SNS COLLEGE OF TECHNOLOGY

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Department of Biomedical Engineering

Course Name: 23BMB101-Electron Devices and Circuits

I Year : II Semester

Unit II –Transistors

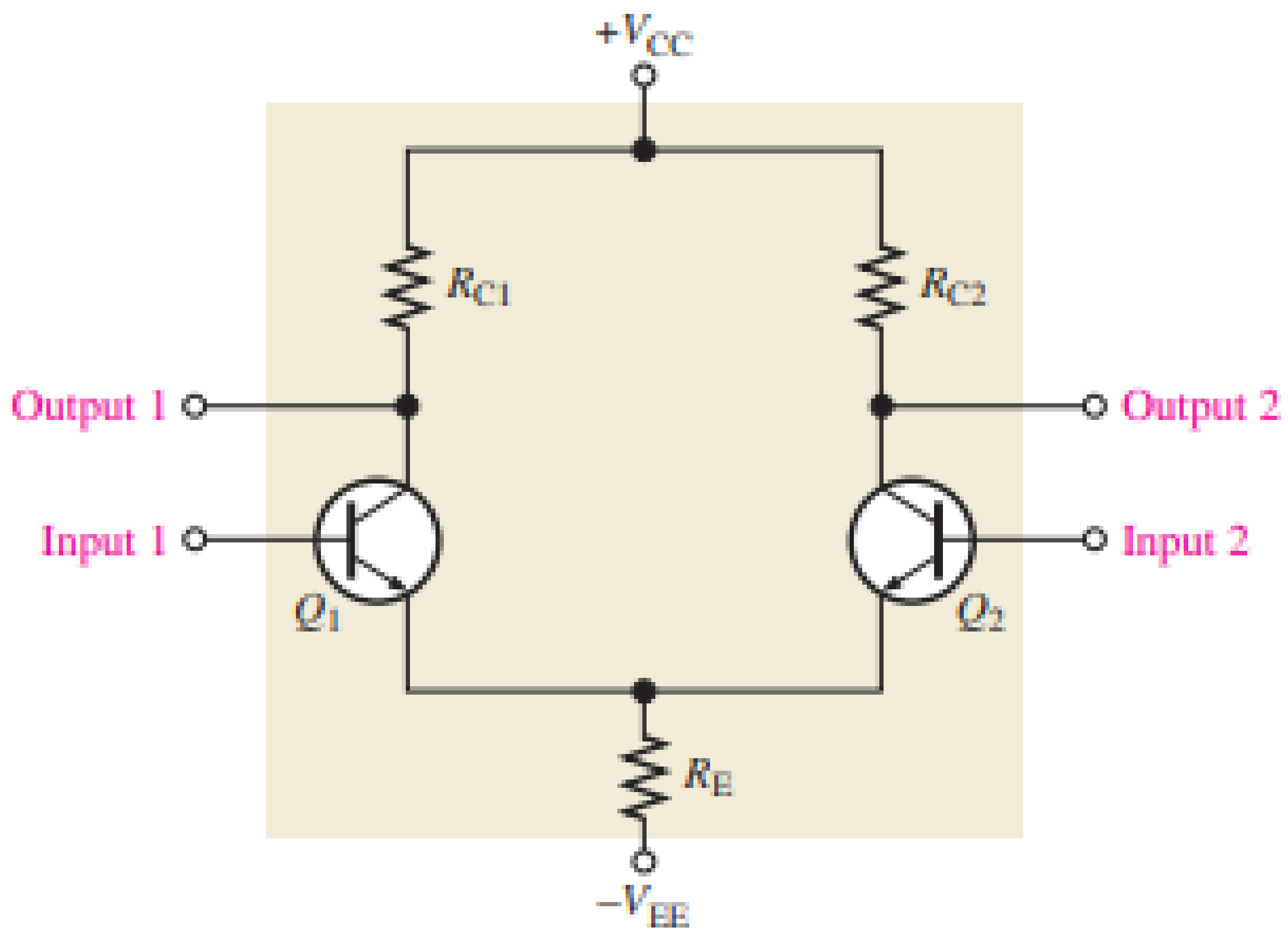
1

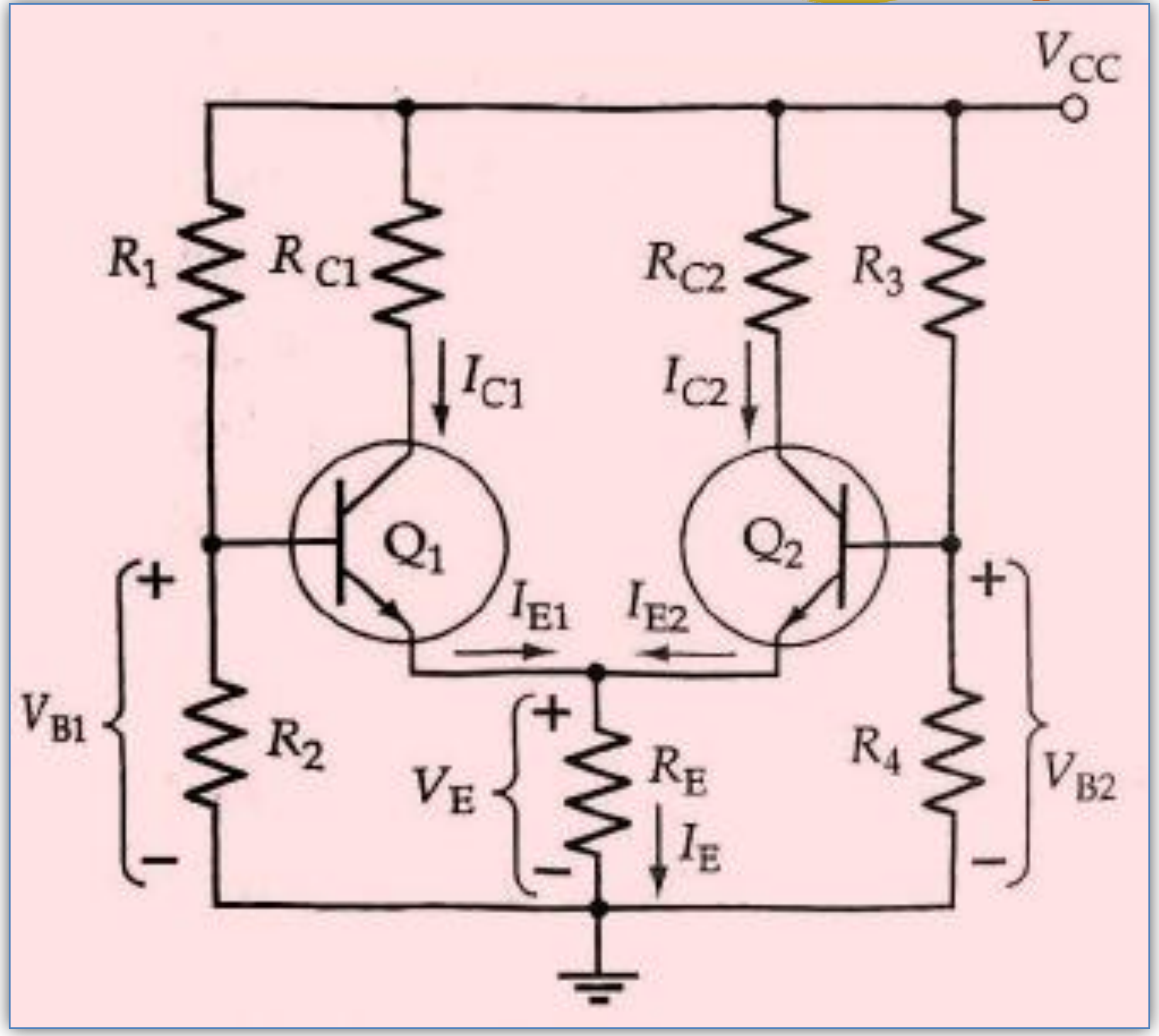
Topic : Differential Amplifier

INTRODUCTION

- The amplifier which amplifies the difference between two input signals is called as Differential amplifier.
- The differential amplifier configuration is very much popular and it is used in variety of analog circuits. It is basic building in operational amplifiers.
- It has both good bias stability and good voltage gain without the use of large bypass capacitors.
- The circuit is also known as an emitter-coupled amplifier, because the transistors are coupled at the emitter terminals.

