AIARC Lab Series

Verifying your FM Handheld Transceiver(HT) Power Output

Why make the measurements?

- HTs are a key asset as part of our EMCOMM response capability.

- They have limited power output, lower capacity battery, lower antenna gain and low antenna elevation.

- They are light weight, portable and will be used across the island at challenging locations due to terrain. Since they are portable they will potentially receive significant shock and vibration which can physically stress the electronics over time.

- At these challenging locations, a one S-Unit at the NCS receiver can mean the difference between “Good Copy” and “No Copy”.

- Knowing your “baseline” output power at the various programmed power levels that your HT supports will enable you to quickly determine if your HT is operating up to par. This is key and could be the difference in getting a critical message through to first responders.

What are we measuring?

The Amateur Radio 2M/70cm band uses Frequency Modulation(FM) for voice communication. FM is a constant envelope modulation, resulting in the following output power relationship for an FM transmitter:

Peak Envelope Power (PEP) = Average Power

Note: This is not true for other modulation modes such as SSB, AM and some digital modes such as QAM(used with VARA) or DQPSK.

A word about bandwidth for 2 Meter/ 70 cm

Typical 2 Meter/ 70 cm transcievers support both a “wide” and a “narrow” bandwidth selection. To avoid confusion, its best to say 25KHz for wideband and 12.5KHz for narrowband. Wideband has different meanings depending on what band and radio service your referring to. For the power measurement, the bandwidth setting on your HT will not have an impact. Typically in the US we use the 25KHz (+/- 5 Khz deviation) “Wide” setting.

What equipment do we need?
For the FM power measurement either a power meter or spectrum analyzer is required.

Option 1: Power Meter (Watt meter)
In general, for the power meter, there are four primary specifications that need to be checked:

1. Maximum input power
2. Minimum input power
3. Frequency Range
4. Peak or Average type meter
5. Requires a 50 ohm dummy load capable of dissipating TX power output

For the Diamond SX20C Power/SWR Meter

Maximum Power: 300 Watts
Minimum Power: 3 Watts
Frequency Range: 3.5MHz to 150MHz
Type: Average reading meter

Reading is in "Watts"

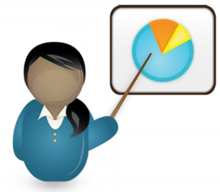
Option 2: Spectrum Analyzer

Using a spectrum analyzer provides a picture of the output spectrum of the HT. Along with measuring the peak power, inspection of spectral purity, harmonics and FM deviation can be performed. Important specifications: Rigol DSA-815

1. <u>Frequency Range:</u> DC to 1.5 GHz
2. <u>Maximum input power (dBm).</u> Check this!!!! 20 dBm
3. <u>Requires an attenuator/ dummy load capable of dissipating TX power</u>: 30 dB attenuation, 50 Watts

Output TX reading is typically in "dBm"

dB and dBm



Definitions:

- dB = 1 decibel
- 1 dB = 1/10 Bel or 10 dB = 1 **Bel**

What is a Bel?

The Bel expresses the “order of magnitude” change or difference for a ratio of two numbers, usually referenced to a power of 10.

For example, say the ratio of two numbers is **10 : 1 = 1 Bel** and **100:1 = 2 Bel** and so on. The Bel is an example of a log scale (base 10) and is used when there is a wide range of values possible.

Mathematically: $A/B = 10^n$ where n = Bels
For example: If A=1000 and B=1 then n = 3 Bels = 30 decibels= 30dB

Remember: **dB is always a ratio of two numbers**.

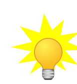
What is a dBm?

The m subscript means “Referenced to a milliWatt”
In the above example: B would equal 1mW.

