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Test & Measurement

- sales
- rentals
- calibration
- repair
- disposal

Complimentary Reference Material

This PDF has been made available as a complimentary service for you to assist in evaluating this model for your testing requirements.

TMG offers a wide range of test equipment solutions, from renting short to long term, buying refurbished and purchasing new. Financing options, such as Financial Rental, and Leasing are also available on application.

TMG will assist if you are unsure whether this model will suit your requirements.

Call TMG if you need to organise repair and/or calibrate your unit.

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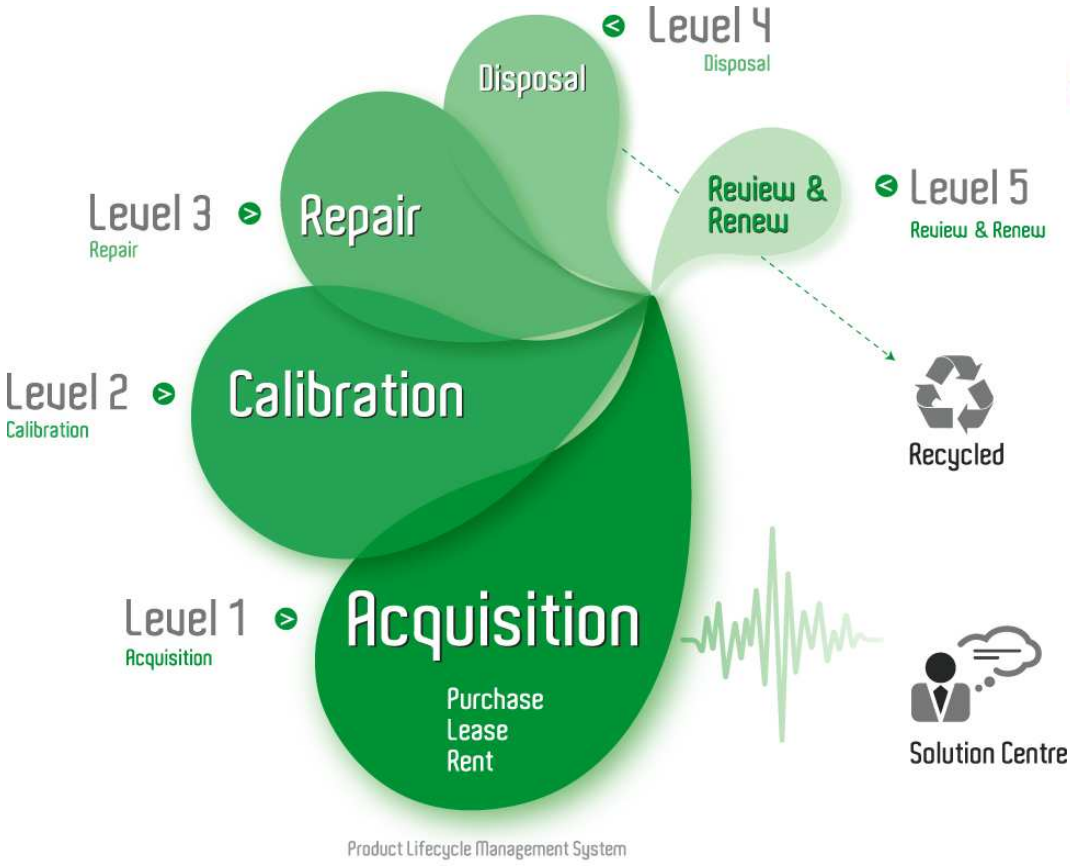


LeCroy

PROBES AND ACCESSORIES
CATALOG 2003

LeCroy

Table of Content

Differential Amplifiers

DA1855A

MAIN FEATURES:

- **Full control from oscilloscope through ProBus interface**
- **DC to 100 MHz bandwidth**
- **100,000: 1 CMRR**
- **Gain of ÷1 or ÷10**
- **State-of-the-art overdrive recovery**
- **Low Noise**

DA1822A

MAIN FEATURES:

- **Full control from oscilloscope through ProBus interface**
- **DC to 10 MHz bandwidth**
- **100,000: 1 CMRR**
- **Gain of 1, 10, 100 & 1000**
- **Selectable upper and lower bandwidth limits**
- **Precision voltage generator (1822A only)**
- **Ideal for automotive and medical electronics**

The DA1822A and DA1855A are stand-alone, high-performance differential amplifiers. They are intended to act as a signal conditioning preamplifier for oscilloscopes and other instruments, providing differential measurement capability. When used with a DA18xxA differential amplifier, oscilloscopes can obtain Common Mode Rejection Ratio (CMRR).

The DA1822A is a high gain differential amplifier providing up to 10 MHz bandwidth. It will extend the dynamic range of an oscilloscope into the microvolt level.

The DA1855A is a 100 MHz differential amplifier which provides fast overdrive recovery.

Overdrive Recovery (DA1855A)

The DA1855A provides the fastest overdrive recovery in any commercially available differential amplifier. This unique capability allows the amplifier to make measurements which would be limited by oscilloscope overdrive recovery.

To avoid overdriving the oscilloscope and defeating the amplifier's overdrive recovery capability, the output of the DA1855A is limited to ±0.5 V.

These two features provide extremely fast system overdrive recovery. In X10 gain, the differential amplifier will typically settle in less than 100 ns to within 1 mV referred to input after a 4 V (8000 %) overdrive.

Fast overdrive recovery is essential when measuring small signals after a large step change. Typical applications where this capability is required include measuring dynamic saturation voltage in power supply switching transistors, and amplifier or D/A converter settling times.

High Gain with Selectable Filtering (DA1822A)

The DA1822A provides four decades of user selectable gain (X1, X10, X100 and X1000). This extends the lower sensitivity of the oscilloscope to 1 or 2 mV / division. User selectable filtering allows bandwidth limiting to reduce noise outside the frequency

range of interest. Low pass filtering is settable in 1/2 decade steps, and high pass filtering is selectable in decade steps. Signal sources such as transducers and electrochemical experiments often have high driving impedances, which introduce measurement error when loaded with even a 1 MW load from the measuring instrument. The DA18xxA amplifiers eliminate the error with a user selectable 100 MW input impedance which places a negligible load on virtually any test circuit.

Full control integration with LeCroy Oscilloscopes

The DA1822A and DA1855A connect to a LeCroy oscilloscope through the ProBus interface. This provides seamless control of all functions of the differential amplifier and the oscilloscope through a single, easy to understand user interface. Computation of the effective gain or attenuation and offset value are transparent – the scale factor, cursor and parameter measurements always indicate the true voltage at the probe tips.

Gain Control Modes

When connected to a LeCroy oscilloscope, two gain control modes are available. AUTO mode, which is the default, controls the oscilloscope scale factor, DA1822A or DA1855A gain and attenuation automatically through the V/Div knob. In this mode, the maximum dynamic range possible by all combinations of control parameters can be accessed just by turning the V/Div knob. In MANUAL mode, the user can independently set the DA1822A or DA1855A gain and attenuation. This mode is sometimes desirable when user does not wish to have amplifier change gain or attenuation during oscilloscope scale factor changes.

Precision Offset

The DA1822A and DA1855A have a built-in Precision Voltage Generator (PVG) which is used as a reference for calibrated offset. The PVG is settable with up to 5 1/2 digits resolution. The offset range of the amplifier is considerably greater than the oscilloscope – up to ±100,000 divisions, depending on the scale factor.

The amplifiers provide two offset modes – Comparator and True Differential. In the comparator mode, the negative input is driven by the PVG reference source. In this configuration, the amplifier operates in a single ended mode, as only the positive input is available for signal input. In the comparison mode, the value of the vertical center of the oscilloscope is equal to the voltage indicated in the PVG readout. The decimal point moves automatically to account for the attenuator setting of the amplifier and any external probes.

The DA1822A and DA1855A also provide a true differential offset mode. As the name implies, a calibrated offset can be added while the amplifier continues to operate in true differential mode. As with the comparison mode, the range of the true differential mode is larger than the offset available in the oscilloscope.

In addition for use of providing the reference voltage for offset, the PVG output is available through a connector on the rear panel to serve as a reference for other applications.

High Common Mode Rejection

The DA1822A and DA1855A feature an outstanding Common Mode Rejection Ratio (CMRR), both at DC and high frequencies. This high performance is critical in demanding applications such as measuring the high side gate drive in power supplies, inverters, motor drives and other power conversion devices with high bus voltages and rejecting line frequency noise when measuring the millivolt output signals from transducers. When used with calibrated DXC series probes (optional accessories), the amplifier's common mode rejection performance is extended to the probe tip.

Other Features

Selectable low pass filters allow the user to truncate the amplifier bandwidth in situations when it is desirable to reduce noise outside the bandwidth of interest. An autozero function automatically removes any output drift from the amplifier without the need to disconnect the input from the test signal. As a convenience when used with other test instruments, effective gain/attenuation indicators show the system gain or attenuation, including the scaling resulting from attenuating probes.

DA1822A and DA1855A Technical Specifications

GENERAL

Amplifier gain (DA1822A):	1, 10, 100 or 1000
Amplifier gain (DA1855A):	1 or 10
Gain accuracy:	±1% + ? uncertainty of termination resistance.
Output Zero:	≤ 2 mV referred to input
Bandwidth (DA1822A):	>10 MHz (X1 or X10 gain), >2.5 MHz (X100 Gain), > 1 MHz (X1000 Gain)
Bandwidth (DA1855A):	>100 MHz (X1 gain)
Output impedance:	50 ohm
Intended output load:	50 ohm
Maximum output (DA1822A):	limited at ±5 V into 50 ohm.
Maximum output (DA1855A):	limited at ±0.50 V into 50 ohm.
Input attenuation:	÷1 or ÷10
Input Impedance:	1 MW ffIffI 20 pF 100 MW resistance selectable in ÷1 attenuation setting only.

MAX DIFFERENTIAL LINEAR INPUT (DA1822A)[1]:

(x1 Gain, ÷1 Attenuator):	±5 V
(x10 Gain, ÷1 Attenuator):	±0.5 V
(x100 Gain, ÷1 Attenuator):	±0.05 V
(x1000 Gain, ÷1 Attenuator):	±5 mV
(x1 Gain, ÷10 Attenuator):	±50.0 V
(x10 Gain, ÷10 Attenuator):	±5 V
(x100 Gain, ÷10 Attenuator):	±0.5 V
(x1000 Gain, ÷10 Attenuator):	±0.05 V

MAX DIFFERENTIAL LINEAR INPUT (DA1855A)[1]:

(X1 Gain, ÷1 Attenuator):	±0.5 V
(X10 Gain, ÷1 Attenuator):	±0.05 V
(X1 Gain, ÷10 Attenuator):	±5.0 V
(X10 Gain, ÷10 Attenuator):	±0.5 V

MAX COMMON MODE INPUT[1]:

(÷1 Attenuator):	±15.5 V
(÷10 Attenuator):	±155 V

DIFFERENTIAL OFFSET RANGE (VDIFF) MODE (DA1822A)[1]

(X1 Gain, ÷1 Attenuator):	±10 V
(X10, X100, or X100 Gain, ÷1 Attenuator):	±1 V
(X1 Gain, ÷10 Attenuator):	±100 V
(X10, X100, or X1000 Gain, ÷10 Attenuator):	±10 V

DIFFERENTIAL OFFSET RANGE (VDIFF) MODE (DA1855A)[1]

(X1 Gain, ÷1 Attenuator):	±10 V
(X10 Gain, ÷1 Attenuator):	±1 V
(X1 Gain, ÷10 Attenuator):	±100 V
(X10 Gain, ÷10 Attenuator):	±10 V

COMPARISON OFFSET RANGE (VCOMP) MODE1

Effective comparison voltage range:	
(÷1 Attenuator):	±15.5 V
(÷10 Attenuator):	±155 V

COMMON MODE REJECTION RATIO, X1 OR X10 GAIN, ÷1 ATTENUATION:

≥ 50,000:	1 (94 dB) @ 70 Hz
≥ 50,000:	1 (94 dB) @ 100 kHz
≥ 316:	1 (50 dB) @ 10 MHz (DA1855A only)

OVERDRIVE RECOVERY (TYPICAL APPLIES TO DA1855A ONLY):

In X10 gain, amplifier settles to within 1 mV referred to the input within 100 nsec from 4 V input. (8000% overdrive)

BANDWIDTH LIMIT FILTERS

DA1822A: LP: 3 MHz, 1 MHz, 300 kHz, 100 kHz, 30 kHz, 10 kHz, 3 kHz, 1 kHz, 300 Hz and 100 Hz

HP: 10 kHz, 1 kHz, 100 Hz, 10 Hz, 1 Hz, and 0.1 Hz

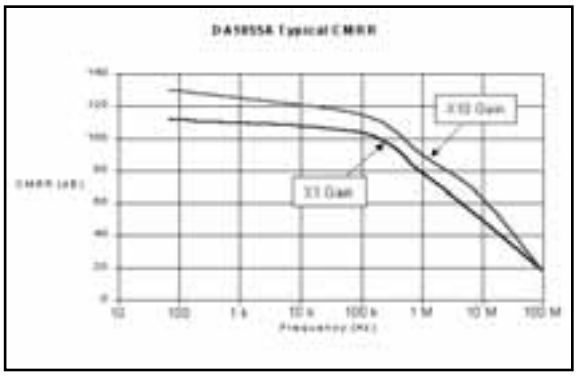
DA1855A: LP: 10 MHz,1.0 MHz and 100 kHz

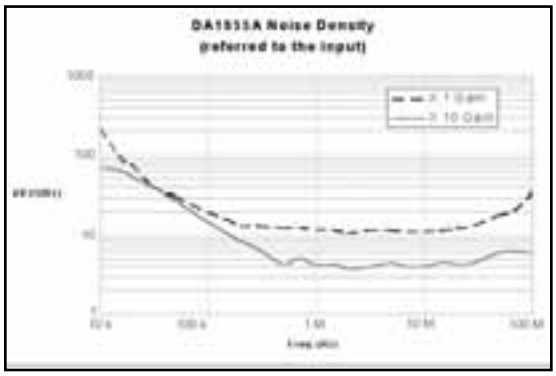
MAXIMUM NON-DESTRUCT INPUT:

250 V peak

PRECISION VOLTAGE SOURCE

Output range:	±15.5 V
DC accuracy:	0.05% of reading +500 μV (15 to 45 °C)
Resolution:	100 μV (5 1/2 digit)





POWER REQUIREMENTS

Line voltage requirement:	100 to 250 V AC
Line frequency range:	48 - 66 Hz
Power Consumption: ff	26 W, ff 36 VA (**DA1822A** and DA1855A)
	ff52 W, ff 72 VA (DA1855A-PR2 and DA1855A-PR2)

