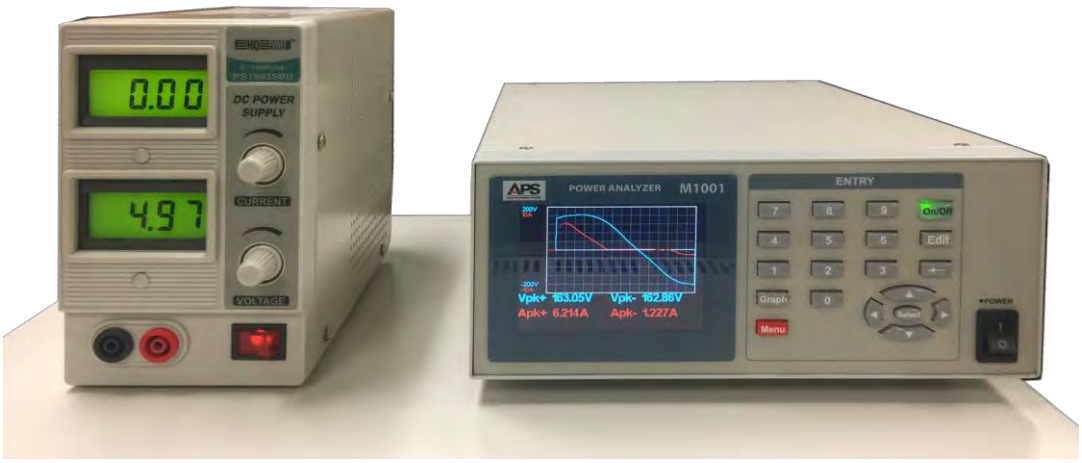
ADAPTIVE POWER SYSTEMS
11771 Mitchell North
Irvine CA 92614
Tel: (949) 752-8400
Email: info@adaptivepower.com
www.adaptivepower.com

APPLICATION NOTE

M1001 AC Inrush Current Measurements

October 11, 2019



Contents

1 Introduction

This application note illustrates the use of the M1001 Power Analyzer's inrush current measurement function for AC powered products. The product used to illustrate this function is a general-purpose programmable bench DC power supply. Inrush current can be an important design consideration, especially for higher power products as large inrush currents at start-up can cause nuisance tripping of circuit breakers or result in open line fuses.

2 EUT Inrush Current Measurement

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 bench DC power supply. The general equipment setup is simple and illustrated in the figure below.

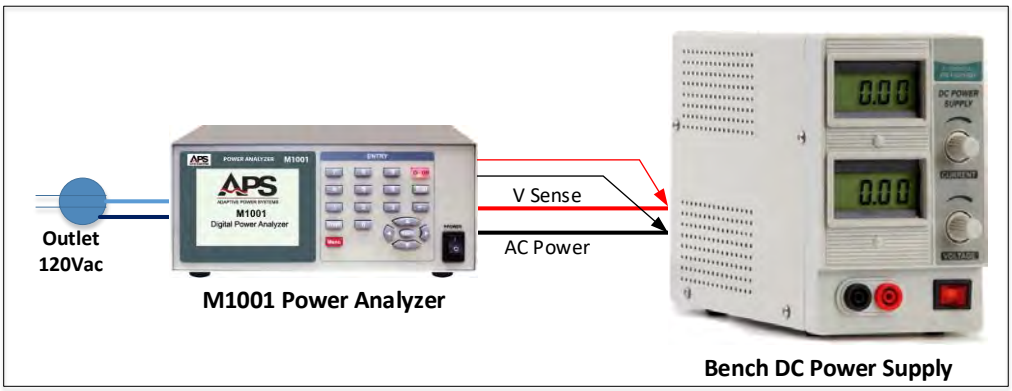


Figure 1: Equipment Setup

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 DC Power Supply (EUT) to the power analyzer.

