Dual-band 10 & 24 GHz Feedhorn for Offset Dishes
Improved for 2020

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Operating multiple bands in the 10 GHz and Up contest is difficult with separate antennas – after locating a station on 10 GHz and peaking the dish, we must start over on a higher band, usually with a narrower beamwidth. Using a dual-band feedhorn for 10 and 24 GHz would very attractive; the dish may first be pointed and peaked up on 10 GHz, then switched over to 24 GHz with no repositioning required.

The 2020 version of the dual-band feedhorn is an improved version of the one that many hams have been using successfully for a number of years. It is a one-piece machined horn designed for common offset dishes that works very well on both bands.

History

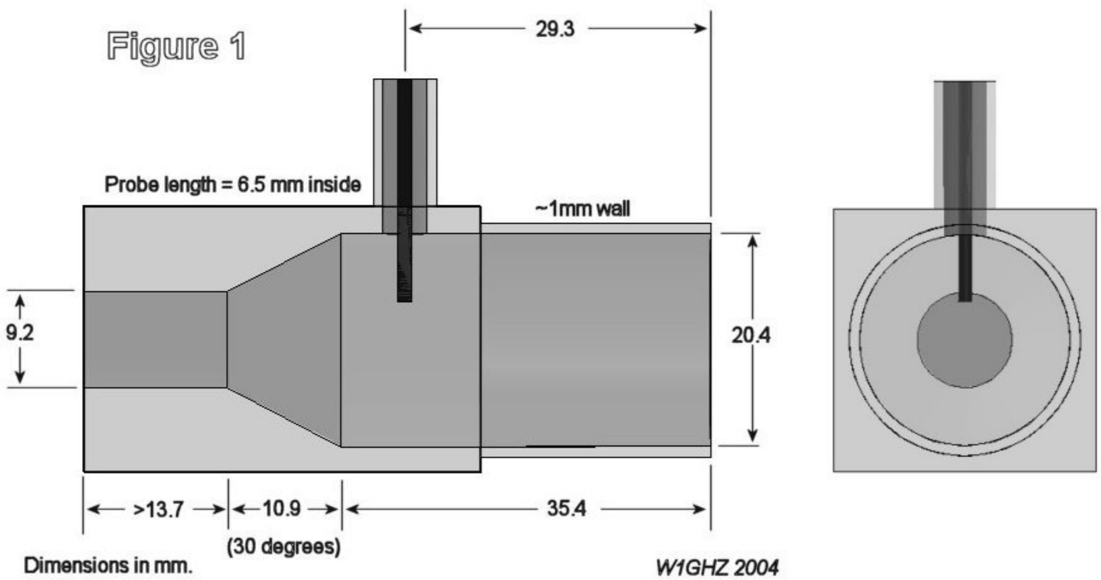
At Microwave Update 2001, AD6FP and AA6IW described[1] a dual-band 10 and 24 GHz feedhorn for shallow and offset dishes. The design was based on previous work of W5LUA[2] and W5ZN[3,4] to develop a dual-band feedhorn more suitable for conventional deep dishes. With the offset dish, we have a distinct advantage – the equipment may be located very near the feedhorn without being in the radiation pattern, minimizing the large feedline losses at the higher microwave frequencies without decreasing gain. Other advantages include higher efficiency feedhorns, less critical focusing, and the ready availability of modest-sized DSS dishes with good surface accuracy.

Gary and Lars included computer simulated radiation pattern plots which look like potentially good feeds, but did not do dish efficiency calculations. However, they did include more important results – sun noise measurements and on the air performance! To calculate efficiencies, I took the published dimensions and resimulated. The results were good, so I wanted to make a feed.

Dual-band Feedhorn Operation

The basis of the dual-band feedhorn design is the W2IMU dual-mode feedhorn[5], dimensioned to feed an offset dish at 24 GHz and excited from the rear with a circular waveguide section. For 10 GHz, an excitation probe fed by an SMA connector is added on the side of the output section of the dual-mode horn. The tapered section of the dual-mode horn acts as a closed end at 10 GHz, so that the output section behaves like a simple “coffee-can” feed at 10 GHz. Figure 1 is a sketch with the dimensions I used for the first version.

