C.L. Houghton WB6IGP
San Diego Microwave Group
6345 Badger Lake Ave.
San Diego CA 92119
[Wb6igp@ham-radio.com]
[clhough@pacbell.net]

Converting Surplus: Overview Covering Coaxial Relays

Converting surplus equipment has always been a fascinating event, both in the converting and the hunt to locate items to convert. What then do we convert?

Well, we convert the things we can find in surplus, scrounging the scrap dealers and swap meets, looking for candidates upon which to work the fine art of reconstruction, to turn that junk into gold. I am not into collecting old fishing lures or going to sporting events. Maybe I am tweaked towards bias, but professional sports are more big business than sporting events.

A point of view from a test equipment junkie

What gets me up and going, besides my very active grandchildren, is the hunt for a choice piece of microwave surplus material that can be modified into something useful. It would be nice if whatever was located in surplus functioned as is, but then that would take the fun out of the hunt and reconstruction. What then can be found in surplus that seems to be overlooked?

The first major thing that I have observed is coaxial relays, especially the 24-volt-actuated SMA postage-stamp-size microwave variety. Most people shun them for several reasons, with the main one being that they don't operate from 12-volt DC. There have been several articles on how to disassemble these expensive microwave relays and rewind the coil for 12 volts DC. I never did that, as it seemed to be too much trouble. A solution, but not for me. What then?

