26 July 2023 | 8 محرم 1445

وَمَا أُوتِيتُمْ مِنَ الْعِلْمِ إِلَّا قَلِيلًا

Lab 02
PRBS and Eye Diagram

Intended Learning Objectives

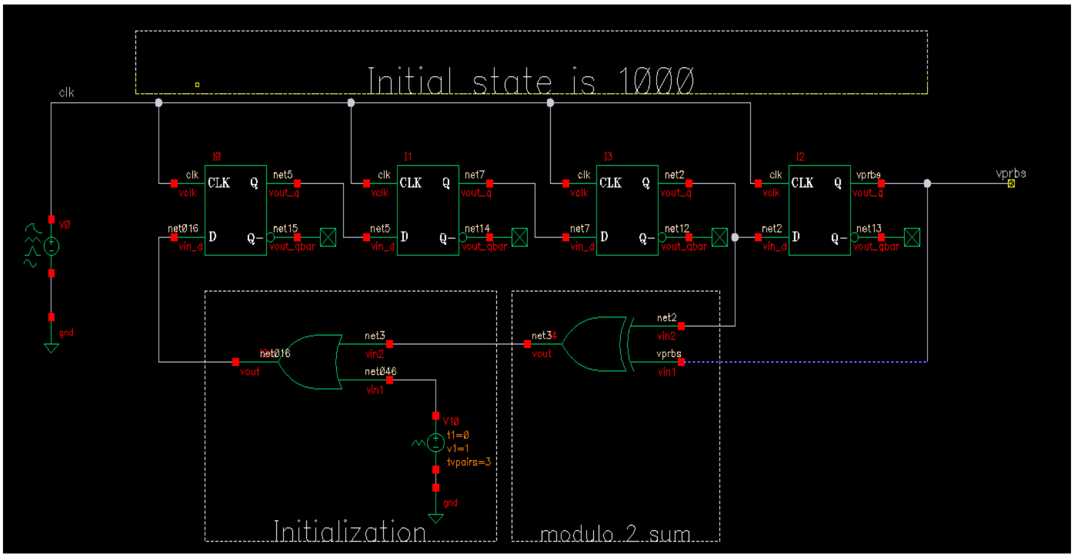
This lab is divided into two parts:

- In Part 1 you will
    - Learn how to generate a pseudo random bit sequence using LFSR (linear feedback shift registers).
    - Learn about the defining characteristics of PRBS.
- In Part 2 you will
    - Use the model of 1-inch FR4 trace (that can be cascaded to get the model of a longer trace) to plot the eye diagram and pulse response of a 6-inch FR4 trace.
    - Compare the worst-case eye opening between simulation and theoretical calculation.

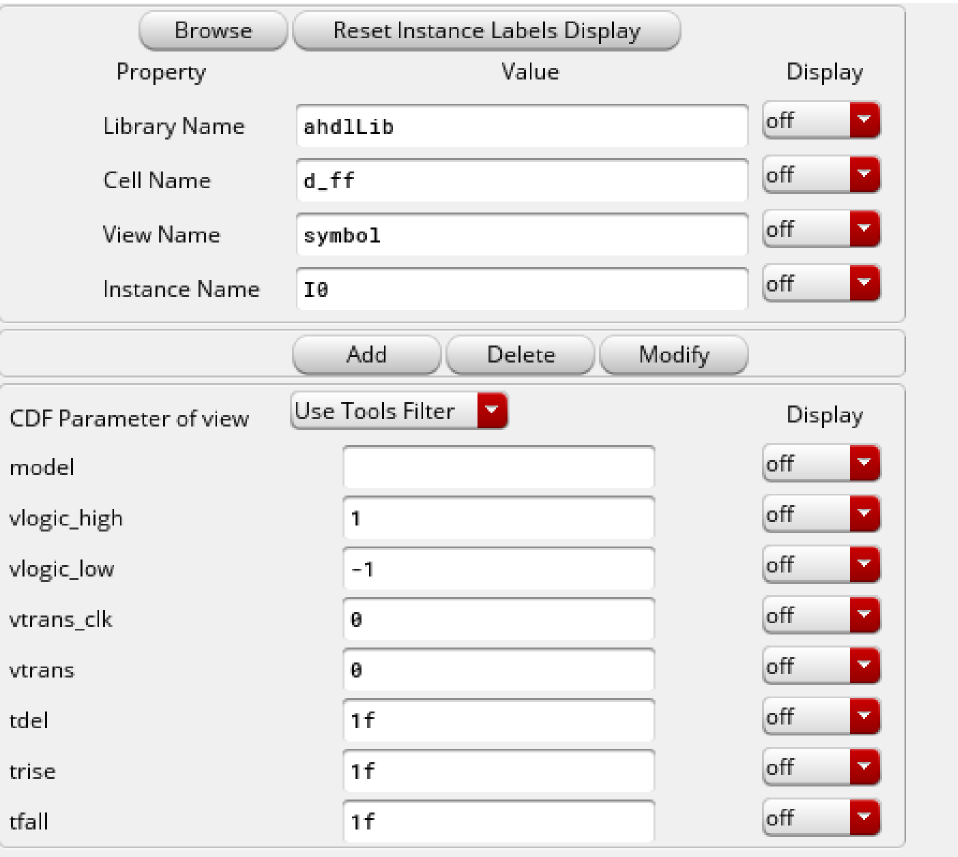
PART 1: Pseudo Random Bit Sequence (PRBS)

