

**FLUKE®**

# **Fluke 43**

## Power Quality Analyzer

### Applications Guide

4822 872 00857

June 1998, Rev. 2, 07/98

© 1998 Fluke Corporation, All rights reserved. Printed in The Netherlands.  
All product names are trademarks of their respective companies.

## **PLACING ORDERS AND GETTING ASSISTANCE**

To locate an authorized service center, visit us on the World Wide Web:

**<http://www.fluke.com>**

or call Fluke using any of the phone numbers listed below:

+1-888-993-5853 in U.S.A. and Canada

+31-402-678-200 in Europe

+1-425-356-5500 from other countries

# Table of Contents

Chapter	Title	Page
	Working Safely .....	1
	How to use this Manual .....	2
	Conventions Used .....	2
	Resetting the Fluke 43 .....	4
<b>1</b>	<b>Beginning Measurements .....</b>	<b>5</b>
	Introduction .....	5
	Measuring Line Voltage .....	6
	Measuring Current .....	7
	Line Voltage and Current Simultaneously .....	8
	Measuring Line Voltage and Current .....	8
	Recording Line Voltage and Current .....	9
	Testing Continuity .....	11
	Measuring Resistance .....	12
	Measuring Capacitance .....	13
	Testing a Diode .....	14
<b>2</b>	<b>Receptacle Branch Circuits .....</b>	<b>15</b>
	Troubleshooting Electrical Distribution Systems .....	15
	Detecting Transients (Phase to Neutral) .....	16
	Monitoring Rapid Voltage Fluctuations .....	19
	Measuring Voltage Harmonics .....	21
	Measuring Current Harmonics .....	22
	Measuring the Load on a Transformer .....	24
	Recording the Load on a Transformer .....	25
	Measuring K-factor .....	27
<b>3</b>	<b>Lighting Loads .....</b>	<b>29</b>
	Introduction .....	29
	Measuring Current Harmonics .....	30
	Measuring Power on Single Phase Loads .....	31
	Measuring Surge Current .....	32

<b>4</b>	<b>Motor Loads .....</b>	<b>35</b>
	Introduction .....	35
	Induction Motors .....	36
	Checking Voltage Imbalance .....	36
	Checking Current and Current Imbalance.....	38
	Measuring Peak and Inrush Current .....	40
	Measuring Power Factor of 3-Phase Motors.....	43
	Grounded Y-Connection with Balanced Load .....	43
	Delta connection or floating systems.....	44
	Measuring Voltage Harmonics .....	46
	Adjustable Speed Drives .....	47
	Checking Current on Phases .....	47
	Measuring Fundamental of Motor Voltage .....	48
	Measuring Frequency of Motor Current .....	49
<b>5</b>	<b>Handling Screens.....</b>	<b>51</b>
	Introduction .....	51
	Saving Screens.....	52
	Viewing and Deleting screens .....	52
	Printing Screens .....	53
	Creating Reports.....	54
<b>6</b>	<b>Definitions .....</b>	<b>55</b>
	<b>Index</b>	

## **Working Safely**



### **Warning**

**To avoid electric shock and/or equipment damage, use caution when connecting test leads to live components. The jaws of alligator clips can create a short circuit between closely spaced live parts. Avoid making connections to feeder conductors or bus bars at elevated potentials. Whenever possible, make connections to the output side of a circuit breaker, which can provide better short circuit protection.**

- Follow all legal requirements. Follow all instructions in the manuals. Obey posted instructions.
- Never assume that a circuit is de-energized. Check it first.
- Always set up the measurement first, then connect the test leads to the circuit.
- Use only test leads and test lead adapters supplied with the Fluke 43 (or safety-designed equivalents as specified in the accessory list, see Chapter 2 of the Users Manual).
- Never use adapters or test leads that have exposed metal parts or insufficient voltage rating.
- Remove all test leads that are not in use.
- Make connections to the instrument first, before connecting leads to a live circuit.
- Connect the ground lead first, then the voltage leads and the current probe. Disconnect in reverse order.
- Route your test leads carefully.

## How to use this Manual

The applications in this manual are grouped in four chapters.

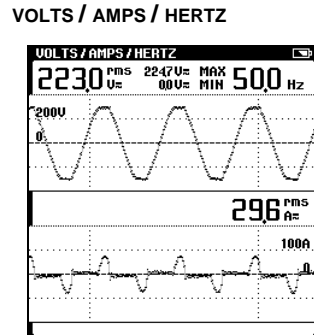
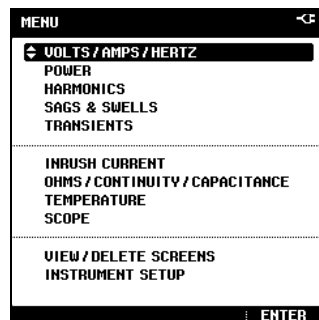
**Chapter 1** contains basic measurements. Start with this chapter to get acquainted with the Fluke 43 and with this manual.

**Chapter 2** contains applications related to problems with receptacle loads and transformers.

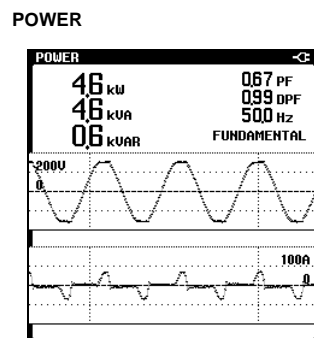
**Chapter 3** contains applications related to lighting systems.

**Chapter 4** focusses completely on motors and motor drives.

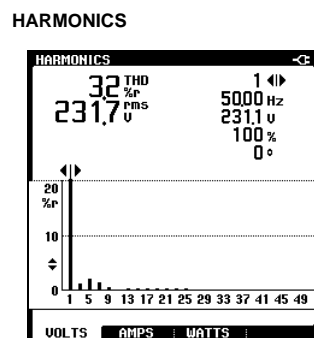
To find an application related to the functions in the main menu, look up the page numbers in the figure.



Pages: 6, 7, 8, 36, 38, 47, 49



Pages: 24, 31, 43, 44

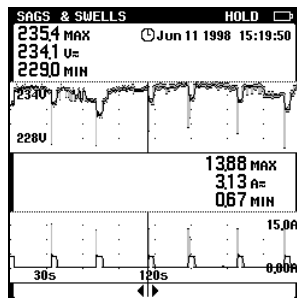


Pages: 21, 22, 27, 30, 46, 48

## Conventions Used

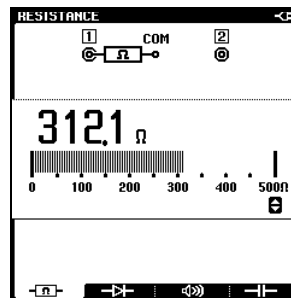
- G** Ground
- N** Neutral
- 1** Phase 1
- 2** Phase 2
- 3** Phase 3

**SAGS & SWELLS**



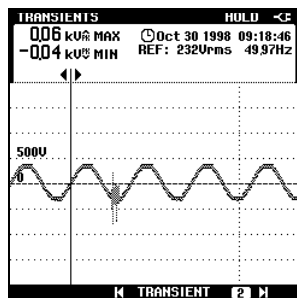
Pages: 9, 19

**OHMS / CONTINUITY / CAPACITANCE**



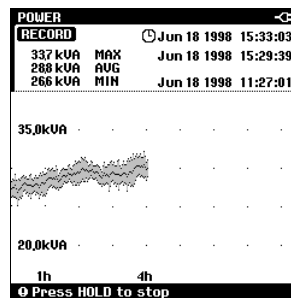
Pages: 11, 12, 13, 14

**TRANSIENTS**



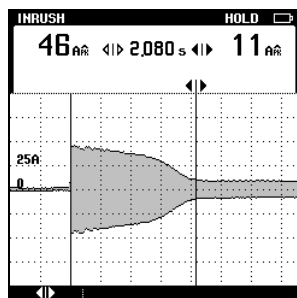
Page: 16

**RECORD**



Page: 25

**INRUSH CURRENT**



Pages: 32, 40

**VIEW / DELETE SCREENS**





Page: 52

## Resetting the Fluke 43

To restore the Fluke 43 to its factory settings and return to the opening screen, reset the Fluke 43. Resetting does not clear screen memories.

Turn the Fluke 43 off and proceed as follows:

- 1  Press and hold.
- 2  Press and release.

The Fluke 43 turns on, and you should hear a double beep, indicating that the reset operation was successful.

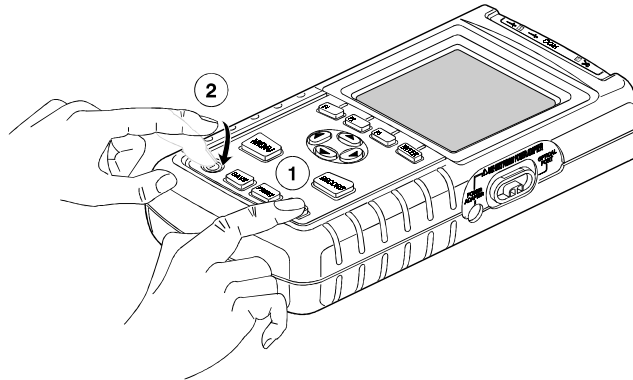



Figure 1. Resetting the Fluke 43

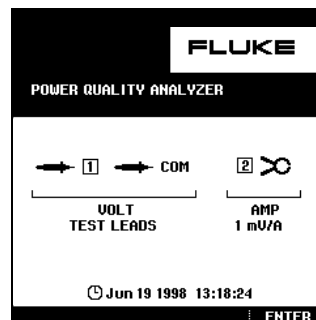
- (3)  Release the HOLD key.

The opening screen with default settings appears on the display.

*Note*

To learn how to setup the Fluke 43, see: "Introducing the Fluke 43" in Chapter 1 of the Users Manual.

- 4  Continue.





# **Chapter 1**

## **Beginning Measurements**

### ***Introduction***





This section provides easy-to-do measurements which you can perform almost anywhere. Begin with these examples to get started with the Fluke 43.

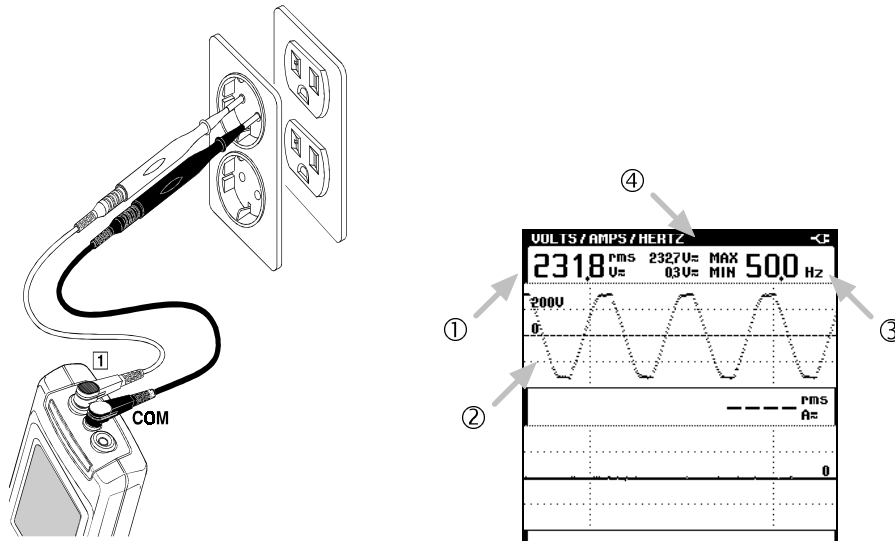
#### *Note*

*It is a good idea to reset the Fluke 43 before you start a new application. This way, you always start from the same setup.*

## Measuring Line Voltage

Determine whether the voltage level, voltage waveform, and frequency from an outlet are correct.

