High-Performance Antennas for 5760 MHz

You've seen lots of equipment for 5760 MHz described in QEX. *Here are some antennas to connect it to.*

By Paul Wade, N1BWT

In the recent series "Practical Microwave Antennas," the measurements and most of the examples were for 10 GHz, as that band has become relatively popular since the inception of the 10-GHz Cumulative Contest.[1,2,3] Some of our other microwave bands have received less attention, particularly 5760 MHz. Recent articles in *QEX* have described some equipment for this band, but there is little specific information available on antennas.[4,5,6]

While I was working on 10-GHz feedhorns for the "Practical Microwave Antennas" articles, I was also working with the late Don Cook, K1DPP, on feedhorns for 5760 MHz. However, I did not want to publish these designs until I was able to measure their performance and verify that they actually work. Recently, KB1VC, WB1FKF and I set up an antenna range for 5760 MHz to measure the feedhorns and compare them with some previously published designs.

[1]Notes appear on page 21.

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Measurements

The antenna range used the same superheterodyne ratiometry technique and setup described in "Practical Microwave Antennas, Part 3." Different mixers and filters were required, so we used home-brew mixers with integrated pipe-cap filters.[7] We were able to make measurements with only one milliwatt of transmitter power by adding a 30-MHz amplifier before the PANFI; the ability to add gain at a low frequency is a real advantage of the superheterodyne technique.

Measurement results are shown in Table 1. We did not have a standard-gain antenna available for 5760 MHz so we used two horn antennas as a gain reference. The *HDL_ANT* computer program described in the "Practical Microwave Antennas" series uses an algorithm for the gain of a horn that has proved quite accurate at 10 GHz, so we carefully measured the physical dimensions of the two horns in order to calculate their gain. When the gains were measured, we found a discrepancy of 0.6 dB in the gain of one horn relative to the other. Since we do not have a standard, there is no way to determine which is in error, so we split the difference. Therefore, the results shown in Table 1 are either 0.3 dB high or low, depending on which horn gain is incorrect, but this is still a small uncertainty for amateur measurements. An uncertainty of 0.3 dB translates into a range of possible efficiencies of 57% to 66% for the highest gain shown, listed as 61%, and a smaller range for lower efficiencies.

A note on measurement technique: we try to do blind measurements, where one person takes the readings and another writes them down, with calculations done later, to limit the human tendency to find the "expected" result.

Dish Feeds for 5760 MHz

The whole point of these measurements is to find efficient feeds for a parabolic dish. Table 1 lists the results and shows several feeds with significantly better performance than previously published designs. Let's discuss them individually:

- WA3RMX triband feed:[8] Like all multiband antennas, this one is a compromise, and performance is significantly less than an optimum feed—less than 20% efficiency on a dish with f/D = 0.45. The original *QST* article suggests an f/D in the 0.25 to 0.4 range, which would be illuminated more efficiently but probably not with better than 30% efficiency. However, many successful contacts have been made using this feed, and it is highly recommended if a multiband antenna is the only way to get a station on 5760 MHz.
- Cylindrical waveguide feed horn: This was described by WØPW in *QEX* with versions for 3.456, 5.76, and 10.3 GHz.[9] WB1FKF made a copy of the 5760-MHz version, and we measured it on the recommended dish as well as on two others, all with f/D = 0.45. In all cases, the efficiency was 20 to 24%.

Like many folks getting started on a new band, WB1FKF copied the published dimensions but had no test equipment to check it out. Since he was able to make successful contacts with it, he assumed it was working well. After we found that the efficiency was rather low, he checked the return loss and found it to be 5 dB (VSWR $\simeq$ 3.5). The possible reflection loss for this mismatch is 1.65 dB, so the actual gain could be that much higher if the feed were perfectly matched. The resultant efficiency could then be as high as 35%.

Even though Don copied the published dimensions carefully, it is not surprising that the VSWR was high. This feed uses an E-field probe to excite the circular waveguide, and I have found the impedance of these probes to be extremely sensitive to their dimensions. The Kumar feed, below, also uses a probe to excite the circular waveguide, and it took a fair amount of cut-and-try to find the best combination of length and diameter for the probe.

