Electronic Devices & Circuits

Dr. Hina Gohar Ali

Hina.gohar@seecs.edu.pk

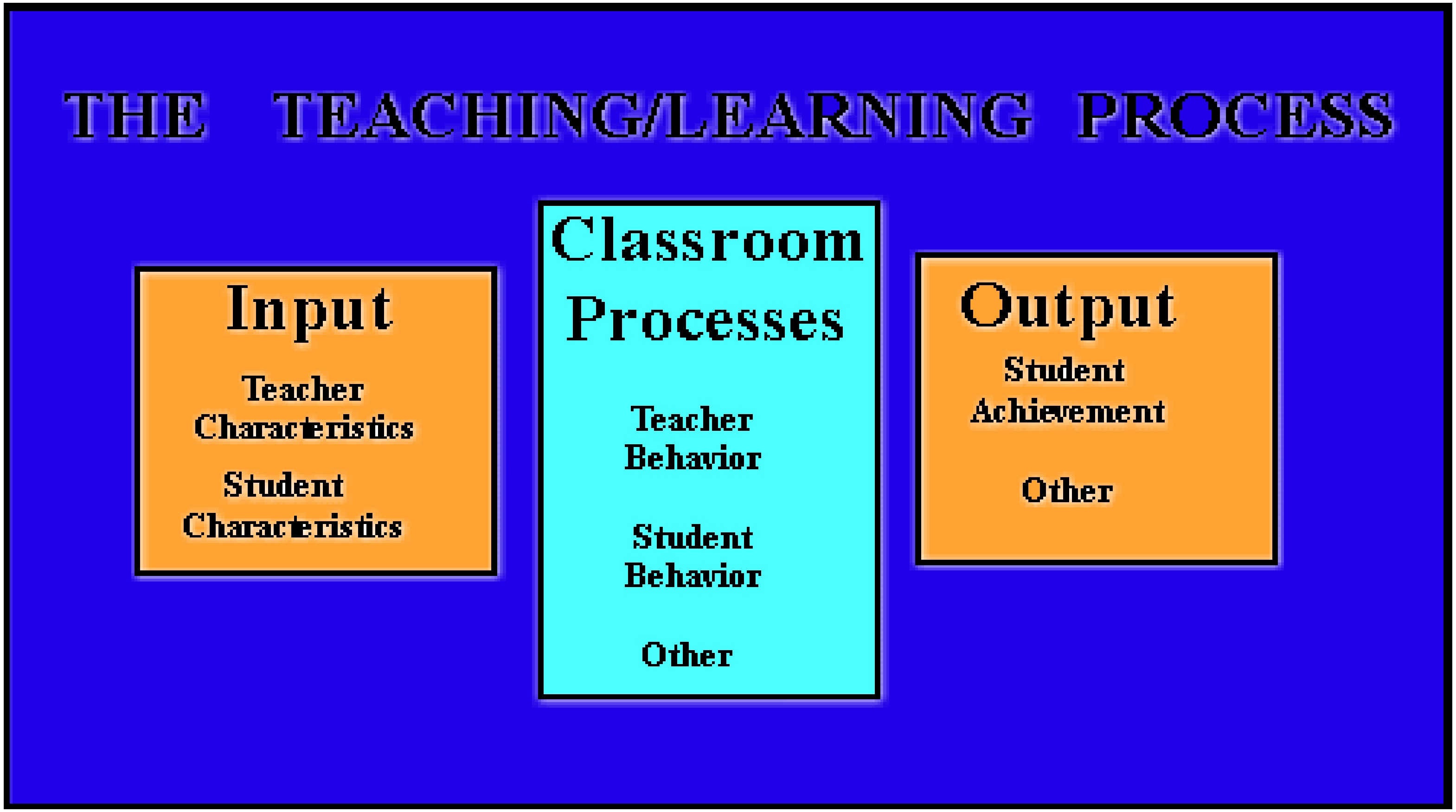
Office : KBS Lab 1st floor SEECS Building

Office Hours: Open door policy/Appointment through emails

Research Interest: Photovoltaic systems, Power Electronics and Control, Renewable energy, Sliding mode control (SMC), Artificial Intelligence for PV systems

Electronic Devices & Circuits

Learning Process



My Intro….

Academic

2007-2010 **B.E Electronic Engineering**
NED University of Engineering & Technology, Karachi-Pakistan

2013- Jan 2015 **MS Electronic Engineering**
GIK Institute of Engineering Sciences & Technology, Topi-Pakistan

Oct 2016-2020 **Doctorate/Ph.D.** Electrical & Telecommunication Engineering (Excellent Grade)
Universitat Autonoma de Barcelona, Spain

Ph.D. Thesis: *Maximum Power Point Tracking of Photovoltaic System using Non-Linear Controllers*

Professional Experience

Feb 2021-Present **Assistant Professor**
SEECS, NUST Islamabad, Pakistan

May 2015-Oct 2016 **Lecturer (Adhoc BPS-18)**
B.U.I.T.E.M.S Department of Electrical Engineering, Quetta Pakistan

Jan 2013-Dec 2014 **Graduate Assistant**
GIK Institute Faculty of Electrical Engineering , Topi-Pakistan

Profile

https://www.linkedin.com/in/hina-gohar-ali-40b7a2197/

https://www.researchgate.net/profile/Hina-Gohar-Ali

https://scholar.google.com/citations?user=Z-5yLJEAAAAJ

Important

Some Rules to be observed

- Please be courteous in class
- Punctuality
- Cell phones/Tabs/ Laptops are not allowed to be used
- Ask questions related to the course …
- Drinking or eating in the class or laboratory is strictly prohibited
- *There are things that you cannot learn from reading notes*
- …

Important Values (to be in good books of Instruct

- Discipline, Respectful & Obedient Students
- Learn Smart & Work Smart
- Focus on Concepts , Revise, Discuss
- Be kind & understand each other
- Mutual understanding, help & build each other
- No Tolerance to any kind of disrespect of Discipline Violation
- Make great memories along with learning
- Keep Good Relation everyone around
- Students really matter (the strength)
- Practice, Practice!!

