User Manual

Tektronix

TDSPWR1
Power Analysis Applications

071-0203-01

This document applies to software version 1.0.0 and above.

Warning
The servicing instructions are for use by qualified personnel only. To avoid personal injury, do not perform any servicing unless you are qualified to do so. Refer to all safety summaries prior to performing service.

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Tektronix, Inc., P.O. Box 1000, Wilsonville, OR 97070–1000

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General Safety Summary

Review the following safety precautions to avoid injury and prevent damage to this product or any products connected to it. To avoid potential hazards, use this product only as specified.

Only qualified personnel should perform service procedures.

While using this product, you may need to access other parts of the system. Read the *General Safety Summary* in other system manuals for warnings and cautions related to operating the system.

Connect and Disconnect Properly. Connect the probe output to the measurement instrument before connecting the probe to the circuit under test. Disconnect the probe input and the probe ground from the circuit under test before disconnecting the probe from the measurement instrument.

Do not apply a potential to any terminal, including the common terminal, that exceeds the maximum rating of that terminal.

Symbols and Terms

Terms in this Manual. This term may appear in this manual:

WARNING. *Warning statements identify conditions or practices that could result in injury or loss of life.*

Preface

This manual contains operating information for the TDSPWR1 Power Analysis Applications. The manual consists of the following chapters:

- The chapter *Getting Started* briefly describes the TDSPWR1 Power Analysis Applications and provides installation instructions.
- The chapter *Operating Basics* covers basic operating principles of the application.
- The chapter *Reference* describes how to perform specific tasks.

Related Documentation

Your oscilloscope user manual provides operating instructions for general oscilloscope features.

Conventions

This manual uses the following conventions:

- This manual refers to the TDSPWR1 Power Analysis Applications as either the Power Analysis Applications or as the application.
- When steps require that you make a sequence of selections using front panel controls and menu buttons, an arrow (→) marks each transition between a front panel button and a menu, or between menus. Names that are for a main menu or side menu item are clearly indicated: Press VERTICAL MENU → Coupling (main) → DC (side) → Bandwidth (main) → 250 MHz (side).
- The waveforms have subscript annotation with the following meanings:
  - V represents electrical potential and is measured in Volts
  - I represents electrical current and is measured in Amperes
  - P represents power (voltage times current) and is measured in Watts
  - E represents energy and is measured in Joules

Contacting Tektronix

Product Support	For application-oriented questions about a Tektronix measurement product, call toll free in North America: 1-800-TEK-WIDE (1-800-835-9433 ext. 2400) 6:00 a.m. – 5:00 p.m. Pacific time Or contact us by e-mail: tm_app_supp@tek.com For product support outside of North America, contact your local Tektronix distributor or sales office.
Service Support	Contact your local Tektronix distributor or sales office. Or visit our web site for a listing of worldwide service locations. http://www.tek.com
For other information	In North America: 1-800-TEK-WIDE (1-800-835-9433) An operator will direct your call.
To write us	Tektronix, Inc. P.O. Box 1000 Wilsonville, OR 97070-1000

Getting Started

Product Description

The TDSPWR1 Power Analysis Applications contain three measurement modes that add power supply analysis capability to your Tektronix oscilloscope. With this application, you can acquire and analyze energy emissions and consumption in accordance with IEC standards. Figure 1 shows an example of the results of a Power Analysis Applications measurement.

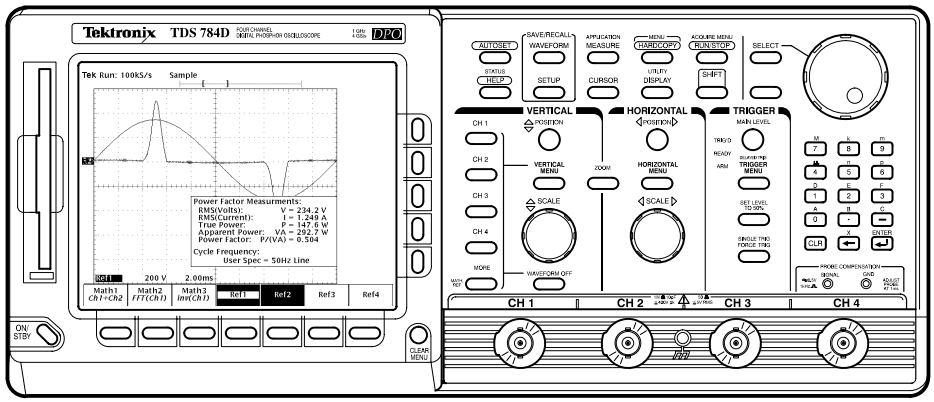

Figure 1: TDSPWR1 Power Analysis Applications

Compatibility

The Power Analysis Applications are compatible with the following Tektronix oscilloscopes:

- All TDS 500D and 700D Digital Phosphor Oscilloscopes with Option 2M (8 MB record length and hard disk drive)
- TDS 700C Color Digitizing Oscilloscopes serial number BO20100 or higher with Option 2M (8 MB record length and hard disk drive) and with firmware version 5.2e and up.

For a current list of compatible oscilloscopes, check the Tektronix, Inc. web site, http://www.tek.com/Measurement/ in the Support category.

Requirements and Restrictions

The TDSRTE1 Run-Time Environment must be installed on the oscilloscope to operate the Power Analysis Applications.

The application does not support external GPIB commands.

Updates

You can find information about this and other applications at the Tektronix, Inc. web site, http://www.tek.com/Measurement/ under the Support category. Check this site for application updates that you can download.

Accessories

There are no standard accessories for this product.

Installation

This application is written on a floppy disk. Updates, if any, can be downloaded from the Tektronix web site.

NOTE. *The Power Analysis Applications requires the TDSRTE1 Run-Time Environment to be installed on the oscilloscope. If you have not already installed the TDSRTE1, you should do so now.*

Installing the Application

To install the application from the floppy disk to your oscilloscope, follow these steps:

1. Power off the oscilloscope.

NOTE. *Additional information about the application or installation is located in a Readme.txt file on the floppy disk. You should insert the floppy disk into a DOS-based personal computer and read the Readme.txt file before you continue.*

If you are updating the application, the Readme.txt file on the Tektronix web site supercedes the Readme.txt file on the floppy disk.

2. Insert the disk in the floppy disk drive and power on the oscilloscope.

   After performing the power-up self-test, the oscilloscope automatically begins the installation procedure.

   As the application loads from the disk, the oscilloscope displays a clock icon to indicate that it is busy. Also, the floppy disk drive LED is on, indicating activity. If the clock icon continues to display after the floppy disk LED has gone out, a problem has occurred with the installation. Repeat the above procedure. If the problem persists, contact your Tektronix representative.

   When the installation is complete, an Installation Complete message displays.

3. Remove the floppy disk and cycle power to the oscilloscope.

Downloading Updates from the Web

If there is an update for this application, it will be available from the Tektronix web site. To install an application update, you will need to download it from the web site to a hard disk, copy it to a DOS-formatted floppy disk, and then install it on your oscilloscope.

***NOTE**. More information about changes to the application or installation is located in a Readme file on the web site. You should read it before you continue.*

To copy the application from the Tektronix web site, follow these steps:

1. Access the Tektronix web site at http://www.tek.com/.
2. Select the Measurement web page.
3. Click the Support category.
4. Click the Application Support Files item. This takes you to an FTP site.
5. Click the TDS/THS Files Area item. This takes you to the application files specific to these oscilloscopes.
6. Scroll through the files to the TDSPWR1 application, and download it to your hard disk drive.
7. If necessary, unzip the file.
8. Copy the application from the hard disk drive to a DOS-formatted floppy disk.
9. Follow the *Installing the Application* procedure on page 3.

Equipment Under Test Connections

The probes you use to connect between your EUT (equipment under test) and oscilloscope depend on the type of measurement you will take: current or power. You can use these schemes as typical ways to connect and to characterize the power supply of an EUT. However, the connection can be to any point of interest.

Current Measurements

When using the Current Harmonics mode, you need to connect a current probe between the EUT and the oscilloscope. Figure 2 shows a typical connection.

WARNING. *To avoid electric shock, you must ensure that power is removed from the EUT before attaching a probe to it. Do not touch exposed conductors except with the properly rated probe tips. Refer to the probe manual for proper use.*

Power down the EUT before connecting the probe to it.

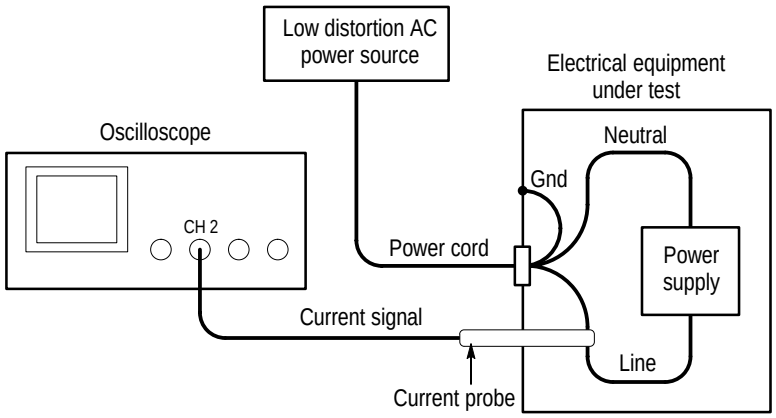

Figure 2: Current measurements configuration

For connection to the Current signal, you can use an oscilloscope probe designed specifically for measuring current, such as the Tektronix TCP202 probe.

The default Current signal is assigned to channel 2.

NOTE. *Do not change the signal assignment of channel 2. The application always uses the input data on channel 2 as the Current signal.*

Power Measurements

When using the Power Factor mode or the Power and Energy mode, you need to connect a voltage probe appropriate for the EUT (such as a differential voltage probe) and a current probe between the EUT and the oscilloscope. Figure 3 shows a typical connection.

WARNING. *To avoid electric shock, you must ensure that power is removed from the EUT before attaching probes to it. Do not touch exposed conductors except with the properly rated probe tips. Refer to the probe manuals for proper use.*

Power down the EUT before connecting probes to it.

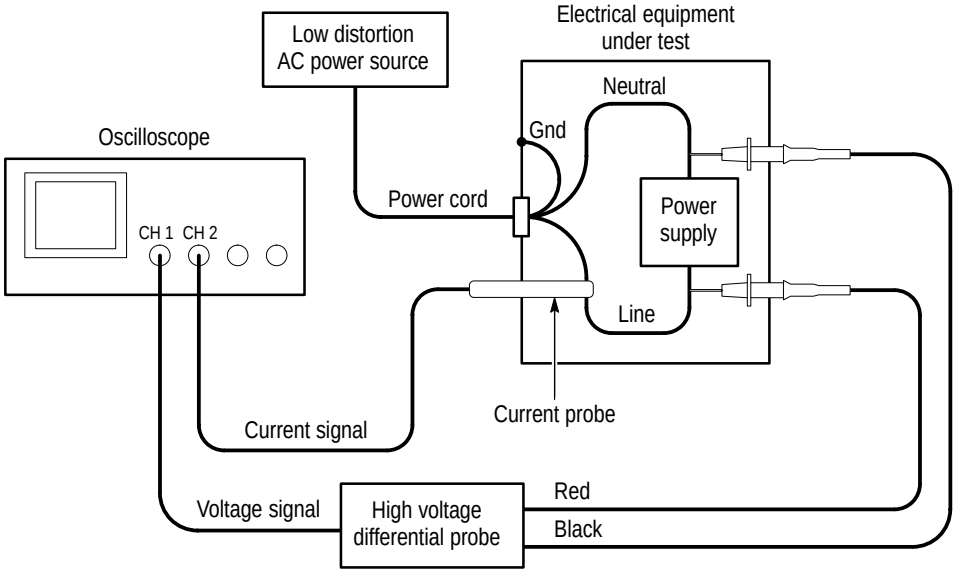

Figure 3: Power measurements configuration

For connection to the Voltage signal, you can use a differential voltage probe, such as the Tektronix P5205, 100 MHz High Voltage Differential Probe. For connection to the Current signal, you can use an oscilloscope probe designed specifically for measuring current, such as the Tektronix TCP202 probe.

Table 1 shows the default channel-to-signal assignments.

Table 1: Power measurements channel assignments

Channel	Reference	Signal assignment
Ch 1	Ref 1	Voltage signal
Ch 2	Ref 2	Current signal

Operating Basics

Functional Overview

This section contains descriptions of the basic functions of the Power Analysis Applications and how to use them. Further details about the basic functions and descriptions of more advanced features are included in the *Reference* section.

Starting the Application

You can start the Power Analysis Applications after it has been installed in the oscilloscope. To start the application, follow these steps:

1. Press SETUP → Select Application (main).
2. Use the general purpose (GP) knob to select hd0, and press SELECT.
3. Use the GP knob to select the TDSPWR1.APP title, as shown in Figure 4, and press Activate Application (side).

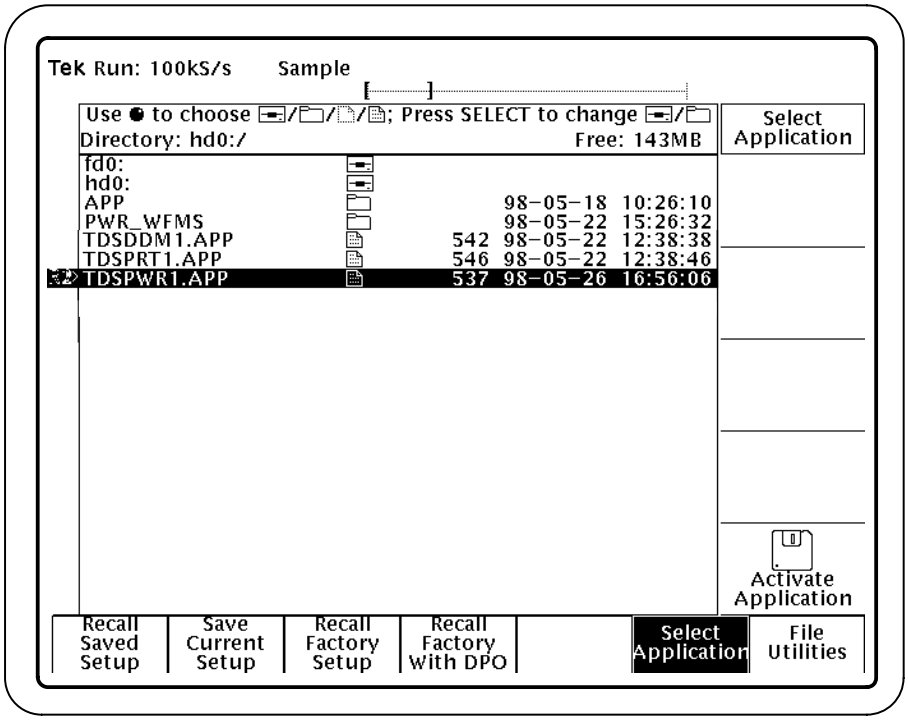

Figure 4: Starting the application

The application starts up and displays as shown in Figure 5.