ENVIRONMENTAL CHARACTERISTICS

Operating Range:	0 to 50 °C
Non-Operating:	-4 to 75 °C

PHYSICAL CHARACTERISTICS

Height:	7.29 cm (2.87") (**DA1822A** and DA1855A)
	8.75 cm (3.4") (**DA1822A-PR2** and DA1855A-PR2)
Width:	21.2 cm (8.36") (**DA1822A** and DA1855A)
	43.9 cm (17.3") (**DA1822A-PR2** and DA1855A-PR2 without rack mounting ears installed)
Depth:	23.2 cm (9.12") (**DA1822A** and DA1855A)
	42.5 cm (16.7") (**DA1822A-PR2** and DA1855A-PR2)
Weight:	2.15 kg (4.75 lbs.) (**DA1822A** and DA1855A)
	9.5 kg (21 lbs.) (**DA1822A-PR2** and DA1855A-PR2)
Shipping Weight:	3.12 kg (6.88 lbs.)
	11.3 kg (25 lbs.) (**DA1822A-PR2** and DA1855A-PR2)

WARRANTY: 3 years

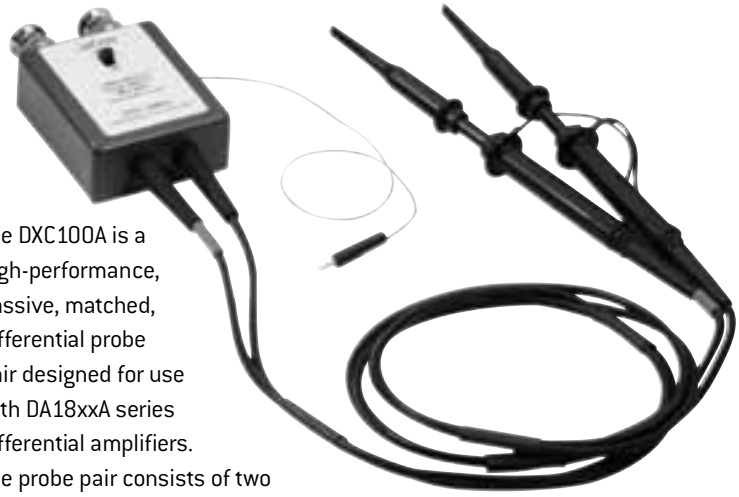
ORDERING INFORMATION	PRODUCT CODE
10 MHz Differential Amplifier with Precision Voltage Generator	DA1822A
Two Channel DA1822A	DA1822A-PR2
DA1822A-PR2 with rackmount	DA1822A-PR2-RM
100 MHz Differential Amplifier with Precision Voltage Generator	DA1855A
Two Channel DA1855A	DA1855A-PR2
DA1855A-PR2 with rackmount	DA1855A-PR2-RM

Differential Amplifiers

DXC100A

MAIN FEATURES:

- **DC to 100 MHz bandwidth with DA1855A**
- **Max. input voltage 500 V**
- **Selectable ÷10 or ÷100 attenuation factor**
- **1.2 meter cable length**



The DXC100A is a high-performance, passive, matched, differential probe pair designed for use with DA18xxA series differential amplifiers. The probe pair consists of two highly matched individual probes that share a common compensation box to allow the attenuation factor on both probes to be simultaneously switched between ÷10 and ÷100. When used with the DA18xxA series differential amplifiers, the probe's attenuation factor is automatically incorporated into the effective gain display, and the scale factor on the LeCroy oscilloscope. When used with a differential amplifier, the DXC100A allows for precise adjustment and matching of transient response and optimization of the system Common Mode Rejection Ratio (CMRR).

DXC200

MAIN FEATURES:

- **Low capacitance**
- **X1 differential probe pair**
- **0.7 meter cable length**

The DXC200 is a pair of x1 probes matched for differential measurement applications. The DXC200 is designed to minimize capacitive loading while still maintaining practical probe-to-circuit attachment. Full DA18xxA series gain and Common Mode Rejection Ratio (CMRR) are maintained. The DXC200 allows the user to take advantage of the DA18xxA series' 100 MΩ input resistance setting.

DXC100A and DXC200 Technical Specifications

DXC100A

Attenuation factor:	÷10 or ÷100
System Bandwidth (-3 dB) (with DA1855A):	100 MHz
System Risetime (with DA1855A):	3.5 ns
Input Resistance:	1 MΩ ±1%
Input Capacitance:	10.5 pF ±0.5 pF
Max. Nondestructive Input Voltage:	500 V DC + peak AC
Length:	1.2 meter

ENVIRONMENTAL CHARACTERISTICS

Operating Range:	0 to 50 °C
Non-Operating:	40 to 71 °C

PHYSICAL CHARACTERISTICS

Weight:	0.18 kg (6.4 oz.)
Shipping Weight:	0.45 kg (1 lb.)

WARRANTY:

	One year

DXC200

Attenuation factor:	1
System Capacitance (with DA18xxA):	< 50 pF
Max Nondestructive Input Voltage:	500 VDC + peak AC
Length:	0.7 meter

DXC200 & DA1855A SYSTEM SPECIFICATIONS

Risetime:	7 ns
Bandwidth (-3 dB):	50 MHz
Input Resistance (selectable):	1 or 100 MΩ
Maximum Nondestructive Input Voltage:	200 VDC + peak AC

ENVIRONMENTAL CHARACTERISTICS

Operating Range:	0 to 50 °C
Non-Operating:	-4 to 75 °C

PHYSICAL CHARACTERISTICS

Weight:	0.14 kg (5 oz.)
Shipping Weight:	0.45 kg (1 lb.)

WARRANTY

	One year

ORDERING INFORMATION	PRODUCT CODE
÷100 or ÷10 Selectable 250 MHz Passive Differential Probe Pair	DXC100A
÷1000 50 MHz Passive Differential Probe Pair	DXC200

Differential Amplifiers

DXC5100
DA101

MAIN FEATURES:

- **Max input voltage 2500 V to ground**
- **÷100 attenuation**
- **DC to 100 MHz bandwidth with DA1855A**
- **< 2.75 pF input capacitance**

The DXC5100 is a passive, high voltage, differential probe pair for use with DA18xxA series differential amplifiers. It is ideal for motor drive and other applications with high bus voltages. When used with the DA101 ÷10 passive external attenuator, up to 5000 volts of differential mode range can be attained, provided that the common mode voltage of 2500 V to ground for each probe is not exceeded. Without the DA101, the DXC5100 maximum differential input voltage is 500 volts.

DXC5100 and DA101 Technical Specifications

DXC5100

Attenuation factor:	÷100, ±1.75%
Max Input Voltage:	2500 V (DC + peak AC)
Input Resistance:	10 MΩ
Input Capacitance:	< 2.75 pF
Cable Length:	3.1 meter
Weight:	275 g (10 oz.)
Shipping Weight:	0.5 kg (1 lb. 1.6 oz.)
Warranty:	One year

DA101

Attenuation factor:	÷10
Weight:	0.10 kg (3.5 oz.)
Shipping Weight:	0.41 kg (0.9 lb.)

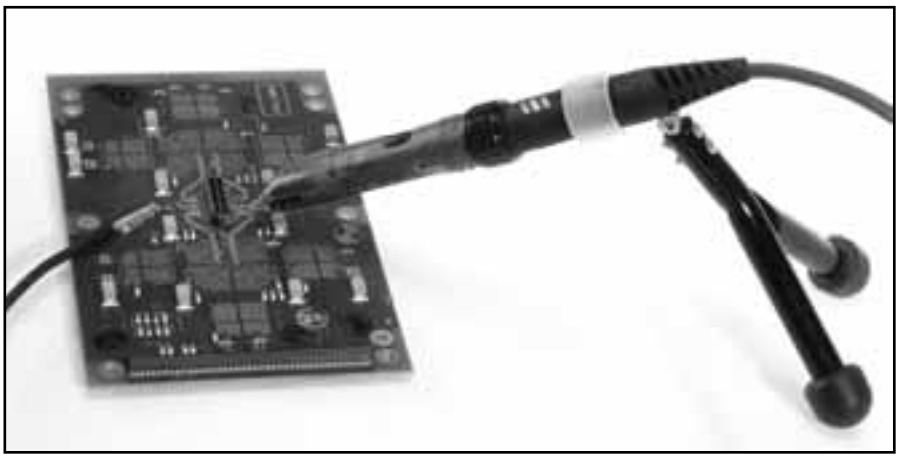
ORDERING INFORMATION	PRODUCT CODE
÷100 250 MHz, 2.5 kV Passive Differential Probe Pair	DXC5100
÷10 1 MΩ Passive Attenuator (use with DXC 5100)	DA101

High Bandwidth Differential Probes

WaveLink D600 D300 D200

LEADING FEATURES:

- **High bandwidth probes**
- **7.5 GHz, 4 GHz, and 2.5 GHz bandwidths**
- **Full system bandwidth at the probe tip for LeCroy 6 GHz, 3 GHz, and 2 GHz instruments**
- **Capture differential or single-ended signals**
- **Unique adjustable TwinTip technology**
- **Includes probe-characterization fixture**
- **AutoColor ID feature matches the probe color to the trace color**
- **Use "FreeHand" probe holder or third party positioners**



A WaveLink probe with its adjustable TwinTips in a "FreeHand" probe holder

WaveLink probes provide industry leading technology for connection of wideband signals to test instruments. Tapping into a high frequency signal in a way that causes minimum disturbance to the device under test while at the same time providing a high integrity connection to a test instrument is a difficult job. New WaveLink probes incorporate LeCroy's acclaimed SiGe technology already in use in the front end amplifiers, ADC's and trigger chips of the WaveMaster DSO's and recently launched WavePro 7000 series. Using a combination of transmission line and active technologies, the WaveLink series has no resonances in the passband, which preserves the amplitude of signal details better than previous probe technologies. WaveLink is where signal integrity begins.

WaveLink probes are targeted to provide full system bandwidth when used with those instruments, but they are also compatible with many other LeCroy products. The three new probes can be used for both differential and single-ended signal acquisition. The D600 (7.5 GHz bandwidth), D300 (4 GHz bandwidth) and D200 (2.5 GHz bandwidth) probes all incorporate unique adjustable TwinTip technology, which allows you to set the spacing of the probe tips in a continuously-variable fashion. The adjustable TwinTips provide user controls of tip spacing from touching (0") to 3 mm (0.12") via thumb wheel adjustment. You can set it and it really stays set. The WaveLink AutoColor ID lights up to match the channel color on your instrument. There is no confusion about which probe is connected to the input channel.

THE ADJUSTABLE TWINTIPS

Half of the probing challenge is to have a probe with the electrical characteristics needed to transfer a signal to a test instrument. The other half is to make a sound mechanical connection that meets the needs of the probing geometry. The adjustable TwinTips are formed from "NiTiNOL," a super-elastic nickel-titanium alloy which has 10 times the elasticity of spring-grade steel. Unlike other probe tip materials, this metal will maintain its sharp points and original

shape even after extensive deformation. When probing a circuit, this means that the probe tips can make contact, flex as you continue to apply pressure, and return to their original form repeatedly.

WaveLink probes can be hand-held, or the included "FreeHand" probe holder can be used. For probing of designs that incorporate dual square-pin test points, WaveLink probes include an SP-ATT square-pin adapter. WaveLink probes also fit nicely in third party horizontal/vertical positioners like the E-Z probe, pictured above. Whether hand-held or attaching multiple probes to closely spaced test points, WaveLink probes offer a smart solution.

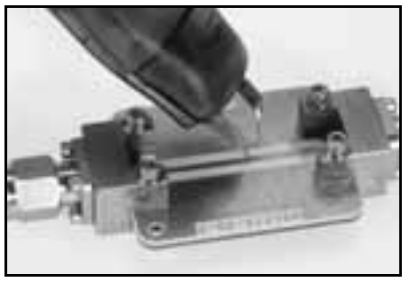
LeCroy scopes provide power to the probes via the ProLink (for D600) or ProBus (for D300 and D200) connections. WaveLink probes can also be used with a wide variety of other instruments, including the most popular spectrum analyzers, through an optional ProLink (PLPA) or ProBus (PBPA) power adapter.

CAPTURING DIFFERENTIAL AND SINGLE-ENDED SIGNALS

In a certain sense, all probing is done differentially. For single-ended measurements, a probe "sees" the difference between a signal and a ground reference. At high bandwidths, it is important to capture a signal and to see it on an oscilloscope the same way the circuit sees it. This means the engineer should not, in general practice, be referencing a single-ended, high frequency signal to a ground point that is inches away, or tie his scope ground to the device under test ground, altering its native ground distribution. New LeCroy probes can be used to capture either a differential or single-ended signal.

WAVELINK PROBES BRING SIGNAL FIDELITY TO HIGH FREQUENCY PROBING

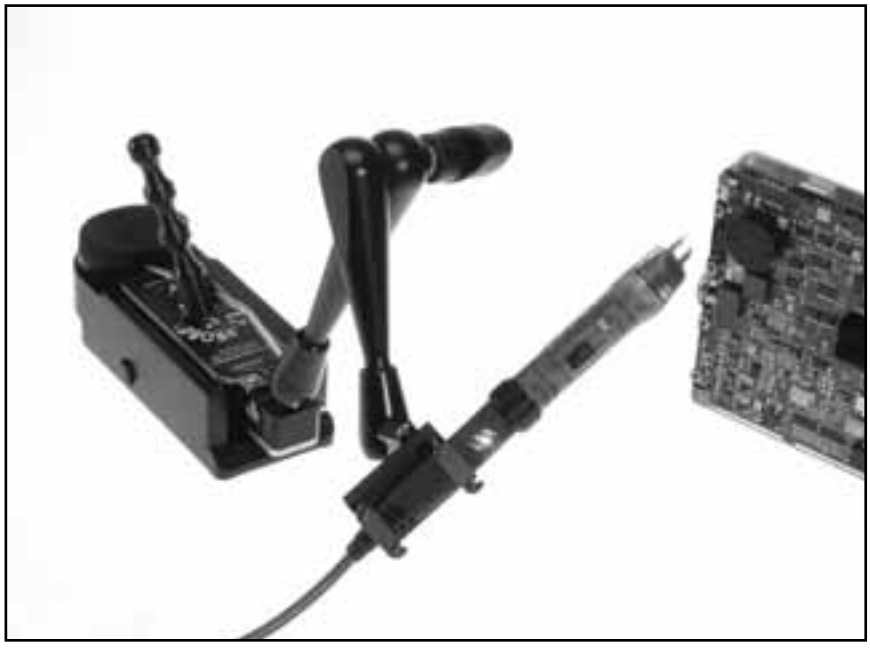
An advantage of the LeCroy combination of high bandwidth SiGe and transmission line design is that the probes present a relatively constant load over the passband, rather than dipping to low values as occurs with probes whose impedance characteristics are dominated by the input capacitance. The short length tips connect directly to a resistive element, which matches the input to the transmission line. The transmission line carries the signal to the SiGe amplifier without the one-quarter wavelength restriction of high impedance designs—a limitation in other very high bandwidth probes. The differential impedance of 4 kohms at DC provides flat impedance over the passband. Low loading of the signal means minimally invasive probing,



ensuring fast signal edges will maintain their integrity.

