

Microelectronics Circuit Analysis and Design

Donald A. Neamen

Chapter 11

Differential and Multistage Amplifiers

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Chapter 11-1

In this chapter, we will:

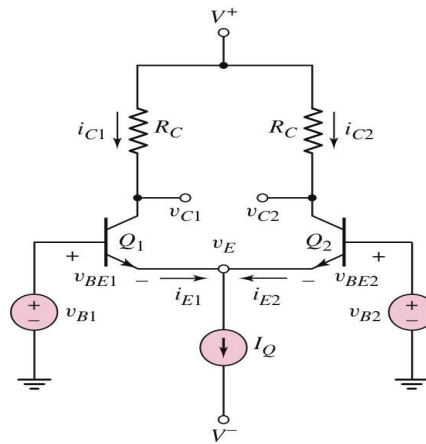
- Describe the characteristics and terminology of the ideal differential amplifier.
- Describe the characteristics of and analyze:
 - the basic bipolar differential amplifier.
 - the basic FET differential amplifier.
 - BJT and FET differential amplifiers with active loads.
 - various BiCMOS circuits.
- Analyze multistage amplifiers.
- Analyze the frequency response of the differential amplifier.

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BJT Differential-Pair Amplifier



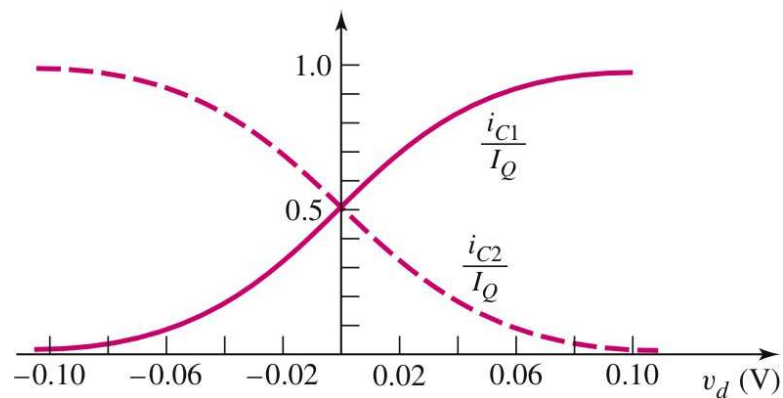
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Chapter 11-3

DC Transfer Characteristics: Bipolar Differential Amplifier



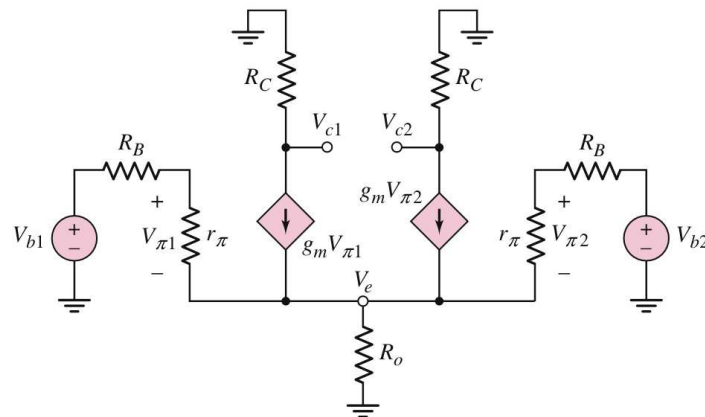
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Small-Signal Equivalent Circuit: Bipolar Differential Amplifier



