

LeCroy

MS-32

Oscilloscope  
Mixed Signal Option



Operator's Manual

February 2005



**LeCroy Corporation**

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<b>SAFETY REQUIREMENTS .....</b>	<b>3</b>
Cleaning .....	3
Use and Maintenance .....	3
DECLARATION OF CONFORMITY .....	4
<b>INTRODUCTION.....</b>	<b>5</b>
Overview .....	5
Warranty.....	5
Returning a Product for Service or Repair .....	5
Technical Support.....	6
Staying Up-to-Date.....	6
<b>STANDARD AND ACCESSORY EQUIPMENT .....</b>	<b>7</b>
The MS-32 Standard Hardware .....	7
The MS-32 Software .....	9
Accessories.....	9
<b>DESCRIPTION OF OPERATION.....</b>	<b>13</b>
<b>GETTING STARTED WITH THE MS-32.....</b>	<b>16</b>
Overview .....	16
Connecting the MS-32 System to the Oscilloscope.....	16
Verifying Proper MS-32 Connection to your Oscilloscope and the Device Under Test .....	20
The Complete System Connection .....	20
Digital Connections .....	21
Group Colors.....	22
Line Colors.....	23
Standard Output Connection .....	23
Threshold Levels.....	24
Minimum voltage swing.....	24
Basic Oscilloscope Operation .....	25
<b>ACCESSING THE MS-32 OSCILLOSCOPE MIXED SIGNAL OPTION</b>	
<b>TOOLSET .....</b>	<b>26</b>
Overview .....	26
Oscilloscope Analog Trigger and MS-32 Digital Trigger .....	26
Digital Trace Groups.....	27
<b>DIGITAL TRACE GROUP SETUP.....</b>	<b>29</b>
Digital Trace Group Dialog .....	29
Digital Logic Threshold Setup .....	31
Overview .....	31
Digital Logic Setup.....	32
<b>DIGITAL TRIGGER SETUP.....</b>	<b>34</b>
Overview .....	34
Creating a Digital Trigger Condition .....	34

## **MS-32 Oscilloscope Mixed Signal Option**

---

Digital Logic Trigger Setup .....	35
Digital Logic Bus Trigger Setup .....	36
Digital Interval Trigger Setup .....	36
Digital Logic Threshold Setup .....	37
<b>CHARACTERIZE DIGITAL OR MIXED SIGNAL SYSTEM PERFORMANCE... 38</b>	
Overview .....	38
Using Cursors.....	38
Using Measurement Parameters .....	39
Measurement Gating.....	39
Using Statistics and Graphing .....	40
<b>ISOLATE AND ANALYZE SIGNAL ACTIVITY .....</b>	<b>41</b>
Capture Long Pre-Trigger Time .....	41
Zooming on Your Waveforms .....	42
<b>APPENDIX A – SPECIFICATIONS .....</b>	<b>44</b>

## SAFETY REQUIREMENTS

This symbol may appear on the product: 

This refers you to additional information contained in the operator's manual. The corresponding information in this manual is similarly denoted.

Before using this product, ensure that its operating environment will be maintained within these parameters:

Temperature: 5 to 40 °C

Humidity: ≤ 80% RH (non-condensing)



### CAUTION

To avoid personal injury or damage to the MS-32 or any equipment connected to it, review and comply with the following safety precautions.

- **Use only as intended.** The MS-32 hardware is intended to be used only with the LeCroy WaveSurfer or WaveRunner series oscilloscopes. Use of the MS-32 and/or the equipment it is connected to in a manner other than specified may impair the protection mechanisms.
- **Connect and disconnect properly.** Avoid damage to cables thru excessive bending.
- **Do not use in wet/damp or explosive atmospheres.**
- **For indoor use only.** The MS-32 is intended for indoor use and should be operated in a clean, dry, environment.
- **Do not operate with suspected failures.** Do not use MS-32 if any part is damaged. All maintenance should be referred to qualified service personnel.
- **Keep product surfaces clean and dry.**

### Cleaning

The outside of the MS-32 hardware should be cleaned with a soft cloth dampened with either deionized / distilled water or isopropyl alcohol. Allow the surface to dry completely before returning the instrument to service.

### Use and Maintenance

The MS-32 is a high quality, precision instrument. To maintain accuracy and signal fidelity, mechanical shock should be avoided, as well as damage to the cables through excessive bending. All maintenance and component replacement should be referred to qualified personnel.

# MS-32 Oscilloscope Mixed Signal Option

## DECLARATION OF CONFORMITY

according to ISO/IEC Guide 22 and EN 45014:1998

**Manufacturer's Name:** LeCroy Corporation

**Manufacturer's Address:** 700 Chestnut Ridge Road  
Chestnut Ridge, NY 10977  
USA

herewith declare that

**Product(s) Name:** Oscilloscope Mixed Signal Option  
**Model Number(s):** MS-32

including all their options are in conformity with the provisions of the following EC directive(s), including the latest amendments, and with national legislation implementing these directives:

**73/23/EEC Low Voltage Directive**  
**89/336/EEC EMC Directive**

and that conformity with Council Directive 73/23/EEC is based on

EN 61010-1: 2001 Safety requirements for electrical equipment for measurement control and laboratory use

and that conformity with Council Directive 89/336/EEC is based on

EN 61326: 1997 +A1:1998 EMC requirements for electrical equipment for measurement control and laboratory use  
+A2:2001+A3:2003

Emissions	EN 55011: 1998+A1:1999	Conducted and Radiated Emissions
	EN 61000-3-2: 2001	Harmonic Current Emissions
Immunity	EN 61000-4-2: 1995+A2:2001	Electrostatic Discharge
	EN 61000-4-3: 2002	RF Radiated Electromagnetic Field
	EN 61000-4-4: 1995+A2:2001	Electrical Fast Transient/Burst
	EN 61000-4-6: 1996+A1:2001	RF Conducted Electromagnetic Field
	EN 61000-4-11: 1994+A1:2001	Mains Dips and Interruptions



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**Warning: This is a Class A product. In a domestic environment this product may cause radio interference, in which case the user may be required to take adequate measures.**

## INTRODUCTION

### Overview

The MS-32 Oscilloscope Mixed Signal Option is a powerful solution for the challenge of measuring multiple, mixed signals in a single oscilloscope. An enhancement tool to the LeCroy WaveRunner 6000 Series and WaveSurfer 400 Series oscilloscopes, the MS-32 extends their testing range by adding 32 digital channels for display or triggering.

The MS-32 is ideally suited for embedded controller testing where there is a proliferation of analog signals (comparators, voltage sources, sensor/actuator signals, etc.) coincident with digital signals (address or data lines, control signals, or peripheral serial data signals). Users can easily debug signals using standard oscilloscope tools such as cursors, measurement parameters, and zooming.

Both oscilloscopes usable with the MS-32 feature large, bright color displays to facilitate signal viewing, plus all the connectivity and documentation capabilities needed to quickly record and distribute information.

This MS-32 manual assumes that you have a basic understanding of discrete electronics, logic analyzers, and LeCroy oscilloscopes, specifically the LeCroy oscilloscope that the MS-32 system will be used with. Where practical or necessary, detail on specific oscilloscope features is included in this manual.

### Warranty

The MS-32 is warranted for normal use and operation, within specifications, for a period of two years from shipment. LeCroy will either repair or, at our option, replace any product returned to one of our authorized service centers within this period. However, in order to do this we must first examine the product and find that the defect is due to workmanship or materials and not due to misuse, neglect, accident, or abnormal conditions or operation.

LeCroy shall not be responsible for any defect, damage, or failure caused by any of the following: a) attempted repairs or installations by personnel other than LeCroy representatives, or b) improper connection to incompatible equipment, or c) for any damage or malfunction caused by the use of non-LeCroy supplies.

Spare and replacement parts, and repairs, all have a 90-day warranty.

The oscilloscope's firmware has been thoroughly tested and is presumed to be functional. This includes MS-32 specific firmware. Nevertheless, it is supplied without warranty of any kind covering detailed performance. Products not made by LeCroy are covered solely by the warranty of the original equipment manufacturer.

### Returning a Product for Service or Repair

The Digital Logic Pod is made for LeCroy by another supplier. If you suspect that you have a problem with this component, you should first contact your local LeCroy service center so that they can ascertain whether this component is defective. If it is, they will give you the option to return it either to LeCroy for repair, or return it directly to the supplier.

## **MS-32 Oscilloscope Mixed Signal Option**

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If you need to return a LeCroy product, identify it by its model and serial numbers. Describe the defect or failure, and give us your name and telephone number. For factory returns, use a Return Authorization Number (RAN), which you can get from customer service. Write the number clearly on the outside of the shipping carton. Return products requiring only maintenance to your local customer service center. Within the warranty period, transportation charges to the service center will be your responsibility.

Products under warranty will be returned to you with transport prepaid by LeCroy. Outside the warranty period, you will have to provide us with a purchase order number before the work can be done. You will be billed for parts and labor related to the repair work, as well as for shipping.

You should prepay return shipments. LeCroy cannot accept COD (Cash On Delivery) or Collect Return shipments. We recommend using air freight.

### **Technical Support**

You can get assistance with installation and operation from your customer service center. Visit the LeCroy Web site at <http://www.lecroy.com> for the center nearest you.

### **Staying Up-to-Date**

Your MS-32 hardware does not need periodic calibration.

LeCroy offers state-of-the-art performance by continually refining and improving the instrument's capabilities and operation. We frequently update both firmware and software during service, free of charge during warranty. Therefore, MS-32 specific software may be periodically updated. You can download firmware and software updates from the LeCroy web-site.

