W1GHZ

MICROWAVELENGTHS

Sequencers for Transverter Control

Several recent Microwavelengths columns have described all the microwave components that comprise a microwave transverter. In future columns, we will describe how to assemble them into a complete transverter system, capable of transmitting and receiving. The one piece we haven't discussed is the circuitry that controls switching between transmit and receive. Since the switching must be done in a careful sequence, the control circuitry is often called a sequencer.

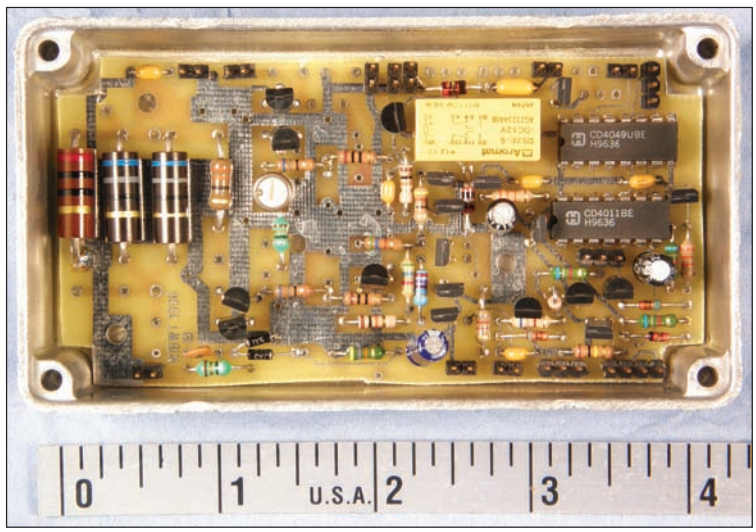

Figure 1 — The tightly packed design of the "Fool-Resistant" Sequencer.

The reason for the switching sequence is to prevent damage to components. Obviously, we don't want to transmit into the receive preamplifier, so we must switch the antenna relay before transmitting. More important is to be sure that the relay contacts are completely closed — microwave relays are easily damaged by hot-switching with any significant amount of RF power present, but can handle the power just fine with the contacts closed and stationary. Microwave power amplifiers can also be damaged if operated without a proper load. Finally, both power amplifiers and preamplifiers can oscillate if not terminated properly while powered — and the oscillation may be destructive.

So the switching sequence must be planned. A typical sequence might be:

1. Detect PTT from IF radio
2. Remove power from preamplifier
3. Switch antenna relay to transmit position
4. Wait for relay to complete switching
5. Apply power to power amplifier
6. Transmit

The sequence is reversed to return to receive.

A typical transceiver has a similar sequence of internal operations, but they are hidden from the operator — he just pushes the microphone button or the key. One difference is that HF transceivers switch quickly, for break-in operation, while most microwave transverters switch relatively slowly to accommodate high-performance microwave relays. Mine take at least a half second for changeover, so I sometimes miss part of a call from someone with a quick thumb.

A sequencer may also be called on to dissipate some IF power — a typical VHF transceiver has an output power of at least a few watts, while the mixer in a transverter tolerates only about a milliwatt. It is easy to attenuate the excess power, but we really don't want the loss on receive as well — it's hard enough to hear weak signals. We would prefer to switch out the attenuator while receiving. Some commercial transverter modules include the switched attenuator, but they still recommend a sequencer if the system includes an additional power amplifier.

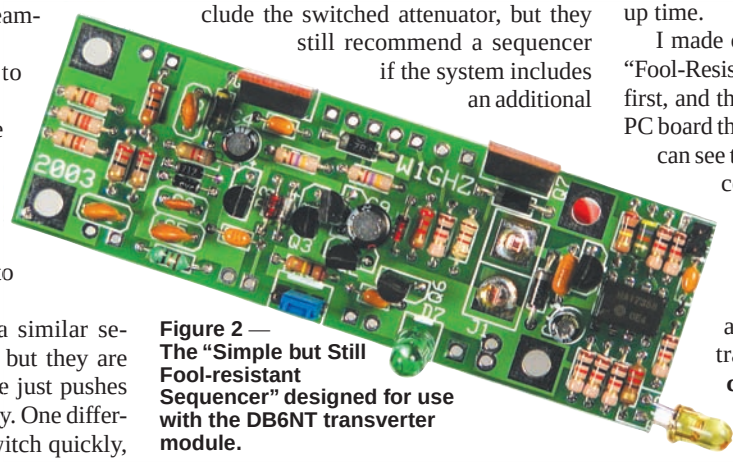

Figure 2 — The "Simple but Still Fool-resistant Sequencer" designed for use with the DB6NT transverter module.

