PA3000 Four-channel, Multi-phase AC/DC Power Analyzer

HOW-TO DEMONSTRATION GUIDE

The Tektronix PA3000 is a one- to four-channel power analyzer that is optimized for testing today's single- and multi-phase, high efficiency power conversion products and designs. Use it to quickly visualize, analyze, and document power efficiency, energy consumption, and electrical performance to the latest regional and international standards.

Each test example in this demo guide discusses two methods of making the same measurements. The first method refers to making the measurements directly on the PA3000 using the front panel, whereas, the second method demonstrates the use of free PWRVIEW Software. In each test example, the second method (PWRVIEW) is the preferred method, because it is easier and enables more user flexibility and customization options.

Tektronix recommends reviewing all of the test examples to reach the best understanding of all features offered by the PA3000 and the PWRVIEW Software.

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Efficiency Testing Single Phase Applications

This example demonstrates a simple method to make efficiency measurements on an external AC-DC power supply that is rated to the level VI efficiency standard. Similar principles can also be applied to efficiency testing on any AC-DC power supply, DC-AC inverter, and other related converter including solar inverter and UPS systems.

WATCH VIDEO
How to Make Efficiency Measuremensts on
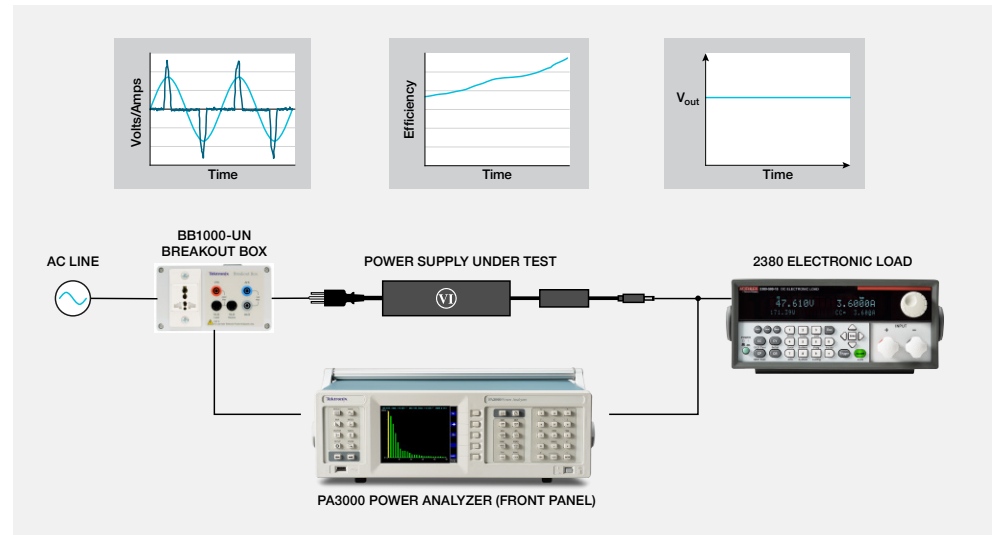AC-DC Power Supply

www.tek.com/
effciency1ph_video

Figure 1-1. Efficiency Testing setup for AC-DC Power Supply.

TEST SETUP

Complete the following steps to setup the efficiency measurement on an AC-DC power supply with the PA3000 Power Analyzer:

1. Connect the AC input on the device under test (DUT) to the first channel of the PA3000 using a Tektronix Breakout Box (BB1000) as shown in the wiring diagram. (See Figure 1-2.)

2. The breakout box taps in to the current signal and measures the voltage across the input terminals. The breakout box makes it easier and safer to connect the input AC signal on the DUT using the 4 mm safety leads provided with PA3000.

3. Connect the output DC terminals on the second channel of the PA3000 using the provided safety leads. The current shunt on the PA3000 is connected in series with the output load; the voltage channels are connected across the positive and negative terminals of the power supply as show in the figure.

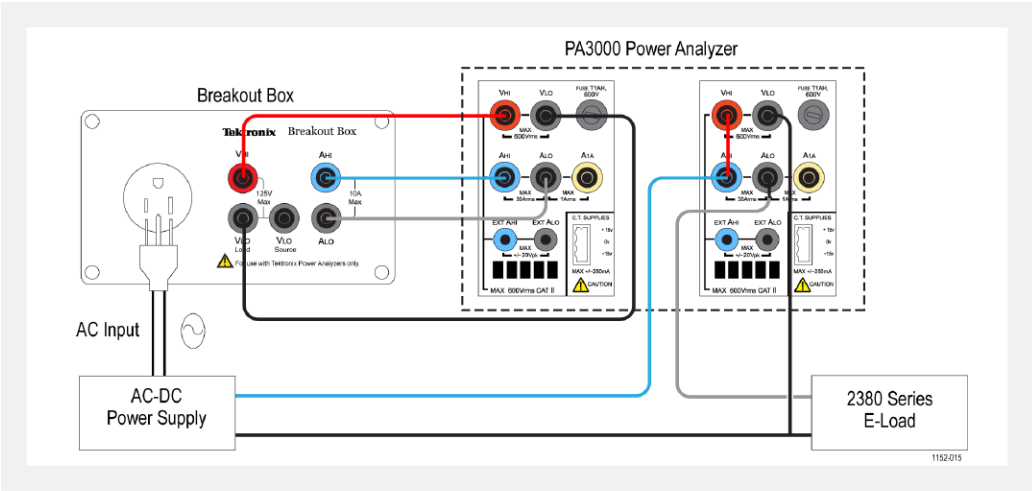4. After making all of the connections, use one of the two methods to make the efficiency measurement.

Figure 1-2. AC-DC efficiency measurement wiring diagram.

METHOD 1: EFFICIENCY MEASUREMENTS ON SINGLE PHASE AC-DC POWER SUPPLIES. (PA3000 DIRECT)

The following steps describe the process for setting up the PA3000 for efficiency measurements on an AC-DC power supply.

WHAT YOU WILL NEED — METHOD 1

- PA3000 Power Analyzer
- AC-DC Power Supply (DUT)
- 4mm Safety Leads

- BB1000 Break Out Box
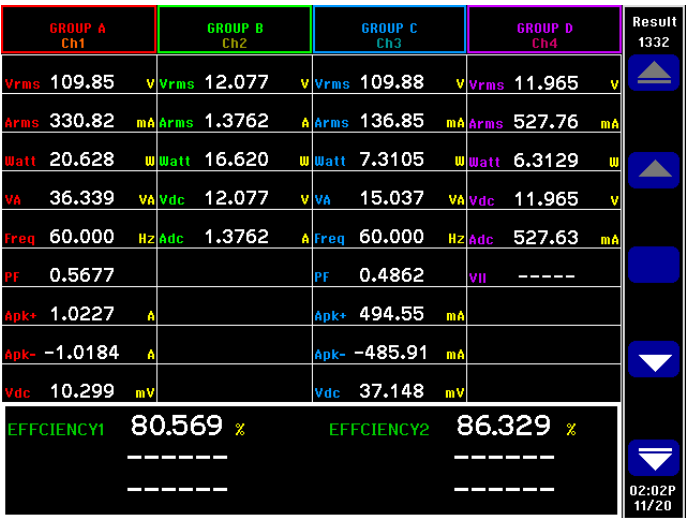- Electronic Load (Keithley 2380) (Optional)
- AC Source (Optional)

Figure 1-3. Efficiency measurement on the PA3000.

This procedure can also be used for testing efficiency on other applications such as UPS systems, LED drivers, or DC-AC inverters.

1. Set the PA3000 to the default configuration:
   - Press ▤.
   - Scroll down to **User Configuration** and press ▶.
   - Select **Load Default Configuration**, and then press ✓ to confirm. The PA3000 will load the defaults and display a confirmation screen. Press **OK** and then return to the Main Menu by pressing ◀.

2. In the Main Menu, go to **Measurements**, press ▶, and then select the desired parameters for the AC input signal.
   - The first channel will be represented as Group A on the yellow bar at the top of the screen.
   - Select the desired measurements: Vrms, Arms, Watts, VA, PF, Acf, Athd, and A Harmonics.

3. Select Group B representing the second channel on the PA3000 by pressing the right arrow key on the left panel of the PA3000.

4. Select the desired measurements for the DC output such as Watt, Vdc, and Adc; deselect any preset measurements that are not needed.

5. After selecting all of the desired parameters, press ▦ to view the Results screen.
   - The PA3000 is now set up for making AC and DC measurements on the first and second channels respectively.

6. Power on the DUT from the AC source; an appropriate load can be applied to the DUT at this point.
   - The Results screen should start updating the real time measurements.

7. The Math function can be used for calculating efficiency. Press Σ to set up efficiency formula.

8. On the Math screen, press the MATH soft key.

9. Select the desired function from the list and then press ▶ to enter the options.
   NOTE: *The Edit Function can be used to edit any specific math formula. While in the edit function, press* ⃝? *to enter the Help menu for help in formatting the function or refer to the information earlier in this manual.*

10. For the efficiency calculations, enter (CH2:W/CH1:W)*100 and then press **OK**. Press ◀ to go back to Math menu where the function can be renamed and units can be added, if desired.

11. Go back to the Math menu and scroll down to the newly edited function and enable the function by pressing ✓. Select all functions that need to be displayed on the screen.

12. Press ▦ to view the Results screen.

13. To view selected math formulas, press Σ.

14. To view math formulas along with other results, press ▦ to view the Results screen and press 🔍 multiple times until the math window appears at the bottom of the screen.

15. PA3000 Power Analyzer is now ready to take efficiency measurements.

Optional Steps when using Keithley 2380 Electronic Load

16. Set the Keithley 2380 Electronic load in Constant-Current (CC) mode by pressing the CC key on the front panel and set the value for full load current based on the output specification of the power supply under test. Press the on/off button.

17. Generally a 30 minute warm-up period is required by the standard, before any efficiency measurements are made on an AC-DC Power Supply.

