

ECE 3254 PreLab 9 notes

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Op-Amp Specifications

Usually Op Amps are treated as ideal elements but there are differences between the ideal and actual characteristics.

Ideal Characteristics

A_{vol} is infinite
 R_{in} is infinite
 R_o is zero

Actual Characteristics

A_{vol} very large (10^5)
 R_{in} very large ($10^6 \Omega$)
 R_o small ($<300 \Omega$)

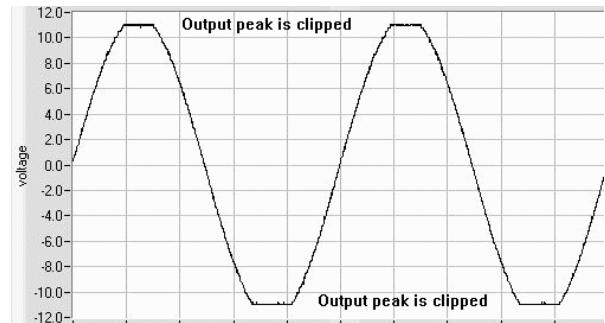
The 741 Operational Amplifier has a maximum power supply rating of $\pm 18V$. The input voltage must have a peak value less than $\pm 15V$, and the input voltage peak must also be less than the supply voltages.

The LM741 data sheet is posted at http://www.ece.vt.edu/ece3254/Notes/741_datasheet.pdf

- Page 2 has the specs you will need.
- Choose the Min or Typical values for AD741 (either is OK) for your calculations, and state whether you used the min or typical value.

Maximum output voltage swing:

- This is how far the output voltage can swing toward the 15V supply rails before clipping occurs. The 741 is not able to go rail-to-rail.
- Look at Output Characteristics \rightarrow Voltage @ R_L
- The op-amp will not be able reach this voltage for small values of R_L . (see Short Circuit Current)



Short Circuit Current:

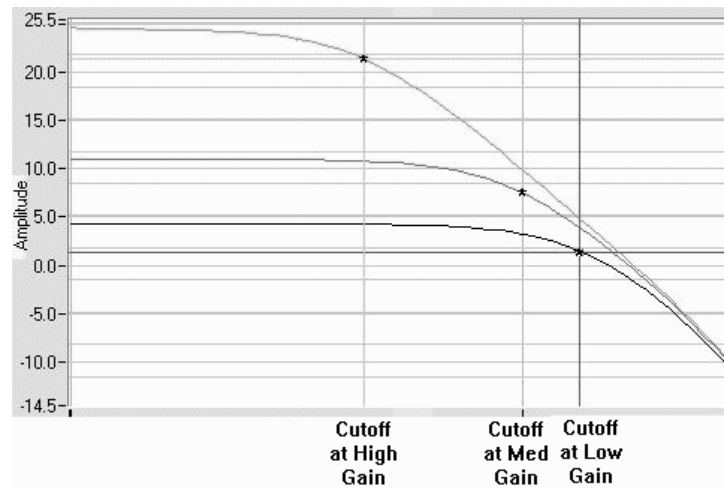
- This is the maximum output current, determined by an internal current limiter, which the op-amp can produce.
- For low values of R_L , the maximum output voltage will be limited by I_{SC} and $V_{o_{max}} = R_L * I_{SC}$
- Look at Output Characteristics \rightarrow Short Circuit Current

The short circuit current will determine the peak output voltage that the amplifier can develop across a small load resistor. For example, an Op Amp may be rated for $\pm 12V$ maximum voltage into 2.2K load, but a 20mA rated short circuit current can only produce $\pm 2V_p$ with $R_L = 100\Omega$. The minimum R_L allowed for a given voltage output will be equal to the expected voltage divided by the short circuit current limit.

For Pspice, use a 1Ω load resistor, which is close enough to a short for the I_{sc} measurement. You do not need to run a transient analysis, just turn on the current bias measurement and run the simulation. I_{sc} will be the current through R_L .

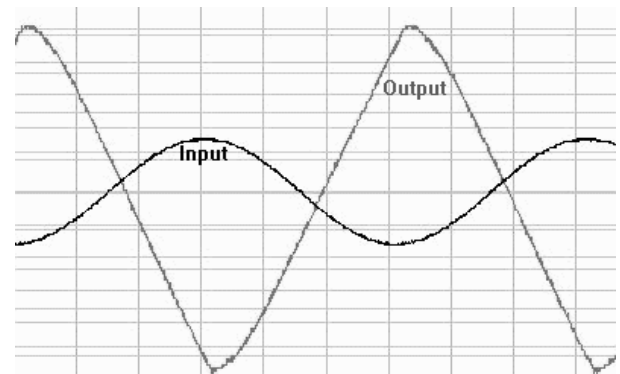
Gain Bandwidth Product:

