LECTURE 6 OP-AMP

Introduction of Operation Amplifier (Op-Amp)

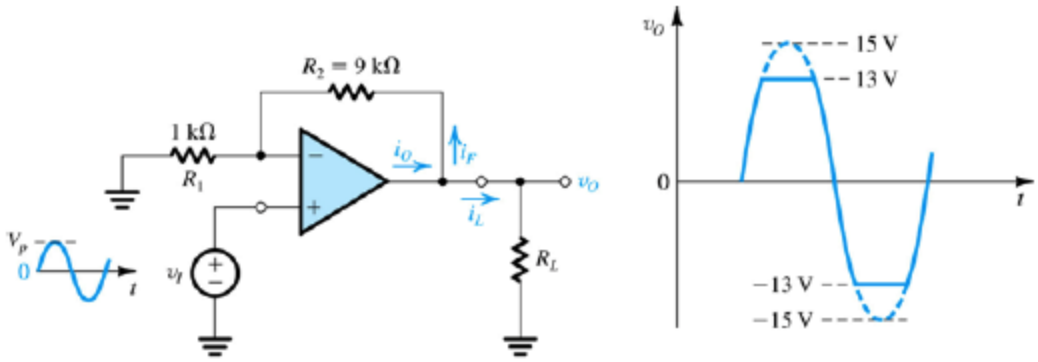
Large signal Operation of OPAMP

Output voltage saturation

- **Rated output voltage** ($v_{O,max}$) specifies the maximum output voltage swing of op amp
- Linear amplifier operation (for the required $v_O < v_{O,max}$): $v_O = (1+R_2/R_1)v_I$
- Clipped output waveform (for the required $v_O > v_{O,max}$): $v_O = v_{O,max}$
- The maximum input swing allowed for output voltage limited case: $v_{I,max} = v_{O,max}/(1+R_2/R_1)$
- Output is typically limited by voltage in cases where R_L is large

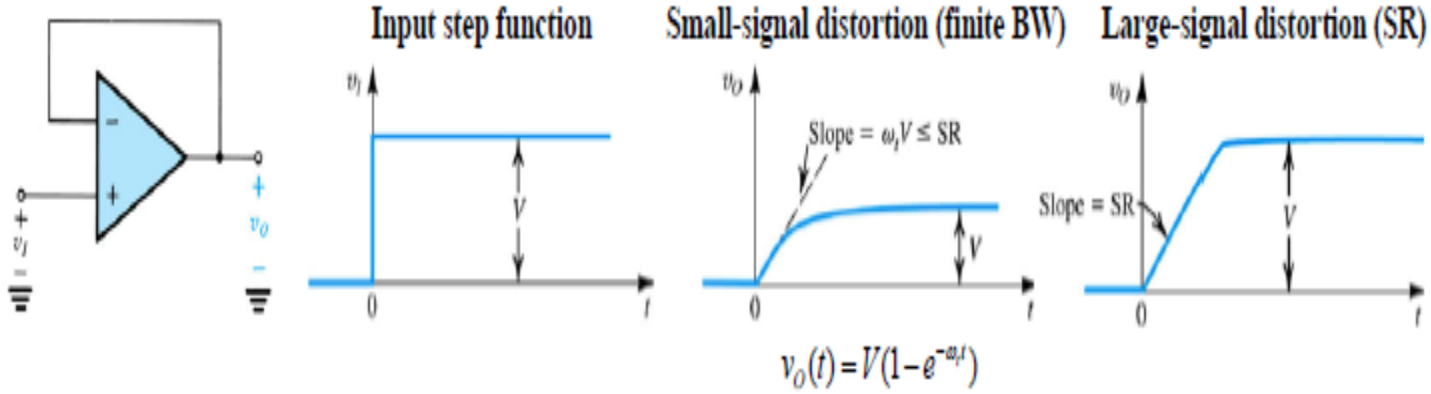
Output current limits

- Maximum output current ($i_{O,max}$) specifies the output current limitation of op amp
- Linear amplifier operation (for the required $i_O < i_{O,max}$): $v_O = (1+R_2/R_1)v_I$ and $i_L = v_O/R_L$
- Clipped output waveform (for the required $i_O > i_{O,max}$): $i_L = i_{O,max} - i_F$
- The maximum input swing allowed for output current limited case: $v_{I,max} = i_{O,max}[R_L \| (R_1+R_2)]/(1+R_2/R_1)$
- Output is typically limited by current in cases where R_L is small



Slew rate

- Slew rate is the maximum rate of change possible at the output: $SR = \left.\frac{dv_O}{dt}\right|_{max}$ (V/sec)
- Slew rate may cause non-linear distortion for large-signal operation.



Full-power bandwidth

- Defined as the highest frequency allowed for a unity-gain buffer with a sinusoidal output at $v_{O,max}$

$$v_i(t) = V_o \sin \omega t \rightarrow v_o(t) = V_o \sin \omega t$$

$$\frac{dv_o(t)}{dt} = \omega V_o \cos \omega t$$

$$\left|\frac{dv_o(t)}{dt}\right|_{max} = \omega V_o < SR \rightarrow \text{distortionless}$$

$$\left|\frac{dv_o(t)}{dt}\right|_{max} = \omega V_o > SR \rightarrow \text{distortion}$$

$$f_M = \frac{\omega_M}{2\pi} = \frac{SR}{2\pi v_{O,max}}$$