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Computer Interfacing and Peripheral Equipment
Laboratory Exercise 03a
Rick L. Swenson

Lab Objective:

Understanding timing parameters, looking closely at glitches, measuring propagations delays

Material:

- TTL logic gates: 74LS04 (Inverter). 74LS08 (AND)
- CMOS logic gates: CD4069 (Totem-Pole Inverter).
- Function Generator, Power supply, Multimeter and Oscilloscope

Introduction:

The timing parameters commonly used in digital circuitry are:

t_r: rise-time
f_t: fall-time
t_{PLH}: Propagation Delay Low to High
t_{PHL}: Propagation Delay High to Low
δ: Average propagation delay

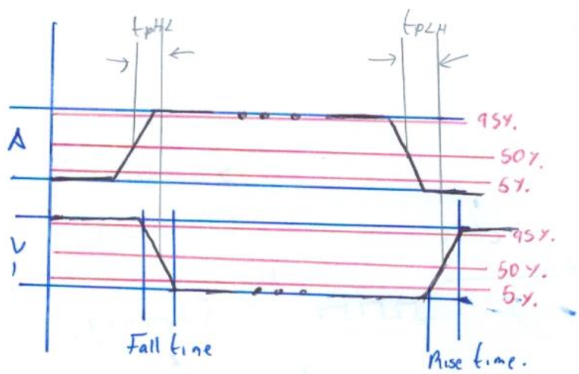


Figure 1: Timing parameters

$$\delta = \frac{t_{PHL} + t_{PLH}}{2}$$

Average Propagation Delay

Part 1: Measuring Timing Parameters

Assemble the circuit shown in Figure 2. Obtain and measure t_r, f_t, t_{PLH}, t_{PHL} and δ using an oscilloscope. First try with a TTL 74LS04 inverter and then with a CMOS CD4069.

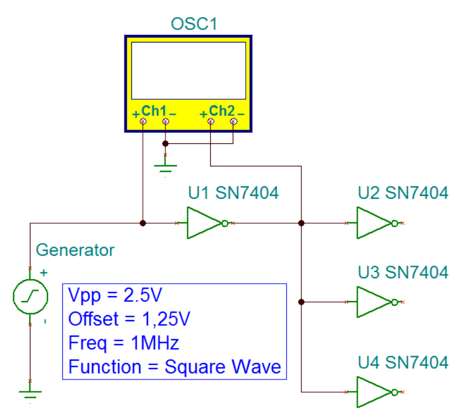
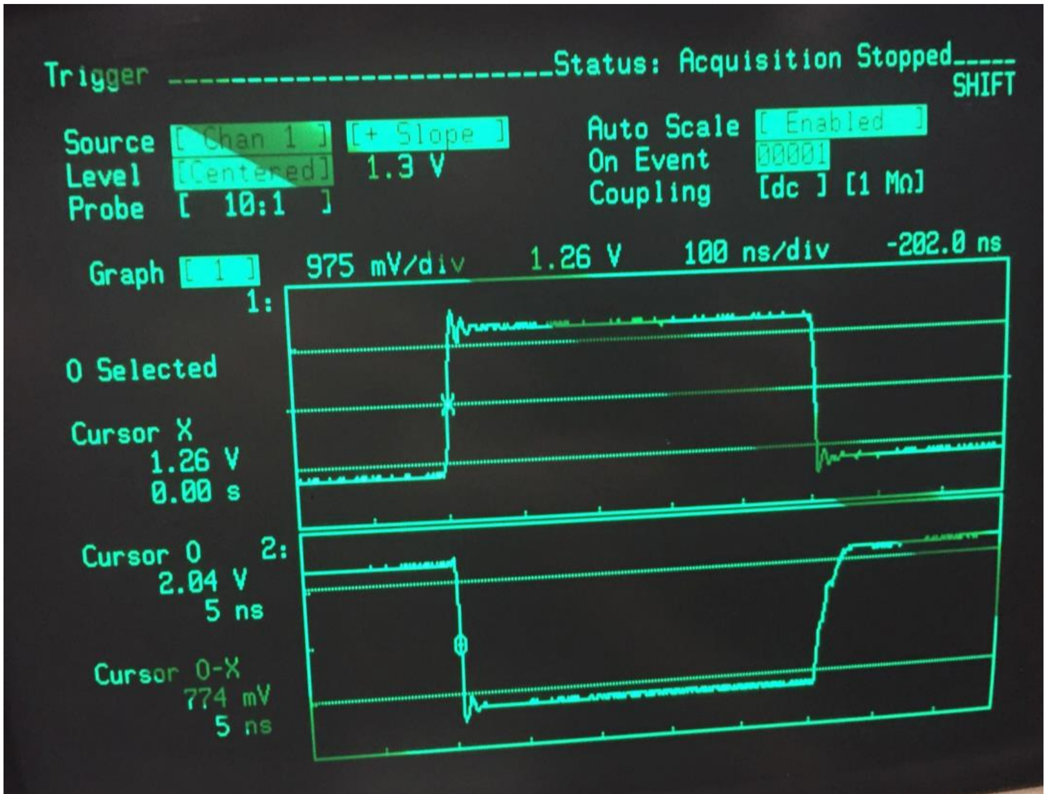


