TELEDYNE LECROY
Everywhere**you**look™

Operator's Manual

MS-250 Mixed Signal Oscilloscope Option

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MS-250 Mixed Signal Oscilloscope Option Operator's Manual

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Welcome

Thank you for purchasing a Teledyne LeCroy MS-250 Mixed Signal Oscilloscope Option.

The MS-250 is a powerful solution for the challenge of measuring multiple, mixed signals in a single oscilloscope. An enhancement to the Teledyne LeCroy oscilloscopes, the MS-250 extends their testing range by adding 18 digital channels for display or triggering.

This MS-250 manual assumes that you have a basic understanding of discrete electronics, logic analyzers, and Teledyne LeCroy oscilloscopes, specifically the model you will use with the MS-250. When necessary, details on specific oscilloscope features are included in this manual.

Contact your nearest Teledyne LeCroy customer service center or national distributor if anything is missing or damaged. We can only be responsible for replacement if you contact us immediately.

Sincerely,

David C. Graef

Vice President and Chief Technology Officer

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Introduction

The MS-250 Mixed Signal Oscilloscope Option is a complete system that adds digital acquisition and triggering capabilities to a Teledyne LeCroy oscilloscope.

Once properly connected to the oscilloscope and the device under test, you will be able to use the oscilloscope user interface for the following:

- **Digital Logic Control**: Set the logic threshold and hysteresis for each lead bank, choosing from standard logic families or entering a custom setting.

- **Digital Group Management**: Combine individual digital lines into bus groups to be managed together. Give lines descriptive logical names, regardless of the physical lead number.

- **Digital Analysis**: Display digital signals as single line traces or collapsed bus traces. Many of the same tools available for analyzing analog signals may be applied to digital signals.

- **Digital and Combined Triggering**: Choose to set an acquisition trigger on a digital signal pattern or a combination of conditions using both analog and digital signals.

The MS-250 is ideally suited for embedded controller testing where there is a proliferation of analog signals coincident with digital signals. You can easily debug signals using standard oscilloscope tools such as cursors, measurement parameters, and zooming. Oscilloscopes compatible with the MS-250 feature large, bright color displays to facilitate signal viewing, plus all the connectivity and documentation capabilities needed to quickly record and distribute information.

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Technical Overview

The MS-250 is an external device that digitally samples waveform data at up to 1 GS/s (for 250 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 MS-250 repeatedly samples each digital channel's voltage level. If the voltage is greater than the threshold voltage, the MS-250 stores a 1 in internal memory. Otherwise, a 0 is stored.
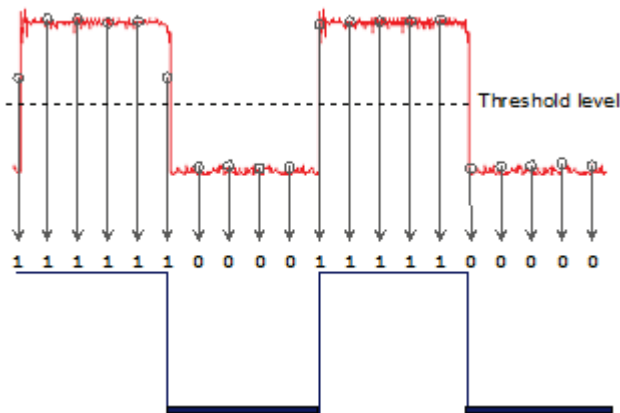
The minimum high voltage level may be defined by the user (using the hysteresis controls) up to 1.4 V above the threshold. The maximum low voltage level may be defined to 1.4 V below the threshold. The minimum signal swing is 100 mV. The indeterminate range of 50 mV around the threshold voltage level is the level below which the MS-250 will not operate. However, the MS-250 can support a signal as low as 100 mV only if the input signal's quality is adequate.

The MS-250 keeps sampling its inputs until the oscilloscope is put into STOP trigger mode. Data is stored in a 50 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 displayed on the oscilloscope in a time-aligned fashion.

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

The USB2.0 cable provides downloading of trigger conditions from the oscilloscope to the MS-250 and uploading of digital data from the MS-250 to the oscilloscope.

