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February 28, 2011
CSC 270
Lab #5

Lab #5: RS Flip-flops and the Tektronix Oscilloscope

Introduction

The focus of this lab was drawing timing diagrams, working with RS flip-flops using NOR gates and RS flip-flops using NAND gates, as well as becoming familiar with using the Tektronix Oscilloscope.

Materials

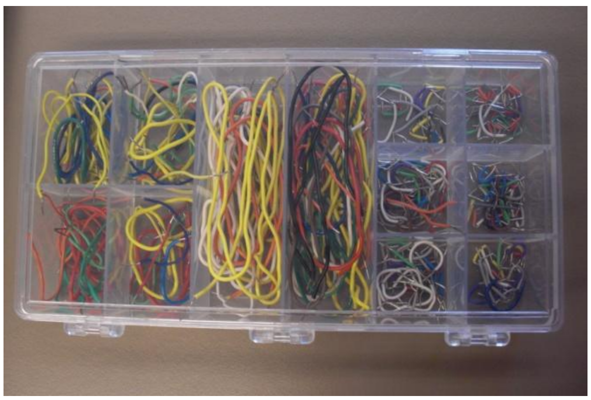

Figure 1. Wiring Kit.

Figure 2. Digital Training Kit.

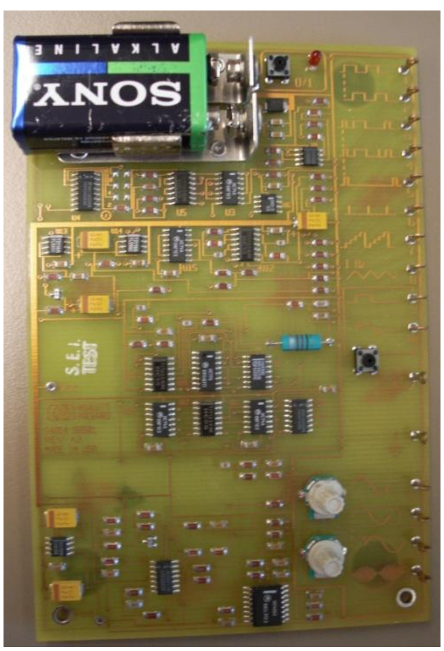

Figure 3. HP Signal Generator Board.

Figure 4. Tektronix MSO3000/DPO3000 Oscilloscope

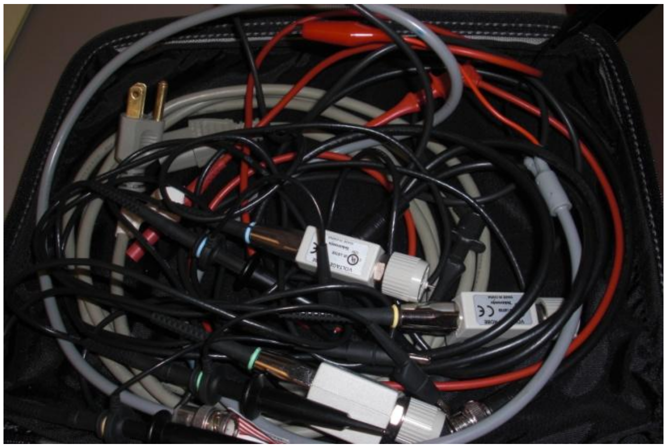

Figure 5. Oscilloscope cables.

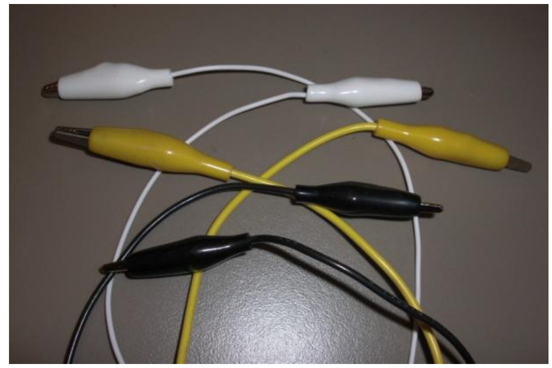

Figure 6. Alligator-to-Alligator Clips.

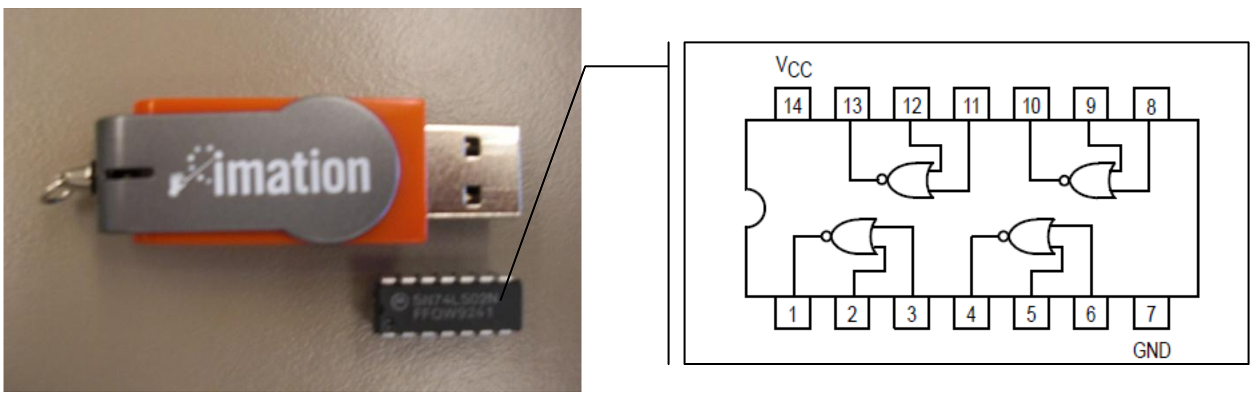

Figure 7. Quad 2-Input NOR Gate 74LS02 Compared to a USB Flash Drive.

