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INTRODUCTION

The purpose of this file is to establish a standardized method that can be used to measure active-mode efficiency and no-load power consumption of AC-DC power supply, according to energy efficiency standards. In this document, active-mode efficiency is the ratio, expressed as a percentage, of the total real output power produced by a power supply to the real input power (AC) required to produce it. No-load consumption is defined as the wattage of real power (AC) consumed by a power supply operating in no load condition.

a. Preparing equipment for test

There are four pieces of equipment needed for the efficiency measurement as below: A programmable AC source; a wattmeter; a load; output voltage and current meters.

1. A programmable AC source

When measuring input power, a programmable AC source is needed instead of a variac or wall outlet. Figure 1 shows the output voltage from a programmable AC source. It outputs a precise voltage and its output waveform is truly a sine wave at either 50 or 60Hz. Figure 2 shows the output voltage from a variac. It is not truly a sine wave which may introduce inaccuracy into the measurement.

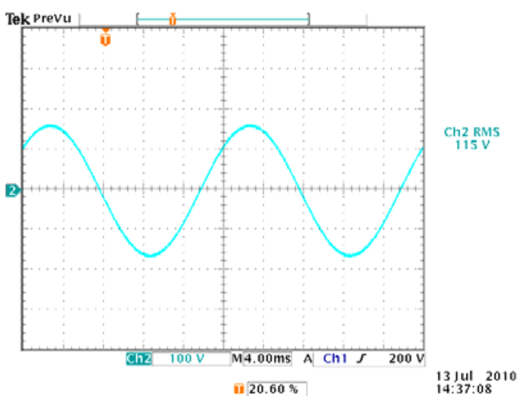


Fig.1 AC voltage from a programmable AC source

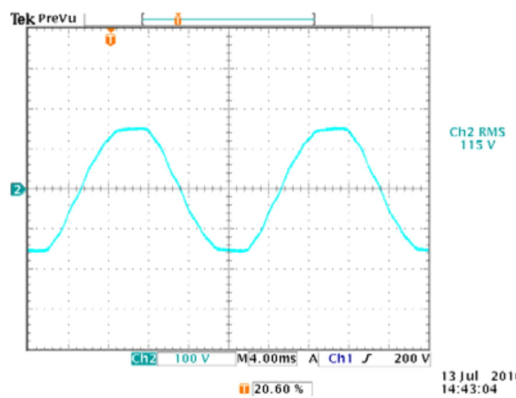


Fig.2 AC voltage from a variac

When testing the efficiency and no load consumption, it is necessary to manually set the voltage and current range of the wattmeter to get the highest accurate data. As is specified in IEC 62301, the input of the power supply shall be the specified voltage±1% and the specified frequency±1%. Table 1 shows the typical nominal electricity supply for some regions.

Table 1 typical nominal electricity supply for some regions

Country/Region	Nominal Voltage and Frequency*
Europe	230V,50Hz
North America	115V,60Hz
Japan**	100V,50/60Hz
China	220V,50Hz
Australia and New Zealand	230V,50Hz

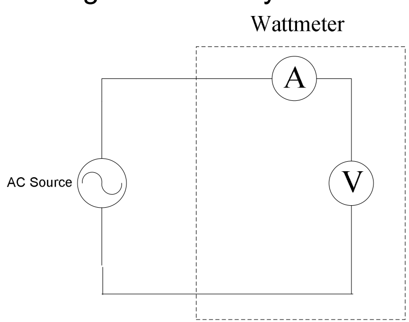
Notes: * Values are for single phase only. Some single phase supply voltage can be double the nominal voltage above (centre transformer tap). The voltage between two phases of a three phase system is 1.73 times single phase value.
** “50Hz” is applicable for the Eastern part of Japan; “60Hz” is applicable for the Western part.

2. A wattmeter

A wattmeter is used to measure the input power. As is specified in IEC 62301, measurements of active power of 0.5W or greater shall be made with an uncertainly of ≤2%. Measurements of active power of less than 0.5W shall be made with an uncertainly of ≤0.01W.The Yokogawa WT210 and equivalent power meter can meet these requirements when properly configured. Please refer to your wattmeter specification or manual to make sure it is qualified for measurement.

A wattmeter contains both a current and a voltage meter. The voltage meter can be placed either before or after the current meter. The configuration of the wattmeter is determined by the load condition as following description.

