

FLUKE®

MDA-550/MDA-510

Motor Drive Analyzer

Users Manual



September 2018

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Introduction

The MDA-550/MDA-510 Motor Drive Analyzer (the Product or test tool) is an extension of the ScopeMeter® Test Tool 190 Series II with additional functionality and accessories that test inverter type motor drives. Inverter type motor drives are known as variable frequency drives or variable speed drives and use pulse width modulation to control ac motor speed and torque. The test tool supports motor drives with signal levels up to 1000 V to ground.

For Motor Drive Analysis, the test tool provides:

- **Key motor drive parameters**
Includes measurement of voltage, current, dc link voltage level and ac ripple, voltage and current unbalance, harmonics (MDA-550), and voltage modulation.
- **Extended harmonics**
Identifies the effects of low and high order harmonics on the electrical power system.
- **Guided measurements**
Guidance for motor drive input, dc bus, drive output, motor input, and shaft measurements (MDA-550).
- **Simplified measurement setup**
Graphically shows how to connect and then automatically triggers according to the selected test procedure.

- **Reports**

Use for troubleshooting and collaborative work with others.

- **Additional electrical parameters**

Full 500 MHz oscilloscope capability is available for the complete range of electrical and electronic measurement on industrial systems.

This manual describes the functions of the Motor Drive Analyzer that are available when you select the Motor Drive Analyzer key. The functionality and specification for the Scope and Recorder modes are described in the *ScopeMeter® Test Tool 190 Series II Users Manual*.

The TrendPlot function in the Recorder mode plots a graph of selected Motor Drive readings over time.

Replace all references to the Meter key in the Users Manual with the Motor Drive Analyzer key. It is not possible to show large readings as described in the section *Making Automatic Meter Measurements* (for models 190-xx4). However, it is possible to show readings together with the waveform as described in the section *Making Automatic Scope Measurements*.

The Motor Drive Analyzer is based on the ScopeMeter test tool model 190-504. All references to models 190-xx2 can be ignored.

The BC190/830 is the model number for the power adapter that complies with new regulations.

The accessory set that is included for the Motor Drive Analyzer is different than the ScopeMeter® Test Tool 190 Series II. See *In The Box* in this manual.

For User Manual corrections, download the latest manual supplement at <http://us.fluke.com/usen/support/manuals>.

How to Contact Fluke

To contact Fluke, use one of these telephone numbers:

- USA: 1-800-760-4523
- Canada: 1-800-36-FLUKE (1-800-363-5853)
- Europe: +31 402-675-200
- Japan: +81-3-6714-3114
- Singapore: +65-6799-5566
- China: +86-400-921-0835
- Brazil: +55-11-3530-8901
- 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.**
- **Carefully read all instructions.**
- **Do not alter the Product and use only as specified, or the protection supplied by the Product can be compromised.**
- **Use only the Fluke power supply, model BC190 (Power Adapter).**
- **Before use, check that the selected/indicated range on the BC190 matches the local line power voltage and frequency.**
- **For the BC190 Power Adapter only use line cords that comply with the local safety regulations.**
- **Use only insulated voltage probes, test leads, and adapters supplied with the product, or indicated by Fluke as suitable for the MDA-550/MDA-510 Motor Drive Analyzer or Fluke 190 II ScopeMeter series.**

- Before use, inspect voltage probes, test leads and accessories for mechanical damage and replace when damaged.
- Remove all probes, test leads and accessories that are not in use.
- Always connect the power adapter first to the ac outlet before connecting it to the product.
- Do not touch voltages >30 V ac rms, 42 V ac peak, or 60 V dc.
- Do not connect the ground spring (see Figure 1 in the *ScopeMeter Test Tool 190 Series II Users Manual*) to voltages higher than 42 V peak (30 Vrms) from earth ground.
- Do not apply more than the rated voltage, between the terminals or between each terminal and earth ground.
- Do not apply input voltages above the rating of the instrument. Use caution when using 1:1 test leads because the probe tip voltage will transmit directly to the product.
- Do not use exposed metal BNC connectors. Fluke offers cables with plastic, safety designed BNC connectors suitable for the Motor Drive Analyzer. See *Optional Accessories* in the Users Manual.
- Do not insert metal objects into connectors.
- Do not wear loose-fitting clothing or jewelry and keep long hair tied back when near rotating machinery. Use approved eye protection and approved personal-protective equipment where necessary.
- Use the Product only as specified, or the protection supplied by the Product can be compromised.
- Do not use the Product if it operates incorrectly.
- Do not use the Product if it is altered or damaged.
- Disable the Product if it is damaged.
- Keep fingers behind the finger guards on the probes.
- Use only correct measurement category (CAT), voltage, and amperage rated probes, test leads, and adapters for the measurement.
- Do not exceed the Measurement Category (CAT) rating of the lowest rated individual component of a product, probe, or accessory.
- Do not use the Product around explosive gas, vapor, or in damp or wet environments.
- Measure a known voltage first to make sure that the Product operates correctly.

- **Examine the case before you use the product. Look for cracks or missing plastic. Carefully look at the insulation around the terminals.**
- **Do not work alone.**
- **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.**
- **The battery door must be closed and locked before you operate the product.**
- **Do not operate the Product with covers removed or the case open. Hazardous voltage exposure is possible.**
- **Remove the input signals before you clean the Product.**
- **Use only specified replacement parts.**
- **Do not use test leads if they are damaged. Examine the test leads for damaged insulation, exposed metal, or if the wear indicator shows. Check test lead continuity.**

Safe Use of Li-ion Battery Pack

The battery pack Fluke model BP291 (52 Wh) has been tested in accordance with the UN Manual of Tests and Criteria Part III Subsection 38.3 (ST/SG/AC.10/11/Rev.3) – more commonly known as the UN 38.3 – tests, and have been found to comply with the stated criteria. The battery pack has additionally been tested according to IEC 62133.

Recommendations for safe storage of battery pack:

- **Do not store battery packs near heat or fire. Do not store in sunlight.**
- **Do not remove a battery pack from its original packaging until required for use.**
- **When possible, remove the battery pack from the equipment when not in use.**
- **Fully charge the battery pack before storing it for an extended period to avoid a defect.**
- **After extended periods of storage, it may be necessary to charge and discharge the battery packs several times to obtain maximum performance.**
- **Keep the battery pack out of the reach of children and animals.**
- **Seek medical advise if a battery or part of it has been swallowed.**

Recommendations for safe use of the battery pack:

- The battery pack must be charged before use. Use only Fluke approved power adapters to charge the battery pack. Refer to Users Manual for proper charging instructions.
- Do not leave a battery on prolonged charge when not in use.
- The battery pack gives the best performance when operated at normal room temperature $20\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$ ($68\text{ }^{\circ}\text{F} \pm 9\text{ }^{\circ}\text{F}$).
- Do not put battery packs near heat or fire. Do not put in sunlight.
- Do not subject battery packs to severe impacts such as mechanical shock.
- Keep the battery pack clean and dry. Clean dirty connectors with a dry, clean cloth
- Do not use any charger other than that specifically provided for use with this equipment.
- Do not use any battery which is not designed or recommended by Fluke for use with the Product.
- Take careful notice of correct placement of the battery in the product or the External Battery Charger.
- Do not short-circuit a battery pack. Do not keep battery packs in a place where the terminals can be shorted by metal objects (e.g. coins, paper clips, pens or other).
- Never use a battery pack or charger showing visible damage.
- Batteries contain hazardous chemicals that can cause burns or explode. If exposure to chemicals occurs, clean with water and get medical aid. Repair the Product before use if the battery leaks.
- Alteration of battery pack: there shall be no attempt to open, modify, reform or repair a battery pack, which appears to be malfunctioning, or which has been physically damaged.
- Do not disassemble or crush battery packs
- Use the battery only in the application for which it is intended.
- Retain the original Product information for future reference.