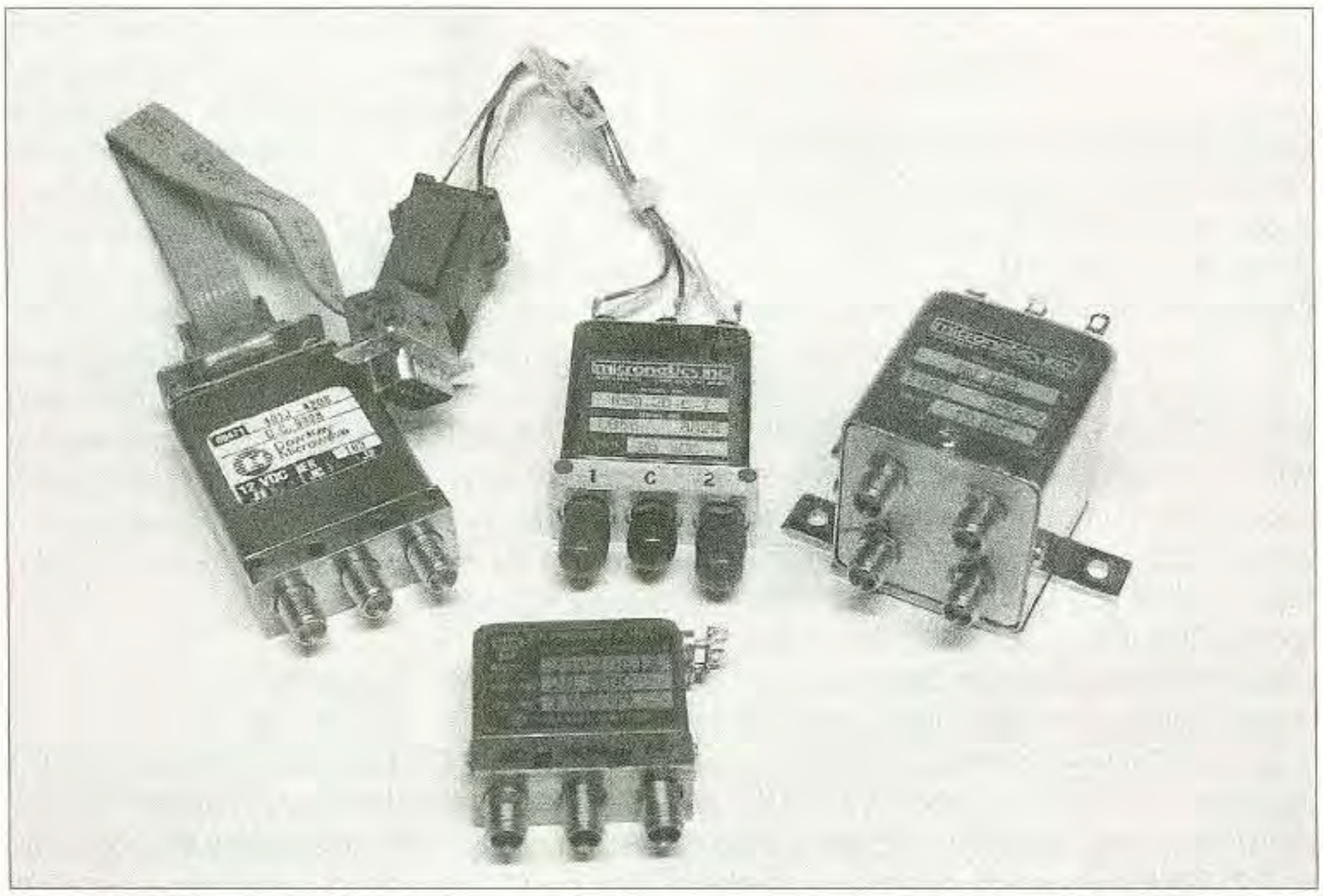

Photo A. *Picture of a few varieties of SMA coaxial relays. From left to right: SMA SPDT latching (left and center top) and a 4-port SMA transfer relay (right top). Standard SMA SPDT 24-volt relay center bottom. All relays rated to 18 GHz.*

Finding a solution

Creating a 24-volt power source to operate these fine relays seemed a project worth taking on. Not wishing to use extra power from batteries for portable operation, main operation from 12 volts was desired for all units constructed. A simple DC voltage booster needed to be developed. In scrounging local sources, I located several DC-to-DC power converters of small physical size that were fully isolated input to output. Of course, if a 12- to 24-volt converter could be located, problem solved. Other alternatives should be explored using other voltage supplies.

A 12- to 5-volt isolated power supply (DC-to-DC power block) seems to be common at most surplus scrap dealers, and can be utilized by stacking the 5-volt output on top of the main 12-volt DC input, creating a +17-volt line for relay switching. Using 24-volt coaxial relays and operating them on 17 volts seemed reasonable. Of 8 relays tested, 4 relays operated from the 17-volt supply. The remaining 4 relays functioned with 19 volts DC applied.

All relays tested in this batch were standard operating relays. DC voltage was applied to switch from Rx common mode to Tx mode. Another type of relay looking similar in physical appearance to the above relay is what is called a "latching" relay. I located some at our local swap meet and purchased the batch. These latching relays were cursed with the old stigma of a 28-volt DC coil. The swap meet seller wanted $5 each for them because wire ends were still soldered to the relays. Such a deal! I counteroffered three for $10 and he accepted, so I took the 6 relays he had.

The relays obtained were Micronetics RSM-2D-L-I type. Without a spec sheet and many no hits searching on the Web for details, I powered them up with my bench supply to test for basic operation and switching contact integrity. They all worked just fine, latching and all. Latching, by the way, means the switch will remain in the selected position even when the DC voltage is removed. To transfer back to its original position another pin needs to have DC applied and it switches back. Again, the DC voltage can be removed and the switch stays in the new latched position — quite a current-saving feature. Nonlatching relays require voltage to be applied all the time the relay is in operated condition. Then when relay voltage is removed, it returns to normal receive condition with no voltage applied. Latching relays require a pulse of DC voltage to toggle to a set state, and no current flows after the latch functions. To go to the other state, it needs a pulse of DC voltage on another control pin and the relay latches in the other state and opens current flow in a new state of operation.

I decided to try the latching relays at a lower voltage switch point and tried 17 volts that I had just used for the other relay tests. All relays latched and switched just fine — no hang-ups or false operations. I set up a simple lamp circuit to watch opening and closure of the SMA relay contacts and finally assured myself that the relays would function not only at 17 volts, but at 12 volts, too.

What a stroke of luck. Every trip foraging through surplus material does not always turn up a gold purse for the search efforts. Many trips turn up nothing. Not to mention trips that did not pan out. If you keep your failures secret, many will think you are a surplus junk man extraordinaire, when in reality what is happening is that a few good trips make up for the many that might have supplied you only with information on new items yet to be received. The early bird gets the worm scenario works here most of the time. If you snooze, you loose. Check out your local swap meets. Lots of dead searches and nothing found, but persistence will pay off, occasionally allowing you to hit the jackpot. It just requires dedication to the search to locate parts inexpensively.

Why, then, was I excited when I located SMA postage-stamp-size microwave coaxial relays? Why not get excited about some BNC or type "N" connectorized coaxial relays? Well, being into microwave operations from 1296 MHz to 10 GHz, it is my opinion that the SMA relay rates

Photo B. *Picture of high-loss BNC relay not usable at 1296 MHz (center top), better suited for low frequencies like 50 or 144 MHz. An early SMA version of a better-than-BNC relay, but still not top performer above 1 GHz, is at far right.*

supreme. They are small, low-profile switches that use a microwave-rated miniature connector. They have been tested to have only a few tenths of loss through the relay contacts and most will handle at 10 GHz, 10 watts of power. It's very important when generating power at microwave frequencies as it is precious and you don't want to give it up to excess loss in components used.