For very low power measurement or no load measurement, the configuration in Figure 3 may result in large measurement error. Due to the finite impedance of the voltage meter in the wattmeter, it also consumes extra power, which is added to the real input consumed by the power supply and causes large measurement error. For example, the WT210 has 2MΩ input impedance, the power consumption is 27mW with 230Vac. So at light or no load condition, better accuracy is obtained when the voltage meter is connected before the current meter as Figure 4. This prevents the current through the voltage meter from being measured by the current meter.



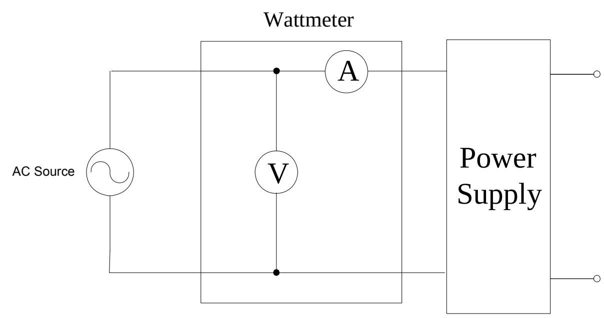


Fig.3 power consumption of voltage meter **Fig.4 right way to test no-load power consumption**

For high power supply, this power loss in voltage meter is negligible. The voltage meter should be connected after the current meter as Figure 5. This prevents the voltage drop across the current meter and the internal wiring of the wattmeter from being incorrectly included in the input power measurement.

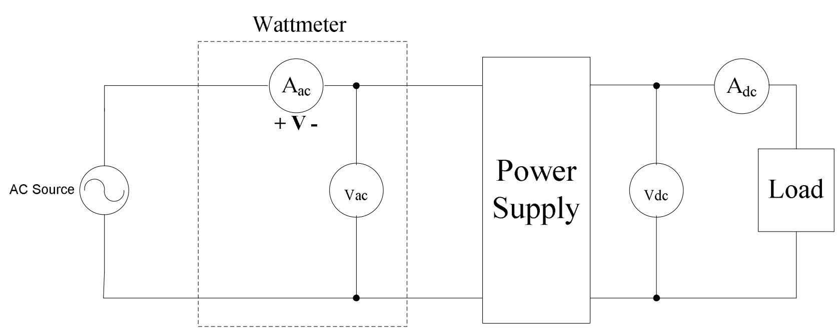


Fig.5 right way to test efficiency

3. A load

All power supplies have a nameplate output current. This is the value used to determine the four active mode load conditions and no load condition. The power supply should be tested at the load conditions shown by table 2.

Table 2 load conditions for the power supply

Percentage of Nameplate Output Current	
Load Condition 1	100%±2%
Load Condition 2	75%±2%
Load Condition 3	50%±2%
Load Condition 4	25%±2%
Load Condition 5	0%

The 2% tolerance is of nameplate output current, not of the calculated current value. For example, a power supply at Load Condition 3 may be tested in a range from 48% to 52% of rated output current.

In order to load the power supply to produce all four active mode load conditions, a set of variable resistive or electronic loads shall be used. The electronic load is preferred and the desired output current can be set in constant current (CC) mode.

4. Output voltage and current meters

A DC current meter and DC voltage meter is required to measure the output power. Two multimeters can also be used to measure the output power, one for voltage measurement and another for current measurement.

To prevent the voltage drop across the current meter and the output cable, the voltage meter should be connected close to the power supply as Figure 5.

b. Efficiency test approach

To measure the efficiency of the power supply, input power and the output power should be measured. Efficiency is calculated as:

$$\eta = \frac{Pout(W)}{Pin(W)} = \frac{Vout(V) * Iout(A)}{Pin(W)}$$

Output power can be easily tested with output current/voltage meters. To measure the input power, a wattmeter such as WAT210 is needed. By using wattmeter, integration mode is preferred because of its highest accuracy. The steps to calculate the integral input are as following:

1. Set the wattmeter to integration mode.
2. Set the interval of integration. (The longer the duration, the more accurate the results will be. One minute is recommended for most application)
3. Read the input energy as $mW * hr$
4. Divide this number by the interval of integration. For example:

$$\frac{Ein(mW - hr)}{Interval(1min)} * \frac{60min}{1hr} * \frac{1}{1000} = Pin(W)$$

Efficiency is tested at 100%, 75%, 50%, 25% of maximum load conditions. The power supply should be operated at 100% load for at least 30 minutes before recording the measurement so as to make the input power reading stable. And make sure that oscilloscope probe or other meters are not connected to the circuit during the measurement.

