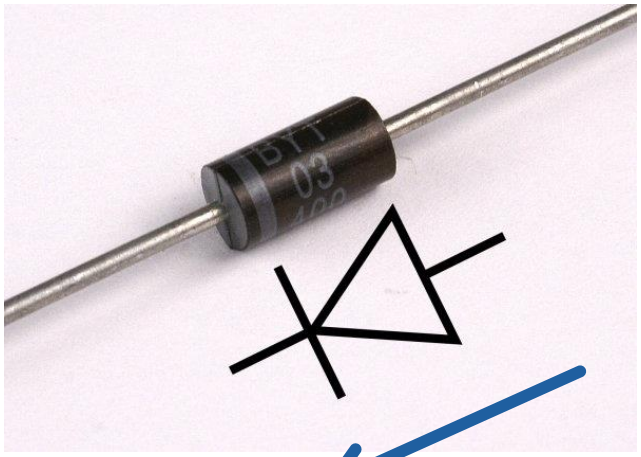
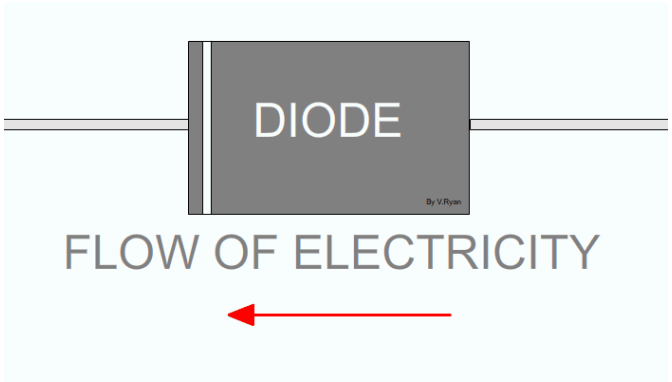
CHAPTER 1
Introduction to Electronics and Basic Amplifiers

