

FLUKE®

438-II

Motor Analyzer

Users Manual

March 2016

©2016 Fluke Corporation. All rights reserved.

All product names are trademarks of their respective companies.

LIMITED WARRANTY AND LIMITATION OF LIABILITY

Each Fluke product is warranted to be free from defects in material and workmanship under normal use and service. The warranty period is three years and begins on the date of shipment. Parts, product repairs, and services are warranted for 90 days. This warranty extends only to the original buyer or end-user customer of a Fluke authorized reseller, and does not apply to fuses, disposable batteries, or to any product which, in Fluke's opinion, has been misused, altered, neglected, contaminated, or damaged by accident or abnormal conditions of operation or handling. Fluke warrants that software will operate substantially in accordance with its functional specifications for 90 days and that it has been properly recorded on non-defective media. Fluke does not warrant that software will be error free or operate without interruption.

Fluke authorized resellers shall extend this warranty on new and unused products to end-user customers only but have no authority to extend a greater or different warranty on behalf of Fluke. Warranty support is available only if product is purchased through a Fluke authorized sales outlet or Buyer has paid the applicable international price. Fluke reserves the right to invoice Buyer for importation costs of repair/replacement parts when product purchased in one country is submitted for repair in another country.

Fluke's warranty obligation is limited, at Fluke's option, to refund of the purchase price, free of charge repair, or replacement of a defective product which is returned to a Fluke authorized service center within the warranty period.

To obtain warranty service, contact your nearest Fluke authorized service center to obtain return authorization information, then send the product to that service center, with a description of the difficulty, postage and insurance prepaid (FOB Destination). Fluke assumes no risk for damage in transit. Following warranty repair, the product will be returned to Buyer, transportation prepaid (FOB Destination). If Fluke determines that failure was caused by neglect, misuse, contamination, alteration, accident, or abnormal condition of operation or handling, including overvoltage failures caused by use outside the product's specified rating, or normal wear and tear of mechanical components, Fluke will provide an estimate of repair costs and obtain authorization before commencing the work. Following repair, the product will be returned to the Buyer transportation prepaid and the Buyer will be billed for the repair and return transportation charges (FOB Shipping Point).

THIS WARRANTY IS BUYER'S SOLE AND EXCLUSIVE REMEDY AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. FLUKE SHALL NOT BE LIABLE FOR ANY SPECIAL, INDIRECT, INCIDENTAL OR CONSEQUENTIAL DAMAGES OR LOSSES, INCLUDING LOSS OF DATA, ARISING FROM ANY CAUSE OR THEORY.

Since some countries or states do not allow limitation of the term of an implied warranty, or exclusion or limitation of incidental or consequential damages, the limitations and exclusions of this warranty may not apply to every buyer. If any provision of this Warranty is held invalid or unenforceable by a court or other decision-maker of competent jurisdiction, such holding will not affect the validity or enforceability of any other provision.

Fluke Corporation
P.O. Box 9090
Everett, WA 98206-9090
U.S.A.

Fluke Europe B.V.
P.O. Box 1186
5602 BD Eindhoven
The Netherlands

Table of Contents

Title	Page
Introduction	1
How to Contact Fluke	1
Safety Information	2
In The Box	2
Motor Measurements	3
Motor Setup	4
Unit Setup	6
Set Analyzer Limits	6
Trend Setup	7
Motor Analyzer Parameters	8
Mechanical Parameters	8
Electrical Parameters	9
View Analyzer Limit	9
Meter Screen	10
Trend	11
NEMA Derating Screen	12
Voltage Unbalance	12
Voltage Harmonics	13

List of Tables

Table	Title	Page
1.	Motor Configurations	3
2.	Motor Analyzer Range and Accuracy	3
3.	Motor Design Type and Characteristics Summary	4
4.	Nameplate Settings and Ranges	5

Introduction

The Motor Analyzer is a feature that measures mechanical power, torque, and rpm on direct-on-line asynchronous motors. It is a standard feature on the Fluke 438-II and available as an optional upgrade for all models in the Fluke 430 Series II (Fluke 430-II/MA Motor Analyzer upgrade). Combined with electrical power and power-quality measurements, the Motor Analyzer feature provides useful information about a motor's mechanical and electrical operational variables and its efficiency.

