Periscope Antenna Revisited – and Performance Demonstrated

Paul Wade W1GHZ ©2023
w1ghz@arrl.net

Many microwavers would like to have a home station on 10 GHz and other bands to take advantage of activity and opportunities for rainscatter and aircraft scatter. But trees and local obstructions may require getting the antenna up high, on a tower. Feedline loss is high at microwaves, and intolerable at 10 GHz and above, even in waveguide, so we must find another way to get the signal up to the antenna. One solution is to put the equipment on the tower with the antenna, and running control and IF signals, plus power, up the tower. Putting sensitive electronics out in the weather, subject to temperature variation and water incursion, sooner or later results in equipment failure. Failures usually occur at inopportune times, during contests or openings, when it may not be convenient or safe to climb the tower for repairs. And many of us are no longer young enough for frequent tower climbing.

Periscope Antenna System

The periscope antenna, sketched in Figure 1, avoids feedline losses and inconvenient location of the electronics. With a dish at ground level, where equipment is easily accessible, and a flat reflector in the air to direct the beam, no feedline is needed on the tower. I used a periscope antenna successfully on 10 GHz at my previous QTH, which was surrounded by trees, and also made contacts on 24 GHz and on 5760 MHz by placing another transverter including dish on top of the 10 GHz dish. I described this system in ***QST*** Microwavelengths for March 2006, and in more detail and online. More recently, periscope systems were in use by Craig, KA5BOU, and Al Ward, W5LUA. Al's system, with the flyswatter shown in Figure 2, is used on 10 GHz and 5760 MHz, He has also used it for contacts on 47 and 78 GHz by sliding appropriate dishes under the flyswatter at ground level, shown in Figure 3.

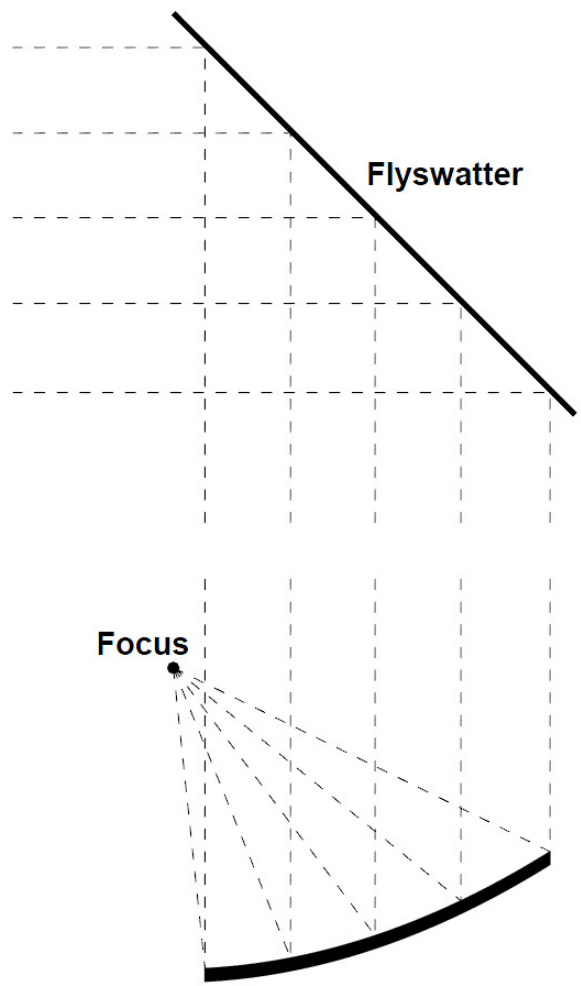

Figure 1 – Periscope Antenna & Offset Dish

Many novel amateur antennas are cited as working well based on making contacts, without any actual performance data. I was never able to verify that my periscope system actually performed as well as calculated – that would have involved moving a comparison system up the tower. However, at my current QTH in Vermont, the terrain slopes off to the west so that I am able to operate 10 GHz from ground level and monitor two beacons continuously – I have the rig outside the shop door ready to go whenever conditions warrant. But trees are growing in other directions and I'd like to get above them, so I started thinking about resurrecting the periscope to increase usable directions.