18. Check for power stability measurements for five minutes on the input of the Power Supply and then log an efficiency measurement at 100% load.

19. Repeat this step at 75%, 50%, 25% and 0% load by entering those values on the front panel of the 2380 Electronic load.

20. Let the Power supply stabilize for five minutes between each load step change.

FURTHER SETTINGS IF REQUIRED

Data Logging. The logging feature allows you to log data over time for prolonged efficiency testing involving load and source sweeps. Use the DATA OUT key to log data to any compatible flash drive connected to the front panel USB connector. The actual logging interval can be changed by pressing ☷ and going to **Interfaces →USB Host Data Out.** The log file will be saved as a .csv file.

Waveforms and Harmonics. To monitor AC input waveforms and harmonics, use the ⬚ or ⬚ key respectively. Switch between channels by using the arrow keys on the left panel. Various options for viewing waveforms and harmonics can be selected from within the Graphs and Waveforms menu.
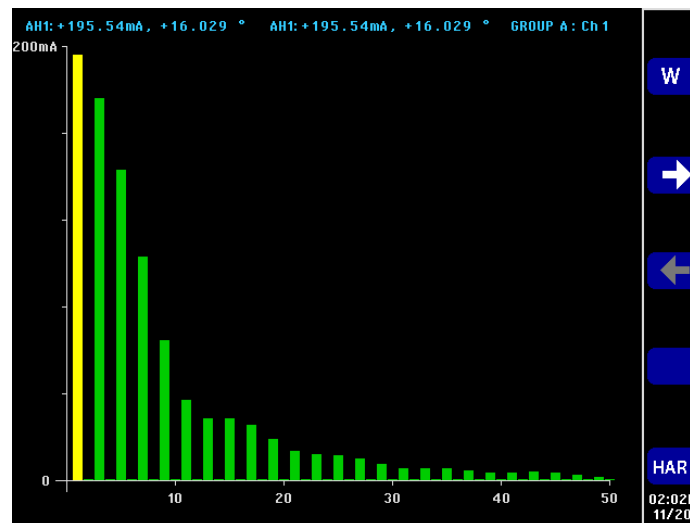
Figure 1-4. Harmonic bar chart on the PA3000.

2380 Electronic Load Programming. The 'List' mode on 2380 Electronic Load can be used to automate efficiency testing.

• The load can be set up to automatically step through a set of different load values. The load can be programmed to execute the list with a fixed time at each step.

• Alternatively, the load can be triggered via a hardware, external trigger or a command from a controller.

• For more information on how to setup list mode on 2380 Electronic Load, refer to the product user manual (Document no: 2380-120-60-901-01 Rev. A)

METHOD 2: EFFICIENCY MEASUREMENTS ON SINGLE PHASE AC-DC POWER SUPPLIES. (PWRVIEW SOFTWARE)

The following steps describe the process for setting up the PWRVIEW software with a PA3000 for efficiency measurements.

WHAT YOU WILL NEED — METHOD 2

- PA3000 Power Analyzer
- AC-DC Power Supply (DUT)
- 4mm Safety Leads
- BB1000 Break Out Box

- PC with PWRVIEW software installed
- USB cable
- Electronic Load (Keithley 2380)
- AC Source (Optional)
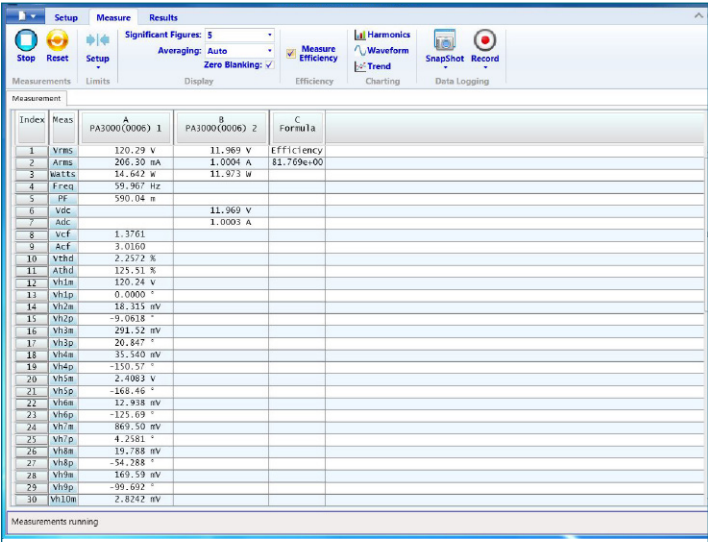
Figure 1-5. Efficiency measurement with the PWRVIEW software.

1. Connect the PA3000 to the computer with the PWRVIEW software installed using the supplied USB cable. Ethernet or GPIB can also be used, if desired.

2. Open the PWRVIEW software by double-clicking the desktop icon.

3. Click the Add button to connect the PA3000. All available instruments will be listed in the selection panel.

4. Select the desired instrument (the PA3000) and then click Connect.

    NOTE: There are various default applications and compliance tests on the left panel from which you can select. This example discusses the AC-DC LED Driver efficiency measurement. This method can also be used for similar AC-DC power supplies

5. Select LED Driver Efficiency under the Applications/Test section on the left panel and then click the Wizard button. The wizard helps with wiring and shunt selections. A 1A shunt or 30A shunt can be selected based on the peak input and output currents.

6. Make changes on the setup wiring as suggested.

7. Click Finish when done, and the page will direct you to the Efficiency Setup tab.

8. Verify the instrument and group information and then click the check box for the Measurement Efficiency. PWRVIEW is now ready to take efficiency measurements.

9. Click the Measure tab page at the top and then click the blue Start button. The measurements will start updating.

10. To add more measurements or change other settings, such as range and filters, go to the Setup tab and select the desired settings.

    NOTE: The measurements must be stopped to make any changes on the Setup page. Stop the measurements by clicking the Stop button on the bottom of the Setup page.

Optional Steps when using Keithley 2380 Electronic Load

11. Set the Keithley 2380 Electronic load in Constant-Current (CC) mode by pressing the CC key on the front panel and set the value for full load current based on the output specification of the power supply under test. Press the on/off button.

12. Generally a 30 minute warm-up period is required by the standard, before any efficiency measurements are made on an AC-DC Power Supply.

13. Check for power stability measurements for five minutes on the input of the Power Supply and then log an efficiency measurement at 100% load.

14. Repeat this step at 75%, 50%, 25% and 0% load by entering those values on the front panel of the 2380 Electronic load.

15. Let the Power supply stabilize for five minutes between each load step change.

FURTHER SETTINGS IF REQUIRED

Waveform, Harmonics, and Trend Chart. In the measurement Grid, you can view Waveform, Harmonics, and Trend charts by clicking the respective icons on the menu bar.
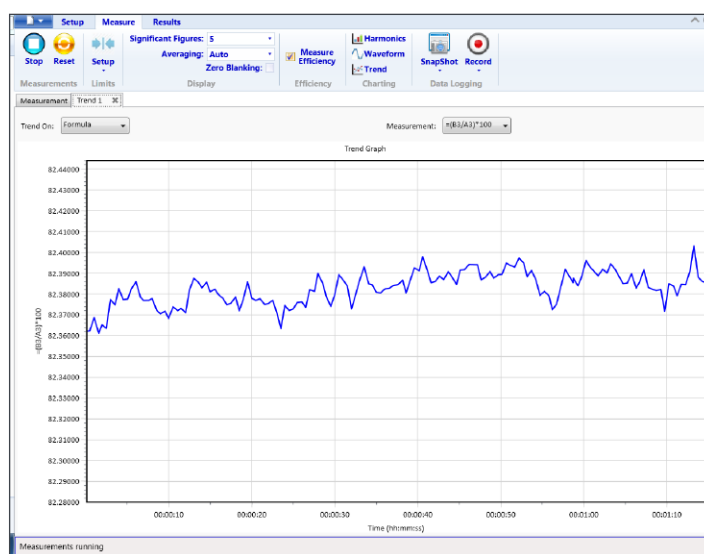

Figure 1-6. Efficiency Trend Chart.

- Waveforms in the PWRVIEW software are constructed using the harmonic data collected from the power analyzer. The accuracy of the waveform depends on the amount of harmonic information available. For optimum results, select maximum number of harmonics to display in the setup area. Selecting 100 harmonics for the PA3000 gives the best results. If no harmonics are selected, waveform feature will display a blank screen.

- The Harmonic bar chart can be enabled for all voltage, current, and watts measurements. Up to 100 harmonics can be selected throug the setup screen. Hovering over any harmonic bar will display the absolute value and percentage of fundamental for that harmonic.

- The Trend chart can be activated for any measurement parameter by either right clicking on the desired parameter or by clicking the Trend icon on menu bar. The Trend chart can be reset by using the Reset button on the menu bar.

Data Logging. Recording data is important for most efficiency measurements where load and source sweep is required.
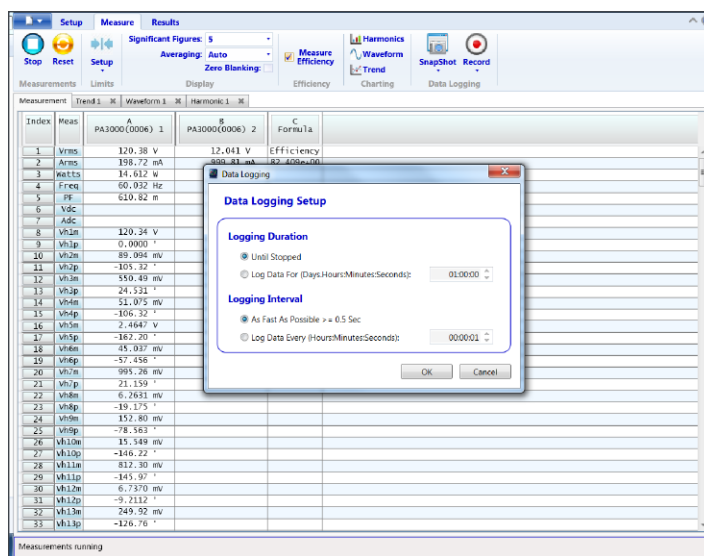
Figure 1-7.
Logging setup.