The feature dynamically measures critical motor variables as the process operates with no need to use additional mechanical sensors or shut down the process.

The Motor Analyzer is for three wire, three-phase DELTA measurement configurations. If any other configuration is active, the feature prompts you to go to the SETUP menu to specify a supported configuration:

- 3-phase Delta
- 3-phase Open Leg
- 3-phase IT
- 2-Element

How to Contact Fluke

To contact Fluke, call one of the following telephone numbers:

- Technical Support USA: 1-800-44-FLUKE (1-800-443-5853)
- Calibration/Repair USA: 1-888-99-FLUKE (1-888-993-5853)
- Canada: 1-800-36-FLUKE (1-800-363-5853)
- Europe: +31 402-675-200
- Japan: +81-3-6714-3114
- Singapore: +65-6799-5566
- Anywhere in the world: +1-425-446-5500

Or, visit Fluke's website at www.fluke.com.

To register your product, visit <http://register.fluke.com>.

To view, print, or download the latest manual supplement, visit <http://us.fluke.com/usen/support/manuals>.

Safety Information

A **Warning** identifies hazardous conditions and procedures that are dangerous to the user. A **Caution** identifies conditions and procedures that can cause damage to the Product or the equipment under test.

Warning

To prevent possible electrical shock, fire, or personal injury:

- Read all safety information before you use the Product.
- Use the Product only as specified, or the protection supplied by the Product can be compromised.
- Comply with local and national safety codes. Use personal protective equipment (approved rubber gloves, face protection, and flame-resistant clothes) to prevent shock and arc blast injury where hazardous live conductors are exposed.
- Do not use the Product if it is damaged.
- Disable the Product if it is damaged.
- Do not work alone.

See the 434-II/435-II/437-II Users Manual for a complete list of Safety Warnings and explanation of Symbols used on the Product.

In The Box

The Motor Analyzer Kit includes:

- 438 Series II Power Quality and Motor Analyzer (Side Strap, Battery Pack BP290 -28 Wh, and 8 GB SD Wireless SD Memory Card installed)
- Decals for Input Sockets (EU & UK, EU, China, UK, US, Canada)
- Hang Strap
- Alligator Clips (set of 5)
- Test Leads, 2.5 m + Color Coding Clips (set of 5)
- Power Adapter
- Regional Power Cord
- Safety Information (Multi-Language)
- CD-ROM with Manuals (Multi-Language), PowerLog Software, and USB drivers
- USB Interface Cable for PC Connection (USB A-to-mini USB B)
- Soft Carry Case C1740

Additional kits are available that include Flexible 6000 A AC Current Probes (set of 4). Contact Fluke for more information about the kits that are available for the Motor Analyzer.

Motor Measurements

Table 1 is a list of supported motors:

Table 1. Motor Configurations

Motor type	3-phase asynchronous
Motor measurement connection	3-Wire Direct on Line
Motor winding connection	WYE or Delta

Table 2 is a list of the range and accuracy of the Motor Analyzer-specific functions. See *Specifications* in the *Fluke 430 Series II Users Manual* for the specifications of the other functions.

Table 2. Motor Analyzer Range and Accuracy

Motor Measurement	Range	Resolution	Accuracy	Default Limit
Mechanical Motor Power	0.7 kW to 746 kW	0.1 kW	±3 % ^[1]	100 % = rated power
	1 hp to 1000 hp	0.1 hp	±3 % ^[1]	100 % = rated power
Torque	0 Nm to 10 000 Nm	0.1 Nm	±5 % ^[1]	100 % = rated torque
	0 lb ft to 10 000 lb ft	0.1 lb ft	±5 % ^[1]	100 % = rated torque
rpm	0 rpm to 3600 rpm	1 rpm	±3 % ^[1]	100 % = rated rpm
Efficiency	0 % to 100 %	0.1 %	±3 % ^[1]	NA
Unbalance (NEMA)	0 % to 100 %	0.1 %	±0.15 %	5 %
Harmonics Voltage Factor (NEMA)	0 to 0.20	0.01	±1.5 %	0.15
Unbalance Derating Factor	0.7 to 1.0	0.1	indicative	NA
Harmonics Derating Factor	0.7 to 1.0	0.1	indicative	NA
Total NEMA Derating Factor	0.5 to 1.0	0.1	indicative	NA