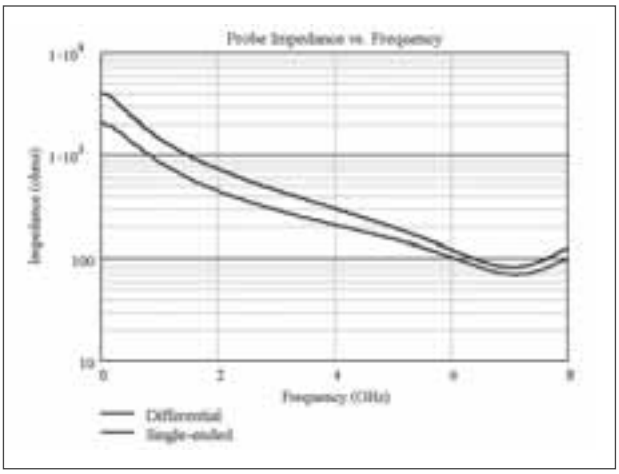
PROBE CHARACTERIZATION

In some cases, engineers want to characterize the precise performance of a probe for a particular bandwidth range and signal amplitude. WaveLink probes include a characterization fixture (PCF-100) standard—which allows you to view the pulse response of the probe and oscilloscope system, and to measure your own s-parameters to model the probe performance. The probes also come with a "FreeHand" probing accessory that holds the probe very stably in a wide variety of geometries.



WaveLink Technical Specifications

	D600	D300	D200
Connection to Instrument	ProLink	ProBus	ProBus
Bandwidth-Probe Alone	7.5 GHz	4 GHz	2.5 GHz
Rise Time-Probe Alone	< 70 ps	< 112 ps	< 160 ps
Input Dynamic Range	±2 Volts	±2 Volts	±5 Volts
Low Frequency Accuracy	0 ±700 mV 2% ±700 mV ±2V 5%	0 ±700 mV 2% ±700 mV ±2V 5%	0 ±1.75 V 2% ±1.75 ±5 V 5%
Input Resistance	4 kohm ±1% differential 2 kohm ±1% single-ended	4 kohm ±1% differential 2 kohm ±1% single-ended	10 kohm ±1% differential 5 kohm ±1% single-ended
Input Capacitance Differential	0.1 pF	0.1 pF	0.1 pF
DC Attenuation	32	32	35
Adjustable TwinTips Dimensions		tip size 0.076 mm (0.003")	
Tip Adjustment Range		touching to 3 mm (0.12")	
Cable Length		1.3 meters	
External Power Supply (option)	PLPA	PBPA	PBPA



Common Mode Rejection	
CMRR	**Frequency**
> 40 dB	**DC – 1 GHz**
> 30 dB	**1 GHz – 4 GHz**
> 20 dB	**4 GHz – 7.5 GHz**

SYSTEM BANDWIDTH WITH INSTRUMENT	D600	D300	D200
Connection to Instrument	ProLink	ProBus	ProBus
WaveMaster 8600A, SDA6000	6 GHz	3 GHz	2 GHz
WaveMaster 8500A, DDA5005	5 GHz	3 GHz	2 GHz
WaveMaster 8300A	3 GHz	3 GHz	2 GHz
WavePro 7300	N/A	3 GHz	2 GHz
WavePro 7100	N/A	1 GHz	1 GHz
WavePro 960, DDA260	N/A	2 GHz	2 GHz

ORDERING INFORMATION	PRODUCT CODE
7.5 GHz Differential Probe and Adjustable TwinTips	D600 and D600AT*
4 GHz Differential Probe and Adjustable TwinTips	D300 and D300AT
2.5 GHz Differential Probe and Adjustable TwinTips	D200 and D200AT

* Requires ProLink

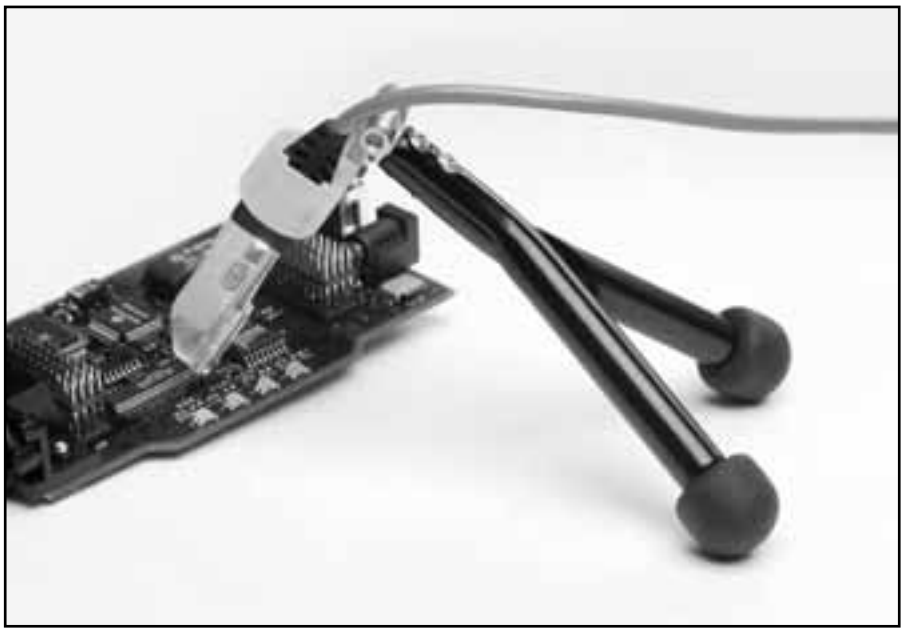
Included:	
Probe Characterization Fixture	
Square-pin Adapter	
“FreeHand” Probe Holder	
0.8 mm Clip	
Short Single Lead	
Soft Accessory Case	
WaveLink Instruction Manual	
Options	
ProLink External Power Adapter	PLPA
ProBus® External Power Adapter	PBPA

Active Probes

HFP3500
HFP2500
HFP1500
HFP1000

LEADING FEATURES:

- **1 GHz to 3.5 GHz Bandwidth**
- **0.7 pF Input Capacitance**
- **±4 V Dynamic Range (HFP3500)**
  ±8 V Dynamic Range (HFP1000, 1500, 2500)
- **±12 V Offset Range**
- **5 Interchangeable Tips for Probing a Variety of Test Points**
- **Replaceable Probe Tip Socket (except HFP3500)**
- **Hands-Free Probing with FreeHand Probe Holder**
- **AutoColor ID Feature Matches the Probe Color to the Trace Color**



HFP probe with ingenious FreeHand probe holder.

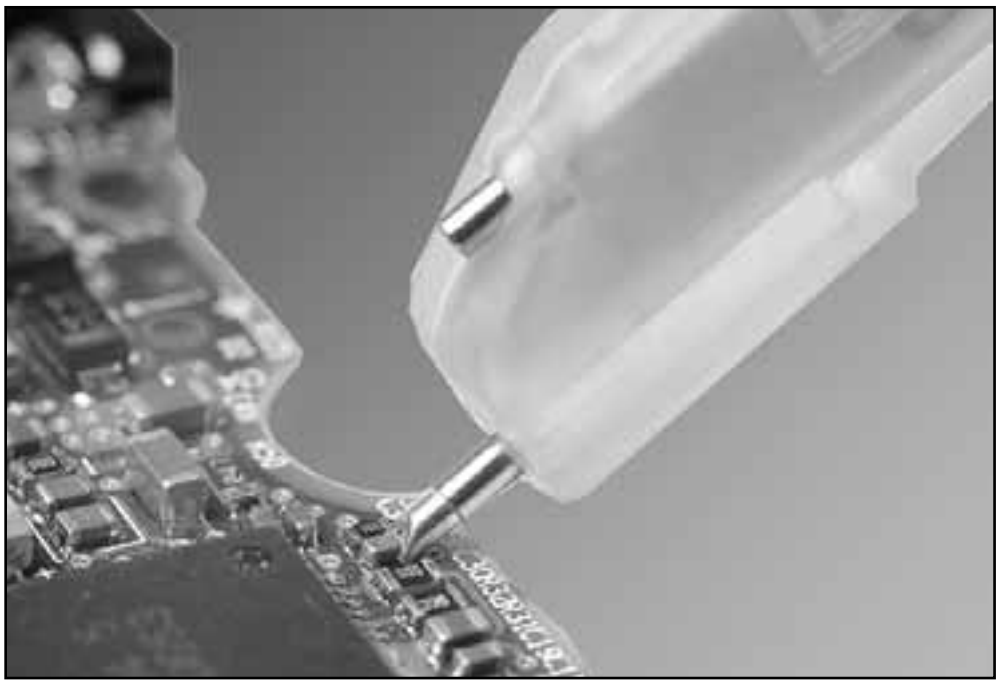
Engineers are using an ever-increasing variety of devices and test points in their designs. In order to access these test points conveniently, today's probing solutions need to be versatile, small and lightweight, while still maintaining a high bandwidth. LeCroy's new HFP series of probes is designed to meet these challenges.

CONVENIENT HANDS-FREE PROBING

Five different styles of tips make probing easier then ever. In addition to a traditional Straight Tip, a Sharp Tip allows easier access to tightly-packed test points and circuit vias. The Bent Sharp Tip — made out of titanium — is ideal for making contact on devices that are spaced close together and prevent the probe from being oriented perpendicular to the circuit. The IC Lead Tip has insulation on one side so it can be wedged between small-geometry IC leads without shorting the test points. The Discrete SMD Tip is designed to fit tightly on surface mount capacitors, resistors and other components.

In conjunction with these innovative probe tips is the LeCroy FreeHand probe holder, which holds the probe on test points. This means several probes can be used at the same time on a variety of test points while maintaining short signal paths to preserve signal fidelity. The end result of "HFP hands-free probing" is the enhanced ability to analyze waveforms instead of focusing on keeping the probe in place.

In addition to these new attachment techniques, traditional IC clips, wire leads, and square pin adapters are available.

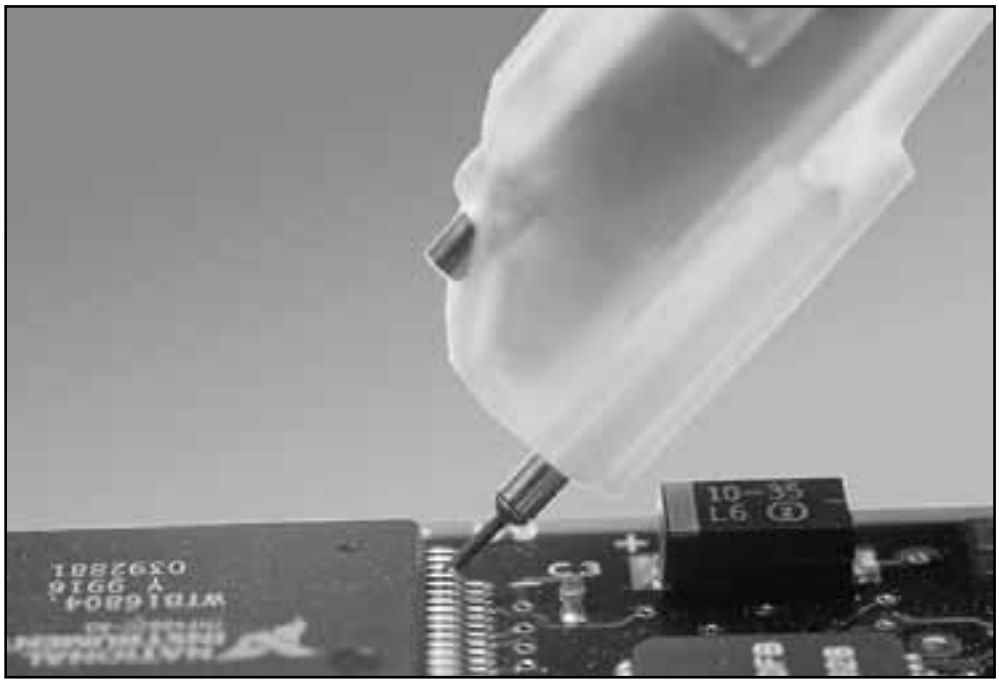


HFP Probe with Discrete SMD Tip on circuit board

EASY TO USE

When the probe is connected to an oscilloscope channel, our AutoColor ID feature automatically illuminates the probe head in that channel's trace color. Users no longer need to manually apply plastic rings or colored tape to determine which channel the probe is connected to.

With the ProBus® interface, the HFP probes become an integral part of the oscilloscope. The probe offset is controlled from the oscilloscope's front panel.



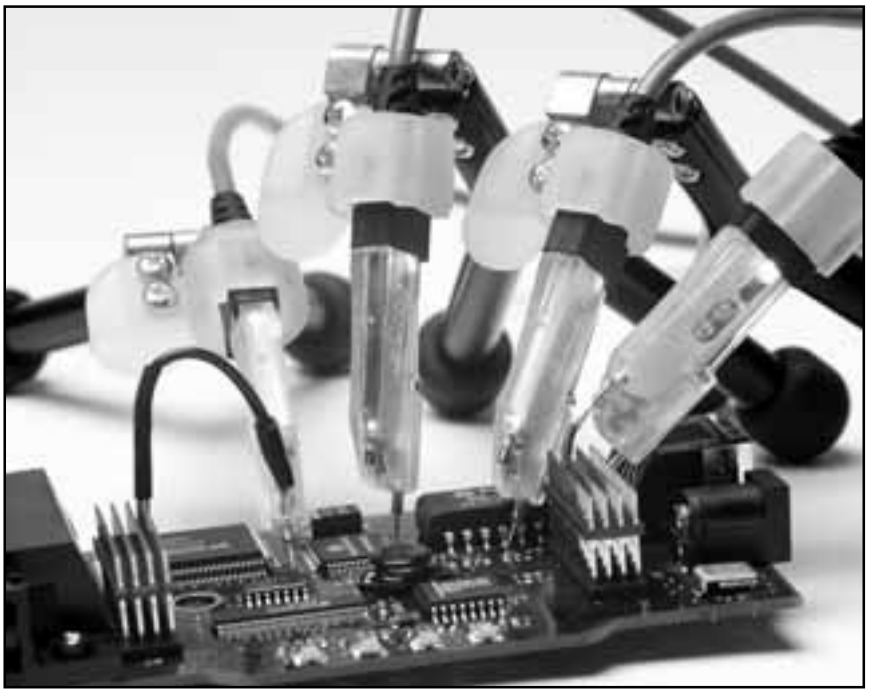
HFP Probe with IC Lead Tip on circuit board

USE WITH OTHER TEST INSTRUMENTS

HFP1000, HFP1500, and HFP2500 probes can be used with LeCroy's WavePro™ series, LC, and Waverunner™ oscilloscopes, with firmware version 8.7.0 or later. The HFP3500 is recommended for use with the WaveMaster series.

When used in combination with the ADPPS adapter for ProBus and power supply, the HFP1000 can be used on any manufacturer's oscilloscope or other test instrument. However, the AutoColor ID feature will not function with non-LeCroy oscilloscopes.

