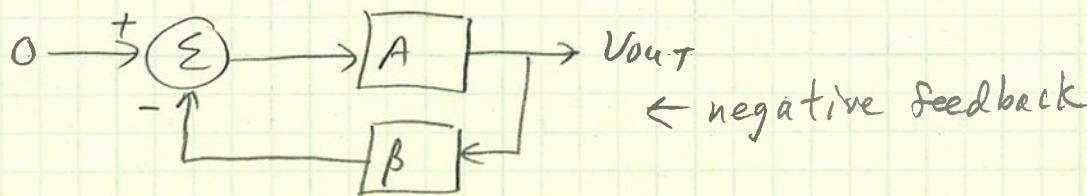


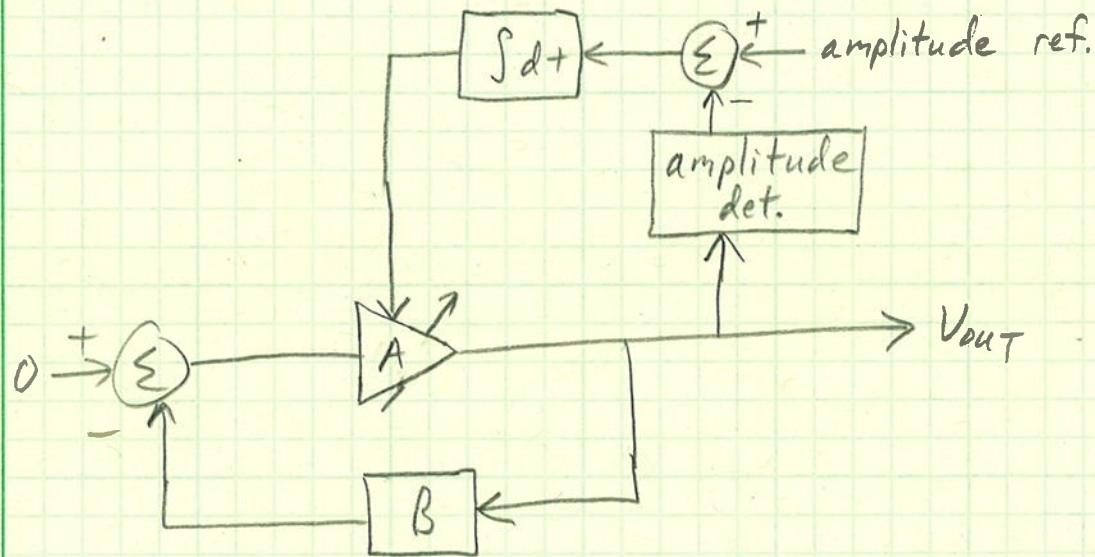
1. Oscillators, continued



$AB = 1 \text{ } [-180^\circ]$ is required to sustain oscillation, but it is not sufficient to achieve oscillation

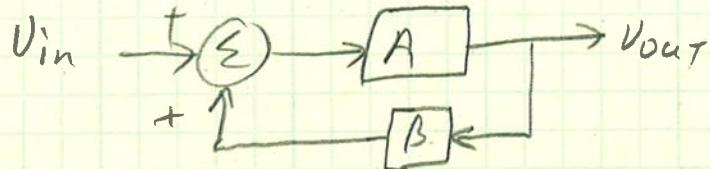
Without oscillation: $|AB| > 1$ with $\angle AB = -180^\circ$ for oscillation to begin, then $|AB|$ should be reduced to 1

→ This is accomplished by an AGC (automatic gain control) function



Often, the AGC function is implemented by some nonlinearity in the oscillator circuit

