



**LabSmith**  
TOOLS FOR SCIENCE

# **LC220 Logic Controller User Guide**

**Documentation for the LC220™ Controller  
and Trig220™ Control Software v. 1.0**

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# INTRODUCTION

The LC220 is a programmable logic and timing controller for coordinating and synchronizing lab equipment and physical experiments. The LC220 provides clocks, counters, triggers, and many other useful functions, with up to 5 ns resolution and 100 ps accuracy.

As you are well aware, controlling and synchronizing experimental equipment are often the most tedious tasks you'll face in the lab. Experimenters regularly build their own controls from scratch or piece together systems from the limited offerings on the market. The LC220 simplifies your control setup, so you can go about the business of gathering data.

The LC220 consists of two components: Trig220 software and the LC220 logic and timing controller. Trig220 lets you configure and run experiments from a simple graphical interface. The LC220 controller provides the connections and control for your experimental devices.

## Parts list

Your LC220 package should include the following items:

1. LC220 controller
2. AC wall transformer
3. Trig220 software installation CD with user's manual
4. 9-pin RS232 cable

If any parts are missing or damaged please contact LabSmith support.

## Specifications

Trig220 software will run on any PC-compatible computer running Microsoft® Windows® XP, or newer. Drivers for National Instruments'® LabVIEW™ software are also available for download. See <http://www.labsmith.com> for more information.

The LC220 includes two TTL-compatible inputs and two TTL-compatible outputs. Voltages in the range 2.5 – 5 V are TTL “highs” and voltages in the

range 0.0 – 0.2 V are TTL “lows.” Intermediate voltages should not be present on inputs and outputs except during transitions. The inputs and outputs are protected against connection to 115 VAC. When disconnected the inputs are read as TTL “highs.”

The LC220 can be connected to/ disconnected from the PC at any time without damage to either unit. This ability allows you to program to LC220 at your computer, then to take the unit to the experiment area for stand-alone use.

## Basic functions

The LC220 provides two functional **channels**, or internal signal paths.

At any time, each channel can be assigned one of eight **timing modes**. Timing modes include clocks, counters, delayed triggers, etc. You can set various **properties** for each timing mode—for example, the delay length on a Delayed Trigger. All modes are aligned to a time base derived from an internal or external clock, allowing resolution down to 5 ns.

Each channel also includes **logic** settings which specify the conditions that will trigger the channel. A channel can be triggered by logical combinations of signals from the inputs and/or the output of the other channel.

All settings and setting profiles for a particular experiment can be stored as an **experiment file** on your computer. Experiment files bear a .tr2 extension.

## How you will use the LC220

In most cases, you’ll use the LC220 as follows:

1. Using the Trig220 software, open an existing experiment file, or create a new file.
2. In Trig220 (or LabView), program the properties and logic for each channel and for the experiment as a whole.
3. Send the properties and logic to the LC220’s memory.
4. Test your program by simulating triggers and examining the outputs using the LC220’s channel LEDs and/or an oscilloscope or other diagnostic tool.
5. Plug your experimental equipment to the LC220.

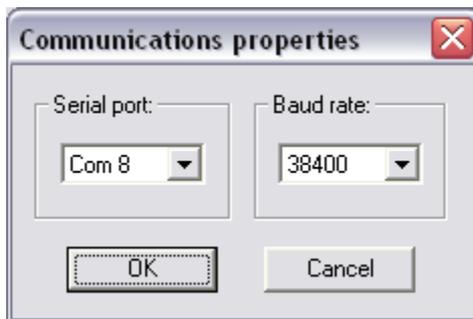
6. Run the experiment, using the LC220 by itself or leaving it tethered to the PC.

## Installing Trig220 Software

Insert the Trig220 Software disk in your CD-ROM drive and execute the setup.exe file.

## Setting up the LC220

1. Verify that your wall socket provides AC voltages within the range setting on the wall transformer supplied with the LC220. If the voltage range is not correct, contact LabSmith ([support@labsmith.com](mailto:support@labsmith.com)) for an alternate. **DO NOT connect the wall transformer to a socket that is beyond the transformer's range setting.** Plug the transformer into an appropriate socket and connect the power to the LC220.
2. Connect the 9-pin cable to the back of the LC220 and to a free serial port on the PC.
3. Press the Power button on the front of the LC220.
4. From your computer, run Trig220.exe to launch the Trig220 software.
5. From within Trig220, select View>Communications options.... The Communications properties screen will open.



6. Select the port to which the LC220 is connected. The LC220 will automatically detect the baud rate, which is typically set to 38400. If the RS232 cable running to your LC220 is greater than 30 m long, you may need to lower the baud rate to achieve reliable communication.

## Field upgradeable software

The firmware in the LC220 is field upgradeable, allowing access to new timing modes and capabilities as they become available.

To upgrade the firmware, download the latest version from [www.labsmith.com](http://www.labsmith.com). Then choose “Update Firmware” on the Actions menu to load data from that file.

## Getting help

This guide is your main source for information on operating the LC220 and Trig220 software. The guide is also available in an Adobe® Acrobat® Portable Document Format (pdf) file for electronic viewing.

Check the LabSmith web site ([www.labsmith.com](http://www.labsmith.com)) for helpful applications notes and other technical information to help you use the LC220.

If you are unable to find the information you need, please contact our technical support team at (925) 292-5161, or e-mail us at [info@labsmith.com](mailto:info@labsmith.com).

If you need to contact support, please let us know your LC220 serial number (located on the bottom of the unit) and the version of software you are using. **To determine the software version number**, select “About Trig220” from the Help menu.



# OVERVIEW OF LC220 CONTROLS

The LC220 is the control unit and interface for your experimental equipment. You will program it using the Trig220 software. Once you've designed, tested and downloaded your program, you can control the LC220 from the computer, or you can run it in stand-alone mode.

Indicators and controls on the LC220 will help you run your experiments. You'll learn all about these functions in the *Experimenting* section later. For now, we'll give you a short tour of the inputs, outputs and controls so you can work with the unit while you learn to use the Trig220 software.



## Inputs and outputs

The LC220 includes the following connectors:

- a 2.1 mm power jack (center positive) for 6 to 9 V DC, 0.6 A power source
- a 9-pin RS232 jack to connect to the Com port of your PC
- two channel input BNC jacks (in1 and in2), normally high (5 V)
- two channel output BNC jacks (outA and outB), normally low (0 V)
- in1 doubles as an input jack for an optional external clock source.

The input and output voltages conform to the TTL standards.