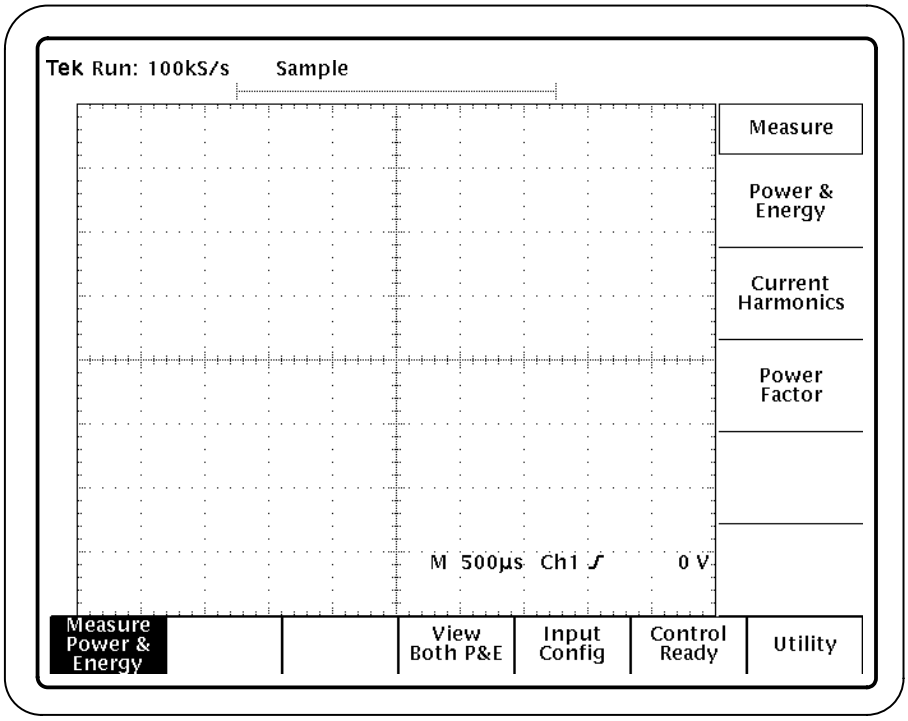

Figure 5: Power Analysis Applications initial display

Using the Local Help

The application includes local help information about the measurements modes, with some explanation of the individual controls.

To display the local help, follow these steps:

1. Press Utility (main) → Help (side). Figure 6 shows the Utility menu.
2. Use the side menu buttons to navigate through the help.

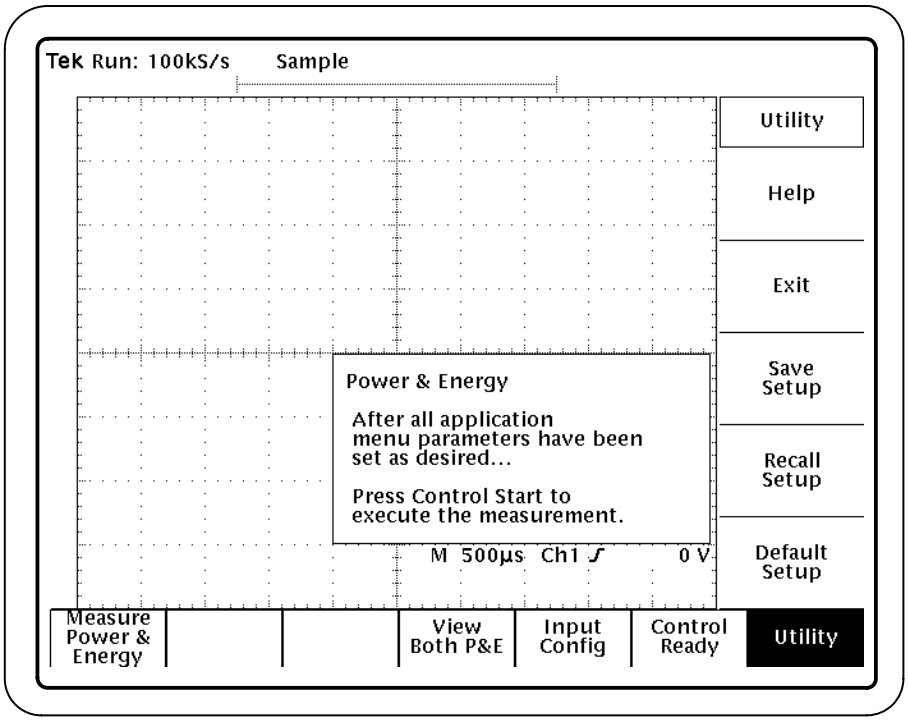

Figure 6: Utility menu

Using Other Functions

You can switch between the Power Analysis Applications and other oscilloscope functions. To access primary oscilloscope functions, press the desired front panel control. To return to the application, push the SHIFT then the APPLICATION front-panel menu buttons as shown in Figure 7.

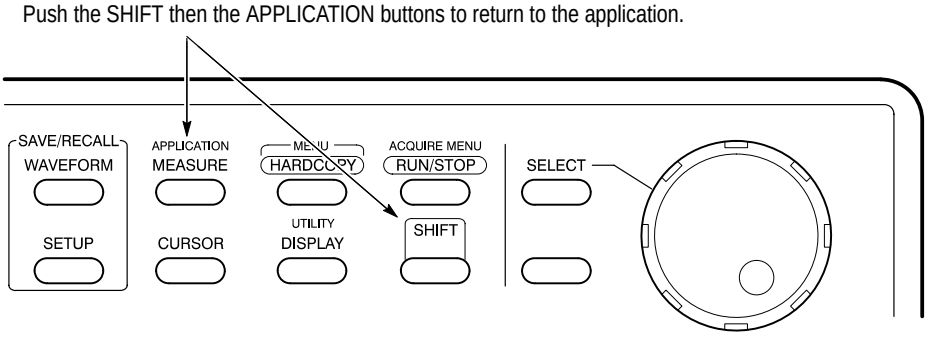

Figure 7: Returning to the application

Taking a Measurement

You can set up the application to measure power emission or consumption characteristics in one of three measurement modes. To do so, follow these steps:

1. To activate the application and select which mode to use, Power and Energy, Current Harmonics, or Power Factor, Press Measure (main) → Mode (side).
2. Select or specify values for other parameters associated with or required by the measurement mode. (See the *Measurement Descriptions* on page 45 for information about individual measurement parameters.)
3. If you want to change trigger settings or localize the measurement, do so now. The application defaults to the settings specified in the Trigger menu.

   The application warns you if the setup is not adequate for the measurement.
4. Press Control (main). Figure 8 shows the Control menu.

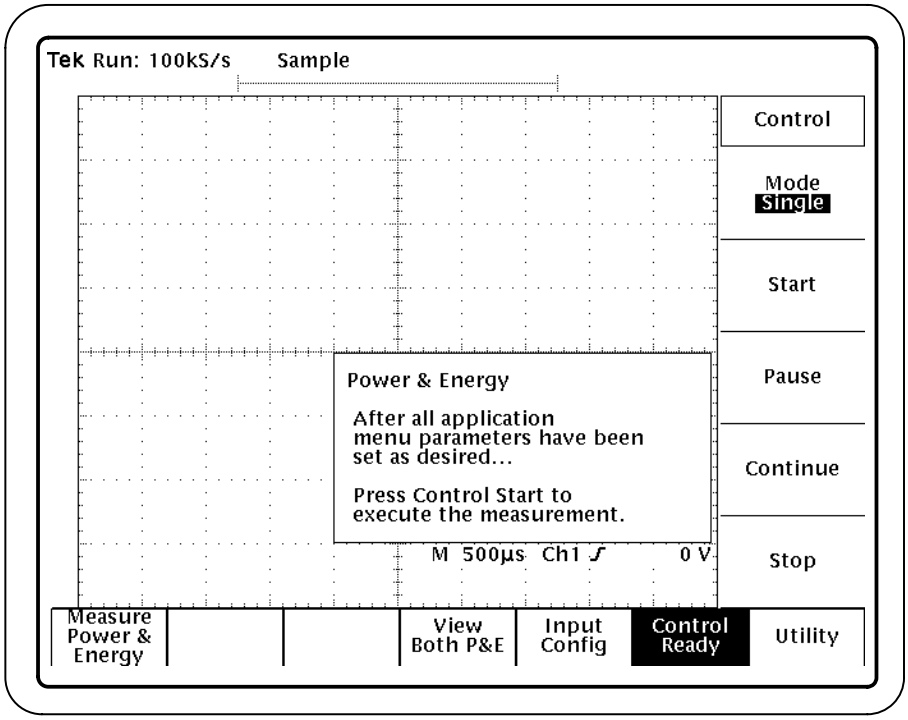

Figure 8: The Control menu

5. Press Mode (side) to select Single or Free Run acquisition mode.

   The Single option performs the measurement and then stops. The Free Run option performs the measurement continually.

In the event that the measurement requires an external operation to occur before it may continue, the readout changes to Pause. After fulfilling the requirements specified in the message box, you must press Continue (side) to finish the measurement.

6. Press Start (side).

***NOTE**. Do not change oscilloscope settings while a measurement is being taken. Doing so can invalidate the measurement.*

Do not attempt to execute external GPIB commands to control the oscilloscope while running the application. Doing so may interrupt the process.

---

7. Wait for the measurement to complete (Single). You can press the Pause or Stop side menu buttons to interrupt or stop the measurement. However, the application will complete the measurement before responding.

In Single mode, when the measurement has successfully completed, the screen displays the updated measurement data. All measurement processing halts, but the waveform acquisitions continue to update on the screen.

Viewing the Waveform

To view parts of the waveform that are obscured by the measurement display readout, push the CLEAR MENU button.

The Power and Energy and the Current Harmonics modes place waveforms in Ref3 and Ref4. If these waveforms are not visible after a measurement, press MORE → Ref3 (main) and then MORE → Ref4 (main).

To return to the application display, push the SHIFT then the APPLICATION front-panel menu buttons.

Exiting the Application

To exit the application, press File Utility (main) → Exit (side).

Tutorial

This tutorial teaches you how to use each of the measurement modes included in the Power Analysis Applications. Further operating information is located in the *Reference* chapter.

Setting Up the Oscilloscope

The tutorial uses the default factory settings to display the waveforms shown in this section. You must set up your oscilloscope to the default factory settings and turn off the active waveform on Ch1 before you start these lessons.

To set the oscilloscope to the default factory settings, press SETUP → Recall Factory Setup (main) → OK Confirm Factory Init (side).

To turn off the display of the active waveform on Ch1, press the WAVEFORM OFF front-panel button.

Starting the Application

To perform these lessons, the Power Analysis Applications must be installed on the oscilloscope. For information on how to do this, see *Installation* on page 3.

To start the application, follow these steps:

1. Press SETUP → Select Application as shown in Figure 4 on page 7.
2. Use the general purpose (GP) knob to select hd0: and press SELECT.
3. Use the GP knob to select TDSPWR1.APP.
4. Press Activate Application (side).

The application starts up and displays its initial screen.

Loading the Reference Waveform Files

The application includes two reference waveform files for use with this tutorial. Both waveforms were taken from the power supply of a class D EUT.

The Voltage waveform is five cycles of the 50 Hz/230 V power supply. You will load it as Ref1 and display it on your oscilloscope.

The Current waveform is from the same power supply. You will load it as Ref2 and display it on your oscilloscope.

To load the reference waveform files, follow these steps:

1. Press WAVEFORM → Recall Wfm to Ref (main) → Recall from file (side).
2. Use the general purpose (GP) knob to select hd0 and press SELECT.
3. Use the GP knob to select WFMS and press SELECT.
4. Use the GP knob to select R1V_50HZ.WFM and press Ref 1 active (side).
5. Press Recall Wfm to Ref (main) → Recall from file (side).
6. Use the GP knob to select R2I_50HZ.WFM and press Ref 2 active (side).
7. Press MORE → Ref 1 (main).
8. Press Ref 2 (main).
9. Press the CLEAR MENU front-panel button to view the waveforms.

   Figure 9 shows Ref1 and Ref2 as they should appear on your display.

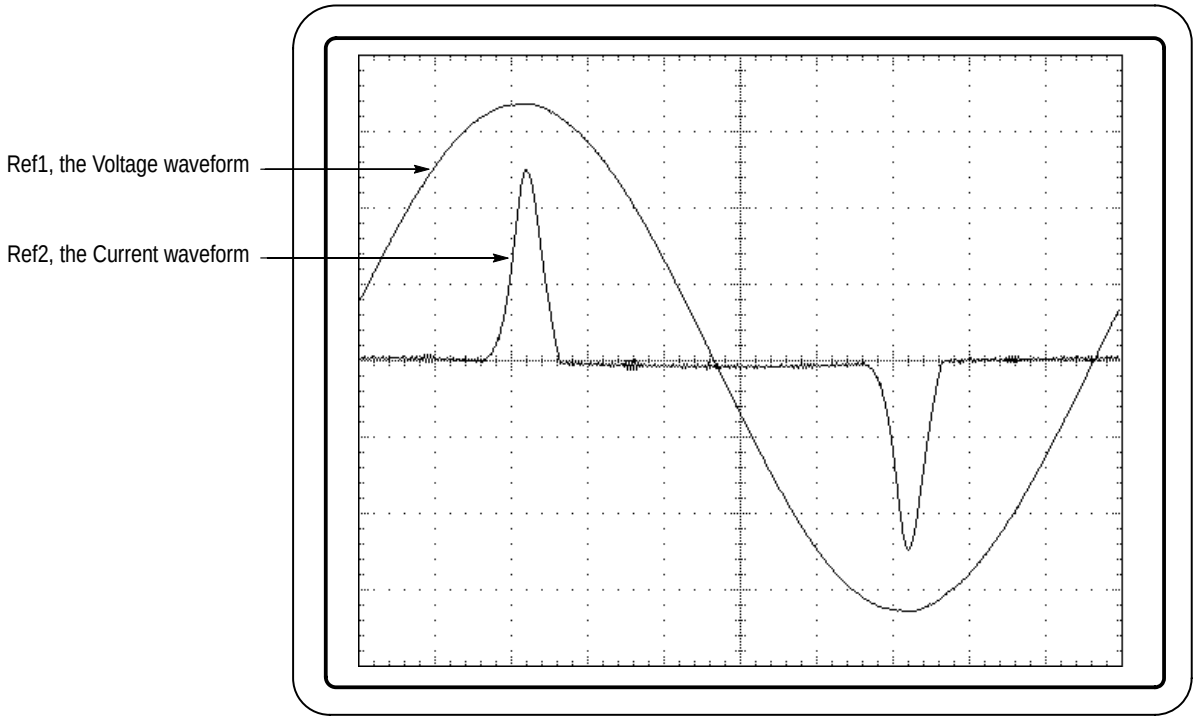

Figure 9: Default tutorial reference waveforms, Ref1 and Ref2

You can work through the tutorial lessons without formatting the waveforms. If you do, be sure to keep in mind that the waveforms on your display will look slightly different than the waveforms shown in the figures in this section.

To scale and reposition Ref1 and Ref2 for easier viewing, follow these steps:

1. Press MORE → Ref 1 (main). Use the VERTICAL SCALE knob to scale down the waveform and the VERTICAL POSITION knob to move the waveform farther up the display.
2. Press Ref 2 (main). Use the VERTICAL POSITION knob to move the waveform farther up the display.
3. Press the CLEAR MENU front-panel button.

   Figure 10 shows the scaled and repositioned reference waveforms.