If A = 1 Watt (1000mW), then:

n = 3 Bels referenced to 1 mW = 30 decibels referenced to 1 mW or short hand:

30 dBm = 1000 mW = 1 Watt



Quiz question → 20 dBm is how many Watts? ______

Bonus Question → 1 mW equals how many dBm? ______

Trick Question → How many Watts = -10dBm (Hint, if A/B is less than 1, dB is a negative number)

Memorize:

+3dB: Increase power by factor of 2. -3dB: decrease power by factor of 2

Cool property of the dB: Use the sum and difference properties of logarithms to calculate total power to delivered to your antenna:

Example: Output power from your HT = 4 Watts What is the equivalent dBm?
1W = 30 dBm. 2 W = 30 dBm + 3 dBm and 4 W = 33 dBm + 3 dBm = 36 dBm

Now say you connect your HT to tripod mounted antenna through 25ft of RG-58 Coax, operating on 2 Meters.

From RG-58 Spec sheet:

Attenuation/ 100 ft.
0.5 dB @ 1 MHz
1.5 dB @ 5 MHz
2.8 dB @ 30 MHz
3.0 dB @ 50 MHz
4.0 dB @150 MHz

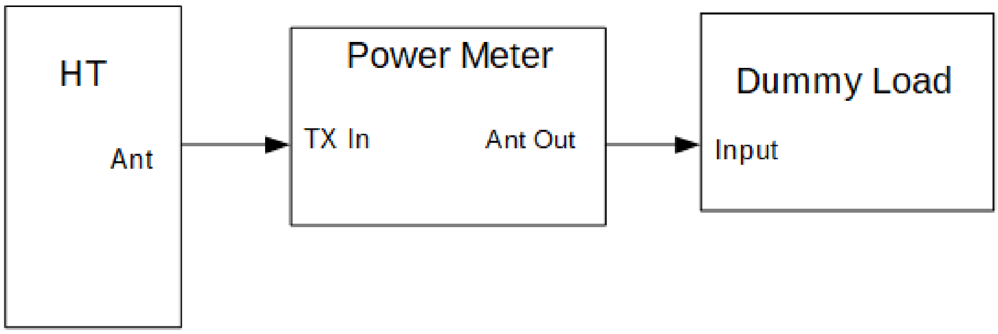
Attenuation from RG-58 Coax at 144-148 MHz approx 1 dB. Then total power delivered to the your antenna on the tripod:

36dBm – 1 dB = 35 dBm = 3.16 Watts

③ dBm to Watt Conversion Table

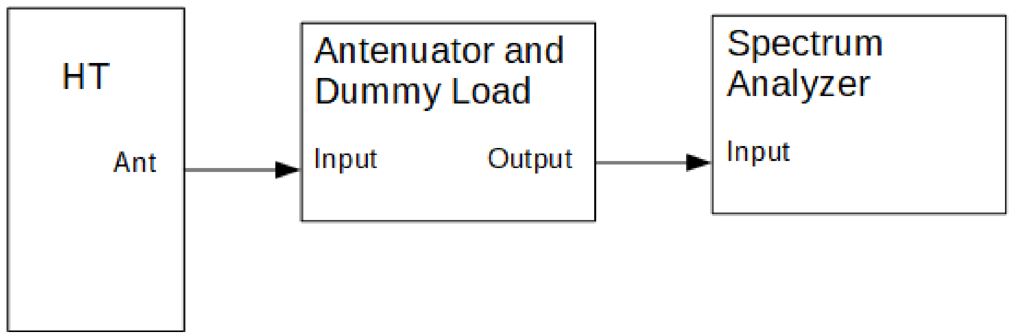
Power (dBm)	Power (watt)	Power (dBm)	Power (watt)
-3 dBm	0.0005 W	10 dBm	10.0 mW
-2 dBm	0.0006 W	15 dBm	31.62 mW
-1 dBm	0.0008 W	20 dBm	100.0 mW
0 dBm	1.0 mW	25 dBm	316.23 mW
1 dBm	1.26 mW	30 dBm	1.0 W
2 dBm	1.58 mW	35 dBm	3.16 W
3 dBm	2.0 mW	40 dBm	10.0 W
4 dBm	2.51 mW	45 dBm	31.62 W
5 dBm	3.16 mW	50 dBm	100.0 W