- To record data using PWRVIEW, click the Record button on the menu bar. The software will start recording all the selected data including formulas and limits.

- To change the data logging rate or to set the total log time, click the down arrow on the Record icon to open the data logging setup. Here you can select the desired logging duration and interval.

- To stop the data logging, click the Stop button.

- All the recorded data is stored in a database on the local computer. To access the data, click the Results tab and then click the Measure icon. The dialog box will present all the archived data.

- Select the desired data set and export to either an Excel or a .csv format.

Custom Limits. Custom limits can also be set with any of the measurement parameters. Custom limits help set limits based on various standards or test specifications.
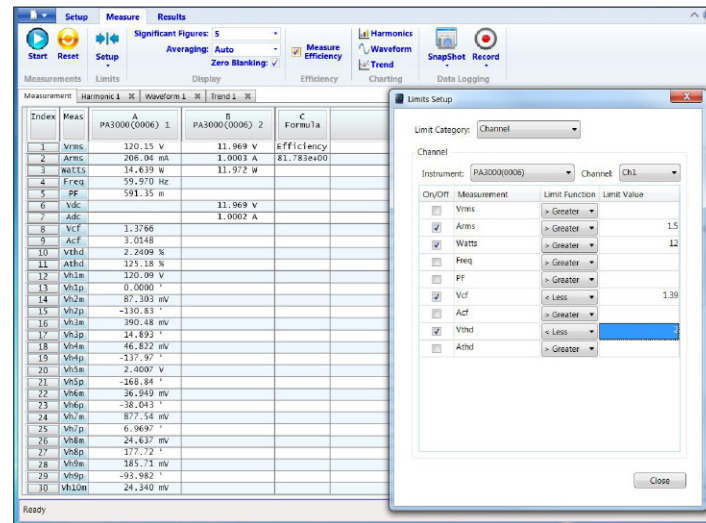

Figure 1-8.
Custom limits.

- To set custom limits, either right-click the desired measurement parameter or click the Limits Setup icon on the menu bar. Stop the measurement update to set up custom limits.

- Custom limits will appear as a separate tab on the measurement grid. The result column will display red fonts if the limits are failing. Hovering over the results will display the limit function, limit value, and relative value.

2380 Electronic Load Programming. The 'List' mode on 2380 Electronic Load can be used to automate efficiency testing.

- The load can be set up to automatically step through a set of different load values. The load can be programmed to execute the list with a fixed time at each step.

- Alternatively, the load can be triggered via a hardware, external trigger or a command from a controller.

- For more information on how to setup list mode on 2380 Electronic Load, refer to the product user manual (Document no: 2380-120-60-901-01 Rev. A)

Efficiency Testing Three Phase Applications

This example demonstrates a simple method to make efficiency measurements on a three phase motor drive. Similar principles can also be applied to efficiency testing on any three phase inverters and other DC-AC converters.
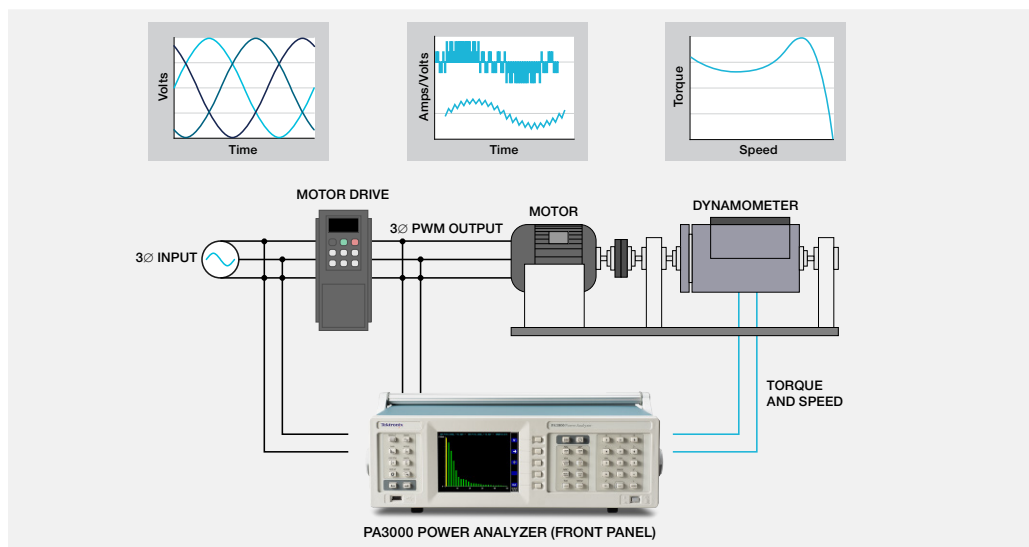
Figure 2-1. Three Phase Efficiency Testing on a PWM Motor Drive.

METHOD 1: EFFICIENCY MEASUREMENTS ON THREE PHASE PWM MOTOR DRIVE (PA3000 DIRECT)

This method demonstrates three phase power and efficiency measurements on a single phase input and three phase output PWM motor drive directly on the PA3000 display.

WHAT YOU WILL NEED — METHOD 1

- PA3000 Power Analyzer
- Three Phase Inverter (Motor Drive)
- 4mm Safety Leads
- BB1000 Break Out Box
- AC Source (Optional)

TEST SETUP

The following steps describe the process to set up the efficiency measurement on a single phase input PWM motor drive using the PA3000.

1. Connect the single phase AC input on the PWM motor drive to the first channel of the PA3000 using a Tektronix BB1000 Breakout Box as shown in wiring diagram.
   – The breakout box taps into the current signal and measures the voltage across the input terminals. It makes it easier and safer to connect input the AC signal on the DUT with the 4mm safety leads provided with the PA3000.
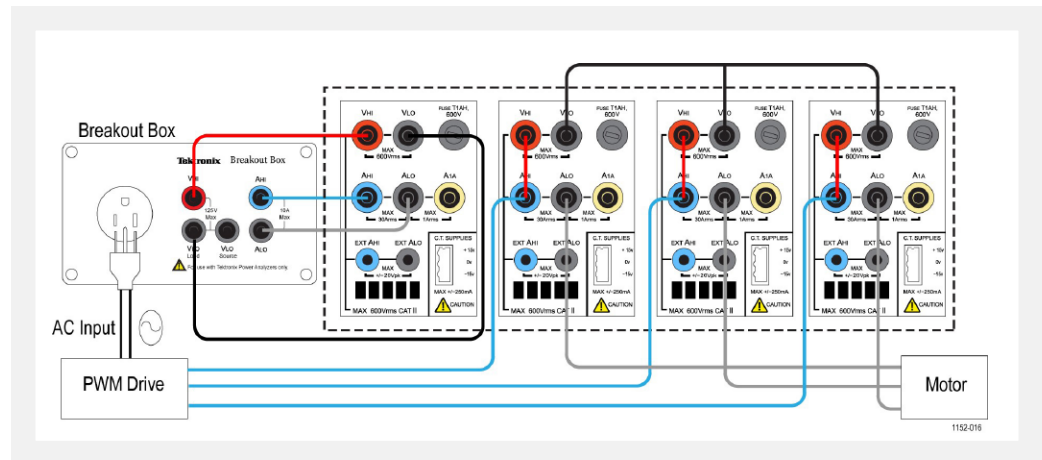
Figure 2-2. PWM motor drive efficiency (1 phase in and 3 phase out).

2. Connect the three phase output of the PWM drive to other three channels using the 3-phase 4-wire configuration as shown in the wiring diagram.
   – All three phases are set up in series with the internal shunt and the voltage is measured across respective phase and neutral.

3. If the motor drive does not have a dedicated neutral cable, create a floating neutral by connecting all three VLO terminals on channels 2, 3, and 4 together.

4. After making all of the connections, set the PA3000 to the default configuration:
   – Press ▤ .
   – Scroll down to **User Configuration** and press ▶ .
   – Select **Load Default Configuration**, and then press ✓ to confirm.

   The PA3000 will load the defaults and display a confirmation screen. Press O K and then return to the Main Menu by pressing ◀ .

5. To select the correct wiring configuration within the Main Menu, go to Inputs →Wiring →Configuration and select **1 Phase 2 Wire** for Group A.

6. Scroll to Group B by pressing the arrow key on the left front panel and select 3 Phase 4 Wire.
   NOTE: If desired, both groups can be named for ease of monitoring. Go back one step and enter the appropriate name using the Group Name option.

7. The PA3000 makes it easy to configure important settings using default modes. For the PWM motor drive output, from the Main Menu, select **Modes → Select Mode →PWM Motor.**
   – The PWM Mode will set up the PA3000 to accurately measure the output voltage of a typical PWM drive that switches at high frequencies. The algorithm applies a proprietary sensing method to determine the actual fundamental power frequency in real time for all power calculations so that the calculated power and harmonic data are always accurate even in dynamic speed conditions.
   – The PWM Mode is not required for the input line frequency measurements.
   – To enable sum measurements for the three phase output on group B, enable the Sum Results column by entering the Main Menu and going to **Measurement Configuration → Sum Results Column → Enabled.**

8. To make the efficiency measurements, enable the Math function by pressing [Σ] and then pressing the MATH soft key.

9. Select the desired function to edit and press [▶] to enter the options.

   NOTE: The Edit Function can be used to edit any specific math formula. While in the edit function, press [?] to enter the Help menu for help in formatting the function or refer to the information earlier in this manual.

10. For the efficiency calculation, enter (GRPB:SUM:W/CH1:W)*100 and then press **O K**. Press [◀] to go back to the Math menu where the function can be renamed and units can be added, if desired.

11. Go back to the Math menu and scroll down to the newly edited function and select the function by pressing ✓ . Select all functions that need to be displayed on the screen.