Active Probes



Hands-free Probing

STANDARD ACCESSORIES

HFP1000 includes:

4 Straight tips
4 Sharp Tips
  1 Square Pin Ground Spring
  1 Short Single Lead
  1 Long Single Lead
  1 Right-Angle Short Single Lead
1 Right-Angle Long Single Lead
2 Clips (0.8 mm)
  1 Replacement Cartridge
  Instruction Manual
Certificate of Calibration

HFP1500 includes:

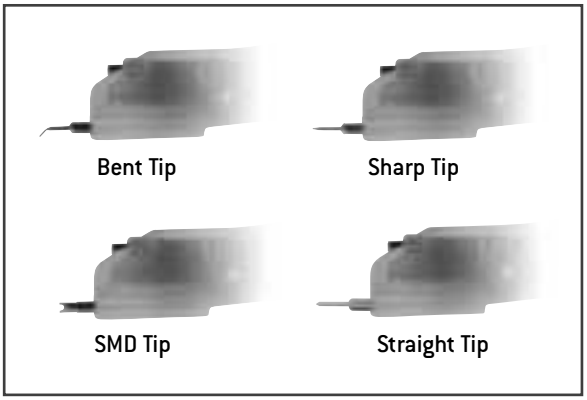
4 Straight Tips
  4 Sharp Tips
  4 Bent Sharp Tips
  4 SMD Discrete Tips
  4 IC Lead Tips
  1 Square Pin Ground Spring
  1 Ground Spring with Hook
  2 Short Single Leads
  2 Long Single Leads
  2 Right-Angle Short Single Leads
2 Right-Angle Long Single Leads
2 Clips (0.8 mm)
  1 FreeHand Probe Holder
  1 Replaceable Cartridge
  1 Soft Accessory Case
  Instruction Manual
  Certificate of Calibration

HFP2500 includes:

all HFP1500 Standard Accessories, and 2 Micro Clips (0.5 mm)1 Low C Tip Cartridge

HFP3500 includes:

all HFP2500 Standard Accessories except replaceable cartridges



Interchangeable HFP Probe Tips

HFP3500/HFP2500/HFP1500/HFP1000
Technical Specifications

ELECTRICAL CHARACTERISTICS

Bandwidth (probe only):	
HFP1000	1 GHz
HFP1500	1.5 GHz
HFP2500	2.5 GHz
HFP3500	3.5 GHz
Input Capacitance:	0.7 pF (measure at 1 GHz)
DC Input Resistance:	100 kΩ
Input Dynamic Range:	
HFP1000, 1500, 2500	±8 V
HFP3500	±4 V
Probe Offset Range:	
HFP1000	N/A
HFP1500, 2500, 3500	±12 V
Attenuation Accuracy:	±1%
Output Zero:	< 4 mV, referred to input
Offset Accuracy:	±1%, ±4 mV, referred to input

GENERAL CHARACTERISTICS

Cable Length:	1.3 m
Probe Head Size:	61 mm (L) x 7.3 mm (W) x 13.1 mm (H)
Input Sockets:	Signal and ground sockets compatible with 0.025" (0.635 mm) square pins, 0.036" (Ø.91 mm) maximum diameter (for round pins)

WARRANTY

	One Year

ORDERING INFORMATION

	PRODUCT CODE
1 GHz Active Voltage Probe	HFP1000
1.5 GHz Active Voltage Probe	HFP1500
2.5 GHz Active Voltage Probe	HFP2500
3.5 GHz Active Voltage Probe	HFP3500
Straight Tip	PACC-PT001
Sharp Tip	PACC-PT002
IC Lead Tip	PACC-PT003
SMD Discrete Tip	PACC-PT004
Bent Sharp Tip	PACC-PT005
FreeHand Probe Holder	PACC-MS001
Replaceable Cartridge (except HFP3500)	PACC-MS002
Low C Cartridge	PACC-MS003
Short Right-Angle Lead	PACC-LD003

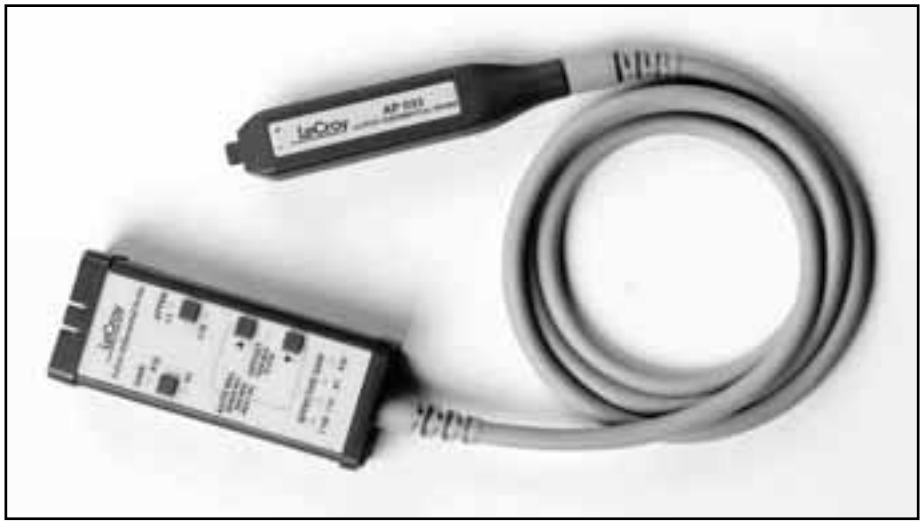
	PRODUCT CODE
Long Right-Angle Lead	PACC-LD004
Short Single Lead	PACC-LD005
Long Single Lead	PACC-LD006
0.8 mm Clips	PK006-4
Micro Clip	PACC-CL001
Ground Spring Hook	PACC-LD001
Square Pin Ground Spring	PACC-LD002
Soft Accessory Case	SAC-01
HFP1000 Instruction Manual, English	HFP1000-0M-E
HFP1500 Instruction Manual, English	HFP1500-0M-E
HFP2500 Instruction Manual, English	HFP2500-0M-E
HFP3500 Instruction Manual, English	HFP3500-0M-E
Offset Pin	405400003

Active Probes

AP034
AP033

LEADING FEATURES:

- **500 MHz bandwidth (AP033)**
- **1 GHz bandwidth (AP034)**
- **x10 gain to ÷10 attenuation range (AP033)**
- **10,000:1 DC CMRR**
- **Low 9 μV/$\sqrt{}$Hz noise(AP033)**
- **1.5 pF/side input C (AP034)**
- **200 μV/div–10 V/div (AP0033)**
- **Input ESD protection**
- **Autozero feature**



The AP033 and AP034 are high-performance active differential probes. High bandwidth, excellent common-mode rejection ratio (CMRR), and low noise make these probes ideal for applications such as disk drive design and failure analysis, as well as wireless and data communication design.

FULLY INTEGRATED

With the ProBus interface, the AP033 and AP034 become an integral part of the oscilloscope. The probe offset can be controlled from the oscilloscope front panel or by using remote control commands (GPIB or RS-232). Sensitivity, offset, input capacitance, and common-mode range are displayed on the scope screen. When used with a LeCroy digital oscilloscope, no external power supply is required.

WIDE DYNAMIC RANGE

The AP033 probe provides a range of sensitivities from x10 gain to ÷10 attenuation (even ÷100 with plug-on attenuator) for diverse signals. The sensitivity can be adjusted continuously from 200 μV/div to 1 V/div when used with a LeCroy oscilloscope (10 V/div with plug-on attenuator).

The AP034 probe provides a range of sensitivities from x1 gain to ÷10 and ÷20 attenuation (with plug-on attenuators) for diverse signals. The sensitivity can be adjusted continuously from 2 mV /div to 2 V/div (2 V/div is achieved with plug-on attenuator) when used with a LeCroy oscilloscope.

AUTOZERO

Autozero can be invoked from the oscilloscope front panel when the input is disconnected from the test circuit. This provides the highest measurement accuracy by removing any residual DC offset from the probe.

USE WITH OTHER INSTRUMENTS

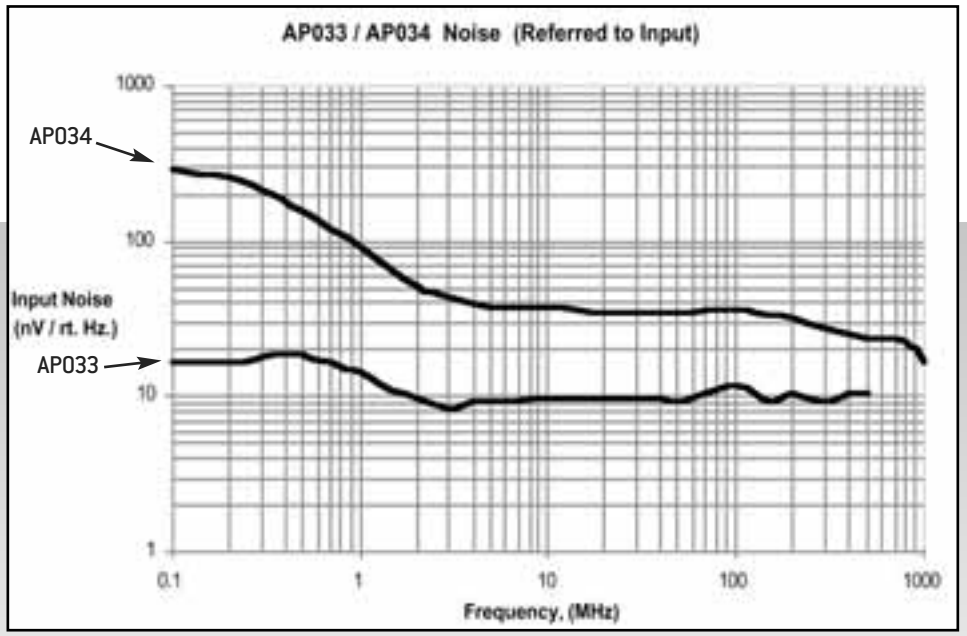
Instruments with 50 Ω inputs, such as spectrum and network analyzers, time interval analyzers, and others, pose a challenge when the signal to be measured is differential or high-impedance. Low noise and high bandwidth make the AP033/AP034 probes an ideal signal conditioner to solve these problems.

The optional ADPPS Power Supply provides power to the AP034 and converts the output to a conventional male BNC connector.

COMMON MODE SENSING AND INPUT PROTECTION (AP033)

It is not uncommon for a differential amplifier to be connected to a signal whose common-mode voltage exceeds the amplifier's common-mode range. Faulty readings, including total loss of signal, can result. The AP033 senses when signals exceed ±5.5 V and switches its input attenuator into the signal path. The oscilloscope shows the new deflection factor, and the probe continues to work.

The same mechanism protects the probe from damage due to large input signals. The probe amplifier is protected from large, fast-rising signals until the input attenuator can provide permanent protection.



AP034 and AP033 Product Specs

AP034

Bandwidth:		1 GHz
Gain:		x1 (÷10 and ÷20 with plug on attenuators)
DC Accuracy:		2% typical (probe only)
Input Impedance:		
2 MΩ II 0.85 pF between inputs		
1 MΩ II1.5 pF each input to ground		
Differential Mode Range:		
±400 mV		(x1)
±4 V		(÷10)
±8 V		(÷20)
Offset Range:		
±1.6 V		(x1)
±16 V		(÷10)
±32 V		(÷20)
Common-Mode Range:		
±16 V		(x1)
±42 V		(÷10)
±42 V		(÷20)
CMRR:		
70 Hz	10,000:1	(80 dB)
1 MHz	100:1	(40 dB)
100 MHz	18:1	(25 dB)
500 MHz	9:1	(19 dB)

AP033

Bandwidth:		500 MHz
Gain Range:		x10, x1, ÷10 (÷100 with plug-on ÷10 attenuator)
DC Accuracy:		1% in x1 without external attenuator
Input Resistance:		1 MΩ (each input to ground), 2 MΩ differential (between inputs)
Input Capacitance:		
3 pF (each input to ground) (÷10)		
6 pF (each input to ground) (÷1)		
1.6 pF differential (between inputs) (÷10)		
3.1 pF differential (between inputs) (÷1)		
Input Voltage Differential Mode Range:		
±40 V		(÷100)
±4 V		(÷10)
±400 mV		(x1)
±40 mV		(x10)
Offset Range:		
±400 mV		(x1, x10)
±4 V		(÷10)
±40 V		(÷100)
Common-Mode Range:		±42 V peak (÷10), ±4.2 V peak (÷1)
CMRR:		
70 Hz	10.000:1	(80 dB)
100 kHz	10.000:1	(80 dB)
1 MHz	1.000:1	(60 dB)
10 MHz	100:1	(40 dB)
250 MHz	5:1	(14 dB)

AP033 AND AP034

Max. Nondestruct Voltage:	±200 VDC continuous
Cable Length:	1.2 m
Operating Temperature:	0 to 50˚C
Standard Accessories:	
÷10 Plug-on Attenuator	
÷20 Plug-on Attenuator (AP034 only)	
Plug-On AC Coupler	
Probe Connection Accessory Kit:	
	Flex Lead Set (1)
	Input "Y" Lead (1)
	Mini Clip, 0.8 mm (3)
	Mini Clip, 0.5 mm (2)
	Ground Lead (1)
	Offset Pins, Round (4)
	Square Pin Header Strip (1)
Warranty:	One year

ORDERING INFORMATION	PRODUCT CODE
1 GHz Differential Probe	AP034
500 MHz Differential Probe	AP033

Active Probes

AP031

LEADING FEATURES:

- **Safe floating measurements**
- **15 MHz bandwidth**
- **700 V maximum input voltage**
- **Works with any 1 MΩ input oscilloscope**

The AP031 is an active differential probe. The differential techniques employed permit measurements to be taken at two points in a circuit without reference to ground.

This allows the oscilloscope to be safely grounded without the use of opto-isolators or isolating transformers.

The two-input signals are processed in the probe, and the resulting output is fed into a single channel of the oscilloscope. The probe's output is a coaxial cable equipped with a standard BNC connector.

The probes are compatible with all 1 MΩ input oscilloscopes. Optional 4 mm banana plug accessories include plunger neck clip (PK30X-1), safe alligator clip (PK30X-2), plunger clamp clip (PK30x-3), plunger jaw clip (PK30X-4), safety spade (PK30X-5).