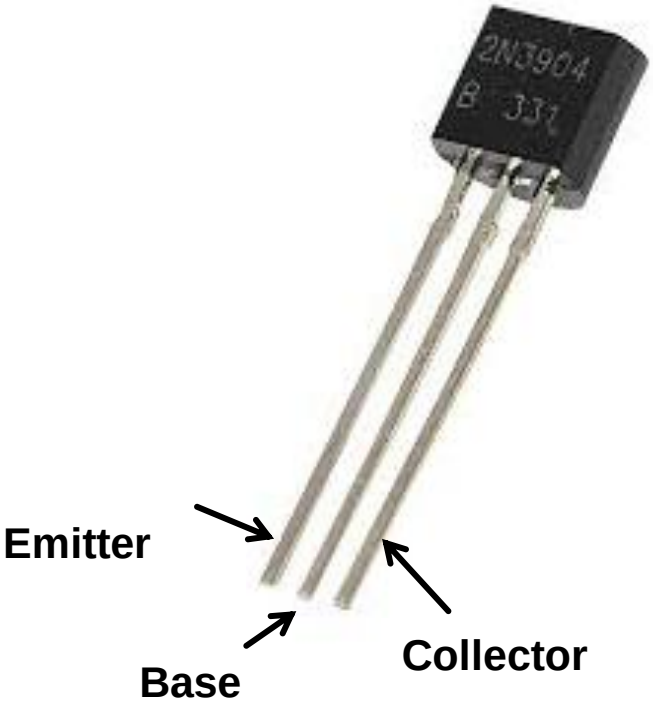
PN Junction - Diode

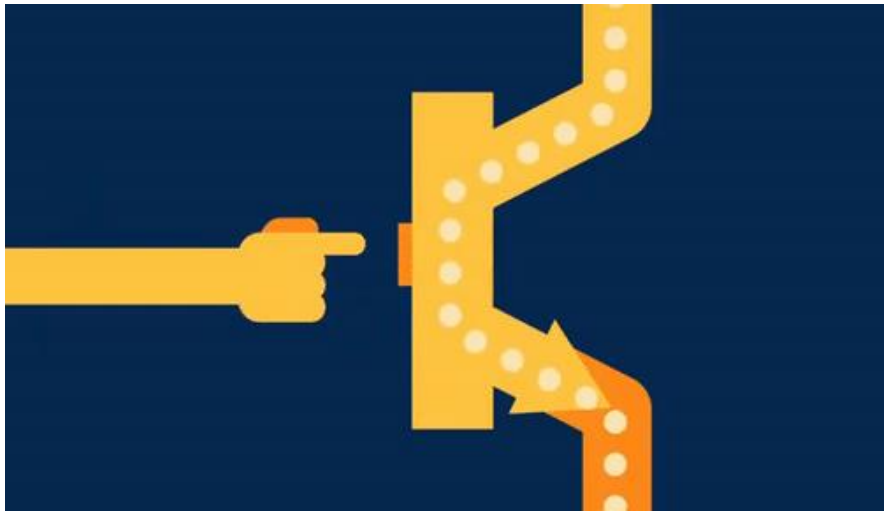


Current Flow



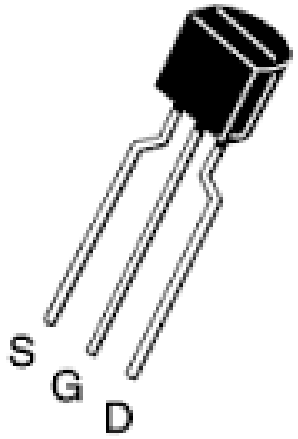
Bipolar Junction Transistor: BJT





Voltage at Base must be large enough to turn on the transistor to allow current to flow

Field Effect Transistor: FET



S = Source
G = Gate
D = Drain

Passive and Active Components

Passive Components:

Do not require/depend on power supply for its operation or the device which electrical characteristics does not depend on the power supply

Examples: Resistor, capacitor, inductor

Active components:

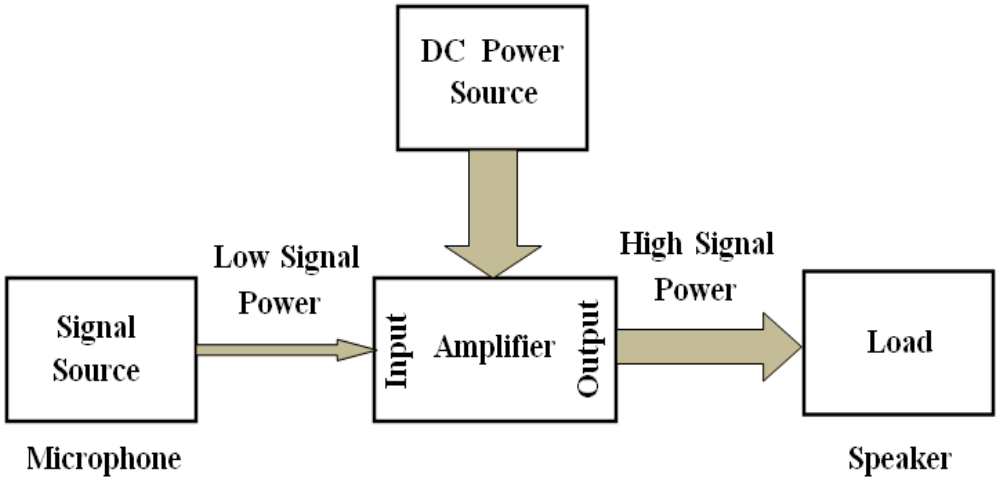
Do require/depend on power supply for its operation or the device which electrical characteristics depend on the power supply

Examples: Transistors such as BJT and FET

Electronic Circuits

- An electronic circuit generally contains both the passive and active components. Therefore, a DC power supply is essential for the operation of its active components. An electronic processing or amplifier devices also need different power source than its DC operating power source called input signal.

