

# Solar Inverter Reconnection Testing

## Procedure

Awais Ahmad, Georgios Konstantinou, John Fletcher

School of Electrical Engineering and Telecommunications, UNSW Sydney

### Abstract

The growth and increasing penetration of distributed energy resources (DER) in Australian power grids is creating new challenges for network management and system security, with less regulated and often unobserved DER accounting for a significant proportion of generation during midday hours. To address these challenges, the University of New South Wales (UNSW Sydney) and the University of Wollongong (UoW), in collaboration with the Australian Energy Market Operator (AEMO) and the Commonwealth Scientific and Industrial Research Organisation (CSIRO), under Theme 9 of the Australian Global Power System Transformation (GPST) consortium on DER and stability for power systems with large penetrations of DER, are conducting a comprehensive reconnection test of DER and loads connected to distribution networks. These tests include but not limited to, residential solar PV inverters, battery energy storage systems (BESS), hybrid energy storage systems (HESS), loads and Electric Vehicles (EVs) / EV chargers. The outcomes of the tests assess the response of these inverter under system reconnection and are used to inform the load modelling, provide feedback to AEMO and OEMs on performance and behaviour of the systems and future networks operation and planning.

### Index Terms

Grid-connected PV inverters, Battery Energy Storage Systems, Hybrid Energy Storage Systems, Electric Vehicles, Loads, AS4777, Voltage disturbance, frequency disturbance, rate of change of frequency (RoCoF)

## CONTENTS

<b>I</b>	<b>Laboratory Setup</b>	4
<b>II</b>	<b>Equipment Used</b>	5
II-A	AC Grid Emulator . . . . .	5
II-B	DC PV Emulator . . . . .	5
II-C	Power Analyser . . . . .	6
II-D	Oscilloscope . . . . .	6
II-E	Current Probes . . . . .	6
II-F	Voltage Probes . . . . .	6
<b>III</b>	<b>Testing Procedure - AS4777.2:2020</b>	7
III-A	Inverter Reconnection Test . . . . .	7
III-A1	<b>Black Start</b> . . . . .	7
III-A2	<b>Enhanced Voltage Management</b> . . . . .	8
<b>IV</b>	<b>Differences to Testing Procedure described in AS4777.2:2020</b>	9
IV-A	Grid Impedance . . . . .	9
IV-B	Power Level Used For Testing . . . . .	9
<b>References</b>		11

## LIST OF FIGURES

1	Experimental set-up in the Room 334 Lab . . . . .	4
2	Regatron ACS-13038 . . . . .	5
3	Regatron Q1-LIN-13041 interface. . . . .	5
4	Yokogawa WT3000 interface. . . . .	6
5	LeCroy HDO4045 interface. . . . .	6
6	Emulated P-V and I-V curves at 1000 W/m <sup>2</sup> and 500 W/m <sup>2</sup> . . . . .	7
7	Inverter reconnection with elevated Voltages. . . . .	8
8	Single-phase inverter testing setup. . . . .	9

## LIST OF TABLES

I	Table 4.1 from [1]. . . . .	10
II	Table 4.2 from [1]. . . . .	10

## I. LABORATORY SETUP

The experimental testing of Fig. 1 is currently being performed in the Power Electronics Research Laboratory, Room 334, Tyree Energy Technologies Building (TETB).

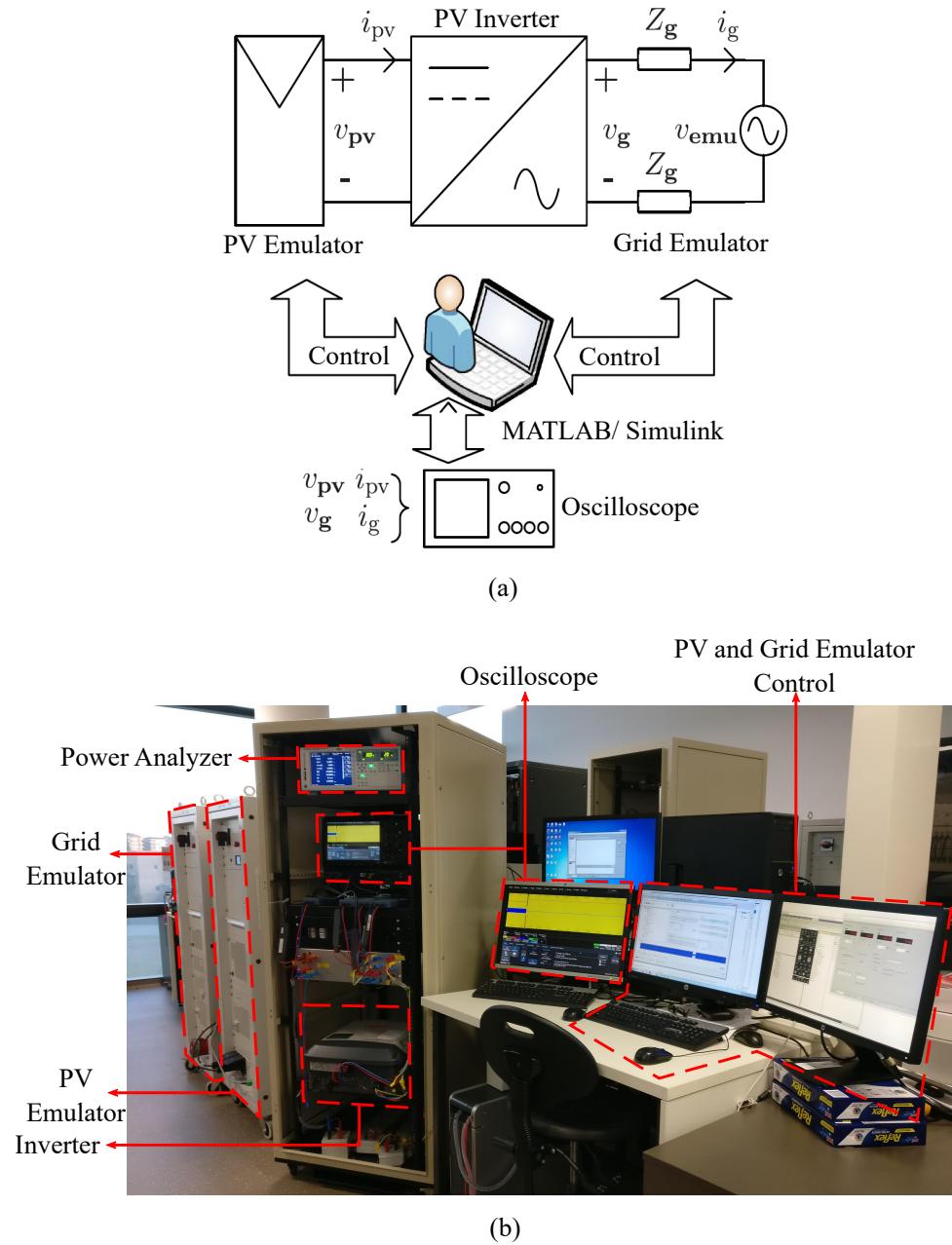


Fig. 1: (a) Schematics of testing setup, and (c) photo of experimental testing setup.

## II. EQUIPMENT USED

### A. AC Grid Emulator

A Regatron ACS-13038 grid emulators is used [2] operating at 230 V rms phase-to-neutral voltage and 50 Hz of nominal grid frequency. These settings can be adjusted in real-time by using proprietary software for this programmable AC source as is depicted in Fig. 2.

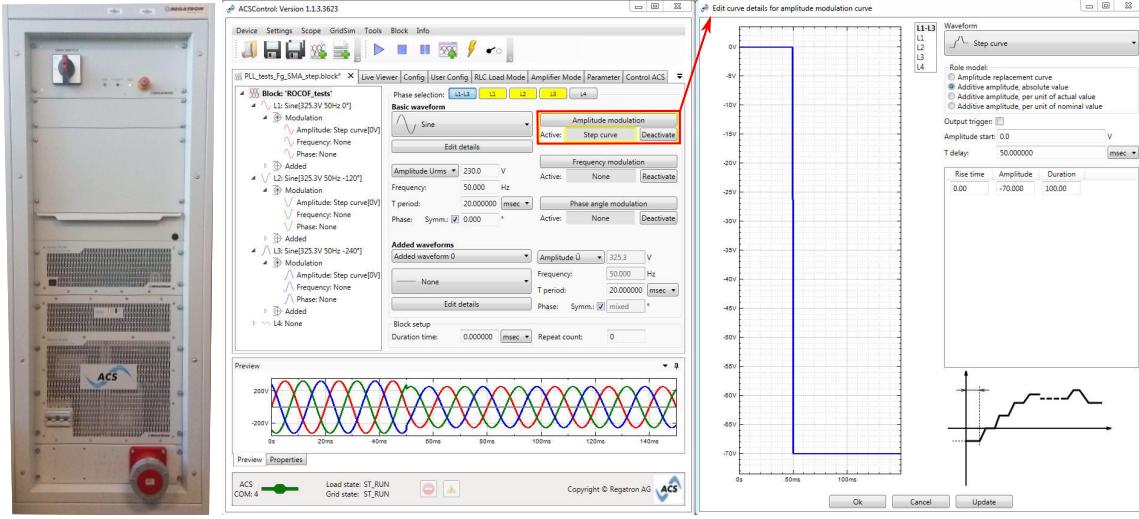


Fig. 2: Regatron ACS-13038 interface.

### B. DC PV Emulator

The PV array emulator is a Regatron Q1-LIN-13041 [2] operating at Standard Test Conditions (STC) conditions ( $1000 \text{ W/m}^2$ - $25^\circ\text{C}$ ). The emulated PV array parameters operating at maximum power point. The interface to this emulated PV array is illustrated in Fig. 3. Note that, the two PV emulators are connected for each array to input of the inverter, if the inverter supports power through two pair of terminals.

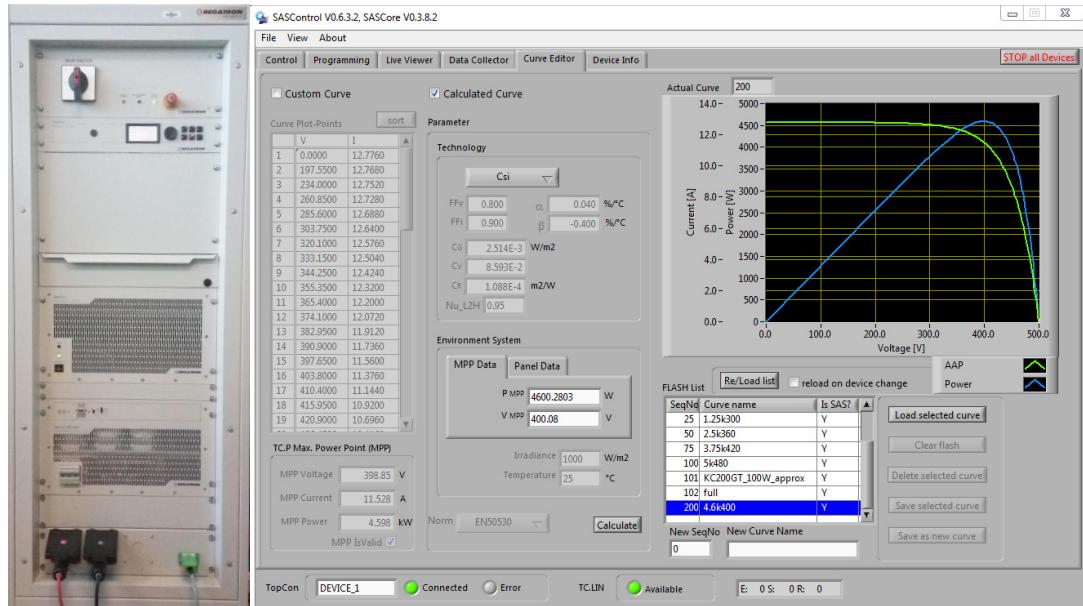


Fig. 3: Regatron Q1-LIN-13041 interface.

### C. Power Analyser

The power analyser is a Yokogawa WT3000 [3]. With this instrument it is possible to measure the inverter efficiency. The interface of this power analyser is illustrated in Fig. 4.



Fig. 4: Yokogawa WT3000 interface.

### D. Oscilloscope

The oscilloscope is a LeCroy HD4096 [4], which is configured with a sampling frequency of 20 kHz<sup>1</sup>. The interface of these instruments is shown in Fig. 5

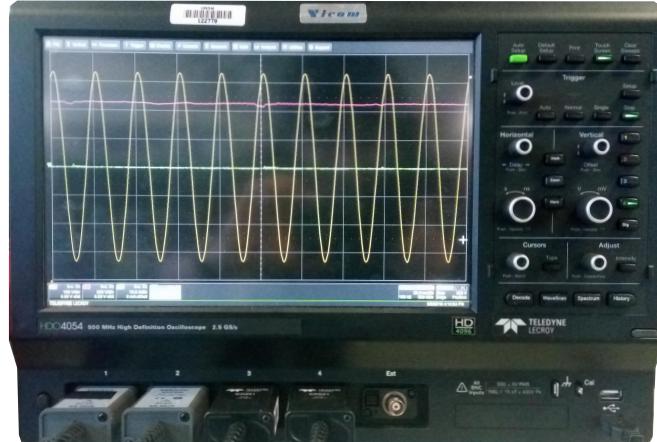


Fig. 5: LeCroy HDO4045 interface.

### E. Current Probes

The current probes are LeCroy CP30. The bandwidth of this current probe is 100 MHz [4].

### F. Voltage Probes

The differential voltage probes are LeCroy ADP300. The bandwidth of this voltage probe is 100 MHz [4].

<sup>1</sup>AS4777 defines the sampling frequency for the measurement of electrical quantities as 10 kHz.

### III. TESTING PROCEDURE - AS4777.2:2020

This section describes the testing of the inverters that comply to the AS4777.2:2020 standard. Emulation of the PV array is performed using default solar PV curves from the Regatron Q1-LIN-13041 according to the Standard EN 50530:2010, defining the maximum voltage and power of the system. All of the experiments below are performed 100% of the rated power of the inverter. Emulated  $P$ - $V$  and  $I$ - $V$  curves for both cases are shown in Fig. 6.

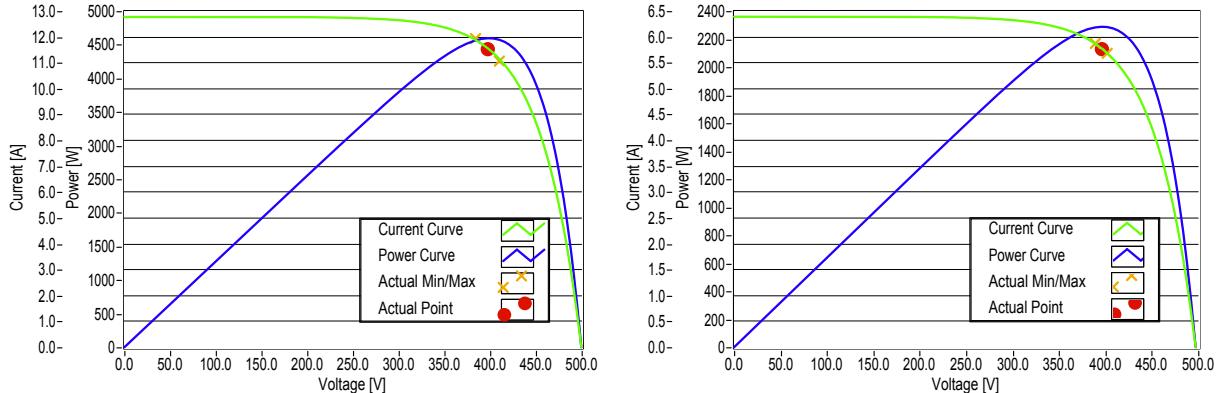


Fig. 6: Emulated P-V and I-V curves at 1000 W/m<sup>2</sup> and 500 W/m<sup>2</sup>.

#### A. Inverter Reconnection Test

**Objective:** This test aims to verify the behavior of the PV inverter under system blackout conditions and capture the behavior of the inverter under reconnection. AS4777.2:2020 defines limits for excursions above and below the nominal reconnection as well as the power ramp rate for the inverter after reconnection. **Notes in the test and the standard:** The standard requires the following conditions should be maintained for the inverter to reconnect with the system after disconnection that are:

- The system voltage should be maintained within the utilization limits of AS 600038 for at least 60s.
- The system frequency should be maintained within the range of 47.5 Hz to 50.15 Hz for at least 60s

This test analyses the inverter behavior during the reconnection when the system frequency or the voltages are a bit above or below the specified limits.

**Test Procedure:** The frequency and voltage variations are pre-programmed in the AC Grid Emulator, and the response of the inverter is captured<sup>2</sup>.

The following tests are performed:

1) **Black Start:** To test the response of the inverter after the system starts for the first time with nominal frequency and voltage. In this test, the inverter is disconnected and restarted with nominal frequency and voltage to observe the reconnection time of the inverter and also the time taken by the inverter after reconnection to reach maximum power.

<sup>2</sup>These tests can be repeated with actual network data captured during faults.

2) **Enhanced Voltage Management:** To test the response of the inverter after the system starts with elevated voltages. In this test, the inverter is disconnected and restarted with nominal frequency but with an elevated voltage level of 265V. This voltage is stepped down 5V every two minutes until it reaches 230V, shown in Fig. 7. The purpose of this test is to find the reconnection voltage levels for each inverter.

