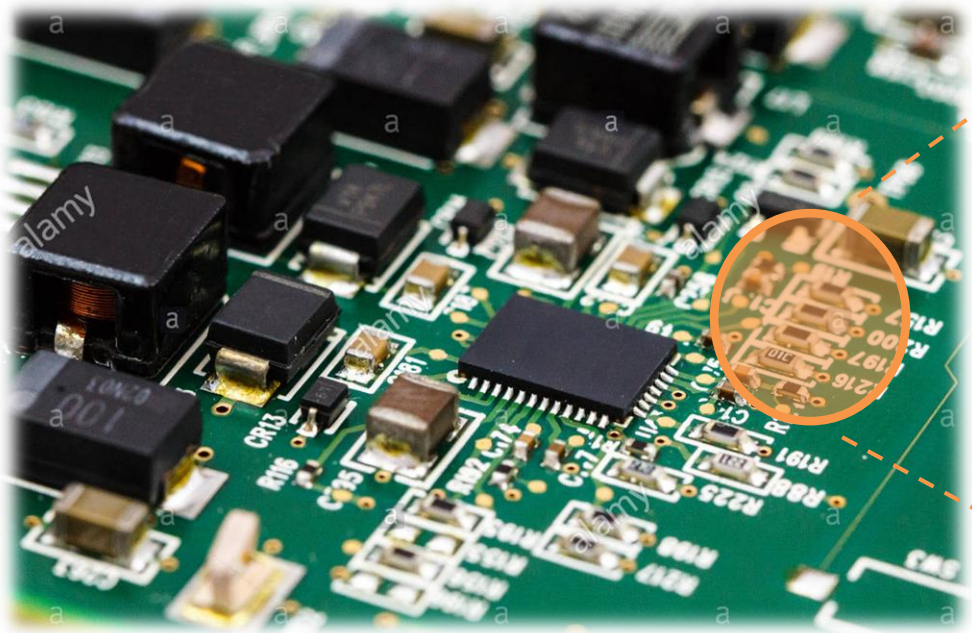
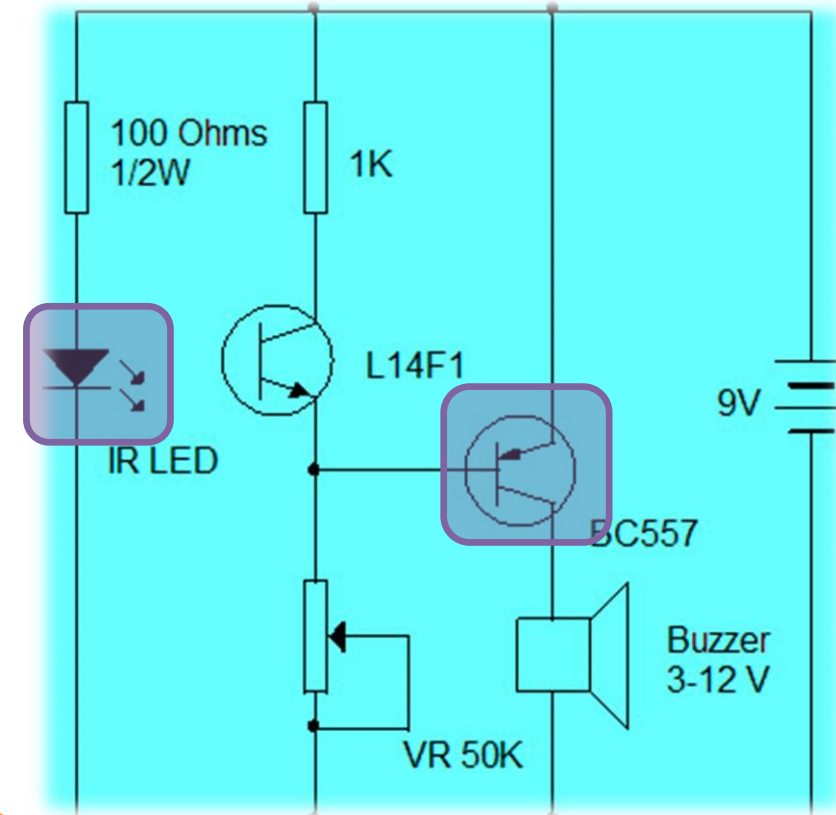


Course Objectives

This course teaches analysis techniques of basic electronic circuits with diodes and transistors.