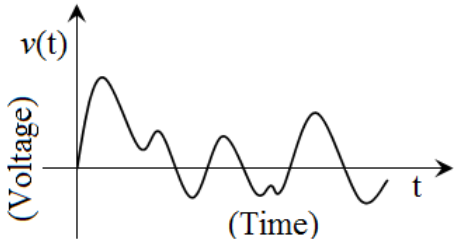
- This input signal characteristics and power can be modified by the electronic circuit with the presence of its DC operating power supply. The processed input signal which is obtained from the electronic circuit is called output signal.



Block diagram of an electronic circuit (Amplifier)

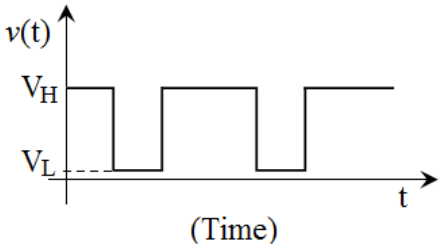
Analog and Digital Signals

An electrical signal is a time varying voltage or current which bears the information by altering the characteristics of the voltage or current. In an analog signal the characteristics of the voltage or current which represents the information can be any value.



Analog signal

Digital signal must have discrete value, it is said quantization. In a digital signal the characteristics of the voltage or current which represents the information has only two values and sometimes it is called binary signal.