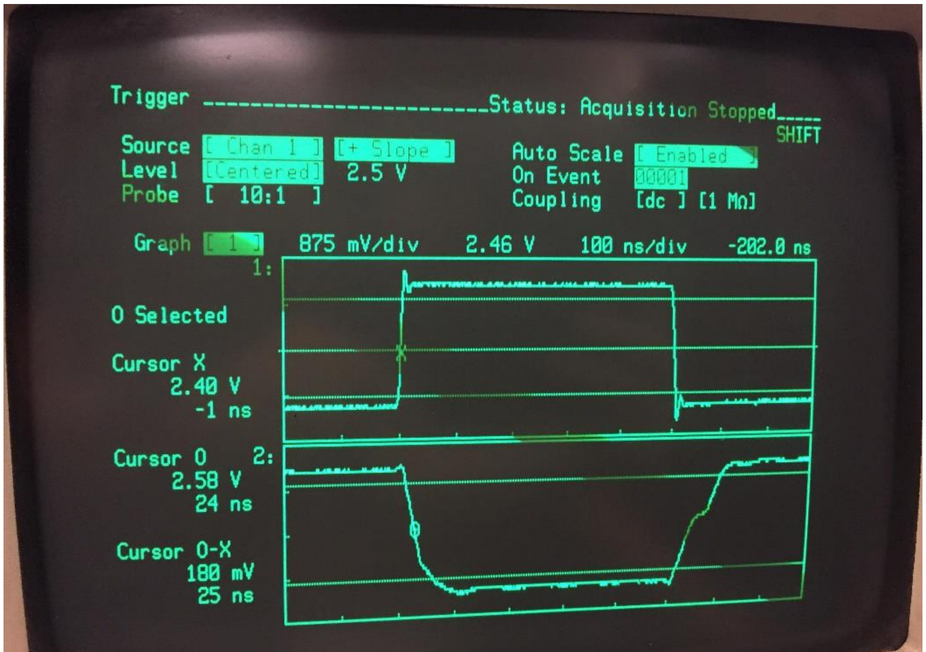
Figure 2: Measuring Timing Parameters

74LS04:



$$t_r = 35\ ns$$
$$t_f = 7\ ns$$
$$t_{PLH} = 5\ ns$$
$$t_{PLH} = 17\ ns$$
$$\delta = \frac{5\text{ ns} + 17\text{ ns}}{2} = 11\ ns$$

CD4069:



$$t_r = 87\ ns$$
$$t_r = 48\ ns$$
$$t_{PLH} = 25\ ns$$
$$t_{PLH} = 53\ ns$$
$$\delta = \frac{25\text{ ns} + 53\text{ ns}}{2} = 39\ ns$$

Part 2: Looking closely for glitches.