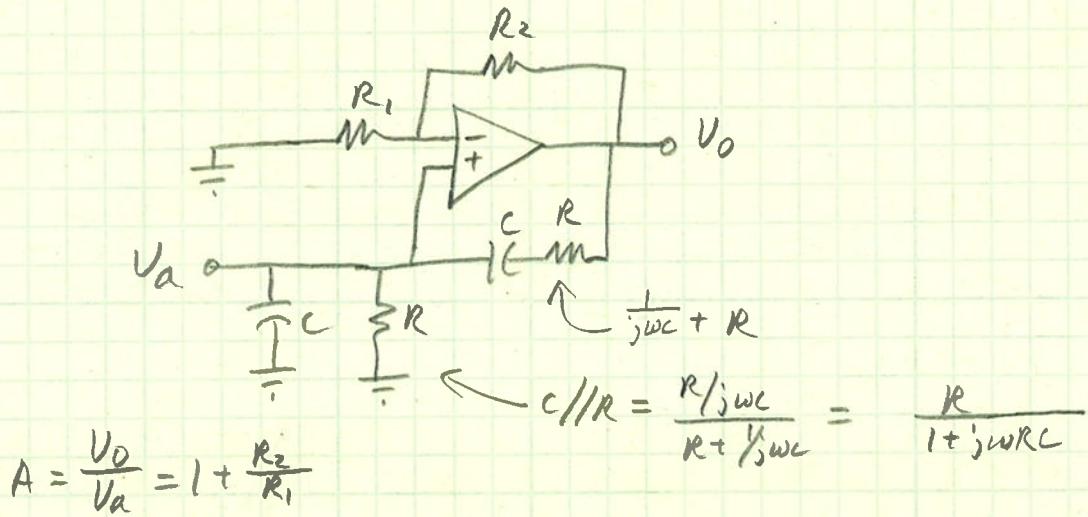
a. Example Oscillator : Wein-bridge Osc w/o AGC
 → Positive Feedback System



$$\frac{V_{out}}{V_{in}} = \frac{A}{1-AB}$$

$$CE: 1-AB=0 \rightarrow AB=1 = 180^\circ$$

Loop gain = $AB = 180^\circ$ for oscillation



$\beta \equiv R-C : R/C$ voltage divider

$$B = \frac{\frac{R}{1+j\omega RC}}{\frac{R}{1+j\omega RC} + R + \frac{1}{j\omega C}} = \frac{R}{R+R+\frac{1}{j\omega C} + \frac{1}{j\omega C} + R}$$

$$= \frac{R}{3R + j(\omega R^2 C - \frac{1}{\omega C})}$$

$$\text{For } AB = 180^\circ \rightarrow j(\omega R^2 C - \frac{1}{\omega C}) = 0$$

$$\therefore \omega R^2 C = \frac{1}{\omega C}$$

$$\omega = \frac{1}{RC} \rightarrow \text{oscillation frequency}$$

$$\text{and } \beta = \frac{1}{3}$$

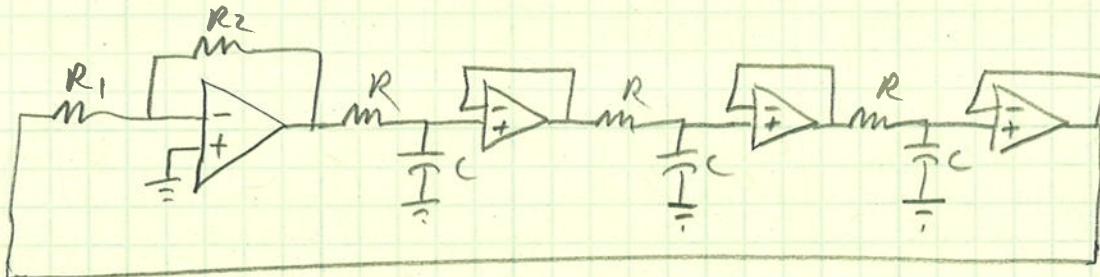
$$AB = \left(1 + \frac{R_2}{R_1}\right) \frac{1}{3} = 1$$

$$1 + \frac{R_2}{R_1} = 3$$

$$\text{or } \frac{R_2}{R_1} = 2$$

\therefore for oscillation at $\omega = \frac{1}{RC}$, $\frac{R_2}{R_1} = 2$

b. Phase Shift Oscillator (w/o AGC)



\rightarrow Negative Feedback Oscillator

$$\text{Loop Gain} = AB \rightarrow \text{need } AB = 1 \angle -180^\circ$$

$$A = \frac{R_2}{R_1} \text{ by definition}$$

$$\beta = \left(\frac{1}{1 + j\omega RC}\right)^3$$

each R-C stage need $\phi = -60^\circ$

$$\therefore -\tan^{-1}\left(\frac{\omega RC}{1}\right) = -60^\circ$$

$$\text{or } \omega RC = \tan(60^\circ) = 1.732$$

$$\therefore \omega = \frac{1.732}{RC}$$

$$|B| = \left(\frac{1}{\sqrt{1^2 + (0.732)^2}}\right)^3 = 0.125$$

$$A = \frac{1}{|B|} = 8$$