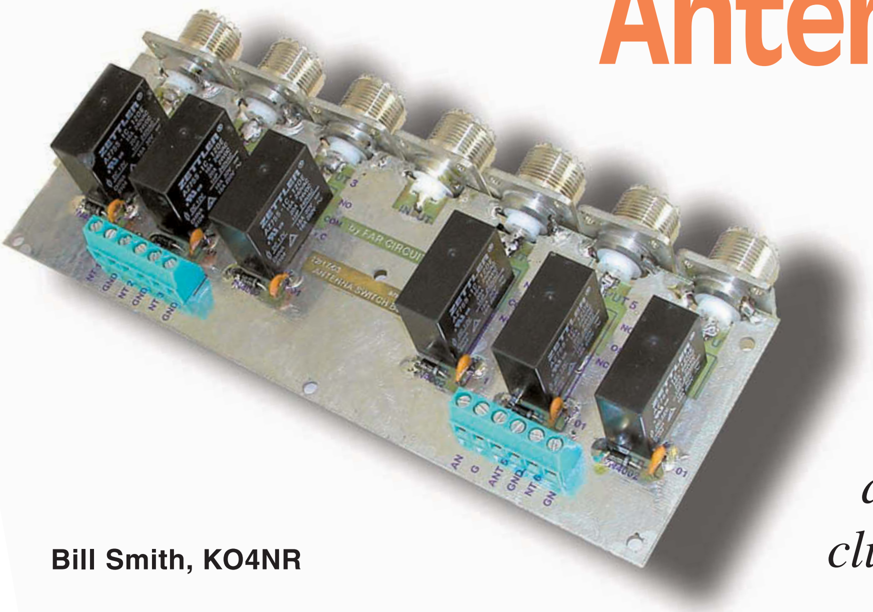
A Low-Cost Remote Antenna Switch



Here's an easy and inexpensive way to reduce the number of antenna feed lines cluttering up your shack.

Bill Smith, KO4NR

How many of us have struggled with getting multiple antenna feed lines into our shacks? I believe it is a common problem that can be easily solved with a suitable remote antenna switch.

My shack is in the basement on the opposite end of the house from the antenna feed lines. My antenna farm consists of a 2 meter beam, an end-fed half-wave sloper and a modified Zepp by NB6Z. I pondered the problem of getting the feed lines for all the antennas into the shack for several days without coming up with a good plan. My dilemma was finding a path to run three or more coaxial feed lines across the top of the basement's suspended ceiling. In addition I would have to win the approval of my wife.

I cautiously began the easement negotiations knowing it would take some time. Negotiations were complicated by the fact that a hole large enough for three or more coaxial feed lines would have to be cut in the house's wood siding. In the end, my wife agreed to a plan that included a small hole in the wood siding and a single coax run across the top of the basement's suspended ceiling. Switching antennas meant frequent trips outside to connect the right feed line to the coax running into the house. I operated this way for over four years, all the while longing for a better way to switch my antennas.

Remote antenna switches were the answer, but they can be expensive. I had seriously considered purchasing one of the many remote antenna switches on the market, but I couldn't decide which one to go with. As if struck by lightning, it came to me: Why not build a switch using one of the many printed circuit board (PCB) power relays on the market? Surely one of the hundreds of PCB power relays available would be suitable for switching antennas.

Relay Selection

The solution to my antenna switching problem presented itself while I was experimenting with PCB relays for use in a linear amplifier's tuned input circuit. The search for a suitable PCB relay for the amplifier revealed interesting innovations in PCB relay design. They now come in small packages, exhibit high dielectric strength and can carry impressive amounts of current.

Although not factory tested for RF use, I found the American Zettler AZ755 series PCB relays to work very well.[1] The AZ755 is rated for 480 W switched power with a resistive load and a maximum switched current of 20 A. Despite the relay's small physical size, the dielectric strength between the contacts and coil is 5 kV RMS, with an impressive 1 kV RMS between the open contacts. This means that the relay is resistant to a flashover that could damage the coil or pit the contacts.