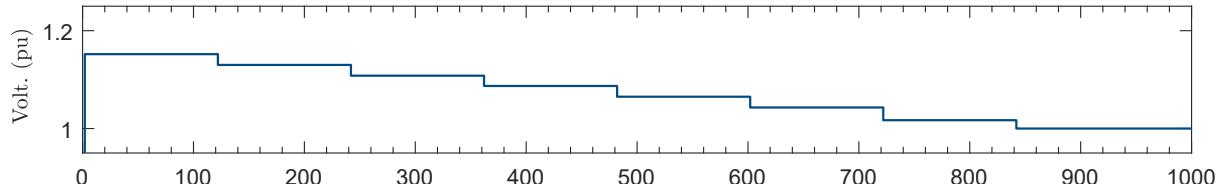


Fig. 7: Inverter reconnection with elevated Voltages.

#### IV. DIFFERENCES TO TESTING PROCEDURE DESCRIBED IN AS4777.2:2020

The tests reported in this procedure do not intend to prove the compliance to AS 4777.2:2020 , but they rather intend to verify the behaviour of the inverter against disturbances appearing in the gird voltage (mainly voltage and frequency variations). Furthermore, there are some differences in the test setup described in this procedure and the one recommended in the above-mentioned Standards, these are described below.

##### A. Grid Impedance

The schematic of the test setup being adopted for single phase inverters is the following:

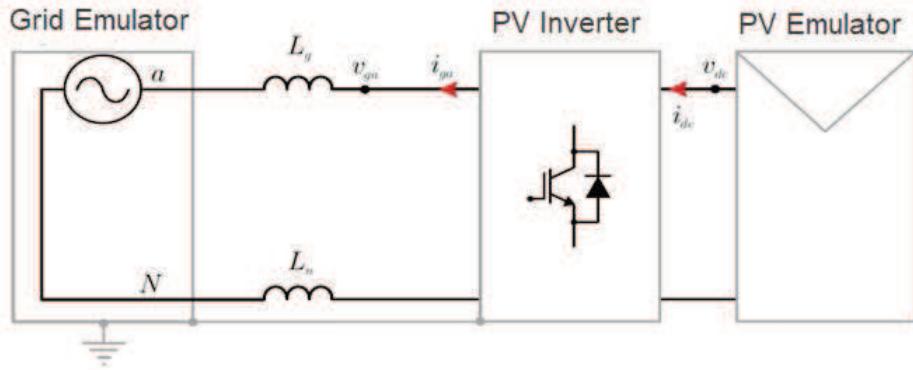


Fig. 8: Single-phase inverter testing setup.

Quoting Appendix A6 of [1, p. 60]:

For single-phase and three-phase inverters with rated current less than 21.7 A per phase, the impedance of the reference network impedance shall be  $0.24 \Omega + j0.15 \Omega$  for each phase conductor and  $0.16 \Omega + j0.10 \Omega$  for the neutral conductor.

For inverters with rated current greater than 21.7 A per phase, the impedance of the reference network impedance shall be  $0.15 \Omega + j0.15 \Omega$  for each phase conductor and  $0.1 \Omega + j0.1 \Omega$  for the neutral conductor.

The above mentioned impedances, see inductances  $L_g$  and  $L_n$  in Fig. 8, are connected between the inverter and the grid emulator. In the setup used in the laboratory, differently from what suggested in [1, p. 43], the impedance used was chosen based on availability of components and it is  $0.12 \Omega + j0.157 \Omega$ , having  $L_g = L_n = 0.5 \text{ mH}$ . The resistive component of such impedance ( $0.12 \Omega$ ) is due to the equivalent series resistance of the inductor and resistivity of the connected cables.

##### B. Power Level Used For Testing

Passive anti-islanding tests specified in the Appendix I2 and I3 of [1, pp. 81-93] allow to verify the disconnection of the inverter from the AC grid for the voltage and frequency limits specified in [1, Table 4.1 & 4.2] (reported below).

**Passive anti-islanding voltage limit values**

Protective function	Protective function limit	Trip delay time	Maximum disconnection time
Undervoltage 2 ( $V <<$ )	70 V	1 s	2 s
Undervoltage 1 ( $V <$ )	180 V	10 s	11 s
Overtvoltage 1 ( $V >$ )	265 V	1 s	2 s
Overtvoltage 2 ( $V >>$ )	275 V	—	0.2 s

TABLE I: Table 4.1 from [1].

**Passive anti-islanding frequency limit values**

	Region	Australia A	Australia B	Australia C	New Zealand
Under-frequency 1 ( $F <$ )	Protective function set point	47 Hz	47 Hz	45 Hz	45 Hz
	Trip delay time	1 s	1 s	5 s	1 s
	Maximum disconnection time	2 s	2 s	6 s	2 s
Over-frequency 1 ( $F >$ )	Protective function set point	51.5 Hz	51.5 Hz	53 Hz	52.5 Hz
	Trip delay time	300 s	300 s	300 s	300 s
	Maximum disconnection time	310 s	310 s	310 s	310 s
Over-frequency 2 ( $F >>$ )	Protective function set point	52 Hz	52 Hz	55 Hz	55 Hz
	Trip delay time	—	—	—	—
	Maximum disconnection time	0.2 s	0.2 s	0.2 s	0.2 s

TABLE II: Table 4.2 from [1].

In order to verify the voltage trip settings, Appendix I2 of [1] states that ‘The energy source supply shall be varied until the AC output of the device under test equals  $50 \pm 5\%$  of its rated current output’. For the tests concerning the verification of the frequency trip settings, Appendix I4 of [1] states that ‘The input supply shall be varied until the AC output of the device under test equals  $50 \pm 5\%$  of its rated output or 10 A, whichever is the lesser’.

In this test procedure, the input power of the inverter has not been set according to the above-mentioned guidelines. A set of commercial inverters with rated power of about 5 kVA were tested. It was decided to test these inverters at full input power to produce a comparable set of results. Also the inverters which were not behaving ideally at full power were also tested for half power.

The input power at which each inverter is tested is specified in the test report of each individual inverter, but generally this does not follow the rule of being half the rated power of the inverter, as stated in [1].

## REFERENCES

- [1] AS4777.2-2020, “Grid connection of energy systems via inverters. Part 2: Grid protection requirements,” 2020. [Online]. Available: <https://www.standards.org.au>
- [2] R. ACS-13038, “Regatron ACS-13038 Datasheet,” 2018. [Online]. Available: <https://www.regatron.com>
- [3] Y. WT3000, “Yokogawa WT3000 Datasheet,” 2016. [Online]. Available: <https://tmi.yokogawa.com>
- [4] L. HDO4045, “LeCroy HDO4045 Datasheet,” 2018. [Online]. Available: <http://teledynelecroy.com>

## 50 kVA / 280 Vrms (L-N) / 72 A TC.ACS Modular Grid Simulator

### Mains Requirements and Specifications

#### Grid Port

Line voltage .....	3 x 360 – 440 V <sub>AC</sub>
Line frequency .....	48 – 62 Hz
Mains connection type .....	3L+PE (no neutral)
Input current .....	3 x 85 Arms
Powerfactor .....	0 – 1
(At nominal power)	

#### Simulation Port: 3L + active N (4 outputs)

Power range .....	0 - 50 kVA
Voltage range .....	0 – 280 Vrms (L-N)
Connection type.....	3L+N+PE
Current range .....	3 x 0 – 72 A
Frequency range (fundamental wave) ....	0 – 1000 Hz
Frequency range (full power).....	16 – 1000 Hz
Modulation bandwidth.....	3 kHz
Resolution frequency .....	0.001 Hz
Accuracy frequency .....	± 10 ppm
Stability frequency (-30° ... 85°) .....	± 25 ppm
DC offset .....	≤1 mV
Bidirectional DC operation .....	allowed .....with power derating (approx. 25 %)

#### Operating Modes

- Four quadrant simulator mode
- Four quadrant voltage amplifier mode
- Hardware in the loop mode

#### Static Accuracy

Load regulation CV.....	< ± 0.3% FS
Line regulation CV .....	< ± 0.1% FS

#### Overloadability

up to 10 s every 600 s .....	1.5 p.u
up to 1 s every 60 s .....	2.0 p.u

### General Specifications

Efficiency at nominal power .....	90 %
Weight .....	approx. 135 kg
Width housing.....	(19") 444 mm
Height housing.....	11 U
Depth with output terminals .....	634 mm
Operating orientation .....	upside
Storage, transport orientation .....	upside
Noise level.....	≤74 dB, at 1 m

### Ambient Conditions

Operating temperature .....	5 – 40 °C
Storage temperature.....	-25 – 70 °C
Relative air humidity (non-condensing) .....	0 – 95 %

### Cooling

External liquid cooling or external air to liquid heat-exchange system using temperature-controlled fans.

#### Heat exchanger

Material.....	Al
Inlet/outlet on rear side size: .....	G ½"
Liquid temperature.....	15 – 35 °C
Flow.....	≥ 5 l/min
Pressure max. .....	≤ 10 bar

### Protection

#### Built-in Protection

Oversupply protection .....programmable  
Overcurrent protection .....programmable  
short circuit protection .....Cont. short circuit allowed  
Islandig, grid off, requirements for the connection of  
micro-generators in public grid according  
VDE 0126/EN 50438.

#### Type of Protection (according EN 60529)

Basic construction .....	IP 20
Mounted in cabinet .....	up to IP 53

### Conformity CE-Marking

#### EMC Directive

EMC emission.....	EN 61000-6-4
EMC immunity.....	EN 61000-6-2

#### Low Voltage Directive

Electronic equipment for use in power installations.....	EN 50178
---	----------

### Standard Programming Interfaces

#### Control Port Input Functions

Amplifier mode:

Voltage setting L1: 0 – 100 % .....	-10 – +10 V
Voltage setting L2: 0 – 100 % .....	-10 – +10 V
Voltage setting L3: 0 – 100 % .....	-10 – +10 V

#### Trigger port

Input 1 (Start) .....	TTL
Input 2 (Stop) .....	TTL
Output (programmable).....	TTL

#### Control Port Output Functions

Analogue output .....	configurable
-----------------------	--------------

#### RS232

9 pin D-sub connector, female	
Isolation to electronics and earth .....	125 Vrms

#### Ethernet

Integrated interface .....	planned
----------------------------	---------

# TopCon Quadro Power Supply

Programmable High-Power DC Supply



TopCon Quadro Power Supply unit with optional front panel control unit HMI

- Constant voltage (0 – 100 %), constant current (0 – 100 %) and constant power operation (5 – 100%) with automatic and fast crossover and mode indication. Internal resistance simulation.
- Finely graduated product line: 52, 65, 100, 130, 200, 400, 500, 600, 800, 1000, 1200 VDC. Power categories of 10, 16, 20 and 32 kW are available for each nominal output voltage.
- Optional extras and accessories complete the product line of power supply units.
- Modular concept for easy power increase: Parallel, series or multiload master-slave-operation for up to eight power supply units.
- High efficiency at a low cost, resulting from the application of innovative IGBT and transformer technology. Primary switched. Galvanic isolated. Full digital control and regulation.
- A user-friendly PC program, the operating and service software TopControl, enables the user to communicate with the power supply.
- TopControl installation file, LabVIEW® and C/C++ API (DLL file) are included in the scope of delivery.
- CE conformity
- Swiss made: Further developed, manufactured and tested in Switzerland by Regatron AG.

## Regatron AG

Kirchstrasse 11  
CH-9400 Rorschach  
Switzerland  
Tel +41 71 846 67 67  
Fax +41 71 846 67 77  
[www.regatron.com](http://www.regatron.com)  
[topcon@regatron.ch](mailto:topcon@regatron.ch)

# 16 kW / 600 VDC / 32 A

TC.P.16.600.400.S

## Mains requirements and output specifications

### AC line input

Line voltage..... 3 x 360 – 440 VAC  
Line frequency ..... 48 – 62 Hz  
Mains connection type ..... 3L+PE (no neutral)  
Input current..... 3 x 32 Arms<sup>1)</sup>  
Leakage current L to PE ..... < 10 mA

### Output ratings

Output power range ..... 0 – 16 kW  
Output voltage range ..... 0 – 600 VDC  
Output current range ..... 0 – 32 A<sup>2)</sup>  
Internal resistance range ..... 0 – 18750 mΩ<sup>3)</sup>

### Operating modes

Voltage regulation (CV)..... 0 – 100 % Umax  
Current regulation (CC)..... 0 – 100 % Imax  
Power regulation (CP)..... 5 – 100 % Pmax

### Static accuracy

Load regulation CV, CC ..... < ± 0,1 % FS<sup>4)</sup>  
Line regulation CV, CC ..... < ± 0.1 % FS<sup>5)</sup>

### Transient response time

Load regulation CV, CC ..... < 2 ms<sup>6)</sup>  
Set value tracking CV, CC ..... < 2 ms<sup>7)</sup>

### Stability

CV, CC ..... < ± 0.05 % FS<sup>8)</sup>

### Temperature coefficient

CV ..... < 0.02 % FS / °C<sup>9)</sup>  
CC ..... < 0.03 % FS / °C<sup>9)</sup>

### Output ripple

300 Hz Vpp ..... < 1.1 % FS<sup>10)</sup>  
300 Hz Vrms ..... < 0.4 % FS<sup>10)</sup>

### Output noise

40 kHz – 1 MHz Vpp ..... < 1.5 V<sup>10)</sup>  
40 kHz – 1 MHz Vrms ..... < 0.1 V<sup>10)</sup>

### Remote sensing

Terminals on rear side ..... Line voltage drop compensation

## General specifications

Efficiency at nominal power ..... 92 %  
Weight ..... 44 kg  
Width front panel ..... 483 mm  
Width housing ..... (19") 444 mm  
Height front panel ..... 265 mm  
Height housing ..... (6 U) 262 mm  
Depth with output terminals ..... 495 mm  
Depth housing ..... 450 mm  
Line input connections: ..... terminal block 4 x 10 mm<sup>2</sup>  
Output terminals: ..... nickel-plated copper bars,  
length: 40 mm, 1 hole 9 mm Ø in each bar

- 1) At nominal output power and line input voltage 3 x 390 VAC / 50 Hz. Soft-start to limit turn-on surge currents.
- 2) Current according to the given power limit of the corresponding units. ( $P=U_{out} * I_{out} \leq 16 \text{ kW}$ ; for  $I_{out} > 27 \text{ A} \rightarrow U_{out} < 600 \text{ V}$ ).
- 3) The maximum value of the internal resistance is automatically calculated via the DC nominal values ( $R_i [\text{mΩ}] = V_{Load} / I_{Load} = 600 \text{ VDC} / 32 \text{ A}$ ) or limited by the maximum  $R_i$ -value: 32000 [mΩ].
- 4) Typical value for 0 – 100 % load variation, at constant line input and temperature conditions.
- 5) Typical value for input voltage variation within 360 – 440 VAC, at constant load and temperature conditions.
- 6) Typical recovery time to within < ± 5 % band of set value for a load step 10 – 90 %, ohmic load, at constant line input and temperature conditions. Transient response time can be slightly affected by multi-unit operation.
- 7) Typical recovery time to within < ± 5 % band of set value for a set value step 10 – 90 %, ohmic load, at constant line input and temperature conditions. Transient response time can be slightly affected by multi-unit operation.
- 8) Maximum drift over 8 hours after 30 minute warm-up time, at constant line input, load and temperature conditions.
- 9) Typical change of output values versus ambient temperature, at constant line input and load conditions.
- 10) Typical value at nominal ohmic load, line asymmetry < 1 Vrms.

Non-ohmic loads can lead to deviations in the technical data. All product specifications are subject to change without notification.