1. Schematic of a PRBS4

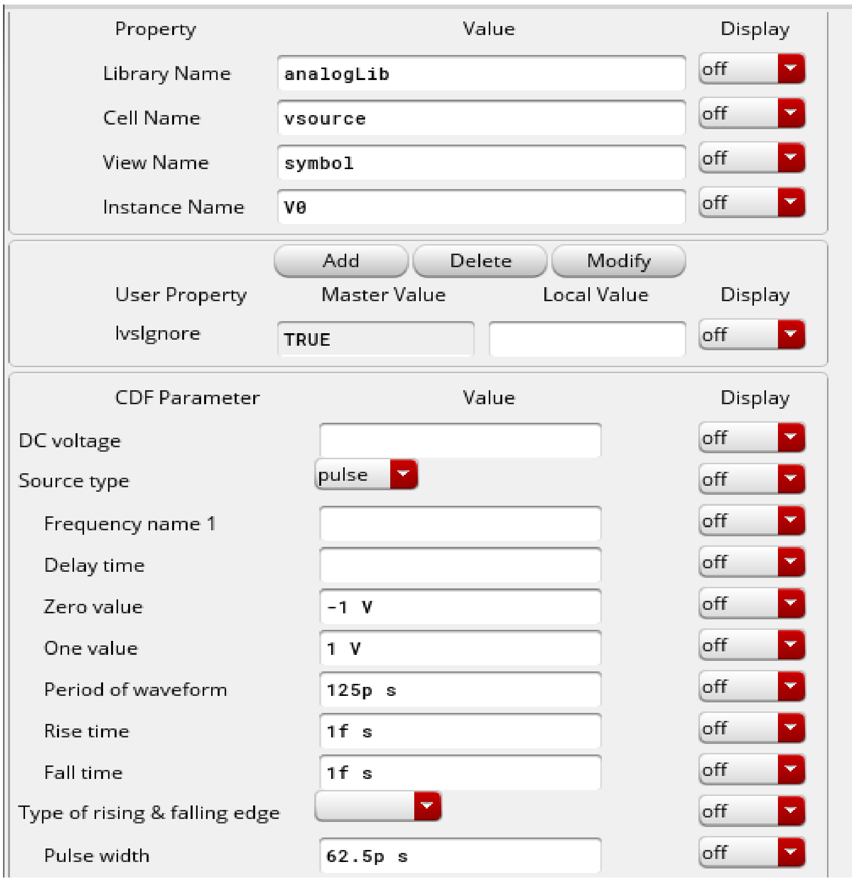
a. create the schematic shown below for a PRBS4