Since software is continuously updated, the dialog boxes and menus you see in your program may be slightly different than what is shown in this manual. The difference should not be enough to affect your understanding of the operation of the MS-32.



## STANDARD AND ACCESSORY EQUIPMENT

### The MS-32 Standard Hardware

The Standard Hardware consists of the following items:

- Qty. 1 **32 Channel Digital Logic Pod** – Provides 32 channel digital acquisition and triggering.
  
- Qty. 1 **10.5” (26.67 cm) Digital Lead Set** – Interfaces the Digital Logic Pod to the device under test. The lead set terminates in a 25 mil pin socket. Micro-gripper probes of various sizes are available as accessories from LeCroy, and may be connected to the lead set. The lead set is divided into four groups. Each group is assigned a color, and each lead within the group is color-coded also (to resistor color-coding standard). In addition, there are several ground leads, and an SMB plug that is used for synchronizing of analog and digital signals on the oscilloscope grid.
  
- Qty. 1 **Power Supply** – Supplies power to the Digital Logic Pod. The power cord supplied with it is country specific.
  
- Qty. 1 **Oscilloscope Interface Module (OIM)** – This module connects to the Digital Logic Pod and Oscilloscope via SMB or BNC connectors. The module is LeCroy ProBus<sup>®</sup> compatible. When plugged into a LeCroy oscilloscope, it is automatically recognized sets up for Digital triggering. The OIM can be connected to any channel, but is more commonly connected to the EXT input (to reserve a channel for an analog signal). Once connected, it does the following:
  - a. Sets the timebase to 100 ns/div by default
  - b. Sets the Analog/Digital Trigger Mode to “Digital” and the trigger source to the input that the OIM is



## MS-32 Oscilloscope Mixed Signal Option

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connected to (either a Channel or External),

- c. If the OIM is connected to External, it sets the oscilloscope trigger to a positive going Edge with a pre-defined trigger level (to trigger on the output pulse when the Digital trigger condition is met) and no trigger holdoff condition. If the OIM is connected to a Channel, the same settings are made with the exception that Vertical Scale is set to 200 mV/div, and Vertical Offset is set to -500 mV.
  - d. Sets the oscilloscope AUX Output to “Trigger Out”
  - e. Sets the Trigger Mode to “Auto”
  - f. Sets the Display Grid to “Single” grid
  - g. Turns on the Digital1 trace
  - h. Displays the Digital Trigger dialog
  - i. Applies a skew correction to all channels (to ensure that the digital data aligns with the analog data). Note: skew correction is not applied to any channel that the OIM is connected to.
- Qty. 1 **USB2.0 Cable** – Downloads trigger conditions from the Oscilloscope to the Digital Logic Pod, and uploads digital channel information to the Oscilloscope. This USB2.0 Cable contains filtering to prevent spurious noise from being introduced into the digital channels.



- Qty. 1 **Magnifying Glass** – To allow simpler connection of micro-gripper probes to very small pitch ICs.



- Qty. 1 **Carrying Case**



- Qty. 1 **Quick Reference Guide**
- Qty. 1 **Operator's Manual**

## The MS-32 Software

The standard MS-32 software adds the following capability to the LeCroy oscilloscope software dialogs:

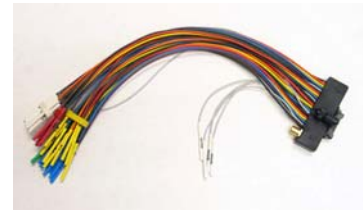
- **Analog/Digital Trigger Mode** – Allows you to choose whether you want to set an analog trigger condition or a digital trigger condition.
- **Digital Trigger** – Allows a digital trigger condition to be set from within the oscilloscope using an easy-to-understand interface.
- **Digital Channels** – Provides a standard, general purpose setup for defining the digital channels and displaying digital lines.
- **Digital Threshold Setup** – Provides the means to define a logic threshold for digital trace calculation.

The MS-32 Hardware and Software requires no traceable calibration or adjustment. However, the oscilloscope that is used with the MS-32 does require periodic calibration and adjustment.

## Accessories

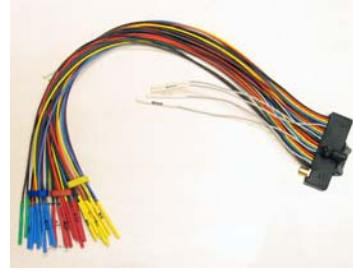
Various accessories are also available to use with the MS-32. These are listed below:

- **MS-32-STDLEADS 10.5" (26.67 cm) Digital Lead Set** – An additional standard digital lead set. This might be convenient to have if you have more than one device under test and do not wish to disconnect/reconnect your cables to use the MS-32 on different DUTs.



## MS-32 Oscilloscope Mixed Signal Option

- **MS-32-STDLEADS-L 14" (35 cm) Digital Lead Set** – A slightly longer digital lead. Maximum digital clock frequency with this lead set is 25 MHz.
- **PK400-1** – Large gripper probe set for 0.10 inch (2.54 mm) pin pitch. Includes 10 probes with color-coded leads.
- **PK400-2** – Medium gripper probe set for 0.04 inch (1.0 mm) pin pitch. Includes 10 probes with color-coded leads.



- **PK400-3** – Small gripper probe set for 0.008 inch (0.2 mm) pin pitch. Includes 10 probes with color-coded leads.



- **MS-32-MICTOR-S** – Mictor connection cable, 3" (7.62 cm) long, 38-pin (32 digital channels).

Note: This cable connection does not allow precise time alignment of analog and digital signals on the oscilloscope.



## MS-32 Oscilloscope Mixed Signal Option

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- **MS-32-MICTOR-L** – Mictor connection cable, 14" (35.56 cm) long, 38-pin (32 digital channels). Maximum digital clock frequency with this lead set is 125 MHz.

Note: This cable connection does not allow precise time alignment of analog and digital signals on the oscilloscope.

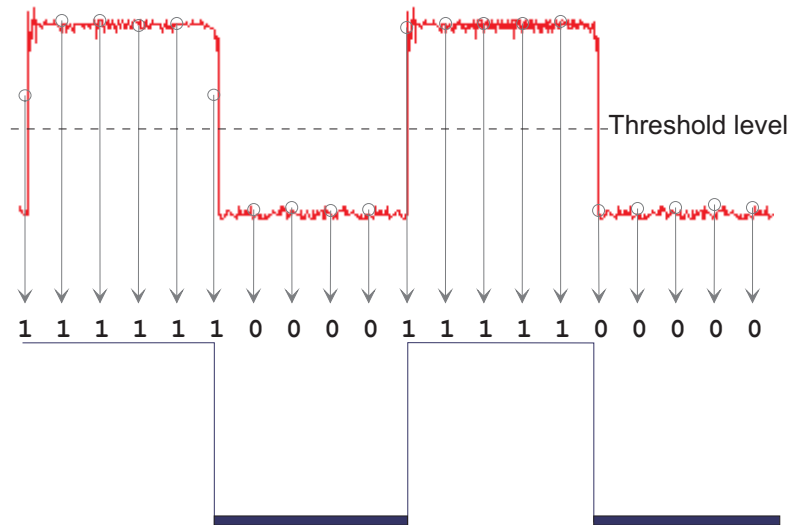


## DESCRIPTION OF OPERATION

The various components of the MS-32 Oscilloscope Mixed Signal Option acquire and store digital data, trigger on digital patterns, interface the external Digital Logic Pod to the oscilloscope, and provide a user friendly interface for control and interpretation of data.

The MS-32 is an external device that digitally samples waveform data at up to 500 MS/s (for 125 MHz digital signals). Unlike a logic analyzer, it operates only in a Timing Analysis mode, so it requires 4x oversampling to determine the correct digital edge position, and does not require the user to input a clock.

While in SINGLE, NORMAL, or AUTO trigger mode, the Digital Logic Pod repeatedly samples each digital channel's voltage level. If the voltage is greater than the threshold voltage, the MS-32 stores a '1' in internal memory. Otherwise, a '0' is stored.



The minimum high voltage level is about 300 mV above the threshold. The maximum low voltage level is about 300 mV below the threshold. The minimum signal swing is 600 mV. The *indeterminate range* of 600 mV around the threshold voltage level is the level below which the MS-32 will not operate. However, the Digital Logic Pod *can* support a signal as low as 600mV only if the input signal's quality is adequate.

The Digital Logic Pod keeps sampling its inputs until the oscilloscope is put into STOP trigger mode. Data is stored in a 1 Mpt internal memory that is periodically transferred to the oscilloscope via the USB2.0 cable. If the oscilloscope is triggering in SINGLE or NORMAL trigger mode, data is acquired and transferred only when the trigger condition is satisfied. The captured data is then displayed on the oscilloscope grid in a time-aligned fashion. If your trigger condition occurs infrequently (approximately <1Hz), you may observe in AUTO trigger mode a non-triggered intermediate acquisition where digital and analog signals are not time-aligned. Switch to "NORMAL" or "SINGLE" to have only triggered (and thus time-aligned) acquisitions displayed.

## MS-32 Oscilloscope Mixed Signal Option

**Note:** AUTO trigger mode should be used with caution if you want time-aligned digital and analog data. AUTO trigger mode waits for the defined trigger condition to be satisfied; but, if the trigger condition is not satisfied before a timeout period has elapsed, the trigger will be “forced,” the acquisition will be stopped, and the data will be acquired at that time.

