Homework 2

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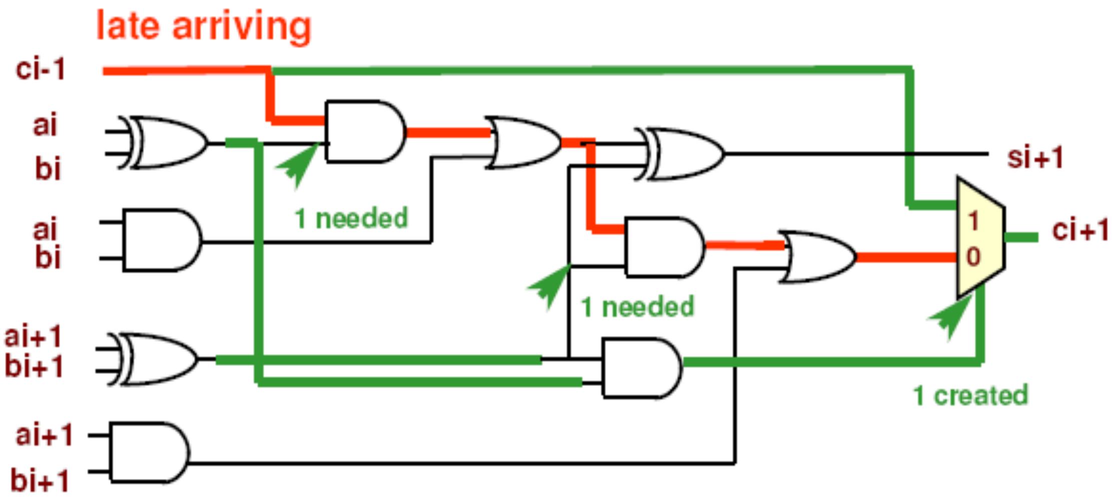
Problem 1:   False Path: those paths which signals never propagate from PI to PO.



To sensitize red path we need:

ai XOR bi && ai+1 XOR bi+1

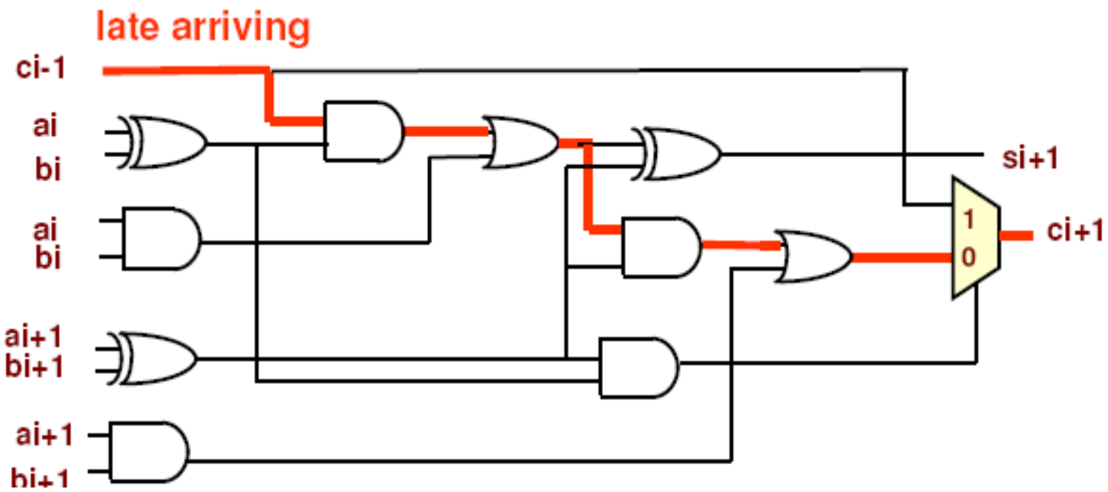
But: red path is false

When above condition is true, MUX selects "1" input, i.e. directly from ci-1

Instead shorter green paths are sensitized

Hence, red path is not the critical path of the circuit!

