Technical Article

Measuring Efficiency, the Right Way

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Efficiency is the most crucial criteria for some power supplies. With high-efficiency controllers like the UCC28780, it is important now more than ever to understand how to conduct a proper efficiency measurement that adheres to regulation standards. In this post, I'll show you how to properly connect and measure AC/DC power supply efficiency.

Proper Test Conditions:

Efficiency measurements are only as good as the connections from which they're made. To make efficiency measurements as accurate as possible the first step is to make sure that no unnecessary equipment/circuitry is connected to the board, such as an oscilloscope connector or other meters that are not needed in the efficiency measurement test itself. If there are connections that draw power that cannot be removed, their power consumption needs to be noted in the measurement or calculation and not neglected. This is critical in low-load and stand-by power, in which any external connections will have a larger impact in the efficiency measurement.

The next step is to place the probes for measurement. One option is to put the probes as close to the output as possible, like on the output capacitor or at the pins of jumper J6 in the UCC28780 evaluation module (EVM), as shown in Figure 1. However, if the power supply has a fixed cable, you should measure from the end of the fixed cable rather than directly from the output. Connecting this way ensures a proper Kelvin connection and provides high-accuracy measurements.

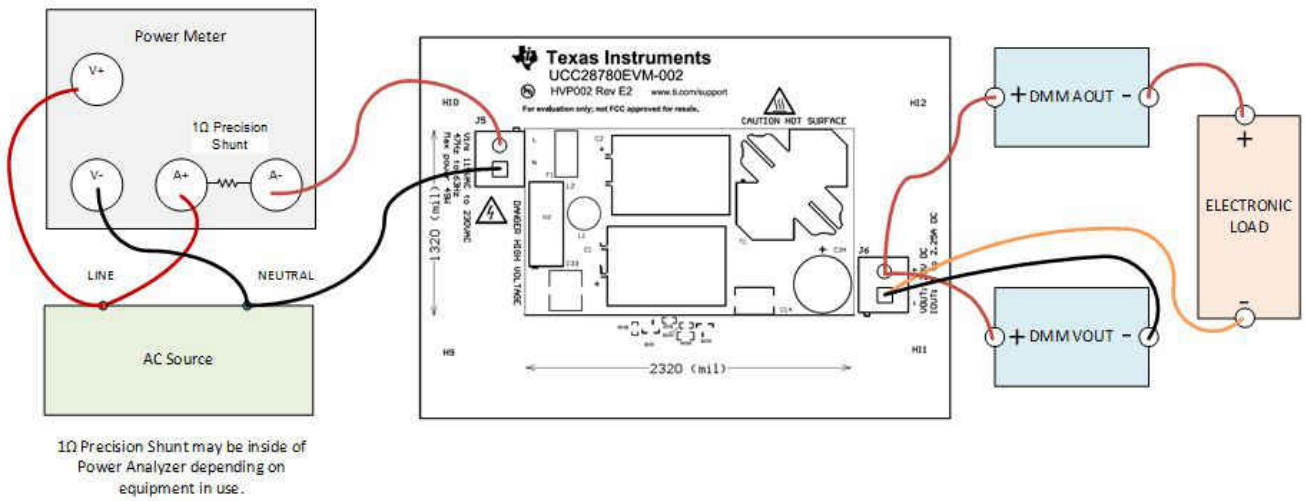

Figure 1. UCC28780EVM Connection Diagram for Efficiency Measurements

Now let's move to the input side of efficiency measurements for AC/DC converters. A dedicated power meter is required, as the two-multimeter setup used on the output side would not be accurate for the input because the multi-meters would not account for the harmonic content like a power meter would. Similar to the output, your goal is still to place the measuring probes as close as possible to the board's input. Both input and output connections are shown in Figure 2, and match the color scheme of Figure 1.