In both “Analog” and “Digital” trigger operation, the timeout value depends on the duration of acquisition, the pre-trigger delay, and the time to arm the analog and digital trigger. The timeout value is not set by the operator, but calculated by the program. It can range from a few milliseconds to seconds. Timeout values are longer during digital trigger operation, since the time required to arm the digital trigger is longer than the time required to arm the analog trigger.

In any trigger mode (AUTO, NORMAL, SINGLE), pressing STOP trigger will cancel the acquisition, which leaves the previously acquired data unchanged.



**If your trigger condition occurs infrequently (approximately < 1 Hz), you may observe in AUTO trigger mode a non-triggered intermediate acquisition where digital and analog signals are not time-aligned. Switch to "NORMAL" or "SINGLE" to have only triggered (and thus time-aligned) acquisitions displayed.**

The Digital Logic Pod both samples incoming data and searches for trigger conditions. When the trigger condition is met, the Digital Logic Pod outputs a pulse at the TRIG OUT connection and is input to the oscilloscope through the Oscilloscope Interface Module (OIM). This pulse occurs roughly 15-30 ns after the trigger condition is met. The pulse has a 500 mV normal level, with a minimum level of 0 V and maximum level of 1 V. The oscilloscope actually triggers on this physical signal edge.

The USB2.0 cable provides downloading of trigger conditions from the oscilloscope to the Digital Logic Pod, and uploading of digital data from the Digital Logic Pod to the oscilloscope.

The Oscilloscope Interface Module (OIM) contains intelligence to identify the Digital Logic Pod to the oscilloscope, and transmits the trigger edge to the oscilloscope input. As part of its “identification” function, the OIM does the following when it is plugged into a channel or the EXT input on the oscilloscope:

- If the OIM is connected to External, it sets the oscilloscope trigger to a positive going edge with a pre-defined trigger level (to trigger on the output pulse when the digital trigger condition is met) and no trigger holdoff condition. If the OIM is connected to a channel, the same settings are made with the exception that Vertical Scale is set to 200 mV/div, and Vertical Offset is set to -500 mV.
- Sets the Analog/Digital Trigger Mode to “Digital” and the trigger source to the input that the OIM is connected to (either a channel or external).
- Sets the timebase to 100 ns/div by default.
- Sets the oscilloscope AUX output to “Trigger Out.”
- Sets the Trigger Mode to “Auto.”
- Sets the Display Grid to “Single” grid.
- Turns on the Digital1 trace



- Displays the Digital Trigger dialog so that it is quick and easy to set up the Digital trigger.
- Automatically applies an acquisition dependent deskew (time shift of the signal) of roughly 70 ns to all of the analog channels (except the one that the OIM is connected to) when the oscilloscope is set to Digital Trigger and the trigger mode is set to NORMAL or SINGLE. This ensures that digital and analog signals are time correlated. When the OIM is disconnected, the deskew is set back to zero seconds.

When the oscilloscope is SINGLE or NORMAL triggered, there are sophisticated algorithms that time align the digital and analog signals on the oscilloscope grid. When the Analog/Digital Trigger Mode is set to "Digital", the algorithm adds the following times:

- The internal propagation time of the Digital Logic Pod from the time the trigger condition is satisfied to the time the trigger pulse out appears
- The propagation time on cables through the OIM to the oscilloscope input.

When the Analog/Digital Trigger Mode is set to "Analog," the algorithm adds the following times:

- The internal propagation time from internal oscilloscope trigger to the oscilloscope AUX output
- The propagation time through the OIM cable to the Digital Logic Pod dedicated input for analog trigger.



**If your trigger condition occurs infrequently (approximately < 1 Hz), you may observe in AUTO trigger mode a non-triggered intermediate acquisition where digital and analog signals are not time-aligned. Switch to "NORMAL" or "SINGLE" to have only triggered (and thus time-aligned) acquisitions displayed.**

# MS-32 Oscilloscope Mixed Signal Option

## GETTING STARTED WITH THE MS-32

### Overview

The MS-32 is a complete system that interfaces to the oscilloscope in a number of ways that make it easier to do the following:

- Choose between analog and digital trigger conditions.
- View all analog and digital signal information on the oscilloscope grid, with all signals time-correlated.

All setup is done in the user-friendly oscilloscope dialogs – it is not required to leave the oscilloscope software to run the MS-32. All normal oscilloscope tools (cursors, measurement parameters, etc.) are available for use with the digital signals.

There are a number of physical connections that must be made to ensure proper operation, but the connection is intuitive and is documented below.

Operation of the WaveRunner or WaveSurfer oscilloscope is not covered in this manual. Reference the on-Line Help or Getting Started Manual for each oscilloscope for complete information on analog triggering, display of analog signals, front panel operation, etc.

### Connecting the MS-32 System to the Oscilloscope

Connect the MS-32 System to the Oscilloscope as follows:

1. Connect the MS-32 Power Supply to the Digital Logic Pod and a power outlet. The “PWR” LED should be lighted.



**Use only the 12 V, 2.5 amp, 30 W transformer provided with the MS-32.**



2. Connect the MS-32 Digital Lead Set to the Digital Logic Pod. Tighten the captive screw to make this connection secure. The lead sets can be connected or removed while the Digital Logic Pod has power. However, the lead sets should not be connected or removed while the Digital Logic Pod is acquiring or triggering.



3. Connect the USB2.0 Cable to one of the oscilloscope's PC-USB2.0 ports.



**The MS-32 Digital Logic Pod does not use power from the USB. Therefore, the power adapter *must* be connected before the USB will recognize the device. The USB cable can be connected first, but the Digital Logic Pod will not be detected until the power is also connected.**



## MS-32 Oscilloscope Mixed Signal Option

4. Connect the other end of the USB2.0 Cable to the MS-32 Digital Logic Pod.



5. Connect the MS-32 Oscilloscope Interface Module (OIM) to the EXT input of the oscilloscope. Make sure that the top (OIM labeled side) is facing up. (Note: make sure that the OIM is at a right angle to the connector when inserting).



6. Connect the SMB plug from the OIM to the Digital Logic Pod SMB receptacle/jack that is labeled TRIG OUT



**When disconnecting the SMB plug from the lead set, disconnect the lead set from the Digital Logic Pod first.**



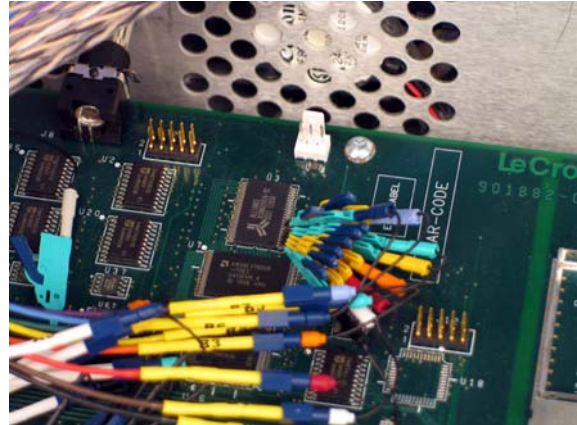
7. Connect the BNC plug from the OIM to the Auxiliary Output on the back of the Oscilloscope



8. Connect the SMB jack from the OIM to the SMB plug on the MS-32 Digital Lead Set.



9. Connect the Digital Leads to the digital lines you wish to observe (using accessory micro-grippers, as necessary or desired).



## MS-32 Oscilloscope Mixed Signal Option

10. Connect the Digital Lead Set ground leads to the ground plane of your device under test. Use the following rules to ensure correct grounding:

- Use the shortest ground lead possible.
- Use the ground lead closest to the digital lines that ground relates to.
- If the ground plane is a pin on an IC, use the ground pin closest to the digital lines that ground relates to.



**Connect at least one ground lead to the test circuit's ground. Connecting several ground leads is even better.**

### Verifying Proper MS-32 Connection to your Oscilloscope and the Device Under Test

The MS-32 Digital Logic Pod has two LEDs on the front of the module. These LEDs will light to indicate proper operation. The LEDs will light as follows:

LED	Indication
PWR	Lit when the Digital Logic Pod is connected to Power
RUN	Flashes when a digital trigger is satisfied in either SINGLE, NORMAL, or AUTO oscilloscope trigger mode

If you are concerned that your digital signals aren't being displayed correctly, it is a good idea to check by viewing the digital signals one at a time with an analog channel. This can point out errors in your connection or in your logic threshold setup.

If you see an error message like this:

“No connection to MS-32 trigger output”

then you need to make sure that the OIM is firmly connected to a channel or to the EXT input.

### The Complete System Connection

When your system is completely connected, it will look like the photo and drawing that follows:



It is usually easiest to debug digital line connection or display problems by viewing the digital information on an analog channel to confirm it's presence, then working back through the sequence above to determine where the connection or display error is.

### Digital Connections

Handle with care!

