Electronics
Semester 5

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Contents

Chapter 1 **Amplifiers** **Page 2**

1.1 Gain of Amplifiers 2

1.2 Equivalent Circuit of an Amplifier 2

1.3 Cascade Amplifiers 3

Chapter 2 **Diodes** **Page 4**

2.1 The Ideal Diode 4

Simple Application: The Half-Wave Rectifier — 4

2.2 Terminal Characteristics of Junction Diodes 5

2.3 The Forward Bias Region 5

Chapter 3 **MOSFETs** **Page 6**

3.1 MOSFET Modes of Operation 6

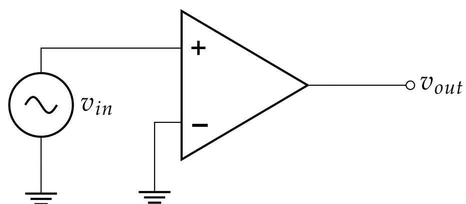
Cut-off — 6 • Triode — 6 • Saturation — 6

Chapter 1

Amplifiers

1.1 Gain of Amplifiers

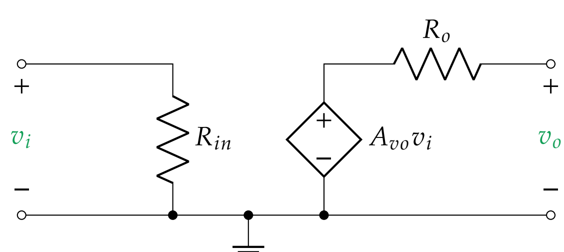
$$\text{Voltage Gain} = \frac{v_{out}}{v_{in}}$$
$$\text{Current Gain} = \frac{i_{out}}{i_{in}}$$
$$\text{Power Gain} = \frac{P_{out}}{P_{in}}$$



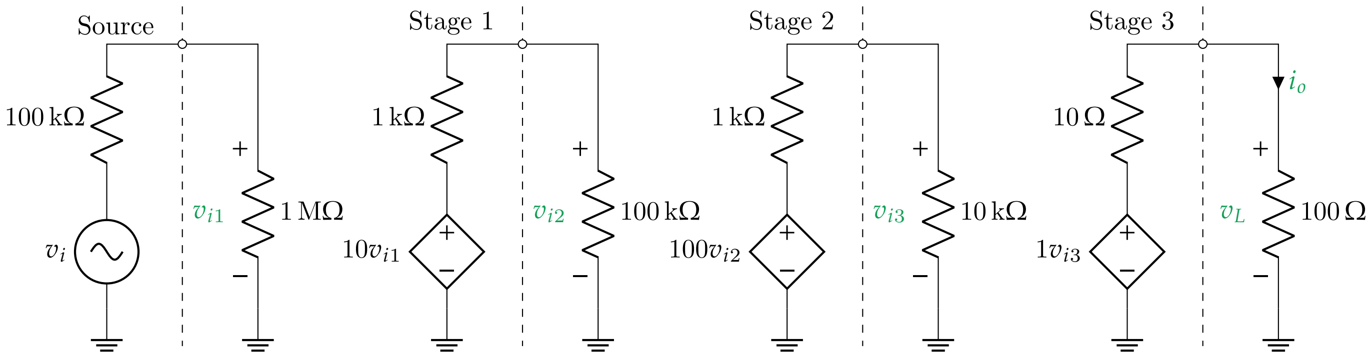
In decibels, the gain is given by

$$\text{Voltage Gain} = 20\log\left(\frac{v_{out}}{v_{in}}\right)$$
$$\text{Current Gain} = 20\log\left(\frac{i_{out}}{i_{in}}\right)$$
$$\text{Power Gain} = 10\log\left(\frac{P_{out}}{P_{in}}\right)$$

