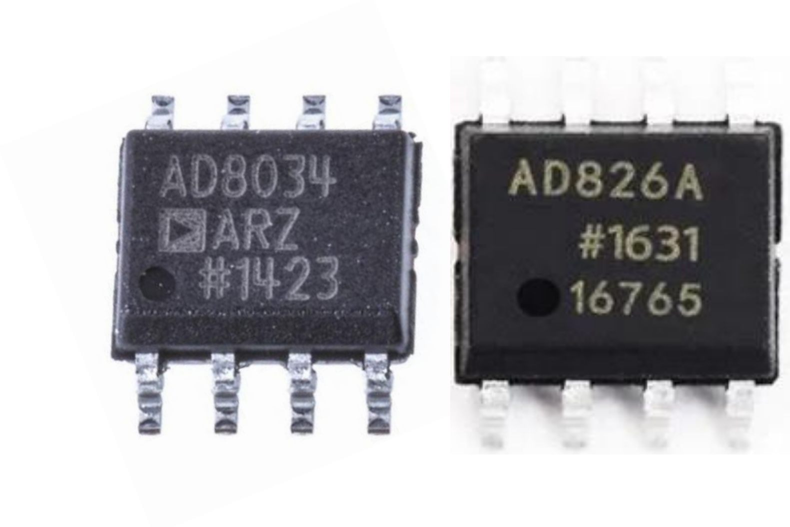
Indian Institute of Space Science and Technology

Opamp Specifications



By:

Nirbhay Tyagi

SC19B091

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Introduction

This report is about the specifications and key feature of two commercially available Opamp's AD826 and AD8034. Both the Opamp's are manufactured by Analog devices and the datasheets are available on www.analog.com. We compared both the Opamps on different Opamp parameters and infer from the graphs and data available in the datasheet. Both the Opamps differ from each other on different parameters and are useful in different applications.

The comparison between the Opamp's is based on different Opamp parameters. The typical, maximum and minimum values are extracted from the datasheets and are presented in tabular form and then inference is given based on comparison and the available data values. The performance characteristics plots also gives us idea of the variation of Opamp parameters with respect to frequency, power supply, temperature etc. Performance characteristics are also useful to determine the working conditions of Opamp for maximum efficiency. Inferences based on these characteristics are also given as per my knowledge and understanding. Both the Opamps have different applications in different fields. They are used in such as Instrumentation, filters, level shifting, buffering, cable drivers, video line driver and much more depending on their specifications and performance in respective environments. Some of the application circuits are also simulated in LTSpice and the simulated output is compared with the real output.

Comparision based on different Opamp Parameters

DYNAMIC PERFORMANCE

Bandwidth:

Parameter	Conditions	Vs	Min	Typ	Unit
	AD826				
Unity Gain Bandwidth	Gain=±1V	±5V ±15V 0, +5V	30 45 25	35 50 29	
Bandwidth for 0.1dB Flatness		±5V ±15V 0, +5V	10 25 10	20 55 20	
Full Power Bandwidth	V_{OUT}=5V p-p R_{LOAD}=500Ω	±5V		15.9	
	V_{OUT}=5V p-p R_{LOAD}=500Ω	±15V		5.6	MHz
	AD8034				
-3dB Bandwidth	G=+1, V_{OUT}=0.2V p-p G=+2, V_{OUT}=0.2V p-p G=+2, V_{OUT}=2V p-p	±5V	65	80 30 21	
	G=+1, V_{OUT}=0.2V p-p G=+2, V_{OUT}=0.2V p-p G=+2, V_{OUT}=2V p-p	5V	70	80 32 21	
	G=+1, V_{OUT}=0.2V p-p G=+2, V_{OUT}=0.2V p-p G=+2, V_{OUT}=2V p-p	±12V	65	80 30 21	

Inference:

1. The unity gain bandwidth of AD826 increases with an increase in supply voltage.
2. The -3dB bandwidth of AD8034 increases with a decrease in gain or with a decrease in V_{OUT} peak to peak.
3. The -3dB bandwidth remains constant with respect to power supply voltage for AD8034.
4. Bandwidth should be high for high speed applications.

