NOTES

The National 220 MHz Newsletter

REPEAT YOUR 13-509

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TURN YOUR TIN LIZZY OF 220 INTO A REAL MACHINE!

(Editor's Note: Since starting 220 NOTES over a year ago, the most often requested article has been one on "how to put a Midland 13-509 rig on as a repeater. Finally, Chuck Adams, WB5WRR, has answered the challenge. Here, in its entirety, is that article. Both Chuck and I would greatly appreciate your comments.--Ed.)

This article will describe the construction of a simple, solid-state, 220 MHz repeater, based on the popular and ubiquitous Uniden boards (Midland 13-509, Clegg FM-76, and Cobra 200 220 MHz mobile transceivers). The article will cover the splitting apart of one of these radios into the receiver, exciter, and power amplifier components and construction of solid-state COS (carrier operated squelch) TOT (time-out timer), audio gating and tail-timer (squelch tail) circuitry.

The major benefits of such a package are:

1. Completely self-contained carrier sensing, audio gating and transmitter-keying. No relays or associated relay problems; i.e., dirty contacts, intermittant contacts or the like.

2. Instantaneous keyup of the transmitter upon receipt of signal. No relay pull-in delays.

3. Fully adjustable time-out timer and tail-timer intervals.

4. Crisp, clean and fully adjustable transmit audio. The repeat audio is not affected by the setting of the volume control. Set the repeater audio once, and forget it!

5. Easy interfacing of external devices (i.e., ID, remote base, etc.)

6. Ease of construction, and minimal expense.

One word of advice BEFORE getting out your cutters and soldering irons: make sure that the radio you plan to cut apart to make your repeater works properly FIRST.

CAUTION: DO NOT ATTEMPT THIS CONVERSION UNTIL YOU HAVE READ AND UNDERSTOOD ALL THAT IS INVOLVED.

Don't find out later that you have cut apart a radio that has problems, because it will be that much harder to troubleshoot it once its lying on the table in pieces!

This article was written in a manner that will hopefully be understood by most people who have some technical (i. e., electronic) knowledge. For the optimum performance of this repeater package, additional knowledge and/or test equipment will be required.

To get the package operating at its best, will require a complete receiver and transmitter alignment. The typical Midland receiver whould hear at least 0.3 uv for 20 dB of quieting. However, few come out of the factory tuned that well. The typical Midland transmitter package should deliver 13 to 16 watts output.

As they comes from the factory, the typical '509 is sweep-tuned to cover the top three MHz of the band. When tuned to your specific frequency pair, additional performance may be realized.

One word of advice BEFORE getting out the cutters and soldering iron: Make SURE that the radio you have works properly FIRST. Don't find out later that you cut apart a radio that has problems, because it will be that much harder to troubleshoot it once it is lying in pieces on the table!

Now that you're ready to begin, grab those wire cutters (most likely with some fear and trepidation, as I did when about to chop up a perfectly good radio), and get started!

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NEW DISTANCE RECORD ON 220 MHz

(Thanks to ARRL and KA9JFR, who sent it in)-- A new world record was set for 220 MHz at 0000Z, March 13, when KP4EOR contacted LU7DJZ over a distance of approximately 3670 miles. The contact was made via transequatorial propogation, utilizing both CW and SSB.

REPEAT YOUR 13-509 (continued from page 1)

EXCITER PREPARATION

Unscrew the exciter board from the radio chassis, and follow these step-by-step instructions to ready the exciter for repeater service:

__1. Cut off, at the board, the following wires: receiver channel wires 1 through 12, transmitter channel wires 1 through 12, wires 25, 26, 28, and 31. None of these wires will be used in repeater operation.

__2. Unplug the RF ouput coax from exciter terminals #29 and 30.

__3. Unsolder the audio coax from R79 and ground (exciter wires # 23 and 24). Leave R79 on the board.

__4. Cut off exciter wire #27 at the relay board in the back of the radio (this wire is usually red.)

__5. Unsolder the ground braid of the coax going to the receiver board from underneath the exciter board.

__6. Jumper the transmitter channel #1 wire to exciter Wire #31 (ground). Place your transmit crystal wire in the transmitter channel #1 socket.

__7. Remove TR24 and jumper the former emitter and collector traces together on the bottom of the board. This disables the VSWR protection circuitry which is neither wanted or needed in repeater service. If not removed, TR24 can cause serious spectral purity problems when stray RF energy gets into it.