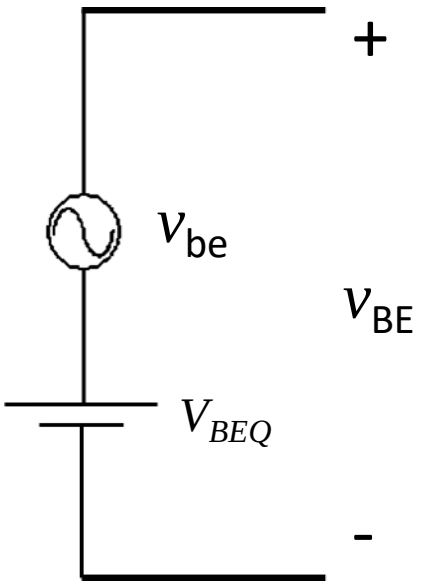


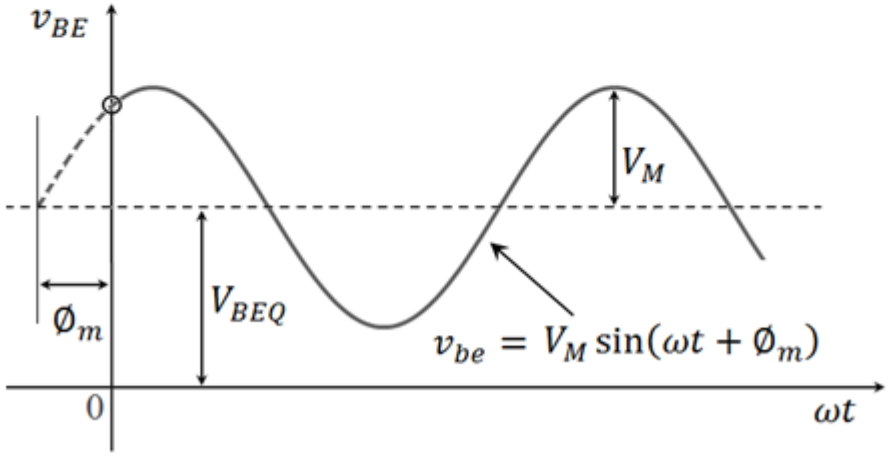
Digital signal

Representation of Signal

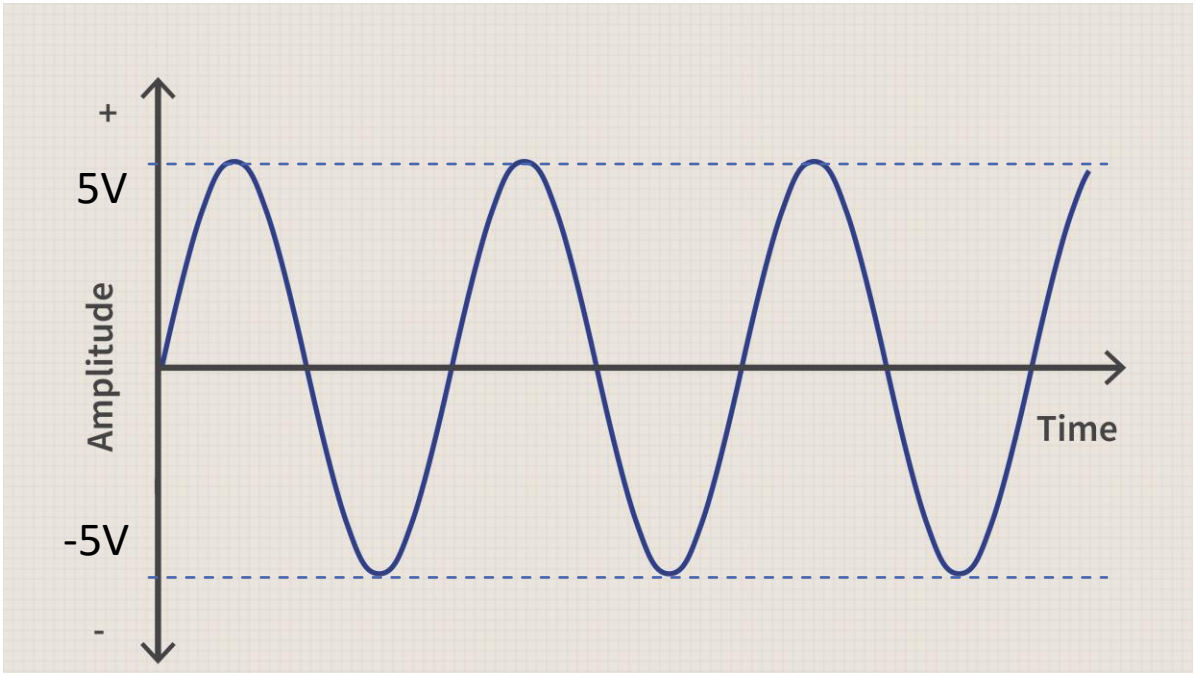
A sinusoidal voltage when it is superimposed on a DC voltage can be represented as

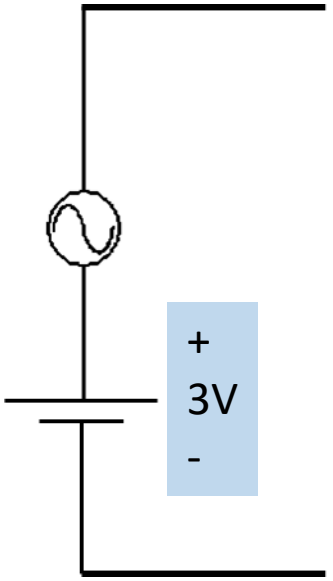
$$v_{BE} = V_{BEQ} + v_{be} = V_{BEQ} + V_M \sin(\omega t + \emptyset_m)$$