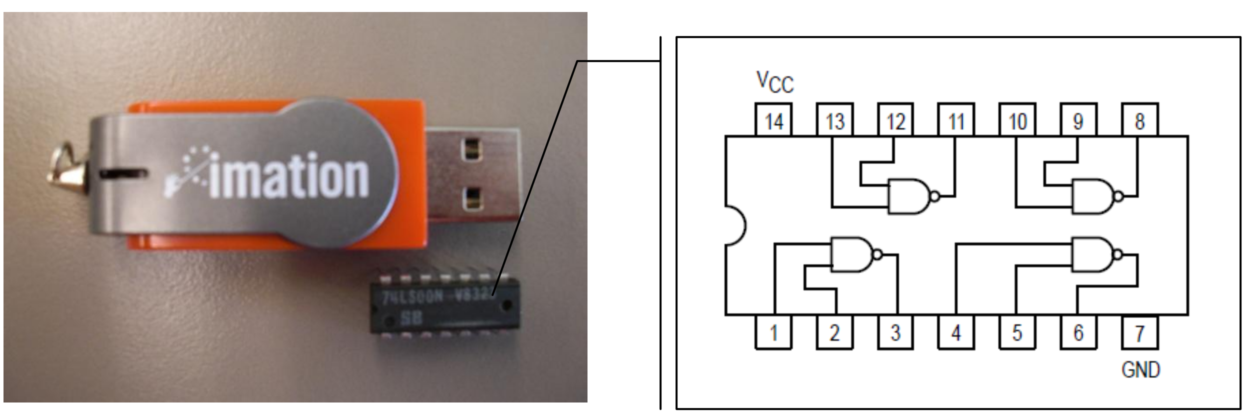

Figure 8. Quad 2-Input NAND Gate 74LS00 Compared to a USB Flash Drive.

The RS Flip-Flop

For this part of the lab, we built a two RS flip-flops—one using NOR gates (Fig. 9) and another one using NAND gates (Fig. 10).

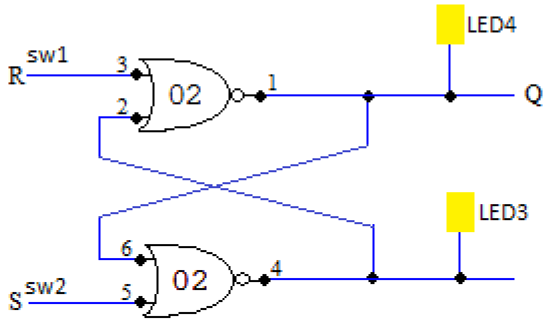

Figure 9. RS Flip-flop Circuit Using NOR Gates.

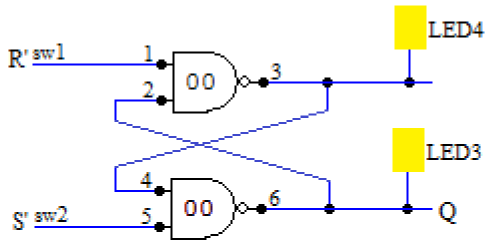

Figure 10. RS Flip-flop Circuit Using NAND Gates.

After building the two different circuits, for each circuit we were able to come up with its corresponding timing diagram based on the states indicated by the LEDs:

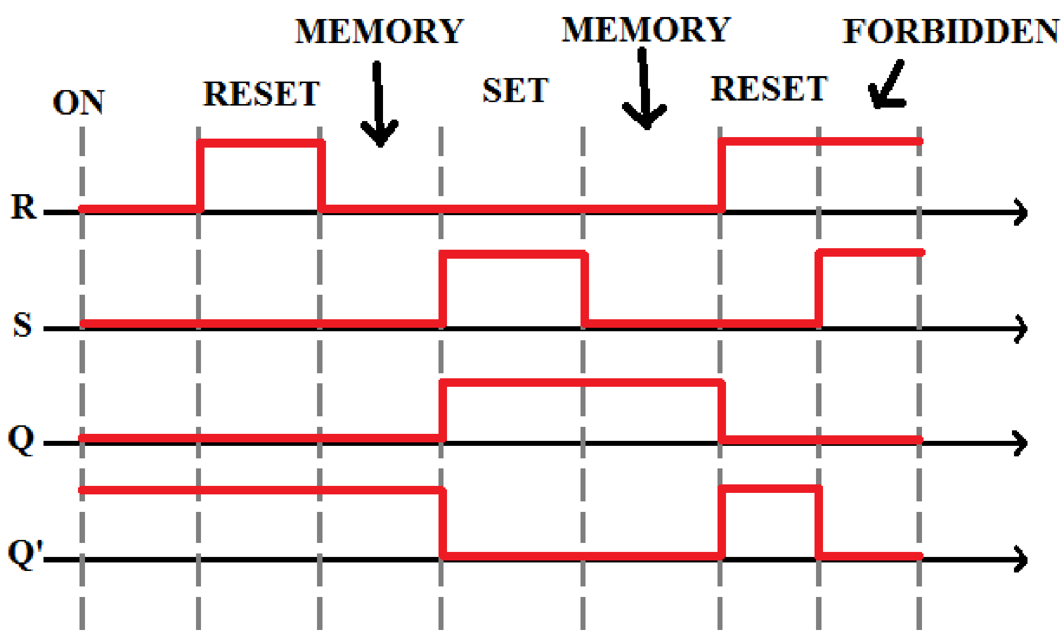

Figure 11. Timing Diagram for RS Flip-flop Using NOR Gates.

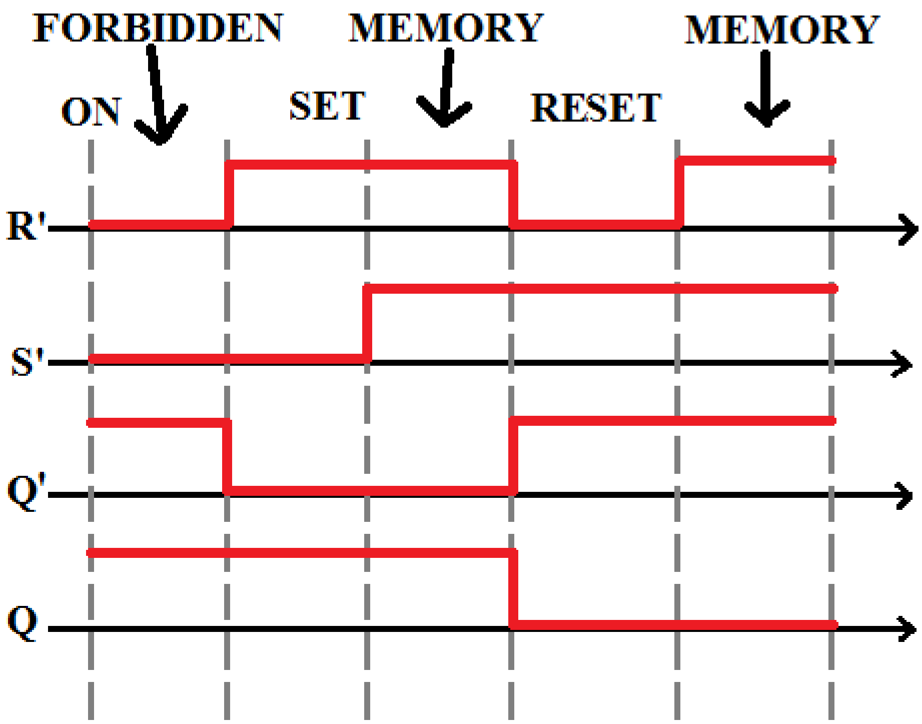

Figure 12. Timing Diagram for RS Flip-flop Using NAND Gates.

These timing diagram confirmed with our understanding of how a flip-flop circuit works.

Tektronix Scope Lab

The Tektronix Scope Lab provided an introduction to using the oscilloscope. To set up the first part of this lab, we took two voltage probes and connected them to inputs 1 and 2 of the scope. To make the probes easier to work with, we color-coded them by attaching colored rings to both ends of the probes. Next, we connected the scope to a HP signal generator board. To do this, we first made sure the battery is fully engaged in its connector on the board. Then we turned the board on and connected Probe 1 of the scope to TP1 and grounded it with the alligator clip attached to the probe.

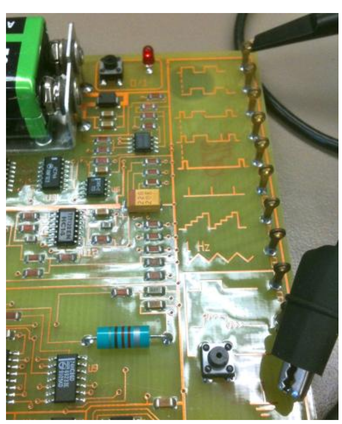

Figure 13. Attaching the Voltage Probe to the Signal Generator Board (Taken from D.Thiebaut).

After pressing the AUTOSET button, a square wave was seen on the scope's screen. Using the position and scale dials around the yellow '1' button, we were able to shift and scale the waveform vertically. Turing the position and scale dials in the upper right corner of the scope allowed us to shift and scale the waveform horizontally. The pan and zoom dials in the upper center of the scope allowed us to control which part of the waveform we wanted to capture to the scope's screen.