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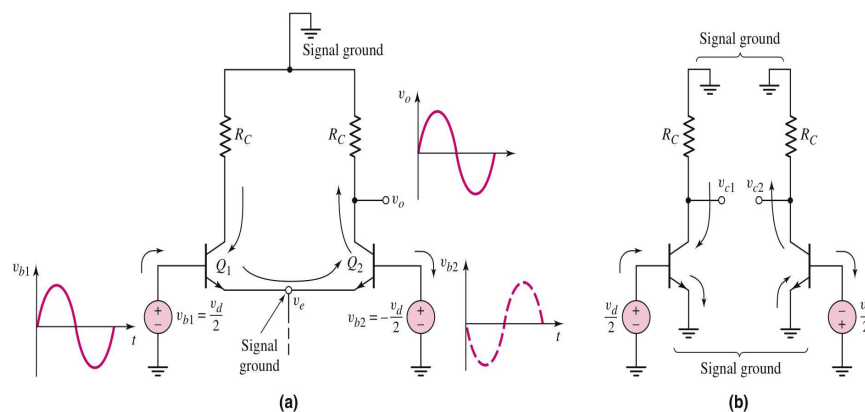
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Equivalent AC Circuit: Bipolar Differential Amplifier

Differential-mode input



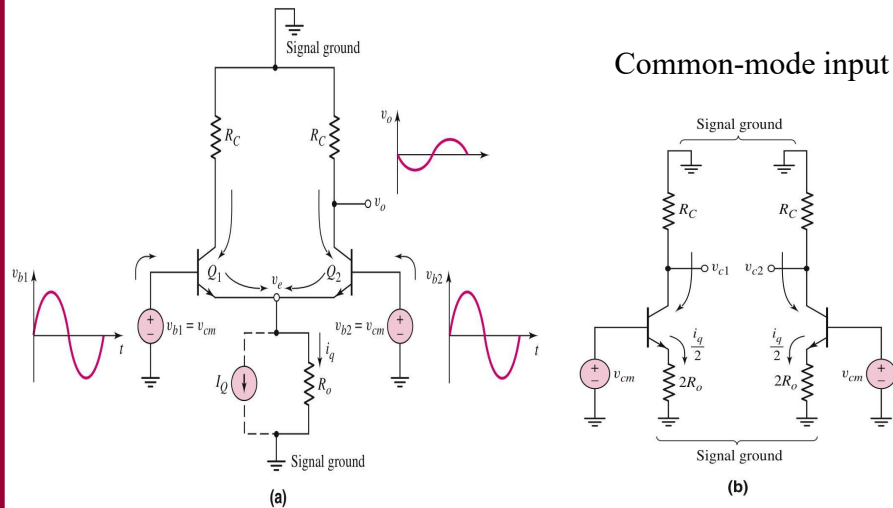
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Equivalent AC Circuit: Bipolar Differential Amplifier



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Problem-Solving Technique: Diff-Amps with Resistive Loads

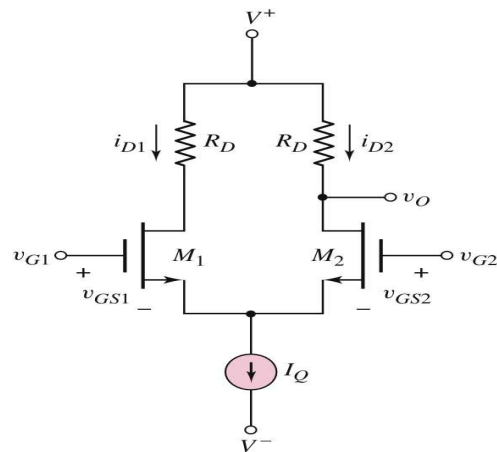
1. Apply pure differential-mode input voltage and use differential-mode half-circuit to determine differential-mode gain.
2. Apply pure common-mode input voltage and use common-mode half-circuit to determine common-mode gain.

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MOSFET Differential Pair



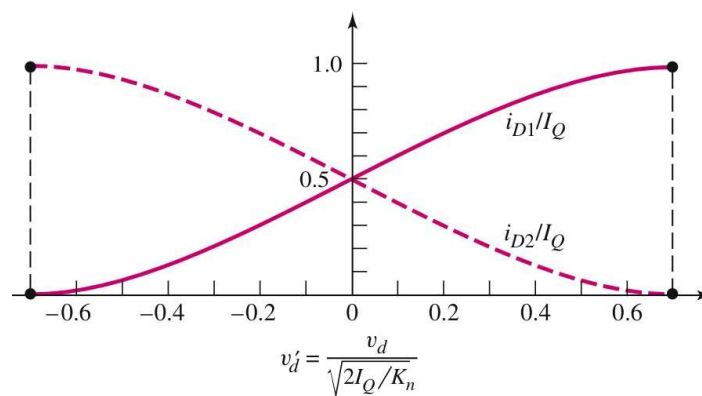
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DC Transfer Characteristics: MOSFET Differential Amplifier



