

ELEC353 Lecture Notes Set 8

The homework assignments are posted on the course web site.

http://users.encs.concordia.ca/~trueman/web_page_353.htm

Homework #4: Do homework #4 by February 8, 2019.

Homework #5: Do homework #5 by February 14, 2019.

Mid-term test: Thursday February 14, 2019.

- Includes Homework #5!
- See the course web site for sample mid-term tests with solutions.
- Study tip:
 - Download the question paper for a mid-term from a previous year.
 - Spend one hour 15 minutes solving the test with your calculator and the formula sheet, but no textbook or notes.
 - Grade your answer against the solution to the test!

Tentative final exam date: Tuesday April 23, 2019, 9:00 to 12:00.

Mid-term Test: Thursday February 14, 2019

What is covered on the mid-term?

Everything done in class up to February 12.

Lecture Notes Set 1 to Set 7

Homework assignments #1 to 5

#1 = lumped and distributed circuit analysis, RC model of a TL

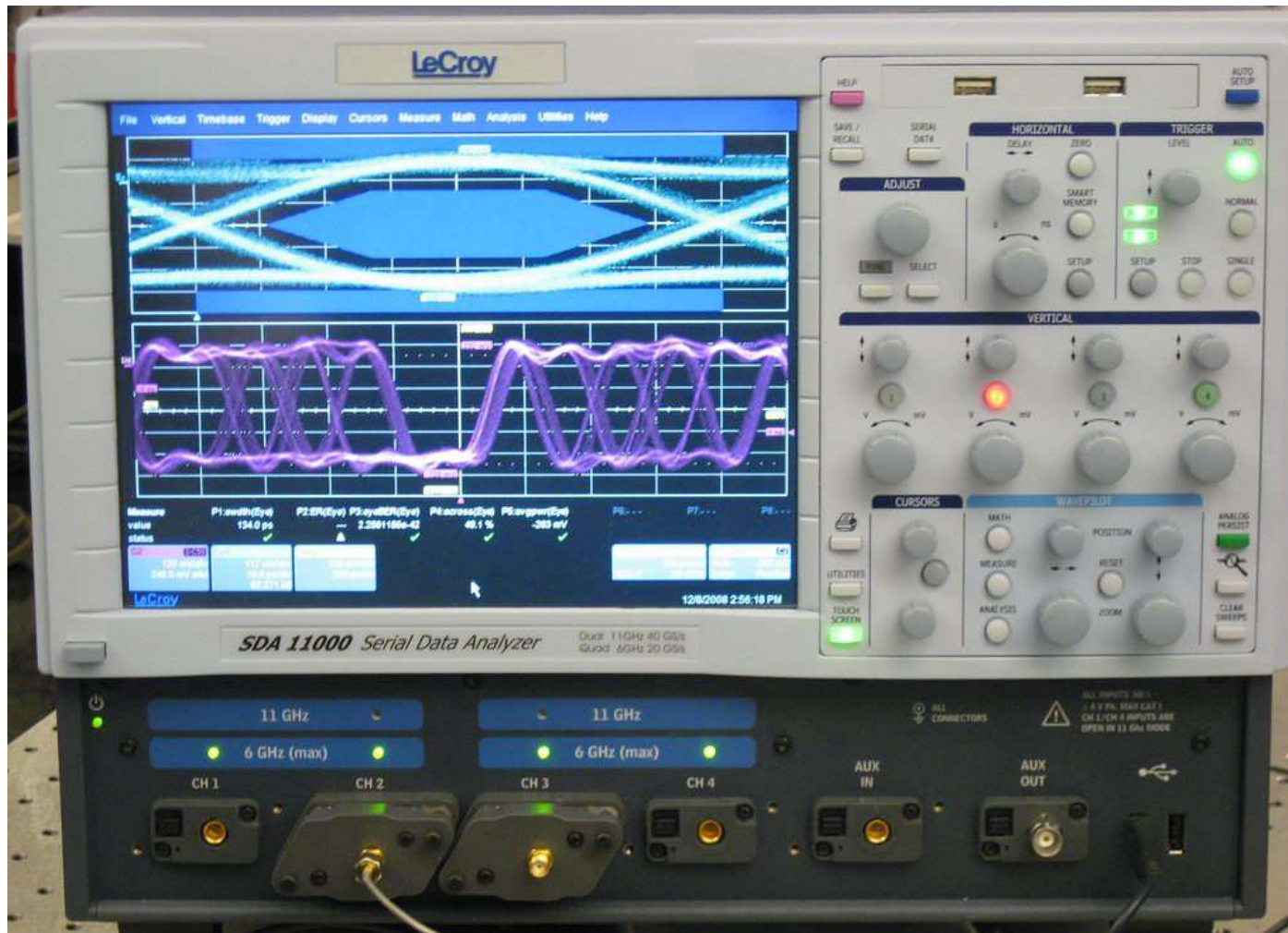
#2 = introductory TL questions, bounce diagram

#3 = TL in series, TL with shunt load

#4 = branching TL, RL load, TDR

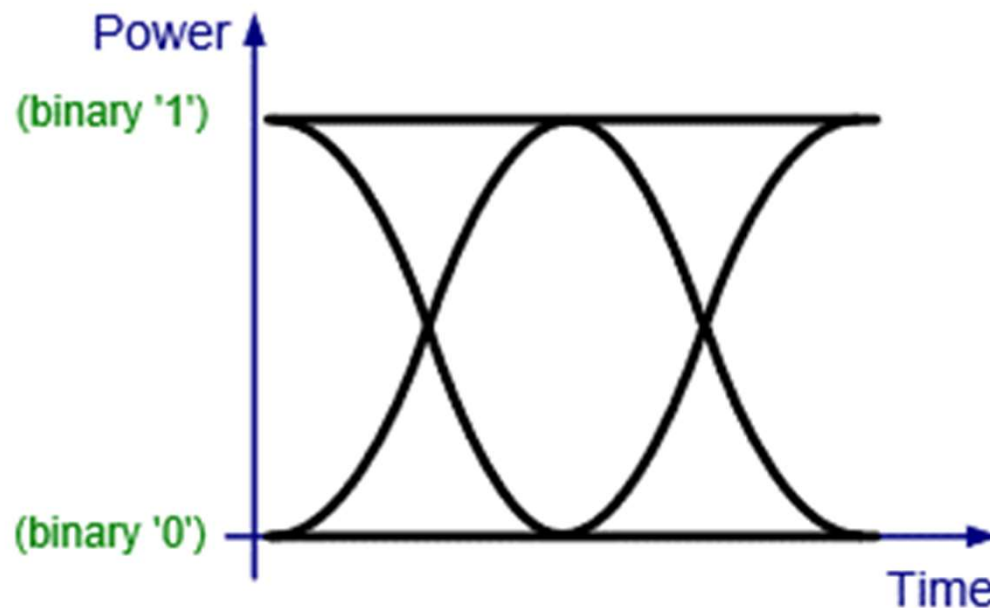
#5 = RL load, transmission lines in series, pulse generator, TDR

Eye Patterns



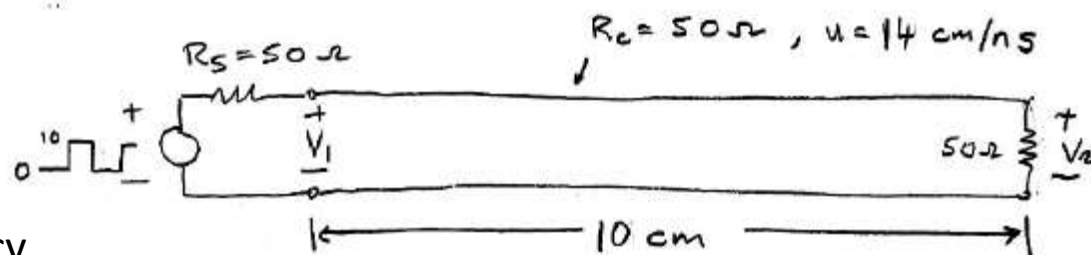
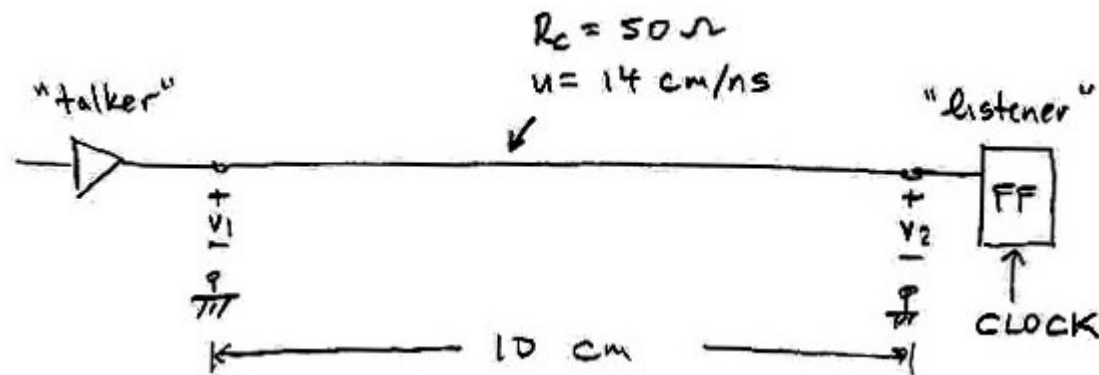
Wikipedia:

In [telecommunication](#), an **eye pattern**, also known as an **eye diagram**, is an [oscilloscope](#) display in which a [digital signal](#) from a receiver is repetitively sampled and applied to the vertical input, while the data rate is used to trigger the horizontal sweep. It is so called because, for several types of coding, the pattern looks like a series of eyes between a pair of rails. It is a tool for the evaluation of the combined effects of channel noise and [intersymbol interference](#) on the performance of a baseband pulse-transmission system. It is the synchronised superposition of all possible realisations of the signal of interest viewed within a particular signaling interval.



An Ideal Transmission Path

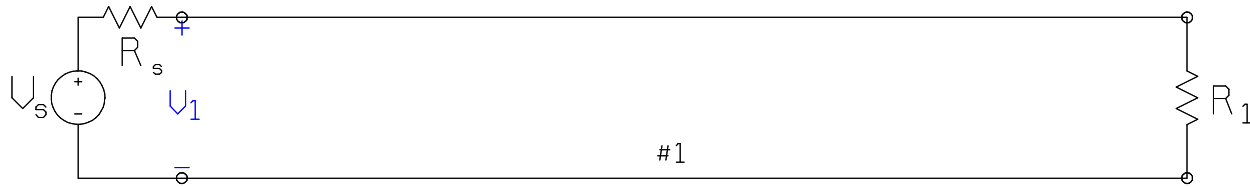
- No mismatch
- No reflections
- The only difference between the “input” and the “output” is the propagation delay of $T_d = \frac{L}{u}$.