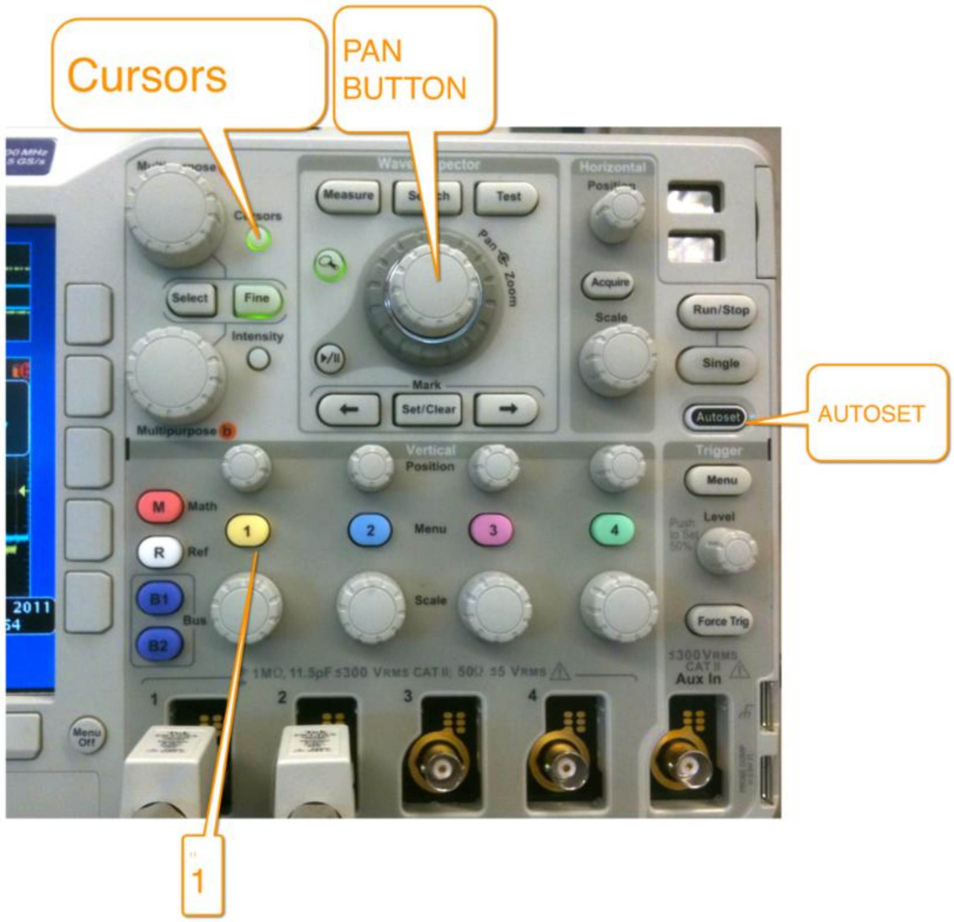

Figure 14. Oscilloscope Control Area (Taken from D. Thiebaut).

After playing with the different dials on the scope, we pressed the cursor button located in the upper left corner of the scope's controller area to turn the cursors on. Moving the cursors around with the Multipurpose a and Multipurpose b dials until we had one period of the wave within the two cursors, we measure the length of the square wave's period to be 2.02μs (Fig. 15).

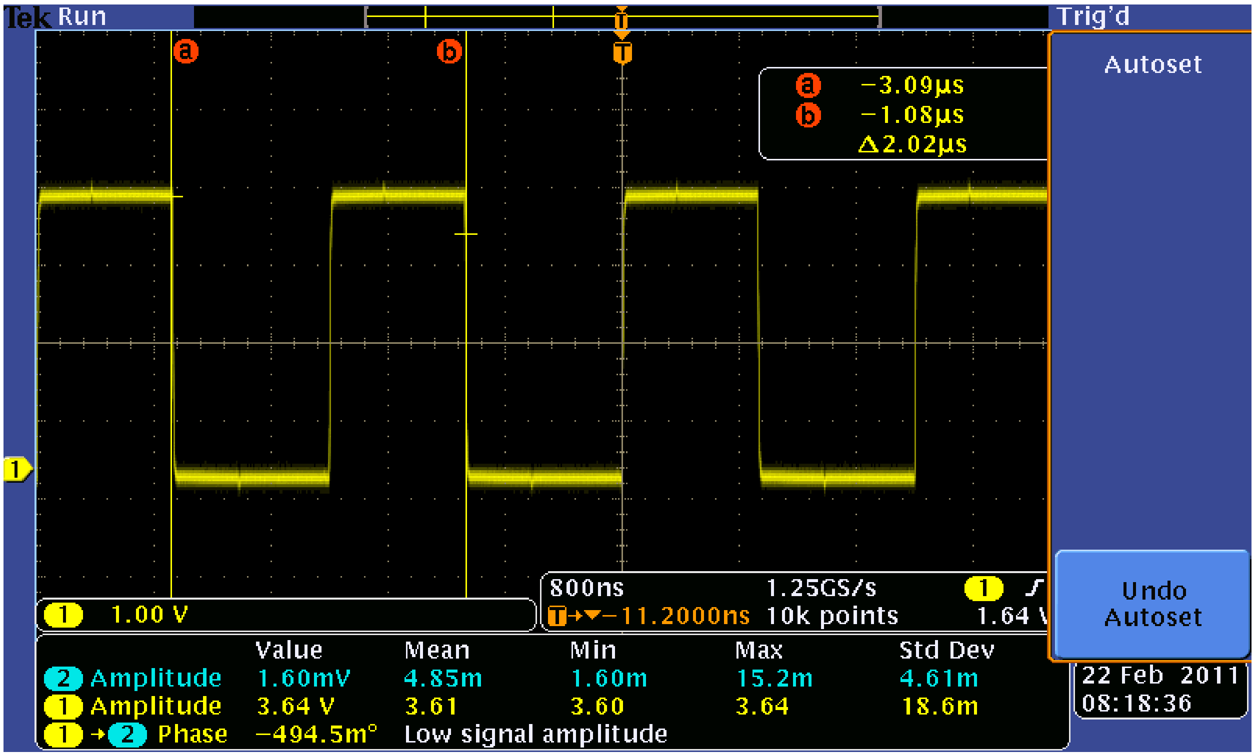

Figure 15. Screen Capture from Oscilloscope of Waveform 1's Period.