While the 24 GHz dual-mode horn has a pattern suitable for an offset dish, the simple 10 GHz horn has a much broader pattern, better suited to a deep dish, so it would have a lot of spillover feeding an offset dish. AD6FP improved the 10 GHz performance by adding a conical horn to narrow the beam, and AA6IW enhanced it further by using a corrugated horn. The dual-mode horn is intended to eliminate edge currents in the rim of the horn, so the addition of the conical horn outside the rim has a much smaller effect at 24 GHz. By varying the horn dimensions, it might be possible to make the patterns and efficiencies very close on the two bands. I had four different corrugated horns on hand, so I tried simulating with each of them. Results were promising, so I bored out the circular waveguide end of each horn on my lathe so that it could be slipped over the end of the dual-band horn.



The most promising corrugated horn was from a Chaparral Offset Feedhorn, which has excellent calculated efficiency for both bands, 76% at 24 GHz and 74% at 10.368 GHz. This is comparable to the best single band feeds – a dual-band feed that does not compromise performance. Also, the phase centers differ by only 1.3 mm, so that the optimum position for 24 GHz is only 0.04λ off at 10 GHz.

The corrugated horn in the machined version is based on the Chaparral horn. The first ones slipped on to the version in Figure 1; later the horn was integrated as a single machined piece[6]. A separate matching plate for WR-42 waveguide at 24 GHz was used with these versions, and low-pass filter was a further enhancement. The 2020 version shown in Figure 2 includes an integral improved 24 GHz matching section.

WR-42 Matching section

WR-42 waveguide is standard at 24 GHz – coax is rather lossy. It can be connected directly to the circular waveguide input to the horn, with a VSWR around 2.5. The matching section is a quarter-wave impedance transformer from the circular waveguide impedance to the rectangular waveguide impedance, optimized using HFSS software. The integral matching plate is slightly longer than the separate matching plates and provides a better match.

Figure 2 – Dual-band 10 & 24 GHz Feedhorns – 2020 version

Low-Pass Filter

A potential problem with a dual-band feed is feedthrough from one band to another. The 24 GHz circular waveguide section is beyond cutoff at 10 GHz, so energy at 10 GHz will not propagate and very little will reach the 24 GHz receiver. However, the 10 GHz probe does pick up 24 GHz energy; with typical powers up to 2 watts, more attenuation is necessary. A simple low-pass filter[7] built into the 10 GHz probe section provides about 25 dB additional attenuation.

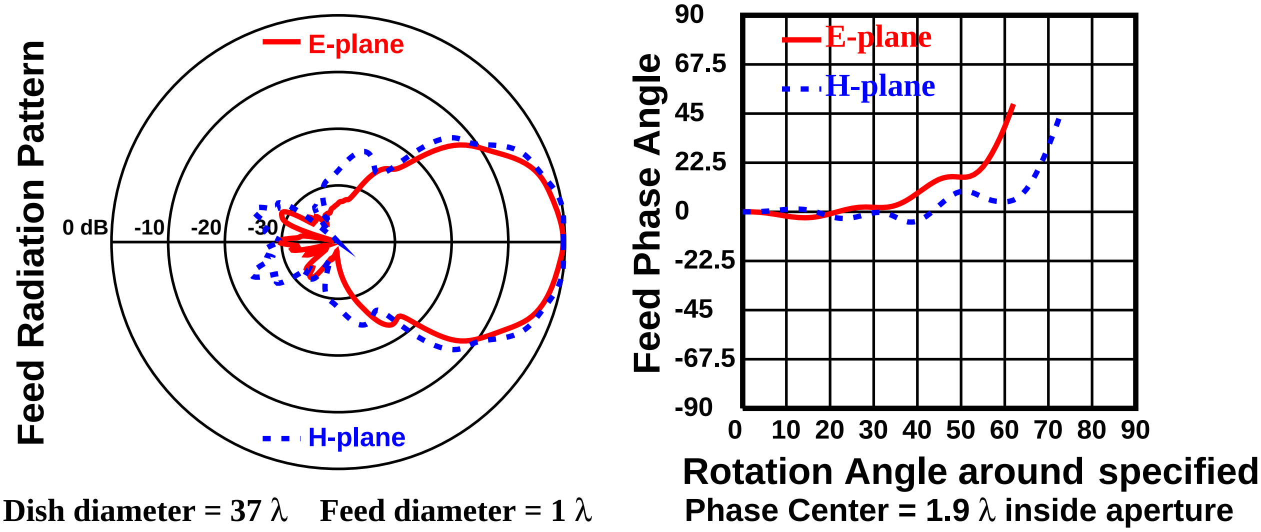
Offset Dishes

The dual-band feedhorn is intended to feed common offset dishes. All TVRO offset dishes use the same basic geometry, regardless of size or shape. That is why there are so many universal LNBs available, which all have a feedhorn suitable for offset dishes. For instance, Channel Master made offset dishes in sizes from 18 inches to 1.2 meters, but all use the same LNB or feedhorn. Other offset dishes intended for applications including transmitting, like satellite internet, might use a slightly different geometry, but the dual-band feedhorn is probably suitable for these as well.

