Home Station—*Part 3*

To complete the microwave home station series, we take a look at getting the signal around the rotator and protection for mast-mounted low-noise amplifiers.

Around the Rotator

One problem that every home station developer has to resolve is getting the signals from the tower to the mast. The dressing of the cable, and the choice of coaxial cable for the rotator loop are two important parts of any effective system. It obviously has to be flexible enough to withstand thousands of rotator cycles without replacement, but we don't want to pay a signal loss penalty.

There are several cable possibilities. One is super-flexible "hardline." Such coax is perhaps a little more expensive than regular hardline, but is able to withstand hundreds to thousands of gentle bend cycles. Another, more flexible but higher loss choice is braided coax. Some types perform well enough at microwave frequencies as shown in Table 1 to justify their use in the relatively short run around the rotator. Remember, these numbers are dB/100 ft, so if you use 10 feet you would divide the number for your coax by 10 to get the dB of loss.

Your coaxial bundle must be dressed in a manner that ensures that the bend is never tight. If the cable bend changes by a large amount each time the mast is rotated, the coax will fail sooner than if the bend change is small. For instance, consider a situation where a 2 foot diameter (1 foot radius) rotator loop is made where the coax takes three turns around the rotator in the tightest configuration. When the rotator is 360° around (unwinding), then the rotator loop coax will take only two turns (see Figure 1A). The circumference will change by 3/2 so the radius will also, changing from 1 foot to 1$^1/_2$ feet assuming that the loop dresses evenly as the mast winds. In this example, the rotator loop radius goes through a very small change. I have found some super-flexible hardline to last over five years in use with greater (worse) radius changes than this example, and braided coax has lasted over 10 years.

Another, perhaps more common way to dress the cable is to have it dangle from the mast, connecting to the tower in a J shape (see Figure 1B). When the mast winds 180° or unwinds 180° from this most relaxed state, the coax goes through a torsion twist. One has to be careful about any guy wires or other obstruction nearby that could catch the coax. The J shape is slightly less desirable because the torsion forces can be more destructive to coaxial cable than a radial bend. Even so, this method, prevalent on HF and VHF installations is commonly found at microwave home sta-

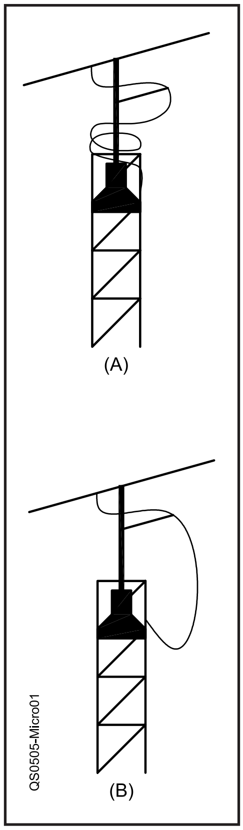

Figure 1—Here are two ways to dress transmission line around a rotator. In (A) the coax will wind and unwind, while in (B) it will twist in a rotation about its axis as well.

K3TUF

Figure 2—A common rotator loop is the "J" shape as shown here on K3TUF's tower.

W3RJW

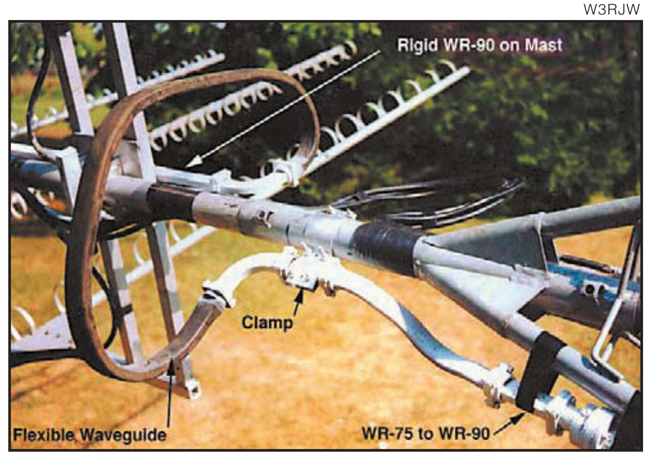

Figure 3—For those who want the minimum loss, flexible waveguide might be the answer.

Table 1

Losses for Some Common Coaxial Cables Used in Home Microwave Station Rotator Loops

Cable Type	*Loss in dB / 100 ft at frequency (MHz)*					
	903	*1296*	*2304*	*3456*	*5760*	*10,368*
Andrew FSJ4-50A $^1/_2$ inch Superflex	3.4	4.1	5.8	7.3	10.1	12.2*
Belden 9913F	4.7	5.7	8.1	10.9	13.5	21*
Andrew FSJ1-50B ¼ inch Superflex	5.7	6.9	9.4	11.8	15.8	22.3
Standard RG-8/U	6.9	8.5	12	15.6	21.8	32.5*

*These values were interpolated from published data. Although several of these cables are not rated at 10,368 MHz, amateurs often use them. Your results are likely to vary.

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Figure 4—A rotary joint can provide coaxial and waveguide rotation, but are very difficult to apply to Amateur Radio rotator and mast systems.

