Homework Assign. 1 due in class today or by 4pm
(turn homework after 12noon to Marge Boehme, VL E278)
TA office hours - Nola Li <gtg019w@mail.gatech.edu>
Monday 10-11 and Thursday 9-11, Room C448 VL

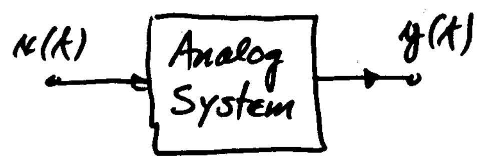
Amplifiers

- Linearity
- Linear amplifier
- decibels
- power flow
- Voltage transfer curve
- Distortion

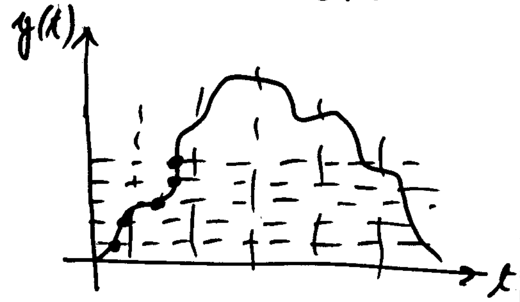
CHAPTER 10 - ANALOG SYSTEMS

(A systems viewpoint of an amplifier)

I) Linearity



Analog is the study of signals which are continuous in amplitude and may or may not be continuous in time.



A system is linear iff

$x_1(t) \to y_1(t)$

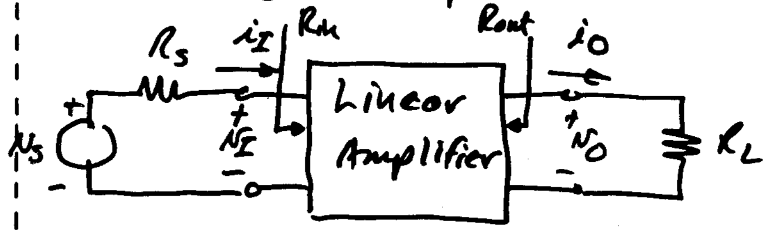
$x_2(t) \to y_2(t)$

and

$x_1(t) + x_2(t) \to y_1(t) + y_2(t)$

for all $x(t)$.

II. Linear Amplifier



1.) Voltage gain

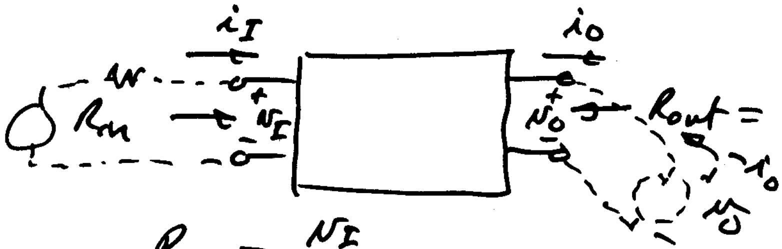
$$A_v = \frac{v_O}{v_I} \quad (R_s = 0) \quad \text{unloaded}$$

$$A_V = A_v \frac{R_{in}}{R_{in} + R_s} \quad \text{(loaded amplifier)} \quad R_{out} \ll R_L$$

2.) Current gain

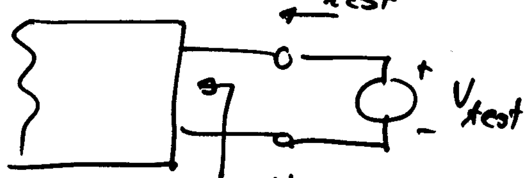
$$A_I = \frac{i_O}{i_I} = \frac{v_O / R_L}{\dfrac{v_S}{R_{in} + R_S}} = \left(\frac{R_{in} + R_S}{R_L}\right) A_V$$

3.) R_{in} and R_{out}



$$R_{out} = -\frac{v_O}{i_O}\bigg|_{v_S = 0}$$

$$R_{in} = \frac{v_I}{i_I}$$



$$R = \frac{V_{test}}{I_{test}}$$

4.) Power gain

$$A_P = A_V A_I$$

III Decibels

Definitions:

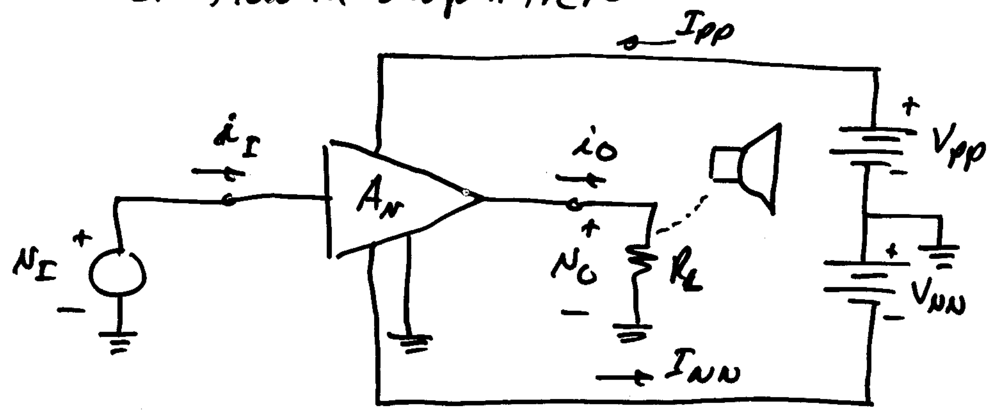
$$A_P(dB) \equiv 10 \log_{10}(A_P)$$
$$A_V(dB) \equiv 20 \log_{10}(A_V)$$
$$A_I(dB) \equiv 20 \log_{10}(A_I)$$

If $R_S = R_L$

Then $A_P = A_V^2 = A_I^2$

~~For~~ A doubling in A_P => 3 dB increase
A " " $A_V (A_I)$ => 6 dB increase
A decade increase in A_P => 10 dB increase
A " " " $A_V (A_I)$ => 20 dB increase

IV. Power flow in amplifiers



What power exists in this circuit?