Electronic Circuit Board



Invisible Burglar Alarm

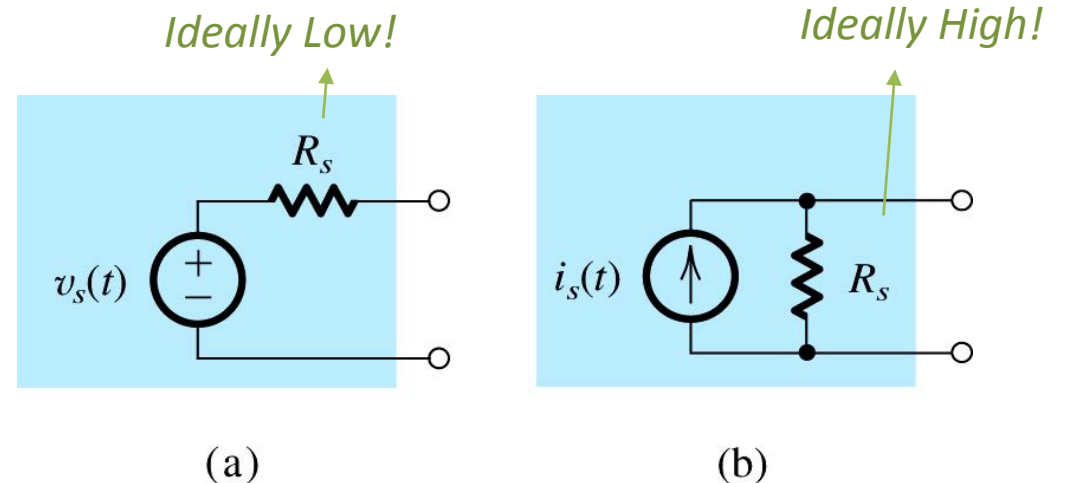
Electronic Systems → Chapter #1

- **Signal** - contains information
- **Transducer** – device which converts signal from non-electrical to electrical form
- **Process** – an operation which allow an observer to understand this information from a signal

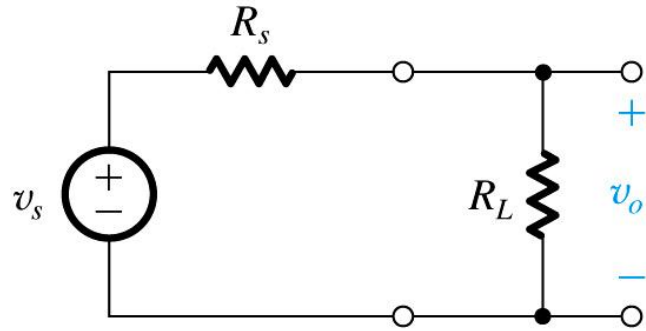
*Process the electrical **signals** received from the **transducer** in some predetermine manner.*

Electrical Signal Representation

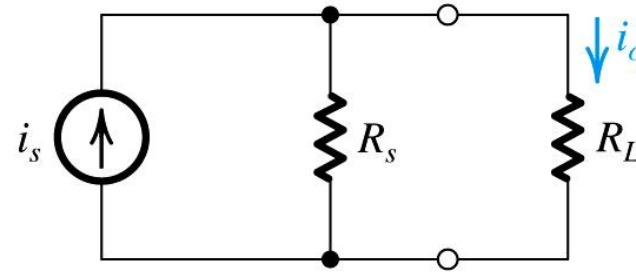
- Thevenin Form** – voltage source $v_s(t)$ with series resistance R_s
- Norton Form** – current source $i_s(t)$ with parallel resistance R_s



Basic Circuit Analysis → Example 1.1



(a)

