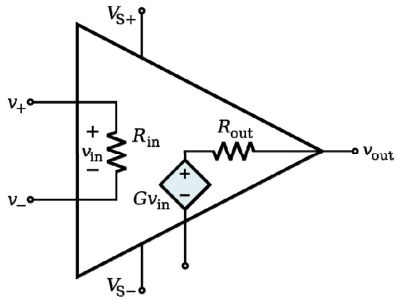
SIERRA COLLEGE

MECH 10
Fundamentals of Electronics

Mechatronics
Real Skills Real Jobs

Class 25
Operational Amplifiers



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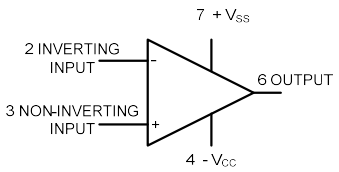
- Operational Amplifier
  - A high gain voltage amplifier with single or differential inputs & excellent common mode rejection
    - Inputs
      - Inverting + non-inverting
      - Differential – amplifies the difference
        - Rejects signals common to both inputs
    - Gain
      - 200,000+ open loop gain
      - Feedback resistor control
      - Extreme gain stability



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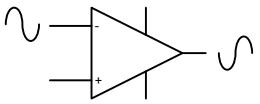
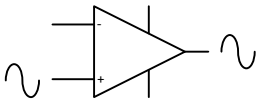
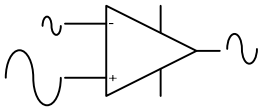
- Operational Amplifier
  - Single-Ended Inputs
    - Inverting; input/output 180° phase shift
    - Non-inverting; input/output 0° phase shift
  - Differential Inputs
    - Non-inverting minus inverting input; phase is vector sum



INVERTING INPUT
$V_{out} = -A_{ol}V_-$



NON-INVERTING INPUT
$V_{out} = (A_{ol} + 1)V_+$



DIFFERENTIAL INPUT
$V_{out} = A_{ol}(V_+ - V_-)$

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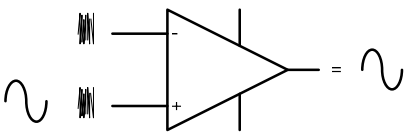
- Operational Amplifier
  - Differential Inputs
    - Common Mode Rejection
      - Identical signals not passed
      - Noise rejection ratio
        - 90 dB (31,600 x reduction)



DIFFERENTIAL INPUT
$V_{out} = A_{ol}(V_+ - V_-)$

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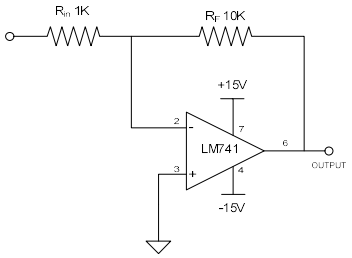
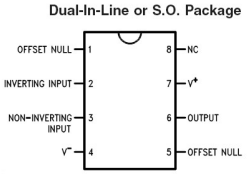
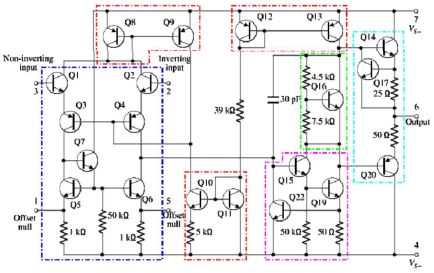
- Operational Amplifier
  - Gain
    - Open loop - 200,000+
    - Closed Loop - easily controlled with input & negative feedback resistors







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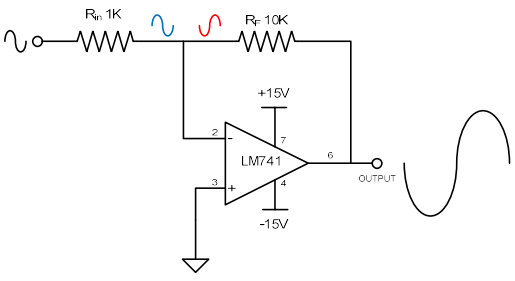
- Operational Amplifier
  - Gain – Inverting Input
    - Negative Feedback
      - Output attempts to hold inverting input at ground potential
      - R_F & R_{in} control gain

$$A_V = \frac{R_f}{R_{in}}$$

Inverting input gain

Example – output must reach 10x input to drive (-) input to cancel (+) input.



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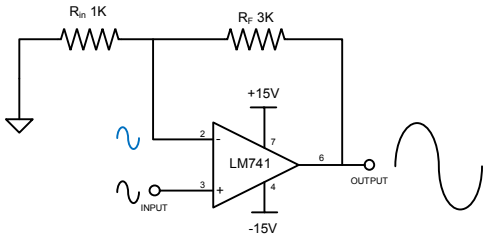
- Operational Amplifier
  - Gain – Non-Inverting Input
    - Negative Feedback
      - Output attempts to hold inverting input at non-inverting potential (+1)
      - R_F & R_{in} control gain

$$A_V = \frac{R_f}{R_{in}} + 1$$

Non-inverting gain



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- Operational Amplifier
  - Applications
    - Amplifiers
      - Inverting, non-inverting amplifier, differential, summing, difference, Schmitt trigger
    - Regulators
      - Voltage & current, trans-conductance, trans-impedance, oscillators
    - Math
      - Differential, integral, A to D conversion

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Lab 25 – Operational Amplifier

Learning Objectives

- Build and test negative feedback operational amplifier circuits
- Use negative feedback to control amplifier gain
- Understand the proportional effect of input / feedback resistors on operational amplifier voltage gains.

		Points Possible
Documentation	Quality of documentation (completeness, neatness, clarity, spelling, grammar)	**10**
Circuit 1	Closed-loop voltage gain – expected and measured recorded and compared; Input & output phase relationship recorded, Open-loop voltage gain - expected and measured recorded and compared	**10**
Circuit 2	Closed-loop voltage gain – expected and measured recorded and compared; Input & output phase relationship recorded; Loaded ground voltage gain - measured value recorded; Open-loop voltage gain – measured & recorded; waveform captured	**10**
Circuit 3	Closed-loop voltage gain – expected and measured recorded and compared;	**5**
Circuit 4	Bode plot included & accurate, waveform captured, phase shift noted	**5**
Conclusions	Questions answered completely & accurately	**10**
	Total	**50**