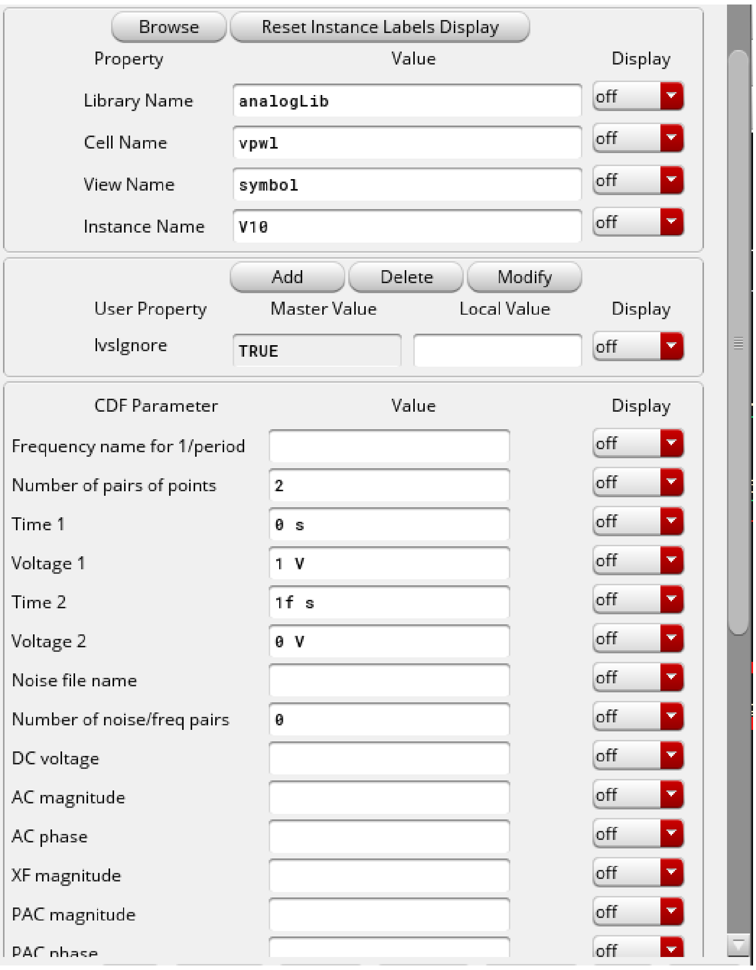
b. The settings of the d flip flops are as shown below



c. The settings of the clock are as shown below



d. The settings of the initializer source (connected to the OR gate)



2. Transient simulation

a. Run a 40 nS transient simulation

b. Plot the output vprbs and note the periodicity of the output and how many ones and zeroes in a period and use the calculator to plot the autocorrelation of the output and the correlation of the output with cyclical shifted versions of itself with various values for this shift and comment on the output waveform

c. After plotting the output and the autocorrelation, list the characteristics of the output that made us call it “pseudo random”

Output plots:

vprbs:

Autocorrelation:

Hints:

a. The autocorrelation function is calculated using the expression below

$$R_x(\tau)=\frac{1}{K}\frac{1}{T_0}\int_{-T_0/2}^{T_0/2} x(t)\,x(t+\tau)\,dt$$

Where T_0 is the period, x(t) is the function, x(t+τ) is a shifted version of the function and K is a normalization factor (we'll set it as 1)

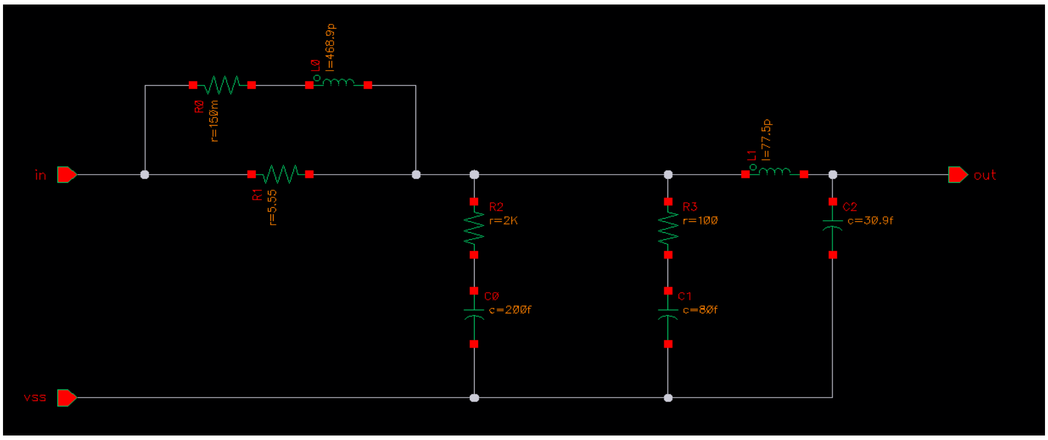
b. Make a variable "tau" and use the expression shown below to calculate the autocorrelation [integ(v("/vprbs" ?result "tran")*lshift(v("/vprbs" ?result "tran") pv("/tau" "value" ?result "variables")) 0 1.875n)/1.875e-9] (remove the square brackets) which integrates the function times itself but shifted by tau over the period and the divides by the period

c. Use parametric analysis to generate the autocorrelation plot when you sweep the "tau" variable from 0 to 10 nS in steps of 125 pS (bit period)