**Ambient conditions**

Operating temperature ..... 5 – 40°C  
 Storage temperature ..... -25 – 70°C  
 Relative air humidity (non-condensing) ..... 0 – 95 %

**Cooling**

Standard: internal temperature-controlled fans  
 Optional: integrated liquid cooling of the power stage,  
 heat exchanger material: AC100 (Al-Ti-alloy),  
 inlet / outlet on rear side, size: G 1/2"

**Protection****Built-in protection**

Overvoltage protection (programmable) ..... 0 – 110 % Umax  
 Overcurrent protection (programmable) ..... 0 – 110 % Imax  
 Max. reactive load voltage ..... ≤ 110 % Umax  
 Short circuit protection ..... Cont. short circuit allowed  
 Internal diagnostics: line input conditions, transformer primary current, temperature conditions, processor idle time, system configuration, system communication, sensor signals, power semiconductors

**Type of protection (IEC 60529)**

Basic construction ..... IP 20 (current bars on rear side excluded)  
 Mounted in cabinet ..... Up to IP 53

**Conformity CE-Marking****EMC Directive**

EMC emission ..... EN 61000-6-4  
 EMC immunity ..... EN 61000-6-2

**Low Voltage Directive**

Electronic equipment for use in power installations ..... EN 50178

**Isolation**

Line to case/ logic ..... 1670 VDC 1s  
 Output to case/ logic ..... 2540 VDC 1s  
 Output to case ..... > 10 MΩ  
     per DC bar ..... 13.6 nF  
     - bar<sup>16)</sup> ..... + 1000 VDC / - 1000 VDC  
     + bar<sup>16)</sup> ..... + 1500 VDC / - 1000 VDC

**Standard programming interfaces****Control port**

Isolation to electronics and earth: 125 Vrms  
 25 pin D-sub connector, female, on rear panel

**Control port input functions**

Output voltage on / off ..... 0 / 24 VAC / DC  
 2 digital application inputs ..... 0 / 24 VAC / DC<sup>12)</sup>  
 Interlock circuit ..... 0 / 24 VDC  
 Voltage setting 0 – 100 % ..... 0 – 10 V  
 Current setting 0 – 100 % ..... 0 – 0 V  
 Power setting 0 – 100 % ..... 10 – 0 V  
 Int. resistance setting 0 – 1000 mΩ<sup>3)</sup> ..... 0 – 10 V

**Control port output functions**

Unit ready / error ..... Relay contact  
 Output voltage on ..... Relay contact  
 Temperature warning ..... Relay contact  
 Actual voltage readback 0 – 100 % ..... 0 – 10 V  
 Actual current readback 0 – 100 % ..... 0 – 10 V  
 Resolution (programming and readback): U, I, P, Ri ..... 0.2 % FS

**Standard programming interfaces (continued)****RS232**

9 pin D-sub connector, female, on front panel  
 Isolation to electronics and earth ..... 125 Vrms  
 Baud rate ..... 38400 baud  
 Resolution (programming and readback):  
 U, I ..... 0.025 % FS  
 P, Ri ..... 0.1 % FS

**Ordering Information****Ordering code**

TC.P.16.600.400.S(.Option)

**Standard Scope of delivery**

TopCon power supply unit ready to install, including:  
     Operating manual (English or German)  
     RS232 cable 1.8 m  
     Installation disc TopControl,  
     LabVIEW® and C/C++ API (DLL file)

**Options****Front panel control unit HMI**

Integrated control, programming and display unit with graphic LC-Display, select wheel, push buttons and interactive text menus

Languages (switchable) ..... English, German  
 Display resolution:

U ..... 4 digits  
 I ..... 3 digits  
 P ..... Kilowatt + 1 decimal digit  
 Ri ..... 1 mΩ

**Remote control unit RCU**

Specifications same as HMI, available in 2 versions:  
     desk top and 19" rackmount  
 max. cable length ..... 40 m  
 Desk top W x H x D ..... 355 x 100 x 290 mm  
 19" rackmount W x H x D ..... 483 x 133 (3 U) x 290 mm

**Further options**

TFEAAP	Function Generating Engine Time-based and parametric programming
SASControl <sup>12)</sup>	SAS application program including TFEAAP
BatControl <sup>12)</sup>	Battery application program
BatSim <sup>12)</sup>	Battery simulation program
CapSim <sup>12)</sup>	Capacitor simulation program
RS232REAR <sup>13)</sup>	RS-232 on front and rear panel
USB <sup>14)</sup>	USB on rear panel
RS422 <sup>13)</sup>	RS-422 on rear panel
ETHERNET <sup>14)</sup>	Ethernet on rear panel
IEEE <sup>14)</sup>	GPIB/ IEEE488.2/ SCPI on rear panel ....cannot be combined with CANOPEN nor with USB
CANOPEN <sup>14)</sup>	CAN/ CANOPEN on rear panel
CANmp	CANmp on rear panel
OptoLink <sup>14)</sup>	OptoLink on rear panel
CANCABLE	Connecting cable .....for Multi-Unit Operation or RCU: 2, 5, 10 m
PACOB	Protection against accidental contact
LCAL	Integrated liquid cooling of the power stage, inlet / outlet on rear side, size G 1/2"
AIRFILTER	Front panel airfilter 6 U
ISR	2 channel Integrated Safety Relay
NSOV	Non-Standard output voltage

11) Ambient temperature or CDF restrictions: refer to output ratings.

12) Customer-specific programmable.

13) This option and RS232: time-shared mode required, if used together.

14) RS232 only on Rear Panel.

15) Please order option RS232REAR separately.

16) Peak Voltage including DC-Output Voltage.

# Linear Post-Processor Unit

## for Regatron Power Supplies

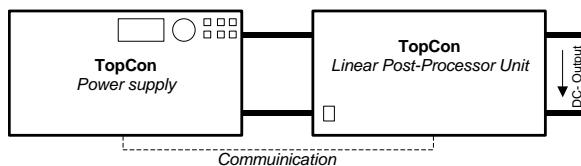


Linear Post-Processor Unit

### Features

- The *Linear Post-Processor Unit* combines the advantages of a primary switched power supply like high efficiency, small outline, light weight, cost efficiency, with the fast, smooth linear controlled output capability of a linear power supply.
- To be used in combination with TopCon power supplies.
- Modular concept for easy power increase: Parallel, master-slave-operation of power supplies and *Linear Post-Processor Units*.
- Very fast digital controller features quick response time, enhanced dynamics and programmable control characteristics.
- User-friendly PC program available. This enables the user to communicate over the power supply to the *Linear Post-Processor Unit*.<sup>1)</sup>
- Seamless integration into the well established TopControl software.
- Swiss made: developed, manufactured and tested in Switzerland by Regatron AG.

### System Configuration (single Modules)



### Regatron AG

Kirchstrasse 11  
CH-9400 Rorschach  
Switzerland  
Tel +41 71 846 67 67  
Fax +41 71 846 67 77  
[www.regatron.com](http://www.regatron.com)  
[topcon@regatron.ch](mailto:topcon@regatron.ch)

# 45 A/22 A/1000 VDC

TC.LIN.SER.45.1000.45

### Input requirements and output specifications

#### Mains input data (Auxiliary Supply)

Voltage .....	85 – 264 V <sub>AC</sub>
Frequency .....	48 – 62 Hz
Input power .....	120 W

#### DC Input ratings

Input voltage .....	0 – 1000 V <sub>DC</sub>
Input current .....	45 A <sub>DCmax</sub>
Leakage current DC to PE .....	< 10 mA

#### Output ratings

Output voltage range .....	0 – 1000 V <sub>DC</sub> <sup>2)</sup>
Drop Voltage (typical) .....	35 V <sup>3)</sup>
Output current full range .....	0 – 45 A <sup>4)</sup>
Output current half range .....	0 – 22 A
Output Capacitor .....	< 10 nF

#### Dissipation Power

Continuous power diss.....	1500 W <sup>5)</sup>
Power diss. < 3 Min.....	2000 W <sup>6)</sup>
Transient power diss.....	Full SOA protection

#### Operating modes

AAP <sup>7)</sup> current regulation.....	0 – 100 % I <sub>max</sub> @0 – (V <sub>max</sub> -V <sub>Drop</sub> )
---	---

#### Resolution

Voltage, current resolution .....	14.5 Bit <sup>8)</sup>
-----------------------------------	------------------------

#### Static accuracy

Load regulation .....	< ± 0.05 % FS typ. <sup>9)</sup>
Line regulation .....	< ± 0.05% FS typ. <sup>10)</sup>

#### Transient response time

Load regulation .....	< 10 µs <sup>11)</sup>
Set value tracking .....	< 50 µs <sup>12)</sup>

#### Stability

.....	< ± 0.02 % FS <sup>13)</sup>
-------	------------------------------

#### Temperature coefficient

Current, voltage .....	< 0.01 % FS/°C <sup>14)</sup>
------------------------	-------------------------------

#### Remote sensing

Terminals on rear side .....	cable voltage drop compensation
------------------------------	---------------------------------

### General specifications

Weight.....	23 kg
Width front panel .....	483 mm
Width housing .....	444 mm (19")
Height front panel.....	265 mm
Height housing .....	262 mm (6 U)
Depth with output terminals .....	485 mm
Depth housing.....	450 mm
DC input terminals max.....	3 x 25 mm <sup>2</sup> (DC+, DC-, PE)
DC Output terminals max .....	3 x 25 mm <sup>2</sup> (DC+, DC-, PE)
Remote Sensing terminals max .....	2 x 10 mm <sup>2</sup> (DC+,DC-)

- 1) Most commonly used parameter are accessible via PC Program TopControl connected to TopCon power supply.
- 2) Maximum Output Voltage = Input Voltage – Drop Voltage.
- 3) Adjustable Value, the Drop Voltage influences directly the power dissipation.
- 4) Full Range / Half Range are selectable by PC program TopControl.
- 5) At ambient temperature 25 °C, for *current half range* 60 % of specified value.
- 6) For Drop Voltage < 250 V<sub>DC</sub>, for *current half range* 50 % of specified value.
- 7) Application Area Programming, e.g. I(U) curves of solar panel / solar array.
- 8) Improved by using oversampling techniques.
- 9) Typical value for 60 % to 70 % load variation, at voltage drop and temperature conditions.
- 10) Typical value for variation within 20 V to 60 V drop voltage, at constant load and temperature conditions.
- 11) Typical recovery time to within < ± 2 % band of set value for a load step 60 % to 70 %, ohmic load, voltage drop > 30 V and constant temperature conditions.
- 12) Typical recovery time to within < ± 2 % band of set value for a set value step 60 % to 70 %, ohmic load, voltage drop > 30 V and constant temperature conditions. Line input and temperature conditions. Transient response time can be slightly affected by multi-unit operation.
- 13) Maximum drift over 6 hours after 30 minute warm-up time, at constant line input, load and temperature conditions.
- 14) Typical change of output values versus ambient temperature, at constant line input and load conditions.

**Ambient conditions**

Operating temperature ..... 5 – 40 °C  
 Storage temperature ..... -25 – 70 °C  
 Relative air humidity ..... 0 – 95 %  
 (non-condensing)

**Cooling**

Fans ..... internal temperature-controlled

**Safety****Type of protection (IEC 60529)**

Basic construction ..... IP 20  
 Mounted in cabinet ..... up to IP 53

**Isolation**

Line to output (auxiliary supply) ..... 4000 V<sub>rms</sub>  
 Line to case (auxiliary supply) ..... 2500 V<sub>rms</sub>  
 DC-Input, Output to case: ..... ± 1000 V<sub>DC</sub>, > 10 MΩ

**Conformity CE-Marking****EMC Directive**

EMC emission ..... EN 61000-6-4  
 EMC immunity ..... EN 61000-6-2

**Low Voltage Directive**

Electronic equipment  
 for use in power installations ..... EN 50178

**Standard programming interfaces****Control port**

Isolation to electronics and earth: ..... 125 V<sub>rms</sub>  
 Connector ..... 15 pin D-sub, female  
 ..... on rear panel

**Control port**

Input functions ..... Future use  
 Output functions ..... Future use

**Standard programming interfaces (continued)****RS232**

Isolation to electronics and earth: ..... 125 V<sub>rms</sub>  
 Connector ..... 9 pin D-sub, female  
 ..... on rear panel  
 Baud rate ..... 38400 baud  
 Resolution (programming and readback):  
 U, I ..... 0.005 % FS

**Ordering code**

TC.LIN.SER.45.1000.45

**Scope of delivery**

TopCon Linear Post-Processor Unit ready to install,  
 including:  
 Operating manual language ..... english  
 RS232 cable length ..... 1.8 m  
 CAN bus ..... CAN cable  
 ..... CANTerm Connector

**Software**

TopControl ..... on Installation disc  
 API (DLL file) ..... for LabVIEW® and C/C++  
 ..... (and other programming languages,  
 ..... to be used in combination  
 ..... with TopCon Power Supplies.)

# DEBUG IN HIGH DEFINITION



## HDO4000A

200 MHz – 1 GHz  
Oscilloscopes



**Lowest Noise and  
Powerful Toolbox**

### HD4096 Technology

Superior User Experience

Powerful, Deep Toolbox

Exceptional Serial Data Tools

The HDO4000A with HD4096 Technology provides exceptional signal fidelity with 12-bit resolution and a superior oscilloscope experience to deliver faster time to insight.

# DEBUG IN HIGH DEFINITION

High Definition Oscilloscopes with HD Technology have a variety of benefits that allow the user to debug in high definition. Waveforms displayed by High Definition Oscilloscapes are cleaner and crisper. More signal details can be seen and measured; these measurements are made with unmatched precision resulting in better test results and shorter debug time.



**Experience HD4096 accuracy, detail, and precision and never use an 8-bit oscilloscope again. Whether the application is general-purpose design and debug, high-precision analog, power electronics, automotive electronics, mechatronics, or other specialized applications, the HD4096 technology provides unsurpassed confidence and measurement capabilities.**

## Clean, Crisp Waveforms

When compared to waveforms acquired and displayed using conventional 8-bit oscilloscopes, waveforms captured with HD4096 12-bit technology are dramatically crisper and cleaner, and are displayed more accurately.

## More Signal Details

16x more resolution provides more signal detail. This is especially helpful for wide dynamic range signals in which a full-scale signal must be acquired while at the same time very small amplitude signal details must be analyzed.

## Unmatched Measurement Precision

HD4096 technology delivers measurement precision several times better than conventional 8-bit oscilloscopes. Higher oscilloscope measurement precision provides better ability to assess corner cases and design margins, perform root cause analysis, and create the best possible solution for any discovered design issue.



	HDO4000A	HDO6000A	HDO8000A	HDO9000
<b>HD Technology</b>	<b>HD4096</b> 12 bits	HD4096 12 bits	HD4096 12 bits	HD1024 10 bits
<b>Bandwidth</b>	<b>200 MHz - 1 GHz</b>	350 MHz - 1 GHz	350 MHz - 1 GHz	1 GHz - 4 GHz
<b>Input Channels</b>	<b>4</b>	4	8	4
<b>Sample Rate</b>	<b>10 GS/s</b>	10 GS/s	10 GS/s	40 GS/s
<b>Standard Toolbox</b>	<b>Basic</b>	Advanced	Advanced	Advanced
<b>Serial Data Tools</b>	<b>TD</b>	TDME	TDME	TDME, SDI, QPHY
<b>User Experience</b>	<b>MAUI with OneTouch</b>	MAUI with OneTouch	MAUI with OneTouch	MAUI with OneTouch



HD1024 technology provides 10 bits of vertical resolution with 4 GHz bandwidth. As with all members of Teledyne LeCroy's HDO family, the HDO9000 utilizes an exceptionally low-noise system architecture that delivers

outstanding effective number of bits (ENOB). Dynamic ADC Configuration permits the ADC to be set to 8, 9, or 10 bits. Optimized filtering provides additional resolution beyond 10 bits (extending up to 13.8 bits).



## DEBUG IN HIGH DEFINITION

Lowest Noise and  
Powerful Toolbox

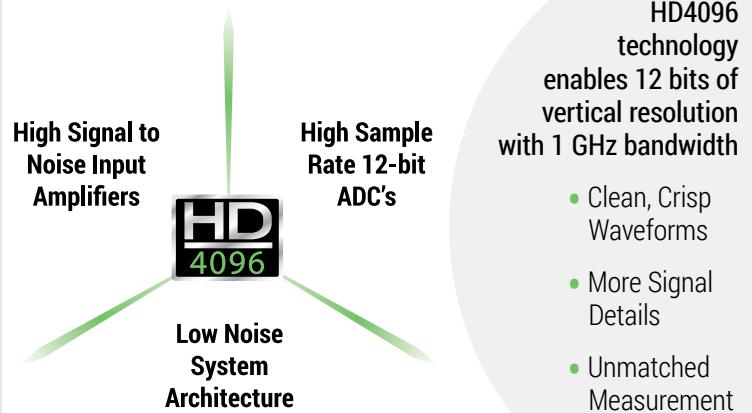
HDO4000A

# HD4096

## High Definition Technology



# Deep Toolbox



## OBSSESSED WITH TOOLS

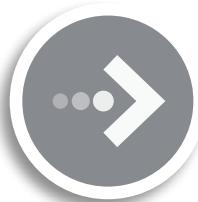
HDO4000A has the greatest breadth and depth of tools, ensuring quick resolution of the most complicated debug tasks.



The HDO4000A with **HD4096 Technology** provides **exceptional signal fidelity** with 12-bit resolution and a **superior oscilloscope experience** to deliver **faster time to insight**.

- 1** HD4096 Technology
- 2** Superior User Experience
- 3** Powerful, Deep Toolbox
- 4** Exceptional Serial Data Tools

# Faster Time to Insight



**Insight** alone is not enough.

Markets and **technologies** change too rapidly.

The **timing** of **critical design decisions** is significant.

Faster Time to Insight is what matters.



# MAUI® – SUPERIOR USER EXPERIENCE



**MAUI – Most Advanced User Interface** was developed to put all the power and capabilities of the modern oscilloscope right at your fingertips. Designed for touch; all important oscilloscope controls are accessed through the intuitive touch screen. Built for simplicity; time saving shortcuts and intuitive dialogs simplify setup. Made to solve; a deep set of debug and analysis tools helps identify problems and find solutions quickly.

## Designed for Touch

MAUI is designed for touch. Operate the oscilloscope just like a phone or tablet with the most unique touch screen features on any oscilloscope. All important controls are always one touch away. Touch the waveform to position or zoom in for more details using intuitive actions.

## Built for Simplicity

MAUI is built for simplicity. Basic waveform viewing and measurement tools as well as advanced math and analysis capabilities are seamlessly integrated in a single user interface. Time saving shortcuts and intuitive dialogs simplify setup and shorten debug time.

## Made to Solve

MAUI is made to solve. A deep set of integrated debug and analysis tools help identify problems and find solutions quickly. Unsurpassed integration provides critical flexibility when debugging. Solve problems fast with powerful analysis tools.