Differential Amplifier





Differential Amplifier

- Fig shows that a basic differential amplifier circuit consists of two voltage-divider bias circuits with a single emitter resistor. The circuit is also known as an emitter-coupled amplifier, because the transistors are coupled at the emitter terminals.
- If transistors Q_1 and Q_2 are assumed to be identical in all respects, and if $V_{B1} = V_{B2}$, then the emitter currents are equal and the total emitter current is

$$I_E = I_{E1} + I_{E2}$$

$$I_E = \frac{V_B - V_{BE}}{R_E}$$

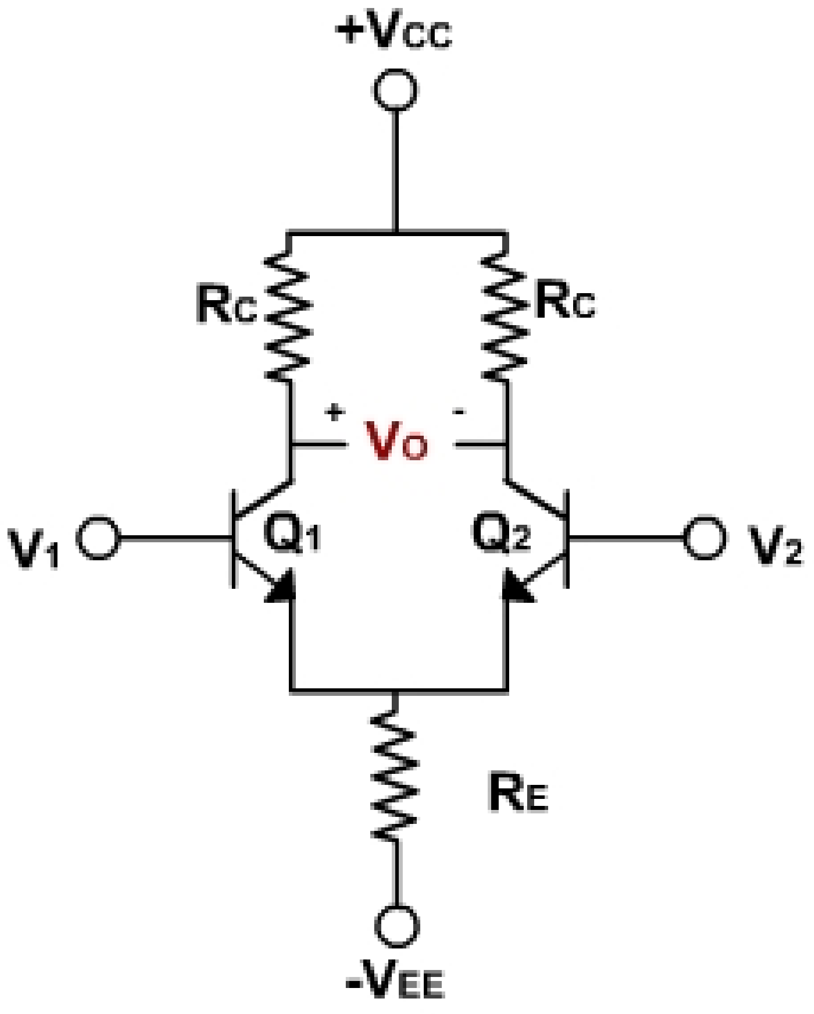