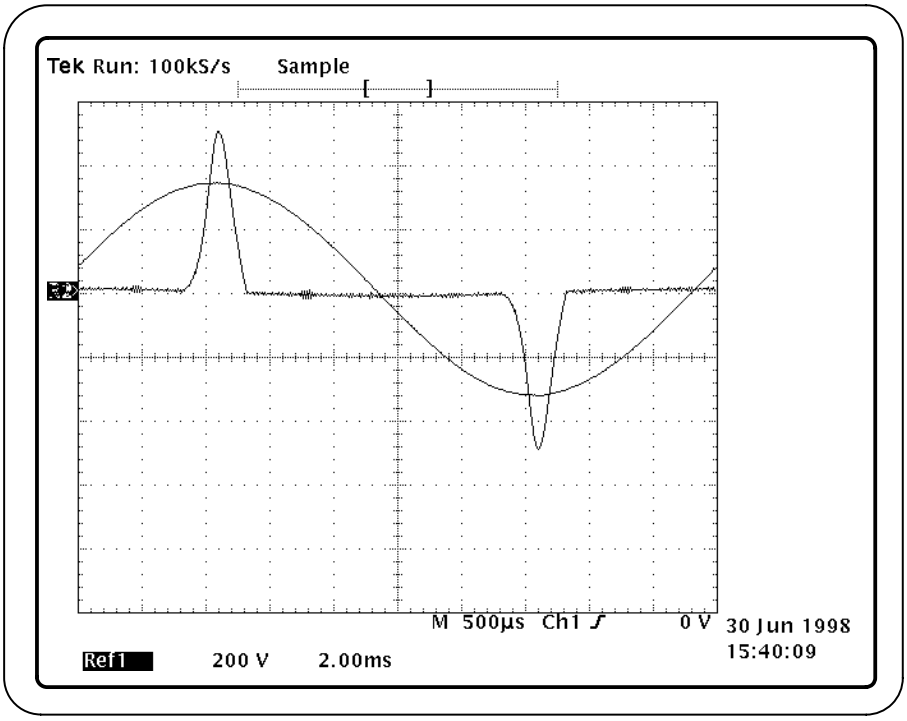

Figure 10: Ref1 and Ref2, scaled and repositioned

4. Push the SHIFT then the APPLICATION front-panel menu buttons to return to the application.

Taking a Power and Energy Measurement

In this lesson, you will use the application to calculate the power and energy waveforms. The calculation is taken from the voltage and current reference waveforms loaded as Ref1 and as Ref2, respectively.

To become familiar with the Power and Energy mode, follow these steps:

1. To select the Power and Energy mode, press Measure (main) → Power & Energy (side).
2. To specify the source of the voltage and current waveforms, press Input Config (main) → V, I Source (side). Select Ref1, 2. The I-Probe Impedance value is ignored because the vertical units are in Amperes.

   Figure 11 shows the Input Config menu with the reference waveforms. The Ref1 waveform is scaled down and both waveforms are positioned higher vertically on the display. This makes them easier to read.

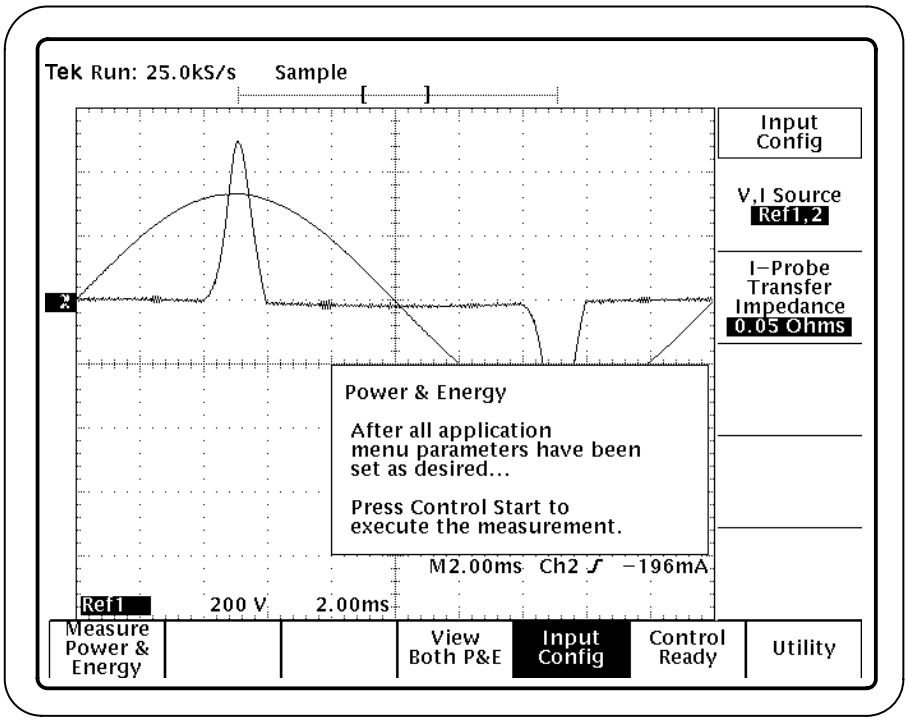

Figure 11: Input Config setup for the Power and Energy lesson

3. To display the power measurement, press View (main) → Power Wfm (side) and select ON.
4. To display the energy measurement, press Energy Wfm (side) and select ON.

Figure 12 shows the View menu.

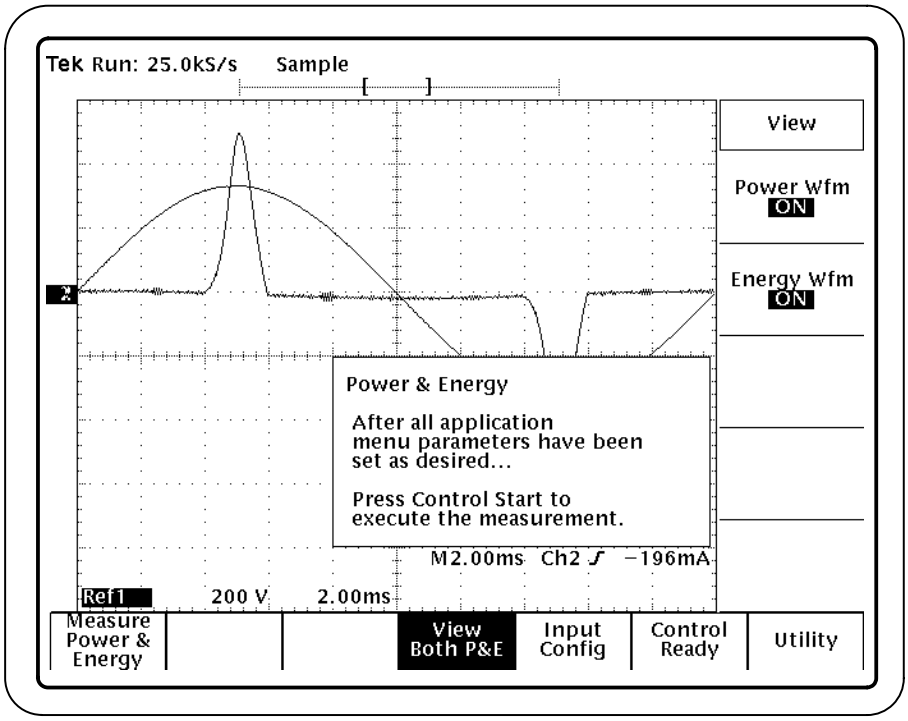

Figure 12: View menu for the Power and Energy lesson

5. To calculate the power and energy waveforms, press Control (main) → Mode (side) and select Single. Then press Start (side).

The state of the Control menu (main) will display Control Sequencing while the application is executing. When the Control menu displays Control Ready, the application has completed the calculations.

6. Wait for the calculations to complete. A message box appears indicating that Ref3 contains the Power waveform and that Ref4 contains the Energy waveform. To display these waveforms, follow these steps:

a. Press the MORE front-panel button.

b. Press Ref3 to display the results of the Power measurement.

c. Press Ref4 to display the results of the Energy measurement.

Figure 13 shows all four reference waveforms.

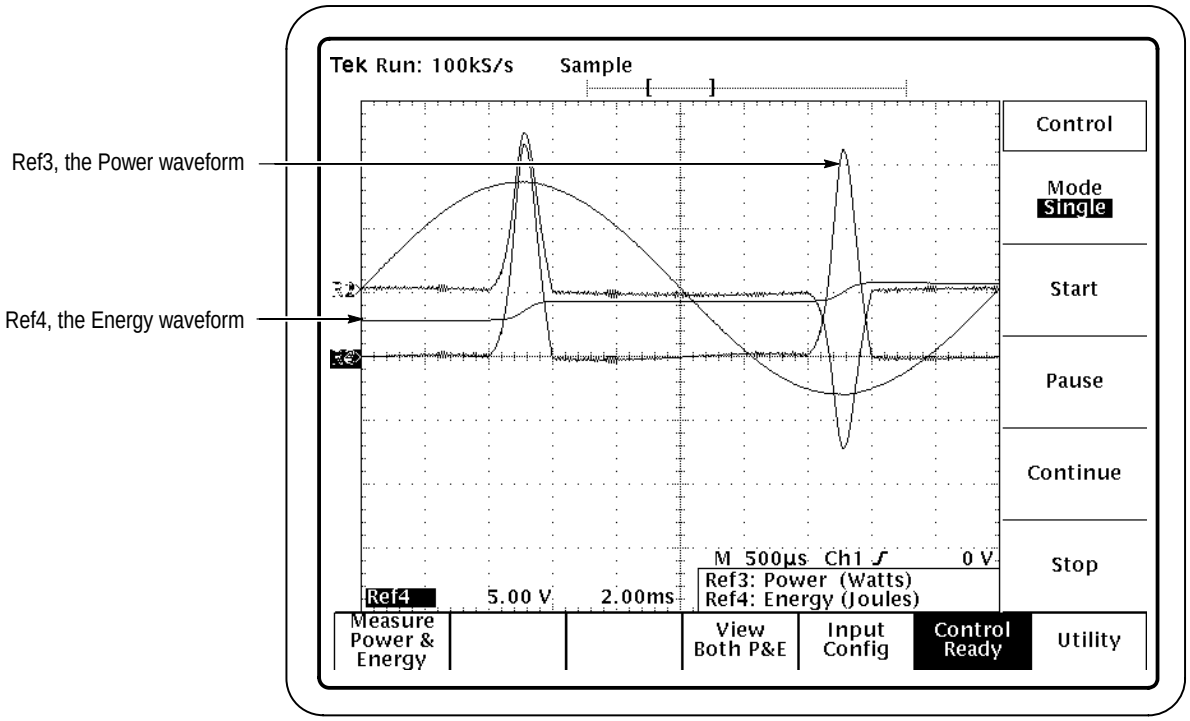

Figure 13: Resulting Ref3 and Ref4 waveforms

You can change the scale and position of the Ref3 and Ref4 waveforms to make them easier to analyze. Figure 40 on page 47 shows an example of the four reference waveforms scaled and repositioned on the screen.

7. When you are finished viewing the waveforms, press the WAVEFORM OFF front-panel button twice to clear the Ref3 and Ref4 waveforms.

8. Press the SHIFT and then the APPLICATION front-panel buttons to return to the application.

Saving a Setup and Exiting the Application

At some point, you might need to interrupt this tutorial. If you intend on continuing later, you need to save the oscilloscope and the application setups.

To save the oscilloscope setup, follow these steps:

1. Use the GP knob to select hd0: and press Create Directory (side).

2. Use the GP knob to select the T and press Enter Char (main). A T appears in the Name: field. Continue selecting and entering letters until the Name: field says TUT, then select and enter your first and last name initials.

3. Press OK Accept (side). A TUTxx directory (where the xx represents your initials) now exists on the hard disk that you can use with this tutorial.
4. Press Save Current Setup (main) → To File (side).
5. Press Save to Selected File (side). The tutorial setup is saved to the hard disk in the TUTxx directory and named TEK00000.SET. If you save subsequent setups, they will be named sequentially by default, such as TEK00001.SET and TEK00002.SET.

   Figure 14 shows a tutorial directory with a saved setup file for each lesson.

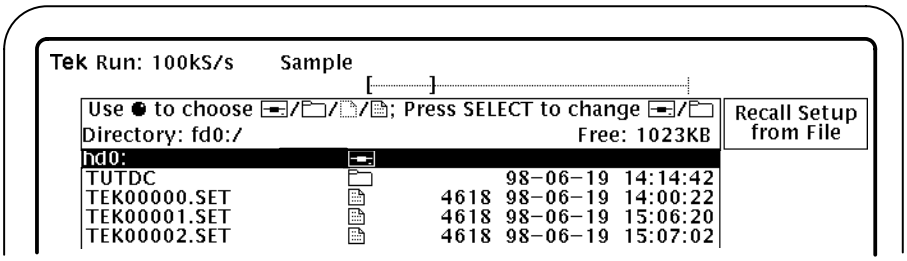

Figure 14: Saved setup files on the hard disk

To save the application setup, follow these steps:

1. Press Utility (main) → Save Setup (side).
2. To exit the application, press Utility (main) → Exit (side).

Recalling a Setup

When you are ready to continue with the tutorial, you can recall any saved setup from your TUTxx directory on the hard disk. You will also need to restart the application as described on page 13.

To recall the oscilloscope setup, follow these steps:

1. Press SETUP → Recall Saved Setup (main) → From File (side).
2. Use the general purpose (GP) knob to select hd0, and press SELECT.
3. Use the GP knob to select the TEK00000.SET (or other setup) title under the TUTxx directory and press Recall From Selected File (side).

To recall the application setup, follow these steps:

1. Press Utility (main) → Recall Setup (side).

2. Recall only the Ref2 waveform as described on page 13 if you plan to continue with the Current Harmonics Measurement lesson.

   Or, recall both the Ref1 and Ref2 waveforms as described on page 13 if you plan to continue with the Power Factor Measurement lesson.

3. Scale and reposition the waveforms as described on page 15, if you want.

Taking a Current Harmonics Measurement

In this lesson, you will use the application to compare the current harmonic line emissions of a class D EUT against the IEC 61000-3-2 limit standard. You will only need to use the Ref2 waveform on Ch2 for this lesson.

To become familiar with the Current Harmonics mode, follow these steps:

1. Press Measure (main) → Current Harmonics (side).

Before starting the measurement, you must configure the application to match the characteristics of the class D EUT from which the reference waveform was taken.

Figure 15 shows the Input Config menu with the reference waveforms.

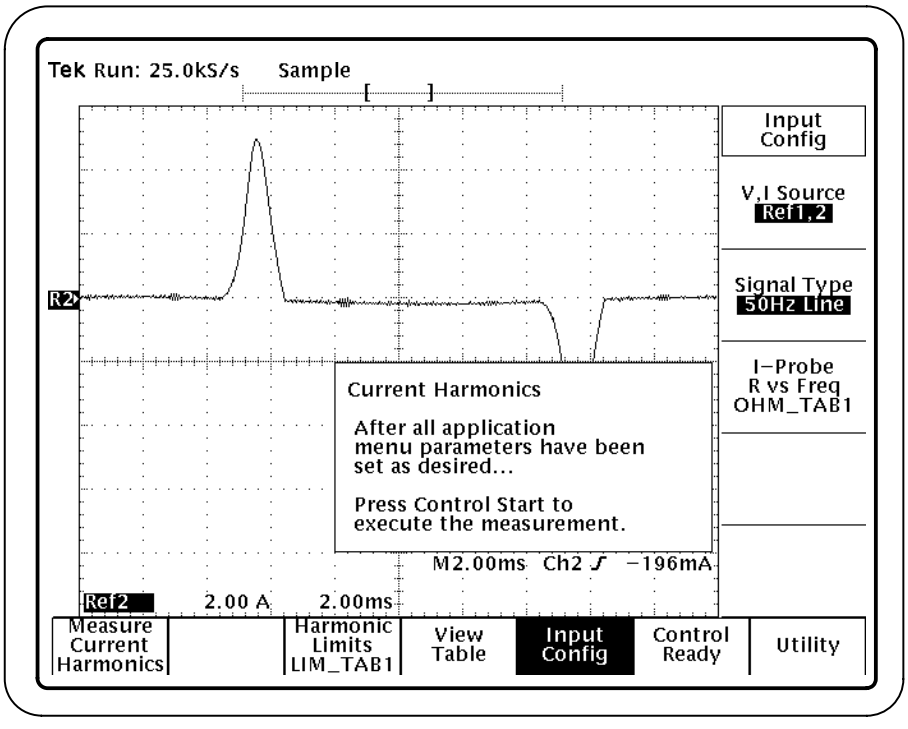

Figure 15: Input Config setup for the Current Harmonics lesson

2. To set up the Input Configuration, follow these steps:

   a. To specify the source of the voltage and current waveforms, press Input Config (main) → V, I Source (side) and select Ref1, 2.

   b. To specify the frequency of the AC line, press Signal Type (side) and select 50 Hz Line. This matches the frequency of the EUT from which the Ref1 and Ref2 reference waveforms were taken.

