

# Lecture 24

## Multistage Amplifiers (I)

### MULTISTAGE AMPLIFIER

#### Outline

1. Introduction
2. CMOS multi-stage voltage amplifier
3. BiCMOS multistage voltage amplifier
4. BiCMOS current buffer
5. Coupling amplifier stages

#### **Reading Assignment:**

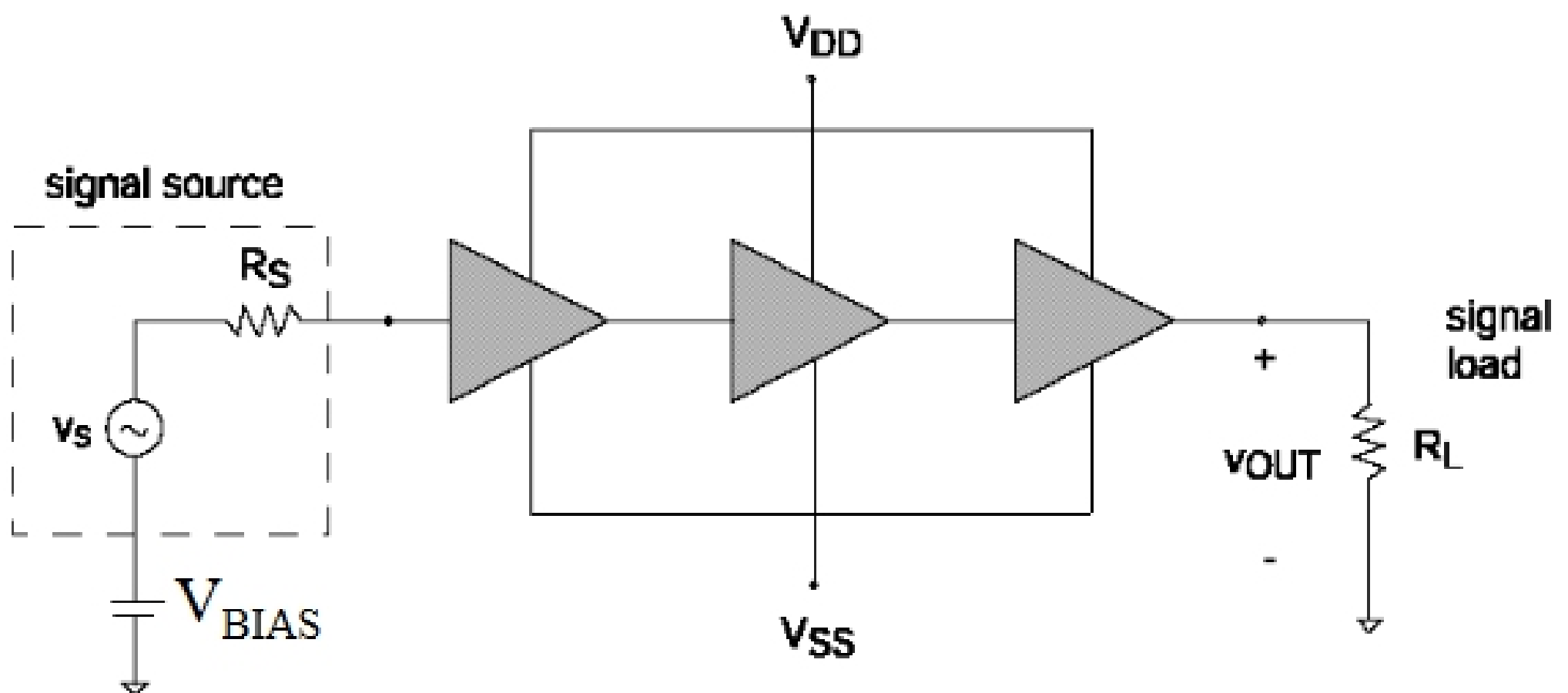
Howe and Sodini, Chapter 9, Sections 9-1-9.3

# 1. Introduction

Most often, single stage amplifier does not accomplish design goals:

- Need more gain than could be provided by a single stage
- Need to adapt to specified  $R_S$  and  $R_L$  to maximize efficiency

⇒ *Multistage amplifier*



Issues:

- What amplifying stages should be used and in what order?
- What devices should be used, BJT or MOSFET?
- How is biasing to be done?

## Summary of single stage amplifier characteristics

Stage	$A_{vo}, A_{io}$	$R_{in}$	$R_{out}$	Key Function
<b>Common Source</b>	$A_{vo} = -g_m(r_o // r_{oc})$	$\infty$	$r_o // r_{oc}$	Transconductance amplifier
<b>Common Drain</b>	$A_{vo} \approx \frac{g_m}{g_m + g_{mb}}$	$\infty$	$\frac{1}{g_m + g_{mb}}$	Voltage Buffer
<b>Common Gate</b>	$A_{io} \approx -1$	$\frac{1}{g_m + g_{mb}}$	$r_{oc} // [r_o(1 + g_m R_S)]$	Current buffer
<b>Common Emitter</b>	$A_{vo} = -g_m(r_o // r_{oc})$	$r_{\pi}$	$r_o // r_{oc}$	Transconductance amplifier
<b>Common Collector</b>	$A_{vo} \approx 1$	$r_{\pi} + \beta_o(r_o // r_{oc} // R_L)$	$\frac{1}{g_m} + \frac{R_S}{\beta_o}$	Voltage buffer
<b>Common Base</b>	$A_{io} \approx -1$	$\frac{1}{g_m}$	$r_{oc} // [r_o(1 + g_m(r_{\pi} // R_S))]$	Current buffer

### Differences between BJT's and MOSFETs

**BJT**

**MOSFET**

$$r_{\pi} = \frac{\beta_o}{g_m}$$

$$g_{mb} \propto g_m$$

$$g_m = \frac{I_C}{V_{th}}$$

$$g_m = \sqrt{2 \frac{W}{L} \mu C_{ox} I_D}$$

$$r_o = \frac{V_A}{I_C}$$

$$r_o = \frac{1}{\lambda I_D}$$