[1] Add 5% error when selecting Motor design type Other
 Specification valid for Motor Power > 30 % of rated power
 Specification valid at stable operating temperature. Run the motor for at least 1 hour at full load
 (2-3 hours if the motor is 50 HP or higher) to obtain stable temperature.

Notes:

- Rated torque is calculated from rated power and rated speed.
- Update rate of Motor Measurements is 1x per second.
- Default Trend duration is 1 week.

Motor Setup

The motor nameplate provides information for the measurement algorithm. This information determines the mechanical parameters from the electrical signals that are used for measurements. It is critical that you enter the nameplate settings accurately to obtain accurate readings.

To open the Motor Setup screen:

1. Push **MENU**. The MENU screen opens.
2. Push **F2** to change the page view.
3. Use **▲▼** to move through the menu selections and highlight **Motor Analyzer**.
4. Push **ENTER** to open the Motor Setup screen.

The screenshot shows the 'Motor Setup' screen with a blue background. At the top, it says 'Motor Setup' in a green header. Below that, 'MOTOR SETUP' is written in white on a blue bar. The main area is titled 'From motor nameplate' and lists several parameters: Rated Power (2.24kW), Rated Speed (3450 rpm), Rated Voltage (208 V), Rated Current (8.4 A), Rated Frequency (60 Hz), Rated Cosφ (0.90), Rated Service Factor (1.15), and Motor Design Type (NEMA-B). The 'Rated Power' value is highlighted with a black bar and white text. At the bottom, there are four buttons: 'UNIT SETUP', 'TREND SETUP', 'DEFAULTS', and 'START'.

5. Use **▲▼** to enter the motor nameplate parameters.

The Motor Analyzer supports motor designs according to NEMA and IEC design types. See Table 3 and Table 4. If the design type is unknown, select **Other**. When set to Other, you must consider an additional error of +5 % for the mechanical motor parameters.

Table 3. Motor Design Type and Characteristics Summary

Motor Design	NEMA-A	NEMA-B	NEMA-C	NEMA-D	NEMA-E	IEC-H	IEC-N
Starting Current	High	Medium	Medium	Medium	Medium	Medium	Medium
Starting Torque	Medium	Medium	High	Very High	Medium	High	Medium
Breakdown Torque	High	Medium	High	Very High	Medium	High	Medium

Table 4. Nameplate Settings and Ranges

Required from motor nameplate	Range	Resolution
Rated Power	746 W to 746 kW	1 W to 1 kW
	1 hp to 1000 hp	1 hp
Rated Speed	231 rpm to 3599 rpm	1 rpm
Rated Voltage	208 V to 1000 V	1 V
Rated Current	Depends on Amp sensor	0.1 A
Rated Frequency	50 Hz or 60 Hz	---
Rated Cos Q (DPF)	0.01 to 1.00	0.01
Rated Service Factor	1.00 to 1.50	0.01
Motor Design Type	NEMA-A, NEMA-B, NEMA-C, NEMA-D, NEMA-E, IEC-H, IEC-N, Other	---

Default values are available for the nameplate settings and ranges. Use **F1** (UNIT SETUP) to open the setup screen to configure these values. The selection depends on the default motor frequency.

Softkeys:

- | | | |
|-----------|--|---|
| F1 | Select UNIT SETUP screen | Opens the Motor Analyzer Function Preference screen. Select metric or imperial units for the mechanical motor power, torque, and the default motor frequency. |
| F2 | Select TREND SETUP screen | Adjusts the duration of the automatic trend recording. The default duration is 7 days. |
| F4 | Select DEFAULTS for the MOTOR SETUP screen | Sets the default values defined in the Function Preferences screen (see UNIT SETUP). The defaults depend on the default motor frequency. |
| F5 | START measurements | Starts the Motor Analyzer function. See <i>Motor Analyzer Parameters</i> on page 8. |

Unit Setup

Use the setup screen to set the analyzer limits and defaults.