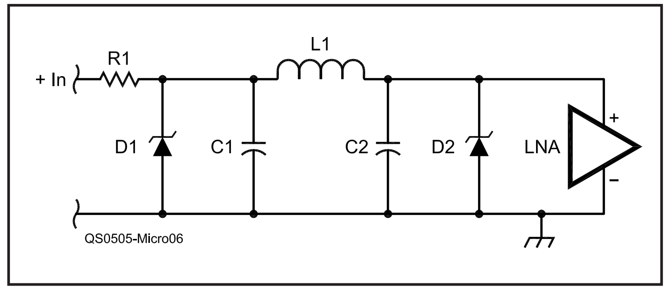

Figure 5—A low pass filter and transient absorbers go a long way to protecting from lightning damage even if the power source is left connected and turned on. Specific component manufacturers and sources are not critical as long as the components have the correct values.

C1, C2—0.01 µF capacitors, 400 WVdc or greater, 1000 V peak rated (BC1587-ND).
D1—50 to 125 V rating, 1.5 kW unidirectional transient absorber (1.5KE68ADICT-ND).
D2—15 V rating 1.5 kW unidirectional transient absorber (1.5KE15ADICT-ND).
L1—1 mH hash choke (M5258-ND).
R1—10 Ω, 3 W wirewound resistor (ALSR3F-10-ND).

tions, and can operate for many years without failure. Figure 2 shows an installation at K3TUF that uses separate coaxial cables for most bands and combines 2 and 3 GHz on a low loss RG-8 style Cable Experts CXP1318FX coax for the rotator loop. At microwave frequencies this cable has similar performance to Belden 9913F.

Some amateurs manage to use waveguide transmission line. Although this is expensive, and somewhat difficult to maintain (it has to be kept dry, usually with a slight pressurization from a dehydration pump mounted indoors), is used on only one band, and poses difficulties for rotators. There are two ways that I have seen amateurs solve the waveguide/rotator problem. One is through use of "flexible waveguide," which, much like flexible hardline, is specially fabricated to allow flexure without breakage much like an accordion bellows. Figure 3 shows an installation at W3RJW's tower.

Yet another technique uses a "rotary joint." These consist of two waveguides connected with a dual coaxial transition through the middle of the bearing (see Figure 4). Some also have coax connections. They were developed for radars, and are occasionally found at hamfests, but difficult to insert into a typical amateur rotator/mast system. Kent, W5VJB, reports successful use of a rotary joint in his home 10 GHz station

Lightning

Protection from lightning is not usually a consideration for hilltop portable and rover operation, but a very real problem for home stations. This is not specifically a microwave concern, and there have been many articles written about lightning protection. However, most HF operators do not have much electronic equipment mounted at the mast. In this limited space I can only give some advice. Once you have done the obvious (disconnect shack equipment from the tower equipment, disconnect from the power mains, use proper lightning grounding for the tower and equipment), the next area to concentrate on is the LNAs and relays.

By having the primary TR relay energize on RECEIVE, then in the non-energized state when the lightning hits, the antenna port will be connected to the transmit line, reducing the chance of the bolt entering the LNA front ends. Further isolation is often provided if the LNAs are multiplexed because of another open relay in the circuit. Lightning does not have very much energy from 1-24 GHz, so this isolation is usually adequate for microwave LNA antenna ports. The greatest damage is usually done through the power connection. There are several causes of this, but most often the ground reference at the top of the tower changes and the power connection does not. This presents a voltage difference between the power connection and the "ground" that can be of reverse polarity or a high enough forward voltage to cause damage. Such conditions can exist even when the shack control circuits are disconnected because the power cable impedance is low at the high slew rates developed by a lightning strike.

Professional installations where power remains connected include a one or two section LC low pass filter in the dc line. They use capacitors with high voltage ratings (see Figure 5) a current limiting resistor and two stages of voltage transient absorption. The parts list given (including DigiKey catalog numbers) is just an example—you can probably use any quality parts with similar rating, or use surface-mounted rather than through-hole components. A similar approach can be taken to protect relays although they are relatively immune because of their high inductance. Substitute a 5 Ω, 3 W resistor for R1 in a relay circuit. If you want to apply this circuit to a number of relays and LNAs, a small circuit board can be developed and replicated. Care should be taken to provide space to prevent arcing at the high voltage points.

A further step can be taken that reduces the chance of damage if the shack relay control and LNA power circuits are powered down but not physically disconnected during a lightning storm. This involves inserting a regular dc relay closure into every power connection at the tower. A single control line may energize them all when the system is in use. This provides an additional gap over which damaging current will have to jump during a strike. By placing a transient absorber across each control and power line before the relay, there are lower impedance paths available to discharge induced potentials.

A Real Sequencer

People have asked me for more information about sequencers—perhaps a circuit that can be reliably built or purchased rather than the sketchy diagrams I presented in previous columns. Here are some pointers to units, some of which I have put to use in the past, and saved me all the problems I faced when I built my own.

Down East Microwave has the DEM TRS available assembled or a kit. They also have transverter interfaces that include some sequencing. Set your browser to **www.downeastmicrowave.com**.

W5UN wrote up an EME station approach for VHF applications, but it applies to microwave home stations as well. See **www.wt.net/~w5un/sequence.gif**.

Advanced Receiver Research model TRS04VD was reviewed in February 1987 *QST*. They can be reached at **www.advancedreceiver.com**.

JWM Engineering SEQ-1 (this one is microprocessor based) was reviewed in Sept 2004 *QST*. See **www.jwmeng.com**.

SSB Electronic sells sequencers specifically for their mast-mounted preamps (**www.ssbusa.com**).