Oscilloscope Triggering with High Speed Comparators

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TEXAS INSTRUMENTS

The oscilloscope is one of the most useful test and measurement tools for electronic engineers. Oscilloscopes are used to analyze electrical signals for the purposes of testing, debugging, and troubleshooting electronic circuits. Without this tool many technological developments would not be possible. Oscilloscopes have come a long way from when they were first invented before WWII. The original analog oscilloscopes have been replaced in the majority of applications by digital oscilloscopes.

Over the years, many advancements have been made to oscilloscopes with the continuing development of software and analog and digital devices, but the basic functionality has remained the same. The oscilloscope operates by taking an electrical signal as an input and displaying this waveform on a screen. To display a repeating waveform, a trigger is required. Without this trigger, multiple copies of the repeating waveform would be drawn all over the display. This would lead to a jumble rather than a clean centered display of the waveform. An example block diagram of the triggering circuit is shown in Figure 1.
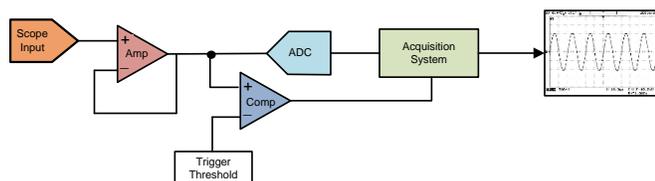

Figure 1. Oscilloscope Triggering Block Diagram

Now that we have introduced the importance of triggering in oscilloscopes, let's discuss how the triggering function is designed in oscilloscopes. The triggering function tells the oscilloscope what data from the input waveform it needs to care about and when the Acquisition System must start processing and displaying this data. The point at which the oscilloscope triggers, or the Trigger Threshold, is configurable by the user and typically based on a falling or rising edge and voltage level of the input waveform.

The trigger system can be implemented in software or hardware. An analog trigger system typically works by monitoring the input waveform with an amplifier and passing this input to a high speed comparator to detect if the trigger threshold set by the user has been reached. The comparator will fire and alert the Acquisition System when the trigger threshold has been met. Only now will the data from the output of the ADC be processed by the Acquisition System and be displayed on the screen.

To properly detect and trigger at any input signal, the comparator must be high speed. High speed is important when the input signal may contain a glitch or very small pulse width. Without a high speed comparator, the system may not be able to trigger on this input signal. The propagation delay of the comparator is part of what makes this triggering possible, but the specific comparator parameters to look for are toggle rate and pulse width. Toggle rate and pulse width for comparators can be compared to the bandwidth parameter for amplifiers. Along with that, it is important that the trigger system is immune to noise to prevent any false triggering. Hysteresis is a key feature that can help comparators with minimizing the effects of noise. The LMH7322 is a good fit for this application with its extremely small pulse width of 260 ps, toggle rate of 3.9 Gb/s, and 75 mV of programmable hysteresis. Size constraints of the overall system can also be important when selecting components for this application. The LMH7322 is available in a small 24-pin WQFN package.
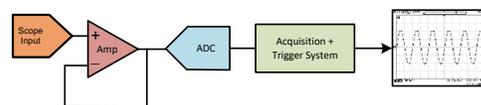

Figure 2. Software Trigger Block Diagram

Software triggers on the other hand work by constantly sampling data from the ADC and determining when the trigger threshold has been reached. The input signal is not split into parallel paths as shown in Figure 2. Once the ADC and software determines the threshold has been reached, the waveform is processed and displayed on the screen.
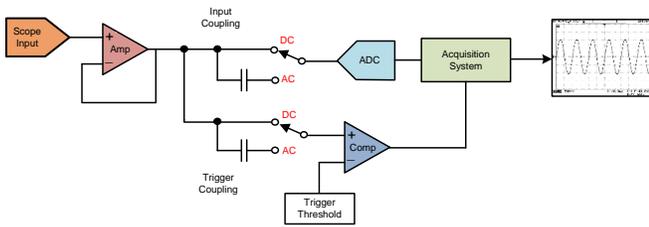
Figure 3. Input and Trigger Coupling Block Diagram

The introduction of analog and software based trigger systems give us the opportunity to discuss why one could be preferred over the other. The AC and DC coupling options on the inputs of the oscilloscope are well known, but less known are the coupling options on the trigger shown in Figure 4. As the software implementation of the trigger does not split up the input signal, the trigger does not have the option to be AC or DC coupled. The trigger instead relies on the input coupling and triggers based on this coupled signal. The downside to this is that you cannot display the DC coupled input waveform while triggering on the AC coupled input waveform.

One example of this drawback is shown when analyzing a spike or glitch on a power line. In this scenario you may want to see both the DC component of the signal and the spike or glitch on top. The resolution of the ADC can be taken up by the DC component of this input signal. The software trigger, without AC coupling, may not have enough remaining resolution to detect the spike or glitch and display the full input signal. On the other hand, Analog trigger systems split up the input of the oscilloscope as shown in Figure 3. This allows for the freedom to have input coupling and trigger coupling independent from each other and avoid the drawback described.
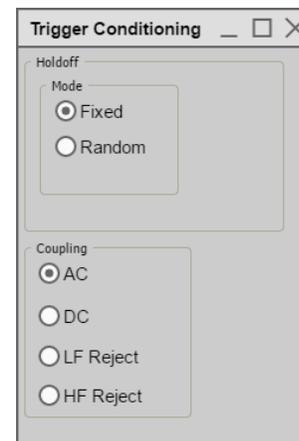
Figure 4. Trigger Coupling Options

As discussed, the triggering system is essential to properly display an electrical signal on an oscilloscope. An analog trigger system however can offer the most freedom in these applications. High speed comparators are at the center of these analog trigger systems. The LMH7322 is a high speed comparator that is a good fit for this application with its small pulse width, high toggle rate, programmable hysteresis, and small size package.

Table 1. Device Recommendations

Device	Toggle Rate	Min Pulse Width	Hysteresis	Supply
LMH7322	3.9 Gb/s	260 ps	75 mV	2.7 V - 12 V
LMH7324	3.72 Gb/s	290 ps	22.5 mV	5 V - 12 V
LMV7220	1.8 Gb/s	-	External	2.7 V - 12 V

Table 2. Other High Speed Comparators

Device	Propagation Delay	Hysteresis	Supply
TIV3501	4.5 ns	6 mV	2.7 V - 5.5 V
LMV7219	7 ns	7 mV	2.7 V - 5 V
TL3016	7.6 ns	External	± 5 V

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