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Root Mean Square

The following is to help alleviate confusion about measurement of RMS (Root Mean Square) values of AC voltage.

RMS, or Root Mean Square, is the measurement used for any time varying signal's effective value: It is not an "Average" voltage and its mathematical relationship to peak voltage varies depending on the type of waveform. By definition, RMS Value, also called the effective or heating value of AC, is equivalent to a DC voltage that would provide the same amount of heat generation in a resistor as the AC voltage would if applied to that same resistor.

Since an AC signal's voltage rises and falls with time, it takes more AC voltage to produce a given RMS voltage. In other words the grid must produce about 169 volts peak AC which turns out to be 120 volts RMS (.707 x 169). The heating value of the voltage available is equivalent to a 120 volt DC source (this is for example only and does not mean DC and AC are interchangeable).

The typical multi-meter is not a **True RMS** reading meter. As a result it will only produce misleading voltage readings when trying to measure anything other than a DC signal or sine wave. Several types of multi-meters exist, and the owner's manual or the manufacturer should tell you which type you have. Each handles AC signals differently, here are the three basic types.

A **rectifier type** multi-meter indicates RMS values for sinewaves only. It does this by measuring average voltage and multiplying by 1.11 to find RMS. Trying to use this type of meter with any waveform other than a sine wave will result in erroneous RMS readings.

Average reading digital volt meters are just that, they measure average voltage for an AC signal. Using the equations in the next column for a sinewave, average voltage (Vavg) can be converted to Volts RMS (Vrms), and doing this allows the meter to display an RMS reading for a sinewave.

A **True RMS** meter uses a complex RMS converter to read RMS for any type of AC waveform.

When taking readings with a **non** True RMS reading meter, a 120 Volt RMS sinewave will still measure about 120 volts RMS. This is because the meter uses the mathematical relationships shown below to give a proper RMS

reading for a sinewave. However if used with a modified sinewave or square wave these meters will only read about 90-105 volts. Don't be misled, there is nothing wrong with the inverter or the meter, and to prove this try the following test. plug in a normal light bulb and check its brightness. If there is only 90-105 volts RMS available it will look orange as it would during a brown out. If it appears to have normal brightness the voltage is approximately 120VAC RMS.

You can see that improper measurement can easily lead someone to believe that a modified sinewave or square wave inverter is not putting out its rated power. For example, remembering that Power = Volts(90-105) x Amps (33) a 4000 watt inverter (24VDC input) would measure out at about 3000-3500 watts if a proper true RMS reading is not taken.

Normally True RMS reading meters are very expensive, such as the Fluke 87 series meters. However, Radio Shack now offers two models priced under $90.00. Check with Radio Shack for details and features.

A few handy things to keep in mind about RMS values that apply when dealing with a sine wave, are as follows:

- Peak Volts AC x .707= Vrms
- Vrms=1.11 x Vavg
- 1.414 x Vrms= Peak Volts AC
- Vavg= .637 x Peak Volts AC

For a modified sinewave or square wave these equations do not apply, and the easiest way to deal with this is to invest in a True RMS reading meter. (For a square wave Vavg, Vrms, and Vpeak are all equal.)