3. To set up the IEC 61000-3-2 limits table, refer to Figures 16 through 19, and follow these steps:

   a. Press Harmonic Limits (main).

      A table displays that contains the default limit values or, if the table was created in a previous session, the limit values already saved in the LIM_TAB1 table.

      Figure 16 shows a default table of harmonic limits values (not used in this lesson) and the Config IEC 61000–3–2 (side) menu item.

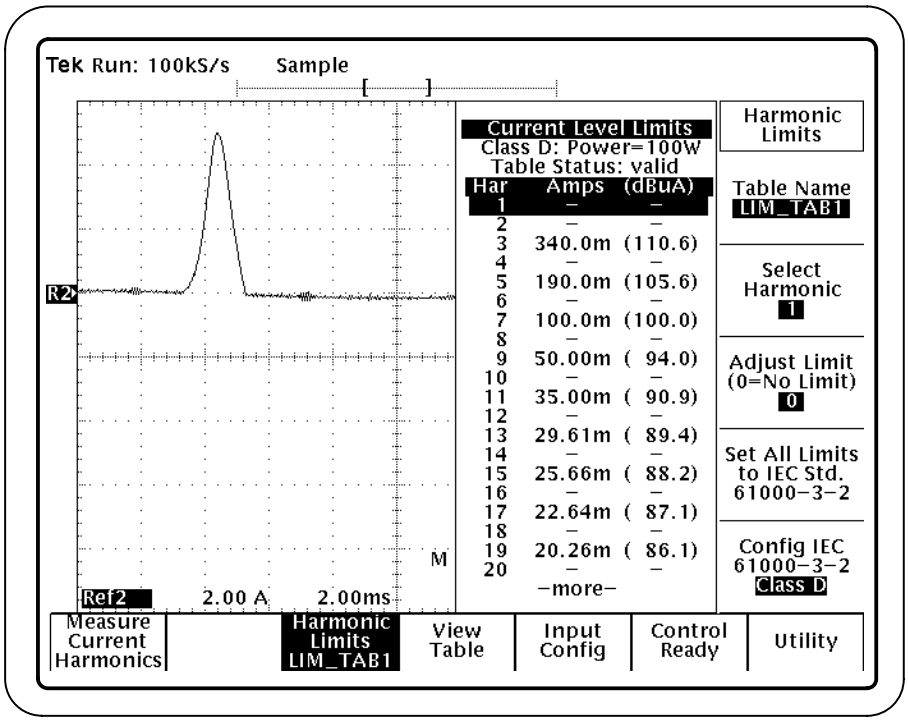

Figure 16: Default table of harmonic limits

   b. Press Config IEC 61000-3-2 (side).

Figure 17 shows the IEC 61000-3-2 configuration menu. The application uses this information to build an IEC 61000-3-2 harmonic limits table.

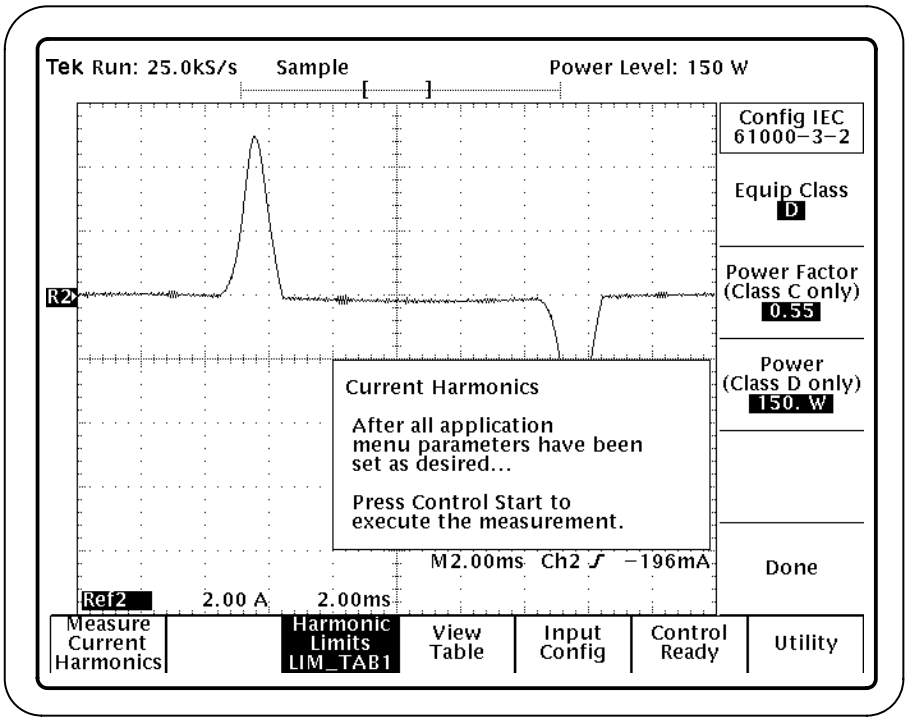

Figure 17: IEC 61000-3-2 configuration for the Current Harmonics lesson

c. Select Equip Class D (side).This matches the equipment class of the EUT from which the Ref1 and Ref2 reference waveforms were taken.

d. Press Power (Class D only) (side) and use the keypad to enter 150 W. This matches the power consumed by the EUT from which the Ref1 and Ref2 waveforms were taken.

e. Press Done.

f. To build the IEC limits table and activate it, press Set All Limits to IEC Std. IEC 61000–3–2 (side).

Figure 18 shows the new values in the LIM_TAB1 harmonic limits table.

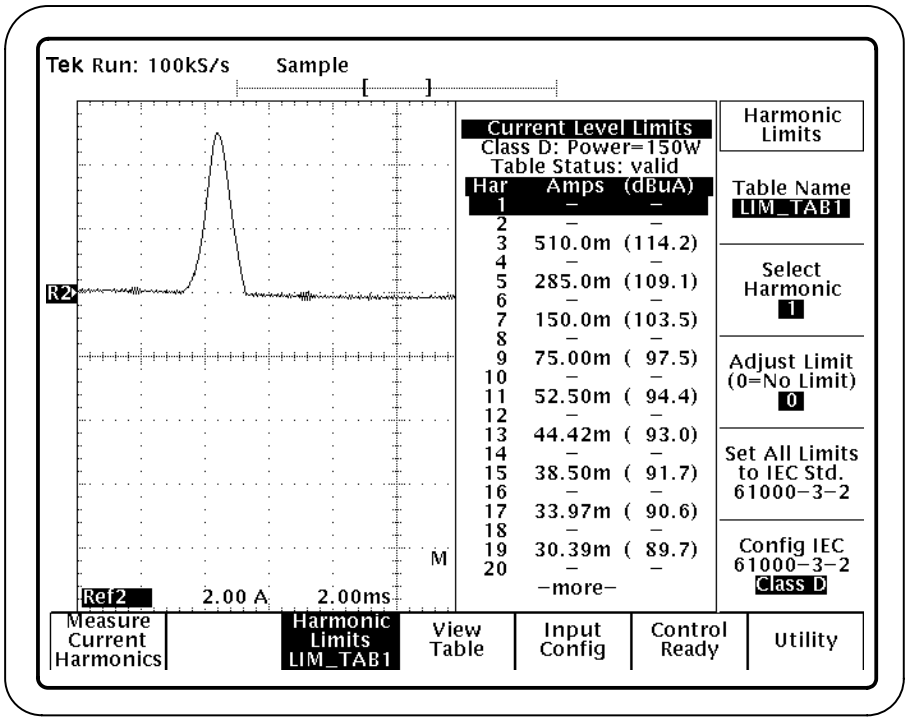

Figure 18: Harmonic Limits LIM_TBL1 values for the lesson

4. To view the results in a table, press View (main) → View As (side) and select Table.

5. To view the first 20 harmonics of the results, press Page (side)and select one.

6. To compare the current harmonics of Ref2 against the LIM_TAB1 limits, press Control (main) → Mode (side) and select Single. Press Control (main) → Start (side).

   The state of the Control menu (main) will display Control Sequencing while the application is executing.

7. Wait for the comparisons to complete, then view the results.

   Figure 19 shows the results. A negative value in the Margin dB column indicates that the harmonic of the EUT exceeded the limits and therefore failed the IEC61000-3-2 standard.

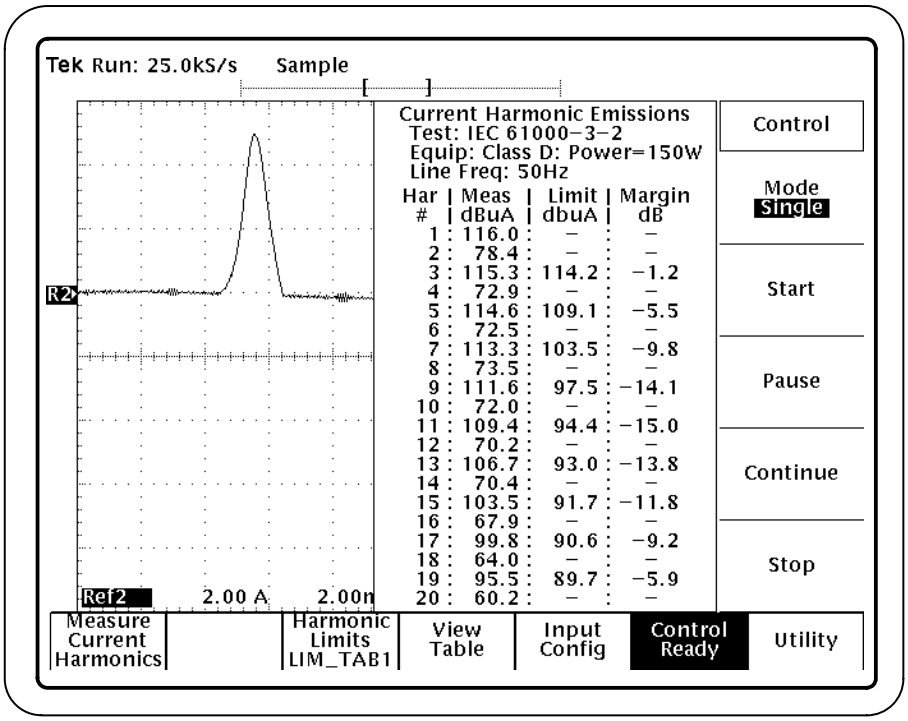

Figure 19: Tabular results for the Current Harmonics lesson

8. To view the results in the form of a bar graph, press View Table (main) → View As (side) and select Bar Graph.

9. To retake the measurements, press Control (main) → Mode (side) and select Single. Then press Control (main) → Start (side).

The state of the Control menu (main) will display Control Sequencing while the application is executing. When the Control menu displays Control Ready, the application has completed the limit comparisons.

10. Wait for the comparisons to complete. The results do not automatically display. To display the results, follow these steps:

a. Press the MORE front-panel button.

b. Press Ref3 to display the results from the EUT as narrow bars.

c. Press Ref4 to display the IEC limits to which the EUT was compared as wide bars.

d. Change the volts per division to 25.0 V for Ref4.

e. Press Ref1 and then the WAVEFORM OFF front-panel button to clear the Ref1 waveform from the display.

f. Press Ref2 and then the WAVEFORM OFF front-panel button to clear the Ref2 waveform from the display.

Figure 20 shows the results formatted as a bar graph. The narrow bars represent the measurement and the wide bars represent the values from the table. A measured levels bar that is higher than the corresponding limit levels bar indicates that the harmonic exceeds the standard (the EUT failed that harmonic).

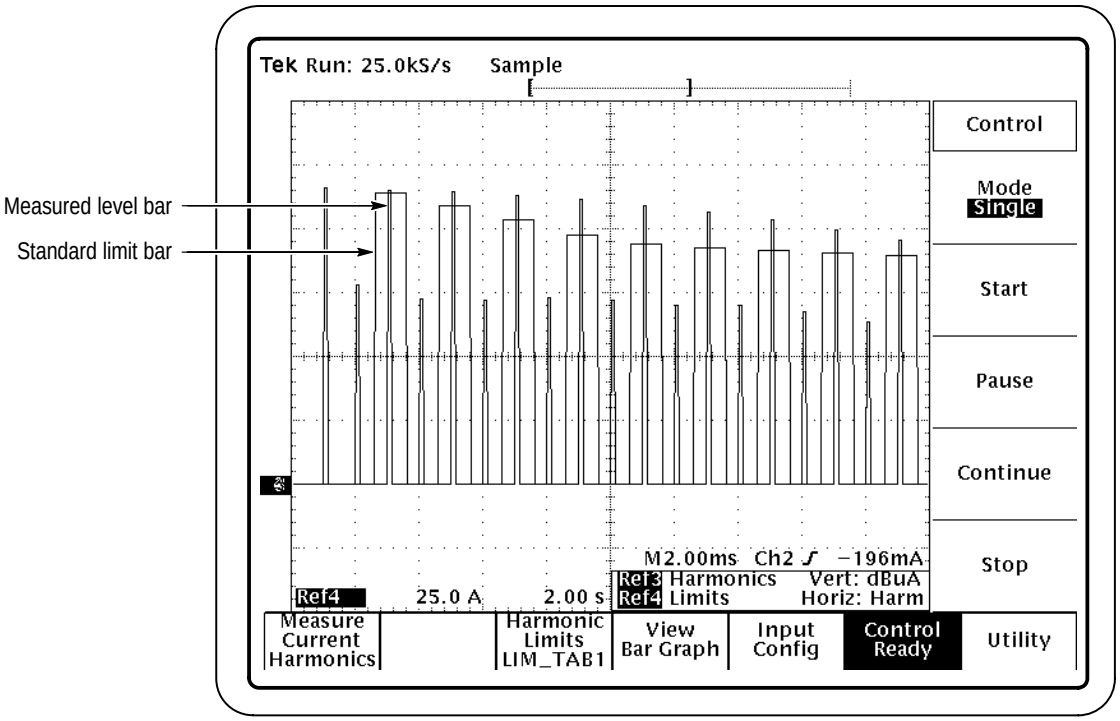

Figure 20: Bar graph results for the Current Harmonics lesson

11. When you are finished viewing the bar graph, press the WAVEFORM OFF front-panel button twice to clear the Ref3 and Ref4 waveforms.