Slew Rate:

Parameter	Conditions	Vs	Min	Typ	Max	Unit
	AD826					

Slew Rate	R_{LOAD}=1KΩ, Gain=-1	±5V ±15V 0, +5V	200 300 150	250 350 200		V/µs
	AD8034					
Slew Rate (25% to 75%)	G=+2V, Vout=4V step	±5V 5V ±12V	55 55 55	80 70 80		

Inference:

1. Slew rate of AD826 is almost 3-4 times greater than that of AD8034.
2. Slew rate is the maximum rate of change of output and it causes the distortion of output signal. The distortion in output signal is more for AD826 if we do not choose adequate frequency.
3. Slew rate increases as supply voltage increases for AD826 but for AD8034 the slew rate remains constant it varies a little with change in dual or single power supply.
4. For higher frequency operations or high-speed applications, we use AD826 as its slew rate is significantly higher.

Settling time:

Parameter	Conditions	Vs	Min	Typ	Max	Unit
	AD826					
Settling Time to 0.1% to 0.01%	-2.5 V to +2.5V 0V-10V Step, A_V =-1 -2.5 V to +2.5V 0V-10V Step, A_V =-1	±5V ±15V ±5V ±15V		45 45 70 70		ns
	AD8034					
Settling Time to 0.1%	G=+2V, Vout=2V step G=+2V, Vout=8V step G=+2V, Vout=2V step G=+2V, Vout=2V step G=+2V, Vout=10V step	±5V 5V ±12V		95 225 100 90 225		

Inference:

1. Settling time of AD826 is less than that of AD8034.
2. Settling time of AD826 remains constant on changing the power supply.
3. Settling time of AD8034 changes with change in output voltage and with power supply also.
4. For lesser distortion of output pulse when the time period of given input pulse is small, the settling time should be as small as possible.

DC PERFORMANCE

Offset Voltage:

Parameter	Conditions	Vs	Min	Typ	Max	Unit
Input Offset Voltage	**AD826**					
	T_{MIN} to T_{MAX}	±5V to ±15V		0.5	2 3	mV
	AD8034					
	V_{CM} =0V T_{MIN} to T_{MAX}	±5V		1	2 3.5	mV
	V_{CM} =0V T_{MIN} to T_{MAX}	5V		1	2 3.5	mV
	V_{CM} =0V T_{MIN} to T_{MAX}	±12V		1	2 3.5	mV

Inference:

1. When we give zero volt across the two terminals the output should be zero, but it does not happen because the two terminals are not identical as they consist of different BJT's.
2. The typical value of offset voltage is greater for AD8034 as compared to AD826.
3. For different operating range temperatures, the maximum value of offset voltage is greater for AD8034.
4. For AD8034, we can see that the input offset voltage is independent of supply voltages.
5. The DC performance of AD826 is better than that of AD8034 as it has a typical offset voltage of 0.5mV.

Input Bias Current:

Parameter	Conditions	Vs	Min	Typ	Max	Unit
Input Bias Current	**AD826**					
	 T_{MIN} T_{MAX}	±5V, ±15V		3.3	6.6 10 4.4	μA
	AD8034					
	 T_{MIN} - T_{MAX}	±5V		1.5 50	11	pA
	 T_{MIN} - T_{MAX}	5V		1 50	10	pA
	 T_{MIN} - T_{MAX}	±12V		2 50	12	pA

Inference:

1. Input bias current of AD8034 is much smaller than that of AD826.
2. AD8034 can be used with high input impedance sources.
3. Because of very low value of input bias current the voltage drop due to the source internal impedance will be negligible.
4. Increases with an increase in power supply for AD8034

Open Loop Gain:

Parameter	Conditions	Vs	Min	Typ	Max	Unit
Open Loop Gain	**AD826**					V/mV
	V_{OUT}=±2.5V	±5V				
	R_{LOAD}=500Ω		2	4		
	T_{MIN} to T_{MAX}		1.5			
	R_{LOAD}=150Ω		1.5	3		
	V_{OUT}=±10V	±15V				
	R_{LOAD}=1KΩ		3.5	6		
	T_{MIN} to T_{MAX}		2	5		
	V_{OUT}=±7.5V	±15V				
	R_{LOAD}=150Ω (50mA Output)		2	4		
	AD8034					dB
	V_{OUT}=±3V	±5V				
	R_{LOAD}=1KΩ		89	92		
	V_{OUT}=0V to 3V	5V				
	R_{LOAD}=1KΩ		87	92		
	V_{OUT}=±8V	±12V				
	R_{LOAD}=1KΩ		88	96		

Inference:

1. The open loop gain of AD8034 is about 10-20 times greater than that of AD826.
2. The error in gain percentage using AD8034 will be significantly lower than that using AD826.
3. The effect on due to the non-ideal close loop gain will be lower for AD8034 as it should be higher and for ideal case it should be infinite.