The AZ755 series relays are offered in a wide variety of configurations. I used American Zettler part number AZ755-1C-12DE. This model has a 12 V dc coil, but you can use any of the available coil voltages in the series. The contact style is Form C, which is single-pole double-throw (SPDT). The E suffix indicates that the relay is epoxy sealed. I thought the epoxy seal would provide better protection from dirt and moisture contamination. If you prefer relays that are not epoxy sealed, drop the E from the part number.

American Zettler relays are readily available on-line from **RelayCenter.com**.[2]

Circuit Design and Board

Figure 1 shows the final circuit. I settled on a switch that would handle up to six antennas, enough for my current antenna farm and possible future expansion. The common contacts of the relays (K1-K6) are connected to SO-239 connectors (J1-J6) for the antenna feed lines. The normally open (NO) contacts are all connected to the RF INPUT connector, J7.

[1]Notes appear on page 41.

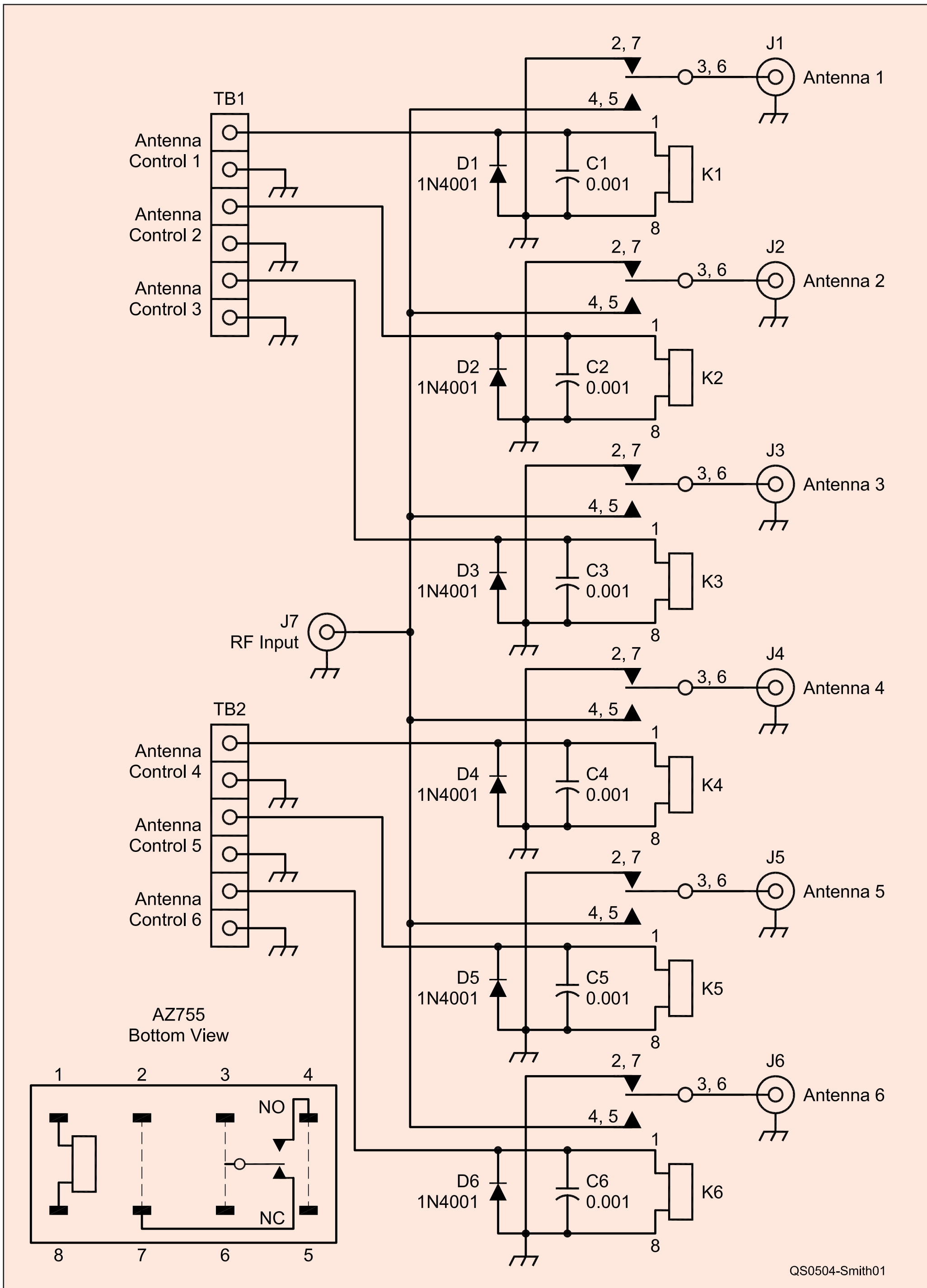


Figure 1—Schematic and parts list for the remote antenna switch. All parts except the PC board and relays K1-K6 are available from Mouser Electronics, 1000 N Main St, Mansfield, TX 76065; 800-346-6873; www.mouser.com.

C1-C6—0.001 µF, 50 V disc ceramic capacitor (Mouser 140-50P5-102K-TB).
D1-D6—1N4001 diode (Mouser 512-1N4001).
J1-J7—SO-239A chassis mount coaxial connector with silver-plated 4-hole square flange and Teflon insulation (Amphenol 83-798 available as Mouser 523-83-798).
K1-K6—SPDT PC board power relay with 12 V dc coil (American Zettler AZ755-1C-12DE). See text.
