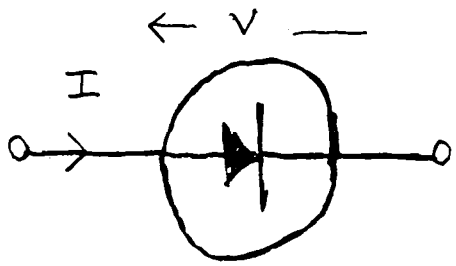
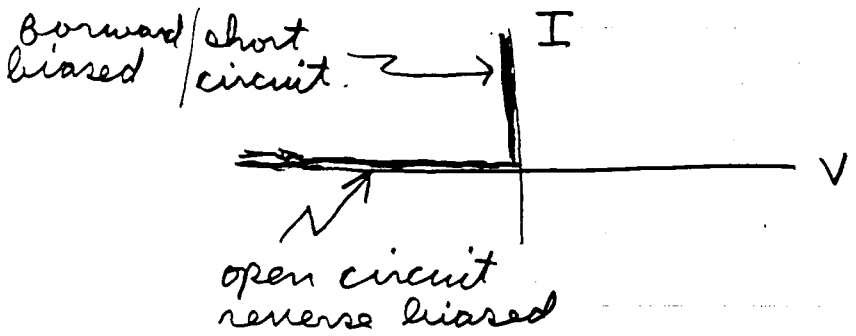
Exp VII — Diodes

Ideal Diode



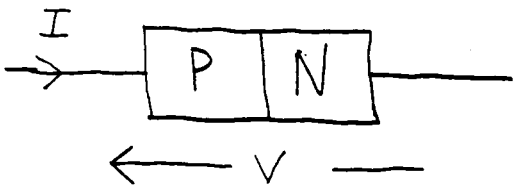
Circuit Symbol

Anode Cathode

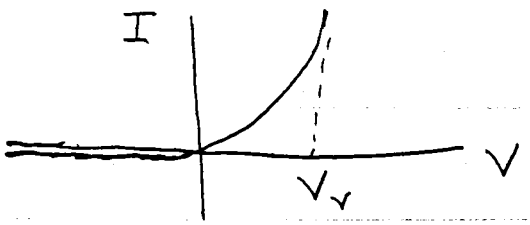


Ideal Diode
I-V Characteristic

Semiconductor Diode — Silicon

① 

pn junction



$V_\gamma \approx 0.6\,V \rightarrow 0.7\,V$

$$I = I_S\left[e^{\frac{V}{nV_T}} - 1\right]$$

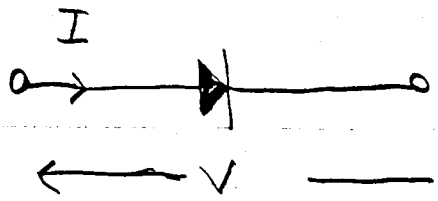
I_S = reverse saturation current $\approx 10^{-15}$ A