Today's Lecture

- About the Course Title
- Basic Concepts
- Operational Amplifiers

Chapter 1

Introduction to Electronics





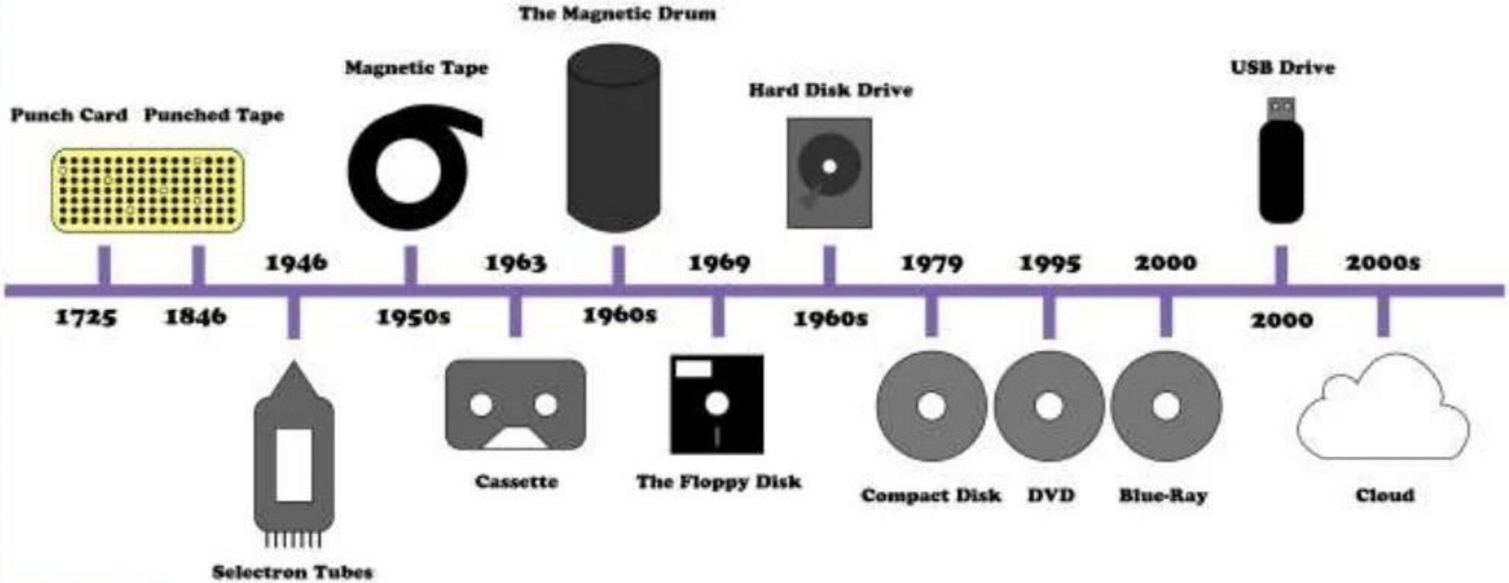


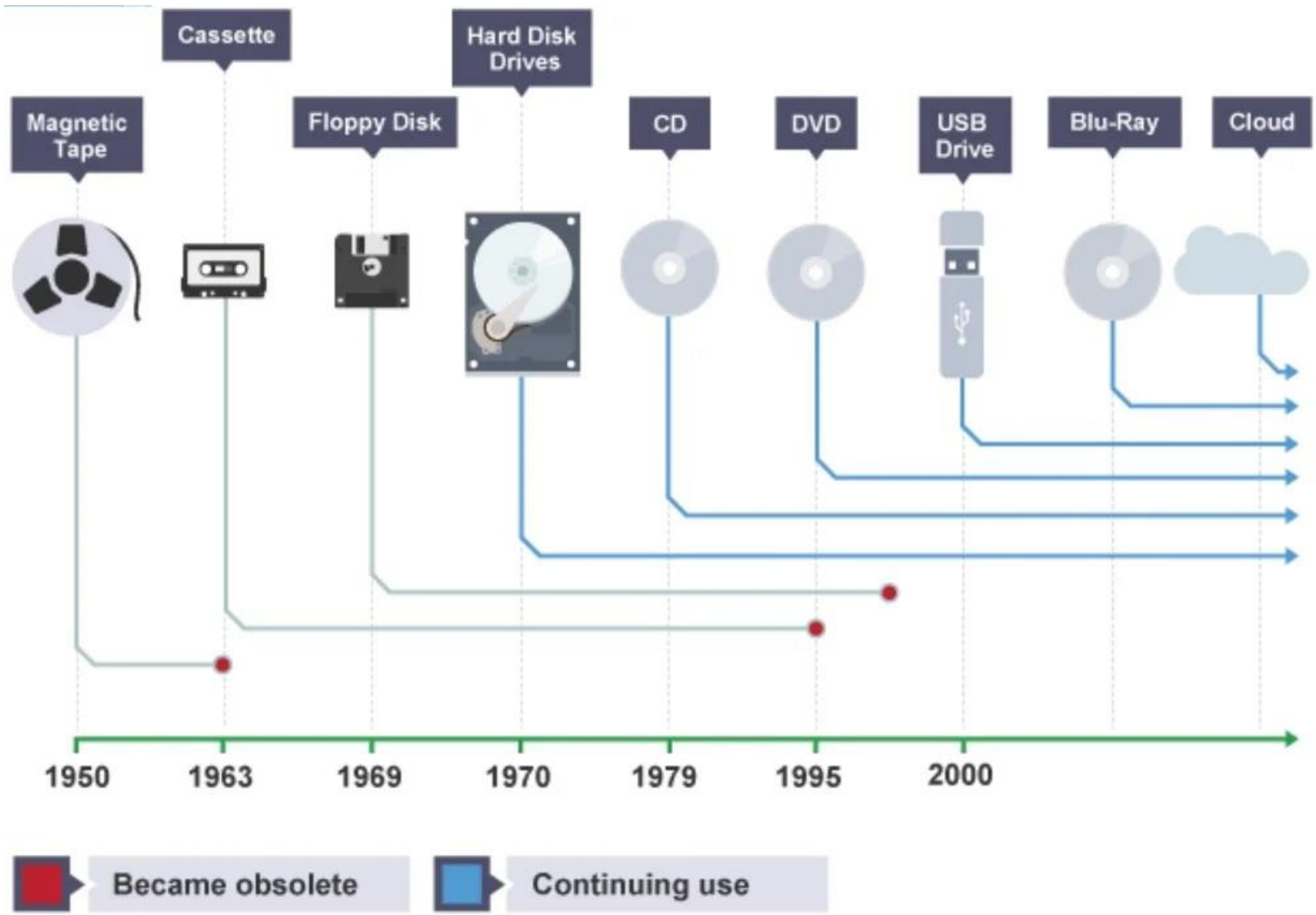


Power switch
Camera
Microphone
The schema
translation switch
USB
Pen



Data Storage Devices Timline



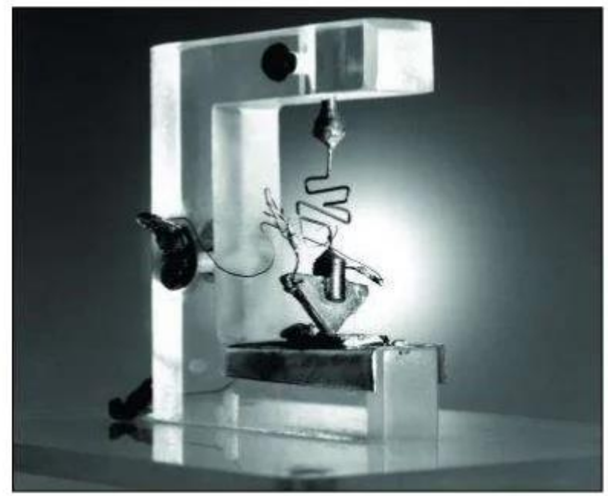


Magnetic Tape
Cassette
Floppy Disk
Hard Disk Drives
CD
DVD
USB Drive
Blu-Ray
Cloud
1950
1963
1969
1970
1979
1995
2000
Became obsolete
Continuing use