TB1, TB2—PC board terminal block with 6 contacts (Mouser 651-1729050).

The normally closed (NC) contacts are all connected to ground so that the antennas are grounded when not in use. To select an antenna, apply 12 V dc to the appropriate ANTENNA CONTROL terminal to energize the relay and connect the ANTENNA to the RF INPUT.

To keep stray RF out, 0.001 µF ceramic disc capacitors (C1-C6) are installed across the relay coils. In addition, 1N4001 diodes (D1-D6) are installed across the coils to prevent voltage spikes when the power is removed from the coil.

Once I located a relay that might work and had a circuit in mind, I contacted FAR Circuits to see if an inexpensive circuit board could be produced. FAR Circuits has built several boards for my linear amplifier projects and has a proven history of supplying high quality circuit boards. Fred at FAR Circuits agreed to design the board[3] for me using the AZ755 relays with SO-239 input and output connectors. He suggested mounting the SO-239s directly to the board to eliminate wiring and minimize SWR problems. The finished board with all components mounted is shown in the title photo. The RF INPUT connector is in the center, with three ANTENNA connectors on each side. The control cable connects to the two terminal blocks.

Assembly Notes

The design is simple and assembly doesn't require special tools. Far too often, projects require sophisticated test equipment and a degree of expertise I don't possess. This project can easily be completed by anyone with basic soldering skills.

