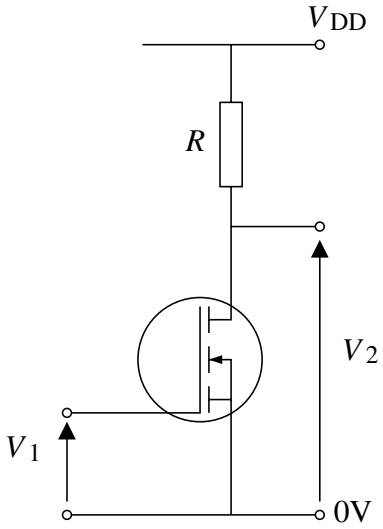
2 Digital Electronics (ijw24)

The figure below shows a circuit using an N-channel MOSFET, along with a table giving the relationship between V_{DS} and I_{DS} for various values of V_{DS}, at $V_{\text{DD}} = 4$ V and $V_{\text{GS}} = 4$ V.



V_{DS}(mV)	160	320	470
I_{DS}(mA)	48	92	130

(*a*) Calculate the value of resistor R and the power dissipated in it when $V_{\text{DS}} = 160$ mV. [4 marks]

(*b*) A capacitor C is connected between the source and drain terminals of the MOSFET. After the MOSFET turns OFF at $t = 0$, the output signal V_2 as a function of time t is given by $V_2 = V_{\text{DD}}(1 - e^{-t/CR})$. Assume that prior to $t = 0$, the MOSFET is ON and $V_2 = 0$ V.

(*i*) Determine an expression for the time taken t_r, for the output signal V_2 to rise from 20% to 80% of its maximum value.

(*ii*) What is the rise time t_r, if $C = 0.1$ μF and R takes the value calculated in Part (*a*)?

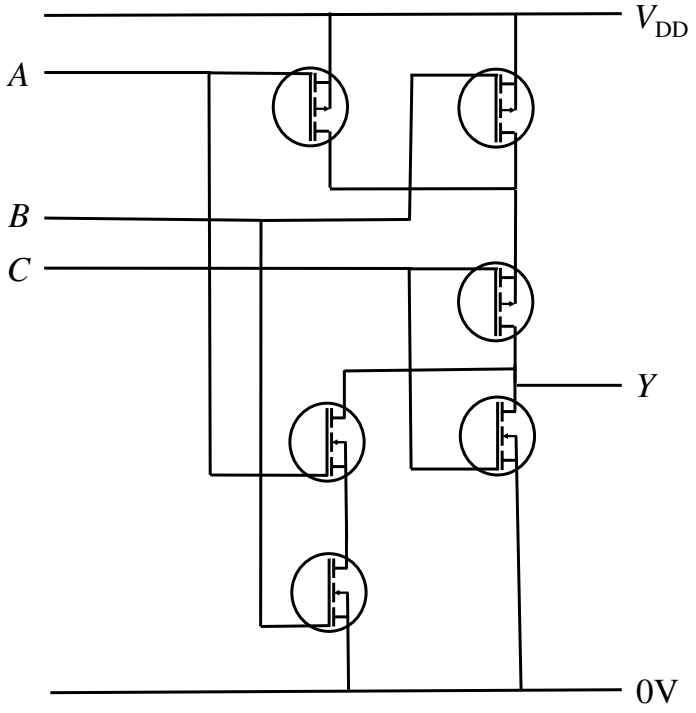
(*iii*) The value of R is changed so as to reduce the rise time to half that in Part (*b*)(*ii*). What is the new value of R?

(*iv*) Using the value of R calculated in Part (*b*)(*iii*), what is the power dissipated in R when the MOSFET is ON (i.e., when $V_{\text{GS}} = 4$ V), and assuming that $V_2 = 320$ mV?

(*v*) Explain how the problem of high static power consumption seen in the N-channel MOSFET circuit can be eliminated. [9 marks]

[continued ...]

(*c*) The logic gate in the following figure has 3 inputs, A, B, and C, and a single output Y. Determine the truth-table for the gate input to output function, and then determine a simplified Boolean expression for output Y in terms of A, B, and C.



[7 marks]