The Greatest Operational Amplifier Course on the Internet.

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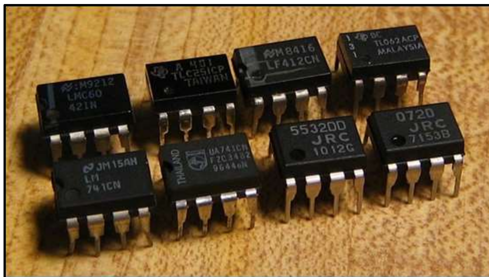

Part One Linear Operational Amplifier

Part One

Operatinal Amplifiers from Soup to Nuts
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- **Operational Amplifier or OP-Amp**
- **There are three basic Operational Configurations**
    - **Inverting**
    - **Non-Inverting**
    - **Differential**
- **We will be discussing the Linear Operational Amplifier First**

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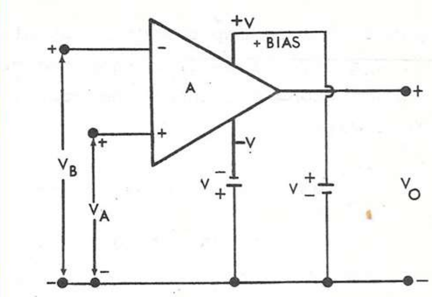

BASIC OP-AMP CIRCUIT MODEL. The *tri-angular* amplifier symbol points in the direction of signal flow.

- **Standard Operational Symbol**
- **Two Inputs , - Inverting**
  + Non _Inverting
- **Output is taken at the Single Output and V_o to Gnd.**
- **The Operational Amplifier has Two Voltage Sources. +V & -V**
- **$V_0 = A(V_A - V_B)$ (Where A is open loop Gain of the Operational Amplifier) (Op-Amp)**
- **Typical Open Loop Gain is around 50000.**

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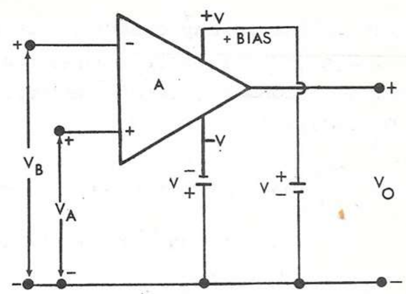

BASIC OP-AMP CIRCUIT MODEL. The *tri-angular* amplifier symbol points in the direction of signal flow.

- **Output of the Operational Amplifier , Cannot have an output greater then either of the Supply Voltage Sources . +V & -V .**
- **Since the typical voltage supply Voltage for the Op - -Amp is +/- 15 Volts DC**

Therefore (0.3 M Volts) x 50000 = 15 VDC ; Small input Voltage will hit the rail of the Power supply.

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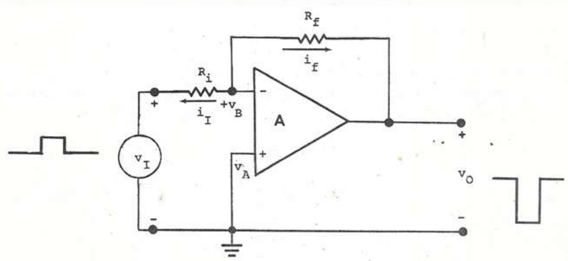

INVERTING AMPLIFIER. *The feedback resistor* R_f *provides a negative-feedback loop from the output to the inverting input. The inverting amplifier has a closed-loop gain equal to* $-(R_f/R_i)$, *where the negative sign indicates that the amplified signal is inverted. The input impedance is equal to the input resistance* R_i.