Recommendations to safe transport of battery packs:

- The battery pack must adequately be protected against short-circuit or damage during transport.
- Always consult the IATA guidelines describing safe air transport of Li-ion batteries.
- Check-in luggage: battery packs are only allowed when installed in the Product.
- Hand carried luggage: a number of battery packs as required for normal and individual use is allowed.
- Always consult national/local guidelines that are applicable for shipment by mail or other transporters.
- A maximum of 3 battery packs may be shipped by mail. The package must be marked as follows: **PACKAGE CONTAINS LITHIUM-ION BATTERIES (NO LITHIUM METAL)**.

Recommendations to safe disposal of a battery pack:

- You must properly dispose of a failed battery pack in accordance with local regulations.
- Do not dispose of the battery as unsorted municipal waste.
- Dispose in discharged condition and cover the battery terminals with isolation tape.

Symbols

Table 1 is a list of symbols used on the Product or in this manual.

Table 1. Symbols

Symbol	Description	Symbol	Description
	Consult user documentation.		DC (Direct Current)
	WARNING. RISK OF DANGER.		Double Insulated
	WARNING. HAZARDOUS VOLTAGE. Risk of electric shock.		Conforms to relevant Australian EMC standards.
	Earth		Certified by CSA Group to North American safety standards.
	AC (Alternating Current)		Conforms to European Union directives.
	Conforms to the Appliance Efficiency Regulation (California Code of Regulations, Title 20, Sections 1601 through 1608), for small battery charging systems.		
CAT III	Measurement Category III is applicable to test and measuring circuits connected to the distribution part of the building's low-voltage MAINS installation.		
CAT IV	Measurement Category IV is applicable to test and measuring circuits connected at the source of the building's low-voltage MAINS installation.		
 Li-ion	This product contains a Lithium-ion battery. Do not mix with the solid waste stream. Spent batteries should be disposed of by a qualified recycler or hazardous materials handler per local regulations. Contact your authorized Fluke Service Center for recycling information.		
	This product complies with the WEEE Directive marking requirements. The affixed label indicates that you must not discard this electrical/electronic product in domestic household waste. Product Category: With reference to the equipment types in the WEEE Directive Annex I, this product is classed as category 9 "Monitoring and Control Instrumentation" product. Do not dispose of this product as unsorted municipal waste.		

In The Box

The test tool includes:

- MDA-550 or MDA-510 Motor Drive Analyzer
- 3 VPS 100:1 high voltage probe sets and alligator clips
- 1 VPS410 10:1 high frequency probe set
- Extension ground lead, 1 meter (only recommended to connect to ground when using the ground lead that is included with the VPS is not practical)
- i400s current clamp for MDA-510, 3 i400s current clamps for MDA-550
- Battery Pack BP291 - 52 Wh (to be installed in the unit)
- Hang Strap
- BC190 Power Adapter
- Regional Power Cords
- Safety Information (Multi-Language)
- USB drive (with multi-language User Manuals and FlukeView ScopeMeter PC Software)
- USB Interface Cable for PC Connection (USB A-to-mini USB B)
- Soft Carry Case C1740

The MDA-550 includes a Shaft Voltage Test Set to make the connection with a rotating shaft:

- set of 3 brushes
- probe holder
- two-piece extension rod
- magnetic base

Input Connections

The top of the test tool has four safety BNC signal inputs. These isolated inputs allow independent floating measurements with each input. See Figure 1.

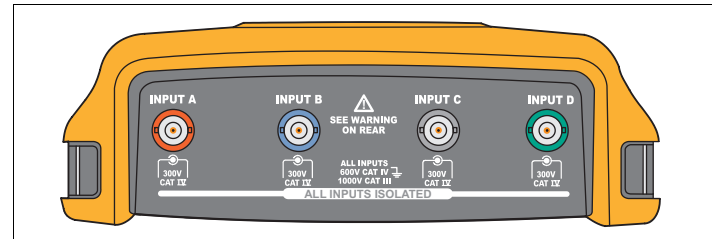


Figure 1. BNC Connectors

To make motor drive voltage and current measurements:

1. Connect the voltage probe to input A.
2. Connect the voltage probe tip to a phase.
3. For Phase-Phase measurements, connect the ground lead to another phase that is used as a reference.
4. For Phase-Ground measurements, connect the ground lead to ground.
5. For the current measurement, place the clamp around one phase and connect the current probe to input B.

After measurement selection, an on-screen connection diagram shows the connections for each measurement.

To make motor drive 3-phase voltage unbalance measurements:

1. Connect the red voltage probe to input A, the blue voltage probe to input B, the gray voltage probe to input C.
2. Connect the probe tip to a phase and the ground leads of each voltage probe to another phase as shown in the connection diagram on the screen after you select the measurement.
3. For each phase, make sure that one probe tip and one ground lead are connected.

To make motor drive 3-phase current unbalance measurements:

1. Connect the current probes to the Inputs A, B and C.
2. Measure the current of each phase.

To make a motor shaft voltage measurement (MDA-550 only):

1. Connect the red VP-410 voltage probe to the input A.
2. Connect the ground lead of the voltage probe to ground.
3. Connect a brush on top of the voltage probe.
4. Place the probe in probe holder.
5. Use the extension rod and magnetic base to keep the probe in a fixed position and the brush in good contact with the motor shaft.

Note

To maximize the benefit of independent isolated floating inputs and to avoid problems caused by improper use, see Chapter 6, Tips in the ScopeMeter Test Tool 190 Series II Users Manual.

For an accurate indication of the measured signal, you must match the probe to the input channel on the test tool.

When using probes that are not included with the Product, see Calibrating the Voltage Probes in the ScopeMeter Test Tool 190 Series II Users Manual.

Navigation and User Interface

Push **MOTOR DRIVE ANALYZER** to display the **Motor Drive Main Menu**. This menu is for the selection of measurements at different locations of the motor drive system. See Figure 2.

