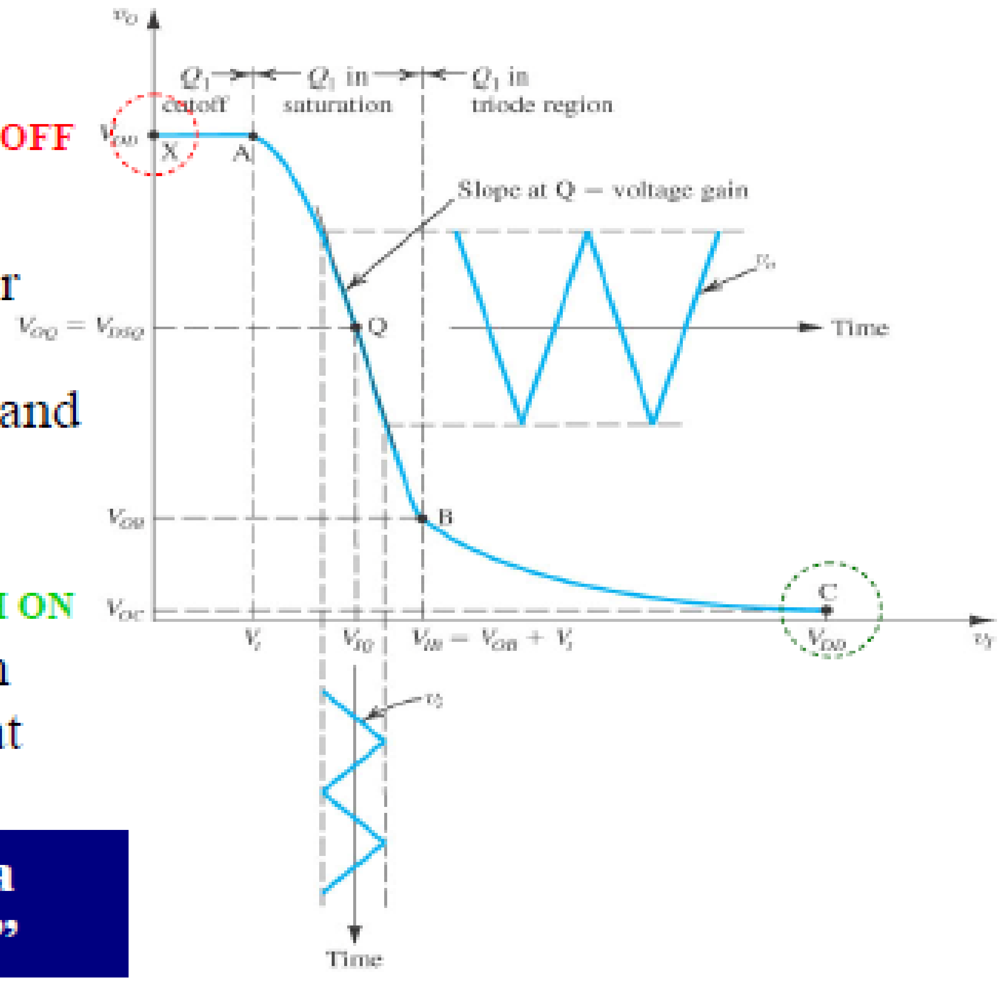
Lecture 13

MOSFET

The Transfer Characteristics – *Graphical Derivation*

Operation as a Switch



- Operate the MOSFET at the Extreme points of the Transfer Curve
- $v_I < V_t$: switch is turned off and $v_o = V_{DD}$ (operate between X and A)
- $v_I = V_{DD}$: switch is turned on and v_o is very small (operate at point C)