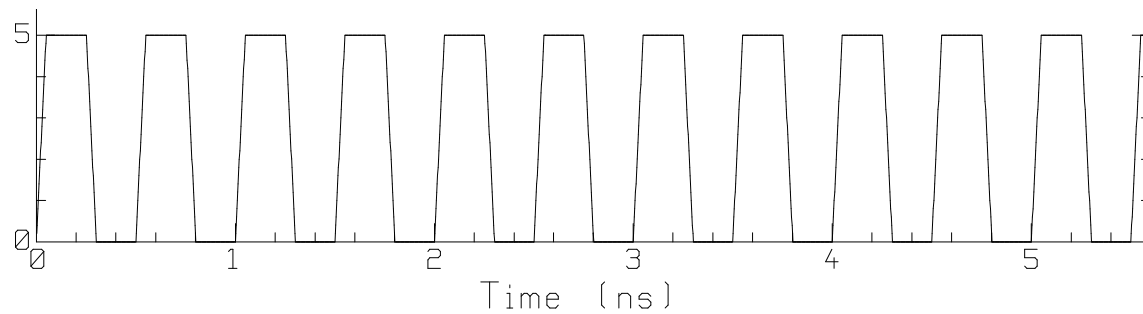
Frequency
2GHz
Rise time
0.05 ns

The transit time on the 10 cm line is $T = \frac{L}{u} = \frac{10}{14} = 0.714 \text{ ns}$

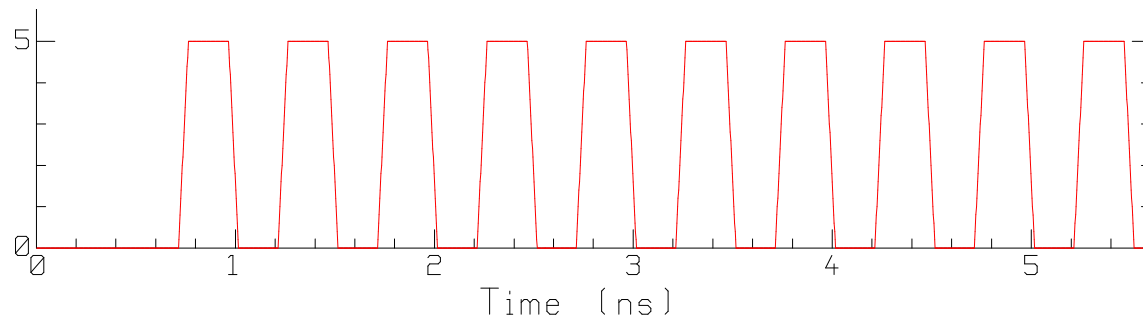
An ideal transmission path:



Input:



Output: a delayed copy of the input.

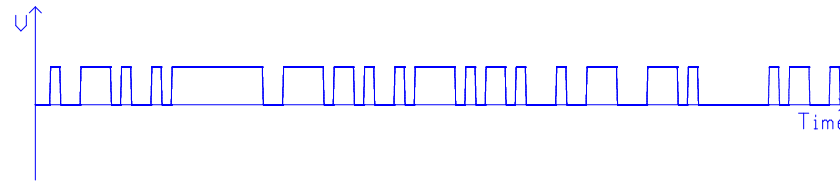
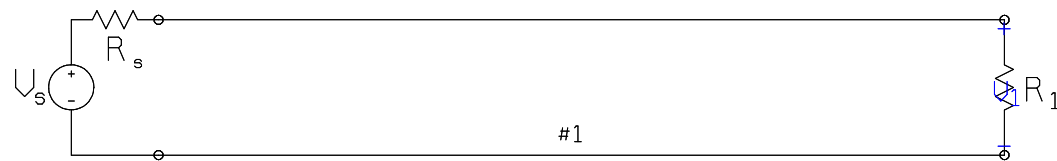


Eye Pattern for the Ideal Communication Channel

Input: V_s is a random series of 0s and 1s.

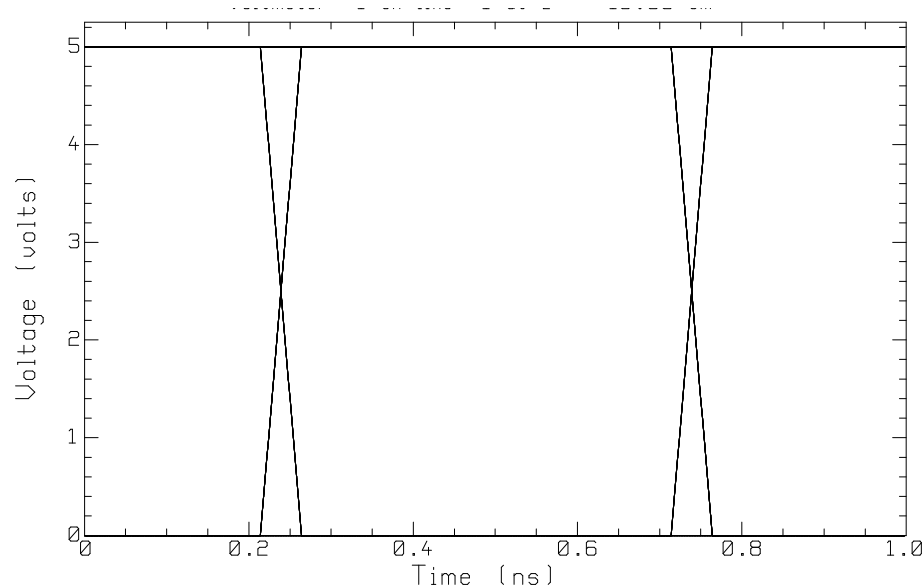
Frequency
2GHz
Rise time
0.05 ns

This is the eye pattern for the bit stream shown above.



Click the mouse on a voltage wave to report the value.

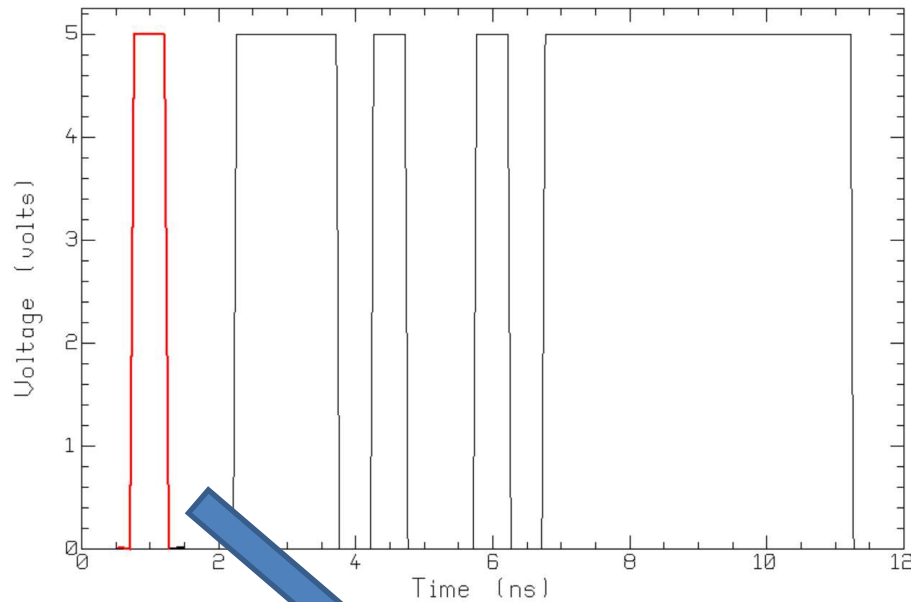
Eye Patn
Plot $v(t)$
Plot $v(z)$
Time Cycle
Continue
Back



Output: for the ideal communication channel, the output is a delayed copy of the input.

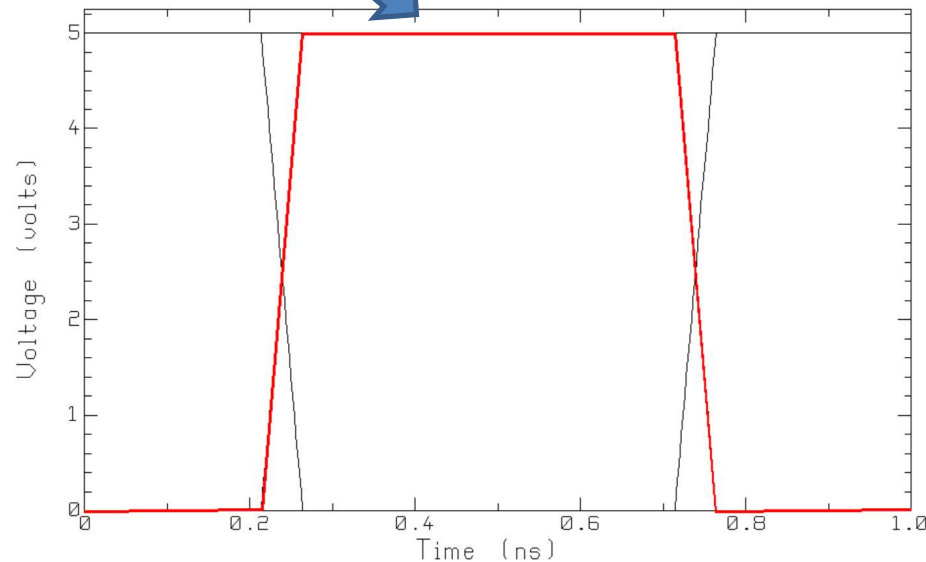
How do we construct the eye pattern?