INPUT CHARACTERISTICS

CMRR:

Parameter	Conditions	Vs	Min	Typ	Max	Unit
Common-Mode Rejection Ratio	**AD826**					dB
	V_{CM}=±2.5V, T_{MIN} to T_{MAX}	±5V	80	100		
	V_{CM}=±12V	±15V	86	120		
	T_{MIN} to T_{MAX}	±15V	80	100		
	AD8034					
	V_{CM}=-3V to +1.5V	±5V	-89	-100		
	V_{CM}=1V to 2.5V	5V	-80	-100		
	V_{CM}=±5V	±12V	-92	-100		

Inference:

1. The CMRR is comparable for both AD826 and AD8034.
2. In specific condition the CMRR of AD826 is greater than that of AD8034.
3. For amplifying differential signal, we need high CMRR.
4. As the typical value of CMRR is 100dB they provide excellent noise rejection

OUTPUT CHARACTERISTIC

Output Voltage Swing:

Parameter	Conditions	Vs	Min	Typ	Max	Unit
Output Voltage Swing	**AD826**					
	R_{LOAD}=500Ω	±5V	3.3	3.8		±V
	R_{LOAD}=150Ω	±5V	3.2	3.6		±V
	R_{LOAD}=1KΩ	±15V	13.3	13.7		±V
	R_{LOAD}=500Ω	±15V	12.8	13.4		±V
	R_{LOAD}=500Ω	0, +5V	+1.5V, 3.5V			V
	AD8034					
	R_{LOAD}=1kΩ	±5V	±4.75V	±4.95V		V
	R_{LOAD}=1KΩ	5V	0.16 - 4.83	0.04 – 4.95		V
	R_{LOAD}=1KΩ	±12V	±11.52V	±11.84V		V

Inference:

1. Output Voltage swing is more for AD826 as compared to AD8033.
2. If our output signal is high because of large gain and our supply is 15V then the output will not be 15V it will be 13.3V for AD826 for a load of 1KΩ.
3. This is because, because of the drop across the internal transistors we get a drop in output voltage.
4. For, AD826 the output voltage swing increases as the load resistance decreases because as the value of load resistance decreases the output current increases and hence, the voltage drop across the transistor increases.

Short Circuit Current:

Parameter	Conditions	Vs	Min	Typ	Max	Unit
Short Circuit Current	**AD826**	±15V		90		mA
	AD8034	±5V		40		mA
		5V		30		mA
		±12V		60		mA

Inference:

1. The magnitude of short circuit current is more for AD826 as compared to AD8033.
2. For AD8034, the short circuit current increases as the supply voltage increases.
3. At different temperatures current may be different.
4. The short circuit is current is to protect the Opamp from failure. It is also known as maximum output current as with no load at the output the Opamp can give a max of this much current.

POWER SUPPLY

Operating Range:

Parameter	Conditions	Vs	Min Typ Max	Unit
Operating Range	**AD826**			V
	Dual Supply Single Supply		±2.5 ±18 +5 +36	
	AD8034		5 24	

Inference:

1. The Supply Voltage of AD826 is greater than that of AD8034.
2. For higher gain, we can get high output voltages without clipping for AD826 than that of AD8034.
3. AD8034 is fully operational on single supply as specified in datasheet and for AD826 we can use either single or dual supply depending on our application.
4. The total supply voltage range is the total voltage between the two supply terminals. The supply ±15V is a total of 30V. The operating voltage range for an op amp might be 6V to 36V. At the low voltage extreme, it is ±2.5V or +5V. At maximum, ±18V or +36V or even -6V/+30V. Unbalanced supplies are okay for an Opamp.
5. If the supply voltage is greater than the maximum specified range then Opamp may break or at lower supply voltage than the minimum specified range the opamp may not work.
6. If our signal amplitude is more but power supply is less than the signal will saturate earlier and will be clipped at the supply voltage.

