W1GHZ

MICROWAVELENGTHS

Avoiding Lossy Feed Lines, With Gain…Perhaps

In the January "Microwavelengths," we looked at feed lines, and found that loss is high at microwave frequencies. The loss not only soaks up our transmit power, but also reduces the receiver signal-to-noise ratio, hurting us in both directions. So, how can we avoid feed line loss for a fixed station?

One way is to put the equipment up in the air. Ed, K1TR, operated successfully in several 10 GHz contests by carrying a portable station up his tower and operating on the tower. While this is good for a few hours of contest operation, frequent climbing would soon become tiresome.

Many stations have placed a transverter on a tower and operated it remotely, realizing better performance than with a lossy feed line. Some feed line is still necessary, from the transverter to the antenna, and it must be flexible unless the equipment rotates with the antenna. A significant amount of dc power must be sent up the tower in addition to IF and switching signals. Condensation, temperature variation, and lightning may present difficulties with reliability and maintenance in some climates.

Frequency Stability

The element most sensitive to temperature is the frequency stability of oscillators. We might choose to keep the master oscillator indoors, and send a reference frequency up the tower, further increasing the number of cables going up the tower. We could put both dc and RF on a cable and use other clever combinations to reduce the total number, but we still end up with a number of cables.

Another possibility is to reduce the equipment on the tower to just the transmit power amplifier and the receive preamp, sending lower level signals through the long feed line and overcoming the loss with inexpensive amplifiers. Tom, WA1MBA, had an elegant installation of this type, with the preamps and power amplifiers for three different microwave bands in one box, selected as needed by a pair of seven-position coax switches. The seventh position was a straight-through connection, for *when* (not if) something failed. The antenna was a dish with a tri-band feed, and only one RF cable was needed down the tower. A compact, lightweight microwave installation, but careful switching is necessary to prevent expensive disasters.

Tom's installation succumbed to a lightning strike, and others' tower-mounted installations have proven hard to maintain. I know of one Connecticut ham who climbed his tower in a January contest snowstorm to replace a malfunctioning transverter.

Up Periscope

My preference is to keep the delicate equipment at ground level and only mechanical equipment in the air. For several years, I have been using a periscope antenna system, with the parabolic dish antenna at ground level and a passive *flyswatter* reflector near the top of the tower. A sketch of this system is shown in Figure 1. Only the flyswatter rotates, so only a short fixed feed line is needed, particularly with the offset dish on the ground

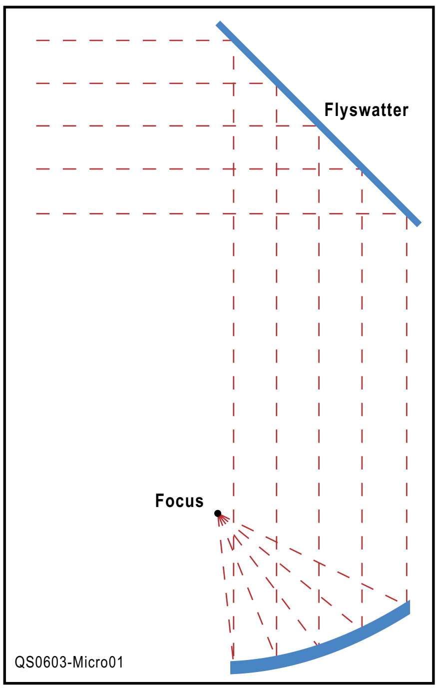

Figure 1 — Periscope antenna system with offset parabolic dish.

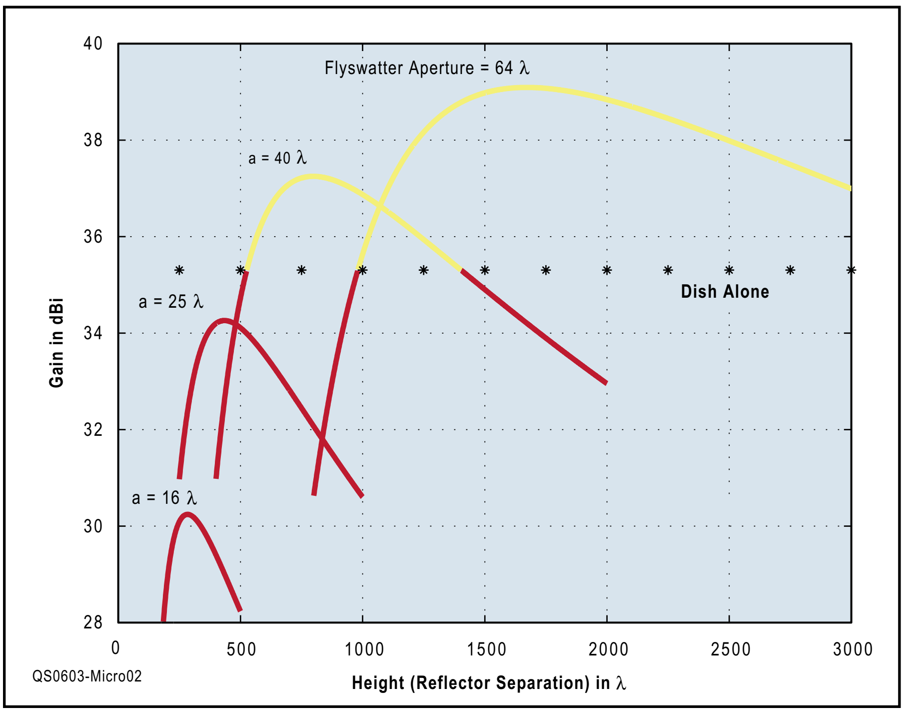

Figure 2 — System gain of periscope antenna system fed by a 25 λ diameter dish.