The Sony Timeline
by Jesús Díaz · Gizmodo
SONY
1946
1950
1955
1958
1960
1963
1965
1967
1968
1970
1971
1974
1975
1979
1980
1982
1983
1984
1985
1987
1988
1989
1990
1991
1992
1994
1995
1996
1997
2000
2003
2004
2005
2006
2007
2009

The Start of the Modern Electronics Era

Bardeen, Shockley, and Brattain at Bell Labs - Brattain and Bardeen invented the bipolar transistor in 1947.



The first germanium bipolar transistor. Roughly 50 years later, electronics account for 10% (4 trillion dollars) of the world GDP.

Electronics Milestones

1874 Braun invents the solid-state rectifier.

1906 DeForest invents triode vacuum tube.

1907-1927 First radio circuits developed from diodes and triodes.

1925 Lilienfeld field-effect device patent filed.

1947 Bardeen and Brattain at Bell Laboratories invent bipolar transistors.

1952 Commercial bipolar transistor production at Texas Instruments.

1956 Bardeen, Brattain, and Shockley receive Nobel prize.

1958 Integrated circuits developed by Kilby and Noyce

1961 First commercial IC from Fairchild Semiconductor

1963 IEEE formed from merger of IRE and AIEE

1968 First commercial IC opamp

1970 One transistor DRAM cell invented by Dennard at IBM.

1971 4004 Intel microprocessor introduced.

1978 First commercial 1-kilobit memory.

1974 8080 microprocessor introduced.

1984 Megabit memory chip introduced.

2000 Alferov, Kilby, and Kromer share Nobel prize

Evolution of Electronic Devices

Vacuum Tubes

(a)

(b)

Discrete Transistors

SSI and MSI Integrated Circuits

(c)

(d)

VLSI Surface-Mount Circuits

Introduction to Electronics

Types of Electricity

- Two forms of electricity ***Static*** and ***Produced***
- ***Static Electricity*** is an electrical charge at rest.
- ***Produced Electricity*** is produced by either magnetism, chemicals, light, heat, or pressure.

Introduction to Electronics

The study of electronics can be broken down into four basic steps:

- Step 1 – Basic Electricity
- Step 2 – Electronic Components
- Step 3 – Electronic Circuits
- Step 4 – Electronic Systems

Materials Used In Electronics

Insulators

- An **insulator** is a material that does not conduct electrical current under normal conditions.
- Most good insulators are compounds rather than single-element materials and have very high resistivities.
- Valence electrons are tightly bound to the atoms; therefore, there are very few free electrons in an insulator.
- Examples of insulators are rubber, plastics, glass, mica, and quartz.

Materials Used In Electronics

★ *Conductors*

- A **conductor** is a material that easily conducts electrical current.
- Most metals are good conductors.
- The best conductors are single-element materials, such as copper (Cu), silver (Ag), gold (Au), and aluminum (Al), which are characterized by atoms with only one valence electron very loosely bound to the atom.

Materials Used In Electronics

- ***Semiconductors***
  - A **semiconductor** is a material that is between conductors and insulators in its ability to conduct electrical current.
  - A semiconductor in its pure (intrinsic) state is neither a good conductor nor a good insulator.
  - Single-element semiconductors are antimony (Sb), arsenic (As), astatine (At), boron (B), polonium (Po), tellurium (Te), silicon (Si), and germanium (Ge).

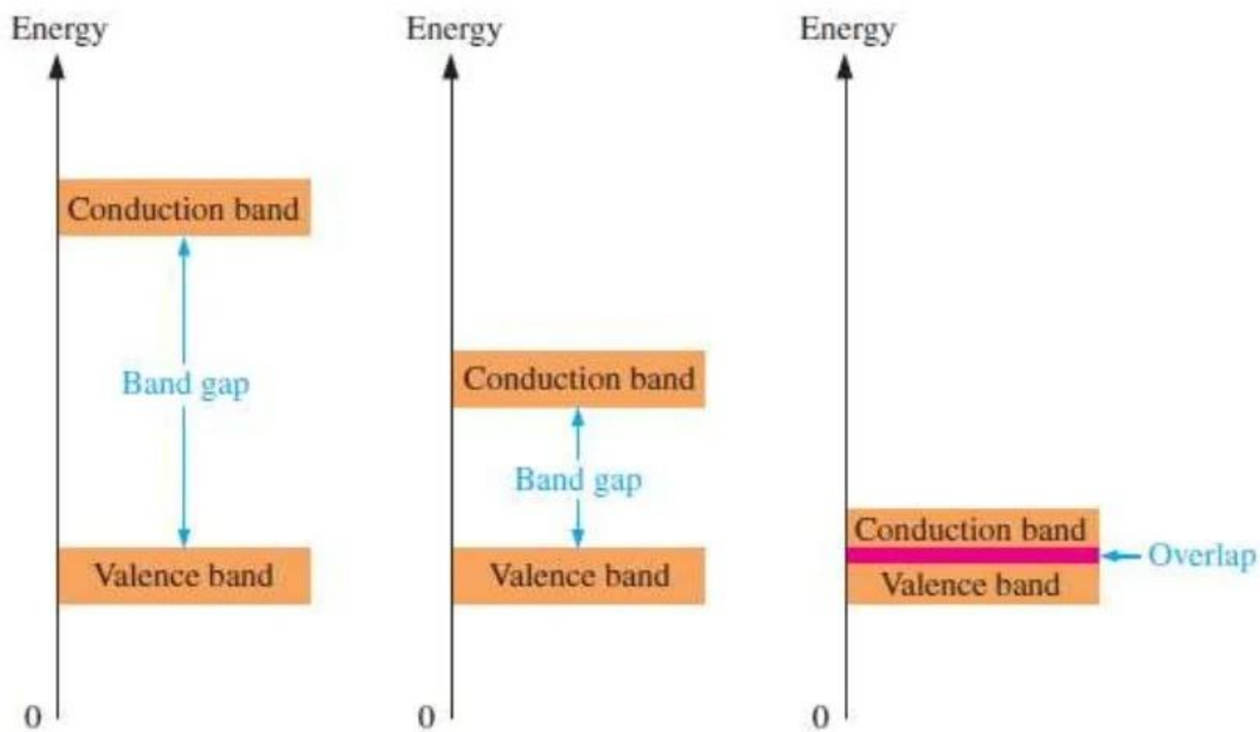
Materials Used In Electronics

- *Semiconductors*
  - Compound semiconductors such as gallium arsenide, indium phosphide, gallium nitride, silicon carbide, and silicon germanium are also commonly used.
  - The single-element semiconductors are characterized by atoms with four valence electrons.
  - Silicon is the most commonly used semiconductor.

