Find R such that VD=0.8V, Vth=0.5V, Kn'=0.4 mA/V2, W/L=0.72/0.18 lambda=0

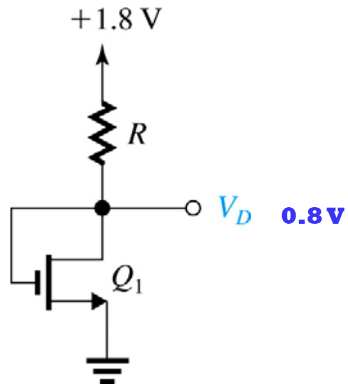

Figure E5.9

Microelectronic Circuits, Sixth Edition Sedra/Smith

Find R_2 to operate at edge of saturation

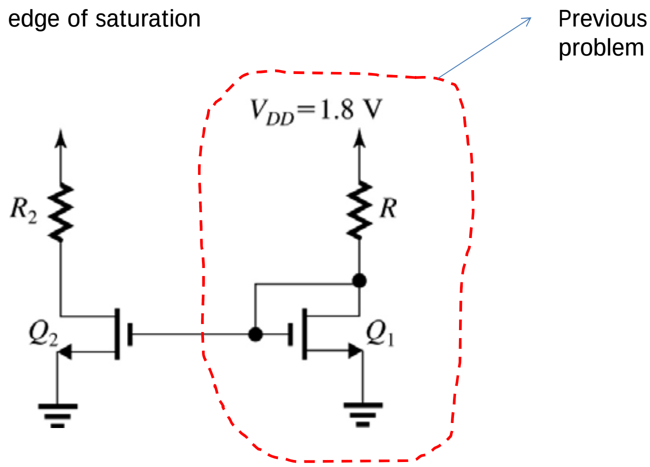

Figure E5.10

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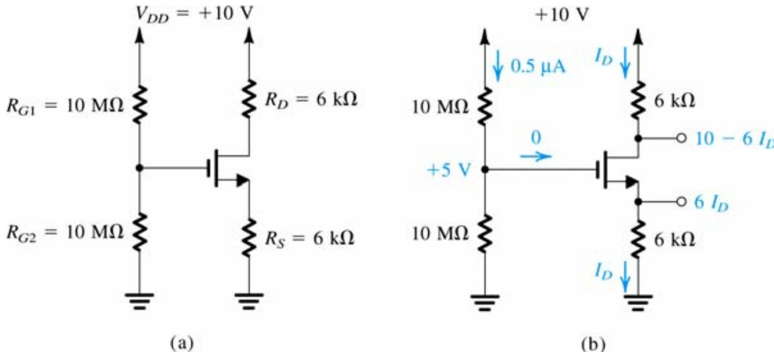


Find the voltages and currents
V_{tn}=1 V, Kn(W/L)=1 mA/V^2

Figure 5.24 (a) Circuit for Example 5.6. (b) The circuit with some of the analysis details shown.

K_p'=K_n'=1mA/V^2, v_{tn}=-v_{tp}=1V
λ=0
Find v_o for v_{in} = -2.5, 0, 2.5

$$v_{GS} < V_{tn}$$

$$v_{GS} > V_t$$
$$v_{DS} > v_{GS} - V_t$$
$$v_D - v_s > v_G - v_s - V_t$$
$$v_{GD} < V_t$$