In addition to the PC board and parts, you'll need a suitable enclosure to keep

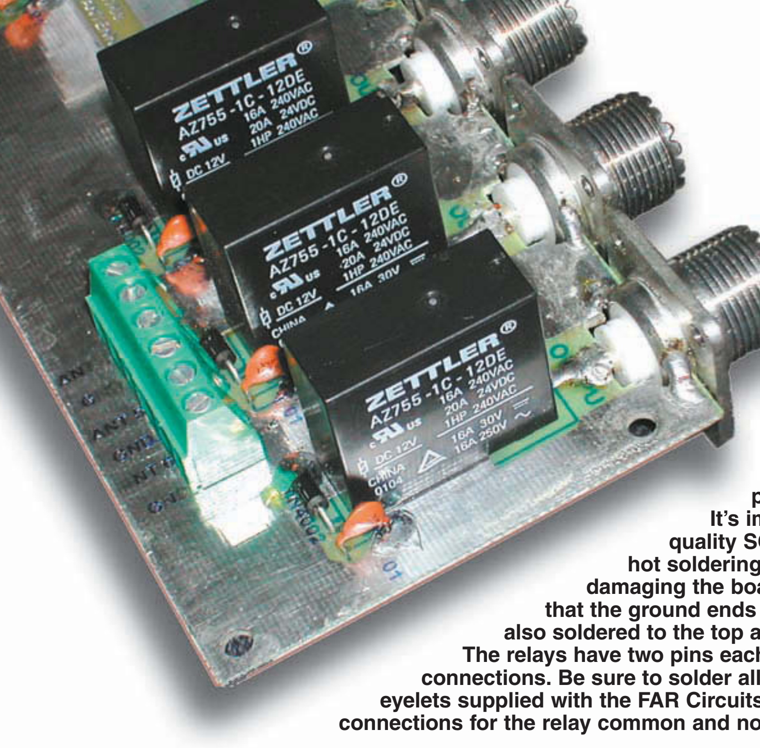


Figure 2—The connector flanges are soldered to the board's ground plane top and bottom. It's important to use good quality SO-239 connectors and a hot soldering iron to avoid damaging the board or connectors. Note that the ground ends of D1-D6 and C1-C6 are also soldered to the top and bottom of the board. The relays have two pins each for the contact connections. Be sure to solder all pins and to install eyelets supplied with the FAR Circuits board to ensure good connections for the relay common and normally closed pins.

the board dry and pests away. I installed mine in a plastic children's lunch box that hangs under my deck. Initially this enclosure was just for testing purposes, but it has worked out so well that I may not change it.

The most difficult part of the project is drilling the holes in the enclosure for the SO-239 connectors and getting everything to line up. You may find it easier to install the connectors in the enclosure first, and then solder them to the board. (Use the board to mark the center line and location of the connectors on the enclosure.) After the connectors are tacked in place, remove the screws holding the SO-239s to the enclosure and remove the total assembly. This ensures a perfect fit when reassembling.

Make sure the SO-239s are all the same type and brand to ensure a uniform fit. The board was designed around the Amphenol connectors recommended in the parts list. They have silver-plated center pins and flanges, and Teflon insulation. The silver plating makes the connectors easier to solder than nickel-plated connectors, and the Teflon insulation is much less prone to melting than the plastic often found on inexpensive connectors. Of course you can use other SO-239 connectors, but you may have to modify the board for a good fit.

Use a *hot* soldering iron when soldering the flange of the SO-239 to the board's ground plane as shown in Figure 2. I used a Sears Craftsman Dual 230/150 W iron and it worked great. Be sure to solder top and bottom.

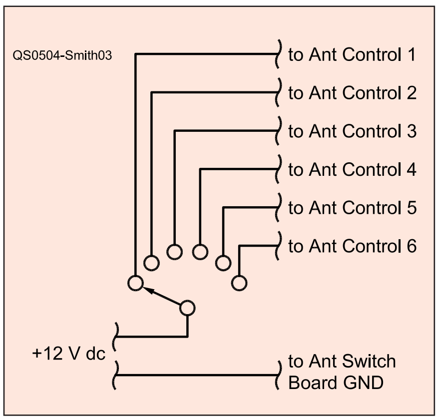


Figure 3—I used a simple 12 V supply and rotary switch in my shack to select antennas.

The PC board is double-sided, and FAR Circuits supplies eyelets with the board to use in the larger holes for the common and normally closed relay pins. They provide for a better connection to the component side of the board. In addition, soldering a short length of no. 14 bare copper wire into the center pin of each SO-239 will give you a better connection to the circuit trace on the board.

