TELEDYNE LECROY
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Operator's Manual

HVD3000 Series High-Voltage Differential Probes

HVD3000 Series

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July, 2015

HVD3000 Series High-Voltage Differential Probes Operator's Manual

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Contents

Introduction

The HVD3000 series high-voltage active differential probes are safe, easy-to-use, and ideally suited for power electronics applications where the reference potential is elevated from ground. The probes feature:

- Differential voltage measurement capability in high common-mode environments (up to 6kVrms)
- Exceptional common-mode rejection ratio (CMRR) across a broad frequency range
- Wide differential voltage range
- High offset voltage capability
- 1% DC and low frequency gain accuracy
- AC or DC coupling
- ProBus interface with automatic scaling
- Auto Zero capabilities

The CMRR for the probes is exceptional out to very high frequencies. This greatly assists in measuring signals in the noisy, high common-mode environments of power electronics. High CMRR combined with low probe noise and high offset capability makes the probes capable of measuring very small control signals floating on high common-mode voltages.

Specifications are provided for using each probe within a wide differential voltage range, and the probe can be safely operated even above this range. The probes will display signal up to the measurable differential voltage before the saturation limit, although the specifications cannot be guaranteed. Within the specified range, the probe is operating below the saturation point of the amplifier, and very reasonable results can be expected.

The probes are calibrated for high-precision measurements to within 1% at DC to low frequency (~10 kHz). This provides for high accuracy of top and base voltage levels of pulse-width modulated signals. The AutoZero capability permits further measurement precision by allowing small offset drifts to be calibrated out of the measurement.

All HVD3000 probes are compatible with any Teledyne LeCroy oscilloscope equipped with the ProBus interface. The ProBus interface makes the probe an integral part of the oscilloscope. Power is provided to the probe through the interface, so there is no need for a separate power supply or batteries. Attenuation is automatically selected based on the oscilloscope gain range (V/div) setting, and the offset adjust is unified with that of the oscilloscope (maximum offset depends on the V/div setting and the oscilloscope model). In general, Teledyne LeCroy 12-bit High Resolution Oscilloscopes (HRO) and HD4096 High Definition Oscilloscopes (HDO) provide the most offset capability over the widest range of V/div settings.

The HVD310x probes require XStream™ software version 7.4 or greater. The HVD3206 and HVD3605 probes require XStream software version 7.8 or greater.

Safety

To maintain the probe in a correct and safe condition, observe generally accepted safety procedures in addition to the precautions specified in this section. **The overall safety of any system incorporating this product is the responsibility of the assembler of the system.**

Symbols

These symbols on the probe and accessories or in documentation to alert you to important safety considerations.

CAUTION of damage to instrument, or **WARNING** of hazard to health. Attend to the accompanying information to protect against personal injury or damage. Do not proceed until conditions are fully understood and met.

HIGH VOLTAGE WARNING. Risk of electric shock.

Double Insulation

Measurement Ground

Precautions

WARNING. To avoid personal injury or damage due to electric shock or fire:

Do not overload; observe all terminal ratings. Do not apply any potential that exceeds the maximum rating of the probe and/or the probe accessory, whichever is less.

Comply with the Voltage vs. Frequency derating curve when measuring higher frequency signals.

Connect and disconnect properly. Always connect the probe input lead to the probe accessories before connecting to a voltage source. Ensure the connections are secure before applying voltage. Do not disconnect leads or accessories from a live circuit.

Keep the probe body and output cable away from the circuits being measured. Only accessory tips are intended for contact with electrical sources.

Use only accessories compatible with the probe. Use only accessories that are rated for the application. Substituting other accessories than those specified in this manual may create a shock /burn hazard.

Keep fingers behind the finger guard of the probe accessories.

Do not remove the probe's casing. Touching exposed connections may result in electric shock.

CAUTION.

Use only as specified. The probe is intended to be used only with compatible Teledyne LeCroy instruments. Use of the probe and/or the equipment it is connected to in a manner other than specified may impair the protection mechanisms.

Do not bend cables excessively. The input leads have a jacket wear indicator that shows through when the jacket is excessively worn. If the white "WEAR" indicator on the input leads is visible, cease use and contact Teledyne LeCroy service for repair or replacement.

Use only within the operational environment listed. Do not use in wet or explosive atmospheres.

Keep product surfaces clean and dry.

Do not operate with suspected failures. Before each use, inspect the probe and accessories for any damage such as tears or other defects in the probe body, cable jacket, accessories, etc. If any part is damaged, cease operation immediately and sequester the probe from inadvertent use.

Operating Environment

Temperature, Operating	0 C to 50 C
Temperature, Non-operating	- 40 C to 70 C
Relative Humidity, Operating	5% to 80% RH (Non-Condensing) 45% RH above 30 C
Relative Humidity, Non-operating	5% to 95% RH (Non-Condensing) 75% RH above 30 C 45% RH above 40 C
Altitude	3000 m (9842 ft) max. Derated to 2000 m (6561 ft.) when used with clip accessories
Usage	Indoors

Voltage Derating for HVD3000 Accessories

Accessory	Part Number	Derated Max. Input Voltage for Combined Probe and Accessory (from either input to ground) *
Spade Terminals	PK-HVA-05	1000 V CAT III
Safety Alligator Clips	PK-HVA-01	1000 V CAT III
Plunger Alligator Clips	PK-HVA-04	1000 V CAT III
Plunger Pincer Clips	PK-HVA-02	1000 V CAT II
Plunger Hook Clips	PK-HVA-03	1000 V CAT II
6kV Alligator Clips	PK-HVA-06	6000 V CAT I ** 1000 Vrms CAT III 1500 Vdc CAT III

* See "IEC/EN 61010-031 Definitions" on page 33.

** CAT I per IEC IEC/EN 61010-031/A1:2008.
"O" (No Rated Measurement Category) per IEC/EN 61010-031:2015.

CAUTION. The operating altitude of the probe is derated to 2000 m (6560 ft) when used with the accessories above.

WARNING. Each accessory has a different measurement (overvoltage) category (CAT) rating. The voltage and CAT rating of the probe are derated to the values in the table above when used with the corresponding accessory.

WARNING. The HVD3206 and HVD3605 probes may be used with the HVD310x accessories. However, the voltage and CAT rating of the probe are derated to the values in the table above when used with the corresponding accessory.

WARNING. To avoid risk of electric shock or fire, do not exceed either the voltage rating or category rating. Keep your fingers behind the finger guard of the probe. Keep the probe body and output cable away from the circuits being measured. Use only the specified accessories.

HVD310x Probes

HVD310x Probe Kit

HVD310x Probe Kit

The HVD310x probes are delivered with the following:

Item	Description	Safety Rating*	Part Number‡	QTY
Spade Terminals (1)	Designed to connect to terminal strips, posts and screws, the overall length is 63 mm (2.48 inches). 4 mm Banana (female) connector. 1 ea. red/black.	Insulated 1000 V CAT III	PK-HVA-05	2
Safety Alligator Clips (2)	Designed to reliably grip large components, such as bus bars and large bolts, the overall length is 92.8 mm (3.65 inches) and the jaw opens to 32 mm (1.26 inch). Only the lower jaw is conducive; the top jaw is insulating plastic. 4 mm Banana (female) connector.1 ea. red/black.	Insulated 1000 V CAT III	PK-HVA-01	2

Item	Description	Safety Rating*	Part Number‡	QTY
Plunger Alligator Clips (3)	The clip is designed to securely grasp thick wires, cables, ground leads, rails, and screw heads. The overall length is 153 mm (6.02 inches); the jaw opens to 23 mm (0.905 inch) max. 4 mm Banana (female) connector. 1 ea. red/black.	Insulated 1000 V CAT III	PK-HVA-04	2
Plunger Pincer Clips (4)	Designed with a long, thin, flexible stem for attaching to hard-to-reach test points, the entire body is fully insulated. The overall length is 161.6 mm (6.36 inch). The pincers can grab leads, pins and wires up to 4 mm (0.157 inch) in diameter. 4 mm Banana (female) connector. 1 ea. red/black.	Insulated 1000 V CAT II	PK-HVA-02	2
Plunger Hook Clips (5)	Designed with a flexible stem to access deep targets in dense environments and a 4.5 mm (0.177 inch) hook to attach to wire leaded parts. The overall length is 157.6 mm (6.20 inches). 4 mm Banana (female) connector. 1 ea. red/black.	Insulated 1000 V CAT II	PK-HVA-03	2
Case	Soft storage case.		SAC-01A	1
Foam	Custom foam insert for storage case.		HVD3106 924228-00 HVD3106-6M 925473-00	1
Operator's Manual			NA	1

* See "IEC/EN 61010-031 Definitions" on page 33 for measurement category definitions.

‡ See "Replacement Parts" on page 29 for information about ordering replacement accessories.

