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## Microwavelengths

# Parabolic Dishes

While it may seem that a parabolic dish is crucial to getting on the air with microwaves, it is easier to complete a contact for all but the longest paths with smaller, easier-to-point antennas, like those in the "Microwavelengths" column from the January 2018 issue of *QST*.

A parabolic reflector has the unique property that all rays (light, radio waves, sound, etc.) originating from a point source at the focus are reflected into a parallel beam (see Figure 1). The feed antenna is the source for radio waves. Most of the energy becomes part of the beam — some misses the reflector, shown as *spillover*, and some is blocked by the feed or mounting hardware. A real feedhorn is too large to be a point source and generate a perfect beam; for a good feedhorn, most of the energy appears to come from a point called the *phase center*.

There are two basic types of parabolic dishes: the classic *prime-focus* dishes, and *offset-fed* dishes, like small satellite TV dishes. While almost all offset-fed dishes have the same basic geometry, prime-focus dishes come in various configurations, from very deep to shallow. They are characterized by the *f*/D ratio, or the ratio of focal length of the parabola to its diameter. Deep dishes (think soup bowl) have an *f*/D of less than about 0.35, while shallow dishes (think dinner plate) have a larger *f*/D and thus a larger focal length for a given diameter. All dishes with the same *f*/D have the same geometry, regardless of size, which simplifies antenna system design.

Usually, we acquire a parabolic reflector first, then find a feedhorn and work out all the mechanical details to make a working antenna. The important factors are:

1. Choosing a feedhorn appropriate to the *f*/D of the reflector.

2. Focusing the dish so that the phase center of the feedhorn is at the focal point of the parabola.

3. Mounting the dish so it can be aimed accurately and with low feed-line loss.

Clearly, we need to find the focal point and *f*/D of the reflector in order to choose a feedhorn and focus it. It may be calculated from the diameter and depth of the parabola, as shown in Figure 2.

Many feeds have been described in amateur and professional literature. I have described and analyzed many of them in the *W1GHZ Microwave Antenna Book Online*, available at **www.w1ghz.org**. Phase center location is included for the feeds to aid in positioning the phase center at the focal point of the parabola. This is the most critical dimension in a dish antenna — try to get it within a quarter wavelength. For deep dishes, focusing errors cause significant reductions in gain.

