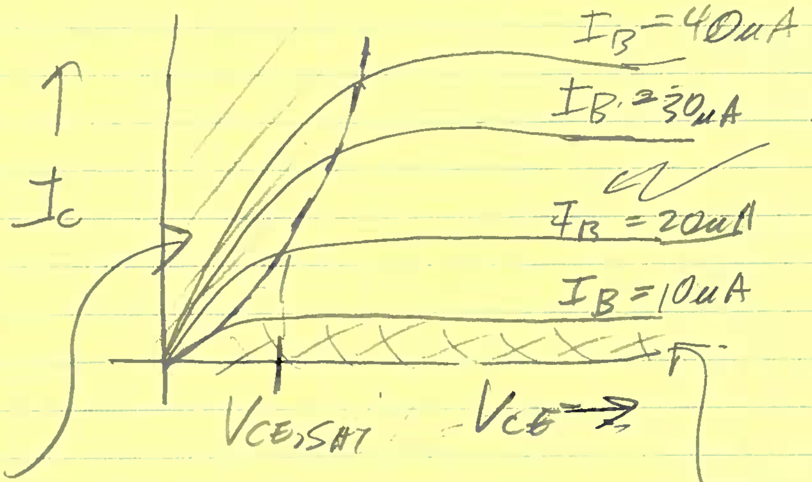
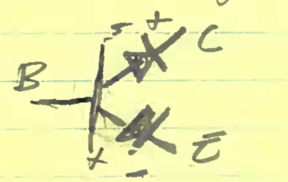
① 4 June 2013

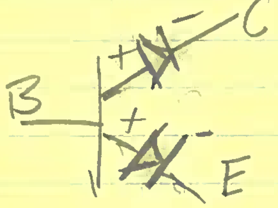
Back to Transistors!



Active Region

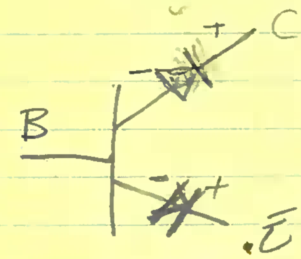


Saturation Region
(ON)

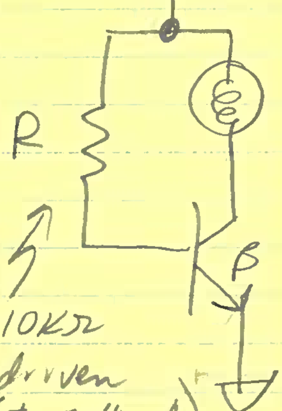


Both Forward biased
High Conduction
Note: $I_C \neq \beta I_B$

Cut off Region
(OFF)



Both Reverse biased
No conduction



$R = 10k\Omega$
overdriven
I_B ($I_B \sim 4mA$)

$$\frac{V_{CC} - V_{BE}}{R} = I_B$$

$$\frac{V_{CC} - V_{CE}}{R_L} \doteq I_C$$

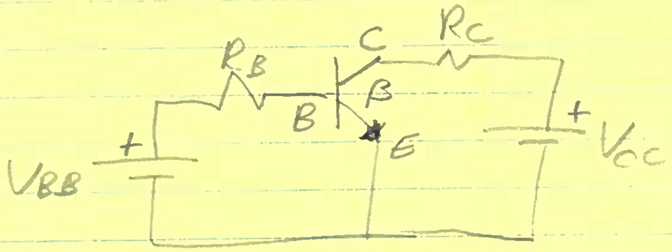
is $I_C > \beta I_B$?

small (from tables)

$$\underbrace{\frac{V_{CC} - V_{CE}}{R_L}}_{\sim 120mA} > \beta \underbrace{\frac{V_{CC} - V_{BE}}{R}}_{\sim 4mA}$$

(2)

Example of a common emitter ckt.



$V_{CC} = +10V$
$R_C = 1k\Omega$
$R_B = 10k\Omega$
$\beta = 100$

$$-V_{BB} + I_B R_B + V_{BE} = 0$$

(1) $I_B = \dfrac{V_{BB} - V_{BE}}{R_B}$; $V_{BE} \simeq 0.7V$

$$-V_{CC} + I_C R_C + V_{CE} = 0$$

(2) $V_{CE} = V_{CC} - I_C R_C$ or $I_C = \dfrac{V_{CC} - V_{CE}}{R_C}$

Case of $V_{BB} = +1.5V$

$I_B = 80\,\mu A$

$I_C = \beta I_B = 8mA$

$V_{CE} = 2V > V_{CE,SAT}$!