## Panel controls

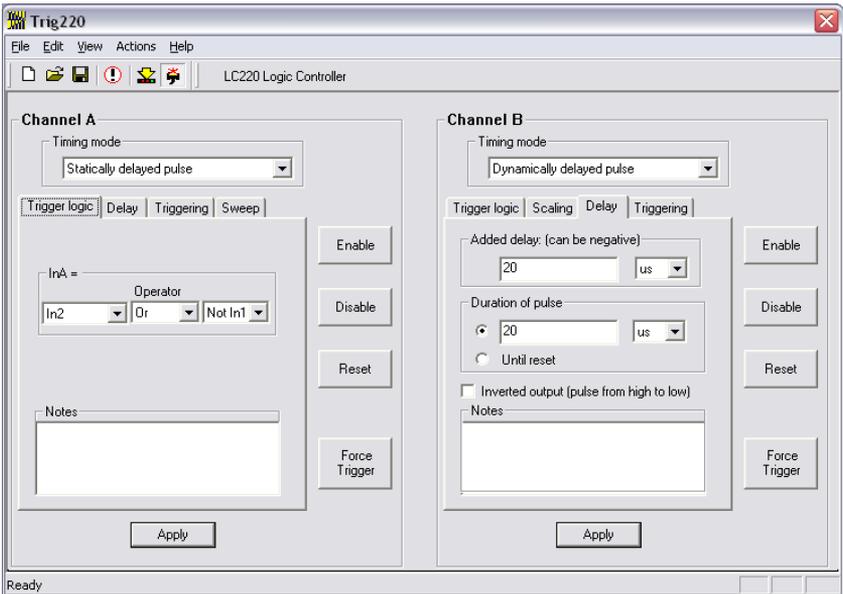
There are three buttons on the LC220. Trigger A and trigger B respectively force channels A and B to be triggered. The effect this has on the channels depends on the timing mode of the channels. The third button, Reset, causes both channels to have their timing modes reset. Again, the effect of the reset depends on the channel settings. These settings are detailed in the following sections.

# TRIG220 SOFTWARE INTERFACE

Trig220 has been designed exclusively for setup and control of the LC220. You'll use Trig220 to set the timing properties and logic for each of the channels and to set up overall properties for the experiment.

## Main screen

When you run Trig220, you'll be greeted by the Main screen:



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**NOTE:** At start-up, the Main screen will show the default program, which sets both channel outputs to a fixed low state.

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From this screen you'll control or access all of Trig220's functions. Most Trig220 functions can be accessed in two ways by selecting an option from a pull-down menu or by pressing a button on the Main screen.

1. Menu options:

The **File menu** lets you open, close and save experiment files (.tr2 files).

The **Edit Menu** lets you cut, copy and paste text as you edit your program.

The **View menu** lets you set up the Trig220 interface. Choose to display or hide the tool bars and status bar, select the font used in Trigger, and set up communications with the LC220.

The **Actions menu** lets you modify the LC220 settings.

2. The buttons are as follows:



The **Reset** button  resets both channels of the LC220. Retriggering counters and delay settings are reset as well.

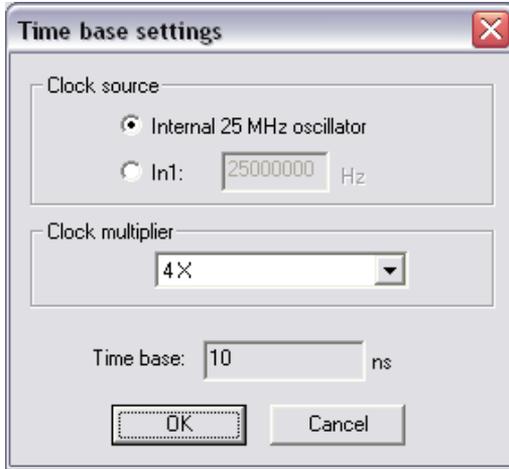
The **Program all settings** button  updates the LC220 with all current settings.

The **Online/Offline** button  toggles between **Online** and **Offline** mode. In **Online** mode this button is depressed, the Com port is open, and settings are transferred to the LC220. In **Offline** mode, this button is not depressed, the Com port is available for other programs and settings are not transferred to the LC220. **Offline** mode is convenient for developing .tr2 settings without an LC220 attached.

The **Main** window panel shows and controls all of the channel settings. This summary may be printed for review and documentation purposes. The text is not freely editable and must be modified through the dialogs. Double-clicking on selected parts of the summary opens the dialog needed to edit the text.

## Time base settings

The “Time base settings” dialog lets you control the time base used by the LC220 for timing. The LC220 measures, delays, and pulses in increments of this time base. For higher timing resolution, you can use a higher clock multiplier. For longer delays, select a lower clock multiplier. A variety of multipliers are available to optimize the increment for your needs. To reach this screen, click “Set time base options...” from the Action menu.



### Clock source

The LC220 can derive its time base from an internal 25 MHz oscillator or from a TTL pulse train provided to In1. If the time base is derived from the external input, you must specify the frequency of this time base so that Trig220 can set the LC220 timing correctly. If the clock frequency specified is 10% higher than actual, the channels using this time base will be 10% long on delays and duration.

### Clock multiplier

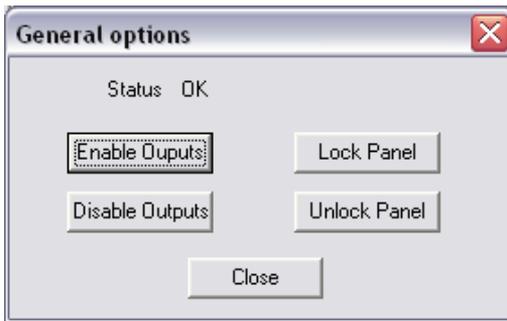
The clock source is multiplied by a user-specified factor to form a high-frequency source for the time base. For example, a multiplier of 4 X on the 25 MHz internal oscillator produces a clock of 100 MHz for a time base of 10 ns.

## Time base

The calculated time base is indicated in this window. This must not be less than 5 ns or greater than 1000 ns for proper operation.

## General options

The “General options” dialog lets you enable and disable the channel outputs and lock or unlock the panel buttons. To open this dialog, click “Set LC220 options...” under the Actions menu.



## Disable/enable outputs

Disabling outputs prevents the LC220 from sending trigger pulses to its output connectors regardless of the inputs or the actions of the channels. Enabling the outputs allows the LC220 to send trigger pulses to its output connectors. These functions are nonvolatile: the enabled and disabled states are restored on power cycle.

## Lock/unlock panel

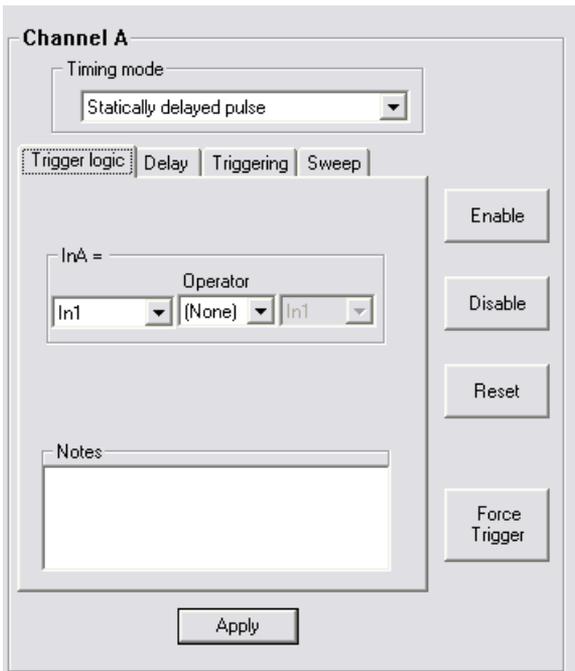
Lock or unlock the front panel buttons using the “Lock Panel” and “Unlock Panel” buttons. This functionality is handy, for example, in an embedded control application where the LC220 should function only in stand-alone or computer-controlled modes. When the panel is locked the buttons are not illuminated. When the panel is unlocked, the front-panel buttons are illuminated.