n = emission coefficient $\approx 1 \rightarrow 2$

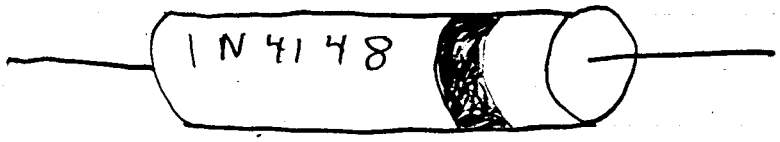
V_T = thermal voltage ≈ 26 mV

V_γ = forward bias voltage

Circuit symbol for semiconductor diode



Physical Package

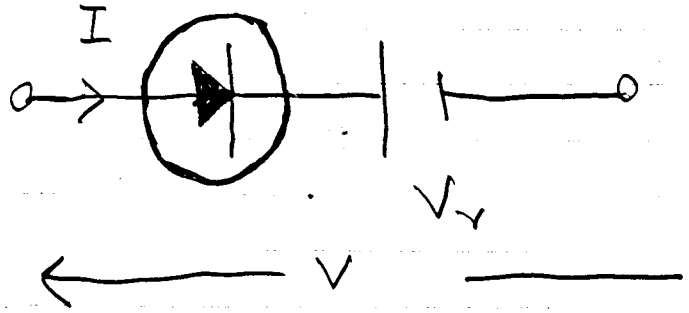


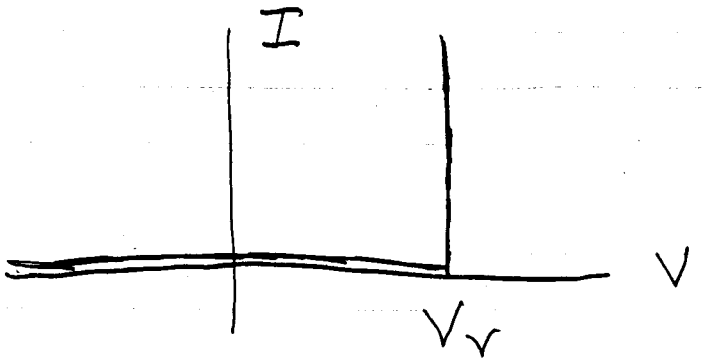
↑ Band on N side

Commonly used model for diodes

① Ideal diode

② Ideal diode and battery





$V_\gamma \simeq 0.7V$

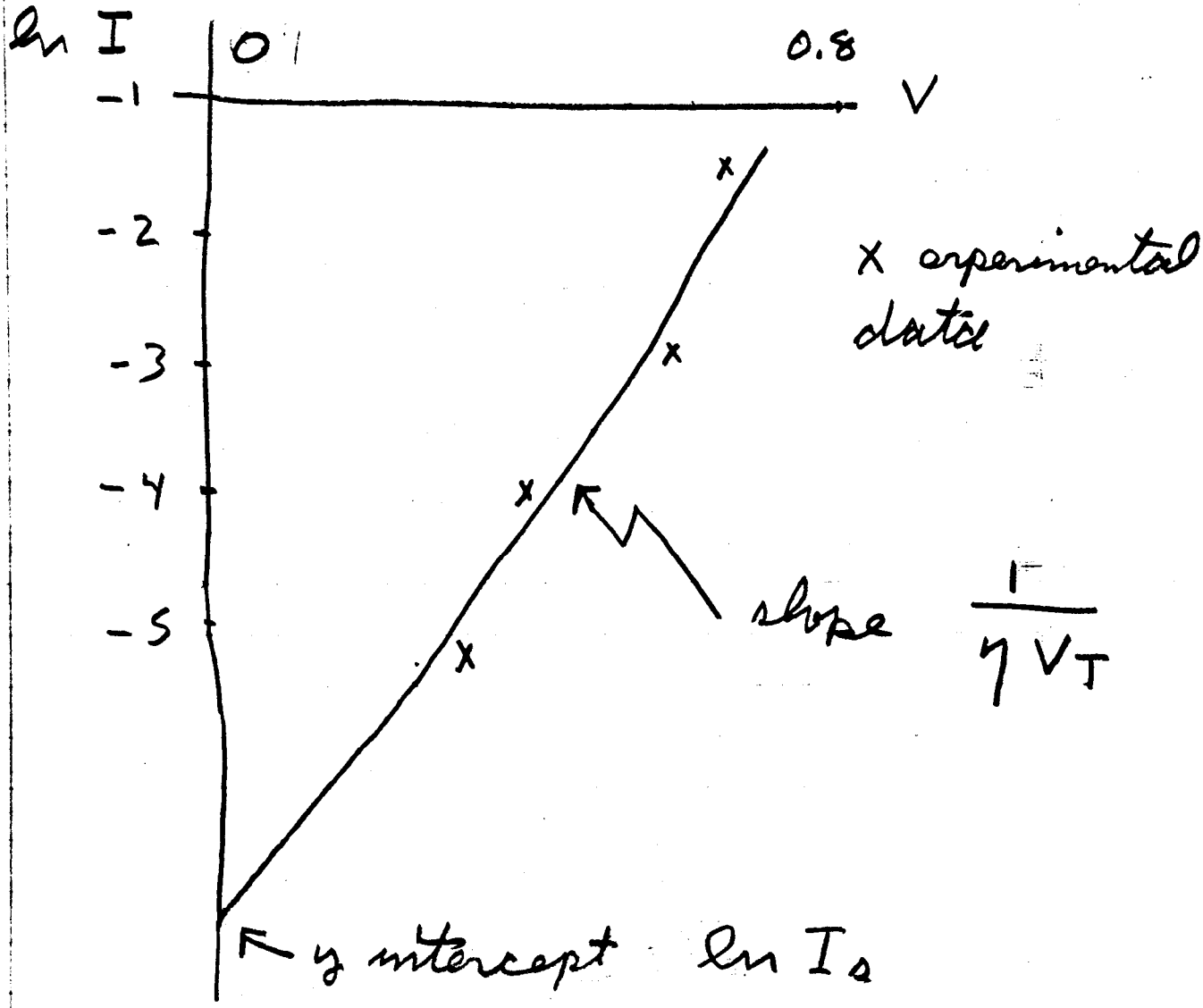
The Diode Equation