- 1  Open the main menu.
- 2   → 
- 3 Make connections as shown below:







- ① The rms voltage should be close to the nominal voltage, for example 120V or 230V.
- ② The waveform should be smooth and sinusoidal.
- ③ The frequency should be close to 50 or 60 Hz.
- ④ The **MAX** and **MIN** readings show the highest and lowest readings since entering the screen.

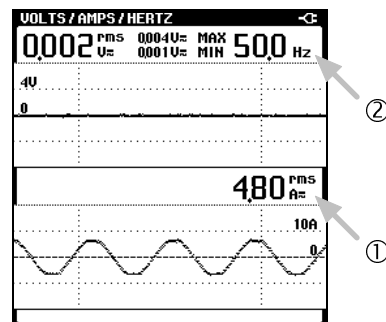
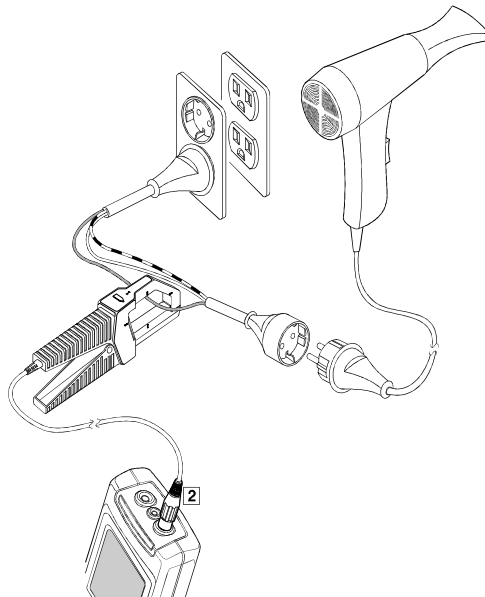
*Note*

*Nominal voltages and frequencies differ by country.*

## Measuring Current

Determine how the current from an outlet is supplied to a load, in this example, a hair dryer.

- 1  Open the main menu.
- 2   
- 3 Make connections as shown below:







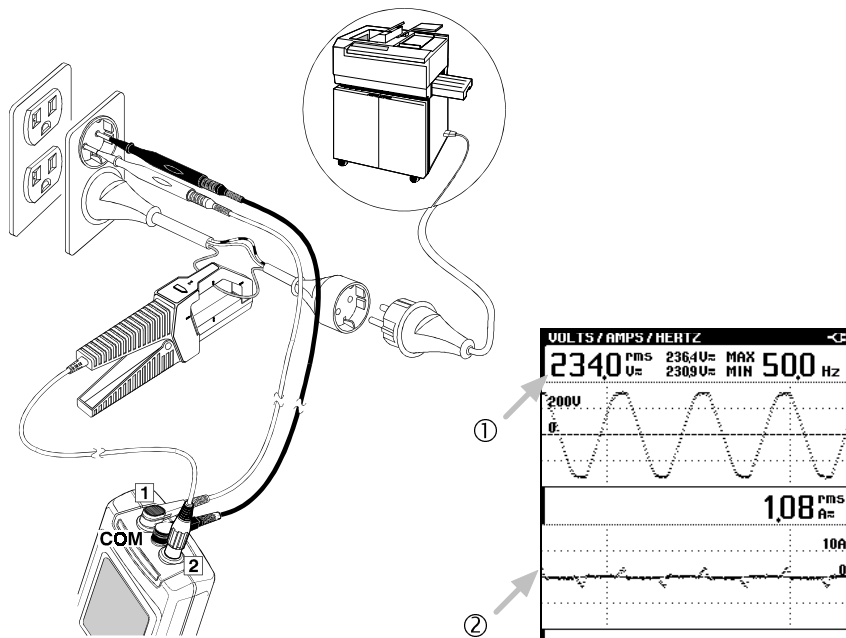
- 4 Turn on the hair dryer.
- ① When the hair dryer is turned on, the current from the outlet increases.
  - ② Notice that without test leads connected, the Fluke 43 measures the frequency of the current signal.

## Line Voltage and Current Simultaneously

### Measuring Line Voltage and Current

Determine the influence of the load current on the voltage.

- 1  Open the main menu.
- 2   
- 3 Make connections as shown below:



- ① The rms voltage should stay within reasonable limits.
- ② The current increases when the copier is warming up or making a copy.





#### Note

*In stead of a copier, you can also use other loads of 1000W or more.*

### **Recording Line Voltage and Current**

By recording the voltage and current, you can establish a possible relation between the two. For recording voltage and current, always use **SAGS & SWELLS**. Basically it does the same as the **RECORD** key, but it can record faster fluctuations. Use the **RECORD** key for all other combinations of readings you want to record.

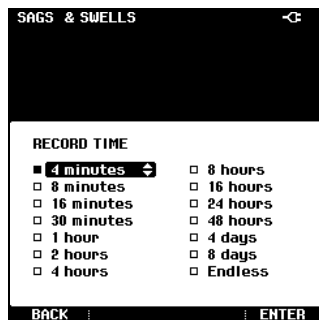
Use the copier again and proceed as follows:

- 1  Open the main menu.
- 2   



Select the desired record time:

- 3   
- 4   



*Note*

*Choosing shorter recording times makes it easier to see details of events on the screen.*

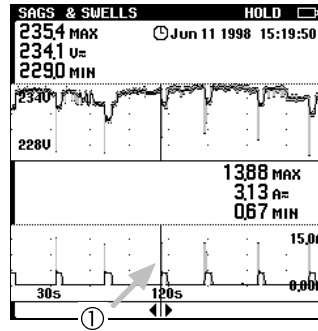
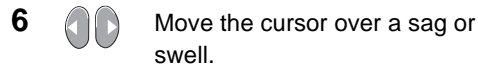
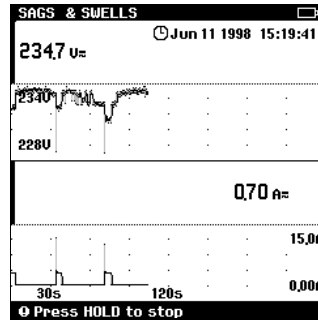
**Fluke 43**  
Applications Manual

---



The Fluke 43 starts recording sags and swells.

Wait for 4 minutes... or press the **HOLD** key to stop the recording.









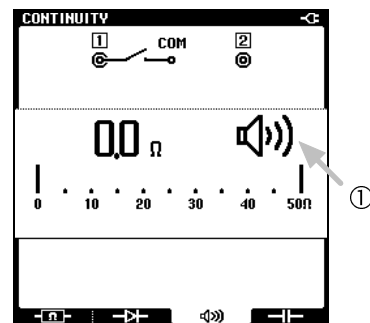
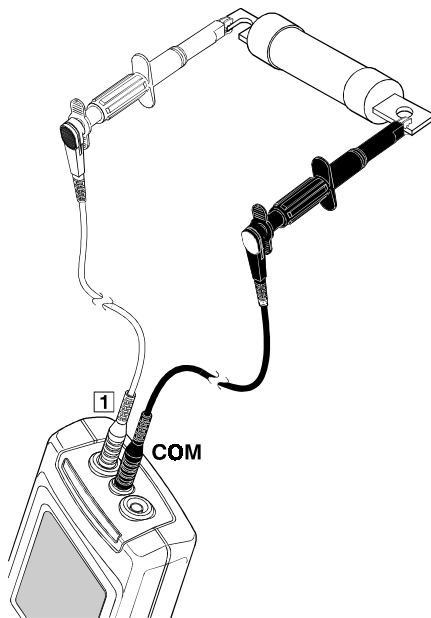
- ① In this example, the high peak current from the copier caused the voltage to drop (voltage sag).

In general, if you find voltage sags, the next step is to look for devices which may cause them. Poor connections or long conductors increase the effect.

## Testing Continuity

Check whether a fuse is broken or open by checking continuity. In general, you can check any circuit for open connection.

- 1  Open the main menu.
- 2   
- 3  Select  (continuity)
- 4 Make connections as shown below:








- ① When the Fluke 43 beeps and shows a beep-icon, the fuse is closed.  
When the Fluke 43 shows **OL** (Over Load), the fuse is open.

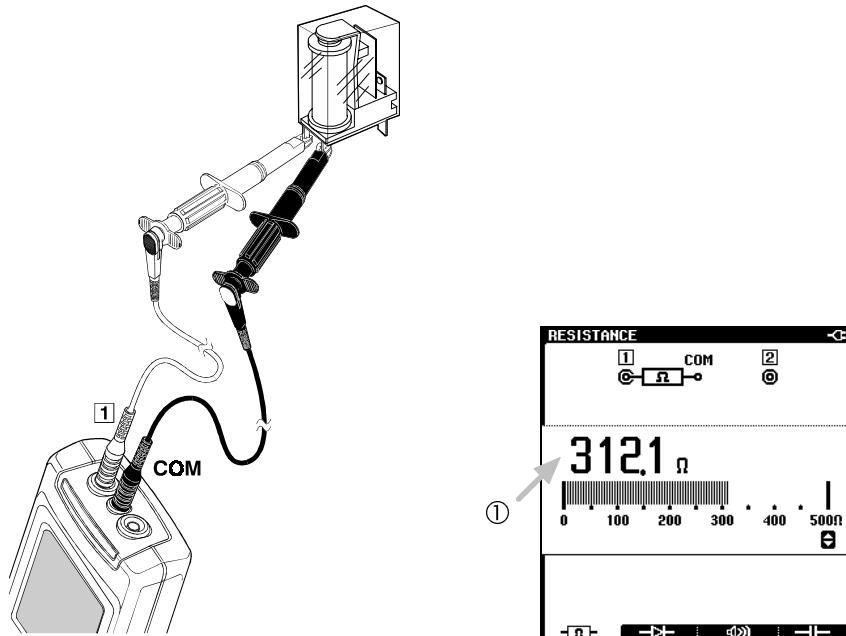
### Note

When the resistance is high ( $>30\Omega$ ), an open circuit is indicated, otherwise the circuit is considered to be closed ( $0 - 30\Omega$ ).

## Measuring Resistance

Measure the resistance of a relay coil (or a resistor).

- 1  Open the main menu.
- 2  **OHMS/CONTINUITY/CAPACITANCE** → 
- 3  Select  (ohm)
- 4 Make connections as shown below:




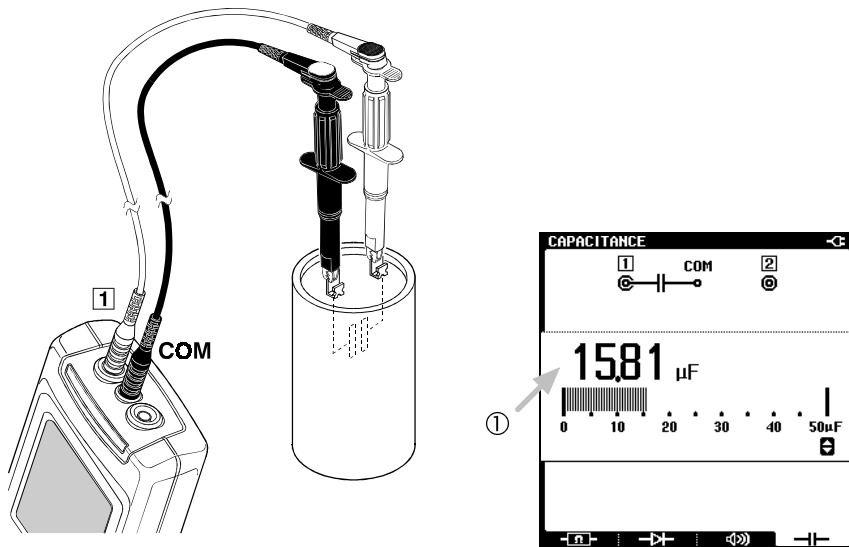
- ① Observe the resistance. A typical reading on the display should be between about 150 and 500Ω. If the reading seems too high, test a known good device and compare the measured values of both devices.