With the same circuit, the red critical path has been proved to be false path. Try to find the true critical path for this circuit. Assume unit gate delay in this circuit.



Solution:

The arrival time is shown in Figure 1.1.

The numbers 1, 2, 3, 4, 5 and 6 mean the delay of the arrival time delay of the path.

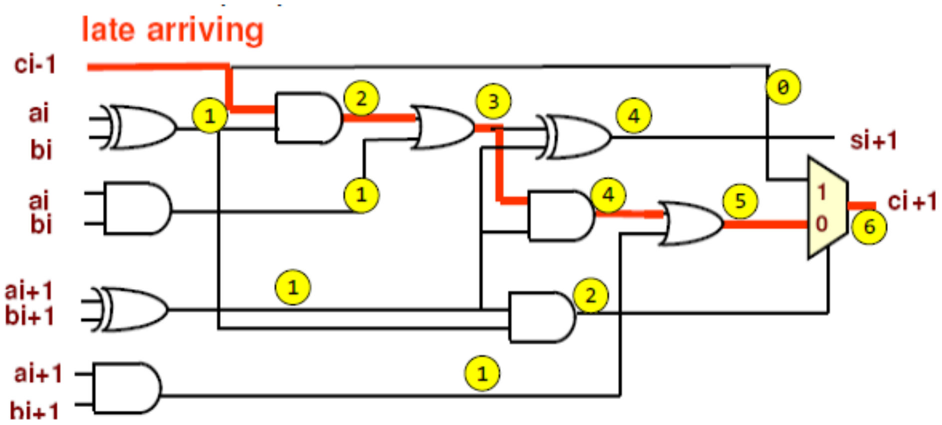


Figure 1.1 Arrival time analysis

By the same method, we can define the required arrival time in Figure 1.2.

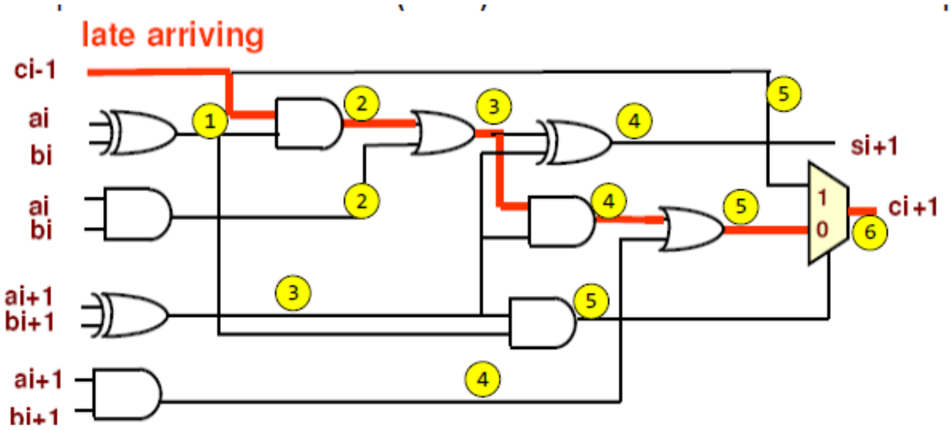


Figure 1.2 Required arrival time analysis

By subtracting the number, we can find the time slack of the circuit in Figure 1.3.