- Kumar feed:[10] This scalar feedhorn has been described by VE4MA for 1296, 2304 and 3456 MHz.[11,12] I scaled the dimensions for 5760 MHz as shown in Fig 1, and K1DPP constructed one with compromise dimensions adjusted for available materials—for instance, the outer ring is made from a film can for a 100-foot roll of film. These compromise dimensions are not necessarily optimum. The probe length and diameter are very critical, so copies would probably require some tuning. Performance was excellent, with 61% efficiency on a 25-inch reflector. A later measurement on a

Table 1—Summary of 5.760 GHz Antenna Measurements

N1BWT, KB1VC, WB1FKF 10/29/94

ANTENNA	*FOCAL DIST (inches)*	*GAIN (dBi)*	*Efficiency*
Horn, Seavy SGA-50 (19.65 dBi calc)		19.3	53%
Surplus AT-802/UPM-9A horn (16.3 dBi calc)		16.6	51%
25-inch dish, *f/D* = 0.45, Satellite City, with the following feeds:			
Clavin feed	11.125	27.5	38%
Clavin feed	10.625	28.3	46%
Clavin feed	10.375	29.2	57%
Clavin feed	10.125	27.9	42%
Kumar (VE4MA) feed (0.25-inch projection)	11.5	29.5	61%
Cylindrical horn feed (1.625-inch ID)		25.3	23%
23-inch dish, antenna center 24 inch, *f/D* = 0.45, , with the following feed (24-inch OD but parabolic surface is 23-inch diameter):			
WA3RMX triband feed	10.875	23.3	17%
Cylindrical horn feed (1.625-inch ID)	11	24.5	23%
	10.625	23.7	19%
	11.5	24.7	24%
30-inch dish, *f/D* = 0.45, (lighting reflector), with the following feeds:			
Kumar (VE4MA) feed (0.25-inch projection)	13.9	(29.7) questionable—see text	(42%)
Rectangular horn, (optimum for *f/D* = 0.47) E=1.37 inch, H=1.6 inch	13.125	31.1	58%
	12.31	29.1	focal sensitivity
	13.62	29.1	focal sensitivity
Cylindrical horn feed (1.625-inch ID)	13.0	26.5	20%
Waveguide to coax transitions:			
WR-137 round flange (3.12-inch flange OD; FXR C601B)	13.625	30.9	56%
WR-137 rect. Flange (2.25 × 1.5-inch flange)	14.25	30.1	46%
WR-159 rect. Flange (2.5 × 1.75-inch flange; marked 549-033489-001 Rev E; waveguide has rounded inner corners, radius 0.25 inch)	12.625	31.3	61%
WR-187 round flange (3.62-inch flange OD; Waveline 301-NF)	12.5	31.1	58%

Range length = 110 feet. $2D^2/\lambda$ = 73 feet. Test height $\simeq$10 feet.

Focal distance: each feed was adjusted for maximum gain, except the WA3RMX triband feed, which was not adjustable and was measured to specified phase center. All other focal distances measured to outermost point.

30-inch reflector of the same f/D was much worse—apparently something went wrong.

- Clavin feed:[13] I scaled the dimensions for 5760 MHz as shown in Fig 2 from my 10368-MHz version (see note 2), and K1DPP machined one. The critical dimension is the slot length, which I filed for best VSWR. This feed also showed very good performance with 57% efficiency. Unfortunately, the dimensions do not fit any readily available materials.
- Rectangular feed horn:[14] My initial estimate of the f/D for the 30-inch reflector was 0.47, so I designed a rectangular horn for an f/D = 0.47. The *HDL_ANT* program generated the horn template shown in Fig 3, which I used to make a horn of flashing copper. The horn, soldered to a piece of WR-137 waveguide, provides very good performance with 58% efficiency. The calculated phase center is 0.02 wavelengths inside the mouth of the horn so we can get a better estimate of the focal point than that found by fitting paper templates generated by *HDL_ANT*.
- Waveguide-to-coax transitions: At 10 GHz, we found that a WR-90-to-coax transition provides about 42% efficiency when used as a dish feed. This is valuable data because it is something readily available for comparisons if there are no antennas with known gain available. For 5760 MHz, there are three usable sizes of waveguide, and I found coax transitions for all three in my collection acquired at hamfests. We were surprised to find how well these worked: a WR-137 transition with a small rectangular flange provided 46% efficiency, close to our expectation, but transitions with large circular flanges showed much higher efficiencies: 56 and 58%. Finally, the highest efficiency was a WR-159 transition with rounded, rather than square, corners on the inside of the waveguide. While large circular flanges may provide the same effect as the choke flange for cylindrical waveguide feed horns described by WA9HUV,[15] we can offer no explanation for the performance of the rounded corner waveguide transition.