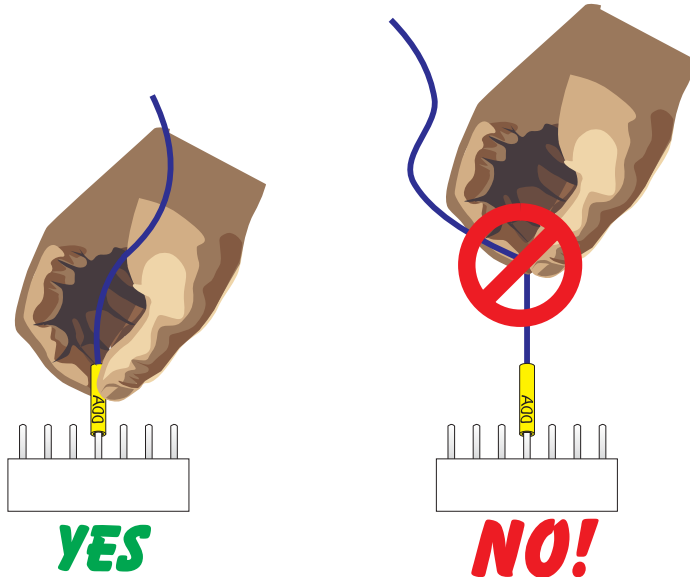


**The MS-32 Digital Lead Set connectors are fragile. Pull the connector base, not the wire. Never bend the connectors.**

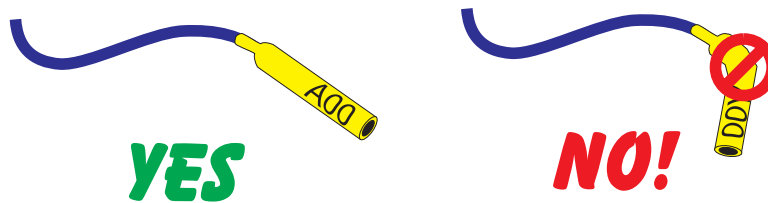
## MS-32 Oscilloscope Mixed Signal Option

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**Pull the connector base,  
not the wire...**



**... and NEVER bend the connectors!**

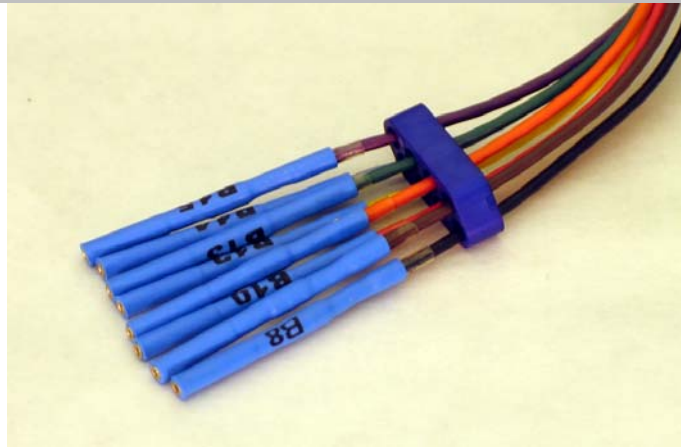


**The connectors are durable and  
well-made, but not indestructible!**

### **Group Colors**

The 32 channels are divided into four physical groups of 8. Each group is bundled and colored. On the lead set, the plastic separator-blocks and terminators match the group color.

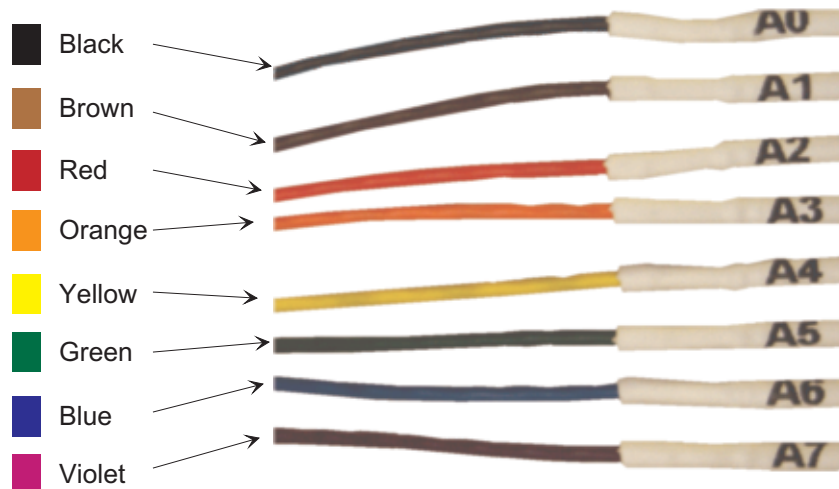




Note: The grouping you assign to the digital lines in the software interface can be different than the physical grouping of digital lines. The physical grouping is for easy identification only of all 32 digital lines.

### **Line Colors**

The wires in each color group use 8 repeating colors



The color sequence corresponds to the resistor color code to make it easy to know the digital line number without having to look at the label.

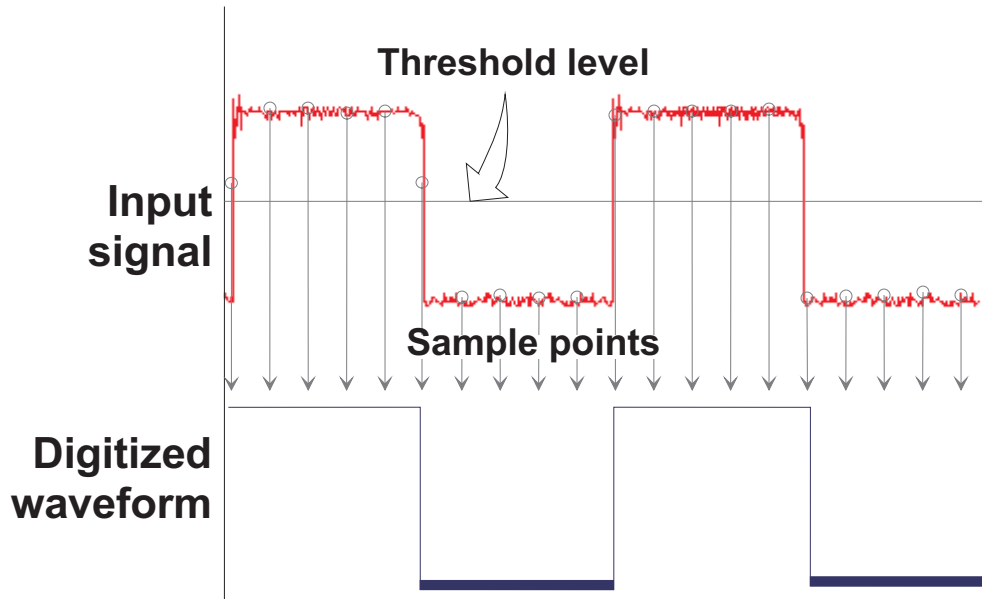
### **Standard Output Connection**

The standard terminations on the digital lead sets can be pushed directly onto 25-mil pins. MicroGrippers or NanoGrippers may also be used to probe the test circuit's pins. LeCroy provides a selection of small, medium, and large grippers for various pitch sizes. A more complete selection of adapter probes is available for most chips from Emulation Technology Inc., Yamaichi Inc., and other manufacturers.

## MS-32 Oscilloscope Mixed Signal Option

### Threshold Levels

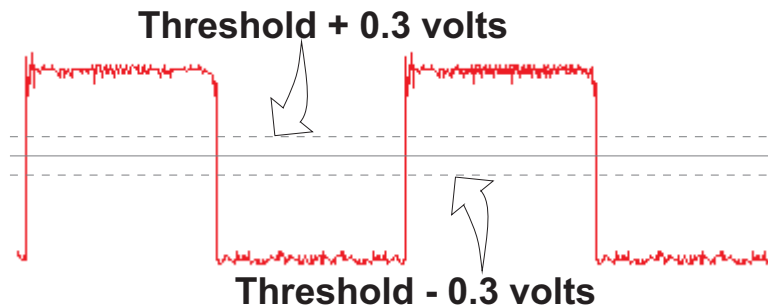
The threshold level determines how the input signal is interpreted. The threshold level can be set in either the Digital Setup or Digital Trigger Setup dialogs (it is the same setup, but is in two different places for operator convenience). Input voltages less than the threshold are converted to '0'. Input voltages greater than the threshold are converted to '1'.



The threshold levels can be set between  $-4.90$  V and  $+5.27$  V. TTL circuits use a threshold voltage level of  $1.58$  V. ECL circuits use a threshold voltage level of  $-1.39$  V. Other threshold settings are available in the setup dialog.

### Minimum voltage swing

The minimum high voltage level is about  $300$  mV above the threshold. The maximum low voltage level is about  $300$  mV below the threshold. Therefore, there is an *indeterminate range* of about  $600$  mV around the threshold voltage level. Signal quality must be high as the  $600$  mV swing is approached.



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### **Basic Oscilloscope Operation**

For information on using the oscilloscope to view analog signals, reference your oscilloscope on-line Help system.

## MS-32 Oscilloscope Mixed Signal Option

### ACCESSING THE MS-32 OSCILLOSCOPE MIXED SIGNAL OPTION TOOLSET

#### Overview

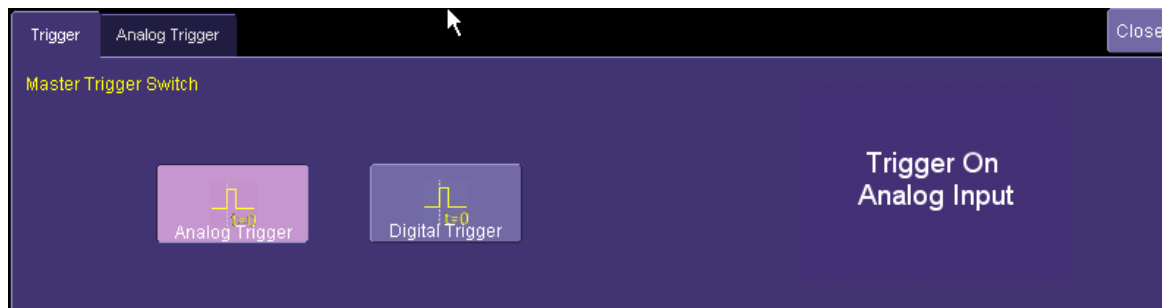
MS-32 trigger and digital line display tools are easily accessible in a variety of ways. The MS-32 option adds additional dialogs (menus) to the existing oscilloscope. These dialogs are defined below:

- Analog/Digital Trigger Mode – allows selection of either an analog trigger condition setup or a digital trigger condition setup.
- Digital Trigger setup – allows set up of the digital trigger condition.
- Digital setup – allows set up of the Digital lines and definition/display of parallel buses. These dialogs are roughly analogous to the analog Channel setup dialogs in terms of how they are accessed and how they operate in software. However, there are no dedicated front panel controls for digital channels as there are with analog channels.
- Logic Setup – allows setup of the logic threshold value that defines the digital trace.