1.) DC power is the power delivered from the batteries to the amplifier.

$$P_{DC} = V_{PP} I_{PP} + V_{NN} I_{NN}$$

2.) Input power from v_I or the source

$$P_{IN} = v_I i_I \quad \text{(typically small)}$$

3.) Power to the load R_L

$$P_{out} = i_O v_O = \frac{v_O^2}{R_L} = i_O^2 R_L$$

4.) Power loss in the amplifier

$$P_{DISS}$$

Power conservation:

$$P_{DC} + P_{IN} = P_{out} + P_{DISS}$$

Efficiency:

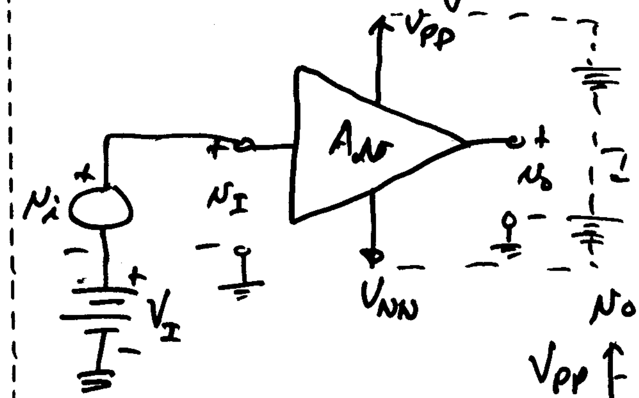
$$\eta = \frac{P_{OUT}}{P_{DC} + P_{in}} \approx \frac{P_{out}}{P_{DC}} \quad (P_{in} \ll P_{DC})$$

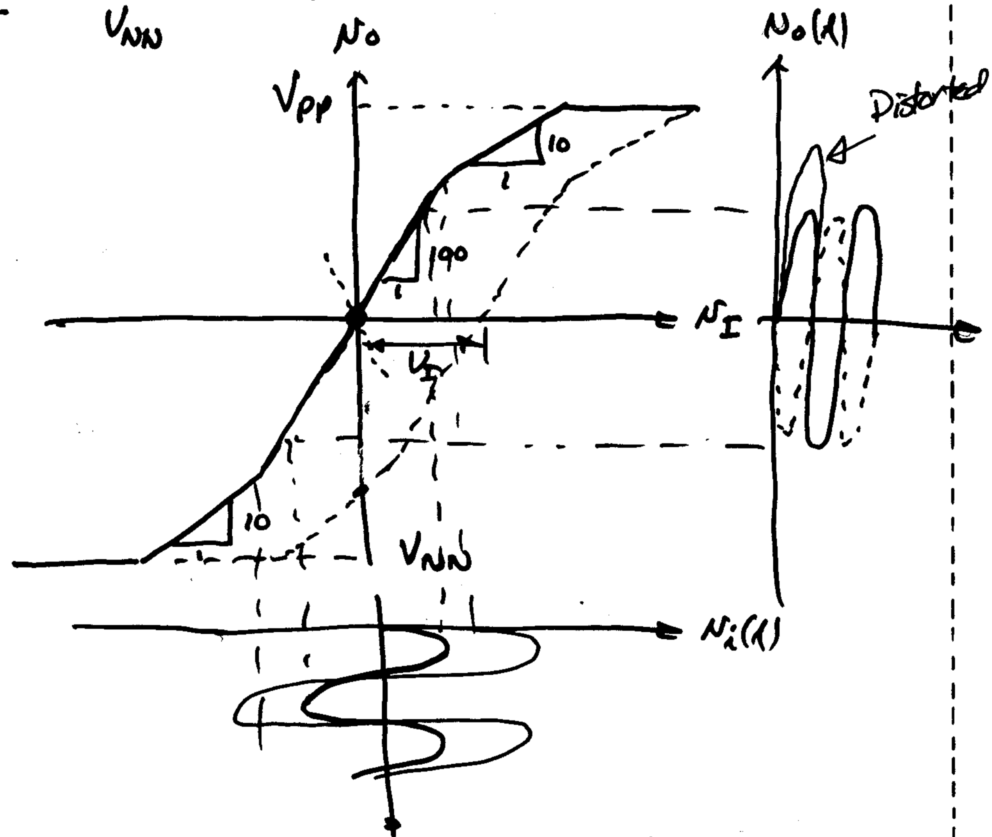
$0\% \, \eta < 100\%$ → Depends on signal level

Typically $\eta \propto$ signal level

V. Voltage Transfer Curve

Output voltage vs. input voltage of an amplifier





Small signal gain = Slope of VTC

$$= \left.\frac{\partial v_o}{\partial v_I}\right|_Q$$

Distortion -

Apply a pure sinusoidal voltage at input of freq = ω. Look for the harmonics at the output

$$v_{out} = a_1 \sin \omega t + a_2 \sin 2\omega t + a_3 \sin 3\omega t + \cdots$$

$$THD = \frac{1}{a_1}\sqrt{a_2^2 + a_3^2 + a_4^2 + \cdots}$$