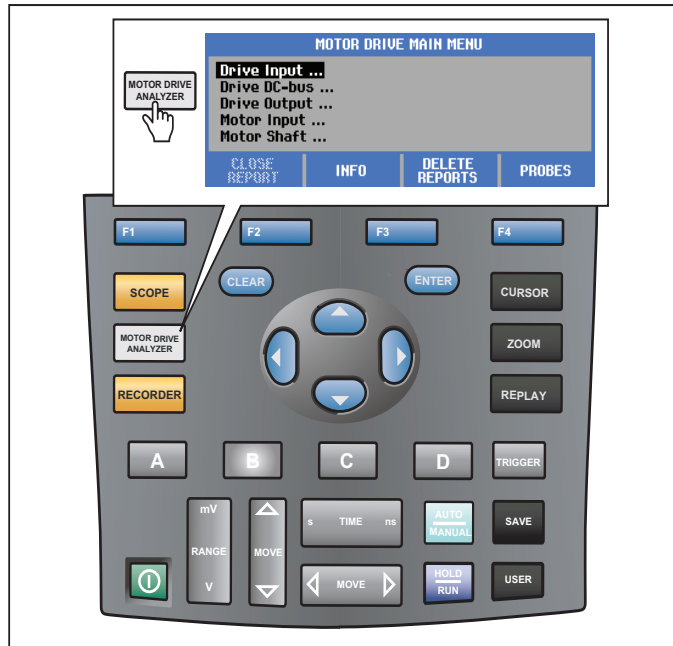


Figure 2. Motor Drive Main Menu

From the submenus the specific measurement is selected with **ENTER**.

The main menu items are:

- **Drive Input**
Use these functions to check drive input conditions. Input voltage relates to the quality of the mains power that feeds the drive. Input current depends on the loading of the drive and the condition of the drive input section.
- **Drive DC-Bus**
Use these functions to check the DC-bus of the drive. DC-bus voltage relates to good drive input and load conditions. DC-bus ripple relates to the drive input circuit, capacitors, and output loading.
- **Drive Output**
Use these functions to check the drive output conditions. The modulated output voltage varies with the motor speed and load. The output current depends on load and correct function of the motor. Unbalance between the phases can cause or indicate problems. The stress on the motor insulation can be determined by measurement of the risetime of a fast modulation pulse.
- **Motor Input**
Use these functions to check the motor input conditions. The measurements are the same as Drive Output and help to determine the influence of the cable. Incorrect wiring between drive and motor can cause contact, voltage drop, and reflection problems that can cause performance drop or damage to the motor. The measurements are stored separately when you select **Save to Report**.

- Motor Shaft Voltage (MDA-550 only)

Use this function to detect bearing grease flash-over currents that can damage motor bearings. These problems can be caused by high shaft voltages due to fast high voltage switching of the drive output circuit. A brush on the tip of a probe measures the rotating shaft voltage.

After you select a measurement location, select the specific measurement with   .

Some measurements require another submenu to select the measurement method. As an example, for voltage and current measurement on the motor drive input, select if the measurement is done between 2 phases or between phase and ground.

After a selection is complete, a connection diagram shows how to connect the voltage probes and current clamps. See Figure 3.

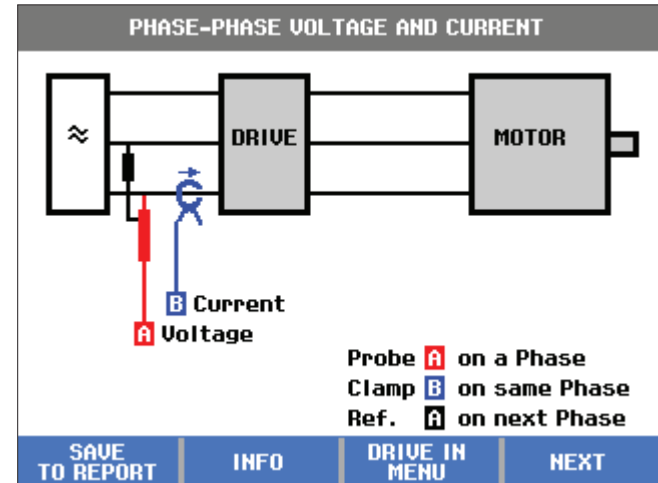


Figure 3. Connection Diagram

Push  or  **NEXT** to show the actual measurement.

Display

The display shows the waveforms ① as well as the readings ② that correspond to the selected measurement. See Figure 4.

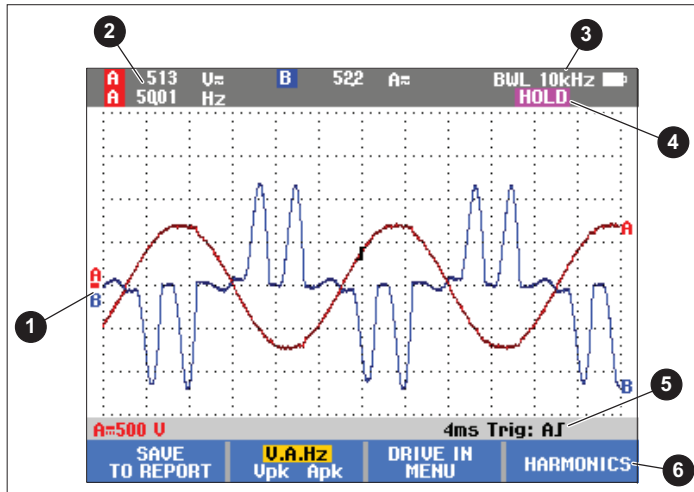


Figure 4. Measurement Screen

BWL ③ indicates that a bandwidth limiter (filter) is applied. The filter is automatically selected for the specific measurement.

AUTO ④ indicates that the Connect-and-View algorithm is applied. The algorithm lets the test tool display complex signals automatically. 1/2 AUTO indicates that the algorithm is partially adapted for optimal results in the selected function.

HOLD shows on the display when you push **HOLD RUN** to freeze the screen.

The Status Bar ⑤ shows the vertical range/division for each active channel, the time/division, and the trigger channel.

The softkeys ⑥ correspond to the four function keys on the Product. The labels and functions change according to the menu that shows on the display.

Note

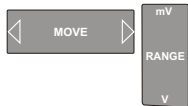
A warning message shows on the top left of the display in Motor Drive Analysis mode to indicate that bandwidth filters are automatically applied on the input and that higher frequency components of the signal are not measured.

Keys

This section is an overview of the keypad functions:



Manually changes the view of the waveform. Select the Input Channel with these keys. The D channel is not used in the Motor Drive Analyzer mode.



Change the view of the waveform on the selected Input Channel.



Changes the time base.



Turn off a channel. Use the same key again to return to the screen with the motor drive button bar.



This key is disabled as special settings apply for motor drive signals.



Use these keys the same as in Scope mode. Use the same key again to return to the screen with the motor drive button bar.



Freezes the screen (all readings and waveforms) at any time.



Removes the button bar from the screen. This is useful when the button bar overlaps part of the waveform.

In the main menu the button bar shows the options for the function keys:

F1 Close Report

A report is a selection of screen bitmaps files. When you save a measurement, use **Save Report** to save a screen bitmap. When all the measurements are done, use **Close Report** in the main menu to close the report. You must close the report before you can start a new report. The report also closes automatically when you turn off the Product.

F1 Copy Report to USB

After a report is closed, you can save the report to a USB drive (max 2 GB).

F3 Delete Report

Delete a saved report.

F3 Info

Use the Info screen to find explanations about the selections and corresponding measurements, including tips and tricks.

F4 Probes

Select the probes to specify the type of voltage and current probes. Make sure the clamp and the measurement instrument are set to the proper range. Use the range select switch on the clamp to adapt the setting if necessary. The arrow on the top of the clamp must face towards the load of the circuit. Connect the current clamp jaws around the conductor to be measured.

