HW3 XIAOANG LI 003996585

P1

Answer:

The critical path is shown by blue line in Fig.1. Staring from the output, we can trace back and find the combinations of input, shown in the figure. Assuming unit gate delay, the critical path delay is 6 unit-gate-delay.

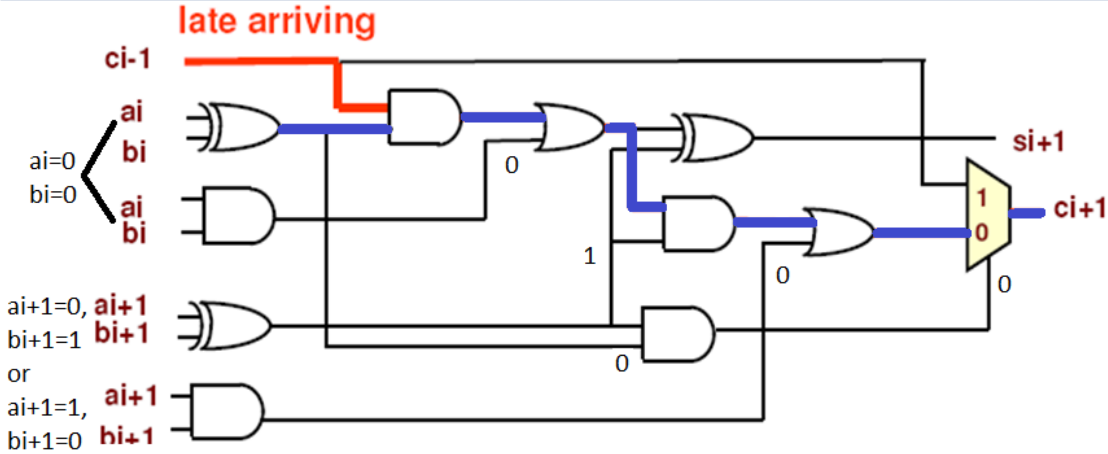
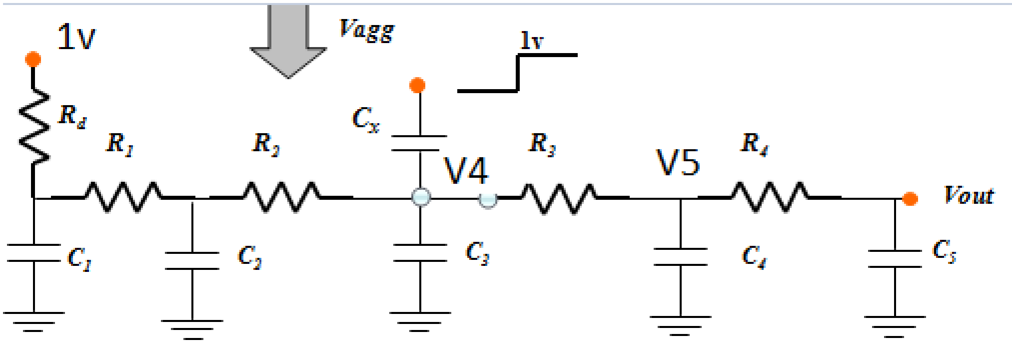


Fig.1 Critical path and input combinations

P2

Answer:



(1) Calculate the transfer function.

$$\frac{1}{Z_2} = \frac{1}{R_d} + sC_1$$

$$\frac{1}{Z_3} = \frac{1}{Z_2 + R_1} + sC_2$$

$$\frac{1}{Z_4} = \frac{1}{Z_3 + R_2} + sC_3 + \frac{1}{R_r}$$

$$R_r = \frac{1}{\frac{1}{R_4 + \frac{1}{sC_5}} + sC_4} + R_3$$

$$V_4(s) = \frac{Z_4}{Z_4 + \frac{1}{sC_x}} V_{agg}(s)$$

$$V_5(s) = \frac{1}{\frac{1}{R_4 + \frac{1}{sC_5}} + sC_4} \cdot \frac{1}{R_r} \cdot V_4(s)$$

$$V_{out}(s) = V_5(s) \frac{\frac{1}{sC_5}}{R_4 + \frac{1}{sC_5}}$$

$$V_{agg}(s) = \frac{1 - e^{-st_r}}{s^2 t_r}$$

$$H(s) = \frac{\frac{1}{sC_5}}{R_4 + \frac{1}{sC_5}} \cdot \frac{1}{\frac{1}{R_4 + \frac{1}{sC_5}} + sC_4} \cdot \frac{1}{R_r} \cdot \frac{Z_4}{Z_4 + \frac{1}{sC_x}}$$

$$V_{out}(s) = \frac{\frac{1}{sC_5}}{R_4 + \frac{1}{sC_5}} \cdot \frac{1}{\frac{1}{R_4 + \frac{1}{sC_5}} + sC_4} \cdot \frac{1}{R_r} \cdot \frac{Z_4}{Z_4 + \frac{1}{sC_x}} \cdot V_{agg}(s)$$