## MAUI with OneTouch

MAUI with OneTouch introduces a new paradigm for oscilloscope user experience. Dramatically reduce setup time with revolutionary drag and drop actions to copy and setup channels, math functions, and measurement parameters without lifting a finger. Use common gestures like drag, drop, and flick to instinctively interact with the oscilloscope. Quickly enable a new channel, math or measurement using the "Add New" button and simply turn off any trace with a flick of the finger. These OneTouch innovations provide unsurpassed efficiency in oscilloscope operation.



**A** Channel, timebase, and trigger descriptors provide easy access to controls without navigating menus.

**B** Configure parameters by touching measurement results.

**C** Shortcuts to commonly used functions are displayed at the bottom of the channel, math and memory menus.

**D** Use the "Add New" button for one-touch trace creation.

**E** Drag to change source, copy setup, turn on new trace, or move waveform location.

**F** Drag to copy measurement parameters to streamline setup process.

**G** Drag to quickly position cursors on a trace.

# POWERFUL, DEEP TOOLBOX

Capture		View		Measure		Math				Analyze				Document			
Triggering	Acquire	Display Grids	Display Views	Zooming	Parameters	Parameter Analysis	Functions	Advanced Functions	Pass/Fail	Anomaly Detection	Serial Decode	Serial Message Analysis	Clock & Timing Jitter	Serial Data Jitter	Serial Data Analysis	Application Packages	Document
1	Exclusion	4	5 MS/s Roll	11	12	13	14	15	16	17-22	17-22	18	19	20	21	22	23
Measurement	Multi-, Cascade Sequence Mode	80ch	Multi-Grid	Segment	Multi-Zoom	All Instance	Statistics	Full Memory FFT	Digital Filters	Mask Test	TriggerScan	Protocol Table	Jitter Overlay	Ti, Rj, Dj	Rj + BiJ Views	Motor + Power	Hardcopy
24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40-45	46
Analoge Digital	12-bit Resolution	Drag & Drop	Waveform Histogram	Vertical Zoom	Parameter Math	Parameter Acceptance	Tracks / Trends	Processing Web	Actions	WaveScan	K28.5 Symbol	Search & Zoom	Jitter Track	Bathtub Curve	DBI + ISI Views	DDR Analysis	WaveStudio
47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63-67	68
Serial Data	100 GHz / 10B	Q-Scope	3D Persistence	Auto-Scroll	Custom Measure	Histogram/Histogram	Demodulation	Boolean Compare	History Mode	RPM=1368 Application Layer	ARDUINO DATAVIEWER Protocol Layer	Bus Parameters	Jitter Histogram	Timing Parameters	Sim	Noise Analysis	LSD
69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85-89	90
91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107-114	115
17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	mipi MP4
Device Loss	Mod Control Loop	One L.L. v.v.	3-Phase	Static/Dynamic	Zoom+Gate	Coherent Receiver	OpticalLinQ	PAM-4 Analysis	VectorLinQ VSA	Ethernet	DDR DDR	Video	Automotive	Pci Express® Pcie	USB	Storage	
40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	
R/W Separation	Multi-Eye View	DDR Tj, Rj, Dj	Debug Toolkit	Virtual Probe													
116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133
134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151
152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169
170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187
188	189	190	191	192	193	194	195	196	197	198	199	200	201	202	203	204	205
206	207	208	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223
224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241
242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259
260	261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277
278	279	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295
296	297	298	299	300	301	302	303	304	305	306	307	308	309	310	311	312	313
314	315	316	317	318	319	320	321	322	323	324	325	326	327	328	329	330	331
332	333	334	335	336	337	338	339	340	341	342	343	344	345	346	347	348	349
350	351	352	353	354	355	356	357	358	359	360	361	362	363	364	365	366	367
368	369	370	371	372	373	374	375	376	377	378	379	380	381	382	383	384	385
386	387	388	389	390	391	392	393	394	395	396	397	398	399	400	401	402	403
404	405	406	407	408	409	410	411	412	413	414	415	416	417	418	419	420	421
422	423	424	425	426	427	428	429	430	431	432	433	434	435	436	437	438	439
440	441	442	443	444	445	446	447	448	449	450	451	452	453	454	455	456	457
458	459	460	461	462	463	464	465	466	467	468	469	470	471	472	473	474	475
476	477	478	479	480	481	482	483	484	485	486	487	488	489	490	491	492	493
494	495	496	497	498	499	500	501	502	503	504	505	506	507	508	509	510	511
512	513	514	515	516	517	518	519	520	521	522	523	524	525	526	527	528	529
530	531	532	533	534	535	536	537	538	539	540	541	542	543	544	545	546	547
548	549	550	551	552	553	554	555	556	557	558	559	560	561	562	563	564	565
566	567	568	569	570	571	572	573	574	575	576	577	578	579	580	581	582	583
584	585	586	587	588	589	590	591	592	593	594	595	596	597	598	599	600	601
602	603	604	605	606	607	608	609	610	611	612	613	614	615	616	617	618	619
620	621	622	623	624	625	626	627	628	629	630	631	632	633	634	635	636	637
638	639	640	641	642	643	644	645	646	647	648	649	650	651	652	653	654	655
656	657	658	659	660	661	662	663	664	665	666	667	668	669	670	671	672	673
674	675	676	677	678	679	680	681	682	683	684	685	686	687	688	689	690	691
694	695	696	697	698	699	700	701	702	703	704	705	706	707	708	709	710	711
712	713	714	715	716	717	718	719	720	721	722	723	724	725	726	727	728	729
730	731	732	733	734	735	736	737	738	739	740	741	742	743	744	745	746	747
748	749	750	751	752	753	754	755	756	757	758	759	760	761	762	763	764	765
766	767	768	769	770	771	772	773	774	775	776	777	778	779	780	781	782	783
784	785	786	787	788	789	790	791	792	793	794	795	796	797	798	799	800	801
802	803	804	805	806	807	808	809	810	811	812	813	814	815	816	817	818	819
820	821	822	823	824	825	826	827	828	829	830	831	832	833	834	835	836	837
838	839	840	841	842	843	844	845	846	847	848	849	850	851	852	853	854	855
856	857	858	859	860	861	862	863	864	865	866	867	868	869	870	871	872	873
874	875	876	877	878	879	880	881	882	883	884	885	886	887	888	889	890	891
894	895	896	897	898	899	900	901	902	903	904	905	906	907	908	909	910	911
912	913	914	915	916	917	918	919	920	921	922	923	924	925	926	927	928	929
930	931	932	933	934	935	936	937	938	939	940	941	942	943	944	945	946	947
948	949	950	951	952	953	954	955	956	957	958	959	960	961	962	963	964	965
966	967	968	969	970	971	972	973	974	975	976	977	978	979	980	981	982	983
984	985	986	987	988	989	990	991	992	993	994	995	996	997	998	999	1000	1001

## Our Heritage

Teledyne LeCroy's 50+ year heritage has its origins in the high-speed collection of data in the field of high-energy physics, and the processing of long records to extract meaningful insight. We didn't invent the oscilloscope, but we did invent the digital oscilloscope, which can take full advantage of advanced digital signal processing and waveshape analysis tools to provide unparalleled insight.

## Our Obsession

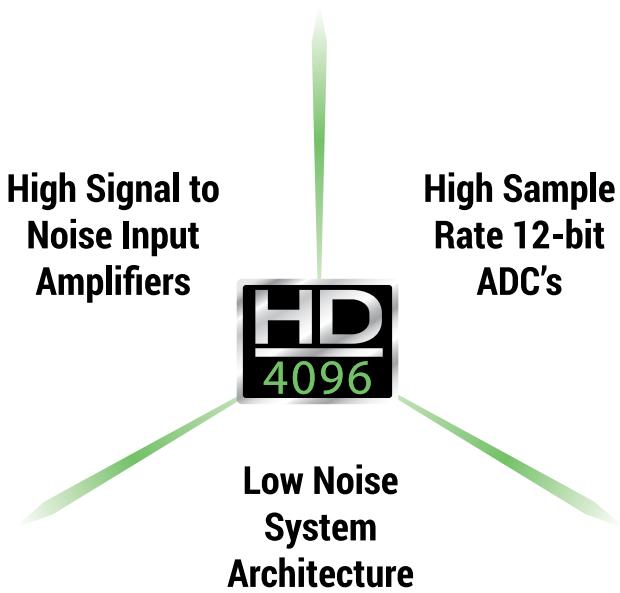
Our developers are true to our heritage – they are more obsessed with making better and smarter tools than anybody else. Our tools and operating philosophy are standardized across much of our product line for a consistent user experience. Our mission is to help you use these tools to understand problems, including the ones you don't even know you have. Our deep toolbox inspires insight; and your moment of insight is our reward.

## Our Invitation

Our Periodic Table of Oscilloscope Tools provides a framework to understand the toolsets that Teledyne LeCroy has created and deployed in our oscilloscopes. Visit our interactive website to learn more about what we offer and how we can help you develop and debug more efficiently.

[teledynelecroy.com/tools](http://teledynelecroy.com/tools)

# HD4096 TECHNOLOGY – 16X CLOSER TO PERFECT

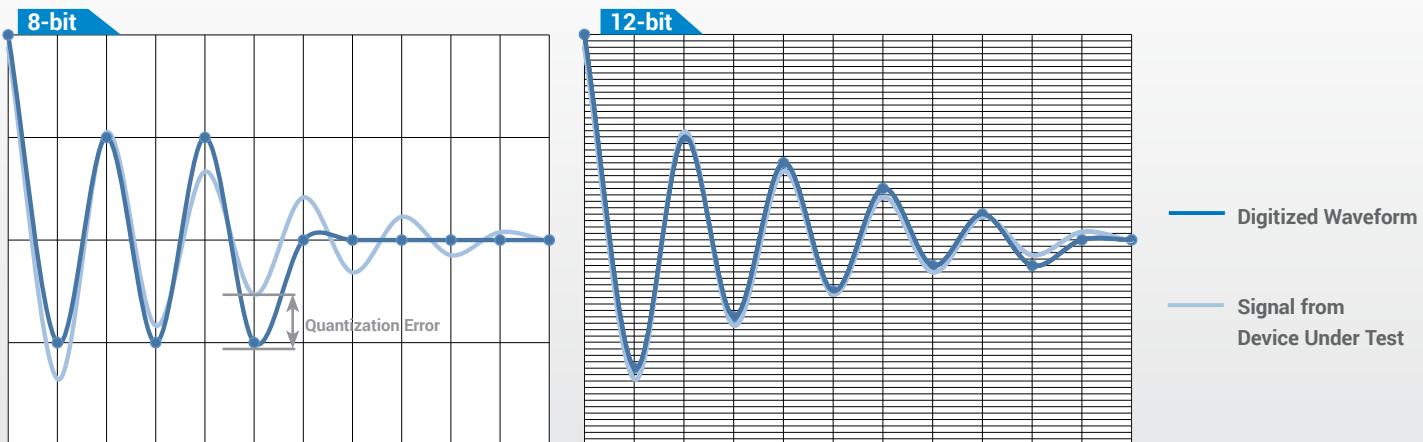


**Teledyne LeCroy HDO high definition oscilloscopes use unique HD4096 technology to provide superior and uncompromised measurement performance:**

- 12-bit ADCs with high sample rates
- High signal-to-noise amplifiers (55 dB)
- Low noise system architecture (to 1 GHz)

Oscilloscopes with HD4096 technology have higher resolution than conventional 8-bit oscilloscopes (4096 vs. 256 vertical levels) and low noise for uncompromised measurement performance. The 12-bit ADCs support capture of fast signals and oscilloscope bandwidth ratings up to 1 GHz, and Enhanced Sample Rate to 10 GS/s ensures the highest measurement accuracy and precision. The high performance input amplifiers deliver pristine signal fidelity with a 55 dB signal-to-noise ratio. The low-noise system architecture provides an ideal signal path to ensure that signal details are delivered accurately to the oscilloscope display – 16x closer to perfect.

## 16x Closer to Perfect



### 16x More Resolution

HD4096 technology provides 12-bits of vertical resolution with 16x more resolution compared to conventional 8-bit oscilloscopes. The 4096 discrete vertical levels reduce the quantization error compared to 256 vertical levels. This improves the accuracy and precision of the signal capture and increases measurement confidence.

# EXPERIENCE THE DIFFERENCE



**Experience HD4096 accuracy, detail, and precision and never use an 8-bit oscilloscope again. Whether the application is general-purpose design and debug, high-precision analog, power electronics, automotive electronics, mechatronics, or other specialized applications, the HD4096 technology provides unsurpassed confidence and measurement capabilities.**

## Clean, Crisp Waveforms

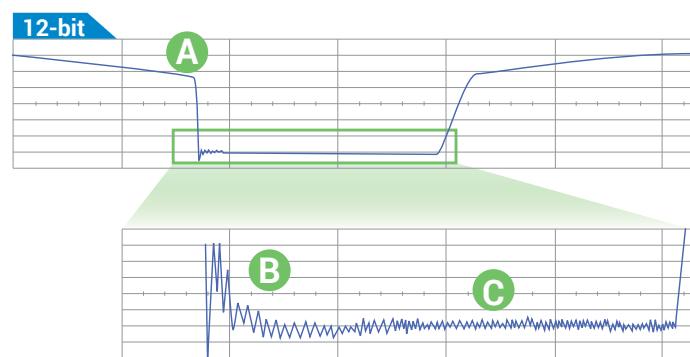
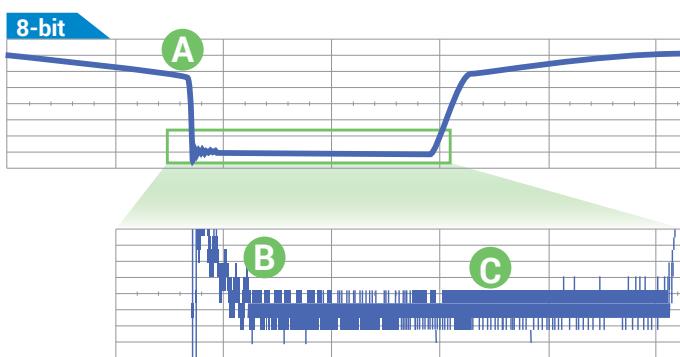
When compared to waveforms acquired and displayed using conventional 8-bit oscilloscopes, waveforms captured with HD4096 12-bit technology are dramatically crisper and cleaner, and are displayed more accurately. Once you see a waveform acquired with HD4096 technology, you will not want to go back to using a conventional 8-bit oscilloscope.

## More Signal Details

16x more resolution provides more signal detail. This is especially helpful for wide dynamic range signals in which a full-scale signal must be acquired while at the same time very small amplitude signal details must be analyzed. 12-bit acquisitions combined with the oscilloscope's vertical and horizontal zoom can be used to obtain unparalleled insight to system behaviors and problems.

## Unmatched Measurement Precision

HD4096 technology delivers measurement precision several times better than conventional 8-bit oscilloscopes. Higher oscilloscope measurement precision provides better ability to assess corner cases and design margins, perform root cause analysis, and create the best possible solution for any discovered design issue.