## Measuring Capacitance

Measure the capacitance of a capacitor ( $\leq 500 \mu\text{F}$ ).






- 1 **MENU** Open the main menu.
- 2 **OHMS/CONTINUITY/CAPACITANCE** → **ENTER**
- 3 **ENTER** Select  (capacitance)
- 4 Make connections as shown below:

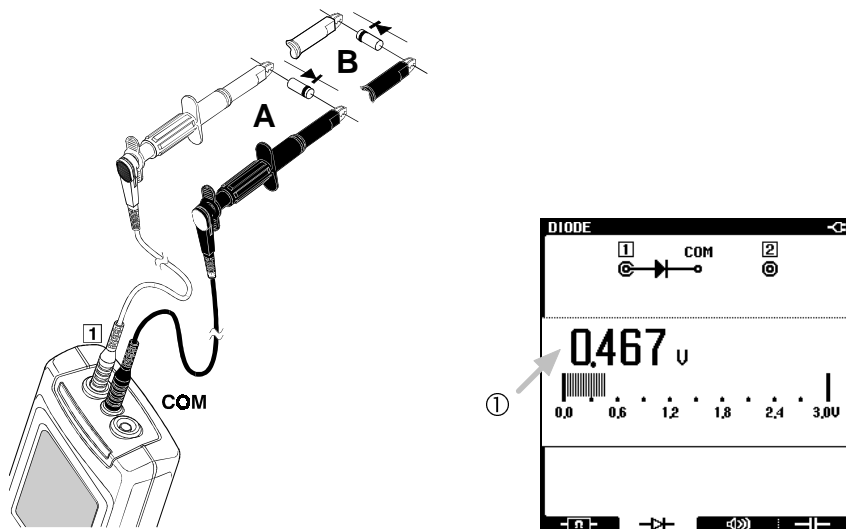


- ① Observe the capacitance. The display shows the measured value of the capacitor. Compare the measured value with the value indicated on the capacitor.

## Testing a Diode

Check a diode in both forward direction and reverse direction. Useful for checking whether the diodes in a rectifier are still intact.

- 1  Open the main menu.
- 2  **OHMS/CONTINUITY/CAPACITANCE** → 
- 3  Select  (diode)
- 4 Make connections as shown below:



- ① Observe the voltage in forward direction (A). It should read about 0.5V.  
Now turn the diode in reverse direction (B) and look at the display again.
- The Fluke 43 should display **OL** (Over Load), indicating a very high resistance. If not, the diode is faulty and should be replaced.

## Chapter 2 Receptacle Branch Circuits

### Troubleshooting Electrical Distribution Systems

The most efficient way to troubleshoot electrical systems, is to begin at the load and work towards the building's service entrance. Measurements are taken along the way to isolate faulty components or loads. This chapter describes typical measurements for troubleshooting problems on receptacle branch circuits.

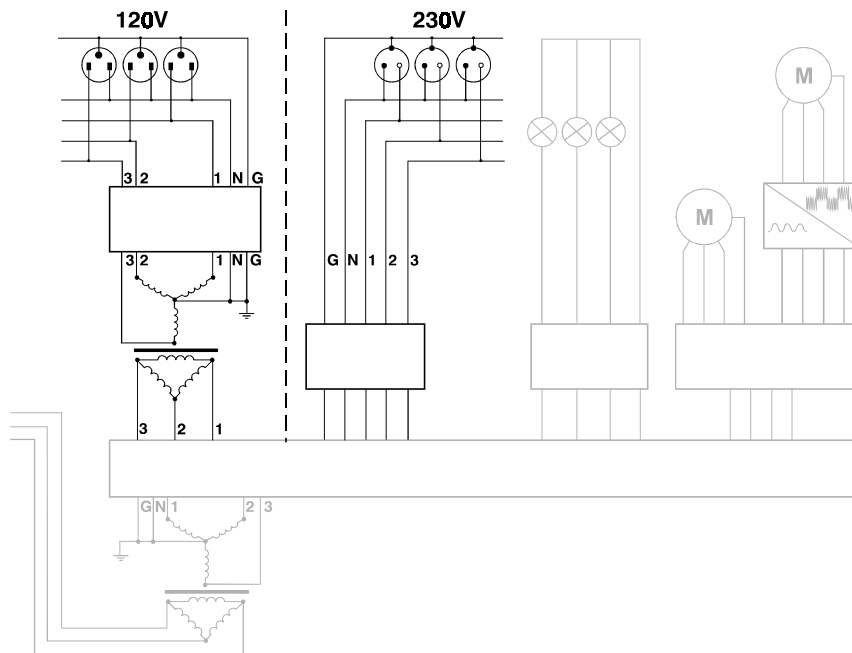









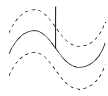
Figure 2. Distribution System: Receptacle Loads

## ***Detecting Transients (Phase to Neutral)***

Disturbances in a distribution system may cause malfunctioning of many types of devices. For example, resetting computers or false tripping breakers. Events occur occasionally, making it necessary to monitor the system for a period of time to find them.

You may look for voltage transients (impulses or spikes) when, for example, computers are resetting spontaneously.

- 1  Open the main menu.
- 2   → 
- 3   → 



*A transient is detected when it crosses the boundaries of the waveform.*

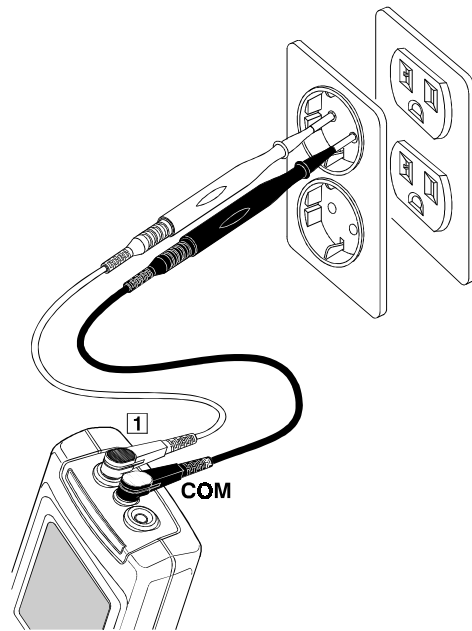
Select a voltage change of 50%.

*If the normal rms voltage is 120V, transients which deviate more than 60V from the normal voltage, are detected. (50% of 120V = 60V).*




- 4   → 

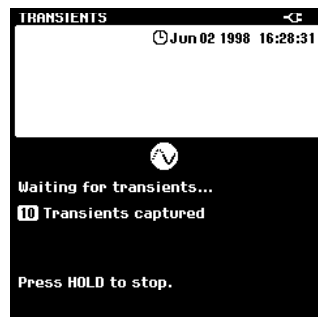
5 Make connections as shown below:



6    

The Fluke 43 starts capturing transients.

7  Press **HOLD** to stop capturing transients.



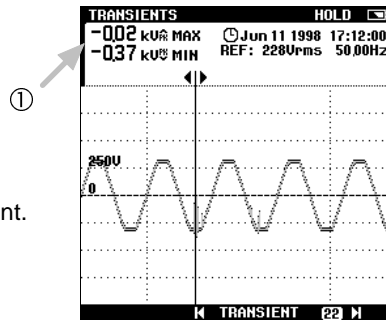
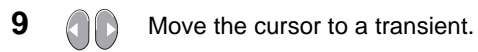
**Fluke 43**  
*Applications Manual*

---

You can now browse through the screens which contain transients:



Choose a screen you want to analyze.






- ① Observe the measured maximum or minimum peak voltage.

If the peak voltage reading indicates **OL** (Over Load), repeat the measurement at a higher value for **VOLTAGE CHANGE**.





## Monitoring Rapid Voltage Fluctuations

Rapid voltage fluctuations in a distribution system may cause lights to flicker. Deviations of only a few cycles (waveform periods) may result in visible dimming.

The **SAGS & SWELLS** function measures the rms voltage over each cycle and displays deviations.

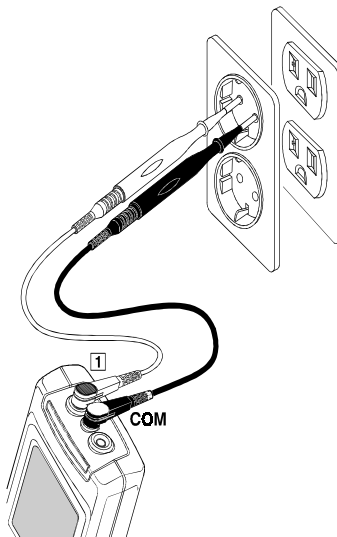
- 1  Open the main menu.
- 2  **SAGS & SWELLS** → 

Select the desired recording time:

- 3  **RECORD TIME** → 
- 4  **4 minutes** (for example) → 



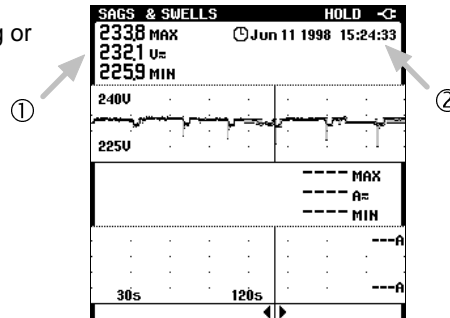
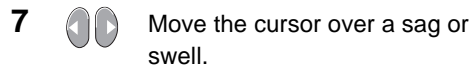
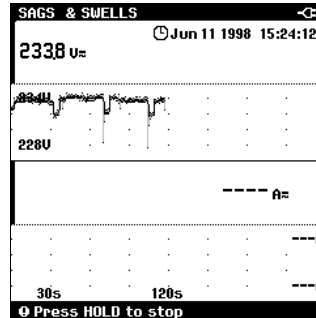
- 5 Make connections as shown below:





The Fluke 43 starts recording sags and swells.

Wait for 4 minutes... or press the **HOLD** key to stop the recording.



- ① Observe the rms voltage of the sag or swell: in case of a sag, read the minimum voltage, in case of a swell the maximum voltage.
- ② Observe the time when it occurred.

Determine where the sag or swell came from:

When the voltage decreases and the current does not change or only slightly, the source of the problem is **upstream**.



When the voltage decreases while the current increases, there is some load that causes the voltage to drop. The source of the problem is **downstream**.








### Tip

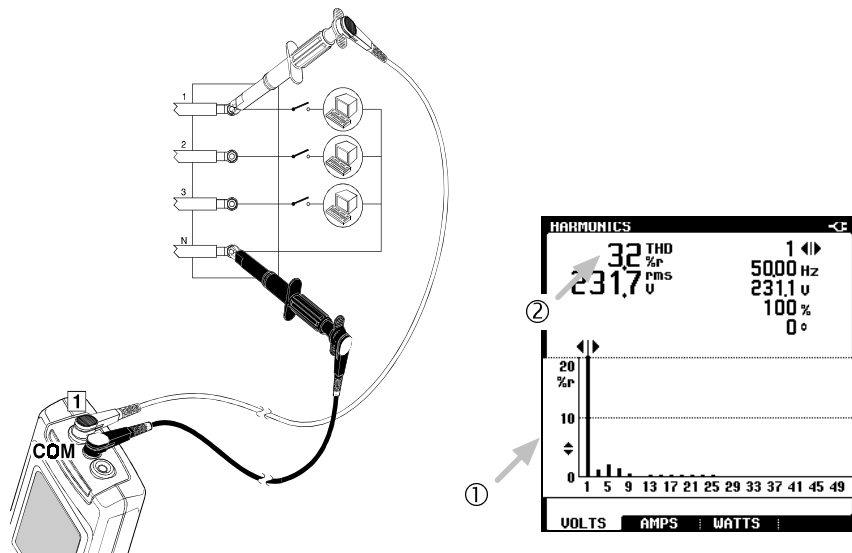
If you find sags or swells, search for equipment which may cause them, such as large motor startups, welders, etc.