1.2 Equivalent Circuit of an Amplifier



1.3 Cascade Amplifiers



In the above circuit, the output voltage is given by

$$v_L = 10 \cdot \frac{1\,\mathrm{M\Omega}}{1\,\mathrm{M\Omega} + 100\,\mathrm{k\Omega}} \cdot 100 \cdot \frac{100\,\mathrm{k\Omega}}{100\,\mathrm{k\Omega} + 1\,\mathrm{k\Omega}} \cdot 1 \cdot \frac{10\,\mathrm{k\Omega}}{10\,\mathrm{k\Omega} + 1\,\mathrm{k\Omega}} \cdot \frac{100\,\Omega}{100\,\Omega + 10\,\Omega} \cdot v_i.$$

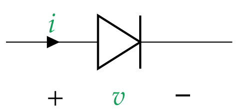
$$A_v = \frac{v_L}{v_i} = 743.876\,\mathrm{V/V}.$$

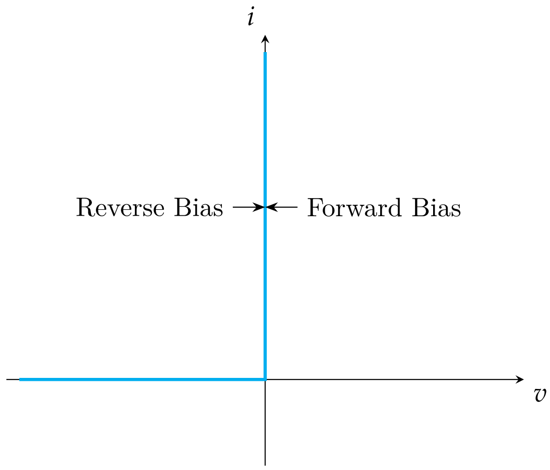
Chapter 2

Diodes

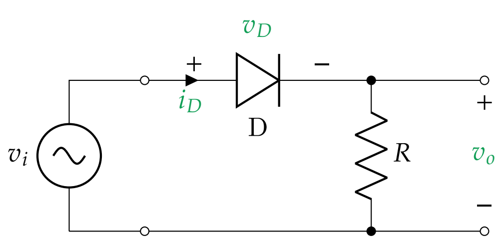
2.1 The Ideal Diode

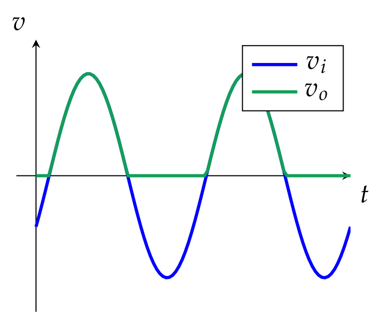
The ideal diode is a two terminal device that allows current to flow in one direction only.



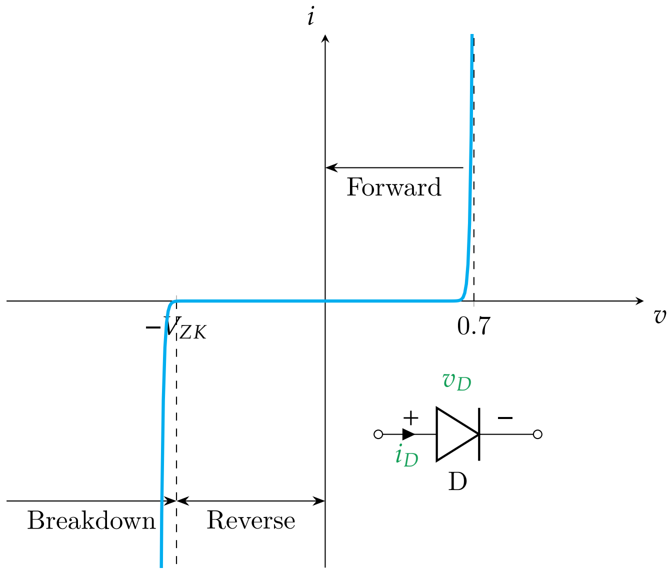


2.1.1 Simple Application: The Half-Wave Rectifier





2.2 Terminal Characteristics of Junction Diodes



The characteristic curve of a diode consists of three regions:

1. The forward bias region, where the diode conducts current. $v_D > 0$.
2. The reverse bias region, where the diode blocks current. $v_D < 0$.
3. The breakdown region, where the diode conducts current in the reverse direction. $v_D < -V_{ZK}$.