- This is the small signal unity gain bandwidth (and cutoff freq f_{high}) for an amplifier gain of ± 1 .
- $|Gain| * Bandwidth = \text{constant}$ (Gain Bandwidth Product).
- As amplifier gain increases, the bandwidth of the amplifier decreases proportionally.
- Look at Frequency Response \rightarrow Unity Gain, small signal

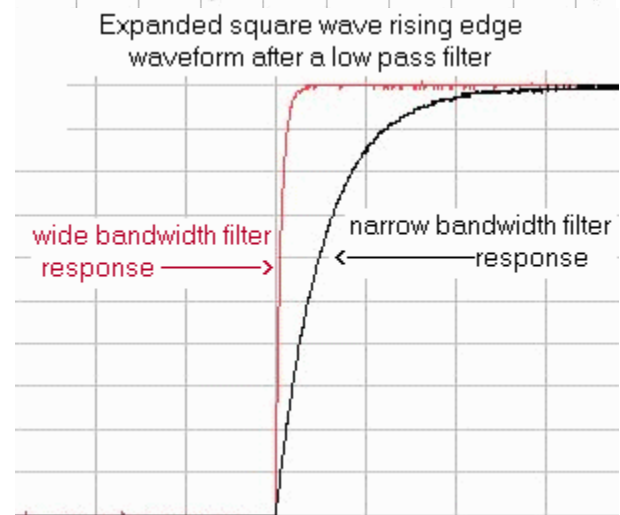


Slew Rate:

- This tells you how quickly the op-amp output voltage can change. ($\Delta V/\Delta t$)
- As the op-amp becomes heavily slew limited, the output waveform becomes distorted and resembles a triangle wave.
- The slew rate does not change with circuit gain.
- Look at Frequency Response \rightarrow Slew Rate



NOTE: When we measure the slew rate in this lab, we are actually measuring the rising edge of a square wave that is limited by the slew rate AND the bandwidth. As you increase amplifier gain, the circuit bandwidth decreases. This decrease in bandwidth limits the circuit's ability to produce clean square wave. A square wave is composed of an infinite series of the fundamental frequency ($f = 1/T$) and its odd harmonics. The waveform edges of a square wave will become rounded as the higher harmonics disappear when the bandwidth decreases.

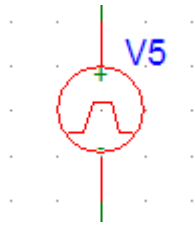
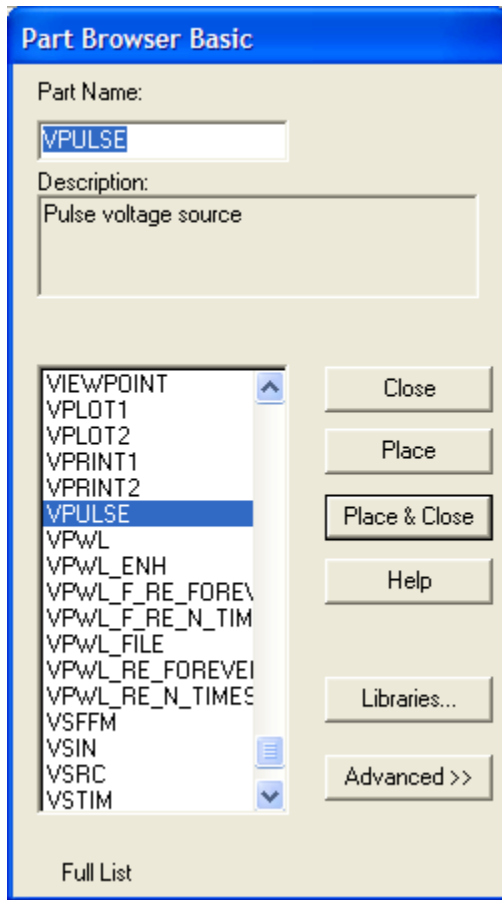


Full Power Bandwidth:

- This is the amplifier bandwidth for a large signal.
- The large signal bandwidth is determined by the slew rate.
- As the amplifier output voltage rises, the Full Power Bandwidth begins to dominate the amplifier's frequency response.
- The Full Power Bandwidth is constant, regardless of the amplifier gain – except when the gain becomes large. For very high gain amplifier circuits, the Small Signal Bandwidth can become low enough to limit the Full Power Bandwidth and slew rate
- Look at Frequency Response \rightarrow Full Power Response

