HKN ECE 342 Review Session 2

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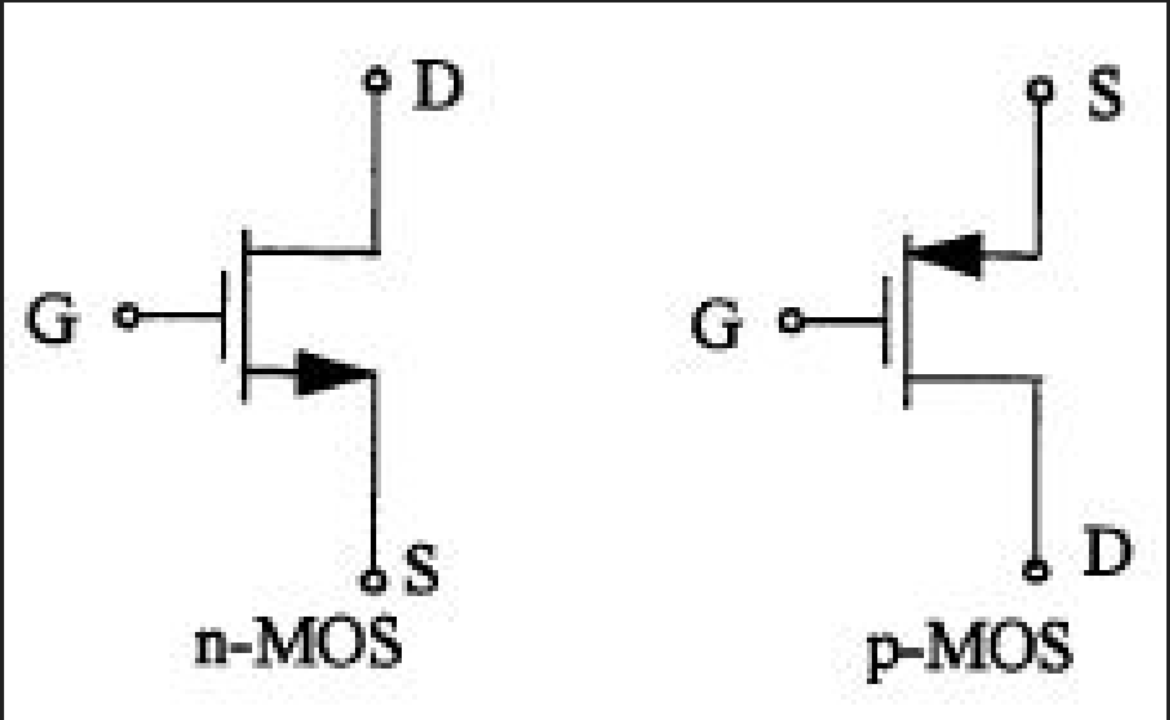
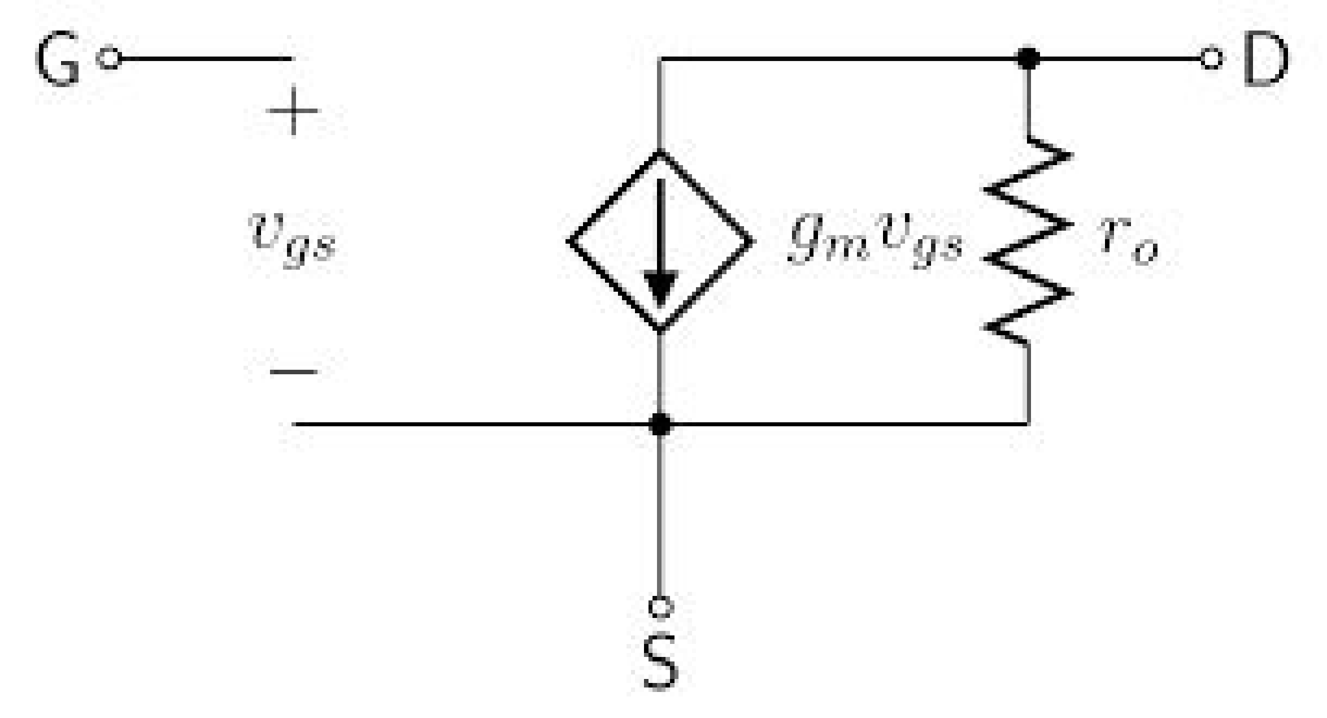
MOSFET’s