When the MS-32 OIM and Digital Logic Pod are connected to the oscilloscope, these dialogs are conveniently accessed with just one or two touches of the screen, making adjustment fast and easy.

#### Oscilloscope Analog Trigger and MS-32 Digital Trigger

A standard WaveRunner or WaveSurfer oscilloscope only allows Analog triggering. The addition of the MS-32 option adds Digital triggering, and a selection for either Analog or Digital triggering. This selection dialog is shown below:



To operate the oscilloscope with a normal analog trigger, simply select “Analog Trigger” in the dialog, and then set up the Analog trigger by touching the Analog Trigger tab, and making the appropriate selections. For more information on setting up an Analog trigger, consult your oscilloscope on-line Help or Getting Started Manual.

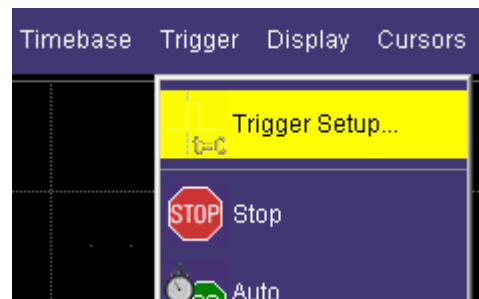
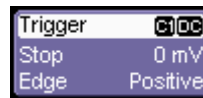
When the MS-32 OIM is connected to the oscilloscope, the trigger will default to Digital Trigger, and the Digital Trigger tab will automatically be displayed on the oscilloscope display. If you don't wish for it to be displayed, you can simply touch “Close” to close the dialog. Or you can select the Trigger tab and select an Analog Trigger instead (in which case the Analog Trigger tab will appear in place of the Digital Trigger tab).

As a convenience to the operator, the Digital Logic Setup dialog is displayed in both the Trigger dialogs and the Digital dialogs. Logic Setup is where you can set the crossing threshold for determining whether the logic level is a 1 or a 0.



Other ways to access the MS-32 Trigger dialogs are listed below:

1. Touch the Trigger descriptor button. If the MS-32 OIM is connected to the oscilloscope, the dialog will default to the Digital Trigger tab. Follow the instructions above to select either an Analog or Digital trigger.
2. Touch Trigger in the menu bar, and select Trigger Setup. Then select either an Analog or Digital trigger (as required).



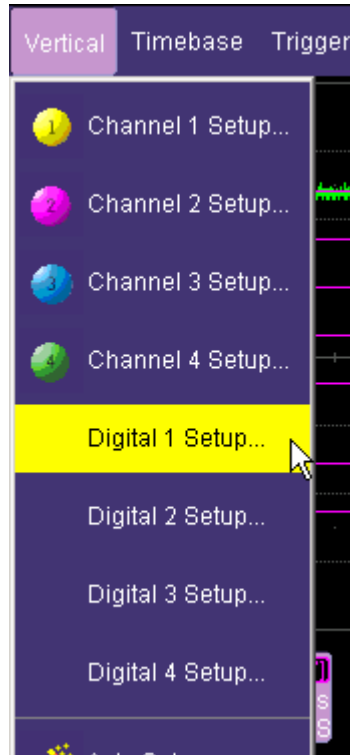
### Digital Trace Groups

These dialogs provide the ability to define up to 4 different groups of digital signals, and associate from 1-32 digital lines with each group. Digital lines may be associated with more than one group. As a group, the signals can be resized, repositioned, named, stored to memory, collapsed into a bus trace/value, or moved to a different grid (WaveRunner 6000 Series only).

You can access these dialogs at any other time by following the instructions below:

## MS-32 Oscilloscope Mixed Signal Option

1. Touch Vertical in the menu bar, and select one of the four Digital traces. This will turn the Digital trace ON, and open the dialog box for that Digital trace.



2. If the Digital trace is already ON (i.e., the background color is light magenta), you can configure the setup dialog for that Digital trace.
3. The Digital descriptor boxes contain information about the Digital Sample Rate (top line) and the maximum number of digital samples (bottom line).



## DIGITAL TRACE GROUP SETUP

Digital trace groups are very similar to analog channels – they can be turned ON or OFF, they can be increased in size, and they can be positioned on the grid. You can also store them as waveform files. In software, they are accessed through the same Vertical dialog as analog channels. Cursors and most timing measurements work with Digital traces also.

Notable differences include the lack of sampling information in the trace data, and the lack of dedicated front panel controls (though some front panel controls double as position and size controls when the Digital trace group is active).

However, Digital trace groups have capability far beyond that of an analog channel. Each Digital trace group can consist of 1-32 digital lines. You can create up to four Digital trace groups, and each digital line can be used in as many or as few groups as desired. You can choose to display the group of digital lines as individual digital traces (one per line), or as a “collapsed” bus with bus data values calculated on screen within the bus trace. Since there are so many digital lines, Digital lines or buses can be renamed so that it is easier to keep track of the multitude of digital signals on the screen.

### Digital Trace Group Dialog

Below is the Digital trace group dialog with an overview of its operation:

The screenshot shows the 'Digital1 Logic Setup' dialog. It features a 'Trace On' checkbox (checked), 'All Lines OFF' and 'All Lines ON' buttons, and a 'Change Line Name' field. A row of checkboxes labeled A7 through A0 allows selecting individual digital lines. Below this is a summary view of 32 digital lines (B15 to A0) with checkboxes. On the right, there are controls for 'Vertical Position' (650e-3), 'Size' (900e-3), 'Bus Name' (Digital1), and buttons for 'Collapse', 'Expand', 'Store', and 'Next Grid'. Five red arrows point from callout boxes to specific controls: 'Trace On', 'Change Line Name', an A4 checkbox, the summary view checkboxes, and the left arrow button.

Turn the Digital trace group ON or OFF, just like a Channel

Change Digital Line name by touching this box



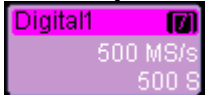

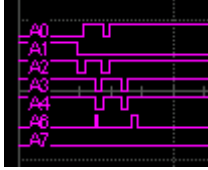

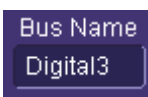
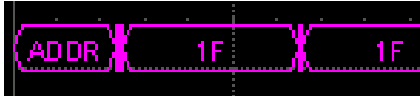
Add a digital line to the Digital trace group by checking this box

Click on these boxes with a mouse, or just use them as a summary view


Use the arrow buttons to scroll through all 32 digital lines

Additional capability is described in the table below:

## MS-32 Oscilloscope Mixed Signal Option

	<p>Provides a method to quickly turn all digital lines in the Digital trace group OFF or ON. The default is for all digital lines to be ON. As lines are turned OFF, they will automatically resize to take up more of the grid and be easier to see.</p>
	<p>There are no dedicated front panel controls for Digital line position or size. However, you can touch these controls twice and enter in a unitless value for position and size using the pop-up keypad. Or you can touch them once, and use the front panel adjust knob to adjust the value. Another way is to make the Digital trace group “active” by touching the descriptor box once</p>  <p>and then using the front panel vertical zoom controls (WaveRunner 6000) or channel controls (WaveSurfer) to adjust the position and size.</p>
	<p>You can view a group of digital traces as individual lines (Expand mode), like this:</p>  <p>Or collapsed into a bus (Collapse mode), like this:</p>  <p>Just select the appropriate button to get the view that you want.</p>
	<p>You can rename the “collapsed” bus so as to more easily identify it when it is on the oscilloscope grid. For instance, if we were to name Digital1 as “ADDR”, it would appear as follows on the grid:</p> 