Let's take the common BNC coaxial relay found in many surplus shops and equipment stores, and look at a recent conversion I checked out for performance. The unit I tested used four BNC relays constructed in a 1296 MHz transverter. The four BNC relays in this converter design switched a 1-watt power amp in and out of the circuit and then switched the receive preamplifier back into the antenna after the transmit relays released. I tested the circuit performance and found that I could only get one half of a watt output on the antenna connector and sensitivity was low in receive. Checking loss through the relay contacts, I found that each BNC relay and associated coaxial cable and connectors contributed about 1 to 2 dB of loss at 1296 MHz.

I tested the BNC relays at 2 meters (144 MHz) and found that the loss was a few tenths of a dB. Not wishing to add relays for VHF use to the junk box, I dumped them. When I checked a large "N" connector–type relay, I found a few tenths of loss at 1296 MHz and good isolation between the switched side and open port of the relay. However, I did not want to use a relay as large as the "N" connector unit and thought it would be better to shift them from high power applications for HF to low microwave frequency use. The SMA relay still reigns supreme due to its very low loss miniature size and great isolation between ports at all microwave frequencies from DC to 10 GHz. Some premium types are rated to 26 GHz.

After rebuilding the 1296 MHz converter and removing all the BNC relays, I was able

Photo C. *Picture of large, high-power "N" connectorized on right, and SMA version of same relay on the left. Both rated to 2 GHz for reasonably good performance. Just large and high-power.*