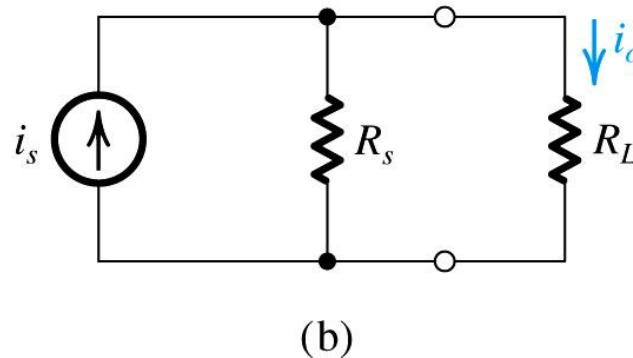
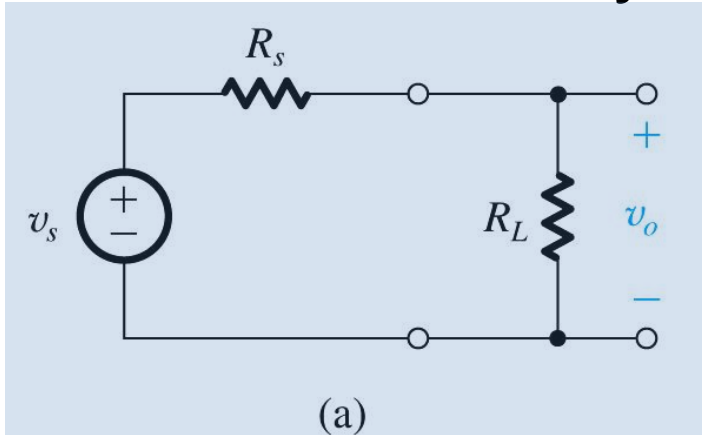


(b)

- How the output resistance of a source (R_s) **limits its ability to deliver a signal** at full strength?
- What is the relationship between the source and output when **maximum power** is delivered?

Concepts: *Power, Efficiency, Maxim Power Transfer*

Basic Circuit Analysis → Example 1.1



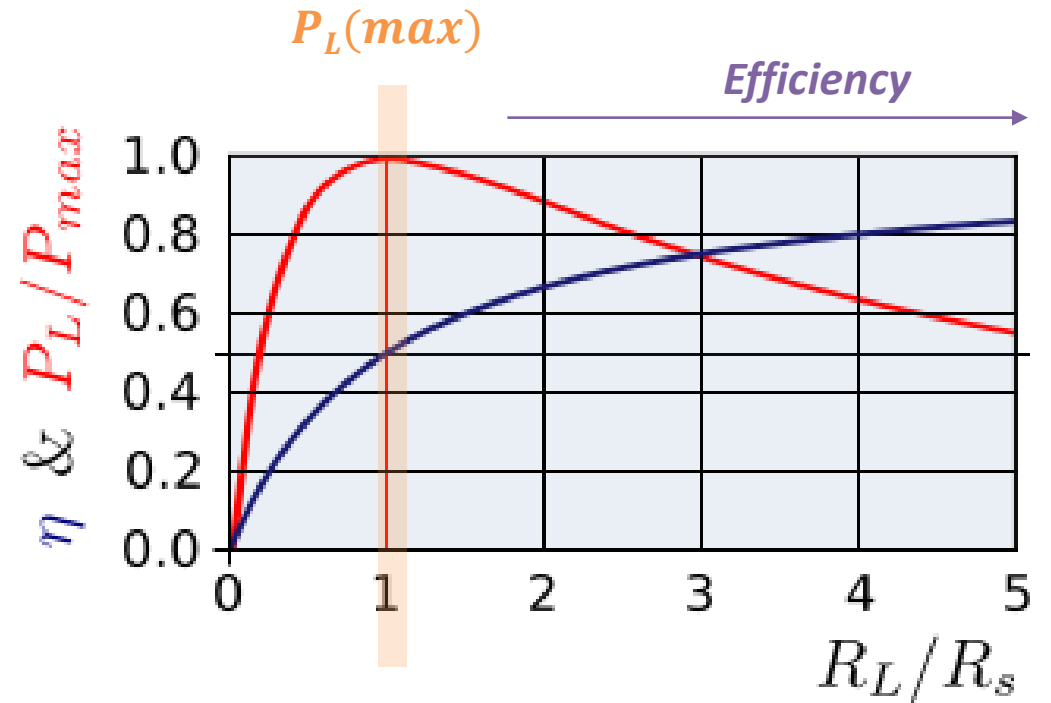
Application: maximum power transfer for solar cells