Band Gap

- Valence shell of an atom represents a band of energy levels and that the valence electrons are confined to that band.
- When an electron acquires enough additional energy, it can leave the valence shell, become a *free electron*, and exist in what is known as the *conduction band.*
- The difference in energy between the valence band and the conduction band is called an *energy gap* or **band gap**.

Band Gap

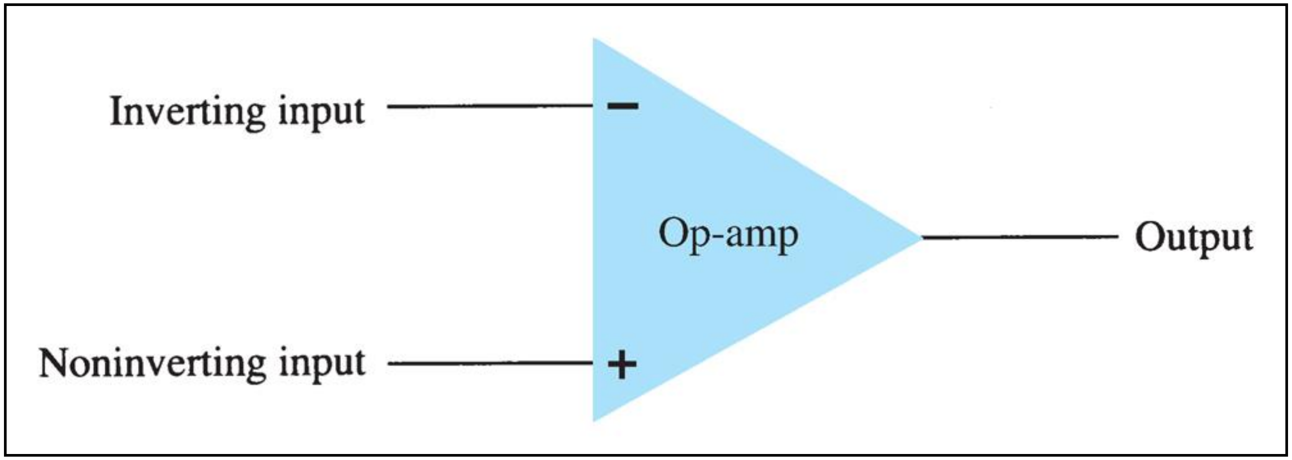


(a) Insulator (b) Semiconductor (c) Conductor

Chapter 2

Operational Amplifiers

The Basic Op-Amp



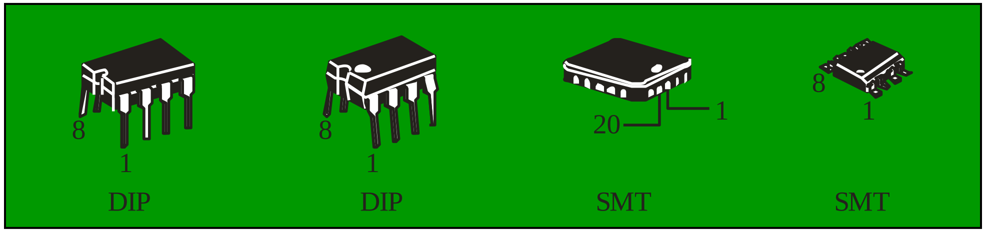
Operational amplifier (Op-amp): A high gain differential amplifier with a high input impedance (typically in MΩ) and low output impedance (less than 100Ω).

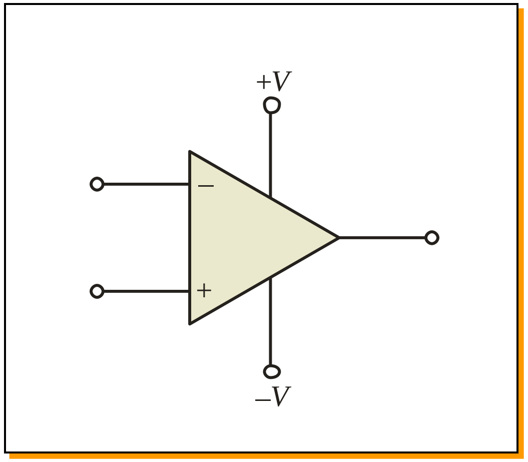
Note the op-amp has two inputs and one output.

The Basic Op-Amp

Operational amplifiers (op-amps) are very high gain dc coupled amplifiers with differential inputs. One of the inputs is called the inverting input (–); the other is called the noninverting input. Usually there is a single output.

Most op-amps operate from plus and minus supply voltages, which may or may not be shown on the schematic symbol.





Op-Amp Gain

Op-Amps can be connected in *open-loop* or *closed-loop* configurations.

Open-loop: A configuration with no feedback from the op-amp output back to its input. Op-amp open-loop gain typically exceeds 10,000.

Closed-loop: A configuration that has a negative feedback path from the op-amp output back to its input. **Negative feedback** reduces the gain and improves many characteristics of the op-amp.

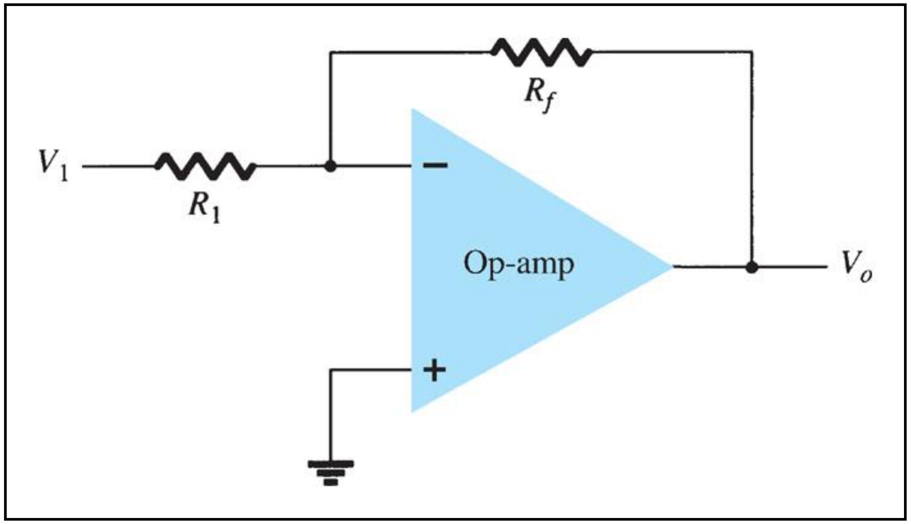
- Closed-loop gain is always lower than open-loop gain.

