HVFO
High Voltage Fiber Optically-isolated Probe

Key Features

Applications
• Upper-side gate drive signal measurements
• Floating control signal or sensor voltage measurements
• EMC, EFT, ESD, and RF immunity testing and system optimization
• Any small signal measurements with high common-mode voltage

60 MHz bandwidth
35 kV common-mode voltage rating (fiber optic isolation)

Superior Noise and Rejection
• 140 dB CMRR
• Low loop inductance
• Low attenuation

Reduced DUT loading, better pulse response compared to conventional HV differential probes

Selectable tips from ±1V to ±40V

Eliminates need to “float” the oscilloscope

ProBus-compatible with many Teledyne LeCroy oscilloscopes

The HVFO is an affordable, optimally designed probe for measurement of small signals floating on an HV bus in power electronics designs or for EMC, EFT, ESD, and RF immunity testing sensor monitoring. It far surpasses the measurement capabilities and signal fidelity of both conventional HV differential probes and acquisition systems that rely on galvanic high voltage isolation. Furthermore, it mitigates the need to rely on dangerous test setups that require floating the oscilloscope and probe.

Optical Isolation is Best
Optical isolation between the probe tip and the oscilloscope input reduces adverse loading of the DUT, provides faithful pulse response, and increases confidence in the measurement. Safety against dangerous high voltage levels can be ensured and unsafe “floating” of the oscilloscope can be avoided.

Superior Noise Rejection
High CMRR (140 dB) provides more accurate representation of the measured signal despite the presence of high dV/dt or dA/dt events elsewhere in the circuit. The test lead is optimized to limit loop inductance and radiated pickup. Tip attenuations are optimized for a wide range of signal amplitudes.

Compact, Simple, Affordable
The HVFO103 is small enough to fit in tight spaces, provides just enough performance for real-world needs, and is affordable enough to fit the tightest of equipment budgets.

Applications
The HVFO is ideal for measuring low voltage (1 to 40V) signals floating on a HV bus, such as in-circuit upper-side gate drive signals and low voltage control, sensor, or sense resistor signals. The probe is also suitable for EMC immunity testing in which a device operation must be monitored in the presence of disturbance signals.
The HVFO provides capability to measure your signal as it truly is, in-circuit, without compromise. Upper-side gate drive signals will be faithfully reproduced without loading and distortion or mysterious ringing, overshoots and transients, providing a clear view of the Miller effect on the gate drive signal. AC and DC sensor signals floating at a high voltage or in the presence of EMC, EFT, ESD, and RF disturbance signals can be acquired with high signal fidelity and correctly correlated to in-circuit and control activities.

The HVFO architecture is simple - a single laser and fiber optic cable is used for optical isolation and modulated signal + data communication, and multiple tips achieve different operating voltage ranges.
**Upper-side Gate Drive Voltage Measurement**

An upper-side device has an applied gate voltage floating above ground. Any conventional HV differential probe with high tip capacitance in parallel with $C_{GE}$ or $C_{GS}$, and/or high impedance and large loop inductance in series with the gate drive impedance will at best load the gate drive signal and at worst cause circuit malfunction. Measurement interference from the low-side device switching can also interfere with proper upper-side gate voltage measurement. The HVFO is optimized for the best upper-side gate drive voltage measurements.

The HVFO (yellow trace) and a conventional HV differential probe (magenta trace) capture an upper-side gate drive signal. The HVFO exhibits a classic, textbook shape while the HV differential probe has more loading and lower-side device high $dV/dt$ signal interference.

**Floating Control or Sensor Signal Measurements**

The HVFO measures only the low voltage sensor voltage across its high impedance input leads. Total load on the device under test (DUT) is very small. Furthermore, the low lead loop inductance, >100 dB CMRR, and low attenuation provide superior signal fidelity, noise and rejection.

The HVFO measures only the small signal voltage with high probe input impedance; therefore, total DUT load is very small. Low tip loop inductance and 140 dB CMRR provide superior signal fidelity, noise and rejection.

The HV differential probe measures the full common mode + sensor voltage. Therefore, the DUT load is ~100 times larger than with the HVFO. This excessive load will impact the signal fidelity and may even cause the circuit to malfunction.
### HVFO Probes

**Product Description:**
High Voltage Fiber Optic Probe, 60 MHz Bandwidth. Includes soft-carrying case, Qty. 1 Amplifier/Modulating Transmitter, Qty. 1 Demodulating Receiver, Qty. 1 1m Fiber Optic Cable, Qty. 1 USB Charging Cable, Qty. 1 Micro-gripper set.