Like the enable/disable I/O functions, these settings are nonvolatile and are restored on power up.

# CHANNEL PROPERTIES

## Channel properties screen

Both channels have a Settings screen in the main application window in which you'll select the timing mode, set the timing properties, and establish the logic that will determine when the channel will trigger.



Channel properties are organized by tabs. The tabs that are relevant for a particular timing mode appear automatically when that timing mode is selected. For convenience, all settings are retained and saved, including those for timing modes that are not currently selected.

Four additional buttons appear next to the tabs:

- **Enable** restores channel functions following a temporary disable. The front panel LED for that channel will glow to indicate the channel's status.
- **Disable** temporarily disables the channel. The channel remains fixed in its “quiescent state” (see *Quiescent States* below). The front panel LED for that channel will be unlit (See *Running Experiments: Channel LEDs*).
- **Reset** reinitializes the internal trigger counters and sweep timing for the current channel. This function can be called simultaneously for all channels by pressing the “Reset” button on the main tool bar.
- **Force Trigger** lets you simulate a valid input signal for the channel (see *Channel Properties: Logic* for more). This button, which is only available with functions that *can* be triggered, is useful both for troubleshooting your channel settings and implementing software control of experiments. You can also force-trigger a channel from the LC220 panel (See *Running Experiments: Force Trigger*).

## Quiescent states

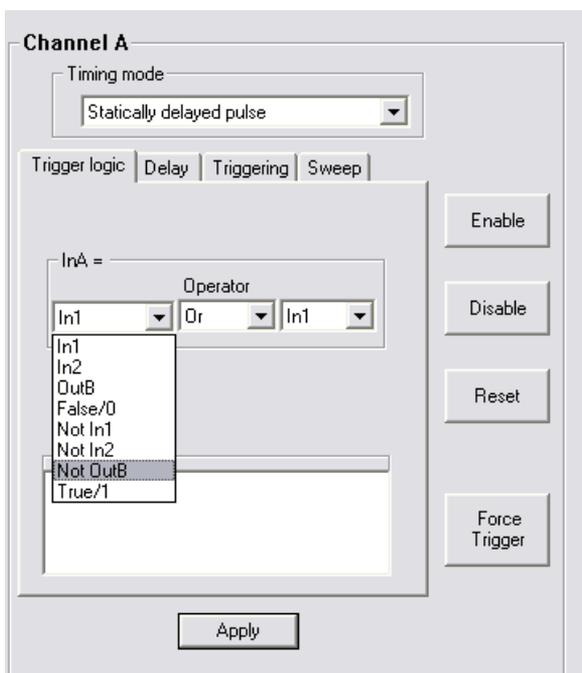
When you disable a channel, its input will not change the output. The “quiescent state” of a channel is the setting of its output when the channel is disabled. You can set each channel’s quiescent state to be a TTL high (3.5–5 V) or low (0–0.2 V) to provide a safe signal to the output device if you need to abort an experiment or stops its progress.

The method for setting the quiescent state depends on the timing mode. Most modes include an “Invert Output” option which sets the output normally High.

## Logic

A channel can be triggered by logical combinations of signals from the inputs and/or other channel output. Channel **logic** determines the combination of signals that triggers the channel.

To define when a channel will trigger, open the channel’s Settings screen then click the “Logic” tab. This tab only appears for timing modes which respond to logic. You will select a trigger logic assignment for the channel from a list of options.



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**NOTE:** Some timing modes do not respond to trigger logic. For example, a channel set to operate as a clock will continue to run regardless of its input.

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## Logic assignments

The logic processor assigns the logical combination of external inputs (In1 and In2) and other channel output that will trigger each channel. Logic assignments have the following format:

[the channel to be triggered] = [the conditions that will trigger it].

Here is an example:

$$\text{InB} = \text{In2}.$$

This assignment means, “Channel B will be triggered when the signal on In2 goes TRUE (reaches ~5 V).”

The assignment:

$$\text{InB} = \text{Not In2}$$

means “Channel B will trigger when the signal on In2 goes FALSE (drops below 0.2 V).”

You can employ compound arguments in logical assignments, such as:

$$\text{InB} = \text{Not OutA And In2.}$$

This means, “Channel B will trigger when the output of Channel A is FALSE and In2 is TRUE.”

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**NOTE:** LC220 inputs are TRUE by default if nothing is connected (i.e., the input is normally weakly pulled high). Grounding an input switches its state to a logical FALSE.

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## Experimenting With Channel Logic

This brief example will show you more about channel logic:

1. Connect a normally-open switch to In1 and another to In2.
2. Connect an LED to OutA.
3. Choose “Output = Input” from the “Timing mode” list for Channel A. In this mode, the output of Channel A is always the same as its input.
4. Select the “Passive” tab and choose “Output = Input.”
5. Select the “Logic” tab and select

$$\text{inA} = \text{in1.}$$

6. Click the “Program all settings” button .

The OutA LED should be glowing, indicating that the output is TRUE, or HIGH (since LC220 inputs are normally HIGH). When you close Switch 1 the LED will turn off, indicating that the output is FALSE, or LOW.

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**NOTE:** The *Channel A* LED on the LC220 glows green while the channel output is LOW, or red when the output is HIGH. But don't be confused! The channel LED does *not* always indicate the channel's output state—only in certain Timing modes. You'll learn more later in the *Timing modes* section.

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7. Next, change the logic assignment to

$$\text{InA} = \text{Not In1.}$$

8. Click the “Program All Settings” button . The LED at Output A will now remain off until you close the switch.

9. Change the logic assignment to

$$\text{InA} = \text{Not In2.}$$

10. Click the “Program All Settings” button. The LED at Output A will remain off until you close Switch 2.

11. Lastly, change the logic assignment to:

$$\text{InA} = \text{Not In1 And Not In2;}$$

12. Click the “Program All Channels” button. The LED at Output A will remain off until both switches are closed.

## Timing modes

In the previous section you learned that logic defines how channels are triggered. In this section you'll use the LC220 timing modes to determine how the channels will respond.

Each channel can be configured to operate in one of eight modes:

- Fixed output
- Output=Input (Passive mode)
- Statically delayed pulse
- Clocked pulse stream
- Validated trigger input (Noise suppression mode)

- Dynamically delayed pulse
- Timer
- Toggled output.

When a timing mode is selected, the relevant property tabs will be displayed.

