

**FLUKE®**

# **438-II**

Motor Analyzer

## Users Manual

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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

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## **Introduction**

The Motor Analyzer is a feature that measures mechanical power, torque, and rpm on direct-on-line asynchronous motors or asynchronous motors driven by a variable speed drive (VSD). 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](http://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 or 3-Wire connected to VSD |
| 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 % <sup>[1]</sup> | 100 % = nominal power <sup>[2]</sup>  |
|                                      | 1 hp to 1000 hp         | 0.1 hp     | ±3 % <sup>[1]</sup> | 100 % = nominal power <sup>[2]</sup>  |
| Torque                               | 0 Nm to 25 000 Nm       | 1 Nm       | ±5 % <sup>[1]</sup> | 100 % = nominal torque <sup>[2]</sup> |
|                                      | 0 lb ft to 18 500 lb ft | 0.1 lb ft  | ±5 % <sup>[1]</sup> | 100 % = nominal torque <sup>[2]</sup> |
| rpm                                  |                         |            |                     |                                       |
| Direct on Line                       | 000 rpm to 3600 rpm     | 1 rpm      | ±3 % <sup>[1]</sup> | 100 % = nominal rpm <sup>[2]</sup>    |
| VSD                                  | 500 rpm to 4140 rpm     |            |                     |                                       |
| Efficiency                           | 0 % to 100 %            | 0.1 %      | ±3 % <sup>[1]</sup> | NA                                    |
| Unbalance (NEMA MG 1)                | 0 % to 100 %            | 0.1 %      | ±0.15 %             | 5 %                                   |
| Harmonics Voltage Factor (NEMA MG 1) | 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 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, when operating at <30 % of rated Motor Power, the mechanical motor power accuracy is ±3 % +0.7 % of rated power and torque accuracy is ±5 % +1.5 % of rated torque.  
 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.  
 Motor must be in near steady state mechanical condition.

[2] For Direct Online Motors the nominal values are identical to the rated values on the Motor Nameplate.  
 For VSD driven motors the nominal values are based on the actual motor frequency.

Notes:

- Rated torque is calculated from rated power and rated speed.
- Update rate of Motor Measurements is 1x for each 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.

| SETUP FUNC. PREF.     |             |
|-----------------------|-------------|
| MOTOR SETUP           |             |
| From motor nameplate  |             |
| Rated Power:          | 10.0kW      |
|                       | ◀ 13.6 hp ▶ |
| Rated Speed:          | 1740 rpm    |
| Rated Voltage:        | 400 V       |
| Rated Current:        | 25.0 A      |
| Rated Frequency:      | 60 Hz       |
| Rated Cosφ:           | 0.85        |
| Rated Service Factor: | 1.00        |
| Motor Design Type:    | NEMA-B      |
| Variable Speed Drive: | NO          |
| UNIT SETUP            | TREND SETUP |
|                       | DEFAULTS    |
|                       | START       |

Table 3 is a list of the supported motor operating ranges.

**Table 3. Motor Operating Range**

| Motor Operating range | Direct on Line | VFD            |
|-----------------------|----------------|----------------|
| Voltage (pU)          |                |                |
| 50 Hz motors          | 0.9 to 1.1     | 0.7 to 1.2     |
| 60 Hz motors          | 0.9 to 1.1     | 0.58 to 1.2    |
| Current (pU)          | 0 to 1.7       | 0 to 1.7       |
| Input Power (pU)      | 0 to 2.2       | 0 to 2.2       |
| Frequency             | 50 Hz or 60 Hz | 40 Hz to 70 Hz |
| Voltage Unbalance (%) | 0 to 5         | 0 to 5         |
| Voltage THD (%)       | 0 to 20        | 0 to 25        |

*Note*

$$pU \text{ (per Unit)} = \text{Measured value} / \text{Rated value}$$

Table 4 is a list of the operating ranges for variable speed drives.