SETUP FUNC. PREF.		FLUKE 438-II 005.00	
MOTOR ANALYZER			
Mechanical Power Unit:	◀	hp	▶
Torque Unit:		lb.ft	
Motor Frequency Default:		60 Hz	
ANALYZER LIMITS	50 HZ DEFAULTS	60 HZ DEFAULTS	BACK

Softkeys:

<input type="button" value="F1"/>	ANALYZER LIMITS	Sets the Analyzer Limits.
<input type="button" value="F2"/>	50 HZ DEFAULTS	Sets the default values for a 50 Hz motor.
<input type="button" value="F3"/>	60 HZ DEFAULTS	Sets the default values for a 60 Hz motor.
<input type="button" value="F5"/>	BACK	Goes to the previous screen.

Note

When you change the 50 Hz or 60 Hz DEFAULTS, go to the Motor Setup screen to activate the new defaults (see page 4).

Set Analyzer Limits

You can adjust the default limit values that show the system performance in various bar graphs. The limits you enter here adjust where the bar graph shows the transition from orange to red. See *Motor Analyzer Parameters* on page 8 for more information.

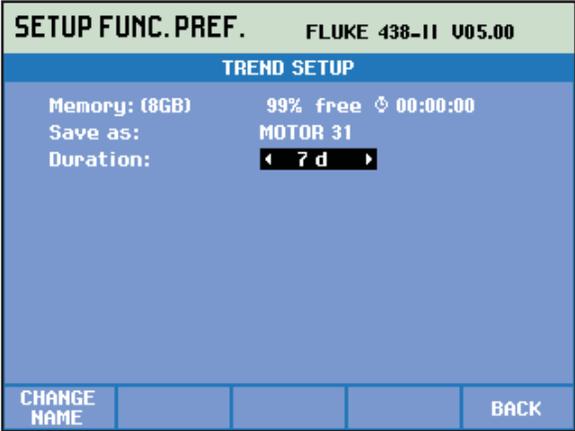
SETUP FUNC. PREF.		FLUKE 438-II 005.00	
MOTOR ANALYZER			
Mechanical Limits			
Power:	◀	100 %	▶
Torque:		100 %	
Speed:		90.0 %	
Efficiency:		90.0 %	
Electrical Limits			
Active Power:		100 %	
Power Factor:		90.0 %	
Unbalance derating:		75.0 %	
Harmonics derating:		75.0 %	
		DEFAULTS	BACK

To change:

1. Use to change a default value.
2. Press to restore the default values.

Trend Setup

The Trend Setup screen is a simplified version of the normal TIMED START screen. Motor Analyzer has an immediate start mode only and TIMED START is not available. To open the screen, go to Motor Setup screen and press **F2**.



The top line is information about the available memory space (43X-series II standard feature).

You can adjust the duration of the TREND. Default is the global TREND duration as defined in the Function Preferences Trend setup screen. The TREND resolution is fixed at 1s.

Softkeys:

- F1** CHANGE NAME Change the name of the data file (43X-series II standard feature).
- F5** BACK Go to the MOTOR SETUP screen.

Motor Analyzer Parameters

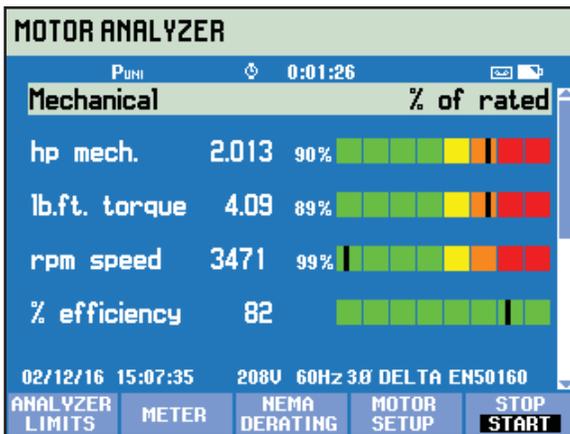
The MOTOR ANALYZER screen shows the important mechanical and electrical parameters relative to their rated values, industry standards, or the NEMA MG 1-2014 standard. A separate screen is available for the Mechanical Parameters and one for the Electrical Parameters.

