TR TIME-DELAY GENERATOR

If you've ever blown up your new GaAsFET preamp or hard-to-find coaxial relay, or are just plain worried about it, this transmit/receive (TR) time-delay generator is for you. This little circuit makes it simple to put some reliability into your present station or to get that new VHF or UHF transverter on the air fast, safe and simple. Its primary application is for VHF/UHF transverter, amplifier and antenna switching, but it can be used in any amplifier-antenna scheme. An enable signal to the TR generator will produce sequential output commands to receive relay, a TR relay, an amplifier and a transverter—automatically. All you do is

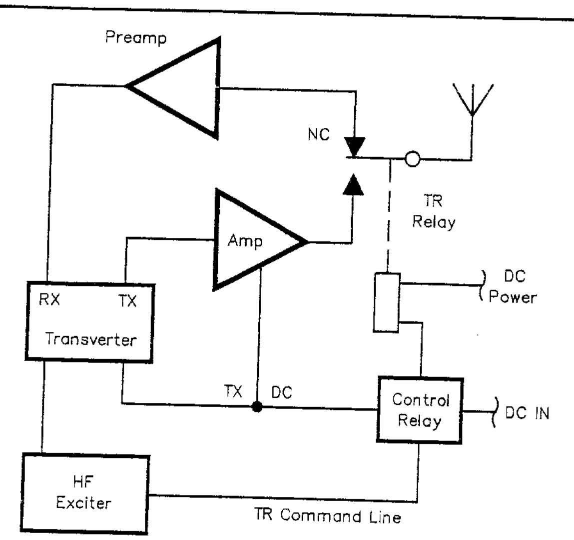


Fig 22.87—A typical VHF or UHF station arrangement with transverter, preamp and power amp. As shown, most TR relays change at the same time.

sit back and work DX! This project was designed and built by Chip Angle, N6CA.

WHY SEQUENCE?

Several problems may arise in stations using transverters, extra power amplifiers and external antenna-mounted TR relays. The block diagram of a typical station is shown in **Fig 22.87**. When the HF exciter is switched into transmit by the PTT or VOX line, it immediately puts out a ground (or in some cases a positive voltage) command for relay control, and an RF signal.

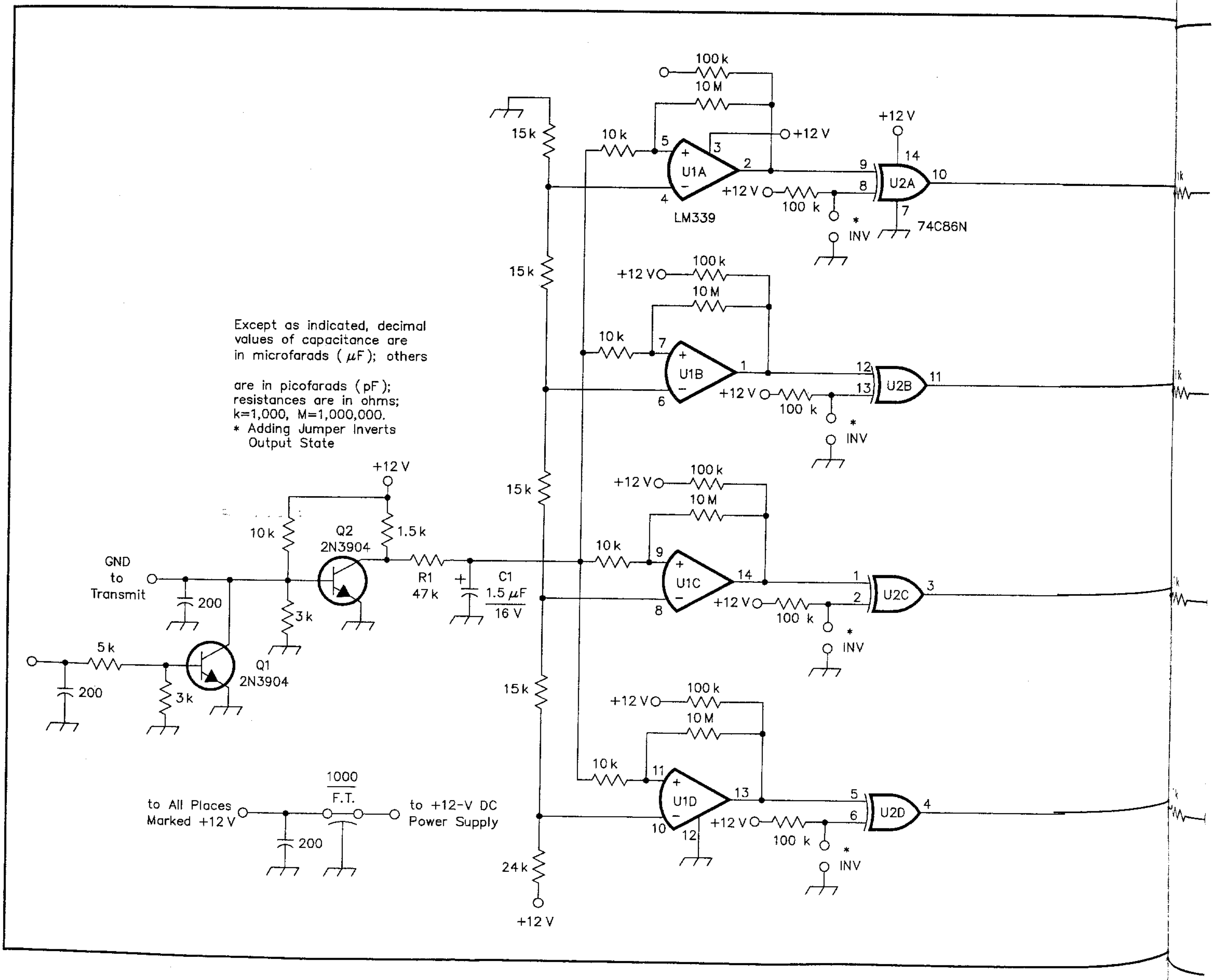
If voltage is applied to the transverter, amplifier and antenna relays simultaneously, RF can be applied as the relay contacts bounce. In most cases, RF will be applied before a relay can make full closure. This can easily arc contacts on dc and RF relays and cause permanent damage. In addition, if the TR relay is not fully closed before RF from the power amplifier is applied, excessive RF may leak into the receive side of the relay. The likely result—preamplifier failure!