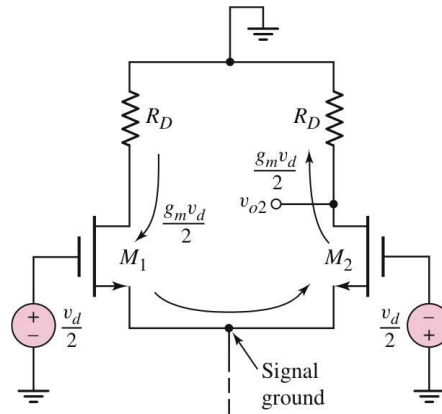
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Small-Signal Equivalent Circuit: MOSFET Differential Amplifier

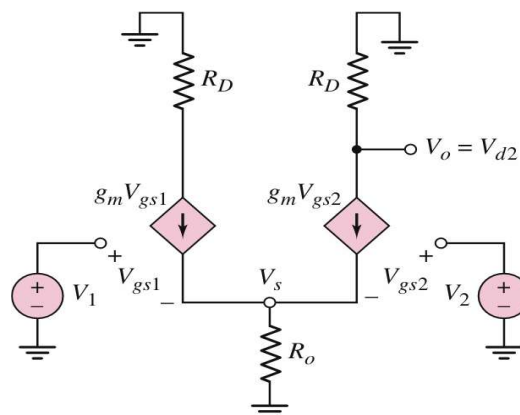


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Small-Signal Equivalent Circuit: MOSFET Differential Amplifier

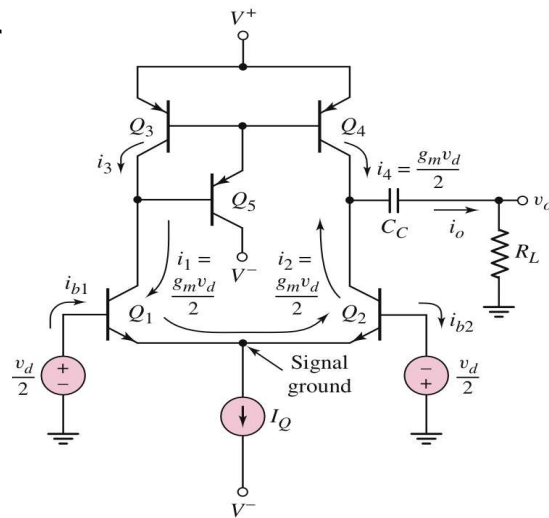


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BJT Diff-Amplifier with 3-Transistor Active Load



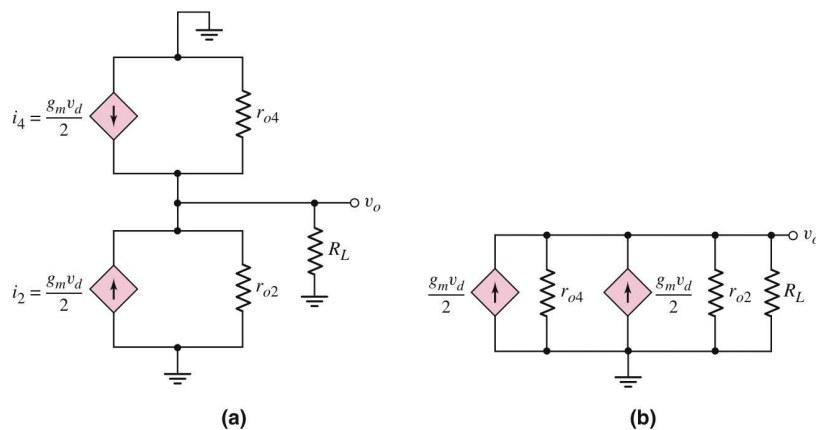
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Small-Signal Equivalent Circuit: BJT Diff-Amplifier with Active Load