$$V_E = V_B - V_{BE}$$

$$I_{E1} = I_{E2} = \frac{I_E}{2}$$

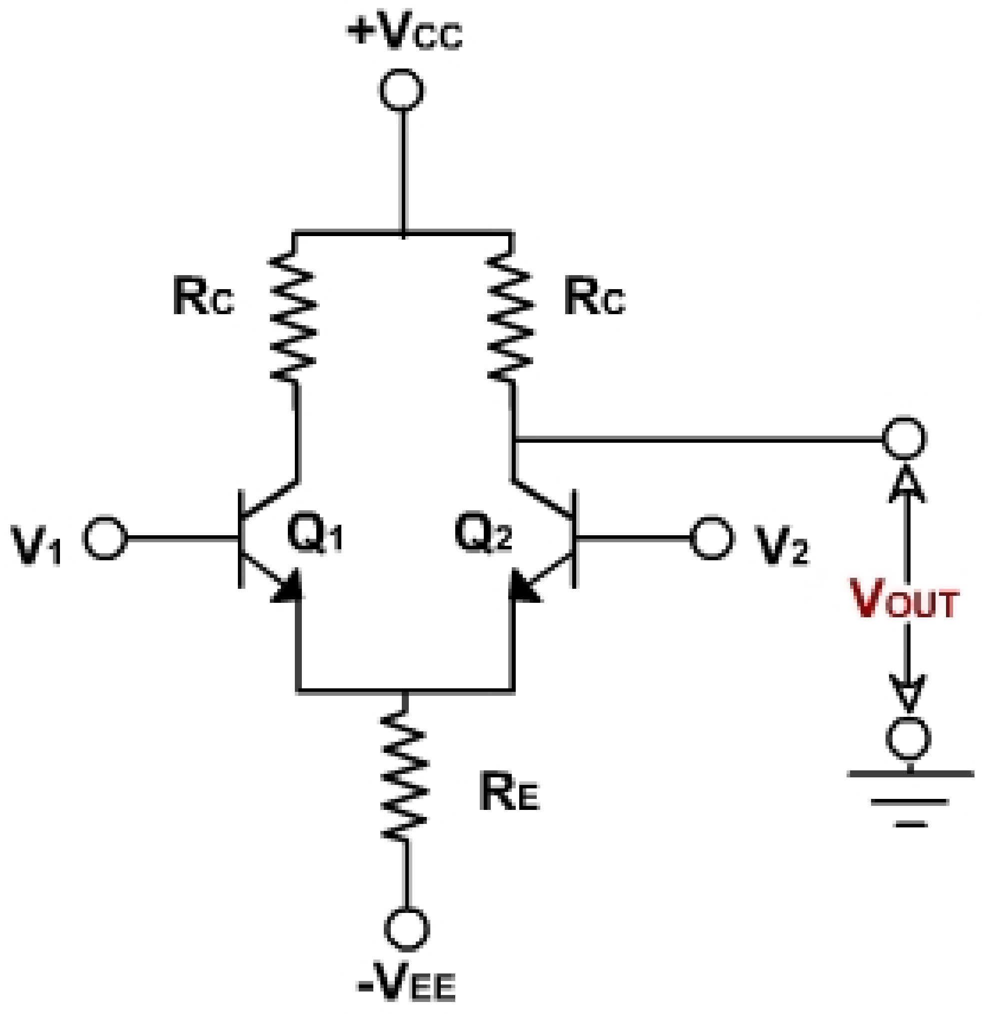
Differential Amplifier

- Like the emitter current in a single-transistor voltage-divider bias circuit, I_E in the differential amplifier remains virtually constant regardless of the transistor h_{FE} value.
- As a result, I_{E1}, I_{E2}, I_{C1} and I_{C2} all remain substantially constant, and the constant collector current levels keep V_{c1} and V_{c2} stable.
- So, the differential amplifier has the same excellent bias stability as a single transistor voltage-divider bias circuit.