12. Press [▦] to view the Results screen.

13. To view selected math formulas, press [Σ].

14. To view math formulas along with other results, go back to the Results screen and press [🔍] multiple times until the math window appears at the bottom of the screen.

You are now ready to take efficiency measurements on a PWM Motor drive with single phase input and three phase output.

FURTHER SETTINGS IF REQUIRED

Torque and Speed Inputs. The overall efficiency of a motor drive system requires measuring real-time speed and torque data.
The PA3000 has four analog and two counter inputs to enable various auxiliary input measurements such as torque and speed.

- Refer to the pin number for desired analog or counter input under Auxiliary inputs/outputs and connect the signal (torque, speed, or others) directly to the respective pin on the AUXILIARY INPUTS/OUTPUTS connector on the rear panel.

- The auxiliary inputs can be enabled and viewed through the math screen. Press [Σ] and then press the MATH soft key to enter options. Select any desired function and edit function as ANA1, ANA2, ANA3, or ANA4 for analog inputs and COUNT1 or COUNT2 for counter inputs to enable and view auxiliary inputs on the screen.

- To view the math screen along with other results, press [🔍] multiple times until the math window appears on the bottom of the display.

Data Logging. The logging feature allows you to log data over time for prolonged efficiency testing involving load and source sweeps. Use the DATA OUT key to log data to any compatible flash drive connected to the front panel USB connector. The actual logging interval can be changed by pressing [☰] and going to **Interfaces → USB Host Data Out**. The log file will be saved as a .csv file.

Waveforms, Harmonics, and Vector Graphs. Waveforms, harmonics, and vector graphs can be enabled for all three phase signals.
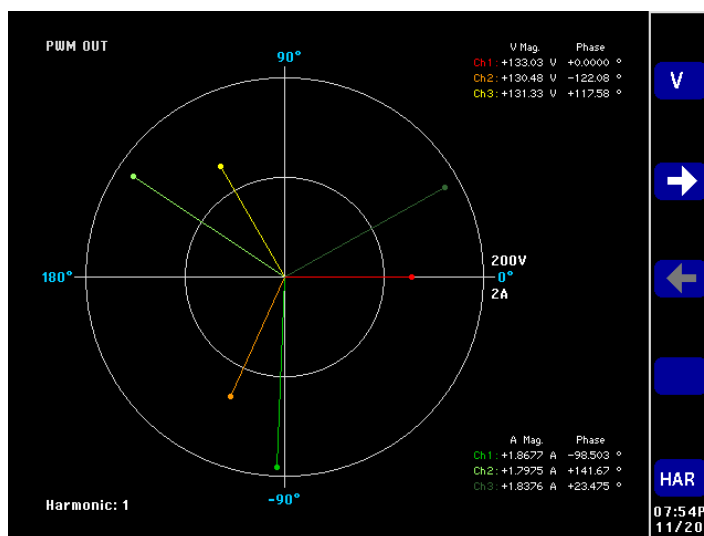
Figure 2-3.
Vector graph
on the PA3000.

- To monitor AC waveforms, harmonics, or the vector graph use the [⎍], [Ⅱⅰ], or [≻] keys respectively.

- Switch between channels using the arrow keys on the front panel.

- Select various options for viewing waveforms and harmonics within the Vector and Waveforms menus.

METHOD 2: EFFICIENCY MEASUREMENTS ON THREE PHASE PWM MOTOR DRIVE (PWRVIEW SOFTWARE)

This method discusses efficiency measurement on three phase input and output PWM motor drives using the PWRVIEW software.

WHAT YOU WILL NEED — METHOD 2

- PA3000 Power Analyzer
- Three Phase Inverter (Motor Drive)
- 4mm Safety Leads

- PC with PWRVIEW software installed
- USB cable
- AC Source (Optional)
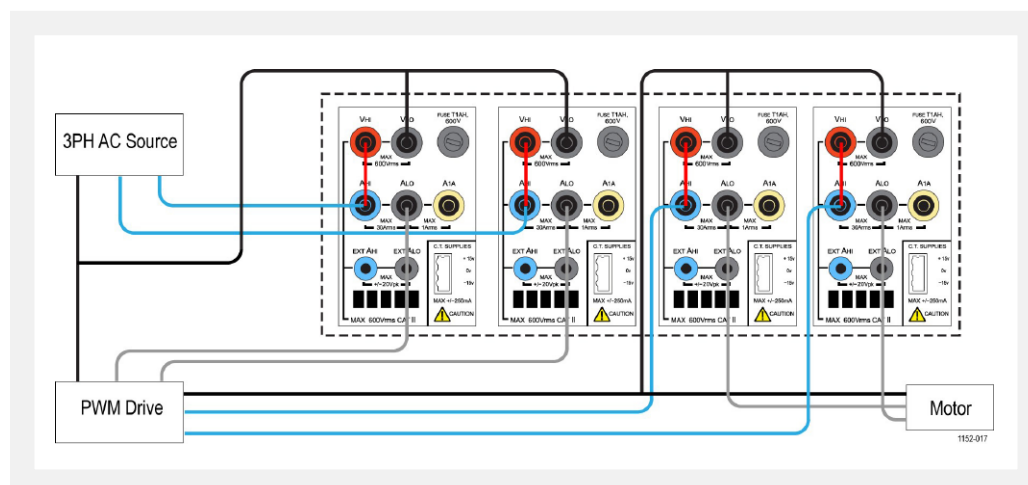
Figure 2-4. PWM Motor drive efficiency (3-phase in and 3-phase out).

TEST SETUP

1. Connect the three phase AC input of the PWM motor drive to the first two channels of the PA3000 as shown in wiring diagram. (See Figure 2-4.)

2. Connect the three phase output of the PWM drive to the other two channels using the configuration as shown in the wiring diagram.

   NOTE: The 3-phase 3-wire (2 Wattmeter) configuration enables testing three-phase signals by using two power channels. This method can be used for simultaneously testing 3-phase input and outputs on a 4-channel power analyzer.

3. After making all of the power connections, connect the PA3000 to the computer with the PWRVIEW software installed using the supplied USB cable. Ethernet or GPIB can used.

4. Open the PWRVIEW software by double-clicking the desktop icon. Click the Add button to connect the PA3000. All available instruments will be listed in the selection panel. Select the desired instrument (the PA3000) and then click Connect.

   NOTE: There are various default applications and compliance tests on the left panel that you can select from.

5. Select PWM Motor Drive Efficiency under the Applications/Test section on the left panel and then click the Wizard button.

6. The wizard helps with wiring and shunt selections.

7. Select the three phase input and three phase output on the wizard and enter the expected current in the appropriate box.

8. Click Finish when done and the page will direct you to the Efficiency Setup tab.

9. Verify that the instrument and group information and then click the check box for the Measurement Efficiency.

10. PWRVIEW is now ready to take efficiency measurements.

11. Go to the Measure tab and then click the blue Start button. The measurements will start updating.

12. To add more measurements or change other settings, such as range and filters, go to the Setup tab and select the desired settings.

    NOTE: The measurements must be stopped to make any changes on the Setup page. Stop the measurements by clicking the Stop button on the bottom of the Setup page.

FURTHER SETTINGS IF REQUIRED

Torque and Speed Inputs. The overall efficiency of a motor drive system requires measuring real-time speed and torque data. The PA3000 has four analog and two counter inputs to enable various auxiliary input measurements such as torque and speed.
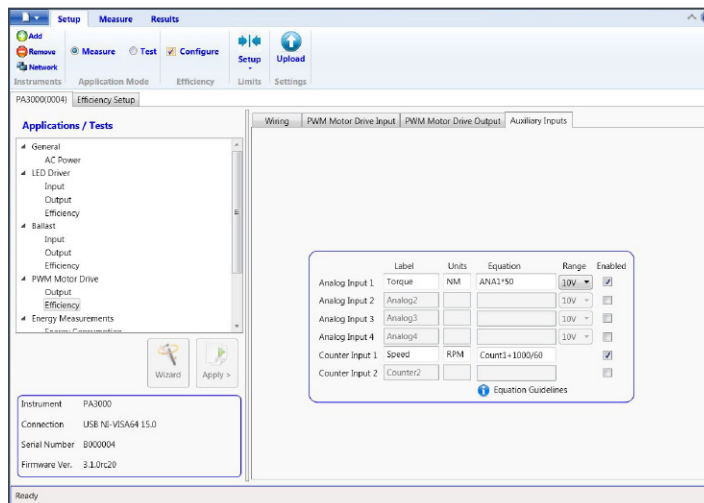
Figure 2-5. Auxiliary inputs setup for torque and speed measurements.

• Refer to the pin number for desired analog or counter input under Auxiliary inputs/outputs and connect the signal (torque,speed, or others) directly to the respective pin on the AUXILIARY INPUTS/OUTPUTS connector on the rear panel.

• To enable the auxiliary inputs using PWRVIEW, go to the Setup tab.

• On the Setup tab, go to the Wiring page and select the check box near the bottom of the page for enabling the Auxiliary Inputs (Analog and Counters). A new tab page named Auxiliary Inputs will be created.

- On the Auxiliary Inputs tab page, enter the desired label, units and equation for the respective analog and counter inputs Equation Guidelines on the bottom can be used for assistance with entering equations. Enable the desired inputs.

- Go to the Measure tab page and click the Start button.

- The selected analog and counter input signals will be displayed on the measurement grid with proper labels and units.

- Desired formulas for further equating system efficiency using analog and counter inputs along with any other measurement parameters can be entered in the Formula column on the measurement grid.

Data Logging. Recording data is important for most efficiency measurements where load and source sweep is required.

- To record data using PWRVIEW, click the Record button on the menu bar. The software will start recording all the selected data including formulas and limits.

- To change the data logging rate or to set the total log time, click the down arrow on the Record icon to open the data logging setup. Here you can select the desired logging duration and interval.

- To stop the data logging, click the Stop button.