Inverting Op-Amp

The input signal is applied to the **inverting (–) input**

The **non-inverting input (+)** is grounded

The **feedback resistor** (R_f) is connected from the output to the negative (inverting) input; providing *negative feedback*.



Inverting Op-Amp Gain

Gain is set using external resistors: R_f and R_1

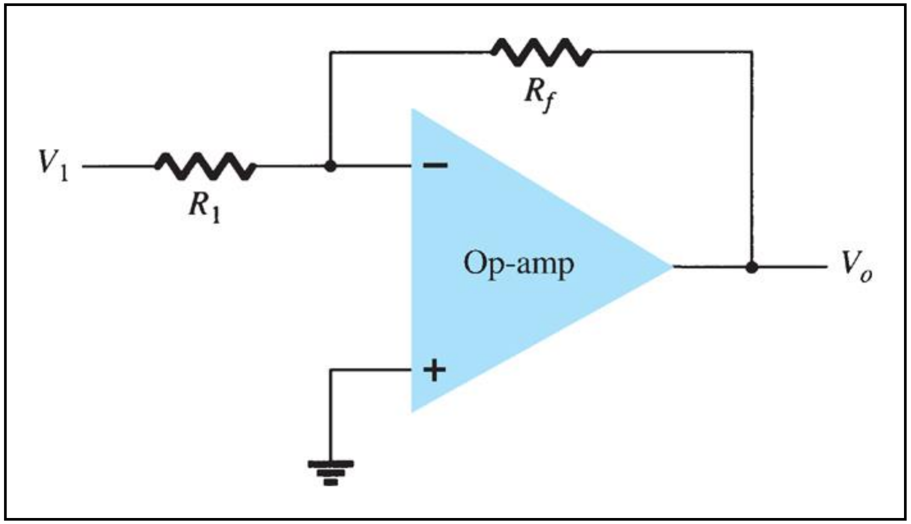
$$A_v = \frac{V_o}{V_i} = \frac{R_f}{R_1}$$

Gain can be set to any value by manipulating the values of R_f and R_1.

Unity gain ($A_v = 1$):

$$R_f = R_1$$

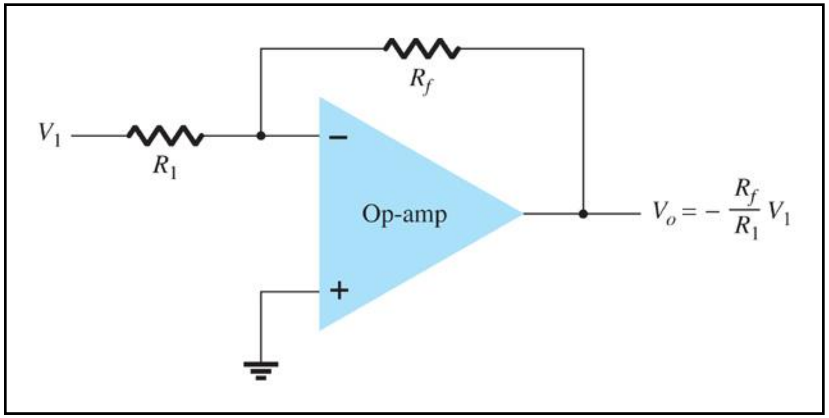
$$A_v = \frac{-R_f}{R_1} = -1$$



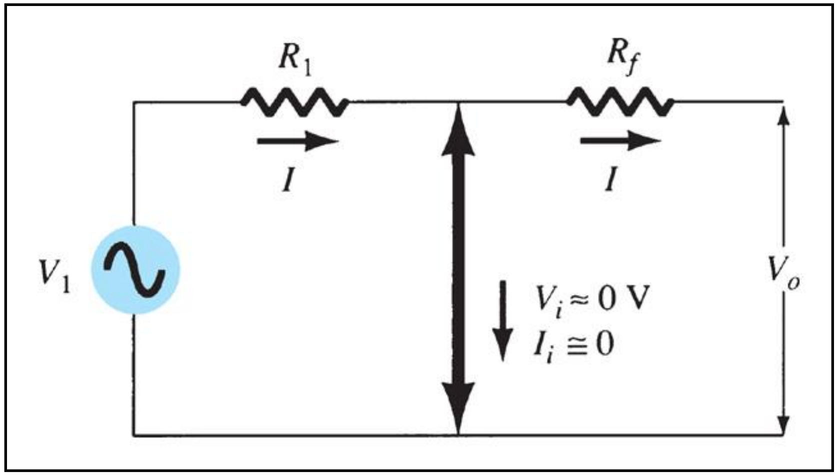
The negative sign denotes a 180° phase shift between input and output.

Virtual Ground

Virtual ground: A term used to describe the condition where $V_i \cong 0$ V (at the inverting input) when the noninverting input is grounded.



The op-amp has such high input impedance that even with a high gain there is no current through the inverting input pin, therefore all of the input current passes through R_f.



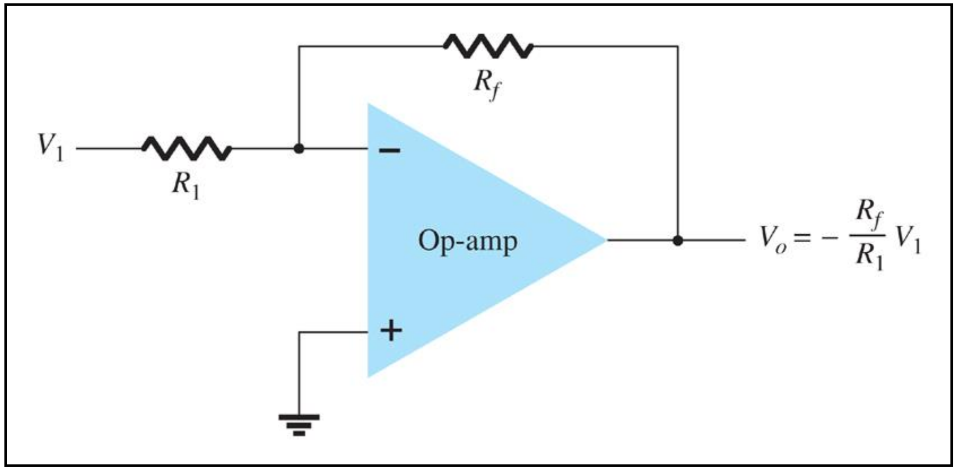
Common Op-Amp Circuits

- Inverting amplifier
- Noninverting amplifier
- Unity follower
- Summing amplifier
- Integrator
- Differentiator