__8. Remove a receiver crystal trimmer cap (C47) and a loading cap (C59) and save for future receiver modifications (to be described later).

__9. Mount the modified exciter board in an RF-tight box (die-cast aluminum is preferred) by the four corner mounting holes, using spacers.

Attach the following cabling as described below to an external connector (preferably through feed-through capacitors for all but the exciter RF output):

__1. Solder a piece of coaxial-type audio cable to R79 (center conductor) and ground (exciter wire #23). Attach the other ends to the external connector.

__2. Solder a wire to the exciter board and run it to the connector.

__3. Make provisions for B+ 12 volts and PTT input terminals and run it to the connector. This will be used for the PTT-tail timer circuit to be described later.

__4. Solder a piece of 50 ohm miniature RF coax (RG-174 or equivalent) to exciter wires #29 (center conductor) and 30 (shield ground), and attach to a BNC or SO-239 connector mounted on the box.

__5. You will have one wire left unconnected. This is exciter wire #27, which keys the exciter when 12 volts B+ is applied. This wire will be attached later.

POWER AMPLIFIER PREPATIONS

__1. Unscre the power amplifier assembly from the radio chassis

__2. Cut off the wire attached to the red feed-through capacitor located closest to the pre-driver transistor at the relay board (this wire is usually yellow).

__3. Attach the free end of this wire to the other feed-through cap which already has a wire on it (this wire is usually red), and cut off the red wire AT THE RELAY BOARD. Leave the RF choke attached between the two feed-through caps closest to each other.

You will now have all three feed-through caps attached to each other, with the free end of the red wire your B+ line.

__4. Cut the RF output coax going to the relay board at the relay board end.

__5. It is strongly suggested that the heavy metal plate to which the pre-driver and power transistors are mounted be removed at this time. Be careful that you do not break any parts which would be used in the repeater.

__6. Mount the power amplifier assembly in an RF-tight box (again, die-cast aluminum is preferred). Mount the amplifier board on the LID of the box, adding heat-sinks to the power transistor studs, and remounting the pre-driver transistor to the outside of the box lid.

__7. Attach the input and output coax lines from the amplifier to connectors (either BNC or SO-239) (C'mon now, Chuck--BNC!--Ed.)

__8. Attach the red wire from the feed-through caps and a wire connected to the power amplifier chassis to an external connector (preferably via feed-through caps) as B+12 volts and ground, respectively.

RECEIVER MODIFICATIONS

Follow these step-by-step instructions to ready the receiver for repeater service:

__1. Unscrew the receiver board from the radio chassis.

__2. Remove the squelch and volume pots from the chassis, leaving all associated wires between the pots and the receiver board intact.

__3. Unsolder the wire (usually purple) from the 27k ohm resistor on the volume pot. leave the resistor attached to the pot.

__4. Unsolder the center conductor of the coaz cable going from the receiver board to the channel select switch AT THE SWITCH. The ground braid of the coax should have already been removed from the bottom of the exciter board.

__5. Cut receiver wire #19 at the relay board in the back of the radio.

__6. Cut receiver wire #18 at the speaker jack in the back of the radio.

__7. Cut receiver wire #17 at the speaker terminal on the back of the receiver.

__8. Cut receiver wire #21 at the receiver board. (this is the former S-meter wire).

__9. Cut the RF input coax going from receiver terminals #15 and #16 to the relay board, at the relay board end.

__10. Attach a wire to the collector of TR13 on the bottom of the receiver board. This wire will attach to the COS sense input of the COS, TOT, and the audio gate circuit, which will be described later.

__11. Rebuild the receiver trimmer cap and loading cap circuit which was on the transmitter exciter board, using C47 and C59 which you previously removed from the

(Continued on next page)

REPEAT YOUR 13-509 (continued from previous page)

__12. Mount the modified receiver board in an RF-tight box (again, die-cast aluminum is preferred) by the four corner mounting holes of the board. Use spacers.

Attach the following cabling as described below to an external connector (preferably via feed-through cap except for the RF input):

__1. Solder the free end of the coax coming from the RF input to a BNC or SO-239 connector mounted on the box. (The center conductor of the coax comes from receiver terminal #16 on the board.)