<u>Test Setup: Power Meter</u>

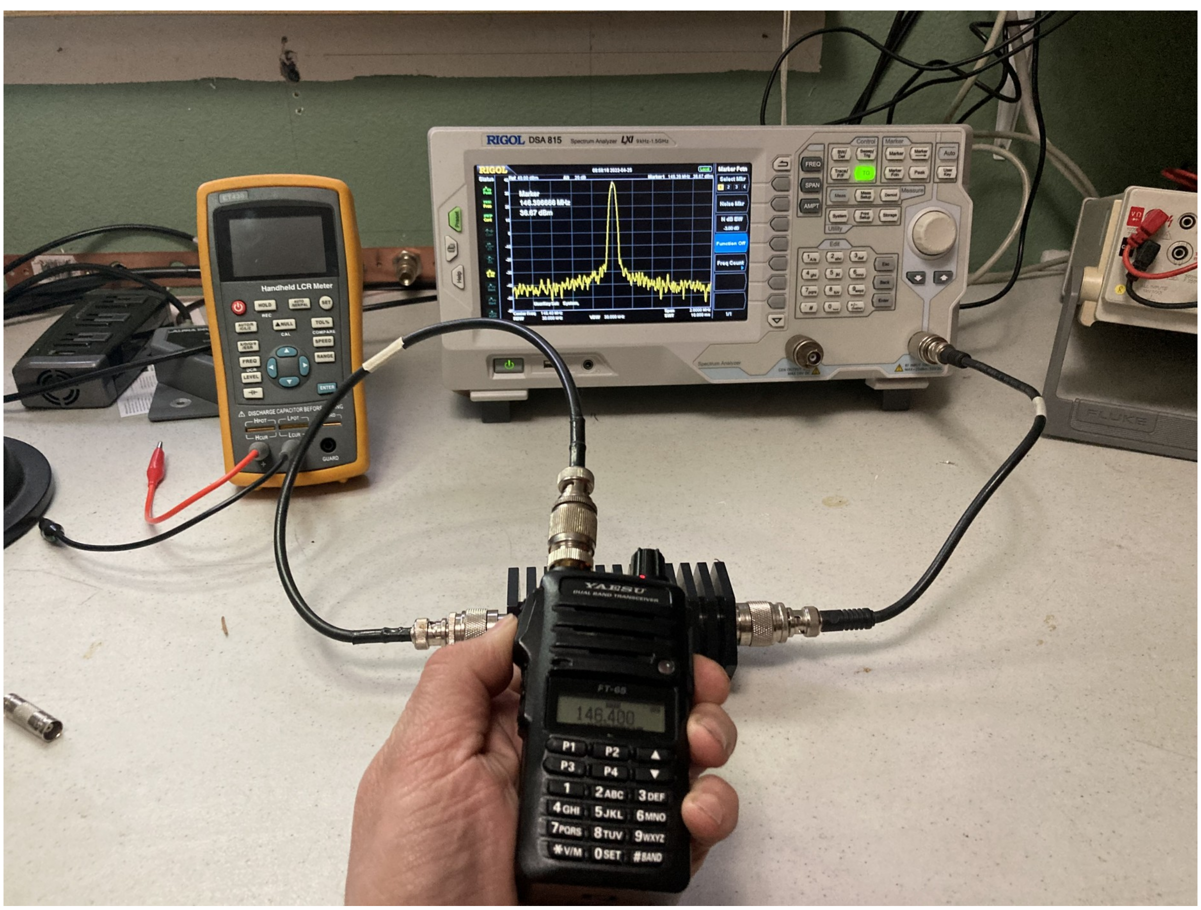


Note: Requires an sma (male or female) to SO-239 adapter at HT antenna port

Test Setup: Spectrum Analyzer



Note : Requires an sma (male or female) to SO-239 adapter at HT antenna port. Patch cables may require type N or BNC connectors.



So to "put a bow" on the math:

1. From above we have: $A/B = 10^n$ where n = Bels
2. Take the log of both sides $\log(A/B) = \log(10^n)$
3. Rewrite the right side of the equation $\log(10^n) = n$
4. Then $\log(A/B) = n$ Bels.
5. $10 \log(A/B) = n$ decibels = n dB
6. $10 \log (A/1mW) = n$ dBm