$$I = I_s \left[e^{\frac{V}{\eta V_T}} - 1 \right]$$

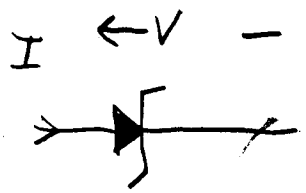
If $V >> V_T$, $V_T = 26\,mV$

$$I \simeq I_s e^{\frac{V}{\eta V_T}}$$

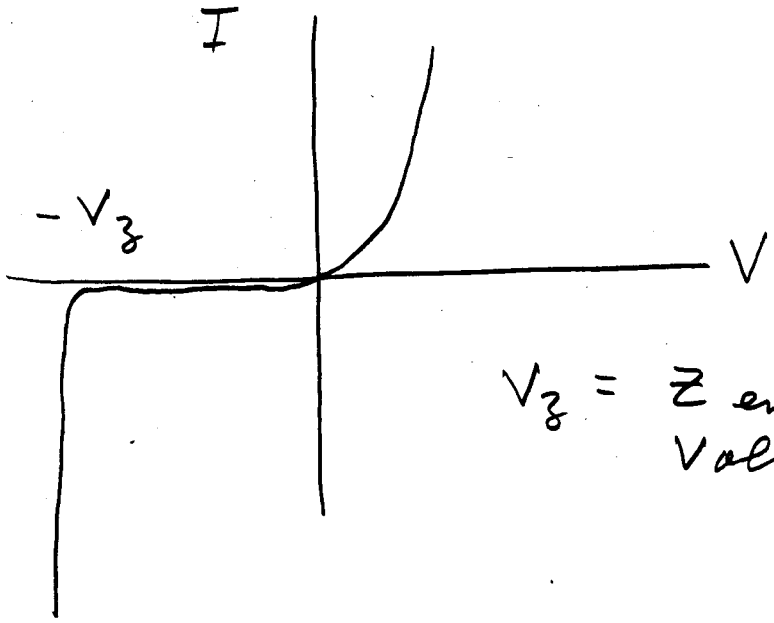
$$\ln I = \ln I_s + \frac{V}{\eta V_T}$$



Zener Diodes

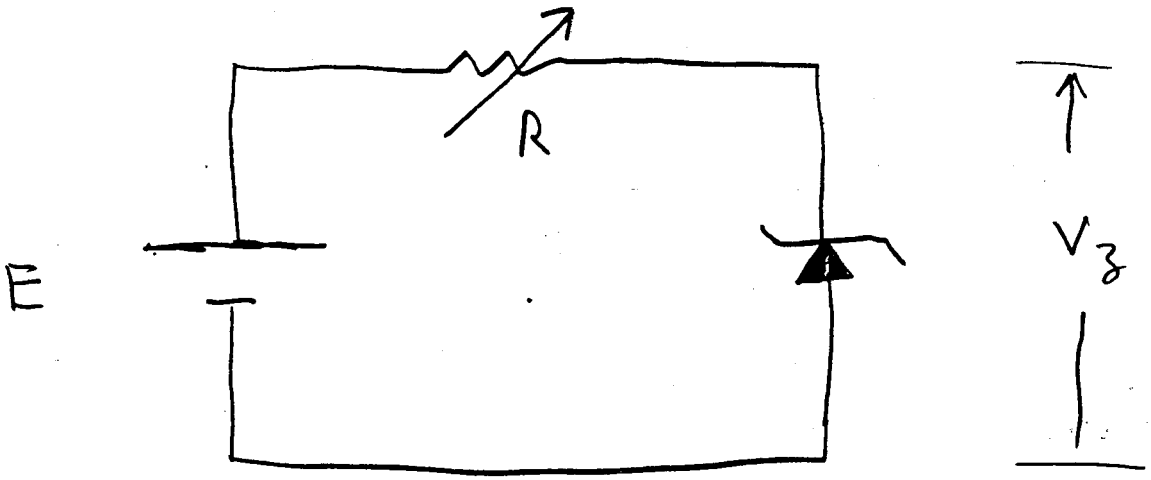


Designed to breakdown at $V = -V_Z$



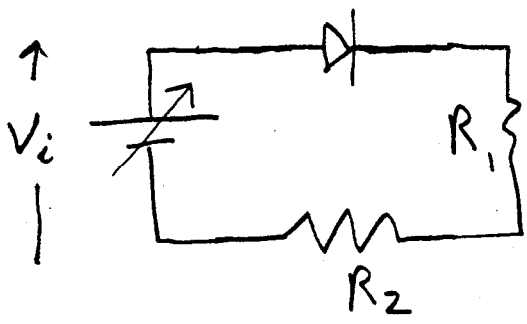
V_Z = Zener breakdown Voltage

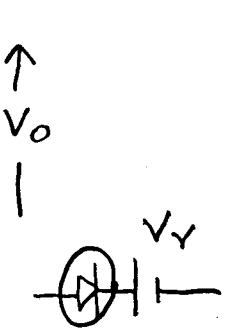
Zener diodes are usually used in their reverse biased breakdown mode