To capture the frequency of the waveform, we kept our cursors as they were and changed the units of the measurements by pushing the Measure button, choosing Configure Cursors, and setting the cursor mode to display in hertz (Hz) instead of seconds (s). After selecting Configure Cursors one more time to remove the menus from the screen, we determined that the frequency of the signal we captured was 496 kHz (Fig. 16), which is consistent with the fact that the frequency is equal to the inverse of the period.

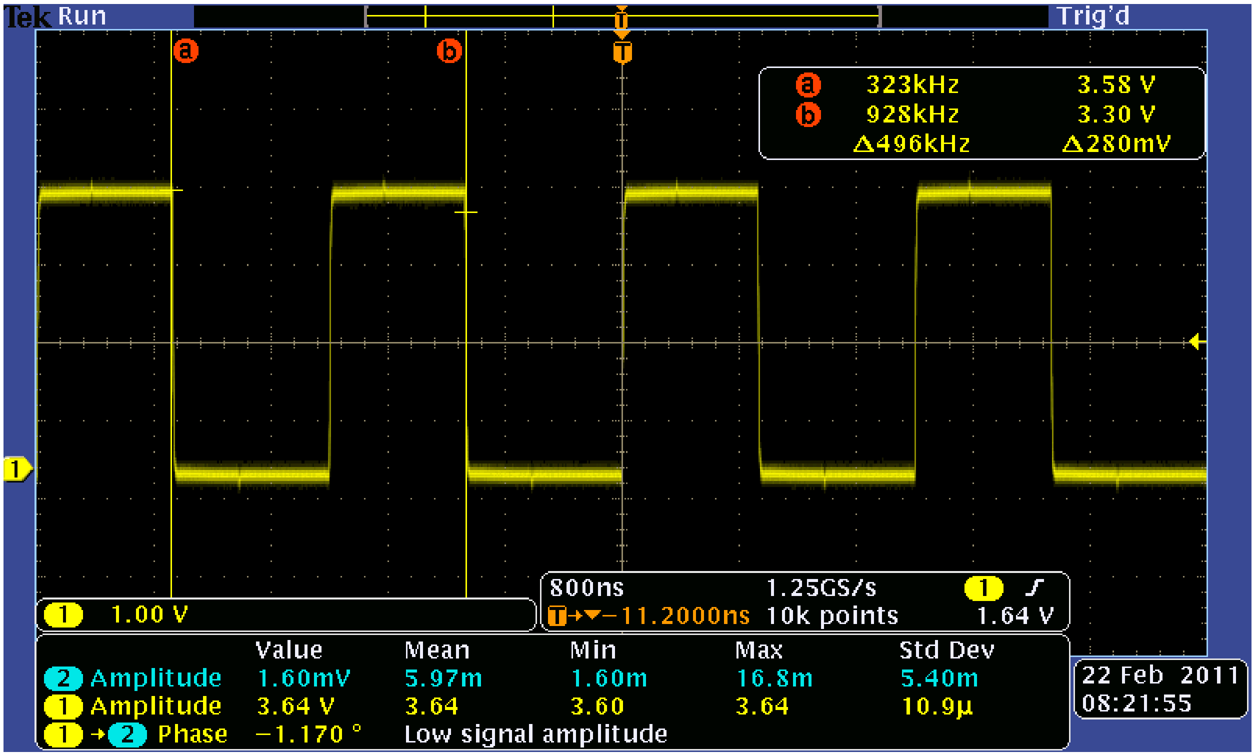

Figure 16. Screen Capture from Oscilloscope of Waveform 1's Frequency.

For our final measurement, we measured the peak-to-peak amplitude of the waveform. To do this, we pushed the Cursors button another time to control both the horizontal and vertical cursors and then the Select button to switch to the horizontal cursors. Using Multipurpose a and Multipurpose b dials, we moved the cursors so that a was at the highest peak of the waveform and b was at the lowest peak of the waveform. The peak-to-peak amplitude was 3.76V (Fig. 17).