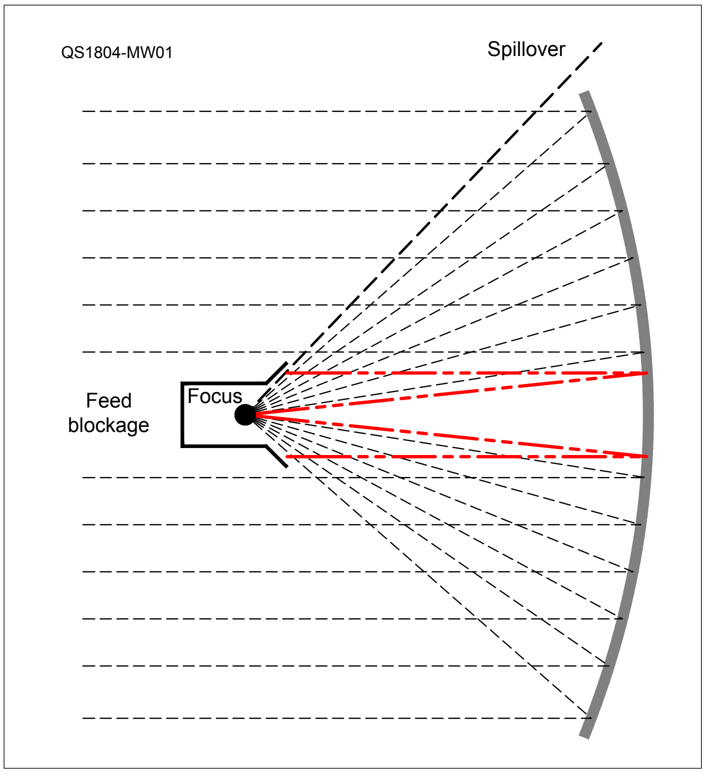


**Figure 1** — Geometry of a parabolic dish antenna.

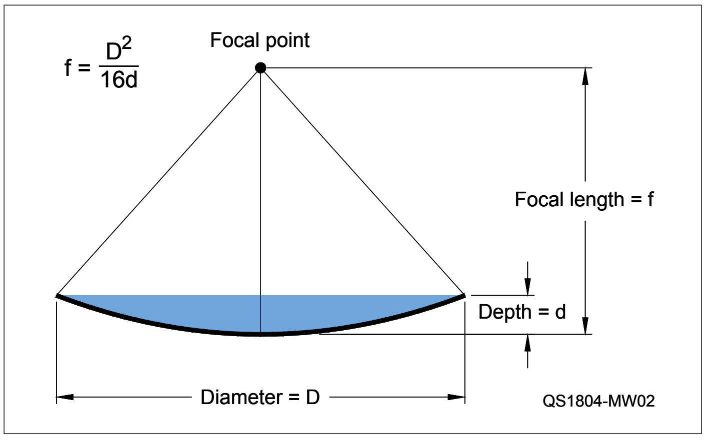


**Figure 2** — Finding the focal point of a parabolic dish.

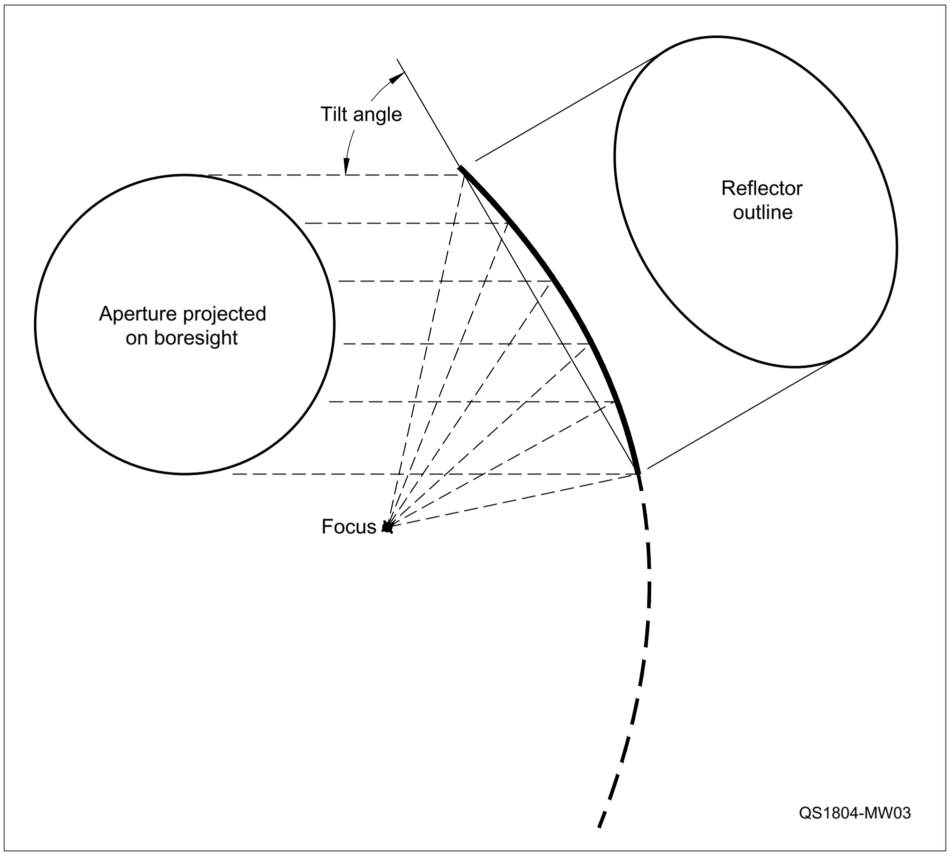


**Figure 3** — Geometry of offset parabolic dish antenna.

**Figure 4** — Good feedhorns that you can buy.

## Offset-Fed Dishes

The focal point location of an offset-fed dish is not intuitive. Figure 3 shows the basic geometry — the reflector is a section of a full parabola, with gain proportional to the reflector area. Most common offset reflectors are oval shaped but must be tilted forward to form the beam, as shown in Figure 3.

The focal point is the same as the original full parabola, but the calculation is bit more involved. Engineer John Legon has found a simple solution using the height and width of the oval and the depth of the reflector.[1] Note that the depth (the deepest point) of an offset reflector is not at the center, but is somewhere along the long axis. Legon's equation is:

$$\text{focal length} = \frac{\text{width}^3}{16 \times \text{depth} \times \text{height}} \qquad \text{[Eq. 1]}$$

Because the bottom edge of these reflectors is at the vertex (center point) of the original parabola, the focal point is level with the bottom edge of the tilted reflector, and is in front of the reflector by the focal length.

The tilt angle is also easily calculated using the height and width of the oval:

$$\text{Tilt angle} = \cos^{-1}\left(\frac{\text{width}}{\text{height}}\right) \qquad \text{[Eq. 2]}$$

For the 18-inch DSS offset dishes, the focal length is about 282 millimeters and the tilt angle is 23°.

## Feedhorns

Building a feedhorn for a 10 GHz parabolic dish is easier than it sounds, though many hams might overlook this possibility and prefer to buy one. Off-the-shelf feeds do exist, and I have located two possibilities — one for prime-focus dishes and the other for offset dishes.

The feedhorn shown on the right in Figure 4 is an Invacom ADF-120. There are several online sellers, and at least one will ship to the US at reasonable cost. The central horn is threaded, so the choke rings screw onto the horn and can be adjusted. Simulations suggest that the best position is with the choke rings screwed all the way back from the aperture. Performance should be very good for *f*/D between about 0.35 and 0.5, which covers most available dishes. The phase center is about 5 millimeters inside the aperture at 10.368 GHz.

The feedhorn on the left in Figure 4 is a Chaparral 11/12 GHz Offset Straight Feedhorn, available directly from the manufacturer.[2] This horn works well at 10.368 GHz on common offset-fed dishes. The phase center of the offset feedhorn is about 24 millimeters inside the aperture at 10.368 GHz.

Both horns can bolt directly to a WR-75 waveguide flange. For a coax connection, surplus WR-75 to coax adapters may be found, or you can easily make your own — see the 2018 edition of *The ARRL Handbook*.

**Notes**

[1]John A. R. Legon, "Calculation of the Focal Length of an Offset Satellite Dish Antenna," **www.john-legon.co.uk/offsetdish.pdf**.

[2]The 11/12 GHz Offset Straight Feedhorn can be found at **www.chaparral.net/feed-horns/offset-straight-feedhorn/**.