Build a GaAsFET Preamp Sequencer

Mast-mount your preamp for maximum performance.

by Ron Klimas WZ1V (ex-WA1VRH)

Thinking about mast-mounting a receiver preamp for your VHF/UHF station? Build this digital sequencer for uncurtailed SSB or semi-break-in CW operating!

If your VHF/UHF station has a few dB of feedline loss, and you use a transceiver, mast-mounting a GaAsFET preamp offers significant receive improvement. You can mount the preamp in-line with the main feedline using a pair of SPDT coaxial relays for isolation during transmit. The big problem is to keep that transmitter RF out of your preamp. Avoiding the pitfalls of a blown device will require adequate relay isolation, transient suppression, and timing control of your transceiver, linear amplifier, and relays.

Circuit Information

The sequencer circuit is shown in Figure 1. A 7805 on-board regulator allows operation from a single 12-volt supply, and provides RFI immunity. Key elements of the sequencer are an RS flip-flop, U2 pins 8–13, used to guarantee continuity of preamp bypass at the beginning of a transmit sequence; and a nominal 110 millisecond delay generated by integrator (R1 + R2) * C1 feeding into Schmitt-trigger U4. This gate has a volt of hysteresis with a positive threshold of 2.8V, and a negative threshold of 1.8V. This guarantees that the output cannot change state until C1's charge changes by at least a volt, thus ensuring a fixed minimum delay under worst-case input conditions. More on this subject later. Bypass switch S1 is provided to manually disengage the preamp. Mode switch S2 routes the keying to either PTT or CW input.

When a ground closure from either the mike PTT or CW key is applied, U3 pin 6 goes high. This sets the RS flip-flop Q output at U2 pin 10 and disengages the preamp. C1 charges toward the positive threshold of Schmitt-trigger gate U4 pin 1.

After a 110 ms delay from (R2 + R1) * C1, U4 pins 4 and 10 go high. This enables AND gate U1 to key the transmitter. The preamp is held disengaged via U2 pin 3 high, and the flip-flop is reset for the next cycle.