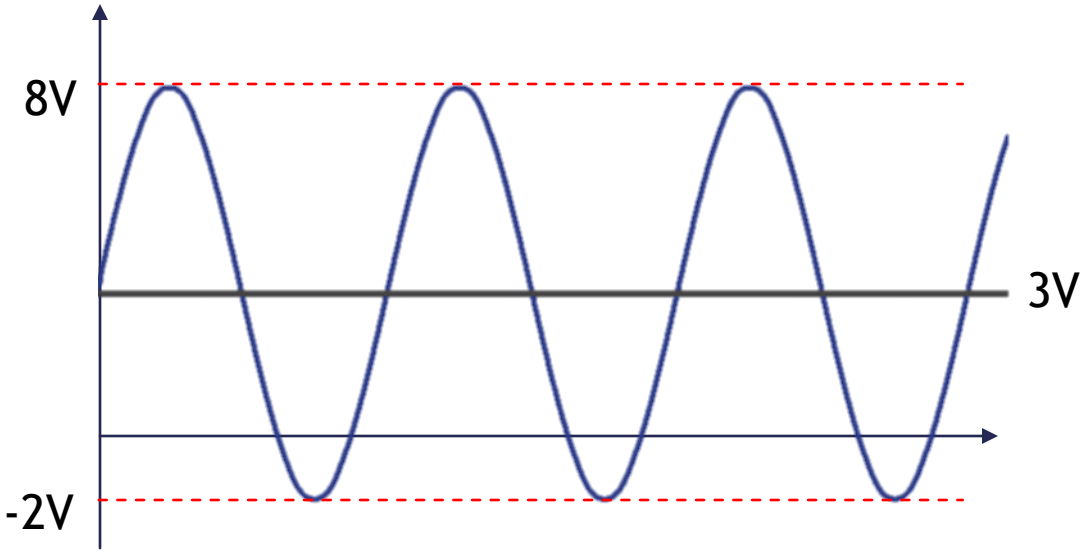




Sinusoidal voltage superimposed on DC voltage V_{BEQ}


+
5V
Amplitude
-5V
-
Time


+
3V
-


8V
3V
-2V

$$v_{BE} = V_{BEQ} + v_{be} = V_{BEQ} + V_M \sin(\omega t)$$

Variable Notation	Meaning
v_{BE}	Total instantaneous value
v_{be}	Instantaneous AC value
V_{BEQ}	DC value

Voltage Amplifier

Amplifier Characteristics

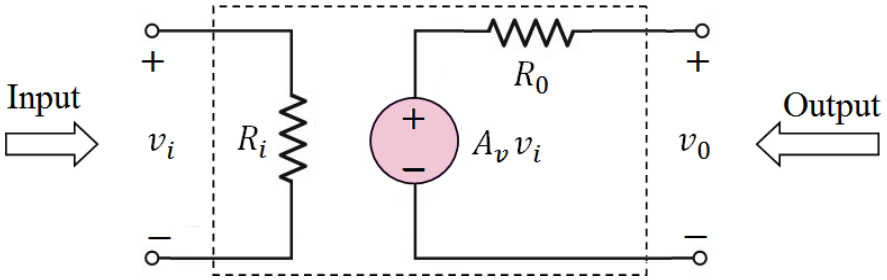
The voltage gain of the amplifier is defined as the ratio between output voltage and input voltage, mathematically

The gain of a voltage amplifier is unit less (there is no unit)

$$A_v = v_0 / v_i$$

Gain = output / input

Av = open circuit voltage gain

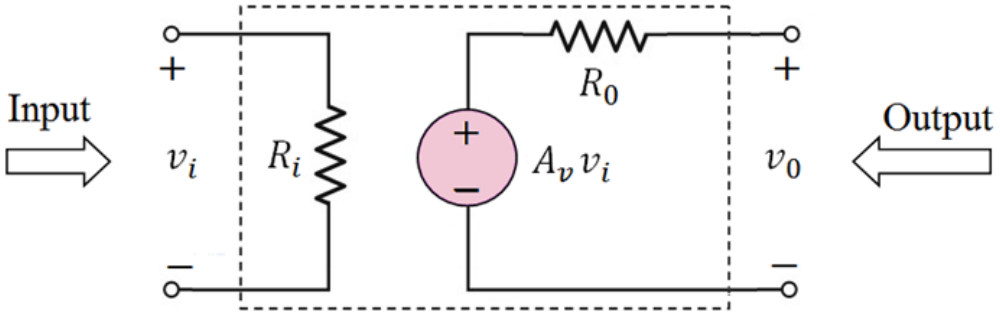


Equivalent circuit of a voltage amplifier

Example 1: The output voltage of an amplifier is 10.5V when its input is 150mV. Determine the voltage gain of the amplifier.