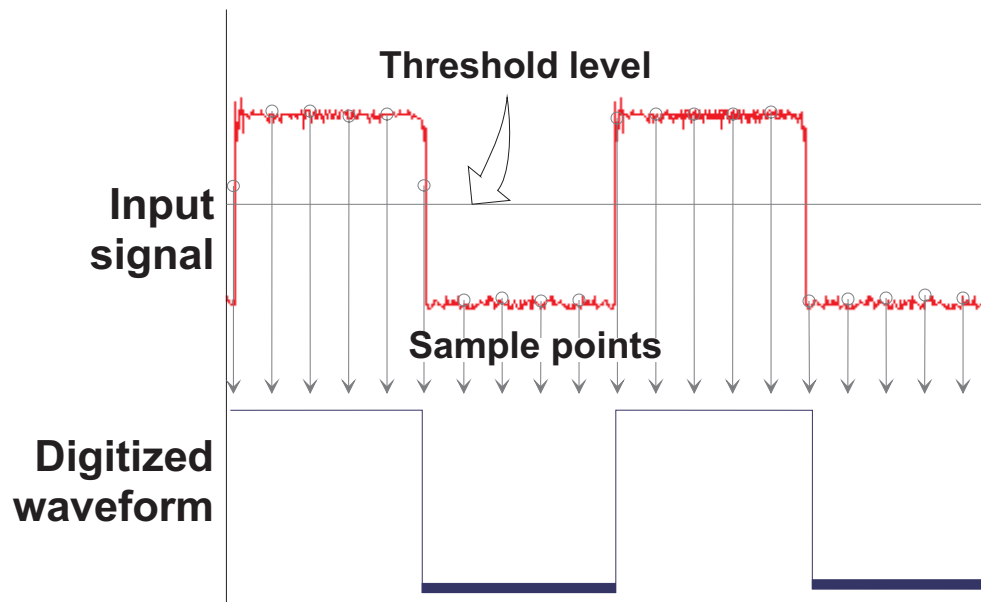


	<p>Where ADDR appeared on the far left side of the grid. Very long bus names can be used, but the longer the name, the more bus data will be obscured.</p>
	<p>You can store a Digital trace group to memory, or move it to another grid, just like you would a Channel. These controls function identically for Channels and Digital trace groups.</p> <p><b>Note:</b> WaveSurfer does not have the Next Grid capability.</p>

## Digital Logic Threshold Setup

### Overview

The threshold level determines how the input signal is interpreted. The threshold level can be set in either the Digital Setup or Digital Trigger Setup menus (it is the same setup, but is in two different places for operator convenience). Input voltages less than the threshold are converted to '0'. Input voltages greater than the threshold are converted to '1'.

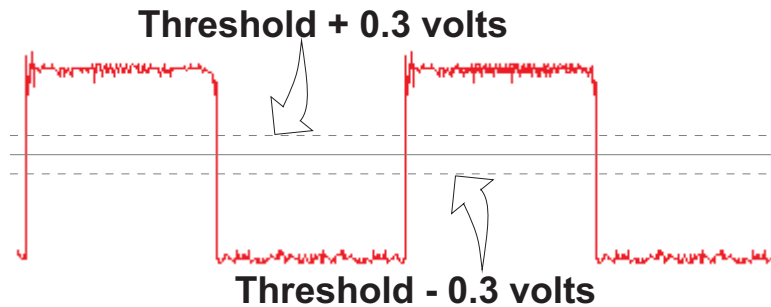


The threshold levels can be set between -4.90 V and +5.27 V. TTL circuits use a threshold voltage level of 1.58 V. ECL circuits use a threshold voltage level of -1.39 V. Other threshold settings are available in the setup dialog.

The minimum high voltage level is about 300 mV above the threshold. The maximum low voltage level is about 300 mV below the threshold. Therefore, there is an *indeterminate range* of about

## MS-32 Oscilloscope Mixed Signal Option

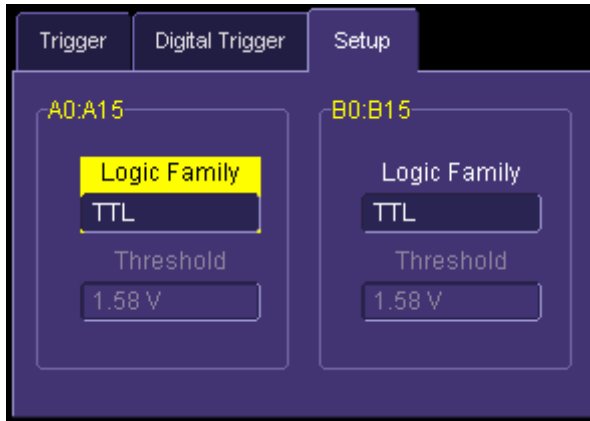
600 mV around the threshold voltage level. Signal quality must be high as the 600 mV swing is approached.



### Digital Logic Setup

The Digital Logic Threshold Setup dialogs are contained in two places: in the Trigger dialogs and in the Digital Setup dialogs. A selection made in one location will affect the value in the other location. Two different logic levels can be selected: one level can be set for the Ax lines and a different level can be set for the Bx lines. When connecting your lines, make sure that all lines with like levels are connected to the same set of 16 digital lines.

Touch the Logic Setup tab to view the dialog shown below:



You can select various Logic Families, or select User Defined and define a custom threshold crossing. Touch inside the Logic Family selection to view a selection list.



If you select User Defined, then you will be able to define the voltage level. Otherwise, the Voltage Level selection will be grayed out.

# MS-32 Oscilloscope Mixed Signal Option

## DIGITAL TRIGGER SETUP

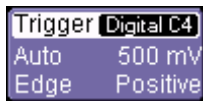
### Overview

MS-32 Oscilloscope Mixed Signal Option has a very powerful and flexible Digital trigger, but it is also very easy to set up for basic triggering. Connecting the MS-32 Digital Logic Pod to your circuit is described in the preceding chapters. This is a requirement in order to be able to digitally trigger.

When the MS-32 option is loaded onto the oscilloscope, an additional trigger dialog is created. This trigger dialog permits you to switch between an analog trigger or a digital trigger, and is shown below:






If you touch Analog Trigger, an Analog Trigger tab will appear. To set up an Analog trigger, reference your oscilloscope's on-line Help or printed Getting Started Manual. If you touch Digital Trigger, a Digital Trigger tab will appear, and the Trigger Descriptor Box will indicate the source as **Digital \*\*\***, with \*\*\* representing the channel or external input that the Oscilloscope Interface Module is plugged into. Reference the picture below:



### Creating a Digital Trigger Condition

There are three different ways to trigger digitally. They are listed below:

	<b>Logic</b> – permits creation of a simple or complex digital trigger condition with a mix of 0, 1, rising edge, falling edge, either edge, or don't care conditions on up to 32 digital lines.
	<b>Logic Bus</b> – permits creation of a digital trigger that corresponds to a hexadecimal bus value for up to 32 digital bits.
	<b>Interval</b> – triggers when a positive or digital edge of a digital signal reoccurs within a specified time period.

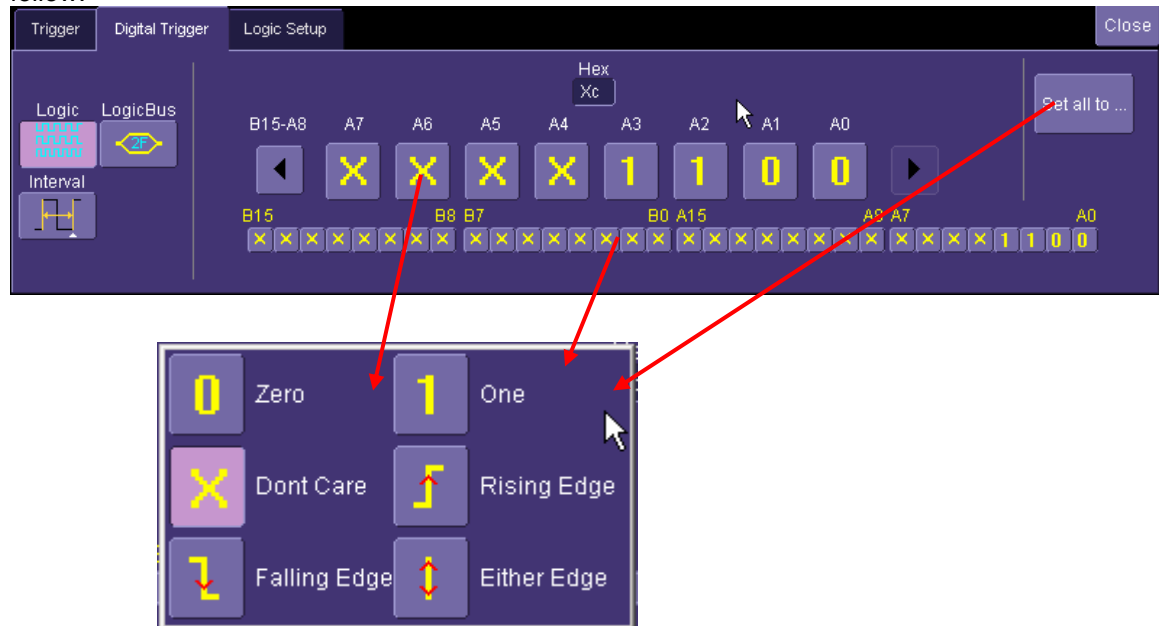
**Note:** The digital logic and logic bus trigger is roughly analogous to the analog pattern trigger in the LeCroy oscilloscope. Since it is not an "edge" trigger, it will trigger when the pattern is satisfied. This may be at the beginning of, in the middle of, or near the end of the pattern.



**If your trigger condition occurs infrequently (approximately < 1 Hz), you may observe in AUTO trigger mode a non-triggered intermediate acquisition where digital and analog signals are not time-aligned. Switch to "NORMAL" or "SINGLE" to have only triggered (and thus time-aligned) acquisitions displayed.**

## Digital Logic Trigger Setup

The Digital Logic Trigger dialog, with detail on some of the setup conditions, is shown in the images that follow:



To select a value for any of the digital lines, touch the existing value (using your finger, or use a mouse pointer) to open the pop-up menu with a list of choices, and select one of the choices. Alternatively, you can set a hex value by byte (or view what the resulting hex value is). Touch the arrow buttons to scroll to the next group of eight digital lines. Note that you may set a digital line to any value in the Logic trigger setup even if it is not defined as part of a Digital group.

**Note:** You may set a digital line to any value in the Logic trigger setup even if it is not defined as part of a Digital group.