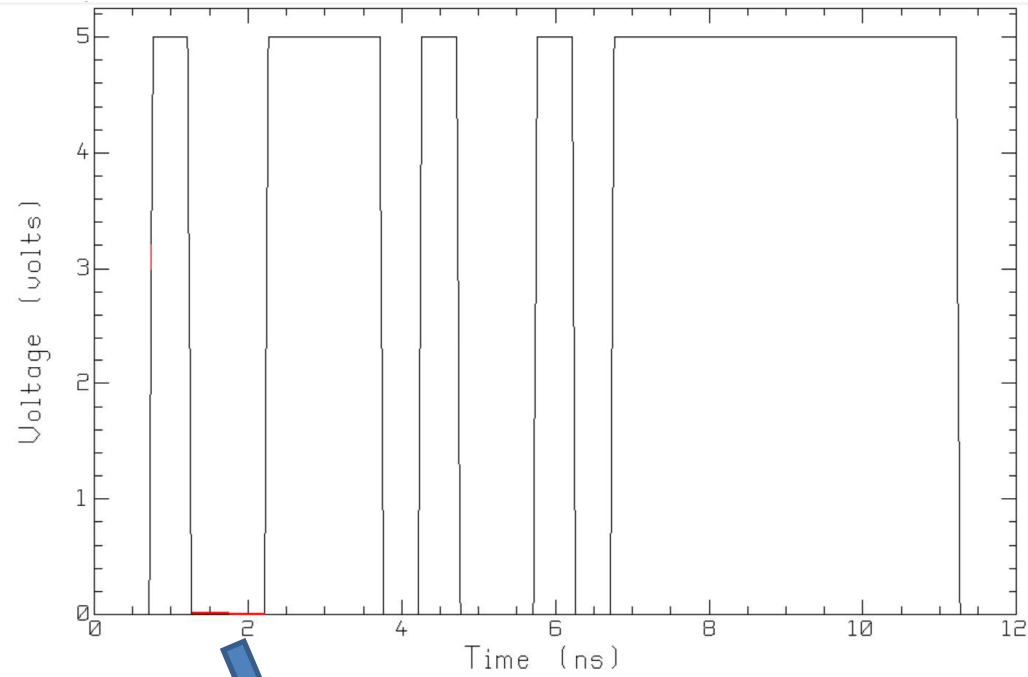
Construct an Eye Pattern



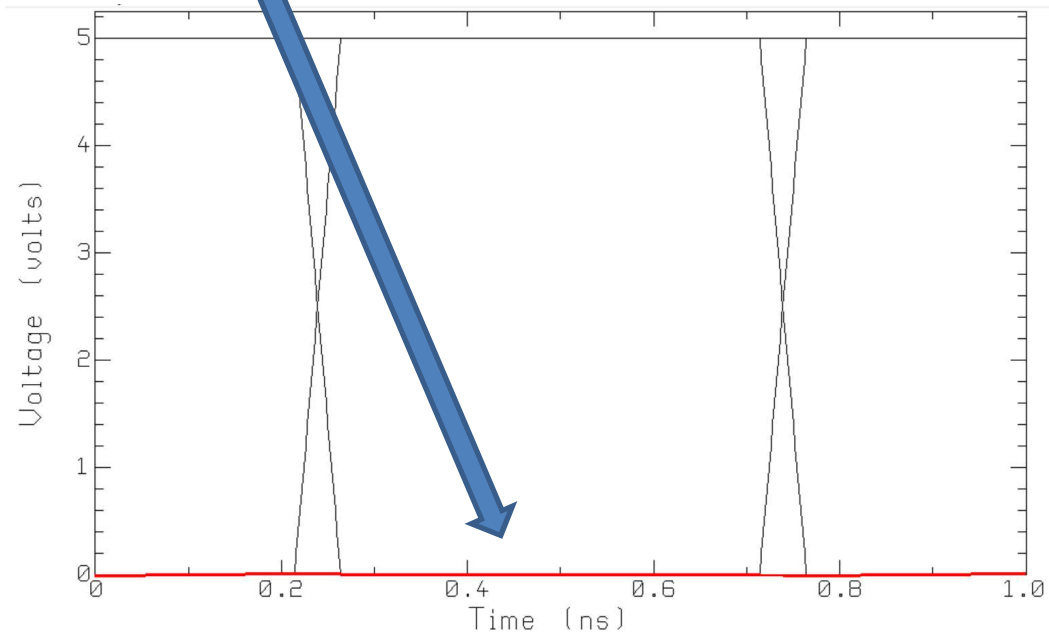
The voltage across the load has a series of 1s and 0s, with transitions lasting 0.05 ns.

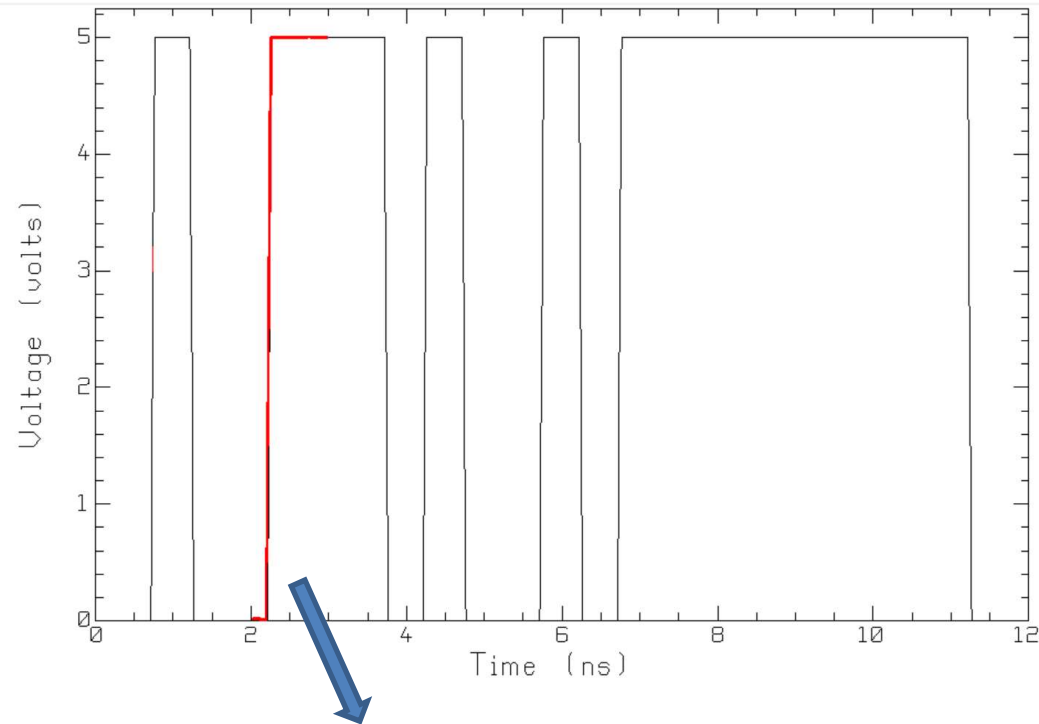
Draw the first “time slot” on an expanded scale, showing the transition up and the transition down.



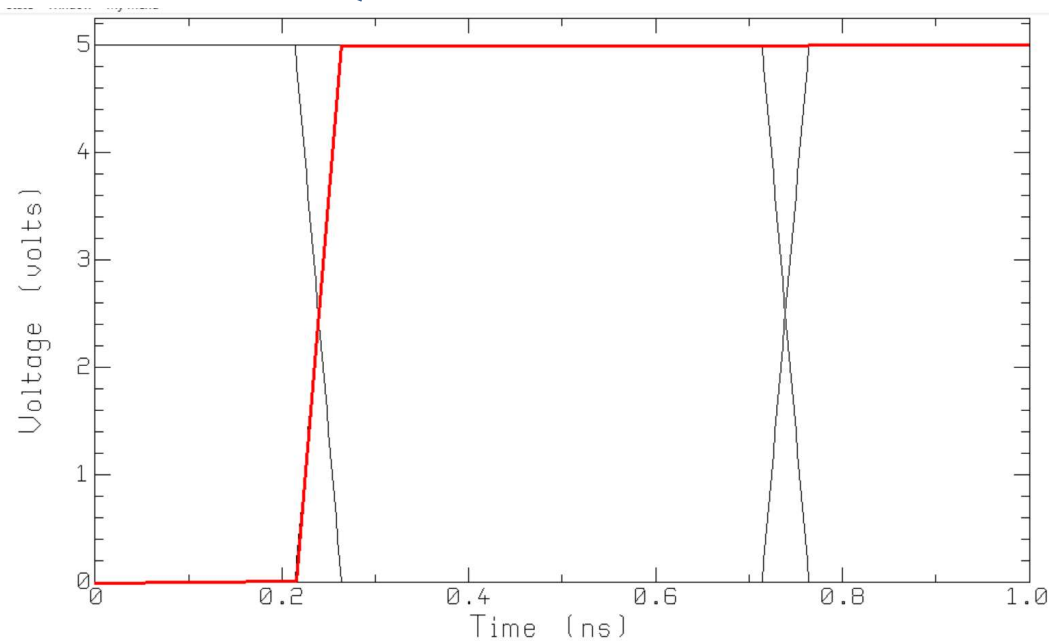


The second time slot has a zero bit.



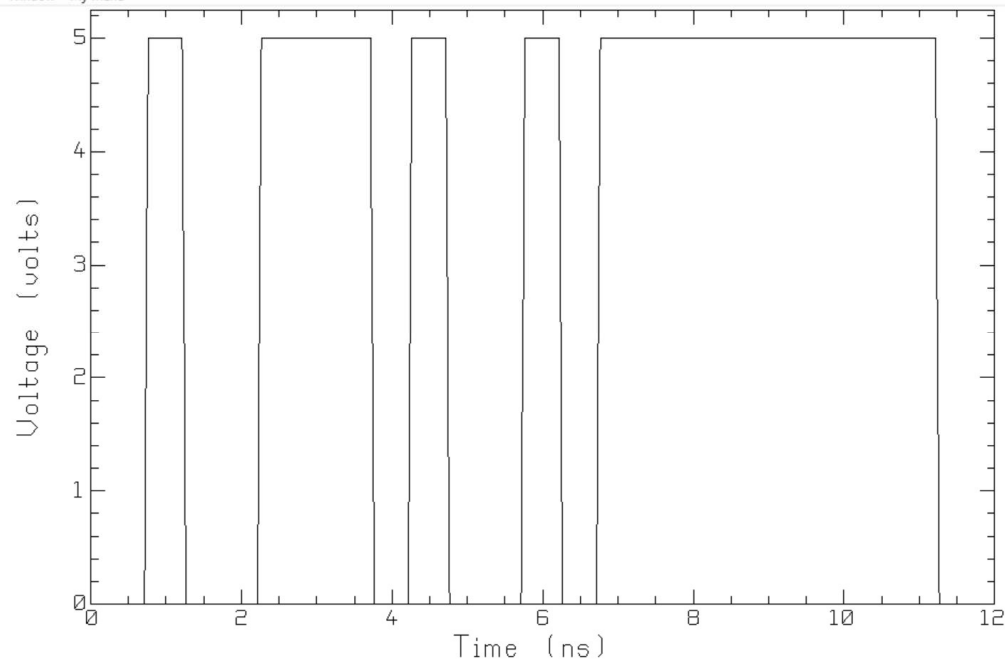


The third time slot has a transition from 0 to 1.



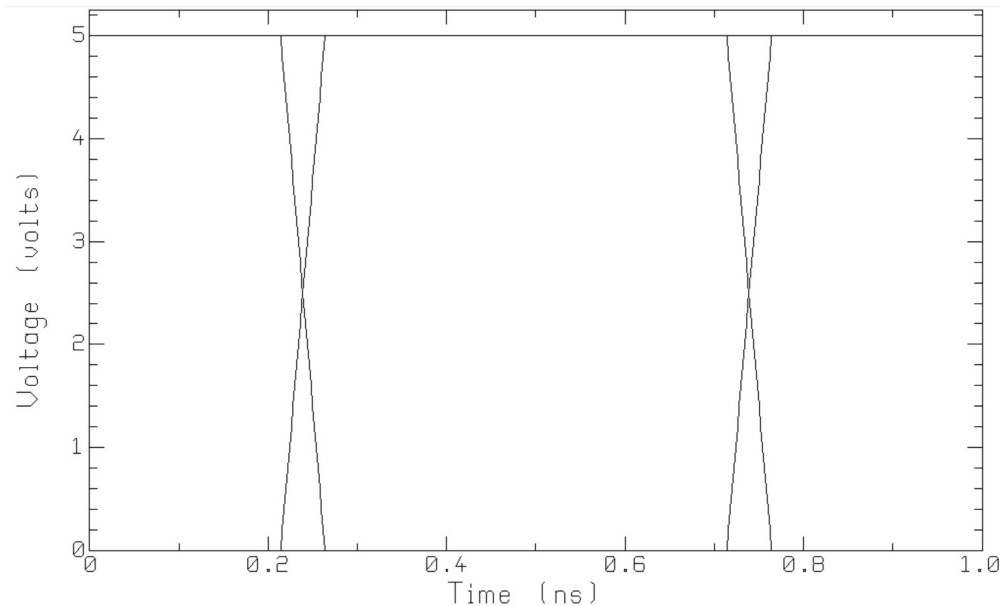
We can continue for the whole sample of 0s and 1s, leading to the complete Eye Pattern diagram for the time sample.