Most transceivers go into a non-defeatable

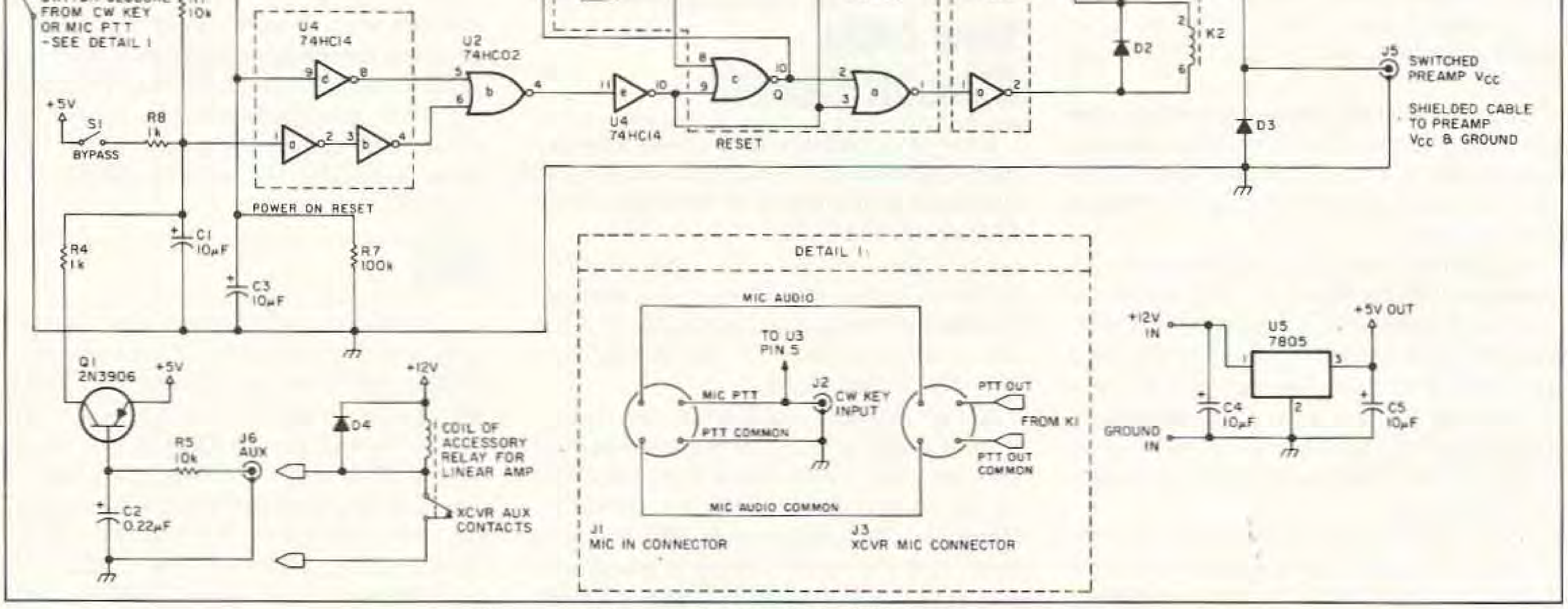

Figure 1. Schematic for the GaAsFET preamp sequencer.

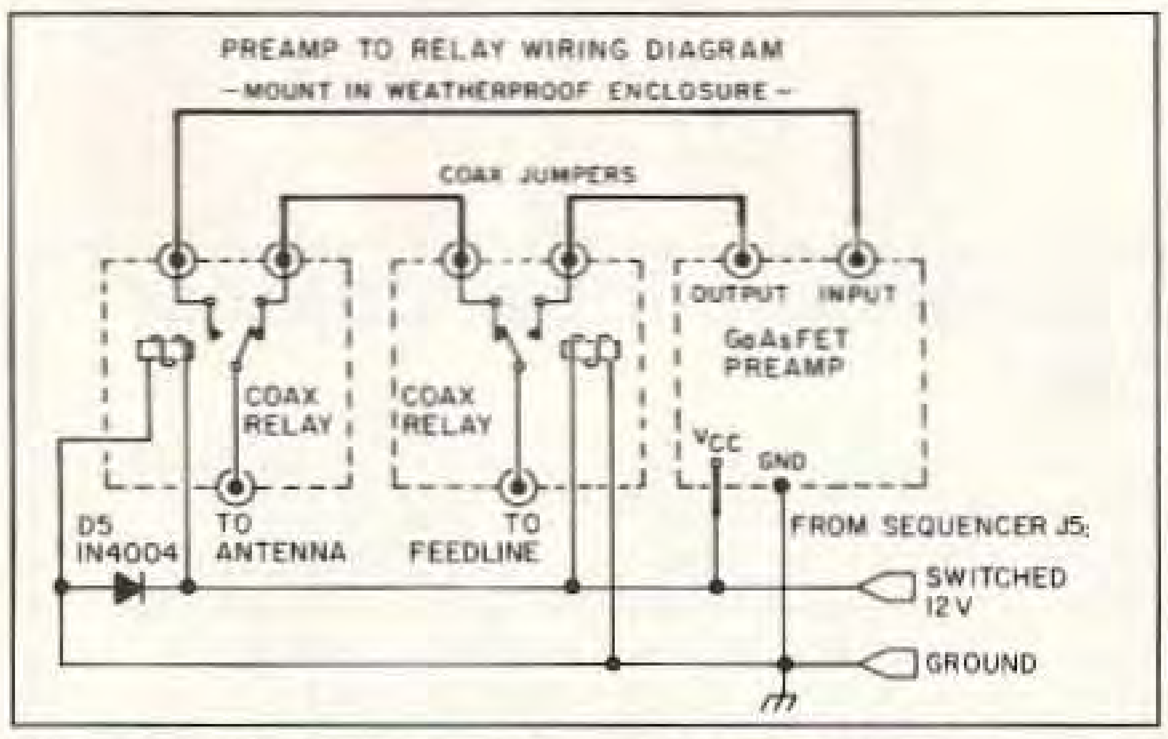

Figure 2. Mast-mounted preamp-to-relay wiring diagram.