NOTE: The HVD310x-NOACC option offers the probe without the accessories.

WARNING. To avoid injury or death due to electric shock, do not handle probe input leads connected to the Spade Terminals while they are connected to a voltage source. Do not use Spade Terminals as hand-held accessories; they are meant to be used as a permanent installation in a test set up.

HVD310x Specifications

For the current specifications, see the product datasheet at teledynelecroy.com. Below are some key product specifications.

Specifications are subject to change without notice.

Guaranteed Specifications

	HVD3102	HVD3106	HVD3106-6M
Bandwidth (probe only)	25 MHz	120 MHz	80 MHz
Risetime 10-90 %	14 ns	2.9 ns	4.4 ns
CMRR Test Limits, 23 C	80 db @ 50 Hz 60 db @ 1 MHz	80 db @ 50 Hz 60 db @ 1 MHz	80 db @ 50 Hz 60 db @ 1 MHz

Electrical Characteristics

Max. Rated Diff. Voltage (between each input)	1500 V (DC + Peak AC)
Max. Measurable Diff. Voltage (before saturation)	2000 V (DC + Peak AC)
Max. Common Mode Voltage (from either input to ground)	± 1500 V (DC + Peak AC) 1000 Vrms
Max. Input Voltage to Earth (from either input to ground)	± 1500 Vpk
Max. Safe Input Voltage * (per IEC 61010-031)	1000 Vrms CAT III
Pollution Degree *	2

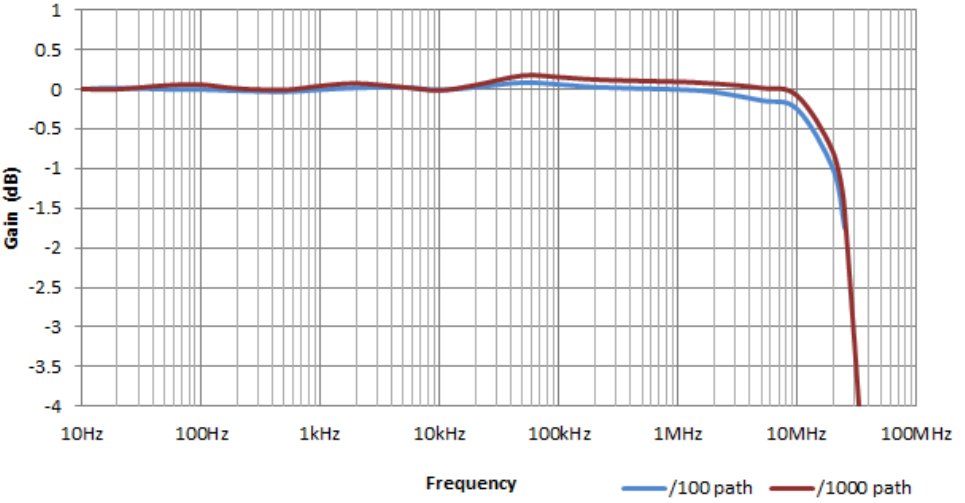
* See "IEC/EN 61010-031 Definitions" on page 33.

Vertical Sensitivity

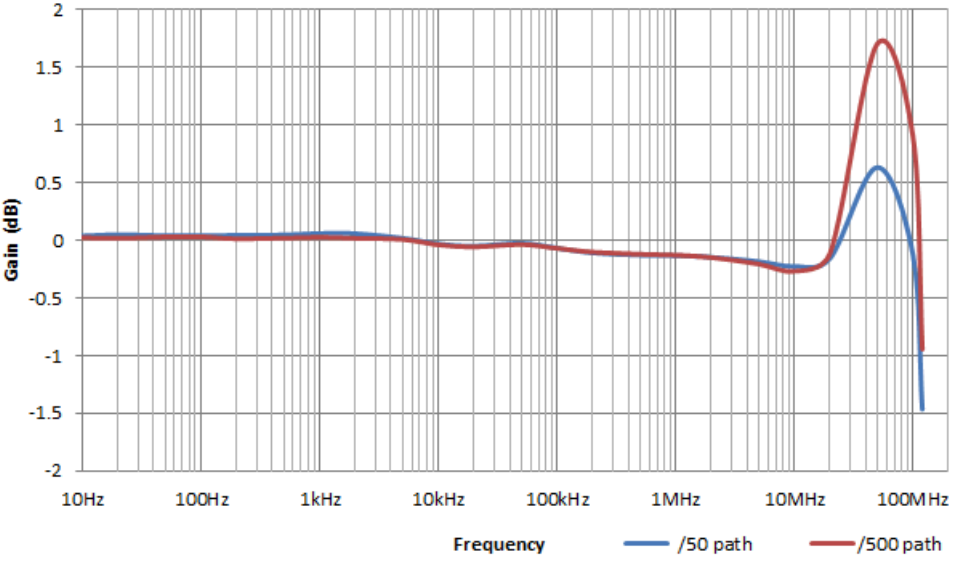
100 mV/Div to 500 V/Div.

