ECE3204 Lecture 10

Lab 2 Circuits
- Integrator
- Follower
- Push-pull

Other Op-Amp Circuits
- Summation
- Subtraction

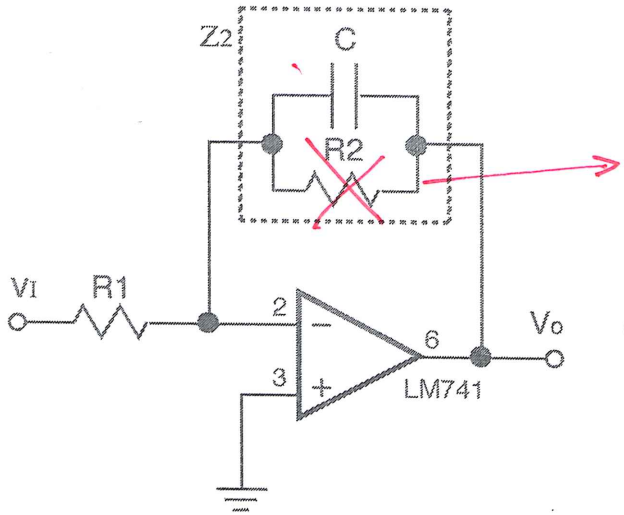


Figure 2.5

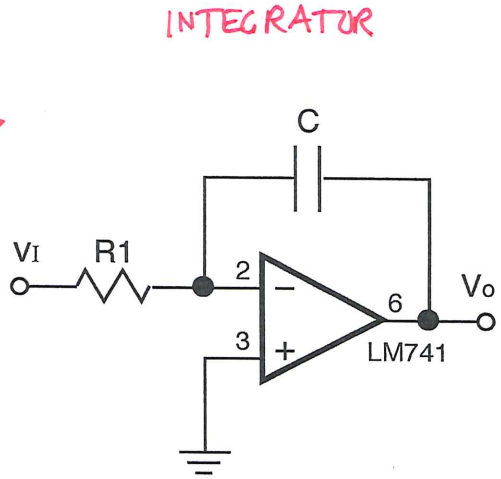
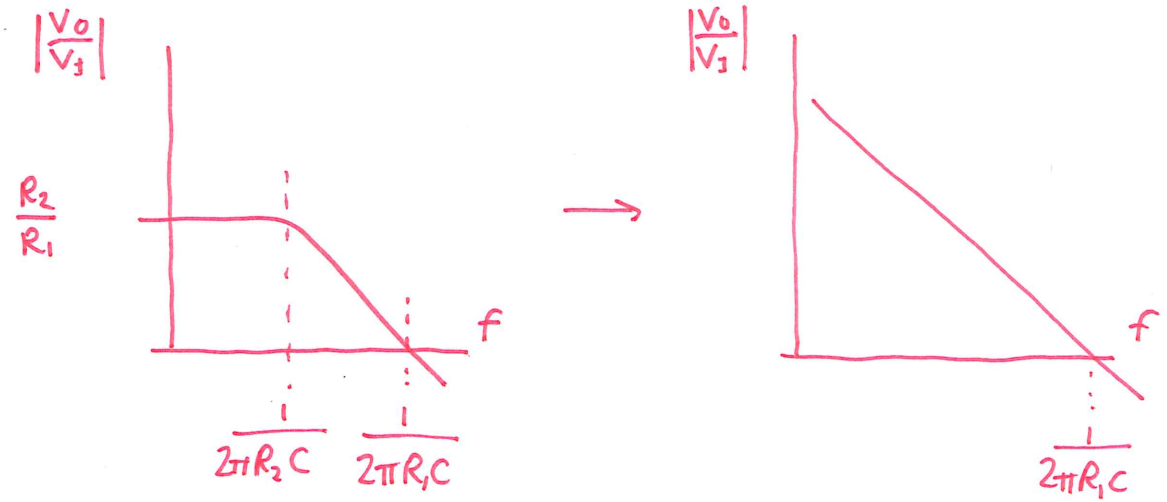
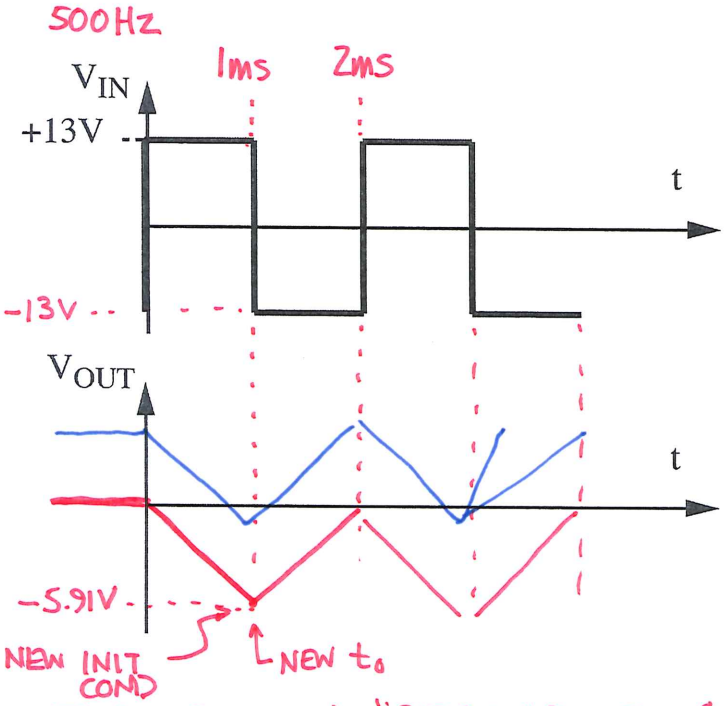