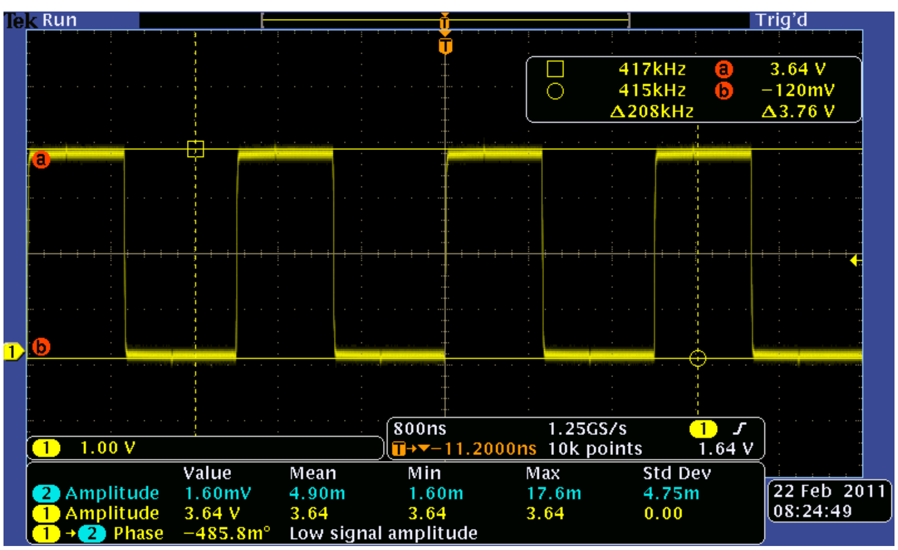

Figure 17. Screen Capture from Oscilloscope of Waveform1's Amplitude.

This value appears unusual when we consider that the power supply of TTL circuits is 5V. The discrepancy in values could be due to the fact that the power supply of the circuit is a battery, which is 5V DC, but the measured waveform is AC.

After taking measurements with waveform 1, we moved on to capture 2 waveforms with the scope by connecting Probe 2 to Test Point 3. After pressing the AUTOSET and the '2' buttons to bring waveform 2onto the screen, waveform 1 appears very clearly but waveform 2 does not. This is due to the fact that waveform 1 is faster than waveform 2 and the scope syncs to signal from Probe 1 by default. To fix this issue, we simply switched the probes such that Probe 1 was connected to Test Point 3 and Probe 2 was connected to Test Point 1. We then measured the frequency of waveform from Test Point 3 as we did with the waveform from Test Point 1 previously. The frequency of the new waveform was 82.8kHz (Fig. 18).

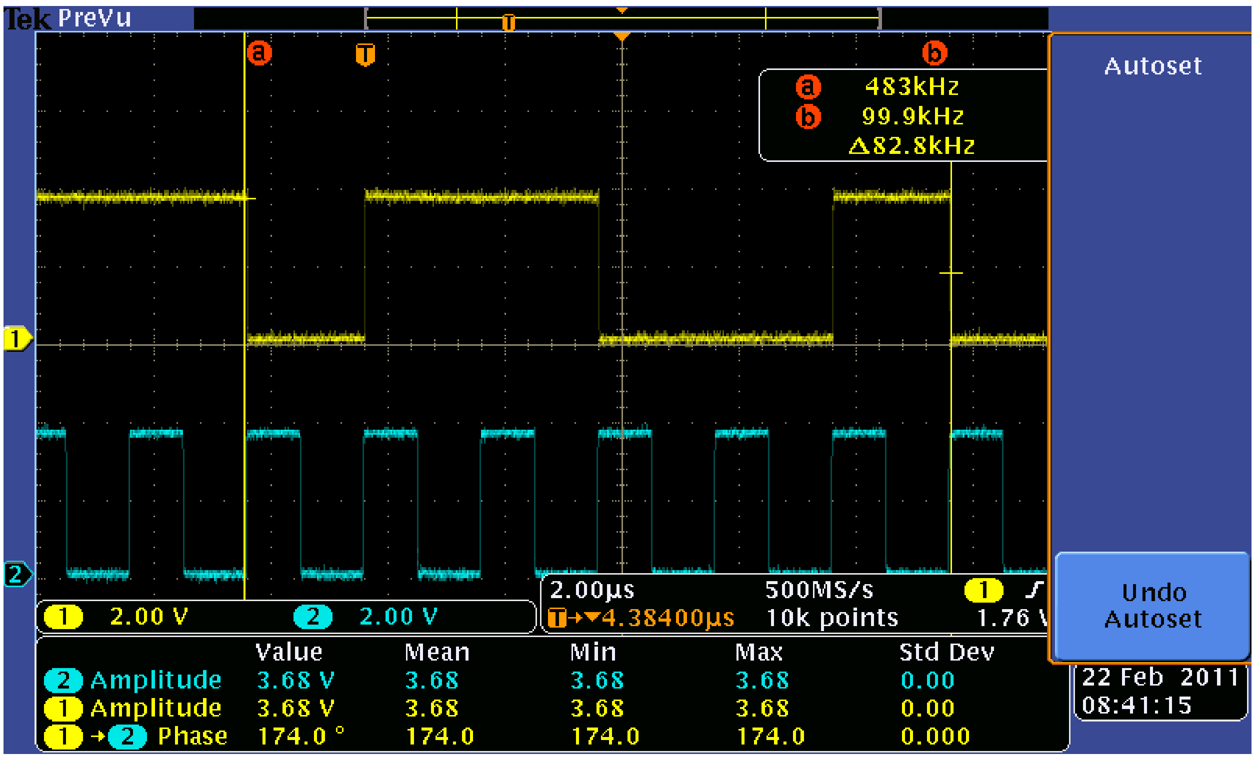

Figure 18. Screen Capture from Oscilloscope of Waveform 2's (Yellow) Frequency.

Finally, we practiced more with two other waveforms—Test Points 2 and 5. Since Test Point 5 is slower than Test Point 2, we connected Probe 1 to Test Point 5 and Probe 2 to Test Point 2 (Fig. 19). Measuring the waveforms as we had done previously, we determined that the waveform from Test Point 2 had a frequency of 499kHz and a period of 2.01µs and the waveform from Test Point 5 had a frequency of 33.3kHz and a period of 30.1µs.