12. Press the SHIFT and then the APPLICATION front-panel buttons to return to the application.

Taking a Power Factor Measurement

In this lesson, you will use the application to measure the RMS voltage and current, the true and apparent power, and the power factor of a class D EUT. There are two standard frequencies and a user-defined frequency on which the application can take the Power Factor measurements.

Standard Frequency

To become familiar with a standard frequency mode, follow these steps:

1. To select the Power Factor mode, press Measure (main) → Power Factor (side).
2. Follow steps 7 through 9 on page 14 to display the Ref1 and Ref2 waveforms. Follow steps 1 through 4 on page 15 to scale and reposition the waveforms.
3. To set up the Input Configuration, follow these steps:
   a. To specify the source of the voltage and current waveforms, press Input Config (main) → V, I Source (side) and select Ref1, 2. The I-Probe Impedance value is ignored because the vertical units are in Amperes.
   b. To specify the frequency of the AC line, press Signal Type (side) and select 50 Hz Line. This matches the frequency of the EUT from which the Ref1 and Ref2 reference waveforms were taken.

   Figure 21 shows the Input Config menu with the reference waveforms.

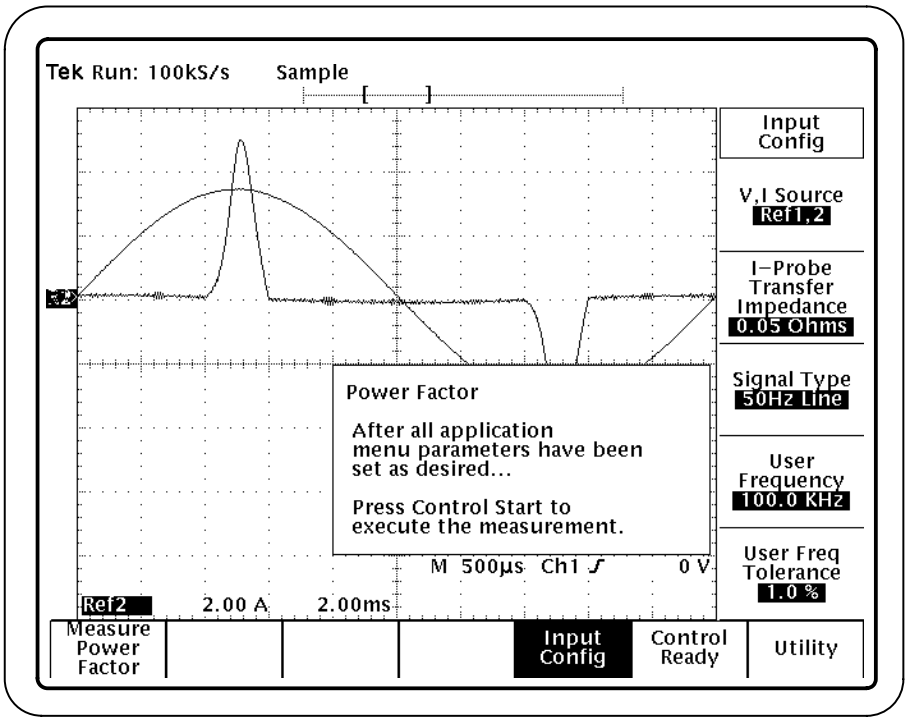

Figure 21: Input Config setup for the Power Factor lesson

4. To take the measurements, press Control (main) → Mode (side) and select Single. Then press Control (main) → Start (side).

The state of the Control menu (main) will display Control Sequencing while the application is executing. When the Control menu displays Control Ready, the application has completed the calculations.

5. Wait for the measurements to complete. Figure 22 shows the results.

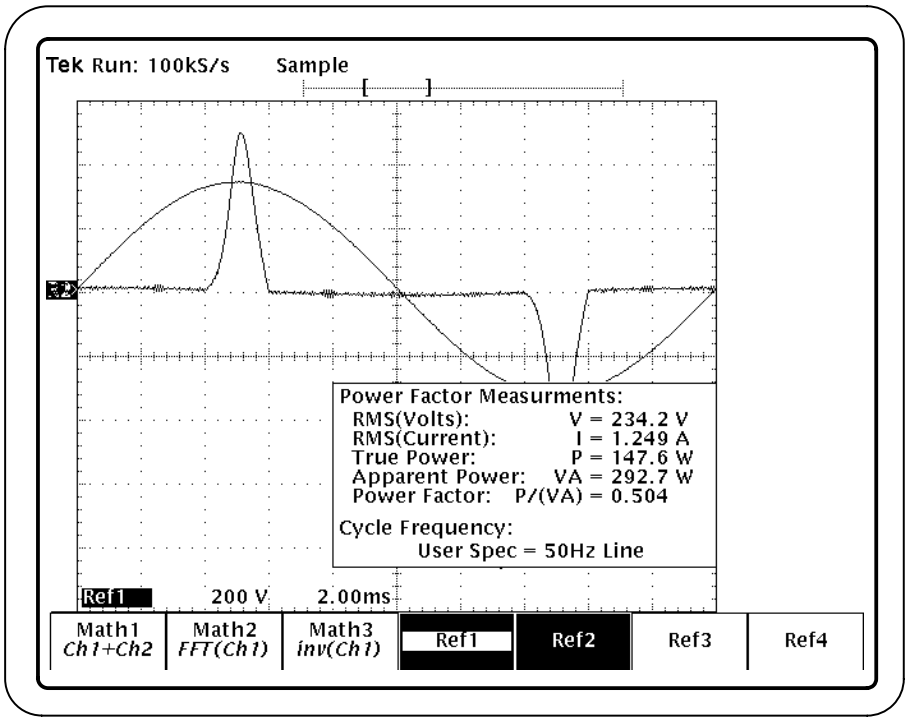

Figure 22: Results for the Power Factor lesson

User-Defined Frequency

You can enter a frequency other than the two standard frequencies. In this lesson, you will enter the value of a standard frequency as if it were a user-defined frequency to show the differences in the results of the measurement.

To become familiar with a user-defined frequency mode, follow these steps:

1. Push the SHIFT then the APPLICATION front-panel menu buttons to return to the application.
2. Press Input Config (main) → Signal Type (side) and select User.
3. Press User Frequency (side) and use the keypad to enter 50 Hz. Figure 23 shows the Input Config menu with a user-defined signal frequency of 50 Hz.
4. Press User Freq Tolerance (side) and use the keypad to enter 1.0%. Figure 23 shows the Input Config menu with the tolerance of the user-defined signal frequency set to 1.0%.

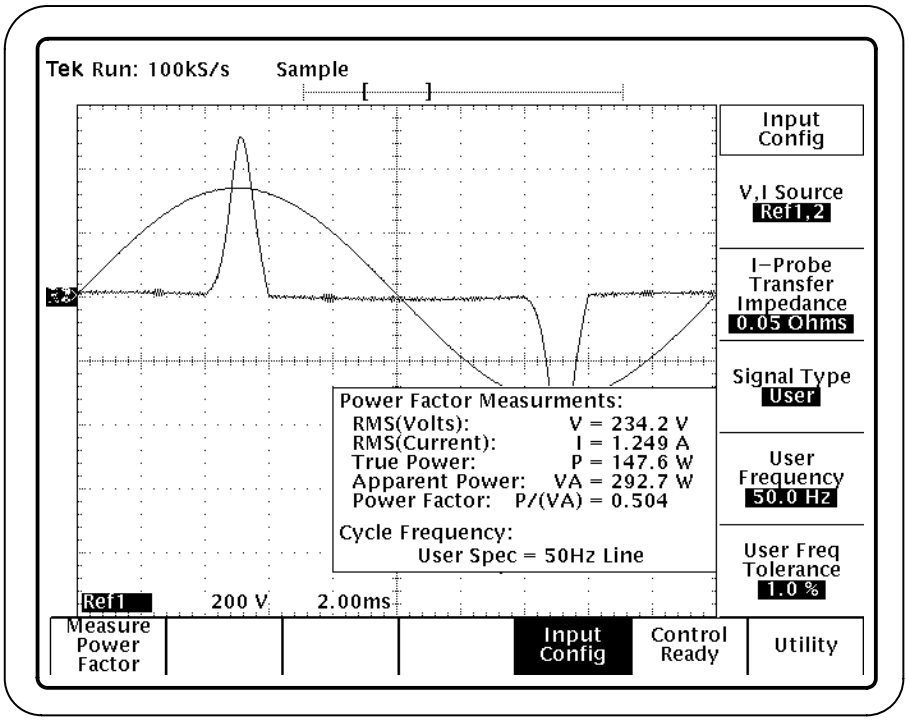

Figure 23: User-defined signal frequency for the Power Factor lesson

5. To take the measurements, press Control (main) → Mode (side) and select Single. Then press Control (main) → Start (side).

6. Wait for the measurements to complete, and the results will display as shown in Figure 24. The last two lines in the results show the user-defined signal frequency and the calculated frequency.

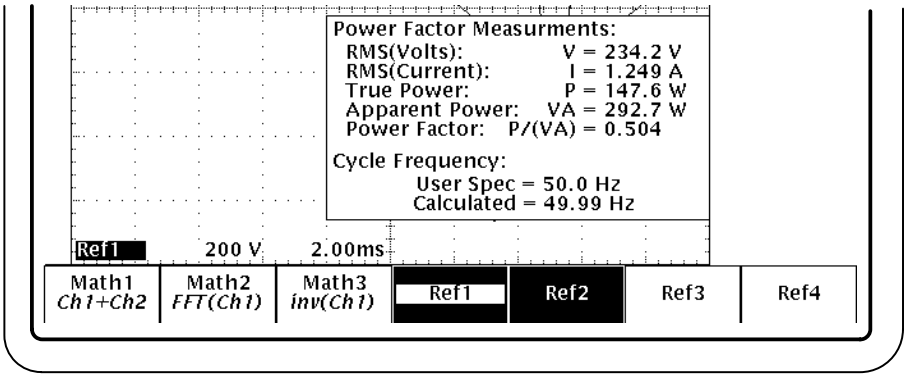

Figure 24: User-defined frequency results for the Power Factor lesson

Reference

Menu Structure

Figure 25 shows the relationship of the application menus.

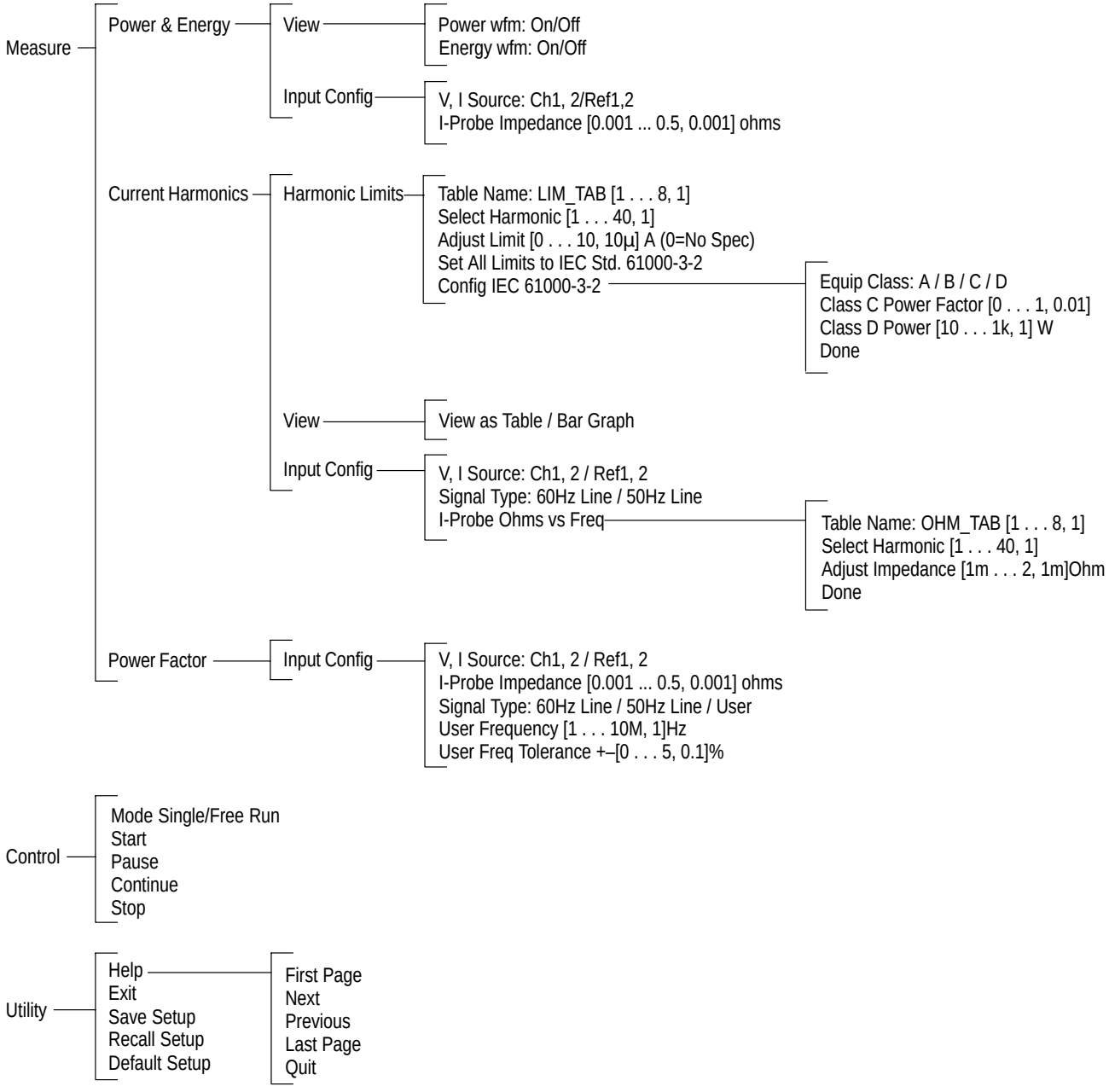

Figure 25: Application menu structure

Setup Parameters

This section describes the menus and menu items for the power measurement modes: Power and Energy, Current Harmonics, and Power Factor.

Saving and Recalling Setups

You can save and recall application menu settings. Figure 26 shows the Utility menu with the save and recall side menus.

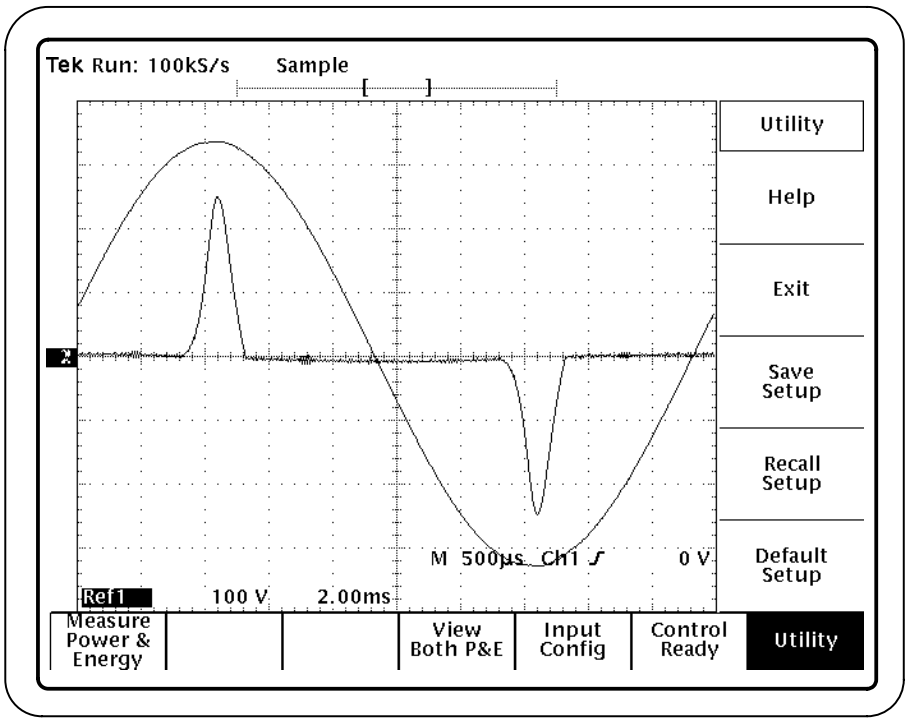

Figure 26: Save Setup and Recall Setup selections in the Utility menu

The save/recall function is controlled from the application Utility menu and contains the following selections:

- To store the current application settings, press Utility (main) → Save Setup (side). The `HD0:/APP/TDSPWR1/TEMP/TDSPWR1.INI` file will contain the stored settings. Once you have saved a setup, that setup will be recalled whenever you start the Power Analysis Applications. Keep in mind that the `HD0:/APP/TDSPWR1/TEMP/TDSPWR1.INI` file is not updated automatically. You must use the Save Setup function to update the file.