Fig 22.88 is a block diagram of a station with a remote-mounted preamp and antenna relays. The TR time-delay generator supplies commands, one after another, going into transmit and going back to receive from transmit, to turn on all station relays in the right order, eliminating the problems just described.

CIRCUIT DETAILS

Here's how it works. See the schematic diagram in **Fig 22.89**. Assume we're in receive and are going to transmit. A ground command to Q2 (or a positive voltage command to Q1) turns Q2 off. This allows C1 to charge through R1 plus 1.5 kΩ. This rising voltage is applied to all positive (+) inputs of U1, a quad comparator. The ladder network on all negative (−) inputs of U1 sets the threshold point of each comparator at a successively higher level. As C1 charges up, each comparator, starting with U1A, will sequentially change output states.

The comparator outputs are fed into U2, a quad exclusive-OR gate. This was included in the design to allow "state programming" of the various relays throughout the system. Because of the wide variety of available relays, primarily coaxial, you may be stuck with a relay that's exactly what you need—except its contacts are open when it's energized. To use this relay, you merely invert the output state of the delay generator by using a



jumper between the appropriate OR-gate input and ground. Now, the relay will be "on" during receive and "off" during transmit. This might seem kind of strange; however, high-quality coaxial relays are hard to come by and if "backwards" relays are all you have, you'd better use them.

The outputs of U2 drive transistors Q3-Q6, which are "on" in the receive mode. Drive from the OR gates turns these transistors "off." This causes the collectors of Q3-Q6 to go high, allowing the base-to-emitter junctions of Q7-Q10 to be forward-biased through the LEDs to turn on the relays in sequential order. The LEDs serve as built-in indicators to check performance and sequencing of the generator. This is convenient if any state changes are made.

When the output transistors (Q7-Q10) are turned on, they pull the return side of the relay coils to ground. These output transistors were selected because of their high beta, a very low saturation voltage (V_{CE}) and low cost. They can switch (and have been tested at) 35 V at 600 mA for many days of continuous operation. If substitutions are planned, test one of the new transistors with the relays you plan to use to be sure that the transistor will be able to power the relay for long periods.

To go from transmit to receive, the sequencing order is reversed. This gives additional protection to the various system components. C1 discharges through R1 and Q2 to ground.