MOSFET Operating Point

- Three regions of operation:
- Cutoff ($V_G < V_T$): $I_D = 0$
- Linear/Triode ($V_G > V_T$, $V_{DS} < V_{GS} - V_T$): $I_D = \mu_{n/p} C_{ox} (W/L)((V_{GS} - V_T)V_{DS} - V_{DS}^2/2)$
- Saturation ($V_G > V_T$, $V_{DS} > V_{GS} - V_T$), $I_D = \mu_{n/p} C_{ox} (W/L)(½)(V_{GS} - V_T)^2$

MOSFET Incremental Model



Gain Calculation

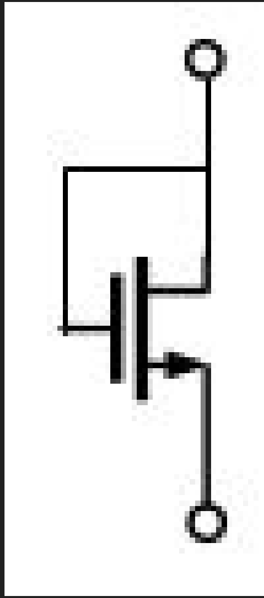
$A_v = -G_M R_{out}$

G_M = Small signal transconductance, ratio of i_{out} to v_{in}

R_{OUT} = Equivalent incremental output resistance

Common Amplifier Topologies

1. Diode-tied Transistor
   a. What is overdrive voltage here?
   b. Is this always in saturation?
2. Common Source/Drain/Gate
   a. Purpose of each topology?
   b. equations
3. Common Source with Degeneration
4. Common Drain with Modulation
5. Cascode



1. Diode Tied Transistor

Common Source/Drain/Gate

$R_{OUT} = R_D \parallel r_{ds}$

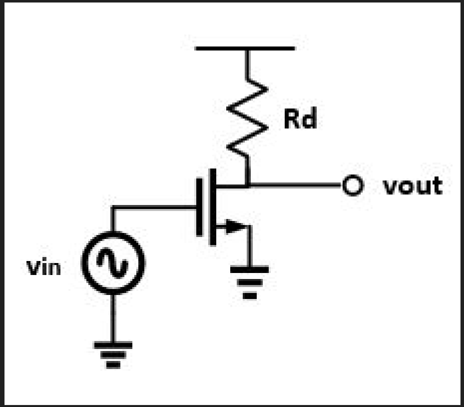
$G_m = g_m$

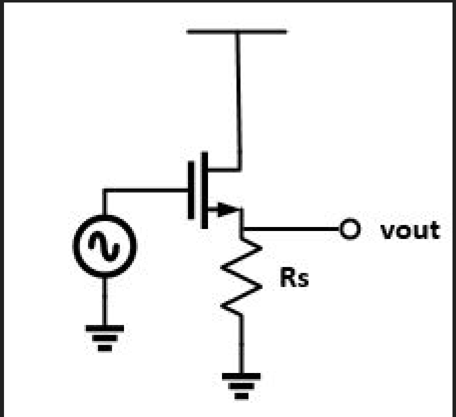
$R_{OUT} = R_S \parallel (r_{ds} \parallel 1/g_m)$