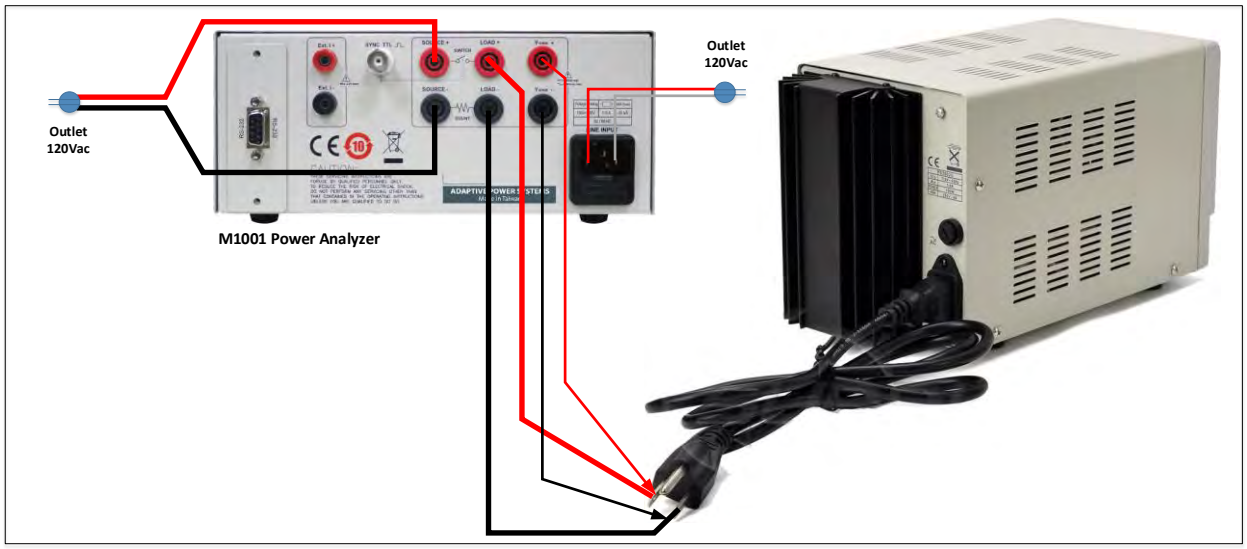


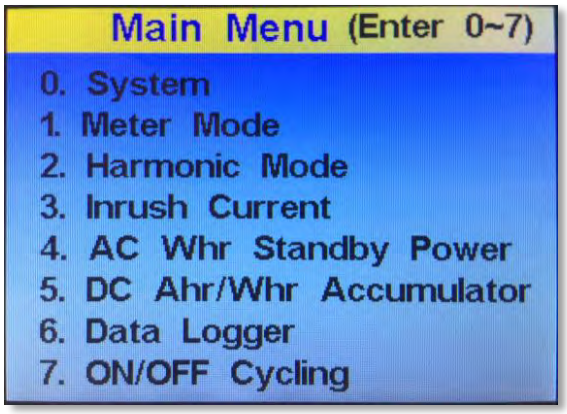
Figure 2: Equipment connections

Note the $\mathbf{V_{SENSE}}$ lines of the power analyzer must be connected to the load input to make sure any wire impedance voltage drops do not affect the inrush current measurement results.

2.3 Initial Power Analyzer Setup

Before we determine the worst-case inrush current of the DC power supply, we need to make sure the power analyzer is configured for AC measurements and will use the correct voltage and current measurement ranges as auto-ranging is not possible when trying to capture the initial current peak value at EUT startup.

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

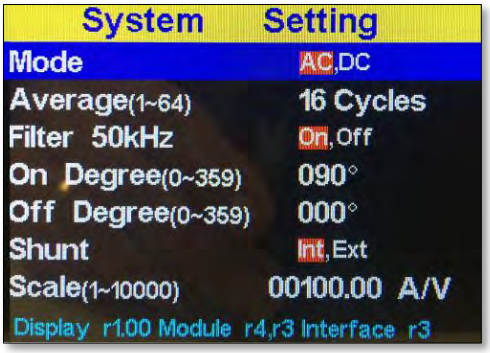


Once in the System Setting menu, press the **Edit** key and use the cursor keys to scroll through the available settings. To change a numeric setting, enter the new value and press the **Select** key inside the cursor keypad. To change alternate fields, use the left and right cursor keys to move between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

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

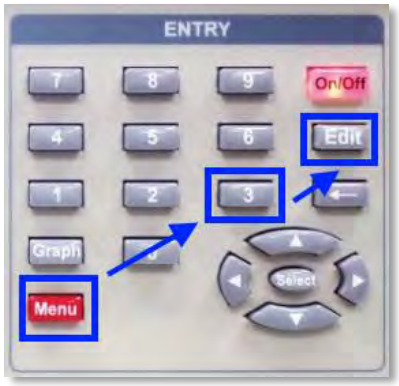
Since we are making AC measurements, we will make the following selections:

- 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.

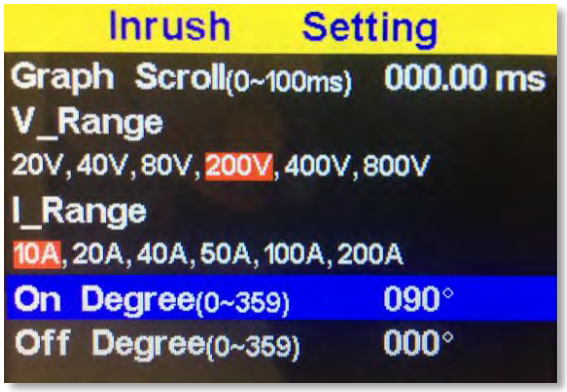
2.4 Selecting AC Inrush Current Mode



Before we can make any measurements, we need to select the **Inrush Current** mode by pressing the **Menu** key followed by the number three key **3** (Inrush Current).