PSRR:

Parameter	Conditions	Vs	Min	Typ	Max	Unit
Power Supply Rejection Ratio	**AD826**					dB
	V_S=±5V to ±15V, T_{MIN} to T_{MAX}		75	86		
	AD8034					
		±2V ±1V	-90 -80	-100 -100		

Inference:

1. PSRR should be a negative value because it is used to calculate rejection. However, the graph shows it as positive number so that a top number in graph denotes higher noise rejection
2. The PSRR for AD8034 has more negative value as compared to AD826.
3. AD8034 shows more rejection to noise and fluctuations of power supply as compared to AD826.

Temperature Range:

The operating and storage temperature range are same for both the Opamps.

Storage Temperature: -65°C to +125°C

Operating Temperature: -40°C to +85°C

Comparison between Typical Performance Characteristics:

CMRR v/s frequency

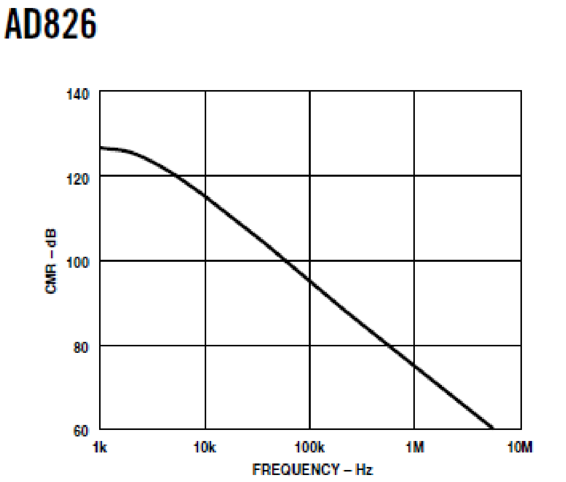


Figure 13. Common-Mode Rejection vs. Frequency

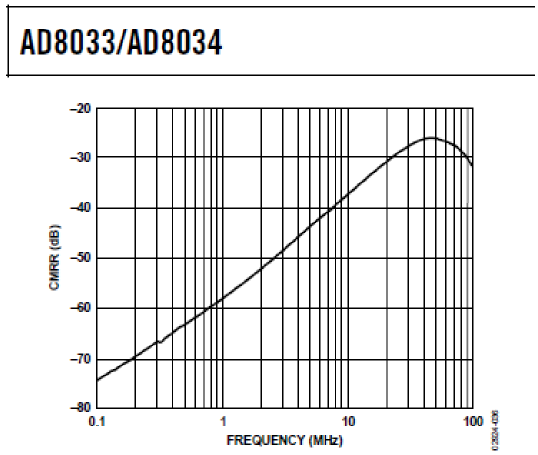


Figure 36. CMRR vs. Frequency (See Figure 50)

Inference:

1. At lower frequencies the CMRR for AD826 is more than that of AD8034.
2. CMRR decreases with increasing frequencies.
3. At higher frequencies the error for differential gain increases significantly.

Input Bias Current v/s Temperature:

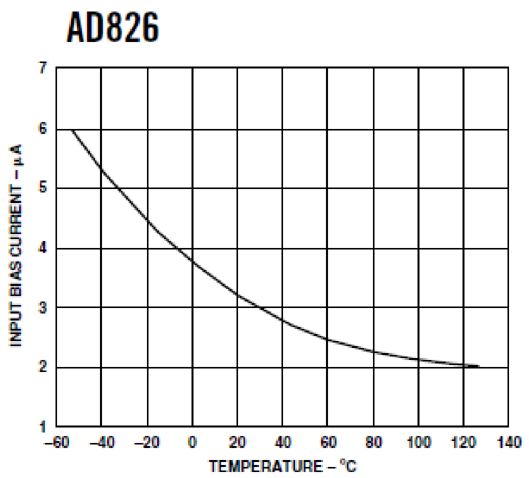


Figure 7. Input Bias Current vs. Temperature

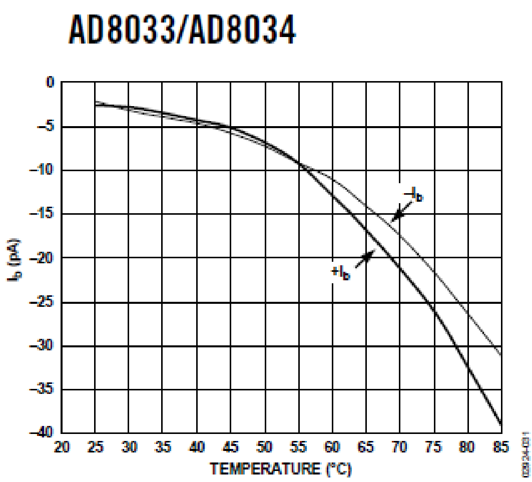


Figure 31. Ib vs. Temperature

Inference:

1. The input bias for AD826 increases with increasing temperature and for AD8034 the magnitude of input bias current increases with increasing temperature.
2. The errors due to input bias currents are lesser for AD8034 because, it is of order of picoamperes as compared to AD826.