Bandwidth

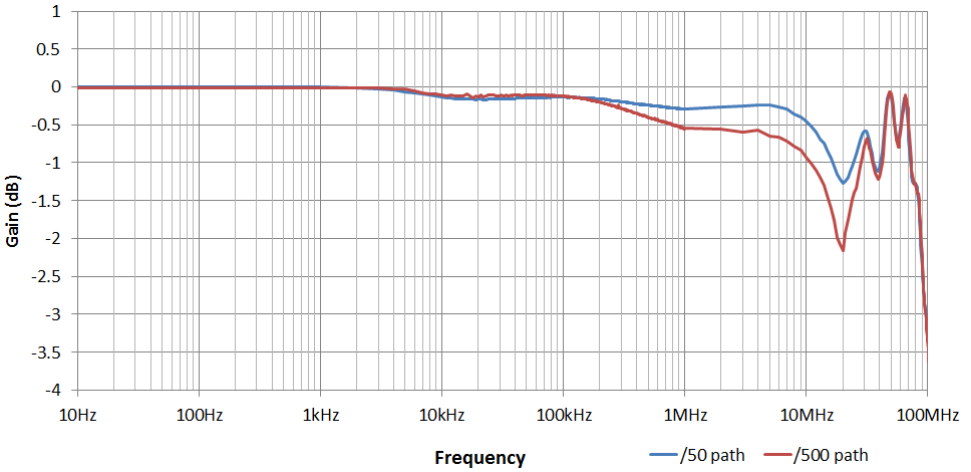
HVD3102 Typical Bandwidth



HVD3106 Typical Bandwidth

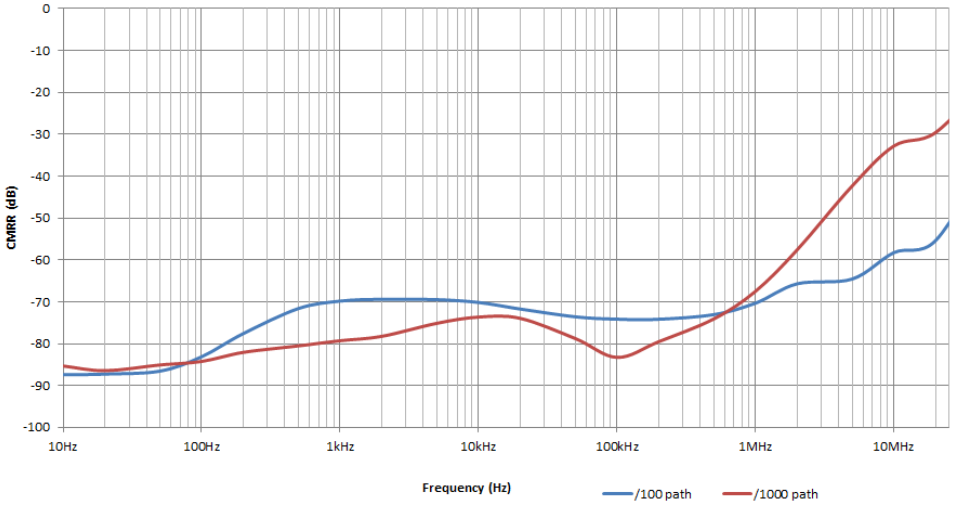


HVD3106-6M Typical Bandwidth

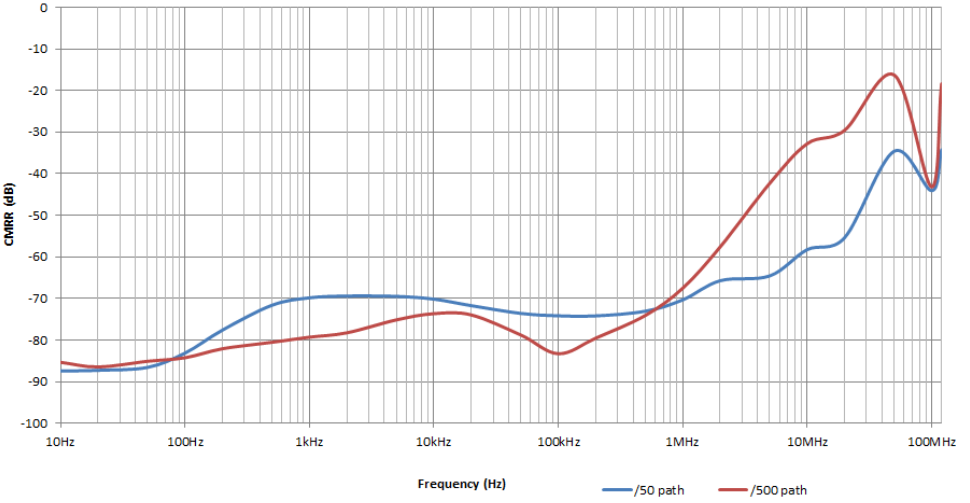


Common Mode Rejection Ratio

HVD3102 Typical CMRR Performance



HVD3106 Typical CMRR Performance

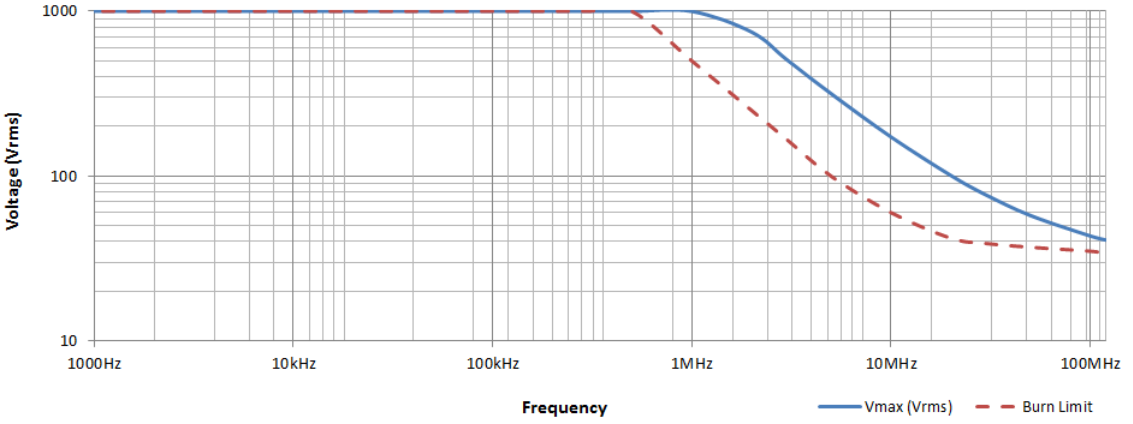


Voltage Derating and Burn Limit

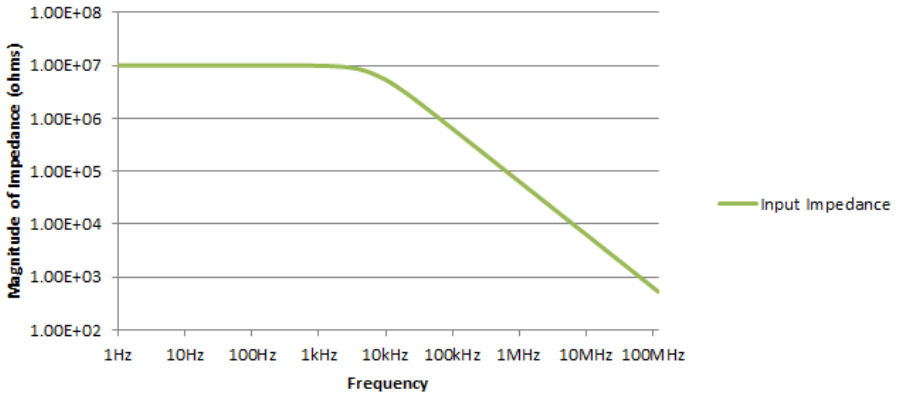
The Maximum Input Voltage curve (solid line) shows the maximum voltage that can be applied to the HVD310x probe inputs without risking damage to the probe.

The lower Burn Limit curve (dashed line) shows the maximum voltage that can be applied to the probe inputs while the operator is handling the inputs. Handling the inputs while connected to active signals above this burn limit could result in injury to the operator.

WARNING. To avoid risk of electric shock or fire, comply with the burn limit when measuring high-frequency signals with hand-held accessories. Do not exceed the voltage or category rating of the probe or accessories (whichever is less). Keep your fingers behind the finger guard of the probe. Keep the probe body and output cable away from the circuits being measured. Use only the specified accessories.



Differential Input Impedance



HVD3206 Probe

HVD3206 Probe Kit

HVD3206 Probe Kit

The HVD3206 probe is delivered with the following:

Item	Description	Safety Rating*	Part Number‡	QTY
6kV Alligator Clip	Designed to reliably grip large components, such as bus bars and large bolts, the overall length is 116 mm (4.57 inches) and the jaw opens to 22 mm (0.87 inch). 1 ea. red/black.	6000 V CAT I ** 1000 Vrms CAT III 1500 Vdc CAT III	PK-HVA-06	2
Case	Soft storage case.		SAC-01A	1
Foam	Custom foam insert for storage case.		925955-00	1
Operator's Manual				1

* See "IEC/EN 61010-031 Definitions" on page 33.

** CAT I per IEC IEC/EN 61010-031/A1:2008.
"O" (No Rated Measurement Category) per IEC/EN 61010-031:2015.

‡ See "Replacement Parts" on page 29 for information about ordering replacement accessories.

HVD3206 Specifications

For the current specifications, see the product datasheet at teledynelecroy.com. Below are some key product specifications.

Specifications are subject to change without notice.

Guaranteed Specifications

	HVD3206
Bandwidth (probe only)	120 MHz
Risetime 10-90 %	2.9 ns
CMRR Test Limits, 23 C	80 dB @ 50 Hz 60 dB @ 1 MHz

Electrical Characteristics

Max. Rated Diff. Voltage (between each input)	2000 V (DC + Peak AC)
Max. Measurable Diff. Voltage (before saturation)	2000 V (DC + Peak AC)
Max. Common Mode Voltage (from either input to ground)	± 2000 V (DC + Peak AC)
Max. Input Voltage to Earth (from either input to ground)	± 2000 Vpk (nominal, either input to ground)
Max. Safe Input Voltage * (per IEC 61010-031)	2000 V (DC + peak AC) CAT I ** 1000 Vrms CAT III 1500 Vdc CAT III
Pollution Degree *	2

* See "IEC/EN 61010-031 Definitions" on page 33.

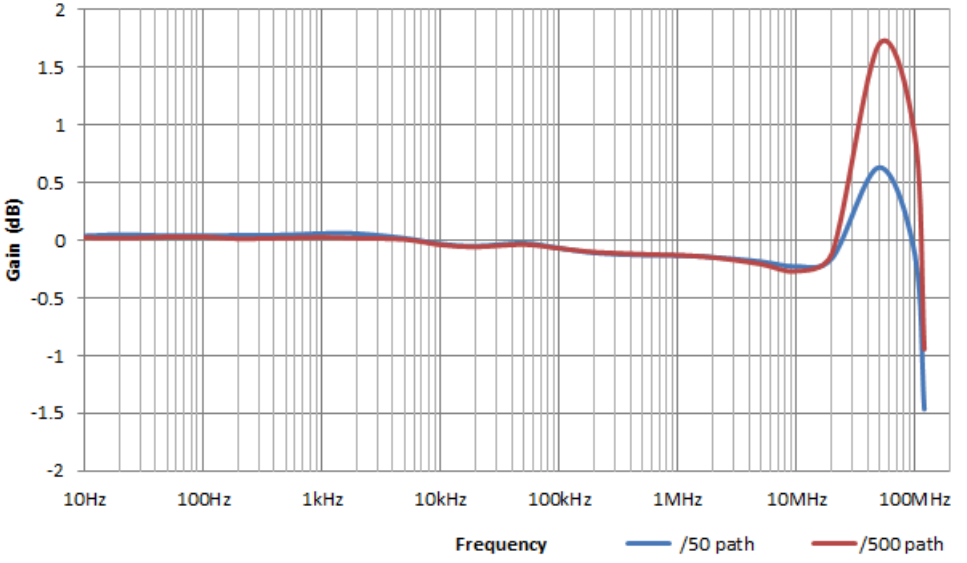
** CAT I per IEC IEC/EN 61010-031/A1:2008.
"O" (No Rated Measurement Category) per IEC/EN 61010-031:2015.

Vertical Sensitivity

100 mV/Div to 500 V/Div.