Powering It Up

To control the switch, I use a 12 V dc power supply in the shack and a small ceramic rotary switch as shown in Figure 3. The switch simply sends 12 V to energize one of the relay coils and select the desired antenna. When 12 V is removed, the normally closed relay contacts connect all feed lines to ground. Connect the PC board's ground plane to your outside lightning protection ground system.

I ran an 8-conductor control cable into the shack using the same route taken when I installed the coax. My wife agreed to it when I explained the cable would eliminate the need to run additional coax into the house. My control cable has #16 conductors and is something I had in my parts collection. There is a chart at **www.altronix.com/html/an101.htm** that you can use to help you determine the right wire size for your installation. Long runs of wire may require larger conductors to prevent unacceptable voltage drops at the relay coils, but the relays will work over a fairly wide range of coil voltages so it's not critical.

Test Results

Once the switch was completed, I performed several tests to see how it worked. The testing was done with my Kenwood TS-850S transceiver, RadioShack MTA-20 digital power meter and Swan Mark 1 linear amplifier. The board was not installed in an enclosure for the initial testing. It was lying on top of a plastic box.

Test 1. For the initial test, I connected the TS-850S (with internal antenna tuner off) to the RF INPUT jack on the antenna switch board. Then I connected one of the antenna jacks on the switch board to the RadioShack power meter and then to a dummy antenna. From 160-10 meters, the internal meter in the TS-850S indicated that the SWR was about 1.2:1, and the external power meter indicated no loss of power through the relay board. My TS-850S is sensitive to SWR and has always folded the power back when transmitting into a high SWR. That didn't happen, so I concluded the SWR with the board in the line must be low.

Test 2. Next I added the Swan Mark 1 amplifier between the transceiver and antenna switch. I measured the power with the digital power meter before and after the antenna switch board and could detect no difference. I operated the amplifier in the CW mode at 1-1.3 kW. The relay got a little warm but no more than I would expect from an energized coil, and it seemed to handle the power just fine. SWR with the switch in line remained low on all bands.

Test 3. For the final test, I borrowed a friend's MFJ-259B antenna analyzer to use as a reality check. For this test, I placed the board under my deck where it would be in normal use, connected it to a dummy antenna, and ran about 70 feet of RG-8X to the antenna analyzer. I then used the MFJ-259B to measure the SWR, reactance (X_s) and resistance (R_s) on each band from 1.8-144 MHz. The results are shown in Table 1.

ARRL Lab Testing. The ARRL Lab had an opportunity to test the completed antenna switch board as well. Insertion loss measured <0.1 dB for 2-50 MHz (for all ports to common). SWR measured 1.1:1 or less from 2-28 MHz, 1.2:1 or less on 50 MHz. Isolation was >60 dB for 2-28 MHz, except for the two innermost ports, which were 50 dB at 28 MHz. Worst-case isolation on 50 MHz was 45 dB.

The various tests showed that although they are not designed for RF, the relays seem to perform well. The board exhibits low SWR, low insertion loss and good isolation over a wide frequency range. It handles 1-1.3 kW during normal intermittent SSB and CW operation (I did not try it with a key-down mode like RTTY).

Summary

This project offers a rewarding solution to managing the number of feed lines snaking through your house. Parts are readily available, and the FAR Circuits PC board makes construction straightforward. If homebrewing is not your cup of tea, don't despair. There are several good commercial antenna switches available from the advertisers in *QST*.

Table 1
MFJ-259B Test Results

Freq (MHz)	*SWR*	*X_s (Ω)*	*R_s (Ω)*
1.8	1.1:1	0	63
2.0	1.1:1	0	61
3.5	1.1:1	5	53
4.0	1.0:1	0	56
7.0	1.0:1	0	57
7.3	1.0:1	0	58
10.1	1.2:1	9	51
10.15	1.1:1	7	49
14.0	1.1:1	7	50
14.35	1.1:1	4	53
18.068	1.1:1	2	50
18.168	1.0:1	0	55
21.0	1.2:1	9	48
21.45	1.1:1	8	52
24.89	1.4:1	5	53
24.99	1.1:1	3	53
28.0	1.1:1	6	50
29.7	1.0:1	0	61
50	1.0:1	0	57
54	1.0:1	0	61
144	1.2:1	11	47
148	1.2:1	9	47

Notes

[1]You can find more information at American Zettler's Web site, **www.americanzettler.com**. A data sheet for the AZ755 series relays may be downloaded from **www.azettler.com/pdfs/az755.pdf**.