(2) Plot the time domain waveform in Matlab (1V DC is ignored without losing the essentials).

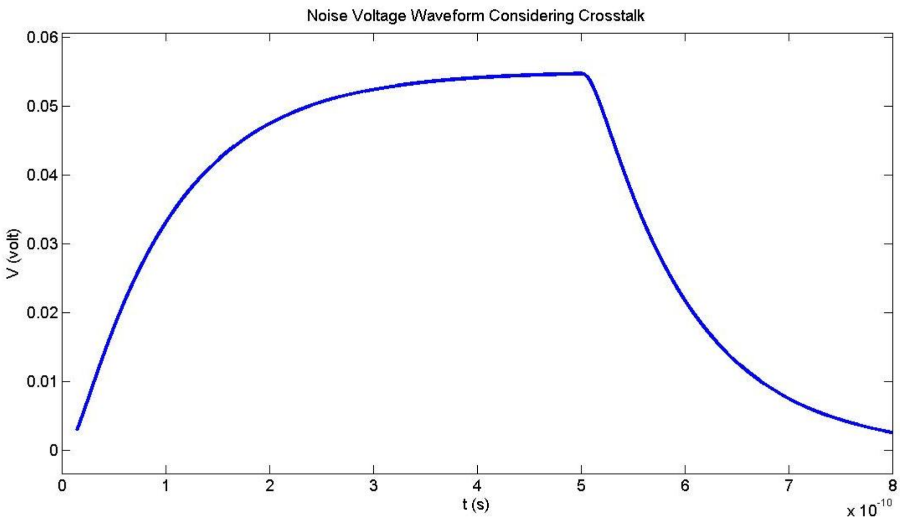


Fig.2 Matlab Simulation Result

(3) SPICE simulation results.

SPICE netlist:

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
Vss 7 0 PULSE(0 1 0 500p)
.op
.TRAN 1p 800p
.print all
.plot all
.END
```

Fig.3 SPIEC Simulation Result

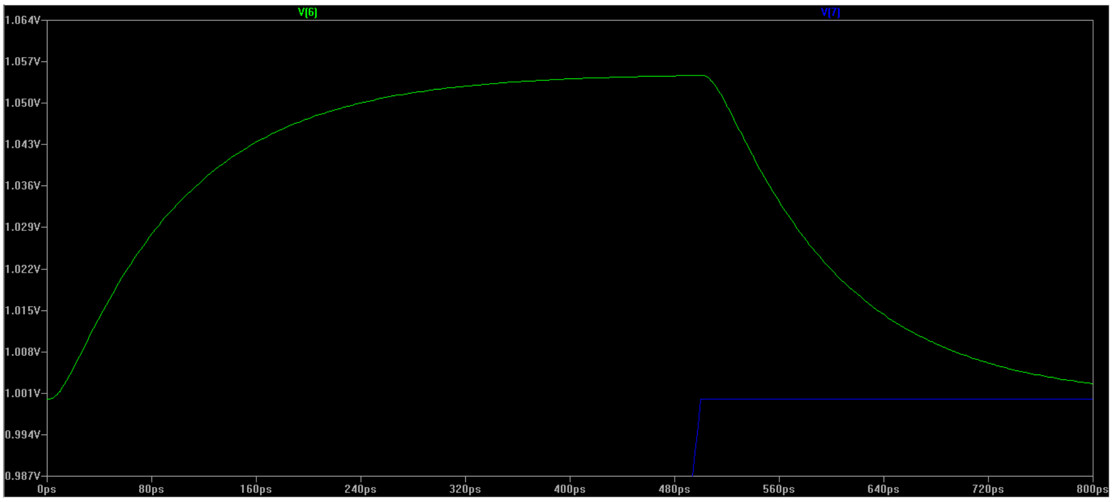


Fig.4 Vout Zoom-in