- Power** $P_L = V_o \cdot I_L = \frac{R_L}{(R_L + R_S)^2} V_s^2$

- Efficiency** $\eta = \frac{P_L}{P_{supply}} = \frac{R_L}{R_L + R_S}$

- Maximum Power**

$$\frac{\partial P_L}{\partial R_L} = 0 \quad @ R_L = R_S$$



Frequency Spectrum → Chapter 1.2

... defines a time-domain signal in terms of the strength of harmonic components

Fourier Series → an expression of a periodic function as the sum of an infinite number of sinusoids whose frequencies are harmonically related

Fourier Series Representation of $f(x)$

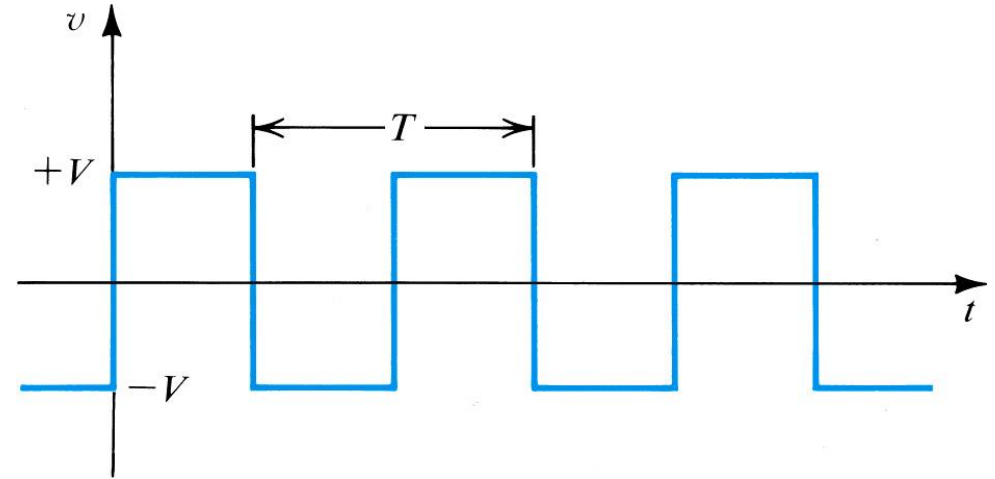
$$f(x) = \frac{a_0}{2} + \sum_{k=1}^{\infty} [a_k \cos(kx) + b_k \sin(kx)]$$

$$a_k = \frac{1}{\pi} \int_{-\pi}^{\pi} f(x) \cos(kx) dx, \quad n \geq 0$$

$$b_k = \frac{1}{\pi} \int_{-\pi}^{\pi} f(x) \sin(kx) dx, \quad n \geq 1$$

Frequency Spectrum

... of a square wave? 



