ENGR 2323 Digital Design Lab
Digital Circuit Timing Measurements

Period and Duty Cycle

The period T of a signal is the time it takes for the signal to repeat itself. Generally, when determining the period of a signal, the fundamental period (minimum period of repetition) is determined. The period is typically measured from 50% of a rising edge to 50% of the next rising edge of the signal. The frequency f of a signal is the inverse of the period $f = \frac{1}{T}$

The period of the signal can be directly measured using the oscilloscope cursers and the auto measure. The frequency of the signal can then be determined from the measured period.

The positive duty cycle of a square/rectangular wave signal is the percentage of time the signal is high, and the negative duty cycle is the percentage of time the signal is low. The duty cycle cannot be directly measured using the oscilloscope, but it can be determined from the period and time high of the signal. The duty cycle is the time high divided by the period (multiply by 100 if a percentage is desired). The time high of the signal is typically measured from 50% of a rising edge to 50% of the next falling edge of the signal.

Figure 1 shows the time high, time low, and period of a square wave signal. The signal in Figure 1 has a duty cycle of 50%.

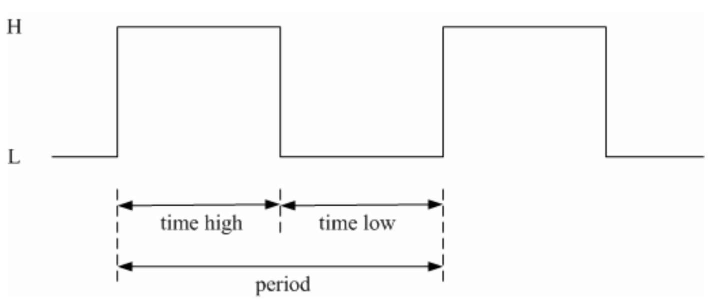

Figure 1. Period and Time High Measurements

Figures 2a and 2b show an example of the oscilloscope captures for measuring the period and duty cycle of a square wave signal. Figure 2a shows the period and Figure 2b shows the time high; the duty cycle is then calculated from time high divided by period. The cursers and the auto measure are both used in this example. For Figure 2b, there is an auto measure for the duty cycle but with the cursers only the time high can be measured. For this example, the period of the signal was determined to be 500 ns and the duty cycle 20%.

The oscilloscope trigger settings can be left on the defaults for these measurements. Once you have acquired the signal, adjust the time scale so that 1.5 to 2 periods of the signal are shown on the screen.