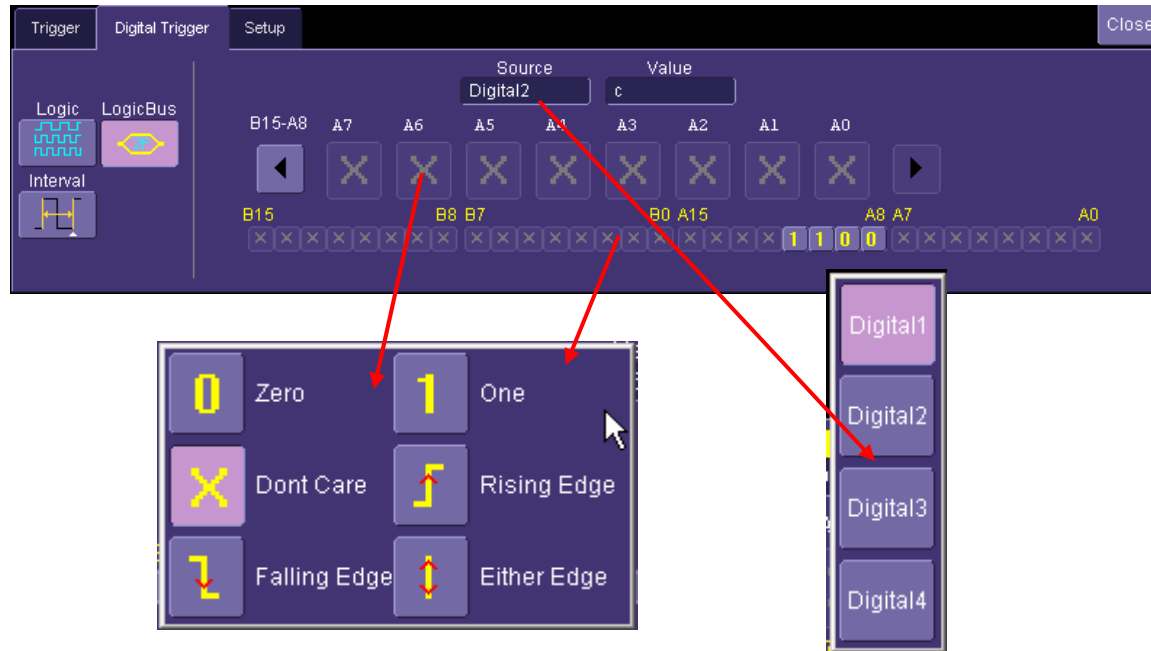
**Note:** You can set multiple digital lines to different edge conditions. However, the edge conditions will always be grouped

# MS-32 Oscilloscope Mixed Signal Option

in an OR trigger condition.

## Digital Logic Bus Trigger Setup

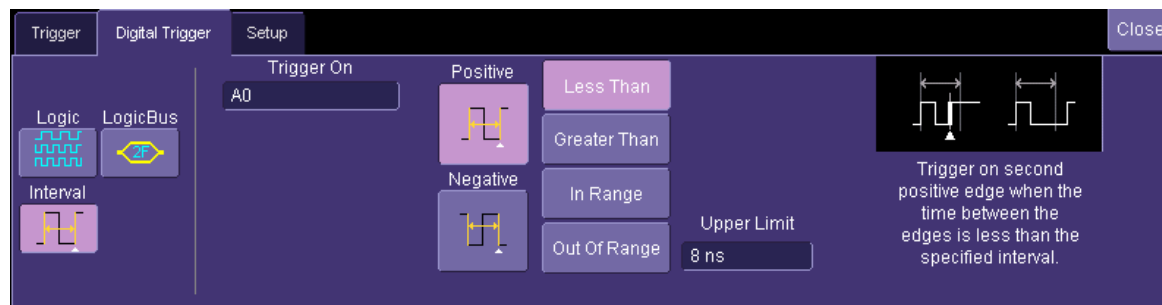
The Digital Logic Bus Trigger setup dialog is shown below:



The Digital Logic Bus trigger dialog is very similar to the Digital Logic trigger dialog. The main difference is that you have to select a Digital source (Digital1, Digital2, Digital3, or Digital4). In addition, only those bits that are defined to be part of that Digital group are allowed to be defined in the Logic Bus setup dialog. A hexadecimal data value can be entered directly, or read as a result of the binary setup.

## Digital Interval Trigger Setup

The Digital Interval Trigger setup dialog is shown below:

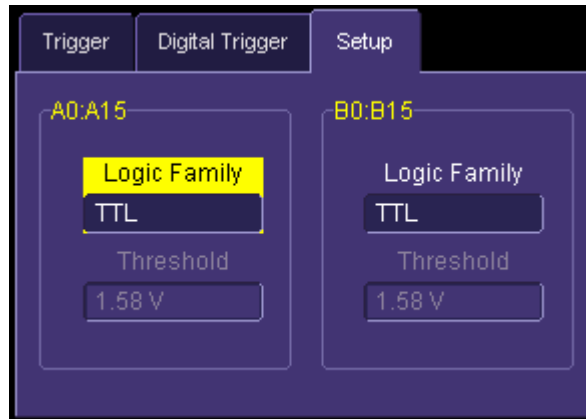


The setup for this case is fairly straightforward. Simply select a digital channel, then define the slope, the time interval, and the condition in which a second occurrence of that digital channel should occur.

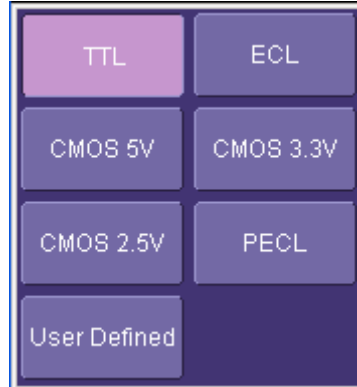
### Digital Logic Threshold Setup

The Digital Logic Threshold Setup dialogs are contained in two places — in the Trigger dialogs and in the Digital Setup dialogs. A selection made in one location will affect the value in the other location. Two different logic levels can be selected — one level can be set for the Ax lines and a different level can be set for the Bx lines. When connecting your lines, make sure that all lines with like levels are connected to the same set of 16 digital lines.

Touch the Logic Setup tab to view the dialog shown below:



You can select various Logic Families, or select User Defined and define a custom threshold crossing. Touch inside the Logic Family selection to view a selection list.



If you select User Defined, then you will be able to define the voltage level. Otherwise, the Voltage Level selection will be grayed out.

# MS-32 Oscilloscope Mixed Signal Option

## CHARACTERIZE DIGITAL OR MIXED SIGNAL SYSTEM PERFORMANCE

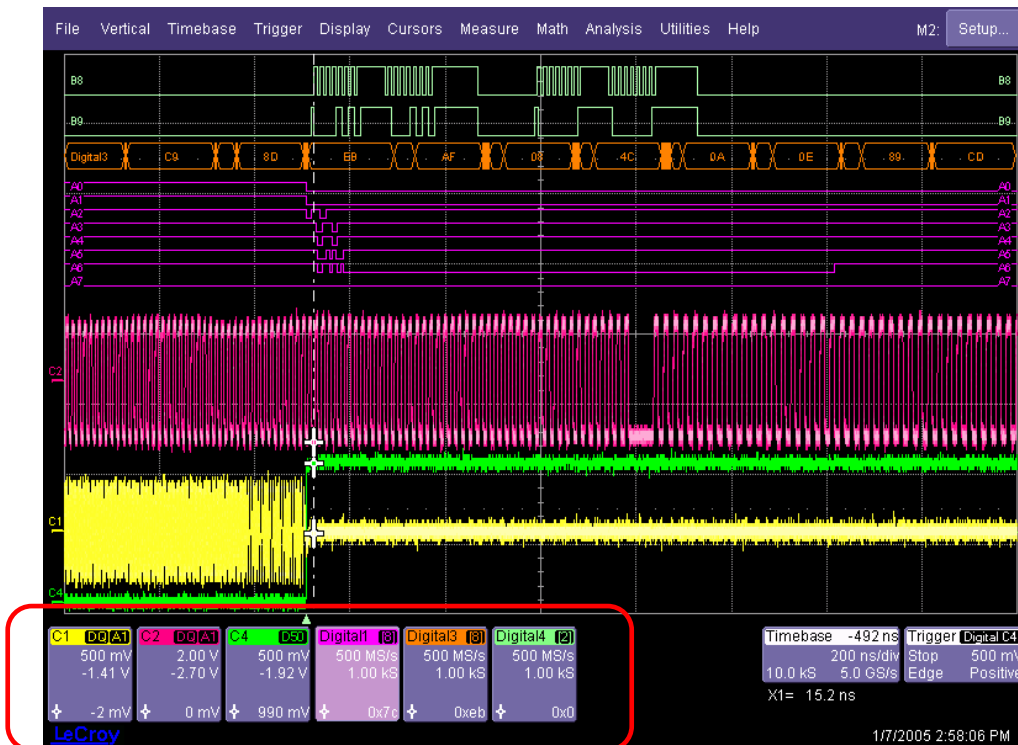
### Overview

The oscilloscope contains a number of built-in tools, such as cursors, measurement parameters, statistics, and optional graphical analysis tools that will allow you to characterize your DUT's performance. The number and type of these tools will change depending on whether you are using a WaveRunner or a WaveSurfer oscilloscope, and what other software options are loaded on your oscilloscope. These can be used on the Digital traces and buses just like they are used on any channel.

You may want to use cursors for making single-shot timing measurements, and measurement parameters when you need to accumulate statistical data over many different acquisitions.

