The Home Station—*Part 2*

In Part 1, in the January 2005 column, we started our look at the home microwave station and saw the benefits of operating at home. The home station needed a sequencer and band switch. Now we will look at some details in switching arrangements that have been employed to make home stations functional and efficient.

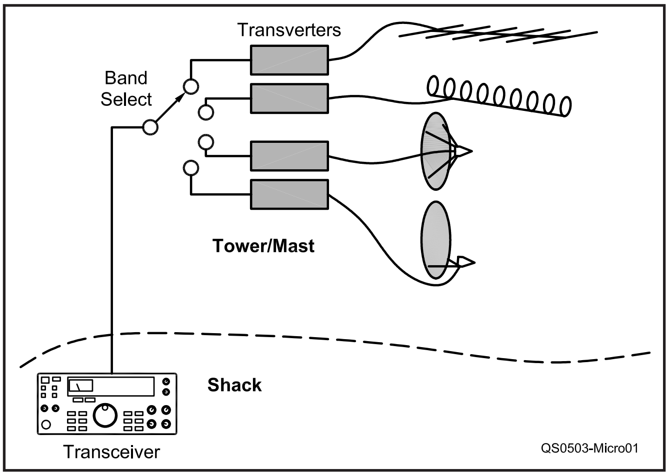

Figure 1—One way to overcome feed-line loss is to mount all the transverters at the mast.

Coax and Transmit Power

As you build up your station, you will come to know that microwave power amplifiers are expensive. Low loss coax, such as hardline, which is needed to minimize power loss, is also expensive. And even if you decide to save some money and trust surplus hardline, the connectors can cost $75 each or more. So, home microwavers face the challenge of using expensive coax and connectors to get the signal to the antenna for every microwave band they want to operate. One common way to operate many bands affordably is to use one piece of high quality coax and switch it between bands as needed.

Another way to deal with the problem is to mount all the transverters at the mast and just run inexpensive coax for the IF radio connection. Figure 1 shows this mast-mounted approach. Reasonable power levels of several watts are now available from affordable transverters, and so this approach is attractive for home stations. There are some disadvantages to the mast-mounted transverter, however. One is that the temperature-sensitive local oscillator is outdoors where there can be big thermal swings, and so frequency stability requires special attention. Of course, climbing the tower (probably twice) to repair a transverter is another disadvantage for most of us. Because transverters are expensive, extra care to reduce lightning damage should be considered when mast-mounting. The rest of this column will be focused on the multiplexed coax approach where the only electronics at the mast are the low noise amplifiers and relays.

As mentioned in this column in November 2004 *QST*, the maximum frequency that a coaxial cable reliably supports depends on its diameter. A formula that provides a close estimate is shown below, where d is the diameter of the inner conductor in inches, D the diameter of the inside surface of the outer conductor in inches, and ε is the relative dielectric constant of the supporting material.

Usually, the manufacturer of cable will leave a frequency margin to guarantee that the coax will not enter the circular waveguide mode if used within specifications. Amateurs will often push beyond the published frequency limits, and perhaps slightly beyond the actual first waveguide mode. For instance, $^1/_2$ inch 50 Ω hardline is occasionally used at 10,368 MHz, although the calculated cutoff frequency is 10,015 MHz, and $^7/_8$ inch is used by some amateurs up to 5760 MHz, although its calculated cutoff is 5336 MHz.

Loss follows a much more complex formula and we generally rely on the specifications provided by the cable manufacturer. It is often expressed in dB per unit length, with dB per 100 feet the most common. Table 1 shows the loss of a few common cables.

As the diameter of the coax increases, the maximum usable frequency is lower, and the loss is lower. So, the best coax choice is the largest that will support the highest frequency in use. The cutoff frequency of coaxial cable is very slightly underestimated by this handy formula:

$$\text{Cutoff in GHz} = \frac{7.50}{\sqrt{\varepsilon} * (D+d)}$$

Table 1
Losses for Some Common Coaxial Cables

These values were interpolated from published data. Actual loss may vary slightly from these numbers.

Cable Type	*Loss in dB/100 ft at Various Frequencies*			
	903 MHz	*1296 MHz*	*2304 MHz*	*3456 MHz*
Andrew Heliax LDF5-50A $^7/_8$ inch hardline	1.2	1.4	2.0	2.6
Andrew Heliax LDF4-50A $^1/_2$ inch hardline	2.1	2.6	3.5	4.6
Times Microwave LMR 400	3.9	4.7	6.5	8.3
Belden 9913F	4.7	5.7	8.1	10.9

A Home Station Coax Relay Circuit

Let's take a look at a home station that employs just two coax runs to operate four bands. In Figure 2, the lowest loss cable is used for the transmit circuit because the amplifiers are mounted in the shack. It is represented in the diagram