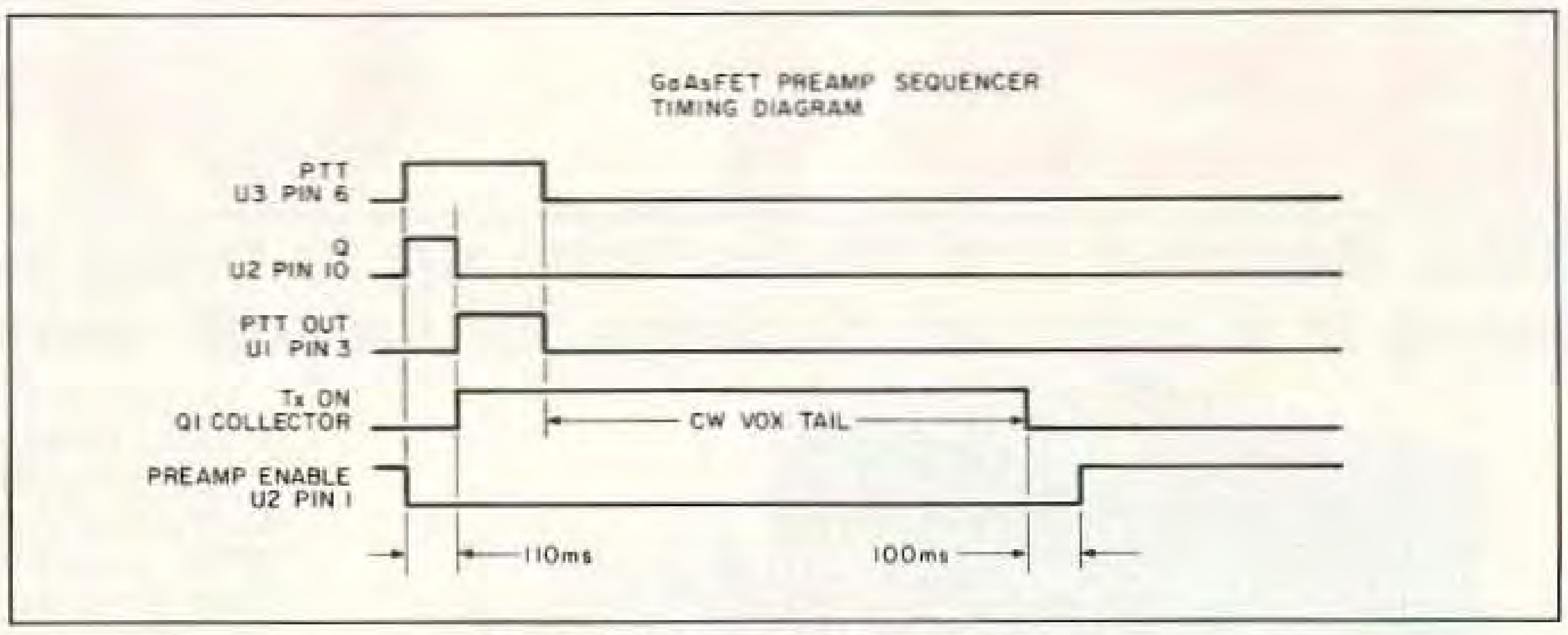

Figure 3. Sequencer timing diagram.