### Using Cursors

Use horizontal cursors to mark locations on the waveform where the time measurement should be done, then read the cursor values to establish the measurement. As necessary, adjust the timebase or create zooms of the channel(s) and the Digital trace groups so as to be able to view the signal with enough detail. This is a good method for single-shot / single measurements.



Note that when Horizontal (Time) cursors are ON, the hexadecimal bus values for each Digital trace group will appear in the Digital descriptor box





This can be useful when trying to measure to a specific bus value.

### Using Measurement Parameters

Measurement parameters can be used to make basic timing and other measurements of your digital or mixed-signal system. Basic parameters, such as Delay, Delta Delay, Frequency, Period, Width, and Duty Cycle (not all parameters are available in WaveSurfer) can be used with a digital line as a source.

**Delay** – Time from the trigger to the first transition at the 50% crossing



**Delta Delay** – Time between the 50% crossing of first transition of two waveforms



**Duty Cycle** – Percent of time data is above 50%



**Frequency** – Frequency of every cycle in a waveform at the 50% level and positive slope



**Period** – Period of every cycle in a waveform at the 50% level and positive slope



**Width** – Width measured at the 50% level (can be positive or negative slope)



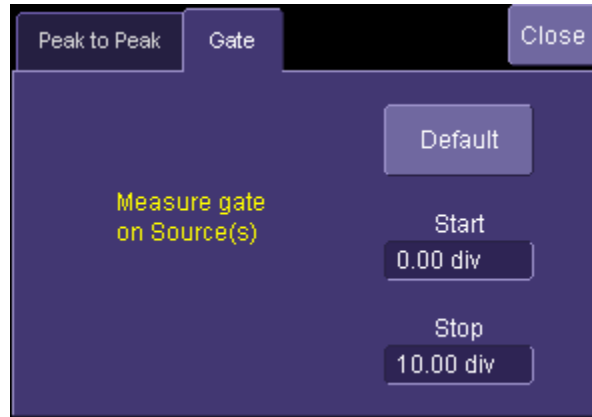
### Measurement Gating

Gating is available on each parameter to allow you to set a measurement window that the parameter should be active in. This allows you to eliminate unwanted portions of the acquisition from your measurement.

## MS-32 Oscilloscope Mixed Signal Option

Select gating from the Measure dialog by selecting the tab for the appropriate measurement (P1, P2, etc.) and then setting the start and stop for the gate. Reference the oscilloscope's on-line Help for more information on how to set gating.

Note: the picture at right is from the WaveRunner 6000 Series. WaveSurfer has similar capability, but is not shown here.



### Using Statistics and Graphing

Statistics and Histicons (WaveRunner 6000 only) allow you to gather numerical and visual information on the distribution of your various measurements.

You can turn on Statistics and Histicons separately in the Measure dialog. Simply touch the appropriate box to checkmark it and turn it ON; or touch it again to turn it OFF.

In addition, some optional LeCroy programs (WaveRunner 6000 only) add capability to produce larger histograms and trends of your measurement parameters. If you have this capability, then you can access it through the Measurement Parameter setup dialog (the Px tab).



## ISOLATE AND ANALYZE SIGNAL ACTIVITY

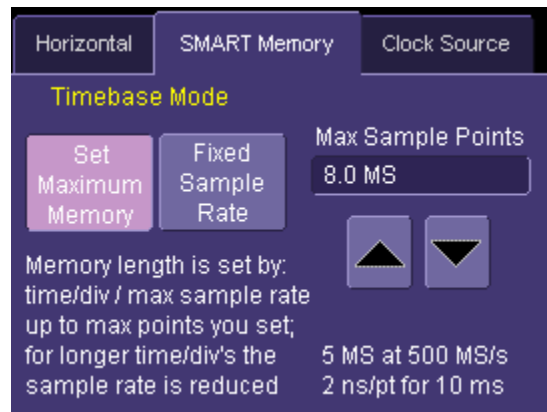
The combination of Analog Triggering, Digital Triggering, Analog Capture, Digital Capture, and normal oscilloscope features is a powerful combination of tools that can make it very easy to find latent HW or SW problems in your circuit. No longer is the oscilloscope a tool just for the hardware engineer. Now the software engineer can also easily visualize the mix of analog and digital signals and relate it to programming code and operation.

Some common mixed signal analysis needs and methods are discussed below:

### Capture Long Pre-Trigger Time

LeCroy oscilloscopes are available with optional very long acquisition memory. For instance, for analog channels, the WaveRunner 6000 oscilloscope can capture up to 12 Mpts on 4 channels, or 24 Mpts on 2 channels. WaveSurfer 400 oscilloscopes can capture up to 1 Mpts on 4 channels or 2 Mpts on 2 channels. The MS-32 option adds 1 Mpts/ch of digital memory. If you wish, all this memory can be 100% pre-trigger, 100% post-trigger, or something in between.

1. Adjust Pre-Trigger and Post-Trigger time by adjusting the Delay knob on the oscilloscope's front panel.
2. Optimize your Sample Rate or Memory Length by accessing the Horizontal Dialog in your oscilloscope and selecting as follows:
  - a. WaveRunner Series - either Set Max Memory mode or Fixed Sample Rate mode.
  - b. WaveSurfer Series – choose a Max Number of Sample Points
3. Note that you must make sure that your timebase setting and memory length combined do not result in too low of a sample rate, or your analog and digital signals may not be acquired accurately.

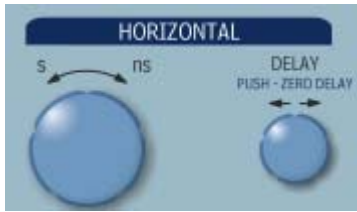


Reference your oscilloscope's on-line Help or Getting Started Manual for more information on these common settings.

# MS-32 Oscilloscope Mixed Signal Option

## Zooming on Your Waveforms

There are a number of ways to zoom a mix of analog and digital signals. The easiest method is to STOP the acquisition and then simply adjust the timebase Time/Div and Delay knobs on the front panel.



Use the Time/Div knob to change the zoom ratio, and the Delay knob to change the position.

**Note:** When you adjust timebase to zoom, the position adjustment is limited by the maximum pre-trigger and post-trigger delay adjustment available in your oscilloscope. Reference your oscilloscope manual for specifications for these delays.

You can also zoom by drawing a box with a mouse pointer around the area that you wish to zoom. Follow these steps:

1. Select the area you wish to zoom by “drawing a box” around it with a mouse pointer.



- If you wish to view all analog and digital traces zoomed together, select “All Digital and Channels” in the pop-up dialog. Otherwise, select any one of the selections.

**Note:** You can only zoom a total of 4 analog/digital traces at a single time. If you have more than 4, and wish to zoom up to 4 together, turn analog channels and digital traces OFF that you do not wish to zoom until you are only displaying 4 traces.

**Note:** WaveRunner 6000A Series zooming is shown here. WaveSurfer zoom pop-up menu is somewhat different.



- A 2<sup>nd</sup> grid is created with the zoomed traces. Use either the zoom control knobs (WaveRunner 6000 Series) or the Vertical/Horizontal control knobs (WaveSurfer 400 Series) to adjust the vertical and horizontal scale and position. Reference your oscilloscope operator's manual for more information.

**Note:** If you choose to zoom “All Digital and Channels”, every signal will be locked in a time-correlated zoom mode, and the horizontal zoom adjustment will be the same for every channel and digital trace.



Reference your oscilloscope's on-line Help or Getting Started Manual for complete information on zooming.

# MS-32 Oscilloscope Mixed Signal Option

## APPENDIX A – SPECIFICATIONS

<b>Digital Channels</b>	
<b>Number</b>	32
<b>Memory</b>	1 Mpts/Ch
<b>Probe Inputs</b>	240 kΩ // 10 pF
<b>Threshold Levels</b>	TTL, ECL, CMOS (2.5, 3.3, 5 V), PECL, or User Defined.
<b>Sampling Rate</b>	1 kS/s to 500 MS/s
<b>Minimum Input Voltage Range</b>	±300 mV around the threshold voltage setting
<b>Digital Channel Grouping</b>	4 digital groups can be defined. Each group may use any combination of 32 digital lines. Groups can be displayed as individual lines, or collapsed into a bus view.
<b>Triggering</b>	User selectable analog (i.e., std. oscilloscope trigger) or digital trigger
<b>Digital Trigger</b>	
<b>Setup Type</b>	Logic, Logic Bus, or Interval
<b>Logic Setup</b>	Up to 32 digital lines, with any combination of 0, 1, or X (don't care). In addition, a Rising Edge, Falling Edge, or Either Edge condition may also be set (note: multiple edges are OR combined).
<b>Logic Bus Setup</b>	Up to 32 digital lines, defined in hexadecimal format
<b>Interval</b>	Define a single digital line, the slope, the condition, and the time period in which the second occurrence of that digital line should occur. Available conditions are <, >, In Range, Out of Range.
<b>Accuracy</b>	+/-1 digital sample (based on digital sample rate)
<b>Certifications</b>	CE Approved. Conforms to EN61326-1 and EN61010-1 (Refer to Declaration of Conformity Page for additional details)
<b>Physical</b>	
<b>Pod Dimensions</b>	3.8" x 6.3" x 1.2" (9.5 x 16 x 3 cm) (W x L x D)
<b>Pod Weight</b>	14 oz. (410 g)
<b>Complete Kit</b>	12.5" x 9.75" x 2.5" (32 x 25 x 6.4 cm) (W x L x D)

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