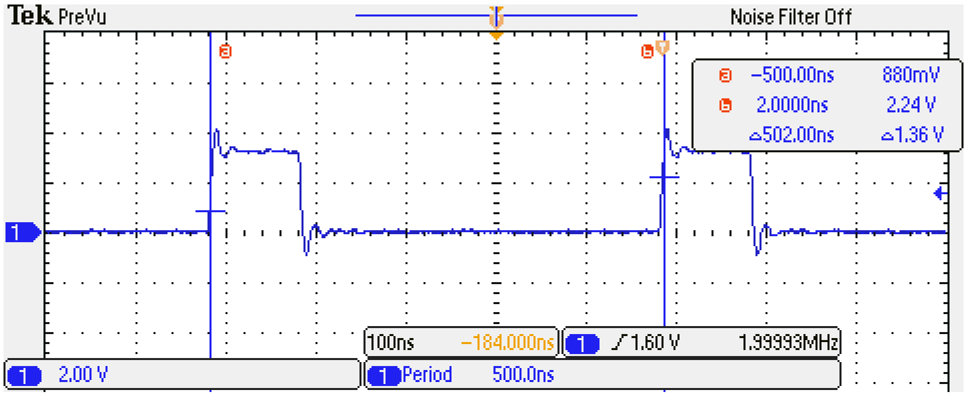

Figure 2a. Oscilloscope Measurement for Period of Signal

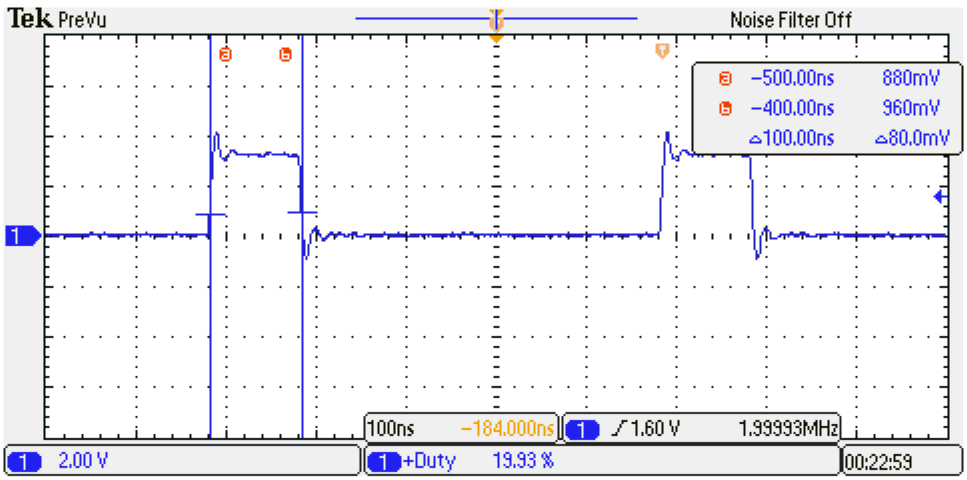

Figure 2b. Oscilloscope Measurement for Time High of Signal

Rise and Fall Time

The rise time is the time it takes for a signal to get from 10% to 90% of its value. The fall time is the time it takes for a signal to get from 90% to 10% of its value. The settling values of the signal is used as the 0% and 100% values; not the highest or lowest value if the signal has overshoot or undershoot. First determine what the steady state high and low values for the signal are. You can then zoom in as much as needed to obtain an accurate measurement of the time.

The oscilloscope trigger needs to be set up to capture the correct portion of the signal. For the rise time, the trigger source is the channel the signal is being measured on, the trigger type is edge, and the trigger slope is rising. For the fall time, the trigger source is the channel the signal is being measured on, the trigger type is edge, and the trigger slope is falling.

Figures 3a and 3b show an example of rise time and fall time measurements. The cursers and the auto measure are both used for the measurements. The rise and fall times in Figures 3a and 3b were 18.25 ns and 8.58 ns respectively.

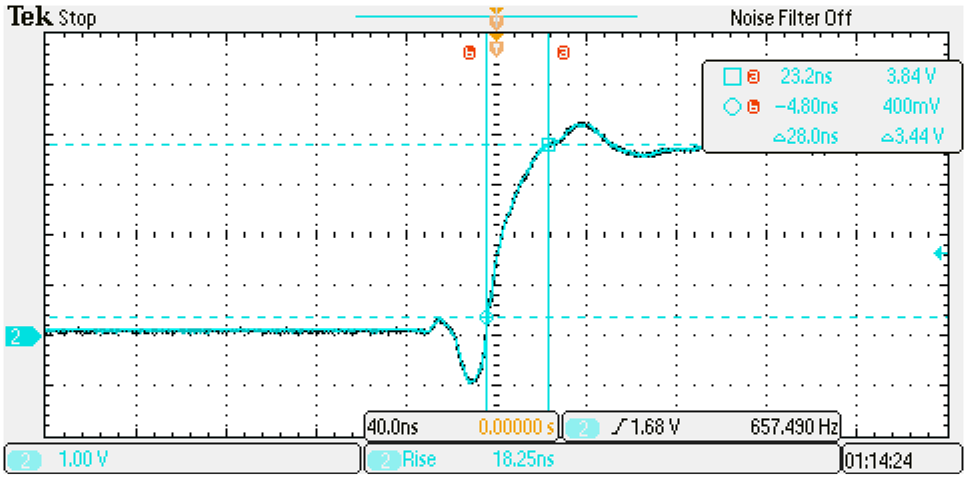

Figure 3a. Oscilloscope Measurement for Rise Time of Signal

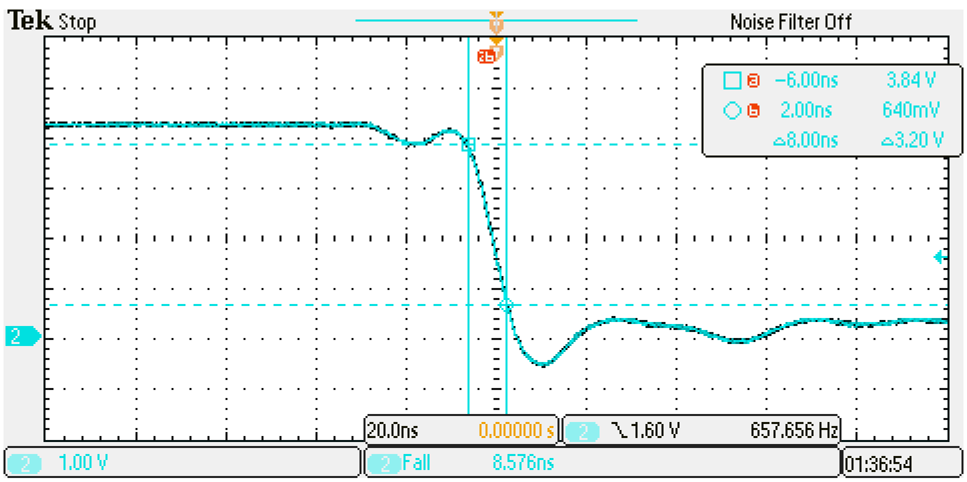

Figure 3b. Oscilloscope Measurement for Fall Time of Signal

Propagation Delay

The propagation delay of a circuit is the time from when the input of a device changes to when output of the device changes. Propagation delays are typically measured from 50% of the input level to change to 50% of the output level change (50% to 50%).