VA & VB inputs track . Since $i_I = I_f$; then Vin = $i_i \times R_i$; Vout = $I_f \times R_f$

Close loop Gain $V_{out} = (Vin) \times -\left(\frac{R_f}{R_i}\right)$; Input Impedance is R_i

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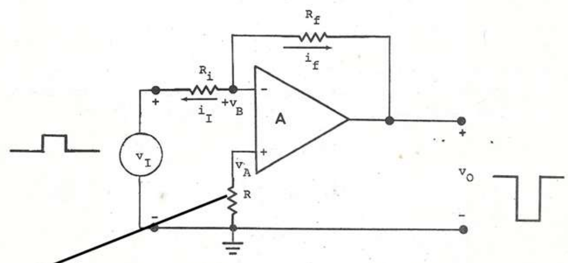
Inverting Amplifier



R = R_f // R_i
Balance the Inputs

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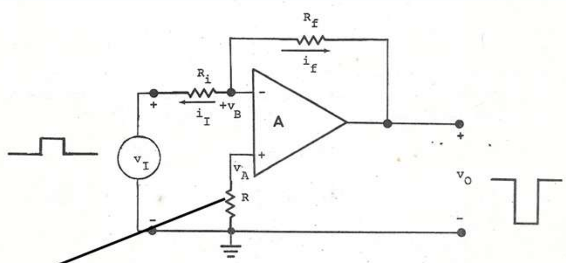
Inverting Amplifier



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VA & VB inputs track . Since $i_I = I_f$; then Vin = $i_i \times R_i$; Vout = $I_f \times R_f$

Close loop Gain V_{out} = (Vin) x - ($\frac{R_f}{R_i}$) ; Input Impedance is R_i

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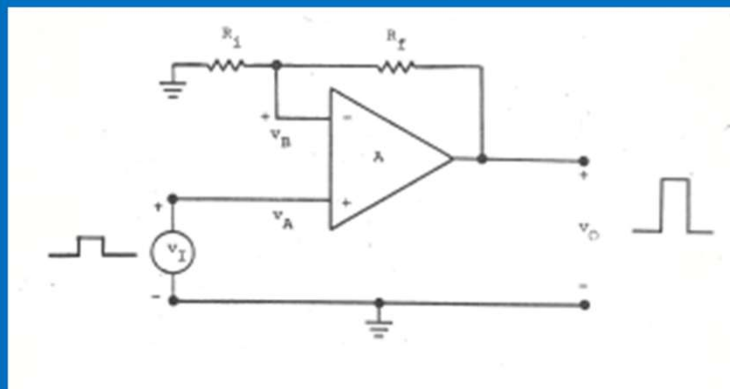
Non-Inverting Amplifier



- **High Input impedance**
- **Input is in Phase with Output**
- **Gain is $1 + \frac{R_f}{R_i}$ = Output**
- **Also Called a Voltage Follower**
- **Low Output Impedance**
- **Primary used a buffer Circuit**

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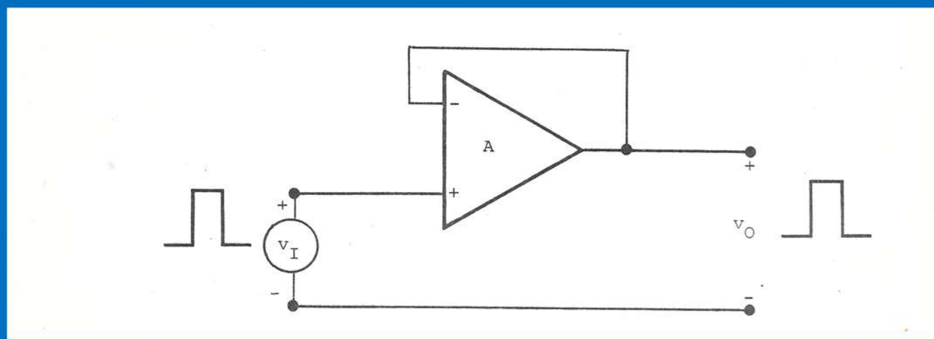
Unity Gain Voltage Follower



- High Input impedance
- Input is in Phase with Output
- Gain is unity Vi=Vo
- High Input Impedance
- Low Output Impedance
- Primary used a a buffer Circuit