PSRR v/s frequency:

AD826

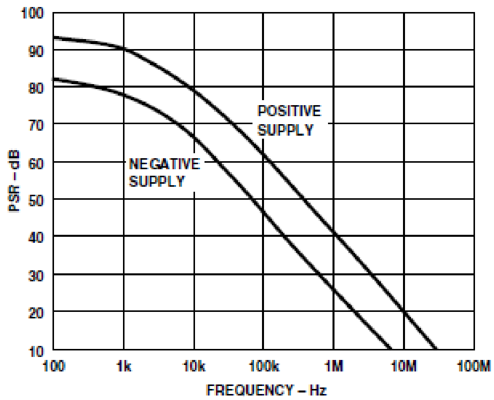


Figure 12. Power Supply Rejection vs. Frequency

AD8033/AD8034

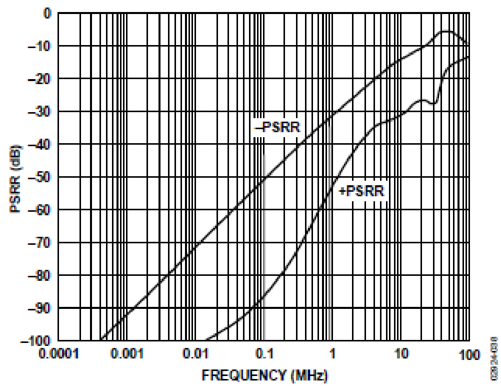


Figure 38. PSRR vs. Frequency (See Figure 49 and Figure 51)

Inference:

1. PSRR decreases with increasing frequency.
2. The plot of PSRR against frequency for AD826 is somewhat smooth as compared to AD8034.
3. At higher frequencies the noise or fluctuations of the output due to power supply will be significantly high.

Open Loop Gain vs Frequency:

AD826

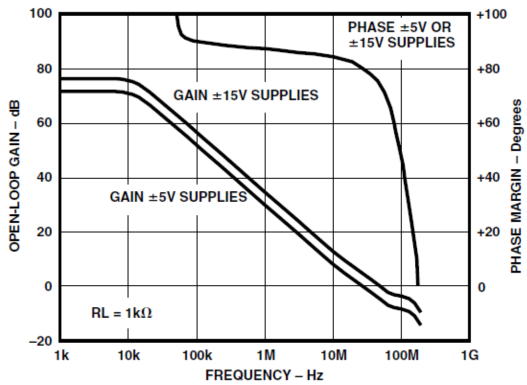


Figure 10. Open-Loop Gain and Phase Margin vs. Frequency

AD8033/AD8034

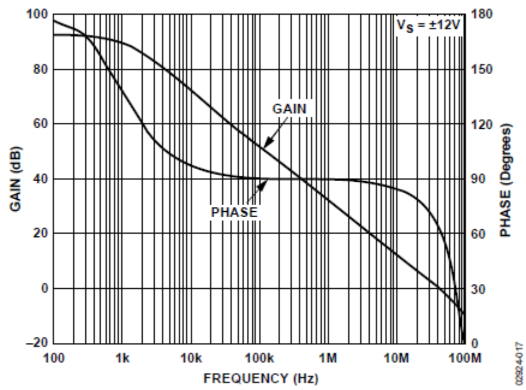


Figure 17. Open-Loop Response

Inference:

1. Open loop gain decreases with increasing frequency for both the Opamps.
2. The open loop gain for AD826 decreases with a decrease in power supply voltage.
3. At same frequencies, the open loop gain is more for AD8034 as compared to AD826.

