

A TUTORIAL ON POWER SUPPLY LOAD TESTING

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The Load Tests documented on this site were performed not just to satisfy my own curiosity, but also to identify the performance differences between brands and technologies.

The two pieces of test equipment I used to perform the load tests are a BK Precision 8514 Electronic Load and a VIZ WD-767 AC Digital Wattmeter. The 8514 load has a capacity of 1200 watts, and can apply a DC load of up to 242 amperes. The WD-767 meter uses true-RMS circuitry to measure both AC line voltage and current, and it employs a four-quadrant multiplier to determine true (real) power consumption. The meter can measure up to 2000 watts and 20 amperes. It is important to realize that true AC power cannot be determined by simply multiplying independent readings of voltage and current- that product is actually volt-amperes (VA), and represents "apparent" power. Determination of "true" power requires a four-quadrant multiplier to perform instantaneous measurements of true-RMS voltage and true-RMS current throughout the AC cycle. True power is measured in watts, and is what you pay your electricity supplier for. The rotating aluminum disk in the traditional kilowatthour (kWh) meter is driven by two magnetic fields displaced by 90 degrees, one proportional to the line voltage and the other proportional to the line current. The instantaneous torque on the disk is proportional to the power consumed, and the number of disk rotations integrated over a time interval is proportional to the energy consumed, expressed as kWh.

The AC Input Power Factor (PF) of an appliance is the ratio of true power to apparent power, or AC Input Watts divided by AC Input VA. Any PF below 0.8 is usually indicative of a load that is relatively inefficient- one whose apparent power is significantly greater than its true power. The difference is due to magnetizing currents that perform no useful work, and are returned to the utility system when the magnetic fields in the inductances collapse. Although the typical customer does not get billed for a poor PF, the utility must provide the infrastructure (power lines and transformers) to handle the extra, non-useful current. In fact, large industrial power users will pay a severe penalty for low-PF loads on their systems.

The load tests were performed using a dedicated, 20-ampere-rated branch circuit. Even so, the line voltage at the receptacle shows an obvious decrease as the AC load current increases. It is important that the AC source for a power supply be "stiff" enough to provide the needed current without an excessive voltage drop. The National Standard Nominal Utilization Voltage is 120 VAC +/- 5%, and that is what your utility must provide. Despite persistent popular usage, there is no such thing as "110 volts" or "220 volts" in the United States, and has not existed here for more than half a century. If your receptacle voltage is less than 114 VAC, there is a problem that must be investigated and corrected.

The common residential power supply to single-family homes is 120/240 VAC, provided by a single transformer that is center-tapped. Cluster homes, trailer parks, condos, apartment complexes, and commercial/light industrial facilities are usually provided 120/208 VAC, derived from a three-phase power transformer. Although a residence in this category will have 120 VAC at all convenience outlets, the higher voltage available to electric ranges, clothes dryers, water heaters, and similar loads is only 208 VAC- not 240 VAC. This may be an issue with a plug-in appliance such as a welder, air compressor, or a linear amplifier. If your 240 VAC appliance seems to have lackluster performance, check the voltage at the outlet to ensure that it meets the requirements of the appliance. Major appliance vendors such as Sears offer special models of electric ranges, clothes dryers, water heaters, and window air conditioners that are designed specifically to run on 208 VAC- but these are listed in the back of the sales books, and some salespeople don't have a clue about their

availability. If a 240 VAC heating appliance such as a range is connected to 208 VAC, it will produce only 75% of its rated heat. This issue is more common than you might think!

Mountaintop repeater sites are particularly vulnerable to voltage sag, primarily due to the heavy current draw of HVAC systems causing significant voltage drop over long power lines. It is ironic that some power supplies- ferroresonant units in particular- respond to low AC input voltage by increasing their current draw, which exacerbates the problem! Some power supplies, primarily linear and ferroresonant types, are remarkably inefficient at low (standby) loads, and generate significant heat even while idling. This is one area where modern switching power supplies are proving their worth.

If you are a DIY electrician, don't scrimp on receptacles! The really cheap (less than a dollar apiece) receptacles found at home improvement stores often have push-in terminals that use brass springs to make contact with the wires. Bad idea! A number of home fires have resulted from these flimsy devices. Play it safe and use specification-grade receptacles for any outlets that may supply a heating appliance, power tool, or similar heavy load.

The Power Supply Load Test reports are generated with an Excel worksheet that performs all of the calculations as the data are entered. The DC Output Volts is displayed on the 8514 electronic load. The Output Watts is simply the product of Load Amps and Output Volts. The AC Input Volts, AC Input Amps, and AC Input watts are displayed on the WD-767 wattmeter. The AC Input VA is the product of AC Input Volts and AC Input Amps. The AC Input PF is the quotient of AC Input Watts divided by AC Input VA. The Overall Efficiency is the quotient of Output Watts divided by AC Input Watts, expressed as a percentage.

In order to make the load tests as realistic as possible, the jumper wires connecting the power supply to the load are four feet long and are #12, #10, #8, or #4 AWG, the same as would be used in the typical base or repeater station installation. Therefore, the voltage at the terminals of the power supply itself is irrelevant, and is not the voltage seen by the radio.

I must take Astron to task for marketing many of their power supplies without considering some significant safety issues. For example, the RS-70M power supply is marketed as having the capacity to provide 57 amperes continuously, and 70 amperes intermittently. Refer to the Load Test Report for the RS-70M, and note that the AC input current exceeds 12 amperes at loads above 50 amperes DC. Why is this important? Because the RS-70M comes with a 12A fuse, and the fuse holder is marked with that value. Twelve amperes happens to be the maximum current that can safely be drawn from a NEMA 5-15R outlet- the "standard" outlet found in homes. This limit is specified in Article 210.21(B)(2) of NFPA70, the National Electrical Code. This NEC limit is what caused the "vacuum cleaner current wars" of several years ago to top out at 12 amperes of "cleaning power." Since the common, parallel-blade plug on vacuum cleaners and similar home appliances is intended to plug into the standard NEMA 5-15R receptacle, the appliance makers cannot legally market any product that draws more than 12 amperes. But, I digress...

The bottom line on this issue here is that some high-current power supplies cannot safely be operated at a load that results in an AC input current in excess of 12 amperes. If the owner of such a power supply finds that the 12A fuse blows repeatedly, he or she may be tempted to substitute a higher-rated fuse- not realizing that doing so will incur the risk of equipment damage or fire. The proper fuse for the RS-70M is a Bussmann MDA-12 (or equal), which is a ceramic, slow-blow fuse rated at 250 volts. More than one such power supply has come into my shop for testing, equipped with an AGC-20 glass automotive fuse rated for 32 volts. Using an automotive fuse in place of an appropriately-rated AC fuse is dangerous!