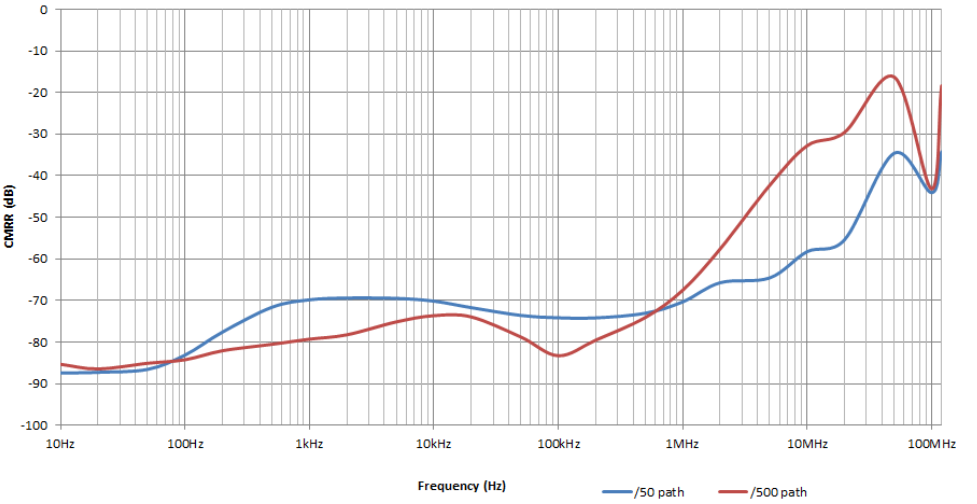
Bandwidth

HVD3206 Typical Bandwidth



Common Mode Rejection Ratio

HVD3206 Typical CMRR Performance

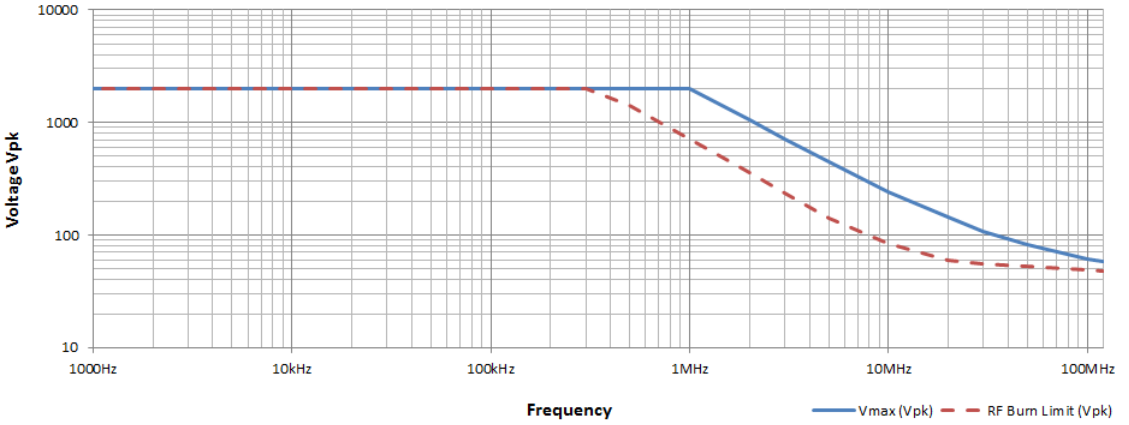


Voltage Derating and Burn Limit

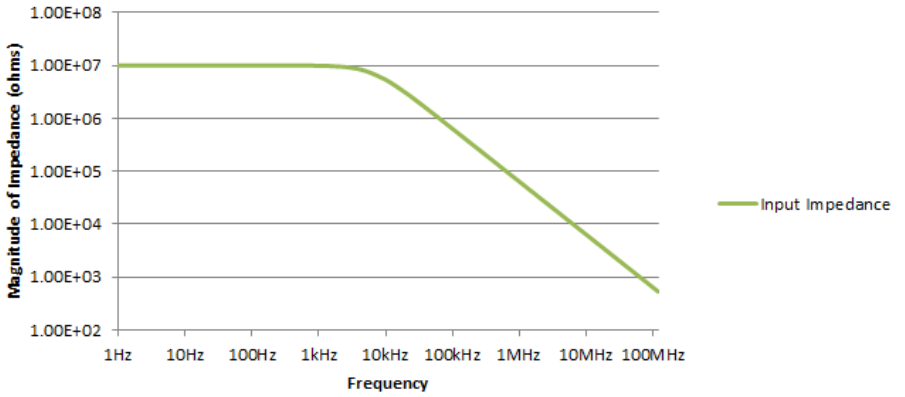
The Maximum Input Voltage curve (solid line) shows the maximum voltage that can be applied to the HVD3206 probe inputs without risking damage to the probe.

The lower Burn Limit curve (dashed line) shows the maximum voltage that can be applied to the probe inputs while the operator is handling the inputs. Handling the inputs while connected to active signals above this burn limit could result in injury to the operator.

WARNING. To avoid risk of electric shock or fire, comply with the burn limit when measuring high-frequency signals with hand-held accessories. Do not exceed the voltage or category rating of the probe or accessories (whichever is less). Keep your fingers behind the finger guard of the probe. Keep the probe body and output cable away from the circuits being measured. Use only the specified accessories.



Differential Input Impedance



HVD3605 Probe

HVD3605 Probe Kit

HVD3605 Probe Kit

The HVD3605 probe is delivered with the following:

Item	Description	Safety Rating*	Part Number‡	QTY
6kV Alligator Clip	Designed to reliably grip large components, such as bus bars and large bolts, the overall length is 116 mm (4.57 inches) and the jaw opens to 22 mm (0.87 inch). Only the lower jaw is conducive; the top jaw is insulating plastic. 1 ea. red/black.	6000 V CAT I ** 1000 Vrms CAT III 1500 Vdc CAT III	PK-HVA-06	2
Case	Soft storage case.		SAC-01A	1
Foam	Custom foam insert for storage case.		925955-00	1
Operator's Manual				1

* See "IEC/EN 61010-031 Definitions" on page 33.

** CAT I per IEC IEC/EN 61010-031/A1:2008.
"O" (No Rated Measurement Category) per IEC/EN 61010-031:2015.

‡ See "Replacement Parts" on page 29 for information about ordering replacement accessories.

HVD3605 Specifications

For the current specifications, see the product datasheet at teledynelecroy.com. Below are some key product specifications.

Specifications are subject to change without notice.

Guaranteed Specifications

	HVD3605
Bandwidth (probe only)	100 MHz
Risetime 10-90 %	4.3 ns
CMRR Test Limits, 23 C	80 dB @ 50 Hz 60 dB @ 10 kHz 60 dB @ 1 MHz (200x) 46 dB @ 1 MHz (2000x)

Electrical Characteristics

Max. Rated Diff. Voltage (between each input)	7000 V (DC + Peak AC)
Max. Measurable Diff. Voltage (before saturation)	7600 V (DC + Peak AC)
Max. Common Mode Voltage (from either input to ground)	± 7600 V (DC + Peak AC) 6000 Vrms
Max. Input Voltage to Earth (from either input to ground)	± 7600 Vpk
Max. Safe Input Voltage * (per IEC 61010-031)	± 8485 V (DC + Peak AC) CAT I ** 6000 Vrms CAT I ** 1000 Vrms CAT III 1500 Vdc CAT III
Pollution Degree *	2

* See "IEC/EN 61010-031 Definitions" on page 33.

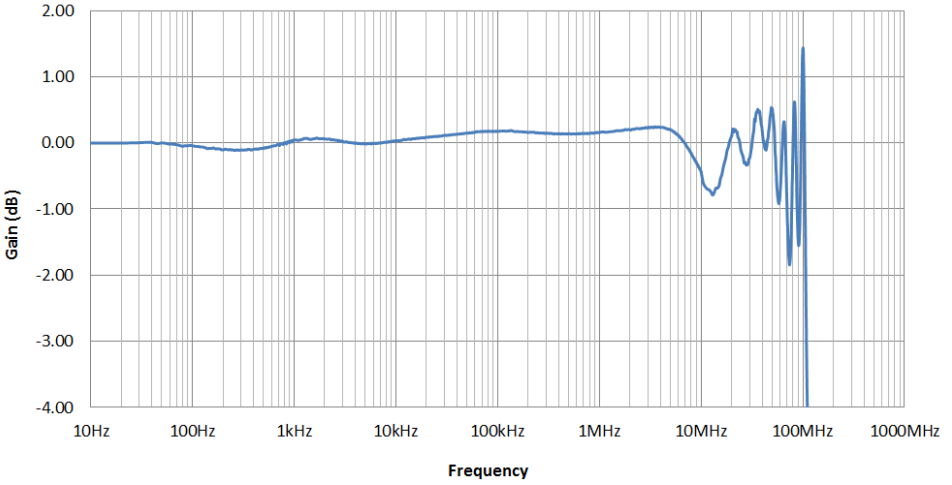
** CAT I per IEC IEC/EN 61010-031/A1:2008.
"O" (No Rated Measurement Category) per IEC/EN 61010-031:2015.