Part 2: Eye Diagram & Pulse Response

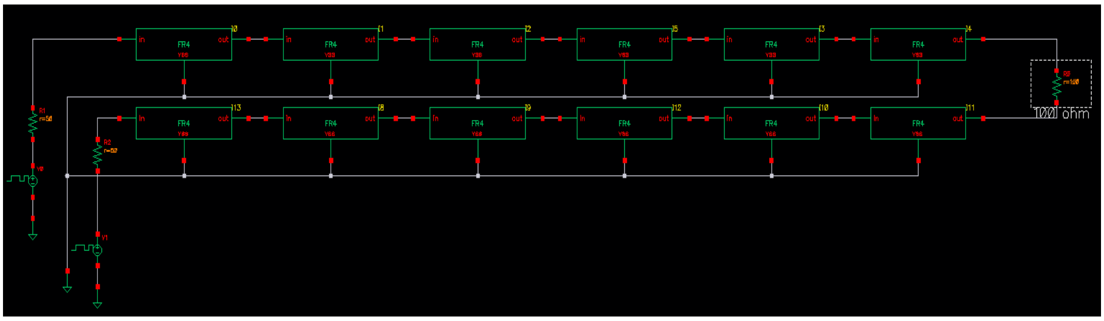
1. Schematic of the 1-inch model

a. Create the schematic shown below for a model of a 1-inch FR4 trace

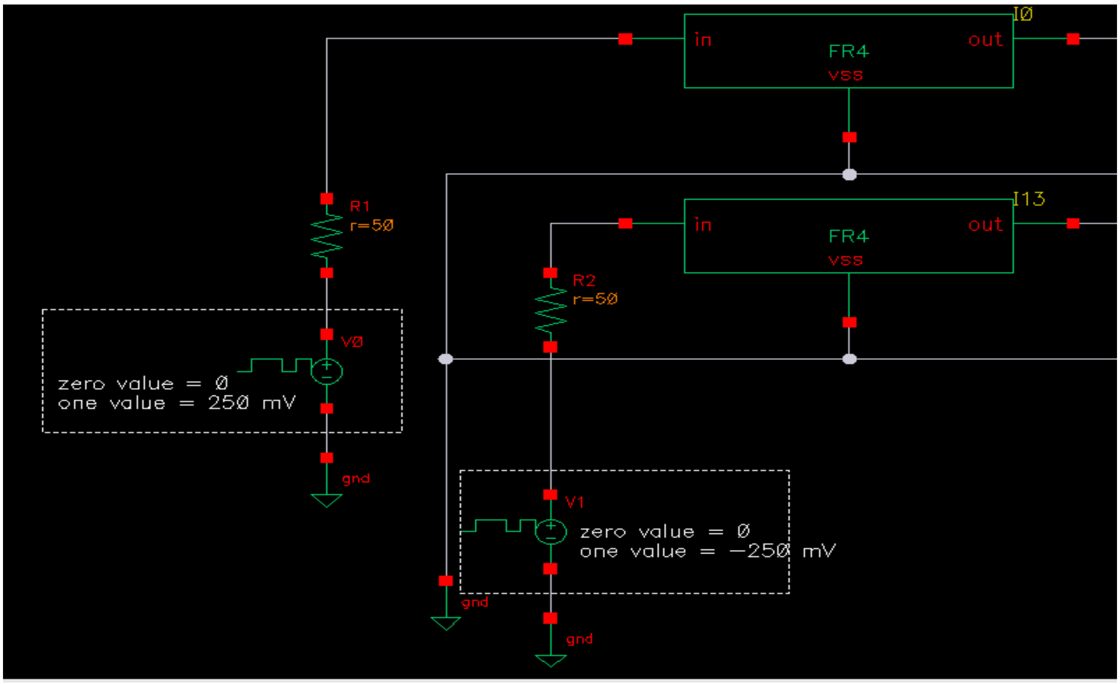


2. Schematic of the 6-inch channel

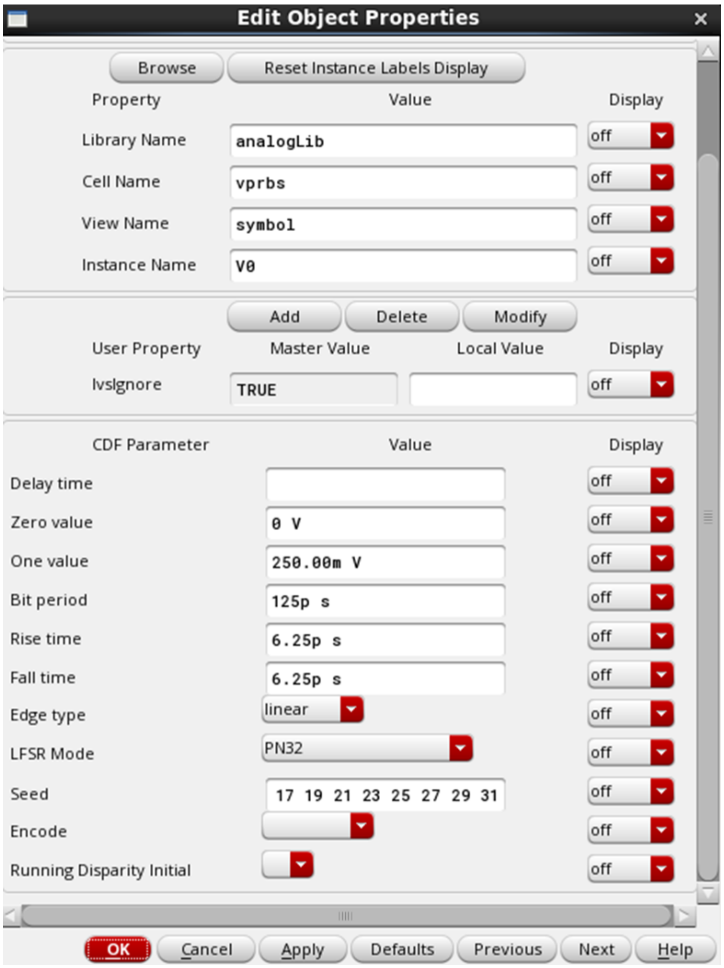