Assemble the circuit shown in Figure 3. Obtain the timing diagram shown in Figure 3 (right)

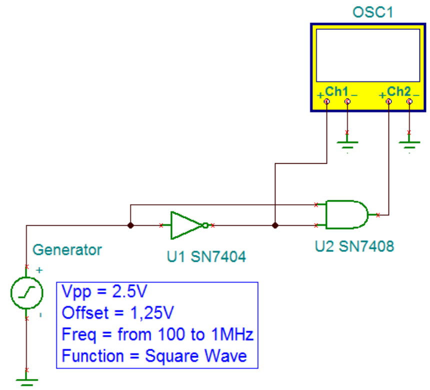
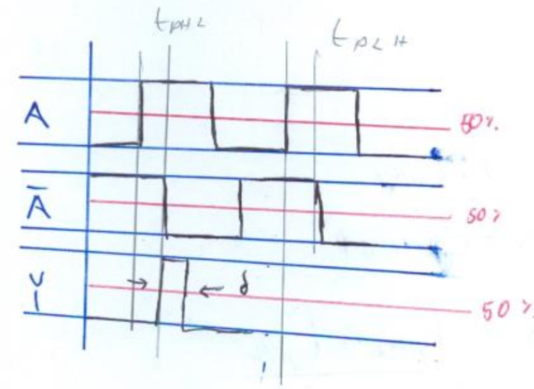
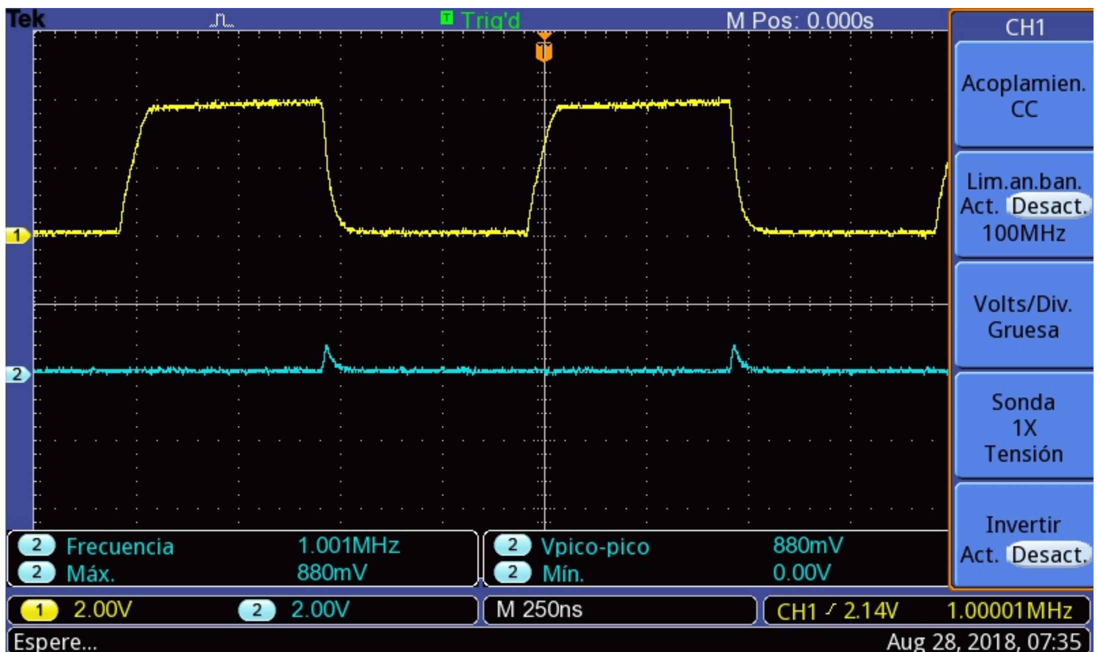
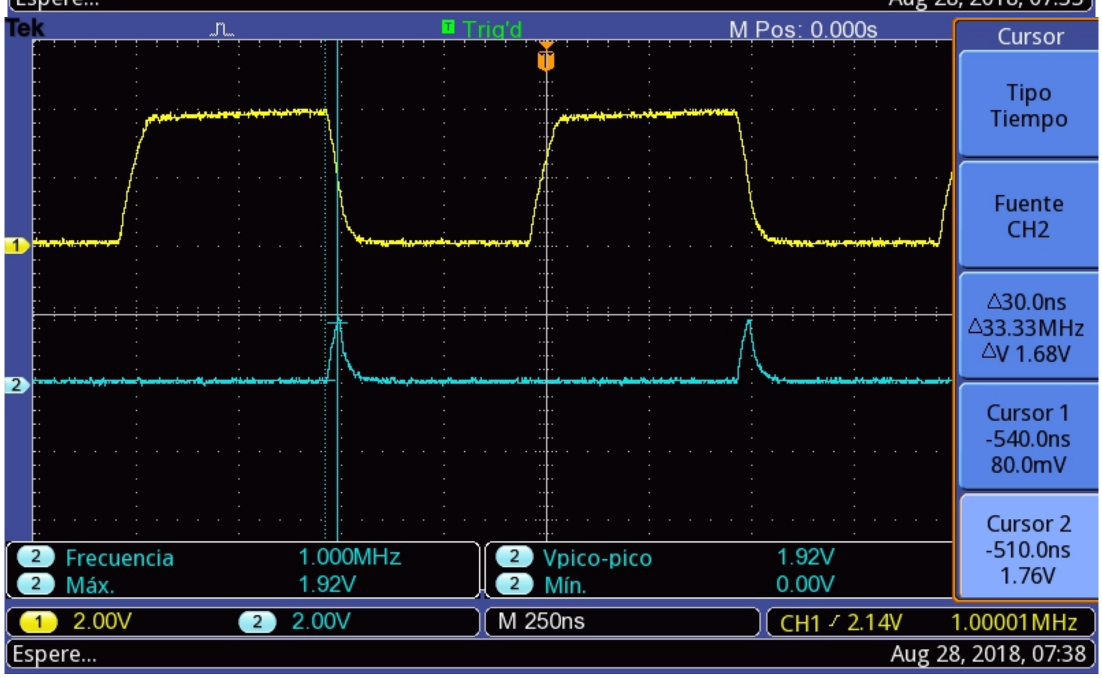


