# Electrical and Electronic Measurements

## Lecture 5: Analog Electronic Voltmeters

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# Lecture Outline:

1. Introduction.
2. Emitter-Follower Voltmeter.
3. FET-input Voltmeter.

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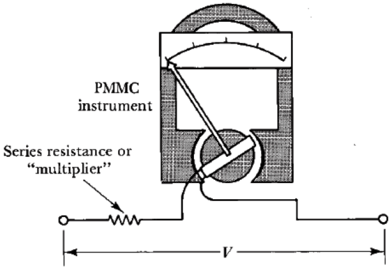
# Introduction:

- The electromechanical instruments have some limitations: as **having low resistance (loading effect)** and **cannot measure very low voltages**.
- The low input voltages need to be **amplified** to measurable levels and electronic circuits are required to **offer high input resistance**.
- Electronic circuits voltmeters with **transistors**, **operational amplifiers** (or op-amp) can be used to amplify small voltage and provide high input resistance .
- These analog circuits include:
  1. Emitter-Follower Voltmeter.
  2. FET-input Voltmeter.



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# Emitter-Follower Voltmeter:

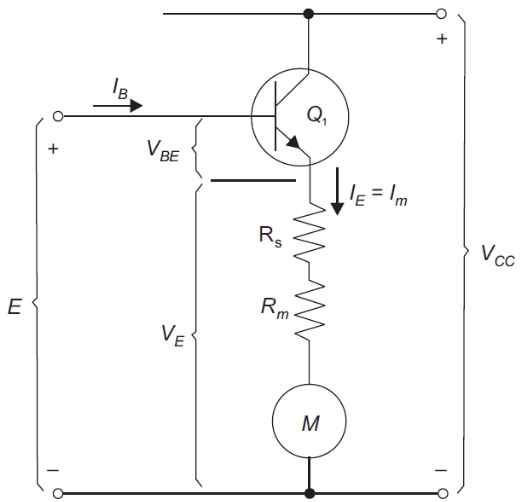
- A BJT emitter follower is used where the PMMC and $R_s$ are connected to the Emitter.
- The voltage to be measured, that is, $E$, is connected to the base of the transistor.
- The base current, $I_b$ is:

$$I_b = \frac{I_m}{\beta}, \qquad \beta : (\text{Transistor gain})$$

- The input resistance, $R_i$ is:

$$R_{in} \approx \frac{E}{I_b}$$

which is **much larger** than $R_s + R_m$ since $I_b$ is small.



# Emitter-Follower Voltmeter:

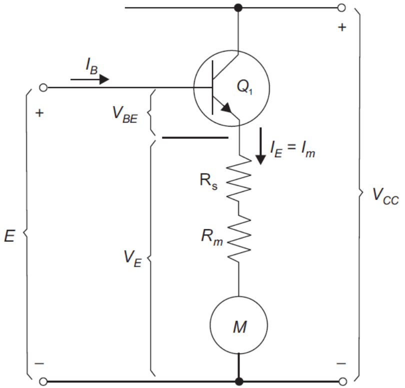
**Example**

A simple emitter-follower voltmeter with: $V_{CC} = 12\ V$, $R_m = 2k\Omega$, $1\ mA$ FSD meter current, and current gain $\beta = 50$.

Determine :

(a) Appropriate multiplier resistance that can give FSD 5 V.

(b) Input resistance




(a)

$$R_s = \frac{V_E}{I_m} - R_m = \frac{E - V_{BE}}{I_m} - R_m = \frac{5 - 0.7}{1\ mA} - 2 = 2.3\ k\Omega$$

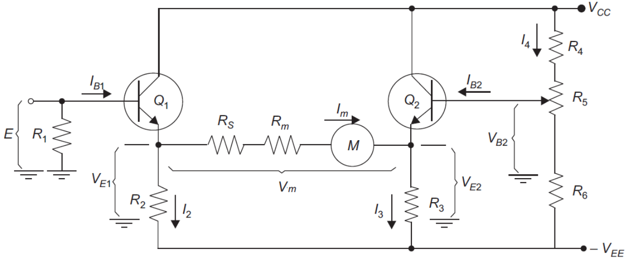
(b) $R_{in} = \frac{E}{I_b} = \beta.\frac{E}{I_m} = 50.\frac{5}{1\ mA} = 250\ k\Omega$

# Emitter-Follower Voltmeter:

- To **reduce the drop** $V_{BE}$, a one more emitter-follower and a voltage divider are used with a $\pm 12\ V$ dual polarity supply is connected.
- When $E = 0$, the resistance $R_5$ is adjusted to make $V_{E2} = 0.7$ and $V_m = 0$.
- When $E$ is exist, the PMMC voltage is:

$$V_m = E - 0.7 - (-0.7) = E$$

- So, the voltage drop is removed.




Modified Emitter-Follower Voltmeter

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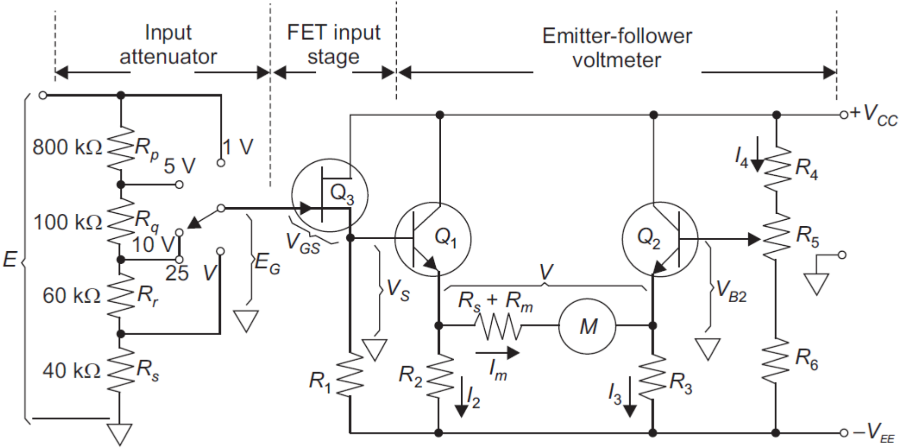
# FET-input Voltmeter:




**Advantage:**

The Field Effect Transistor (FET) provide extremely high input resistance.

# End of Lecture

Best Wishes

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