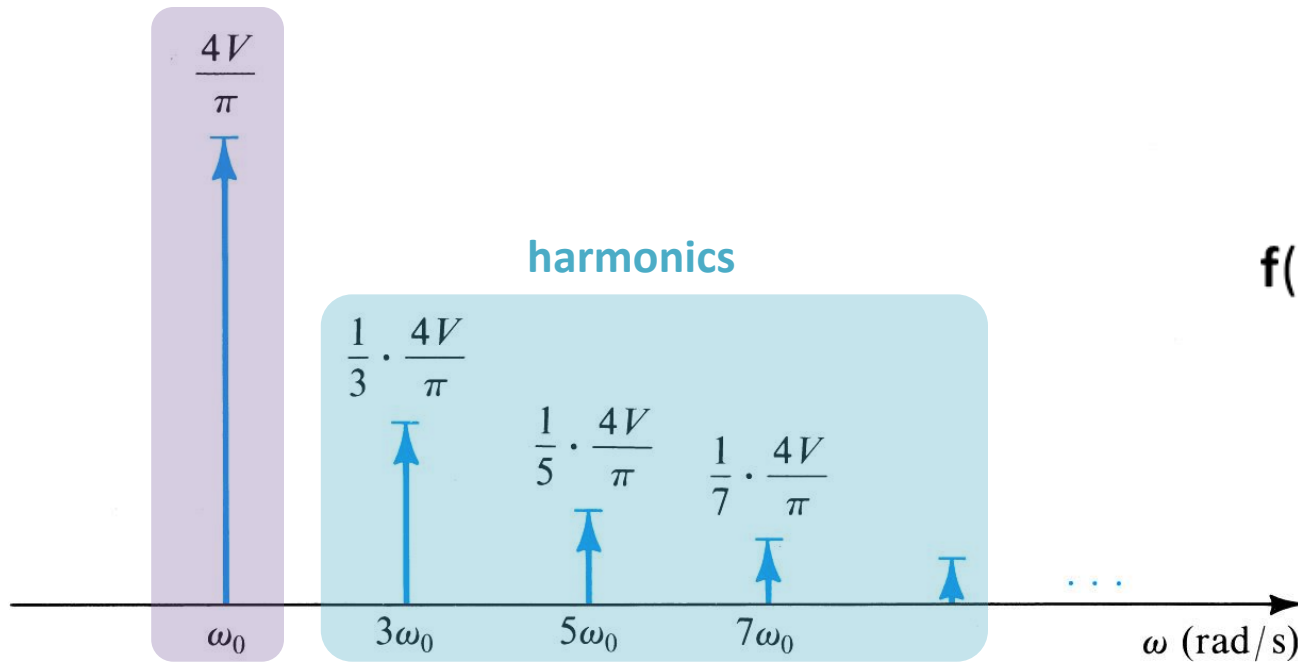
$$f(x) = \frac{4V}{\pi} \left[\sin(\omega_0 t) + \frac{1}{3} \sin(3\omega_0 t) + \frac{1}{5} \sin(5\omega_0 t) + \dots \right]$$

fundamental

harmonics



fundamental



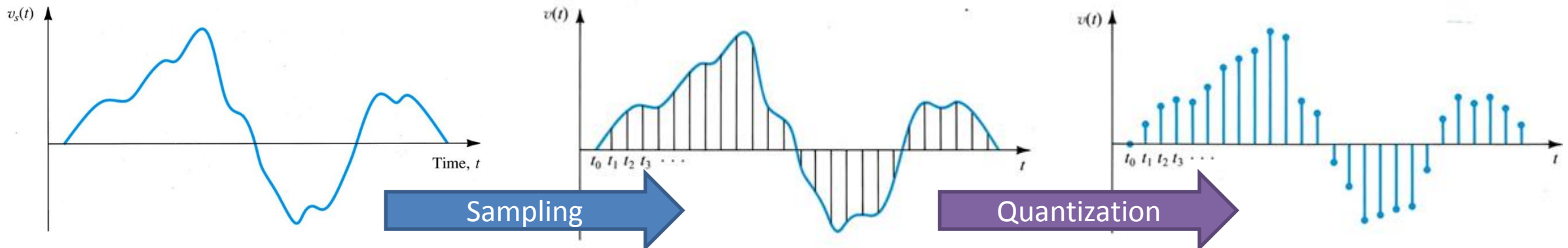
Analog & Digital Signals → Chapter 1.3

- **analog signal** – is continuous with respect to both value and time
- **discrete-time signal** – is continuous with respect to value but sampled at discrete points in time
- **digital signal** – is quantized (applied to values) as well as sampled at discrete points in time