a. Create the schematic shown below for a model of the differential 6-inch FR4 trace



b. Place two differential PRBS sources as shown below with 50 ohms connected in series



c. Adjust the setting of the PRBS sources as shown below



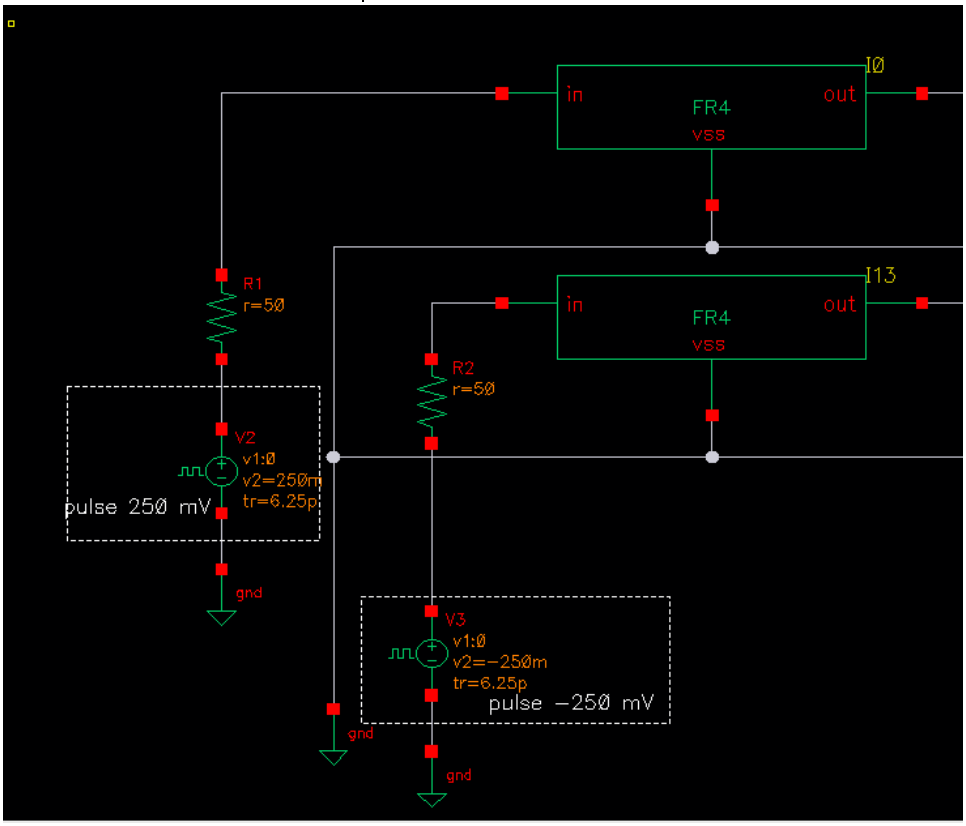
3. Transient simulation and eye diagram plotting