Motor Drive Input

The Motor Drive Input functions check the drive input conditions. Input voltage relates to the quality of the mains power that feeds the drive. Input current depends on the loading of the drive and the condition of the drive input section.

Voltage and Current

Voltage and Current measurements check for supply voltage, current, and frequency at the Motor Drive input.

The measurement is done on one of the phases and for 3-phase systems can be repeated for the other phases. Voltage measurements between two phases (Phase-Phase) or between phase and ground (Phase-Ground) is selected in the submenu.

The display shows the voltage waveform in red and the current waveform in blue. The rms voltage, rms current and frequency are displayed as readings in the top of the display.

For displayed readings, use  to change to the Volt Peak readings or Current Peak readings: Peak-Peak, Maximum Peak, Minimum Peak as well as the Crest Factor (ratio between peak and rms value). This only changes the readings. The voltage and current waveform continue to show on the display with no change.

Tips:

- The test tool can compare the rms voltage against the intended nominal voltage. The V_{rms} should be $\pm 10\%$ of the intended voltage.
- If the voltage is low:
 - Check if the local circuit is overloaded.
 - Check if the load of the circuit matches the current rating of the circuit breaker. A high current load can result in a low voltage on the drive input.
 - Check the sizing of the conductor feeding the circuit to see whether the cable size is within specifications compared to local requirements.
 - If the voltage is $\pm 10\%$ of intended voltage, the voltage level is not the problem during the measurement period. Certain conditions can cause the voltage to go outside of the acceptable limits during other time periods.
 - When the Motor Drive is on, the waveform does not have a typical sinewave, for example, it can look more like a camel hump shape. The current readings and waveform shape can vary as the load changes.
 - Compare the measured frequency against the specified frequency intended for that circuit. Nominal frequency (typical 50 Hz or 60 Hz) should be within 0.5 Hz of specification.
 - When using a MDA-550, select Harmonics to determine the harmonics related to the waveform shape for both voltage and current (see Harmonics section).

Voltage Unbalance

Voltage Unbalance checks for the difference between the Phase-Phase voltages for 3-phase systems.

At the simplest level, all three phases of voltage should always have the same magnitude. Expressing unbalance as a percentage provides one number to describe the situation. To calculate the unbalance value:

$$\% \text{ unbalance} = (\text{maximum deviation from average} / \text{average of three phases}) \times 100 \%$$

While voltage unbalance at motor terminals can adversely affect motor operation, it can also cause problems at the input side of the drive. As little as 2 % to 3 % voltage unbalance on the input to a motor drive can cause voltage notching and excessive current to flow in one or more phases. Voltage unbalance can also cause tripping of the current overload fault protection on the motor drive.

Tips:

- The source of unbalance voltage could be poor installation practices or loads that need to be correctly optimized. Another common cause of voltage unbalance is single-phase loads dropping in or out on the same feed as the 3-phase motor drive. To minimize or eliminate this problem, increase the kVA rating of the transformer or provide a separate feed for the motor drive.
-  changes the readings that are displayed in the top of the screen to the peak-peak values of each phase as well as the highest Crest Factor (ratio between peak and rms value) of one of the phases.

Current Unbalance

Current Unbalance checks for the difference between current levels of the phases for 3-phase systems. To calculate the unbalance value:

$$\% \text{ unbalance} = (\text{maximum deviation from average} / \text{average of three phases}) \times 100 \%$$

Tips:

- Current unbalance should be <6 % and depends on load current and circuit capacity. Excessive current unbalance can point to or cause drive rectifier problems that result in the motor overheating. Current unbalance can be caused by voltage unbalance. For example, 1 % of voltage unbalance can result in 3 % to 4 % of current unbalance.
-  changes the readings that are displayed in the top of the screen to the peak-peak values of each phase as well as the highest Crest Factor (ratio between peak and rms value) of one of the phases.

Harmonics (MDA-550 only)

The MDA-550 provides harmonics analysis. Harmonics are periodic distortions of the voltage and current sine wave. Harmonics occur when multiples of the fundamental waveform are superimposed over the fundamental. You can consider the signal as a combination of various sine waves with different frequencies. The contribution of each of these components to the full signal is shown as a bar. For example, a 5th harmonic is 300 Hz (5 x 60) for 60 Hz systems or 250 Hz (5 x 50) for 50 Hz systems. The effect of these harmonics is distortion of the voltage or current. The sum of all distortions from the 2nd harmonic to the 50th harmonic divided by the fundamental component is expressed as the Total Harmonic Distortion (THD).

The readings in the top of the screen show the ac rms value of the signal, the fundamental (H1) value, the frequency of the fundamental and the THD value.

To view the reading for the harmonic component:

1. Select **F4** **Harmonics**.
2. Push **F2** **Input** to select the channel for the harmonics display.

For Voltage and Current measurements, select A for the Voltage harmonics on Channel A and select B for the Current harmonics on Channel B.

For Unbalance measurements, select A, B, or C to show the voltage or current harmonics for the selected channel.
3. Push  to vertically zoom in on the harmonics display.
4. Push **F3** **Scale Options** to change the vertical scale.
5. Use the   **ENTER** to switch the vertical scale between % of fundamental frequency and linear voltage or current value.
6. In Scale Options, toggle between the TDD reading and the THD reading for a current waveform.

TDD or Total Demand Distortion is the ratio of the rms value of all the current harmonic components to the maximum demand current entered as a value. This can be useful when running at low load conditions. In that case THD would be relatively high, but the harmonic currents generated would be low, and the effect on the supply system is negligible.

The distortion caused by the harmonics can affect the operation of other electrical equipment on the same circuit. Other loads such as motors and transformers can overheat, have shortened life, and ultimately fail due to the presence of harmonics.

Tips:

- Voltage and current harmonics are closely related, but the percentage levels are usually very different. Voltage are a low number and current harmonics are a higher number.
- Voltage THD exceeding 6 % on any phase can require more investigation. Harmonics can be reduced by modification to the drive, installation of harmonic filters, or other solutions for harmonic mitigation. When installing a filter, the harmonics measurement can be done before and after the installation to verify the performance of the filter.
- Scale Options show the higher frequency components by selecting 2 kHz to 9 kHz or 9 kHz to 150 kHz as the horizontal scale. The horizontal scale shows frequencies instead of harmonics numbers.
- The frequency components are calculated using an FFT algorithm based on the acquired waveform. The horizontal scale is linear as the values are not related to the fundamental frequency.
- Use these frequency ranges to determine to what extent a drive (for example, with an active front end) that operates on the same input power is affecting the input section of the drive under test with high frequency components. This also can influence filters on the input of the drive.

Motor Drive DC-Bus

The Motor Drive DC-Bus functions check the intermediate circuit of the motor drive.

Warning

To prevent possible electrical shock, fire, or personal injury, be aware that the voltage that is present on the dc bus outputs remains on these outputs after the motor drive is turned off. The amount of time depends on the internal impedance.

Voltage DC Level

The Voltage DC Level checks the value and stability of the internal DC-bus of the drive and influence of braking or power feedback (if supported by the drive).

The readings show the dc level, as well as, the peak and peak-peak value. Use Voltage AC Ripple for a closer look at the ac component.