AD826 – Typical Characteristics:

Common Mode Voltage Gain vs Supply:

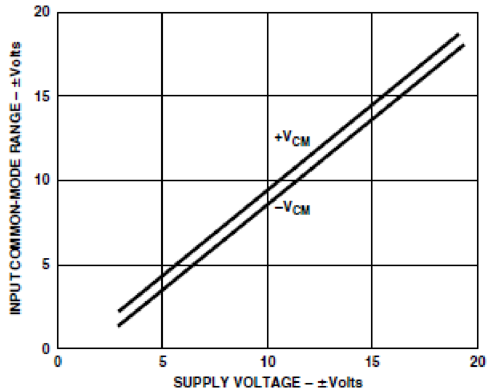


Figure 1. Common-Mode Voltage Range vs. Supply

Inference:

1. Input common mode voltage range increases with supply voltage.
2. The relation between common mode voltage range and supply voltage is linear.

Output Voltage Swing:

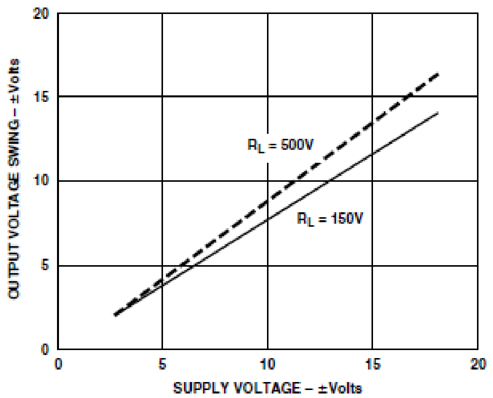


Figure 2. Output Voltage Swing vs. Supply

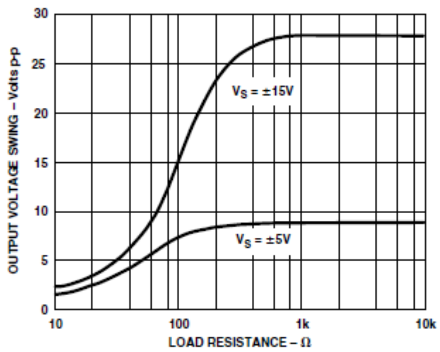


Figure 3. Output Voltage Swing vs. Load Resistance

Inference:

3. At low load impedances output voltage value changes rapidly as at low impedances the output current increases which results in greater voltage drop across the BJT's.

1. The difference between the expected output voltage and the obtained output voltage is less for higher loads.
2. The output voltage swing increases with increasing supply voltage.
3. At low load impedances output voltage value changes rapidly as at low impedances the output current increases which results in greater voltage drop across the BJT's.

Slew Rate:

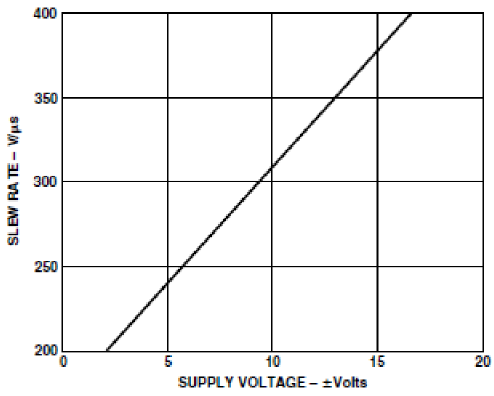


Figure 5. Slew Rate vs. Supply Voltage

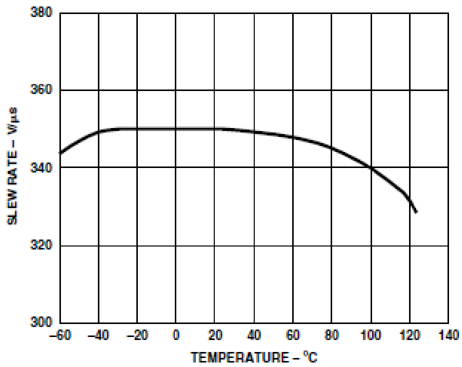


Figure 18. Slew Rate vs. Temperature

Inference:

1. The slew rate increases with increasing supply voltage.
2. Slew rate remains almost constant in the operating range of Opamp.