- All the recorded data is stored in a database on the local computer. To access the data, click the Results tab and then click the Measure Icon. The dialog box will present all the archived data.

- Select the desired data set and export to either an Excel or a .csv format.

Waveform, Harmonics, and Trend Chart. In the measurement grid, you can view waveforms, harmonics, and trend charts by clicking the respective icons on the menu bar.
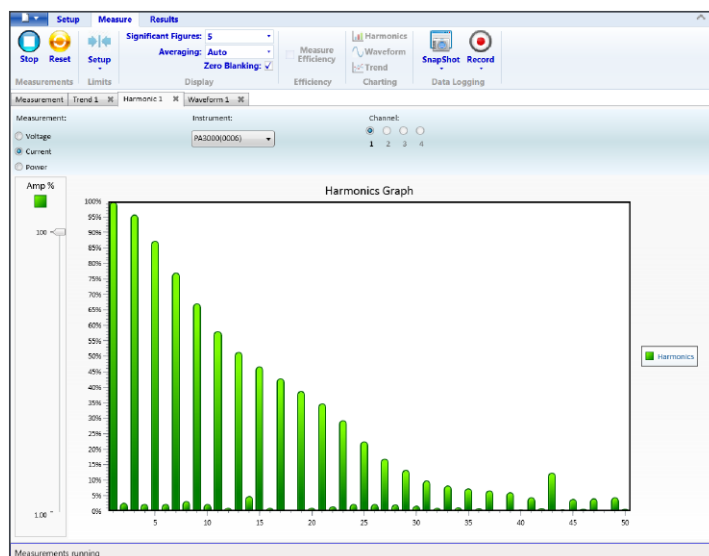

Figure 2-6. Harmonic bar chart.

- Waveforms in the PWRVIEW software are constructed using the harmonic data collected from the PA3000. The accuracy of the waveform depends on the harmonic information available. For optimum results, select the maximum number of harmonics to display in the setup area. Selecting 100 harmonics for the PA3000 gives the best results. If no harmonics are selected, waveform feature will display a blank screen.

- The Harmonic bar chart can be enabled for all voltage, current, and watts measurements. Up to 100 harmonics can be selected through the setup screen. Hovering over any harmonic bar will display the absolute value and percentage of fundamental for that harmonic.

- The Trend chart can activated for any measurement parameter by either right-clicking the desired parameter or by clicking the Trend icon on menu bar. The Trend chart can be reset by clicking the Reset button on the menu bar.

Custom Limits. Custom limits can also be set with any of the measurement parameters. Custom limits help set limits based on various standards or test specifications.

- To set custom limits, either right-click the desired measurement parameter or click the Limits Setup icon on the menu bar. Stop the measurement update to set up custom limits.

- Custom limits will appear as a separate tab on the measurement grid. The result column will display red fonts if the limits are failing. Hovering over the results will display the limit function, limit value, and relative value.

Energy Consumption Testing

Energy consumption testing on home and office appliances is required for compliance to many international and regional standards programs such as ENERGY STAR®. Energy consumption testing involves the integration of power consumed over a long period of time, often days. Use the dedicated Integration Mode on the PA3000 to make energy consumption testing easier and faster.

WATCH VIDEO

How to Make Energy Consumption Measurements on Appliances

www.tek.com/consumption_video
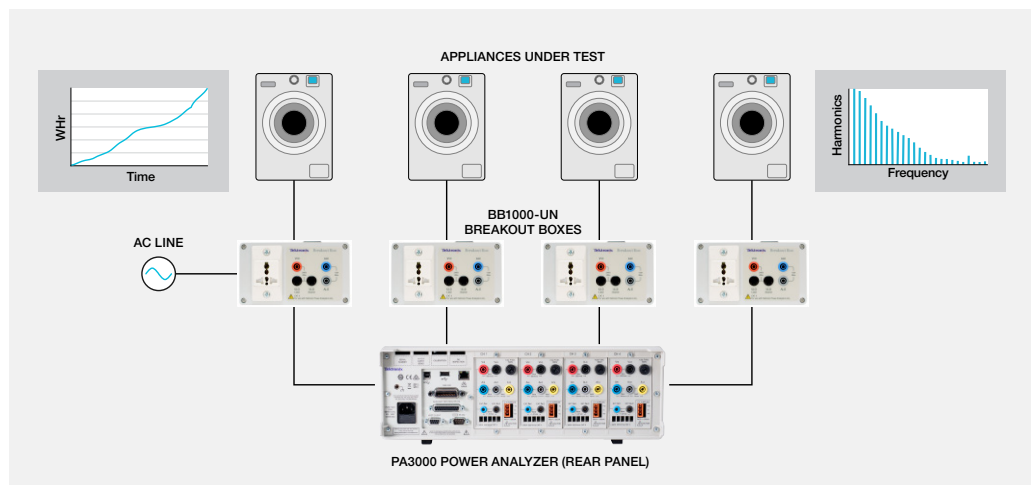
Figure 3-1. Energy Consumption Testing on Home and Office Appliances.

TEST SETUP

The following steps describe the process to set up energy consumption measurements on a home or office appliance using a PA3000. This method can be used for testing energy consumption of any DUT that plugs into the AC wall socket for power.
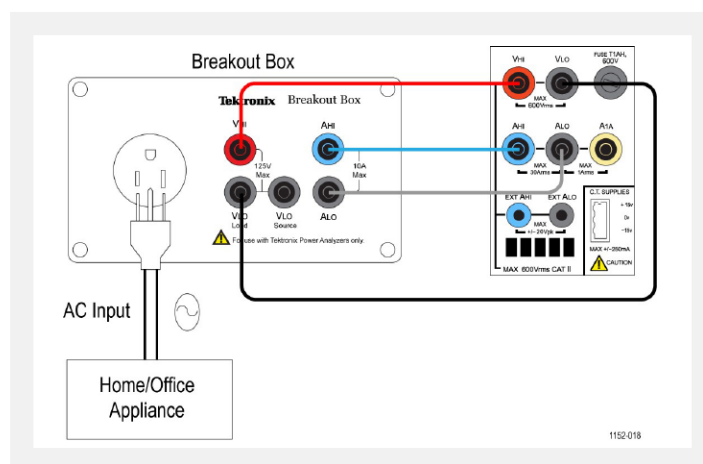
Figure 3-2. Energy consumption measurements wiring diagram.

1. Connect the AC input on the DUT to the first channel of the PA3000 using a Tektronix BB1000 Breakout Box as shown in the wiring diagram.

   The breakout box taps in to the current signal and measures the voltage across the input terminals. It makes it easier and safer to connect the input AC signal on the DUT using the 4 mm safety leads provided with the PA3000.

2. After making all the connections, use one of the two methods to make efficiency measurements.

METHOD 1: ENERGY CONSUMPTION MEASUREMENTS (PA3000 DIRECT)

The following steps describe the process to set up energy consumption testing on home or office appliances using the PA3000.

WHAT YOU WILL NEED — METHOD 1
- PA3000 Power Analyzer
- Home or Office Appliance (DUT)
- 4mm Safety Leads
- BB1000 Break Out Box
- AC Source (Optional)

Figure 3-3. Energy consumption testing on the PA3000.

TEST SETUP

1. Set the PA3000 to the default configuration:
   - Press [≡].
   - Scroll down to **User Configuration** and press [▶].
   - Select **Load Default Configuration**, and then press ✓ to confirm.

   The PA3000 will load the defaults and display a confirmation screen.
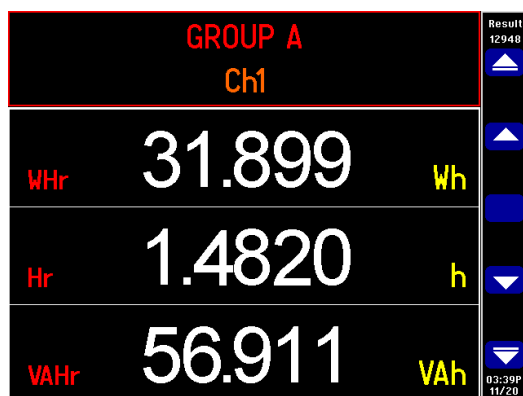
   Press **OK** and then return to the Main Menu by pressing [◀].

2. To enable the Integrator mode, go to **Modes→ Select Mode→ Integrator.**

3. Press [◀], select **Setup Modes→ Integrator Setup**, and select the desired start method.
   - Manual works by pressing INTEG RUN key to start and stop integration.
   - Clock allows for setting up a specific time to start integration.
   - Level allows you to set trigger levels on a specific signal to start the integration measurement.

4. Go back to the Integrator Setup menu to configure the clock start, duration or the trigger level.

   NOTE: The Integrator Setup menu also provides an option to set up the target power factor for the design. This feature displays the value of VArs required to correct the average power factor to the target power factor.

5. After you have set the integration mode and selected the start-stop method, press [▦].
   The PA3000 will display integration parameters such as: Hr, Whr, VAHr, and AHr.

6. Power on the DUT and the results on the PA3000 should start updating.
   - The integration results will display zero until it is triggered either manually using the INTEG RUN key on the front panel or by the selected start method.
   - The LED under the INTEG RUN key stays on while integration measurements are running.

7. To stop the integration, press the INTEG RUN key again; to reset, use the RESET/CLEAR key.

The integrator can be run simultaneously on all groups/channels on the PA3000. While in the integrator mode, the integration graph can be enabled by pressing [∫(t)] . The graph displays all integration measurements for a given group. Scroll through the different groups by using the arrow keys on the front panel. Other parameters to graph can be selected by pressing the INT soft key.