Plot all the transitions:



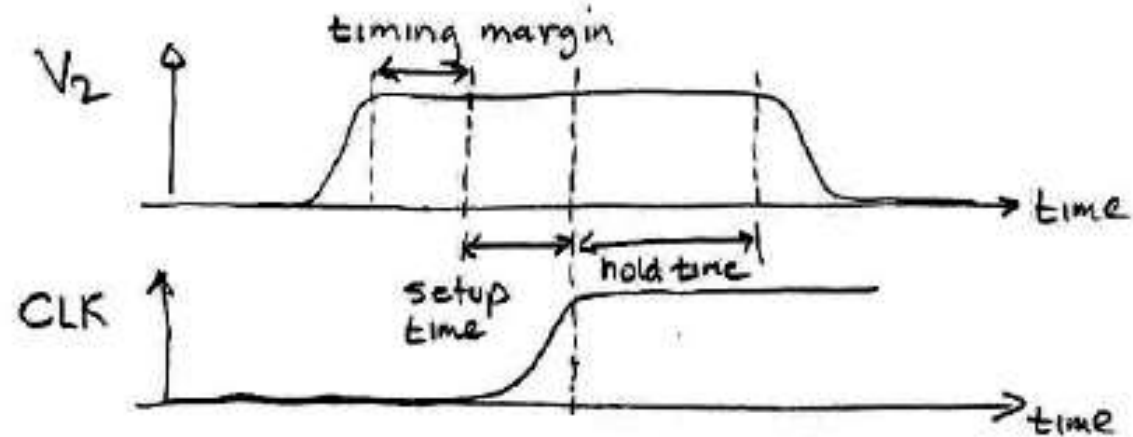
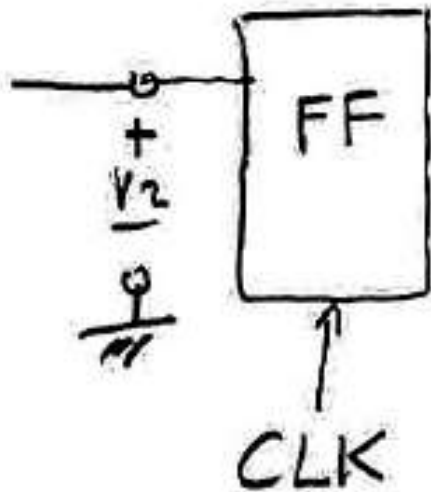
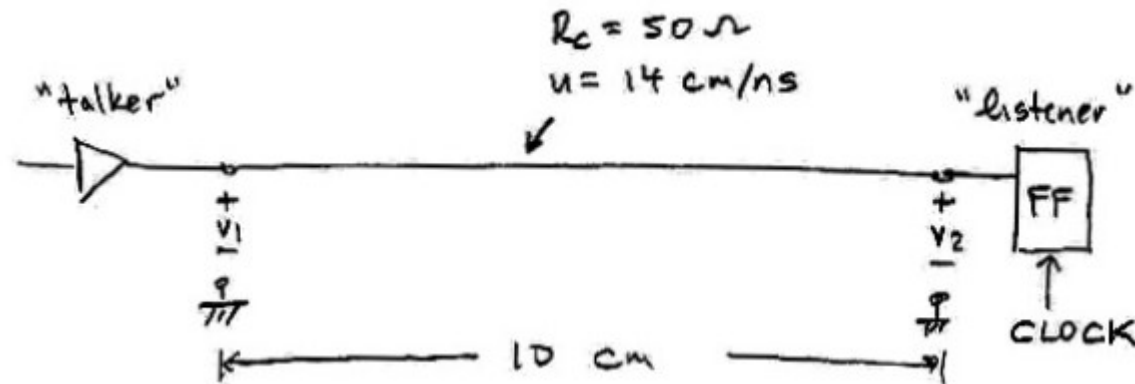
Plot all the 0s and 1s to get the complete eye pattern.

In real practice eye patterns include thousands and thousands of transitions from 0 to 1 and from 1 to 0.



What can we learn from an eye pattern?

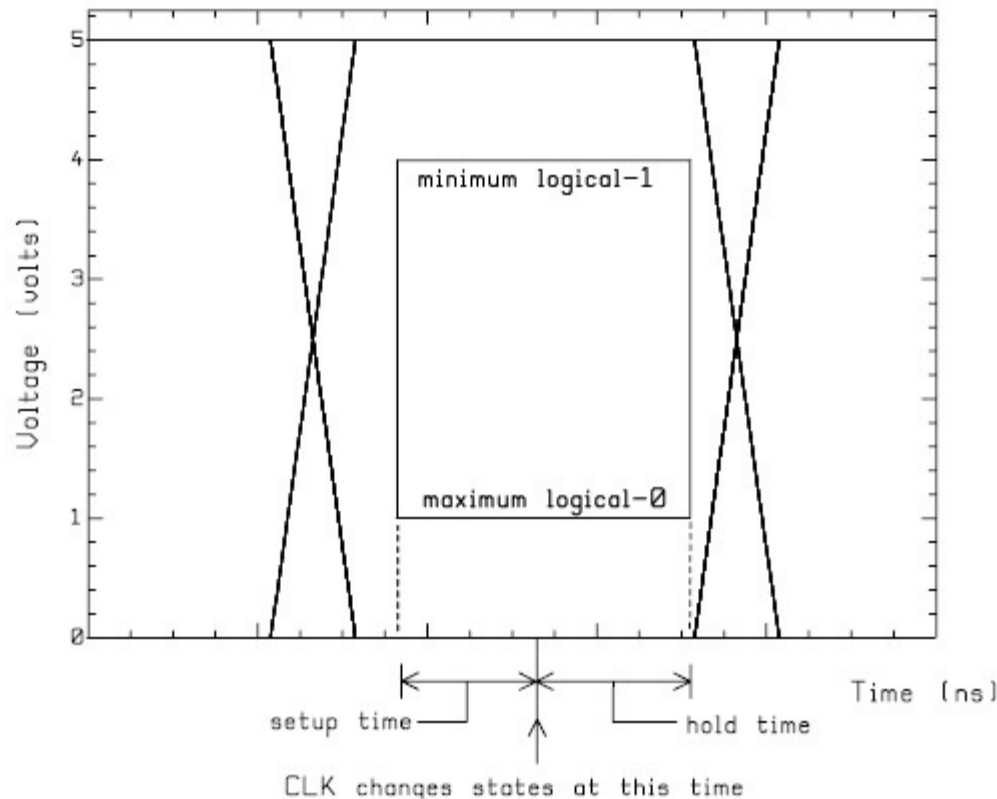
What is “fast enough” in a digital circuit?



Interpreting Eye Patterns

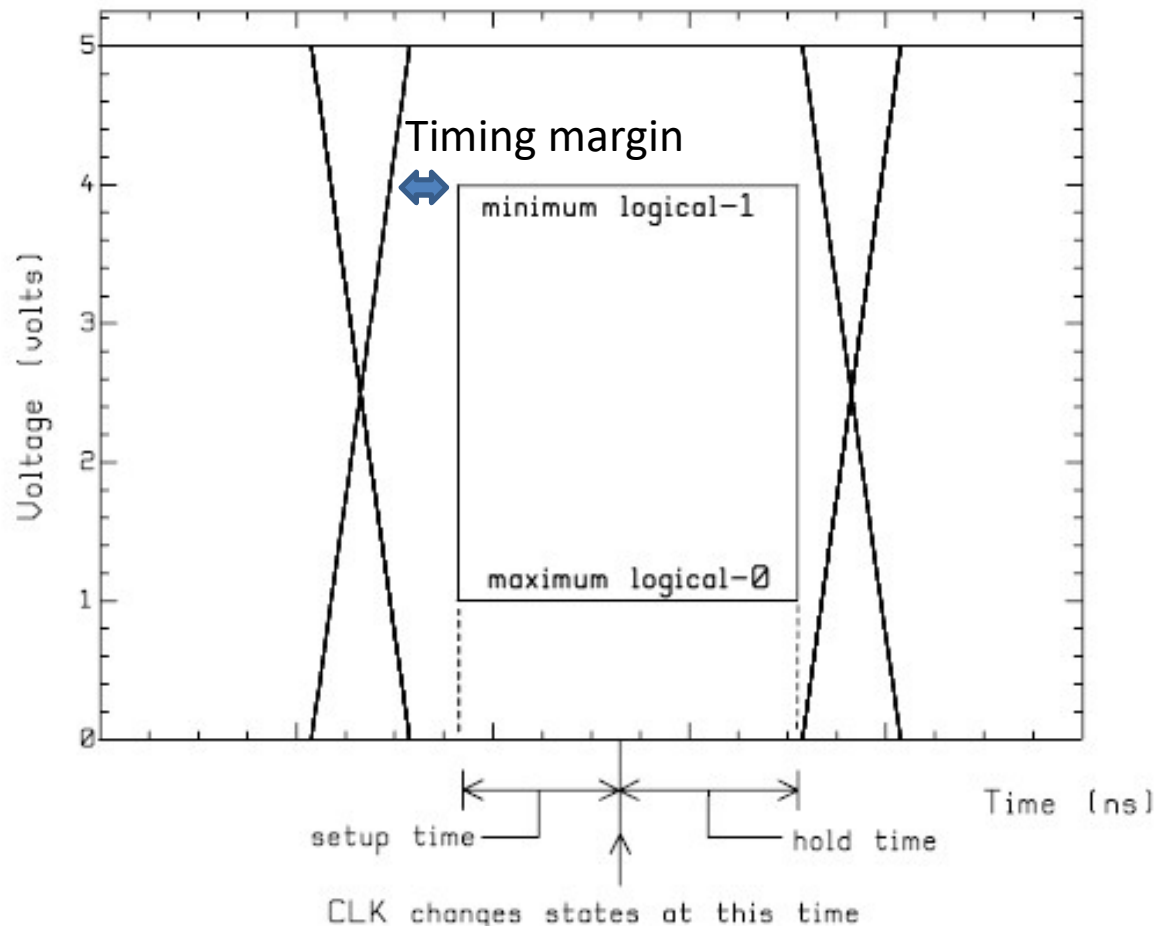
Suppose for our logic family, the specs are:

- 0 to 5 volt logic
- The minimum voltage for “logical 1” is 4 volts
- The maximum voltage for “logical 0” is 1 volt



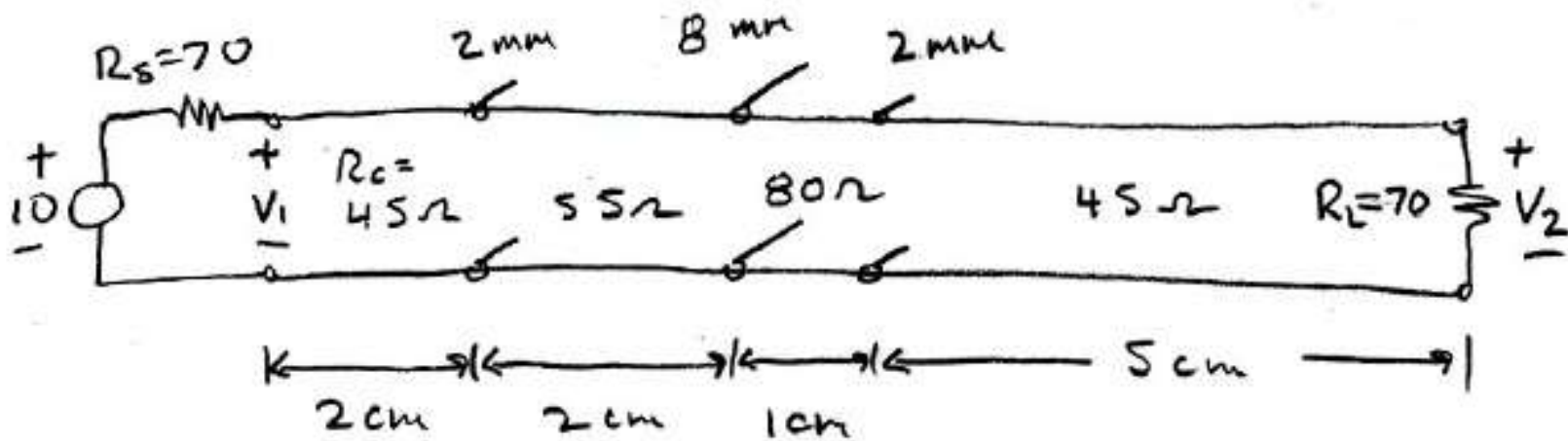
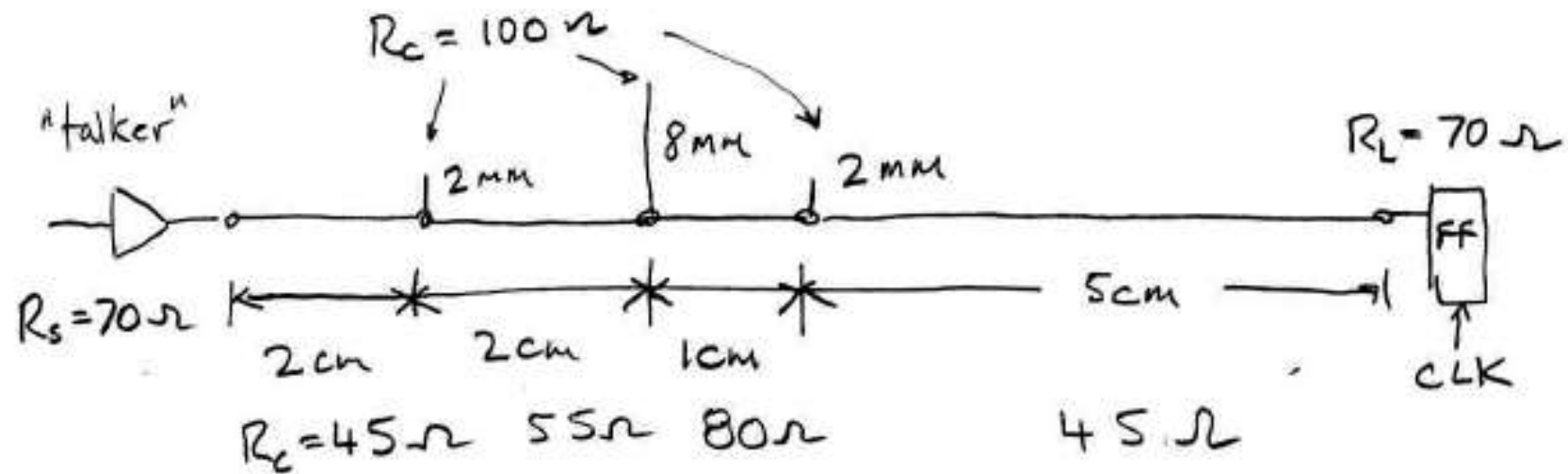
- The “timing margin” is the amount of time between the instant when the data is “valid” and the instant when the setup time starts.
- Note that the “timing margin” is about 1/3 of the setup time in this example.

Timing Margin



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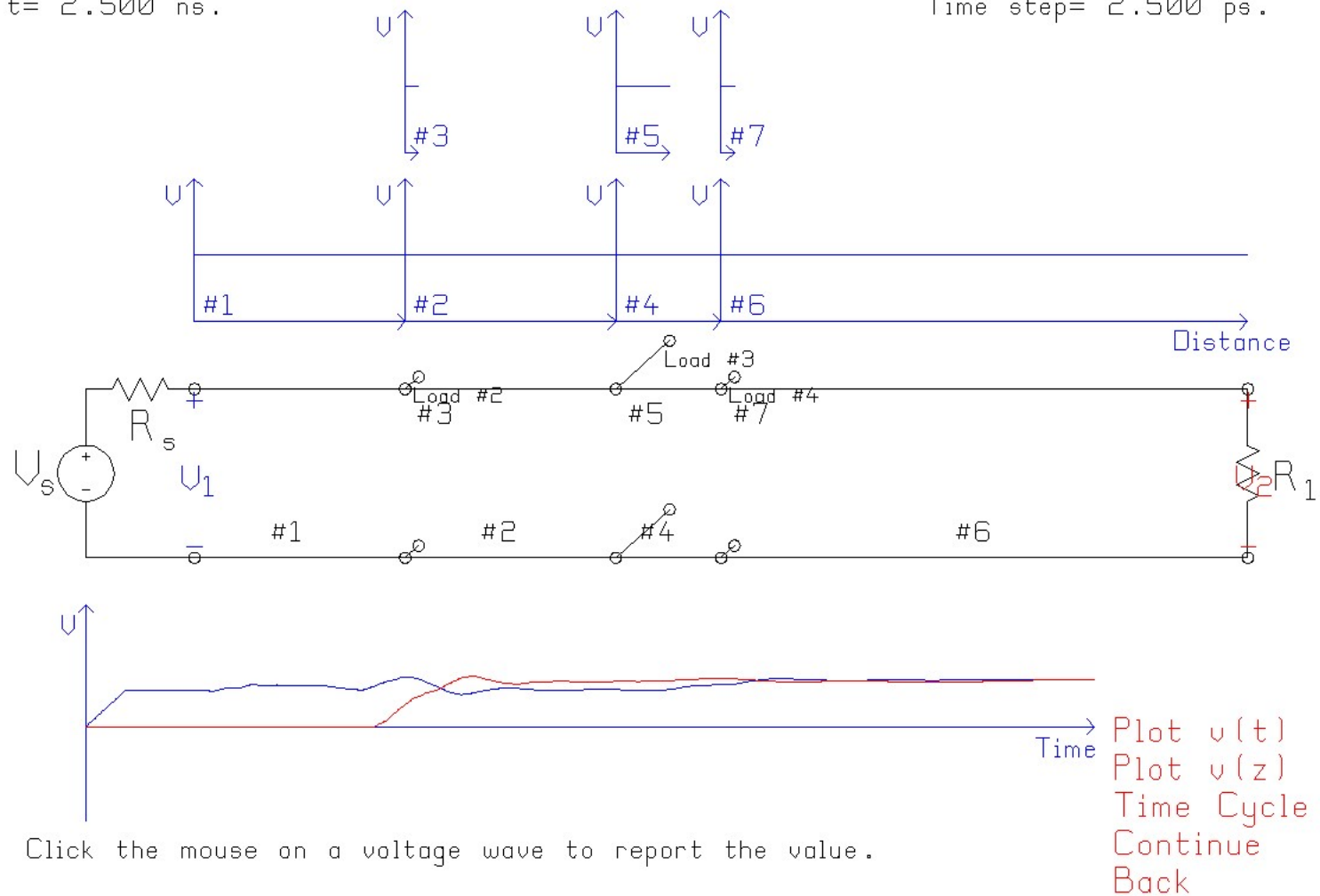
Realistic Communication Path