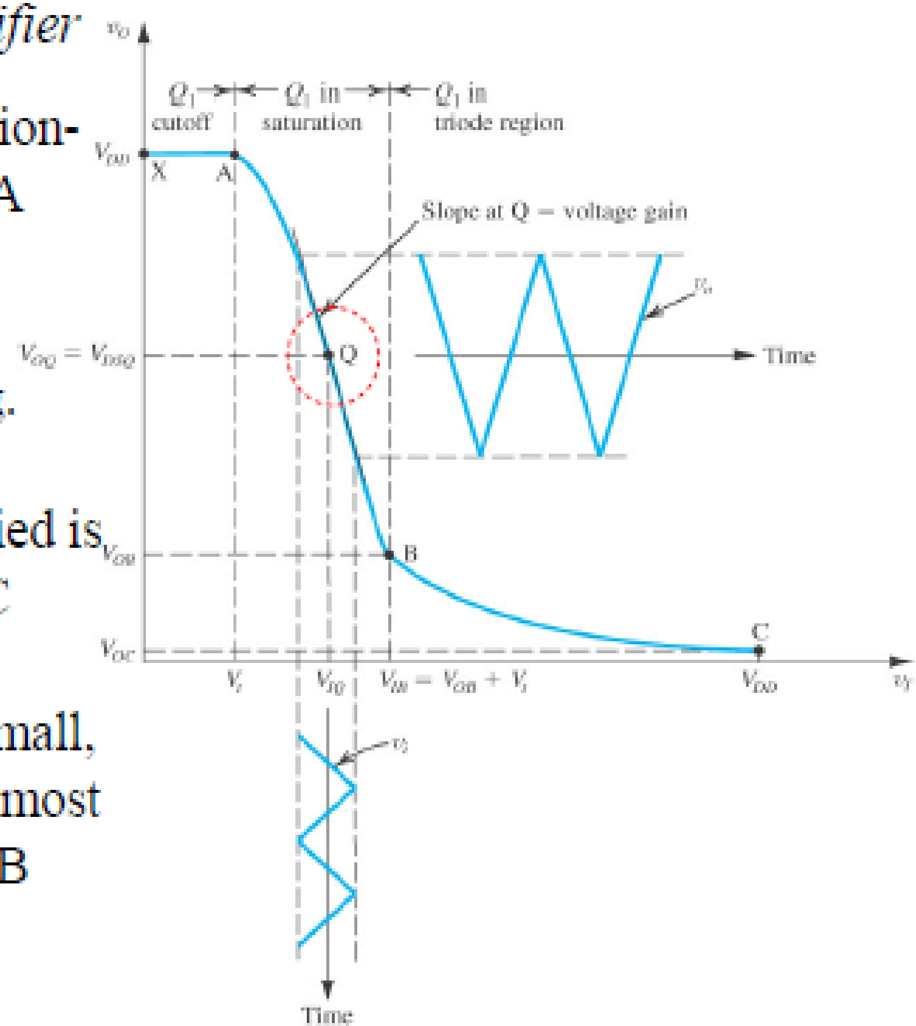
MOSFET Operates as a "Digital Logic Inverter"

The Transfer Characteristics – *Graphical Derivation*

Operation as a Linear Amplifier

- We make use of the Saturation-mode segment of the curve (A Through B)
- The MOSFET is biased somewhere in the middle, e.g. point Q
- The AC signal to be amplified is then superimposed on the DC Voltage V_{IQ}
- By keeping v_i sufficiently small, we restrict operation to the almost linear region between A and B
- **Gain (A_v):**

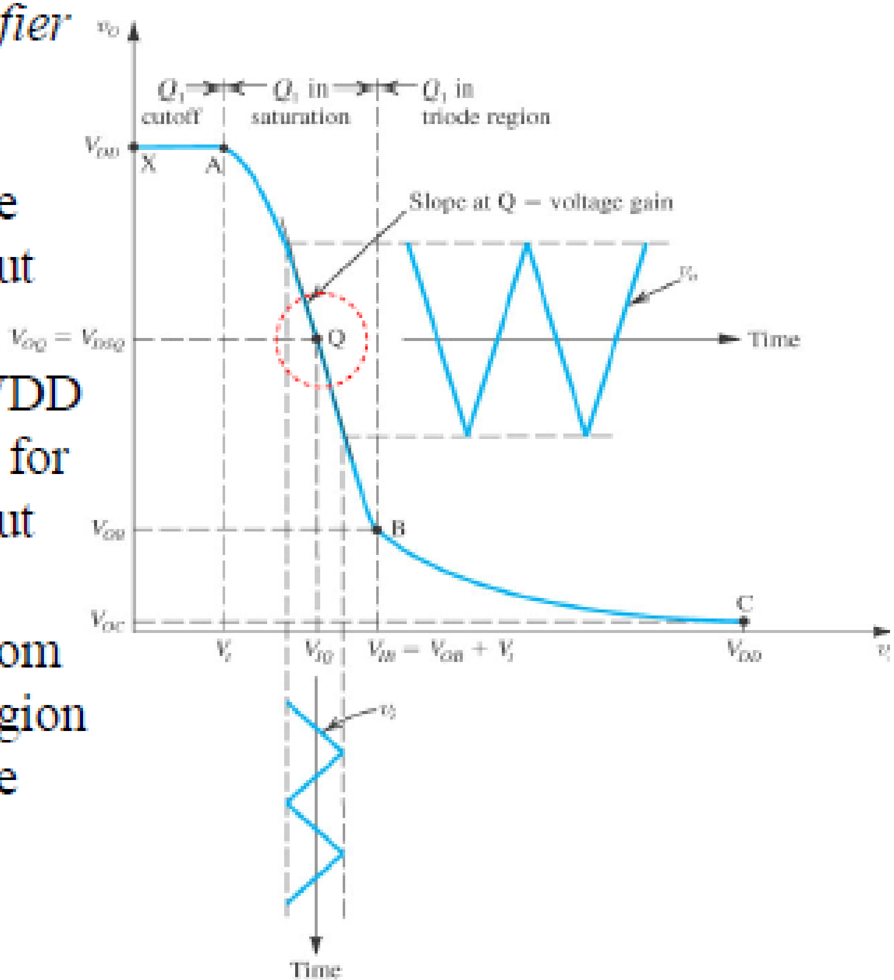
$$A_v = \left.\frac{dv_o}{dv_I}\right|_{v_I = V_{IQ}}$$