Figure 2 – W5LUA Flyswatter on rotating tower

Figure 3 – W5LUA 47 & 78 GHz dishes at base

It occurred to me that I could set up a horizontal periscope system, with both dish and flyswatter near ground level, to do a direct comparison and verify performance. On a spring-like day in December, I retrieved the old flyswatter from the woods and set it up on an antenna positioner, shown in Figure 4. The positioner was recently acquired in hopes of using the positioner for an EME dish, but here is used to move flyswatter in both azimuth and elevation. The experiment was to compare the horizontal periscope, using my backup 10 GHz system, which has an 18-inch dish, with the 24-inch dish of my usual 10 GHz system.

Figure 4 – Flyswatter in horizontal configuration

The first step was to compare the two systems, set up side-by-side. On both beacons, N1JEZ/b at FN34om, 42 km distant, and VE2TWO/b at FN25uk, 195 km distant, the 18-inch system was about 1 dB weaker than the 24-inch system. The expected difference would be 2.4 dB, but the smaller system has a preamp – perhaps some improvement is needed in the larger one.

The location of the smaller dish was marked and the flyswatter placed at the same location, in Figure 5, with 24 inch comparison dish at left under the plastic bag. The optimum periscope distance between an 18-inch (17λ) dish and a 30-inch (26λ) flyswatter can be estimated from Figure 6 (from http://w1ghz.org/antbook/chap8.pdf) as about 300 wavelengths, or 28.5 feet. Gain is predicted by the graph to be about 1.4 dB higher than the gain of the dish alone. Comparisons were made again, this time between the 24-inch dish and the periscope system. On the closer beacon, the periscope system was about 2 dB better than the 24-inch dish, but on the distant beacon signals were about equal. All signals had significant QSB, so the level recorded was the highest seen on the panadapter in a period of about one minute.   As a double-check, the comparisons were done again the following morning with the same results. An impending snowstorm necessitated terminating the experiment and dismantling the periscope system.