NOTE. *If you want to save the existing configuration, you must use the Save Setup feature to store the present application settings.*

You can recall the settings in the HD0:/APP/TDSPWR1/TEMP/TDSPWR1.INI file at any time. To do so, press Utility (main) → Recall Setup (side).

- To recall the factory default menu settings, press Utility (main) → Default Setup (side).

The Power Analysis Applications Save/Recall function is totally independent of the primary oscilloscope Save/Recall function stored in nonvolatile RAM.

Measuring Power and Energy

The Power and Energy mode displays instantaneous power curves based on the waveform measurements from the electrical potential in Volts and the electrical current in Amperes. Figure 27 shows the initial display after selecting this mode.

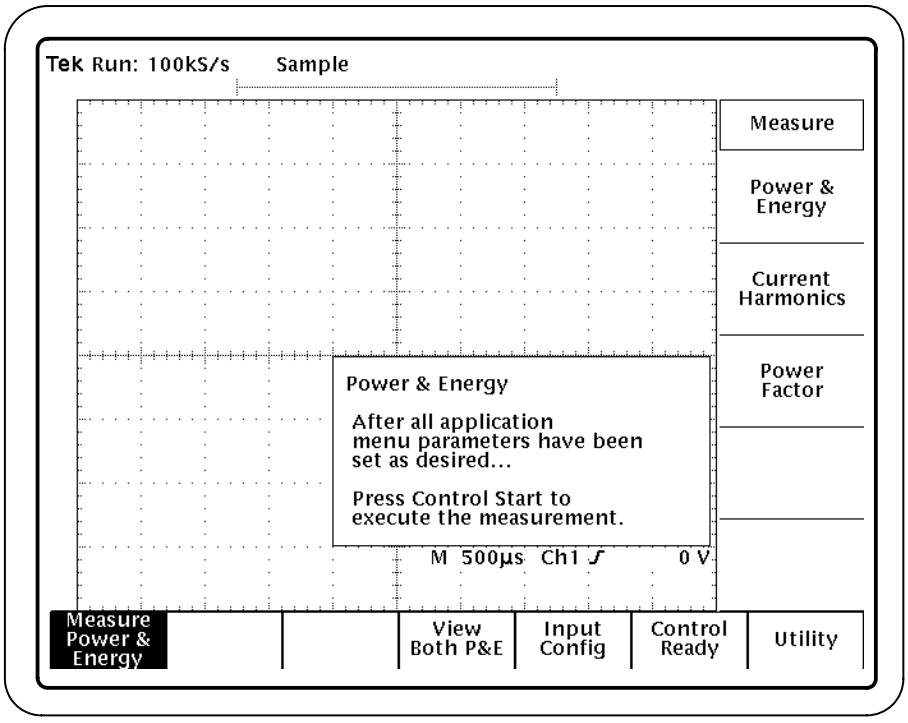

Figure 27: Power & Energy initial display

To set up the Power and Energy mode, refer to Figure 28, Figure 29, and follow these steps:

1. Press View (main). You can use the View menu to define what measurement to display: power, energy, or both power and energy. Figure 28 shows the View menu.

   Press Power Wfm (side). In the Power Wfm menu item, you can select On to display the power waveform or Off.

   Press Energy Wfm (side). In the Energy Wfm menu item, you can select On to display the energy waveform or Off.

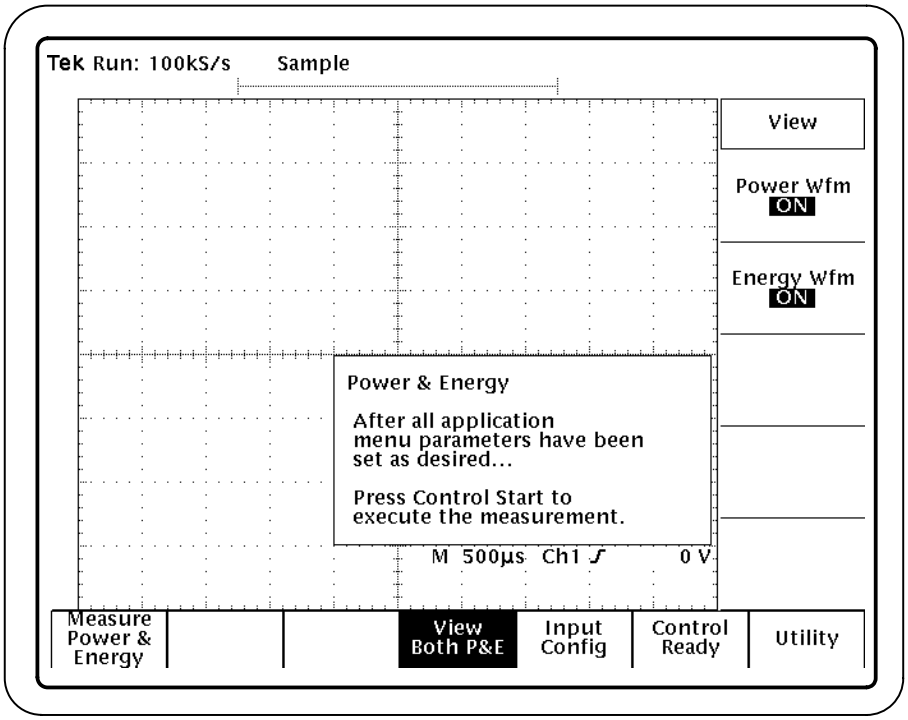

Figure 28: Power & Energy View menu

2. Press Input Config (main). You can configure the source of input data and the probe impedance, if need be. A TekProbe, such as the TCP 202, does not require an impedance value. Figure 29 shows the Input Config menu.

   Press V, I Source (side). In the V, I Source menu item, you can select Ch1,2 to measure active data from channels 1 and 2, or Ref 1, 2 to measure reference waveforms 1 and 2.

Press I-Probe Impedance (side). In this menu item, you can select an insertion impedance value, such as the voltage to current conversion factor. The range is from 0.001 ohms to 0.5 ohms in 0.001 increments.

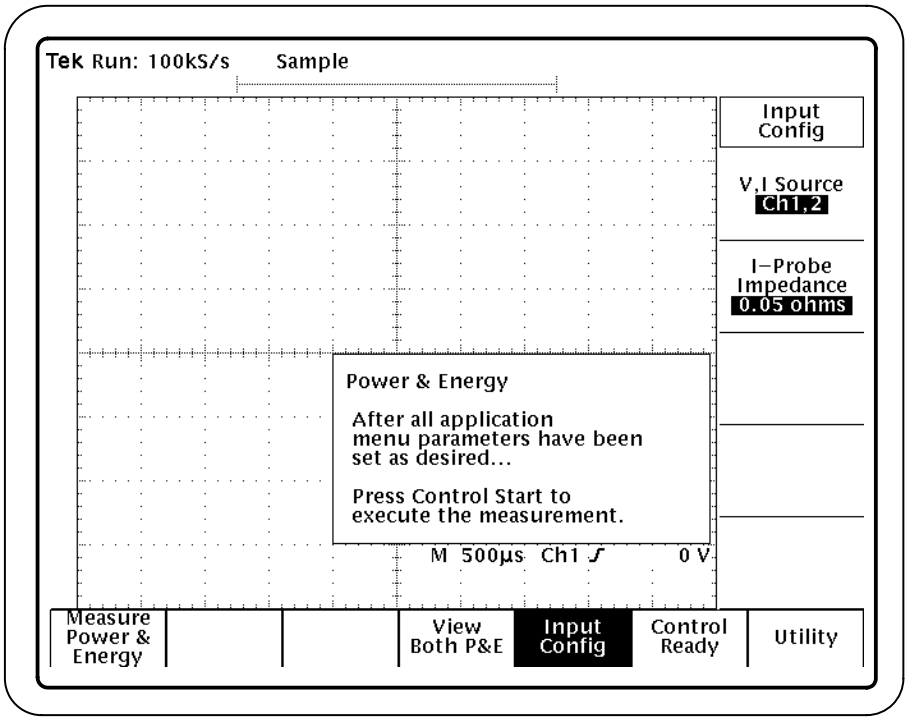

Figure 29: Power & Energy Input Config menu

3. After the measurement is set up, press Control (main) → Start (side).

When the measurement is complete, a message appears indicating that Ref3 contains the Power waveform and that Ref4 contains the Energy waveform. To display Ref3 and Ref4, refer to step 6 on page 17.

Table 2 lists the waveform names and gives a definition of what each represents.

Table 2: Power and Energy waveform definitions

Waveform name	Definition
Source (input)	
Ch1/Ref1	Voltage
Ch2/Ref2	Current
Target (output)	
Ref3	Power
Ref4	Energy (Integral of power)

Figure 40 on page 47 shows an example of the four reference waveforms scaled and repositioned on the screen.

Measuring Current Harmonics

The Current Harmonics mode compares the harmonic current emissions from the EUT injected into the public supply system against the limits specified in the IEC standard 61000-3-2. You can view the results as a table or as a graph. Figure 30 shows the initial display after selecting this mode.

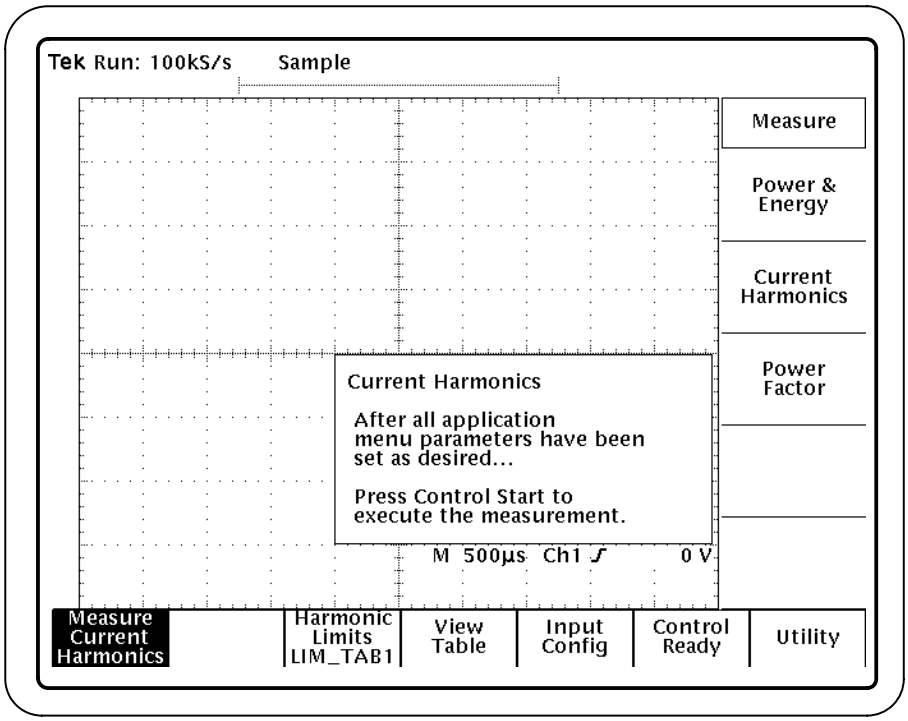

Figure 30: Current Harmonics initial display

To set up the Current Harmonics mode, refer to Figures 31 through 35, and follow these steps:

1. Press Harmonic Limits (main).

   You can use the Harmonic Limits Table menu to set the current limits for harmonics to the IEC 61000-3-2 standard or to individual limit values.

2. Press Table Name (side) to select one of eight tables, LIM_TAB1 to LIM_TAB8, if limit values have been created for all eight tables.

Multiple saved tables are most useful for customized limit values. You should reserve the use of LIM_TAB1 for standard IEC levels.

3. Press Select Harmonic (side) to select a harmonic for limit adjustment.
4. Press Adjust Limit (side) to enter a custom value for the selected harmonic.

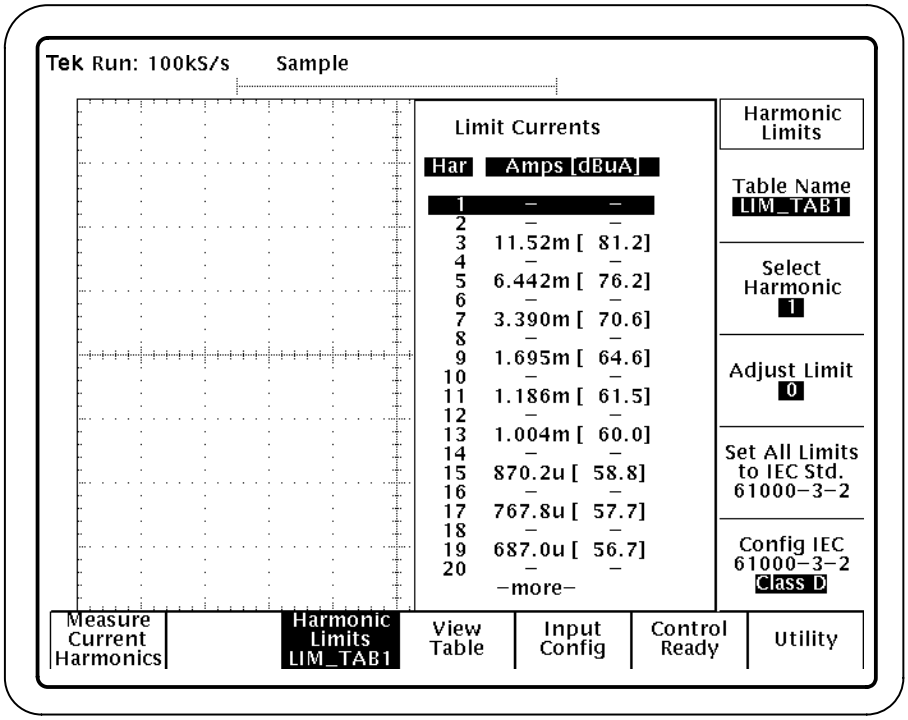

Figure 31: Harmonic Limits Table menu with default values

5. Press Config IEC 61000–3–2 (side). Figure 32 shows the Config IEC 61000-3-2 menu.

   Press Equip Class (side) and match the class of the EUT: A, B, C, or D.

   Class A or B EUTs do not need any other configuration.

