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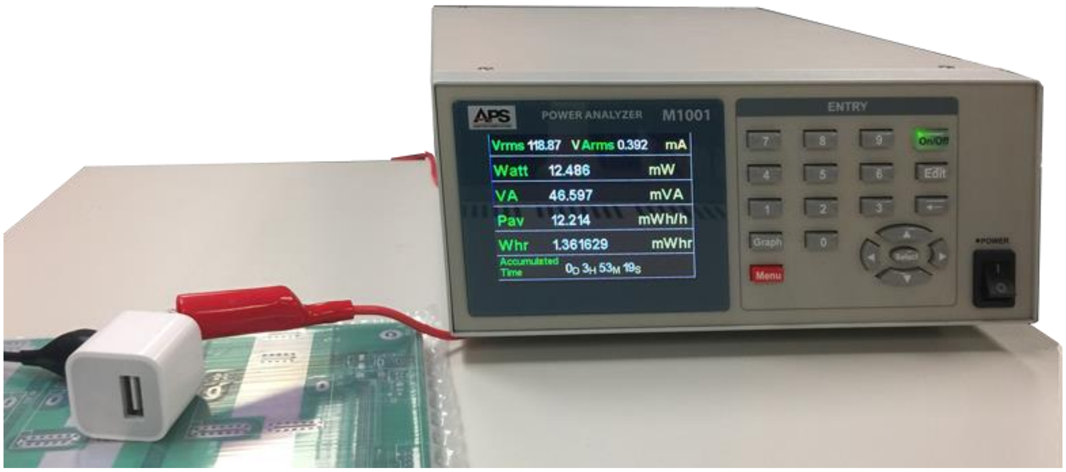
APPLICATION NOTE

M1001 AC Standby Power Measurements

October 10, 2019



Contents

1 Introduction

This application note illustrates the use of the M1001 Power Analyzer's Standby Power measurement function for AC powered products. The product used to illustrate this function is a 5 Watt Smartphone Charger.

2 AC Measurement Functions

2.1 Equipment Setup

Before any measurements can be made, it is imported to set up the equipment used. For this application, we will use a standard US 120Vac, 60Hz power outlet to provide power to the EUT.

The EUT for this example is a generic 5W USB smartphone charger. Many of these are plugged into a standard US AC outlet 24/7 while no phone is plugged in. As such, the standby power they consume while not charging and actual smartphone is multiplied by 8,760 hours every year.

The general equipment setup is illustrated in the figure below.

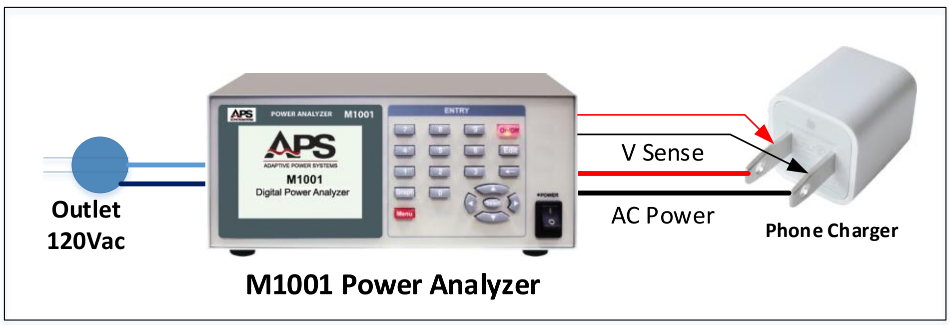


Figure 1: Equipment Setup

2.2 Measurement cable wiring

The connections between the power source (wall outlet), power analyzer and load are shown in Figure 2 below. Follow the illustration to connect the phone charger to the power analyzer.