Vertical Sensitivity

300 mV/Div to 2000 V/Div.

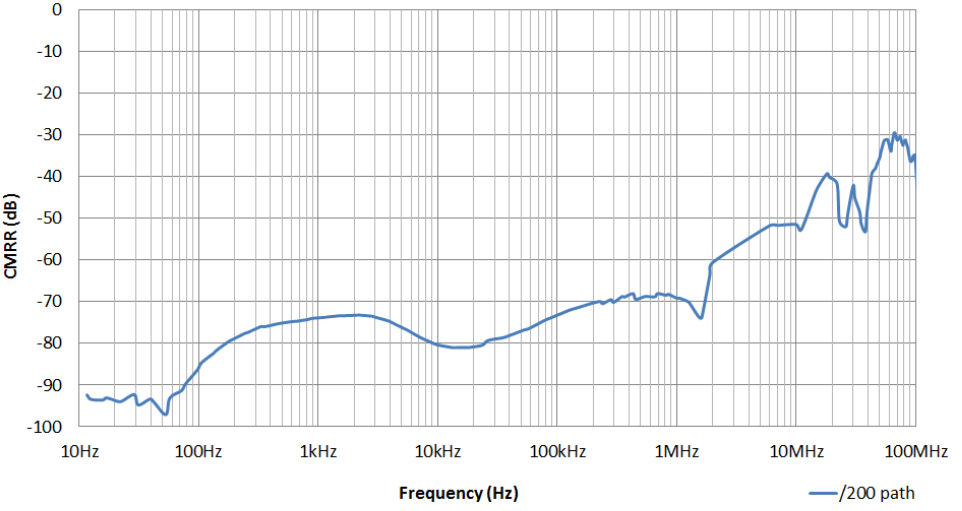
Bandwidth

HVD3605 Typical Bandwidth



Common Mode Rejection Ratio

HVD3605 Typical CMRR Performance

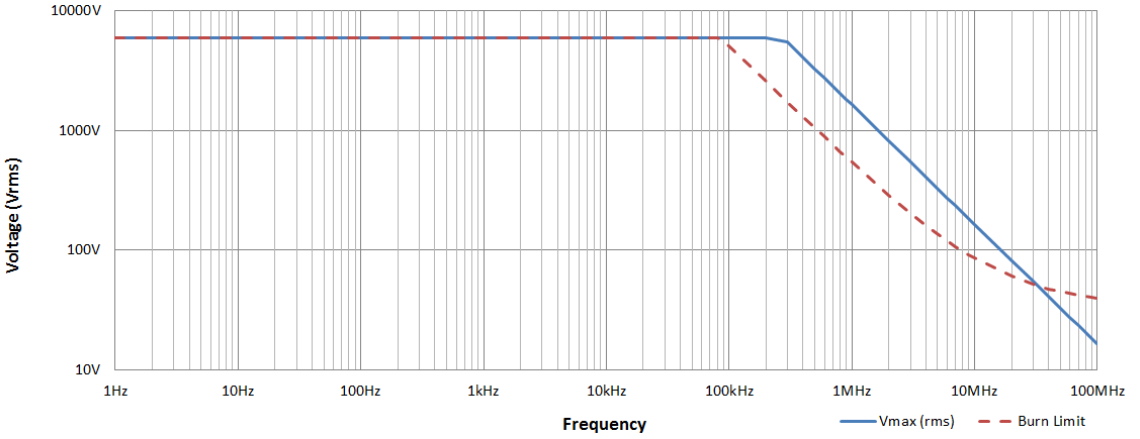


Voltage Derating and Burn Limit

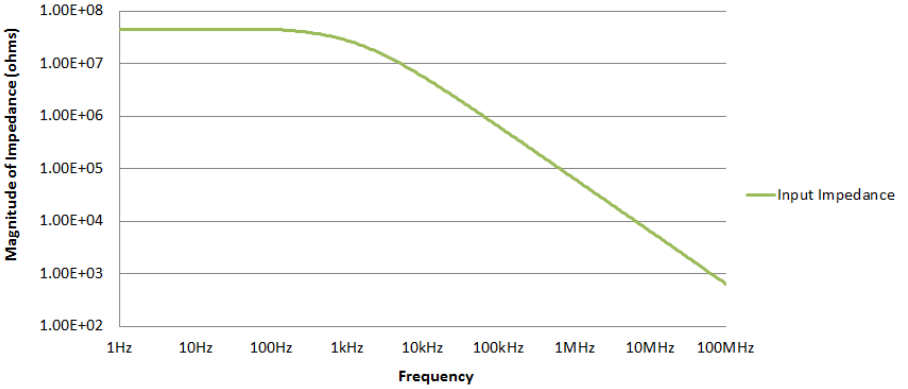
The Maximum Input Voltage curve (solid line) shows the maximum voltage that can be applied to the HVD3605 probe inputs without risking damage to the probe.

The lower Burn Limit curve (dashed line) shows the maximum voltage that can be applied to the probe inputs while the operator is handling the inputs. Handling the inputs while connected to active signals above this burn limit could result in injury to the operator.

WARNING. To avoid risk of electric shock or fire, comply with the burn limit when measuring high-frequency signals with hand-held accessories. Do not exceed the voltage or category rating of the probe or accessories (whichever is less). Keep your fingers behind the finger guard of the probe. Keep the probe body and output cable away from the circuits being measured. Use only the specified accessories.



Differential Input Impedance



Functional Test Procedure

This procedure should be performed to confirm the basic operation of an HVD3000 series probe, or to aid in determining the source of a problem rather than to verify the accuracy of the probe. You can perform the Functional Test without removing the probe covers.

Other than a Teledyne LeCroy oscilloscope, no special test equipment is required for the functional test.

1. Connect the probe to any vertical channel on the oscilloscope.
2. Select the channel to which the probe is connected.
3. Touch **AUTO ZERO** on the probe dialog.
4. If necessary, adjust the **OFFSET** to 0.000 V.
5. Using accessory clips, attach the red clip to the + CAL out and the black clip to the ground post of the CAL out signal. For oscilloscopes with the CAL signal on a BNC connector, a BNC-to-Banana adapter (e.g., Pomona model 1296) may be used.
6. Press **AUTOSETUP**.
7. Set the sensitivity of the probe to 1 V/Div.
8. Set the CAL output to 1 Vp-p square wave.
9. Verify that the displayed square wave is 1 Vp-p centered at +0.5 V.
10. Reverse the accessory leads on CAL out and verify that the displayed square wave is still 1 V, but is now centered at –0.5 V.
11. Change the **COUPLING** on the channel setup dialog to **Grounded** to verify that the signal disappears and that the trace is still centered on the screen.
12. Verify that the probe attenuation shows the following:
    - x100 for HVD3102
    - x50 for HVD3106 and HVD3206
    - x200 for HVD3605
13. Set the VOLTS/DIV to 100 V.
14. Verify that the probe attenuation now shows:
    - x1K for HVD3102
    - x500 for HVD3106 and HVD3206
    - x2K for HVD3605

Performance Verification Procedure

This procedure can be used to verify the warranted characteristics of an HVD3000 series probe. If the product does not meet specifications, it should be returned to a Teledyne LeCroy service center. As there are no user accessible adjustments, there is no adjustment procedure.

Required Equipment

The following table lists the test equipment and accessories (or their equivalents) that are required for performance verification of the probe. This procedure is designed to minimize the number of calibrated test instruments required. Because the input and output connector types may vary on different brands and models of test instruments, additional adapters or cables may be required. Only the parameters listed in boldface in the "Minimum requirements" column must be calibrated to the accuracy indicated.

Description	Minimum Requirements	Example Equipment
Digital Multimeter	**DC: 0.1% accuracy** **AC: 0.2% accuracy** to measure 7 mVrms to 37 Vrms at 70 Hz	Agilent 34401A Fluke 8842A-09 Keithley 2001
Function Generator	Output sine wave: 20 Vpp HVD310x and HVD3602 37 Vrms HVD3605 * * May require an amplifier to obtain required voltage, such as Tegam 2340.	Agilent 33120A Stanford Research DS34 Leader LAG-120B
BNC Coaxial Cable	Male-to-Male 50 Ω Cable	Pomona 5697-36
Calibration Fixture	ProBus Extender Cable	Teledyne LeCroy PROBUS-CF01
Banana Plug Adapter	Female BNC-to-Dual Banana Plug	Pomona 1269 Mueller BU-00260
Insulated Banana Plug Insulated Banana Couplers (2)	Insulated BNC-to-Shrouded Banana Plug	Mueller BU-5671-B-12-0 Mueller BU-32601-2 (R) Mueller BU-32601-6 (B)

Preliminary Procedure

1. Connect the probe under test to the female end of the ProBus Extension Cable. Connect the male end of the ProBus Extension Cable to channel 1 (C1) of the oscilloscope.
2. Turn on the oscilloscope and allow at least 30 minutes warm-up time before performing the Certification Procedure.
3. Turn on the other test equipment and allow these to warm up for the time recommended by the manufacturer.
4. While the instruments are reaching operating temperature, make a photocopy of the Performance Verification Test Record (following this topic), and fill in the necessary data.