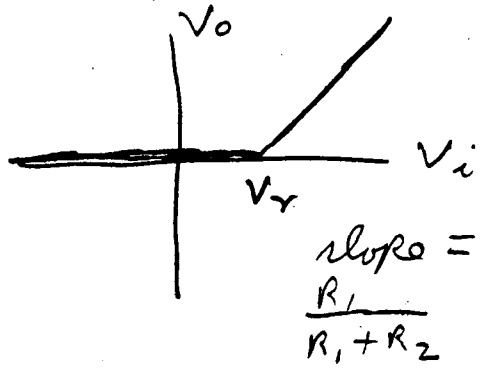


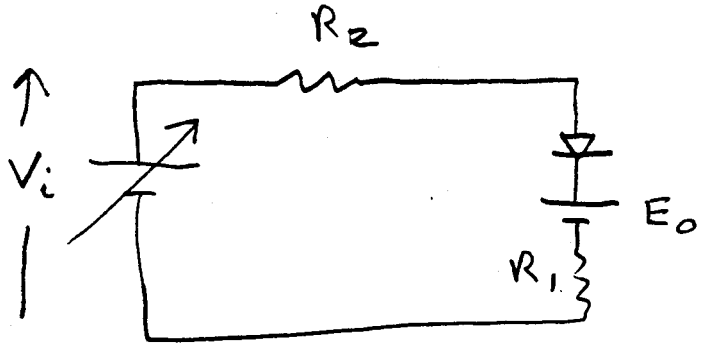
Voltage Reference

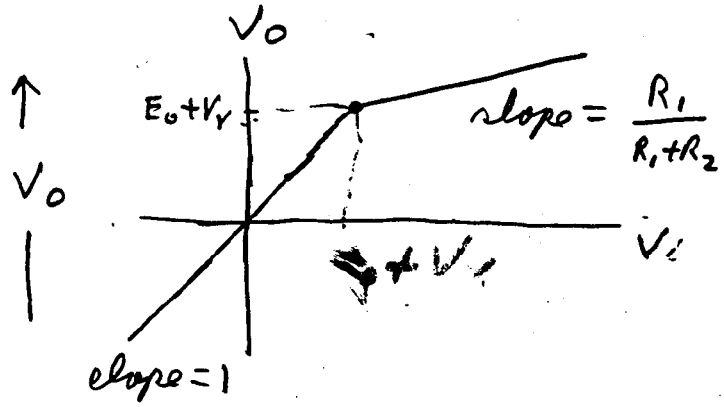
DC Transfer Function of Nonlinear Diode Circuits