FURTHER SETTINGS IF REQUIRED

Data Logging. The logging feature allows you to log data over time for prolonged efficiency testing involving load and source sweeps. Use the DATA OUT key to log data to any compatible flash drive connected to the front panel USB connector. The actual logging interval can be changed by pressing [≡] and going to I**nterfaces →USB Host Data Out.** The log file will be saved as a .csv file

Ranging. By default the PA3000 is auto-ranging. Auto-ranging is fast and generally unnoticeable, but might lead to loss of data while the auto-ranging occurs. Using a fixed range while measuring energy consumption ensures that no data is lost during the ranging process. To set a fixed range, press [≡] and go to **Ranging →Current Range**, and then choose a suitable fixed range, based on the measurements made during auto-ranging. If the range is too low, a warning message will display. This will not harm the PA3000. The range should not be set too high as this will compromise the overall accuracy.

METHOD 2: ENERGY CONSUMPTION TESTING (PWRVIEW SOFTWARE)

The following steps describe the process to set up energy consumption tests on home or office appliances using a PA3000 with the PWRVIEW software.

WHAT YOU WILL NEED — METHOD 2

- PA3000 Power Analyzer
- Home or Office Appliance (DUT)
- 4mm Safety Leads
- BB1000 Break Out Box

- PC with PWRVIEW software installed
- USB cable
- AC Source (Optional)

1. Use the same test setup as with the preceding PA3000 direct example.

2. After making all of the power connections, connect the PA3000 to the computer with the PWRVIEW software installed using the supplied USB cable. Ethernet or GPIB can also be used.

3. Open the PWRVIEW software by double-clicking the desktop icon.

4. Click the Add button to connect the PA3000. All available instruments will be listed in the s selection panel.

5. Select the desired instrument (the PA3000) and then click Connect.
   NOTE: There are various default applications and compliance tests on the left panel.

6. Select Energy Consumption under the Applications/Test section on the left panel and then click the Wizard button.

7. The wizard helps with wiring and shunt selections.

8. The PA3000 can compute the value of VArs required to correct the power factor to a target value. This can be selected with the wizard by entering the desired power factor.

9. Click Next to review and then click Finish.

10. Go to the Measure tab and then click the Start button to start the measurements.
    All integration measurements will be initialized as zero values.

11. Click the green Start button on the top ribbon to start the integration.
    Each of the integration measurements should start updating in real time.

12. Reset the integration, if needed, by clicking the green Reset button.

13. Each individual channel can be used to run integration testing on more than one device.

Integration testing can also be used for three phase devices. Select Integration from the Mode drop-down menu on the Setup page for desired channels or for the three phase group.

FURTHER SETTINGS IF REQUIRED

Trend Chart. The integration graph can be activated through
the Trend chart feature in PWRVIEW.

- The Trend chart can be activated for any integration measurement by either right-clicking the
  desired parameter or by clicking the Trend icon on the menu bar. The Trend chart can be reset
  by using the Reset button on the menu bar.
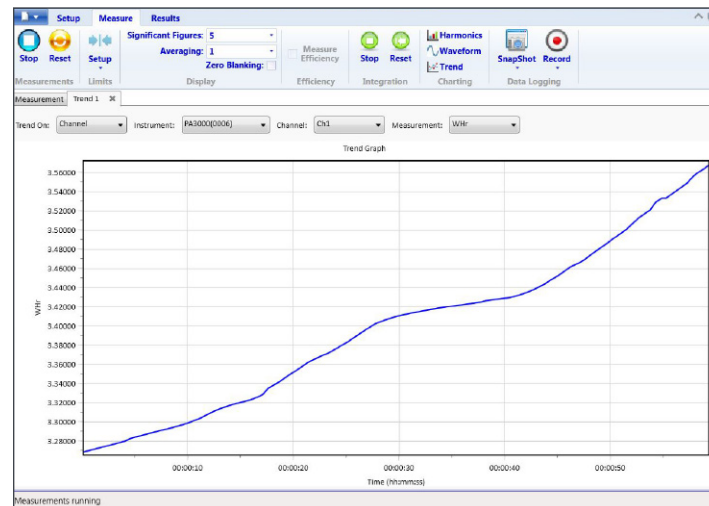
Figure 3-4.
Integration
trend chart.

Data Logging. Recording data is important for most energy consumption testing.

- To record data using PWRVIEW, click the Record button on the menu bar. The software
  will start recording all the selected data including formulas and limits.

- To change the data logging rate or to set the total log time, click the down arrow on the Record
  icon to open the data logging setup. Here you can select the desired logging duration and interval.

- To stop the data logging, click the Stop button.

- All the recorded data is stored in a database on the local computer. To access the data,
  click the Results tab and then click the
  Measure icon. The dialog box will present all the archived data.

- Select the desired data set and export to either an Excel or a .csv format.

Custom Limits. Custom limits can also be set with any of the measurement parameters. Custom limits help set limits based on various standards or test specifications.

Figure 3-5.
Custom limits.

- To set custom limits, either right-click the desired measurement parameter or click the Limits Setup icon on the menu bar. Stop the measurement update to setup custom limits.

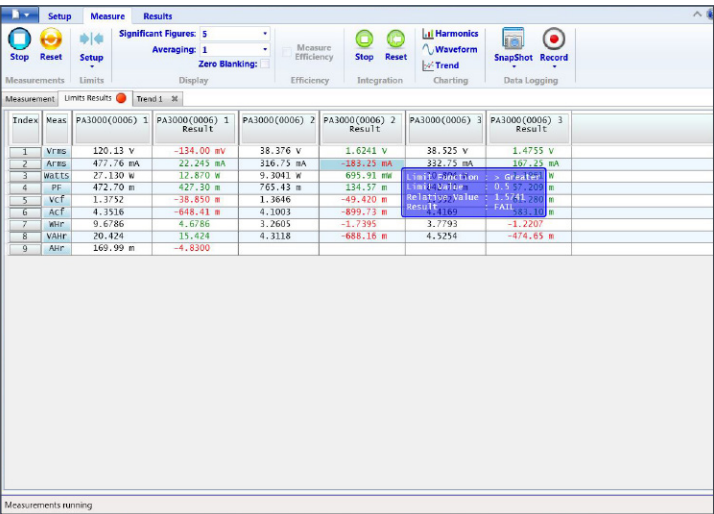- Custom limits will appear as a separate tab on the measurement grid. The result column will display red fonts if the limits are failing. Hovering over the results will display the limit function, limit value, and relative value.

Standby Power Measurements (IEC 62301 Ed. 2.0)

Power supplies, adapters and common electrical and electronic goods often operate in standby mode. The cumulative power drawn by these and other common loads is significant and programs such as International Efficiency Standards, ENERGY STAR® and the European Eco-Directives seek to limit the power drawn by equipment when in standby mode. The typical standby power levels continue to decrease from the 1 Watt initiative of 2010 towards the level VI efficiency standards of 2016. the following section demonstrates how to test for standby power per IEC 62301 standard.
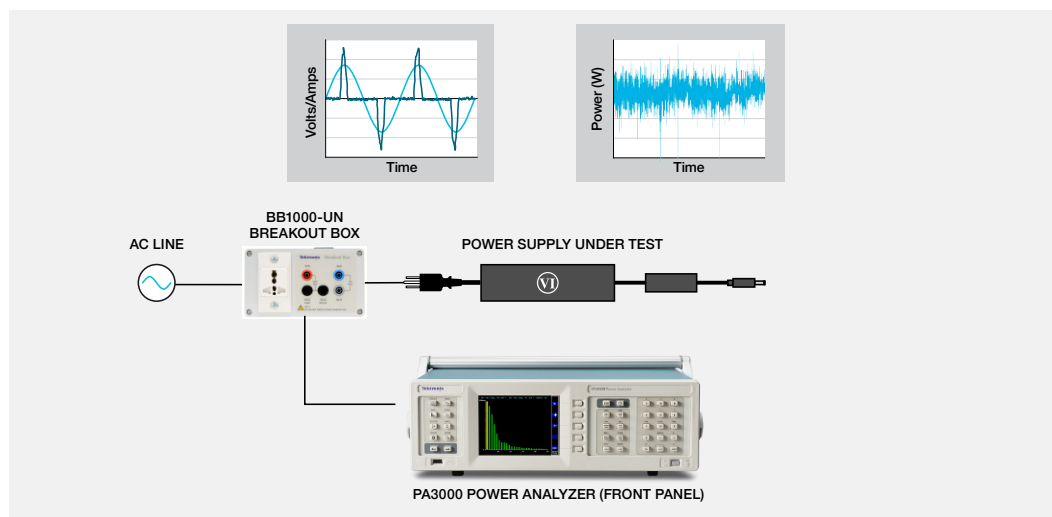
Figure 4-1. Standby power testing on AC-DC power supply.

WATCH VIDEO
How to Make Standby Power Measurements

www.tek.com/standby_video

TEST SETUP

Complete the following steps to set up the PA3000 to make the standby power measurements:
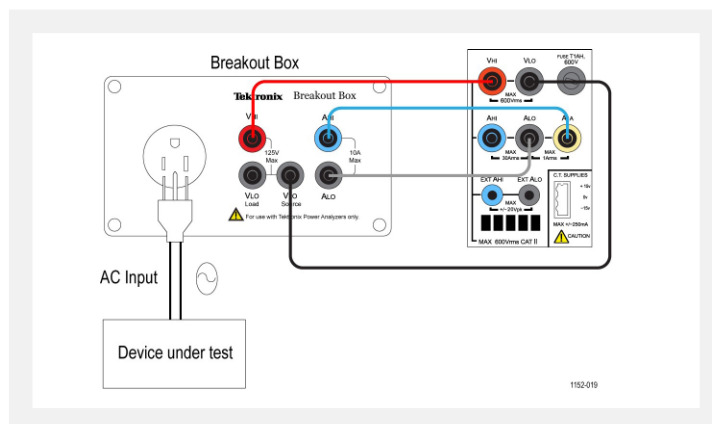
Figure 4-2. Standby power measurements wiring diagram.

1. Connect the DUT using Tekronix BB1000 Breakout Box (BB1000.) See wiring diagram Figure 4-2.

2. Use the 1A shunt on the PA3000 for better accuracy if the expected current is below 1A.

3. Use the VLO Source connection for voltage. Using the VLO Source terminal for standby power measurements, moves the voltage low node to the source side of the current shunt. This helps eliminate measurement errors due to current drawn by voltmeter impedance of PA3000. This is important while making very low standby power measurements. For all other measurements, VLO Load terminal should be used.