The dc bus voltage should be about 1.414 times the rms line voltage, except when controlled rectifiers (IGBT) are used in the input section. A dc voltage that is too low can trip the drive. Low voltage can be caused by low input mains voltage or distorted input voltage by flat topping.

Tips:

- Use the **RECORD** function to check the dc voltage stability over time and detect slow fluctuations. The test tool continuously records the digital readings of the measurements and displays these as a graph.
- The TrendPlot graph rolls from right to left like a paper chart recorder. Observe that the recorded time from start appears at the bottom of the screen. The present reading appears on top of the screen.
- See *Using the Record Functions* chapter in the *ScopeMeter® Test Tool 190 Series II User Manual* for more information.

Voltage AC Ripple

The Voltage AC Ripple function detects rapid fluctuations and ac components on the dc-bus.

Tips:

- A slight ripple can be visible and is load dependent. If the peaks of ripple have a different repetitive level, one of the rectifiers could be malfunctioning.
- Ripple voltages >40 V can be caused by malfunctioning capacitors or the drive rating is too small for the connected motor and load.

Motor Drive Output

The Motor Drive Output functions check the drive output conditions. The modulated output voltage varies with the motor speed and load. The output current depends on load and correct function of the motor. Unbalance between the phases can cause or indicate problems. The stress on the motor insulation can be determined by measurement of the risetime of a fast modulation pulse.

Voltage and Current (Filtered)

Voltage and Current (Filtered) are measurements of the voltage, current, and frequency at one of the phases of the motor drive output. The measurement is done with a 10 kHz bandwidth filter so that a sinewave shaped voltage waveform shows instead of the pulse width modulated signal.

The voltage measurement is done between two phases (Phase-Phase). The current measurement is done on a single phase. Repeat the measurement for the other phases.

The display shows the voltage waveform in red and the current waveform in blue. The PWM voltage, rms current, frequency, and Volt/Hz factor (ratio between voltage and frequency) show as readings at the top of the display. The PWM voltage shows and not the rms voltage, as PWM voltage represents the effective voltage of the switching output based on the average value of samples over a whole number of periods of the fundamental frequency.

F2 changes the readings on the display to Volt Peak readings or Current Peak readings: Peak-Peak, Maximum Peak, Minimum Peak, and Crest Factor (ratio between peak and RMS value).

Tips:

- Use the V/Hz ratio to check if the ratio is within specified limits for the motor.
- If V/Hz is too high the motor will overheat and if V/Hz is too low the motor will lose torque.

Note

The peak voltage readings here are the peak of the effective voltage and not the peaks of the actual PWM voltage. Use the Voltage Modulation function to measure PWM voltage.

- The Voltage and Current (filtered) function detects motor overloading. Stable Hz with unstable V readings points to dc bus problems. Unstable Hz with stable V readings points to IGBT problems. Unstable Hz and unstable V readings points to speed control circuits.
- Check the output voltage on the motor drive with the nameplate rating. The current must be within the specified Full Load Amps for the motor. Consider the motor service factor that specifies the percentage of overloading the motor can handle for short periods of time.
- If the output current is too high, the motor can run hot. A 10-degree temperature rise can equal 50 % decrease in stator insulation life.

Voltage Modulation

Use voltage modulation to display the modulated output signal. The submenu has selection for what reference is used for the measurement.

Phase-Phase

Phase-Phase shows the modulated signal between 2 phases. The PWM voltage, voltage peak-peak, frequency, and volt/frequency ratio show as readings in the top of the display. PWM voltage shows on the display but not the rms voltage. PWM voltage represents the effective voltage of the switching output based on the average value of samples over a whole number of periods of the fundamental frequency.

F2 adjusts the zoom level (1, 2, or 3) of the waveform as well as the corresponding readings.

For Zoom 2, the test tool selects a time base that shows the pulses in more detail and the readings change to Volt Peak Max, Volt Peak Min, and delta voltage between the upper and lower levels.

F4 **BURST** (positive or negative) selects either the positive part of the modulated signal or the negative part of the modulated signal. This selection also applies when you change to Zoom 3.

For Zoom 3, the test tool selects a time base that shows the edge of pulse of the modulation signal. A pulse with a high peak is selected automatically to find the highest dV/dt value.

The readings change to Volt Peak Max, dV/dt, risetime, and overshoot percentage when Peak is selected as Risetime with **F4**. The risetime measurement is based on the IEC 60034-17 method that uses the 10 % and 90 % values of the peak of pulse. This peak value is used as dt in the dV/dt reading and the Peak Voltage as dV. Make sure that the slope that is automatically selected is indeed the pulse of the PWM signal and not of an interference. The start of the slope must be around the 0-level.

F4 **LEVEL** selects the readings for Delta Voltage, dV/dt, risetime, and overshoot percentage. The risetime measurement is based on the NEMA MG1 Part 30.1 method that uses the 10 % and 90 % values of the voltage level. This value is used as dt in the dV/dt reading and the level voltage as dV.

To change the view of the waveform manually in any of the Zoom modes:

1. Push  or .
2. To change the time base, use the  key.
3. Use the voltage, time, and dV/dt reading to see if the steepness of the switching impulses is within the motor insulation specification.

Tips:

- High voltage peaks can damage the motor insulation and drive output circuit and cause the drive to trip. Overshoot higher than 50 % of nominal voltage can be problematic.

- Measure on the motor input to check the pulses on the input of the motor and the influence of the cable.
- When installing a filter, do the dV/dt measurement before and after the installation to verify the performance of the filter.

Phase-Ground

When you connect the reference lead to ground, the test tool shows switching pulses for each phase. Typically, a sinewave shows on top of the modulated signal as the ground level is not the star point of the 3-phase system. Due to the fluctuations in signal level to ground, a stable signal is not always automatically shown in all zoom modes.

Compared to the Phase-Phase measurement, the carrier frequency shows as the reading when you select Zoom 2, as the waveform shows the switching of one phase, as compared to the mix of two phases switching in Phase-Phase.

Zoom 3 shows the same parameters as Phase-Phase and can be high voltage peaks to ground that could damage the motor insulation. The Phase-Ground signal can damage different parts of the insulation. When filters are applied, higher peaks can be visible when measuring Phase-Ground compared to Phase-Phase.

Tips:

- Make sure that the slope that is automatically selected is the pulse of the PWM signal and not of an interference. The start of the slope must be around the 0-level.
- When a drive has a dc bus with intermediate 0-level (middle point of DC+ and DC-) that can be accessed with a reference lead, the same measurement can be applied.

Phase DC- or DC+

The measurements with a dc positive or negative bus signal as reference is the same as for Phase-Phase but with an offset relative to the dc level. The Phase dc measurement is also used to measure switch frequency, identify IGBT problems, or to check if the signal is floating up and down to indicate a system grounding problem.

Spectrum (MDA-550 only)

The MDA-550 includes spectrum analysis in voltage modulation mode. In this mode, no hardware filter is enabled. This function shows the spectral content of the motor drive output voltage waveform. It performs an FFT (Fast Fourier Transform) to transform the amplitude waveform from the time domain into the frequency domain. The switching frequency shows as high peaks. For phase-phase measurement, 2x the switching frequency shows as it is the combination of two phases switching. For Phase-Ground measurements, only the switching frequency of the drive shows as a peak in the spectrum.