To open the screen:

1. Go to the MOTOR SETUP screen.
2. Press **F5** (START).
3. Use **▲▼** to move between the screens for electrical and mechanical parameters.

Mechanical Parameters

The Mechanical Parameters screen shows power, torque, and speed at a glance. This screen also shows the efficiency (ratio between electrical power supplied and mechanical power delivered) in %. A colored bar graph indicates the performance of the motor compared to its rating.



The actual value for each parameter shows in the appropriate unit, its relative value in % of rated value or standard, and a bar graph that shows the system performance as:

- good (green)
- adequate (yellow)
- poor (orange)
- bad (red)

Use **▲▼** to move between the screens for electrical and mechanical parameters.

The limit values where the bar graph turns from orange to red are set to NEMA and industry standards.

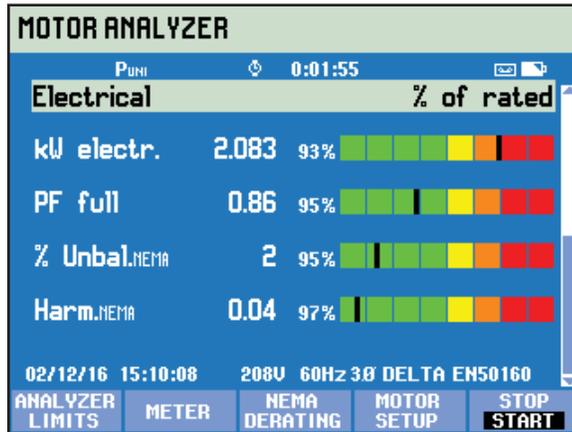
To view these limits, press **F1** to open the ANALYZER LIMITS menu.

Note

The default setting for efficiency is not to show a good or bad indication because the motor can operate only at its rated efficiency at nominal load. For expert use, you can customize the limits. See Set Analyzer Limits on page 6.

Electrical Parameters

The second screen is the electrical power and power factor. It shows the voltage unbalance and harmonics voltage factor according to NEMA MG1.



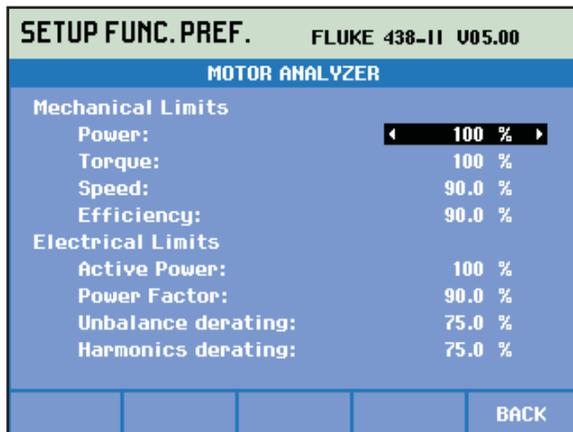
Use **←** **→** to move between the screens for electrical and mechanical parameters.

Softkeys:

- F1** View ANALYZER LIMITS screen.
- F2** Select METER screen.
- F3** Select NEMA DERATING screen.
- F4** View MOTOR SETUP screen.
- F5** STOP measurements and save measurement results.

View Analyzer Limit

The View Analyzer Limit screen has the same information as the Set Analyzer Limits screen but is read-only. The only allowed action is **F5** (OK or BACK) to go to the Motor Analyzer screen where the LIMITS screen was activated.