Case of $V_{BB} = 10.7V$

$I_B = 1mA$

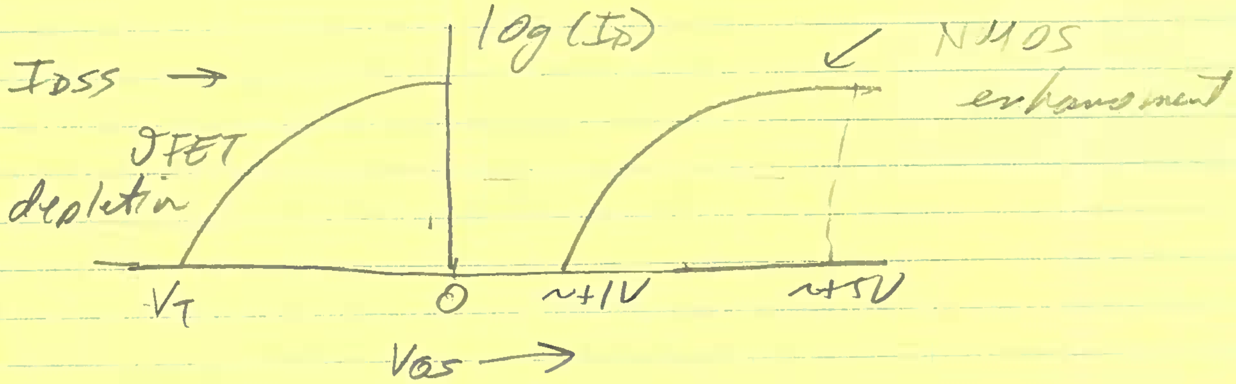
$I_C = 100mA$ }
$V_{CE} = -90V$ } Impossible as $V_{CE} < V_{CE,SAT}$. So linear analysis does not hold.

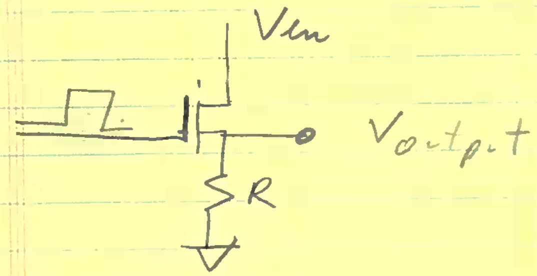
$V_{CE} = V_{CC,SAT} = 0.1V$

$I_C = \dfrac{V_{CC} - V_{CE,SAT}}{R_C} = 9.9mA$ } "β" ≈ 10

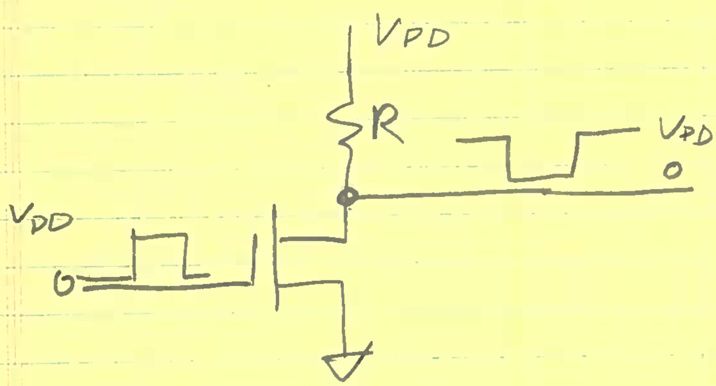
$I_E = I_C + I_B = 10.9mA$ } High current with reduced gain