Voltage Unbalance

The Voltage Unbalance checks for a difference between the Phase-Phase voltages for 3-phase systems. The unbalance value is calculated by dividing the maximum rms voltage deviation of one of the phases and the average rms voltage of all phases.

Voltage unbalance at motor terminals can adversely affect motor operation and can also cause tripping of the current overload fault protection on the motor drive.

F2 changes the readings that show at the top of the screen to the peak-peak values of each phase as well as the highest Crest Factor (ratio between peak and rms value) of one of the phases.

Current Unbalance

Current Unbalance checks for a difference between current levels of the phases in 3-phase systems.

The value is calculated by dividing the maximum rms current deviation of one of the phases and the average rms current of all phases. Current unbalance should be $<6\%$ and depends on load current and circuit capacity.

Make sure the phase currents are equal. If one of the phases shows a failure, it can cause the motor to run hot, not start after stopping, and loose efficiency. A phase failure can be due to motor drive output malfunction or bad connection between motor drive and motor and can cause motor overheating.

F2 changes the readings that show in the top of the screen to the peak-peak values of each phase as well as the highest Crest Factor (ratio between peak and rms value) of one of the phases.

Motor Input

The functions for motor input are identical to motor drive output, except that the phase-dc bus measurements are left out for voltage modulation, as it is not practical to use the dc bus as reference on the motor input.

Use the motor input functions to do the same measurements and check the influence of the cable between the motor drive and the motor and then document the measurements separately in a report. The voltage modulation measurements are useful to show voltage peaks that are too high when the cabling is not properly matched.

Motor Shaft (MDA-550 only)

The Motor Shaft function detects bearing flash-over that can damage motor bearings. The measurement requires a connection to the rotating shaft of the motor. For this measurement, brushes are included as accessories. Alternatively, you can use a stranded wire probe. Fluke recommends the VP410 10:1 Voltage Probe. See Figure 5.

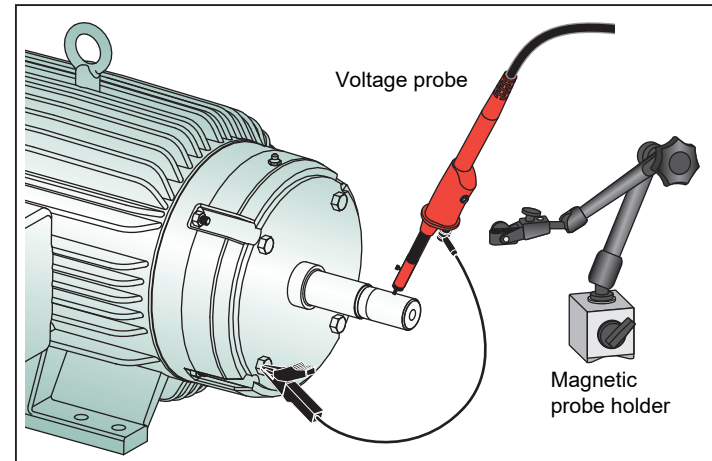


Figure 5. Motor Shaft Test Setup

⚠ Caution

For safety, stop the motor.

To set up:

1. Remove the black protective cap and black insulation sleeve from the probe tip.
2. Place the brush on top of the voltage probe.
3. Turn the screw to tighten the brush on the probe.

4. Place the probe in the magnetic probe holder. Extend the probe holder with the included two-piece extension rod.

Note

Use the probe holder to keep the probe in a fixed position and the brush in contact with the motor shaft.

5. Make sure that it is possible to make good electric contact with the shaft before you do the measurement.
6. Use one of the ground leads to contact the motor chassis that is the reference ground.

When it is not possible to connect near the shaft, an extension cord with 4 mm connections on both ends is included for extending the connection to the ground lead. The measurement can be done on the driven and the non-driven end of the motor.

7. Turn on the motor.
8. Do the measurement after the motor warms up to normal operating temperature.

With this function you can determine the number of flash-overs that occur between shaft and motor chassis, also referred to as electrical discharge machining. When motor shaft voltages exceed the bearing grease insulation capability, flash-over currents occur and cause pitting and grooving of the bearing races.

Tips:

- Under direct 50/60 Hz mains operation, the shaft voltage is normally <1 V.
- Due to the fast edges of the switching voltage from a motor drive, the shaft voltage for a motor powered by a motor drive can be much higher. High Voltage can cause large breakdown currents across the grease barrier causing damage to the bearings.
- Normal, unavoidable shaft voltage due to asymmetry in the air-gap magnetic field result in peak voltages <5 V and slower than 100 ns, which, in general, are not damaging.
- Voltage discharges of >15 V and transition times faster than 50 ns can point to grease flash-over currents that can damage bearings. However, no fixed values can be given that can be considered damaging for the motor, as there are many factors that influence this value.

After selecting the Motor Shaft Voltage measurement, the display shows the voltage waveform. The voltage peak-peak reading shows at the top of the display. Select

F2 **EVENTS ON** to view the discharge event and count the amount of discharge events. Only the discharge events show. The readings at the top of the display show the Volt Peak-Peak, dV/dt, and falltime or risetime as well as the number of events/second. Expect about 20 seconds before the number of events/second shows on the display.

Use **F4** **DEFINE EVENTS** to define what is considered a discharge event.

In this screen, select the maximum voltage change and maximum rise or fall time that will be counted and displayed as an event.

Tips:

- No waveform is visible when no events are detected.
- If excessive shaft voltage is measured, check that the voltage discharges can be reduced by adapting the cabling, grounding, drive parameters, or lubricant. If this is not possible or does not help, use the shaft grounding devices or the isolated shaft.
- If a bearing runs hot or is noisy and high shaft voltages are measured, bearing flash-over currents can be the primary source of excessive bearing wear.
- Check other sources of bearing wear, such as, coupling misalignment or looseness.

Replay

The test tool automatically stores the 100 most recent screens:

1. Push **HOLD RUN** or **REPLAY** to freeze memory contents.
2. Use the functions in the **REPLAY** menu to step back through the stored screens to find the screen of interest.

You can use this feature to see previous measurements, such as the last shaft voltage discharge waveforms.

To save a replay screen to a report:

1. Push the **MOTOR DRIVE ANALYZER** twice.
2. Push **F1** **SAVE TO REPORT**.
3. Push **REPLAY** to return to the Replay screen.

Report

The MDA-500 Series simplifies the process of gathering data and writing test reports with a built-in report generator.

At each test point or measurement there is the option to create, update, or modify a report:

1. Push **F1** **SAVE TO REPORT** to save the screen as a .png file.
2. Enter a name for the drive that is measured.
The test tool uses the drive name as the name of a directory and automatically creates names for the .png files based on the selected measurement.
3. When all measurements on a drive are done, push **F1** **CLOSE REPORT** in the Main Motor Drive menu.
4. The next time you push **F1** **SAVE TO REPORT**, enter a new name for the report.
5. After a report is closed, push **F1** **COPY REPORT TO USB** to save a report to a USB drive.
The USB drive included with the test tool has 2 GB of memory and is the maximum memory size supported by the test tool.
6. Push **F3** **DELETE REPORTS** to remove saved reports and free up the internal memory.