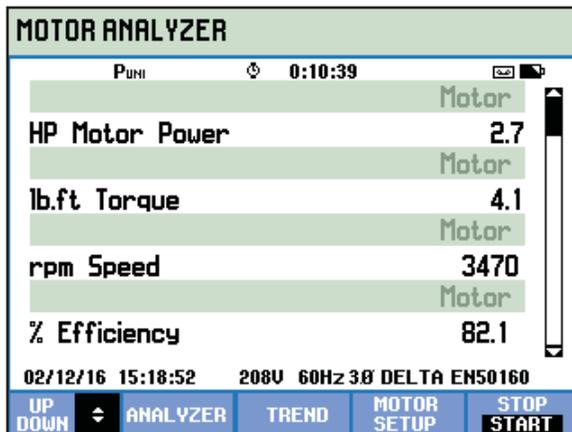


To change the information:

1. Go to the MOTOR ANALYZER screen or METER screen.
2. Press **F5** to stop the process.

Meter Screen

The METER screen shows all measurements in the Motor Analyzer mode as a table view.



Available readings:

Motor Power	(k)W or hp
Torque	Nm or lb.ft

Note

To select between kW or hp and Nm or lb.ft in, see Unit Setup on page 6.

Speed	rpm
Efficiency	%
Frequency	Hz
Harmonics (HVF) NEMA	no unit
Unbalance (%) NEMA	%
Harmonics Derating Factor (HDF)	no unit
Unbalance Derating Factor (UDF)	no unit
Total Derating Factor	no unit

The other parameters are existing logger parameters in the 430 Series-II:

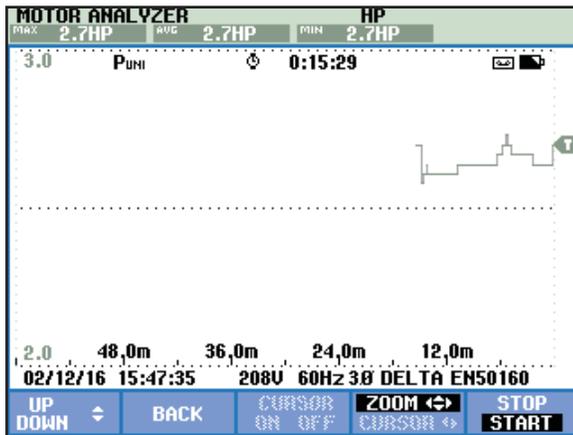
Active Power	(k)W
Apparent Power	(k)VA
Reactive Power	(k)var
Power Factor	no unit
Cos ϕ /DPF	no unit
Harmonic Power	(k)VA
Unbalance Power	(k)VA
Voltage	(k)V
Current	(k)A
Volt THD%x	%
Amp THD%x	%
Unbalance	%

Softkeys:

- F1  to scroll through the METER screen.
- F2 Opens the ANALYZER screen.
- F3 Opens the TREND screen.
- F4 Opens the MOTOR SETUP screen.
- F5 STOP measurements and save measurement results.

Trend

The Trend screen is the standard trend function from the 43X-Series II that shows the recorded measurement data over time.



Note

The Power Quality EVENT capture function is not available in Motor Analyzer.

NEMA Derating Screen

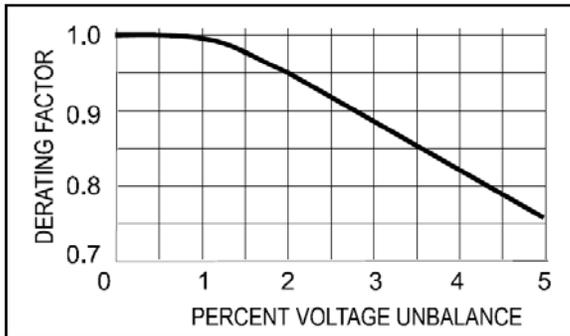
NEMA has guidelines for the application of induction motors to the characteristics of the power system. The NEMA standard MG 1 2014 recommends derating the permissible motor load if Voltage Unbalance or Voltage Harmonics exist in the power system.

Voltage Unbalance

When the line voltages applied to a polyphase induction motor are not equal, unbalanced currents in the stator windings will result. A small percentage of voltage unbalance will result in a much larger percentage of current unbalance. Consequently, the temperature rise of the motor that operates at a particular load and percentage voltage unbalance is greater than the motor that operates under the same conditions with balanced voltages.