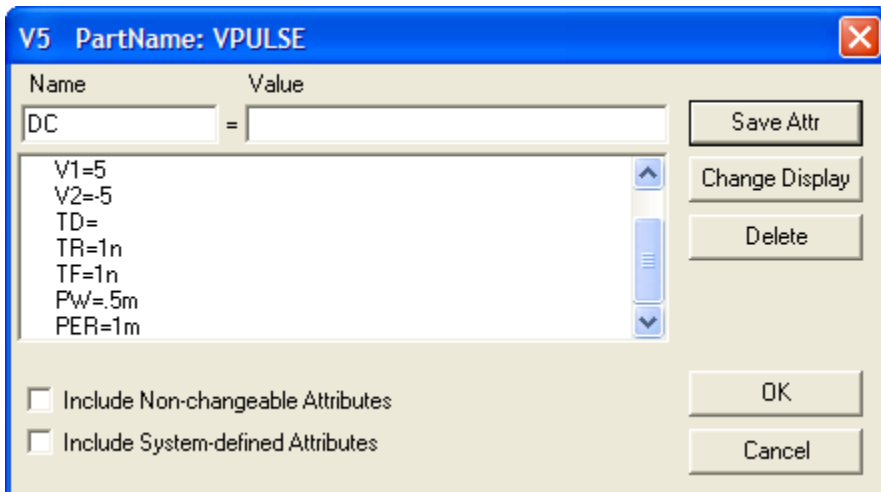
Pspice Slew Rate Notes

For the square wave generator, use a VPULSE source.

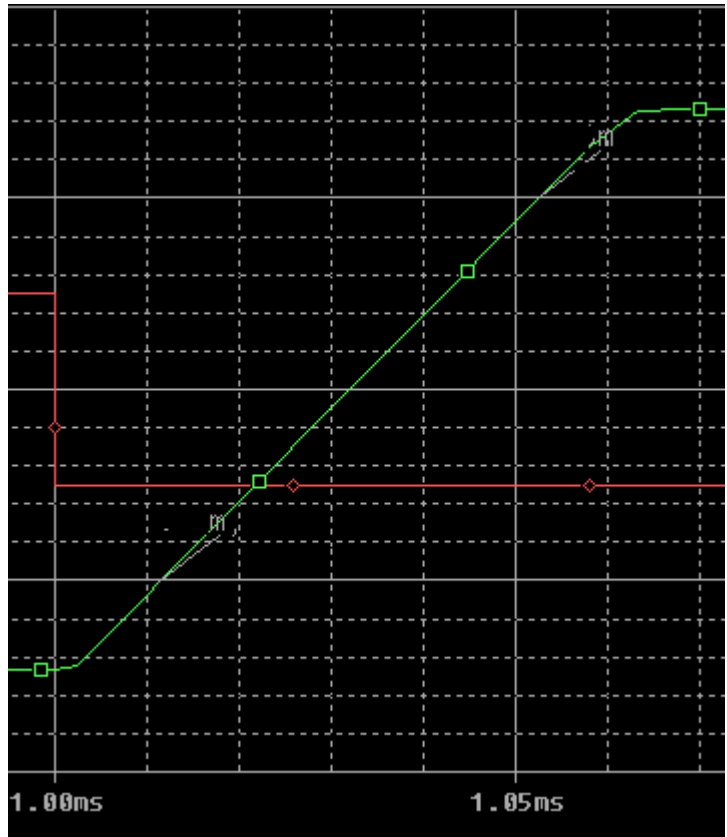
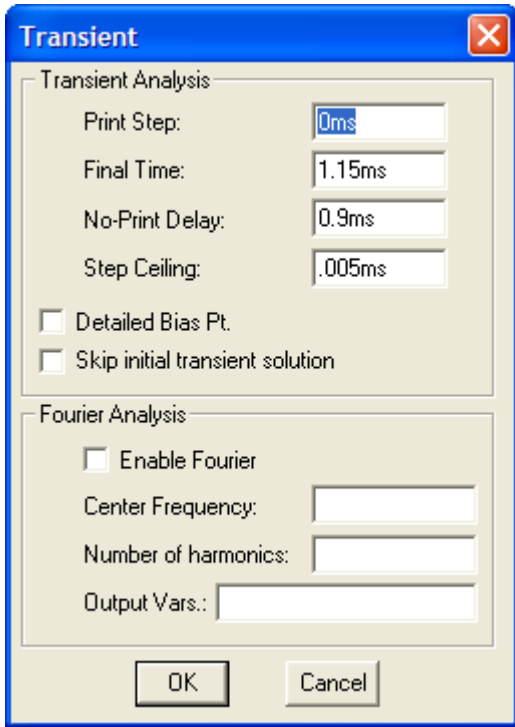


Set the VPULS for a 1kHz, 10Vpp square wave with no DC offset.
 $V_{max} = 5V$, $V_{min} = -5V$, period = 1ms, and the pulse width is $\frac{1}{2}$ of the period or 0.5ms.

As shown below, set the VPULSE for 5V and -5V for the voltages, TR (rise time) to 1ns, TF (fall time) to 1ns, PW (pulse width) to .5ms, and PER (the period) to 1ms.



Set the Transient Analysis to begin simulation at $t=0$, begin display at 0.9ms, take 5ns steps, and end the simulation at 1.2ms. This expands the slope of the output waveform for Slew Rate measurement. The result should look similar to the partial capture below right.



The red trace is the input square wave and the green trace is the resulting output ramp, which is the output result limited by the slew rate. Place your cursor markers at about +10 and -10 volts on the output waveform, then calculate the slew rate from the cursor measurements.