$$v_{DS} < v_{OV}$$
$$v_{GD} > V_t$$

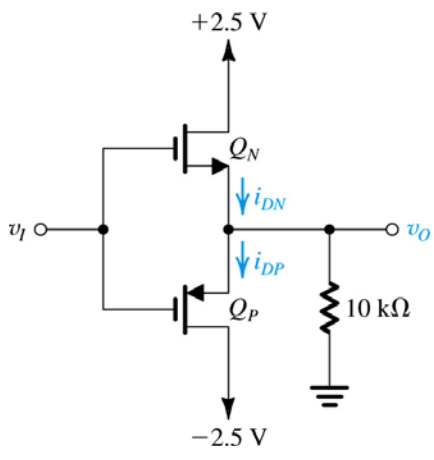


Figure E5.15

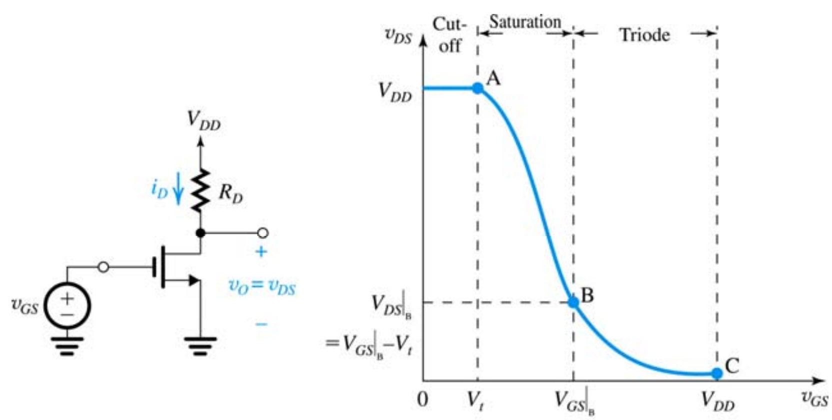
MOSFETs as Amplifiers

- In saturation, the MOSFET acts as a voltage controlled current source

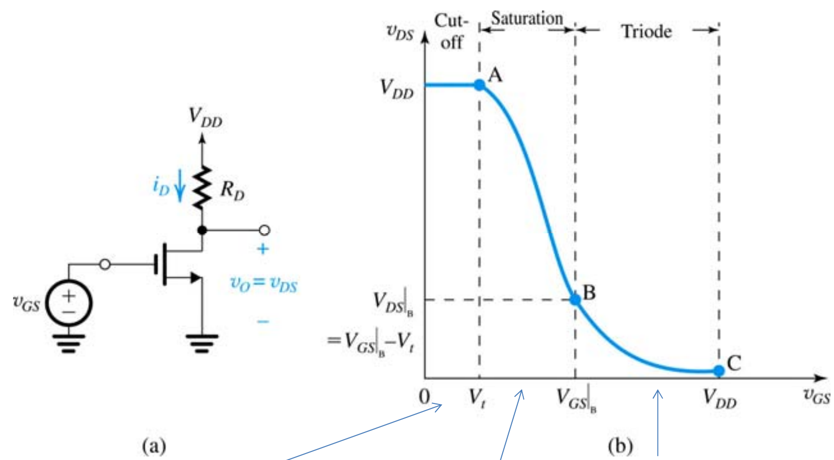
$$i_D = \frac{1}{2} k_n^{'} \left(\frac{W}{L} \right) V_{ov}^2 (1 + \lambda v_{DS})$$

- Non-linear V_{ov}^2
- If the current (i_D) flows in a resistive load, output voltage is proportional to i_D.

MOSFET as an amplifier
$v_o = v_{DS} = V_{DD} - i_D R_D$
Later, we will discuss small signal equivalent circuit



(a) (b)



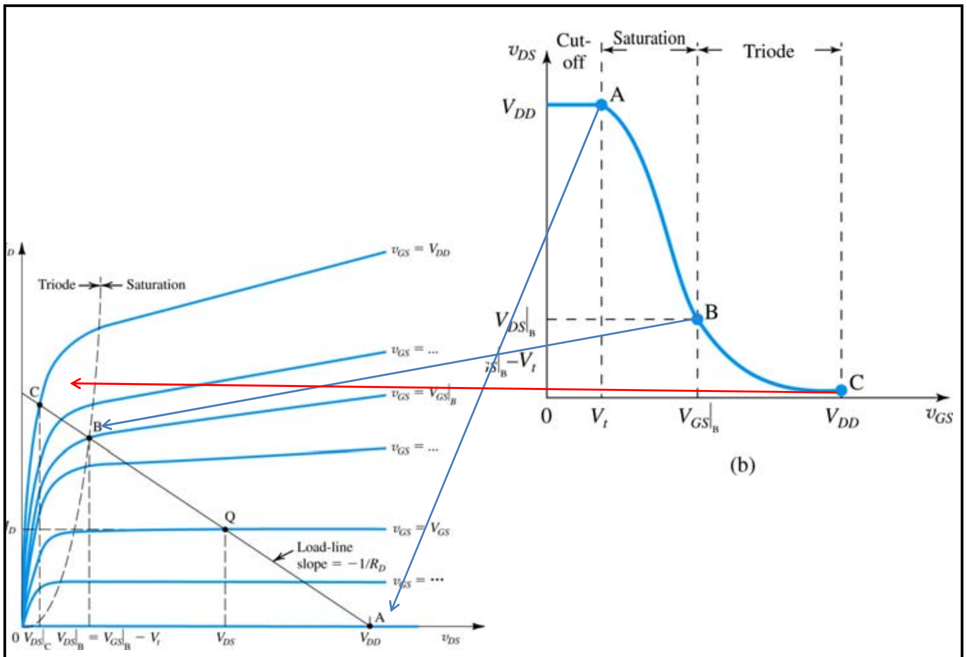
(a)