After 30 minutes warm up time the first measurement should be made at 100% load. The input power should be monitored for a period of 5 minutes to assess the stability of the power supply. If the power level does not drift by more than 5% of the maximum value observed, the power supply can be considered stable and the measurements can be recorded at the end of the 5 minutes period. If AC input power is not stable over a period of 5 minutes, we should continue to record the input power at 5-minute intervals until it becomes stable.

The mentioned 5 minutes stability period should also be applied to the measurement under any load condition. Note that only one warm up period of 30 minutes is required. To get the highest accuracy, it may be necessary to set the current range of the wattmeter manually if the line or load condition is changed.

c. No-load consumption test approach

For no load consumption measurement, integration mode of 1 minute interval is preferred because of its high accuracy. Before the test, all output load and all output meters should be disconnected. And set the current range of the wattmeter to get the highest accuracy. Last, we must make sure that the voltage meter is connected before the current meter as Figure 4.

The power supply should operate at no load condition for at least 15 minutes before recording the measurement so as to make the input power reading stable. After 15 minutes warm up time, the No-load power consumption should be monitored for a period of 5 minutes. If the test data does not drift by more than 5% of the maximum value observed, the power supply can be considered stable and the measurements can be recorded at the end of the 5 minutes period. Otherwise, we should continue to record the input power at 5 minute intervals until it stabilizes.

When the input voltage is changed from high line to low line at no load, the input bulk capacitor will provide energy for a long time. Figure 6 shows the input bulk capacitor voltage when input AC voltage changes from 230V to 115V at no load condition. So during this over 40 seconds period, the input bulk capacitor rather than AC source provides the energy for the power supply.

For this reason, If we change the AC line voltage to test the no load consumption, the load should be applied first to discharge the input bulk capacitor. And then remove the load to test the no load consumption at another line voltage.

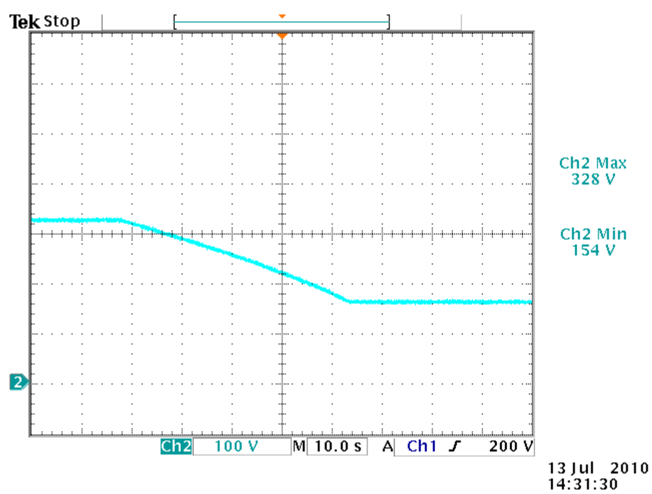


Fig.6 input bulk capacitor voltage

d. Efficiency and No-Load Consumption calculation

Efficiency is calculated by dividing the power supply’s measured active output power at a given load condition by the active ac input power measured at that load condition. Average efficiency can also be calculated by calculating the average value of the efficiency values calculated at test conditions 1, 2, 3 and 4 in Table 2. For multiple-output power supply, it is designed to output more than one dc voltage level. So the efficiency is the ratio, expressed as a percentage, of the total real output power to the real input power required to produce it, using the following equation:

$$\eta = \frac{\sum_i P_{o,i}}{P_{in}} * 100$$

Where $p_{o,i}$ is the output power of the i^{th} output, P_{in} is the input power.

No-load power consumption is equal to the active AC input power at no load condition. Integration mode of 1 minute interval is preferred by using wattmeter. The input power is calculated as the following equations:

$$Pin(mW) = \frac{Ein(mW * hr)}{Interval(1min)} * \frac{60min}{1hr}$$

Where $E_{in}(mW * hr)$ is the input energy reading from wattmeter as $mW * hr$.