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**NOTE:** All timing property tabs include a space for Notes. These notes are saved and appear in the Main Screen program summary area. It is good practice to document your settings extensively. As with all programming, good documentation will simplify the process of creating, debugging and running your experiments.

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For each timing mode you'll be able to set up a simple example to view the output of the channel.

**To set up for the experiments later in this section:**

1. Make sure that the LC220 is connected to the PC.
2. Plug a normally open push-button trigger switch into In1. The button will represent our triggering “event.”
3. Open Channel A’s Setting screen, and select the “Statically delayed pulse” timing mode (you’ll learn about Statically delayed pulse mode shortly).
4. Select the “Logic” tab and select the logical assignment:  
$$\text{InA} = \text{Not In1.}$$

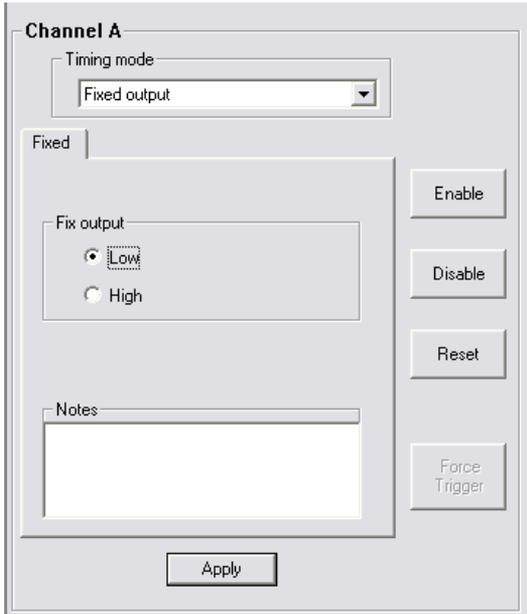
Then click Apply. With this logic, Channel A will trigger when you depress the trigger button.
5. Plug an oscilloscope to Output A to observe the channel output. Remember, the output voltage will vary from 0 to 5 V.

**“Apply” versus “Program All Channels”**

Each properties screen includes an “Apply” button which, when clicked, will send the current timing properties to the channel on the LC220. The other channel function, for example retriggering counters and triggering, is not affected.

“Program All Channels” updates the time base settings and all the channel settings of the LC220. Both channels are reset.

## Fixed output mode



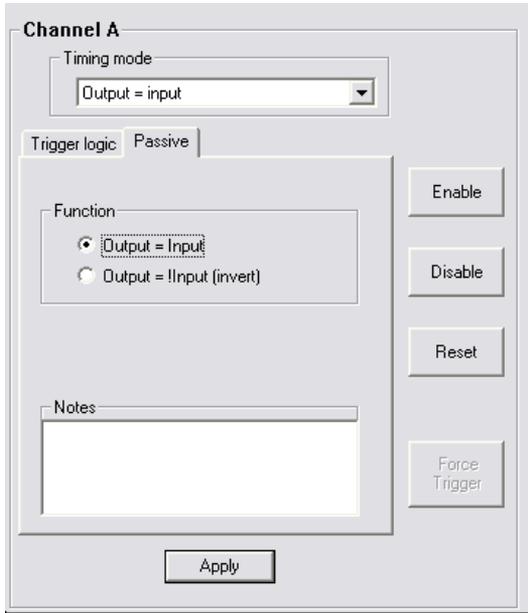
In this mode, the channel output remains in the selected state (Low or High), regardless of the input.

**The panel LED** for the channel will glow green when the output is low or red when the output is high.

### To try fixed output mode:

On the “Properties” tab of Channel A, choose “Fixed Output.” Choose “Low” or “High” as the output state, then click “Apply” to save the settings. At Output A, the signal will remain a steady TTL logic low or high, depending on your selection.

## Passive mode (Output = Input)



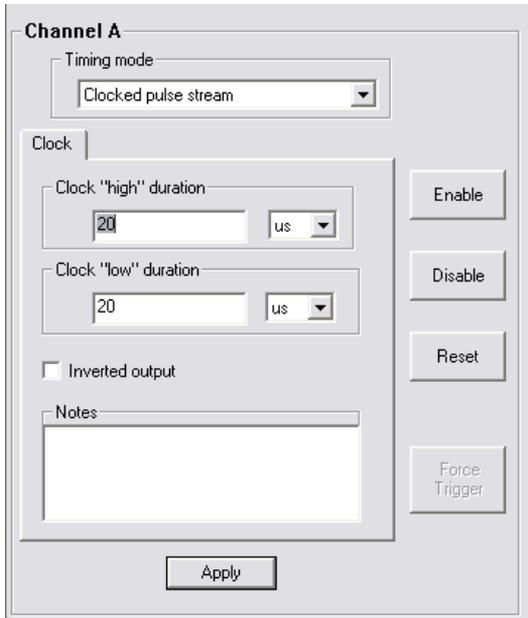
In passive mode, the output signal equals the input signal or its logical inverse.

**The panel LED** for the channel will glow green when the output is Low or red when the output is high.

**To try passive mode:** On Channel A's Settings screen, select the "Output=Input" timing mode. In the Function box, choose "Output=Input," then Click "Apply" to save the settings.

When the trigger button is not depressed (i.e., the input signal is low), the signal at Output A will be a TTL low. Now, depress the trigger button at Input 1—the signal at Output A will go high. If you select "Output=!Input (invert), the channel output will remain high until you depress the trigger.

## Clocked pulse stream mode



In clock mode, the output of the channel is a steady stream of pulses. You set the pulse duration and delay between pulses. A clock channel's input does not affect its output.

**The panel LED** for a clock channel will glow green when the output is low or red when the output is high.

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**NOTE:** For a high-frequency clock the LED will alternate between red and green so quickly that it will appear as a continuous pale green, yellow or orange light.

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As mentioned earlier, the LC220 can operate with different time bases (see *Time Base Settings*). With a 5-ns time base (internal clock X 8, the clock pulse and duration can range from 0.48  $\mu$ s to 52.4 ms. At longer time bases, this range is proportionally longer, for example at 320-ns time base (internal clock X 1/ 8) the pulse duration can range from 30.1  $\mu$ s to 3.35 s.

To set the pulse duration, select the timing units (seconds, microseconds, milliseconds or nanoseconds), then enter a duration in the “Clock high duration” box.

To set the time between pulses, select the units, then enter the duration in the “Clock low duration” box.

A clock’s quiescent state is normally low (See *Channel Properties: Quiescent States*). Check the “Inverted output” box if the quiescent state for the channel should be high instead.