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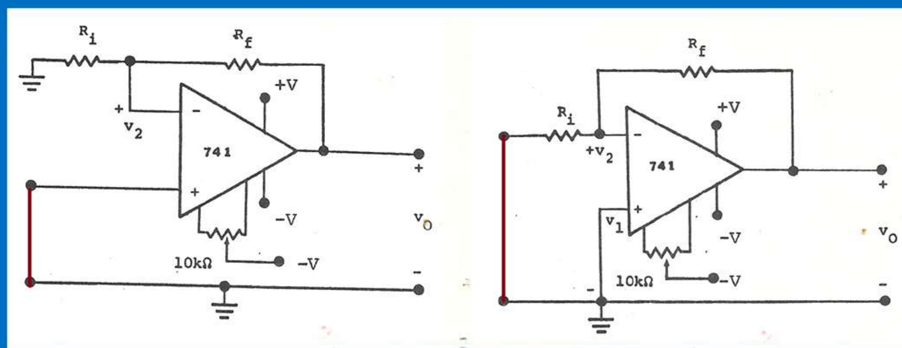
Off-Set Voltage



- **Offset Voltage is caused by the mismatch of internal component's**
- **Offset voltage is multiplied by the gain therefore if the gain is 10 , the input offset voltage is 10 mv then output offset voltage is 100 mv.**
- **Potentiometer is placed accross the Null inputs and adjusted out with the Input(s) at ground.**

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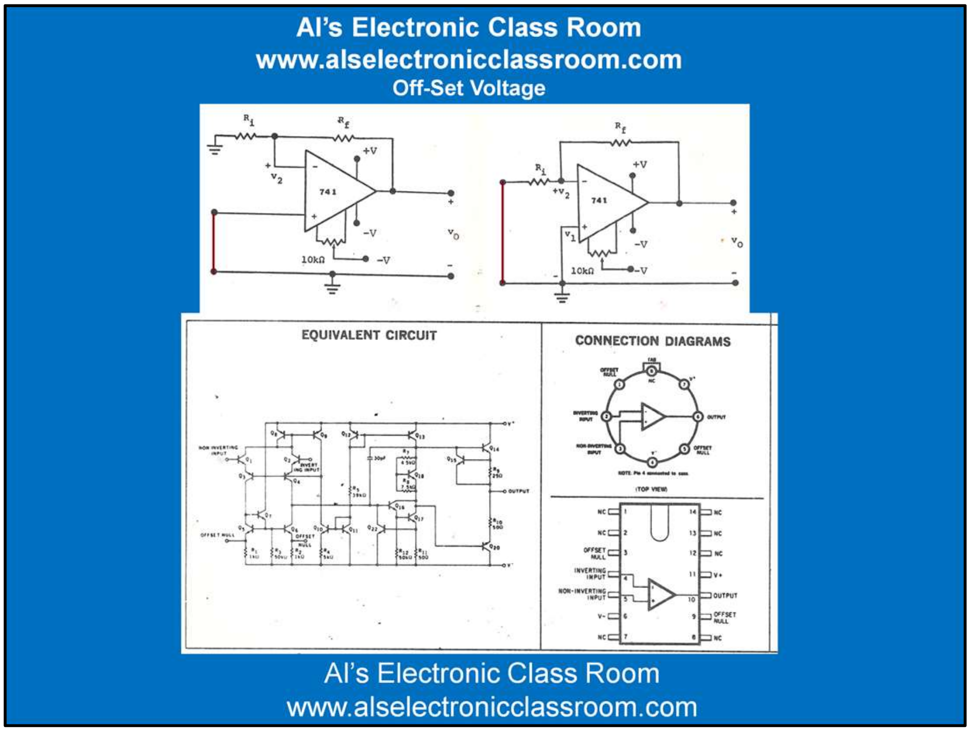
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Off-Set Voltage
R1
Rf
+V
-V
741
v2
v1
vO
10kΩ
EQUIVALENT CIRCUIT
NON INVERTING INPUT
INVERTING INPUT
OFFSET NULL
OUTPUT
CONNECTION DIAGRAMS
(TOP VIEW)
NC
OFFSET NULL
INVERTING INPUT
NON-INVERTING INPUT
V-
V+
OUTPUT
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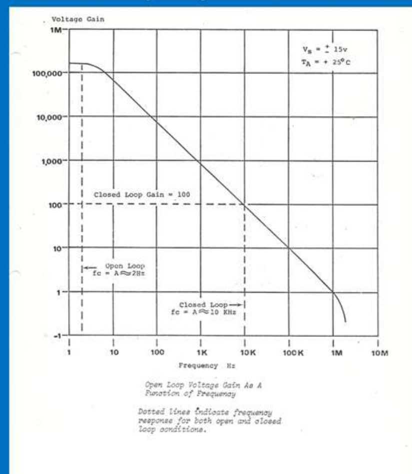
Frequency Chart ; Bode Plot