METHOD 1: STANDBY POWER QUICK CHECK (PA3000 DIRECT)

The front-panel mode of the PA3000 is designed to give product designers a fast, yet reliable, check of standby power consumption. Enabling standby power mode automatically sets a long averaging time to average the typical power variations and bursts and it disables low-level blanking so that very low power and current values can be displayed.

NOTE: The PA3000 samples continuously in standby mode to ensure that no data is lost. If the expected standby current is lower than 1A, select the 1A shunt input of the PA3000.

WHAT YOU WILL NEED — METHOD 1
- PA3000 Power Analyzer
- AC cellphone charger (DUT)
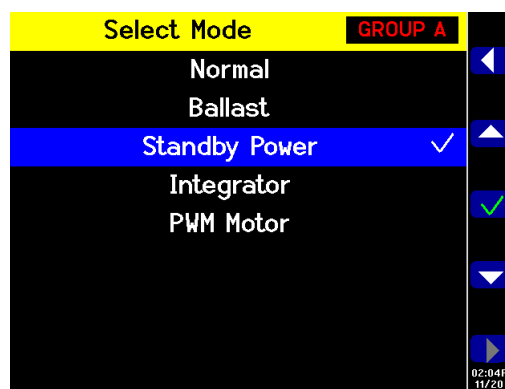- 4mm Safety Leads
- BB1000 Break Out Box
- AC Source (Optional)

Figure 4-3. Standby power mode.

1. To select the 1 A shunt, go to the Main Menu (press ☰), go to **Inputs → Shunt** and select **Internal 1 A**; press ✓ to confirm.

2. To enable the dedicated Standby Power mode go to the Main Menu, go to

3. **Modes → Select Mode → Standby Power**, and then press ✓ to confirm.

4. Press ⊞ to start making the standby measurements.

FURTHER SETTINGS IF REQUIRED

Integration time window. The default integration time is 10 seconds. This can be adjusted as required in the **Modes → Setup Modes → Standby Setup**. If the DUT is stable, select a shorter time for faster measurements. If the measurements are unstable, choose a longer integration time. If in doubt, use the full-compliance method built-in to the PWRVIEW software.

Ranging. By default the PA3000 is auto-ranging. Auto-ranging is fast and generally unnoticeable, but might lead to loss of data while auto-ranging occurs. Using a fixed range while measuring standby power ensures that no data is lost during the ranging process. To set a fixed range, choose **Inputs → Ranging → Current Range** and then choose a suitable fixed range, based on the measurements made during auto-ranging. If the range is too low, a warning message will display. This will not harm the PA3000. The range should not be set too high, as this will compromise the overall accuracy.

Bandwidth. For low power standby signals that have undesired high frequency components, low bandwidth filters can be enabled. A low bandwidth 10 kHz filter is available through the Inputs setup. Applying low pass filters might vary the RMS values of voltage, currents, and power as high frequency components affect the RMS values.

Autozero. Use the **Autozero → Run Now** function under the System Configuration menu to run autozero before running a standby power test. This will make sure that all the offsets are compensated and the low current and power readings are accurate.

All settings can be saved for later use in the User Configuration menu.

METHOD 2: IEC 62301 ED. 2.0 FULL COMPLIANCE STANDBY POWER TESTING (PWRVIEW SOFTWARE)

The PWRVIEW software along with PA3000 can test the standby power using full compliance techniques of IEC 62301 Ed. 2.0 / EN50564. Measurements are made easy by using the PWRVIEW software and for making accurate measurements for full compliance standby testing. The software calculates real time instability and executes power averaging as required by the standard.

WHAT YOU WILL NEED — METHOD 2

- PA3000 Power Analyzer
- AC Cellphone Charger (DUT)
- 4mm Safety Leads
- BB1000 Break Out Box
- PC with PWRVIEW software installed
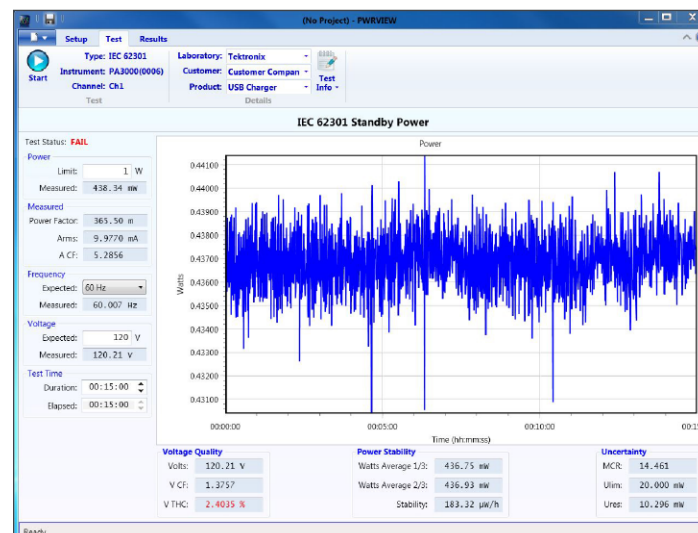- USB cable
- AC Source (Optional)

Figure 4-4.
Full compliance
IEC 62301 Standby
power test.

TEST SETUP

1. Use the same test setup as with the preceding PA3000 direct example.

2. After making all of the power connections, connect the PA3000 to the computer with the PWRVIEW software installed using the supplied USB cable. Ethernet or GPIB can also be used.

3. Open the PWRVIEW software by double-clicking the desktop icon.

4. Click the Add button to connect the PA3000. All available instruments will be listed in the selection panel.

5. Select the desired instrument (the PA3000) and then click Connect.
   NOTE: There are various default applications and compliance tests on the left panel that you can select from.

6. Click the Test button in the Application Mode area in the Menu bar. This enables the grayed out Compliance tests on the left panel.

7. Select the IEC 62301 Standby Power option under the Compliance tests and then click the Wizard button. The wizard provides easy steps to setup up the standby power test.

8. Enter the appropriate information on the respective pages of the wizard and then click through all of the steps to correctly set up the PA3000 for the test.

9. If the input current is less than 1A, use the 1A shunt on the PA3000 for better resolution and accuracy.

10. After applying all of the settings, click the Test tab on the top of the PWRVIEW window.
    – Test details such as laboratory, customer, product information, and environmental c conditions can be filled in on the top ribbon before starting the test.
    – The left panel allows you to select the required power limit, expected frequency, and input voltage.
    – The default time for running the standby power test according to IEC 62301 is 15 minutes; this can be changed based on regional or local requirements.
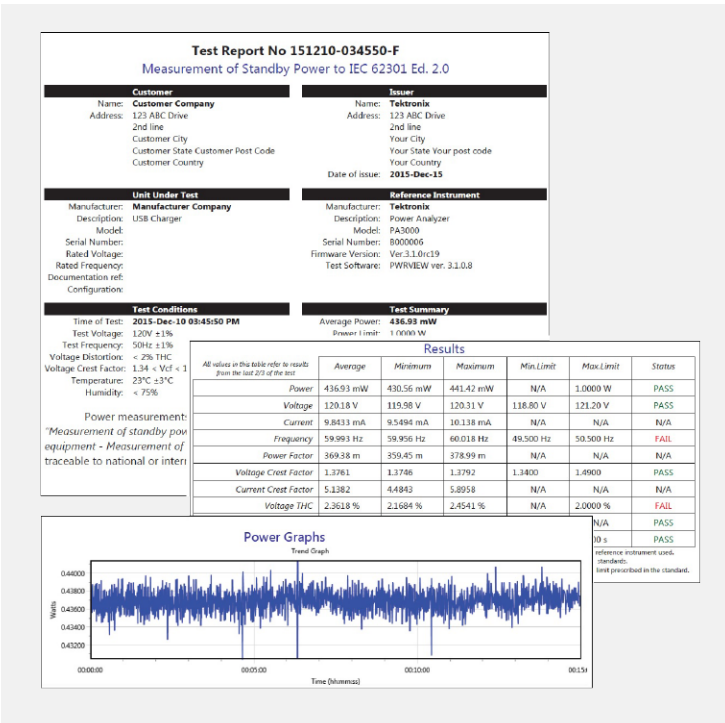
Figure 4-5.
IEC 62301
Ed. 2.0 standby
power test report.

11. After completing all of the settings, click the Start button.
   – The test will run for the time duration selected and will update all the required measurements in the left panel. The standby power variation over time is displayed graphically.
   – Voltage quality, power stability, and uncertainty are also evaluated in real time as required by the standard.
   – The test will display the Pass/Fail status based on all evaluated parameters.
   – The test summary can be reviewed under the Results tab. All of the required parameters will be summarized with a Pass/Fail status under Test Summary and General Results.
   – The Power Readings tab allows you to scroll through the time scale and to debug specific issues on a given time stamp. Use the scroll bar on the top of the window to scroll through the time line.
   – The test results can be exported as a full report by clicking the Full Report PDF icon on the top ribbon. Alternately, the raw data can exported using the Export CSV icon.

FURTHER SETTINGS IF REQUIRED

Ranging. By default, the PWRVIEW software sets up the PA3000 current range in Auto-Up-Only. The Auto-Up-Only option ranges up the PA3000 until it finds the highest range where the input signal is not clipped. This helps with setting the best range for the test. Otherwise, if the expected peak currents are known, a manual range can be selected for higher accuracy. The manual range can be selected for the selected shunt through the setup page under range options.

Bandwidth. For low power standby signals that have undesired high frequency components, low bandwidth filters can be enabled. A low bandwidth 10 kHz filter is available through the setup screen under the filter drop down option. Applying low pass filters might vary the RMS values of voltage, currents, and power as high frequency components affect the RMS values.

