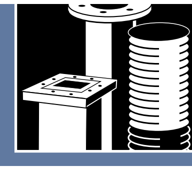

dB and dBm

The dB (decibel) is a logarithmic unit comparing two power levels.

$$dB = 10 \log_{10} \frac{P_1}{P_2}$$

Where P_1 is the larger power
If P_1 = 10 watts and P_2 = 1 watt, then

$$dB = 10 \log_{10} \frac{10}{1} = 10\ dB$$

The dBm is a comparison to a reference power of 1 milliwatt (0.001 watt).

$$dBm = 10 \log_{10} \frac{P_1}{0.001}$$

If P_1 = 5 watts, then

$$dBm = 10 \log_{10} \frac{5}{0.001} = 37\ dBm$$

Power (watts)	dBm
1	30
2	33
5	37
10	40
20	43

Free Space Propagation Attenuation (Isotropic)

English Units:

$$L_{fs} = 96.6 + 20 \log_{10} D + \log_{10} f$$

Where L_{fs} = loss in free space in dB
D = path length in miles
f = frequency in GHz

For a path length of 30 miles at 6.175 GHz:

$$L_{fs} = 96.6 + 20 \log_{10} 30 + 20 \log_{10} 6.175$$
$$= 96.6 + 29.5 + 15.8$$
$$= 141.9\ dB$$

Metric Units:

$$L_{fs} = 92.5 + 20 \log_{10} D + 20 \log_{10} f$$

Where L_{fs} = loss in free space in dB
D = path length in kilometers
f = frequency in GHz

For a path length of 50 kilometers at 6.175 GHz:

$$L_{fs} = 92.5 + 20 \log_{10} 50 + 20 \log_{10} 6.175$$
$$= 92.5 + 34.0 + 15.8$$
$$= 142.3\ dB$$

Calculating Receive Signal Level and Antenna Grain

When transmitter power is expressed in dBm and all other units are expressed in dB, receive power in dBm can be calculated using the following formula:

$$P_r = P_t - L_{w1} - L_{f1} + G_{a1} - L_{fs} + G_{a2} - L_{w2} - L_{f2}$$

Where: P_r = receive power level (dBm)
P_t = transmit power (dBm)
L_w = transmission line losses
L_f = filter losses
L_{fs} = free space path loss
G_{a1} = transmit antenna gain
G_{a2} = receive antenna gain

Thus for a 6.175 GHz system with a transmit power of 5 watts (37 dBm) and 200 feet of Type EWP52 HELIAX elliptical waveguide (attenuation 1.2 dB/100 feet) at each end, filter losses of 0.5 dB at each end, and Andrew UHX8-59H, UHX8-59H antennas at each end (Mid-band Gain 41.3 dB) over a path 30 miles long (L_{fs} = 141.9 per preceding example).

$$P_r = 37 - 2.4 - .5 + 41.3 - 141.9 + 41.3 - 2.4 - .5$$
$$= 28.1 dBm$$

When the minimum receive signal level required to meet performance objectives (C) is known and the necessary fade margin (FM) is added, the total antenna gain (Gt) required can be calculated using the following expression:

$$G_t = P_t - L_{w1} - L_{f1} - L_{fs} - L_{w2} - L_{f2} - FM\ 96\ C$$

In the above system with a transmit power of 5 watts (37 dBm), 200 feet of EWP52 elliptical waveguide (attenuation of 1.2 dB/100 ft) at each end, filter losses of 0.5 dB at each end, operating over a 30 mile path, assuming a receive signal threshold level requirement (C) of -70 dBm and a desired fade margin of 38 dB, the total antenna gain (G_t) required is:

$$G_t = 37 - 2.4 - .5 - 141.9 - 2.4 - .5 - 38 - (-70) = -78.7$$

To achieve the system performance goal, a negative gain (loss) of 78.76 dB must be made up by the gain of the antennas. If antennas with equal gain are used at each end of the path, each antenna must then have a gain of 39 dB. Andrew UHX8-59H antennas with a mid-band gain of 41.3 dB will, therefore, satisfy the requirement.

Calculation of System Return Loss

Resultant system return loss is governed by the phase relations between the standing waves of individual components and cannot be precisely calculated. The resultant return loss can be estimated, however, using the procedure described below. The 0.7 multiplication factor, mentioned in Step 5, is based on data taken by Andrew on thousands of antenna systems. Properly installed transmission systems will typically measure well within the calculated resultant return loss. Andrew specifications include safety margins and components are typically better than the published return loss specifications. For this reason, systems using all Andrew components will usually ensure much better system return loss performance than the calculated values.

A conversion table for VSWR, Return Loss and Reflection Coefficient appears on page 189.

Step 1. Using the table on page 189, convert VSWR or RL to reflection coefficients, in decimal form, for all components in the system.

Step 2. Divide components into three groups:

- *Top (antenna, radome, flex, etc.)*
- *Transmission Line (waveguide or cable feeder)*
- *Bottom (flex, elbow, pressure window, etc.)*

Step 3. Add the reflection coefficient of all top components and convert the total to RL. Double the calculated attenuation in dB of the transmission line feeder and add this to the previous figure. Then convert the total back to a reflection coefficient.

Step 4. To the final reflection coefficient obtained in Step 3, add the reflection coefficient of the transmission line and all bottom components.

Step 5. Multiply the total reflection coefficient from Step 4 by 0.7 and convert the result to VSWR or return loss.

Example

Steps 1 and 2:

	VSWR	Reflection Coefficient
Top Components		
Antenna	1.06	0.029
Flex Section	1.03	0.015
Transmission Line		
Waveguide, Attenuation: 2.36 dB	1.06	0.029
Bottom Components		
Flex Section	1.03	0.015
Pressure Window	1.01	0.005

Step 3:

(1) Add top components [0.029 + 0.015 = 0.044]

(2) Convert to return loss (from table on page 189) [27.1 dB]

(3) Double Transmission Line attenuation [2 x 2.36 = 4.72 dB]

(4) Add (2) and (3) [27.1 + 4.72 = 31.8 dB]

(5) Convert 31.8 dB to reflection coefficient = 0.026 (from table on page 189)

Step 4:

(6) Add (5) and transmission line and bottom component [0.026 + 0.029 + 0.015 + 0.005 = 0.075]

Step 5:

(7) Multiply (6) by 0.7 [0.075 x 0.7 = 0.0525]

Convert to VSWR = 1.1 (from table on page 189) [1.1 is estimated peak system VSWR]

Convert to Return Loss = 25.5 (from table on page 189) [25.5 dB is estimated peak system return loss]

Microwave Antenna System Computer

The Andrew "Microwave Antenna System Computer/Transmission Line Selector" is available on request. The computer includes useful scales and tables for calculating parabolic antenna characteristics, free space propagation, HELIAX cable and waveguide performance, and other antenna system calculations.

To obtain a copy, ask for Bulletin 8525 (English units) or M8525 (metric units). The metric unit is available with instructions in English, Italian, German, Spanish, and French.