**A Clean, Crisp Waveforms** | Thin traces show the actual waveform with minimal noise interference

**B More Signal Details** | Waveform details lost on an 8-bit oscilloscope can now be clearly seen

**C Unmatched Measurement Precision** | Measurements are more precise and not affected by quantization noise

# HDO4000A AT A GLANCE



**HDO4000A oscilloscopes have 4 analog input channels, 12-bit resolution using Teledyne LeCroy's HD4096 high definition technology, up to 1 GHz of bandwidth and a compact form factor with a large 12.1" multi-touch display. They are ideal for debug and troubleshooting of power electronics designs, digital power management or power integrity analysis, automotive electronics systems, and deeply embedded or mechatronic designs.**

## Key Features

**4 analog channels**

**12-bit ADC resolution, up to  
15-bit with enhanced resolution**

**200 MHz, 350 MHz, 500 MHz and  
1 GHz bandwidths**

**Long Memory – up to 50 Mpts**

**Multi-language User Interface**

**WaveScan - Search and Find**

**LabNotebook Documentation and  
Report Generation**

**History Mode**

**Spectrum Analyzer Mode**

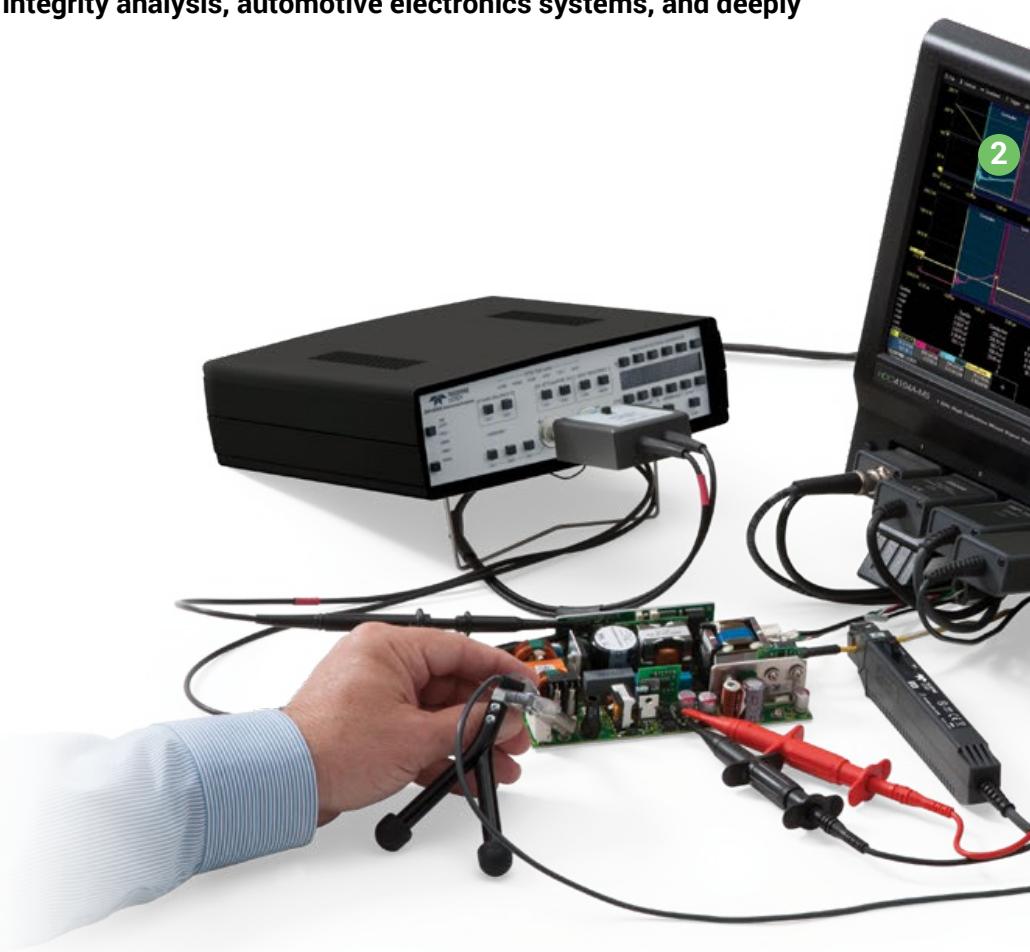
**Power Analysis Software**

**16 Digital Channel MSO option**

**Serial Trigger and Decode options**

**12.1" WXGA multi-touch screen display**

**Wide probe selection for power  
electronics, embedded electronics,  
and mechatronics applications**



## Power Electronics

Measure single-device(s), half, or Full/H-bridge outputs, including gate-drive voltages. Measure device loss or switch-mode power supply power or control loop performance, including line harmonics. The best performing HV probes support full characterization of all aspects of the power conversion system.

## Automotive Electronics

Automotive electronic control units (ECUs) are tested to stringent standards. 12-bits and 250 Mpts provides the amplitude and time resolution needed for better and more intuitive cause-effect analog signal analysis. Deep digital logic capture and extensive serial data toolsets provides an all-in-one characterization tool for the complex, dynamic behavior of the vehicle ECUs.



## Digital Power Management, Power Integrity

12-bit accuracy and precision and 1 GHz of bandwidth is perfect for transient rail response, rail voltage power integrity, crosstalk and harmonics evaluation. Specialized probes, analysis software, and serial decoders make fast work of complex embedded system power management and integrity validation.

## Deeply Embedded and Mechatronic Systems

Today's consumer appliances and industrial systems combine complex embedded controls, power electronics, and sensors to achieve the highest efficiency and provide important control and other benefits. Time-to-market, cost and quality pressures place exceptional demands on new product test, debug and troubleshooting.

- 1 Only 13 cm (5") Deep – The most space-efficient oscilloscope for your bench from 200 MHz to 1 GHz
- 2 12.1" Widescreen (16 x 9) high resolution WXGA color multi-touch screen display.
- 3 Built-in stylus for touch screen
- 4 Local language user interface front panel overlay
- 5 "Push" Knobs – All knobs have push functionality that provides shortcuts to common actions such as Set to Variable, Find Trigger Level, Zero Offset, and Zero Delay
- 6 Waveform Control Knobs for channel, zoom, math and memory traces
- 7 Dedicated buttons to quickly access popular debug tools
- 8 Easy connectivity with two convenient USB ports on the front, two on the side
- 9 Mixed Signal Capability - Debug complex embedded designs with integrated 16 channel mixed signal capability
- 10 Rotating and Tilting Feet provide 4 different viewing positions
- 11 Auxiliary Output and Reference Clock Input/Output connectors for connecting to other equipment
- 12 USBTMC (Test and Measurement Class) port simplifies programming

# POWERFUL MIXED SIGNAL CAPABILITIES



The HDO4000A High Definition Oscilloscopes offer powerful mixed signal solutions that combine high definition analog channels with the flexibility of digital inputs. The HDO4000A-MS options provide an integrated 16 digital channels and a 1.25 GS/s sampling rate to create an all-in-one debug machine.

## Integrated 16-Channel Mixed Signal Capability

With embedded systems growing more complex, powerful mixed signal debug capabilities are an essential part of modern oscilloscopes. The 16 integrated digital channels and set of tools designed to view, measure and analyze analog and digital signals enable fast debugging of mixed signal designs.

## Extensive Triggering

Flexible analog and digital cross-pattern triggering across all 20 channels provides the ability to quickly identify and isolate problems in an embedded system. Event triggering can be configured to arm on an analog signal and trigger on a digital pattern.

## Advanced Digital Debug Tools

Using the powerful parallel pattern search capability of WaveScan, patterns across many digital lines can be isolated and analyzed. Identified patterns are presented in a table with timestamp information and enables quick searching for each pattern occurrence.

Use a variety of the many timing parameters to measure and analyze the characteristics of digital busses. Powerful tools like tracks, trends, statistics and histicons provide additional insight and help find anomalies.

Quickly see the state of all the digital lines at the same time using convenient activity indicators.



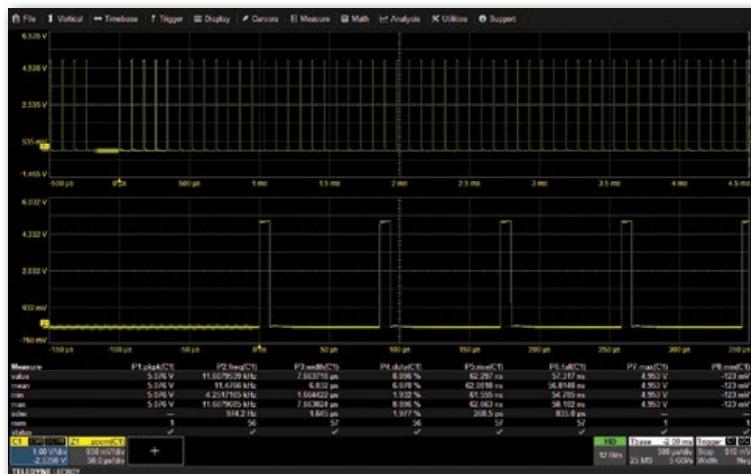
# STANDARD TOOLS FOR ADVANCED ANALYSIS

HD  
4096



## WaveScan Advanced Search

WaveScan provides powerful isolation capabilities that hardware triggers can't provide. WaveScan allows searching analog, digital or parallel bus signal in a single acquisition using more than 20 different criteria. Or, set up a scan condition and scan for an event over hours or even days.



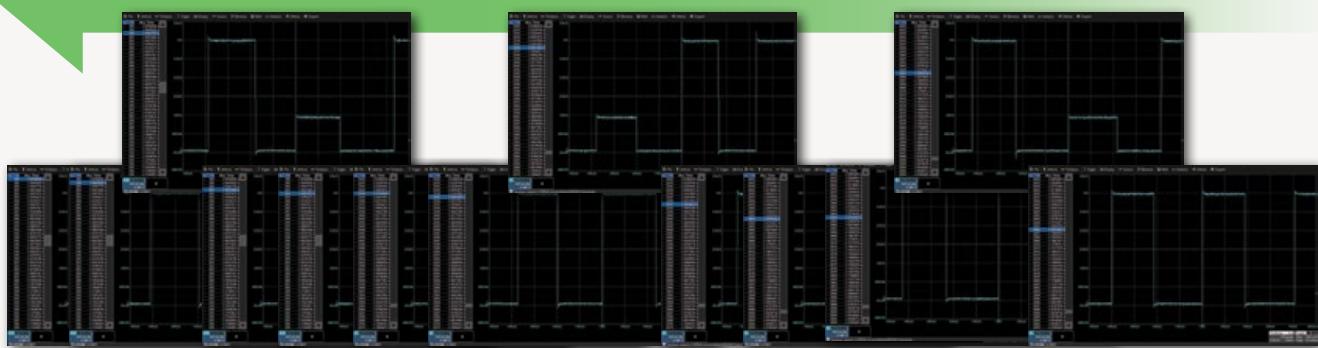
## Advanced Math and Measure

With many math functions and measurement parameters available, the HDO4000A can measure and analyze every aspect of analog and digital waveforms. By utilizing HD4096 technology, the HDO4000A measures 16 times more precisely than traditional 8-bit architectures. Additionally, the HDO4000A provides statistics, histicons and trends to show how waveforms change over time.

## History Mode Waveform Playback

Scroll back in time using History Mode to view previous waveforms and isolate anomalies. Use cursors and measurement parameters to quickly find the source of problems. History mode is always available with a single button press, no need to enable this mode and never miss a waveform.

**Go Back in Time to Identify the Source of a Problem**

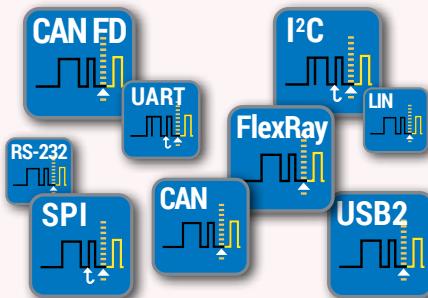


# EXCEPTIONAL SERIAL DATA TOOLS

The HDO4000A features the widest range and most complete serial data debug toolsets.

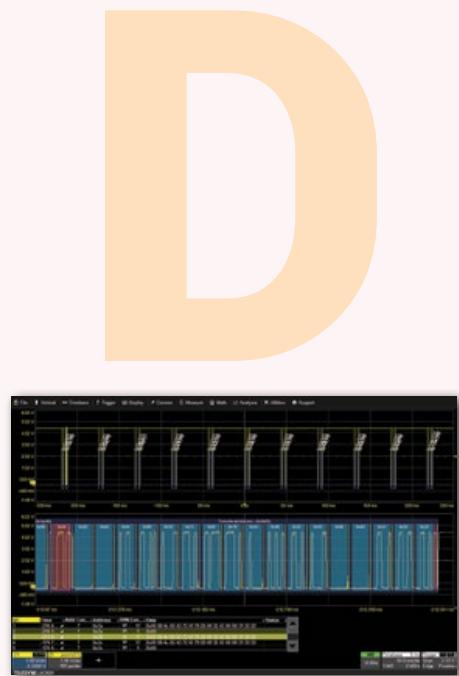
- Triggering
- Decoding

HDO4000A Serial Data Protocol Support	
	Trigger Decode
I <sup>2</sup> C	• •
SPI	• •
UART-RS232	• •
USB2-HSIC	• •
CAN	• •
CAN FD	• •
FlexRay	• •
LIN	• •
SENT	•
ARINC429	•
MIL-STD-1553	• •
SPACEWIRE	• •
Ethernet (10/100Base-T)	• •
MDIO	•
USB 1.1/2.0	• •
8b/10b	• •
D-PHY/CSI-2/DSI	• •
DigRF3G	•
DigRFv4	•
SPMI	•
Audio (I <sup>2</sup> S, LJ, RJ, TDM)	• •
Manchester	• •
NRZ	• •



## Trigger

Powerful, flexible triggers designed by people who know the standards, with the unique capabilities you want to isolate unusual events. Conditional data triggering permits maximum flexibility and highly adaptable error frame triggering is available to isolate error conditions. Efficiently acquire bursted data using Sequence Mode to maximize the oscilloscope's memory usage. Sequence Mode enables the oscilloscope to ignore idle time and acquire only data of interest.



## Decode

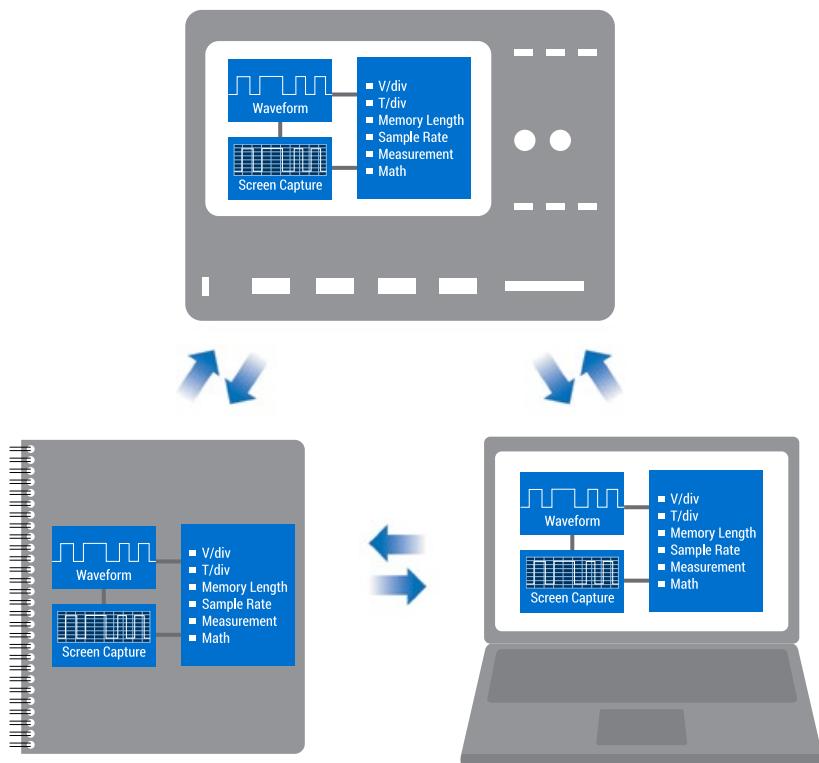
Decoded protocol information is color-coded to specific portions of the serial data waveform and transparently overlaid for an intuitive, easy-to-understand visual record. All decoded protocols are displayed in a single time-interleaved table. Touch a row in the interactive table to quickly zoom to a packet of interest and select a column header to create filter criteria, as is commonly done in spreadsheets. Easily search through long records for specific protocol events using the built-in search feature.

# DOCUMENTATION AND SEQUENCE MODE

HD  
4096

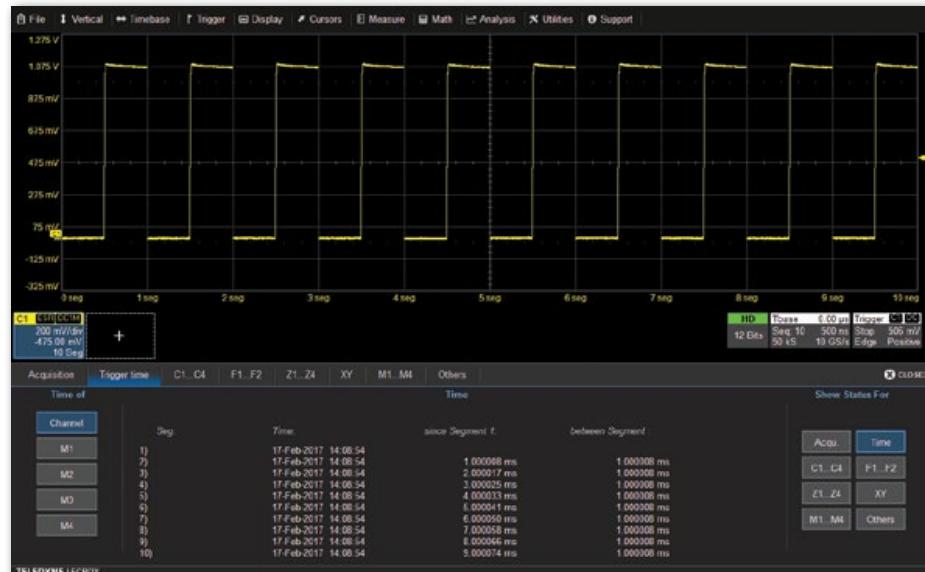
## LabNotebook Documentation Tool

LabNotebook is a standard feature of HDO4000A and is the ideal documentation tool. LabNotebook automatically saves all displayed waveforms, oscilloscope setup file, and a screen image with a single button press, eliminating the need to navigate multiple menus to save all these files independently. Report files can be annotated and shared with colleagues to fully document all results. Easily recreate experiments and compare tests results amongst colleagues across the world by recalling LabNotebook files back onto the oscilloscope or view on a PC using WaveStudio.



## Advanced Waveform Capture with Sequence Mode

Use Sequence mode to store up to 10,000 triggered events as segments. This is ideal when capturing fast pulses in quick succession or when capturing events separated by long time periods. Each segment has a timestamp and dead-time between triggers is less than 1  $\mu$ s. Isolate rate events over time by combining with advanced triggers.