   Class C EUTs require a power factor. Press Class C Power Factor (side) to select the power factor, or enter the factor using the keypad and press ENTER. The range is from 0 to 1 in 0.01 increments.

   Class D EUTs require a value for Watts consumed. Press Class D Power (side) and use the GP knob to select the power consumed, or use the keypad to enter the power consumed. The range is from 10 to 1000 Watts in whole numbers.

   Press Done to return to Harmonic Limits (main).

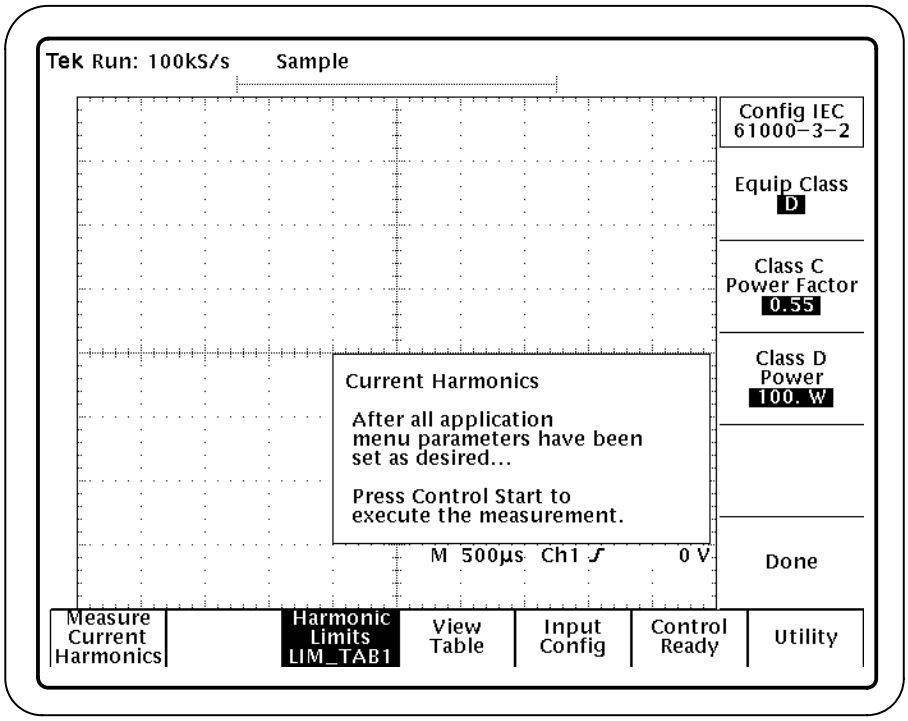

Figure 32: Config IEC 61000-3-2 configuration menu

6. To set the current limits in the selected limit table to levels dictated by the Config IEC 61000–3–2 menu, press Harmonic Limits (main) → Set All Limits to (side).

Figure 33 shows a harmonic limits table for a class D EUT with a total power consumption of 100 Watts.

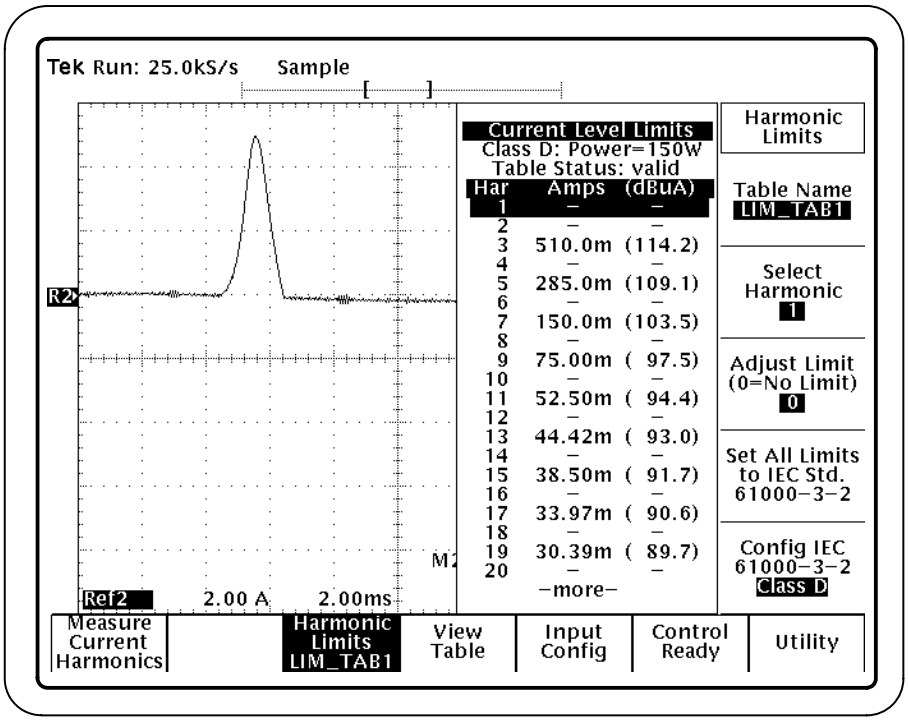

Figure 33: An activated current harmonic limits table

7. Press View (main). You can use the View menu to choose the format of the results as tabular or graphical. Figure 34 shows the View menu.

Press View As (side). You can select Table to view the results in table form or Graph to view the results as a bar graph.

The results display in a table and contain the measured levels, limit levels, and margin for the fundamental and harmonics two through forty (twenty per page). A negative value in the Margin column indicates that the harmonic exceeds the standard. (The EUT failed that harmonic.) Measured and limit currents are given in dBuA units while the margins are given in dB units.

When viewing the results as a graph, the horizontal scale is 2 harmonics per division and the vertical scale is 50 dBuA per division. The narrow bars represent the measurement and the wide bars represent the values from the table. A measured levels bar that is higher than the corresponding limit levels bar indicates that the harmonic exceeds the standard (the EUT failed that harmonic).

8. Press View (main) → View Page (side). You can select which page number to display.

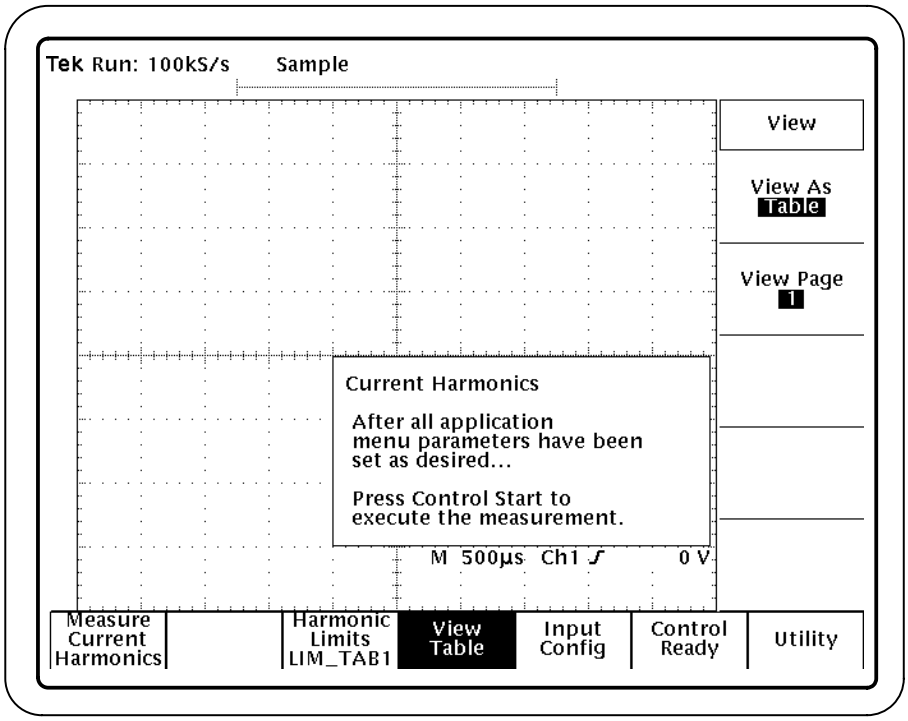

Figure 34: Current Harmonics View menu

9. Press Input Config (main). You can configure the source of input data and the cycle frequency of the power line. Figure 35 shows the Input Config menu.

Press V, I Source (side). You can select Ch1,2 to measure active data from channels 1 and 2, or Ref 1, 2 to measure reference waveforms 1 and 2.

Press Signal Type (side). You can select the line frequency that matches the power source, 60 Hz or 50 Hz, or choose user as the type of signal.

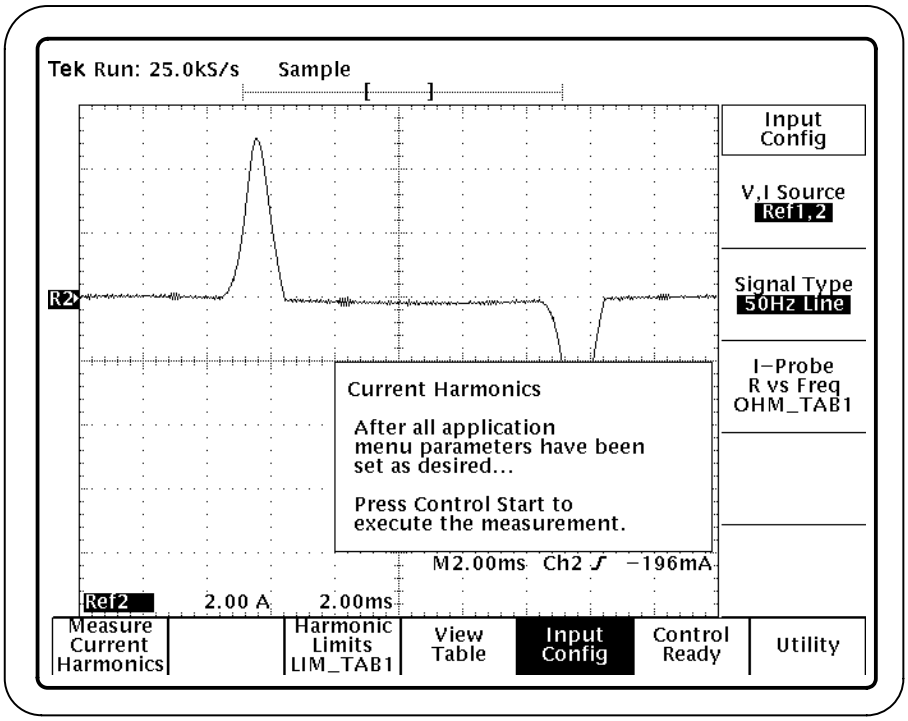

Figure 35: Current Harmonics Input Config menu

10. Press lnput Config (main) → I-Probe R vs Freq (side). Figure 36 shows the I-Probe R vs Freq configuration menu.

You can use the I-Probe R vs Freq menu to set the transfer impedance of the probe at each harmonic frequency.

11. Press Table Name (side) to select an active table from the eight available: OHM_TAB1 through OHM_TAB8. You can specify a unique set of transfer impedance values or ratios in each table for your specific use.

12. Press Select Harmonic (side) to select a harmonic for transfer impedance adjustment.

13. Press Adjust R as a) Ohms b) Ratio (side) to enter a custom transfer impedance for the selected harmonic.

If you are using a TekProbe, you need to set only the ratio of the actual versus the nominal impedance. The oscilloscope can identify this type of probe and will automatically apply the value as a ratio. The range of ratios is from 0.001 to 2.0 in 0.001 increments.

If the probe is not a TekProbe, the value you enter is handled as ohms. The range is from 0.001 ohms to 2.0 ohms in 0.001 increments.

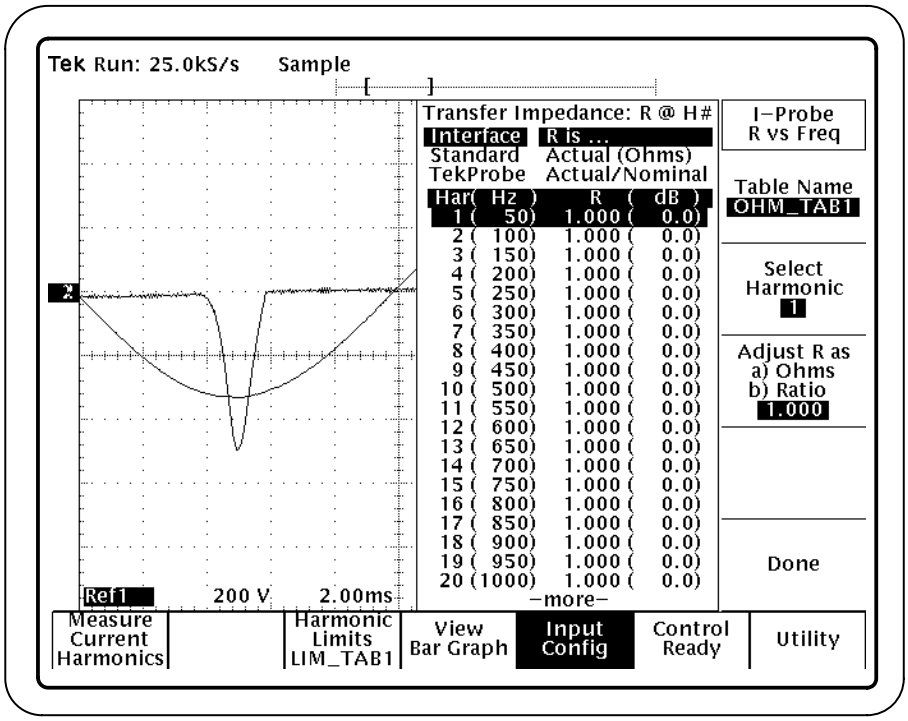

Figure 36: I-Probe R vs Freq configuration menu

14. After the measurement is set up, press Control (main) → Start (side).

If you select View As Table, when the measurement is complete, the results display formatted as a table. Refer to Figure 19 on page 24 for an example of results in a table form

If you select View As Bar Graph, when the comparisons are complete, the results do not display. To display the bar graphs, follow step 10 on page 24. Figure 20 on page 25 for an example of the results as a bar graph.

Table 3 lists the waveform names and gives a definition of what each represents.

Table 3: Current Harmonics waveform definitions

Waveform name	Definition
Source (input) Ch2/Ref2	Current
Target (output) Ref3 Ref4	 Measured level Standard limit

Measuring Power Factors

The Power Factor mode displays the RMS values for the voltage and current, the true power, the apparent power, and the power factor of an EUT. Figure 37 shows the initial display after selecting this mode.