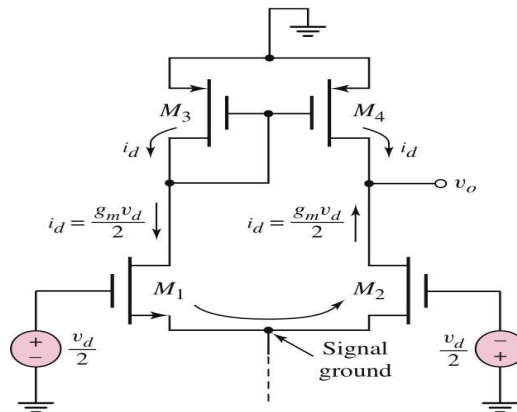
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AC Equivalent Circuit: MOSFET Diff-Amp with Active Load

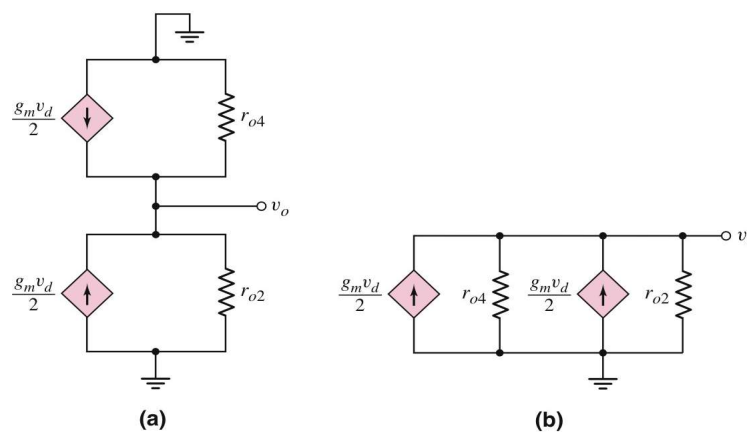


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Small-Signal Equivalent Circuit: MOSFET Diff-Amplifier with Active Load

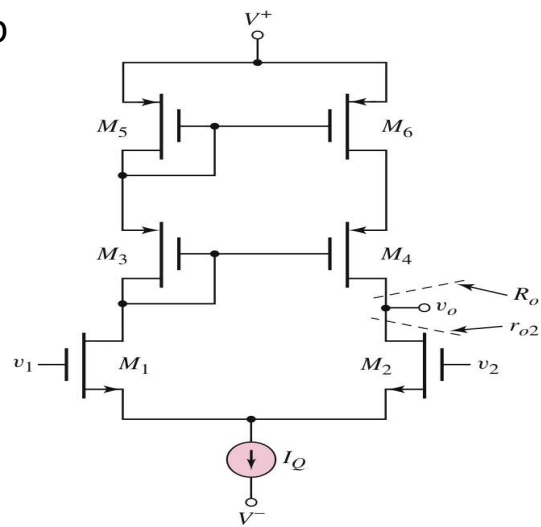


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MOSFET Diff-Amp with Cascode Active Load



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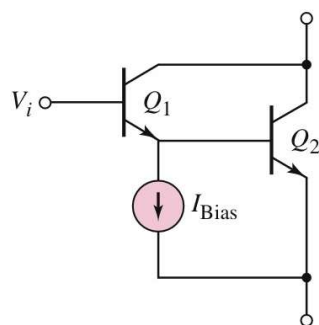
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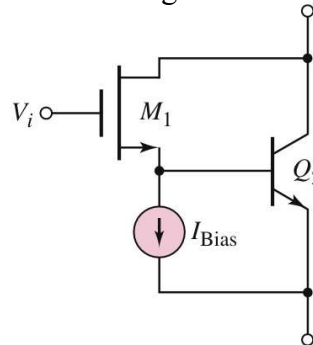
Darlington Pair