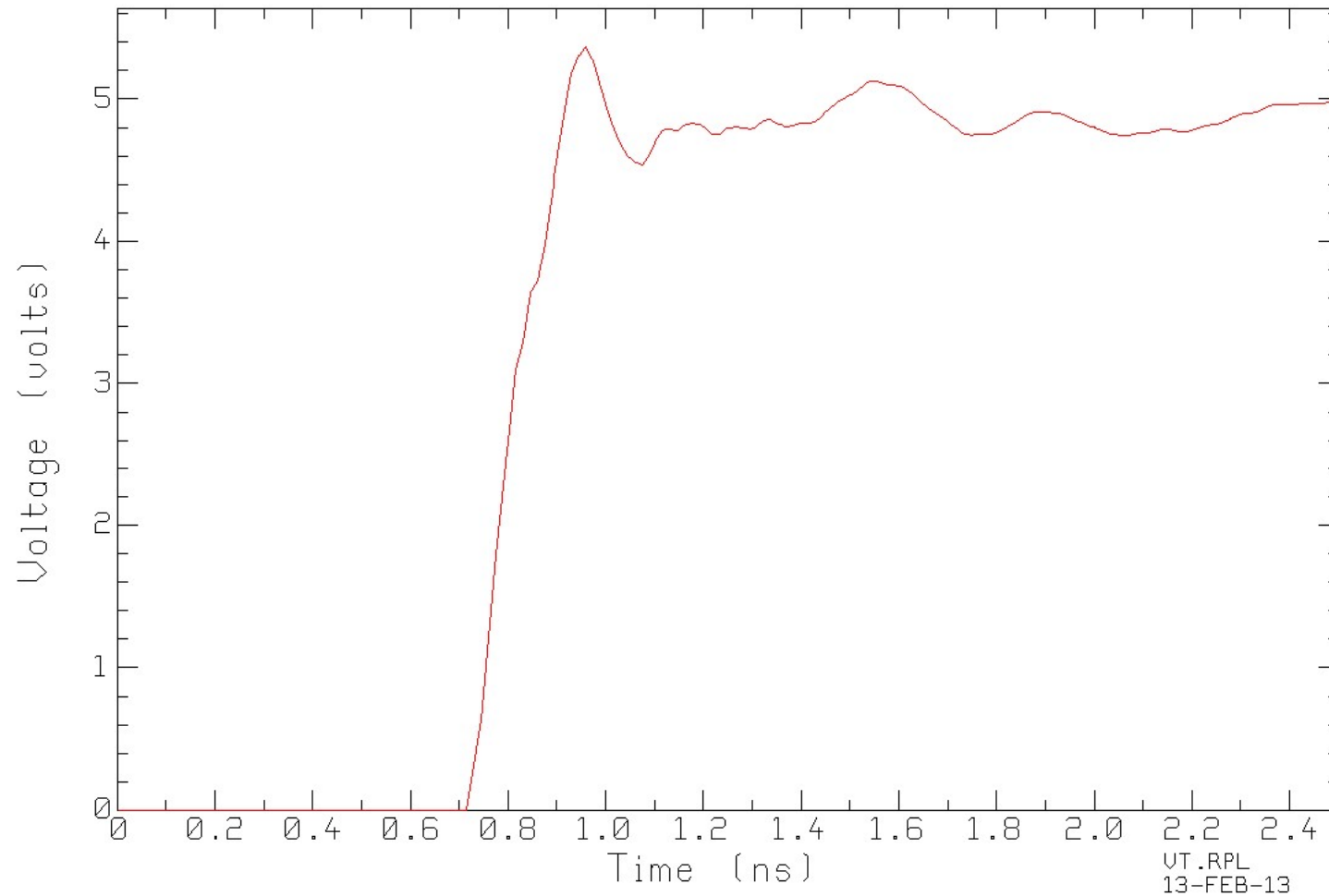
Step Response

$t = 2.500 \text{ ns.}$

Time step= 2.500 ps.



Step Response

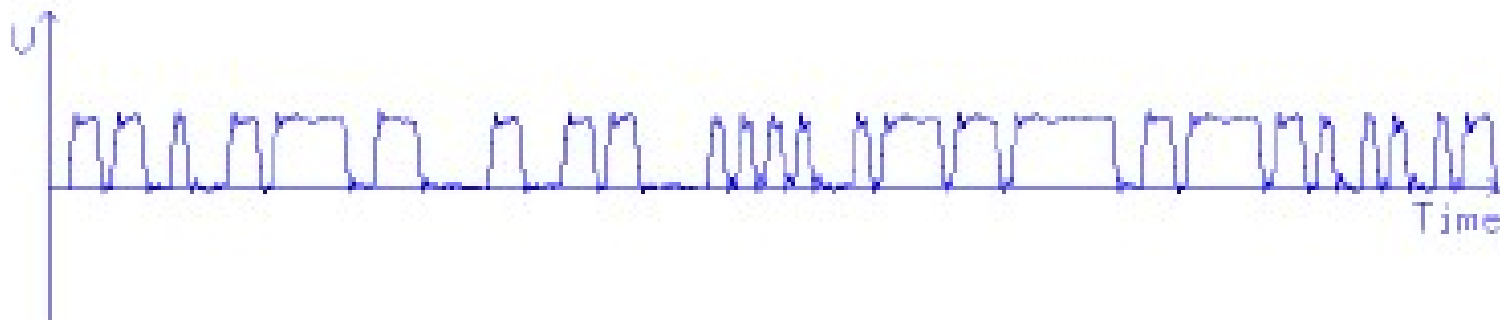
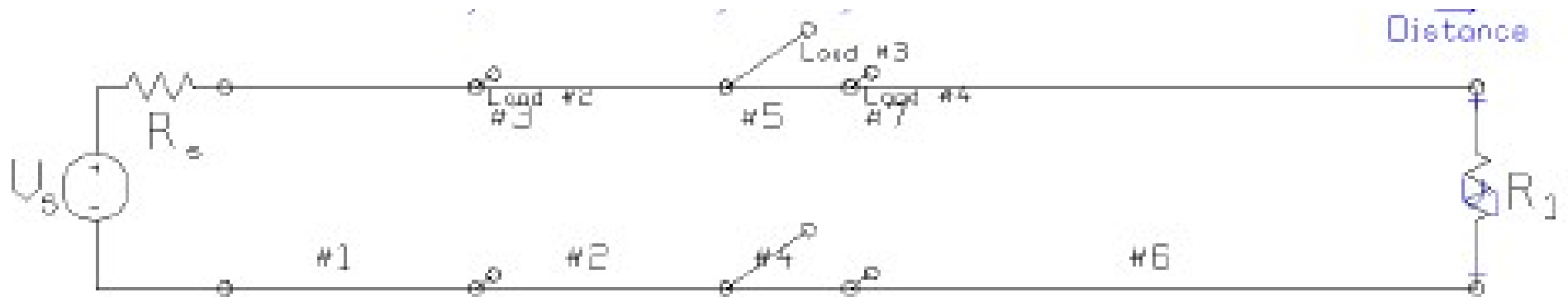


The time slot for each bit is 1 ns. The step takes more than 2 time slots to settle.

Does the step response settle fast enough?

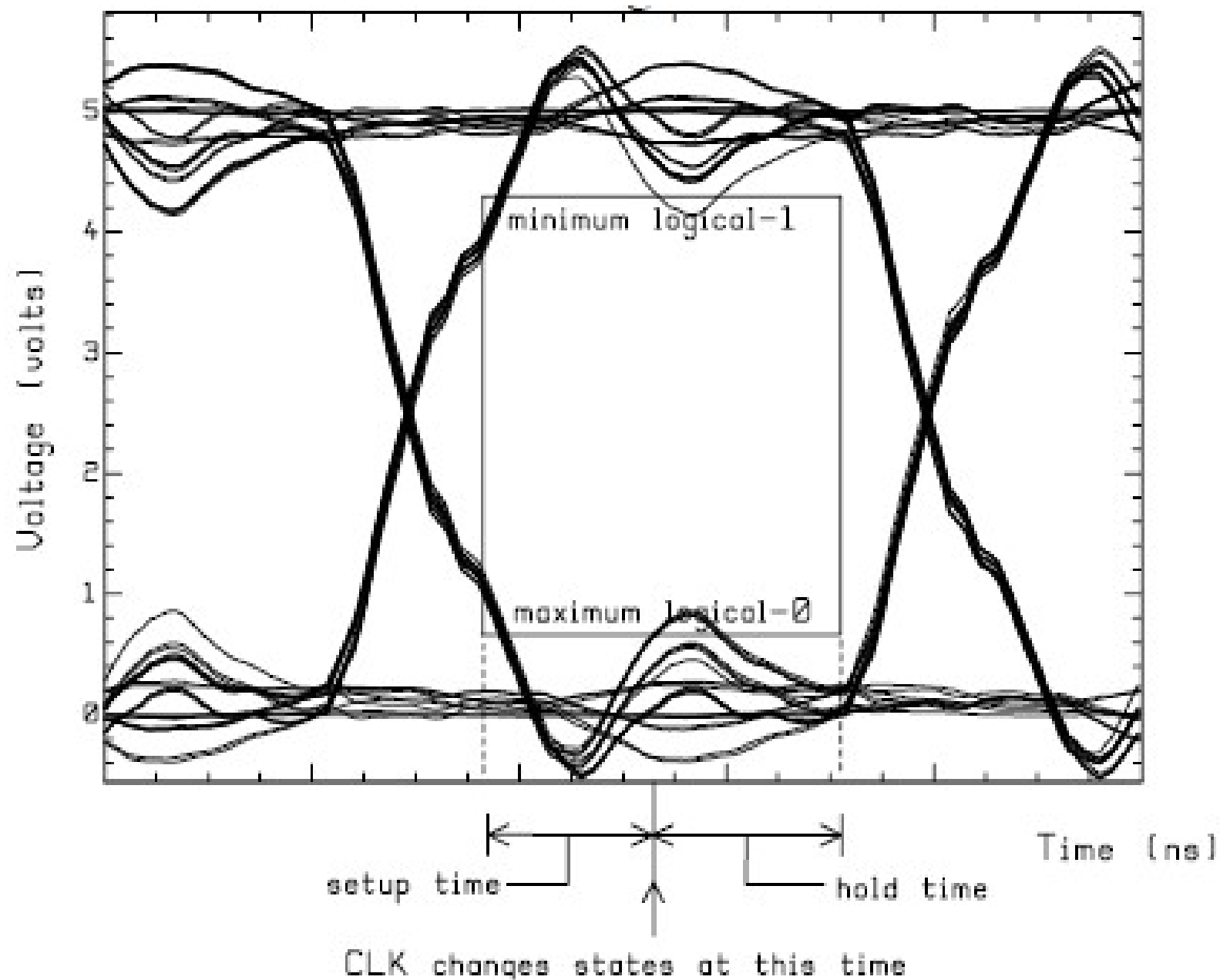
How do we judge what is “fast enough”?

Examine many transitions from 0 to 1 and from 1 to 0 to verify that each transition meets the timing requirements:

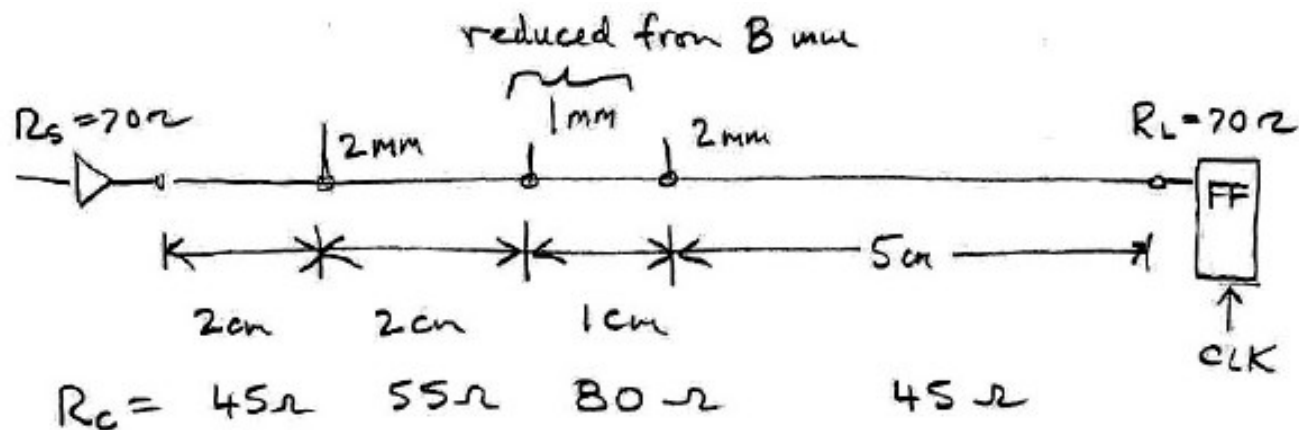
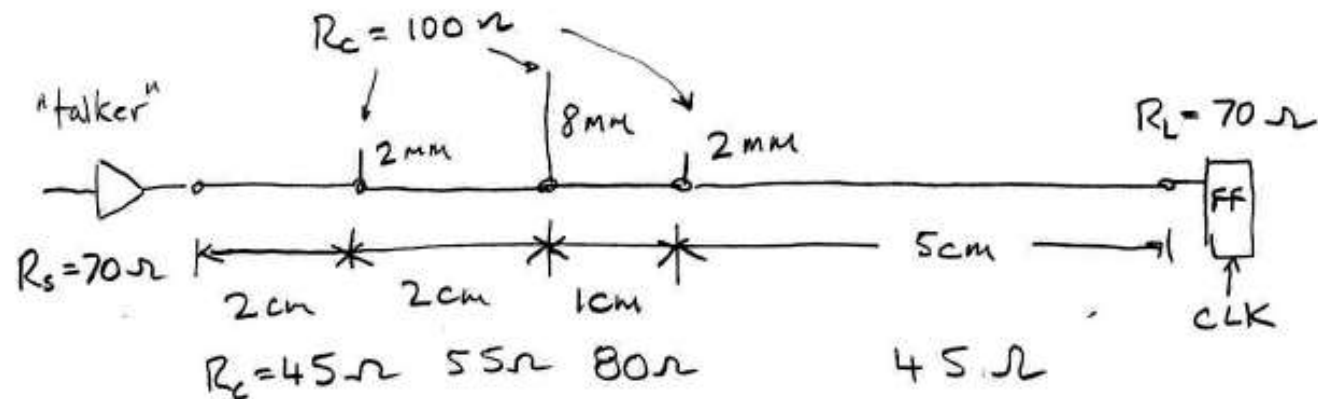