Fig 22.90 shows the relative states and duration of the four output commands when enabled. With the values specified for R1 and C1, there will be intervals of 30 to 50 milliseconds between the four output commands. Exact timing will vary because of component tolerances. Most likely everything will be okay with the values shown, but it's a good idea to check the timing with an oscilloscope just to be sure. Minor changes to the value of R1 may be necessary.

Most relays, especially coaxial, will require about 10 ms to change states and stop

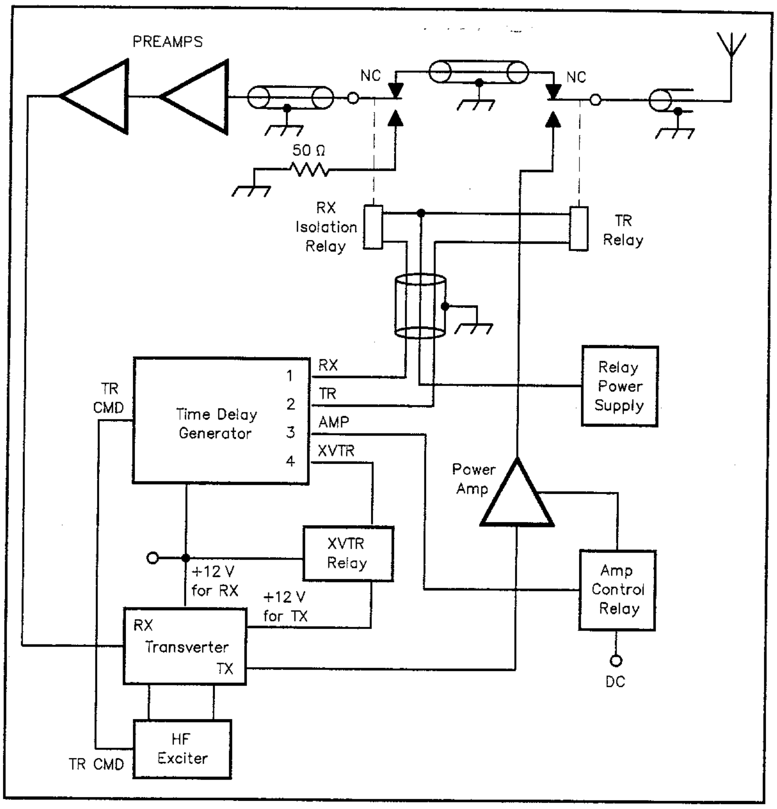


Fig 22.88—Block diagram of the VHF/UHF station with a remote-mounted preamp and antenna relays. The TR time-delay generator makes sure that everything switches in the right order.