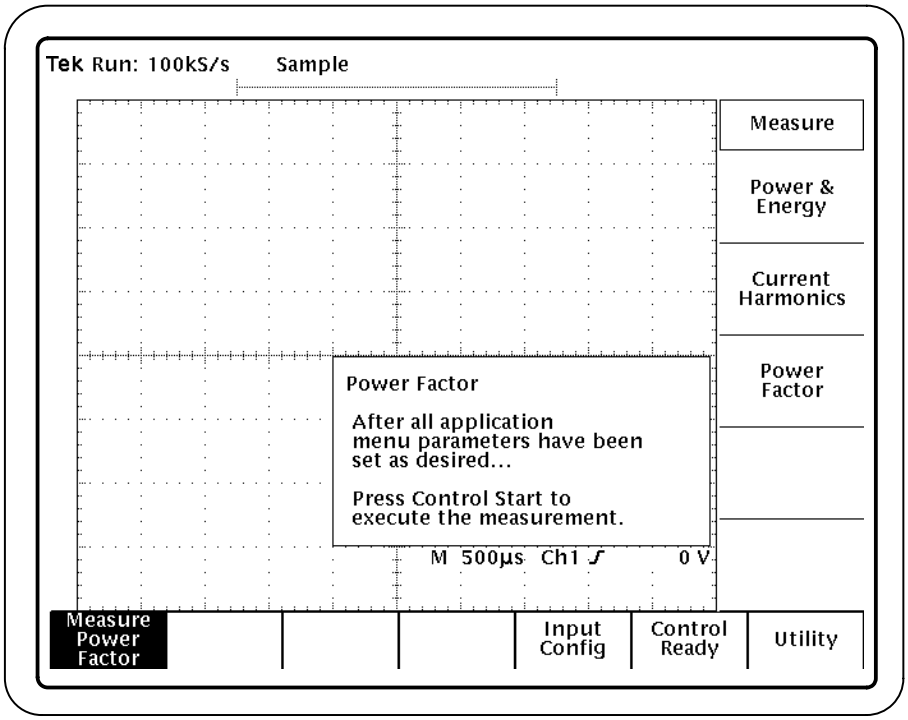

Figure 37: Power Factor initial display

To set up the Power and Energy mode, refer to Figure 38, and follow these steps:

1. Press Input Config (main). You can configure the source of input data and the probe impedance, if need be. Figure 38 shows the Input Config menu.

   Press V, I Source (side). In the V, I Source menu item, you can select Ch1,2 to measure active data from channels 1 and 2, or Ref 1, 2 to measure reference waveforms 1 and 2.

   Press I-Probe Impedance (side). In the I-Probe Impedance menu item, you can select an insertion impedance value, such as the voltage to current conversion factor. A TekProbe does not require an impedance value. The range is from 0.001 to 0.5 ohms in 0.001 increments.

   Press Signal Type (side). In the Signal Type menu item, you can select from one of two standard line frequencies, 50 Hz or 60 Hz, or a User frequency.

Press User Frequency (side). If User is selected as the Signal Type, you can enter the frequency of your EUT. The range is from 1 Hz to 1 MHz in 1.0 Hz increments.

Press User Freq Tolerance (side). You can define a relative margin above and below the user frequency in which the application will search before taking the measurement. The margin is from 0 to ±5% in 0.1 increments. If you are sure that the user-defined frequency is correct, enter 0 to cancel the frequency search.

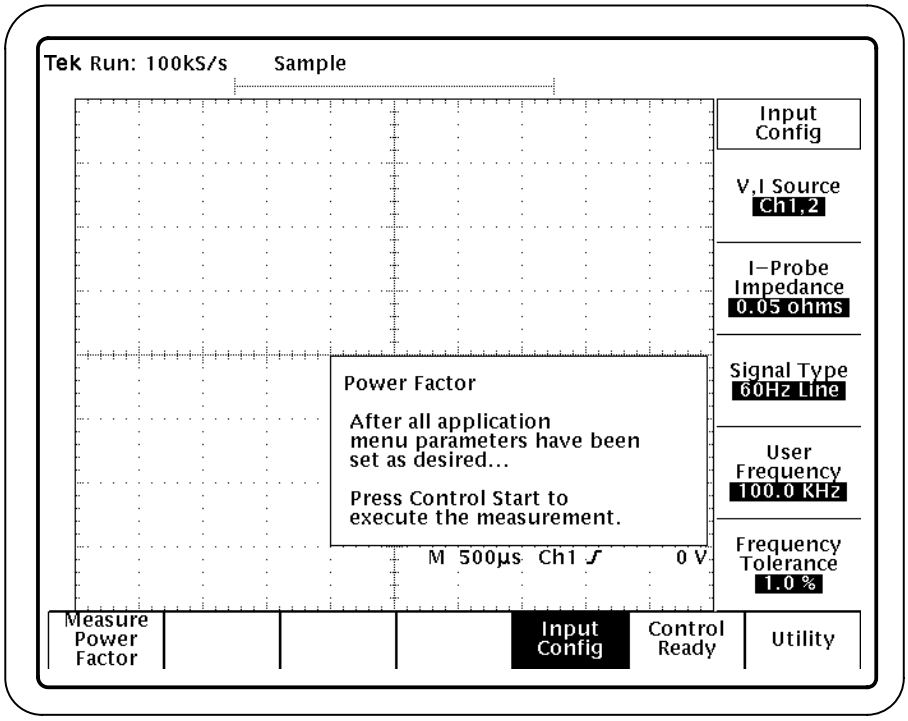

Figure 38: Power Factor Input Config menu

2. After the measurement is set up, press Control (main) → Start (side).

When the measurement is complete, the results display. Refer to Figure 22 on page 27 for an example of the results from a Power Factor measurement for a standard frequency. Refer to Figure 24 on page 28 for an example of the results for a User Signal Type frequency.

Localizing Measurements

You can control the amount of data to measure by adjusting the Record Length or Horizontal Scale in the oscilloscope horizontal menu. By specifying both the trigger position, the starting point and the total length of the measurement, you can effectively size the area of interest.

Measurement Descriptions

This section contains descriptions of the Power Analysis Applications measurements. The descriptions include information about how to take the measurement and information about the algorithm used to perform the measurement operation.

There are three measurement modes: Power and Energy, Current Harmonics, and Power Factor. Figure 39 shows an example of the results for each mode.

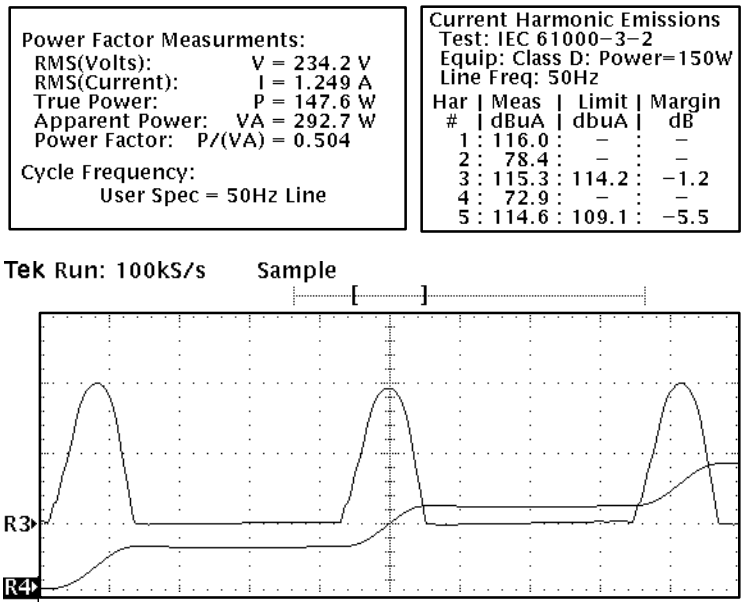

Figure 39: Examples of the results for all three measurements

Measurements will continuously update if you select the Free Run mode in the Control menu before starting the measurement. If you do not select the Free Run mode and want to take another measurement, press Start (side) again.

Warning Messages

All power analysis measurements provide a warning if the input conditions do not support accurate measurements. For example, the Current Harmonics measurement warns you if the time/div is not 2 ms and the record length is less than 2500.

Power and Energy Measurements

The Power and Energy mode requires two waveforms; a voltage waveform (electrical potential measured in Volts) and a current waveform (measured in Amperes), and calculates the instantaneous power and energy curves from them.

Definition

The Power and Energy waveforms are calculated using the following equations:

$$p(n) = v(n) \cdot i(n)$$

$$e(n) = \sum_{m=1}^{n} p(m)$$

Where:

n is the sampled data waveform index

v is the electrical potential across an EUT

i is the electrical current through an EUT

p is the power

e is the energy

Procedure

To set up the oscilloscope, use the following guidelines:

1. The voltage signal is on Ch1 or Ref1; the current signal is on Ch2 or Ref2.
2. The vertical scale for the voltage and current signals must be set so that they do not exceed the vertical range of the TDS oscilloscope.
3. When possible, limit the bandwidth (such as to 20 MHz) and acquire data using the Hi Res mode. This increases the accuracy of the measurement.
4. The time per division must be set small enough to capture sufficient signal detail and avoid aliasing.

To set up the measurement, from the Power Analysis Application display, follow these steps:

1. To select the Power and Energy measurement, press Measure (main) → Power & Energy (side).
2. Select the curves that you plan to analyze from the View menu; the Power waveform and/or the Energy waveform.

3. Select the voltage and current waveform sources in the Input (main) → V, I Source (side).
4. If you want to localize the measurement, do so now. The application defaults to the settings specified in the Trigger menu.
5. Press Control (main) → Start (side) to start the measurement.
6. Wait for the measurement to complete, and display the waveform of interest: the Power waveform as Ref3 and/or the Energy waveform as Ref4. For details on how to display Ref3 and Ref4, refer to step 6 on page 17.

   Figure 40 shows an example of the reference and resulting waveforms scaled and repositioned for easier analysis.

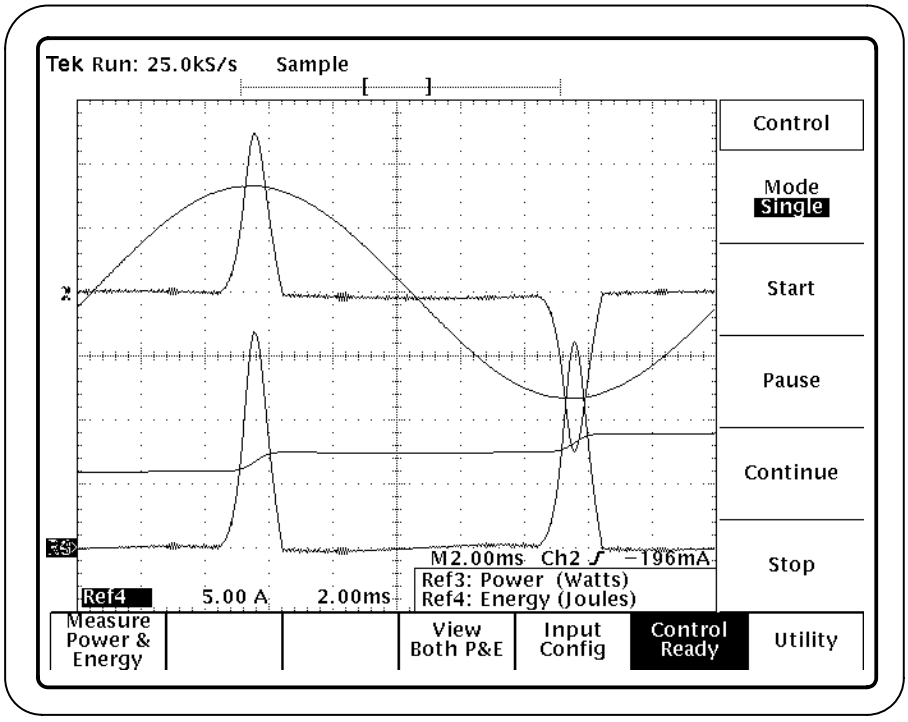

Figure 40: Power and Energy measurement results

Test Methodology

To take the Power and Energy measurement, the application calculates the power and energy as defined for the entire voltage and current waveforms.

Current Harmonics Measurements

The Current Harmonics mode measures the RMS magnitude of a current component who's frequency lies in the n^{th} harmonic of the fundamental line frequency, w_{line}. This mode calculates the harmonic current emissions injected into the public supply system, and compares the results to limits specified in the IEC standard 61000-3-2, part 3.

You can view the measurement results as a table or as a bar graph.

Definition

A current harmonics measurement at the n^{th} harmonic of the power line frequency is based on the following equations:

$$H(n\ \Omega_{line}) = \sqrt{2}\ |I\ (n\ \Omega_{line})|$$

Where: *H* is the RMS current

I is the DFT for a sample data current waveform, defined as:

$$I(n\ \Omega_{line}) = \sum_{m=1}^{N} i(m)e^{-j\,n\,\Omega_{line}(m-1)}$$

i is the current waveform

n is the harmonic number

$$\Omega_{line} = \frac{f_{line}}{f_s} \cdot 2\pi$$

f_{line} is the cycle frequency of the power line

f_s is the sample rate of the sample data

N is the number of samples in the record that contain a whole number of fundamental power line cycles.

Procedure

To set up the oscilloscope, use the following guidelines:

1. The current waveform must be present on Ch2 or as Ref2.
2. The time per division must be set to 2 ms.
3. The record length must be set to at least 2500 samples.
4. When possible, limit the bandwidth (such as to 20 MHz) and acquire data using the Hi Res mode. This increases the accuracy of the measurement.

To set up the measurement, from the Power Analysis Application display, follow these steps:

1. To select the Current Harmonics measurement, press Measure (main) → Current Harmonics (side).
2. Select the current waveform source as Ch2 or Ref2 in the Input (main) → V, I Source (side).
3. If you want to localize the measurement, do so now. The application defaults to the settings specified in the Trigger menu.
4. Press Control (main) → Start (side) to start the measurement.
5. Wait for the measurement to complete, then view the results. Figure 19 on page 24 and Figure 20 on page 25 show examples of the results in the two different formats.

Test Methodology

The application performs the measurement according to the following algorithm:

1. Imports the current waveform.
2. Checks that the time/div sample rate is equal to 2 ms and that there are at least 2500 points in the record.
3. Checks that the current waveform meets the required conditions.
4. Performs the DFT at the first through the fortieth harmonic of f_{line}.
5. Calculates and compares the current harmonics with the IEC limits table.

Power Factor Measurements

The Power Factor mode calculates the power factor for a voltage and current waveform pair. To calculate the power factor, the application must first calculate the RMS (Volts), RMS (Amperes), True Power, and Apparent Power. The application also displays these values.

Definition

The Power Factor and related measurements are based on the following equations:

$$V_{RMS} = \sqrt{\frac{1}{N}\sum_{n=1}^{N} v^2(u)}$$

$$I_{RMS} = \sqrt{\frac{1}{N}\sum_{n=1}^{N} i^2(n)}$$

$$P_{TRUE} = \frac{1}{N}\sum_{n=1}^{N} i(n) \cdot v(n)$$

$$P_{APPARENT} = V_{RMS} \cdot I_{RMS}$$

$$P_{FACTOR} = P_{TRUE} / P_{APPARENT}$$

Where: *v* is a voltage waveform

i is a current waveform

N is the number of samples that spans a whole number of signal cycles

Procedure

To set up the oscilloscope, use the following guidelines:

1. Set the horizontal scale to a minimum of four divisions (400 samples) per signal cycle.

   To measure 50 or 60 Hz lines, the waveform must contain at least one full signal cycle.

   To measure user-defined lines, the waveform must contain at least two full signal cycles.

2. When possible, limit the bandwidth (such as to 20 MHz) and acquire data using the Hi Res mode. This increases the accuracy of the measurement.

To set up the measurement, from the Power Analysis Application display, follow these steps:

1. To select the Power Factor measurement, press Measure (main) → Power Factor (side).
2. Press Control (main) → Start (side) to start the measurement.
3. Wait for the measurement to complete, then view the results. Figure 22 on page 27 shows the results for a standard frequency. Figure 24 on page 28 shows the results for a User Signal Type frequency.

Test Methodology

The application performs the measurement according to the following algorithm:

1. Checks that the time/div sample rate is equal to 2 ms and that there are at least 2500 points in the record.
2. Checks that the current waveform meets the required conditions.
3. For user-defined frequencies, searches for the exact frequency.
4. Verifies the cycle frequency and determines if there is sufficient data to take the measurement.
5. Calculates the power factor and related measurements.

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