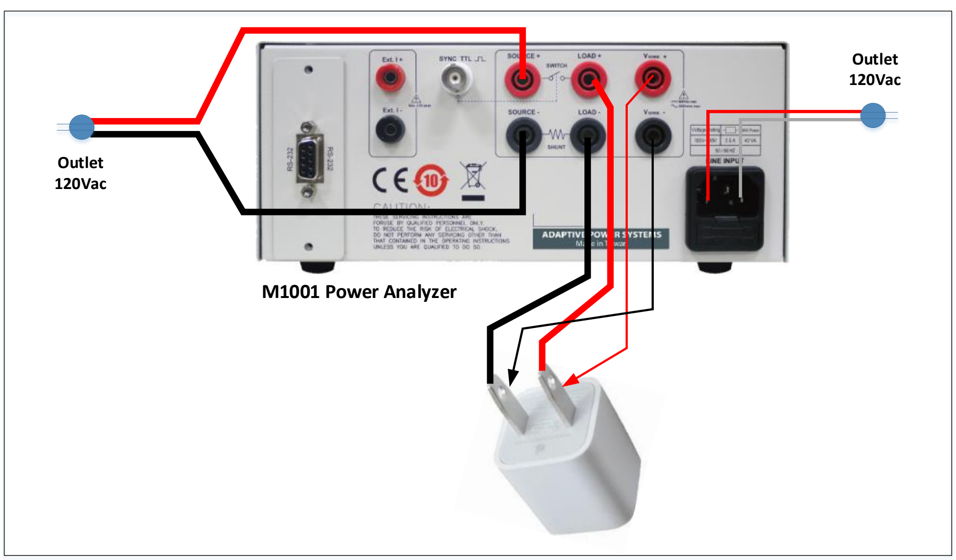


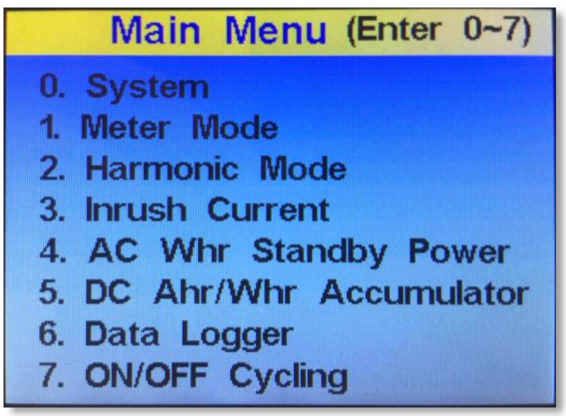
Figure 2: Equipment connections

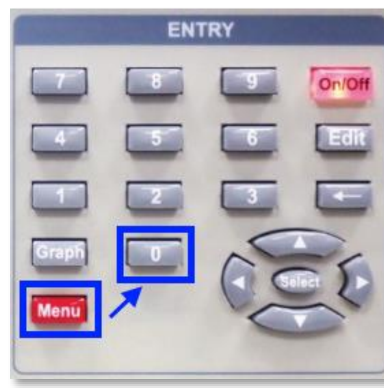
Note the V_{SENSE} lines of the power analyzer must be connected to the load input to make sure any wire impedance voltage drops do not affect the measurement results. While the current in this application is expected to be very low, the power calculation is a function of both current and voltage measurement so any error in voltage reading due to I*R losses in the connection cabling will have a significant impact on the power calculation and thus the standby power consumption measurement result.

2.3 Initial Power Analyzer Setup

Before we determine Standby Energy consumption of the charger, we would like to measure basic power characteristics first using the Meter Mode of the power analyzer. We will be using the internal current shunt of the M1001, as the expected current levels of this 5W phone charger are low, well below the 20Arms max. rating of the internal shunt.

Settings are made from the System Setting menu, available by pressing the **Menu** key followed by the number zero key **0**.



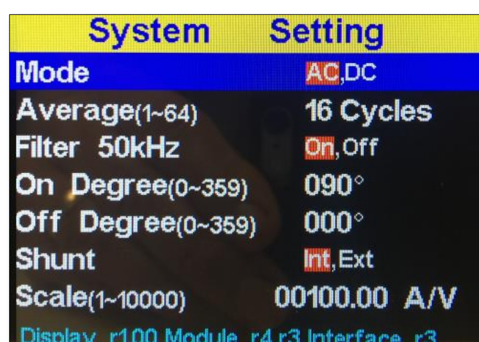


Once in the System Setting menu, press the **Edit** key and use the cursor keys to scroll through the available settings. To change a numeric setting, enter the new value and press the **Select** key inside the cursor keypad. To change alternate fields, use the left and right cursor keys to move between field settings and press **Select** when done.

Use the up down cursor keys to move to the next setting.

Since we are making AC measurements, we will make the following selections:

- Mode AC
- Average 16
- Filter 50 kHz On
- On Degree 090°
- Off Degree 000°
- Shunt Int (Internal)



This is reflected in the System Setting screen shown here. The average setting will results in more stable readings as systematic noise will be reduced as a result of averaging 16 readings. Lower averaging settings may be used for faster update rates as needed.

2.4 Phone Charging Operation Measurements

To establish a base line, we will first measure the power demand of the charger when actually charging a partially discharged smartphone. In this case, the phone battery was about 65% full so not completely discharged. The state of charge (SOC) of the battery will affect the actual current and thus power drawn from the battery charger.