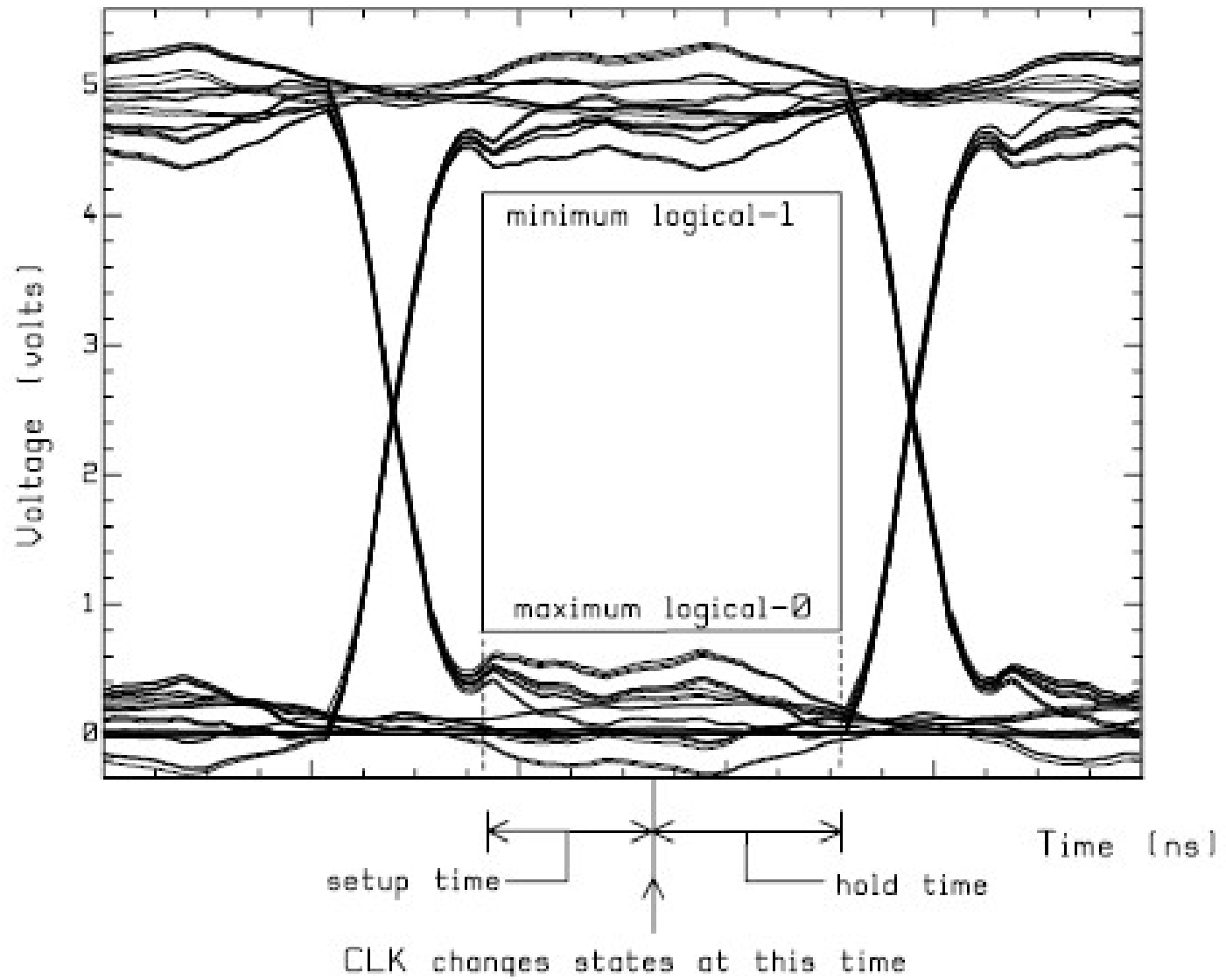
Click the mouse on a voltage wave to report the value.

Eye Potn
Plot vlt)
Plot ulz)
Time Cycle
Continue
Back

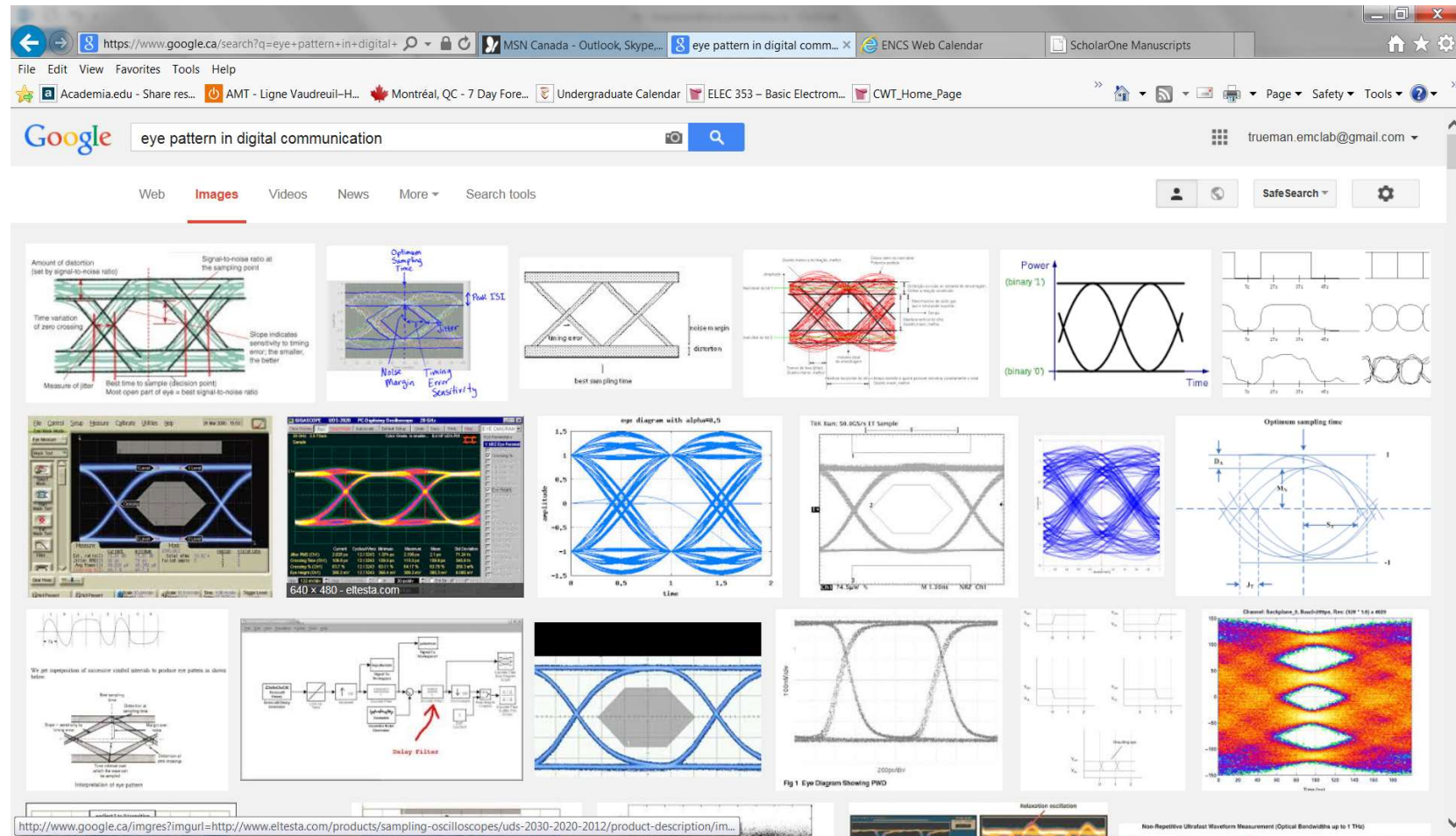


How can we “clean up” the eye pattern?





Eye Patterns on the Internet



This page has many pictures of eye patterns

https://www.google.ca/search?q=eye+pattern+in+digital+communication&biw=1536&bih=757&tbm=isch&tbo=u&source=univ&sa=X&ei=3GrbVlzZKpT_yQTT3YHwCQ&ved=0CCMQsAQ

Browser window showing the ON Semiconductor website. The address bar displays: http://www.onsemi.com/pub_link/Collateral/AND9075-D.PDF. The page title is "AND9075/D". The main heading is "Understanding Data Eye Diagram Methodology for Analyzing High Speed Digital Signals". The ON Semiconductor logo is displayed, along with the text "ON Semiconductor®" and the website URL "http://onsemi.com". The section "APPLICATION NOTE" is highlighted. The "Introduction" section begins with: "The data eye diagram is a methodology to represent and analyze a high speed digital signal. The eye diagram allows key parameters of the electrical quality of the signal to be quickly visualized and determined. The data eye diagram is constructed from a digital waveform by folding the parts of" (text is cut off). The text continues on the right side: "time on horizontal axis. By repeating this construction over many samples of the waveform, the resultant graph will represent the average statistics of the signal and will resemble an eye. The eye opening corresponds to one bit period and is typically called the Unit Interval (UI) width of the eye diagram. An ideal digital waveform with sharp rise

This paper has a really good detailed explanation about eye patterns and what they are:

http://www.onsemi.com/pub_link/Collateral/AND9075-D.PDF

http://www.ni.com/white-paper/3299/en/ MSN Canada - Outlook, Sky... Digital Waveform Timing - ... Digital Waveform Timing... x ENCS Web Calendar ScholarOne Manuscripts

File Edit View Favorites Tools Help

Academia.edu - Share res... AMT - Ligne Vaudreuil-H... Montréal, QC - 7 Day Fore... Undergraduate Calendar ELEC 353 - Basic Electrom... CWT_Home_Page

25 ppm accuracy would run at a rate of 100 MHz \pm 2.5 kHz. If the two digital I/O devices are acquiring data for 5 seconds at that rate and accuracy, they could be out of synchronization by up to 500 μ s, or 5 clock periods, after 5 seconds of acquisition.