Percent voltage unbalance = $100 \times (\text{maximum voltage deviation from average voltage}) / \text{average voltage}$

If the voltages are unbalanced, the permissible motor load should be derated. The following derating curve is recommended by NEMA for motors with normal starting torque and is implemented in the NEMA Derating screen.

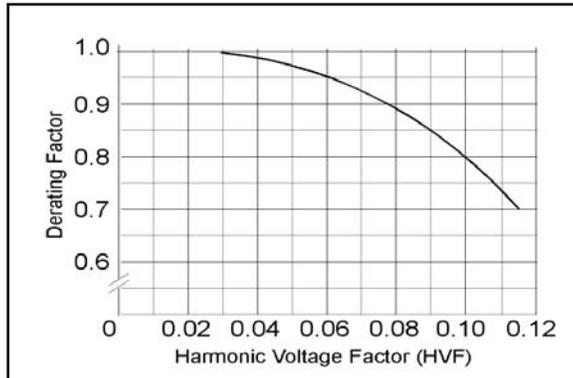


Voltage Harmonics

Harmonic currents are introduced when the line voltages applied to the motor include voltage components at frequencies other than the fundamental frequency of the supply (50 Hz or 60 Hz).

The temperature of the motor operating at a particular load and per unit voltage harmonic factor will therefore be greater than that for the motor operating under the same conditions with only voltage at the fundamental frequency applied.

When a voltage is applied to the motor that consists of components at frequencies other than the fundamental frequency, the rated power of the motor should be derated according to the Derating Factor shown below.



The Harmonic Voltage Factor (HVF) is defined as:

$$\sqrt{\sum_{n=5}^{n=\infty} \frac{V_n^2}{n}}$$

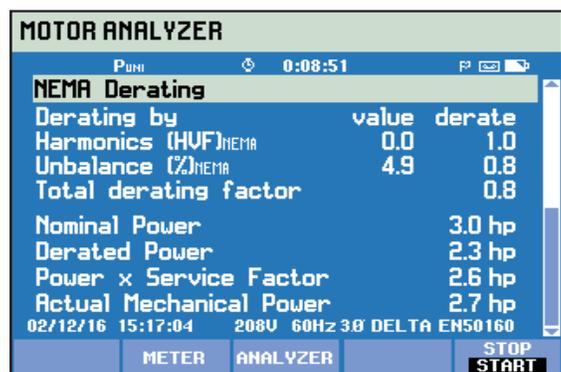
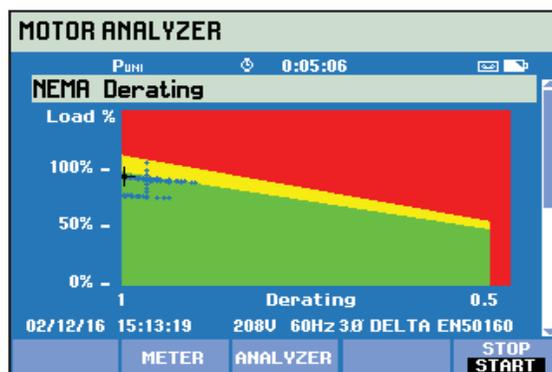
n = order of odd harmonic, not including those divisible by three
 V_n = the per-unit magnitude of the voltage at the n th harmonic frequency

The total derating is found by multiplying the Derating due to Unbalance and due to Harmonics.

To open:

1. Go to the ANALYZER screen.
2. Push F3.

The NEMA Derating screen shows the Motor Load (vertical axis) relative to the advised derating due to voltage unbalance or voltage harmonics (horizontal axis).



The actual load and derating factor is indicated with a cross-hair. The green area indicates a motor that operates within rated limits. The yellow area indicates the permissible Service Factor area (the Service Factor is from the nameplate on the motor and entered in the Motor Setup screen). The red area indicates the overload area for the motor. A 'persistence' function that plots the cross-hair center in blue color is automatically enabled and shows the cross-hair position during the complete measurement.

The 2nd screen is selected with  . This screen shows the readings used to plot the Derating graph.

Softkeys:

-  Access METER screen.
-  Access ANALYZER screen.
-  STOP measurements and save measurement results.