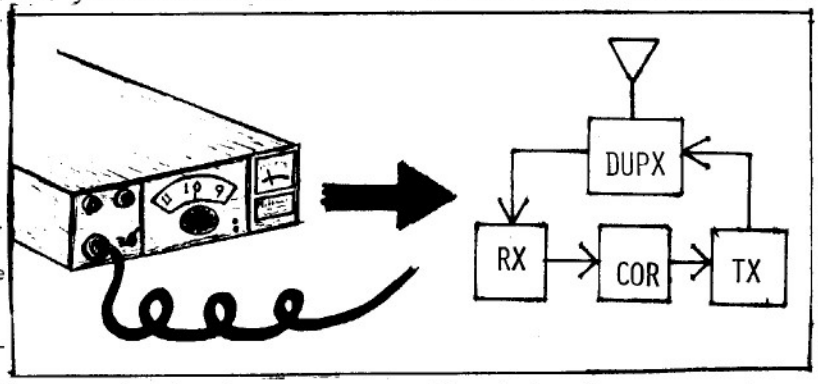
__2. Attach receiver wire #19 (usually orange) to B+ 12 volts on the external connector.

__3. Attach receiver wire #17 (usually black) to the external connector. This is the ground connection.

__4. Attach receiver wire #18 (usually blue) to the external connector for local speaker high-power feed, if desired.

__5. Mount the volume and squelch pots on the box.

__6. You will have one wire not connected: the wire to the collector of TR 13. This wire will be connected to the COS sense input of the COS, TOT, and audio gate circuit, later.



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NOTES ON THE FEEDTHROUGH CAPACITORS USED IN THIS PROJECT

In all cases where feed-through capacitors are suggested, use 1000 uuf (1000 pf, or .001) BOLT-ON caps ONLY Higher value capacitors can cause audio shaping problems, while lower value casp may not provide enough capacitance to ground to remove stray RF in the leads. Bolt-on caps are required since it is rather difficult to solder to aluminum! Erie brand feed-through capacitors are reccomended by this writer.

COS, TOT, AND AUDIO GATE CIRCUIT CONSTRUCTION

Refer to the Scematic in Figure 1, and construct the circuit from that schematic. Either point-to-point soldering or wire-wrap construction is acceptable. I would suggest building the circuit on a 44-pin edge card and mounting it in a socket on the inside lid of the receiver box. This circuit will provide a COS output (active "low") and gated audio to the exciter circuit, while providing for a repeater timeout function.

PTT AND TAIL-TIMER CIRCUIT CONSTRUCTION

Refer to Figure 2 (next page) and construct the circuit from that schematic. I would suggest building the circuit on a small piece of perf-board which can them be attached to the inside of the lid of the exciter box with double-sided tape, or spacers. This circuit provides the transmitter on-off switching and carrier delay, and is driven by the output of the COS, TOT, and audio gate circuit, or any other device which goes Low Active.

The exciter draws approximately 110 ma. at 12 volts DC when keyed. An NE555 or NE556 timer chip is capable of sinking 150 ma. on its output. AN NE556 is suggested in this application due to its larger package size and heat dissipation characteristics. Note that only half of the chip is used. The output of the timer chip is high (+12 V. DC) when active, and will drive the exciter directly. Instant solid state! The power amplifier is connected to +12 volts at all times and is a Class C device: no RF output and no current draw occurs if there is no drive from the exciter.

FINAL ASSEMBLY

Upon completion of all the preceding work, I would suggest mounting these boxes on a rack panel. Mall all of the appropriate connections between the finished components, such as the audio, keying, supply voltages, and RF. Double check all of your work up to this point

Now you are ready to power up the box and make the final adjustments.

FINAL SETUP AND ADJUSTMENT

At this point, you should have completed the layout and construction of the repeater. I will assume that you have already set up both the receiver and exciter to their

(continued on page 6)

