VLED = +5VDC for LED power
4.) ALL RESISTORS ARE 1/4W 5% TOL. UNLESS OTHERWISE STATED.
5.) ALL CAPACITORS ARE 16V ELECTROLYTIC / 50V CERAMIC UNLESS OTHERWISE STATED.
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Title
NHRC-4/M2 Repeater Controller (Digital)
Size B
Document Number NHRC-4/M2 (Digital)
DRAWN BY: N1LTL
Rev B
Date: Monday, January 18, 1999
Sheet 1 of 2

7. Parts List

The following is the bill of materials for revision "B" of the NHRC-4/M2 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	IRFI510G		N Channel HEXFET	IRF	IRFI510G	or equivalent
		Q6	IRFI510G		N Channel HEXFET	IRF	IRFI510G	or equivalent
		Q9	IRFI510G		N Channel HEXFET	IRF	IRFI510G	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/M2 PCB REV B	NHRC	NHRC-4/M2 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.

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