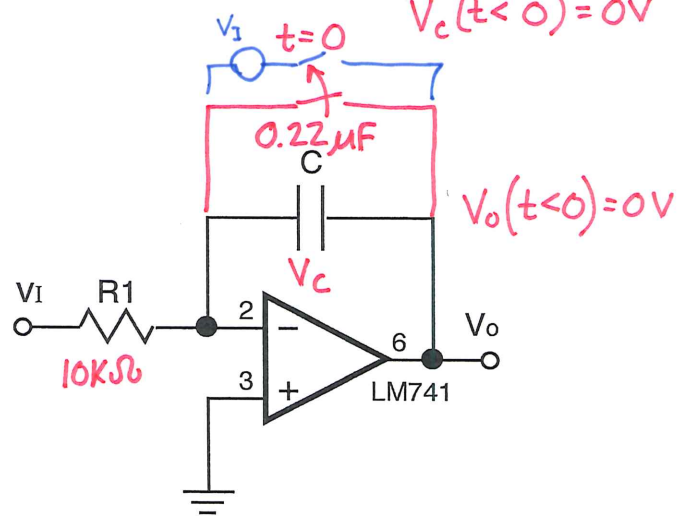
Figure 2.6



Integrator Application: Square Wave - Triangle Wave



INITAL CONDITION



$R_1C = (10k\Omega)(0.22\mu F) = 2.2\,msec$

$\tau = R_1C$ SIGNIFICANCE?

TIME DOMAIN: "PIECEWISE TIME" APPROACH

FROM $0 < t < 1msec$: V_I CONSTANT

$$V_o(t) = \frac{-1}{R_1C}\int_{t_o}^{t} V_{IN}(t)\,dt + \underbrace{V_o(t_o)}_{\text{INIT COND}}$$