(b)

$v_{gs} < V_t$ cut off

v_{gs} increases when $v_{DS} = v_{GS} - V_t$ →Triode

v_{gs} increases when reaches V_t MOSFET is ON
Since initially v_{DS} is high (no drop on R_D) $v_{DS} > v_{GS} - V_t$ →Saturation



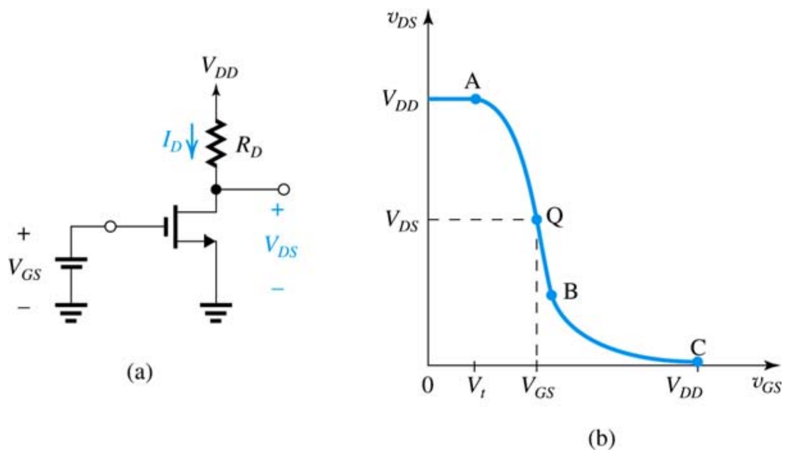


Figure 5.28 Biasing the MOSFET amplifier at a point Q located on the segment AB of the VTC.

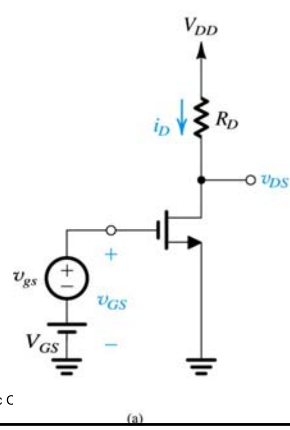
$$v_{DS} = V_{DD} - 1/2\, k_n R_D (v_{GS} - V_t)^2$$

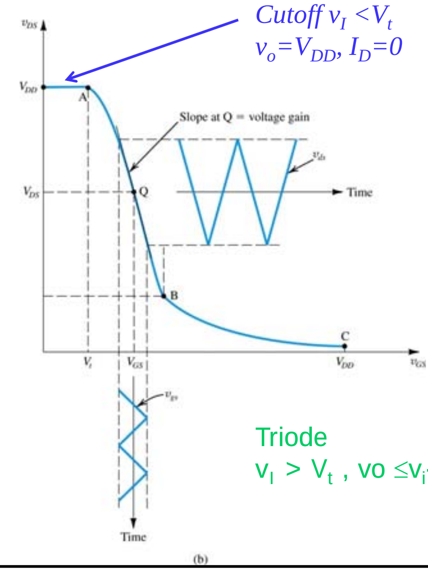
$$A_v = \left[\frac{dv_{DS}}{dv_{GS}}\right]_{v_{GS}=V_{GS}}$$

$$A_v = -k_n R_D V_{OV}$$

Saturation
$v_I > V_t$, $v_o \geq V_I - V_t$

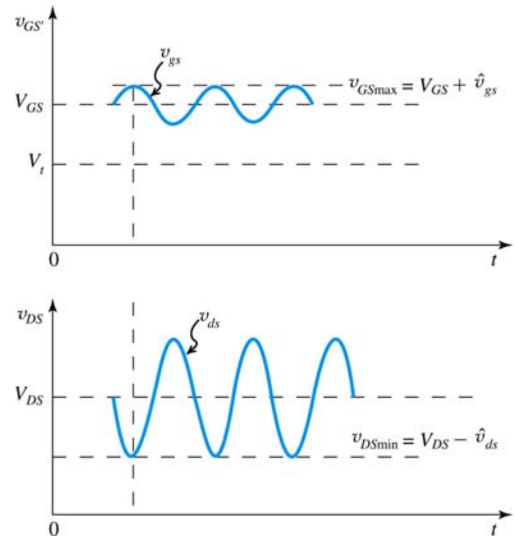
Cutoff $v_I < V_t$
$v_o = V_{DD}$, $I_D = 0$