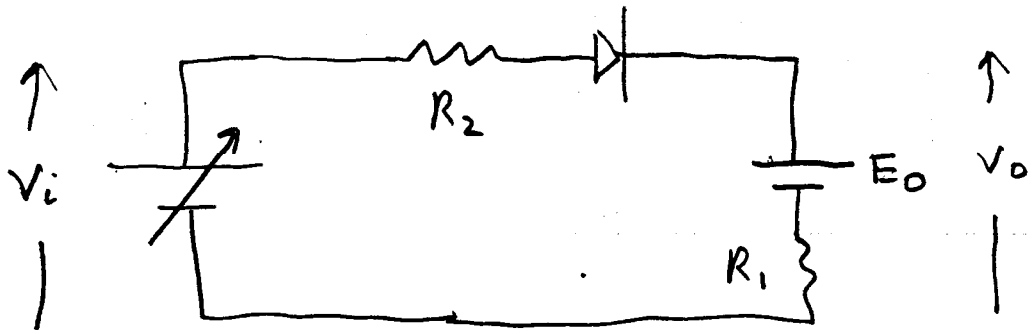


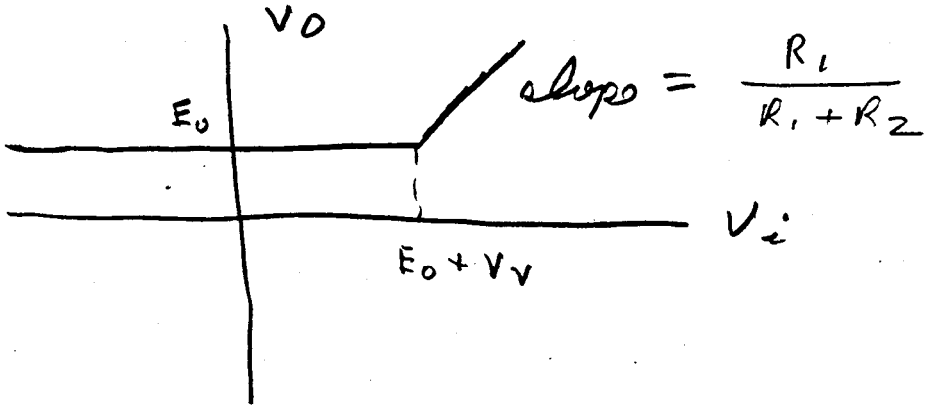




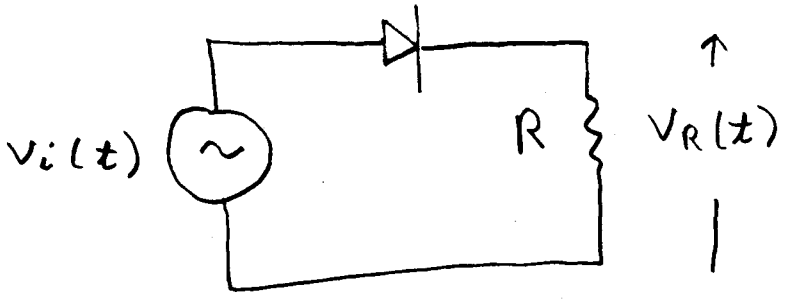


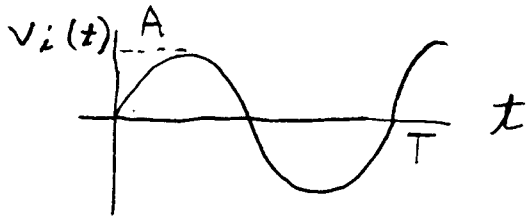


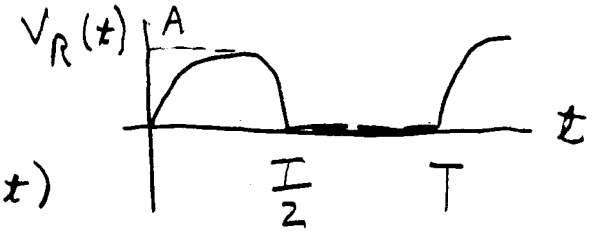




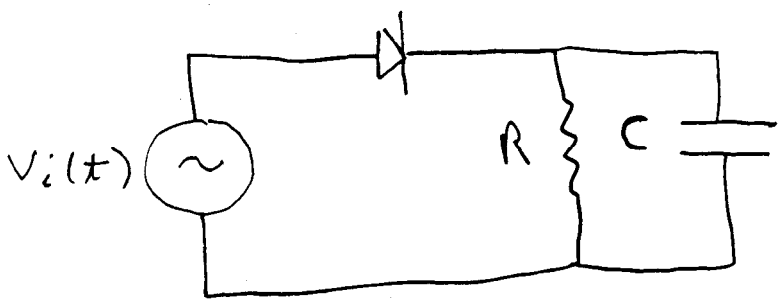
Half Wave Rectifier