**Ordering Information**

<table>
<thead>
<tr>
<th>Product Description</th>
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<tr>
<td>HVFO Probes</td>
<td>HVFO103</td>
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**Attenuating Tips must be ordered separately.**

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<tr>
<th>Tip Range</th>
<th>Code</th>
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<tbody>
<tr>
<td>±1V (1x)</td>
<td>HVFO100-1X</td>
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<tr>
<td>±5V (5x)</td>
<td>HVFO100-5X</td>
</tr>
<tr>
<td>±20V (20x)</td>
<td>HVFO100-20X</td>
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<tr>
<td>±40V (40x)</td>
<td>HVFO100-40X</td>
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**Spare Amplifier/Modulating Transmitter (permits constant operation - charge one while another is being used)**

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<tr>
<td>HVFO103-XMITTER</td>
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**1m Spare Fiber Optic Cable Accessory**

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<td>HVFO1M-FIBER</td>
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**2m Fiber Optic Cable Accessory**

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<td>HVFO2M-FIBER</td>
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**6m Fiber Optic Cable Accessory**

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**NIST Traceable Calibration Certificate**

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**Certifications**

- CE Declaration of Conformity
  - RoHS2 Directive 2011/65/EU

**Specifications**

- **Electrical**
  - **Bandwidth:** 60 MHz (typical, with tip attached)
  - **Rise Time (10-90%):** 7.5 ns (typical)
  - **Input Dynamic Range:** ±1V, ±5V, ±20V, ±40V (DC+peak AC) respectively with 1X, 5X, 20X or 40X attenuating tips. All tips are purchased as accessories (none are included with HVFO103 probe).
  - **Maximum Non-destruct Voltage:** 5 times the operating voltage rating (tip dependent)
  - **Common Mode Voltage Range:** ±35 kV (DC+Peak AC) (not for hand-held use, with adequate spacing between probe components and earth ground)
  - **Maximum Voltage to Earth:** ±35 kV (DC+Peak AC) (not for hand-held use, with adequate spacing between probe components and earth ground)
  - **Maximum Safe Input Voltage:**
    - For hand-held use, 30 Vrms / 60 Vdc per IEC/EN 61010-031:2015
    - For constant operation, charge one amplifier while another is being used
  - **Offset:** Offset capability determined by oscilloscope offset available in a given gain (V/div) setting after accounting for total probe attenuation (total probe attenuation is twice the tip attenuation).
  - **Sensitivity:** 50 mV/div to 1 V/div (1X tip), 250 mV/div to 5 V/div (5X tip), 1 V/div to 20 V/div (20X tip), 2 V/div to 40 V/div (40X tip)
  - **Gain Accuracy:** 2% (LF, guaranteed)
  - **Input Impedance:** 1 MΩ || 34 pF (1X tip); 5 MΩ || 26 pF (5X tip); 10 MΩ || 22 pF (20X tip); 10 MΩ || 22 pF (40X tip)

- **Noise, Rejection, and Electromagnetic Compatibility (EMC)**
  - **CMRR (typical):** 140 dB (100 Hz), 120 dB (to 1 MHz), 85 dB (to 10 MHz), 60 dB (to 60 MHz)
  - **Noise (Probe only):** 7 mVrms (1X tip), 35 mVrms (5X tip), 140 mVrms (20X tip), 280 mVrms (40X tip)
  - **Electrostatic Discharge (ESD):** 8 kV contact discharge and 10 kV air discharge per IEC61000-4-2, criteria A
  - **Radiated RF Electromagnetic Field Immunity:** 25 V/m (80 MHz to 2.7 GHz) per IEC61000-4-3, criteria A
  - **Immunity to Conducted Disturbance Induced by RF Fields:** 10 V/m (150 kHz to 80 MHz) per IEC61000-4-6, criteria A

- **Environmental**
  - **Temperature:** 0°C to 50°C (operating), -20°C to 70°C (non-operating)
  - **Humidity:** 5% to 80% RH (non-condensing) up to 30°C, decreasing linearly to 45% RH at 50°C (operating)
    - 5% to 95% RH (non-condensing), 80% RH above 30°C, 45% RH above 50°C (non-operating)
  - **Altitude:** Up to 3000 m (operating), 10,000 m (non-operating)
  - **Pollution Degree:** 2, Indoor Use Only

- **Certifications**
  - CE Declaration of Conformity
    - RoHS2 Directive 2011/65/EU

**Customer Service**

Teledyne LeCroy oscilloscopes and probes are designed, built, and tested to ensure high reliability. In the unlikely event you experience difficulties, our digital oscilloscopes are fully warranted for three years and our probes are warranted for one year. This warranty includes:

- No charge for return shipping
- Long-term 7-year support
- Upgrade to latest software at no charge