③

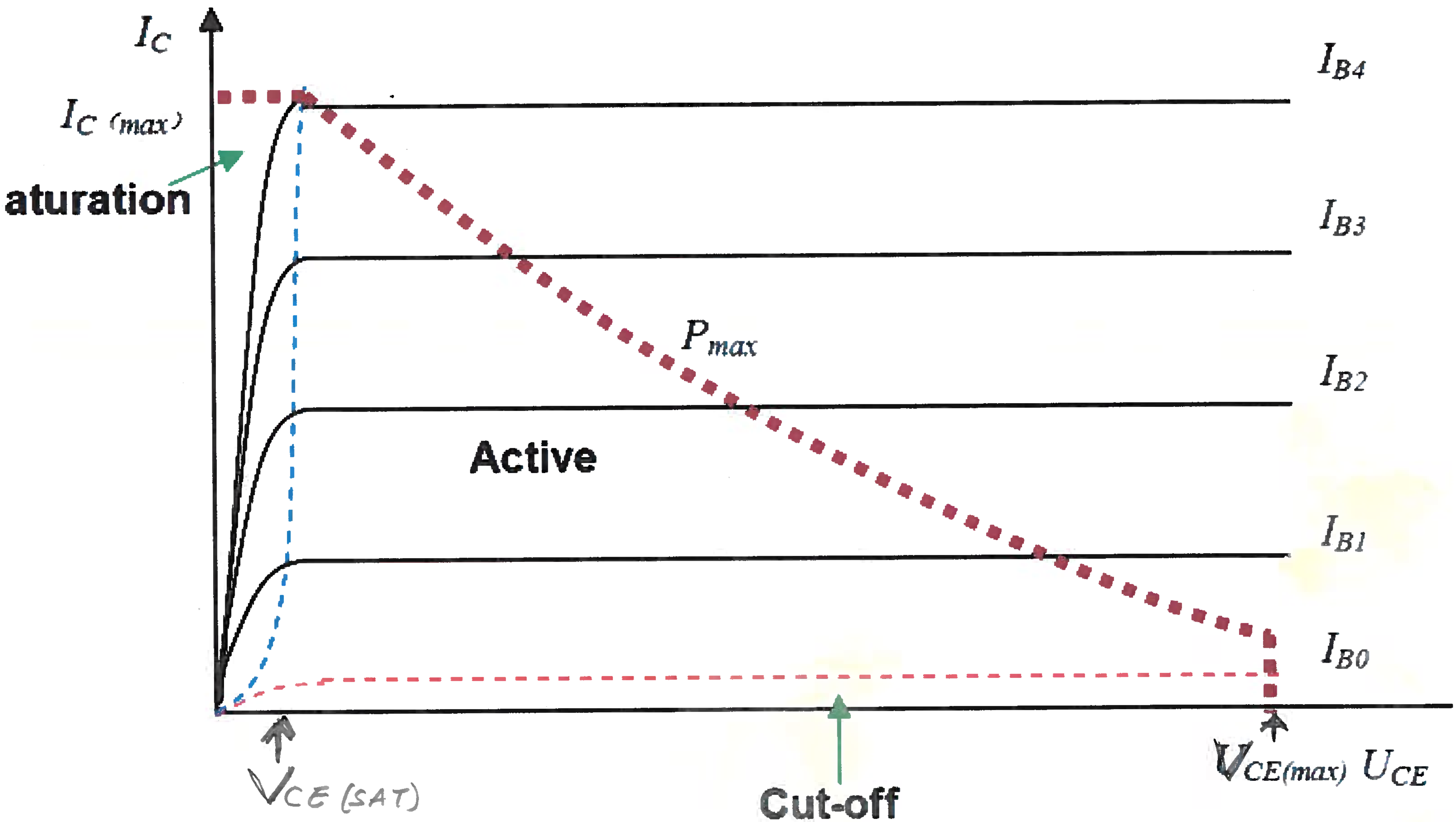




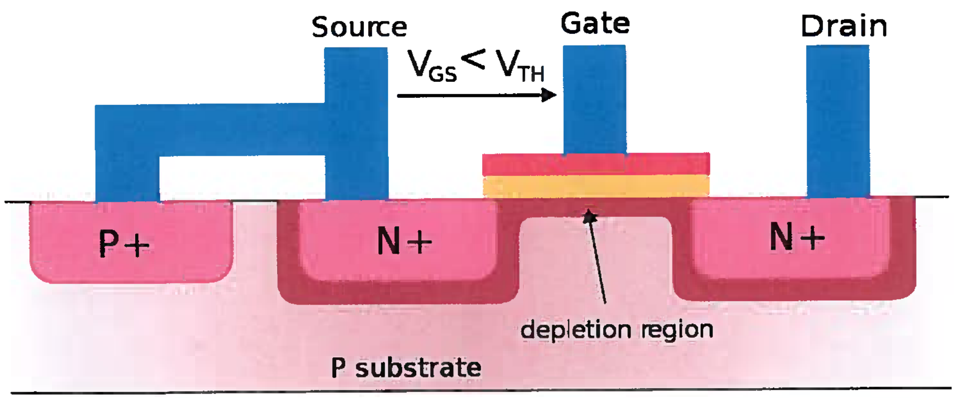
Inversion - Critical for logic

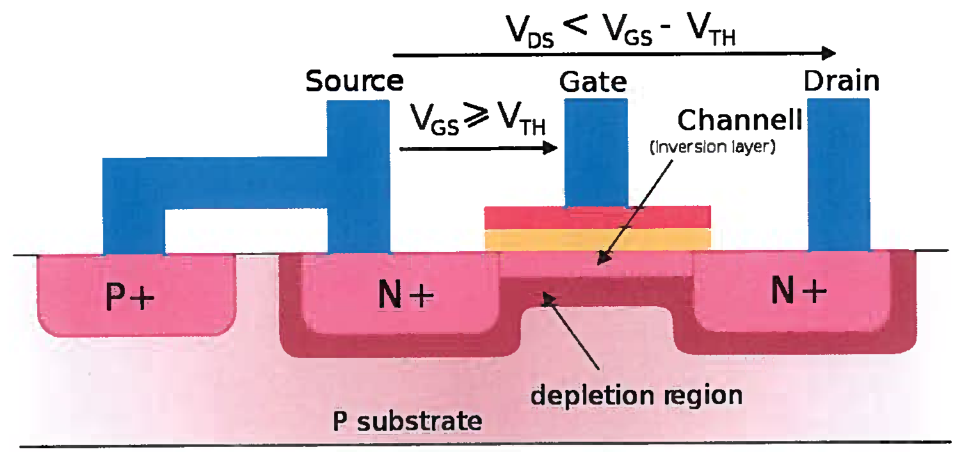


Inverter

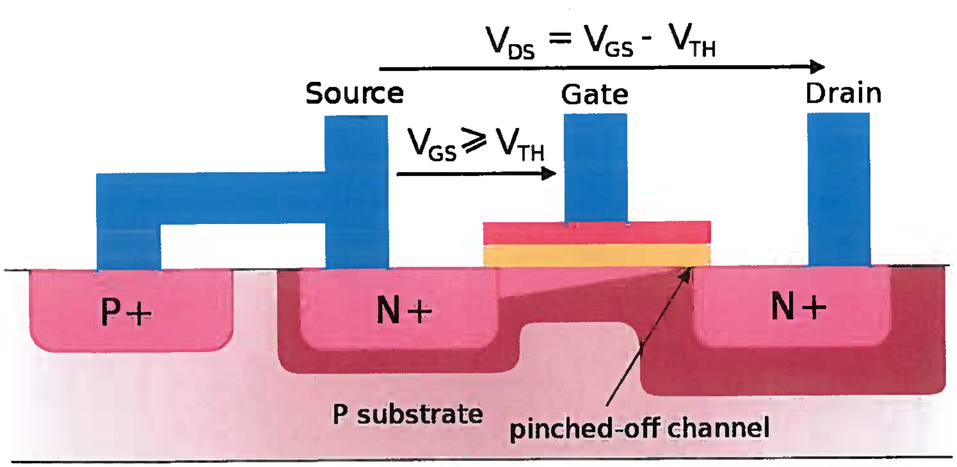


I_C
$I_{C\ (max)}$
aturation