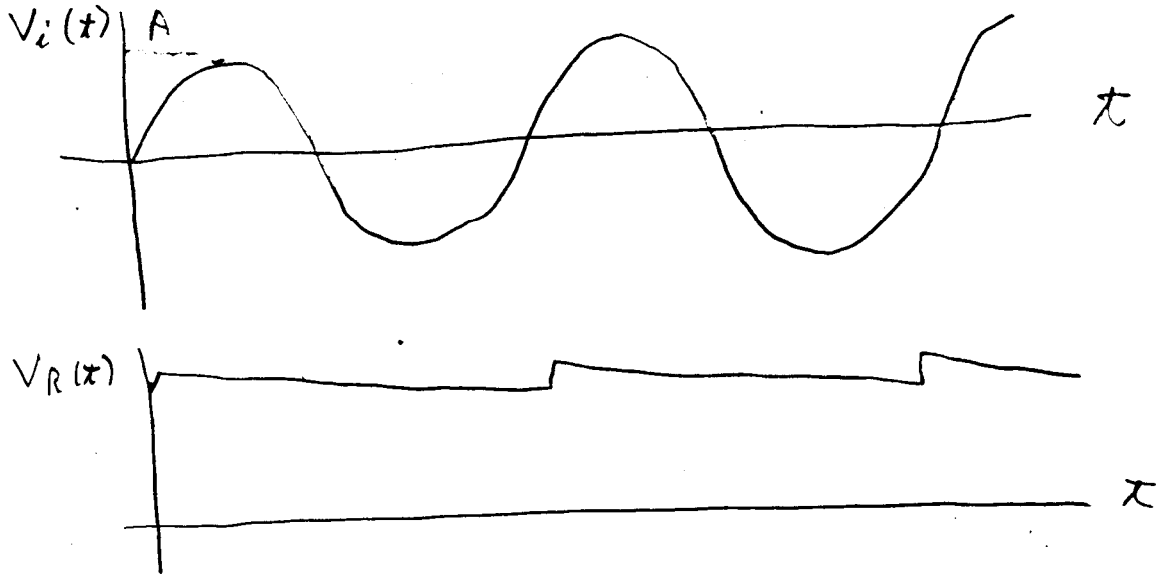




$E_{DC} = \frac{A}{\pi} \equiv$ DC level of $V_R(t)$



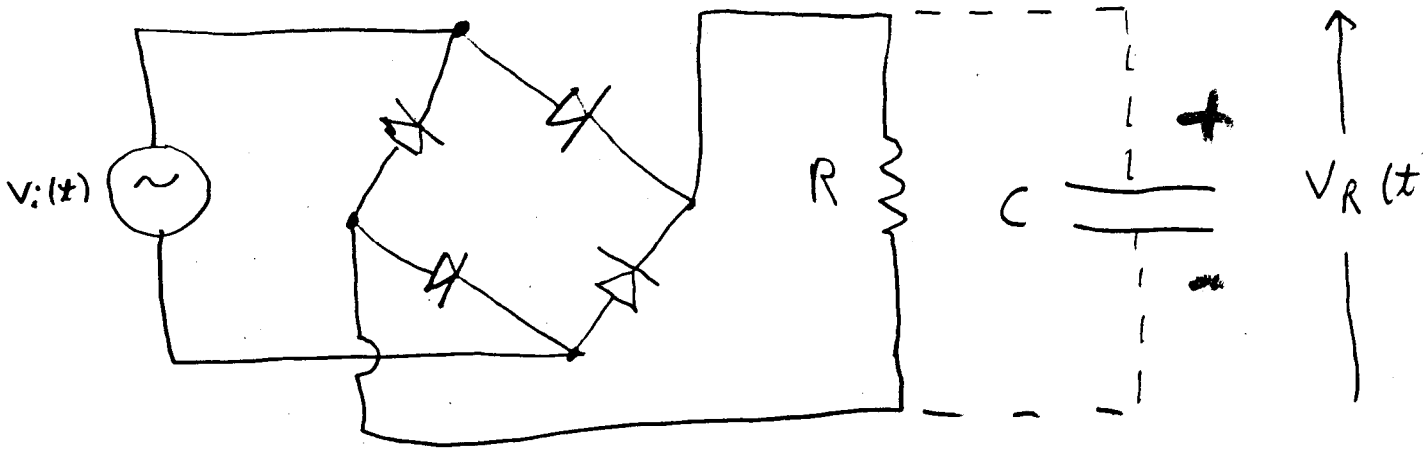
$R_C >> T$

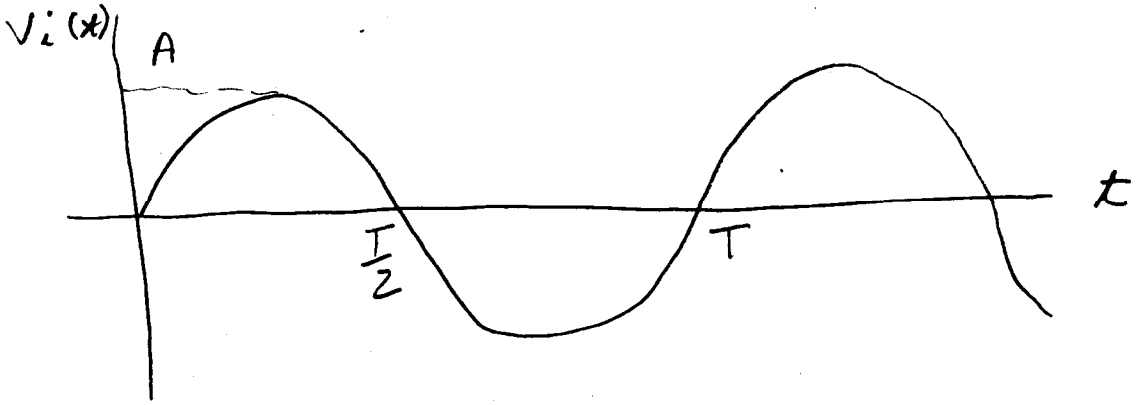


$E_{DC} \approx A$

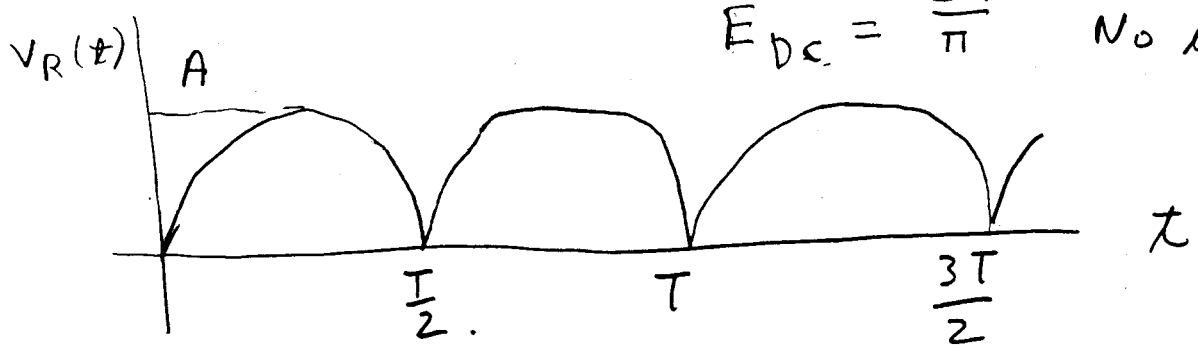
$V_R(t) =$ DC + ripple

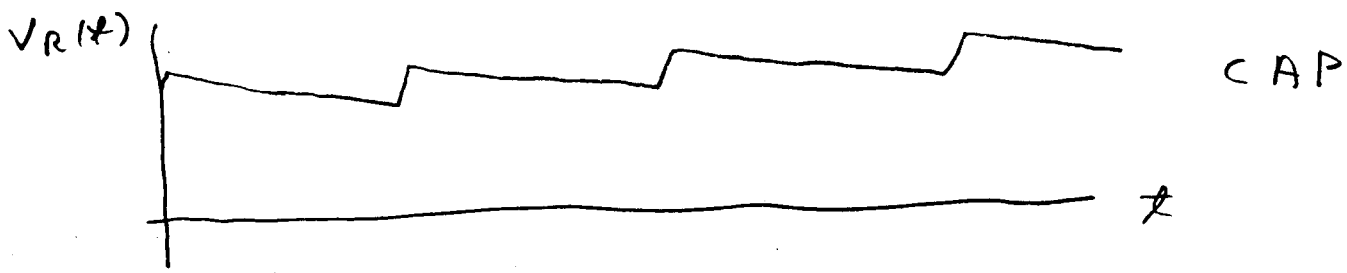
