WHAT IS TOTAL SYSTEM GAIN AND WHY SHOULD I CARE?

- System gain is the total gain of your station. That includes your transmitter power, amplifier power, feedline loss and antenna gain.
- Some countries have a license class that designates the effective radiated power (ERP) hams can legally use.
- Depending on license class, U.S. amateur radio stations are limited to a maximum of 1500 Watts and in some cases only 200 Watts.
- All licensed amateur radio operators in the USA are required to conform to the FCC RF Exposure rules. Each antenna you use must meet the acceptable maximum permissible exposure (MPE).

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WHAT IS OVERALL SYSTEM GAIN AND HOW DO WE DETERMINE IT?

- Your total system gain is the output power of your transmitter (Watts), Power Amplifier (Watts), Feedline Losses (dB), and Antenna Gain (dBd or dBi).
- Confused about Effective Radiated Power (ERP) and Effective Isotropic Radiated Power (EIRP)?
- Lets make sense of those antenna standards used by the antenna manufacturers.

- There are various types of antennas for Amateur Radio use. They range from a basic wire dipole or Inverted Vee antenna to a Vertical antenna or a Beam Antenna.
- Basic wire antennas do not have any gain, but other directional antennas with gain have their gain figures referenced to the basic wire dipole or to a theoretical antenna known as an Isotropic Radiator.
- The Isotropic Radiator is an antenna in free space that radiates power in all directions. Sort of like a radiating globe in space.
- If you look at the specifications on your non-dipole/gain antenna you will see it has a manufacturers gain rating either in dBi (dB gain referenced to an Isotropic Radiator) or dBd (gain referenced to a dipole antenna.
- The measurement of gain in dBi is 2.14 units higher than dBd.

- Example: I have a 28 element Log Periodic Antenna that I use on 50 MHz through 1.3 GHz. The manufacturer lists the gain of my antenna at 8.5 dBi or 6.36 dBd.
- Knowing your antenna gain allows you to determine the Effective Radiated power in dBi or dBd.
- Lets take an example of a directional antenna with gain, and determine the actual Radiated Power from the antenna based on several factors. These include the Transmitter Power, Feedline Loss and Antenna Gain. We will use the Effective Radiated Power (ERP).

- What things do we know that will be used to calculate our ERP?
  - We know our transmit frequency and output in Watts, or can measure those with a frequency counter and a Wattmeter.
  - We should know the length of our transmission line so we can determine the loss in the line by researching the cable type.
  - We also know the gain of our directional antenna based on the manufacturer's data.

- I'm using Belden LMR-400 feedline for my antennas, so I went on the Internet and found a calculator that provides LMR-400 loss based on feedline length and the transmitting frequency you will use.
  - Lets assume my transmitter output is 50 Watts to the transmission line
  - 100 feet of LMR-400 transmission line has a loss of 1. 5 dB @ 144 MHz
  - My antenna has a gain of 6.36 dBd

In order to calculate the ERP we first have to convert our transmitter power of 50 Watts to dBm so we can determine the ERP. To do this we use the formula:

$$P_{(DBM)} = 10 \cdot LOG_{10}(P_{(W)}) + 30$$

$$P_{(DBM)} = 10 \cdot LOG_{10}(50W) = 16.9897$$

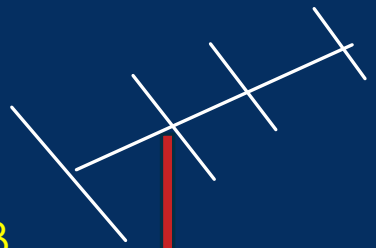
$$P_{(DBM)} = 16.9897 + 30 = 46.989700$$

- Now that we know the Transmitter Power Output is 46.9897 dBm we can calculate our system gain.

Output 46.9897 dBm

Transmission Line loss = 1.5dB

Antenna Gain = 6.36 dBd



Our Calculated System ERP = 46.9897 dBm – 1.5 dB + 6.36 dBd = **51.8497 dBm**

Transmitter power

Line Loss

Antenna Gain

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- Finally we have to convert our ERP of 51.8497 dBm back to Watts to determine the RF power from the antenna.

$$P_{(W)} = 10 \cdot \log_{10}{}^{(P(dBm)/10)}/1000$$

$$P_{(W)} = 10 \cdot \log_{10}{}^{((51.8497 - 30)/10}$$

$$P_{(W)} = 10 \cdot \log_{10}{}^{(21.8497)/10}$$

$$P_{(W)} = 10 \cdot \log_{10}{}^{(2.18497)}$$

$$P_{(W)} = 153.09817$$

- We calculated that with the transmitter power of **50 Watts** taking into consideration the feedline loss and the antenna gain, the power from the antenna (System Power) is **153 Watts**.

On-Line RF Power Calculators

- If you don't want to break out your scientific calculator, there are sites that will do the calculations for you. You just enter the information and your requested power value (Watts, dBm, etc.) will be shown. Here are a few of those sites
  - https://www.rapidtables.com/convert/power/index.html
  - https://www.everythingrf.com/rf-calculators
  - https://www.pasternack.com/t-calculator-power-conv.aspx
- To determine the loss of your coaxial cable or hardline you can check out this site.
  - https://www.rfportal.app/calculations/cable-loss/

The End