a. Run transient simulation for 200 nS
b. Make sure to set step = 1 pS from transient simulation's options
c. Take the differential output and plot the eye diagram from measurement tools (or from eyedigram function in calculator)

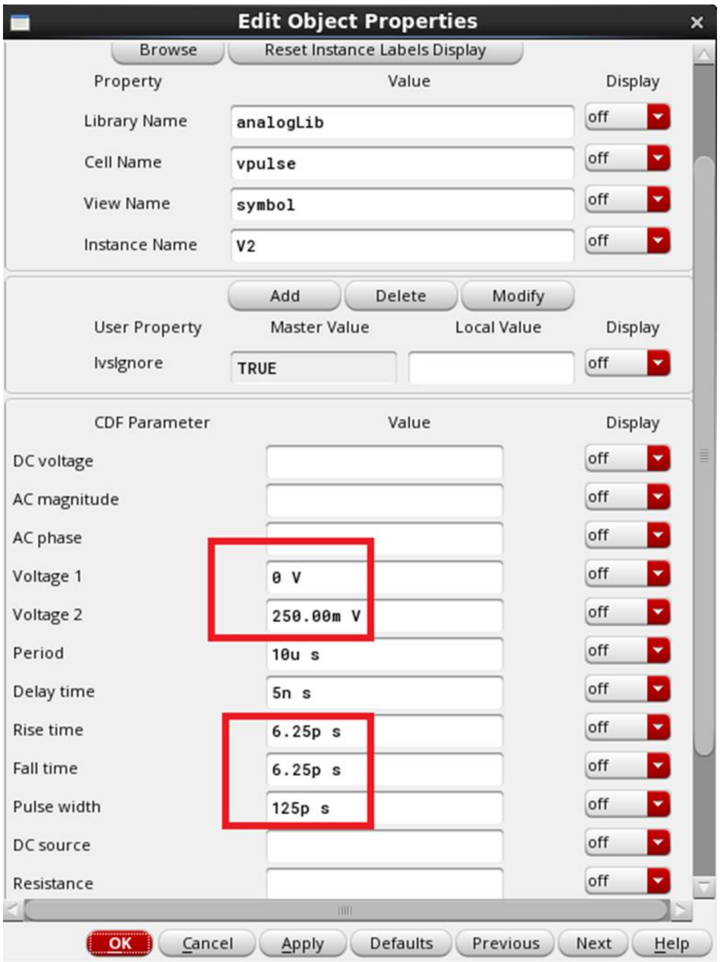
Output plots:
Eye diagram:

4. Transient simulation and pulse response plotting

a. Place two differential pulse sources as shown below with 50 ohms connected in series



b. Adjust the setting of the pulse sources as shown below



Output plots:
Pulse response:

a. Determine main, pre and post cursors from the pulse response

b. Using the relation shown below, compare between simulated and measured worst case eye opening

$$s(t) = \left(\underbrace{y_0^{(1)}(t) + \sum_{\substack{k=-\infty \\ k \neq 0}}^{\infty} y^{(1)}(t-kT)\Big|_{y(t-kT)<0}}_{\text{"1" pulse worst-case "1" edge}} - \underbrace{\sum_{\substack{k=-\infty \\ k \neq 0}}^{\infty} y^{(1)}(t-kT)\Big|_{y(t-kT)>0}}_{\text{"1" pulse worst-case "0" edge}} \right)$$