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Figure 3 — Flyswatter side-mounted on tower.

as shown. A conventional dish would also work, but a longer feed line would be needed unless the rig was placed right at the feed, thus blocking part of the beam.

Some advantages of the periscope antenna system are readily apparent. In addition to keeping all the microwave electronics at ground level, the flyswatter is just a flat reflector, not specific to any frequency. Thus, we can switch bands at ground level — I normally use the periscope on 10 GHz, but have made contacts on 5.76 GHz and 24 GHz by placing a portable station for the additional band on top of the fixed 10 GHz dish, pointing straight up at the flyswatter. Another advantage is that the tilted flat reflector has much less wind load than a dish of the same area.

However, the real advantage of the periscope system is that it can have more gain than the dish alone. With the right combination, the periscope system can provide several dB of gain over the dish alone. A feed line with gain rather than loss!

For best performance, the flyswatter must be larger than the dish and the distance between them must be greater than the Rayleigh distance of the dish:

$$\text{Rayleigh distance} = \frac{2D^2}{\lambda},$$

where D is the diameter of the dish. To achieve high gain requires a big dish, a bigger flyswatter, and a very high tower. Figure 2 shows gain curves for one example, a 25 λ diameter dish, which is a reasonable size at 10 GHz (The chart is in wavelengths — using the 10 GHz approximation that 10 $\lambda \cong$ 1 foot might give a better feel for sizes). For all the details, see the *W1GHZ Microwave Antenna Book — Online* at **www.w1ghz.org**.

G-Line

In the column on microwave feed lines, I made no mention of "G-line." Nick Leggett, N3NL, pointed out a *QST* article demonstrating that G-line does work at 1296 MHz: G. Gatherell, K6LK, "Putting the G-Line to Work" *QST*, Jun 1974, p 11.

If anyone has successfully used G-line at higher frequencies, please publish the results.

Figure 4 — Offset dish at base of tower under flyswatter (W1GHZ checking focus with string).

Dealing with Mechanics

The periscope system looks straightforward in Figure 1, but there are still problems to solve — all mechanical. What is missing in the sketch is a support structure; since I couldn't find a skyhook, the flyswatter had to go on the tower. If it is attached to the central rotating mast, then it travels around the outside of the tower, and the dish on the ground must follow. Instead, I chose to side-mount the flyswatter near the top of the tower, hanging down from an inexpensive rotator as shown in Figure 3, so that the RF path from the dish is unobstructed. The disadvantage is that the signal must travel through the tower in one direction, and I tried to pick the least-populated direction. However, I still had to make a contact through the tower for a new grid.

Although my QTH is not a great microwave location, I have been able to work six grid squares on 10 GHz. Some of them required enhancement from rain scatter or snow scatter. To better take advantage of scatter, the flyswatter includes a provision for tilt as well as rotation, using a surplus TVRO actuator donated by Jud, K2CBA.

If the flyswatter is completely adjustable, then the dish need not be mounted vertically below, since the flyswatter can be adjusted to reflect in any direction. Calculating the required angle would involve a bit

WB6CWN

Figure 5 — WB6CWN periscope antenna on moveable cart.

of solid geometry, but it would be easy for a computer. I chose to keep things simple and stick to a vertical periscope, with the dish mounted next to the tower as shown in Figure 4. With the offset dish, the feedhorn is accessible and out of the RF beam, and the equipment can be attached to the tower. The feedhorn is located at the focus of the dish using the string technique discussed in a previous column.

One interesting problem is polarization: the radiated polarization changes as the flyswatter rotates. This doesn't seem to be a significant problem for rain and snow scatter, but has probably made some other contacts more difficult. One solution would be to rotate the feed as well as the flyswatter; another might be circular polarization, which I plan to experiment with someday. Circular polarization would result in a 3-dB loss in all directions, while the current setup is better than that for 240° of rotation out of 360, and only really bad for a small angle on each side. And any signal is better than none!

Another ham who has used a periscope system is Frank, WB6CWN. His system, shown in Figure 5, is mounted on a cart, so he can push it around the yard and find clear spots between various obstructions. The periscope antenna peers over the bushes, just as we did as kids with toy periscopes.

The Sidelobe Issue

So why doesn't everyone use a periscope? They were used for commercial microwave installations in the past, but are no longer allowed because the flyswatter generates larger sidelobes than a dish. Since most commercial sites have become very crowded, interference is a serious concern. For hams, however, sidelobes are not a serious concern, at least until 10 GHz becomes as crowded as 40 meters.

Other passive reflectors can also be useful, for contacts over otherwise obstructed paths. We have had success using mountains, buildings, and even large towers as reflectors. Airplane scatter can also be effective if you are quick.

These are a few ways to overcome high feed line loss, and I'm sure there are others. The best solution may be different for each situation, so be creative. I am constantly amazed at the ingenuity of hams — you can find a way to get some signal on the air.