Certification Procedure

1. Set the function generator to sine wave, 70 Hz, and an output voltage of approximately:
   - 7 Vrms (into a high impedance output) for HVD310x and HVD3206
   - 37 Vrms for HVD3605
2. Set the DMM to measure AC Volts.
3. Connect the function generator output to the DMM, using a BNC cable and a female BNC to dual banana plug adapter.
4. Adjust the function generator output voltage until the DMM reads:
   - 7 V ±0.01 V for HVD310x and HVD3206
   - 37 V ±0.01 V for HVD3605
5. Record the DMM reading to 1 mV resolution in the Test Record.
6. Disconnect the BNC cable from the function generator and from the BNC-to-banana plug adapter on the DMM. (Leave the banana plug adapter connected to the DMM).
7. Connect the BNC connector from the probe extender cable to the BNC-to-banana plug adapter on the DMM.
8. Connect the insulated banana plug adapter to the function generator.
9. Using the insulated banana couplers, connect the positive lead (red) of the probe under test to the positive output of the BNC-to-banana plug adapter and the negative lead (black) to the negative or return output.
10. Set the oscilloscope scale factor to:
    - 20 V/Div for HVD310x and HVD3206
    - 50 V/Div for HVD3605
11. Record the DMM reading to 0.01 mV resolution in the Test Record.
12. Multiply the measured output voltage recorded in step 11 by the actual probe attenuation factor, then divide this number by the function generator output voltage (probe input voltage) recorded in step 5. Subtract 1 from this number and multiply the result by 100 to

get the error in percent:

$$\%Error = \left(\frac{PrAttenuation \; x \; MeasuredOutputVoltage}{InputVoltage} - 1\right) x \; 100$$

NOTE: The actual probe attenuation can be found by using the XStream Browser. Follow the procedure below.

13. Record the answer to two significant places (± x.xx%) on line 13 in the Test Record.
14. Verify that the error ≤ 1.00%.
15. Decrease the oscilloscope scale factor to 5 V/Div.
16. Record the DMM reading to 0.01 mV resolution in the Test Record.
17. Multiply the measured output voltage recorded in step 16 by the actual probe attenuation factor, then divide this number by the function generator output voltage (probe input voltage) recorded in step 5. Subtract 1 from this number and multiply the result by 100 to get the error in percent.

    NOTE: Recheck the actual probe attentuation in the XStream Browser, as it will now be a different value than in step 12. Click the Refresh button in XStream browser if the previous session is still open.
18. Record the answer to two significant places (±x.xx%) on line 18 in the Test Record.
19. Verify that the error is ≤ 1.00%.

This completes the Performance Verification Procedure. Complete and file the Test Record as required to support your internal calibration procedure. If the criteria in steps 14 or 19 are not met, contact your local Teledyne LeCroy service center.

Checking Probe Attenuation in XStream Browser

Probe attenuation and other values can be found by using the XStream Browser application that is installed with the oscilloscope firmware.

1. Choose **File > Minimize** to show the oscilloscope desktop, then double-click the XStream Browser icon.
2. From the browser menu bar, choose **File > Connect to Local Instrument**.
3. Navigate to **LeCroy.XStreamDSO > Acquisition > C1 > InputB > HVDxxxx** (where xxxx is your probe model number). The value is shown next to PrAttenuation.
4. Close XStream browser and touch the oscilloscope icon (bottom right of desktop) to return to the oscilloscope software.

NOTE: These steps are tailored to the Performance Verification procedure. You can find any value at any time by changing the path to reflect the probe's actual input channel and row (C*x* > Input A|B).

HVD3000 Test Record

Serial Number: _____

Asset / Tracking Number: _____

Date: _____

Technician: _____

Equipment	Model	Serial Number	Calibration Due Date
Oscilloscope			
Digital Multimeter			
Function Generator[1]			
1 In this Performance Verification Procedure, the function generator is used for making relative measurements. The output of the generator is measured with a DMM or oscilloscope. Thus, the generator is not required to be calibrated.			

Step	Description	Intermediate Data	Test Result
5	Function Generator Output Voltage	V	
11	Probe Output Voltage	V	
13	Gain Error (test limit ± 1 %)		%
16	Probe Output Voltage	V	
18	Gain Error (test limit ± 1 %)		%

Permission is granted to photocopy this page to record the results of the Performance Verfication procedure. File the completed record as required by applicable internal quality procedures.

- Line numbers correspond to steps in the procedure that require the recording of data.
- Record the actual specification limit check under "Test Result". The test limits are included in all of these steps.
- Record other measurements and intermediate calculations that support the limit check under "Intermediate Results".

Operation

Connecting to the Test Instrument

The HVD3000 Series probes have been designed for use with Teledyne LeCroy oscilloscopes equipped with the ProBus interface. When you attach the probe output connector to the oscilloscope's input connector, the instrument will:

- Recognize the probe
- Set the oscilloscope input termination to 1 MΩ
- Activate the probe control functions in the oscilloscope user interface.

NOTE: For accurate measurements, connect the probe to the oscilloscope and allow to warm up for at least 20 minutes. Perform Auto Zero prior to connecting the probe to the DUT.

Connecting to the Test Circuit

Two inputs are available at the probe tip to connect the probe to a circuit under test. For accurate measurements, both the + and – inputs must be connected to the test circuit. Positive voltages applied to the + input (red) relative to the – input (black) will deflect the oscilloscope trace toward the top of the screen.

To maintain the probe's high performance capability, exercise care when connecting the probe. Increasing the parasitic capacitance or inductance in the input paths may introduce a "ring" or slow the rise time of fast signals. Input leads that form a large loop area will pick up any radiated electromagnetic field that passes through the loop and may induce noise into the probe inputs. Because this signal will appear as a differential mode signal, the probe's common mode rejection will not remove it. This effect can be reduced by twisting the input leads together to minimize the loop area.

WARNING. To avoid electric shock or fire, maintain the input leads in good condition. The leads have a jacket wear indicator that shows through when the jacket is excessively worn. If the white "WEAR" indicator on the input leads is visible, cease use and contact Teledyne LeCroy service for repair or replacement.

High common mode rejection requires precise matching of the relative gain or attenuation in the + and – input signal paths. Mismatches in additional parasitic capacitance, inductance, delay, and a source impedance difference between the + and – signals will lower the CMRR. Therefore, it is desirable to use the same length and type of wire and connectors for both input connections. When possible, try to connect the inputs to points in the circuit with approximately the same source impedance.

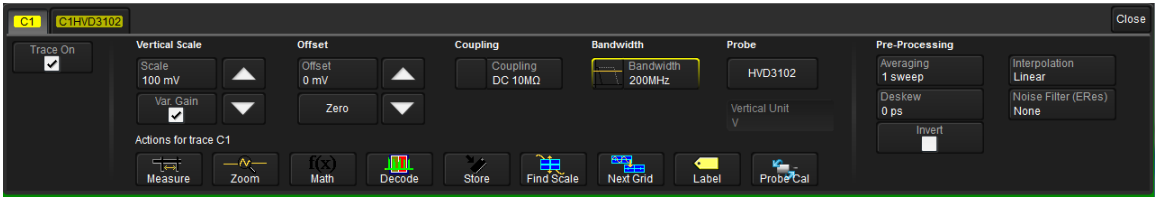
The probes may be stacked on one top of another during usage to conserve space. Since the probe body generates heat, and the stacking reduces cooling, it is recommended that ambient temperatures not exceed 30 degrees C while stacked probes are in operation. The exceptional CMRR performance should prevent interference between probes when they are stacked, but

take care to separate the probe leads during operation.

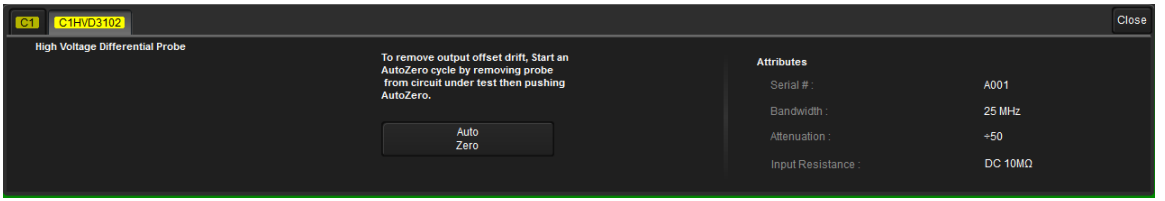
WARNING. To avoid electric shock or fire, keep the probe body and output cable away from the circuits being measured, as they cannot provide adequate protection if they come in contact with electrical sources.