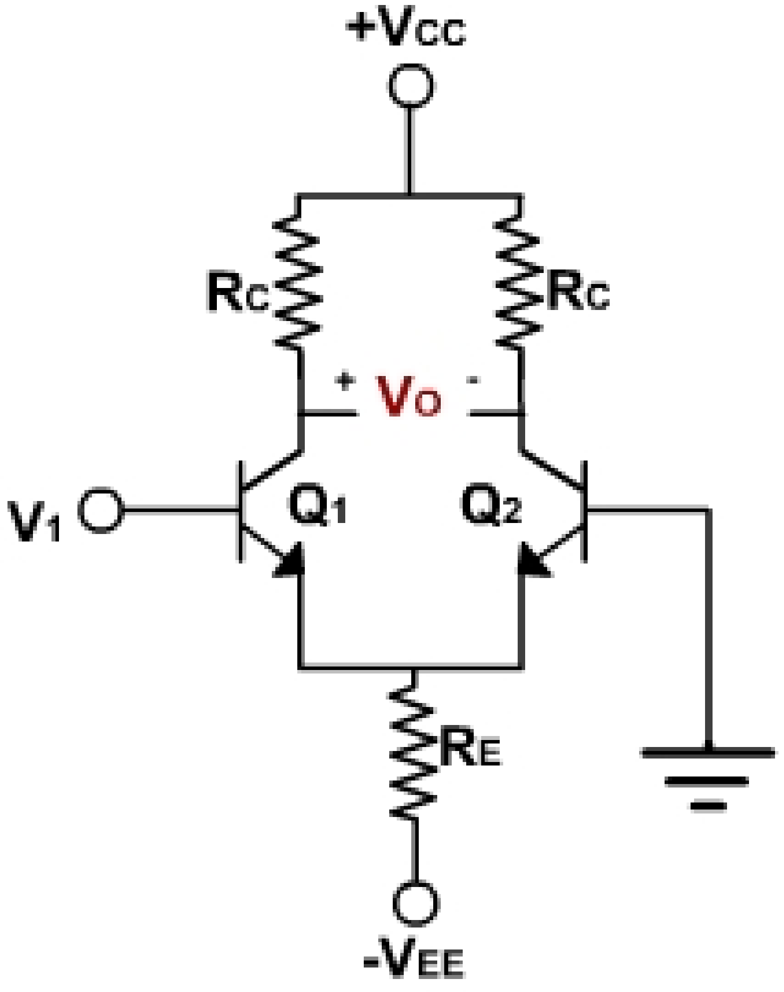
Differential Amplifier



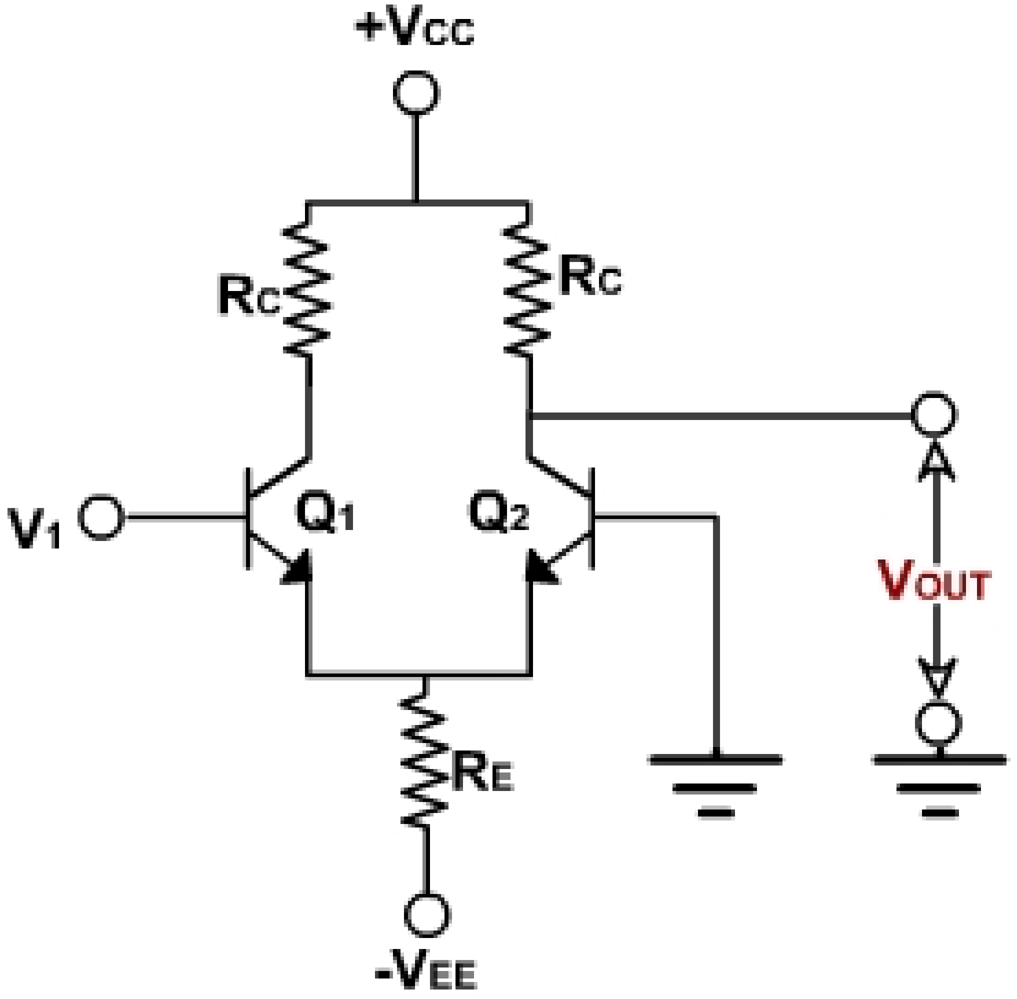
Dual input, balanced output differential amplifier.



Dual input, unbalanced output differential amplifier.