- Open loop gain is about 2 at 2 Htz rolls of at a factor of ten as frequency is increased by a factor of 10 or 10 Db per octave (Meaning gain drops by ½ when frequency dbls)
- Close loop gain is 100 roll off starts at 10 khz, then continues to Roll off at the same rate as open loop gain.

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Slew Rate

FAIRCHILD LINEAR INTEGRATED CIRCUITS μA741C

ELECTRICAL CHARACTERISTICS ($V_S = \pm 15$ V, $T_A = 25°C$ unless otherwise specified)

PARAMETERS (see definitions)	CONDITIONS	MIN.	TYP.	MAX.	UNITS
Input Offset Voltage	$R_S \leq 10$ kΩ		2.0	6.0	mV
Input Offset Current			20	200	nA
Input Bias Current			80	500	nA
Input Resistance		0.3	2.0		MΩ
Input Capacitance			1.4		pF
Offset Voltage Adjustment Range			±15		mV
Input Voltage Range		±12	±13		V
Common Mode Rejection Ratio	$R_S \leq 10$ kΩ	70	90		dB
Supply Voltage Rejection Ratio	$R_S \leq 10$ kΩ		30	150	μV/V
Large-Signal Voltage Gain	$R_L \geq 2$ kΩ, $V_{out} = \pm 10$ V	20,000	200,000		
Output Voltage Swing	$R_L \geq 10$ kΩ	±12	±14		V
	$R_L \geq 2$ kΩ	±10	±13		V
Output Resistance			75		Ω
Output Short-Circuit Current			25		mA
Supply Current			1.7	2.8	mA
Power Consumption			50	85	mW
Transient Response (unity gain)	$V_{in} = 20$ mV, $R_L = 2$ kΩ, $C_L \leq 100$ pF				
Risetime			0.3		μs
Overshoot			5.0		%
Slew Rate	$R_L \geq 2$ kΩ		0.5		V/μs
The following specifications apply for $0°C \leq T_A \leq +70°C$:					
Input Offset Voltage				7.5	mV
Input Offset Current				300	nA
Input Bias Current				800	nA
Large-Signal Voltage Gain	$R_L \geq 2$ kΩ, $V_{out} = \pm 10$ V	15,000			
Output Voltage Swing	$R_L \geq 2$ kΩ	±10	±13		V

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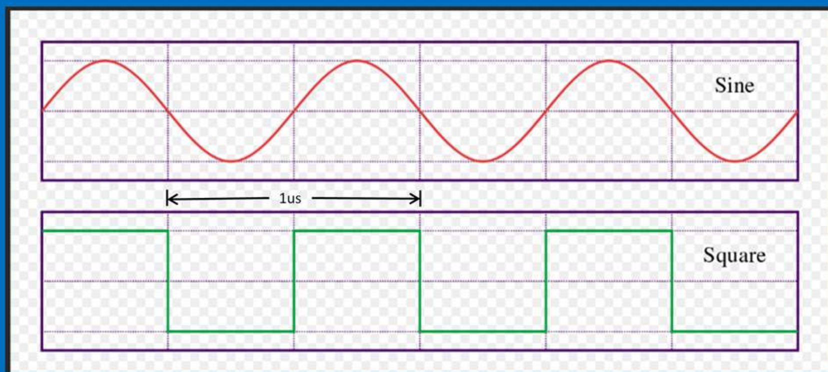
Slew Rate



