平面顯示技術導論 HW #2

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1. An equivalent circuit of a single LCD pixel is shown below. The transistor will be replaced by a $50\,\Omega$ resistor which is connected between V_s and V_d. Assuming $C_{st} = 3\,\mathrm{pF}$, and $C_{lc} = 5\,\mathrm{pF}$, a step function V_G is applied at $t = 0$ to turn on the TFT, $V_D = 0$ (at $t < 0$), $V_S = 5\,\mathrm{V}$.

   (a) Please calculate how long it takes to charge up C_{lc} from $0\,\mathrm{V}$ to 90% of V_s (i.e. $4.5\,\mathrm{V}$).

   Ans: First we calculate the time constant $\tau = R(C_{lc} + C_{st}) = 0.4\,\mathrm{ns}$.

   $$\mathrm{e}^{-t/\tau} = 1 - 0.9 \quad \Rightarrow \quad t = \tau \log 10 \quad \Rightarrow \quad t \approx 0.92\,\mathrm{ns}$$

   (b) Please calculate how long it takes to charge up C_{lc} from $0\,\mathrm{V}$ to $4.5\,\mathrm{V}$ if V_s becomes $9\,\mathrm{V}$.

   Ans: The time constant remains the same, but now $4.5\,\mathrm{V}$ is only 50% of $9\,\mathrm{V}$.

   $$\mathrm{e}^{-t/\tau} = 1 - 0.5 \quad \Rightarrow \quad t = \tau \log 2 \quad \Rightarrow \quad t \approx 0.277\,\mathrm{ns}$$

   (c) Please comment on the overdrive technology.

   Ans: The overdrive technology would give better respond speed, since its charging time is shorter.

2. Questions:

   (a) What is the duration (time), T_3, of the scan line 110? And what is $(t_2 - t_1)$ when the data line is enabled?

   Ans: If 320×120 means that there are 320 scan lines, then

   $$T_3 = 1\,\mathrm{s}/30/320 \quad \approx 104.2\,\mu\mathrm{s},$$

   Else

   $$T_3 = 1\,\mathrm{s}/30/120 \quad \approx 277.8\,\mu\mathrm{s}.$$

No matter what, we have

$$(t_2 - t_1) = 1\,\mathrm{s}/30/120/320 \qquad \approx 0.868\,\mu\mathrm{s}$$

(b) What is the maximum capacitance of capacitor 104?
Ans: Let $\Delta t = (t_2 - t_1)/2, \tau = RC$ where $R = 10\,\Omega$.

$$\mathrm{e}^{-\Delta t/\tau} \leq 1 - 0.8 \implies \frac{\Delta t}{\tau} \geq \log 5 \implies RC = \tau \leq \frac{\Delta t}{\log 5}$$
$$\implies C \leq \frac{\Delta t}{R \log 5} = \frac{t_2 - t_1}{2R \log 5} \approx 27.0\,\mathrm{nF}$$

(c) Assuming the first OLED selected in the columns, after the data line is disable, the circuit is in the discharge process. Can the fully-on period of the OLED last the entire scan line period (T_3)?
Ans: No, from the previous question we knew that

$$\tau \leq \frac{\Delta t}{\log 5}$$

Let V^* be the voltage of capacitor 104 just after the data line is disabled, and we know that $V^* \leq V_{\mathrm{data}}$. Let t^* be the time needed for the voltage to drop to $0.8V_{\mathrm{data}}$, which is greater than $0.8V^*$, then

$$t^* \leq \tau(-\log 0.8) = \frac{\log 5/4}{\log 5}\Delta t \approx 0.14\,\Delta t,$$

Which is much smaller than $2\Delta t = t_2 - t_1$, and not to mention T_3.

(d) Please plot (hand draw is OK) I_{OLED} vs. time once V_{data} is enabled.
We knew that $V_{104} = V_{\mathrm{data}}(1 - \mathrm{e}^{-t/\tau})$ from the previous problems. And we assume that $I_{\mathrm{OLED}} \propto V_{104}^2$ (Since $I \propto V^2$ in MOS).