Operating with an Oscilloscope

When the probe is connected to a Teledyne LeCroy oscilloscope, the displayed scale factor and measurement values will be adjusted to account for the effective gain of the probe. The probe's internal attenuation is shown on the Probe dialog, which is added to the oscilloscope's input channel dialogs when a probe is detected.



Channel setup dialog with Probe dialog behind it.



Probe dialog.

Probe Volts/Div and Attenuation

The front panel Volts/Div knob controls the oscilloscope's scale factor and the probe's internal attenuation to give full available dynamic range. Some transition of the scale factor will result in a change of attenuation.

Offset

Offset allows you to remove a DC bias voltage from the differential input signal while maintaining DC coupling. This ensures that the probe will never be overdriven while a signal is displayed on screen and prevents inaccurate measurements.

The total usable offset of the oscilloscope and probe system is a function of the oscilloscope V/div setting, oscilloscope offset at that V/div setting, probe attenuation, and probe offset at that attenuation setting, and this total maximum offset may be calculated.

First, it is necessary to know the oscilloscope front end V/div setting with the probe

connected. This may be calculated as follows:

Oscilloscope Front End V/Div = (Probe and Oscilloscope) V/Div ÷ Probe_Attenuation

Once the oscilloscope front end V/div value is known, then it is possible to know the maximum offset available in the oscilloscope at this V/div setting either by referencing the oscilloscope specifications or setting the maximum offset value on the oscilloscope for that V/div setting.

Then, the maximum offset available with the probe and oscilloscope combination can be calculated as:

Max Positive Offset Available

Max Positive Offset (Probe and Oscilloscope together) =
*Oscilloscope Positive Offset (at Oscilloscope Front End V/div) * Probe Attenuation – 10V*

Max Negative Offset Available

Max Negative Offset (Probe and Oscilloscope together) =
*Oscilloscope Negative Offset (at Oscilloscope Front End V/div) * Probe Attenuation + 10V*

In both cases, the maximum offset available cannot exceed the following:

	x50	x100	x200	x500	x1000	x2000
3102	NA	±150V	NA	NA	±1500V	NA
3106	±150V	NA	NA	±1500V	NA	NA
3206	±150V	NA	NA	±1500V	NA	NA
3605	NA	NA	±600V	NA	NA	±6000V

NOTE: The offset values reported in the oscilloscope's channel descriptor box may deviate slightly from expected values, based on calculations per the formulas above. The reported probe attenuation is a "nominal" value and can deviate slightly from the actual value measured during calibration and stored with the probe. The actual offset value reported uses the actual "as measured" probe attenuation value. This provides for higher DC and low frequency gain accuracy than would otherwise be possible.

AC Coupling

In general, using offset to adjust a differential DC voltage on the screen is the preferred method to measure transient signals in the presence of a larger DC voltage. The offset has limits that will cause a signal that is beyond the linear operating range of the probe to go off the screen, preventing measurement errors.

There are times, however, when it is convenient to use AC coupling to remove the DC component of the measured signal from the measurement. Selecting AC10MΩ uses the scope AC coupling at the probe output to remove any steady state value from the displayed voltage. The maximum linear input voltage is as follows:

	x50 (<7V/div)	x100 (<7V/div)	x200 (<28V/div)	x500 (>7V/div)	x1000 (>7V/div)	x2000 (>28V/div)
3102	NA	200Vpk	NA	NA	2000Vpk	NA
3106	200Vpk	NA	NA	2000Vpk	NA	NA
3206	200Vpk	NA	NA	2000Vpk	NA	NA
3605	NA	NA	760Vpk	NA	NA	7600Vpk

NOTE: Since this AC coupling is on the probe output, DC voltages beyond the linear range of the probe will cause the amplifier to saturate and make the displayed waveform inaccurate. It is important not to exceed the maximum linear input values when using AC coupling.

Bandwidth Limiting

To comply with various test standards used for quantifying output noise of power supplies, the probe is capable of switching the bandwidth limit from Off (maximum bandwidth) to 20 MHz in the channel Vertical Adjust dialog.

Auto Zero

Auto Zero corrects for DC offset drifts that naturally occur from thermal effects in the amplifier. The probe incorporates Auto Zero capability to remove the DC offset from the probe's differential amplifier output to improve the measurement accuracy. Auto Zero is invoked manually from the Probe dialog that appears behind the Channel setup dialog when the probe is connected to the oscilloscope.

NOTE: Remove the probe from the test circuit before performing Auto Zero.

Always perform Auto Zero after probe warm-up (recommended warm-up time is 20 minutes). Depending on the measurement accuracy desired and/or the change in the ambient temperature where the probe is located, it may be necessary to perform Auto Zero more often. If the probe is disconnected from the oscilloscope and re-connected, repeat Auto Zero after a suitable warm-up time.

For example, the DC offset drift of the HVD310x probes is 70 µV/°C (worst-case) referred to the output. If the probe is set to 50x attenuation and the ambient temperature changes by 10°C, then the DC offset drive could be as high as (70 µV/°C)(50)(10°C) = 35mV (referenced to the probe tip). If the probe is being used to measure a 3Vp-p signal, then the DC offset drift in this case could be a little more than 1%. If the signal measured was 1400Vp-p in 500x attenuation mode, then the DC offset (in the same ambient temperature condition) could be as high as (70 µV/°C)(500)(10°C) = 350 mV due to the probe tip, but any offset accuracy error from the oscilloscope itself would likely dominate the measurement.

Auto Zero is disabled when AC coupling is selected.

Maintenance

Cleaning

Clean only the exterior surfaces of the device using a soft cloth or swab dampened with water or 75% isopropyl alcohol solution. Do not use harsh chemicals or abrasive cleansers. Dry the probe and accessories thoroughly before making any voltage measurements.

CAUTION. The HVD3000 probes are not waterproof. Under no circumstances submerge the probe in liquid or allow moisture to penetrate it.

Calibration Interval

This probe has no adjustments. The recommended calibration interval is one year. A Performance Verification Procedure is included in this manual.

Service Strategy

The HVD3000 series probes utilize fine-pitch surface mount devices. It is, therefore, impractical to attempt repair in the field. Defective probes must be returned to a Teledyne LeCroy service facility for diagnosis and exchange.

CAUTION. Do not remove the covers. Refer all servicing to qualified personnel.

A defective probe under warranty will be replaced with a factory refurbished probe. Replacement probes are factory repaired, inspected, and calibrated to the same standards as a new product.

A probe that is not under warranty can be exchanged for a factory refurbished probe for a modest fee. You must return the defective probe in order to receive credit for the probe core.

Replacement Parts

Replacement probe accessories can be ordered through your local sales office:

Probe	Replacement Parts	Part Number
HVD310x	Probe Accessory Kit *	PK-HV-001
HVD3206	6kV Alligator Clips	PK-HVA-06
HVD3605	6kV Alligator Clips	PK-HVA-06

* Individual probe accessory tips can be purchased through your regional service center. Refer to the accessory part numbers listed earlier in this manual.

Returning a Product for Service

Contact your regional Teledyne LeCroy service center for calibration or other service. If the product cannot be serviced on location, the service center will give you a **Return Material Authorization (RMA) code** and instruct you where to ship the product. All products returned to the factory must have an RMA.

Return shipments must be prepaid. Teledyne LeCroy cannot accept COD or Collect shipments. We recommend air-freighting. Insure the item you're returning for at least the replacement cost.

1. Remove all accessories from the device.
2. Pack the product in its case, surrounded by the original packing material (or equivalent). Do not include the manual.
3. Label the case with a tag containing:
   - The RMA
   - Name and address of the owner
   - Product model and serial number
   - Description of failure or requisite service
4. Pack the product case in a cardboard shipping box with adequate padding to avoid damage in transit.
5. Mark the outside of the box with the shipping address given to you by Teledyne LeCroy; be sure to add the following:
   - ATTN: <RMA code assigned by Teledyne LeCroy>
   - FRAGILE
6. **If returning a product to a different country:**
   - Mark the shipment as a "Return of US manufactured goods for warranty repair/recalibration."
   - If there is a cost for the service, list the cost in the Value column and the original purchase price "For insurance purposes only."
   - Be very specific about the reason for shipment. Duties may have to be paid on the value of the service.

Extended warranty, calibration, and upgrade plans are available for purchase. Contact your Teledyne LeCroy sales representative.