Solution: Here, $v_0 = 10.5\text{V}$ and $v_i = 150\text{mV} = 0.15\text{V}$

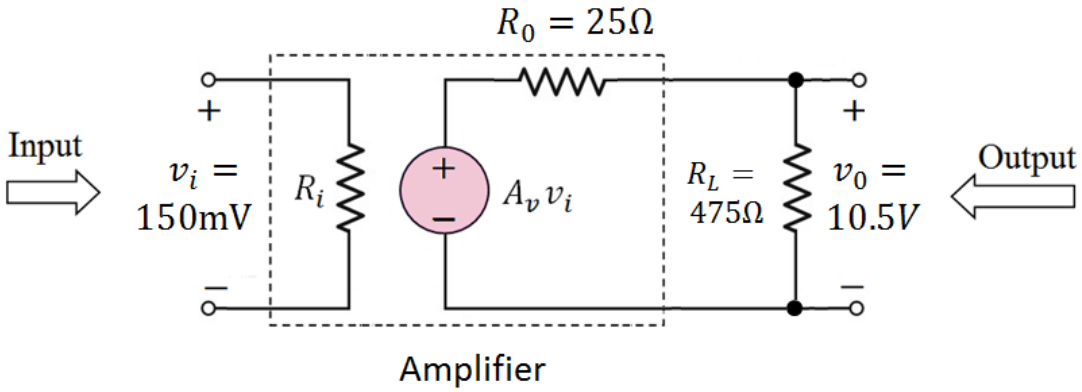
So the voltage gain, $A_v = \frac{10.5\text{V}}{0.15V} = 70$



Equivalent circuit of a voltage amplifier

Example 2: A load resistance of 475Ω is connected with the output of a voltage amplifier as shown in the Figure. The output voltage across the load resistance is 10.5V when the amplifier input is 150mV. Determine the open circuit voltage gain, A_V of the amplifier. Assume that the output resistance of the amplifier is 25Ω.

Avvi ≠ vo



Solution: Here, $v_0 = 10.5\text{V}$ and $v_i = 150\text{mV} = 0.15\text{V}$

Output current in the circuit, $i_0 = \frac{10.5V}{475\Omega} = 22.1mA$

So the open circuit voltage of the amplifier can be calculated by using KVL at the output loop

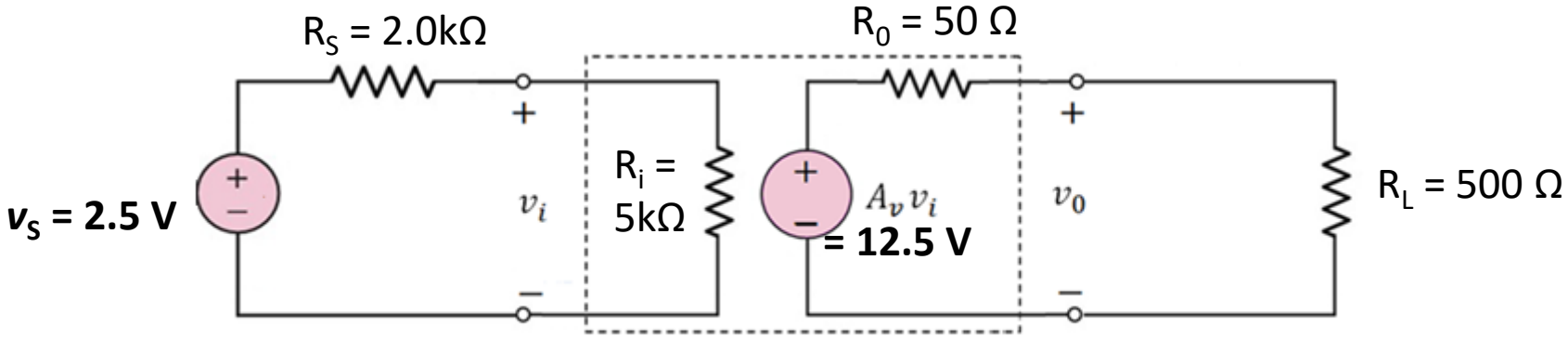
$$A_v v_i = R_0 i_0 + R_L i_0 = 25\Omega \times 22.1\text{mA} + 475\Omega \times 22.1\text{mA} = 11.05V$$