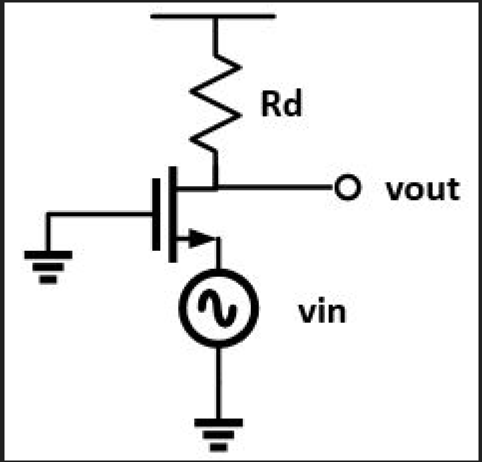
$G_m = - g_m$

$R_{OUT} = R_D \parallel r_{ds}$

$G_m = - g_m$

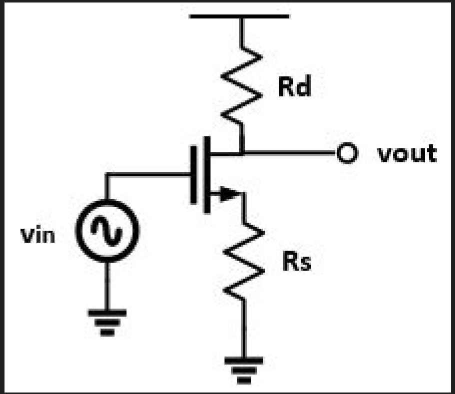






Degeneration

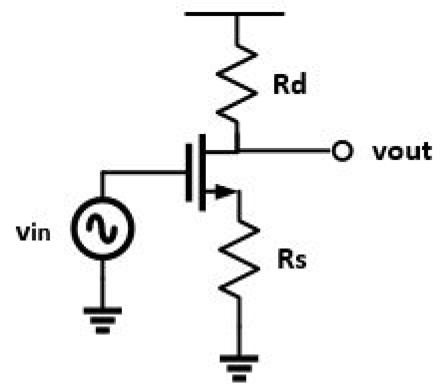
When a resistance is "viewed" through the drain, it appears bigger by a factor related to the transconductance.



$$R_{eq} = r_{ds} + R_S + g_m r_{ds} R_S$$

Degeneration Example

Most common circuit with degeneration is a common source with a source resistance.

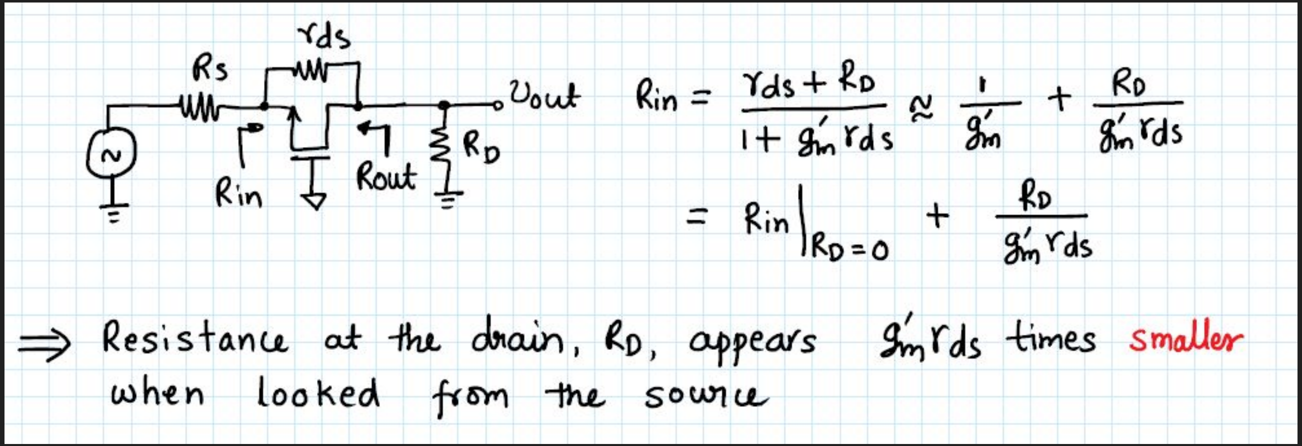


$$R_{OUT} = R_D \,||\, (r_{ds} + R_S + g_m r_{ds} R_S)$$

$$G_m = g_m/(1 + g_m R_s)$$

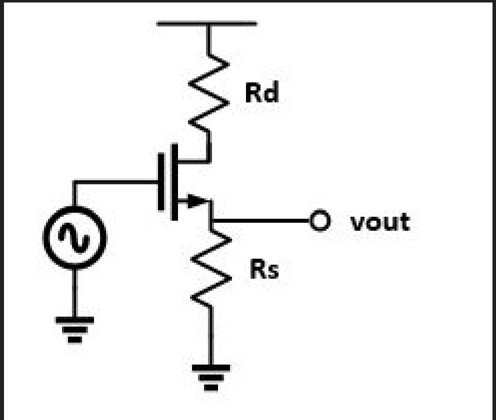
Modulation

Resistances seen through the source seem smaller. Consider Rin from below:



$R_{IN} = R_S + 1/g_m(1 + R_S/r_{ds})$ for $g_m r_{ds} >> 1$

Modulation Example



Cascode