Standard Hardware

The MS-250 is delivered with the following hardware:

Part	Description	QTY MS-250
Mixed Signal Accessory	Provides 18-channel digital acquisition and triggering.	1
16" Digital Leadset	Interfaces the MS-250 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 Teledyne LeCroy, and may be connected to the lead set. The lead set is divided into two banks. Each lead within the bank is color-coded (to resistor color-coding standard) and has an individual ground connection. In addition, there are two common ground leads available for use.	1

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Part	Description	QTY MS-250
Bus Cable	1.3m cable to connect Mixed Signal Accessory to the main oscilloscope unit, includes USB2.0 cable. This connection provides timebase synchronization, cross-triggering and power.	1
3" Flexible Ground Lead	Lead for grounding individual digital inputs	5
Ground Extender	Connect to ground port of any digital input and make a simple signal and ground connection to a 0.1" square pin header.	20
Carrying Case		1
Operator's Manual		1

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Accessories

You may purchase these optional accessories separately:

Accessory	Part Number	Description
Digital Leadset	MSO-DLS-18	Additional 16" leadset for inputting lines D0-D17. This can be useful if you have more than one device under test and don't wish to disconnect/reconnect leads.
Large Gripper Probe Set	PK400-1	Large gripper probe set for 0.10 inch (2.54 mm) pin pitch. Includes 10 probes with color-coded leads.
Medium Gripper Probe Set	PK400-2	Medium gripper probe set for 0.04 inch (1.00 mm) pin pitch. Includes 10 probes with color-coded leads.

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Accessory	Part Number	Description
Small Gripper Probe Set	PK400-3	Small gripper probe set for 0.008 inch (0.2 mm) pin pitch. Includes 10 probes with color-coded leads.
Mictor Cable	MSO-MICTOR	Mictor Connection cable, 16" (40.64 cm), 36 channel connector
Interconnect Cable	MSO-3M	Interconnect cable, 16" (40.64 cm), mates with 3M connectors 2520-6002 and 2520-5002.

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Connecting the Mixed Signal Device

Connecting to the Oscilloscope

To connect the Mixed Signal accessory to your oscilloscope:

1. Connect the Bus Cable to the LBUS connector on the oscilloscope. Be sure the head is turned so that the positioning wedge fits into the groove at the top of the connector. Fasten the thumb screws.

2. Connect the USB 2.0 cable (attached to the Bus Cable) to any of the USB ports on the oscilloscope.

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3. Connect the other end of the Bus Cable to the MS-250. Again, be sure to align the wedge and the groove. Fasten the thumb screws.

4. Connect the other end of the USB 2.0 Cable to the MS-250.

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5. Connect the Digital Leadset to the Digital Inputs D0 – D17 connector on the opposite end of the MS-250 and fasten the thumb screws.

NOTE: Each digital line has a ground connection for optimal performance. Two additional ground leads common to the whole leadset are also available.

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Digital Connections

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

Digital Banks

Each 18-channel lead set is divided into two physical banks of 9 leads, and each bank is bundled with a plastic separator.
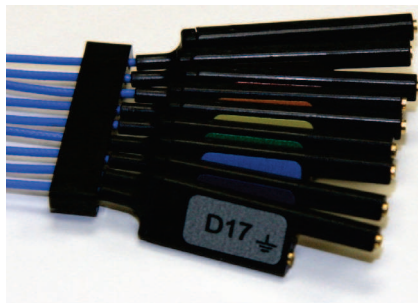
Each lead bank (D0-D7, D8-D15, etc.) will share the same Logic Family (or custom logic Threshold), regardless of how the individual lines are assigned to digital bus groups.

Connector Colors

The leads in each bank use 9 repeating colors. The color sequence corresponds to the resistor color code, making it easier to know the digital line number without having to look at the label.

Standard Output Connection

The standard terminations on the digital leadset can be pushed directly onto 25-mil pins. MicroGrippers or NanoGrippers may also be used to probe the test circuit's pins. Teledyne 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.

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Digital Setup

Digital Logic Setup

Each lead bank requires a Logic Setup to determine the assignment of a 1 or 0, depending on the measured voltage relative to the Threshold.