Warranty: One year

DIFFERENTIAL PROBES

Common Mode Maximum Input Voltage
Rejection Ratio DC + Peak AC

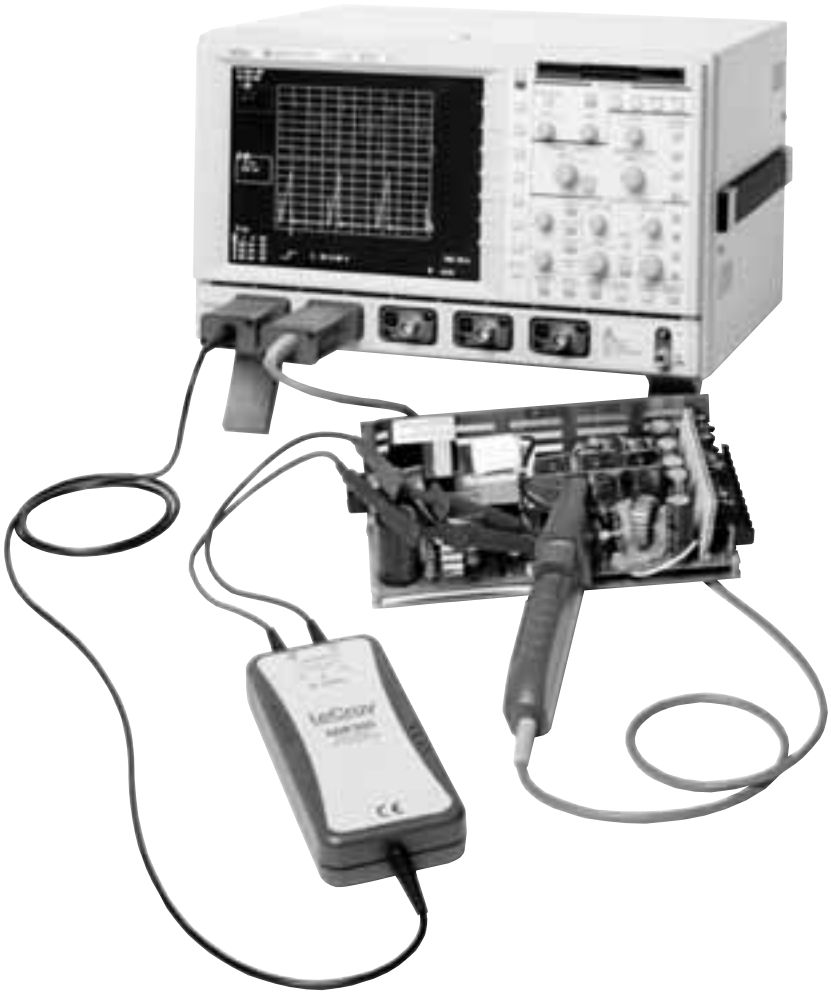
Model	Bandwidth (MHz)	Input R (MΩ)	50 Hz	200 kHz	Attenuation	Diff. V	Com. mode V
AP031	15	4	-86	-56	÷10/÷100	±70/±700	±700

ORDERING INFORMATION	PRODUCT CODE
15 MHz High Voltage Differential Probe	AP031

ADP305
ADP300

LEADING FEATURES:

- **20 MHz and 100 MHz bandwidth**
- **1,000 Vrms common mode voltage**
- **1,400 Vpeak differential voltage**
- **EN 61010 CAT III**
- **80 dB CMRR at 50/60 Hz**
- **ProBus system**
- **Full remote control**



ADP30X high-voltage active differential probes are safe, easy-to-use probes ideally suited for measuring power electronics. The ADP300 is good for troubleshooting low-frequency power devices and other circuits where the reference potential is elevated from the ground or the location of ground is unknown. The ADP305 is designed for measuring the high-speed floating voltages found in today's high-speed power electronics.

EASY-TO-USE

With the ProBus interface, the ADP30X becomes an integral part of the oscilloscope. The attenuation, offset, and bandwidth limit are all controlled from the oscilloscopes front panel or by using the remote control commands. This means the complete measurement setup can be saved and recalled by the oscilloscope, and all measurement values will be correct.The oscilloscope provides power to the probe, so there is no need to worry about a separate power supply or changing batteries.

AUTOZERO

The ADP30X offset can be easily set to zero by pushing a button in the oscilloscope's coupling menu, even when connected to live circuits. This makes it easy to get accurate measurements.

MEETS EN 61010 CATEGORY III REQUIREMENTS

Safety is the top priority when you work around high-voltage signals. The ADP300 and ADP305 are both designed to the standards required for Installation Category III. This means that in addition to being used on appliances and portable equipment (CAT II), they can be used in fixed-installation environments.

AP305 and AP300 Technical Specifications

ELECTRICAL CHARACTERISTICS

Bandwidth:		
ADP300	20 MHz	
ADP305	100 MHz	
Differential Voltage: 1,400 Vpeak		
Common Mode Voltage: 1,000 Vrms CAT III		
Low-Frequency Accuracy (probe only): 1% of reading		
CMRR:		
	50/60 Hz	80 dB (10,000:1)
	100 kHz	50 dB (300:1)
Max. Slew Rate (referenced to input):		
ADP300	60,000 V/μs	
ADP305	300,000 V/μs	
AC Noise (referenced to input):	50 mVrms	
Attenuation:	÷100/÷1000 (automatically selected by scope)	
Input Impedance:		
	Between inputs	8 MΩ, 6 pF
	Each input to ground	4 MΩ, 1 pF
Sensitivity:		
ADP300 1 V/div to 350 V/div		
ADP305 200 mV/div to 350 V/div		

GENERAL CHARACTERISTICS

Overall Length:	2 meters
Input Connectors:	4 mm shrouded banana plug
Operating Temperature:	0 to 50 °C
Warranty:	One year

STANDARD ACCESSORIES

ADP300

Instruction Manual
Certification of Calibration
Plunger Hook Clip (1-Red, 1-Blue)
Straps for Holding Probe

ADP305

All ADP300 Accessories
Safety Spade (1 Red, 1 Blue)
Plunger Clamp Clip (1 Red, 1 Blue)
Plunger Jaw Clip (1 Red, 1 Blue)
Safe Alligator Clip (1 Red, 1 Blue)
Soft Accessory Case

ORDERING INFORMATION	PRODUCT CODE
20 MHz, 1400 V Differential Probe	ADP300
100 MHz, 1400 V Differential Probe	ADP305

Passive Probes

PP002A, PP005A PP006A

LEADING FEATURES:

- **Bandwidth from 350 MHz to 500 MHz**
- **Probe encoding ring for automatic scale factor readout on LeCroy oscilloscopes**

HIGH IMPEDANCE PASSIVE PROBES

Frequency compensation on high impedance probes is accomplished through the use of adjustment screws. All LeCroy digital oscilloscopes provide a calibration output on their front panel to enable this adjustment. The LeCroy WavePro, Waverunner, and LC series oscilloscopes provide internal capability of adjusting both amplitude and frequency of the calibration output to suit user preferences. The output is applied to a front panel connector for easy access while adjusting the probes.

LOW CAPACITANCE PASSIVE PROBES

Low capacitance passive probes provide a better solution for higher frequency applications than high impedance passive probes. They are less expensive than high bandwidth active probes; however, they are compatible only with the 50 Ω input oscilloscopes. For more information on low capacitance passive probes, see pages 172-174.

PROBE ACCESSORY KIT

The PKxxx probe accessory kits provide the capability to surface mount probe components. A variety of tips and clips are available as shown as on the following page.

HIGH IMPEDANCE PASSIVE PROBES

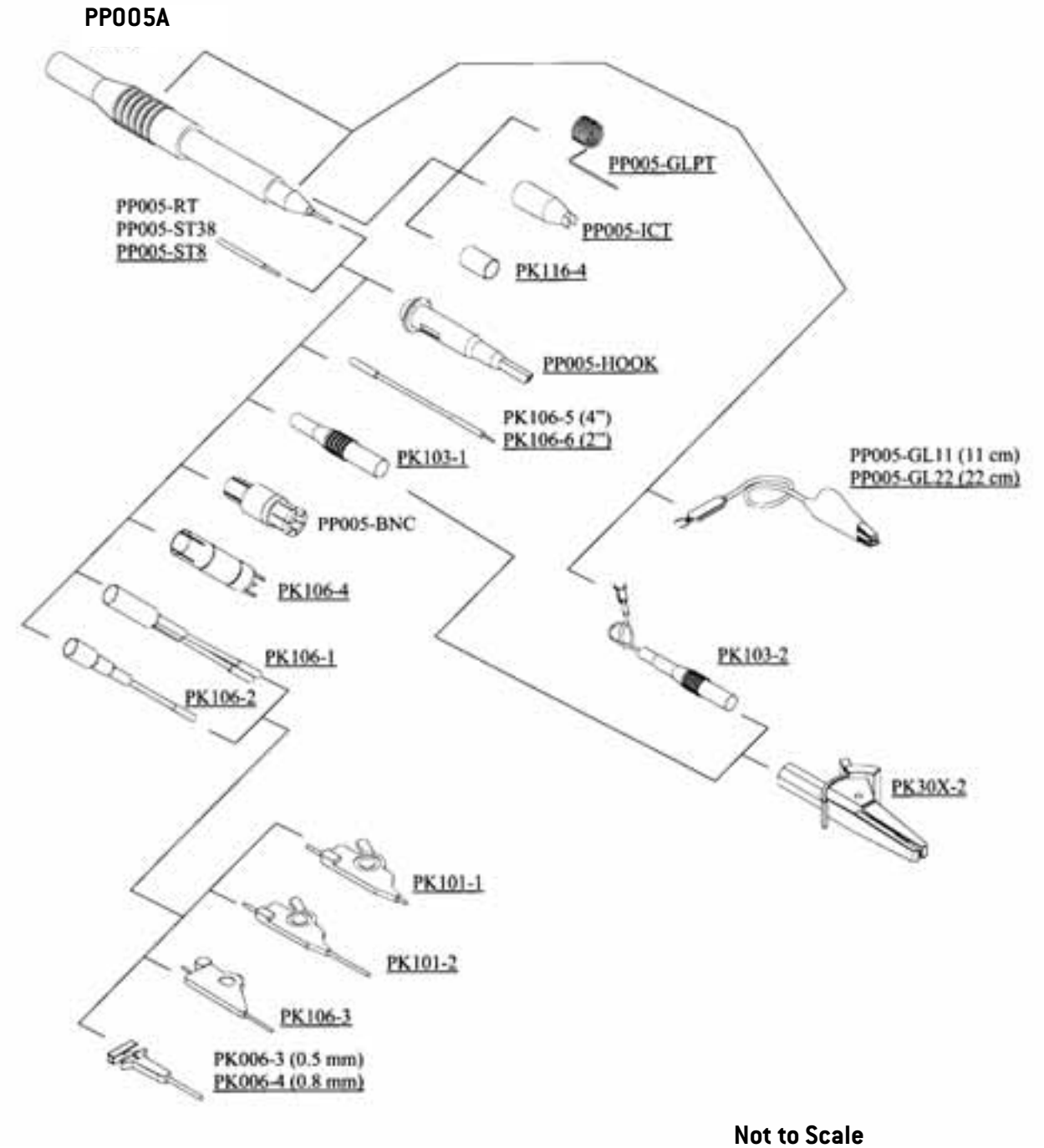
Model Number	Bandwidth	Input R	Input C	Attenuation	Maximum Voltage	Recommended Oscilloscope
PP002	350 MHz	10 M Ω	14.0 pF	÷10	500 V Cat I	3
PP005A	500 MHz	10 M Ω	11.0 pF	÷10	500 V Cat I	1, 6
PP006A	500 MHz	10 M Ω	12.0 pF	÷10	600 V Cat II	2
SS-082R	400 MHz	10 M Ω	13.0 pF	÷10	600 V	4
SS-0130R	100 MHz	10 M Ω	12.5 pF	÷10	600 V	5

COMPATIBILITY

1 = LCxxx, 93xx, LA314, LA354	4 = LA303/314
2 = Waverunner scopes	5 = LA302, LPxxx
3 = 9304, LT224	6 = WavePro

PP005A – Recommended Accessory Diagram

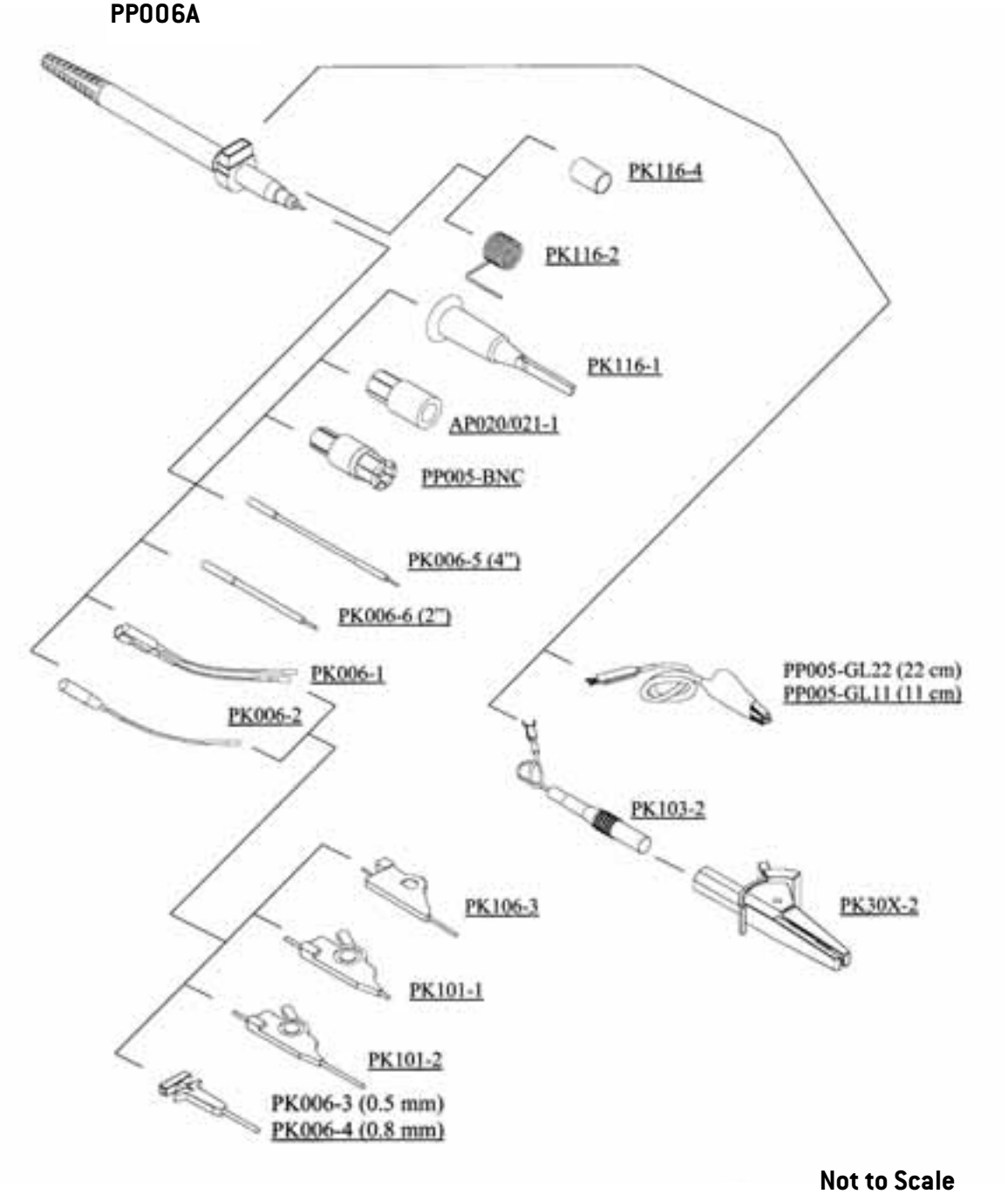
PP005A



Not to Scale

PP006A – Recommended Accessory Diagram

PP006A



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Probe Kits and Accessories – PP002, PP005A, PP006A

PP002

PK001 - Probe accessories for PP002

PP001/002-1	Ground lead PP001 & PP002
PP001/002-2	Probe tip to BNC adapter
PP001/002-3	Sprung hook PP001 & PP002
AP020/021-2	Ground Bayonet
NA	M/F lead - long (4")
NA	M/F lead - short (2")

PK006 - SMT accessories for AP020, PP006

K006-1	Dual lead adapter PK006
PK006-2	Single lead adapter PK006
PK006-3	0.5 mm clip (black and red)
PK006-4	0.8 mm clip (black and red)
NA	M/F lead - long (4")
NA	M/F lead - short (2")