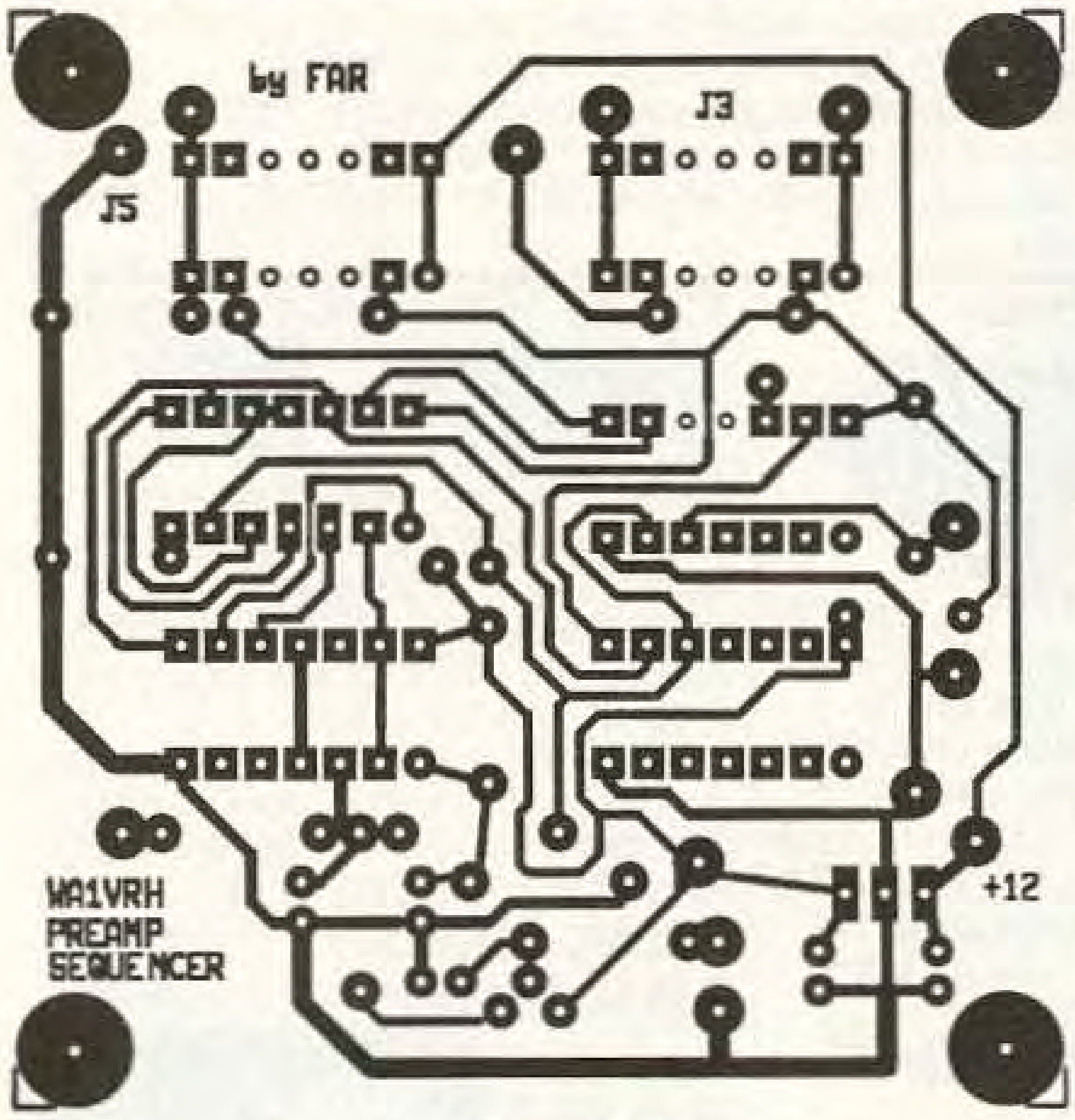

Figure 4. PC board foil pattern.