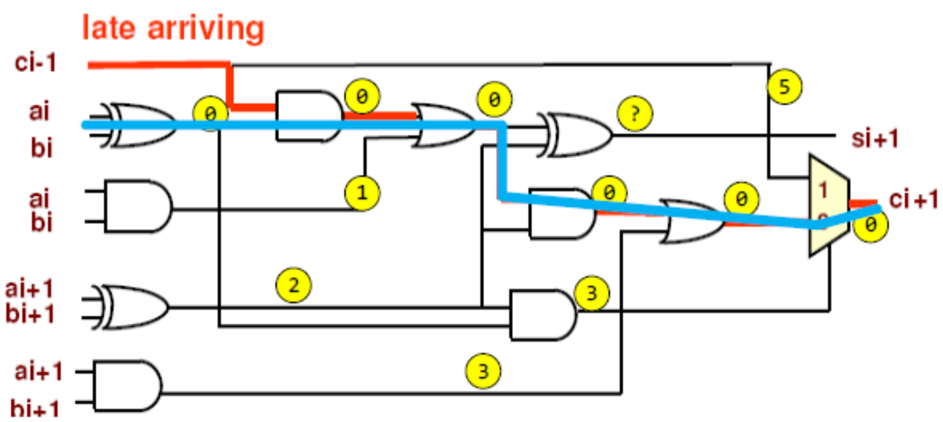
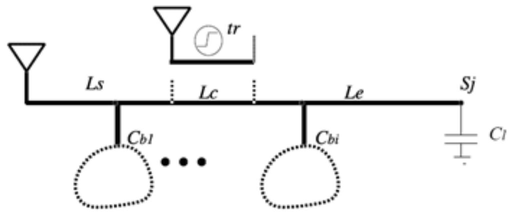


Figure 1.3 Time slack analysis

The critical path is the path with zero time slack as the blue solid line depicts in Figure 1.3.

Problem 2: Given the layout of a victim net and an aggressor net above it. Try to calculate noise voltage output & waveform considering crosstalk using the noise model from [aspdac'01].



Vdd = 1V

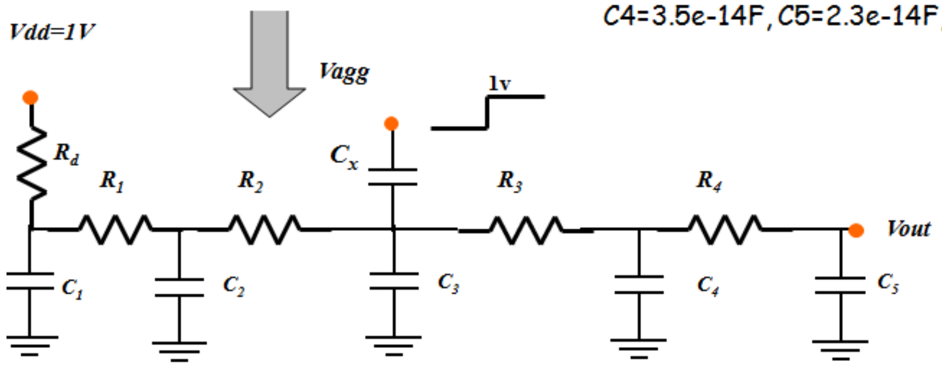
Tr: step input with rising time is 500ps

Rd = 300 Ω, R1=100 Ω, R2=150 Ω,

R3= 250Ω, R4=300Ω

C1=2e-14F, C2=5e-14F, C3=1.5e-14F

C4=3.5e-14F, C5=2.3e-14F, Cx=5e-14F.



Solution:

According to [aspdac'01], we can incorporate the lumped capacitance to C_1, C_2 and C_L in Figure 2.1.

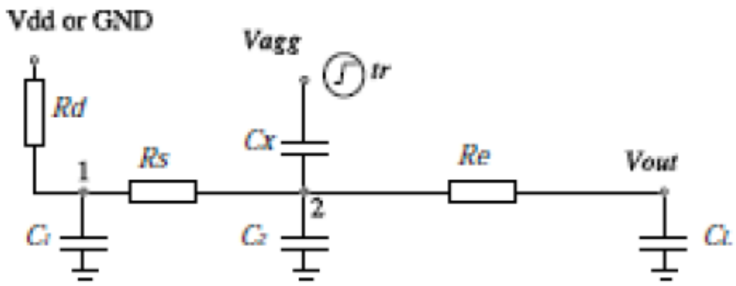


Figure 2.1 Lumped model

We can then calculate the parameters of the lumped model as follows:

$R_s = R_1 + R_2 = 250\Omega$

$R_e = R_3 + R_4 = 550\Omega$

$C_x = 5e - 14D$

$R_d = 300\Omega$

$C_1 = C_1 + 0.4 * C_{b1} = 4e - 14F$

$C_2 = C_3 + 0.6 * C_{b1} + 5/11\, C_{b2} = 6.091e - 14F$

$C_L = C_5 + 6/11 * C_{b2} = 4.21e - 14\text{F}$

And we apply the formula:

$$V_{out} = \frac{t_x}{t_v}\left(1 - e^{-t/t_v}\right), o \leq t \leq t_r$$

$$V_{out} = \frac{t_x}{t_v}\left(e^{-\frac{t-t_r}{t_v}} - e^{-t/t_v}\right), t > t_r$$

Where $t_r = 5e - 12s, t_x = (R_d + R_s) * C_x = 2.75e - 11s$

$t_v = (R_d + R_s) * (C_x + C_2 + C_l) + R_e C_L + R_d C_L = 1.0275e - 10s$

Then we have figure 2.2.

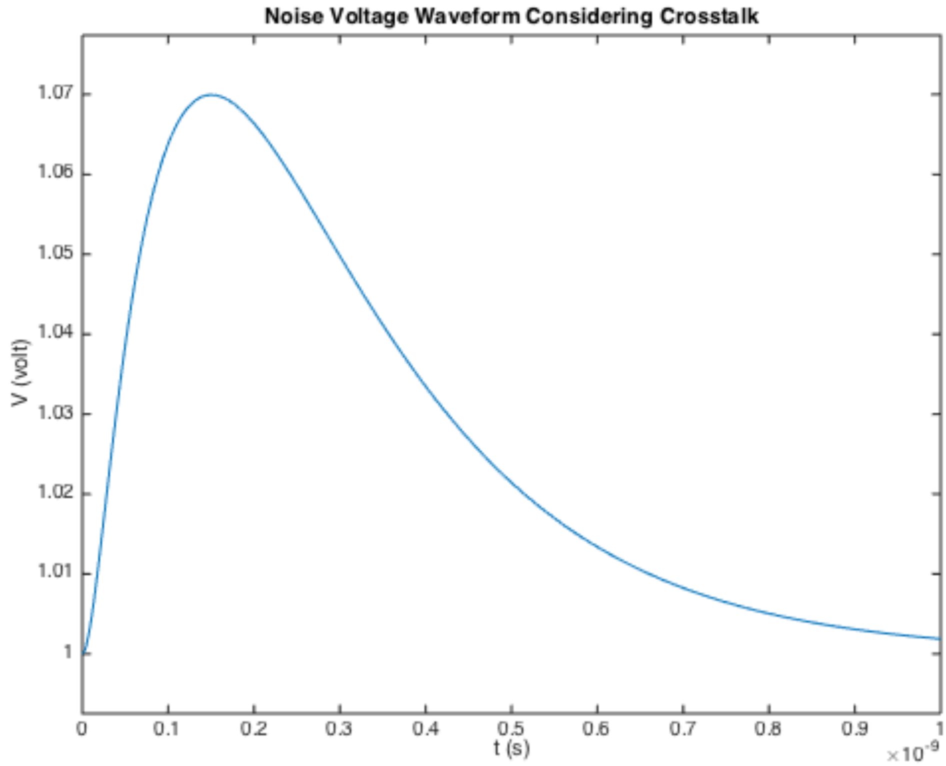


Figure 2.2 Vout output figure

If we do the same job in Spice, we can find the same result as Figure 2.3 shows.

rc.sp

```
crosstalk
Rd 2 1 300
R1 2 3 100
R2 3 4 150
R3 4 5 250
R4 5 6 300
C1 2 0 2e-14
C2 3 0 5e-14
C3 4 0 1.5e-14
c4 5 0 3.5e-14
C5 6 0 2.3e-14
Cx 7 4 5e-14

VDD 1 0 DC 1V
Vagg 7 0 exp (0 1 0ps 200ps 2000ps 0ps)

.op
.TRAN 1p 1000p

.print all
.plot all
.END
```