When the test tool is turned off, an active Report is closed automatically.

For copying or deleting stored reports:

1. Push .
2.  **FILE OPTIONS.**
3. Use   to highlight **COPY** to copy to USB, **MOVE** to USB and delete, **RENAME** to rename the report name or **DELETE** to delete the report.
4. Push .
5. Use   to highlight the report.
6. Push  to confirm.

Successive saved screens are represented by the last 2 digits in the filename. As an example, when **SAVE TO REPORT** is selected for the second time in the Motor Drive Output, Voltage Modulation, Phase-Phase mode, the filename is OUVMP02.PNG.

Table 2 shows the filenames that correspond to the selected function.

FlukeView 2

Refer to the section *Connecting to a Computer* in the *Fluke 190 Series II Users Manual* for information about how to connect the USB cable to a computer.

The setup program of the *FlukeView 2 for ScopeMeter Test Tools* is available on the USB drive included with the Product.

After installation:

1. Start the FlukeView 2 software.
2. Push **HELP** to access the documentation for the program.

Measurements Overview

Table 2 is a list of the measurements you can do with the test tool.

Table 2. Measurement and Analysis Combinations

Test Point	Subgroup	Reading 1	Reading 2	Reading 3	Reading 4	Report Filename
Motor Drive Input						
Voltage and Current						
Phase-Phase	V-A-Hz	V AC+DC	A AC+DC	Hz		INVCFP
	V Peak	V Peak max	V Peak min	V pk-to-pk	Crest Factor	
	A Peak	A Peak max	A Peak min	A pk-to-pk	Crest Factor	
Phase-Ground	V-A-Hz	V AC+DC	A AC+DC	Hz		INVCFG
	V Peak	V Peak max	V Peak min	V pk-to-pk	Crest Factor	
	A Peak	A Peak max	A Peak min	A pk-to-pk	Crest Factor	
Voltage Unbalance	Unbalance	V AC+DC	V AC+DC	V AC+DC	Unbalance	INVUNB
	Peak	V pk-to-pk	V pk-to-pk	V pk-to-pk	max Crest Factor	
Current Unbalance	Unbalance	A AC+DC	A AC+DC	A AC+DC	Unbalance	INCUNB
	Peak	A pk-to-pk	A pk-to-pk	A pk-to-pk	max Crest Factor	
Motor Drive DC Bus						
DC		V DC	V pk-to-pk	V Peak max		DCVCF
Ripple		V AC	V pk-to-pk	Hz		DCVRPL

Table 2. Measurement and Analysis Combinations (cont.)

Test Point	Subgroup	Reading 1	Reading 2	Reading 3	Reading 4	Report Filename
Motor Drive Output						
Voltage and Current (Filtered)	V-A-Hz	V PWM	A AC+DC	Hz	V/Hz	OUVCF
	V Peak	V Peak max	V Peak min	V pk-to-pk	Crest Factor	
	A Peak	A Peak max	A Peak min	A pk-to-pk	Crest Factor	
Voltage Unbalance	Unbalance	V PWM	V PWM	V PWM	Unbalance	OUVUNB
	Peak	V pk-to-pk	V pk-to-pk	V pk-to-pk	max Crest Factor	
Current Unbalance	Unbalance	A AC+DC	A AC+DC	A AC+DC	Unbalance	OUCUNB
	Peak	A pk-to-pk	A pk-to-pk	A pk-to-pk	max Crest Factor	
Voltage Modulation						
Phase-Phase	Zoom 1	V PWM	V pk-to-pk	Hz	V/Hz	OUVMPP
	Zoom 2	V Peak max	V Peak min	Delta V		
	Zoom 3 PEAK	V Peak max	Delta V/s	Risetime Peak	Overshoot	
	Zoom 3 LEVEL	Delta V	Delta V/s	Risetime Level	Overshoot	
Phase-Ground	Zoom 1	V PWM	V pk-to-pk	V Peak max	V Peak min	OUVMPPG
	Zoom 2	V Peak max	V Peak min	Delta V	Hz	
	Zoom 3 PEAK	V Peak max	Delta V/s	Risetime Peak	Overshoot	
	Zoom 3 LEVEL	Delta V	Delta V/s	Risetime Level	Overshoot	

Table 2. Measurement and Analysis Combinations (cont.)

Test Point	Subgroup	Reading 1	Reading 2	Reading 3	Reading 4	Report Filename
Phase-DC +	Zoom 1	V PWM	V pk-to-pk	V Peak max	V Peak min	OUVMDC+
	Zoom 2	V Peak max	V Peak min	Delta V	Hz	
	Zoom 3 PEAK	V Peak max	Delta V/s	Risetime Peak	Overshoot	
	Zoom 3 LEVEL	Delta V	Delta V/s	Risetime Level	Overshoot	
Phase-DC -	Zoom 1	V PWM	V pk-to-pk	V Peak max	V Peak min	OUVMDC-
	Zoom 2	V Peak max	V Peak min	Delta V	Hz	
	Zoom 3 PEAK	V Peak max	Delta V/s	Risetime Peak	Overshoot	
	Zoom 3 LEVEL	Delta V	Delta V/s	Risetime Level	Overshoot	
Motor Input						
Voltage and Current (Filtered)	V-A-Hz	V PWM	A AC+DC	Hz	V/Hz	MIVCF
	V Peak	V Peak max	V Peak min	V pk-to-pk	Crest Factor	
	A Peak	A Peak max	A Peak min	A pk-to-pk	Crest Factor	
Voltage Unbalance	Unbalance	V PWM	V PWM	V PWM	Unbalance	MIVUNB
	Peak	V pk-to-pk	V pk-to-pk	V pk-to-pk	max Crest Factor	
Current Unbalance	Unbalance	A AC+DC	A AC+DC	A AC+DC	Unbalance	MICUNB
	Peak	A pk-to-pk	A pk-to-pk	A pk-to-pk	max Crest Factor	

Table 2. Measurement and Analysis Combinations (cont.)

Test Point	Subgroup	Reading 1	Reading 2	Reading 3	Reading 4	Report Filename
Voltage Modulation						
Phase-Phase	Zoom 1	V PWM	V pk-to-pk	Hz	V/Hz	MIVMPP
	Zoom 2	V Peak max	V Peak min	Delta V		
	Zoom 3 PEAK	V Peak max	Delta V/s	Risetime Peak	Overshoot	
	Zoom 3 LEVEL	Delta V	Delta V/s	Risetime Level	Overshoot	
Phase-Ground	Zoom 1	V PWM	V pk-to-pk	V Peak max	V Peak min	MIVMPG
	Zoom 2	V Peak max	V Peak min	Delta V	Hz	
	Zoom 3 PEAK	V Peak max	Delta V/s	Risetime Peak	Overshoot	
	Zoom 3 LEVEL	Delta V	Delta V/s	Risetime Level	Overshoot	
MDA-550 Only						
Motor Shaft						
Shaft Voltage	Events off	V pk-to-pk				SHAFTV
	Events on	Delta V	Rise/Fall time	Delta V/s	Events/s	
Motor Drive Input, Output, and Motor Input						
Harmonics	Voltage	V AC+DC	V fundamental	Hz fundamental	%THD	
	Current	V AC+DC	A fundamental	Hz fundamental	%THD/TDD	