Threshold Level

The threshold level determines how the input signal is interpreted. Input voltages less than the threshold are converted to 0, while input voltages greater than the threshold are converted to 1.
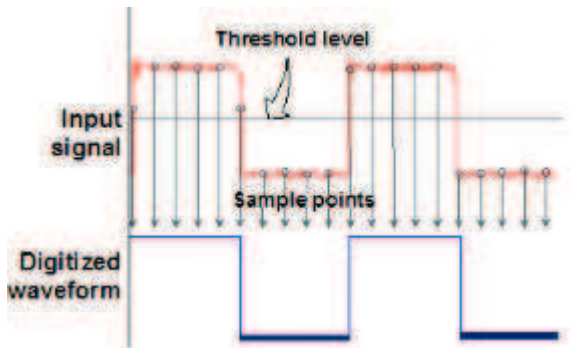
To set Threshold:

1. Go to Vertical > Digital 1 Setup to Display the Digital Setup dialog. Open the **Logic Setup** tab.

2. For each available lead bank, Touch **Logic Family** and either chose one of the standard families or User Defined.

    TTL circuits use a threshold voltage level of 1.58 V. ECL circuits use a threshold voltage level of -1.39 V.

3. If you chose User Defined, enter a custom **Threshold** and **Hysteresis**.

    Custom threshold levels can be set between −10.0 V and +10.0 V.

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Minimum Voltage Swing (Hysteresis)

You can define the minimum high voltage and maximum low voltage levels using the **Hysteresis** controls.

- Minimum high voltage may be set up to 1.4 V above the threshold.

- Maximum low voltage may be set up to 1.4 V below the threshold.

The minimum signal swing is 100 mV. The indeterminate range of 50 mV around the threshold voltage level is the level below which the MS-250 will not operate. However, the MS-250 can support a signal as low as 100 mV only if the input signal's quality is adequate.

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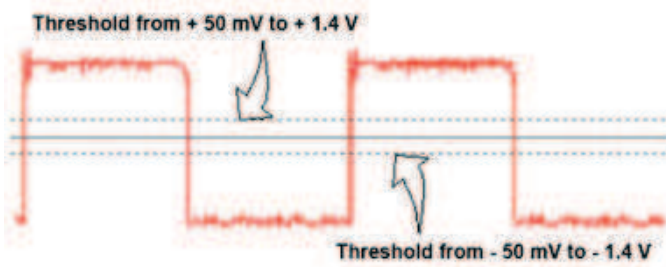
Digital Group Setup

This procedure organizes the digital lines into groups, which correspond to buses. The lines within a single group can be displayed individually, or collapsed into a Bus trace.

You can set up a total of two, distinct groups: Digital1 and Digital2. Each group is designated by its own Digital setup dialog.

Any lines from any lead bank can be combined into a single group, and individual lines can be assigned to as many groups as you wish.

NOTE: While lines can be combined in any way, each lead bank can only have a single logic setup, so be aware of that when choosing lines.

1. Go to Vertical > Digital 1 Setup to Display the Digital Setup dialog.

2. Open the dialog for the group you wish to configure (e.g., Digital1).

3. Check the box for each line to be added to the group. If a line is in a bank other than the one displayed, touch the left or right arrow buttons until that bank is shown on the dialog.

TIP: Use the All Lines Off and All Lines On buttons to quickly deselect/select lines.

NOTE: Along the bottom of the dialog is an indicator for each line in all the lead banks. As you add lines to the group, the indicator is checked, so you can always see all the lines currently in the group. You can also use these checkboxes to select lines.

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Displaying Digital Traces

The **Trace On** checkbox is selected by default, so if you are connected to a live input, you should see digital traces appear as you add lines to the group.

To turn off the trace display, clear Trace On.

⚠️ **CAUTION.** Do not use the All Lines Off or All Lines On buttons to control the display. Doing so will erase your digital group set up. Use the Trace On checkbox to show or hide the traces.

Position Traces

In **Position**, enter the number of divisions (positive or negative) relative to the zero line of the grid where the display begins. The top of the first trace appears at this position.

In **Line Height**, enter the total number of grid divisions each line should occupy. The selected traces (Line or Bus) will appear in this much space.

Individual traces are resized to fit the total number of divisions available. In the example below, each trace takes up one division.

To move the entire group of traces to another grid, touch the **Next Grid** button at the bottom right of the dialog.

NOTE: This button will only appear if your oscilloscope has this capability.

Change Trace Style

When Trace On is enabled, digital Line traces show the state of each line relative to the threshold. You can also view a digital Bus trace that collapses all the lines in a group into their Hex values. At the far right of the dialog, choose to either:

- **Expand** the group into individual line traces. The size and placement of the lines depend on the number of lines, the Vertical Position and Line Height settings.