## Measuring Voltage Harmonics

You can perform a quick check on harmonics in a power distribution system by measuring the Total Harmonic Distortion on the voltage.





- 1  Open the main menu.
- 2   
- 3  Select VOLTS.
- 4 Make connections as shown below:

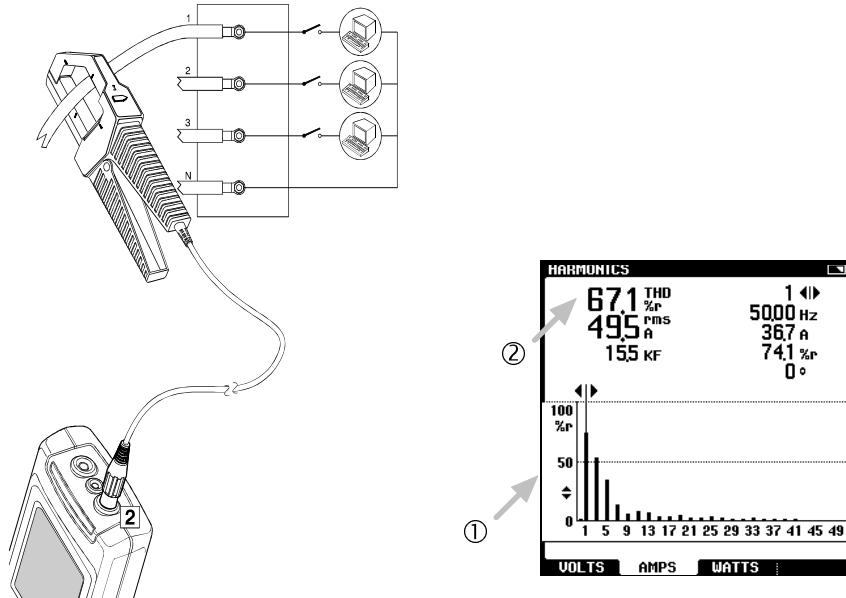



- (5)  Scale the harmonics spectrum screen to see more or less details.
- ① Look at the harmonics spectrum screen. Check the spectrum for severe harmonics.
- ② If the THD is lower than 5%, the voltage distortion level is probably acceptable.

## Measuring Current Harmonics

Non-linear loads produce current harmonics which may cause voltage distortion.

- 1  Open the main menu.
- 2  **HARMONICS** → 
- 3  Select **AMPS**.
- 4 Make connections as shown below:



- (5)  Scale the harmonics spectrum screen to see more or less details.
- ① Look at the harmonics spectrum screen. Check the spectrum for severe harmonics.
- ② Read the THD. It indicates the harmonic distortion on the current signal. Usually, the current signal can tolerate more harmonics than the voltage signal.

**Tip**





Measure harmonic currents at the point of common coupling to check whether the THD and individual harmonics comply with national standards (like IEEE-519). It is incorrect to apply such standards to specific loads.

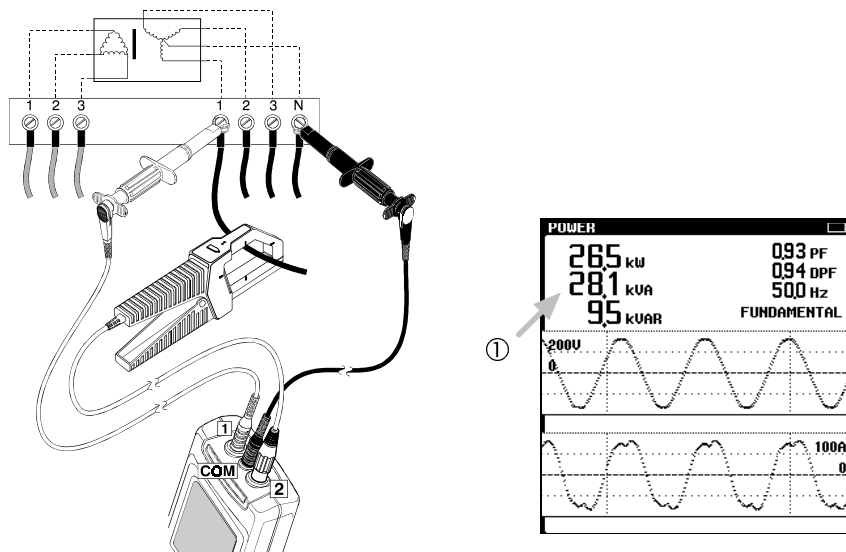
Zero-sequence harmonics (3rd, 9th, 15th, ...) add in neutral conductors or bus bars. This can cause overheating in neutral wires.

By measuring current harmonics at several places in a distribution system, you can track the harmonic source. The closer you get to the source, the more severe the current THD will be.

## Measuring the Load on a Transformer

Measure the total kVA on all three phases to check the load on a transformer.

- 1  Open the main menu.
- 2   **POWER** 
- 3 Make connections as shown below:







- ① Look at the kVA reading. It shows the apparent power on phase 1. Write down the value ( $kVA_1$ ).
- 4 Repeat the measurement on phase 2 and phase 3 (keep the black test lead connected to the neutral). Write down the values for  $kVA_2$  and  $kVA_3$  and calculate  $kVA_{TOTAL}$

$\underline{\hspace{2cm}} kVA_1 + \underline{\hspace{2cm}} kVA_2 + \underline{\hspace{2cm}} kVA_3 = \underline{\hspace{2cm}} kVA_{TOTAL}$
---

Compare this result with the transformer kVA rating. If the result is close to, or over the nameplate reading of the transformer, reduce the load on the transformer. If this is impossible, the transformer should be replaced by a unit with a higher kVA (or K-rating if harmonic currents are present).

### Recording the Load on a Transformer

By recording the kVA during several hours, you can find out if there are specific moments during the day that the transformer may become overloaded.

- 1  Open the main menu.
- 2  **POWER** 
- 3  Open the RECORD menu.







Select the desired record time:

- 4  **RECORD TIME** 
- 5  **8 hours** 



Select the first reading to record:

- 6  **FIRST READING** 
- 7  **VA** 



Repeat step 6 and 7 to select the second reading, or continue with step 8.

**Fluke 43**  
*Applications Manual*

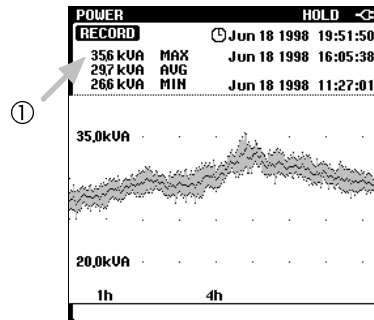
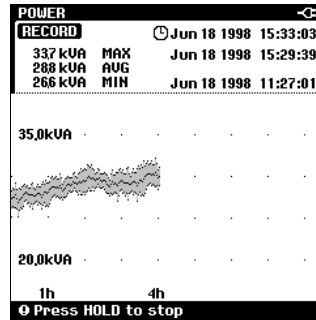
---

Use the power adapter to prevent automatic shutdown during recording.



The Fluke 43 starts recording the kVA reading.

Wait for 8 hours... or press the HOLD key to stop the recording.








- ① Look for high kVA-readings during the day.

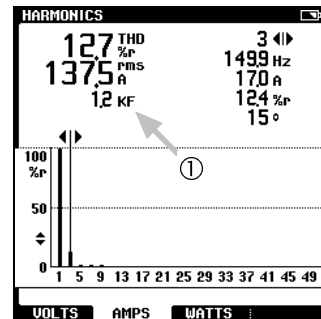
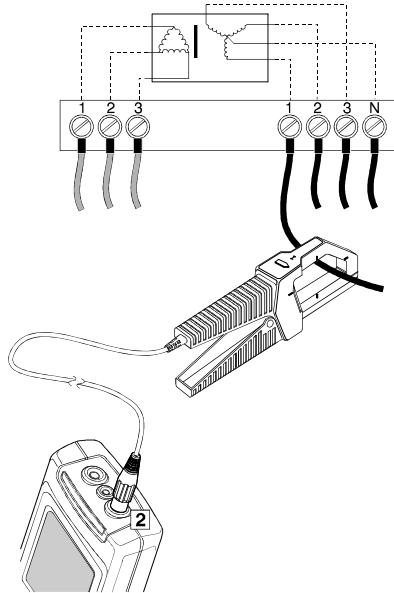
*Note*

*Note that the kVA of only 1 phase was recorded. Record the other two phases also before drawing conclusions.*

## Measuring K-factor

K-factor is an indication of the amount of harmonic currents. High harmonic orders influence the K-factor more than low harmonic orders.

- 1  Open the main menu.
- 2   
- 3  Select AMPS.
- 4 Make connections as shown below. Measure the K-factor under full load.



- ① Observe the K-factor (KF).
- 5 Measure the K-factor on phase 2 and phase 3 too, and take the highest KF-reading.

(continue on next page)

**Fluke 43**  
*Applications Manual*

---

If the measured K-factor is higher than the K-factor specified on the transformer, you either must replace the transformer by a transformer with a higher K-rating, or reduce the maximum load on the transformer.

When choosing a replacement transformer, use the next trade-size higher than the highest measured K-factor. For example, a measurement of 10.3 KF on an installed transformer means replacing it with a K-13 unit.



# Chapter 3 Lighting Loads

## Introduction

This chapter provides applications of problems and phenomena that are likely to occur in a lighting system.

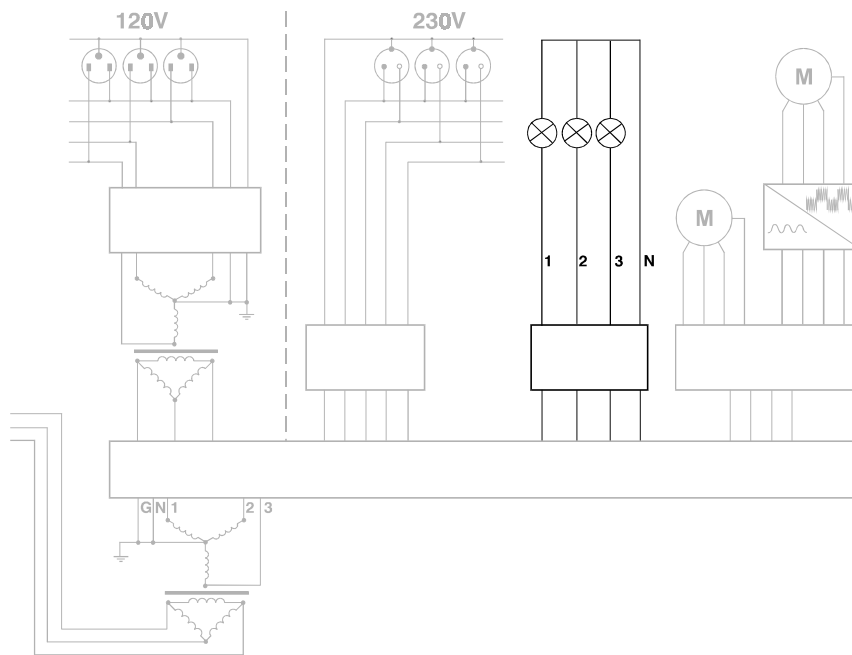





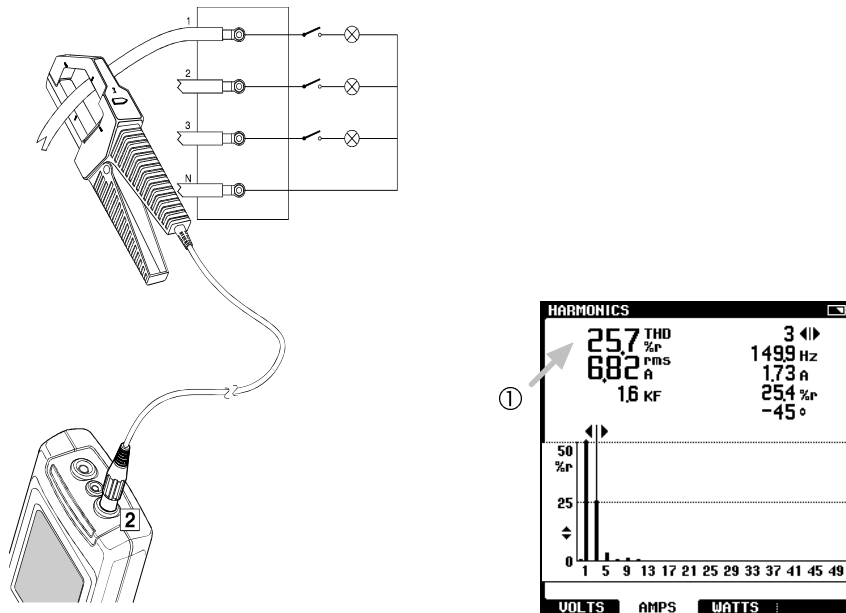


Figure 3. Distribution System: Lighting Loads

## Measuring Current Harmonics

Check whether the lighting system causes excessive harmonics. These may influence the system.