# SPECTRUM ANALYZER OPTION

**HD  
4096**

## Key Features

**Spectrum analyzer style controls for the oscilloscope**

**Dual Spectrum Capability**

**Select from six vertical scales (in dB, V, or A)**

**Automatic frequency peak identifications**

**Display up to 20 markers, with interactive table readout of frequencies and levels**

**Easily make measurements with reference and delta markers**

**Automatically identify and mark fundamental frequency and harmonics**

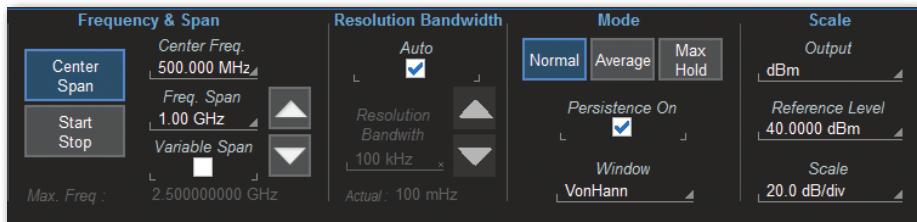
**Spectrogram shows how spectra changes over time in 2D or 3D views**



Use two independent input settings and frequency ranges for advanced spectrum analysis.

## Simplify Analysis of FFT Power Spectrum

Get faster and better insight to the frequency content of any signal with use of the Spectrum Analyzer mode on the HDO4000A. This mode provides a spectrum analyzer style user interface with controls for start/stop frequency or center frequency and span. The resolution bandwidth is automatically set for best analysis or can be manually selected. Peak search automatically labels spectral components and presents frequency and level in an interactive table. Utilize up to 20 markers to automatically identify harmonics and quickly analyze frequency content by making measurements between reference and delta markers. Spectrograms display a 2D or 3D history of the frequency content to provided insight into how the spectrum changes over time.



Spectrum analyzer style controls simplify waveform analysis in the frequency domain.

# POWER ANALYSIS OPTION



## Key Features

**Automated measurement zone identification with color-coded overlays**

**Control loop and time domain response analysis**

**Line power and harmonics tests to IEC 61000-3-2**

**Total harmonic distortion table shows frequency contribution**

**B-H Curve shows magnetic device saturation**

## Power Analyzer Automates Switching Device Loss Measurements

Quickly measure and analyze the operating characteristics of power conversion devices and circuits with the Power Analyzer option. Critical power switching device measurements, control loop modulation analysis, and line power harmonic testing are all simplified with a dedicated user interface and automatic measurements. Areas of turn-on, turn-off, and conduction loss are all identified with color-coded waveform overlays for faster analysis.

Power Analyzer provides quick and easy setup of voltage and current inputs and makes measurements as simple as the push of a button. Tools are provided to help reduce sources of measurement errors and the measurement parameters provide details of single cycle or average device power losses.

Beyond the advanced power loss measurement capabilities, the Power Analyzer modulation analysis capabilities provide insight to understand control loop response to critical events such as a power supply's soft start performance or step response to line and load changes. The Line Power Analysis tool allows simple and quick pre-compliance testing to EN61000-3-2.

# PROBES

HD  
4096

Teledyne LeCroy offers an extensive range of probes to meet virtually every probing need.

## ZS Series High Impedance Active Probes

ZS1000, ZS1000-QUADPAK  
ZS1500, ZS1500-QUADPAK



High input impedance ( $1\text{ M}\Omega$ ), low  $0.9\text{ pF}$  input capacitance and an extensive set of probe tips and ground accessories make these low-cost single-ended probes ideal for a wide range of applications. The ZS Series is available up to 4 GHz bandwidth.

## Differential Probes (200 MHz – 1.5 GHz)

ZD1500, ZD1000,  
ZD500, ZD200  
AP033



High bandwidth, excellent common-mode rejection ratio (CMRR) and low noise make these active differential probes ideal for applications such as automotive electronics and data communications. AP033 provides 10x gain for high-sensitivity measurement of series/shunt resistor voltages.

## Active Voltage/Power Rail Probe

RP4030



Specifically designed to probe a low impedance power/voltage rail. The RP4030 has 30V built-in offset adjust, low attenuation (noise), and high DC input impedance with 4 GHz of bandwidth and a wide assortment of tips and leads, including solder-in and U.FL receptacle connections.

## High Voltage Fiber Optically-isolated Probe

HVFO103



The HVFO103 is a compact, simple, affordable probe for measurement of small signals (gate-drives, sensors, etc.) floating on an HV bus in power electronics designs, or for EMC, EFT, ESD, and RF immunity testing sensor monitoring. Suitable for up to 35kV common-mode. 140 dB CMRR.

## HVD Series High Voltage Differential Probes

HVD3102, HVD3106 (1 kV)  
HVD3206 (2 kV)  
HVD3605 (6 kV)



Available with 1, 2 or 6kV common-mode ratings. Excellent CMRR (65 dB @ 1 MHz) at high frequencies is combined with low inherent noise, wide differential voltage range, high offset voltage capabilities, and 1% gain accuracy. The ideal probe for power conversion system test.

## High Voltage Passive Probes

HVP120,  
PPE4KV, PPE5KV, PPE6KV



The HVP and PPE Series includes four fixed-attenuation probes covering a range from 1 kV to 6 kV. These probes are ideal for lightning/surge or EFT testing, or for probing in-circuit beyond the range of a LV-rate passive probe.

## Differential Amplifier

DA1855A  
DXC100A, DXC200  
DXC-5100, DA101



The DA1855A is a stand-alone high performance 100 MHz differential amplifier with 100 dB CMRR and HV common-mode when combined with a suitable probe pair (sold separately). It is ideal for semiconductor device conduction/switching loss or high sensitivity voltage measurements.

## Current Probes

CP030, CP030-3M, CP030A  
CP031, CP031A  
CP150, CP150-6M  
CP500, DCS015



Available in bandwidths up to 100 MHz with peak currents of 700 A and sensitivities to 1 mA/div. Extra-long cables (3 or 6 meters) available on some models. Ideal for component or power conversion system input/output measurements. DCS015 deskew calibration source also available.

## Probe and Current Sensor Adapters

TPA10, TPA10-QUADPAK  
CA10, CA10-QUADPAK



TPA10 adapts supported Tektronix TekProbe-compatible probes to Teledyne LeCroy ProBus interface. CA10 is a programmable adapter for third-party current sensors that have voltage or current outputs proportional to measured current. QUADPAKs of four pieces each are available.

# SPECIFICATIONS

**HD  
4096**

Vertical - Analog Channels	HDO4024A HDO4024A-MS	HDO4034A HDO4034A-MS	HDO4054A HDO4054A-MS	HDO4104A HDO4104A-MS
Bandwidth @ 50 Ω (-3 dB)	200 MHz	350 MHz	500 MHz	1 GHz
Rise Time (10–90%, 50 Ω)	1.75 ns	1 ns	700 ps	450 ps
Input Channels	4			
Vertical Resolution	12-bits; up to 15-bits with enhanced resolution (ERES)			
Effective Number of Bits (ENOB)	8.8 bits	8.7 bits	8.6 bits	8.4 bits
Vertical Noise Floor				
1 mV/div	70 μVrms	85 μVrms	100 μVrms	145 μVrms
2 mV/div	70 μVrms	85 μVrms	100 μVrms	145 μVrms
5 mV/div	75 μVrms	90 μVrms	105 μVrms	150 μVrms
10 mV/div	80 μVrms	95 μVrms	110 μVrms	155 μVrms
20 mV/div	100 μVrms	110 μVrms	130 μVrms	185 μVrms
50 mV/div	195 μVrms	210 μVrms	265 μVrms	275 μVrms
100 mV/div	340 μVrms	360 μVrms	450 μVrms	500 μVrms
200 mV/div	1.00 mVrms	1.10 mVrms	1.25 mVrms	1.75 mVrms
500 mV/div	1.90 mVrms	2.10 mVrms	2.60 mVrms	2.75 mVrms
1 V/div	3.40 mVrms	3.70 mVrms	4.50 mVrms	4.90 mVrms
Sensitivity	50 Ω: 1 mV/div–1 V/div, fully variable; 1 MΩ: 1 mV/div–10 V/div, fully variable			
DC Vertical Gain Accuracy (Gain Component of DC Accuracy)	±(0.5%) F.S. offset at 0 V			
Channel-Channel Isolation	DC-200 MHz: 60 dB (>1000:1), (For any two input channels, same V/div settings, typical)	DC-200 MHz: 60 dB (>1000:1), 200 MHz up to rated BW: 50 dB (>300:1), (For any two input channels, same V/div settings, typical)	DC-200 MHz: 60 dB (>1000:1), 200 MHz up to rated BW: 50 dB (>300:1), (For any two input channels, same V/div settings, typical)	DC-200 MHz: 60 dB (>1000:1), 200-500 MHz: 50 dB (>300:1), 500 MHz up to rated bandwidth: 40 dB (>100:1) (For any two input channels, same V/div settings, typical)
Offset Range	50 Ω: 1 mV - 4.95 mV: ±1.6 V, 5 mV - 9.9 mV: ±4 V, 10 mV - 19.8 mV: ±8 V, 20 mV - 1 V: ±10 V 1 MΩ: 1 mV - 4.95 mV: ±1.6 V, 5 mV - 9.9 mV: ±4 V, 10 mV - 19.8 mV: ±8 V, 20 mV - 100 mV: ±16 V, 102 mV - 198 mV: ±80V, 200 mV - 1 V: ±160 V, 1.02 V - 10 V: ±400 V			
DC Vertical Offset Accuracy	±(1.0% of offset setting + 0.5%FS + 0.02% of max offset + 1mV)			
Maximum Input Voltage	50 Ω: 5 Vrms, 1 MΩ: 400 V max (DC + Peak AC ≤ 10 KHz)			
Input Coupling	50 Ω: DC, GND; 1 MΩ: AC, DC, GND;			
Input Impedance	50 Ω ± 2.0%; 1 MΩ ± 2.0%    16 pF,			
Bandwidth Limiters	20 MHz, 200 MHz			
Horizontal - Analog Channels				
Acquisition Modes	Real-time, Roll, Random Interleaved Sampling (RIS), Sequence			
Time/Division Range	200 ps/div - 1.25 ks/div with standard memory (up to 2.5 ks/div with -L memory); RIS available at ≤ 10 ns/div; Roll Mode available at ≥ 100 ms/div and ≤ 5 MS/s			
Clock Accuracy	±2.5 ppm + 1.0ppm/year from calibration			
Sample Clock Jitter	Up to 10 ms acquired time range: 280 fsrms (internal timebase reference)			
Delta Time Measurement Accuracy	$\sqrt{2} * \sqrt{\left(\frac{\text{Noise}}{\text{SlewRate}}\right)^2 + (\text{Sample Clock Jitter})^2} \text{ (RMS)} + (\text{clock accuracy} * \text{reading}) \text{ (seconds)}$			
Jitter Measurement Floor	$\sqrt{\left(\frac{\text{Noise}}{\text{SlewRate}}\right)^2 + (\text{Sample Clock Jitter})^2} \text{ (RMS, seconds, TIE)}$			
Jitter Between Channels	Analog Channels: 2 psrms (TIE, typical); Digital Channels: 350 ps (maximum) between any two channels Analog-Digital Channels: <5ns (maximum) between any analog and any digital channel			
Channel-Channel Deskew Range	±9 x time/div. setting, 100 ms max., each channel			
External Timebase Reference (Input)	10 MHz ±25 ppm at 0 to 10 dBm into 50 Ω			
External Timebase Reference (Output)	10 MHz, 2.0 dBm ±1.5 dBm, sinewave synchronized to reference being used (internal or external reference)			
Acquisition - Analog Channels				
Sample Rate (Single-shot)	10 GS/s on all 4 Channels with Enhanced Sample Rate			
Sample Rate (Repetitive)	125 GS/s, user selectable for repetitive signals (20 ps/div to 10 ns/div)			
Memory Length (# of Segments in Sequence Mode)	Standard: 12.5 Mpts/ch for all channels, 25 Mpts (interleaved) (10,000 segments) Option - L: 25 Mpts/ch for all channels, 50 Mpts (interleaved) (10,000 segments)			
Intersegment Time	1 μS			
Averaging	Summed averaging to 1 million sweeps; continuous averaging to 1 million sweeps			
Enhanced Resolution (ERES)	From 12.5- to 15-bits vertical resolution			
Envelope (Extrema)	Envelope, floor, or roof for up to 1 million sweeps			
Interpolation	Linear or Sin x/x (2 pt and 4 pt); 5 or 10 GS/s Enhanced Sample Rate defaults to 2 pt or 4 pt Sin x/x respectively			

# SPECIFICATIONS

**HD  
4096**

HDO4024A HDO4024A-MS	HDO4034A HDO4034A-MS	HDO4054A HDO4054A-MS	HDO4104A HDO4104A-MS
-------------------------	-------------------------	-------------------------	-------------------------

## Vertical, Horizontal, Acquisition - Digital Channels (with HDO4000A-MS only)

Input Channels	16 Digital Channels
Threshold Groupings	Pod 2: D15 - D8, Pod 1: D7 - D0
Threshold Selections	TTL, ECL, CMOS (2.5 V, 3.3 V, 5 V), PECL, LVDS or User Defined
Maximum Input Voltage	±30V Peak
Threshold Accuracy	±(3% of threshold setting + 100mV)
Input Dynamic Range	± 20V
Minimum Input Voltage Swing	400mV
Input Impedance (Flying Leads)	100 kΩ    5 pF
Maximum Input Frequency	250 MHz
Sample Rate	1.25 GS/s
Record Length	Standard: 12.5 MS (25 MS interleaved) - 16 Channels Optional L: 25 MS (50 MS interleaved) - 16 Channels
Minimum Detectable Pulse Width	2 ns
Channel-to-Channel Skew	350 ps
User Defined Threshold Range	±10 V in 20 mV steps
User Defined Hysteresis Range	100 mV to 1.4 V in 100 mV steps

## Triggering System

Modes	Normal, Auto, Single, and Stop			
Sources	Any input channel, External, Ext/10, or line; slope and level unique to each source (except for line trigger)			
Coupling	DC, AC, HFRej, LFRej			
Pre-trigger Delay	0-100% of memory size (adjustable in 1% increments of 100 ns)			
Post-trigger Delay	0-10,000 Divisions in real time mode, limited at slower time/div settings or in roll mode			
Hold-off	From 2 ns up to 20 s or from 1 to 99,999,999 events			
Trigger and Interpolator Jitter	≤ 4 ps rms (typical)	≤ 4 ps rms (typical)	≤ 3.5 ps rms (typical)	≤ 3.5 ps rms (typical)
Internal Trigger Level Range	±4.1 div from center (typical)			
External Trigger Input Range	Ext: ±400 mV, Ext/10: ±4 V			
Maximum Trigger Rate	1,000,000 waveforms/sec (in Sequence Mode, up to 4 channels)			
Trigger Sensitivity with Edge Trigger (Ch 1-4)	0.9 division: 10 MHz 1.0 divisions: 200 MHz	0.9 division: 10 MHz 1.0 divisions: 200 MHz 2.0 divisions: 350 MHz	0.9 division: 10 MHz 1.0 divisions: 200 MHz 1.5 divisions: 250 MHz 2.0 divisions: 500 MHz	0.9 division: 10 MHz 1.0 divisions: 200 MHz 1.5 divisions: 500 MHz 2.0 divisions: 1 GHz
Trigger Sensitivity with Edge Trigger (External Input)	0.9 division: 10 MHz 1.0 divisions: 200 MHz 2	0.9 division: 10 MHz 1.0 divisions: 200 MHz 2.0 divisions: 350 MHz	0.9 division: 10 MHz 1.0 divisions: 200 MHz 1.5 divisions: 250 MHz 2.0 divisions: 500 MHz	0.9 division: 10 MHz 1.0 divisions: 200 MHz 1.5 divisions: 500 MHz 2.0 divisions: 1 GHz
Max. Trigger Frequency, Smart Trigger	200 MHz	350 MHz	500 MHz	1 GHz

## Trigger Types

Edge	Triggers when signal meets slope (positive, negative, or either) and level condition
Width	Triggers on positive or negative glitches with selectable widths. Minimum width 1.5ns, Maximum width: 20 s
Glitch	Triggers on positive or negative glitches with selectable widths. Minimum width 1.5ns, Maximum width: 20 s
Window	Triggers when signal exits a window defined by adjustable thresholds
Pattern	Logic combination (AND, NAND, OR, NOR) of up to 5 inputs (4 channels and external trigger input). Each source can be high, low, or don't care. The High and Low level can be selected independently. Triggers at start or end of the pattern.
TV-Composite Video	Triggers NTSC or PAL with selectable line and field; HDTV (720p, 1080i, 1080p) with selectable frame rate (50 or 60 Hz) and Line; or CUSTOM with selectable Fields (1-8), Lines (up to 2000), Frame Rates (25, 30, 50, or 60 Hz), Interlacing (1:1, 2:1, 4:1, 8:1), or Sync Pulse Slope (Positive or Negative)
Runt	Trigger on positive or negative runts defined by two voltage limits and two time limits. Select between 1 ns and 20 ns
Slew Rate	Trigger on edge rates. Select limits for dV, dt, and slope. Select edge limits between 1 ns and 20 ns
Interval	Triggers on intervals selectable between 1 ns and 20 s
Dropout	Triggers if signal drops out for longer than selected time between 1 ns and 20 s
Triggers with Exclusion Technology	Glitch, Width, Interval, Runt, Slew Rate - Trigger on intermittent faults by specifying the expected behavior and triggering when that condition is not met
Qualified (Timeout or State/Edge Qualified)	Triggers on any input source only if a defined state or edge occurred on another input source. Delay between sources is selectable by time or events. (Note: event B pattern trigger cannot include analog channels).
Low Speed Serial Protocol Trigger (Optional)	I2C, SPI (SPI, SSPI, SIOP), UART-RS232, CAN1.1, CAN2.0, CAN FD, LIN, FlexRay, MIL-STD-1553, AudioBus (I2S, LJ, RJ, TDM), USB1.x/2.0

# SPECIFICATIONS



	HDO4024A HDO4024A-MS	HDO4034A HDO4034A-MS	HDO4054A HDO4054A-MS	HDO4104A HDO4104A-MS
--	-------------------------	-------------------------	-------------------------	-------------------------

## Measurement Tools

Measurement Functionality	Display up to 8 measurement parameters together with statistics, including mean, minimum, maximum, standard deviation, and total number. Each occurrence of each parameter is measured and added to the statistics table. . Histicons provide a fast, dynamic view of parameters and wave shape characteristics. Parameter gates define the location for measurement on the source waveform.
Measurement Parameters - Horizontal + Jitter	Delay (from trigger, 50%), Duty Cycle (50%, @level), Edges (@level), Fall Time (90-10, 20-80), Frequency (50%, @level), Period (50%, @level), Δ Period (@level), Phase (@level), Rise Time (10-90, 20-80), Skew, Time (@level), Δ Time (@level), Width+, Width-
Measurement Parameters - Vertical	Amplitude, Base, Maximum, Mean, Minimum, Peak-to-Peak, RMS, Std. Deviation, Top.
Measurement Parameters - Pulse	Area, Base, Fall Time (90-10, 80-20), Overshoot (positive, negative), Rise Time (10-90, 80-20), Top, Width+, Width-

## Math Tools

Math Functionality	Display up to 2 math functions traces (F1-F2). The easy-to-use graphical interface simplifies setup of up to two operations on each function trace, and function traces can be chained together to perform math-on-math.
Math Operators - Basic Math	Average (summed), Average (continuous), Difference (-), Envelope, Floor, Invert (negate), Product (x), Ratio (/), Reciprocal, Rescale (with units), Roof, Sum (+).
Math Operators - Filters	Enhanced resolution (to 15 bits vertical)
Math Operators - Frequency Analysis	FFT (power spectrum, magnitude), up to full record length. Select from Rectangular, VonHann, Hamming, FlatTop and Blackman Harris windows.
Math Operators - Functions	Absolute value, Derivative, Integral, Invert (negate), Reciprocal, Rescale (with units), Square, Square root, Zoom (identity).