PK106 - SMT accessories for PP005/65, PPExkV

PK106-1	Dual lead adapter
PK106-2	Single lead adapter
PK106-3	0.5 mm clip (orange)
PK106-4	Probe tip to PCB adapter
PK106-5	M/F lead - long (4")
PK106-6	M/F lead - short (2")
PK106-8	0.5 mm clip (yellow)

Additional accessories

PP001/002-1	Ground lead PP001 & PP002
PP001/002-2	Probe tip to BNC adapter
PK006-3	0.5 mm clip (black and red)
PK006-4	0.8 mm clip (black and red)

PP005

PK101 - Microclip accessories for PP005

PK106-2	Single lead adapter
NA	QFPIC Clip (1300 mm 0.5 mm pitch)
PACC-CL001	QFPIC Clip (0.5 mm pitch)

PK102 - Probe accessories for PP005

PP005-HOOK	Sprung hook (black)
PP005-ST38	Spring tip (0.38 mm
PP005-ST8	Spring tip (0.8 mm)
PP005-RT PK116-2	Rigid tip V2A
PP005-BNC	Prove tip to BNC adapter)
PP005-GL11	Ground lead (11 cm)
PP005-GL22	Ground lead (22 cm)
PP005-GLPT	Ground lead (short sp probe tip
NA	IC insulating tip
NA	Probe tip to banana plug adapter
NA	Screw driver

PK103 - Probe accessories for PPE1.2kV, PPE2kV

PP005-HOOK	Sprung hook (red)
PP005-G22	Ground lead (22 cm)
PK30x-2	Crocodile clip
PP005-BNC	Probe tip to BNC adapter
NA	IC insulating tip
NA	Screw driver
NA	Probe tip to banana plug adapter
NA	Ground lead with banana plug
PP005-ST8	Spring tip (0.8 mm)
PP005-RT	Rigid tip V2A

PP006

PK006 - SMT accessories for AP020, PP006

PK006-1	Dual lead adapter PK006
PK006-2	Single lead adapter PK006
PK006-3	0.5 mm clip (black and red)
PK006-4	0.8 mm clip (black and red)
NA	M/F lead - long (4")
NA	M/F lead - short (2")

PK116 - Probe accessories for PP006

PK116-1	Sprung hook
PK116-2	Ground lead
PK116-3	Ground pin
NA	Insulating tip
NA	Screw driver

Additional Accessories

PP001/002-1	Ground lead
AP020/021-1	Probe tip-to-BNC adapter
AP020/021-2	Ground bayonet
PACC-CL001	QFPIC Clip (0.5 mm pitch)
PP005-BNC	Probe tip-to-BNC adapter
PP005-GL11	Ground lead (11 cm)
PP005-GL22	Ground lead (22 cm)
PP005-GLPT	Ground lead (short sp probe tip)
PK30x-2	Crocodile clip
PK106-3	0.5 mm clip (orange)
PK106-5	M/F lead - long (4")
PK106-6	M/F lead - short (2")

Ordering Information PP002, PP005A, PP006A

PASSIVE PROBES	PRODUCT CODE
÷10, 350 MHz, 10 MΩ Passive Probe	PP002
÷10, 350 MHz, 10 MΩ Passive Probe	PP006A
÷10, 500 MHz, 10 MΩ Passive Probe	PP005A

PROBE ACCESSORY KITS — ORDERING INFORMATION	PRODUCT CODE
Probe Accessory Kit for PP001/2	PK001
Probe Accessory Kit for PP061/62/64	PK003
Probe Accessory Kit for AP020/21	PK004
SMT Probe Kit for AP020	PK006
SMT Probe Kit for AP022	PK022
Microclip Accessories for PP005A	PK101
Standard Accessories for PP005A	PK102
SMT Probe Kit for PP005A	PK106
Probe Accessory Kit for PP006A	PK116

High Frequency Ultra Low Capacitance Probes

PP066

Transmission Line Probing

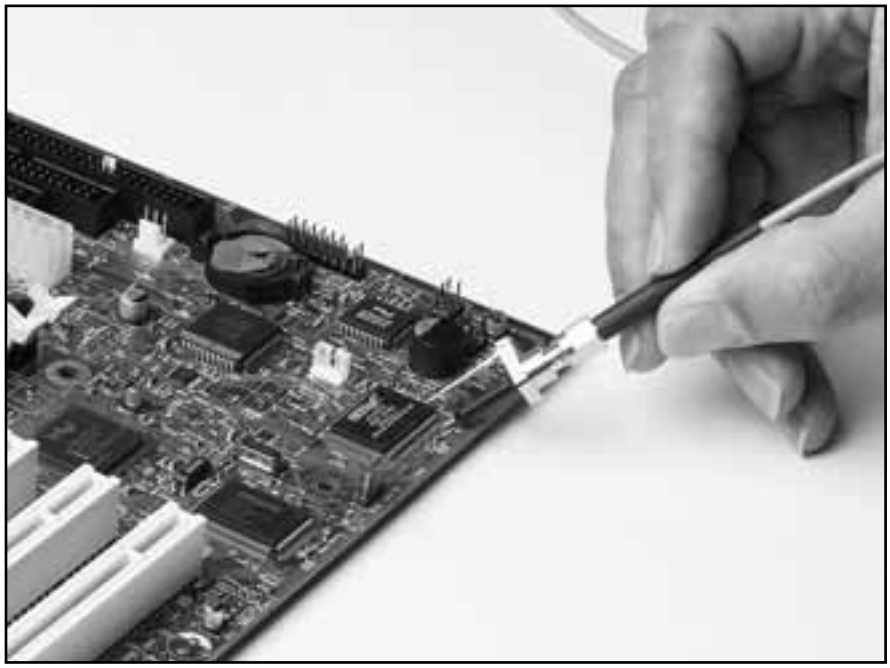
The PP066 is a high-bandwidth passive probe designed for use with the WaveMaster™ and other high-bandwidth oscilloscopes that have 50 Ω input termination. This very low capacitance probe provides an excellent solution for higher frequency applications, especially the probing of transmission lines with 20–100 Ω impedance.

Flexibility

Interchangeable attenuator tips provide the user a choice of input resistances and sensitivities. The probe cable connection is a standard SMA. PP066 probes are suited to a wide range of design applications including probing of analog and digital ICs commonly found in computer, communications, data storage, and other high-speed designs.

Signal Integrity at High Bandwidth

When measuring very high frequencies, use of a probe with low input capacitance is the key to preserving signal integrity. A 1 pf active probe, though nominally high impedance, loads a 1 GHz signal with 159 ohm capacitive reactance ($X = 1/2\pi fC$). The PP066 preserves high bandwidth content of signals, retaining proper signal shape even for very fast edges.



The PP066 passive probe has lower circuit loading at high frequencies than an active probe.

PROBING HIGH SPEED SIGNALS

— Steve Sekel, LeCroy Corporation

Accurately measuring digital waveforms with oscilloscopes becomes increasingly challenging as edge speeds become faster. Often, interconnecting the test circuit to the oscilloscope is the most difficult part of the problem. Designers frequently select an active probe as the tool of choice for this task. However, in many situations a lesser known type of passive probe can provide better performance at a lower cost.

Probing any circuit for the purpose of making a measurement will change its operation. This is often the case when it comes to measuring waveforms with high frequency content. Extremely small parasitic elements added to the probe circuit can greatly distort the signal being measured.

Probe loading is usually the most significant factor that contributes to waveform distortion. Any real life voltage signal can be diagrammed as a Thévenin equivalent model represented as an ideal voltage source with a series impedance between it and the test point where the probe is connected (see the figure on back). The impedance in the probe to ground forms a voltage divider, which attenuates the measured signal. If the impedances were purely resistive, this effect could be easily compensated for by applying a scalar multiplier to the measured waveform amplitude. However, the reactive portions of the circuit's source impedance and the measurement probe create a frequency dependent attenuation that cannot be effectively corrected. As the frequency content of the signal being measured increases, even the most minute parasitic capacitance and inductance will

impart significant attenuation, greatly distorting the appearance of the measured waveform.

Consider an example where we probe a fast digital signal with a 1 ns transition time, using a high-quality passive probe. The input impedance of these probes is generally 1 MΩ in parallel with about 10 pF. If the source impedance of the circuit being tested is 30 Ω , the 1 MΩ resistive component of the probe creates virtually no DC attenuation.

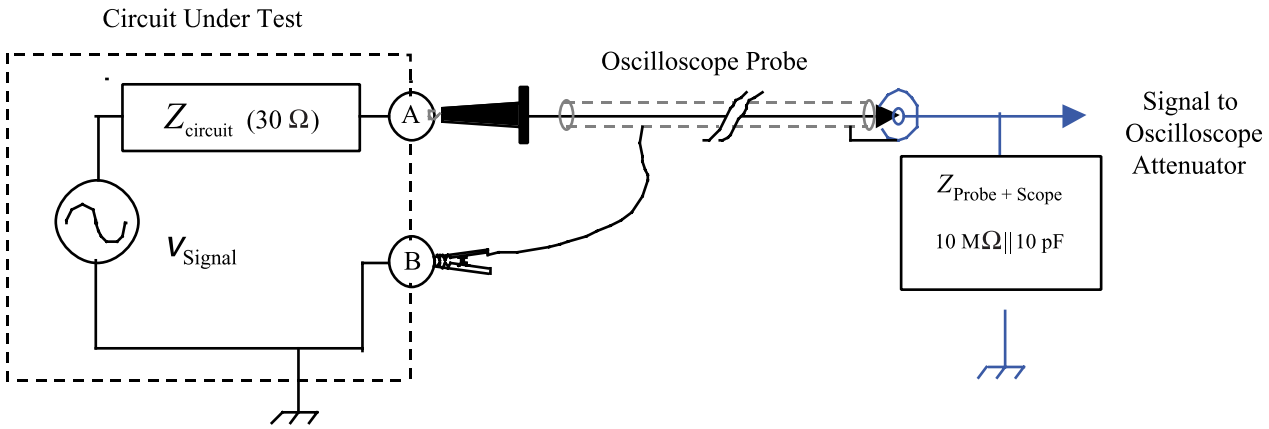
However, the effect of the capacitance is significant. Using the basic rule to translate rise time into frequency, 1 ns rise time corresponds to approximately 350 MHz. The capacitive reactance of 10 pF at 350 MHz is 45 Ω. So during the 1 ns transition, the impedance in the lower leg of the voltage divider would be 45 Ω rather than 1 MΩ, attenuating the signal by approximately 40%.

Since we usually cannot tolerate measurements that include 40% or greater errors, an active probe is often used to measure high-speed signals. A typical input of 1 pF capacitance for an active probe represents a tenfold improvement over a high-quality passive probe.

However, even at 1pF, the active probe can present too much loading in very fast circuits. At 3.5 GHz a 1 pF active probe loads a signal with the same 45 ohm capacitive reactance as the 10 pF passive probe caused at 350 MHz. In many applications, a relatively unknown type of passive probe will give better performance than an active probe, at considerably less cost. These probes are known under several names including transmission line, low capacitance, low impedance, or Z_0 probes. Regardless of what they are called, they all work under the same principle. In these probes, a 50 Ω controlled impedance transmission line is used in place of the probe cable. Rather than driving a 1 MΩ oscilloscope input, the probe requires the oscilloscope input to be set to 50 Ω termination. Adding a tip resistor to the transmission line provides attenuation and raises the input resistance to reduce DC loading of the circuit being measured.

Over a specified operating range of frequencies, the input impedance of a transmission line will appear purely resistive, in this case 50 Ω. Lacking the capacitive component in the lower leg of the attenuator, no shunting capacitance is required across the tip resistor to compensate the divider. In theory, such a probe would have zero input capacitance; Real life probes have a small capacitance, resulting from the proximity of the ground connection in relation to the tip. However, the capacitance is very low, often 0.2 pF or less.

The only potential downside to the transmission line probe is the lower input resistance. A ÷10 probe has an input resistance of 500 Ω and a ÷20 probe weighs in at 1 kΩ. This low input resistance is why many designers have avoided using them in the past. With the increasing speed of modern digital systems, however, the transmission line



Simplified model of probe loading effects

High Frequency Ultra Low Capacitance Probes

probe deserves serious consideration. Most modern high-speed digital circuits are not impacted by the resistive loading. The voltage swings tend to be lower and the ICs can drive lower impedance loads. The 1 KΩ load will not adversely affect the operation of transmission line busses, which are becoming common in modern digital systems.

One thing that you will notice when you open the package of one of these transmission line probes is the relative lack of probe interconnect accessories. There is a practical reason for this. To appreciate the high-bandwidth performance these probes can offer, it's extremely important to avoid introducing parasitic reactive elements into the input connections. If you really need to probe circuits with fast edges, forgo using probes with 10 cm ground leads, and attaching miniature SMD lead clips with 5 cm extension leads in front of the probe tips.

These practices will have devastating effects on waveform fidelity, and may possibly alter the circuit operation. By providing a simple yet elegant solution to probing high-frequency signals, LeCroy's capacitance transmission line probe preserves signal fidelity and allows high-bandwidth test equipment to properly measure circuit characteristics.

SPECIFICATIONS

Electrical Characteristics:	
Bandwidth:	DC to 7.5 GHz
Risetime:	< 47 ps
Input C:	< 0.20 pF
Input R:	
500 Ω (÷10 cartridge)	
1000 Ω (÷20 cartridge)	
Maximum Voltage:	15 V rms
Cable Length:	1 m

ORDERING INFORMATION	PRODUCT CODE
Passive Probe 7.5 GHz	PP066
Included with PP066 probe	
PACC-AD001	SMA to BNC adapter
PP066-OM-EPP066	User's' Manual

Current Probes

150 amp, 10 MHz CP150 (left) and the 15 amp, 50 MHz CP015 (right)

CP015
CP150

AC/DC Current Probe

LEADING FEATURES:

CP015

- **15 A rms continuous current**
- **50 MHz bandwidth**
- **Measure pulses up to 50 A peak**

CP150

- **150 A rms continuous current**
- **10 MHz bandwidth**
- **Measure pulses up to 500 A peak**

Both probes are ProBus® compatible

MEASURE AC AND DC CURRENTS

Measuring AC, DC, and impulse currents has just become easier with the introduction of the CP015 and CP150 probes. Based on a combination of Hall effect and transformer technology, these current probes are ideal for making accurate power measurements. There is no longer a need to own an AC and a DC current probe, because the CP015 and CP150 can measure both.

SMALL FORM FACTOR

Insulated wires aren't always easily accessible, which is why a small form factor solution will greatly simplify measuring. However, while retaining a small form factor, the CP015 and CP150 have a large jaw size, enabling most common insulated wires (in the current range of the respective probes) to be measurable.

DEGAUSS AND AUTOZERO

The degauss function, measurement units, and scale factors are all controlled from the oscilloscope's front panel. This means all measurements and units will be correct without the need to compensate for attenuation differences between the probe and the oscilloscope. In addition, the oscilloscope provides power to the probe, so there is no hassling with an external power supply or changing batteries.

When using the CP015 and CP150 probes, the measurement system offsets can be easily set to zero by pushing a button in the oscilloscope's coupling menu. This makes it easy to get accurate measurements.

The CP015 and CP150 can be used with LeCroy oscilloscopes with firmware version 8.6.0 or later.

