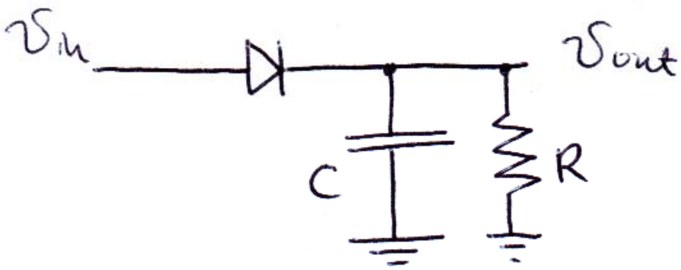
P3360/AEP 3630

Lecture 15

Diode applications (contd.)

Last talked about DC restoration

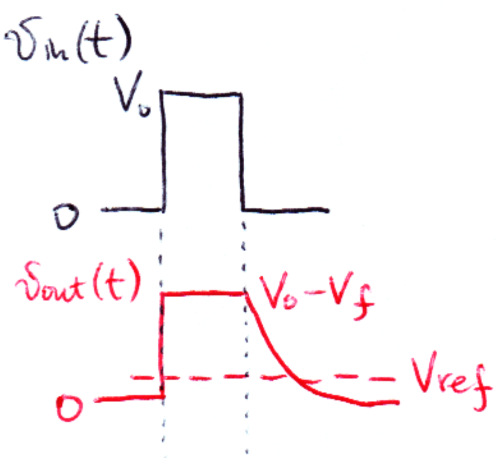
⑦ Pulse stretcher



$v_{in} > v_{out} + V_f$: D is ON

cap is charging up quickly

$v_{out} = v_{in} - V_f$

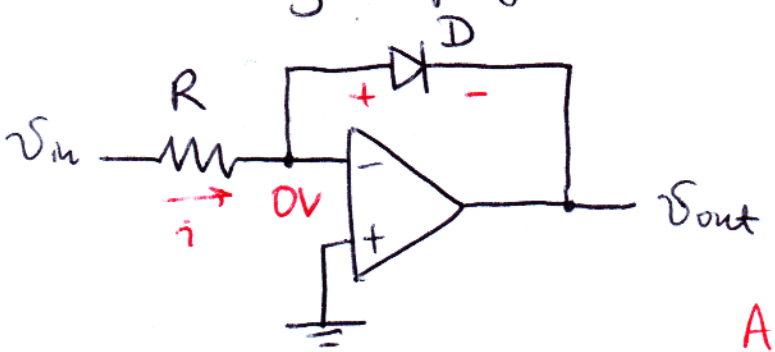


$v_{in} < v_{out} + V_f$: D is OFF

the cap. discharges into R

– e.g. use a comparator to generate a longer square pulse

⑧ Log amplifier



– if diode is a part of feedback network ⇒ "operational configuration"

Approx. model is no good here!

$$i = \frac{v_{in}}{R} \; ; \; v_{out} = -v_D \; ; \; i = I_o e^{\frac{v_D}{V_T^*}} \text{ or}$$

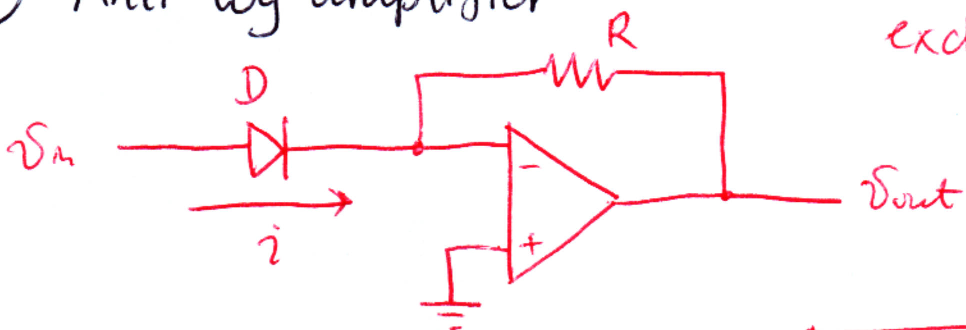
$$v_D = V_T^* \ln \frac{i}{I_o}$$

$$\Rightarrow \boxed{v_{out} = -V_T^* \ln \frac{v_{in}}{R I_o}}$$

- use to transport large dynamic range signal "companding"
- use to multiply (divide), e.g. $\ln A \cdot B = \ln A + \ln B$

⑨ Anti-log amplifier

exchange $R \leftrightarrow D$



$$v_d = v_{in} \; , \; i \simeq I_o e^{\frac{v_{in}}{V_T^*}} \; , \; \boxed{v_{out} = -iR = -I_o R e^{\frac{v_{in}}{V_T^*}}}$$