Eye Diagram

An eye diagram is constructed by looking at the outputs of a digital transmitter over three time periods. These three time periods are three periods of the main system clock, t_p , demarked by the blue vertical dashed lines on Figure 5. If the transmitter outputs three logical '0' value over the time period, the plot might look like the green plot on Figure 5. An eye diagram, shown in figure 5, is constructed by overlaying all of the possible combinations of 0's and 1's (0 1 1 in pink, 1 1 0 in yellow, 0 0 1 in blue, 1 0 0 in green) on single plot.

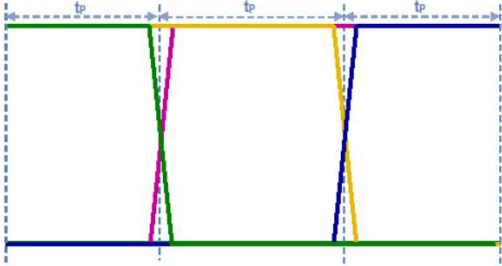


Figure 4. Example of an Eye Diagram

The Eye Diagram is a timing analysis tool providing the user with a good visual of timing and level errors. See Figure 6. In real life, errors like Jitter are very difficult to quantify since they change so often and are so small. Therefore, an eye diagram is a very good tool for finding the maximum Jitter as well as voltage level errors. As these errors increase, the white space in the center of the eye diagram decreases. That space is defined by two characteristics; the eye width and the eye height.

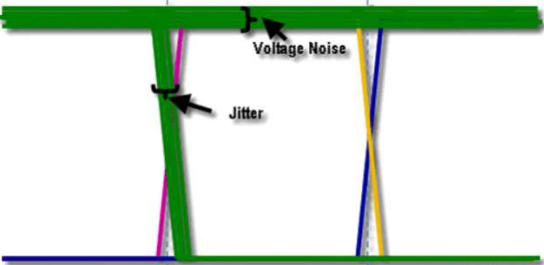
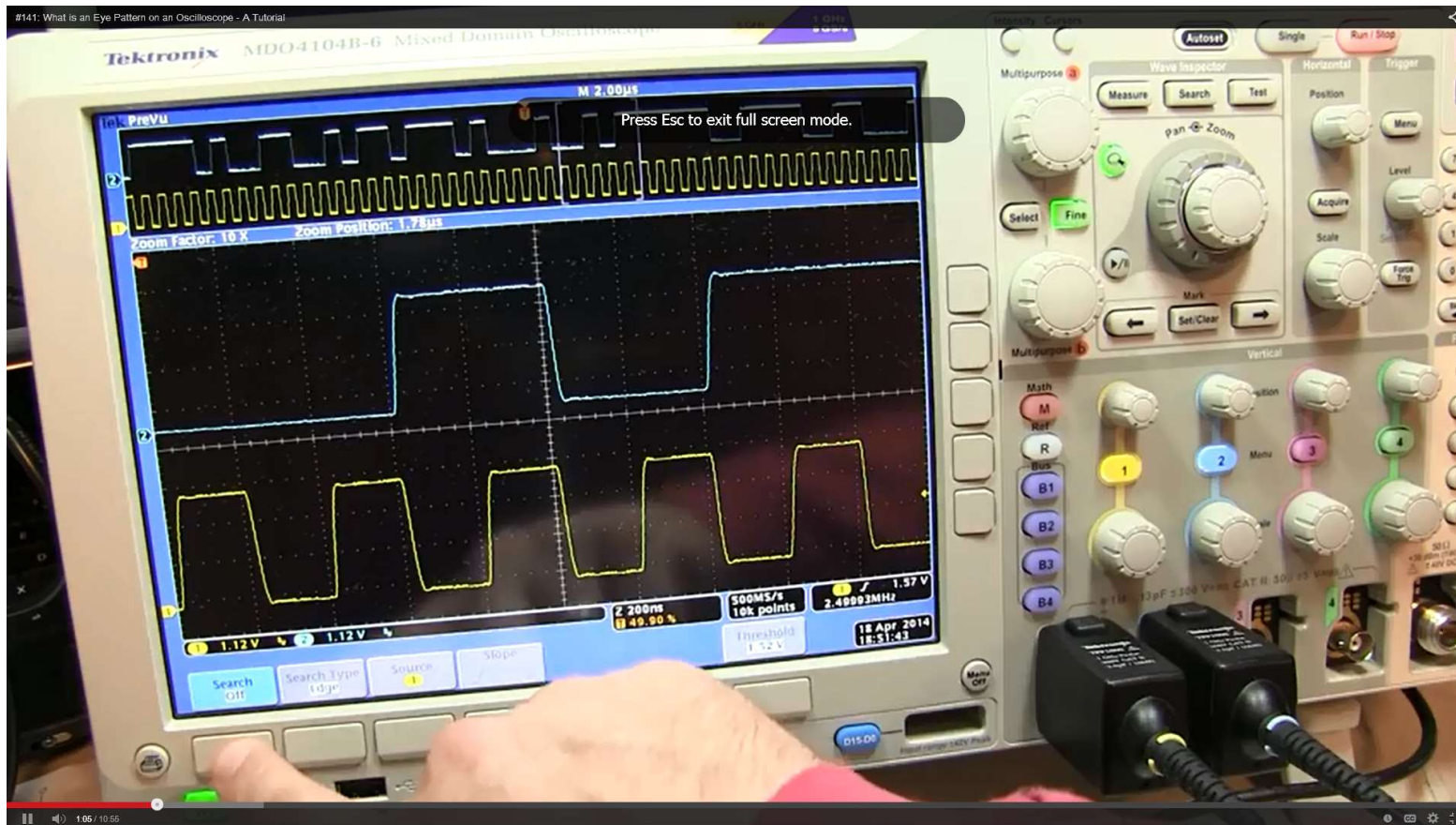


Figure 5. Jitter and Voltage Noise View from an Eye Diagram

This note about eye patters giving a basic explanation:

<http://www.ni.com/white-paper/3299/en/>

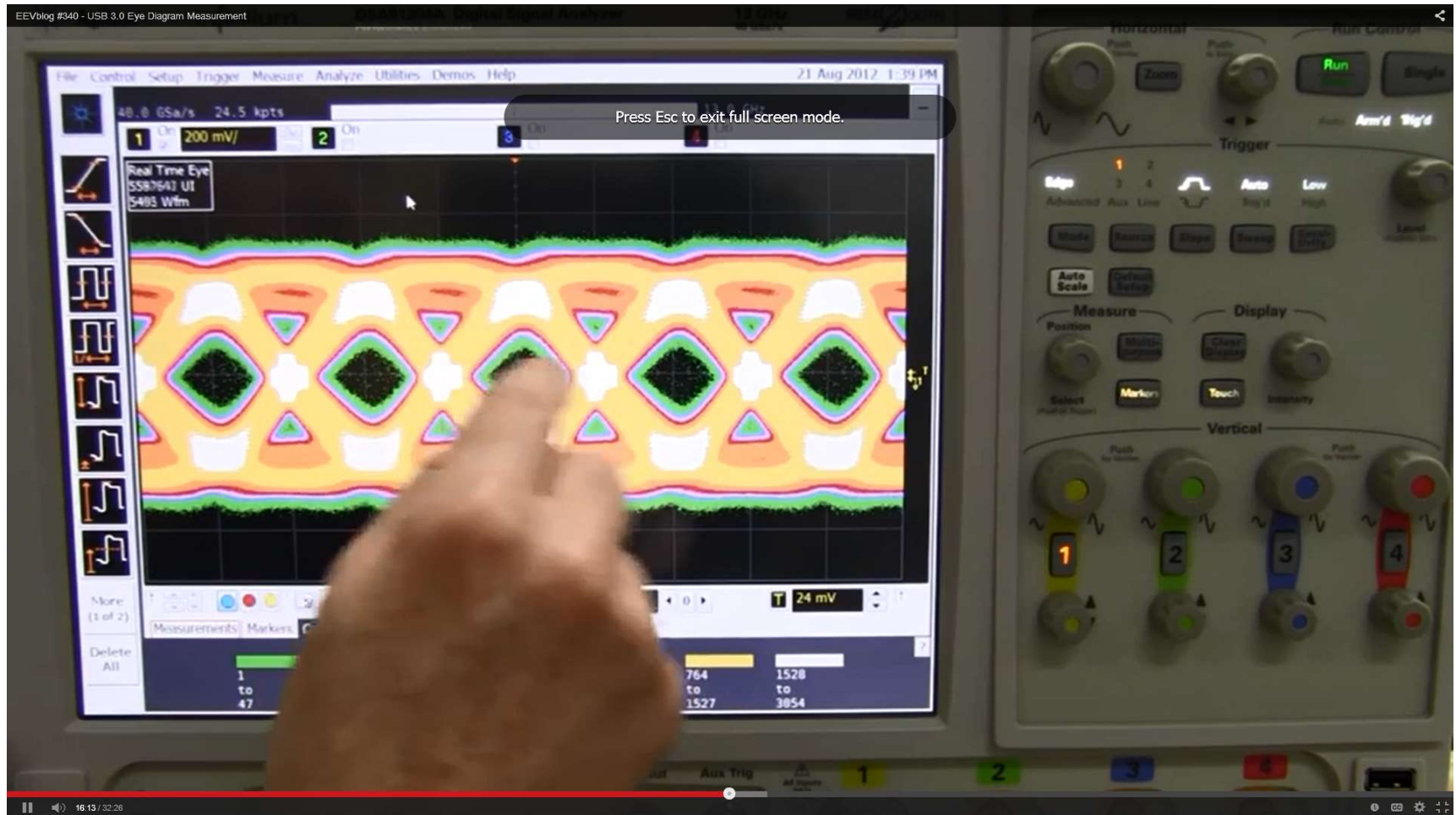
Eye Pattern Videos on You Tube



Video explaining eye patterns on an oscilloscope screen:

https://www.youtube.com/watch?v=cL7QsELuv_M

11 minutes



Long video explaining how to use a great oscilloscope with eye patterns:
<https://www.youtube.com/watch?v=o8DPlqWVmzk>
33 minutes!