CP015 and CP150 Technical Specifications

ELECTRICAL CHARACTERISTICS

Max. Continuous Input Current :	
CP015	15 A
CP150	150 A
Bandwidth (probe only) :	
CP015	50 MHz
CP150	10 MHz
Max. Peak Current (at pulse width) :	
CP015	50 A (≤ 10 µs)
CP150	500 A (≤ 30 µs)
Max. In-Phase Current (across all oscilloscope channels) :	
CP150	500 A
Low-Frequency Accuracy (probe only at 23 +3 °C) :	
CP015	1%
CP150	1%
Risetime :	
CP015	≤ 7 ns
CP150	≤ 35 ns
AC Noise (referenced to input) :	
CP015	≤ 2.5 mA
CP150	≤ 25 mA
Insertion Impedance :	
CP015	0.5 Ω at 5 MHz
CP150	0.1 Ω at 5 MHz
Minimum Sensitivity :	
CP015	20 mA/div*
CP150	200 mA/div*
Coupling :	DC and ground

* Depends on scope model.

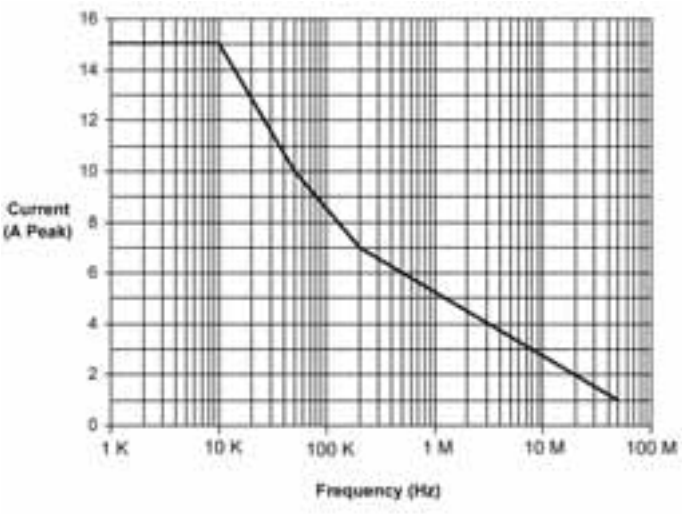
GENERAL CHARACTERISTICS

Cable Length :	2 meters
Weight (probe only) :	
CP015	230 g (8.1 oz.)
CP150	500 g (17.6 oz.)
Usage Environment :	Indoor
Operating Temperature :	0 C to 40 °C
Max. Altitude :	2000 meters
Max. Relative Humidity :	80%
Warranty :	One year
Max. Conductor Size (diameter) :	
CP015	5 mm (0.2")
CP150	20 mm (0.79")
Interface : ProBus, 1 MΩ only	
Maximum Insulated Wire Voltage :	
CP015	300 V CAT I
CP150	600 V CAT II
	300 V CAT III

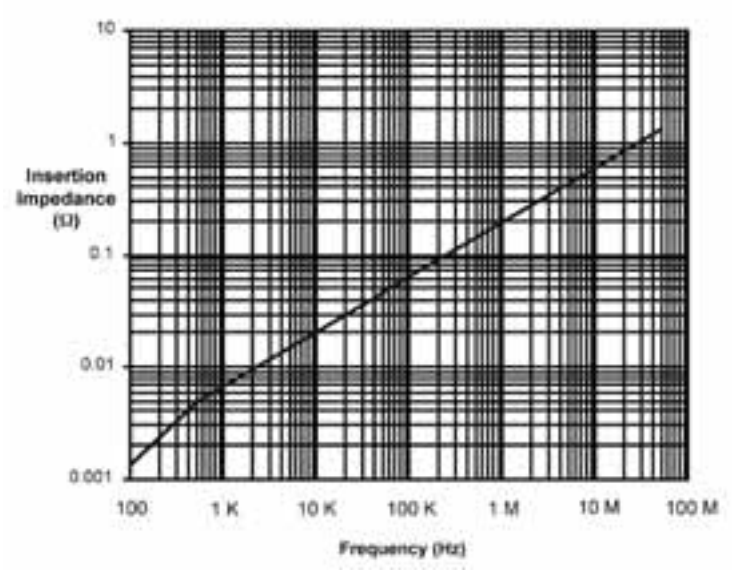
ORDERING INFORMATION	PRODUCT CODE
15 A DC/AC Current Probe, 50 MHz	CP015
150 A DC/AC Current Probe, 10 MHz	CP150
CP015 Instruction Manual, English	CP015-OM-E
CP150 Instruction Manual, English	CP150-OM-E

CP015 and CP150 Technical Specifications

CP015

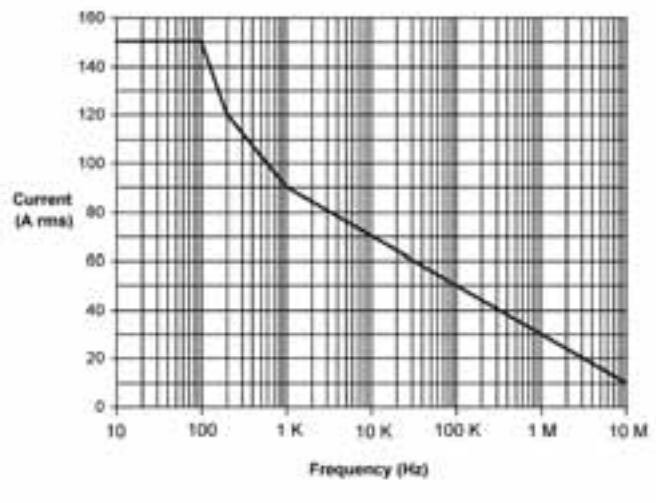


Maximum Input Current vs. Frequency

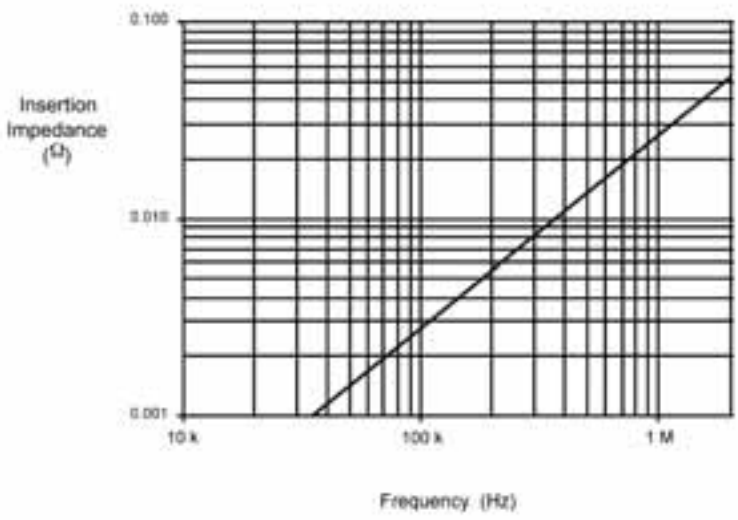


Insertion Impedance vs. Frequency

CP150



Maximum Input Current vs. Frequency



Insertion Impedance vs. Frequency

Current Probes

CP500
AC/DC Current Probe

LEADING FEATURES:

- **500 Amps rms**
- **2 MHz bandwidth**
- **Integrated with Oscilloscope**
  - **– No external amplifier required**
  - **– Automatic scaling**
  - **– Units in Amperes**
- **Small probe size with large jaw**

The CP500 is an AC and DC coupled 500 Amp current probe with DC to 2 MHz frequency response. This probe plugs directly onto the LeCroy oscilloscope requiring no external power amplifiers. The probe becomes fully integrated with the oscilloscope, including probe DeGauss, Autozero, automatic setup of scale factor sensitivity, and measurement units in amperes.

MEASURING AC AND DC CURRENTS

Based on a combination of Hall effect and transformer technology, the CP500 current probe is ideal for making accurate AC, DC, and impulse current measurements. Current levels of 500 amps (rms) continuous are easily captured. Multiple probes can be used with LeCroy oscilloscopes providing single or three-phase measurements up to 1000 amps combined in-phase current levels.

SMALL FORM FACTOR

The combination of the probe's small form factor and large probe jaw makes access in tight areas easier while accommodating large conductor sizes.

INTEGRATED WITH OSCILLOSCOPE

Sources of measurement error can include errors from manual setup of the probe with the oscilloscope. DeGaussing the probe, setting correct Zero offsets, setting correct sensitivities on the oscilloscope, and having parameter units in amperes (for additional computation of watts and joules) are all automatically completed through the LeCroy Probus connection. Integration of the probe and the oscilloscope eliminates these errors. In addition there are many benefits of not having a bulky external amplifier, such as:

- **Lower Noise** – eliminates the ground loop created by the second power cable
- **Cost Savings** – saves purchasing an additional power supply
- **Space Savings** – consolidates equipment
- **Time Savings** – measurements are automatically integrated with oscilloscope
- **Error Reduction** – scale factors, zero offsets, units, and math analysis are managed by the oscilloscope

The CP500 can be used with LeCroy oscilloscopes using firmware version 9.1.0 or later.

The CP500 is the newest member of the LeCroy family of Current Probes with 500 Amp (continuous) capability.

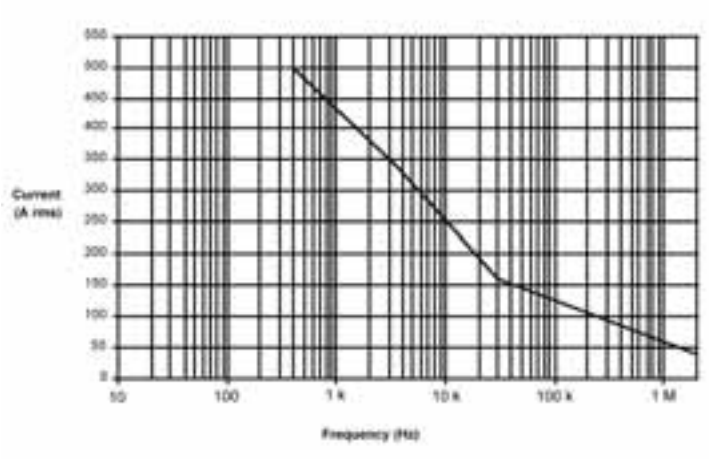
CP500 Technical Specifications

ELECTRICAL CHARACTERISTICS:

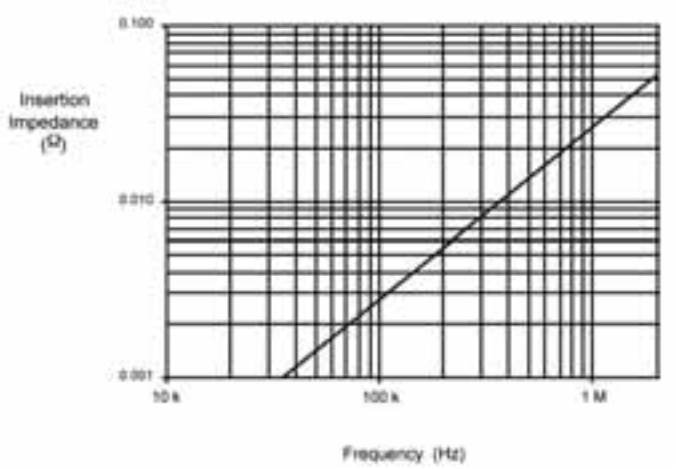
Max. Continuous Input Current:	500 A
Bandwidth (probe only):	2 MHz
Max. Peak Current:	700 A
Max. In-Phase Current (across all oscilloscope channels):	1150 A
Low-Frequency Accuracy (probe only at 23 ± 3 °C):	
0 to 500 amp	±1% of reading ±500 mA
500 to 700 amp peak	±2% of reading
Risetime:	≤ 175 ns
AC Noise (referenced to input)	≤ 25 mA rms
Coupling:	AC and DC

GENERAL CHARACTERISTICS

Cable Length:	6 m
Weight (probe only):	640 g (1.41 lbs.)
Usage Environment:	Indoor
Operating Temperature:	0 C to 40 ° C
Max. Altitude:	2000 m (6562 feet)
Max. Relative Humidity:	80%
Max. Conductor Size (diameter):	20 mm (0.79")
Interface:	ProBus, 1 MΩ only
Maximum Insulated Wire Voltage:	600 V CAT II, 300 V CAT III
Warranty:	One year



Maximum Input Current vs. Frequency



Insertion Impedance vs. Frequency

ORDERING INFORMATION	PRODUCT CODE
500 A DC/AC Current Probe, 2 MHz	CP500
CP500 Instruction Manual, English	CP500–OM–E

Current Probes

AP015

LEADING FEATURES:

- **DC - 50 MHz bandwidth**
- **±30 A max DC current**
- **±50 A peak pulse current**
- **Measurement units in amperes**
- **Overheating detection and degauss function**
- **ProBus-sensed automatically by LeCroy oscilloscopes**
- **Full remote control**

The AP015 current probe allows the oscilloscope to measure current flowing through a conductor. The AP015 is based on a combination of Hall effect and transformer technology that allows measurements to be made on DC, AC, and impulse currents.

FULLY INTEGRATED SYSTEM

ProBus compatibility ensures full integration of the AP015 features into the oscilloscope. The probe is fully operational whenever it is attached to the instrument. There is no need for external amplifiers or power supplies. All controls are menu-driven from the oscilloscope screen, avoiding the need for accessing probe-mounted controls, which can be particularly difficult and dangerous in some applications. Full remote control is possible over GPIB or RS-232-C interfaces.

AUTOZERO & DEGAUSS FUNCTIONS

Temperature changes and continuous exposure to DC currents can magnetize the core and create offsets in all AD/DC current probes. The AP015 includes a degauss feature to remove residual magnetic fields from the core, and an autotzero feature to eliminate output offset. These features can be conveniently accessed through the coupling menu, and by using remote control commands.

AUTOMATIC MEASUREMENT UNIT CONVERSION

Automatic unit conversion and calibration ensures correct interpretation of data and avoids the painstaking task of recording and applying conversion and scaling factors.

All waveforms acquired from the AP015 are automatically calibrated and adjusted to be scaled in ampere units. A wide range of functions can be applied to current waveforms.

All functions and measurements recognize ampere vertical scales and adjust the resulting waveform or calculation units, including mixed-unit conversions.

OVERHEATING DETECTION

The AP015 is equipped with an automatic overheating detection circuit that generates a warning message, displayed on the oscilloscope's screen, to avoid damaging the probe.

PROBE UNLOCK DETECTION

The Probe Unlock Detection feature prevents bad probe head ground connections and ensures correct measurements. If the probe head is not properly locked, the probe sends an interrupt to the scope, which then displays a warning message.