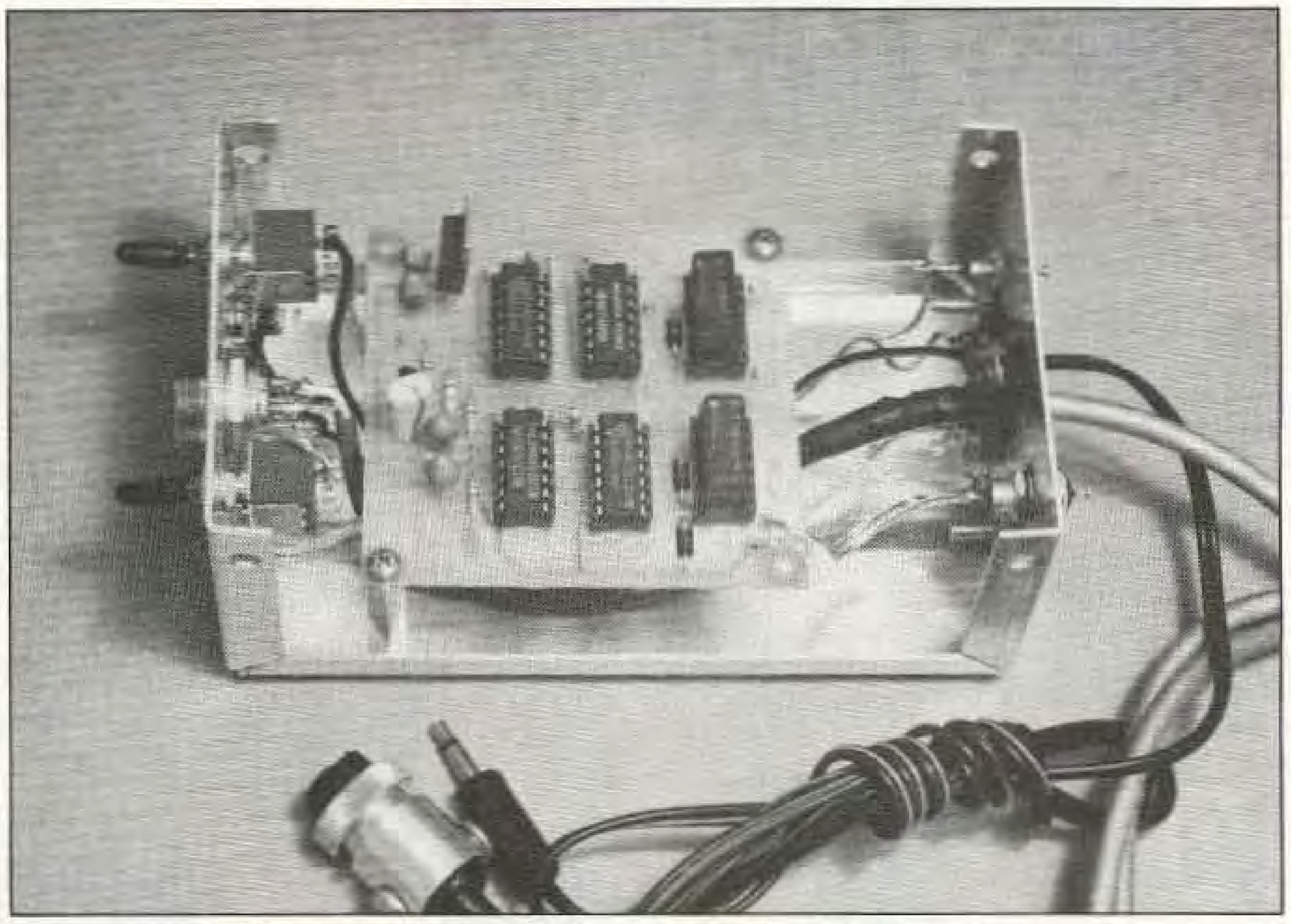

Photo. Inside view of the completed preamp sequencer.