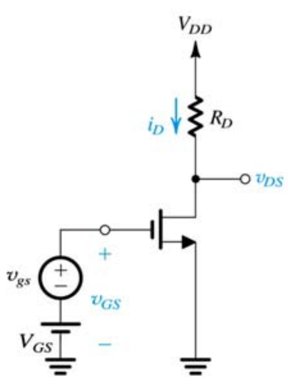




Triode
$v_I > V_t$, $v_o \leq v_i - V_t$

$$V_{DS} = V_{DD} - 1/2\, k_n R_D (v_{GS} - V_t)^2$$
$$v_{GS}(t) = V_{GS} + v_{gs}(t)$$





(a)

2 Designs for a gain of 10

1. Changing R_D while keeping V_{OV} constant
2. Changing V_{OV} while keeping R_D constant

V_t=0.4V, V_{DD}=1.8V, V_{GS}=0.6V, K_n'=0.4mA/V_2, W/L=10, R_D = 17.5KΩ

VTC by Graphical Analysis

- Not used in circuit analysis, used only to illustrate for gaining a greater insight into circuit operation.
- From elementary circuit theory we have
- $V_{DD} = i_D R_D + v_{DS}$
- That represents a line with a slope of -1/RD
- The transistor operates on a point along that line.

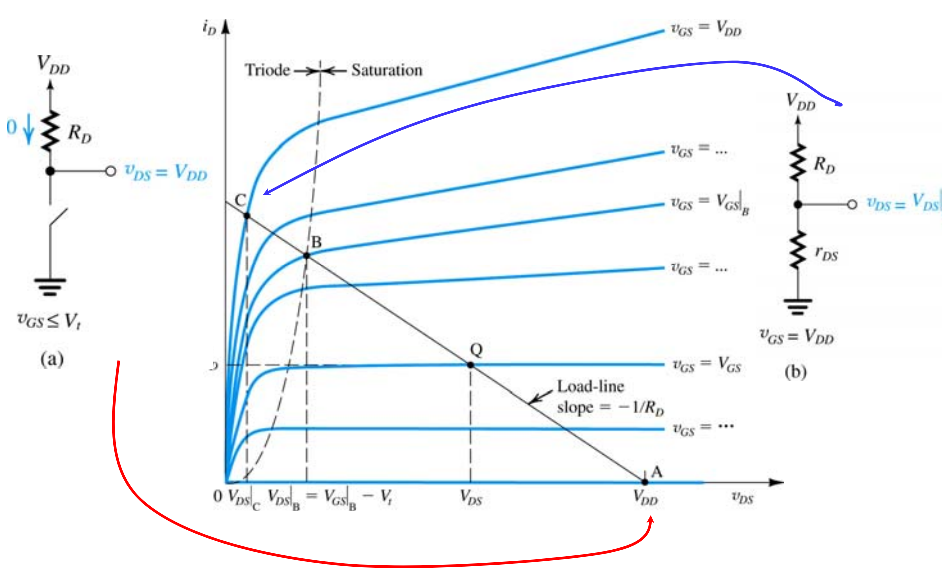


Figure 5.31 Graphical construction to determine the voltage transfer characteristic of the amplifier in Fig. 5.29(a).

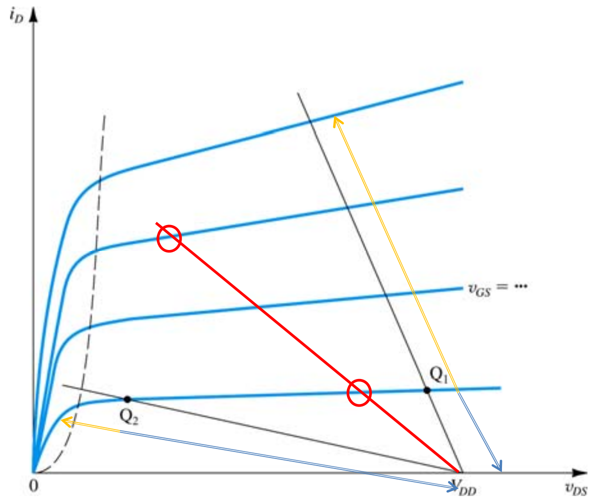


Figure 5.33 Two load lines and corresponding bias points. Bias point Q_1 does not leave sufficient room for positive signal swing at the drain (too close to V_{DD}). Bias point Q_2 is too close to the boundary of the triode region and might not allow for sufficient negative signal swing.