**To try Clock mode:**

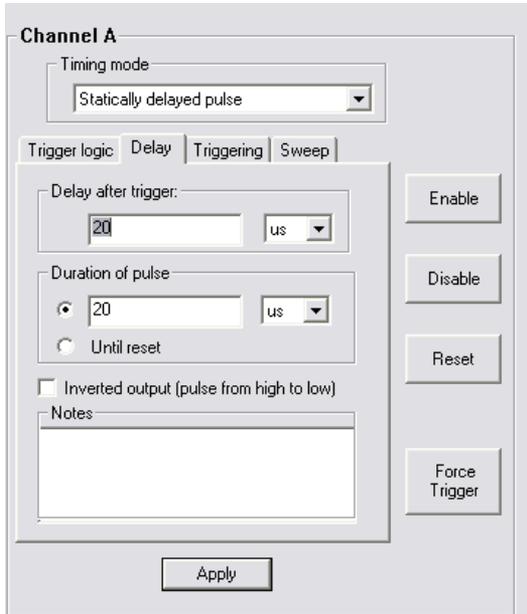
1. On the Time base settings screen, select internal clock and a clock multiplier of “1/8 X”.
2. On Channel A’s Properties tab, choose “Clock” as the mode, select an “on” duration of 100 ms and an “off” duration of 500 ms. Click “Apply” to save the settings.

The signal at Output A will go repeatedly go high for 100 ms then go low for 500 ms.

## Statically delayed pulse mode

Upon receiving an input signal, a delayed trigger waits a specified delay time, then sends a pulse to the channel output. This mode has several property tabs.

*Delay*



On the Delay tab you'll specify:

- Delay after trigger**     The delay between a valid trigger and an output signal
- Duration of pulse**     The duration of the output signal
- Until Reset**             The output will remain high after a valid trigger, until the channel is reset
- Inverted Output**        Check the box to set the output high until a valid trigger.

The range of settings you can use with the delayed trigger depend upon the current timing mode:

<b>Time base</b>	<b>5 ns</b>	<b>320 ns</b>
<b>Delay range</b>	20 ns to 21.47 s	1.28 $\mu$ s to 1374 s
<b>Duration range</b>	7.7 $\mu$ s to 21.47 s.	493 $\mu$ s to 1374 s
<b>Delay / Duration resolution</b>	5 ns	320 ns

## Triggering

This tab lets you control how the channel will trigger:

The screenshot shows the 'Channel A' configuration window with the 'Triggering' tab selected. The 'Timing mode' is set to 'Statically delayed pulse'. The 'Trigger logic' section has three radio buttons: 'Normal' (selected), 'Skip N triggers', and 'Retrigger N times'. The 'N=' field is set to 0. The 'Automatically reset count/sweep' section has three radio buttons: 'Never' (selected), 'On in1 high', and 'On in1 low'. There is a checkbox for 'Check after completing each trigger' which is unchecked. The 'Trigger on' section has two radio buttons: 'Input high (level trigger)' and 'Rising input (edge trigger)' (selected). There is a 'Notes' text area at the bottom left. On the right side, there are four buttons: 'Enable', 'Disable', 'Reset', and 'Force Trigger'. At the bottom center, there is an 'Apply' button.

### Normal

The channel can retrigger an unlimited number of times

### Skip N triggers

The channel triggers only after the specified number of input pulses (between 0 and 2,147,483,647).

### Retrigger N times

Limits the number of retriggers allowed between resets (between 0 and 2,147,483,647). To allow a channel to be triggered again after reaching the limit, the channel must be reset. To reset both channels, press the “Reset” button on the LC220 or choose Actions>Reset in Trig220. To reset only one channel, click the “Reset” button next to the channel settings.

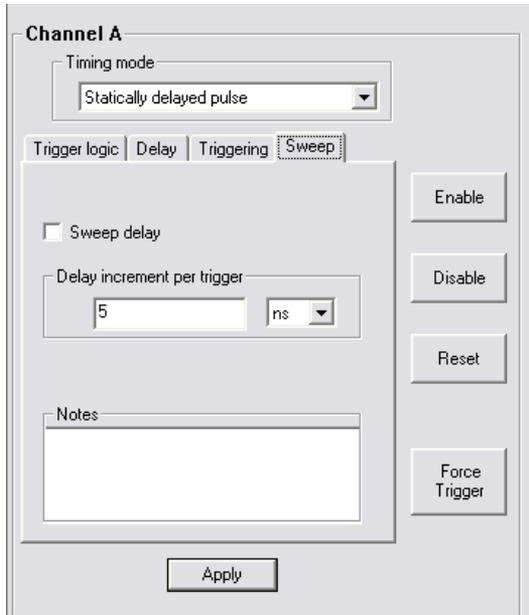
### Trigger on rising input

Sets the channel to be edge triggered. In other words, an input signal that stays high triggers the channel only once.

## Trigger on input high

Allows the channel to be repeatedly triggered while an input is high. This setting could be used for generating a low-precision gated clock, for example. However, the latency time between retriggerers is indeterminate (typically around 10  $\mu$ s) so a clock made this way is not suitable for applications requiring high precision.

## Sweep



To facilitate time-delay scanning experiments, the delay of the pulse relative to the trigger can be “swept” or incremented by a specified value each time the channel is triggered. The sweep value must be positive. The increment resolution is equal to the time base (e.g., as short as 5 ns).

**The panel LED** for the delayed trigger will glow green until an input signal is detected. The LED will be unlit for the delay time and will glow red for the duration time. What happens next depends upon the channel settings:

Retriggering enabled?	Edge triggered?	The channel LED...
no	yes or no	remains red (no more triggers accepted)
yes	no	glows green (waiting for next trigger)
yes	yes	is off; glows green once input goes low.

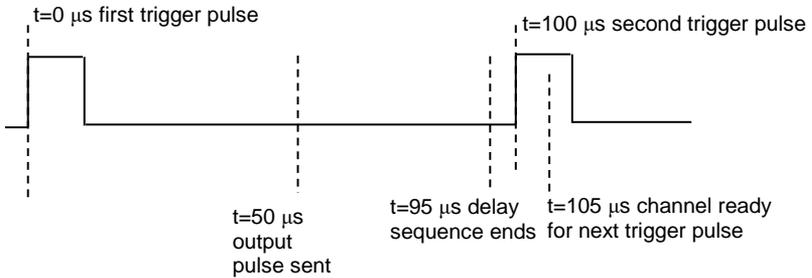
### To try the delayed pulse mode:

1. Under Time base settings, choose internal clock X 1/8 (320 ns time base).
2. In Channel A's properties screen, select "Statically delayed pulse."
3. On the Delay tab, enter a delay of 1 s and duration of 500 ms.
4. On the Triggering tab choose "Retrigger N Times" and set N=0. Choose "Input high (level trigger)," then click "Apply" to save the settings.
5. Click the trigger pushbutton. One second after you push it, the output of Channel A will go high for 500 ms.
6. The channel LED remains red, indicating it is not ready to trigger. Push the button again. You'll see that you cannot retrigger the channel. Click the "Reset" button on the LC220—the LED glows green and you can once again trigger the channel.
7. On the Triggering tab, choose "Retrigger N times," set N=5, then click "Apply." Depress and hold the trigger button. As long as the trigger is depressed (i.e., the input signal is high) the channel will continue to trigger until the limit is reached.
8. Again on the Triggering tab, select "Rising Input (Edge Trigger)" then click "Apply." Depress and hold the trigger button. The channel will trigger only once, no matter how long you hold the button. Release the button and depress it again, and the channel will be triggered once more (switch bounce may produce triggers when the button is released).
9. On the Delay tab, check "Inverted output," then click "Apply." The output will be the inverse of that described in Step 4.
10. On the Sweep tab, set the sweep to 0.5 s per trigger, and on the Delay tab select Normal. Click "Apply." The time delay before the output pulse will increase with each trigger.