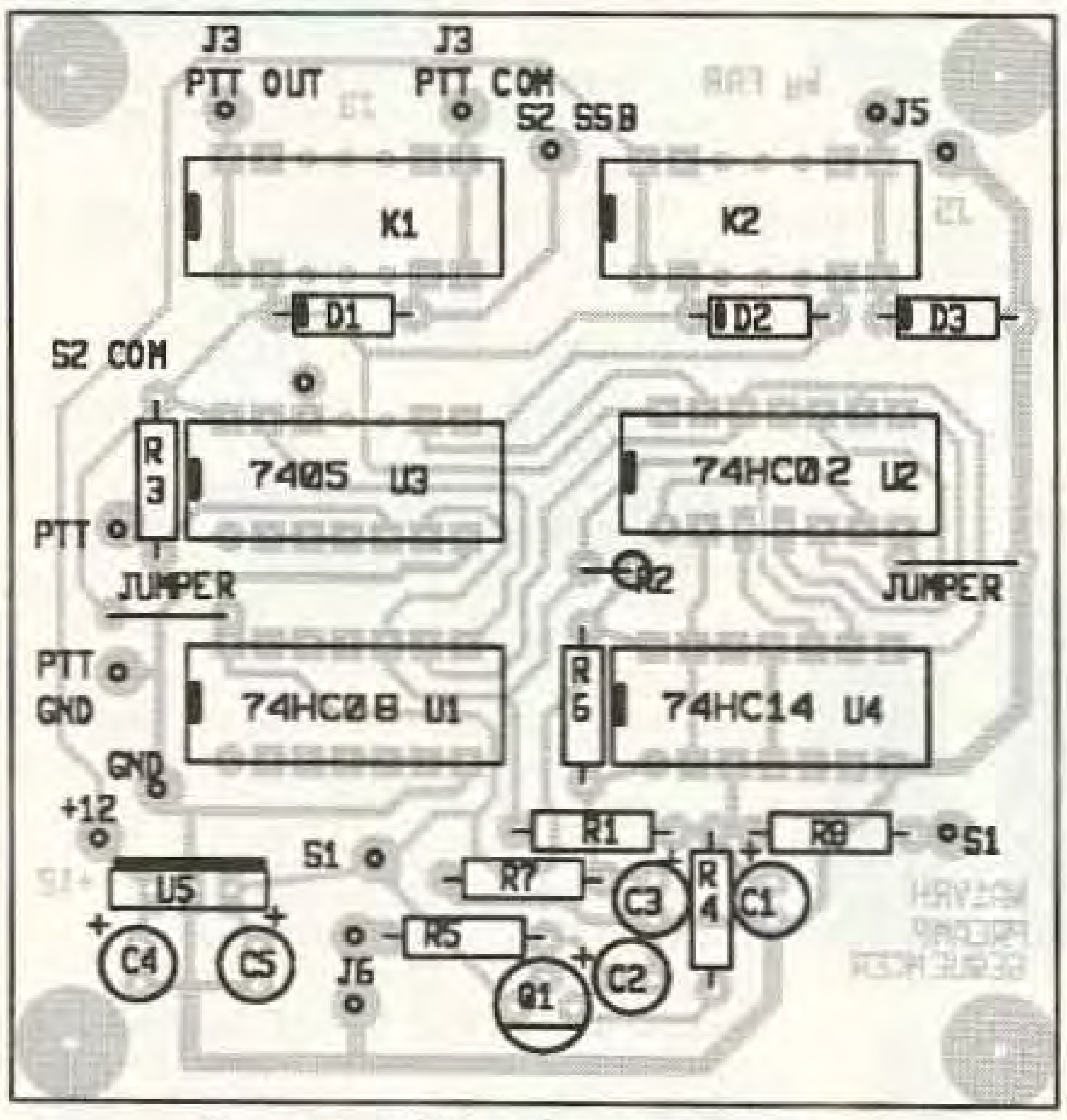

Figure 5. PC board parts placement.

GaAsFET Preamp Sequencer

Part	Description
U1	74HC08 AND IC
U2	74HC02 NOR IC
U3	7405 open collector inverter IC
U4	74HC14 Schmitt inverter IC
U5	7805 +5VDC regulator
Q1	2N3906 PNP transistor
C1,3,4,5	10 µF, 25V tantalum, 20% or better
C2	0.22 µF, 25V tantalum, 20% or better
R2,3,4,8	1.0k, 0.25W, 5%
R1,5,6	10k, 0.25W, 5%
R7	100k, 0.25W, 5%
D1,2,3,4,5	1N4004 rectifier or equivalent
J1,3	mike chassis connector
J2,4,5,6	mini-phone jack open circuit
K1,2	5V coil SPST DIP relay Mouser P/N 433-D31A310 or equivalent
S1,2	SPDT mini toggle switch
CC1,2	16-pin component carrier adapter plug

All parts are available through Mouser Electronics, P.O. 699, Mansfield TX 76063; (800) 346-6873. A blank PC board is available for $4 + $1.50 shipping per order from FAR Circuits, 18N640 Field Court, Dundee IL 60118.

VOX mode during CW semi-break-in operation. This is a fast attack, slow decay VOX that holds the transmit mode on between CW characters while you send, preventing relay chatter. Unfortunately, residual RF is usually present at the output during this apparently idle mode. A linear amplifier would most surely bring this up to a level that could be potentially damaging to a preamp engaged in the line. The decay time of this "VOX tail" also varies from rig to rig. Therefore, the sequencer must be able to sense this condition and keep the preamp disengaged. This is done by interfacing the transceiver's AUX contacts, used to hard-key a linear amp, into the sequencer via Q1. The fixed minimum worst case time for the Schmitt trigger to change state is 44 ms. This is derived from the following capacitance discharge equation:

$$V_{C1} = E_{MAX} \bullet e^{-t/RC}$$
$$1.8 = 2.8 \bullet e^{-t/10k \bullet 10\,\mu F}$$
$$0.643 = e^{-t/100ms}$$
$$\ln(0.643) = -0.442$$
$$0.442 = t/100ms$$
$$t = 44.2\ ms$$

The time constant (R5 × C2) for Q1 to conduct after the AUX contacts close is only 2.2 ms, however. Therefore, Q1 will recharge C1 long before a state change could occur. The integrator R1 × C1 is forced to guarantee a full discharge cycle of 100 ms, maintaining absolute protection of your preamp at all times. None of the commercial or published designs I've seen yet will guarantee this level of timing integrity on both the make and break sides of the cycle under every type of input condition. A popular design, using comparators with inadequate hysteresis and no latching/feedback techniques, may work fine on SSB, but invites disaster on CW. Figure 3, the timing diagram, summarizes this system's operation.