My first sequencer was based on the article by Zack Lau, KH6CP (now W1VT), "T/R Switching Low-Power 903 and 1296 Transverters," *QEX*, July 1992, p 16. He left some attenuation inline all the time and switched from additional transmit attenuation to a small monolithic microwave integrated circuit (MMIC) receive amplifier using a small RadioShack relay. The rationale is that a MMIC is a cheap fuse if the switching fails, while microwave mixers are more expensive and harder to replace.

I liked the idea of fail-safe switching and expanded on it in my article "A 'Fool-Resistant' Sequenced Controller and IF Switch for Microwave Transverters," *QEX*, May 1996, p 14. I added a step to the sequence described above, so that RF power from the IF transceiver is detected and absorbed until the switching sequence is complete — there is no RF sent to the transverter until everything is ready. As an option, the RF detection may be used to initiate the switching sequence, as is common in "brick" amplifiers. Switching by RF detection is not recommended, but allows operation to continue when an IF rig fails — even an FM handheld transceiver can be used in a pinch. I also added an interlock signal for power amplifiers needing a warm-up time.

I made one classic error in designing the "Fool-Resistant" Sequencer — I chose the box first, and then had to cram everything onto a PC board that fit into the box. In Figure 1, you can see that there is very little room left for connectors and wiring. This cramming made it more difficult to build and only a couple of dozen copies have been made.

More recently, I constructed a 10 GHz system using a DB6NT transverter module (**www.db6nt.com**). The module incorporates the switched attenuator, but recommends a sequencer for use

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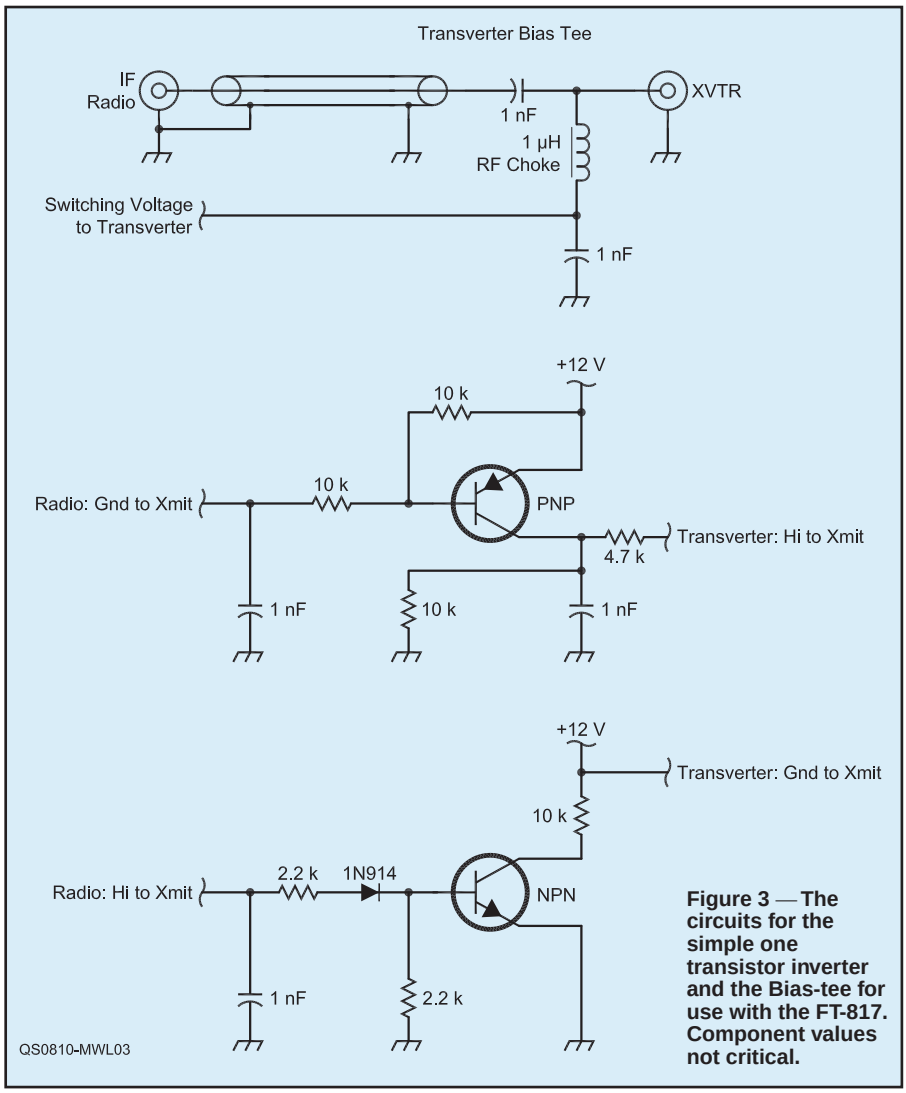