Figure 5 – Horizontal periscope test at ground level

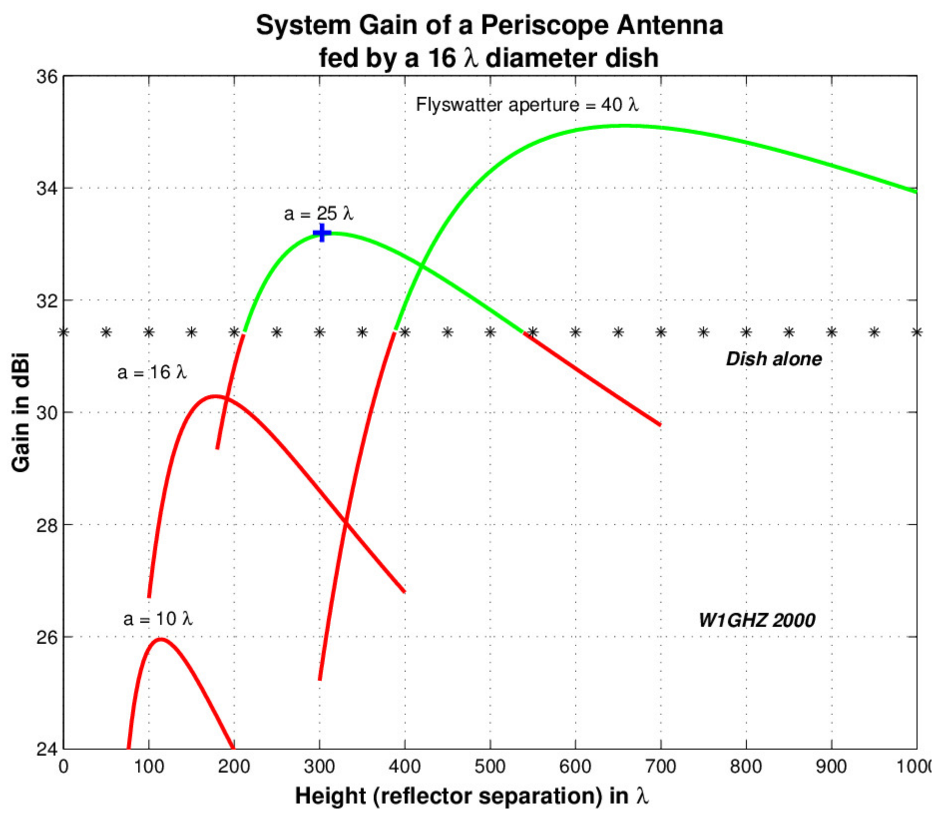

Figure 6 – Predicted performance (at +) of this horizontal periscope system

The conclusion is that the periscope system, with an 18-inch dish and 30-inch flyswatter, has gain equal to or better than the 24-inch dish. This is higher than the 18-inch dish alone, so the periscope system adds gain. The 28.5 feet separation is suitable for a small tower like mine; a higher tower would require a larger dish and possibly a larger flyswatter to provide gain over the dish alone. Appropriate curves and a spreadsheet for estimating may be found at http://w1ghz.org/antbook/chap8.pdf. The spreadsheet data for this horizontal periscope is captured in Figure 7. But even if the optimum distances and sizes can't be achieved, getting above trees or obstructions without feedline loss can still be a win. The curves can be used to evaluate tradeoffs.

PERISCOPE ANTENNA GAIN CALCULATOR			
	W1GHZ 2000		
ENTER INPUT PARAMETERS HERE:			
Frequency	**10.368**	GHz	
Dish diameter	**0.5**	meters	Note: 1 meter = 3.28 feet
Flyswatter Aperture	**0.76**	meters	
Height (reflect. Spacing)	**8.7**	meters	
Suggested flyswatter =	***0.7***	***meters - for this height and frequency***	
READ FINAL RESULTS HERE:			
System Gain	**33.5**	dBi	
Dish Gain	**32.1**	dBi	
"FEEDLINE" equivalent	**1.4**	dB (effective gain of periscope over dish)	

Figure 7 – Spreadsheet for this horizontal periscope system

Another thing that quickly became obvious is that the periscope beamwidth is that of the 30-inch aperture of the flyswatter, much sharper than the smaller dish. As KA5BOU pointed out, tilting the flyswatter in a vertical periscope system changes the beam elevation 2° for each degree of flyswatter tilt. In the horizontal periscope, it is the azimuth that changes twice as fast, and aiming the horizontal flyswatter is not intuitive. Also, the antenna positioner moves too rapidly, so peaking the antenna positioner on a weak signal with QSB was difficult.

Implementation

The W5LUA system is on a rotating tower, so both the dish and flyswatter rotate with the tower and only a small actuator is needed to optimize tilt for elevation. The KA5BOU system, and my original one, both have the dish and flyswatter in fixed positions, with a rotating and tilting flyswatter. At one heading, the beam passes through the tower; there is some loss, but it still seems usable – I've made contacts through the tower. The rotating flyswatter means that polarization changes with rotation, so correction is necessary – rotating the feedhorn is one solution. A less than optimal solution might be circular polarization, with a 3 dB penalty in all directions, on both transmit and receive. The reduction in complexity might be an acceptable tradeoff.

The dish does not have to be directly under the flyswatter. The dish can be near the shack with the tower further away, but still pointed at the flyswatter. Since almost everyone now uses a computer in the shack, the proper azimuth and tilt for the flyswatter can be calculated for each beam heading – just a bit of vector geometry. A small Arduino or Raspberry Pi could be programmed to control the flyswatter.

My original flat flyswatter on the tower was centered on the rotator, reducing torque, so that only a small inexpensive rotator and tilt actuator were needed. I never saw the flyswatter move with wind.

Conclusion

The periscope system has been shown to work as predicted. It eliminates feedline loss, and can even provide gain. The delicate equipment is at an accessible location, reducing the need for tower climbing. If you are considering a home station for 10 GHz, it might be a good choice.