The open circuit voltage gain of the amplifier, $A_v = \frac{11.05V}{0.15V} \cong 73.67$

Avvi = open circuit voltage

Ex. 3: The open circuit voltage of a voltage amplifier is 12.5V when its input is connected to a signal source. Assume that the signal source voltage is 2.5 V and its resistance is 2.0kΩ respectively. If the input and output resistance of the amplifier is 5kΩ and 50Ω respectively.

i. Calculate the value of Av
ii. The amplifier output is connected to drive a load resistance 500Ω, determine the output voltage across the load resistance.



Equivalent circuit of a voltage amplifier

1. Calculate the value of v_i
2. We know that the open circuit voltage, $A_v v_i = 12.5$ V
3. For part (ii) Use KVL or voltage divider to calculate output across the load.

1. Calculate the value of v_i

$$vi = \left(\frac{Ri}{Ri + Rs}\right) vs$$

$vi = (5/7) * 2.5$

$vi = 1.786\ V$

2. We know that the open circuit voltage, $A_v v_i = 12.5\ V$

$A_v v_i = 12.5\ V$

$A_v = 12.5 / 1.786 = 7$

3. For part (ii) Use KVL or voltage divider to calculate output across the load.

$$vo = \left(\frac{RL}{RL + Ro}\right) A_v v_i$$

$vo = (500/550) * 12.5$

$vo = 11.36\ V$

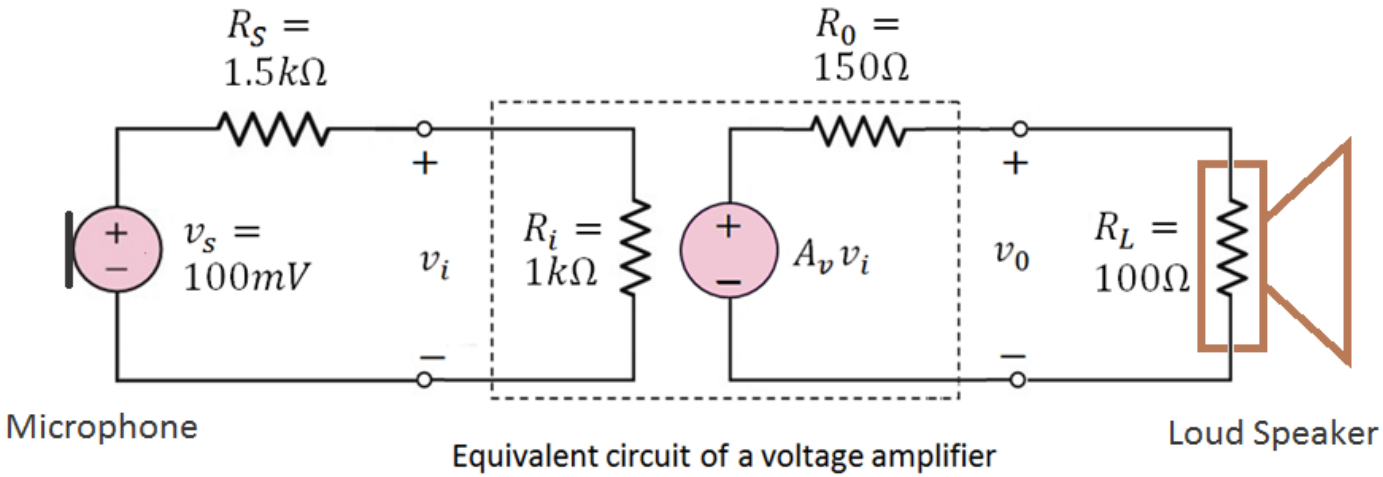
Answers:

$A_V = 7.0$

Voltage across load = 11.36 V

Ex. 4:

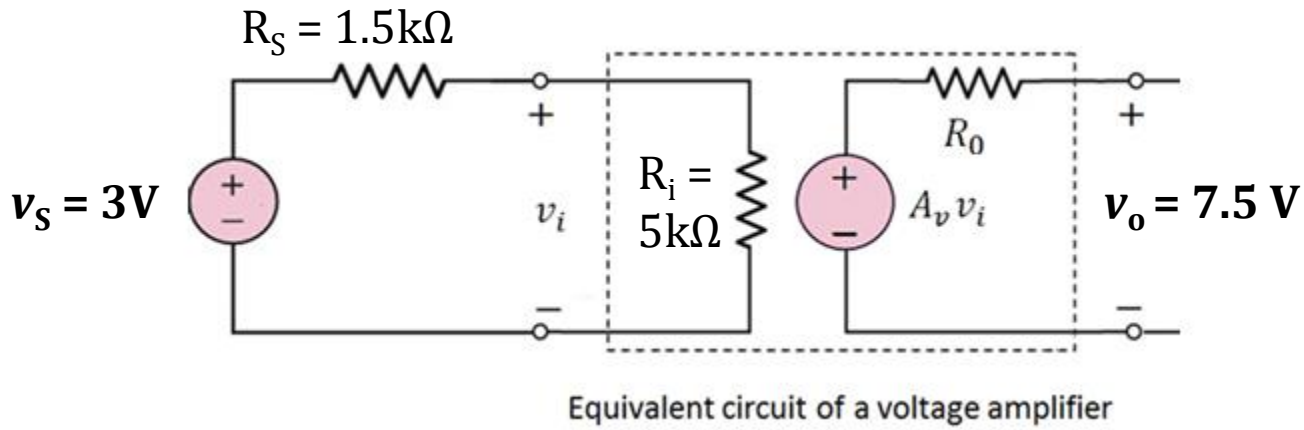
The figure shows a public address system i.e. a voltage amplifier input is connected with a microphone (input signal source) and output of the amplifier is connected with a loud speaker (load). If the voltage of the microphone is 100 mV determine the output voltage across in the speaker. Assume that the gain of the amplifier $A_v = 100$ the input and output resistances are, $R_i = 1k\Omega$, $R_0 = 150\Omega$ respectively. It is also assume that the microphone and speaker resistances are $R_S = 1.5k\Omega$ and $R_L = 100\Omega$ respectively.



1. Must calculate v_i
2. Calculate the open circuit voltage, $A_v v_i$
3. Then use voltage divider to find out the voltage across R_L

Answer: 1.6V

Ex. 5: The open circuit voltage of a voltage amplifier is 7.5V when its input is connected to a signal source. Assume that the signal source voltage is 3.0V and its resistance is 1.5kΩ respectively. If the input resistance of the amplifier is 5kΩ, what would be the voltage gain of the amplifier.



Equivalent circuit of a voltage amplifier

1. Must calculate v_i
2. We know that the open circuit voltage, $A_v v_i = 7.5$ V
3. Calculate A_V

Answer: 3.25