- 1  Open the main menu.
- 2   
- 3  Select AMPS.
- 4 Make connections as shown below. Turn all lights on.







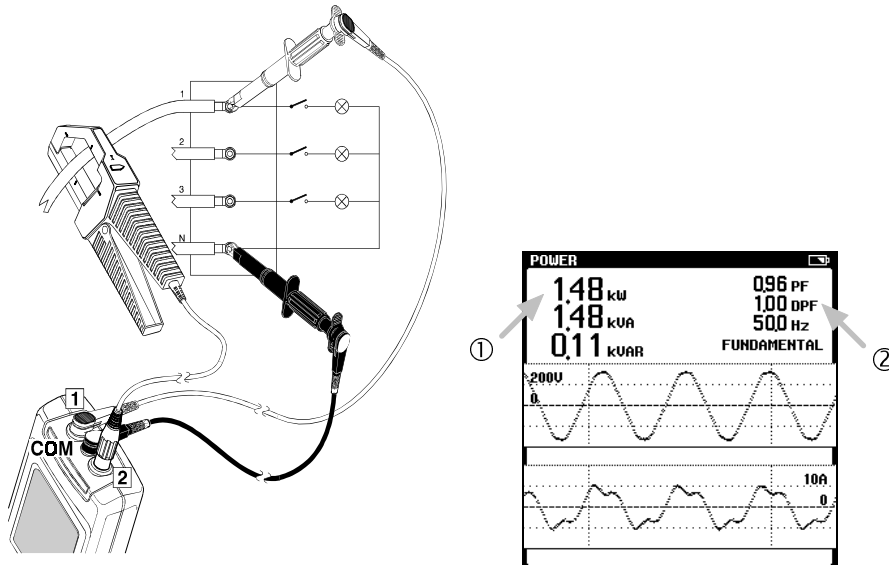
- ① Look at the harmonics spectrum and read the THD value. If the current THD is less than 20%, the harmonic distortion is probably acceptable.

Consider replacing lights with a better quality (which produces less harmonics) or install a harmonic filter to avoid the injection of harmonics into the system.

## Measuring Power on Single Phase Loads

Inductive loads, such as fluorescent lamps, cause a phase shift between the voltage and the current. This influences the real power consumption.

- 1  Open the main menu.
- 2   
- 3 Make connections as shown below:







- ① Look at the W reading. It shows the real power consumption of the lights.
- ② Look at DPF ( $\cos \varphi$ ) reading. Low DPF means that corrective measures have to be taken such as installing capacitors to correct the phase shift between the voltage and the current.

*Note*







*If PF and DPF differ greatly, this indicates the presence of harmonics. Check for harmonics first, before installing capacitors.*

## **Measuring Surge Current**







Check for a high inrush currents that may cause voltage sags in a 'weak' lighting system. A system is considered 'weak' when it has a high impedance.

- 1  Open the main menu.
- 2   → 

Set the expected maximum current during the inrush:

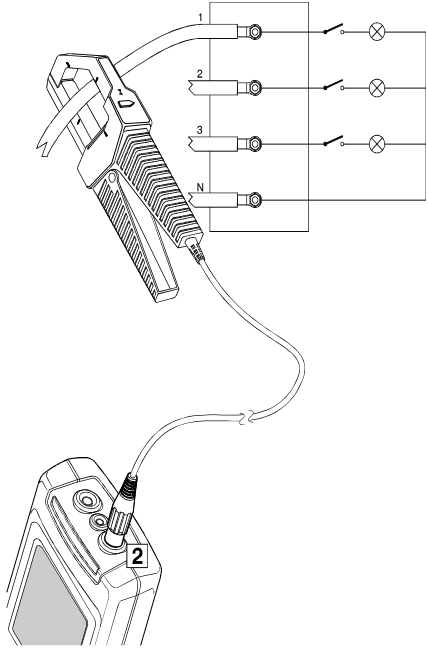
- 3   → 
- 4   → 

Set the expected inrush time:

- 5   → 
- 6   → 



7 Make connections as shown below:






8    → 

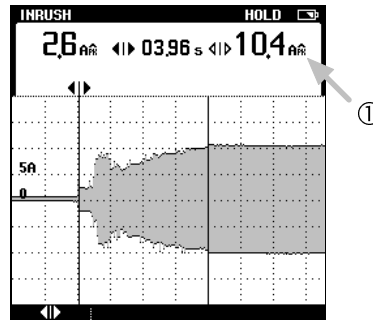
9 Turn on the lights.  
If nothing happens:

 Press HOLD to stop.

Repeat the measurement at a lower value for **MAXIMUM CURRENT** in step 3 and 4.



- 10  Move the left cursor to the beginning of the inrush.
- 11  Select the right cursor.
- 12  Move the right cursor to the end of the inrush.



- ① Read the peak current. It indicates the maximum current during the moment the lights were turned on.

### Tip

Perform a sags and swells measurement (see chapter 2: “*Monitoring rapid Voltage Fluctuations*”) while turning on the lights to examine whether voltage sags will occur in other parts of the distribution system.

## Chapter 4 Motor Loads

### Introduction

This section provides examples that you can use to troubleshoot induction motors with and without an adjustable speed drive.

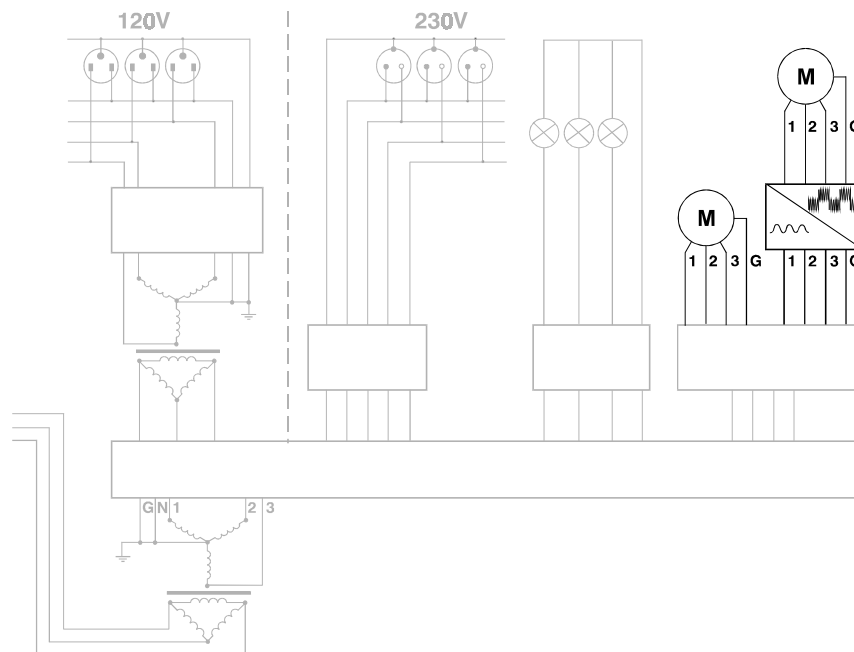






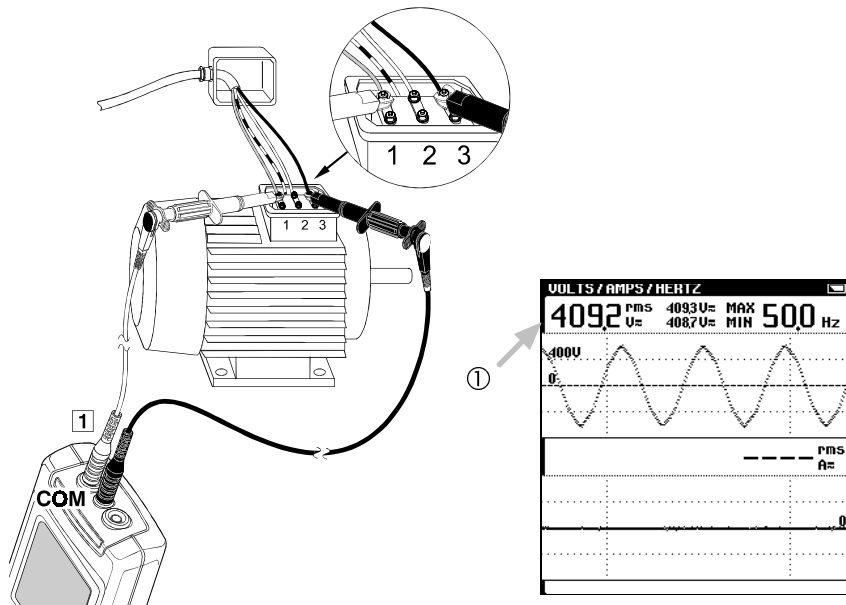
Figure 4. Distribution System: Motor Loads

## Induction Motors

### Checking Voltage Imbalance

For 3 phase induction motors, the supply voltage on all three phases should be in balance. Voltage imbalance causes high unbalanced currents in the stator windings, resulting in overheating and reduced motor life.

- 1  Open the main menu.
- 2   → 
- 3 Make connections as shown below:



- ① Write down the voltage reading of phase 1 to phase 3 ( $V_{1-3}$ ).
- 4 Repeat this measurement for phase 2 to phase 3, and for phase 1 to phase 2. Write down the values for  $V_{2-3}$  and  $V_{1-2}$ .



**5** Calculate the voltage imbalance (fill in your measurement results):

**a** First calculate the average voltage:

<b>Average Voltage:</b>		
$\frac{\text{___ } V_{1-3} + \text{___ } V_{2-3} + \text{___ } V_{1-2}}{3}$	$= \frac{\text{___ } V}{3}$	$= \text{___ } V_{\text{AVERAGE}}$

**b** Second, calculate the maximum deviation from the mean. Ignore the minus signs:

<b>Maximum Deviation:</b>		
$V_{1-3} - V_{\text{AVERAGE}} = \text{___ } V$		
$V_{2-3} - V_{\text{AVERAGE}} = \text{___ } V$	<b>Largest deviation:</b>	$\text{___ } V_{\text{DEVIATION}}$
$V_{1-2} - V_{\text{AVERAGE}} = \text{___ } V$		

**c** Finally, calculate the voltage imbalance:

<b>Voltage Imbalance:</b>		
$\frac{\text{___ } V_{\text{DEVIATION}}}{\text{___ } V_{\text{AVERAGE}}}$	$\times 100\%$	$= \text{___ } \%$





Voltage imbalance for three-phase motors should not exceed **1%**. Voltage imbalance may be caused by bad connections, contacts or fuses; or is caused by problems at the source transformer.

