Transmitter Output Power for Amateur Radio Stations

Notes prepared by Bruce VK2DEQ

These notes summarise the information provided in the **LCD** (*Radiocommunications Licence Conditions (Amateur Licence) Determination 2015*) on the conditions related to the transmitter output power for amateur radio stations in Australia. They also include notes about the methods used to measure transmitter output power and give details of some sources with information about "home-brewing" suitable power measuring equipment.

Summary from LCD

	Maximum Transmitter Output Power	
	pX – (Peak Envelope Power) [Emission modes J3E, R3E & C3F]	**pY** – (Mean Power) [All other emission modes]
ADVANCED	400 W	120 W
STANDARD	100 W	30 W
FOUNDATION	10 W	----------

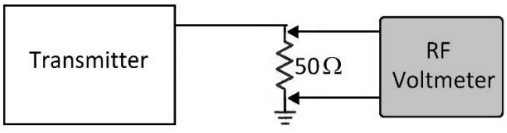
Notes:

- Emission modes J3E/R3E are amplitude modulated single sideband supressed/reduced carriers containing a single analog voice channel. Emission mode C3F (only available to an advanced station) is amplitude modulated vestigial sideband containing a single analog television channel.
- For frequencies in the MF and HF bands where the necessary bandwidth exceeds a specified value (see LCD for details) the maximum power spectral density from the transmitter must not exceed 1 watt per 100 kHz.
- The radiated power from a station operating in the 630 m band must not be more than 5 watts pX EIRP. The radiated power from a station operating in the 2200 m band must not be more than 1 watt pX EIRP. (These two bands are only available to advanced stations).
- Amateur stations are not restricted by any equipment and/or measuring standards and the LCD does not specify how the transmitter output power is to be measured.

Measuring Transmitter Output Power

The ITU Radio Regulations define **pX** (Peak Envelope Power) as the average power delivered by a transmitter during one RF cycle at the crest of the modulation envelope under normal operating conditions; and **pY** (Mean Power) as the average power delivered by a transmitter over a long time compared with the lowest modulating frequency.

Transmitter output power can be measured by connecting the transmitter to a suitable purely resistive 50 Ω load (a "dummy load") and measuring the RF voltage across the load.



$$P\ (pX \text{ or } pY) = \frac{(V_{rms})^2}{R}$$

Different methods are used to measure the output power. For transmitters with a constant level carrier (e.g. CW, unmodulated AM, FM, etc) the voltage across the load is measured when the transmitter is keyed and the mean power (pY) calculated. For SSB modulation there is no power

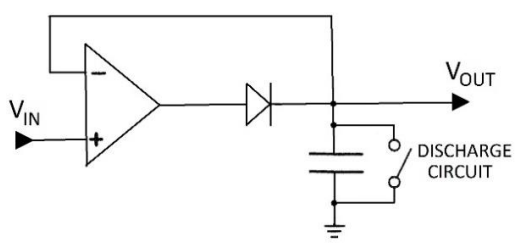
output until modulation is applied. Two equal and non-harmonically audio tones mix with the carrier to produce a steady modulation envelope. The voltage across the load is measured and the peak envelope power (pX) calculated.

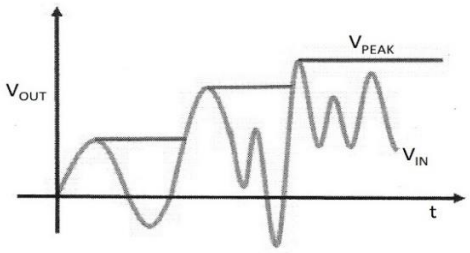
Home-brewing a Conventional Wattmeter.

For the home constructor, each volume of *Radio Projects for the Amateur* Drew Diamond VK3XU describes various simple power meters (and "dummy" loads) suitable for measuring pY at HF and low VHF frequencies. An article titled *Simple RF-Power Measurements* (*QST* June 2001) provides circuits and construction details of a very versatile meter able to accurately measure power from nanowatts to 100 W at frequencies from DC up to about 500 MHz. This circuit was the starting point for *The VK3AQZ Wide Range RF Power Meter Project* recently described in *Amateur Radio*, Volume 90 (2022), No. 2 & 3.

Home-brewing a Peak Reading Wattmeter

A conventional wattmeter can be extended to measure peak power by the addition of a peak-hold amplifier. In the basic peak-hold circuit (see below) the amplifier acts as a voltage follower and the capacitor is charged whenever V_{IN} is greater than V_{OUT}. The capacitor retains the peak charge until it is discharged.





In an article titled *Peak Amplifier for an RF Wattmeter* Owen Duffy (VK1OD/VK2OMD) describes a practical generic amplifier circuit which would allow a conventional meter to measure the peak amplitude voltage of an SSB voice waveform. Similar circuits (with full details) are described in the RSGB publication *Test Equipment for the Radio Amateur*, 3rd Edition, §6.8 & §6.9.

Note: If the meter displays the peak voltage, then $\mathrm{V_{rms}} = \frac{\mathrm{V_{peak}}}{\sqrt{2}}$ and $\mathrm{pX} = \frac{(\mathrm{V_{peak}})^2}{2\ \mathrm{R}}$.

Notes:

- Many in-line SWR meters (of the type which use a current transformer as the sensing device and therefore independent of frequency) are calibrated to measure pY when used with a 50 Ω load. Such meters are often built into the transmitter.
- With any RF measurements the frequency limitations of the equipment will always need to be considered.
- Power is sometimes expressed in units of **dBm** or **dBW** – that is in decibels with respect to either one milliwatt (1 mW) or one watt (1 W). Thus;

$$\mathrm{P(dBm)} = 10\ \log\left(\frac{\mathrm{P(W)}}{0.001}\right) \quad \text{or} \quad \mathrm{P(dBW)} = 10\ \log\left(\frac{\mathrm{P(W)}}{1}\right)$$

Building and calibrating an RF wattmeter (and "dummy load") is a project well able to be undertaken by most amateur radio operators. Why not make this your next practical amateur radio project?