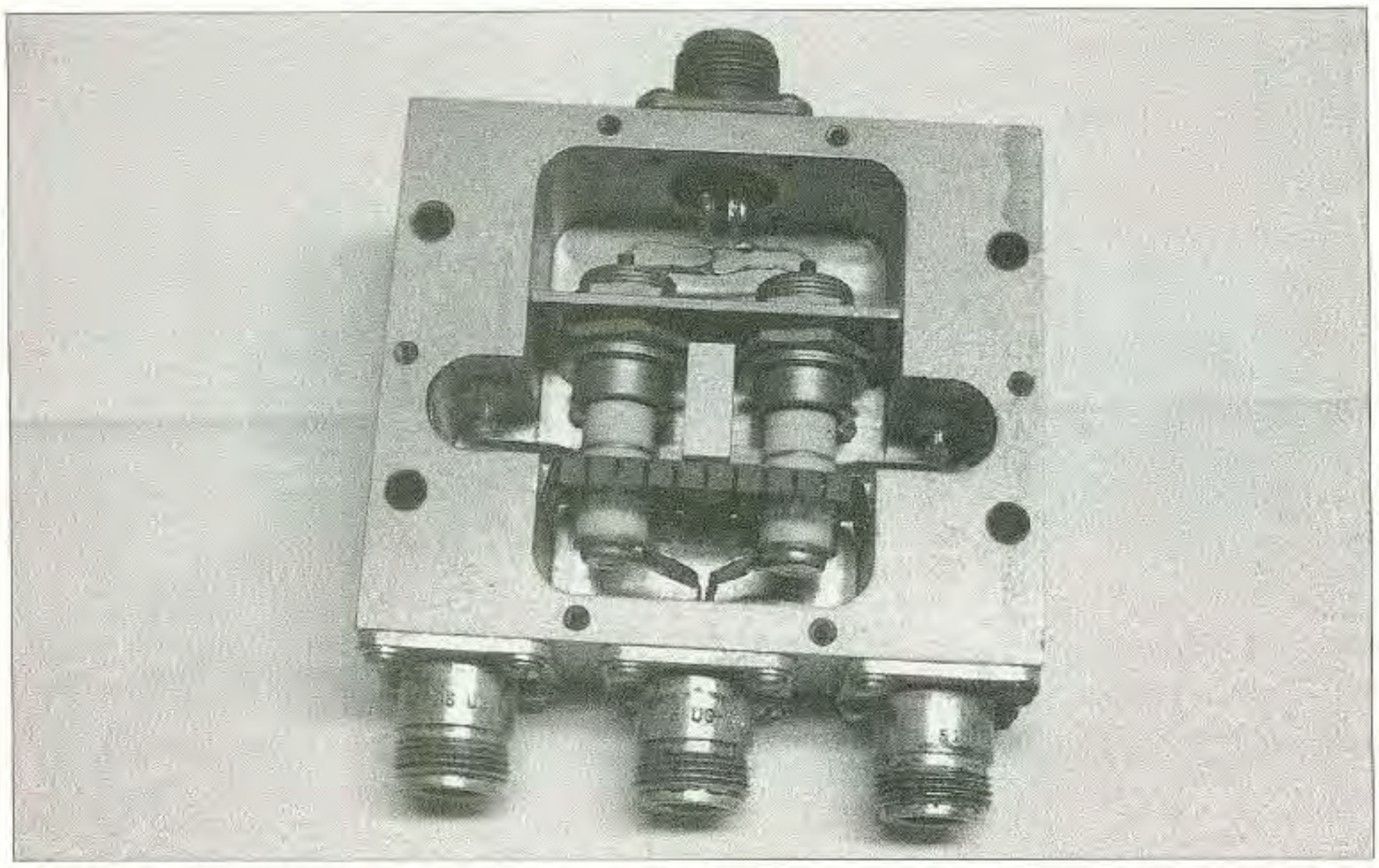

Photo D. *Very high-power coaxial switch constructed with vacuum relay contacts for very high-power handling RF switching capabilities. These types of relays use vacuum switch contacts and solenoid driver coils, which are totally replaceable. Photo with cover removed shows the white ceramic body of each switch element for a single pole double throw (SPDT) coax relay. This coax relay is getting high-tech and very high-power.*

to improve the receive sensitivity some 4 dB on transmit and now have 1.2 watts of power output on the system. Removing the BNC relays and their high switching loss did the trick. By changing the circuit's switching configuration I was able to use only one SPDT SMA coaxial relay to do all the switching. I deemed it was not necessary to switch the preamp and power amp, and let the coax switching take place on preamp in and RF out to the antenna. With the old design using BNC relays, the isolation between preamp and the power RF amplifier would have been very poor and possibly destroyed the RF preamp if switching were done with a single BNC relay. Isolation at 1296 MHz with the SMA relay measured in excess of 30 dB loss between the switched side of the relay and the nonswitched side.

The bottom line with RF coaxial relays is to pick up what you can for your projects but have a handle on which type will better serve your application and frequency of operation specifications. Yes, the SMA connector is the best choice for microwave frequencies. Power specifications roll off as frequency is increased. I haven't observed any real problems running 10 watts of power at 10 GHz. I would not try to push ratings and go for the maximum power, as I am a conservative user and believe in not pushing the maximum envelope. Do I use an SMA relay for switching the 1 and 5 watt amplifiers described in last month's 73 Magazine column? You bet! SMA forever.

Some general rules on SMA coaxial switches are: (1) Small size can handle higher power levels, with some manufacturers claiming several hundred watts at VHF and derated in power at 10 GHz to the 20-watt range. (2) Isolation or crosstalk between open and closed side of the switch is rated in dB and can be as great as 50 dB in some relays. These are maximum ratings for certain types, and I recommend not pushing any device to its maximum ratings.

"N" type relays are rated in the 500- to 1,000-watt range at HF/VHF and are reduced in power to the 50- to 100-watt ranges at frequencies of 2 to 3 GHz. Typically, they are large in size and can be outfitted with SMA connectors as shown in **Photo C**, if you look close. I don't try and push ratings, and I reserve this type of relay for HF to 1296 MHz high-power rigs.

Photo E shows the largest coaxial relay in my collection. It weighs in at 7 pounds, and that's without connectors attached. It's made for very-large-diameter one-inch helix cable for industrial high-power switching. A centerpiece to be sure of, or a great door stop if you're not into very high-power relays.

BNC and related UHF connectors and associated relays are better left for 2 to 30 MHz for the purist. Yes, I know they are used at much higher frequencies, but compared to "N" and "SMA" types, the BNC and UHF connectors are left in the dust. If you locate a relay and want to determine its ratings, try searching the Web for its original manufacturer. However, it might be difficult, as most companies have merged or just gone away.

As with all projects, and especially amateur microwave-related items covering this coaxial relay application, I will be glad to answer questions. Drop me a note on E-mail to [wb6igp@hamradio.com].

Well, that's it for this month. Coming up, I will be covering usage of microwave attenuators, detectors, and other coaxial test devices. 73, Chuck WB6IGP. 73

Photo E. *Now, just when you think you have seen everything, here is a coaxial relay, with connectors, that weighs in at seven pounds. A short section of coax cable is attached with connectors on each end, contributing a half pound. Consider this relay in the multi-multi-kilowatt level. Shown with smaller "N"- and SMA-type relays for size comparison; miniature SMA shown center front is 1-inch square.*