analog signal

discrete-time signal

digital signal

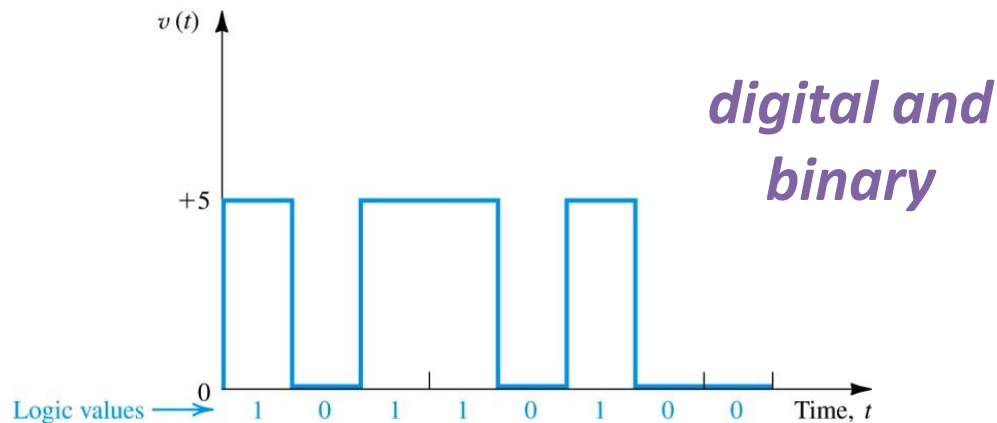
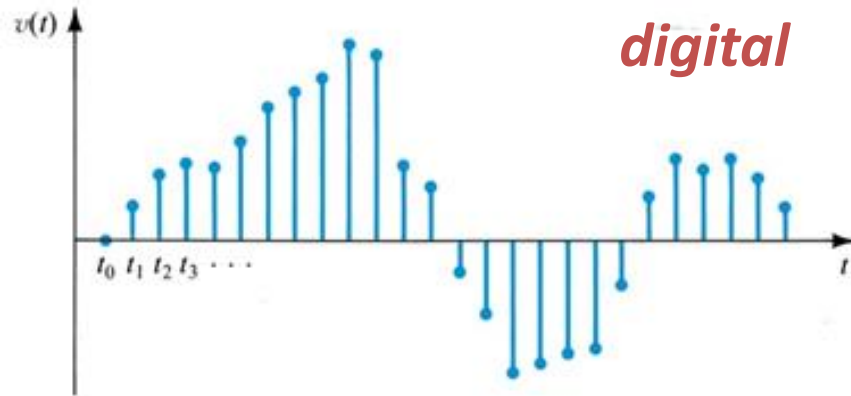


Analog & Digital Signals

Are digital and binary synonymous?



No. The binary number system (base₂) is one way to represent digital signals.



$$y = \underbrace{b_0 2^0 + b_1 2^1 + b_2 2^2 + \dots}_{\text{base 10} \leftarrow \text{base 2}}$$

$\underbrace{b_0}_{\text{LSB}}$

$$\dots + b_3 2^3 + \dots \underbrace{b_{n-1}}_{\text{MSB}} 2^{n-1}$$

Binary Signal: a digital signal with only 2 distinguishable levels!

Amplifiers → Chapter 1.4

Why is signal amplification needed?

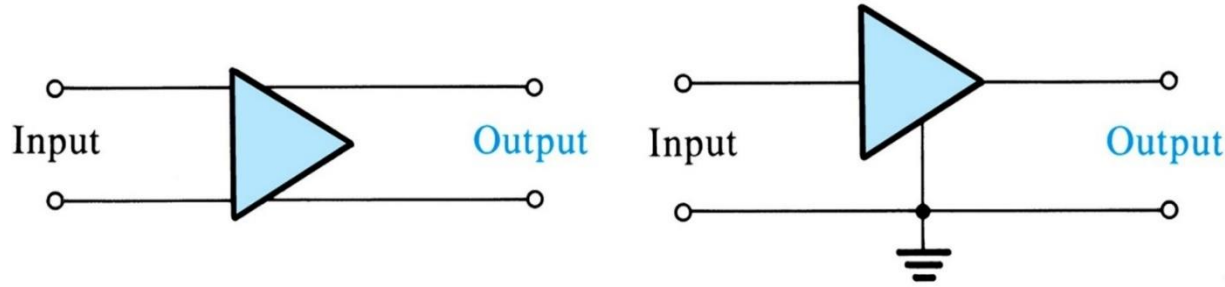
Because many transducers yield output at low power levels (mW)

- **Voltage Amplifier** – is used to boost voltage levels for increased resolution
- **Power Amplifier** – is used to boost current levels for increased “intensity”



- **Linearity** – is property of an amplifier which ensures a signal is not “altered” from amplification
- **Distortion** – is any unintended change in output

Amplifier Circuit Symbol



Differential Input /
Differential Output

Single-Ended Input /
Single-Ended Output

Voltage Gain

$$V_{out}(t) = A_V \cdot V_{in}(t)$$

$$V_{o1}(t) - V_{o2}(t) = A_V \cdot [V_1(t) - V_2(t)]$$

$$V_{o1}(t) = A_V \cdot V_1(t)$$

- Gain in decibels...