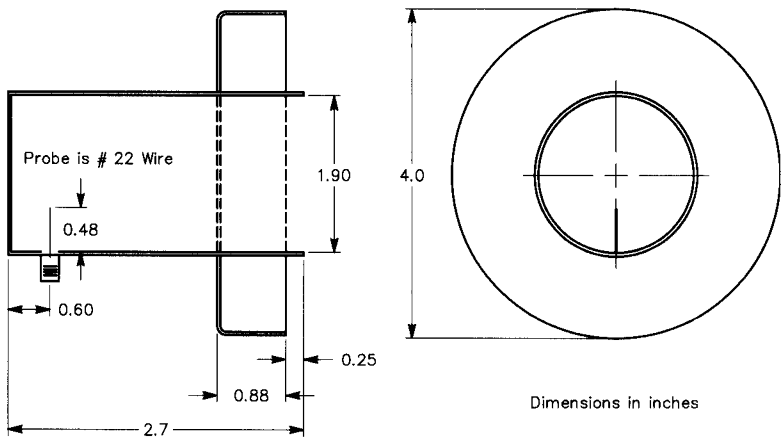

Fig 1—Kumar feed for 5760 MHz. Dimensions may not be optimum. An SMA connector is used.

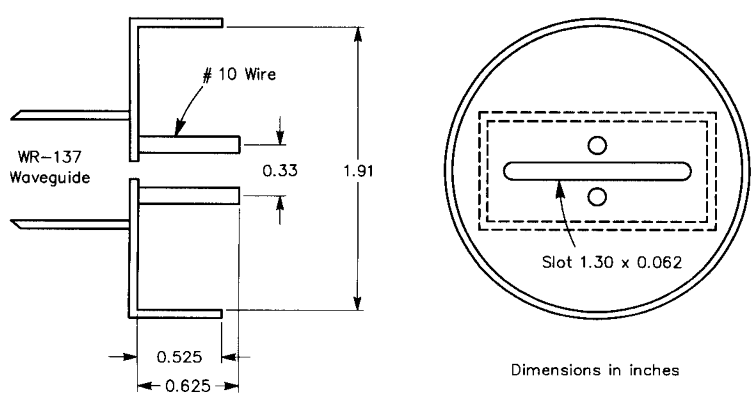

Fig 2—Clavin feed for 5760 MHz.

Recommendations

All the dishes we had available have an f/D ratio of 0.45. At this f/D, the Kumar, Clavin and rectangular feedhorn all offer very good performance. For dishes with other f/D ratios, the recommendations are the same as those offered in "Practical Microwave Antennas, Part 2"; the Kumar and Clavin feeds are better for the f/D range of 0.35 to 0.45, while rectangular feedhorns may be optimized for any f/D greater than 0.45. If you find a surplus waveguide-to-coax transition, it may provide performance as good as the ones we measured, but be sure to adjust it carefully; as Table 1 shows, the focal distances, and thus the apparent phase centers, vary widely.

At 5760 MHz, the focal length of the dish is not quite as critical as at 10 GHz since a wavelength is nearly twice as long. However, two of the feeds in Table 1 were measured with varying focal distance to show the loss associated with small focal-length errors. Getting the feed exactly at the focal point is still the most important aspect of dish efficiency and gain.

Finally, match the impedance of the antenna to the transmission line—a low VSWR is important at all frequencies, and even more so at microwaves where transmission line losses are high. In "Practical Microwave Antennas" I made the assumption that this would be obvious, but our measurements here are a reminder that the obvious sometimes needs restatement.