Figure 3 — The circuits for the simple one transistor inverter and the Bias-tee for use with the FT-817. Component values not critical.

Figure 4 — The complete Bias-tee mounted on the FT-817 ready for action.

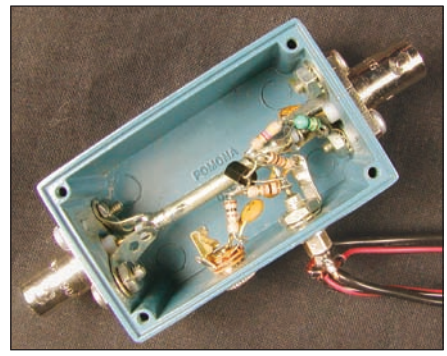

Figure 5 — A view of the dead-bug construction techniques used to build the Bias-tee.

with a power amplifier. A simpler sequencer was in order, so I designed the "Simple but Still Fool-resistant Sequencer" shown in Figure 2. No RF switching is included, only dc power, so it is completely solid-state. This version has proven easy-to-build and many copies are in use. Kits are available from WA3IAC at **chuckwa3iac@yahoo.com**.

Other sequencer designs have been published, ranging from simple ones with just a time delay to programmable ones using a Programmable Interface Controller (PIC) microprocessor. Commercial units are available from DB6NT and Down East Microwave (**www.downeastmicrowave.com**). The DEMI TC (Transverter Control) uses only relays, including an inexpensive RF relay intended for wireless networks. Relays are easier to understand than PIN diode switching and allow more flexibility. I'm still considering what to use in my future transverters — perhaps an improved "Fool-Resistant" design is in order.

Reliable Control Lines

A transverter is often at a distance from the operator and IF transceiver — from a few feet for a portable operation, to the top of a tower for a home station. The control line, or PTT, that switches between transmit and receive, is one more wire to connect, in addition to dc power and IF coax. On portable rigs, the connectors are often small and unreliable, which is one reason why I include RF sensing in my sequencers. A better way is to send the control signal as a voltage on the IF coax; inside the transverter box, a capacitor keeps the dc voltage out of the mixer while an RF choke connects the dc but not the RF to the sequencer. One fewer wire and coax connectors are usually more robust.

Some of the older IF transceivers, like the venerable IC-402, connected a switching voltage to the RF output connector — typically, 8 V on transmit and 0 V on receive.

This is so convenient that many of us modified other rigs to do the same; an RF choke and a current-limiting resistor for safety are all that is needed. The newer rigs, like the popular FT-817, however, cover many bands and have more complicated switching. They also have very tiny parts. I looked over the schematic and layout, but didn't find a simple way to make the modification. Instead, I chose to insert the voltage onto the coax, using a device often referred to as a Bias-tee. This is simply a small box with three connectors, using an RF choke and a capacitor to combine the voltage onto the coax, as shown in Figure 3.

Since the FT-817 Accessory jack grounds the TR pin on transmit, the opposite of previous rigs, I faced another choice: fix this or modify all my transverters. This would make the transverters incompatible with other rigs, so I added a simple one-transistor inverting circuit, shown in Figure 3, to the Bias-tee. Figure 4 shows a complete Bias-tee in action and Figure 5 shows the "dead-bug" style construction inside the Bias-tee.

Whether you homebrew everything or buy all the pieces, it will be necessary to provide the switching and control — there aren't any turnkey microwave radios yet. And don't choose the box until you know what must go inside.

Microwave Update

Microwave Update 2008, the worldwide gathering of microwavers, will be held October 17-18 in Bloomington, Minnesota. See **www.microwaveupdate.org** for details.

I hope to see you there.

All photos by Paul Wade, W1GHZ QST