A power-on-reset is provided to reset the flip-flop to a known state on power-up. 1N4004 diodes are placed across all relay coils for transient suppression.

Construction

If you don't want to use the PC board patterns, you can construct the circuit on a 0.100-inch grid phenolic prototype board using wire-wrap sockets and component carrier adapter plugs for passive components. Use short connections between C4, C5, and U5, however. The 1N4004 diodes connections across each relay coil should also be kept short. (Don't forget to solder one across your accessory relay coil).

> ***"It is advisable to test your circuit before wiring in your preamp head/coax relays."***

If you have two or more items to key on transmit (such as a transverter and a linear amplifier), you will need an accessory relay with as many pairs of contacts as you have items. If you use your AUX contacts to directly key your only accessory, install a 2.2k resistor between the J6 tip and +12V. If your transceiver outputs a positive voltage on transmit, feed it through a 2.2k resistor into the base of an NPN power transistor to switch your 12V accessory relay, wiring it's collector and grounded emitter to J6. The relay coil connects between +12V and the collector.

The chassis-mounted mike connectors are mounted on the aluminum box enclosure, and are wired to bypass all signals except PTT and CW in/out.

You will need to make up jumper cables to mate with your transceiver's connectors. Be especially certain of the integrity of the connection from your AUX contacts and J6, since this provides closed-loop feedback to the sequencer. Another consideration is the connection between the sequencer and preamp/relays. I have tried in the past to use the main feedline shield as power ground to the preamp, with a single wire for switched Vcc. I can tell you from experience what happens if you forget to turn off your GaAsFET while unscrewing the feedline connector from your equipment. The inductive kickback, having no path to bleed off, blew a device. The diodes absorb the transient only while ground is connected. Use an unspliced length of RG-58/59, or some kind of shielded cable, for DC power to save yourself this experience!

Circuit Check-Out

It is advisable to test your circuit before wiring in your preamp head/coax relays. Connect your microphone and CW key to the sequencer. Make no connections to your transceiver yet. Obtain three LEDs and a 47 µF capacitor. Observing polarity, clip lead the 47 µF capacitor in parallel with C1. Solder 1k resistors in series with each LED. Observing polarity, clip lead the LED indicators across J5 switched Vcc and ground, J3 PTT out and +12V, and between J4 tip and +12V. Clip lead the J3 PTT out common point to ground. Apply 12 volts. The "preamp" LED across J5 should be the only one on. Place S2 in SSB position. As you key the mike PTT, you should just be able to perceive the "preamp" LED across J5 extinguish before the "PTT" LED across J3 comes on. When you unkey the mike, the LED across J3 should extinguish just before the LED across J5 re-lights.

Place S2 in the CW position and look for the same results, but at the "CW out" LED across J4. Check to see that you can briefly light the J4 LED with a "dah" from your key. Finally, short J6 tip to ground with a clip lead. The LED on J5 should remain off as long as this short is connected. This completes the checkout.

Operation

With everything in place, and S1 to preamp on position, S2 to SSB, when power is applied the preamp should be on. When you PTT the mike, you will just notice the receiver quiet before TX comes on. When you unkey, TX should go off before the preamp comes on. Set S2 to CW. Attempt to send a dah. The first dah will be abbreviated to a dit sound on your rig's sidetone if you use a keyer 13–20 wpm. This is normal, a result of the 110 ms delay. You will have to get accustomed to sending out an "extra" abbreviated dah at the start of each CW transmission. Alternatively, you can also flip S1 to bypass, start transmitting, and flip S1 back in the middle of your transmission. This manual bypass switch is wired so that the end of cycle delay is always present to protect your device.

Closing Comments

I have used this design at my station with a 2 meter multimode rig and a kilowatt amplifier for years with great success. If you are tempted to decrease the delay time, be aware that the average relay takes between 5 and 10 ms to close, but about twice as long to release as a result of the coil diode re-circulating current back into the collapsing field. The contacts are likely to have bounce for several more ms. Other things to consider are the switching times of your transceiver and accessory relays. Should you have a scope to measure and add these times up, plus a reasonable safety margin, and come up with less than 100 ms, you could then decrease C1 by a corresponding amount. I would not recommend it otherwise. 73

You may contact Ronald Klimas WZ1V at 458 Allentown Rd., Bristol CT 06010.