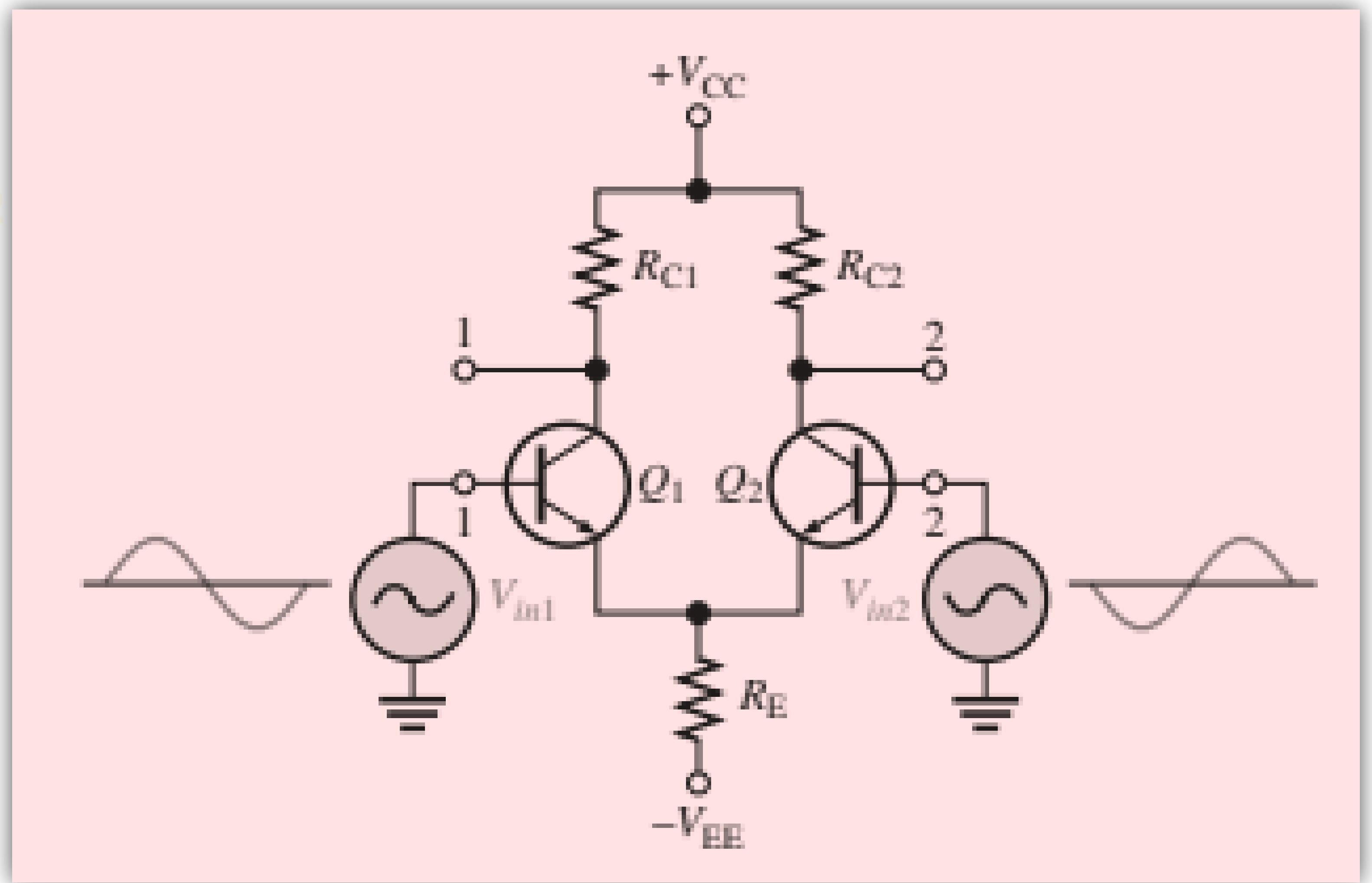
Single input balanced output differential amplifier



Single input unbalanced output differential amplifier.