Full Wave Rectifier





$E_{DC} = \frac{2A}{\pi}$ No cap

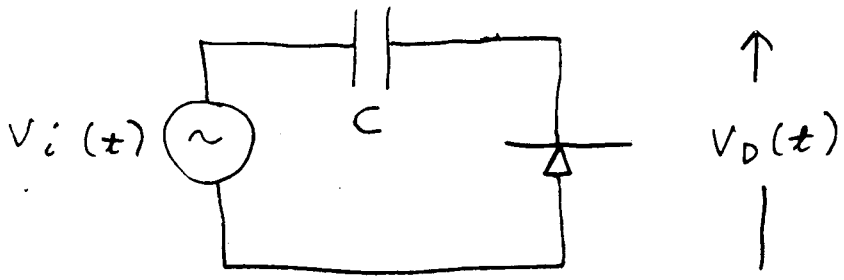


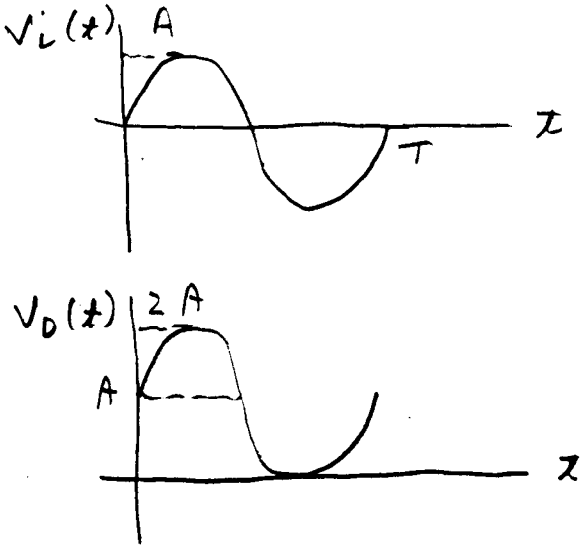


$E_{DC} \simeq A$

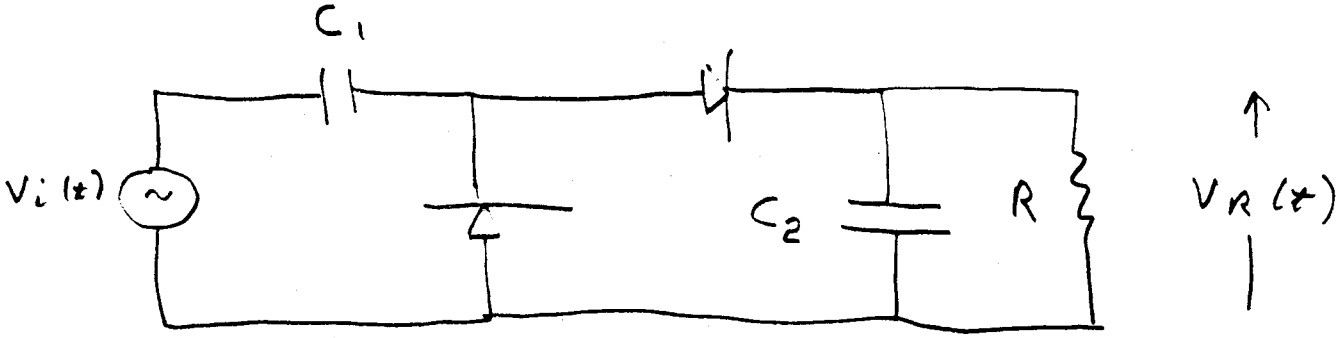
$V_R(t) = DC + ripple$

Clamper

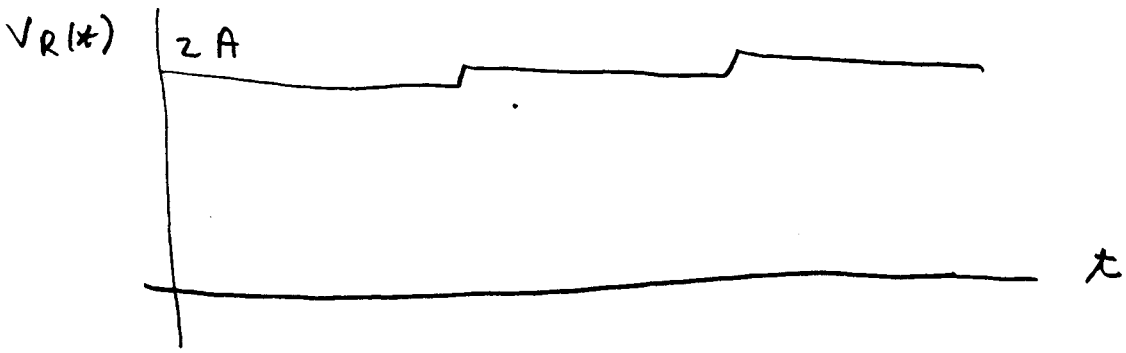




Voltage Doubler