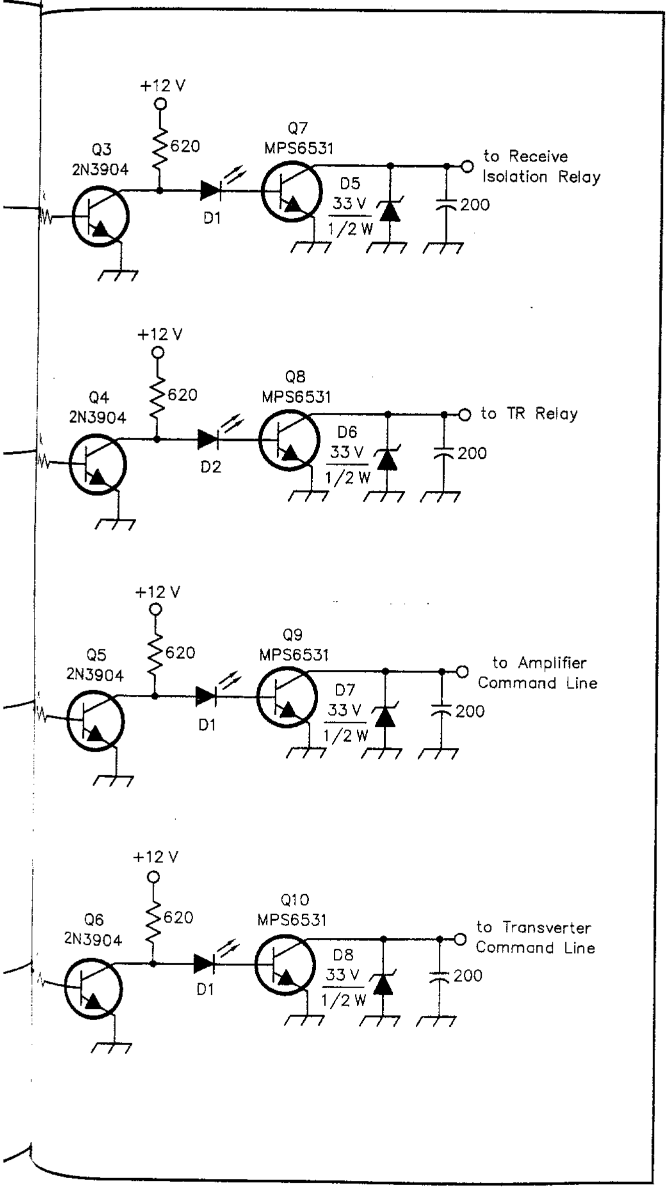


Fig 22.89—Schematic diagram of the TR time-delay generator. Resistors are 1/4 W. Capacitors are disc ceramic. Capacitors marked with polarity are electrolytic.

D1-D4—Red LED (MV55, HP 5082-4482 or equiv.)
D5-D8—33-V, 500-mW Zener diode (1N973A or equiv.)
C1—1.5-µF, 16-V or greater, axial-lead electrolytic capacitor. See text.
Q1-Q6—General purpose NPN transistor (2N3904 or equiv.)
Q7-Q10—Low-power NPN amplifier transistor, MPS6531 or equiv. Must be able to switch up to 35 V at 600 mA continuously. See text.
R1—47-kΩ, 1/4-W resistor. This resistor sets the TR delay time constant and may have to be varied slightly to achieve the desired delay. See text.
U1—Quad comparator, LM339 or equiv.
U2—Quad, 2-input exclusive or gate (74C86N, CD4030A or equiv.)

[2]See the **References** chapter for a template.

bouncing. The 30-ms delay will give adequate time for all closures to occur.

CONSTRUCTION AND HOOKUP

One of the more popular antenna changeover schemes uses two coaxial relays: one for actual TR switching and one for receiver/preamplifier protection. See Fig 22.88.

Many RF relays have very poor isolation especially at VHF and UHF frequencies. Some of the more popular surplus relays have only 40-dB isolation at 144 MHz or higher. If you are running high power, say 1000 W (+60 dBm) at the relay, the receive side of the relay will see +20 dBm (100 mW) when the station is transmitting. This power level is enough to inflict fatal damage on your favorite preamplifier.

Adding a second relay, called the RX isolation relay here, terminates the preamp in a 50-Ω load during transmission and increases the isolation significantly. Also, in the event of TR relay failure, this extra relay will protect the receive preamplifier.

As shown in Fig 22.88, both relays can be controlled with three wires. This scheme provides maximum protection for the receiver. If high-quality relays are used and verified to be in working order, relay losses can be kept well below 0.1 dB, even at 1296 MHz. The three-conductor cable to the remote relays should be shielded to eliminate transients or other interference.

By reversing the RX-TX state of the TR relays (that is, connecting the transmitter Hardline and 50-Ω preamp termination to the normally open relay ports instead of the normally closed side), receiver protection can be provided. When the station is not in use and the system is turned off, the receive preamplifier will be terminated in 50 Ω instead of being connected to the antenna. The relays must be energized to receive. This might seem a little backward; however, if you are having static-charge-induced preamplifier failures, this may solve your problem.

Most coaxial relays aren't designed to be energized continuously. Therefore, adequate heat sinking of coaxial relays must be considered. A pair of Transco Y relays can be energized for several hours when mounted to an aluminum plate 12 inches square and $\frac{1}{4}$ inch thick. Thermal paste will give better heat transfer to the plate. For long-winded operators, it is a good idea to heat sink the relays even when they are energized only in transmit.

Fig 22.91 shows typical HF power amplifier interconnections. In this application, amplifier in/out and sequencing are all provided. The amplifier will always have an antenna connected to its output before drive is applied.