2.3 The Forward Bias Region

In the forward bias region, the diode conducts current. The current is given by

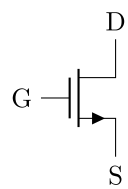
$$i = I_S \left(e^{\frac{v}{V_T}} - 1 \right).$$

Where I_S is the reverse saturation current, and $V_T \approx 25\,\mathrm{mV}$ is the thermal voltage.

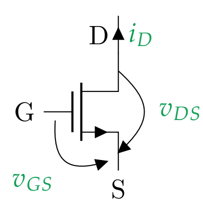
Chapter 3

MOSFETs

A MOSFET is a Metal Oxide Semiconductor Field Effect Transistor. It is a voltage controlled device. It has three terminals: the gate, the source, and the drain.



3.1 MOSFET Modes of Operation



3.1.1 Cut-off

In this mode, the MOSFET is off ($i_D = 0$). The MOSFET is in cut-off when $v_{GS} \leqslant V_{th}$. Where V_{th} is the threshold voltage of the MOSFET.

3.1.2 Triode

In this mode, the MOSFET is on ($i_D \neq 0$). The MOSFET conducts current from the drain to the source. The MOSFET is in triode when $v_{GS} > V_{th}$ and $v_{DS} < v_{GS} - V_{th}$.

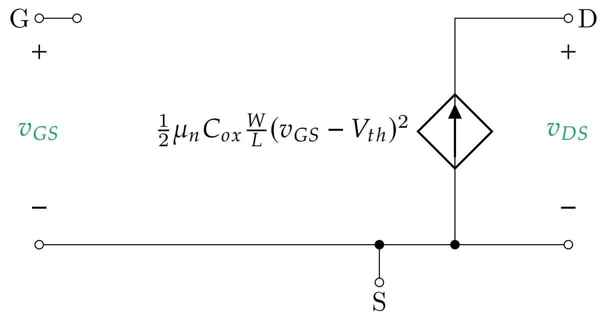
$$i_D = \mu_n C_{ox} \frac{W}{L} \left[(v_{GS} - V_{th}) v_{DS} - \frac{v_{DS}^2}{2} \right].$$

3.1.3 Saturation

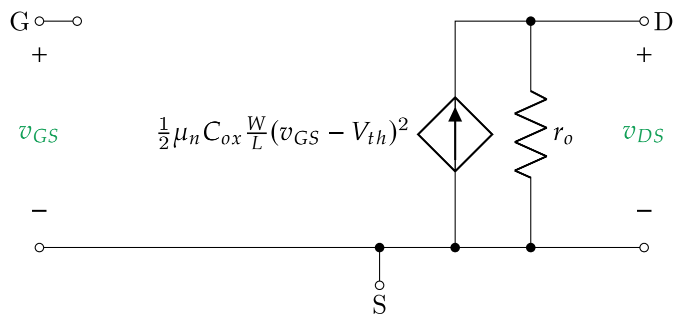
In this mode, the MOSFET is on ($i_D \neq 0$). The MOSFET conducts current from the drain to the source. The MOSFET is in saturation when $v_{GS} > V_{th}$ and $v_{DS} > v_{GS} - V_{th}$.

$$i_D = \frac{1}{2} \mu_n C_{ox} \frac{W}{L} (v_{GS} - V_{th})^2.$$

The large signal model of a MOSFET in saturation is as follows:



Accounting for the early effect.



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