Bipolar configuration



(a)

BiMOS configuration



(b)

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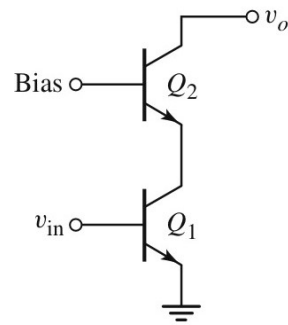
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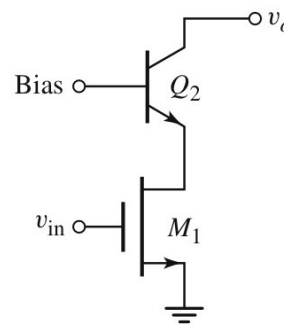
Cascode Configuration

Bipolar configuration



(a)

BiMOS configuration



(b)

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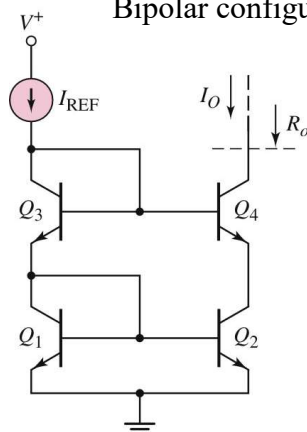
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Cascode Constant-Current Source

Bipolar configuration

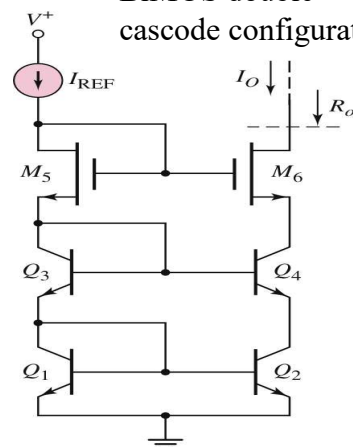


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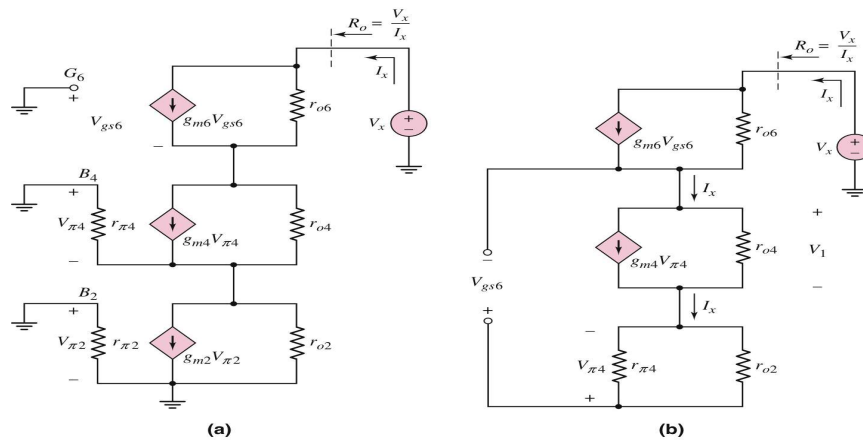
BiMOS double cascode configuration



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Small-Signal Equivalent Circuit: BiMOS Double Cascode Current Source