Diode :

"p-n junction"

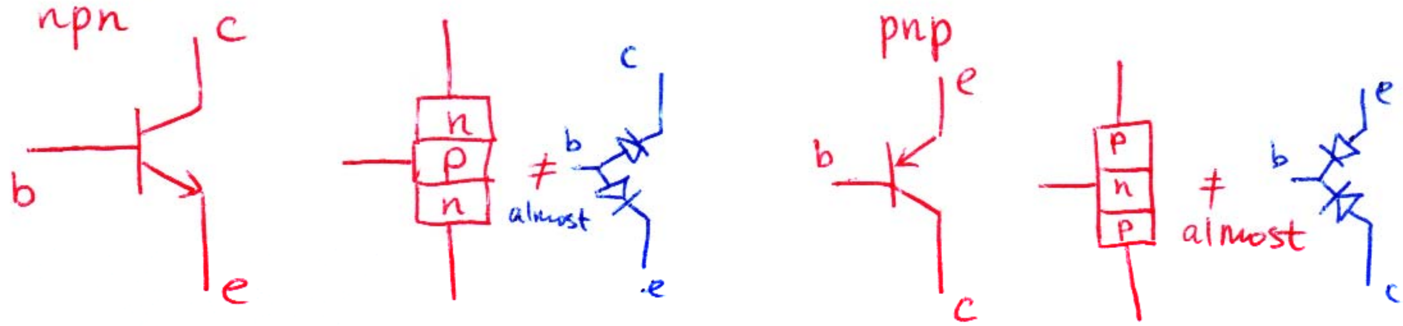
positive carriers, negative carriers } thru dopants added to Si

Transistor :
- 3 terminal nonlinear device
- response between 2 terminals is modified by input supplied to the 3rd.

Bipolar junction transistor (BJT)

back-to-back pn junctions fabricated in a single semiconductor crystal

2 types



2N3904 2N3906

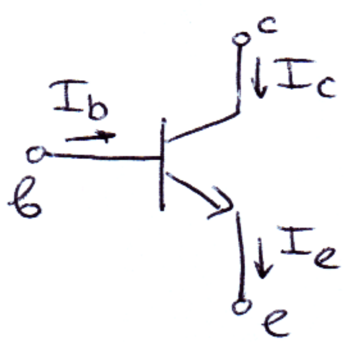
b = base e = emitter c = collector

arrow on emitter: direction of current flow when b-e junction is forward biased

npn ↔ pnp if all voltages and currents reversed

will only discuss npn

npn normal operation $\boxed{V_{ce} \gg V_{be} \gtrsim 0.6V}$



b-e junction is forward biased

$V_b - V_e \gtrsim V_D$ (used to be called $V_f \sim 0.6V$)

b-c junction is reversed biased

$V_b - V_c \lesssim V_D$

KCL : $I_e = I_b + I_c$

For diode "analog" such biasing would result in

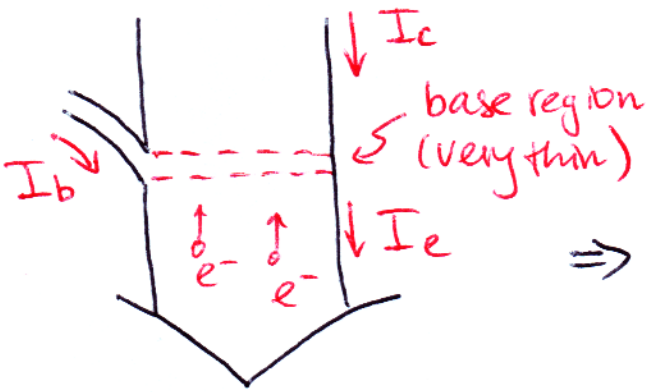
$$I_c \sim 0 \,, \quad I_e \simeq I_b \,, \quad \Rightarrow \frac{I_c}{I_e} \simeq 0$$

But in transistor $\boxed{\frac{I_c}{I_e} \equiv \alpha} \sim 1$ (slightly less than 1)

$$I_e = \frac{I_c}{\alpha} = I_b + I_c \,, \qquad \boxed{\frac{I_c}{I_b} \equiv \beta = \frac{\alpha}{\alpha - 1}} \gg 1$$

$$\frac{I_e}{I_b} = 1 + \beta$$

Typical values: $\alpha \sim 0.99$; $\beta \sim 100$



base region is so thin that e^-'s reaching it are swept into collector without reaching the base

Large I_c is controlled by small I_b

$\Rightarrow$ transistor in normal operation behaves as current controlled current source

N.B. transistor not symmetric with respect to e and c
e.g. circuits with e, c exchanged

different doping to maximize trans. action