- **Collapse** the group into a single bus trace.

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Digital line traces 1 division high starting at position 4 (top of grid).

Digital bus trace 1 division high starting at position 4.

Store Display

To store the entire group and display setup to an internal memory, touch the **Store** button at the far right of the dialog. You can recall this setup to the grid in the future by choosing Math > Memory Setup and selecting Trace On for the respective memory.

Renaming Digital Lines

You can give each line a user-defined name to make the interface more intuitive.

1. Touch the **Dx button** immediately below the Dx selection checkbox (the words "Change Line Name" appear at the far left of the row).

2. Use the virtual keyboard that appears on the touch screen to enter a new name. When finished, click **OK**.

    The new line name now appears on the Dx button, instead of the original line number. The number remains over the checkbox.

NOTE: The number of letters that appear will depend on the resolution of your oscilloscope display. Keep names short so lines are easily identifiable.

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Digital Triggering

Setting Up Digital Triggers

To access the Trigger setup dialogs, do one of the following:

- Choose **Trigger > Trigger Setup** from the menu bar

- Press the **front panel Trigger Setup** button

- Touch the **Trigger descriptor box**

The main Trigger dialog contains the trigger type selections.

Other controls will appear depending on the trigger type selection (e.g., Slope for Edge triggers). These are described in the set up procedures for each trigger.

The trigger condition is summarized in a preview window at the far right of the Trigger dialog. Refer to this to confirm your selections are producing the trigger you want.

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Pattern Trigger

Pattern is the default trigger when the Mixed Signal option is connected to the oscilloscope, as these users generally wish to find and trigger upon digital logic patterns.

However, a Pattern trigger can also be set on a user-defined pattern of High or Low voltage levels in analog channels (including the External Trigger input), or a combination of digital and analog patterns when Mixed Signal capabilities are available.

On the Trigger dialog, select **Pattern** trigger type. Open the Digital Pattern dialog to display the controls.
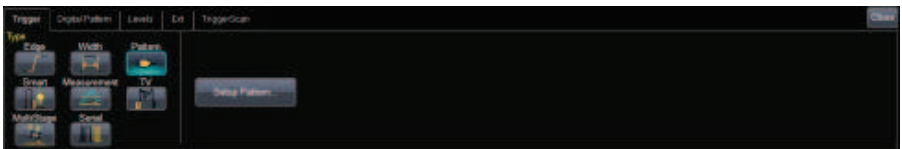
Digital Pattern

The Logic Bus method simplifies pattern set up by utilizing digital groups and logic you have already defined on the Digital Setup dialogs. A digital pattern is set on a single bus (group) manually or by applying a hexadecimal value, while the remaining lines are disabled ("Don't Care").

If you have not set up digital groups, you can set a digital pattern line by line using the Logic method. All available lines remain active for selection.

1. Open the **Digital Pattern** dialog.

2. At the far right of the dialog, choose either **Logic Bus** or **Logic**.

3. Optionally, deselect **Filter Out Unstable Conditions**. This default filter ignores short glitches in logic state triggers that last less than 3.5 ns.

4. If using Logic Bus, touch **Source** and select the digital group. Any lines that are not in this group will now be disabled.

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5. To apply a digital logic pattern, either:

    - Enter the hexadecimal value of the pattern (in **Hex** or **Value**). Lines will take a logical 1, 0, or X ("Don't Care") according to the pattern. Disabled lines will remain X.

    - Touch the **Dx button** for each active line, and select whether it must be High or Low compared to the logic threshold. Depending on your selection, a logical 1 (High) or 0 (Low) now appears on the dialog. Leave X selected for any line you wish to exclude from the pattern. Use the Left and Right Arrow buttons to display lines in other digital banks.

    NOTE: As an alternative to a digital logic pattern, you may set edge conditions on any line. Touch the **Dx button** and choose the edge. Edge conditions always assume a logical OR in the overall trigger criteria.

    TIP: As you work, the checkboxes along the bottom of the dialog will change to show the pattern. You can also use these checkboxes to make selections.

6. If you have not already set a logic threshold, open the **Levels dialog** and select a **Logic Family** for each digital bank from which you've selected lines. To set a custom logic threshold, choose Logic Family User Defined, then enter the **Threshold** voltage and **Hysteresis**.