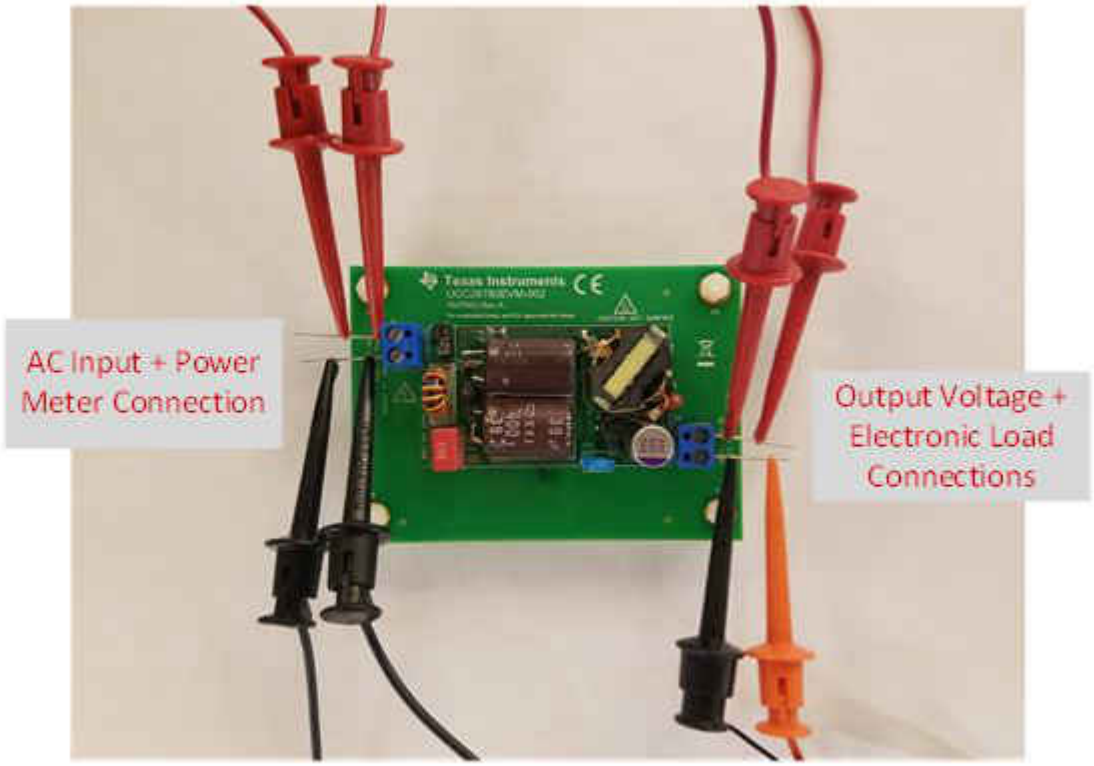

Figure 2. Probe Connections for Efficiency Measurements

Proper Testing Procedure:

Title 10 Electronic Code of Federal Regulations outlines the correct way to conduct power-supply efficiency measurements, and will be linked in the additional resources. Here are the steps for performing an accurate efficiency measurement:

- Turn on an AC source with a high line voltage (230AC/50Hz for Europe or 115AC/60Hz for U.S.A) and with a 100% load. Let the device under test operate for at least 30 minutes to ensure that the board is warmed up and stable for measurements.
  - The unit under test is considered stable if the AC input power does not deviate/drift more than 5% from the maximum power value observed.
  - If the AC input power is not stable after five minutes, continue to monitor the input power in five-minute periods until the reading is stable.
    - If after many waiting periods the input power is not stable, follow the International Electrotechnical Commission (IEC) 62301 standard test procedure, which states to measure the average power, or derive the power from an average energy measurement.
- After the initial warm up period, take the first measurement at a 100% load. Use an AC power meter to monitor the input power for a period of five minutes before assessing the stability of the power supply.
- The remaining load conditions are 75%, 50%, 25%, 10% and 0% load, in that order. You only need one warm up time of 30 minutes, so these subsequent measurements only need a minimum of five minutes to become stable enough to record measurements.

A test procedure would then look like this:

1. Warm up the unit under test for 30 minutes under a full load, 230VAC/50Hz or 115VAC/60Hz.
2. Assess the stability of the unit and take measurements if stable.
   a. If not stable, continue to monitor output until stable.
   b. Drop load to 75%; monitor for five minutes to assess stability then take measurement.
   c. Drop load to 50%; monitor for five minutes to assess stability then take measurement.
   d. Drop load to 25%; monitor for five minutes to assess stability then take measurement.
   e. Drop load to 10%; monitor for five minutes to assess stability then take measurement.
   f. Drop load to 0%; monitor for five minutes to assess stability then take measurement.

Figure 3 outlines the test procedure in a flowchart diagram.

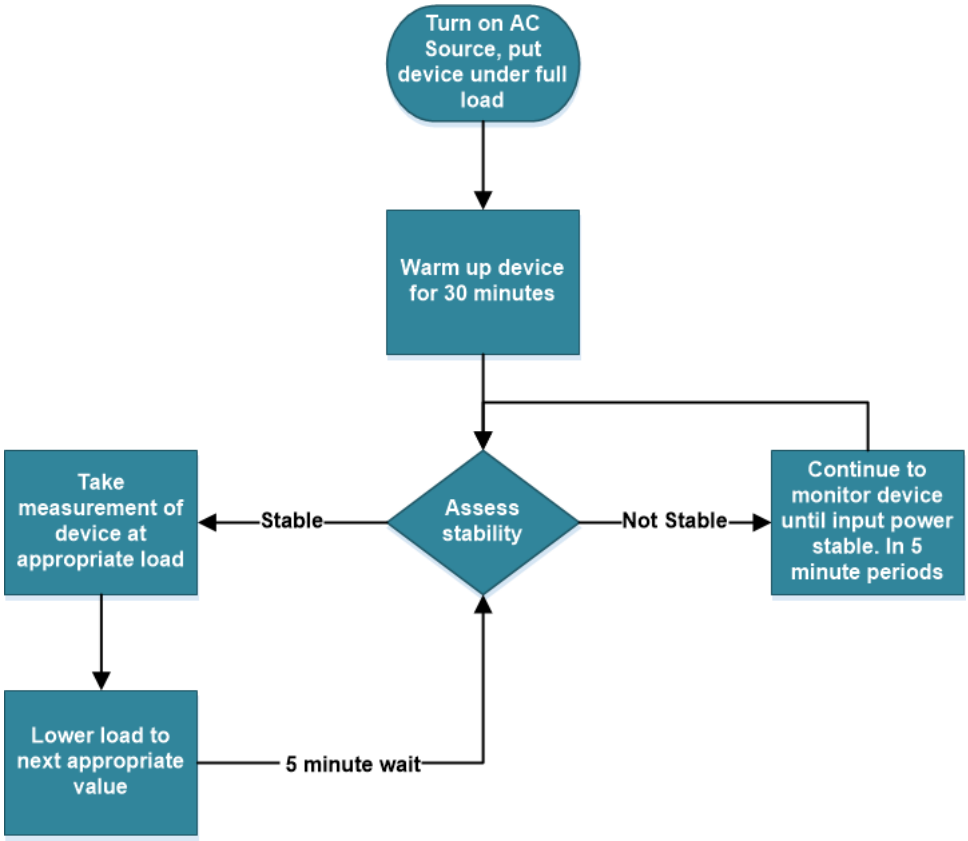

Figure 3. Efficiency Measurement Procedure

Conclusion:

Engineers can test things many ways. As the industry continues to push for higher and higher efficiencies in power supplies, it is important to have a good grasp on what a consistent testing environment and procedure look like.

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