Inverting/Noninverting Amplifiers

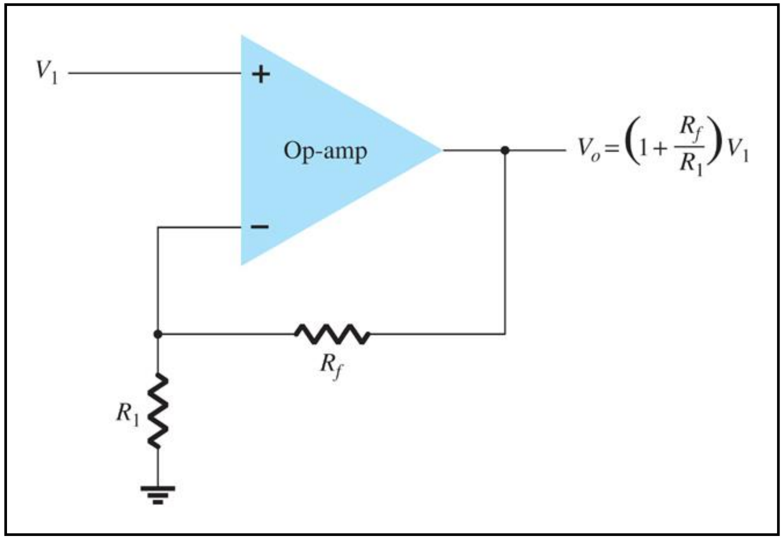
Inverting Amplifier

$$V_o = \frac{-R_f}{R_1} V_1$$



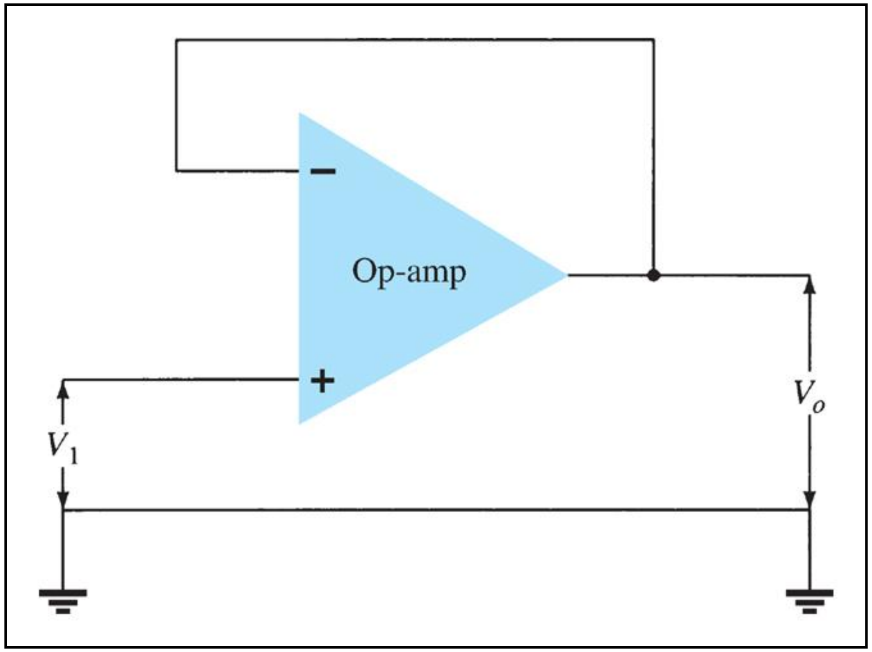
Noninverting Amplifier

$$V_o = (1 + \frac{R_f}{R_1}) V_1$$



Unity Follower

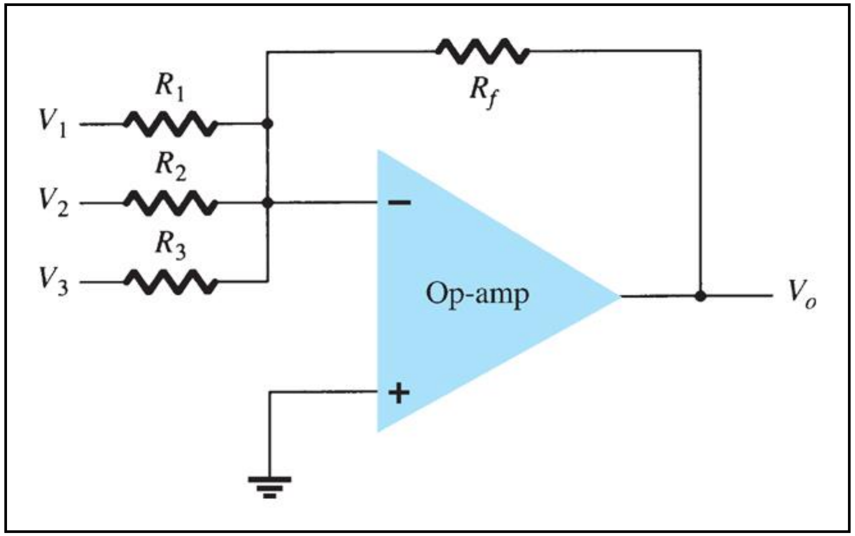
$$V_o = V_1$$



Summing Amplifier

Because the op-amp has a high input impedance, the multiple inputs are treated as separate inputs.