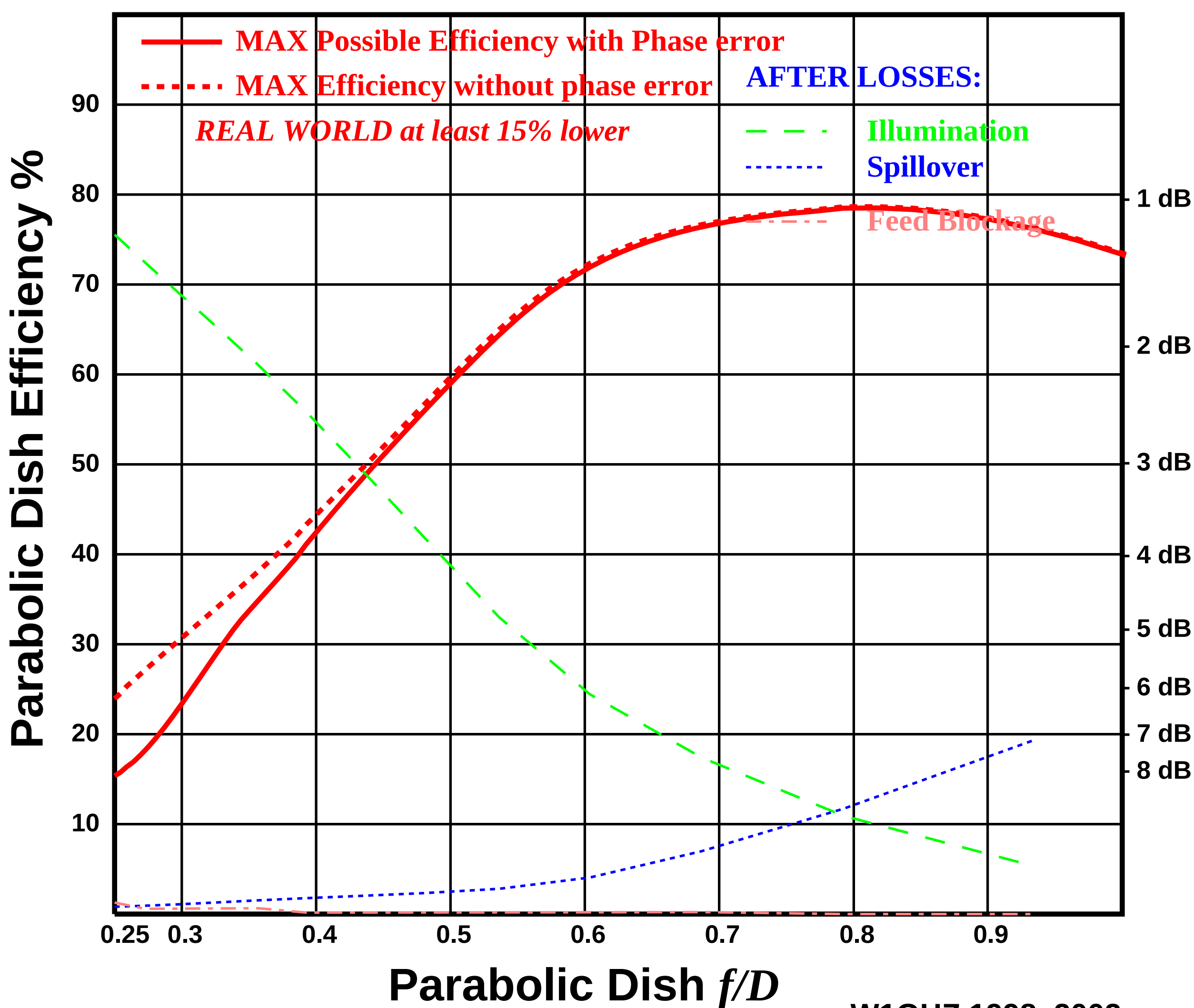
The common offset dishes require a feed with an illumination angle equivalent to an ***f*/D** around 0.6 to 0.7. Efficiency plots for the dual-band feedhorn are shown in Figures 3 and 4, both at the optimum phase center for 24 GHz, 23.6 mm inside the aperture. At 10 GHz, the best ***f*/D** is about 0.65, with a calculated efficiency of about 75%. The best ***f*/D** at 24 GHz is about 0.8, so the dish will be slightly under-illuminated, but efficiency for