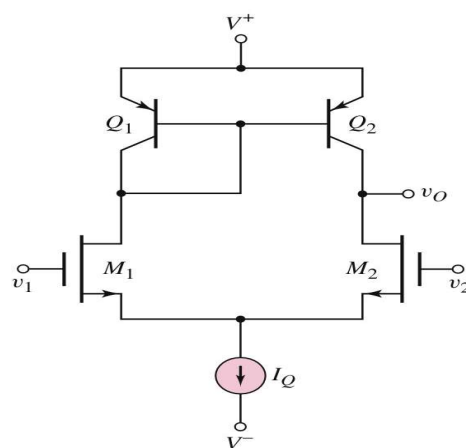


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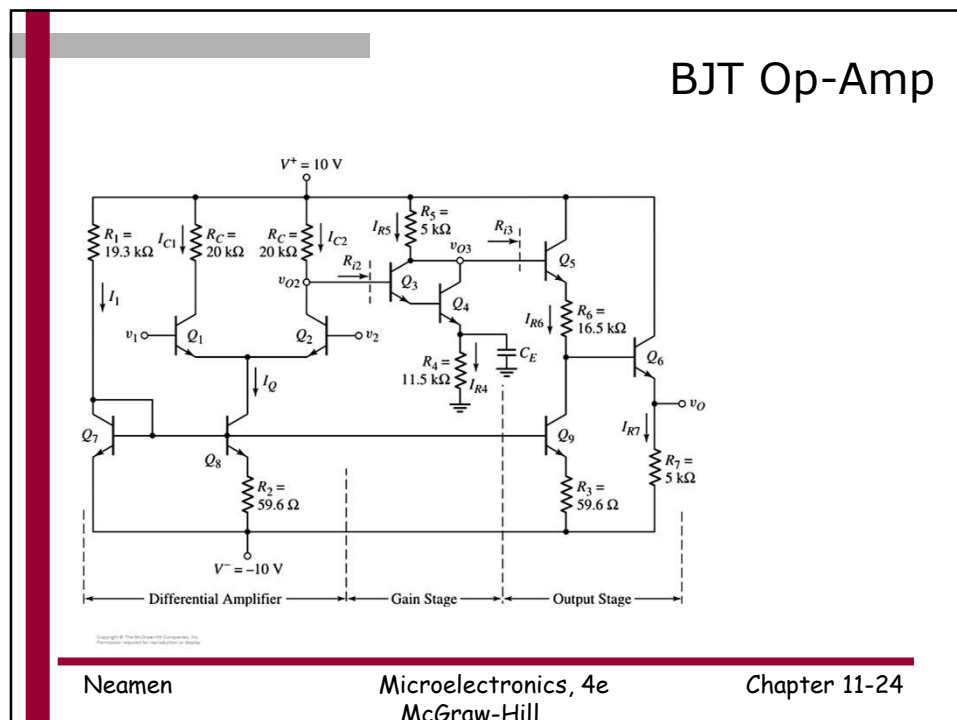
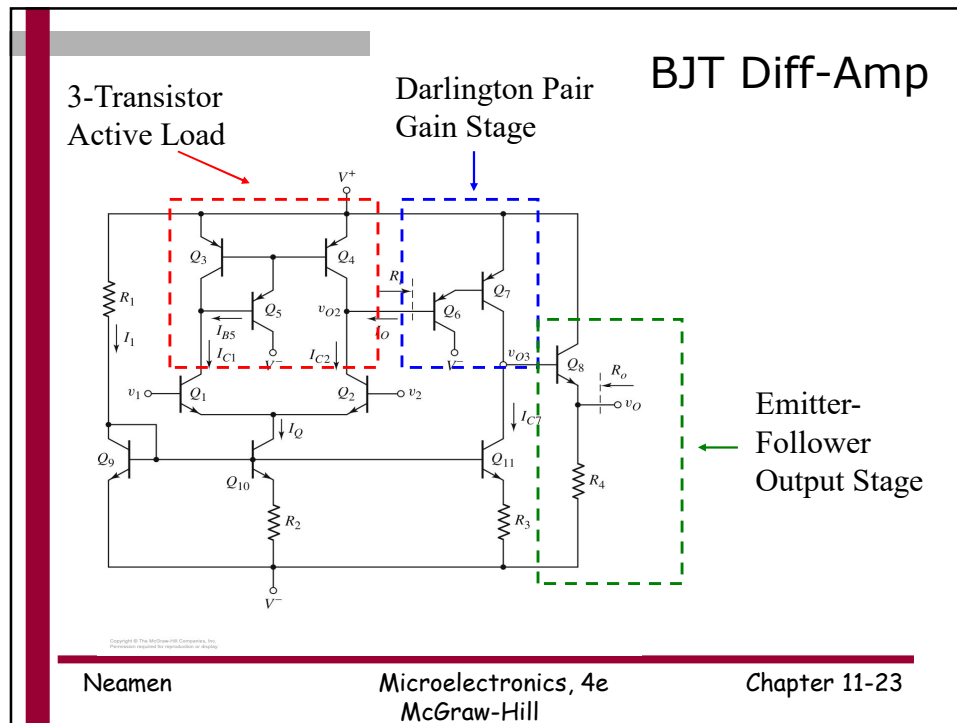
BiMOS Diff-Amp