If you are not familiar with the M1001 power analyzer use for regular AC measurements, refer to APS application note titled “APS M1001 Power Analyzers - AC Load measurements”.

Figure 3: Current, Power and VA drawn from 120Vac outlet

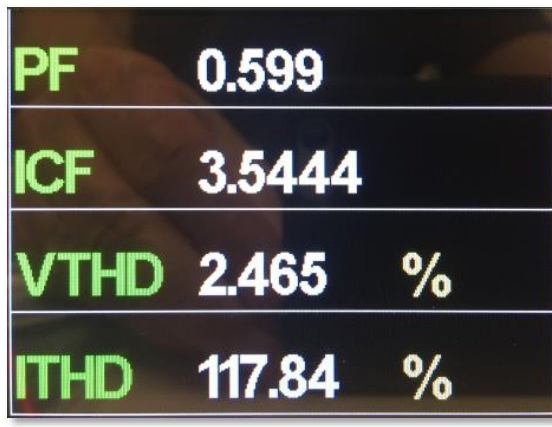


Figure 4: Power Factor, Current Crest Factor and Current distortion

As you can see, the 5Watt charger pulls about 6.6 Watts of AC power from the 120Vac output to deliver its maximum output of 5 Watts (5Vdc @ 1000mA). That represents an efficiency of about 75%.

From the low power factor and high current crest factor and distortion evident from Figure 4, it is clear that the current waveform is not exactly sinusoidal so this is clearly not a linear charging device. Pressing the **Graph** key located directly above the **Menu** key will toggle the power analyzer display to its Scope display mode. See Figure 5. The current waveform shape indicates an inexpensive SCR controlled rectifier design was used in this AC to DC power converter.

Figure 5: Phone Charger Voltage and Current

2.5 Non-Charging Operation Measurements

Next, let us look at the power consumption of the phone charger when no phone is plugged in, i.e. under no load conditions.

The setup of the power analyzer remains the same. We just unplug the phone from the USB charging cable. The M1001 Power Analyzer will detect the much lower current that occurs under no load and change its current measurement range to one of its lowest ranges to get the best possible accuracy and resolution for the current measurement.

Compare the data from Figure 6 and Figure 7 with that under load shown in Figure 3 and Figure 4 earlier.

Figure 6: No Load Current, Power and VA drawn from 120Vac outlet

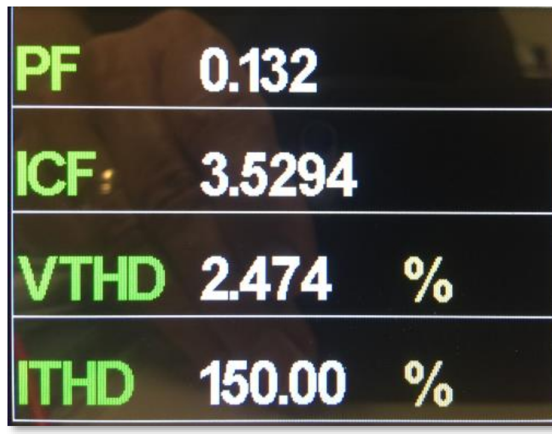


Figure 7: No load Power Factor, Current Crest Factor and Current distortion

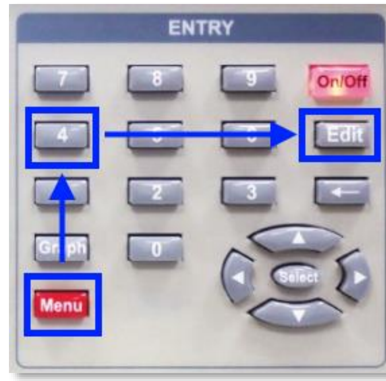
Clearly, with no battery to charge, the charger only draws losses associated with solid-state power conversion from the utility. Thus, even under no-load conditions, the battery charger pulls 26.734 mWatts from the power outlet.

Interestingly, the current distortion is even higher under no load conditions as there is barely any fundamental current. Switch to Scope mode shows a barely noticeable current spike near the 90° and 270° phase angle of the AC voltage. See Figure 8, yellow highlights.

So how does that translate to energy consumption under no load conditions, i.e. most of the time while the charger is left plugged in? We turn to the AC Standby Power measurement mode of the M1001 power analyzer for the answer next.