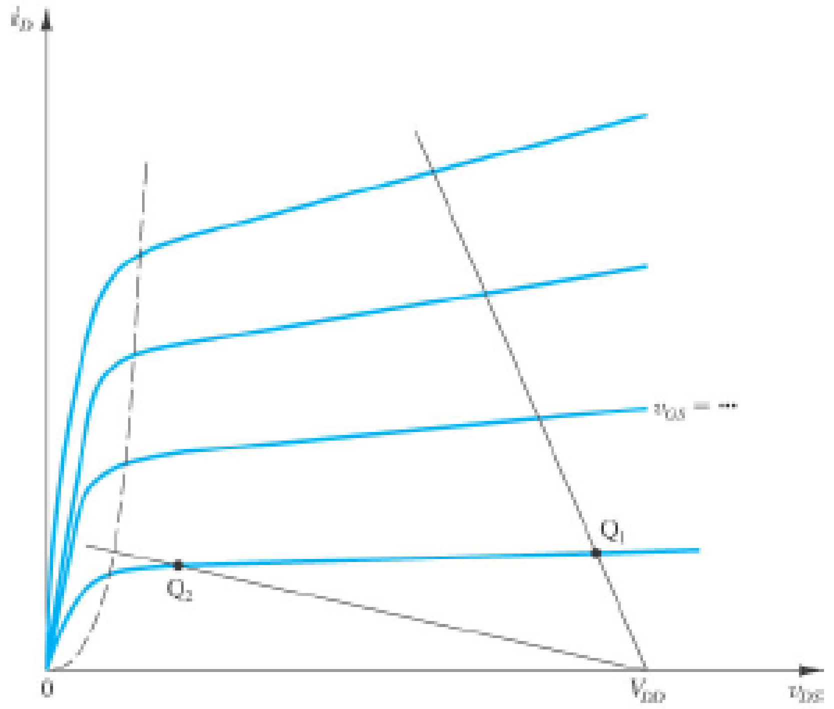
The Transfer Characteristics – *Graphical Derivation*

Operation as a Linear Amplifier

- V_{DSQ} should be of such value to allow for the required output signal swing
- V_{DSQ} should be lower than VDD by sufficient amount to allow for the positive peaks of the output signal (sufficient *headroom*)
- V_{DSQ} should also be away from the boundary of the Triode region (point B) to allow for negative peaks (*sufficient legroom*)



How to Bias a MOSFET Amplifier?



- **Bias Point Q1:** does not leave sufficient room for positive signal swing at the drain (too close to *VDD*)
- **Bias Point Q2:** too close to the boundary of the Triode region and might not allow for sufficient negative signal swing

Analytical Expressions for the Transfer Characteristics

- Derive $v_o = f(v_I)$
- Cut-off Segment:

$$V_I \leq V_t \; and \;\; v_o = V_{DD}$$

- Saturation Segment:

$$v_o = V_{DD} - \frac{1}{2} R_D \mu_n C_{ox} \frac{W}{L} (v_I - V_t)^2$$

$$A_v = -R_D \mu_n C_{ox} \frac{W}{L} (V_{IQ} - V_t)$$

- Triode Segment:

$$v_o = V_{DD} - R_D \mu_n C_{ox} \frac{W}{L} \left[(v_I - V_t) v_o - \frac{1}{2} v_o^2 \right]$$