Parabolic Antenna Calculations

By John Jaminet, W3HMS and Curt Wann, K4ITO, 9 March 2010

The charts in the ARRL Handbook, the ARRL Antenna Handbook, and the F4DAY Website have the calculations for common size dishes and the formulas. The modern EXCEL spreadsheet just cries out to be used so that a microwaver or EME operator can determine gain and ERP for various dish sizes and ERP power levels. This is very helpful for planning your station. It could also be helpful, after some modification, to permit economic analysis of the best tradeoffs/costs in additional dish size and/or power. We did not do the economic analysis here but we mention the idea as food for thought for downstream use by someone, please.

The following explains how to use the spreadsheet.

Use 1: Print completely and use as a printed document.

Use 2: Bring up this EXCEL and change the frequency, dish size in feet, or value of RF power at the feed. You can also change k for different feed efficiencies to see what the effect is with a different dish-feed. These actions may answer the question of what will be the ERP with say 250 watts and a dish increase of 1 foot/meter?

The informal conclusion that one-half foot increase equals ½ dB increase is a simple "rule of thumb", at least on 23 cm. We note, as all will recognize, that a power increase does not increase the gain on receive so a dish size increase may have more value than a power increase. Please note that we have addressed only round dish sizes often used by a ham. Others are invited to do the same for offset dishes, please!

The EXCEL is based on the dish size in feet but this can be adjusted on any line by "cut and try" to yield a desired metric size, example 3.8 meters.

This EXCEL was developed using the following formulas obtained from the Paul Wade, W1GHZ, Online Microwave Antenna Book, Section 4. The authors would like to express their appreciation to Paul, W1GHZ and to Rex, VK7MO, for their helpful suggestions for both this article and the Excel which have been incorporated.

The referenced EXCEL is obtainable by an EMAIL to W3HMS@aol.com asking that it be attached.

Assumptions used:

1. Antenna efficiency, k, is the standard 55%.
2. Frequency is 1296.050 MHz.
3. Dish in meters is feet times 12 inches divided by 39.37 inches/meter, rounded to one decimal place.
4. Wavelength in meters is 300 divided by the frequency in MHz.
5. ERP is CW key down with stated watts at feed.
6. SWR and reflected power loss occurs before the stated power, e.g. 100 watts at the antenna feed point.

7. That all round dishes should be 10 Lambda (wavelengths) or more for the calculations to be valid. Paul nicely added a column to the Excel to show that anything less than this will show in red in both the printed and the on screen versions. Note, for example, that 7.5 ft is 9.7 Lambda.

8. That this Excel shows only the far-field ERP. Rex, VK7MO kindly observed that it should therefore not be used for near-field calculations to meet EMR requirements.

Formula to calculate dbi gain, G_{dbi}:

$$G_{dbi} = 10\log_{10}\left(\frac{k(2\pi r)^2}{\lambda^2}\right)$$

where:

k = *efficiency*

r = *parabola dish radius in meters*

$$\lambda = \frac{\textit{speed of light in meters}}{\textit{frequency in Hz}} = \frac{3\times 10^8}{F_{Hz}} = \frac{300}{F_{MHz}}$$

Formula to calculate dBd gain, G_{dBd}:

$$G_{dBd} = G_{dbi} - 2.1$$

Formula to calculate power gain factor, P:

$$P = 10^{\frac{GdBd}{10}}$$

Formula to calculate *ERP*:

$$ERP = kwP$$

where:

k = *efficiency*

w = *power in watts*

P = *power gain factor*

Example: Parabola dish is 10 feet in diameter (radius r = 1.5 meters), power is 100 watts at the feed, and frequency is 1296.05 MHz.

$$G_{dbi} = 10\log_{10}\left(\frac{k(2\pi r)^2}{\lambda^2}\right) = 10\log_{10}\left(\frac{0.55\times(2\times 3.14\times 1.5)^2}{\left(\frac{300}{1296.05}\right)^2}\right) = 29.6dbi$$

$$G_{dBd} = G_{dbi} - 2.1 = 27.5dBd$$

$$ERP = kwP = 0.55\times 100\times 10^{27.5\div 10} = 55\times 10^{2.75} = 30890.7 \ watts$$

Sources for formulas:
http://www.sengpielaudio.com/calculatorVoltagePower.htm
- site provides a calculator to convert DB to watts

http://www.mogami.com/e/cad/db.html
- site shows formulas to covert DB back to watts