I_{B4}
I_{B3}
P_{max}
I_{B2}
Active
I_{B1}
I_{B0}
$V_{CE\ (SAT)}$
Cut-off
$V_{CE(max)}$ U_{CE}

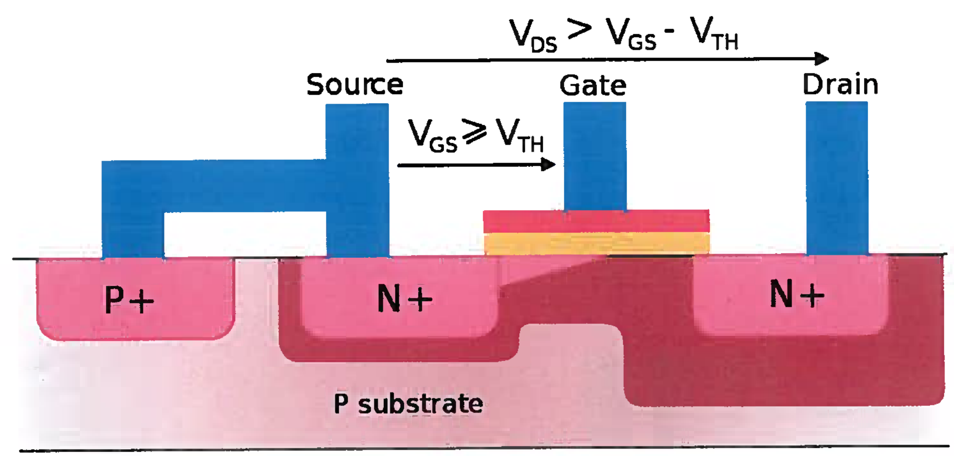




Linear operating region (ohmic mode)



Saturation mode at point of pinch-off



Saturation mode