Propagation delay measurements used both channels of the oscilloscope; Channel 1 for the input signal and Channel 2 for the output signal. The trigger source should be channel and the trigger type should be edge. The trigger slope will need to be set according to which propagation delay, low to high or high to low, you are measuring.

Figures 4a and 4b show an example of propagation delay measurements. Figure 4a shows a low to high propagation delay measurement. The delay is named according to the output signal not the input signal. In Figure 4a, the output signal changes from low to high when the input signal changes from high to low. Figure 4b shows a high to low propagation delay measurement. The cursers and the auto measure are both used for the measurements.

The low to high propagation delay was 31.14 ns and the high to low propagation delay was 21.27 ns.

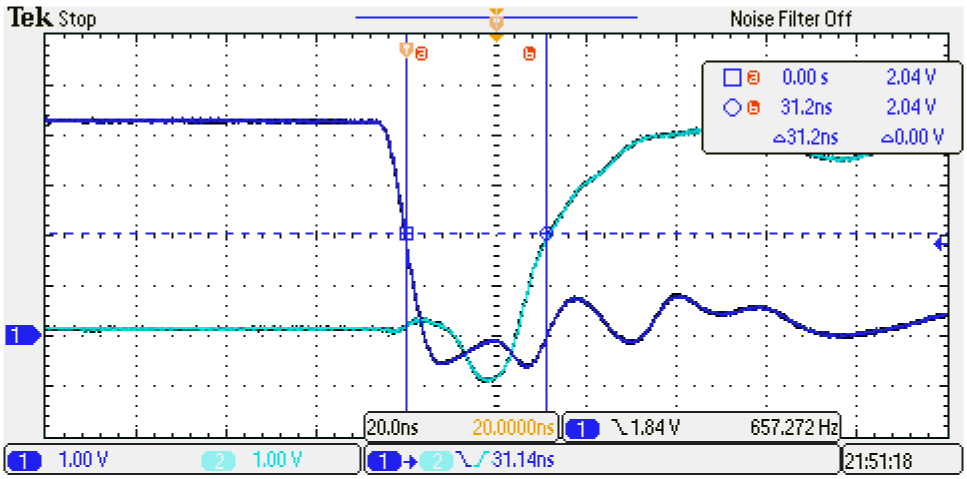

Figure 4a. Oscilloscope Measurement for Low to High Propagation Delay

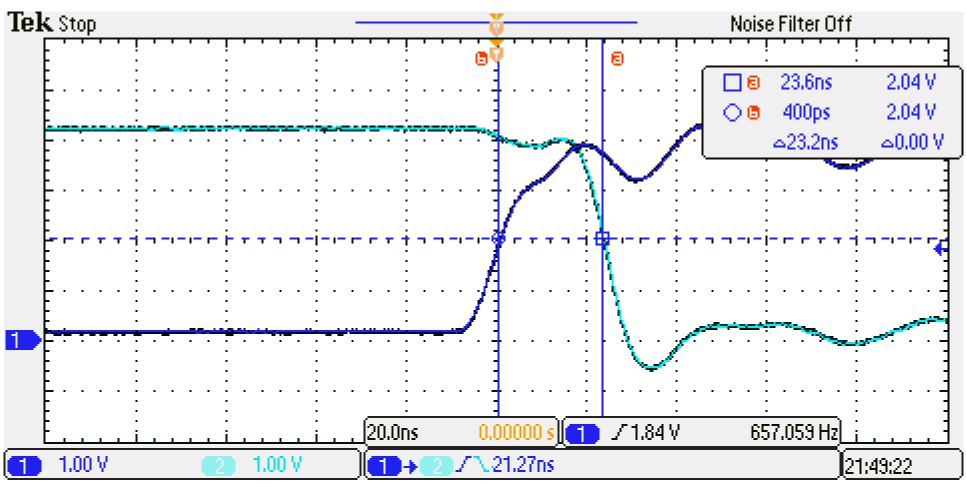

Figure 4b. Oscilloscope Measurement for High to Low Propagation Delay

References

None

Last modified Thursday, August 25, 2022