    NOTE: Digital lines inherit the Logic Setup made when defining digital groups. However, you can change the logic threshold on the Levels dialog, as well. The two settings are linked; they will always reflect whatever was last selected on either dialog. Logic thresholds can only be set per lead bank, not individual line.

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Analog Pattern

1. To add the analog pattern to the digital pattern, leave your digital pattern as is and skip to step 2.

   To create an analog-only pattern, touch **Set All To...** and select **Don't Care**. This will eliminate any meaningful digital pattern and activate all the Boolean operators.

2. Touch the **Left Arrow** button until the C1-EXT group of inputs is displayed in the main section of the dialog.

3. Touch the **Cx button** for each input to be included in the pattern, and select whether it must be High or Low compared to the threshold Level you will set.

   Depending on your selection, a logical 1 (High) or 0 (Low) now appears on the dialog. Leave Don't Care ("X") selected for any input you wish to exclude.

4. Select the Boolean operator (AND, NAND, OR, or NOR) that describes the relationship among inputs (e.g., C1 must be High AND C2 must be Low).

   **NOTE**: Only the AND operator is available when combining analog and digital patterns. In the example above, all digital lines have been set to Don't Care ("X"), so all operators are available.

5. Open the **Levels dialog** and enter the voltage threshold for each input included in the trigger.

6. If you've included EXT as an input, open the **Ext dialog** and enter the **Attenuation**.

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Edge Trigger

Edge triggers upon a achieving a certain voltage level in the positive or negative slope of the waveform. It is the default trigger selection on standard oscilloscopes.

On the Trigger dialog, select **Edge** trigger type to display the controls.
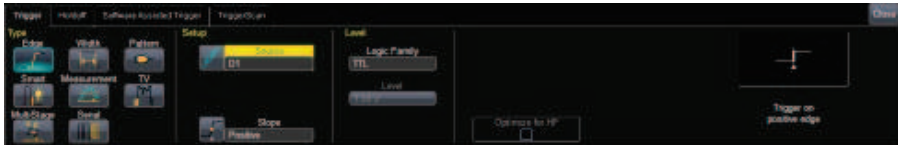
1. Choose the **Source** digital line.

2. Choose the **Slope** (edge) upon which to trigger.

3. Choose the **Logic Family** that marks the High-Low logic threshold. To enter a custom threshold, choose Logic Family User Defined and enter the voltage **Level**.

    NOTE: The Logic Family will default to any Logic Setup associated with that line in a previous digital group setup.

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Width Trigger

Width triggers upon finding a positive- or negative-going pulse width when measured at the specified voltage level.

On the Trigger dialog, select **Width** trigger type to display the controls.

1. Choose the **Source** input line.

2. Choose the line **Polarity** on which to trigger.

3. Choose the **Logic Family** that marks the High-Low logic threshold. To enter a custom threshold, choose Logic Family User Defined and enter the voltage **Level**.

    NOTE: The Logic Family will default to any Logic Setup associated with that line in a previous digital group setup.

4. Use **Width Condition is** settings to create an expression describing the triggering pulse width. This may be:

    - Any width **Less Than** an **Upper Value**.

    - Any width **Greater Than** a **Lower Value**.

    - Any width **In Range** or **Out Range** of values. You may describe the range using either:

        - **Limits**, an absolute **Upper Value** and **Lower Value**.

        - **Delta**, any **Nominal width** plus or minus a **Delta** width.

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Glitch Trigger

Glitch triggers upon finding a fixed pulse-width time or time range.

On the Trigger dialog, select **Smart** trigger type, then **Glitch** to display the controls.

1. Choose the **Source** input line.

2. Choose the **Polarity** on which to trigger.

3. Choose the **Logic Family** that marks the High-Low logic threshold. To enter a custom threshold, choose Logic Family User Defined and enter the voltage **Level**.

   NOTE: The Logic Family will default to any Logic Setup associated with that line in a previous digital group setup.

4. Use **Glitch Condition is** settings to create an expression describing the glitch width. This may be:

   - Any width **Less Than** an **Upper Value**.

   - Any width **In Range** of values marked by the specified **Upper Value** and **Lower Value**.

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Interval Trigger

Interval triggers upon finding a specific interval, the time (period) between two consecutive edges of the same polarity: positive to positive or negative to negative. Use the interval trigger to capture intervals that fall short of, or exceed, a specified range.