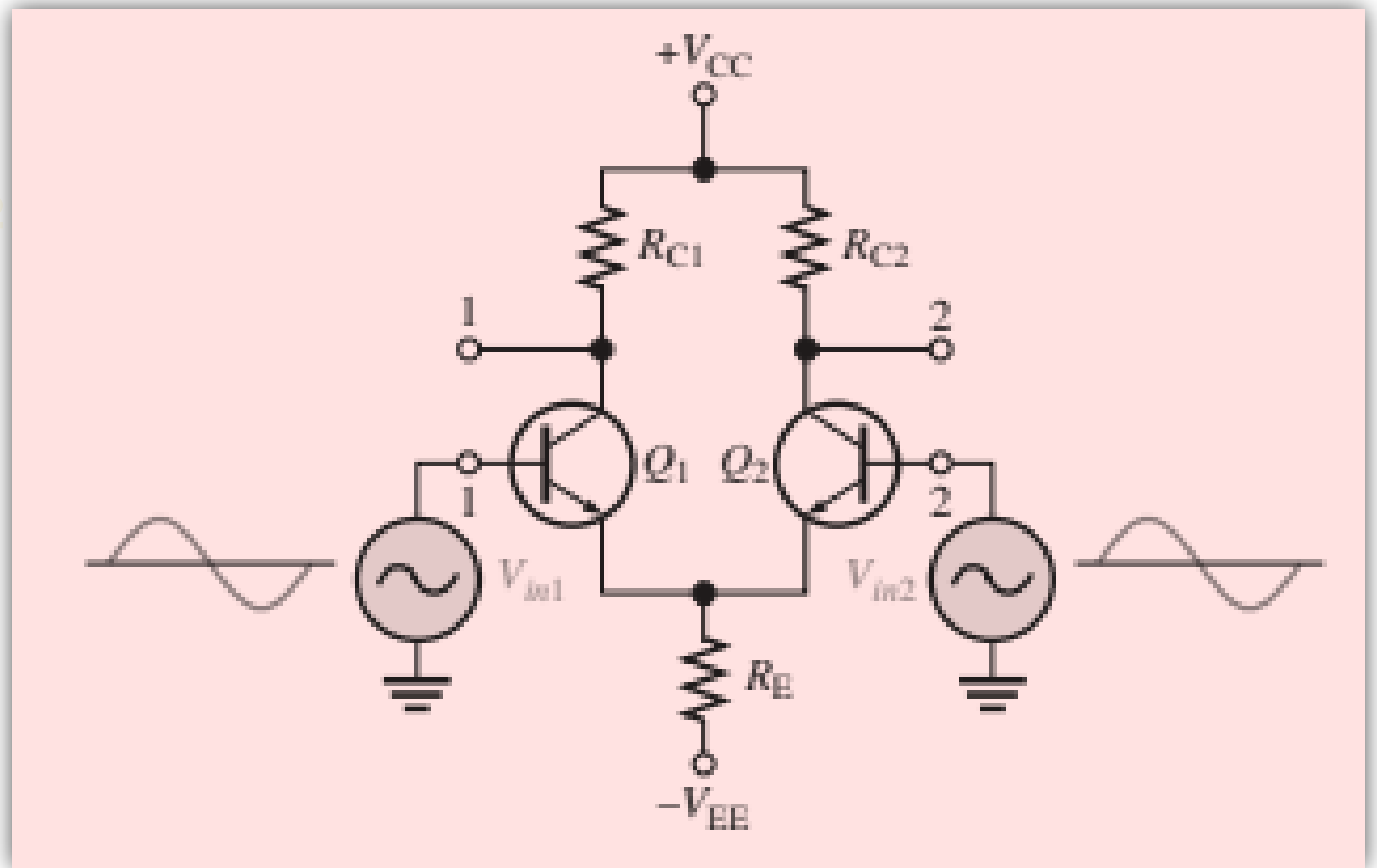
Differential Mode of operation

- In differential mode, the two input signals are equal in magnitude but opposite in phase, the differential input voltage V_d is,
  - $V_d = V_1 - V_2 = V_{in}/2 - (-V_{in}/2) = V_{in}$
- Hence the differential gain is given by,
  - $Ad = V_{out}/V_d = V_{out}/V_{in}$
- So,
  - $A_d = -h_{fe} * R_c / (2(h_{ie} + R_s))$