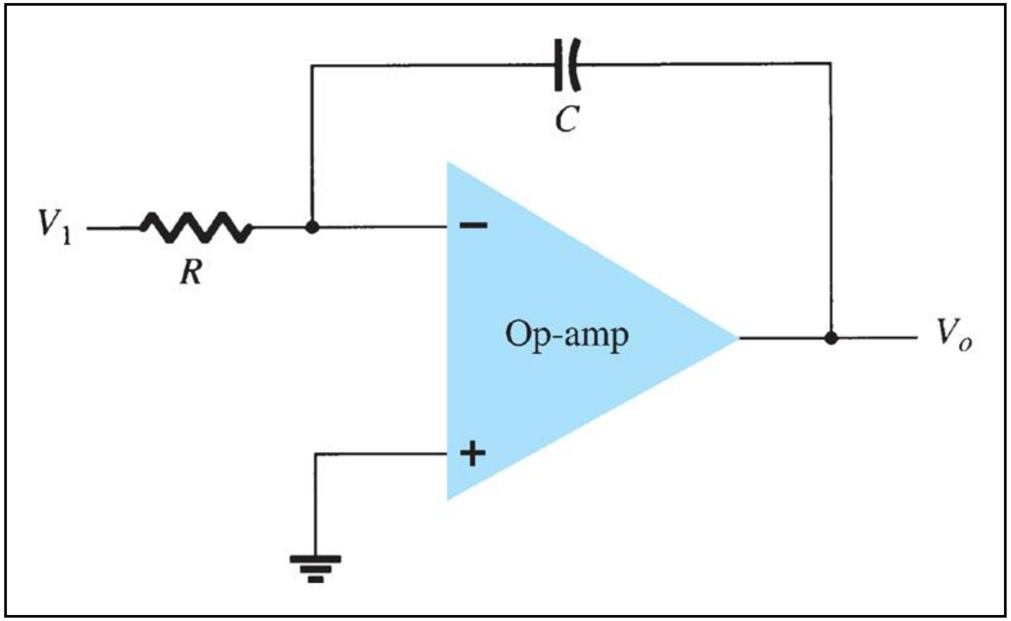
$$V_o = -\left(\frac{R_f}{R_1}V_1 + \frac{R_f}{R_2}V_2 + \frac{R_f}{R_3}V_3\right)$$



Integrator

The output is the integral of the input; i.e., proportional to the area under the input waveform. This circuit is useful in low-pass filter circuits and sensor conditioning circuits.

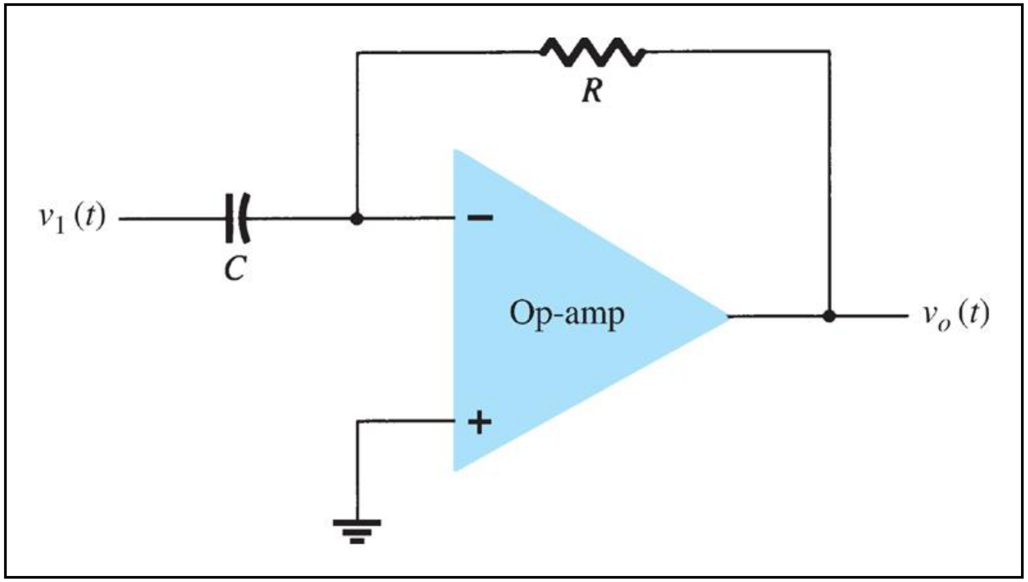
$$v_o(t) = -\frac{1}{RC}\int v_1(t)dt$$



Differentiator

The differentiator takes the derivative of the input. This circuit is useful in high-pass filter circuits.

$$v_o(t) = -RC\frac{dv_1(t)}{dt}$$



DC-Offset Parameters

Even when the input voltage is zero, an op-amp can have an output **offset**. The following can cause this offset:

Input offset voltage
Input offset current
Input offset voltage *and* input offset current
Input bias current

Input Offset Voltage (V_{IO})

The specification sheet for an op-amp indicates an **input offset voltage** (V_{IO}).

The effect of this input offset voltage on the output can be calculated with

$$V_{o(offset)} = V_{IO}\,\frac{R_1 + R_f}{R_1}$$

Input Offset Current (I_{IO})

If there is a difference between the dc bias currents generated by the same applied input, this also causes an output offset voltage:

The **input offset current** (I_{IO}) is specified in the specifications for an op-amp.

The effect of I_{IO} on the output offset voltage can be calculated using:

$$V_{o(offset)} = V_{o(offset\ due\ to\ V_{IO})} + V_{o(offset\ due\ to\ I_{IO})}$$

Total Offset Due to V_{IO} and I_{IO}

Op-amps may have an output offset voltage due to V_{IO} and I_{IO}. The total output offset voltage equals the sum of the effects of both:

$$V_o(offset) = V_o(offset\ due\ to\ V_{IO}) + V_o(offset\ due\ to\ I_{IO})$$

Input Bias Current (I_{IB})

A parameter that is related to input offset current (I_{IO}) is called **input bias current** (I_{IB})

The input bias currents are calculated using:

$$I_{IB}^{-} = I_{IB} - \frac{I_{IO}}{2}$$

$$I_{IB}^{+} = I_{IB} + \frac{I_{IO}}{2}$$

The total input bias current is the average of the two:

$$I_{IB} = \frac{I_{IB}^{-} + I_{IB}^{+}}{2}$$

Frequency Parameters

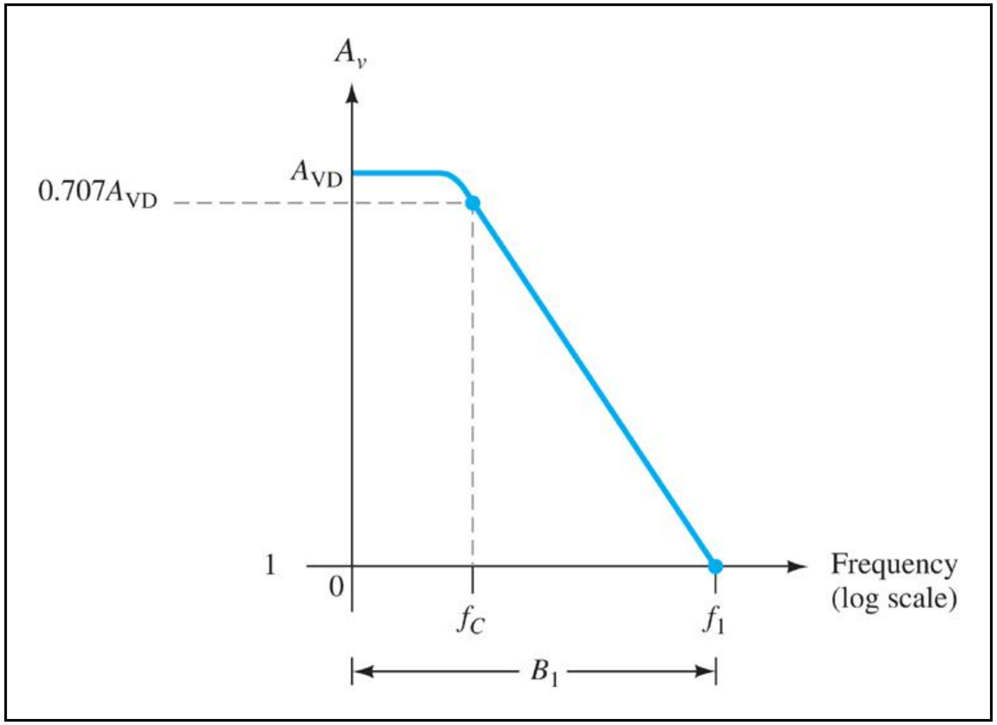
An op-amp is a wide-bandwidth amplifier. The following factors affect the bandwidth of the op-amp:

Gain

Slew rate

Gain and Bandwidth

The op-amp's high frequency response is limited by its internal circuitry. The plot shown is for an open loop gain (A_{OL} or A_{VD}). This means that the op-amp is operating at the highest possible gain with no feedback resistor.



In the open loop mode, an op-amp has a narrow bandwidth. The bandwidth widens in closed-loop mode, but the gain is lower.

Slew Rate (SR)

Slew rate (SR): The maximum rate at which an op-amp can change output without distortion.

$$SR = \frac{\Delta V_o}{\Delta t} \qquad \text{(in V/}\mu\text{s)}$$

The SR rating is listed in the specification sheets as the V/μs rating.

Maximum Signal Frequency

The slew rate determines the highest frequency of the op-amp without distortion.

$$f \leq \frac{SR}{2\pi V_p}$$

where V_P is the peak voltage

General Op-Amp Specifications

Other op-amp ratings found on specification sheets are:

Absolute Ratings

Electrical Characteristics

Performance

Absolute Ratings

These are common maximum ratings for the op-amp.

Absolute Maximum Ratings

Supply voltage	±22 V
Internal power dissipation	500 mW
Differential input voltage	±30 V
Input voltage	±15 V

Electrical Characteristics

μA741 Electrical Characteristics: $V_{CC} = \pm 15$ V, $T_A = 25°C$

Characteristic	Minimum	Typical	Maximum	Unit
V_{IO} Input offset voltage		1	6	mV
I_{IO} Input offset current		20	200	nA
I_{IB} Input bias current		80	500	nA
V_{ICR} Common-mode input voltage range	±12	±13		V
V_{OM} Maximum peak output voltage swing	±12	±14		V
A_{VD} Large-signal differential voltage amplification	20	200		V/mV
r_i Input resistance	0.3	2		MΩ
r_o Output resistance		75		Ω
C_i Input capacitance		1.4		pF
CMRR Common-mode rejection ratio	70	90		dB
I_{CC} Supply current		1.7	2.8	mA
P_D Total power dissipation		50	85	mW

Note: These ratings are for specific circuit conditions, and they often include minimum, maximum and typical values.

CMRR

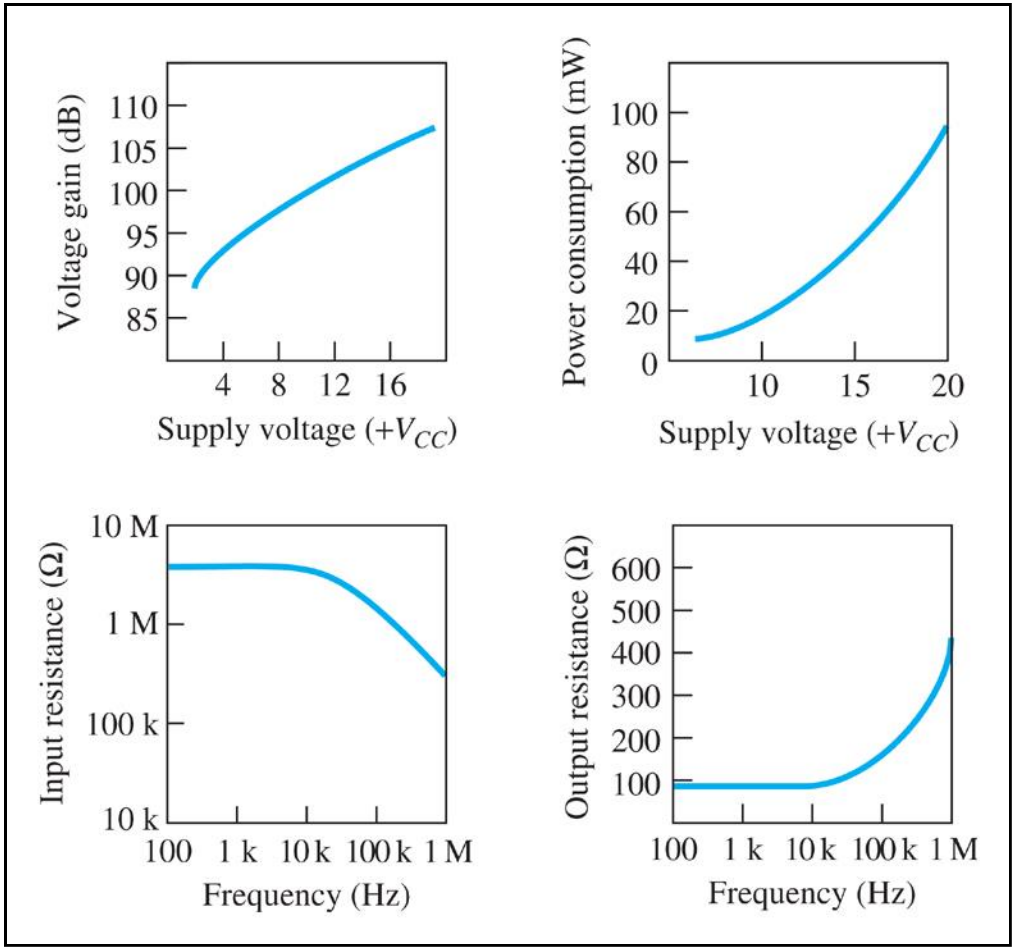
One rating that is unique to op-amps is **CMRR** or **common-mode rejection ratio**.

Because the op-amp has two inputs that are opposite in phase (inverting input and the non-inverting input) any signal that is common to both inputs will be cancelled.

Op-amp CMRR is a measure of the ability to cancel out common-mode signals.

Op-Amp Performance

The specification sheets will also include graphs that indicate the performance of the op-amp over a wide range of conditions.



Summary

That's all for Today !