On the Trigger dialog, select **Smart** trigger type, then **Interval** to display the controls.

1. Choose the **Source** input line.

2. Choose the **Slope** (edge) from which to measure.

3. Choose the **Logic Family** that marks the High-Low logic threshold. To enter a custom threshold, choose Logic Family User Defined and enter the voltage **Level**.

    NOTE: The Logic Family will default to any Logic Setup associated with that line in a previous digital group setup.

4. Use **Interval Condition is** settings to create an expression describing the triggering interval. This may be:

    -   Any width **Less Than** an **Upper Value**.

    -   Any width **Greater Than** a **Lower Value**.

    -   Any width **In Range** or **Out Range** of values. You may describe the range using either:

        -   **Limits**, an absolute **Upper Value** and **Lower Value**.

        -   **Delta**, any **Nominal width** plus or minus a **Delta** width.

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Dropout Trigger

Dropout triggers when a signal loss is detected. The trigger is generated at the end of the timeout period following the last edge transition that meets the trigger conditions. It is used primarily in single-shot applications with a pre-trigger delay.

On the Trigger dialog, select **Smart** trigger type, then **Dropout** to display the controls.

1.   Choose the **Source** digital line.

2.   Choose the **Slope** (edge) to watch for transitions.

3.   Choose the **Logic Family** that marks the transition threshold. To enter a custom threshold, choose Logic Family User Defined and enter the voltage **Level**.

     NOTE: The Logic Family will default to any Logic Setup associated with that line in a previous digital group setup.

4.   Under **Dropout Condition is...**, enter the time interval after which to trigger if no transition occurs at that Slope and Level.

Qualified Trigger

Qualified arms the trigger on the A event, then fires on the B event. In Normal trigger mode, it automatically resets after the B event. The options for the B event depend on the type of A event. You may apply additional Holdoff by time or number of events.

On the Trigger dialog, select **Qualified** or **MultiStage > Qualified** trigger type to display the controls, depending on your oscilloscope.

Then, on the **Qualified dialog** choose the A and B events.
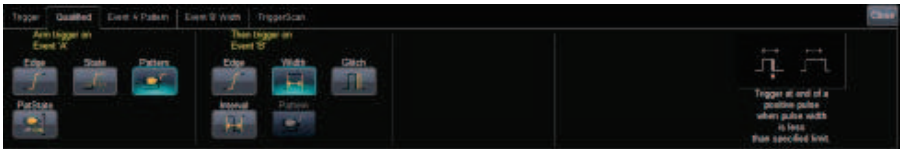
Besides an Edge or Pattern trigger, two special conditions may be selected as the arming ("A") event:

- State, voltage measured above or below a threshold Level.

- PatState, a pattern that persists over a user-defined number of events or time. Like Pattern triggers, PatState events may be analog voltage patterns, digital logic patterns, or a mix of both, depending on the oscilloscope's capabilities.

NOTE: On a standard oscilloscope, Pattern and PatState events will default to the analog pattern setup dialog. On a Mixed-Signal oscilloscope, Pattern and PatState events will default to the digital pattern setup dialog.

Once you've selected the A and B events on the Qualified dialog, set up the conditions on the respective sub-dialogs exactly as you would a single-stage trigger.

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Reference

Returning a Product for Service

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

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

1. Remove all accessories from the device.

2. Pack the product in its case, surrounded by the original packing material (or equivalent). Do not include the manual.

3. Label the case with a tag containing:

    - The RMA
    - Name and address of the owner
    - Product model and serial number
    - Description of failure or requisite service

4. Pack the product case in a cardboard shipping box with adequate padding to avoid damage in transit.

5. Mark the outside of the box with the shipping address given to you by Teledyne LeCroy; be sure to add the following:

    - ATTN: <RMA code assigned by Teledyne LeCroy>
    - FRAGILE

6. **If returning a product to a different country:**

    - Mark the shipment as a "Return of US manufactured goods for warranty repair/recalibration."

    - If there is a cost for the service, list the cost in the Value column and the original purchase price "For insurance purposes only."

    - Be very specific about the reason for shipment. Duties may have to be paid on the value of the service.

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Technical Support

Live Support
Registered users can contact their local Teledyne LeCroy service center at the number listed on our website. You can also request Technical Support via the website at:

teledynelecroy.com/support/techhelp

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