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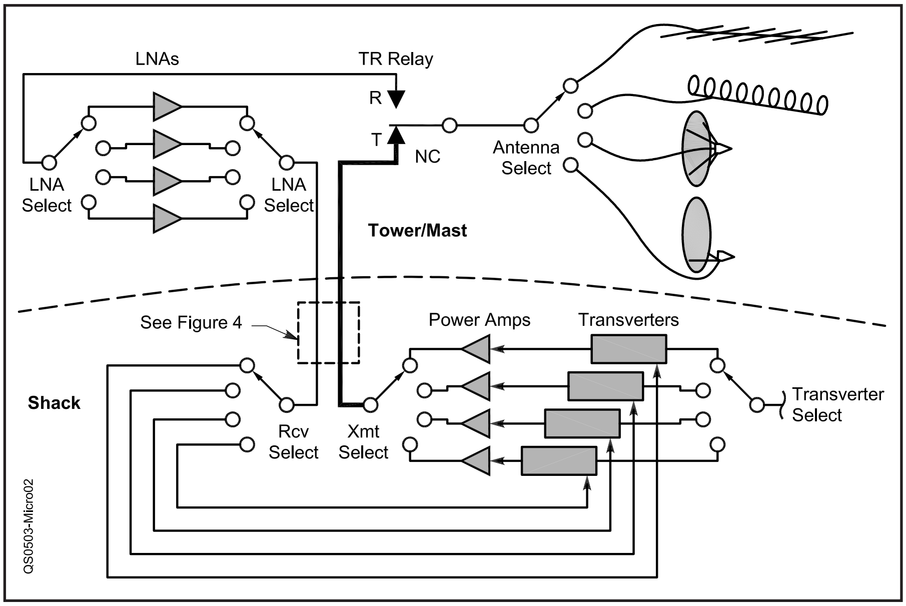

Figure 2—A coax and relay circuit that uses one transmit and one receive coax run operating four microwave bands.

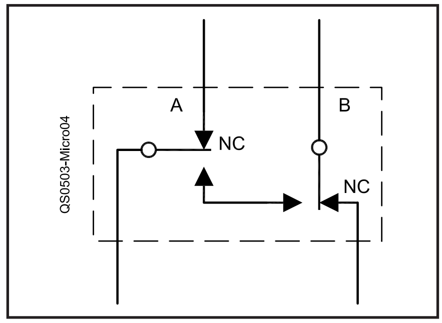

Figure 4—By placing these two relays into the receive and transmit coax lines at the shack, it is possible to bypass tower mounted LNAs

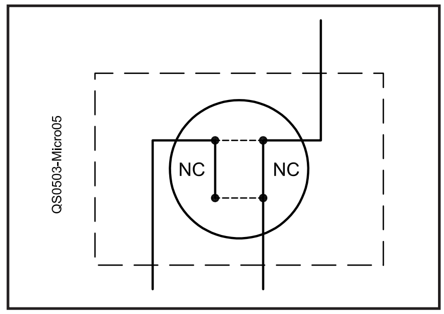

Figure 5—It is possible to use a single "transfer" relay instead of the two relays in Figure 4.

Figure 3—This photo shows a surplus Transco brand four-port N-type relay.

with the heavy line. Another, less expensive cable can be used for the receive run because low noise amplifiers are mounted at the mast and overcome the higher loss of that cable. For instance, one might use $^{7}/_{8}$ inch hardline for transmit on 903, 1296, 2304 and 3456 MHz. The receive cable might be $^{1}/_{2}$ inch Andrew Heliax LDF4-50A hardline, or perhaps Times Microwave LMR400, Belden 9913 or some such high quality cable.

All of the 4-port relays are switched together to the chosen band. A typical surplus 4 port relay with N connectors by Transco capable of handling fairly high power through 10 GHz is shown in Figure 3. Relays capable of handling lower power, suitable for use in the receive path could be less bulky and are likely fitted with SMA connectors. In our circuit, energizing a particular port on all 4-port relays selects the transverter, LNA, and antenna into the appropriate lines for operation.

Then, at the appropriate moment in the transmit sequence, the mast-mounted TR relay is energized to switch between transmit and receive. Other circuits, such as LNA power, transverter control, amplifier keying and IF radio, are also switched by the sequencer. In systems where a hundred or more watts are being transmitted, even a good TR relay might have enough leakage (insufficient isolation) to put significant power levels into the sensitive LNA. One has to consider whether it is advisable to also de-energize the LNA multiport relay to further isolate the LNA prior to transmit.

Bypassing LNAs

I have had several inquiries regarding the possibility of bypassing LNAs as may be required during contesting operation where overload is a real possibility. A high power winning contest station is less than 40 miles away from my QTH, and when either of us is pointed at the other station, front-end overload is a reality. Even more frustrating is the failure of an LNA during a contest. One can continue to operate, albeit with less receive sensitivity, if a bypass capability is available. I have seen several circuits employed to accommodate LNA bypass. I chose the one described here because it puts the extra components in the shack where it is easier to maintain and minimizes the control circuits and relays on the tower. Also, this circuit has the advantage of using the higher quality transmit coax for the receive circuit during bypass.

To implement the bypass system, the circuit in Figure 4 is inserted into the Figure 2 circuit where the dashed box is shown. Relay A is inserted into the receive coax and relay B is inserted into the transmit coax. Both are shown in normally connected (non-energized) state, making the circuit the same as the original. To bypass the LNA, the tower TR relay is left in the transmit position. Then, relays A and B are energized during receive.

Figure 5 shows a way to accomplish this function with only one relay—a transfer relay. As shown, the left two and the right two connections are made when there is no energy applied. With application of the coil voltage, those connections are broken, and the dashed connections (upper pair and lower pair) are made. Just as with the two relay circuit, to bypass the LNA the TR relay on the tower is left in the transmit position and the transfer relay is energized during receive.

In the next installment, we will finish the home microwave station with some pointers about lightning, getting around the rotator, and some resources for sequencers. QST