Dual-band 10 & 24 GHz Feedhorn at 24.192 GHz

Figure 3



Dish diameter = 37 λ   Feed diameter = 1 λ



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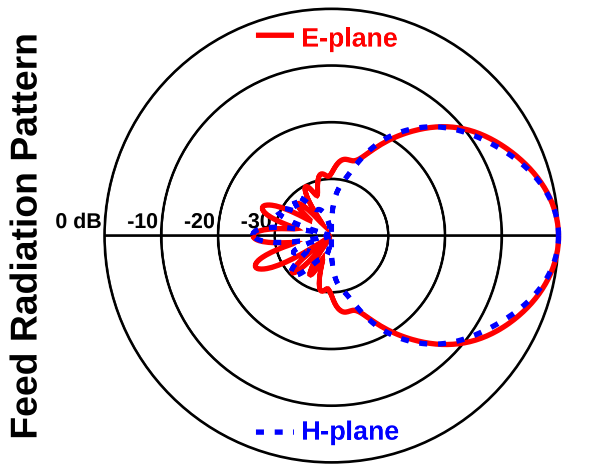
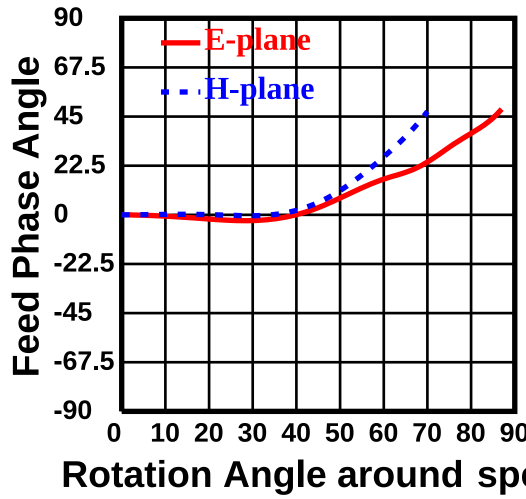
Dual-band 10 & 24 GHz Feedhorn at 10.368 GHz