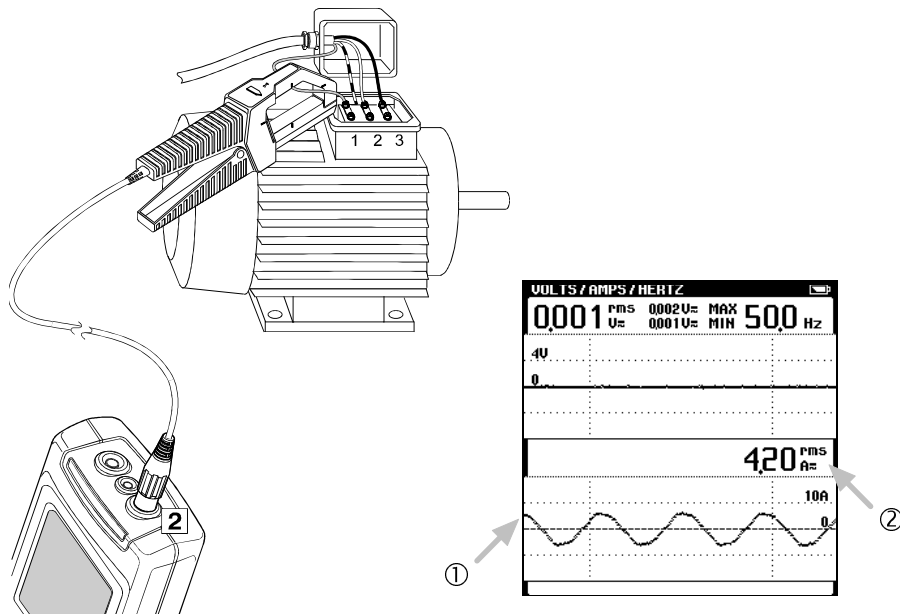
**Example**

<b>a</b>	$\frac{403 V_{1-3} + 391 V_{2-3} + 406 V_{1-2}}{3} = \frac{1200 V}{3} = 400 V_{\text{AVERAGE}}$
<b>b</b>	$403 V_{1-3} - 400 V_{\text{AVERAGE}} = 3 V$ $391 V_{2-3} - 400 V_{\text{AVERAGE}} = -9 V$ <b>Largest deviation:</b> $9 V_{\text{DEVIATION}}$ $406 V_{1-2} - 400 V_{\text{AVERAGE}} = 6 V$
<b>c</b>	$\frac{9 V_{\text{DEVIATION}}}{400 V_{\text{AVERAGE}}} \times 100\% = 2.25 \%$

### Checking Current and Current Imbalance

After checking voltage imbalance, check for current and current imbalance. Unbalanced currents cause overheating and reduce motor life. Also single phasing (complete loss of power on one of the phases feeding the motor) may cause overheating in the two other phase windings.

- 1  Open the main menu.
- 2   
- 3 Make connections as shown below. Run the motor at full load.



- 1 If no current is present, you may assume an open fuse or winding.
- 2 Write down the current reading ( $A_1$ ).
- 4 Repeat this measurement for phase 2 and phase 3. Write down the values for  $A_2$  and  $A_3$ .

- 5 Calculate the current imbalance. Use the same formula as in the previous section but substitute current for voltage.

Current imbalance for three-phase motors should not exceed **10%**.

**Example**





<b>a</b>	$\frac{33 A_1 + 29 A_2 + 34 A_3 = 96 A_{\text{TOTAL}}}{3} = 32 A_{\text{AVERAGE}}$
<b>b</b>	$\begin{aligned} 33 A_1 - 32 A_{\text{AVERAGE}} &= 1 \text{ A} \\ 29 A_2 - 32 A_{\text{AVERAGE}} &= -3 \text{ A} \\ 34 A_3 - 32 A_{\text{AVERAGE}} &= 2 \text{ A} \end{aligned}$ <p style="text-align: right; margin-right: 50px;">Largest value: 3 A<sub>DEVIATION</sub></p>
<b>c</b>	$\frac{3 A_{\text{DEVIATION}}}{32 A_{\text{AVERAGE}}} \times 100\% = 9.4 \%$

*Note*







*To detect single phasing, always check the current on all three phases. When a voltage measurement is made at the motor terminals, the voltages will read close to normal as motor action is inducing voltage into the open winding.*

## **Measuring Peak and Inrush Current**







High inrush currents of motors can cause breakers to trip or fuses to open.

- 1  Open the main menu.
- 2   → 

Set the maximum expected current during the inrush. This might be 6 to 14 times the full load current of the motor.

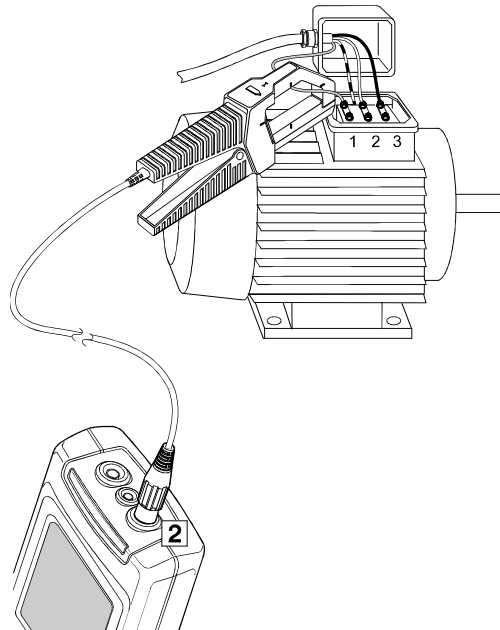
- 3   → 
- 4   → 

Set the expected inrush time:

- 5   → 
- 6   → 

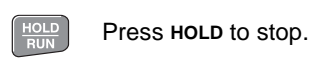


7 Make connections as shown below:



9 Turn the motor on.

If nothing happens:




Repeat the measurement at a lower value for **MAXIMUM CURRENT** in steps 3 and 4.




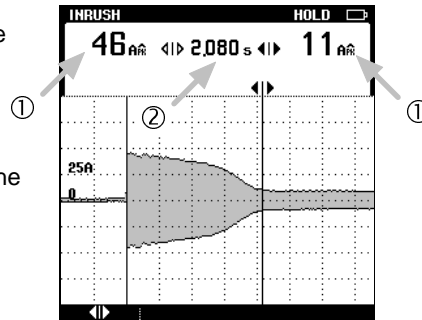
**Fluke 43**  
*Applications Manual*

---

**10**  Move the left cursor to the beginning of the inrush.

**11**  Select the right cursor.

**12**  Move the right cursor to the end of the inrush.



① Read the peak currents at the cursors. Can fuses and breakers withstand these currents? Are conductors properly sized?

② Read the time between the cursors. Can fuses and breakers withstand the inrush current during this period? Fast acting breakers and fuses may trip.





**13** Repeat this measurement for phase 2 and phase 3.

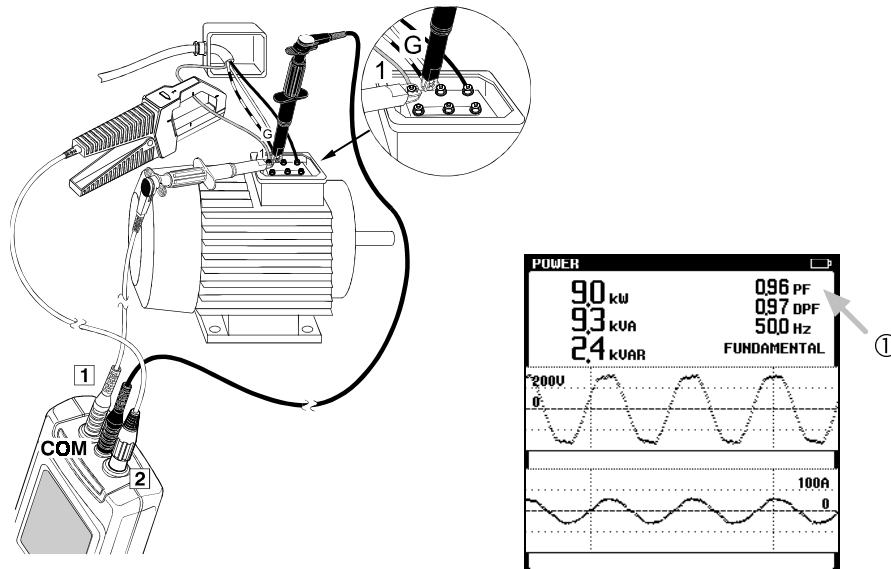
### Measuring Power Factor of 3-Phase Motors

A power factor with a value close to 1 means that nearly all supplied power is consumed by the motor. A power factor of less than 1 results in extra currents, called *reactive currents*. This requires larger power lines and transformers. Also there will be more power loss in the transmission lines.

#### Grounded Y-Connection with Balanced Load

For balanced motors with a grounded Y-connection, you can read the Power Factor directly from the screen. To test for a grounded Y, simply check the three phase-to-ground voltages. If the voltages are stable and equal, then the system is wired as a grounded Y. Measure Power Factor as follows:





- 1  Open the main menu.
- 2   → 
- 3 Make connections as shown below. Run the motor under normal full load (power factor decreases at less than full load).

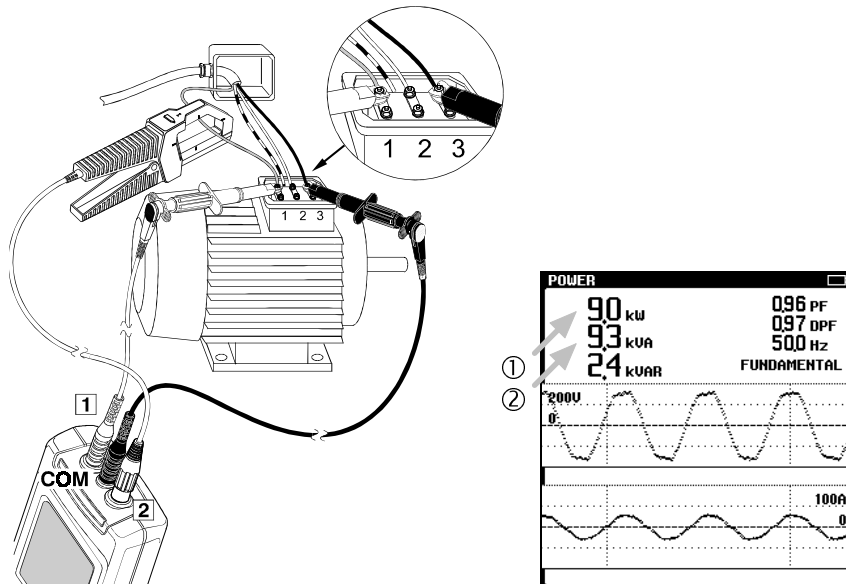


- ① Observe the Power Factor.

### Delta connection or floating systems

For delta systems, the procedure is more complex. Use the following procedure to calculate the Power Factor for a 3-phase grounded delta connected motor or for floating sources.

- 1  Open the main menu.
- 2   → 
- 3 Make connections to phase 1 and 3 as shown below. Run the motor under normal full load (power factor decreases at less than full load).



- ① Write down the true power reading ( $kW_t$ ) from phase 1 to 3.
- ② Write down the apparent power reading ( $kVA$ ).



- 4 Move the red test lead and the current probe to phase 2 (keep the black test lead attached to phase 3).