Conclusion

It should be apparent that signifi-

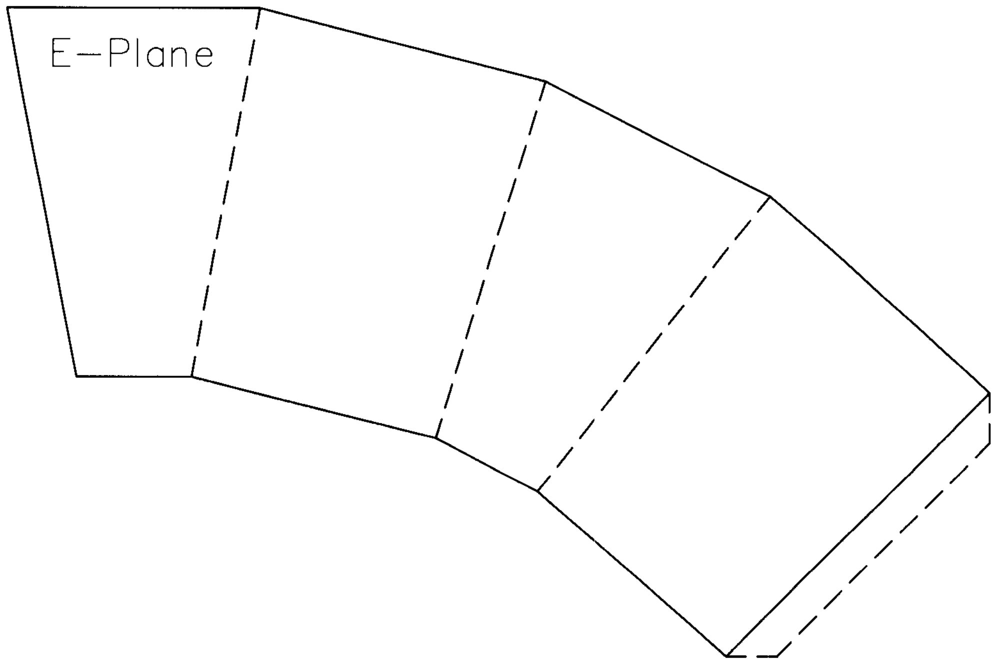

Fig 3—Full-size template for a 7.2-dBi horn for 5760 MHz, suitable for illuminating a dish with *f/D*≈0.47.

cant improvements in dish efficiency are available, compared to previously published feed designs for 5760 MHz. How significant? The measurements show a gain increase of 3 to 4 dB with no increase in dish size, weight or wind loading—enough to double the range of a pair of stations making this improvement.

Acknowledgment

Don Cook, K1DPP, provided both enthusiasm and machining skills for this project. Unfortunately, he became a Silent Key before it was completed. He was a true friend and helped all the hams who knew him; we all miss him.

Notes

[1]Wade, P., N1BWT, "Practical Microwave Antennas, Part 1," *QEX*, September 1994, pp 3-11.

[2]Wade, P., N1BWT, "Practical Microwave Antennas, Part 2," *QEX*, October 1994, pp 13-22.

[3]Wade, P., N1BWT, "Practical Microwave Antennas, Part 3," *QEX*, November 1994, pp 16-24.

[4]Lau, Z., KH6CP/1, "A 5616-MHz Local Oscillator," *QEX*, May 1993, pp 15-19.

[5]Cook, R., N2SB, "5760 MHz from the Junkbox," *QEX*, May 1994, pp 20-24.

[6]Lau, Z., KH6CP/1, "A Low-Noise PHEMPT Amplifier for 5760 MHz," *QEX*, September 1994, pp 28-31.

[7]Wade, P., N1BWT, "Mixers, Etc., for 5760 MHz," *Proceedings of Microwave Update '92*, ARRL, 1992, pp 71-79.

[8]Hill, T., WA3RMX, "A Triband Microwave Dish Feed," *QST*, August 1990, pp 23-27.

[9]Hilliard, D.L., WØPW, "Antenna Ideas for 3.5, 5.8, and 10.3 GHz," *QEX*, January 1988, pp 3-5.

[10]Kumar, A., "Reduce Cross-Polarization in Reflector-Type Antennas," *Microwaves*, March 1978, pp 48-51.

[11]Malowanchuk, B. W., VE4MA, "Selection of an Optimum Dish Feed," *Proceedings of the 23rd Conference of the Central States VHF Society*, ARRL, 1989, pp 35-43.

[12]Malowanchuk, B. W., VE4MA, "VE4MA 3456-MHz circular polarization feed horn," *Feedpoint*, November/December 1991, North Texas Microwave Society.

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[14]Evans, D., G3RPE, "Pyramidal horn feeds for paraboloidal dishes," *Radio Communication*, March 1975.

[15]Foot, N. J., WA9HUV, "Second-Generation Cylindrical Feedhorns," *Ham Radio*, May 1982, pp 31-35.