Specifications

DC Voltage (V DC)

Maximum voltage with 10:1 or 100:1 probe.....	1000 V
Maximum resolution with 10:1 or 100:1 probe.....	1 mV
Full scale reading.....	999 counts
Accuracy at 4 s to 10 us/div.....	$\pm(3 \% + 6 \text{ counts})$

AC voltage (V AC)

Maximum voltage with 10:1 or 100:1 probe.....	1000 V
Maximum resolution with 10:1 or 100:1 probe.....	1 mV
Full scale reading.....	999 counts
50 Hz	$\pm(3 \% + 10 \text{ counts}) -0.6 \%$
60 Hz	$\pm(3 \% + 10 \text{ counts}) -0.4 \%$
60 Hz to 20 kHz	$\pm(4 \% + 15 \text{ counts})$
20 kHz to 1 MHz	$\pm(6 \% + 20 \text{ counts})$
1 MHz to 25 MHz	$\pm(10 \% + 20 \text{ counts})$

True-rms voltage (V AC+DC)

Maximum voltage with 10:1 or 100:1 probe.....	1000 V
Maximum resolution with 10:1 or 100:1 probe.....	1 mV
Full scale reading.....	1100 counts
DC to 60 Hz	$\pm(3 \% + 10 \text{ counts})$
60 Hz to 20 kHz	$\pm(4 \% + 15 \text{ counts})$
20 kHz to 1 MHz	$\pm(6 \% + 20 \text{ counts})$
1 MHz to 25 MHz	$\pm(10 \% + 20 \text{ counts})$

PWM Voltage (V Pwm)

Purpose	To measure on pulse width modulated signals, like Motor Drive inverter outputs
Principle.....	Readings show the effective voltage based on the average value of samples over a whole number of periods of the fundamental frequency
Accuracy	As V AC+DC for sinewave signals

Peak Voltage (V Peak)

Modes	Max peak, Min peak, or pk-to-pk
Maximum voltage with 10:1 or 100:1 probe.....	1000 V

Maximum resolution with 10:1 or 100:1 probe	10 mV
Accuracy	
Max peak, Min peak	±0.2 division
Pk-to-Pk	±0.4 division
Full scale reading	800 counts
Amperes (AMP) with current clamp	
Ranges	Same as V AC, VAC+DC or V Peak
Scale Factors	0.1 mV/A, 1 mV/A, 10 mV/A, 20 mV/A, 50mV/A, 100 mV/A, 200 mV/A, 400 mV/A
Accuracy	Same as V AC, VAC+DC or V Peak (add current clamp accuracy)
Frequency (Hz)	
Range	1.000 Hz to 500 MHz
Full scale reading	999 counts
Accuracy	±(0.5 % + 2 counts)
Voltage Hz ratio (V/Hz)	
Purpose	To show the measured Vpwm value (see Vpwm) divided by the fundamental frequency on Variable AC Motor Speed drives
Accuracy	% Vrms + % Hz
Voltage Unbalance Drive Input	
Purpose	To show the highest percentage difference of one of the phase vs. average of the 3 true-rms voltages
Accuracy	Indicative percentage based on V AC+DC values
Voltage Unbalance Drive Output and Motor Input	
Purpose	To show the highest percentage difference of one of the phase vs. average of the 3 pwm voltages
Accuracy	Indicative percentage based on V Pwm values
Current Unbalance Drive Input	
Purpose	To show the highest percentage difference of one of the phase vs. average of the 3 ac current values
Accuracy	Indicative percentage based on A AC+DC values
Current Unbalance Drive Output and Motor Input	
Purpose	To show the highest percentage difference of one of the phase vs. average of the 3 ac current values
Accuracy	Indicative percentage based on A ac values
Rise and Fall time	
Readings	Voltage difference (dV), time difference (dt), voltage vs. time difference (dV/dt), overshoot
Accuracy	Same as oscilloscope accuracy

Harmonics and Spectrum

Harmonics	DC to 51st
Spectrum ranges	1 kHz to 9 kHz, 9 kHz to 150 kHz (20 MHz filter on), up to 500 MHz (voltage modulation)

Shaft Voltage

Events / second	Indicative percentage based on rise and fall time (Impulse discharges) measurements
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Report Data Capture

Number of screens	Typical 50 screens can be saved in Reports (depends on compression ratio)
Transfer to PC	Using 2 GB USB stick or mini-USB to USB cable and FlukeView® 2 for ScopeMeter®

Probe Settings

Voltage Probe	1:1, 10:1, 100:1, 1000:1, 20:1, 200:1
Current Clamp	0.1 mV/A, 1 mV/A, 10 mV/A, 20mV/A, 50mV/A, 100mV/A, 200 mV/A, 400 mV/A
Shaft Voltage Probe.....	1:1, 10:1, 100:1
VPS4xx Probe accuracy when adjusted on the test tool	
DC to 20 kHz	±1 %
20 kHz to 1 MHz.....	±2 %
1 MHz to 25 MHz.....	±3 % (for higher frequencies the probe roll off starts affecting the accuracy)

Safety

General	IEC 61010-1: Pollution Degree 2
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Measurement

IEC 61010-2-030

BNC Input A, B, (C, D)

From any terminal to earth ground.....	1000 V CAT III, 600 V CAT IV
Between any terminal	300 V CAT IV

IEC 61010-2-031

Voltage Probe VPS410 10:1

From any terminal to earth ground.....	1000 V CAT III, 600 V CAT IV
Between any terminal	1000 V CAT III, 600 V CAT IV

Voltage Probe VPS42x 100:1

From any terminal to earth ground.....	1000 V CAT III 600 V CAT IV
Between probe tip and reference lead	2000 V

Note: Voltage ratings are given as “working voltage”. They should be read as Vac-rms (50-60 Hz) for ac sinewave applications and as Vdc for dc applications.

Electromagnetic Compatibility (EMC)

International	IEC 61326-1: Portable Electromagnetic Environment IEC 61326-2-2 <i>CISPR 11: Group 1, Class A</i> <i>Group 1: Equipment has intentionally generated and/or uses conductively-coupled radio frequency energy that is necessary for the internal function of the equipment itself.</i> <i>Class A: Equipment is suitable for use in all establishments other than domestic and those directly connected to a low-voltage power supply network that supplies buildings used for domestic purposes. There may be potential difficulties in ensuring electromagnetic compatibility in other environments due to conducted and radiated disturbances.</i> <i>Caution: This equipment is not intended for use in residential environments and may not provide adequate protection to radio reception in such environments.</i> <i>Emissions that exceed the levels required by CISPR 11 can occur when the equipment is connected to a test object.</i>
Korea (KCC)	Class A Equipment (Industrial Broadcasting & Communication Equipment) <i>Class A: Equipment meets requirements for industrial electromagnetic wave equipment and the seller or user should take notice of it. This equipment is intended for use in business environments and not to be used in homes.</i>
USA (FCC).....	47 CFR 15 subpart B. This product is considered an exempt device per clause 15.103.

Note

For EMC immunity, see Section 8, Table 3 in the ScopeMeter Test Tool 190 Series II Users Manual.