voltage gain in decibels = $20 \log|A_V| \text{ dB}$

current gain in decibels = $20 \log|A_i| \text{ dB}$

power gain in decibels = $10 \log(A_p) \text{ dB}$

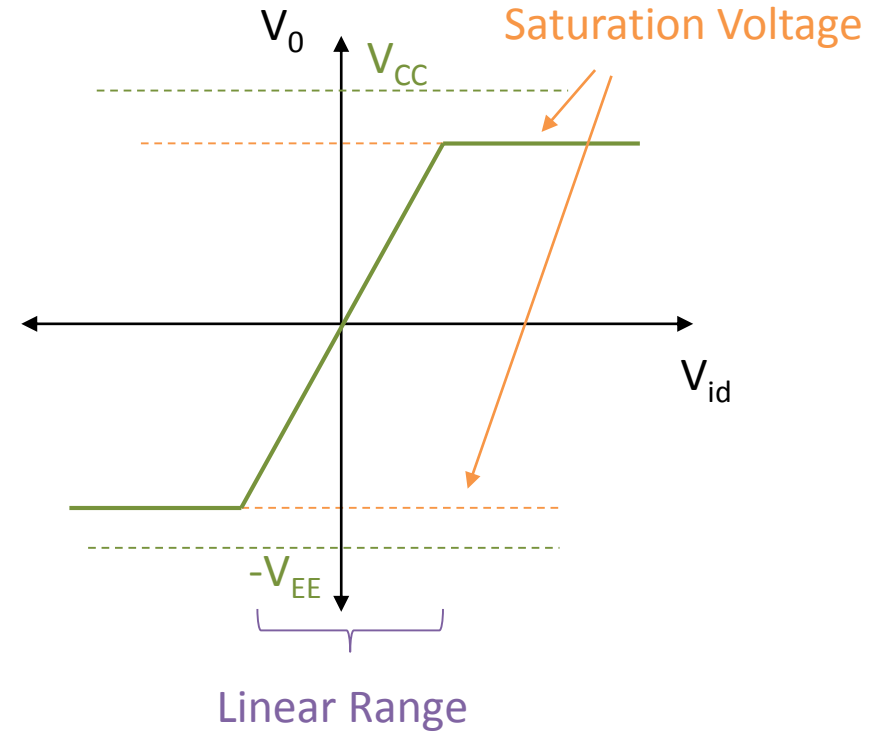
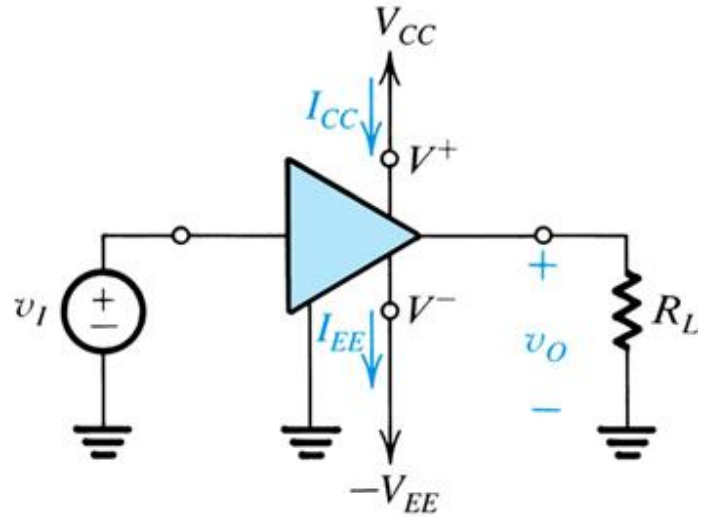
What is one main difference between an amplifier and a transformer?



An amplifier may be used to boost power delivery!

$$\text{power gain } (A_p) = \frac{\text{load power } (P_L)}{\text{input power } (P_i)} = \frac{v_o i_o}{v_i i_i}$$

Amplifiers Power & Saturation



• **Conservation of power** $\longrightarrow P_{V_I} + P_{V_{CC}} + P_{V_{EE}} = P_L + P_{amp}$

• **Efficiency** \longrightarrow

• **Limited Linear Range**

• **Saturation Voltage**

$$\eta = \frac{P_L}{P_{in}} = \frac{P_L}{P_{V_I} + P_{V_{CC}} + P_{V_{EE}}}$$