**Table 4. VSD Operating Range**

| Drive Operating range                         | VFD        | Note   |
|---|------------|--|
| Over/Under Voltage from Nominal V/f Curve (%) | -15 to +15 | The lower limit applies up to rated frequency; above rated frequency the saturation of the V/f curve is accommodated |
| Carrier Frequency (kHz)                       | 2.5 to 20  |  |

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

The Motor Analyzer supports motor designs according to NEMA and IEC design types. See Table 5 and Table 6. 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 5. 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 6. 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<br>Direct on Line<br>VSD          | 300 rpm to 3600 rpm<br>800 rpm to 3600 rpm                  | 1 rpm       |
| Rated Voltage<br>50 Hz motors<br>60 Hz motors | 170 V to 1000 V<br>208 V to 1000 V                          | 1 V         |
| Rated Current                                 | 1 A to 1500 A   | 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:

- |           |  |   |
|-----------|--|---|
| <b>F1</b> | 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. |
| <b>F2</b> | Select TREND SETUP screen                  | Adjusts the duration of the automatic trend recording. The default duration is 7 days.  |
| <b>F4</b> | 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.                      |
| <b>F5</b> | START measurements                         | Starts the Motor Analyzer function. See <i>Motor Analyzer Parameters</i> on page 8.   |

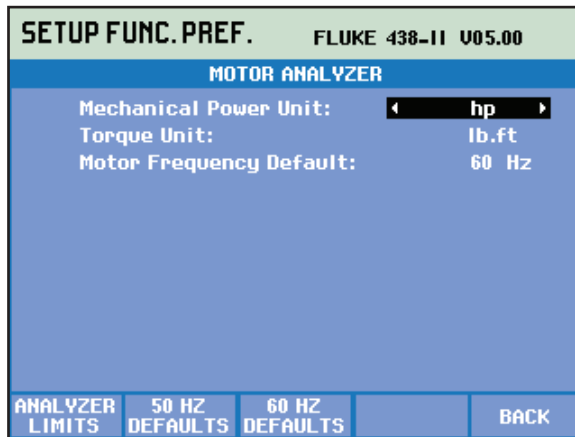
See Table 7 for a list of the supported VSDs.

**Table 7. Supported Variable Speed Drives**

| Drive Characteristics  | Supported Range   |
|------------------------|---|
| Drive Output Frequency | 41 Hz to 69 Hz  |
| Drive Type             | Voltage Source Inverter only  |
| Drive Control Method   | V/f (Volt over Hertz) only, open loop vector control, closed loop vector control, and drive with and without encoders |

## Unit Setup

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



Softkeys:

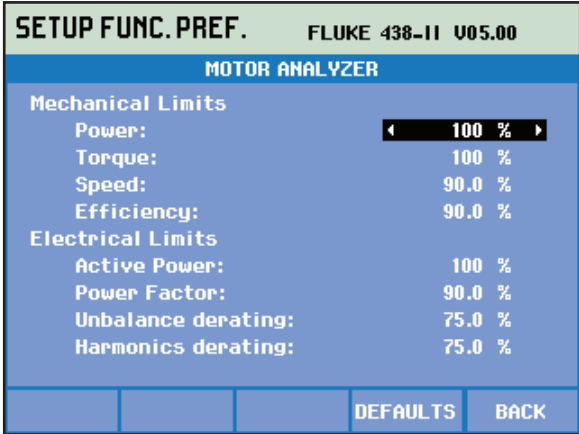
- |                                   |                 |  |
|-----------------------------------|-----------------|--|
| <input type="button" value="F1"/> | ANALYZER LIMITS | Sets the Analyzer Limits.                  |
| <input type="button" value="F2"/> | 50 HZ DEFAULTS  | Sets the default values 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.

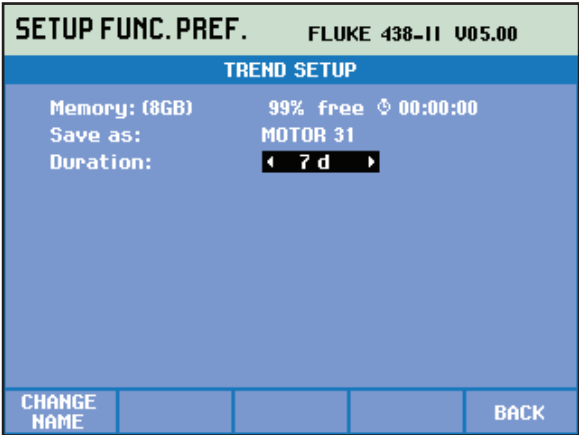


To change:

1. Use to change a default value.
2. Press **F4** 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:

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

## Motor Analyzer Parameters

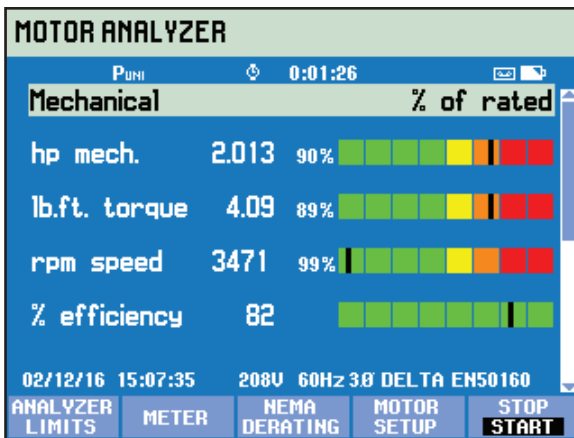
The MOTOR ANALYZER screen shows the important mechanical and electrical parameters relative to their rated values, industry standards, or the NEMA MG 1-2014 standard. A separate screen is available for the Mechanical Parameters and one for the Electrical Parameters.

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.

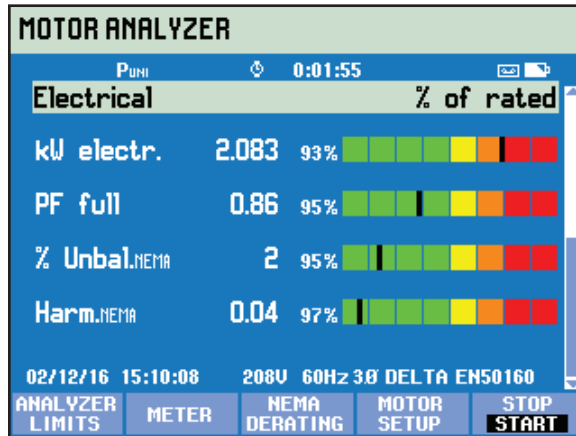
To view these limits, press **F1** to open the ANALYZER LIMITS menu.

#### 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 7.*

## 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.



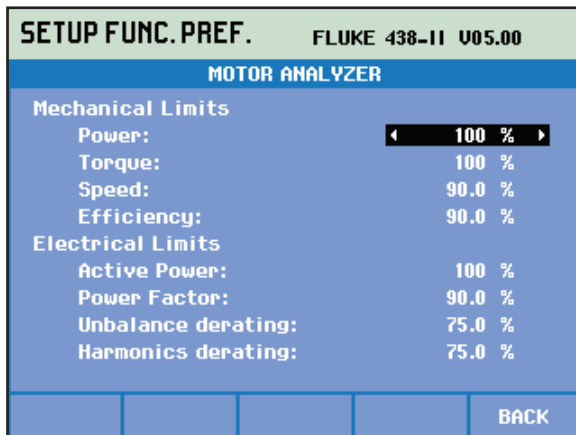
Use **◀▶** to move between the screens for electrical and mechanical parameters.

Softkeys:

- F1** View ANALYZER LIMITS screen.
- F2** Select METER screen.
- F3** Select 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.

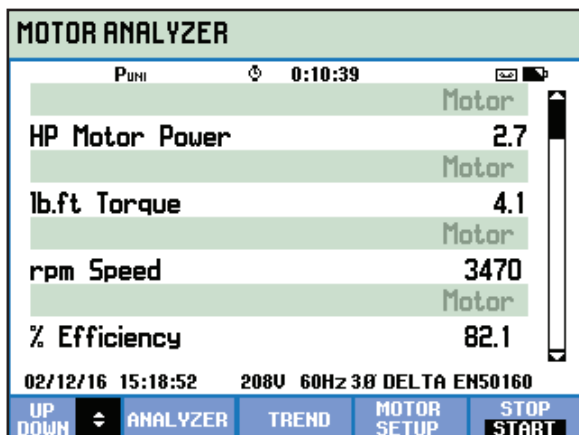


To change the information:

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:

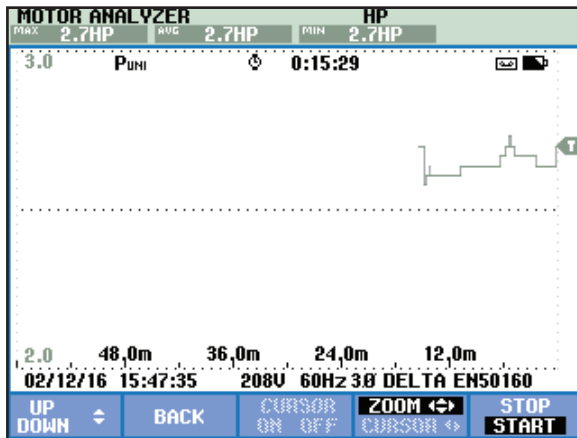
Active Power (k)W  
Apparent Power (k)VA  
Reactive Power (k)var  
Power Factor no unit  
Cos φ/DPF no unit  
Harmonic Power (k)VA  
Unbalance Power (k)VA  
Voltage (k)V  
Current (k)A  
Volt THD%x %  
Amp THD%x %  
Unbalance %

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.*

## 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.

*Note*

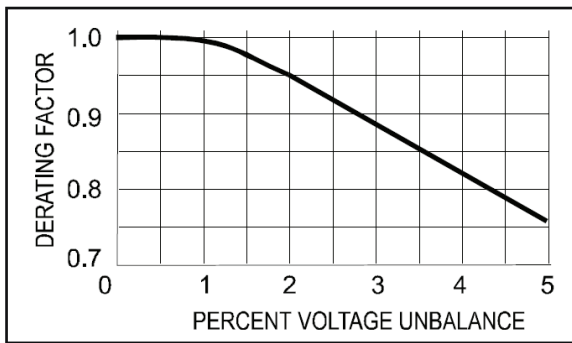
*The Derating screen is not available when Variable Speed Drive is set to YES.*

## 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.



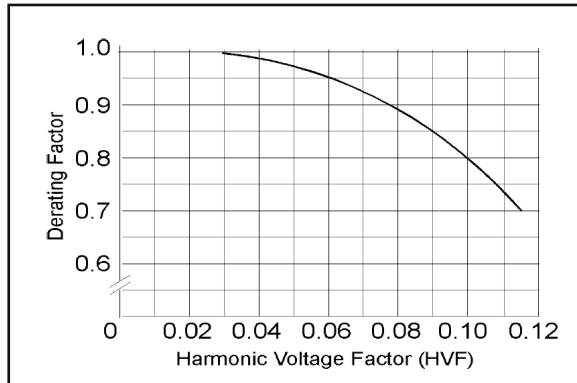


## Voltage Harmonics

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:

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

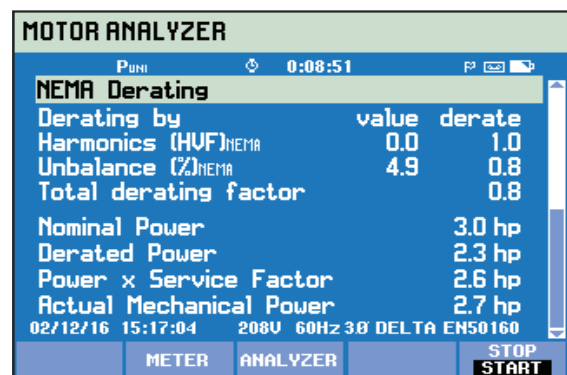
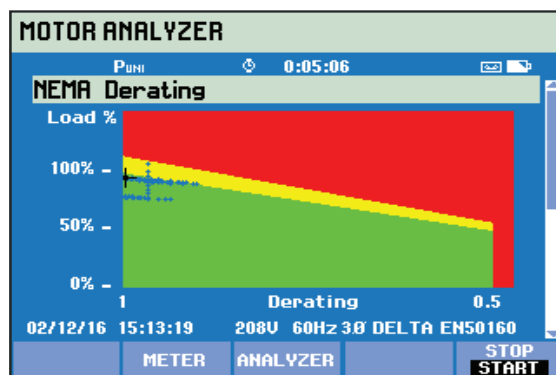
n = order of odd harmonic, not including those divisible by three  
V<sub>n</sub> = the per-unit magnitude of the voltage at the nth harmonic frequency

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 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 2<sup>nd</sup> 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.