$$V_o(t) = \frac{-1}{2.2ms}\int_{0}^{t}(+13V)\,dt + 0$$

$$V_o(t) = \left(\frac{-13V}{2.2ms}\right)t$$

AT END $t = 1msec$

$$V_o(1ms) = \frac{(-13V)(1msec)}{2.2msec} = -5.91V$$

FROM $1ms < t < 2msec$: $V_I = -13V$ CONSTANT

$$V_o(t) = \frac{-1}{R_1C}\int_{1msec}^{t}(-13V)\,dt + (-5.91V)$$

$$V_o(t) = \frac{+13V}{2.2msec}(t - 1msec) + (-5.91V)$$

AT END $t = 2msec$

$$\underbrace{\frac{+13V}{2.2msec}(2msec - 1msec)}_{+5.91V} - 5.91V$$

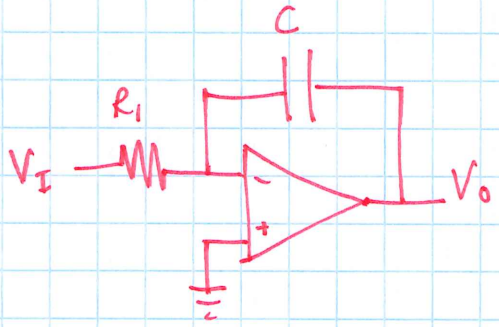
INTEGRATOR

$$V_o = \frac{-1}{\tau}\int V_I(t) + V(t_o)$$

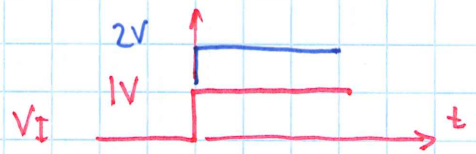
TAKE d/dt OF BOTH SIDES

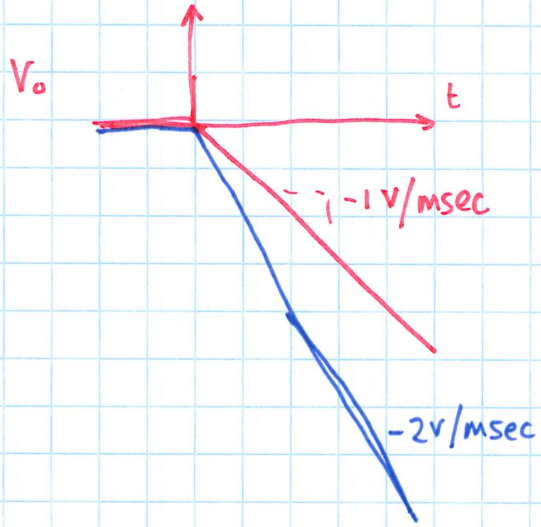
$$\frac{dV_o}{dt} = \frac{-1}{\tau} V_I = \frac{-V_I}{\tau}$$

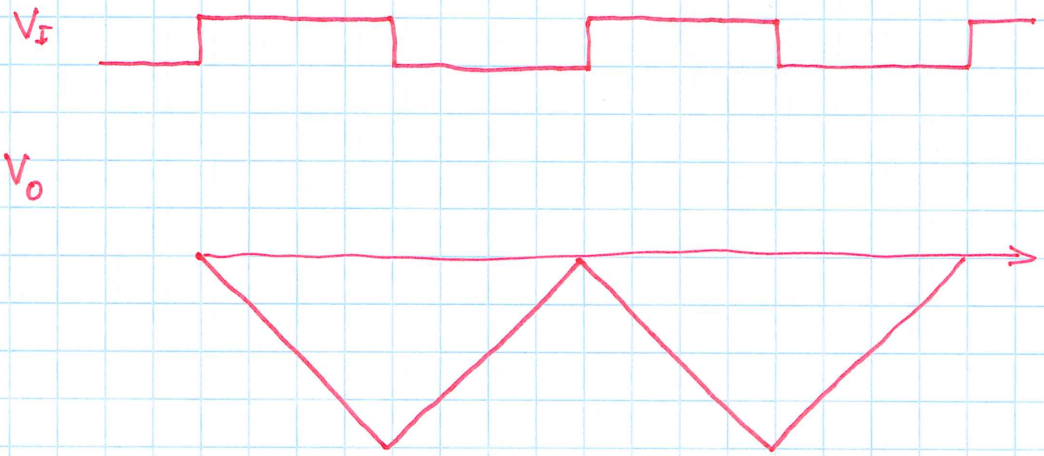
RATE OF CHANGE OF OUTPUT FOR A GIVEN INPUT V_I