[2]**www.relaycenter.com**. At publication time, the AZ755-1C-12DE relays used in this project were $2.25 each plus shipping and handling, with a minimum order of $25.

[3]The circuit board is available from FAR Circuits, 18N640 Field Ct, Dundee, IL 60118 for $11 plus $2 shipping and handling. For ordering information, see the FAR Circuits Web site at **www.farcircuits.net** and look under the Repeater Controller & Station Accessory heading.

Bill Smith, KO4NR, enjoys repairing and modifying vintage linear amplifiers, including a Swan Mark 1 and Heath Warrior. He usually operates 17 and 40 meter SSB, and especially likes chatting with other hams who share his passion for building and working on equipment. Employed as maintenance manager at a gas fired energy plant, Bill can be reached at 244 Cameron St, Manchester, NH 03103, or by e-mail at **ko4nrbs@yahoo.com**.

New Products

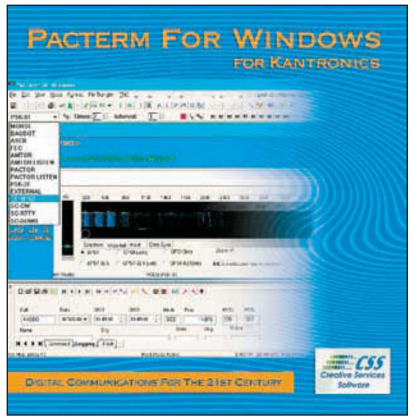
QRP PROTOTYPING KIT

◊ The QRP Prototyping Kit has been added to the Alden McDuffie kit product line. This kit is designed to save time for those constructing a project. The kit includes case, printed circuit board (PCB) with "dead bug" construction area and pads with layout for SO-239 coaxial connectors, two 3.5 mm audio jacks and two alternate-action switches. All those parts are included. The printed circuit board is designed to fit in their 3.2×4×1.25 inch project case.

A step-by-step manual is designed to assist in building the kit and planning the project. Included are the case, mechanical drawings, schematic and parts list for the PCB kit. Price: fully assembled with case, $54.95; full kit, $42.95; PCB kit without case, $29.95. For more information, contact Alden McDuffie, PO Box 3636, Lawrence, KS 66046; tel 785-766-0404; **www.aldenmcduffie.com**.

PACKET TERMINAL SOFTWARE

◊ *PacTerm 3 for Windows* and *PkTerm 3 for Windows* are offered in preview version by Creative Services Software.



This new release includes a new user interface in a single window, a built-in generic logging program, the MT63 soundcard mode, PSK 62.5 mode, TCP/IP support and more.

New sound card modes just plug in. This means a ham can create a dynamic linked library (DLL) file for any mode, put that DLL into the *PacTerm* or *PkTerm* folder and that new mode appears on the HF mode menu of *PacTerm* or *PkTerm 3*.

The software includes sample skeleton source code to allow a user to create their own modem (HH_DUMB.DLL and source code). Also included is the source code for the HH_MT63.DLL.

Neither program requires a TNC. There is a soundcard only mode that will work with the RIGblaster, MFJ units, Timewave's soon to be released Hamhub and homebrew interfaces.

Price: *PacTerm for Windows and PkTerm for Windows*, $99.95; upgrades from earlier versions, $49.95. Both programs include a 30 day full featured demo version, so hams and MARS users can try them out before purchase. For more information or to order, see **www.cssincorp.com**.