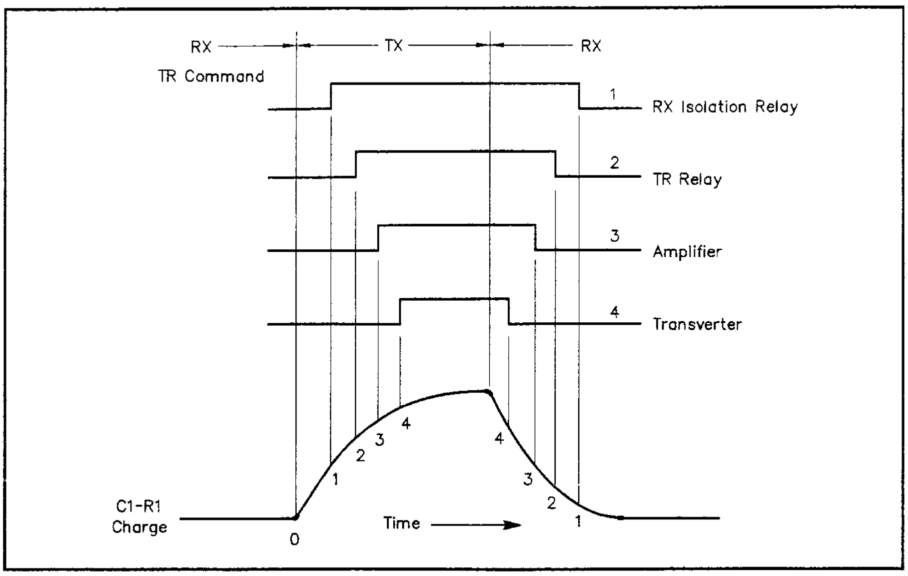


Fig 22.90—The relative states and durations of the four output commands when enabled. This diagram shows the sequence of events when going from receive to transmit and back to receive. The TR delay generator allows about 30 to 50 ms for each relay to close before activating the next one in line.

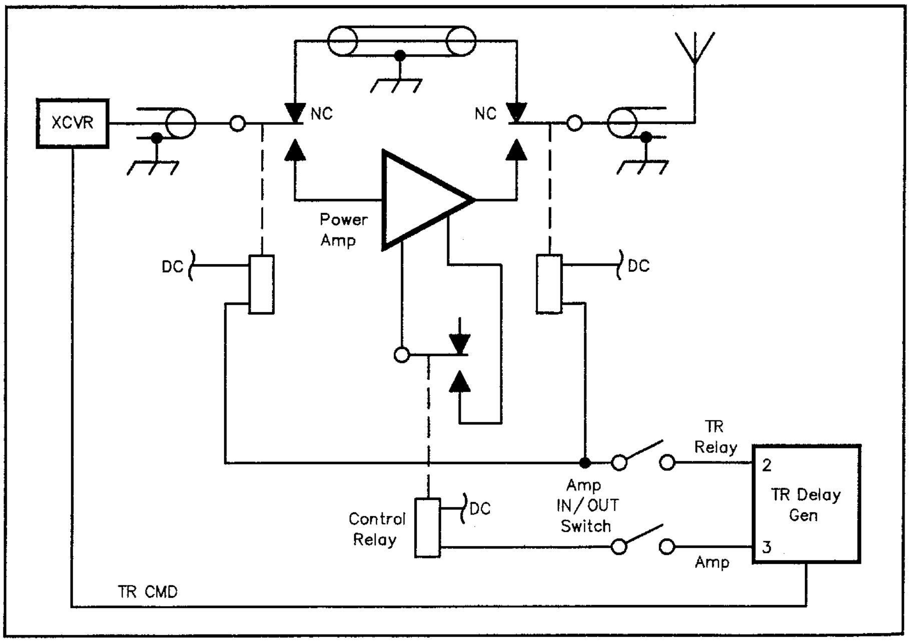


Fig 22.91—The TR time-delay generator can also be used to sequence the relays in an HF power amplifier.

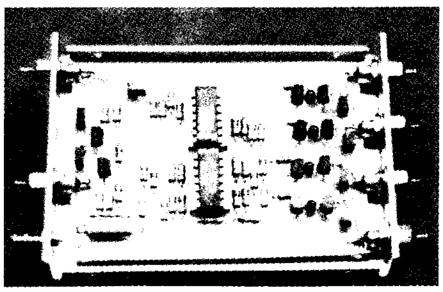


Fig 22.92—The completed time-delay generator fits in a small aluminum box.

Many TR changeover schemes are possible depending on system requirements. Most are easily satisfied with this TR delay generator.

The TR delay generator is built on a $2\frac{1}{2} \times 3\frac{1}{4}$-inch PC board.[2] See **Fig 22.92**. Connections to the rest of the system are made through feedthrough capacitors. Do not use feedthrough capacitors larger than 2000 pF because peak current through the output switching transistors may be excessive.