Write down the value for true power reading ( $kW_2$ ). If the power factor is smaller than 1,  $kW_1$  and  $kW_2$  will be different even if the load currents are equally balanced. Note that the apparent power (kVA) is equal to the first measurement.

- 5 Calculate the power factor (fill in your measurement results):

$\frac{\text{___ } kW_1 + \text{___ } kW_2}{\sqrt{3} * \text{___ } kVA} = \frac{\text{___ } kW_{TOTAL}}{\text{___ } kVA} = \text{___}$
--

**Example**





<b>Measured: <math>kW_1 = 170 kW</math>   <math>kW_2 = 68 kW</math>   <math>kVA = 188 kVA</math></b>		
$\frac{170 kW + 68 kW}{1.73 * 188 kVA} = \frac{238 kW_{TOTAL}}{325,6 kVA} = 0.73$		

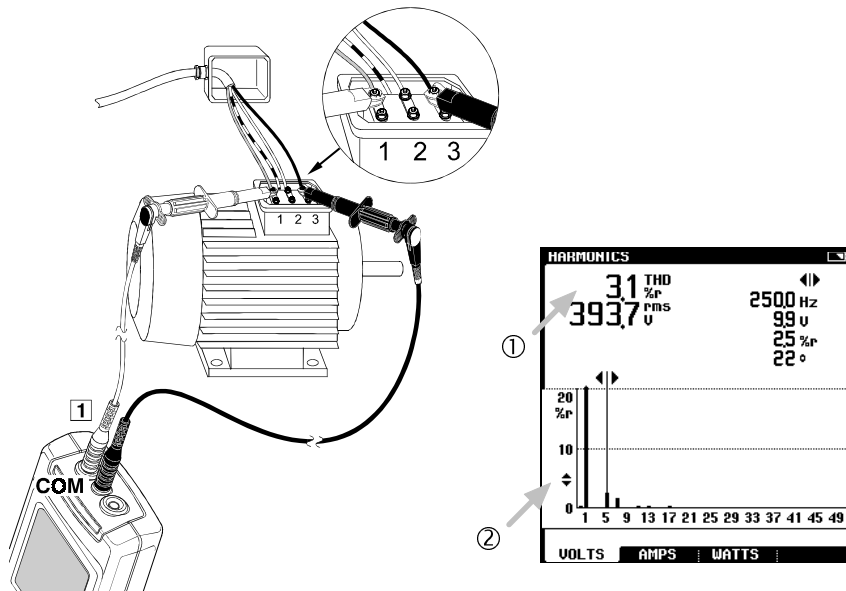
Poor power factor can be improved by adding capacitors in parallel with the load.

If harmonics are present, consult with a qualified engineer before installing capacitors. Non-linear loads such as adjustable frequency motor drives cause non-sinusoidal load currents with harmonics. Harmonic currents increase the kVA and thereby decrease total power factor. Poor total power factor caused by harmonics requires filtering for correction.

## Measuring Voltage Harmonics

When the supply voltage is distorted by harmonics, the motor can suffer from overheating.

- 1  Open the main menu.
- 2   → 
- 3 Make connections as shown below:







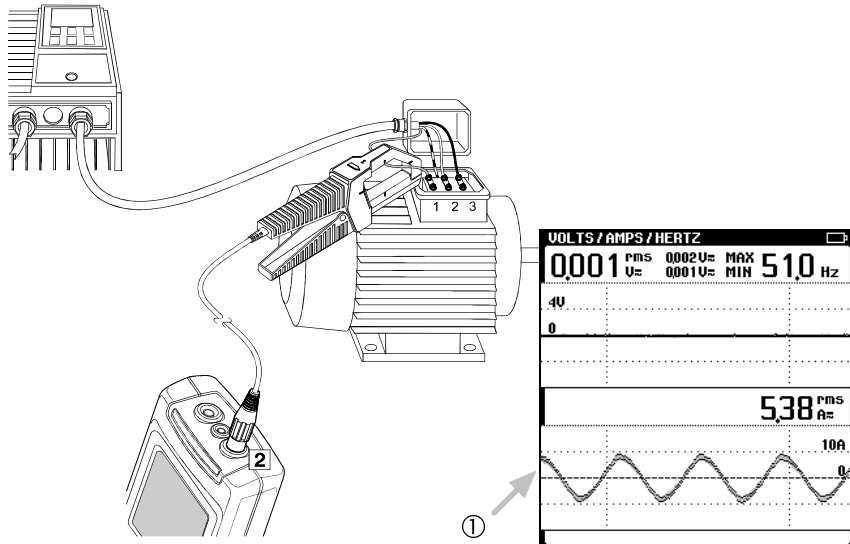
- ① Look at the THD reading. In general, the Total Harmonic Distortion of the voltage supplied to an induction motor should not exceed 5%.
- ② Look at the harmonic spectrum.  
Negative sequence harmonics (5th, 11th, 17th, etc.) will cause most heating because they try to run the motor slower than fundamental (they create reverse rotating magnetic fields within the motor). Positive sequence harmonics (7th, 13th, 19th, etc.) also cause heating because they try to run the motor faster than fundamental.

## Adjustable Speed Drives

### Checking Current on Phases

When a motor drive is tripping, first check for voltage imbalance (see “Checking Voltage Imbalance”). Then check the current on all three phases feeding the motor.

- 1**  Open the main menu.
- 2**   
- 3** Make connections as shown below. Run the motor at full load.







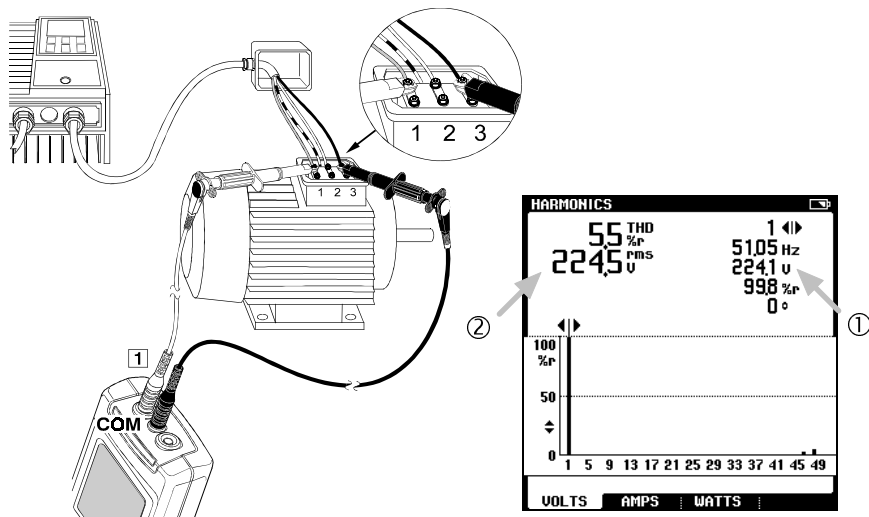
① If no current is present, you may assume an open fuse or an open circuit in wiring. The drive will trip.

- 4** Repeat the measurement for phase 2 and phase 3.

## Measuring Fundamental of Motor Voltage

Check the condition of a drive.





- 1  Open the main menu.
- 2  **HARMONICS** → 
- 3  Move the cursor over the fundamental (1<sup>st</sup>).
- 4 Make connections as shown below. Run the motor at full speed and full load.

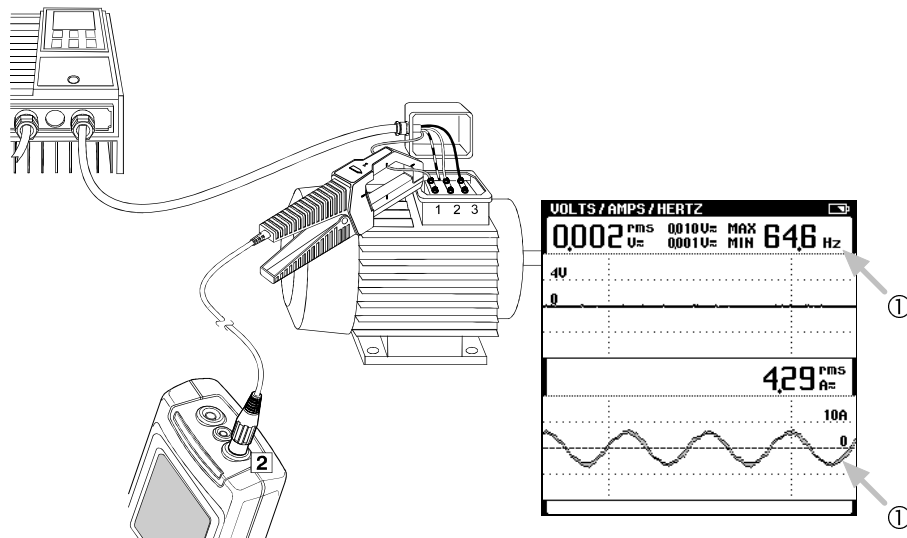


- ① Read the voltage of the fundamental. The voltage should be slightly less than the line voltage. If the voltage is significantly lower than the line voltage, it indicates an improper drive. To be sure, compare with a known good drive.
- ② Read the total rms voltage. If the value on the drive display is lower, the display probably shows the average voltage instead of the rms voltage.

### Measuring Frequency of Motor Current

The frequency of the motor current correlates with motor speed.

- 1  Open the main menu.
- 2   → 
- 3 Make connections as shown below:



- ① Vary the speed of the motor and look at the frequency and the waveshape of the current. The frequency of the current should correlate with the speed of the motor.
- 4 Repeat this measurement for phase 2 and phase 3.

*Note*

*Because there is no voltage signal present, the frequency is calculated from the current signal on input 2.*



## Chapter 5 Handling Screens

### Introduction

This section describes saving, viewing and printing of screens. It also describes how screens can be used in Word® documents to create reports.

First, perform a measurement, for example measuring line voltage. Use this screen to experiment. Of course, you can use any result screen instead.

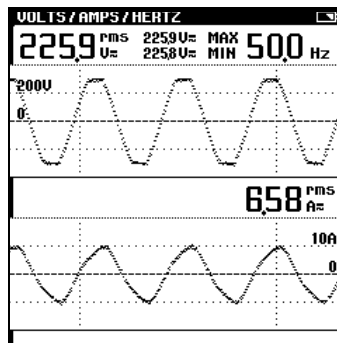



Figure 5. VOLTS/AMPS/HERTZ screen

## Saving Screens











Almost any measurement screen that is on the display, can be saved by simply pressing the **SAVE** key. Only when the message "Press HOLD to stop" is displayed, the **SAVE** key is disabled.

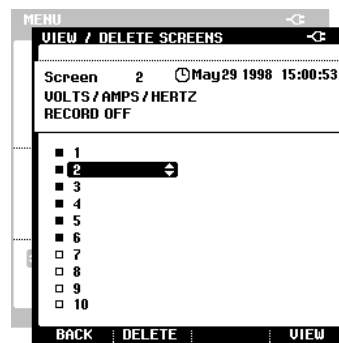
- 1  Save the screen.

After a few moments you will see a message telling that the screen has been saved. Repeat this action several times to fill more memories with screens.







If you try to save a screen while all memories are filled, you will see a message telling that you first must delete one or more memories.

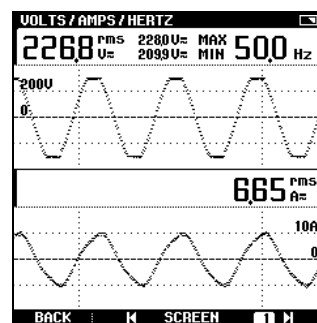
## Viewing and Deleting screens

- 1  Open the main menu.
- 2    → 
- 3     Select a screen.
- 4  Press **VIEW**.