Figure 3: Looking for a Glitch



Timing diagram showing glitch





Part 3: Ring Oscillator

Assemble the circuit shown in Figure 4. It is called a ring oscillator. It is a simple way of determining the average propagation delay for a digital circuit. Notice that an odd number of gates is required to make it oscillate at full frequency. Determine the average propagation delay δ by carefully taking measurements in the oscilloscope.

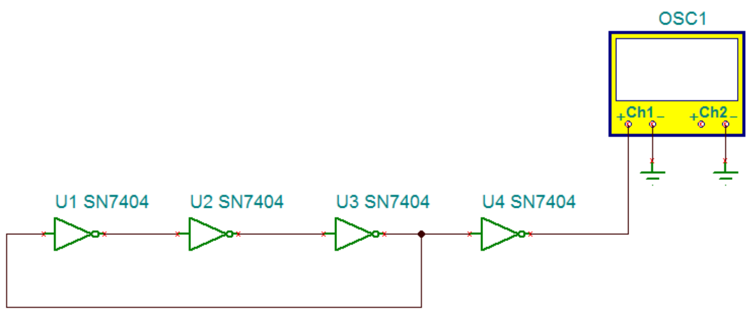
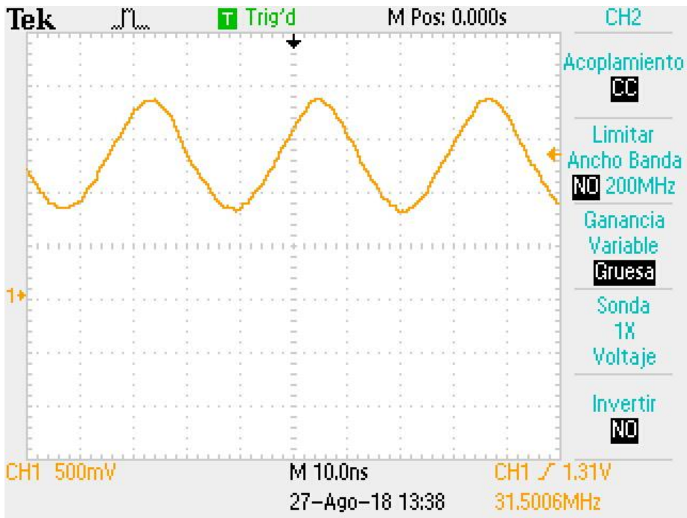


Figure 4: A ring Oscillator



$$f = 31.5\ MHz$$

$$\text{average propagation delay} = \frac{1}{3 * f} = 10.582\ ns$$