AP015 Technical Specifications

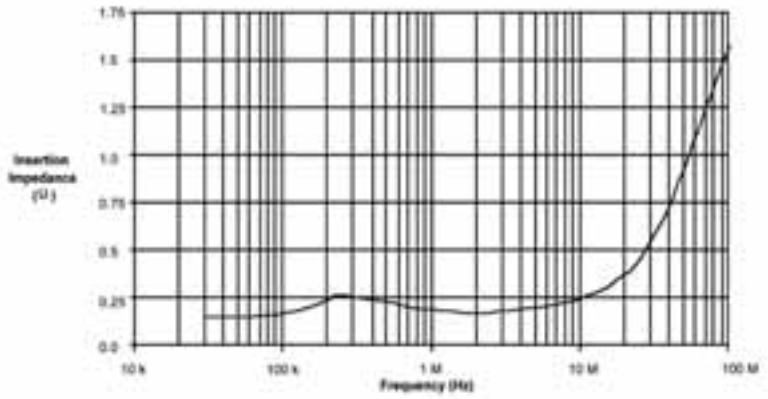
ELECTRICAL CHARACTERISTICS

System Bandwidth:	DC to 50 MHz
Max. DC Current:	±30 A
Max. Peak Pulse Current:	±50 A with pulse width < 10 s
Max. In-Phase Current (across all oscilloscope channels):	66 A
Offset Range:	±100 A maximum*
Output Sensitivity:	10 mA/div to 20 A/div*
Coupling:	AC, DC, GND
DC Accuracy (at 25 °C):	±1% of reading to 15 A, ±2% of reading to 30 A
Maximum Insulated Wire Voltage:	
	300 V CAT I
	150 V CAT II
Rise Time:	< 7 ns
Insertion Impedance:	< 0.06 Ω at 5 MHz

* Depends on the oscilloscope used.

GENERAL CHARACTERISTICS

Max. Conductor Size:	5 mm
Operating Temperature:	0 C to 40 °C
Max. Conductor Size:	5 mm
Cable Length:	2 m
Interface:	ProBus, 1 MW only
Weight:	300 g
Usage Environment:	Indoor
Maximum Altitude:	2000 m



Insertion Impedance vs. Frequency

DCS015

DESKEW CALIBRATION SOURCE

To make an accurate instantaneous power measurement, you must align your voltage and current waveforms in time. The DCS015 allows you to calibrate your voltage and current probes so that you can achieve matching delays. Using the resample function on a ProBus compatible oscilloscope, you are able to align the edges of the voltage and current square waves, which aligns your probes in time allowing precise instantaneous power measurements. The DCS015 has both voltage (approximately 5 V) and current (approximately 100 mA) time- aligned outputs. The CP015, AP015, along with any compatible voltage probe are designed to work with the DCS015.

ORDERING INFORMATION	PRODUCT CODE
30 Amp, 50 MHz	AP015
Deskew source for CP015 and AP015	DCS015

High Voltage Probes

PPE1.2KV
PPE2KV
PPE4KV
PPE5KV
PPE6KV
PPE20KV

LEADING FEATURES:

- **Suitable for safe, accurate high-voltage measurements**
- **1.2 kV to 20 kV**

The PPe series includes five fixed-attenuation probes covering a range from 2 kV to 20 kV, and one switchable probe providing ÷10/÷100 attenuation for voltage inputs up to 1.2 kV.

All fixed-attenuation, standard probes automatically re-scale any LeCroy 9300C, Waverunner, WavePro, or LC series oscilloscope for the appropriate attenuation factor of the probe.

HIGH-VOLTAGE PROBES SELECTION GUIDE

Types	Bandwidth (MHz)	Input R (Ω)	Input C (pF)	Attenuation	Maximum Voltage (Cat I)	Probe Encoding	Cable
PPE1.2kV[1]	400	50 M	<6	10:1 / ÷100	600 V/1.2 kV	No	2 m
PPE2kV[1]	400	50 M	<6	100:1	2 kV	Yes	2 m
PPE4kV[1]	400	50 M	<6	100:1	4 kV	Yes	2 m
PPE5kV[1]	400	50 M	<6	100:1	5 kV	Yes	2 m
PPE6kV[1]	400	50 M	<6	1000:1	6 kV	Yes	2 m
PPE20kV[2]	100	50 M	<2	1000:1	20 kV (40 KV peak)	Yes	3 m

Supplied with probe: [1]Probe Kit: Trimming tool, ground lead, rigid tip, IC insulator, BNC adapter, tip insulator, spring hook, red crocodile clip. 4mm safety ground lead, and green/yellow crocodile clip. [2]Probe Kit: trimming tool, and ground lead with a crocodile clip.

ORDERING INFORMATION	PRODUCT CODE
10:1 / 100:1, 600 V/1.2 kV max. voltage, 400 MHz	PPE1.2kV
100:1, 2 kV DC + peak AC pulse, 400 MHz	PPE2kV
100:1, 4 kV DC + peak AC pulse, 400 MHz	PPE4kV
100:1, 5 kV DC + peak AC pulse, 400 MHz	PPE5kV
1000:1, 6 kV DC + peak AC pulse, 400 MHz	PPE6kV
1000:1, 20 kV DC + peak AC pulse, 100 MHz	PPE20kV
Probe Accessory Kit for PPE1.2kV, PPE2/4/5/6kV	PK103
Probe Accessory Kit for PPE20kV	PK104

General Purpose Accessories

GPR10
ADPPS

- **ADPPS power supply**
- **Printer paper**

GPR10: PRINTER PAPER

Graphic printer paper for internal oscilloscope printers. Box of 10 rolls.

ADPPS POWER SUPPLY

Provides power to the AP033/34 and HFP 1000 active probes; allows the probe's output to be connected to other non-ProBus test equipment. Possible test equipment include: spectrum analyzers and network analyzers.

AP-1M

- **500 MHz Typical**
- **1 M Ω input impedence path**
- **FSR +/- 8 volts**

The AP-1M accessory offers a convenient method to provide a high impedance input when using a WaveMaster series instrument, including the DDA5005 and SDA series. Applications which combine one or more high speed signals along with the need to look at larger voltage, slower signals will benefit from the AP-1M which provides a 1 Megohm input impedance path and a full scale range of +/- 8 volts. Customers who wish to use a x10 passive probe on their WaveMaster for lower frequency signals, or specialty probes such as current probes that require a 1-Megohm input path, can use the AP-1M. In addition the AP-1M also enables an offset voltage range up to +/- 50 volts.

ORDERING INFORMATION	PRODUCT CODE
Graphic Printer Paper /10 rolls	GPR10
ProBus to BNC and Power Adapter for AP03X and HFP1000 probes	ADPPS
1 MΩ Adapter for the WaveMaster Oscilloscope	AP-1M

Carrying Cases

SAC-01
LTxxx-TC2
WPxxx-SCC
WPxxx-TC1
WPxxx-TC1/RC
WM-SCC
WM-TC1

LEADING FEATURES:

- **Soft accessory case**
- **Carrying cases**
- **Transit cases**

SOFT ACCESSORY CASE SAC-01

The soft accessory case is an ideal way to store a probe with all its manuals and accessories. It can be attached to the top of an instrument using velcro strips. With a pocket on the inside flap meant for the storage of manuals, as well as an interior with enough room for a probe and its many accessories, you will never be hunting for a part again.

Orderable part number: SAC-01

CARRYING CASE

These soft cloth carry bags have an internal pouch for the instruction manuals and accessories. Designed for customers who use their oscilloscope in several different locations: the carry bag also acts as a protective cover.

Orderable part number:
LTXXX-TC2 Waverunner Soft Carring Case
WPXXX-SCC WavePro Soft Carring Case
WM-SC WaveMaster Soft Carring Case

TRANSIT CASES

LeCroy transit cases are made of both high-density polyethylene plastic, and heavy-duty reinforced aluminum. Light weight and measuring approximately 25" x 23" x 14" cm (size given for WaveMaster Series), these cases are ideal for transporting oscilloscopes by air, land or sea.

Orderable part number:
WPXXX-TC1 WavePro Transit Case
WPXXX-TC1/RC WavePro Transit Case with Removable Casters
WM-TC1 WaveMaster Transit Case

Scope Accessories

OC1024/1021

Oscilloscope Carts

LEADING FEATURES:

- **Fabricated from steel and aluminum and finished with a durable powder-coat epoxy**
- **Height- and angle-adjustable shelves**
- **Base bin included for storage of larger instruments and accessories**
- **Mounting straps included on cart to secure test instruments**
- **High quality 4" casters (2 locking) help negotiate curbs**
- **Supports entire range of LeCroy oscilloscope line**
- **OC1024 provides a drawer for safe storage of small, delicate leads and cables**
- **OC1024 has "pegboard" style side panels for storage of probes, cables, and accessories**

OC1024 & OC1021 scope carts are sturdy and mobile.

The new line of instrument carts from LeCroy provides users with a compact, mobile tool for keeping all of their LeCroy test equipment handy. In today's test and measurement environment, floor space is at a premium and workflow patterns change frequently. These carts create a whole new category of mobile workstations designed to address workspace confines.

By making LeCroy's technology mobile, the carts make it easier and less costly to work with high performance test and measurement tools.

The OC series carts accommodate WavePro, Waverunner, LCXX, 93XX, LAXX, and 94XX Series Oscilloscopes from LeCroy.

OC1024/1021 Specifications

OC1024

Width:	57.9 cm (22.8")
Depth:	55.9 cm (22")
Height:	137 cm (54")
Weight:	36 kg (79 lbs.)

OC1021

Width:	54.8 cm (21.6")
Depth:	55.9 cm (22")
Height:	76.2 cm (30")
Weight:	21.8 kg (48 lbs.)

TOP SHELF

Width:	50.8 cm (20") [46.48 cm (18.3") between side extrusions]

TILT SHELF

Width:	45.9 cm (18.1")
Depth:	50.8 cm (20")

BOTTOM BIN

Width:	49.5 cm (19.5")
Depth:	43.1 cm (17")
Height:	4.0 cm (1.6")

ORDERING INFORMATION	PRODUCT CODE
137 cm (54") high Oscilloscope cart with height and angle adjustable tilt shelf, top shelf with drawer, bottom bin, mounting straps, and "pegboard" style side panels. Supports all models in LeCroy oscilloscope line.	OC1024
76.2 cm (30") high Oscilloscope cart with height and angle adjustable tilt shelf, bottom bin, and mounting straps. Supports all models in LeCroy oscilloscope line.	OC1021

O To E Converters

OE425
OE525
OE455
OE555

Multi-mode Optical-to-Electrical Converters

LEADING FEATURES

- **Frequency range to 5 GHz (6 GHz optical)**
- **62.5 µm multi-mode fiber input**
- **Broad wavelength range: 500 nm–870 nm (OE425) and (OE525) 950 nm–1630 nm (OE455) and (OE555)**
- **High responsivity: 1.1 V/mW**
- **Low noise: 1.1 µW rms**

OE455M optical-to-electrical converter shown with multi-mode fiber jumper attached.

These wide-band multi-mode optical-to-electrical converters are designed for measuring optical communications signals. Their broad wavelength range and multi-mode input optics make these devices ideal for applications including Gigabit Ethernet and Fibrechannel, as well as SONET/SDH up to 2.5 Gb/s.

The OE425 and OE455 are ProBus® modules compatible with WavePro and Waverunner oscilloscopes as well as WaveMaster instruments when used with a LPA-BNC adapter.

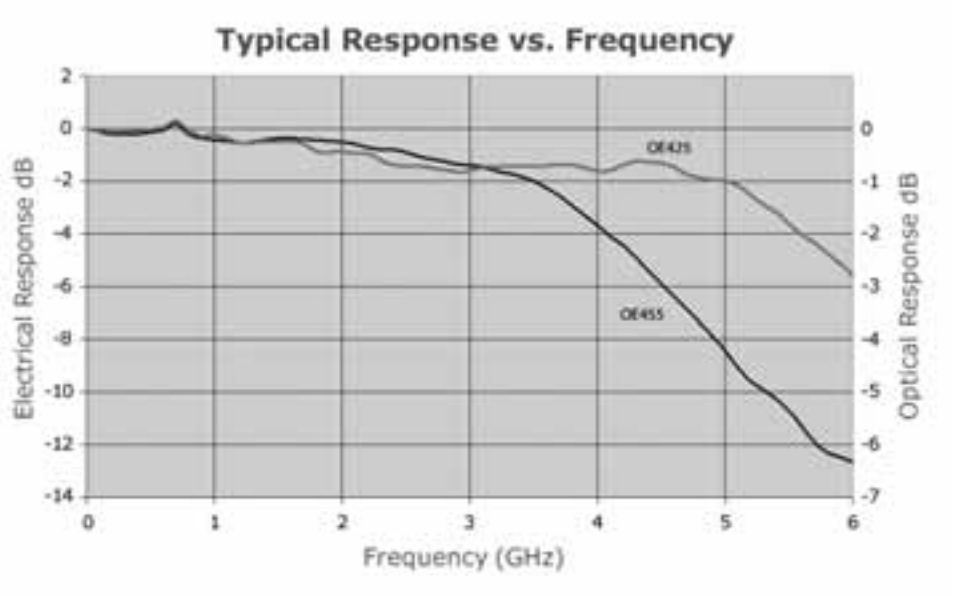
The OE525 and OE555 are ProLink® modules compatible with WaveMaster, SDA and DDA instruments.

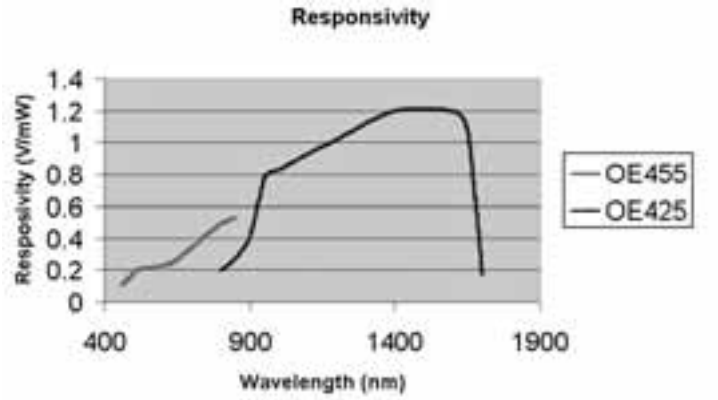
UNIVERSAL CALIBRATED REFERENCE RECEIVERS

The O/E converters contain calibration data that can be used to create optical reference receivers for SONET/SDH (up to OC48/STM16), Fibre Channel, Gigabit Ethernet and other optical standards. This feature is available when the O/E is used on a WaveMaster series oscilloscope. This universal reference receiver supports any data rate up to 3 GHz and remains calibrated on any channel of any WaveMaster.

O to E Converter Technical Specifications

	OE425/OE525	OE455/OE555
Wavelength Range:	500–870 nm 460–870 nm (.1V/MW)	950–1630 nm 800–1630 nm (.1V/MW)
Conversion Gain:	0.5 V/mW	1.1 V/mW
Bandwidth:	5 GHz (6 GHz optical)	3.5 GHz (4.5 GHz optical)
Equivalent Noise:	2.2 μW rms	1.2 μW rms
Maximum Optical Power (at 5% saturation):	2.2 mW	1.3 mW
Rise Time:	90 ps	108 ps
Maximum Safe Input:	5.5 mW	1.3 mW
Temperature Drift:	.00275 dB/deg. C	.00275 dB/deg. C
Frequency Response Ripple:	1.1 dBe	1.1 dB
Connector Type:	FC/PC	FC/PC





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Long wavelength O/E Converter (950–1630 nm) (ProBus)	OE455
Short wavelength O/E Converter (500–870 nm) (ProLink)	OE525
Long wavelength O/E Converter (950–1630 nm) (ProLink)	OE555

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