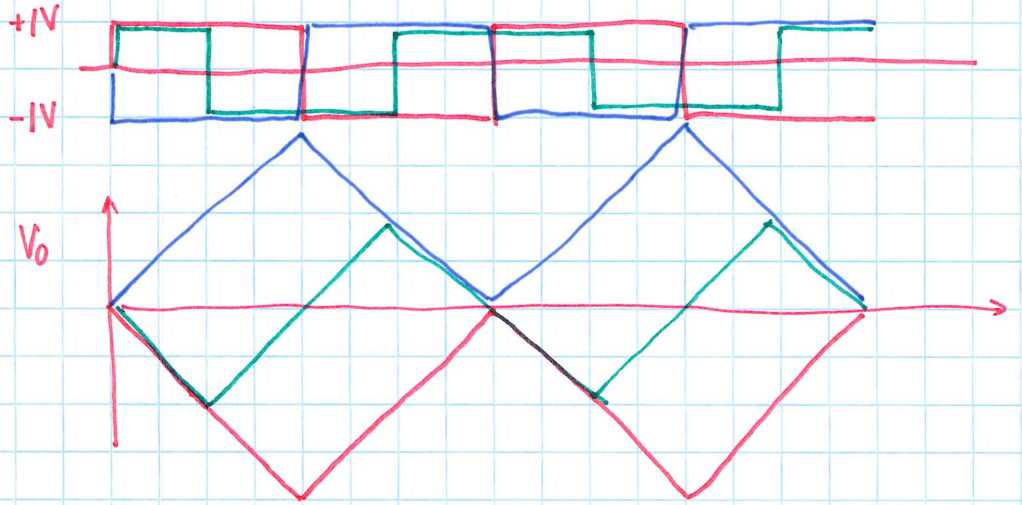
τ = 1msec





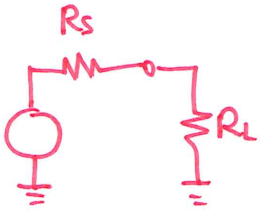


$$\frac{dV_o}{dt} = \frac{-V_{IN}}{1mse}$$



Voltage Follower

V_o FOLLOWS V_s



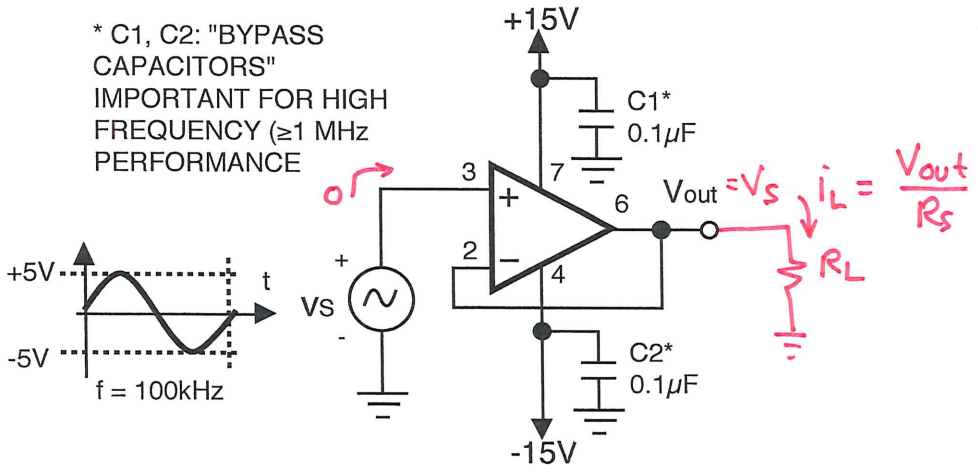
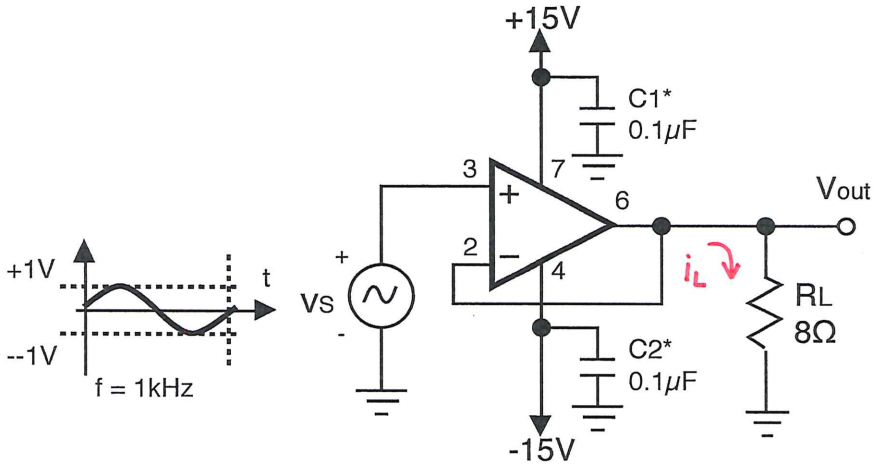