- Slew rate is the Rise Time of the operational amplifier. This specification is important when there is a large voltage swing on a Square wave.
- The slew Rate for the above Wave Forms is 0.5v /μs.
- If my frequency above is 1 Mhz and the Wave form has a peak Voltage of 1 v peak

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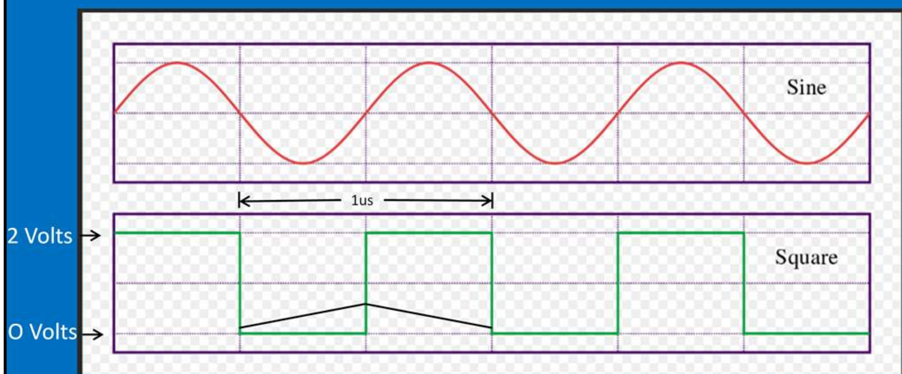
Slew Rate



- Slew rate is the Rise Time of the operational amplifier. This specification is important when there is a large voltage swing on a Square wave.
- The slew Rate for the above Wave Forms is 0.5v /μs.
- If my frequency above is 1 Mhz and the Wave form has a peak Voltage of 2 v peak

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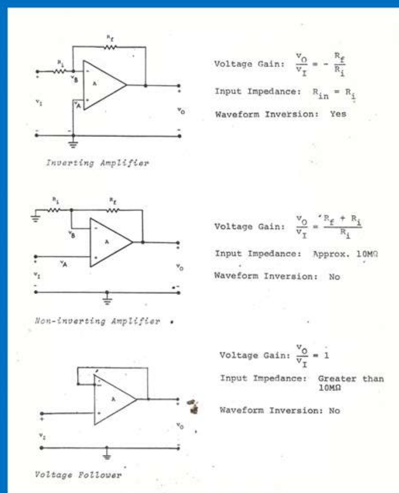
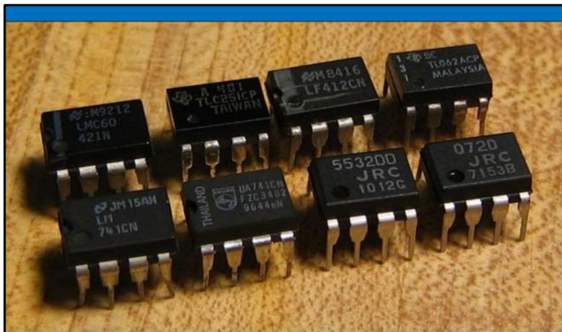
Linear Op Amp Summary



- **Voltage Gain = Vi = - $\frac{Rf}{Ri}$**
- **Input Impedance = Ri**
- **Inversion yes = input; output by 180 degrees**

- **Voltage Gain = Vi = 1 + $\frac{Rf}{Ri}$**
- **Input Impedance = High Input Impedance**
- **Inversion no = input; output in Phase**

- **Voltage Gain = 1**
- **Input Impedance = High Input Impedance**
- **Inversion no = input; output in Phase**



Continue to Part two Differential Operational Amplifier

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