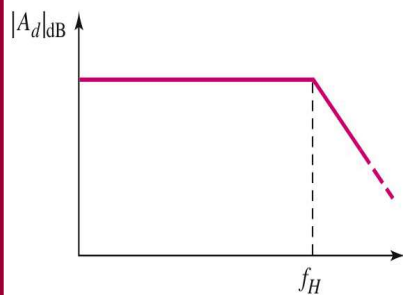
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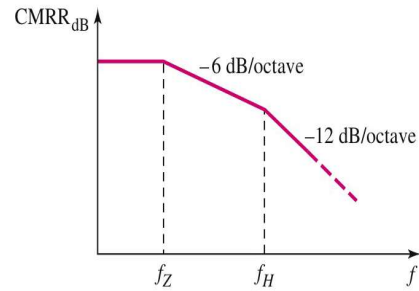


Frequency Response of Diff-Amp



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Differential-mode gain



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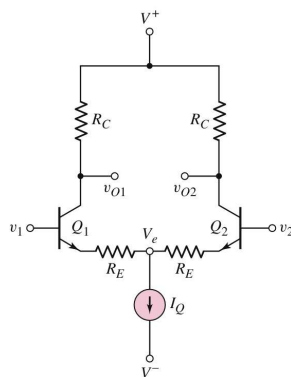
Common-mode rejection ratio
(CMRR)

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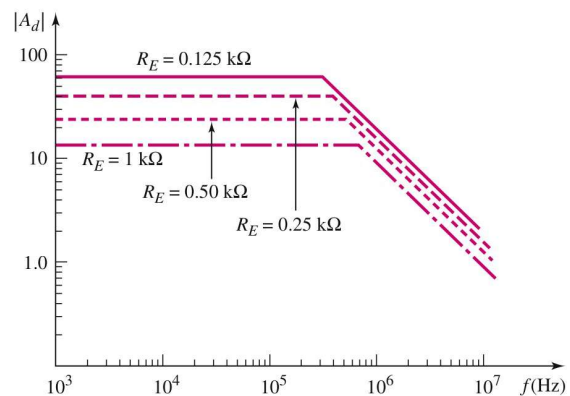
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BJT Diff-Amp with Emitter-Degeneration Resistors



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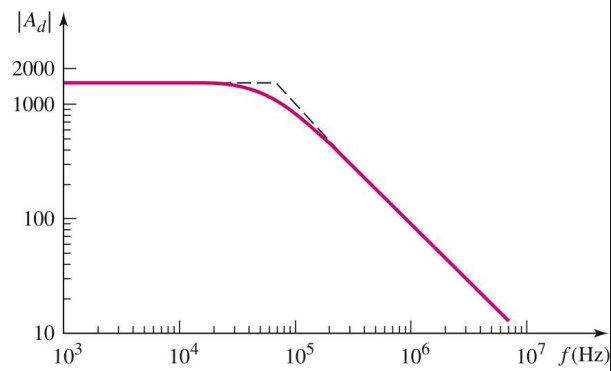
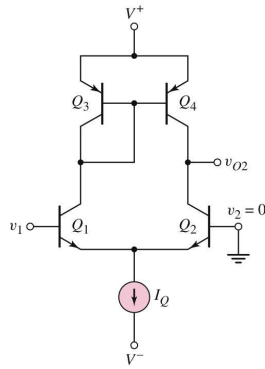
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BJT Diff-Amp with Active Load and Single-Sided Input



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