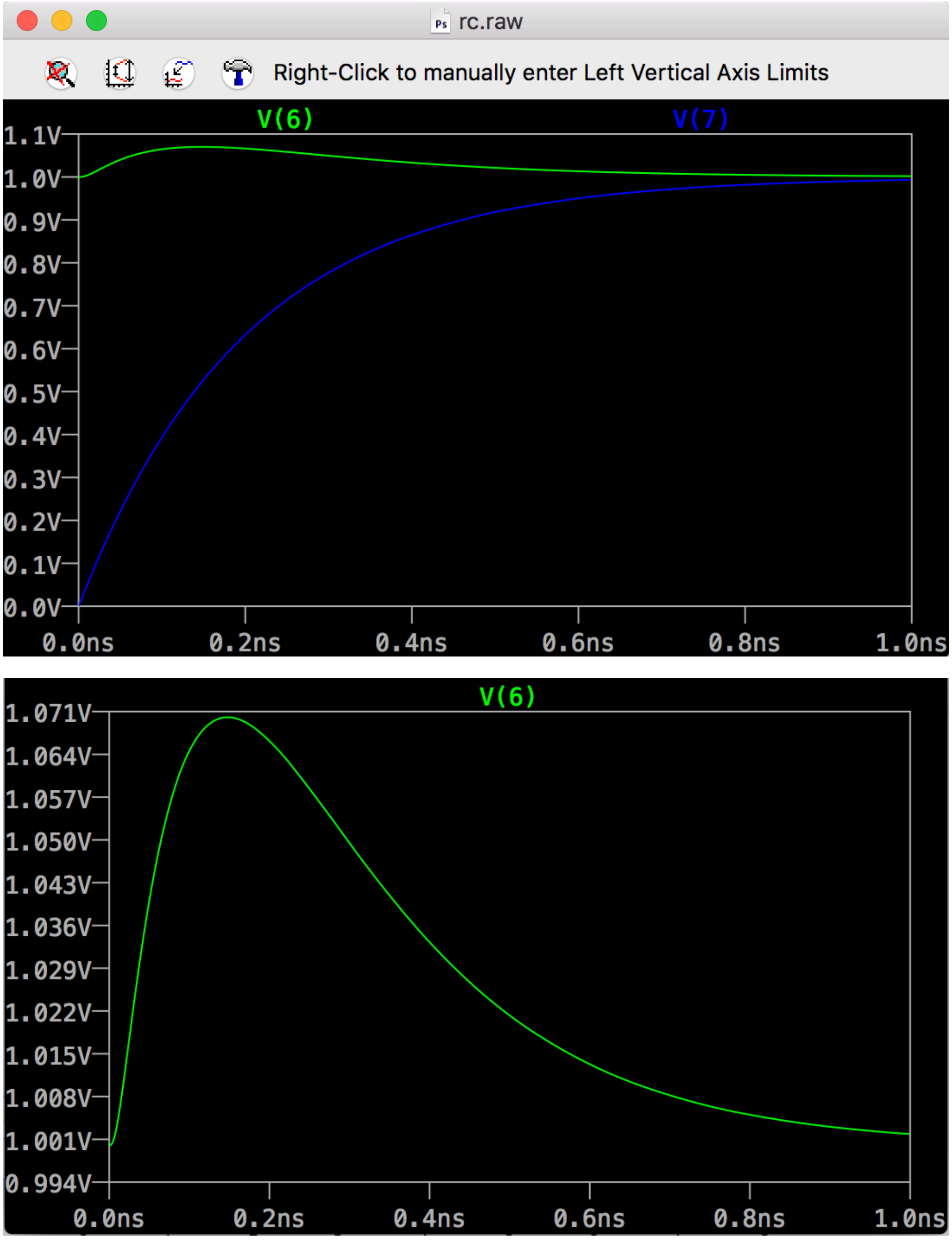


Figure2.3 Spice results