## Measurement and Math Integration

Trend (datalog) of up to 1 million measurement parameters.

## Pass/Fail Testing

Pass/Fail Testing	Mask Test (pre-defined or user-defined mask, waveform All In, All Out, Any In, or Any Out conditions) with following THEN Save (waveforms), Stop, Alarm, (send) Pulse, Hardcopy (send email, save screen image, save to clipboard, send to printer), or (save) LabNotebook.
-------------------	---

## Display System

Display Size	Color 12.1" widescreen flat panel TFT-Active Matrix with high resolution touch screen
Display Resolution	WXGA; 1280 x 800 pixels
Number of Traces	Display a maximum of 8 traces. Simultaneously display channel, zoom, memory, math, and X-Y traces
Grid Styles	Auto, Single, Dual, Quad, Octal, Tandem, Quattro, X-Y, Single+X-Y, Dual+X-Y
Waveform Representation	Sample dots joined, or sample dots only

# SPECIFICATIONS

**HD  
4096**

	HDO4024A HDO4024A-MS	HDO4034A HDO4034A-MS	HDO4054A HDO4054A-MS	HDO4104A HDO4104A-MS
<b>Processor/CPU</b>				
Type	Intel® Core™ i3-2330E Dual, 2.2 GHz (or better)			
Processor Memory	8 GB standard standard			
Operating System	Microsoft Windows® 7 Pro 64-Bit Embedded			
	Teledyne LeCroy MAUI™ with OneTouch			
<b>Connectivity</b>				
Ethernet Port	Supports 2 10/100/1000BaseT Ethernet interface (RJ45 ports)			
USB Host Ports	Minimum 6 total (incl. 2 front panel) USB 2.0 ports support Windows compatible devices			
USB Device Port	1 USBTMC port			
GPIB Port (Optional)	Supports IEEE – 488.2 (External)			
External Monitor Port	DVI connector, HDMI connector and 15 pin D-Type WXGA compatible DB-15 to support customer-supplied external monitor. Includes support for extended desktop operation with WXGA resolution on second monitor. Supports touch screen integration of external monitor (Note: external display can not use a Fujitsu touch-screen driver).			
Remote Control	Via Windows Automation, or via Teledyne LeCroy Remote Command Set			
<b>Probes</b>				
Standard Probes	Qty. (4) ÷10 Passive Probes			
Probing System	ProBus. Automatically detects and supports a variety of compatible probes			
<b>Power Requirements</b>				
Voltage	100–240 VAC ±10% at 45-66 Hz; 110-120 VAC ±10% at 380-420 Hz; Automatic AC Voltage Selection; Installation Category 300 V CAT II			
Power Consumption (Nominal)	200 W / 200 VA			
Max Power Consumption	320 W / 320 VA (with all PC peripherals and active probes connected to 4 channels)			
<b>Environmental</b>				
Temperature	Operating: 5 °C to 40 °C; Non-Operating: -20 °C to 60 °C			
Humidity	Operating: 5% to 90% relative humidity (non-condensing) up to +31 °C, Upper limit derates to 50% relative humidity (non-condensing) at +40 °C; Non-Operating: 5% to 95% relative humidity (non-condensing) as tested per MIL-PRF-28800F			
Altitude	Operating: 3,048 m (10,000 ft) max at +30 °C; Non-Operating: Up to 12,192 meters (40,000 ft)			
Random Vibration	Operating : 0.31 g <sub>rms</sub> 5 Hz to 500 Hz, 15 minutes in each of three orthogonal axes; Non-Operating: 2.4 g <sub>rms</sub> 5 Hz to 500 Hz, 15 minutes in each of three orthogonal axes			
Functional Shock	30 g <sub>peak</sub> , half sine, 11 ms pulse, 3 shocks (positive and negative) in each of three orthogonal axes, 18 shocks total			
<b>Physical</b>				
Dimensions (HWD)	11.48"H x 15.72"W x 5.17"D (291.7 mm x 399.4 mm x 131.31 mm)			
Weight	12.9 lbs. (5.86 kg.)			
<b>Certifications</b>				
CE Certification UL and cUL Listing	CE Compliant, UL and cUL listed, confirms to: UL 61010-1 (3rd Edition), UL 61010-2-030 (1st Edition) CAN/CSA C22.2 No.61010-1-12			
	CE Compliant, UL and cUL listed, confirms to: UL 61010-1 (3rd Edition), UL 61010-2-030 (1st Edition) CAN/CSA C22.2 No.61010-1-12			
<b>Warranty and Service</b>				
	3-year warranty; calibration recommended annually. Optional service programs include extended warranty, upgrades, and calibration services			

# ORDERING INFORMATION

**HD  
4096**

Product Description	Product Code	Product Description	Product Code
<b>HDO4000A Oscilloscopes</b>			
200 MHz, 10 GS/s, 4 Ch, 12.5 Mpts/Ch 12-bit HD	HDO4024A	Electrical Telecom Mask Test Package	HDO4K-ET-PMT
Oscilloscope with 12.1" WXGA Touch Display		Spectrum Analysis Option	HDO4K-SPECTRUM
350 MHz, 10 GS/s, 4 Ch, 12.5 Mpts/Ch 12-bit HD	HDO4034A	Power Analysis Option	HDO4K-PWR
Oscilloscope with 12.1" WXGA Touch Display			
500 MHz, 10 GS/s, 4 Ch, 12.5 Mpts/Ch 12-bit HD	HDO4054A		
Oscilloscope with 12.1" WXGA Touch Display			
1 GHz, 10 GS/s, 4 Ch, 12.5 Mpts/Ch 12-bit HD	HDO4104A		
Oscilloscope with 12.1" WXGA Touch Display			
<b>HDO4000A-MS Mixed Signal Oscilloscopes</b>			
200 MHz, 10 GS/s, 4+16ch, 12.5 Mpts/Ch 12-bit HD	HDO4024A-MS	ARINC 429 Symbolic Decode Option	HDO4K-ARINC429bus DSymbolic
Mixed Signal Oscilloscope w/ 12.1" WXGA Color Display		Audiobus Trigger and Decode Option for I <sup>2</sup> S, LJ, RJ, and TDM	HDO4K-Audiobus TD
350 MHz, 10 GS/s, 4+16ch, 12.5 Mpts/Ch 12-bit HD	HDO4034A-MS	CAN, LIN and FlexRay Trigger and Decode Option	HDO4K-AUTO
Mixed Signal Oscilloscope w/ 12.1" WXGA Color Display		CAN FD Trigger and Decode Option	HDO4K-CAN FDbus TD
500 MHz, 10 GS/s, 4+16ch, 12.5 Mpts/Ch 12-bit HD	HDO4054A-MS	CAN Trigger and Decode Option	HDO4K-CANbus TD
Mixed Signal Oscilloscope w/ 12.1" WXGA Color Display		D-PHY Decode Option	HDO4K-DPHYbus D
1 GHz, 10 GS/s, 4+16ch, 12.5 Mpts/Ch 12-bit HD	HDO4104A-MS	DigRF 3G Decode Option	HDO4K-DigRF3Gbus D
Mixed Signal Oscilloscope w/ 12.1" WXGA Color Display		DigRF v4 Decode Option	HDO4K-DigRFv4bus D
<b>Included with Standard Configurations (HDO4000A and HDO4000A-MS)</b>			
÷10 Passive Probe (Total of 1 Per Channel), Getting Started Guide, Anti-virus Software (Trial Version), Microsoft Windows Embedded Standard 7 P 64-Bit License, Commercial NIST Traceable Calibration with Certificate, Power Cable for the Destination Country, Protective Front Cover, 3-year Warranty		ENET Decode Option	HDO4K-ENETbus D
<b>Included with HDO4000A-MS</b>			
16 Channel Digital Leadset, Extra Large Gripper Probe Set (Qty. 22), Ground Extenders (Qty. 20), Flexible Ground Leads (Qty. 5)		FlexRay Trigger and Decode Option	HDO4K-FlexRaybus TD
<b>Memory Option</b>			
25 Mpts/ch (50 Mpts interleaved) memory	HDO4KA-L	I <sup>2</sup> C, SPI and UART Trigger and Decode Option	HDO4K-EMB
<b>Hardware Options</b>			
Removable Solid State Drive Package (includes removable solid state drive kit and two solid state drives)	HDO4KA-RSSD	I <sup>2</sup> C Bus Trigger and Decode Option	HDO4K-I2Cbus TD
Additional Removable Solid State Drive	HDO4KA-RSSD-02	LIN Trigger and Decode Option	HDO4K-LINbus TD
<b>General Accessories</b>			
External GPIB Accessory	USB2-GPIB	MDIO Decode	HDO4K-MDIObus D
Soft Carrying Case	HDO4K-SOFTCASE	Manchester Decode Option	HDO4K-Manchesterbus D
Rack Mount Accessory	HDO4K-RACK	MIL-STD-1553 Trigger and Decode Option	HDO4K-1553 TD
Accessory Pouch	HDO4K-POUCH	NRZ Decode Option	HDO4K-NRZbus D
<b>Local Language Overlays</b>			
German Front Panel Overlay	HDO4K-FP-GERMAN	SENT Decode Option	HDO4K-SENTbus D
French Front Panel Overlay	HDO4K-FP-FRENCH	SPI Bus Trigger and Decode Option	HDO4K-SPIbus TD
Italian Front Panel Overlay	HDO4K-FP-ITALIAN	SPMI Decode	HDO4k-SPMibus D
Spanish Front Panel Overlay	HDO4K-FP-SPANISH	SpaceWire Decode Option	HDO4K-SpaceWirebus D
Japanese Front Panel Overlay	HDO4K-FP-JAPANESE	UART and RS-232 Trigger and Decode Option	HDO4K-UART-RS232bus TD
Korean Front Panel Overlay	HDO4K-FP-KOREAN	USB 2.0 Trigger and Decode Option	HDO4K-USB2bus TD
Chinese (Tr) Front Panel Overlay	HDO4K-FP-CHNES-TR	USB2-HSIC Decode Option	HDO4K-USB2-HSICbus D
Chinese (Simp) Front Panel Overlay	HDO4K-FP-CHNES-SI		
Russian Front Panel Overlay	HDO4K-FP-RUSSIAN		

# ORDERING INFORMATION



Product Description	Product Code	Product Description	Product Code
<b>Probes and Amplifiers</b>			
250 MHz Passive Probe for HDO4000A, 10:1, 10 MΩ	PP017	500 MHz Differential Probe	AP033
500 MHz Passive Probe 10:1, 10 MΩ	PP018	200 MHz, 3.5 pF, 1 MΩ Active Differential Probe, ±20 V, 60V common-mode	ZD200
500 MHz Passive Probe, 5mm, 10:1, 10 MΩ	PP026	1 GHz, 1.0 pF, 1 MΩ Active Differential Probe, ±8 V, 10V common-mode	ZD1000
Power/Voltage Rail Probe. 4 GHz bandwidth, 1.2x attenuation, ±30V offset, ±800mV	RP4030	1.5 GHz, 1.0 pF, 1 MΩ Active Differential Probe, ±8 V, 10V common-mode	ZD1500
Browser for use with RP4030	RP4000-BROWSER	1 GHz, 0.9 pF, 1 MΩ High Impedance Active Probe	ZS1000
1,500 V, 120 MHz High-Voltage Differential Probe	HVD3106	Set of 4 ZS1000	ZS1000-QUADPAK
1kV, 80 MHz High Voltage Differential Probe with 6m cable	HVD3106-6M	1.5 GHz, 0.9 pF, 1 MΩ High Impedance Active Probe	ZS1500
1kV, 120 MHz High Voltage Differential Probe without tip Accessories	HVD3106-NOACC	Set of 4 ZS1500	ZS1500-QUADPAK
1,500 V, 25 MHz High-Voltage Differential Probe	HVD3102	1 Ch, 100 MHz Differential Amplifier with Precision Voltage Source	DA1855A
1kV, 25 MHz High Voltage Differential Probe without tip Accessories	HVD3102-NOACC	100:1 or 10:1 Selectable, 250 MHz Passive Diff. Probe Pair	DXC100A
2kV, 120 MHz High Voltage Differential Probe	HVD3206	1:1, 50 MHz Passive Differential Probe Pair	DXC200
2kV, 80 MHz High Voltage Differential Probe with 6m cable	HVD3206-6M	100:1, 250 MHz, 2.5kV High Voltage Probe Pair	DXC5100
6kV, 100 MHz High Voltage Differential Probe	HVD3605	10x, 1 MΩ Passive Attenuator for DXC Series Probes	DA101
High Voltage Fiber Optic Probe, 60 MHz (requires accessory tip)	HVF0103	100:1 400 MHz 50 MΩ 1 kV High-voltage Probe	HVP120
±1V (1x) Tip Accessory for HVFO103	HVF0100-1X-TIP	100:1 400 MHz 50 MΩ 4 kV High-voltage Probe	PPE4KV
±5V (5x) Tip Accessory for HVFO103	HVF0100-5X-TIP	1000:1 400 MHz 50 MΩ 5 kV High-voltage Probe	PPE5KV
±20V (20x) Tip Accessory for HVFO103	HVF0100-20X-TIP	1000:1 400 MHz 50 MΩ 6 kV High-voltage Probe	PPE6KV
30 A; 100 MHz Current Probe – AC/DC; 30 A <sub>rms</sub> ; 50 A <sub>peak</sub> Pulse	CP031	TekProbe to ProBus Probe Adapter	TPA10
30 A; 100 MHz High Sensitivity Current Probe – AC/DC; 30 A <sub>rms</sub> ; 50 A <sub>peak</sub> Pulse	CP031A	Set of 4 TPA10 TekProbe to ProBus Probe Adapters.	TPA10-QUADPAK
30 A; 50 MHz Current Probe – AC/DC; 30 A <sub>rms</sub> ; 50 A <sub>peak</sub> Pulse	CP030	Programmable Current Sensor to ProBus Adapter for use with third party current sensors	CA10
30 A; 50 MHz High Sensitivity Current Probe – AC/DC; 30 A <sub>rms</sub> ; 50 A <sub>peak</sub> Pulse	CP030A	Set of 4 CA10 Programmable Current Sensor to ProBus Adapters for use with third party current sensors	CA10-QUADPAK
150 A; 10 MHz Current Probe – AC/DC; 150 A <sub>rms</sub> ; 500 A <sub>peak</sub> Pulse	CP150		
500 A; 2 MHz Current Probe – AC/DC; 500 A <sub>rms</sub> ; 700 A <sub>peak</sub> Pulse	CP500		
Deskew Calibration Source for CP031, CP030 and AP015	DCS015		

## 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



1-800-5-LeCroy  
teledynelecroy.com

Local sales offices are located throughout the world.  
Visit our website to find the most convenient location.

