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Understanding Feed Horns for Parabolic Dishes

A dish antenna has two parts: the parabolic reflector and the feed antenna that transitions RF energy from the feed line to the dish. At microwave frequencies, the feed is commonly a feed horn. There seems to be a lack of understanding of feed horns, even among some experienced microwavers. It's time for a review of the basics.

Parabolic Dish Illumination

A parabolic dish is a quasi-optical reflecting lens. Energy arriving from a distant source is reflected by the dish to converge on the focal point. In the other direction, transmitted energy emitted at the focal point is reflected by the parabolic reflector into a narrow beam. Any energy emitted that does not illuminate the reflector is wasted, so we want a source that only illuminates the reflector.

A feed horn is chosen to illuminate the desired parabolic reflector. A typical feed horn radiation pattern is selected and positioned to be about 10 dB down at the edges of the reflector to provide the best aperture efficiency, yielding the best gain. Figure 1 shows how a feed horn for a prime-focus dish must cover a wide illumination angle (120 to 180 degrees depending on the focus-to-diameter ratio, or f/D), while a feed horn for an offset dish covers a narrower angle (about 80 degrees for common TV satellite dishes). The feed horn should be matched to the reflector, so the 10 dB down circle of the horn should meet the edge of the dish when the feed horn is at the focus.

An open waveguide radiates with a rather wide beamwidth, which might be usable as a feed horn for some prime-focus reflectors; coffee cans have been used at lower frequencies. Because beamwidth is inversely proportional to aperture size (a larger aperture produces a narrower beamwidth), the narrower beam needed for an offset dish can be realized by flaring the waveguide into a horn with a larger aperture.

One problem with simple waveguide feed horns is that currents in the waveguide wall at the aperture create large side lobes in the E-plane (azimuth for horizontal polarization). This makes the radiation pattern asymmetrical, illuminating the reflector unevenly, wasting power, and reducing efficiency and gain. A circular waveguide flaring out into a funnel-shaped horn has the same problem.