You can now browse through the saved screens:

- 5     
- 6  Press **BACK** to return to the overview screen.



From the overview screen you can delete screens:

- 7  Press **DELETE**.

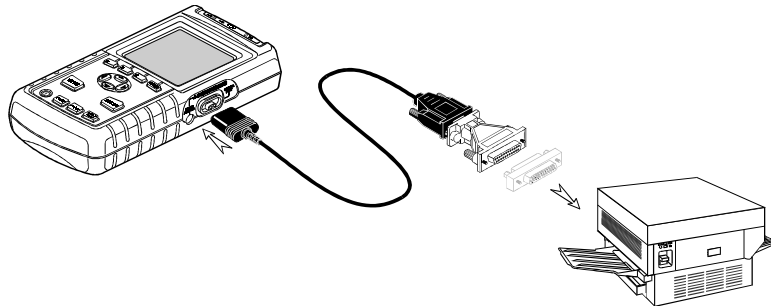
A message appears asking you whether you want to delete this screen. After you confirm, the screen will be deleted.




## Printing Screens

You can print both actual screens and saved screens.

- 1 Connect the Fluke 43 to a printer as shown in the picture below.



- 2  Print the actual screen.  
To print a saved screen, view it first (see previous section "Viewing and Deleting Screens").

If the printer does not print, refer to the Users Manual manual for troubleshooting tips.



### Note

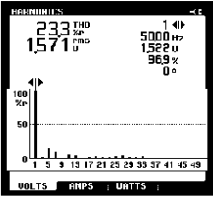
*You can also print screens using FlukeView. Refer to your FlukeView Users Manual for instructions.*


## **Creating Reports**

You can use actual screens or saved screens directly in Word documents which is very useful for creating reports.

First install the FlukeView software for the Power Quality Analyzer by running the **SETUP** program from the floppy disk. (Refer to your FlukeView Users Manual for the complete installation procedure.) The FlukeView **SETUP** program installs a predefined report with the name **QREPORT.DOC**.

- 1 Connect the Fluke 43 to the PC (see FlukeView Users Manual).
- 2  Open the document **QREPORT.DOC**.  
FlukeView 1.0  
Qreport
- 3 Fill out the form by clicking on the grey fields and typing your text.
- 4  Click this button to insert the actual screen from the Fluke 43 into your report.
- 5 Type a description in the **Description** field.

<b>Fluke 43 Power Quality Analyzer Test Report</b>	
<b>Company:</b>	Fluke Industrial
<b>Contact:</b>	A. Person
<b>Address:</b>	Street 43
<b>Zip:</b>	1234 AB
<b>City:</b>	Almelo
<b>Phone:</b>	12 345 678910
<b>Fax:</b>	12 345 678911
<b>E-mail:</b>	aperson@almelo.fluke.nl
<b>Date:</b>	May 6, 1998
<b>Instrument Screen:</b>	
	
<b>Description:</b> On these lines you can type your description.	

- 6  Click this button to print your report.

## Chapter 6

# Definitions

### Active Power

The Active Power (Watt) is that portion of electrical power that is real. It includes heat losses. Utility charges are based on Watts.

### Apparent Power

Apparent Power (VA) is the product of the rms voltage and current which relates to the effective load seen by the transformer and current carrying conductors.

### Black out (see outage)

### Brown out (see sag)

### Cos $\phi$ (see Displacement Power Factor, DPF)

### Displacement Power Factor, DPF (Cos $\phi$ )

The ratio of real power to apparent power. Displacement Power Factor is the cosine of the phase angle between the fundamental current and the fundamental voltage (cos  $\phi$ ). Inductive loads cause current to lag behind voltage, while capacitive loads cause current to lead voltage.

The displacement power factor uses only the fundamental of the signal for its calculation. (*see also: Power Factor*)

DPF	Interpretation
0 to 1	current leads or lags, device is consuming power.
1	current and voltage in phase, device is consuming power.
-1	current and voltage in phase, device is generating power.
-1 to 0	current leads or lags, device generating power.

### Dropout

A discrete voltage loss. A voltage sag\* for a very short period of time (milliseconds).

### Harmonic (component)

**Fluke 43**  
Applications Manual

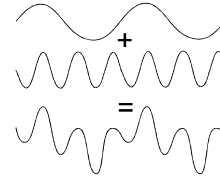
---

A sinusoidal component of an ac voltage that is a multiple of the fundamental frequency.

**Harmonic Distortion**

Periodic distortion of the sine wave. The waveform becomes distorted when higher frequency components are added to the pure sine wave.

(see also: Total Harmonic Distortion)



**Harmonic Order**

A number indicating the harmonic frequency: the first harmonic is the fundamental frequency (50 Hz or 60 Hz), the third harmonic is the component with three times the fundamental frequency (150 Hz or 180 Hz), and so on.

Harmonics can be positive-sequence (+), zero-sequence (0) or negative-sequence (-). Positive-sequence harmonics try to run the motor faster than fundamental; negative-sequence harmonics try to run the motor slower than fundamental. In both cases the motor loses torque and heats up.

Order	F	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	etc.
Frequency	50	100	150	200	250	300	350	400	450	500	600	...
	60	120	180	240	300	360	420	480	540	600	660	...
Sequence	+	-	0	+	-	0	+	-	0	+	-	...

If waveforms are symmetrical, even harmonics disappear.

**Impulse (see Transient)**

**Inrush current**

The initial surge of current required by a load before resistance or impedance increases to its normal operating value.

**K-factor**

A number indicating losses in transformers due to harmonic currents. Higher order harmonics influence the k-factor more than lower order harmonics.

The following definition is used in the Fluke 43 for computing the K-factor:

$$KF = \frac{\sum (h^2 \times I_h^2)}{\sum I_h^2}$$

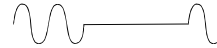
Where: h = harmonic order  
I<sub>h</sub> = harmonic current as a percentage of the fundamental

**Nonlinear load**

Electrical loads in which the instantaneous current is not proportional to the instantaneous voltage. The load impedance varies with the voltage. Electronic loads, with diode/capacitor front-ends are nonlinear loads.

**Outage**

Long term power interruption, longer than 1 minute.



**Overvoltage**

The voltage is above its nominal value on a long term (longer than 10 cycles).



**Point of Common Coupling (PCC)**

Point where utility responsibility ends and building owner responsibility begins. Usually at the main transformer or at the revenue meter.

**Power Factor (PF)**

The ratio of real power to apparent power. Inductive loads cause current to lag behind voltage, while capacitive loads cause current to lead voltage. Also the presence of harmonic currents decrease the Power Factor.

The power factor uses the total rms value, thus including all harmonics, for its calculation. (see also: *Displacement Power Factor*)

PF	Interpretation
0 to 1	not all supplied power is consumed, reactive power present.
1	device is consuming all supplied power, no reactive power.
-1	device is generating power, current and voltage in phase.
-1 to 0	device generating power, current leads or lags.

**Reactive Power**

The Reactive Power (VAR) is the reactive component of the apparent power, caused by a phase shift between ac current and voltage in inductors (coils) and capacitors.

VARs are present in a distribution system as a result of inductive loads, such as motors, reactors, and transformers. VAR's are compensated for by correction capacitors.

**Real Power (see Active Power)**

**Sag**

A sag is a temporary voltage decrease caused by, for example, large equipment starting up or shutting down.



The duration is usually from one cycle to a few seconds.

**Spike (see Transient)**

**Surge (see see also Swell)**

The term surge is sometimes associated with lightning-related overvoltages.

**Swell**

A swell is a temporary voltage increase. The duration is usually from one cycle to a few seconds.



**Total Harmonic Distortion (THD)**

THD is the amount of harmonics in a signal as a percentage of the total RMS value (THD-R) or as a percentage of the fundamental (THD-F). It is a measure of the degree to which a waveform deviates from a purely sinusoidal form. 0% indicates that there is no distortion. You can select THD-R or THD-F in the instrument setup menu.

**Transient**

A very short and sharp increase or decrease in the voltage (or current) on a waveform.

(Also: impulse, spike)



**True Power (see Active Power)**

**Undervoltage**

The voltage is below its nominal value on a long term (longer than 10 cycles).



**VA (see Apparent Power)**

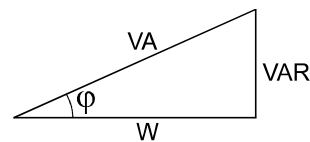
Volt Ampere

**VAR (see Reactive Power)**

Volt Ampere Reactive

**W (see Active Power)**

Watt



# Index

## —A—

Active Power, 55  
Adjustable Speed Drives, 47  
Apparent Power, 55

## —B—

Black out, 55  
Brown out, 55

## —C—

Capacitance, Measuring, 13  
Capacitive Loads, 55  
Continuity, Testing, 11  
Conventions, 2  
Cos  $\phi$  (DPF), 55  
Cos  $\phi$ , Measuring, 31  
Current and Voltage, Measuring, 8  
Current Imbalance, 38  
Current, Measuring, 7, 47

## —D—

Deleting Screens, 52  
Diodes, Testing, 14  
Displacement Power Factor, 55  
Displacement Power Factor,  
    Measuring, 31  
Documenting, 54  
Downstream, 20  
DPF (Cos  $\phi$ ), 55  
Dropout, 55

## —F—

Frequency Of Motor Current,  
    Measuring, 49  
Frequency, Measuring, 6  
Fundamental Of Motor Voltage,  
    Measuring, 48  
Fuses, Testing, 11

## —H—

Harmonic  
    Component, 55  
    Distortion, 56  
    Order, 56  
Harmonics  
    Current, 22, 30  
    Negative-sequence, 56  
    Positive-sequence, 56  
    Voltage, 21, 46  
    Zero-sequence, 56

## —I—

Imbalance  
    Current, 38  
    Voltage, 36  
Impulse, 58  
Impulses, Detecting, 16  
Inductive Loads, 55  
Initial Settings, 4  
Inrush current, 56  
Inrush Current, Measuring, 32, 40

## —K—

KF, 56

**Fluke 43**  
*Applications Guide*

---

K-factor, 56

K-factor, Measuring, 27

**—L—**

Lighting Loads, 29

Line Voltage, Measuring, 6

**—M—**

Main Menu, 2

Motor Loads, 35

**—N—**

Negative Sequence Harmonics, 46

Nonlinear load, 57

**—O—**

Outage, 57

Overvoltage, 57

**—P—**

PCC, 23, 57

Peak Current, 34, 42

Point Of Common Coupling, 23, 57

Positive Sequence Harmonics, 46

Power

Active, 55

Apparent, 55

Reactive, 57

Real, 57

Single Phase, 31

True, 58

Power Factor, 57

Power Factor, Measuring, 43

Printing Screens, 53

**—R—**

Reactive Power, 57

Real Power, 57

Receptacle Loads, 15

Recording

One or Two Readings, 25

Sags and Swells, 9

Report, Creating, 54

Resistance, Measuring, 12

**—S—**

Safety Precautions, 1

Sag, 57

Sags & Swells, Recording, 9, 19

Saving Screens, 52

Screens

Deleting, 52

Printing, 53

Saving, 52

Using in Word, 54

Viewing, 52

Spike, 58

Spikes, Detecting, 16

Surge Current, 56, 58

Surge Current, Measuring, 32

Swell, 58

**—T—**

THD, 58

Total Harmonic Distortion, 58

Current, 22, 30

Voltage, 21, 46

Transformer

Measuring K-factor, 27

Measuring Load, 24

Transient, 58

Transients, Detecting, 16

True Power, 58

**—U—**

Undervoltage, 58

Upstream, 20

**—V—**

VA, 58

VAR, 58

Viewing Screens, 52

Voltage and Current, Measuring, 8

Voltage Fluctuations, Recording,  
19

Voltage Imbalance, 36

**—W—**

W, 58