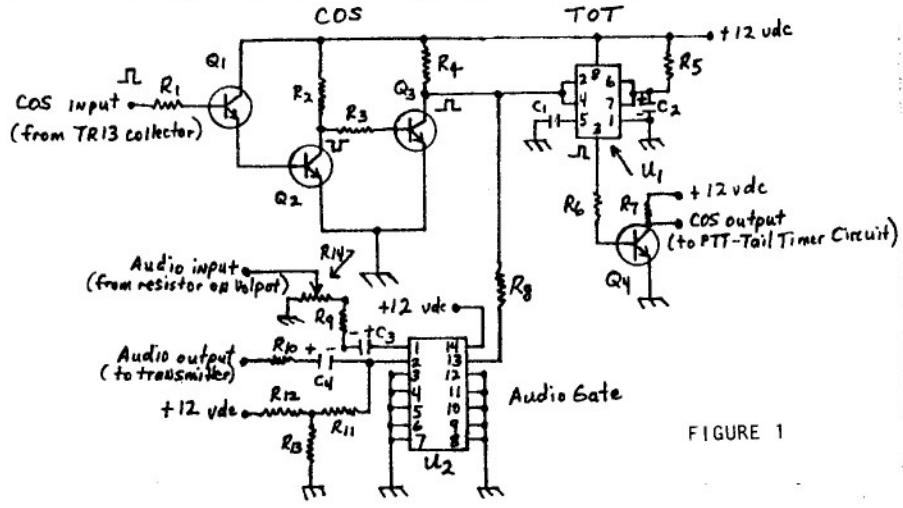

FIGURE 1

PARTS LIST, Figure 1

R1, R2, R3	--15k, ½watt
R4, R7	--3.3k, ½ watt
R5	--470k, ½ watt, or 1 meg pot*
R6	--1k, ½ watt
R8	--10k, ½ watt
R9, R10	--10 ohms, ½ watt
R11	--100k, ½ watt
R12, R13	--15k, ½ watt
R14	--50k pot
Q1-Q4	--2N2222A
U1	--NE555 IC
U2	--CD4066 CMOS IC
C1	--.01 ufd. disk
C2	--220 ufd. 16 vdc electrolytic
C3, C4	--2.2 ufd. 16 vdc electrolytic

* 470k ohms gives about 4 minutes of timeout interval.

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proper operating frequencies. About all that needs to be adjusted on the repeater is the audio deviation.

The only pot on the exciter board is the deviation adjustment. Many people commonly refer to it as the "mic gain" adjustment, but its not that really. Set the deviation of the exciter to a maximum of ±5kHz with the audio source feeding it (from the receiver) at maximum level.

R14 on the COS-TOT/audio gate circuit controls the receiver audio. Set R14 for what I call "unit gain"; that is, a transmitter deviation of ±2kHz on the repeater receiver input (for example, a single tone out of a Cushman or some other test box, set for 2 kHz deviation, and feeding your repeater receiver) should cause the transmitter on the repeater to also deviate 2kHz. This will allow for a smooth audio response. However, any audio input which deviates more than 5kHz soming into the repeater receiver will be limited (clipped) to the 5kHz preset maximum at the repeater transmitter, as it should be.

COMMENTS ON DUPLEXERS

Your system is only as good as its weakest link, so don't scrimp on either the duplexer or the antenna. I have found that reject-only duplexers, such as the Phelps Dodge "mobile" type, will not give good results by themselves because there is no attenuation of transmitter white noise around the receiver frequency. This may be overcome by the addition of a band-pass cavity at the receiver, tuned to the receiver frequency (a fairly high Q is desirable here), or by using duplexers with both pass and reject characteristics. Examples of these are WACOM, TX/RX, and Decibel Products.

Make sure to use double shielded coax cable, such as RG-214, for all duplexer cables

IN CONCLUSION

Repeaters have a reputation of being "strange critters, and all kinds of quirks and glitches can occur which can sometimes frustrate the builder. However, if you plan your system well, use good construction practices and equipment, plus a dose of common sense, you can build a machine of which you can be proud, a machine which will operate for long periods of time with little or no maintainance.

So, Heat up those soldering irons, sharpen your wire cutters, and get cracking---YOU can build one, too!

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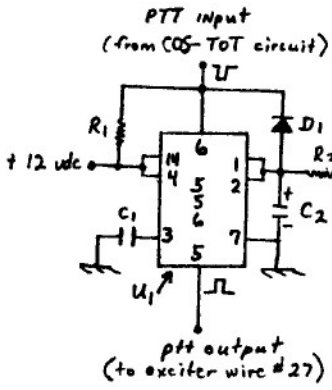

FIGURE 2

PARTS LIST, FIG. 2

R1--3.3k, ½ wt.
R2--22k, ½ wt., OR 50k pot*
C1--.01 ufd. disk
C2--100 ufd., 16 vDC
D1--1N914
U1--NE556**

*22k ohms equals about 4 seconds of delay

** no connection to pins 8, 9, 10, 11, 12, or 13.