## Important delay timing considerations

Once the LC220 has begun a delay sequence, it ignores incoming trigger pulses. There is also a delay of approximately  $10\ \mu\text{s}$  (at a  $5\ \text{ns}$  time base) after the completion of a delay sequence while the channel resets for the next trigger. This effect can be used to skip triggers, but if misunderstood it can cause unexpected results.

For example, in the diagram below, two trigger pulses arrive  $100\ \mu\text{s}$  apart. The channel is functioning in Statically delayed pulse mode, with a delay of  $50\ \mu\text{s}$  and a duration of  $45\ \mu\text{s}$  pulse. It would: receive the first pulse; wait  $50\ \mu\text{s}$ ; send a  $45\ \mu\text{s}$  output pulse; and trigger again at the second pulse. But the extra  $10\ \mu\text{s}$  delay at the end of the sequence will cause the channel to ignore the second trigger pulse.



## Validated trigger input mode (noise suppression)

The screenshot shows the 'Channel A' configuration window. The 'Timing mode' dropdown is set to 'Validated trigger input'. The 'Validate' tab is selected. The 'Minimum duration of valid trigger (delay)' is set to 30 us. The 'Duration of pulse' section has '30 us' selected with a radio button, and 'Until reset' is unselected. The 'Inverted output (pulse from high to low)' checkbox is unchecked. There is a 'Notes' text area. On the right side, there are buttons for 'Enable', 'Disable', 'Reset', and 'Force Trigger'. At the bottom center is an 'Apply' button.

The noise suppression function eliminates false triggers due to noise on the input signal by requiring the signal to remain high (or low) for a specified duration. If the signal drops out during that period, the output will remain low and the channel will look for the next input signal. Once an input signal is deemed “valid,” a pulse of user-specified duration will be sent to the channel output.

Unlike an analog filter which “smears” the signal edge, this noise suppression function digitally blocks false triggers, retaining the sharp edges on the real trigger signal.

As with Statically delayed pulse mode, you have additional controls over the channel.

On the **Validate** tab, choose:

- |                          |   |
|--------------------------|---|
| <b>Minimum duration</b>  | The minimum length of an input pulse that will trigger the channel            |
| <b>Duration of pulse</b> | The duration of the output signal   |
| <b>Until Reset</b>       | The output will remain high after a valid trigger, until the channel is reset |

**Inverted Output** Check the box to set the output high until a valid trigger.

On the **Triggering** tab choose:

**Normal** The channel can retrigger an unlimited number of times

**Skip N triggers** The channel triggers only after the specified number of valid input pulses (between 0 and 2,147,483,647).

**Retrigger N times** Limits the number of retriggers allowed between resets (between 0 and 2,147,483,647). To allow a channel to be triggered again after reaching the limit, the channel must be reset. To reset both channels, press the “Reset” button on the LC220 or choose Actions>Reset in Trig220. To reset only one channel, click the “Reset” button next to the channel settings.

**Trigger on input high** While the input is high, channel can be repeatedly triggered.

**Trigger on rising input** Sets the channel to be edge triggered (i.e., an input signal that stays high will only trigger the channel once).

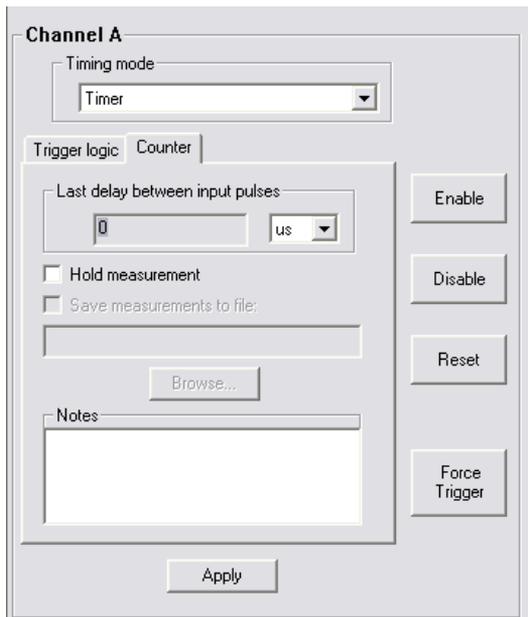
**The panel LED** for the noise suppression channel will glow green until an input signal is detected. It will then glow red until the duration period has elapsed. At this point, the LED will respond as follows:

<b>Retriggering enabled?</b>	<b>Edge trigger?</b>	<b>LED</b>
no	yes or no	remains red (no more triggers accepted)
yes	no	glows green (waiting for next trigger)
yes	yes	is off; glows green when trigger goes low

### To try validated trigger mode:

1. Under Time base settings, choose internal clock X 1/8 (320 ns time base).
2. In Channel A's properties, select "Validated Trigger Input" mode.
3. On the Validate tab, enter a "Minimum duration" and "Duration of output pulse" of 1 second each.
4. On the Triggering tab, select "Retrigger N times," and set N=50. Click "Apply" to save the settings.
5. Now, depress the trigger button. If you hold the button down for more than one second (the minimum duration), the output of Channel A will go high. If you release the button before one second elapses, the output will remain low, and the channel will wait for another input pulse.

### Timer mode



The counter/timer mode determines the time delay between two separate input signals and reports it back to the PC. You can view the counter output in the Properties tab.

Use the channel's logic to select the input signals that will be compared by the timer (see *Channel Properties: Logic* above).

Normally, the counter will report a value each time a pair of pulses is measured. To retain the current measurement, check the "Hold measurement" button; the counter will not update the delay display until this button is cleared.

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**NOTE:** To switch from Timer mode, first click the Disable button and ensure the channel LED is unlit, indicating that the channel is disabled. This will help you avoid unexpected behaviors when the counter is transmitting measurements rapidly (e.g., >1000 measurements/second).

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**NOTE:** When you first run the LC220, channels that are configured as counters are initially disabled and must be enabled either by clicking the "Enable" button on the channel's Properties screen, or by using the front panel (See *Experimenting: Disable/Enable Channels* below).

---

The panel LED for the timer will be green until the first trigger, red until the second trigger and off while the count data is reported and the channel waits for the input to return low.

The output of a channel in timer mode is always high.

---

**NOTE:** The LC220 may be measuring time differences faster than it can display them all on the monitor.

---

Now, check "Hold measurement." Note that the displayed measurement does not change. Un-check "Hold Measurement", then check "Hold measurement" again to freeze another measurement.