Figure 8: No load Voltage and Current waveform

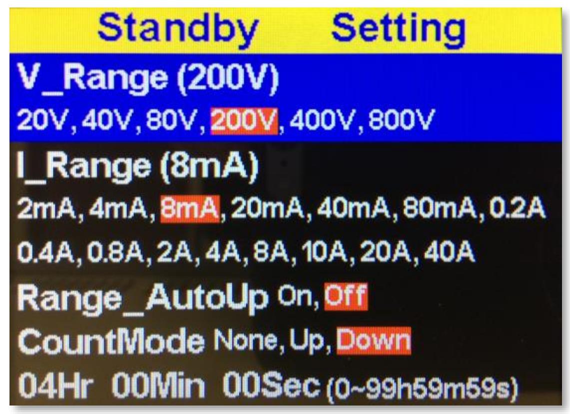
2.6 Selecting AC Whr Standby Power Mode



Before we can make any measurements, we need to select the Standby Power mode by pressing the **Menu** key followed by the number four key **4** (AC Whr Mode).

Next, we need to configure the Standby Power mode for the application at hand. This is accomplished by pressing the **Edit** key and use the cursor keys to scroll through the available settings.

The Standby Power Mode allows selection of a fixed range for voltage and current. This allows continuous, no-gap measurements to ensure no data is lost during the integration time window. For our example, we will set up as follows:



- Use the 200V range as our power source (US grid voltage) is 120Vac rms.
- For current, we expect a low current so will use one of the lower ranges of 8 mA. That should more than cover the standby current level we measured before.
- Range Auto Up allows the power analyzer to change to a higher range if an out of range condition occurs but we don't anticipate this with this type of EUT so we leave if off.
- The integration interval is displayed counting up, down or not displayed as the test is running. We set it to count down from the integration time to zero.
- The integration time is set at four hours. Should be more than enough to be representative for an entire year of use for this type of EUT.

When done, press the **Edit** key to return to the Standby Power screen. We are now ready to start the test pressing the **On/Off** key in the upper right corner of the keypad. Once pressed, this key back light will change to green (**On/Off**) and the integration interval will start counting down from four hours to zero.

2.7 Integrating Energy Use

To obtain reliable energy consumption data, it is important to run this measurement for a long enough period to be representative of actual use cycles. In our example, the charger is likely plugged in around the clock in most cases so we can run just a few hours and extrapolate from there.

We will let the test run for four hours in our case so the energy consumption calculated per hour will represent four hours of no load use.

As we have seen, we can either count this four-hour period up or down. We chose to count down so we let the unit run until the measurement period counts down to zero. Figure 9to the right shows a snap shot of the screen with 2 hours, 49 mins and 2 second left to acquire data before the end of our four-hour integration window.

So far, the charge has consumed 14.39 mWhr of energy in about an hour and 10 mins.

Figure 9: Intermediate mWHr Result

2.8 Final Result and Implications

At the end of the selected four-hour integration time, the result of the energy consumption is available on the power analyzer screen as shown in Figure 10.

Figure 10: Final mWHr Result after 4 hours

Our 5W phone charge subject consumes a standby energy level of 12.149 mWh/h. Annual energy consumption can be calculated by multiplying this number by the number of hours in a year:

1 Year = 356 days * 24 Hours = 8,760 hours

Energy use = 8,760 h * 12.149 mWh/h = 106.425 Wh or 0.106425 kWh.

Actual cost will depend on local electricity rates. For a home consumer operating just above base line usage in California, the local utility rate equals 0.392 $/kWh which yields about $0.0417 or a little over 4 cents to run a smartphone charger in idle mode per year.

That does not sound that bad but if we consider that there are about 265.9 million smartphone users in the USA alone (Source: Statista Digital Market Outlook 2019 estimate), if all of them have a charger plugged in all year round, the total cost in wasted electricity is around $ 11 million per year.

Waste not, want not….!

For more information on energy use and standby power, see https://standby.lbl.gov/

3 Other M1001 Measurement Functions

Additional measurement functions of the M1001 are covered in other application notes. Contact Adaptive Power Systems or its representative for copies of other power analyzer application notes.

- Standard Meter Mode
- Inrush Current measurement
- Measurement Data Logging
- ON/OFF Power Cycling

4 Summary

Gathering key measurements and harmonics content for an AC load is quick and easy when using a dedicated power analyzer.

5 Contact Information

For product information or technical support by region, contact our exclusive equipment representative shown below.

NORTH AMERICA	EUROPE	ASIA
PPST Solutions	**Caltest Instruments GmbH.**	**PPST Shanghai Co. Ltd.**
Irvine, USA	Kappelrodeck, Germany	Shanghai, China
Phone: +1(888) 239-1619	Phone: + 49(0)7842-99722-00	Phone: +86-21-6763-9223
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M2000 Series Power Analyzers

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