AC Source. The IEC 62301 standby power full compliance test requires the AC source to be very stable as detailed in the standard. The voltage and frequency are required to be within 1% tolerance. In addition, the input voltage total harmonic content (VTHC) must be within 2% for the first 13 harmonics and the voltage crest factor (VCF) must be within the 1.34 to 1.49 range. Tektronix recommends using a stable external AC source that meets standard requirements for the full compliance testing.

WATCH VIDEO
How to make Inrush
Current Measurements

www.tek.com/inrush_
video

Inrush Current Testing

Most electrical devices draw initial current that is significantly higher than the nominal steady state current due to low input impedance. Motor drives and transformers are known to have inrush current twenty times higher than the steady state currents. It is important to characterize inrush current to determine input conductor and fuse ratings.

TEST SETUP

Complete the following steps to set up the PA3000 to take the inrush current measurements:

• Connect the DUT using a Tekronix BB1000 Breakout Box as shown in the wiring diagram. (See Figure 5-1.)

• Use the 30A shunt on the PA3000 for inrush current measurements. Using the 1A shunt is not recommended for inrush current because peak currents can be quite high, even for applications where the nominal steady state current is below 1A.
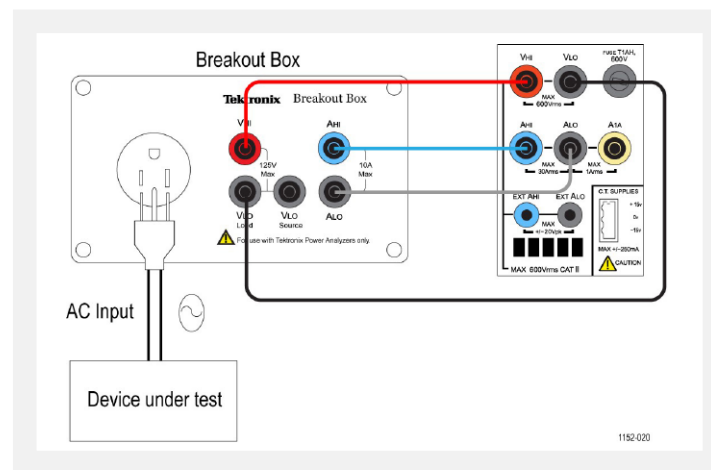

Figure 5-1. Inrush current measurement wiring diagram.

METHOD 1: INRUSH CURRENT MEASUREMENTS (PA3000 DIRECT)

The following steps describe the process for setting up the PA3000 for the inrush current measurements.

WHAT YOU WILL NEED — METHOD 2

- PA3000 Power Analyzer
- Home or Office Appliance (DUT)
- 4mm Safety Leads
- BB 1000 Break Out Box
- AC Source (Optional)

1. Set the PA3000 to the default configuration:
   – Press [≡].
   – Scroll down to **User Configuration** and press [▶].
   – Select Load **Default Configuration**, and then press ✓ to confirm.

   The PA3000 will load the defaults and display a confirmation screen. Press **OK** and then return to the Main Menu by pressing [◀]

   NOTE: The PA3000 needs to be configured to continuously sample and return non-averaged results. It also needs to be configured to store peak values.

2. Ranging must be fixed on both the voltage and current channels to enable continuous sampling. To select a manual range, go to the Main Menu (press) [≡], go to **Inputs →Ranging → Current/Voltage range**, and then select an appropriate range.

   If the expected inrush current is not known, select the highest range and then dial down, as required, after repeating the test as needed for more accurate results

3. The PA3000 automatically blanks all the results that are lower than ten percent of the range. Blanking is continuously active and can interfere with recording the inrush event.
   To disable the blanking, go to the Main Menu, go to **System Configuration→Blanking→Off.**

4. Set the averaging to one so that the results are not averaged over time.
   Go to the Main Menu, go to **System Configuration→ Averaging→ Channel Averaging.**
   Set the value in the window to 1.

5. Turn off the Autozero function under the System Configuration menu.

6. To enable Peak Hold, the Maximum and Minimum Hold columns need to be enabled.
   Go to the Main Menu and go to **Measurement Configuration→ Maximum Hold→Enabled**.
   Repeat the step for the Minimum Hold.

   When enabled, the Maximum and Minimum hold columns will record both positive and negative cycle peaks.

7. Enable the Peak current measurement parameters in the Measurements menu.
   Select both the Apk+ and Apk- because the peak can be either positive or negative.

8. After setting up the PA3000, connect the DUT to the breakout box.

9. The inrush current will be displayed in the Max and Min columns on the Results screen.
   The PA3000 will hold the maximum sample value for the positive and the negative cycles.

Figure 5-2.
Min-Max columns
for the Inrush current
measurement.

10. To reset the Max and Min values, press the RESET/CLEAR key.

Tektronix recommends repeating the inrush current measurements by connecting the DUT several times to capture the highest possible peak value. The highest possible peak value occurs on the peak voltage cycle, and it is important to capture this point for the maximum inrush current. It is also important to wait a few moments between connecting the DUT to allow the input capacitance on the device to completely discharge.

FURTHER SETTINGS IF REQUIRED

Data Logging. The logging feature allows you to log repeated inrush current events in the form of raw data. Use the DATA OUT key to log data onto a flash drive attached to the front panel USB connector. Turn on the data logging before first connecting the device and run the data logging through repeated plug-in events to capture all inrush events.

Screen Save. The screen save function allows you to save the current screen from the PA3000. This can be useful for quickly capturing the inrush current readings. Press the SCREEN SAVE key to save the data as a .bmp file to a flash drive connected to the front panel USB connector.

METHOD 2: INRUSH CURRENT MEASUREMENTS (PWRVIEW SOFTWARE)

The PWRVIEW software makes it easy to quickly check inrush current measurements on the measurement grid.

WHAT YOU WILL NEED — METHOD 2

- PA3000 Power Analyzer
- Home or Office Application (DUT)
- 4mm Safety Leads
- BB1000 Break Out Box

- PC with PWRVIEW software installed
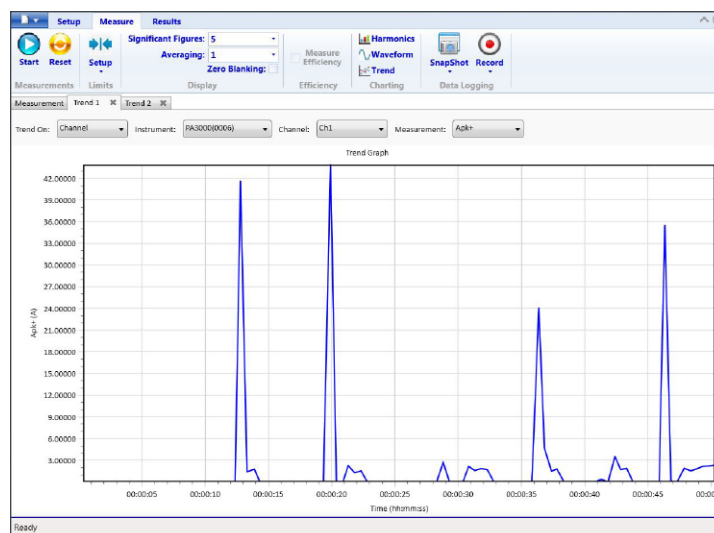- USB cable
- AC Source (Optional)

Figure 5-3.
Inrush current measurement.

1. Use the same test setup as with the preceding PA3000 direct example.

2. After making all of the power connections, connect the PA3000 to the computer with the PWRVIEW software installed using the supplied USB cable. Ethernet or GPIB can also be used, if desired.

3. Open the PWRVIEW software by double-clicking the desktop icon.

4. Click the Add button to connect the PA3000.
   All available instruments will be listed in the selection panel.

5. Select the desired instrument (the PA3000) and then click Connect.

6. On the Setup page, select the Group A tab.

7. Select the highest current range from the Range selection under the Current Channel settings
   Any other range can be selected if the expected peak inrush current is known.

8. Select the Apk+ and Apk- measurements along with any other desired parameters.

9. Go to the Measure grid and clear the Zero Blanking check box in the top ribbon.

10. Select averaging of 1 from the drop-down menu for averaging.

11. Click the Start button. The measurements will start updating.

12. When the measurement grid is updating, connect the DUT to measure the inrush current.

13. Hover over the Apk+ and Apk- measurements to find the maximum positive and negative inrush current.

14. To graphically view the inrush current peak, right-click Apk+ and Apk- and then select the Trend Measurements.

    The Trend chart will start updating with real time results of Apk+ and Apk- values.
    Connecting the DUT will graphically show the inrush current peak value.

15. To reset the Min and Max values on the Trend graph, click the Reset icon.

Tektronix recommends repeating the inrush current measurements by connecting the DUT several times to capture the highest possible peak value. The highest possible peak value occurs on the peak voltage cycle and it is important to capture this point for the maximum inrush current. It is also important to wait a few moments between connecting the DUT to allow the input capacitance on the device to completely discharge.

FURTHER SETTINGS IF REQUIRED

Data Logging. All instances of inrush current testing can be recorded using the Record feature of the PWRVIEW software.

- To record data using PWRVIEW, click the Record button on the menu bar.
  The software will start recording all the selected data including formulas and limits.

- To stop the data logging, click the Stop button.

- All the recorded data is stored in a database on the local computer.
  To access the data, click the Results tab and then click the Measure icon.
  The dialog box will present all the archived data.

- Select the desired data set and export to either an Excel or a .csv format.

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Finland +41 52 675 3777
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Germany* 00800 2255 4835
Hong Kong 400 820 5835
India 000 800 650 1835
Indonesia 007 803 601 5249
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Malaysia 1 800 22 55835
Mexico, Central/South America and Caribbean 52 (55) 56 04 50 90
Middle East, Asia, and North Africa +41 52 675 3777
The Netherlands* 00800 2255 4835
New Zealand 0800 800 238
Norway 800 16098
People's Republic of China 400 820 5835
Philippines 1 800 1601 0077
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