Figure 2.3

Current Limiting



$i_L = \frac{V_o}{R_L} = \frac{1V}{8\Omega} = 125mA$

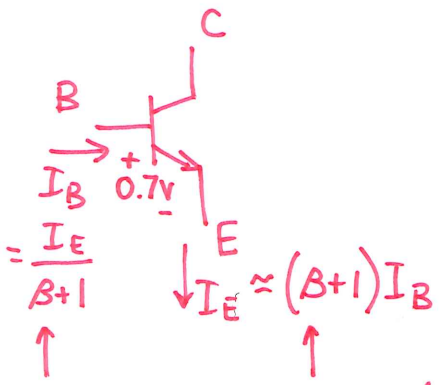
$i_{L(MAX)} \approx 25\,mA$

Fig. 2.4

Push-Pull Amplifier

MICRO I: BJT

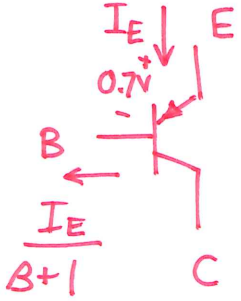
NPN



BJT CURRENT GAIN ~~β~~

100-200 FOR 3904, 3906

PNP



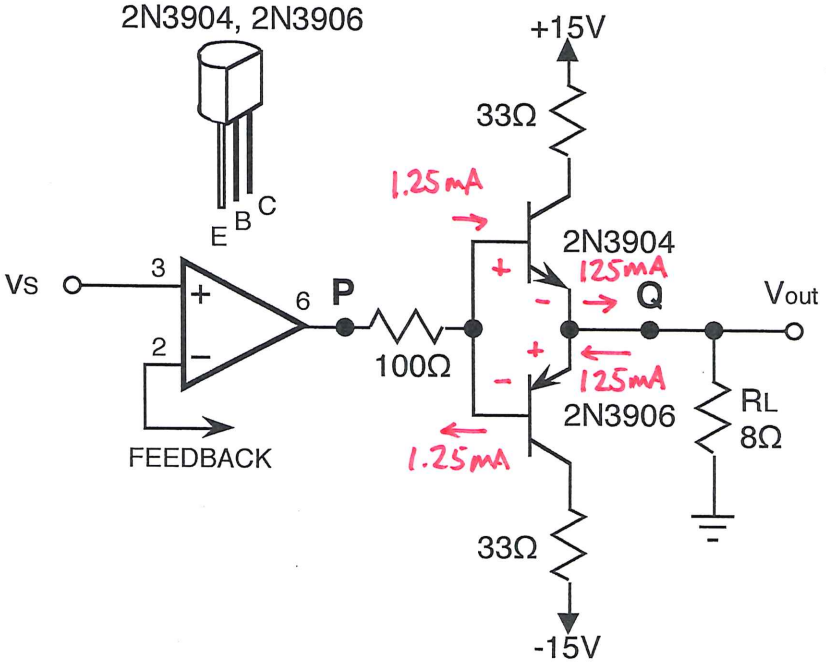
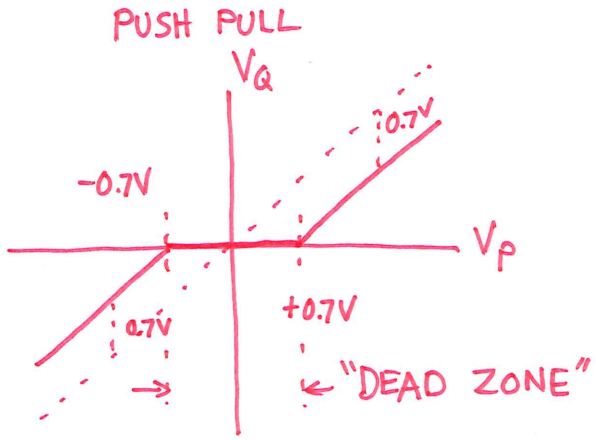
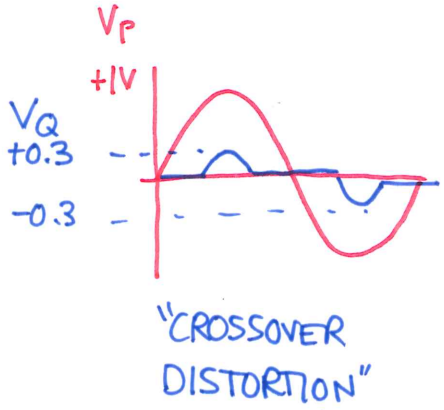
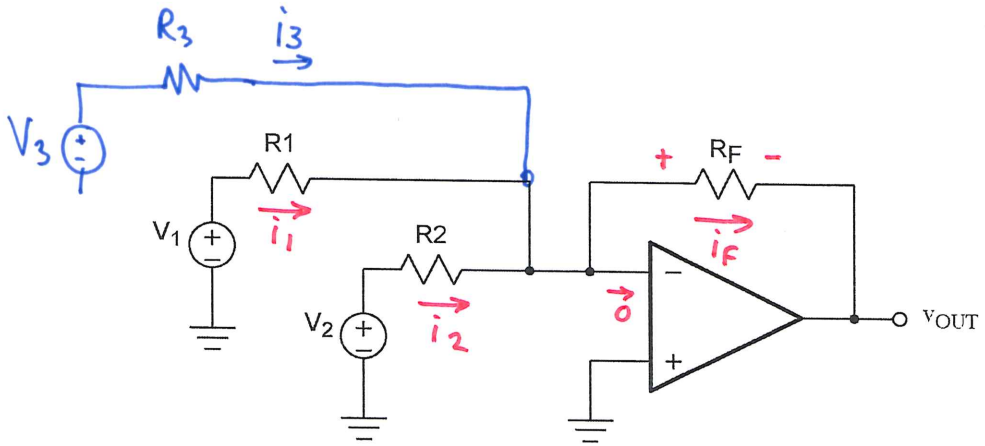


Figure 2.7





Summation



NEGATIVE FB ✓ $\Rightarrow V_- = 0V$

OHM'S LAW

$$i_1 = \frac{V_1}{R_1} \qquad i_2 = \frac{V_2}{R_2}$$

OUTPUT

$$V_o = -i_F R_F$$

KCL AT - INPUT:

$$i_1 + i_2 = i_F$$

} KCL IS DOING THE SUMMATION

$$\frac{V_1}{R_1} + \frac{V_2}{R_2} = \frac{-V_o}{R_F}$$

REARRANGE

$$V_o = -\left[\left(\frac{R_F}{R_1}\right)V_1 + \left(\frac{R_F}{R_2}\right)V_2 + \left(\frac{R_F}{R_3}\right)V_3\right]$$

Subtraction