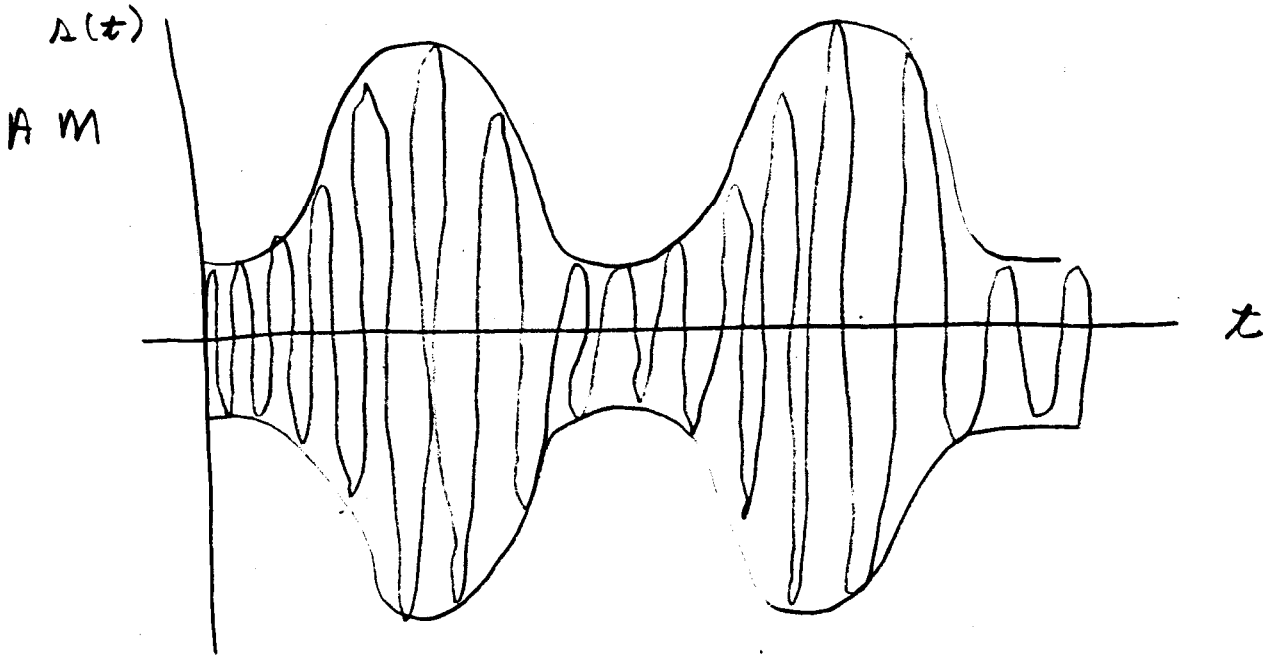


$RC_2 >> T$



$V_R(t) \simeq 2A$

Envelope Demodulator

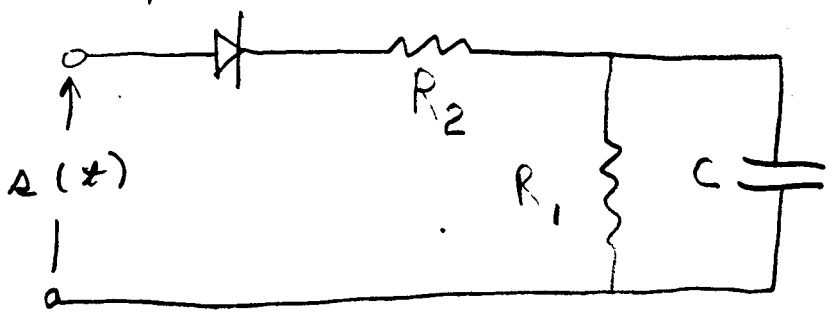


$$s(t) = A\left[1 + m\cos\omega_m t\right]\cos\omega_c t$$

modulation

carrier $\omega_c >> \omega_m$

Envelope Demodulator



$$\hat{m}(t) = DC + A_0\cos\omega_m t$$