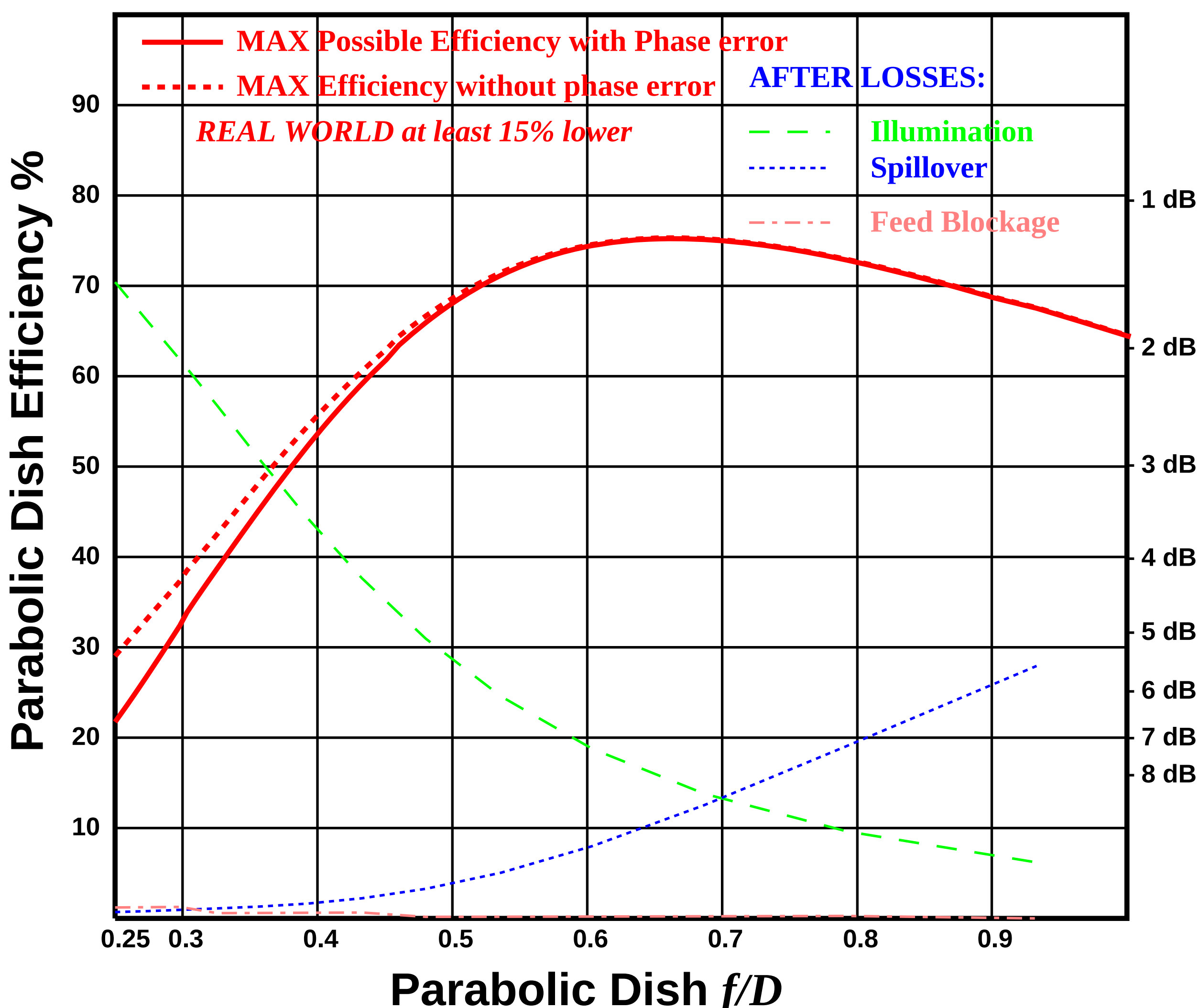
Figure 4





Dish diameter = 15.8 λ Feed diameter = 0.5 λ

Phase Center = 0.816 λ inside aperture



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an ***f*/D** of 0.65 is still about 75%. This is excellent performance – the best single-band feed will not be much better.

Phase Center

The calculated phase centers at both bands are shown in Figures 3 and 4 in wavelengths, and appear quite different. However, the physical distances are very similar: at 24 GHz, the phase center is 23.6 mm inside the aperture (front plane of the horn), while at 10 GHz, the phase center is 24.9 mm inside the aperture. Since the phase center is more critical at the higher frequency, the 24 GHz phase center is recommended, and is used in Figure 4. The difference at 10 GHz is about 1% in efficiency between the ideal phase center and the 24 GHz one.

Most important is that the phase center is at the focal point of the dish – see w1ghz.org for details on finding the focal point. Offset dishes are quite forgiving with regard to focal point errors, with only a slight reduction in gain. Focusing errors just shift the beam slightly – *but the beam will shift differently at the two frequencies*. The major advantage of this dual-band feed is that you can find a station on 10 GHz, where signals are strong and the beam is wider, then switch to 24 GHz without moving the antenna and hope to find the (usually) much weaker 24 GHz signal.

Getting the beams aligned at both frequencies is more difficult for elevation. Any error in feedpoint position in either the vertical or axial direction will shift the elevation, with a different shift at each frequency[8]. Finding the elevation peak is also difficult, as it can be confused by ground reflections. The ideal technique would be to peak on sun noise at both frequencies – if you can measure sun noise, the system is working pretty well.

Feedhorn Measurements

Based on measurements of about three dozen of the 2020 dual-band feedhorns:

10.368 GHz return loss – 19.5 to 27 dB
24.192 GHz return loss – 17,5 to 19 dB

Port to port isolation at 24.192 GHz – approximately 33 dB

References:

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6. Paul Wade, W1GHZ, "Improving the Dual-band 10 & 24 GHz Feedhorn for Offset Dishes." http://w1ghz.org/new/dualband_feedhorn.pdf
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