Next, we need to configure the Inrush Current 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 Inrush Current Mode allows selection of a fixed range for voltage and current. Auto-ranging is not possible for this measurement as there is only one initial current cycle. 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 peak current less than 10A so will use the 10A range. That should more than cover the inrush current for this small Lab DC Supply. We can always change it if it turns out the be higher.
- The On Degree determines at what phase angle the internal on/off electronic switch of the power analyzer is triggered. We expect the inrush current to be the highest at the peak of the AC voltage so we start out with a setting of 90°.
- For our purposes, the turn off degree angle is not important so we leave it at 0°.

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 backlight will change to green (**On/Off**) and power will be applied to the EUT at the 90° phase angle of the AC voltage.

2.5 Inrush Current at 90 degrees

The measurement result will be visible immediately as only the first cycle of the current is captured and displayed and shown in Figure 3. A peak current of 6.413 Amps occurs at about 100°, shortly after input voltage is applied.

Note: To repeat the test, make sure to press the green **On/Off** button so the EUT has time to discharge any internal bias supply capacitors.

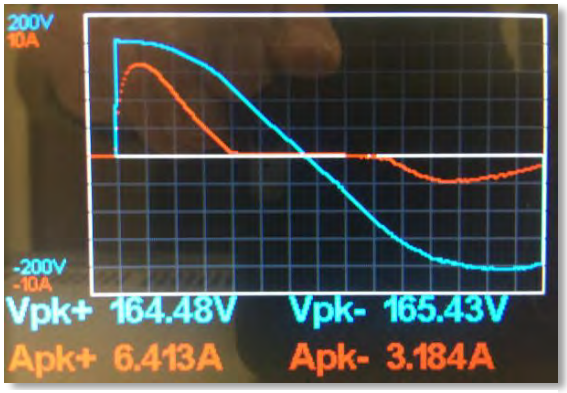


Figure 3: AC input Current at 90°

Running back to back Inrush Current tests on the same EUT will not provide good results as the internal capacitors will still be partially charged, thus reducing the maximum inrush current level.

Always allow sufficient time between tests to allow capacitors in the EUT to fully discharge.

2.6 Inrush Current at 270 degrees

Let us repeat the inrush current measurement at the opposite polarity of the AC voltage by changing the On Degree setting in the Inrush Setting screen to 270°. (See section 2.4 for instructions).

Clearly, the initial inrush current of this EUT is considerably lower (1.900 Apeak) on the negative cycle of the AC voltage.

Figure 4: AC Inrush Current at 270 Degrees

2.7 Other Phase Angle Settings

A quick test at other phase angles like 45° - Figure 5 - reveals a somewhat lower inrush current (5.724 Apeak) than at 90° as expected. At 60°, inrush current is lower still at 5.724 Apeak.

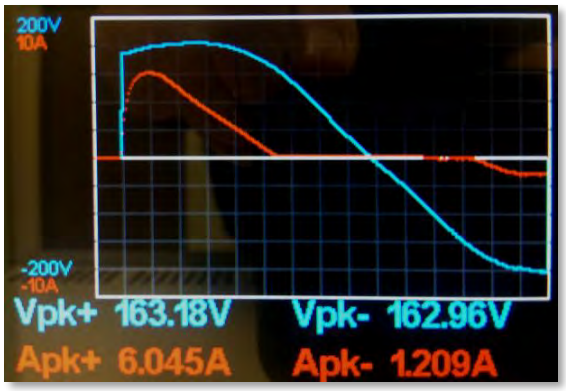


Figure 5: Inrush Current at 45 Degrees

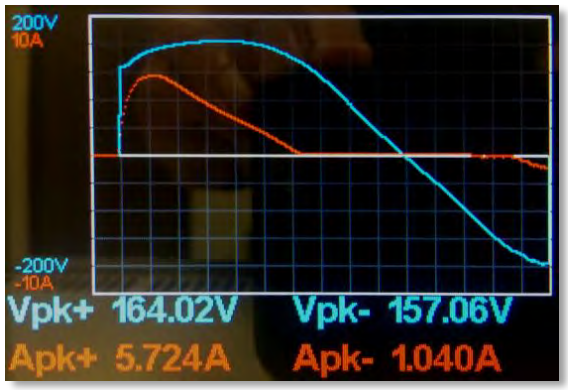


Figure 6: Inrush Current at 60 Degrees

Our initial setting of 90 degrees seems to be to worst case for AC inrush current on this EUT.

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
- Standby Power Whr 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
Fax: +1 (949) 756-0838	Fax: + 49(0)7842-99722-29	Fax: +86-21-5763-8240
Email: info@ppstsolutions.com	Email: support@adaptivepower.com	Email: support@adaptivepower.com

M2000 Series Power Analyzers

ADAPTIVE POWER SYSTEMS
17711 Mitchell North
Irvine, CA 92614
United States
Tel: +1.949.752-8400
Fax: +1.949.756-0838