# Current Probes



## Key Features

- **ProBus active probe interface with automatic scaling in A/div**
- **Autozero and degauss capabilities built into instrument's user interface**
- **CP030**
  - 30 A<sub>rms</sub> continuous current
  - 50 A<sub>peak</sub> current
  - 50 MHz bandwidth
- **CP030A**
  - 30 A<sub>rms</sub> continuous current
  - 50 A<sub>peak</sub> current
  - 50 MHz bandwidth
  - 1 mA/div sensitivity
- **CP031**
  - 30 A<sub>rms</sub> continuous current
  - 50 A<sub>peak</sub> current
  - 100 MHz bandwidth
- **CP031A**
  - 30 A<sub>rms</sub> continuous current
  - 50 A<sub>peak</sub> current
  - 100 MHz bandwidth
  - 1 mA/div sensitivity
- **CP150**
  - 150 A<sub>rms</sub> continuous current
  - 500 A<sub>peak</sub> current
  - 10 MHz bandwidth
- **CP500**
  - 500 A<sub>rms</sub> continuous current
  - 700 A<sub>peak</sub> current
  - 2 MHz bandwidth

**Teledyne LeCroy current probes do not require the breaking of a circuit or the insertion of a shunt to make accurate and reliable current measurements. Based on a combination of Hall effect and transformer technology, Teledyne LeCroy current probes are ideal for making accurate AC, DC, and impulse current measurements.**

## Wide Range of Applications

Teledyne LeCroy current probes are available in a variety of models for a wide range of applications. The full range of Teledyne LeCroy current probes includes models with bandwidths up to 100 MHz, peak currents up to 700 A and sensitivities to 1 mA/div. Teledyne LeCroy current probes are often used in applications such as the design and test of switching power supplies, motor drives, electric vehicles, and uninterruptible power supplies.

## High Sensitivity

The CP030A and CP031A provide a high sensitivity of 1 mA/div. This allows for more precise low current measurements on Teledyne LeCroy oscilloscopes. When used with HDO high definition oscilloscopes with HD4096 technology, users will obtain highly accurate, low current waveforms with unmatched 12-bit resolution for improved debug and analysis.

## Fully Integrated

All Teledyne LeCroy current probes are powered through the Teledyne LeCroy ProBus® connection and require no additional hardware. Along with providing power, the ProBus connection allows the current probe and oscilloscope to communicate, resulting in current waveforms automatically displayed on screen in Amps, and calculated power traces scaled correctly in Watts. This full integration also allows for Degauss and Autozero functions to be done directly from the oscilloscope's user interface.

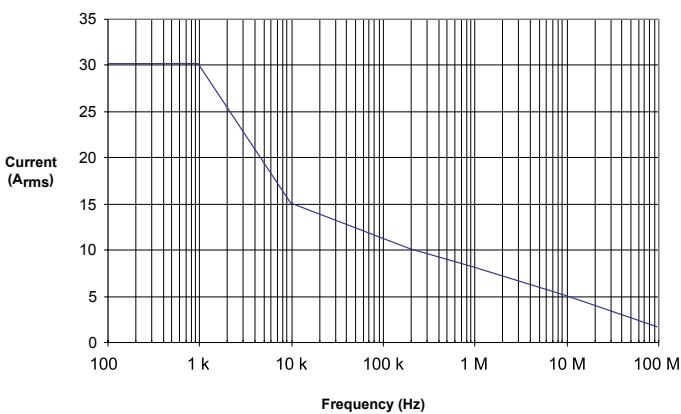
## Deskew Calibration Source

The DCS025 deskew calibration source has both voltage and current time-aligned signals, which enables the precise deskew of voltage and current probes. Most voltage probes along with 30, 150 and 500A current probes are compatible with the DSC025.

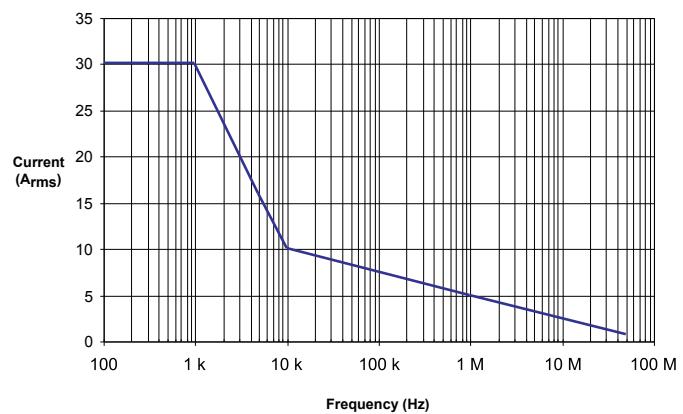
## CP031 / CP031A



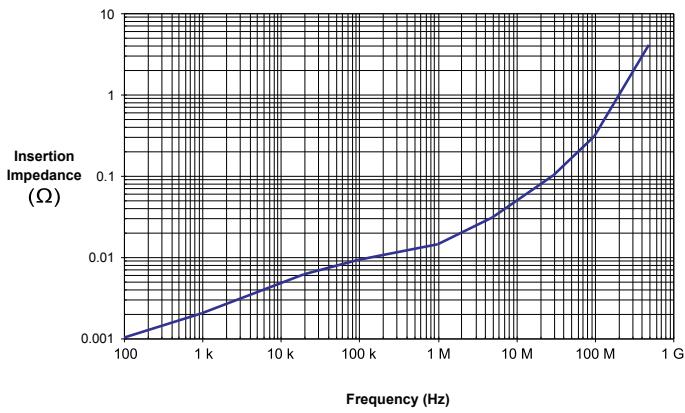
## CP030 / CP030A



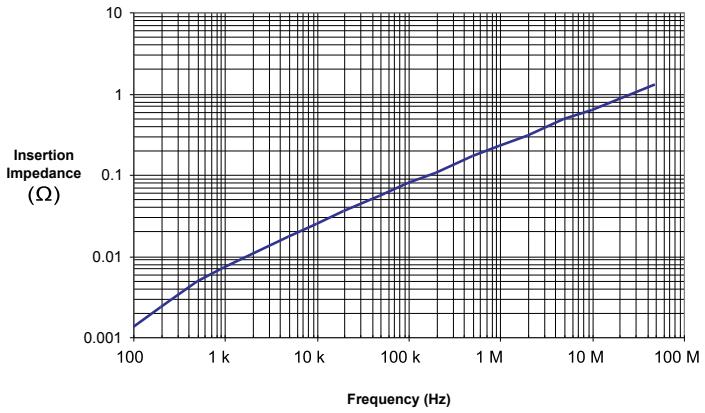
Maximum Input Current vs. Frequency



Maximum Input Current vs. Frequency\*

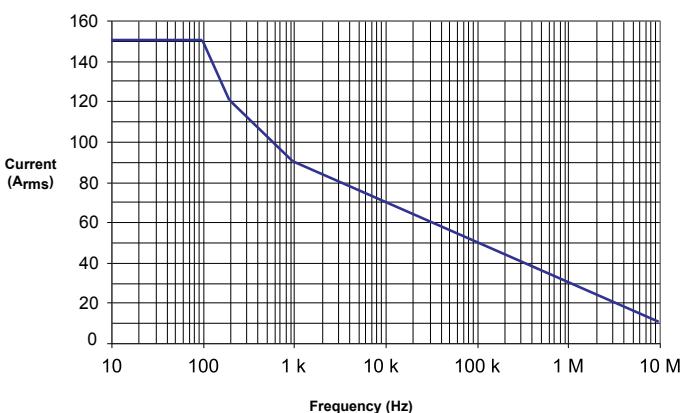
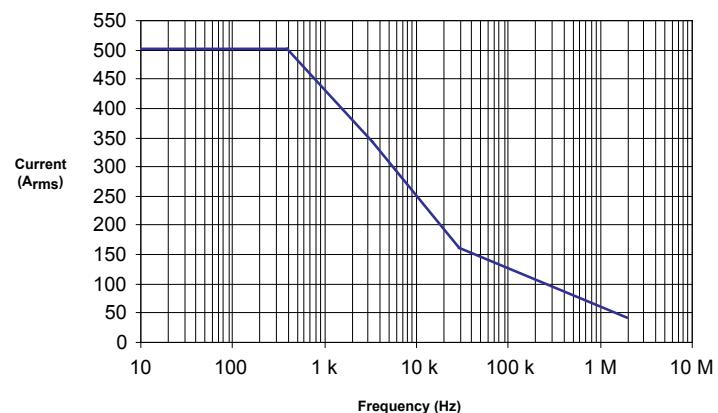
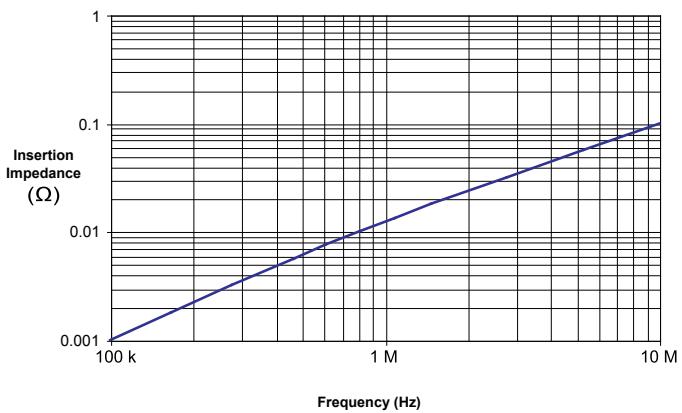
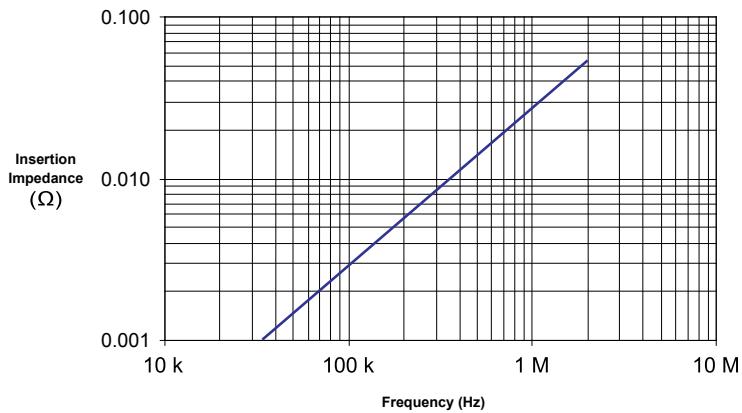


Insertion Impedance vs. Frequency  
(typical)



Insertion Impedance vs. Frequency\*  
(typical)

\*This performance does not apply to CP030-3M model.

**CP150****CP500****Maximum Input Current vs. Frequency\*****Maximum Input Current vs. Frequency****Insertion Impedance vs. Frequency\*  
(typical)****Insertion Impedance vs. Frequency  
(typical)**

\*This performance does not apply to CP150-6M model.

# SPECIFICATIONS & ORDERING INFORMATION

Specifications	CP030 (CP030-3M)	CP030A	CP031	CP031A	CP150 (CP150-6M)	CP500
Electrical Characteristics*						
Max. Continuous Input Current		30 A <sub>rms</sub>			150 A <sub>rms</sub>	500 A <sub>rms</sub>
Bandwidth	50 MHz (10 MHz)		100 MHz		10 MHz (5 MHz)	2 MHz
Rise Time (typical)	≤ 7 ns (≤ 35 ns)		≤ 3.5 ns		≤ 35 ns (≤ 70 ns)	≤ 175 ns
Max. Peak Current		50 A <sub>peak</sub> (non-continuous)			300 A <sub>peak</sub> (non-continuous); 500 Apeak ≤ 30 µs	700 A <sub>peak</sub> (non-continuous)
Output Voltage	0.1 V/A	0.1 V/A & 1 V/A	0.1 V/A	0.1 V/A & 1 V/A		0.01 V/A
Max Continuous Input Current at 1 V/A (100mA/div or less)	–	5 A	–	5 A		–
Offset Range at 1V/A (100mA/div or less)	–	±5 A	–	±5 A		–
Minimum Sensitivity	10 mA/div	1 mA/div	10 mA/div	1 mA/div		100 mA/div
Low-Frequency Accuracy					1%	
AC Noise at 20 MHz BWL	≤ 2.5 mA	≤ 150 µA	≤ 2.5 mA	≤ 150 µA	≤ 6.0 mA	≤ 8.0 mA
Coupling					AC, DC, GND	

## General Characteristics

Cable Length	1.5 m (3 m)	1.5 m			2 m (6 m)	6 m
Weight	240 g (290 g)	260 g	240 g	260 g	500 g (600 g)	630 g
Max. Conductor Size (Diameter)	5 mm			20 mm		
Interface	ProBus, 1 MΩ only					
Usage Environment	Indoor					
Operating Temperature	0 °C to 40 °C					
Max. Relative Humidity	80%					
Max. Altitude	2000 m					
Maximum Insulated Wire Voltage	300 V CAT I			600 V CAT II, 300 V CAT III		

\* Electrical Characteristics Guaranteed at 23 °C ±3 °C

CP03x, CP150, and CP500 probes (and long cable versions of these) are compatible with any Teledyne LeCroy oscilloscope with a ProBus interface running firmware version 4.3.1.1 or greater.

CP03xA probes are compatible with most Teledyne LeCroy oscilloscopes with a ProBus interface running X-Stream™ firmware version 7.8.x.x or later, including WaveSurfer Xs-A, MXs/MXs-A/MXs-B, and 10; HDO4000, 6000, 8000, and 9000; MDA800, HRO/WaveRunner 6 Zi, WaveRunner 8000, Xi/Xi-A/ MXi/MXi-A, WavePro/SDA/DDA 7 Zi/Zi-A; WaveMaster/SDA/DDA 8 Zi/Zi-A/Zi-B, and LabMaster 9 Zi-A series. WavePro 7000/7000A series are compatible if they are running Windows XP Professional and X-Stream™ firmware version 7.8.x.x or later. WaveSurfer Xs series must be upgraded to Windows XP Professional. Contact your local service center regarding upgrades.

## Ordering Information

Product Description	Product Code
30 A; 50 MHz Current Probe – AC/DC; 30 Arms; 50 A Peak Pulse, 1.5 meter cable	CP030
30A; 10 MHz Current Probe - AC/DC, 30 Arms; 50 A Peak Pulse, 3 meter cable (not EMC compliant)	CP030-3M
30 A; 50 MHz High Sensitivity Current Probe – AC/DC; 30 Arms; 50 A Peak Pulse, 1.5 meter cable	CP030A
30 A; 100 MHz Current Probe – AC/DC; 30 Arms; 50 A Peak Pulse, 1.5 meter cable	CP031
30 A; 100 MHz High Sensitivity Current Probe – AC/DC; 30 Arms; 50 A Peak Pulse, 1.5 meter cable	CP031A
150 A; 10 MHz Current Probe – AC/DC; 150 Arms; 500 A Peak Pulse, 2 meter cable	CP150
150 A; 5 MHz Current Probe – AC/DC; 150 Arms; 500 A Peak Pulse, 6 meter cable (not EMC compliant)	CP150-6M
500 A; 2 MHz Current Probe – AC/DC; 500 Arms; 700 A Peak Pulse, 6 meter cable	CP500
Deskew Calibration Source	DCS025

## 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



1-800-5-LeCroy  
teledynelecroy.com

Local sales offices are located throughout the world.  
Visit our website to find the most convenient location.

## ADP300 ADP305 High Voltage Differential Probes



### Key Features

- **20 MHz and 100 MHz bandwidths**
- **1,000 VRMS common mode voltage**
- **1,400 Vpeak differential voltage**
- **EN61010 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 ground or the location of ground is unknown. The ADP305 is designed for measuring the high-speed floating voltages found in today's 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 oscilloscope 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 scope 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 EN61010 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 in addition to being used on appliances and portable equipment (Cat II), they can be used in fixed-installation environments.

# SPECIFICATIONS & ORDERING INFORMATION

## Specifications

	<b>ADP300</b>	<b>ADP305</b>	<b>General Characteristics</b>	
<b>Electrical Characteristics</b>				
Bandwidth	20 MHz	100 MHz	Overall Length	2 meters
Differential Voltage	1400 v peak		Input Connectors	4mm shrouded banana plug
Common Mode Voltage	1000 vrms Cat III		Operating Temperature	0° C to 50° C
Best Low-Frequency Accuracy (probe only)	1% of reading		Max Altitude	2000 meters
CMRR	50/60 Hz 80 dB (10,000:1)	100kHz 50 dB (300:1)	Max Relative Humidity	80% (max 31° C)
Max. Slew Rate (referenced to input)	60,000 V/us	300,000 V/us	Warranty	One year
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	1 V/div to 350 V/div	200 mV/div to 350 V/div		

## Ordering Information

<b>Product Description</b>	<b>Product Code</b>
1,400 V, 20 MHz High-Voltage Differential Probe	AP300
1,400 V, 100 MHz High-Voltage Differential Probe	AP305
Plunger Hook Clips (Quantity 2 - 1 Red, 1 Blue)	PK30X-1
Safety Alligator Clips (Quantity 2 - 1 Red, 1 Blue)	PK30X-2
Plunger Jaw Clips (Quantity 2 - 1 Red, 1 Blue)	PK30X-3
Plunger Clamp Clips (Quantity 2 - 1 Red, 1 Blue)	PK30X-4
Safety Spade Terminals (Quantity 2 - 1 Red, 1 Blue)	PK30X-5

## 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



1-800-5-LeCroy  
[teledynelecroy.com](http://teledynelecroy.com)

Local sales offices are located throughout the world.  
Visit our website to find the most convenient location.