## Dynamically-delayed pulse mode

The dynamic delay is a unique feature. First, it measures the time difference between two pulses, like a counter. Next, it scales that difference by a user-

defined factor. It subtracts an offset value, waits the duration of the dynamically calculated delay, then sends a pulse to the channel output.

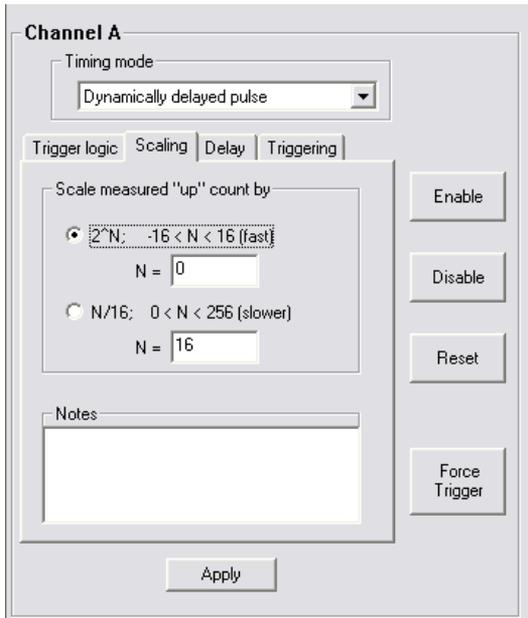
---

**NOTE:** The dynamic delay is particularly useful for ballistics or gas dynamics experiments, in which the velocity of a projectile or wave must be calculated and used to time the triggering of an experimental device.

---

Dynamically delayed pulse mode includes several properties tabs.

*Scaling*



In the calculation of the delay, the measured delay between two pulses is scaled by a factor of  $2^N$ , where  $-16 < N < 16$ , or  $N/16$ , where  $0 < N < 256$ . The former scaling is faster and a scaling of 1:1 is fastest. Scaling can typically be done at rates  $> 50$  kHz at a 5-ns time base.

The maximum delay between input pulses is 52 ms at a time base of 5 ns and 3.3 s at a time base of 320 ns. The maximum delay resulting from the scaling and offset calculations is respectively 21.47 s and 1374 s at 5-ns and 320-ns time bases.

## Delay

**Channel A**

Timing mode  
Dynamically delayed pulse

Trigger logic | Scaling | Delay | Triggering

Added delay: (can be negative)  
20 us

Duration of pulse  
 20 us  
 Until reset

Inverted output (pulse from high to low)

Notes

Enable  
Disable  
Reset  
Force Trigger

Apply

### Added Delay

Set an offset value to subtract from the scaled delay length. This is useful when accounting for camera shutters or other lag times in experimental equipment. The offset value can be positive (shortens the delay time) or negative (lengthens the delay time) and the resolution is set by the time base (e.g., 10 ns).

### Duration of pulse

The duration of the output signal

### Until Reset

The output will remain high after a trigger until the channel is reset

### Inverted Output

Check to set the output high until a valid trigger. The duration of the pulse and other properties are the same as for the delayed trigger.

### Triggering

The triggering options are the same as those for Delayed Pulse After Triggering mode:

<b>Normal</b>	The channel can retrigger an unlimited number of times
<b>Skip N triggers</b>	The channel triggers only after the specified number of input pulses (between 0 and 2,147,483,647).
<b>Retrigger N times</b>	Limits the number of retriggers allowed between resets (between 0 and 2,147,483,647). To allow a channel to be triggered again after reaching the limit, press the “Reset” button on the LC220 or choose Actions>Reset Channels in Trigger.
<b>Trigger on rising input</b>	Sets the channel to be edge triggered. In other words, an input signal that stays high triggers the channel only once.
<b>Trigger on input high</b>	This option is not used in this mode.

**The panel LED** for a dynamically-delayed trigger will remain green until a valid input signal is detected. When an input signal is detected, the LED will glow red until the output signal is sent. At this point the LED will return to green if retriggering is allowed, or it will glow red to indicate that no more input signals will be accepted.

### **To try the dynamically-delayed pulse mode:**

You can simulate the experiment above, using the trigger button to represent Sensor 1, and a delayed trigger in Channel B to represent the signal from Sensor 2. Connect your oscilloscope to the Output C to view the results.

1. Under Time base settings, choose internal clock X 1/8 (320 ns time base).
2. On Channel A’s Properties window, select “Delayed Trigger” mode, with a delay and duration of 500 ms each. Setup for edge triggering and allow retriggering.
3. On Channel A’s Logic tab, select: inA = not in1; This logic will cause the delayed trigger to pulse 100 ms after the button press.
4. On Channel B’s Properties window, select “Dynamically Delayed Pulse” mode. Set up for scaling by  $2^N$ , where  $N = 1$ , and set the Added Delay to – 200  $\mu$ s and the duration to 100 ms. Allow unlimited retriggering.

5. On Channel B's Logic tab, select:  $\text{inB} = \text{outA}$  or  $\text{not in1}$ . This routes the button push signal and the delayed signal to channel B.
6. Since you've made changes to multiple channels, click the "Program All Settings" button.

Now the test is ready. Depress and release the trigger button quickly. Channel A will produce a trigger pulse 500 ms later. Both the button push and delayed signal will appear on the inputs of Channel B. When Channel B receives the button-push signal, it will begin its count. When Channel B receives the delayed pulse from Channel A, it will calculate the time difference (500 ms), multiply it by  $32/16$ , and subtract the  $200 \mu\text{s}$  offset. 999.8 ms after receiving the signal from Channel A, Channel B will send a 100 ms output pulse.

## Toggled output mode

This mode toggles its output state upon every input pulse. It functions like a flip-flop and is useful for a variety of logical and control purposes. The minimum input-pulse state duration is 10 ns and the edge-to-toggle delay is < 20 ns.

The screenshot shows a software interface for configuring Channel A. At the top, the title "Channel A" is displayed. Below it, a "Timing mode" dropdown menu is set to "Toggled output". There are two tabs: "Trigger logic" and "Toggle", with the "Toggle" tab selected. Under the "Toggle" tab, the text "Toggle output at each trigger" is present. Below this, the "Initial state" is configured with two radio buttons: "Low" (which is selected) and "High". To the right of these settings are four buttons: "Enable", "Disable", "Reset", and "Force Trigger". At the bottom of the panel is an "Apply" button. A "Notes" text area is located at the bottom left of the configuration area.

The only user settings for this mode are the initial state, which may be either low or high.

**The panel LED** for the channel will glow green when the output is low or red when the output is high.

# RUNNING EXPERIMENTS

Once you've created a program you're ready to set up and perform your experiment.

## Storing and recalling experiment files

As mentioned earlier, an experiment file is a document which resides on your PC, containing all of the logic, properties, and settings profiles for a particular experiment. Experiment files bear the .tr2 extension.

**To save an experiment**, choose "Save As" from the File menu. Name the file, then store it on your hard drive in an accessible place.

**To reuse an experiment file**, choose File>Open, and locate the file. When you click "OK," the file's settings will appear in Trig220. Click "Program all settings" to download the settings to the LC220.