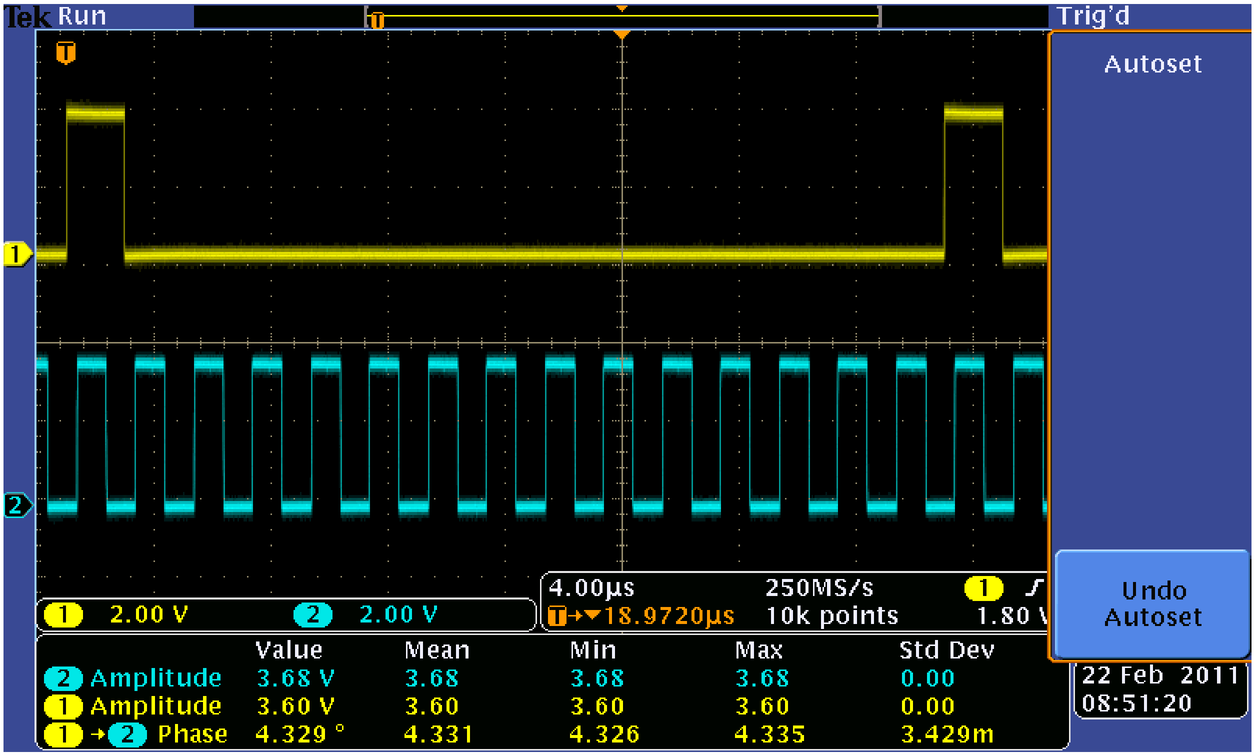

Figure 19. Screen Capture from Oscilloscope of Test Points 2 (Blue) and 5 (Yellow).

The screen captures used were obtained by plugging a USB flash drive into the USB flash drive port of the scope and pushing the save button located to the right of the port.

Waveforms of RS Flip-Flops

After becoming familiar with using the oscilloscope and HP signal generator board, we connected our RS flip-flop circuits to the scope and signal generator board. To do this we connected the grounds of the RS flip-flop circuits with the ground of the signal generator board. By connecting the scope and signal generator with the RS flip-flop circuits, we were able to get an electronic generation of the timing diagram for the flip-flop circuits. The following are edited captures of the behavior of the NOR RS flip-flop (Fig. 20) and NAND RS flip-flop (Fig. 21) that indicate the different states of the timing diagrams:

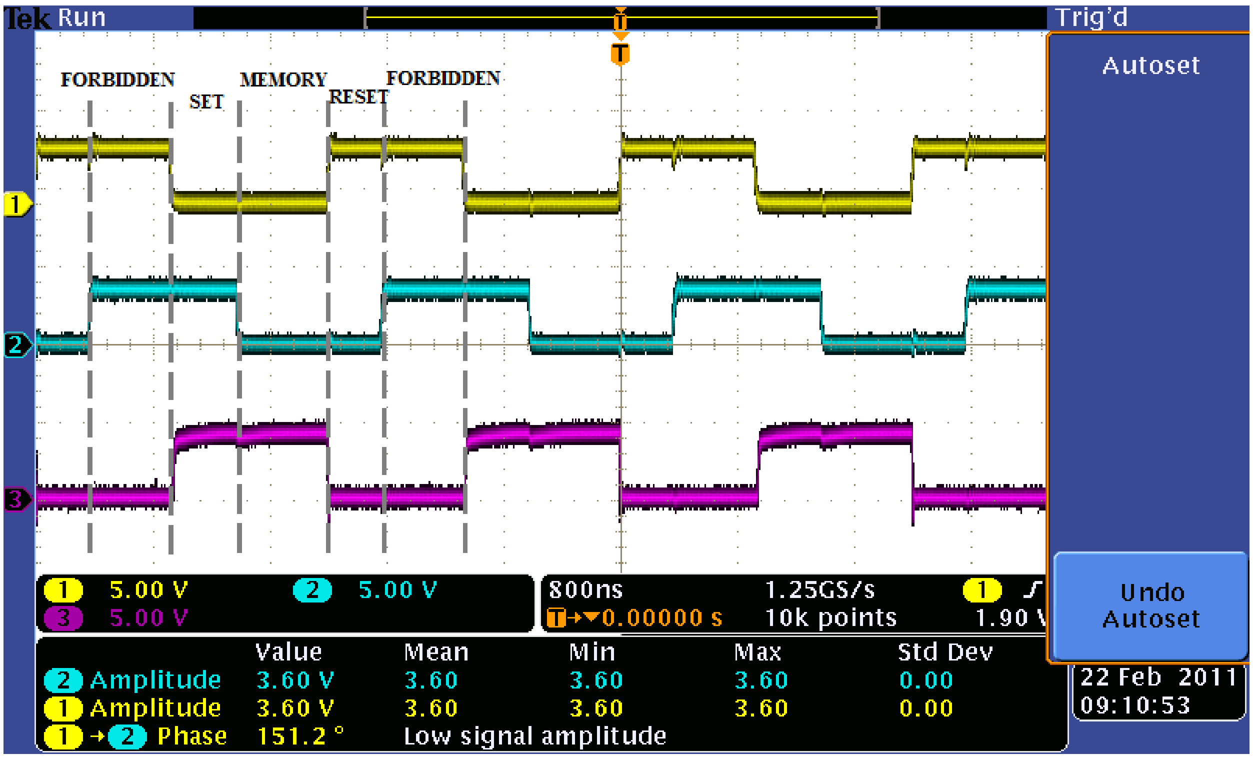

Figure 20. Annotated Screen Capture of RS Flip-Flop with NOR Gates
(Yellow = R, Blue = S, Purple = Q).

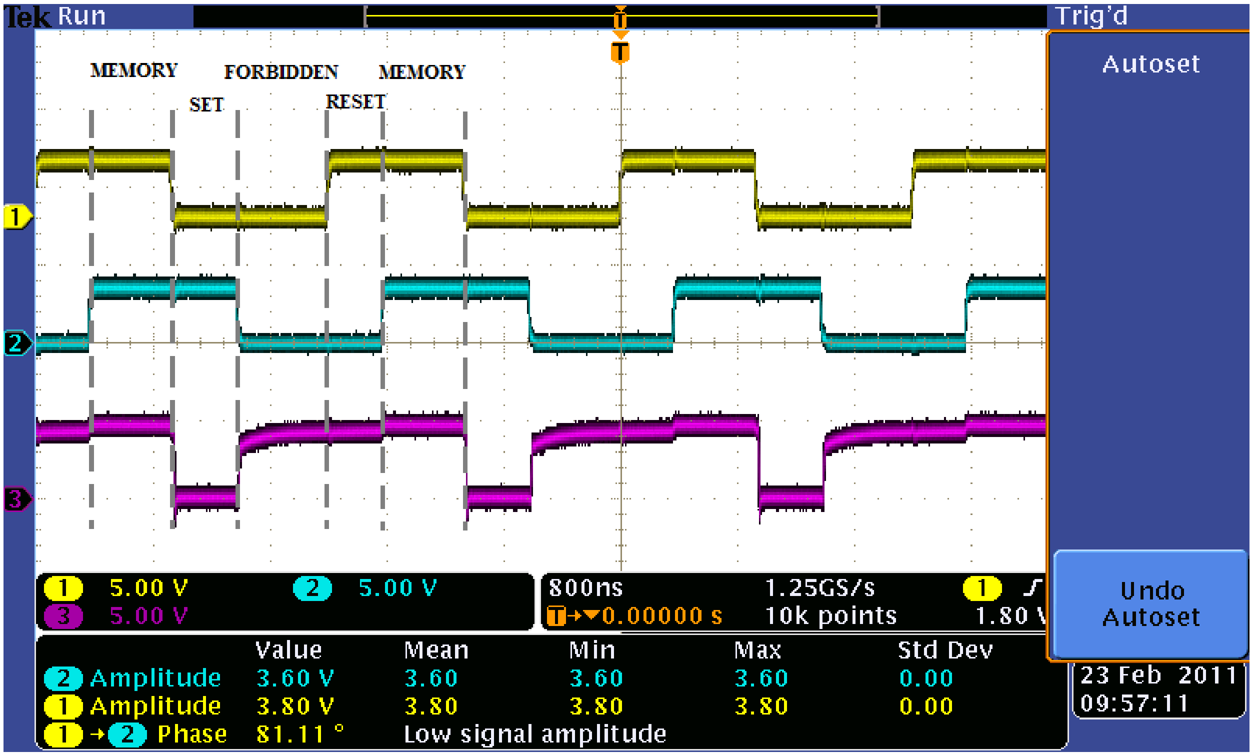

Figure 21. Annotated Screen Capture of RS Flip-Flop with NAND Gates
(Yellow = R', Blue = S', Purple = Q).

The figures obtained from the oscilloscope were consistent with the timing diagrams produced from the first part of the lab (Figs. 11 and 12).