Contact Us

Our regional service centers are:

World Wide Corporate Office
Teledyne LeCroy
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teledynelecroy.com
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contact.corp@teledynelecroy.com
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support@teledynelecroy.com

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For a complete list of offices by country, including our sales & distribution partners, visit:

teledynelecroy.com/support/contact

Reference

Common Mode Rejection Ratio

The ideal differential probe/amplifier would sense and amplify only the differential mode voltage component and reject the entire common mode voltage component. Real differential amplifiers are not perfect, and a small portion of the common mode voltage component appears at the output.

Common Mode Rejection Ratio (CMRR) is the measure of how much the amplifier rejects the common mode voltage component. CMRR is equal to the differential mode gain (or normal gain) divided by the common mode gain. Common mode gain is equal to the output voltage divided by the input voltage when both inputs are driven by only the common mode signal. CMRR can be expressed as a ratio (e.g., 10,000:1) or implicitly in dB (e.g., 80 dB). Higher numbers indicate greater rejection (better performance).

The first order term determining the CMRR is the relative gain matching between the **+** and **–** input paths. Obtain high CMRR values by precisely matching the input attenuators in a differential amplifier. The matching includes the DC attenuation and the capacitance which determines the AC attenuation. As the frequency of the common mode component increases, the effects of stray parasitic capacitance and inductance in determining the AC component become more pronounced. The CMRR becomes smaller as the frequency increases. Therefore, the CMRR is usually specified in a graph of CMRR versus common mode frequency.

The common mode frequency in these graphs is assumed to be sinusoidal. In real life applications, the common mode signal is seldom a pure sine wave. Signals with pulse wave shapes contain frequency components much higher than the repetition rate may suggest. This makes it very difficult to predict actual performance in the application for CMRR-versus-frequency graphs. The practical application of these graphs is to compare the relative common mode rejection performance between different probes and amplifiers.

Differential Mode and Common Mode

Differential probes sense the voltage difference that appears between the **+** and **–** inputs. This is referred to as the Differential or Normal Mode voltage. The voltage component that is referenced to earth and is identical on both inputs is rejected by the amplifier. This is referred to as the Common Mode voltage and can be expressed as:

$$V_{CM} = \frac{V_{+input} + V_{-input}}{2}$$

Differential Mode Range and Common Mode Range

Differential Mode range is the maximum signal that can be applied between the **+** and **-** inputs without overloading the amplifier, which otherwise would result in clipping or distorting of the waveform measured by the oscilloscope.

The Common Mode Range is the maximum voltage with respect to earth ground that can be applied to either input. Exceeding the common mode range can result in unpredictable measurements. Because the Common Mode signal is normally rejected, and not displayed on the oscilloscope, be careful to avoid accidentally exceeding the common mode range.

IEC/EN 61010-031 Definitions

IEC/EN 61010-031/A1:2008

Measurement Category III (CAT III) applies to test and measuring circuits connected to the distribution part of the building's low-voltage mains installation.

Measurement Category II (CAT II) applies to test and measuring circuits connected directly to utilization points (socket outlets and similar points) of the low-voltage mains installation.

Measurement Category I (CAT I) applies to test and measurement circuits that are not intended to be directly connected to the mains supply.

Pollution Degree 2 refers to an operating environment where normally only dry non-conductive pollution occurs. Conductivity caused by temporary condensation should be expected.

IEC/EN 61010-031:2015

Measurement Category III (CAT III) applies to test and measuring circuits connected to the distribution part of the building's low-voltage mains installation.

Measurement Category II (CAT II) applies to test and measuring circuits connected directly to utilization points (socket outlets and similar points) of the low-voltage mains installation.

No Rated Measurement Category (O) applies to other circuits that are not directly connected to the mains supply.

NOTE: The 2015 version of the standard eliminates the Measurement Category I (CAT I) and creates a new rating, "O", which refers to "Other circuits that are not directly connected to the mains". Products that conformed to Measurement Category I in the 2008 version of the standard may now be classified as "O".

Pollution Degree 2 refers to an operating environment where normally only dry non-conductive pollution occurs. Conductivity caused by temporary condensation should be expected.

Certifications

EMC Compliance

EC Declaration of Conformity - EMC

The probe meets the intent of EC Directive 2004/108/EC for Electromagnetic Compatibility. Compliance was demonstrated to the following specifications as listed in the Official Journal of the European Communities:

EN 61326-1:2013, EMC requirements for electrical equipment for measurement, control, and laboratory use.[1, 2, 3]

1 This product is intended for use in nonresidential areas only. Use in residential areas may cause electromagnetic interference.

2 Emissions exceeding the levels required by this standard may occur when product is connected to a test object.

3 To ensure compliance with the applicable EMC standards, use high quality shielded interface cables.

EUROPEAN CONTACT:*

Teledyne LeCroy Europe GmbH
Im Breitspiel 11c
D-69126 Heidelberg
Germany
Tel: + 49 6221 82700

Australia & New Zealand Declaration of Conformity—EMC

The probe complies with the EMC provision of the Radio Communications Act per the following standards, in accordance with requirements imposed by Australian Communication and Media Authority (ACMA):

AS/NZS CISPR 11:2011 Radiated and Conducted Emissions, Group 1, Class A.

AUSTRALIA / NEW ZEALAND CONTACTS:*

RS Components Pty Ltd.
Suite 326 The Parade West
Kent Town, South Australia 5067

RS Components Ltd.
Unit 30 & 31 Warehouse World
761 Great South Road
Penrose, Auckland, New Zealand

* Visit teledynelecroy.com/support/contact for the latest contact information.

Safety Compliance

EC Declaration of Conformity - Low Voltage

The probe meets the intent of EC Directive 2006/95/EC for Product Safety. Compliance was demonstrated to the following specifications as listed in the Official Journal of the European Communities:

IEC/EN 61010-031/A1:2008 Safety requirements for electrical equipment for measurement, control, and laboratory use – Part 031: Safety requirements for hand-held probe assemblies for electrical measurement and test. [1]

U.S. Nationally Recognized Agency Certification

The probe has been certified by Underwriters Laboratories (UL) to conform to the following safety standard and bears UL Listing Mark:

UL 61010-031-2010 (First Edition) - Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use - Part 031: Safety Requirements for Hand-Held Probe Assemblies for Electrical Measurement and Test. [2]

Canadian Certification

The probe has been certified by Underwriters Laboratories (UL) to conform to the following safety standard and bears cUL Listing Mark:

CAN/CSA-C22.2 No. 61010-031-07/A1:2010 - Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use - Part 031: Safety Requirements for Hand-Held Probe Assemblies for Electrical Measurement and Test. [3]

1 Probe tested to conform to IEC/EN 61010-031:2015. Certification pending.

2 Probe tested to conform to UL 61010-031-2015 (Second Edition). Certification pending.

3 Probe tested to conform to CAN/CSA-C22.2 No. 61010-031-15. Certification pending.

Environmental Compliance

End-of-Life Handling

The product is marked with this symbol to indicate that it complies with the applicable European Union requirements to Directives 2002/96/EC and 2006/66/EC on Waste Electrical and Electronic Equipment (WEEE) and Batteries.

The product is subject to disposal and recycling regulations that vary by country and region. Many countries prohibit the disposal of waste electronic equipment in standard waste receptacles. For more information about proper disposal and recycling of your Teledyne LeCroy product, please visit teledynelecroy.com/recycle.

Restriction of Hazardous Substances (RoHS)

The product and its accessories conform to the 2011/65/EU RoHS2 Directive.

Warranty

THE WARRANTY BELOW REPLACES ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTY OF MERCHANTABILITY, FITNESS, OR ADEQUACY FOR ANY PARTICULAR PURPOSE OR USE. TELEDYNE LECROY SHALL NOT BE LIABLE FOR ANY SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, WHETHER IN CONTRACT OR OTHERWISE. THE CUSTOMER IS RESPONSIBLE FOR THE TRANSPORTATION AND INSURANCE CHARGES FOR THE RETURN OF PRODUCTS TO THE SERVICE FACILITY. TELEDYNE LECROY WILL RETURN ALL PRODUCTS UNDER WARRANTY WITH TRANSPORT PREPAID.

The product is warranted for normal use and operation, within specifications, for a period of one year from shipment. Teledyne LeCroy will either repair or, at our option, replace any product returned to one of our authorized service centers within this period. However, in order to do this we must first examine the product and find that it is defective due to workmanship or materials and not due to misuse, neglect, accident, or abnormal conditions or operation.

Teledyne LeCroy shall not be responsible for any defect, damage, or failure caused by any of the following: a) attempted repairs or installations by personnel other than Teledyne LeCroy representatives, b) improper connection to incompatible equipment, or c) use of non-Teledyne LeCroy supplies. Furthermore, Teledyne LeCroy shall not be obligated to service a product that has been modified or integrated where the modification or integration increases the task duration or difficulty of servicing the product. Spare and replacement parts and repairs all have a 90-day warranty.

Products not made by Teledyne LeCroy are covered solely by the warranty of the original equipment manufacturer.

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