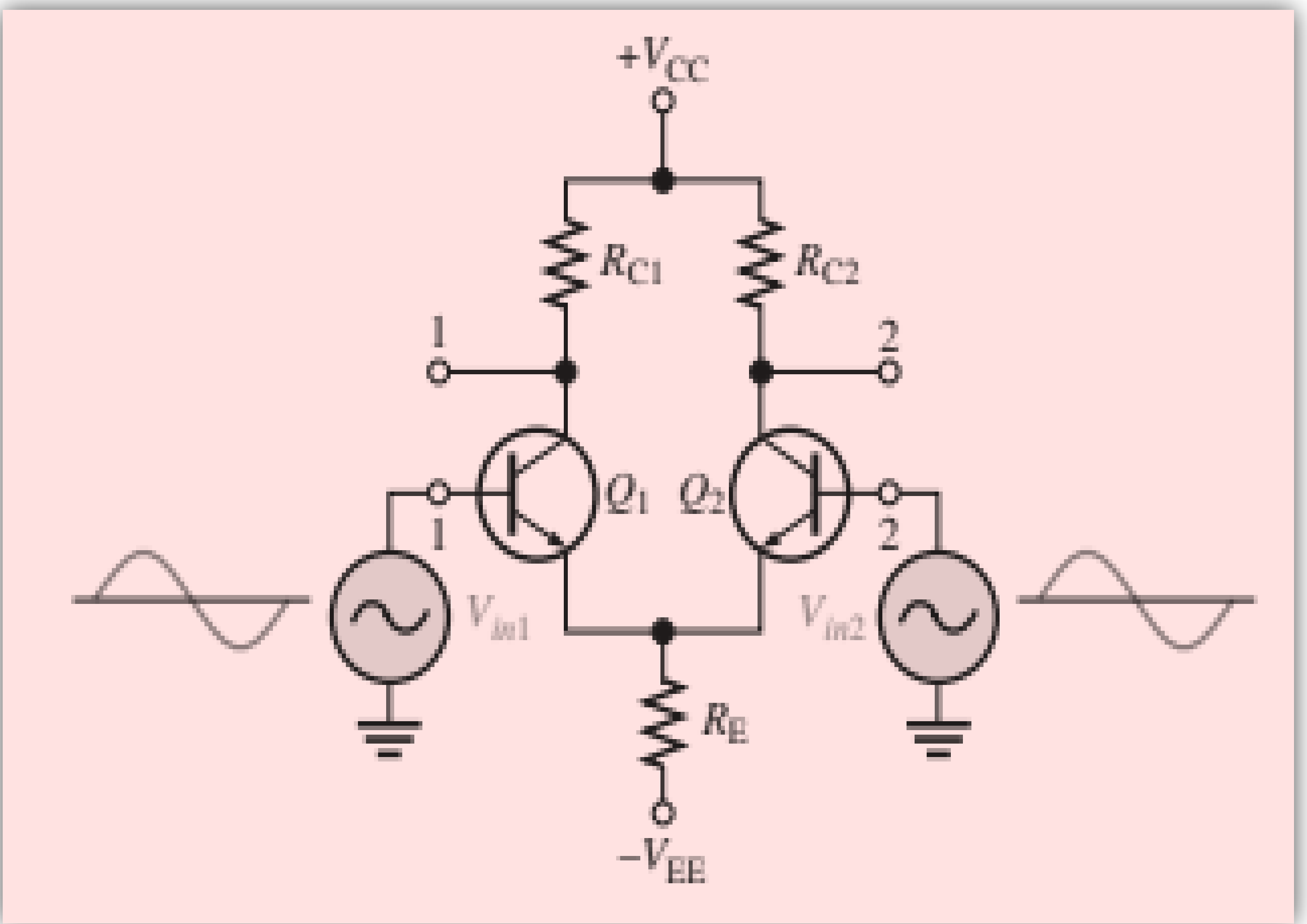
Common Mode of operation

- One of the most important aspects of the operation of a diff-amp can be seen by considering the common-mode condition where two signal voltages of the same phase, frequency, and amplitude are applied to the two inputs.
- When the input signals are applied to both inputs, the outputs are superimposed and they cancel, resulting in a zero output voltage. This action is called **common-mode rejection**.



Common Mode of operation

- In common mode differential amplifier mode, the two inputs are of same magnitude and in phase, so we have,
  - ✓ $V_1=V_2=V_{in}$
- The common mode signal V_{cm} is the average of the two input signals i.e,
  - ✓ $V_{cm} = (V_1+V_2)/2 = (V_{in}+V_{in})/2 = V_{in}$
- The output voltage in common mode is given by,
  - ✓ $V_{out} = A_{cm}*V_{in}$
  - ✓ or, $A_{cm} = V_{ou}t/V_{in}$



Common-Mode Rejection Ratio

- Unwanted signals (noise) appearing with the same polarity on both input lines are essentially cancelled by the diff-amp and do not appear on the outputs.
- The measure of an amplifier's ability to reject common-mode signals is a parameter called the **CMRR (Common Mode Rejection Ratio).**
- Ideally, a diff-amp provides a very high gain for desired signals (differential) and zero gain for common-mode signals. . The higher the differential gain with respect to the common-mode gain, the better the performance of the diff-amp in terms of rejection of common-mode signals.
- This suggests that a good measure of the diff-amp's performance in rejecting unwanted common-mode signals is the ratio of the differential voltage gain $A_{v(d)}$ to the common-mode gain, A_{cm}

$$\mathrm{CMRR} = \frac{A_{v(d)}}{A_{cm}}$$