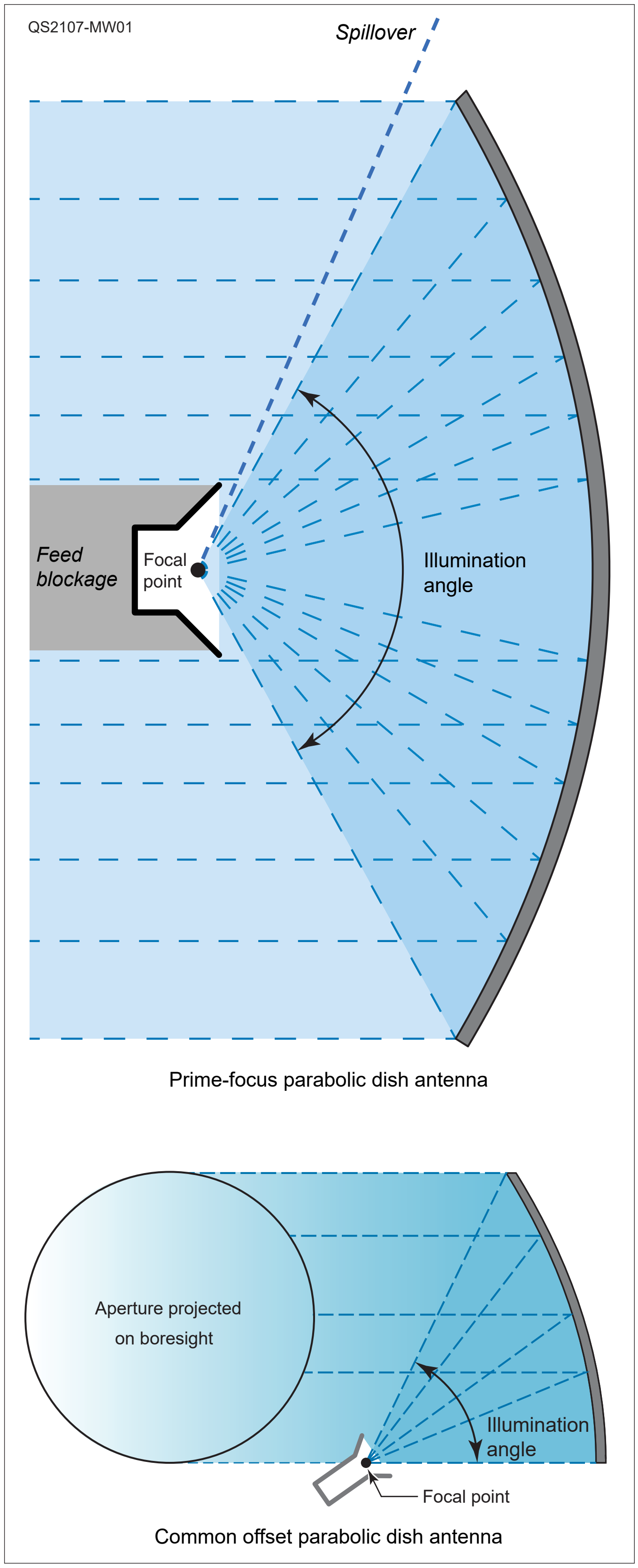

Figure 1 — Prime-focus and offset parabolic dish antennas showing illumination angles.

Figure 2 — Choke rings improve dish gain and efficiency to make better feed horns. On the left are single and multiple choke rings for prime-focus. At the right is a conical horn with rings for an offset feed horn.

However, the width and height of a rectangular horn can be varied independently to make the radiation pattern more symmetrical and to move the side lobes so that they miss the reflector. Thus, a carefully designed rectangular horn can be a good feed horn for an offset dish. A template for one may be found in *The ARRL Antenna Book*, 24th edition, page 15-74.

The effect of the currents in the waveguide can be reduced and performance can be improved by adding choke rings around the waveguide (see Figure 2). Adding multiple rings (often called a Chaparral feed) makes the feed more broadband, but a single ring is adequate for an amateur band. The classic choke ring, popularized by Barry Malowanchuk, VE4MA, is ½ λ deep and ½ λ wide around the circular waveguide. Performance can be further improved by optimizing the dimensions, which is explained in more detail at **www.w1ghz.org/antbook/conf/high_efficiency_prime_feeds.pdf**.

Standalone satellite TV horns are rare today, as most are integrated into a low-noise block (LNB) assembly, but some can be cut off and modified. For lower bands, similar horns can be homebrewed by scaling the dimensions. Some metal work may be required, either with sheet metal (see Figure 3) or by finding pipe, tin cans, and cake tins with approximately the desired dimension. Another possibility is 3D printing a feed horn, then coating the plastic with conductive metal, as described in the January 2019 "Microwavelengths" column.

The Phase Center

The parabolic reflector has a focal point where energy is focused, but feed horns are much larger than a point. The radiation from a good feed horn appears to emanate from a single point, which we call the *phase center*, at least over the illumination angle. Better feed horns have the same phase center in both the E-plane (azimuth) and H-plane (elevation). When the phase center of the feed

Figure 3 — Larger feed horns for lower frequency bands can be fabricated from sheet metal, like the one Chip Taylor, W1AIM, is adjusting on his 16-foot dish for 1296 MHz.

horn is placed at the focal point of the dish and the feed horn is pointed at the center of the reflector, the dish antenna is complete.

For prime focus feed horns, the phase center is located near the center of the waveguide aperture. For the phase center of offset feed horns, it is typically inside the horn. Exact feed horn placement can be optimized by using sun noise or a sufficiently long antenna range.

On-Air Testing

The best antenna is the one that is on the air and making contacts. Getting on the air usually involves some compromises, so don't obsess about making everything perfect. Just do your best, try it out, and you'll see where improvements are needed over time.

All photos provided by the author.