---

**NOTE:** Good file naming protocol will help your experiments go more smoothly. For example, if you are saving multiple versions of a combustion experiment, store all files in the same directory, with the names "combustion1.trg", "combustion2.tr2", etc. Or, better yet, use descriptive names such as "combust - 50us delay.tr2", "combust - 60us delay.tr2", etc.

---

## Panel controls and indicators

The front panel of the LC220 is designed to help you run experiments without computer control. This functionality allows you to program the unit at a workstation, then to move the unit to the experimental environment.

### Channel LEDs

As mentioned earlier, the LEDs for each channel provide information on each channel's status:

1. A green light on a channel typically indicates that the channel is waiting for an input trigger.

When a channel is in Fixed output, Clocked pulse stream, Output=Input or Toggled output timing modes, the green light indicates that the output is currently LOW for that channel.

2. A red light typically indicates that the channel is in the process of triggering.

When a channel is in Fixed output, Clocked pulse stream, Output=Input or Toggled output timing modes, the red light indicates that the output is currently HIGH for that channel.

3. When a channel indicator is steadily off, the channel is disabled (see *Enable/Disable Channels* below). The channel indicator also turns off during delays and while waiting for the input to return low for an edge trigger.

The following chart provides an overview of the front panel channel LEDs:

Mode	Off	Green	Red
Fixed output	--	Output is Low	Output is High
Output = Input (Passive)	--	Output is Low	Output is High
Clocked pulse stream	--	Output is Low	Output is High
Statically delayed pulse	In delay period	Waiting for trigger; if retriggering is on, light will glow green once input goes low	In duration period; if retriggering is off, light remains red after duration period
Validated trigger (Noise suppression)	--	Waiting for trigger; if retriggering is on, light will glow green once input goes low	In duration period; if retriggering is off, light remains red after duration period
Timer	Timer data is being reported, waiting for input to go low	Waiting for first trigger pulse	Waiting for second trigger pulse
Dynamically delayed pulse	--	Waiting for trigger; if retriggering is on, light will glow green once input goes low	In duration period; if retriggering is off, light remains red after duration period
Toggled output	--	Output is Low	Output is High

---

**NOTE:** Channel LEDs provide important information about the channels, but an oscilloscope remains a useful tool for diagnosing channel outputs, particularly for high-speed experiments.

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## Output LED

The output (right-most) LED glows green when outputs are enabled and red when outputs are disabled. (See *Running Experiments: Disable/ Enable channels* below).

## Trigger A and Trigger B

This function lets you simulate an input trigger on the respective channel, regardless of the channel's logic settings or state. This is a useful way to initiate a timing sequence without actually performing the live experiment. You can also trigger a channel from within the Trig220 software (See *Channel Properties: Force Trigger* above).

## Reset

The Reset button returns both channels to the last programmed settings. It resets and reinitializes retriggering counters and the delays of any channels that are undergoing a delay sweep.

# GLOSSARY

Apply	Sends a channel's current timing settings to the LC220.
Baud Rate	The speed of communication via the Com port.
Channel	One of eight internal signal paths in the LC220.
Channel input	The signal which feeds one of the eight channels. A channel input can be triggered by signals from any combination of signals from the input jacks and/or channel outputs.
Channel settings	The logic and timing settings which determine how a channel functions.
Com port	A serial port on a PC computer. The LC220 communicates with the computer via an RS-232 cable connected to a Com port.
Controller	The LC220 hardware unit.
Counter/timer mode	This timing mode determines the time delay between two separate input signals.
Delay	The time between the arrival of an input trigger and the release of an output pulse.
Duration	The length of an output pulse.
Dynamically delayed pulse	Timing mode measures the time difference between two pulses, scales that difference by a user-defined factor, waits the duration of that calculated delay, then sends a pulse to the channel output.
Edge triggering	This channel setting ensures that an input signal which stays high will only trigger the channel once.
Enable/disable outputs	A function which disables or suspends a channel (or all channels) temporarily.
External clock	A signal applied to in1 that can optionally be used to generate the time base of the LC220.

Firmware	The internal code of the LC220 controller. The firmware, as well as the Trig220 control software, can be field-upgraded. Latest upgrades are available at <a href="http://www.labsmith.com">www.labsmith.com</a> .
Input	One of two input jacks on the LC220. Signals from these inputs can be logically combined to trigger either channel.
Lock/unlock panel	A function that disables all front panel functions (including the power button) to avoid tampering/accidental changes when the LC220 is embedded in an experiment.
Logic	The set of assignments that determines when a channel will trigger.
Noise suppression	Also called “Validated Trigger Input” mode. This timing mode eliminates false triggers due to noise on the input signal by requiring the signal to remain high (or low) for a specified duration.
Output	One of two output jacks on the LC220. The output signals are determined by the timing channels.
Program all settings	A function which sends all logic and timing settings to the LC220.
Programmable logic controller	A device which combines logic and timing processors for precise control of physical experiments.
Reset	Returns all channels of the LC220 to their waiting condition. Retriggering Counters and delay settings are reset as well.
Retrigger	A channel setting that allows the channel to be triggered more than once if subsequent trigger pulses are received.
Scaling	In the Dynamically Delayed Trigger timing mode, scaling determines the ratio of the distance between the two input sensors to the distance of the target.

Settings file	A PC file (with a .tr2 extension) that contains all the logic and timing settings for an experiment.
Skip triggers	A setting that allows a channel to trigger only after the specified number of input pulses.
Statically delayed pulse	In this timing mode, a channel waits for an input signal, waits a specified delay time then sends a pulse to the channel output.
Sweep	In the Delayed Pulse After Trigger timing mode, this settings facilitates time-delay scanning experiments in which the delay of the pulse relative to the trigger must be incremented by a specified value each time the channel is triggered.
Time base	The minimum increment of time used by the LC220. This can range from 5 ns to 1000 ns and can be generated from an internal or external clock.
Timer	Counter/Timer mode determines the time delay between two separate input signals and reports it back to the PC.
Timing mode	The eight functions that each channel can perform.
Toggle mode	Toggles its output state upon every input pulse.
Trigger	An input signal that initiates a channel function.
Trig220	The control software for the LC220.
Trigger validation mode	Also known as “Noise Suppression” mode. This timing mode eliminates false triggers due to noise on the input signal by requiring the signal to remain high (or low) for a specified duration.
Update firmware	This menu function allows you to upgrade your LC220’s firmware to the latest version, available at <a href="http://www.labsmith.com">www.labsmith.com</a> .

## **To Our Valued Customers**

### **User's Manual and Trig220 Control Software:**

To obtain the most up-to-date version of this user's manual and Trig220 Control Software please refer to our website at:

<http://www.labsmith.com>

### **Corrections to this user's manual and Trig220 Control Software:**

Please contact [support@labsmith.com](mailto:support@labsmith.com) to report any information that is missing or in error in this user's manual or in the Trig220 Control Software.

### **Sample Files and Application Notes:**

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