Short Circuit Current v/s Temperature:

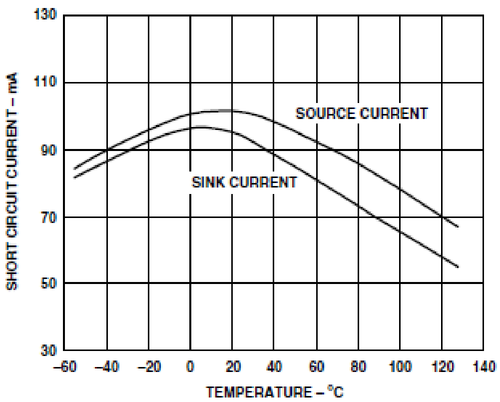


Figure 8. Short Circuit Current vs. Temperature

Inference:

1. Short circuit current decreases with increasing temperature after its peak value.
2. The short circuit current is maximum near the room temperature.

Open-Loop Gain vs Load Resistance:

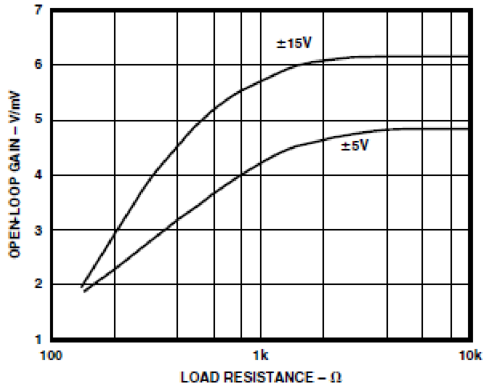


Figure 11. Open-Loop Gain vs. Load Resistance

Inference:

1. The open loop gain increases with increases in power supply.
2. It also increases with increase in load resistance and remains almost constant after a certain value of load resistance.

Unity Gain Bandwidth vs Temperature:

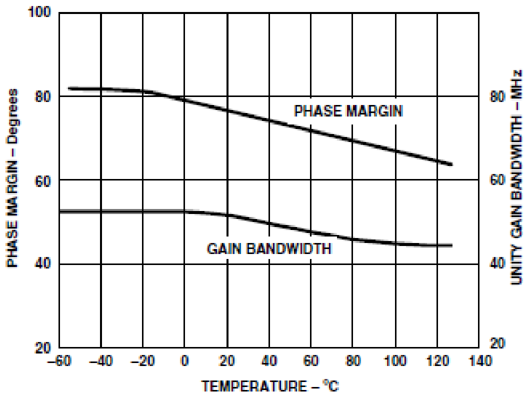


Figure 9. Unity Gain Bandwidth and Phase Margin vs. Temperature

Inference:

1. The unity gain bandwidth decreases with increasing temperature.
2. The decrease is about 10 to 15MHz but as it is in the order of MHz. It affects the gain of the Opamp.

Output Voltage vs Frequency:

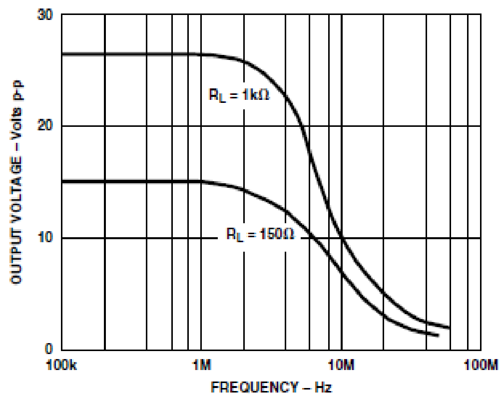


Figure 14. Large Signal Frequency Response

Inference:

1. At high frequency the output voltage decreases exponentially.
2. It remains constant for low frequencies and decreases as frequency increases.
3. Output Voltage also increases with a increase in load resistance.

Closed Loop Gain vs Frequency:

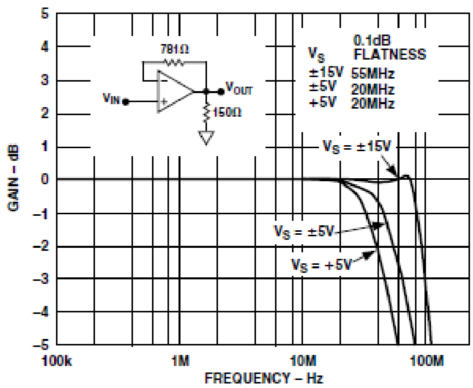


Figure 19. Closed-Loop Gain vs. Frequency

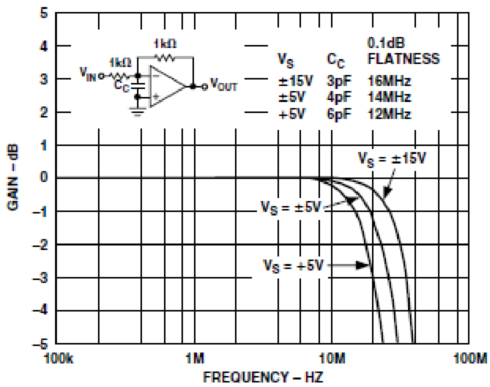


Figure 22. Closed-Loop Gain vs. Frequency, Gain = –1

Inference:

1. As, the power supply voltage increases the cut-off frequency increases.
2. Gain decreases with an increase in frequency.
3. It remains constant for low frequencies and decreases significantly for higher frequencies.

AD8033/AD8034– Typical Characteristics:

Input Offset Voltage vs Common-Mode Voltage:

Inference

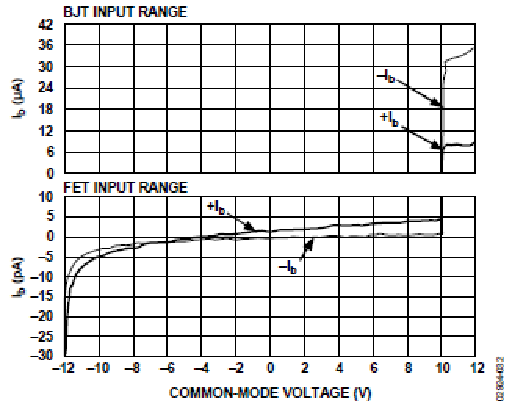


Figure 32. I_b vs. Common-Mode Voltage Range

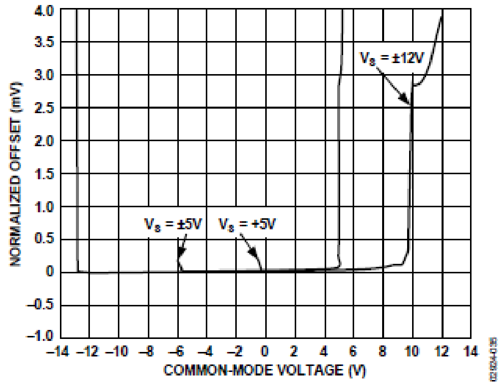


Figure 35. Input Offset Voltage vs. Common-Mode Voltage

Inference:

1. The magnitude of input bias current decreases with an increase in common mode voltage, remains constant and then again increases for FET.
2. In case of BJT, the input bias current remains 0 for a wide range of common mode voltage and suddenly increases after a certain point.
3. The input offset voltage remains almost constant except few peaks at the extreme points with respect to common mode voltage.
4. The rapid change in input offset voltage corresponds to the rapid change of input bias current.

Open Loop Gain vs Output Voltage for Various R_L:

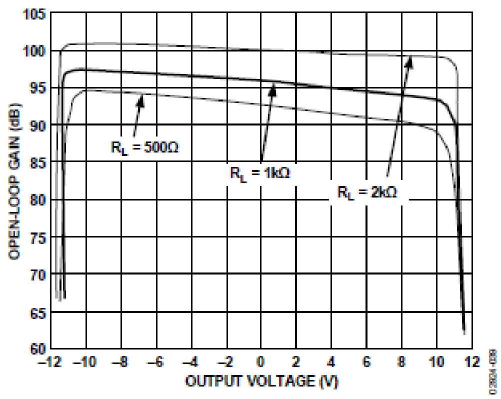


Figure 39. Open-Loop Gain vs. Output Voltage for Various R_L

Inference:

1. The open loop gain increases with an increase in load resistance.
2. The open loop gain decreases with an increase in output voltage.

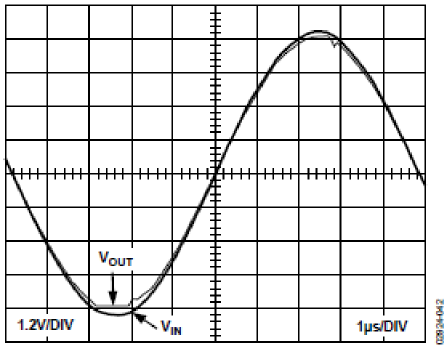


Figure 42. G = +1 Response, V_S = ±5 V

Inference:

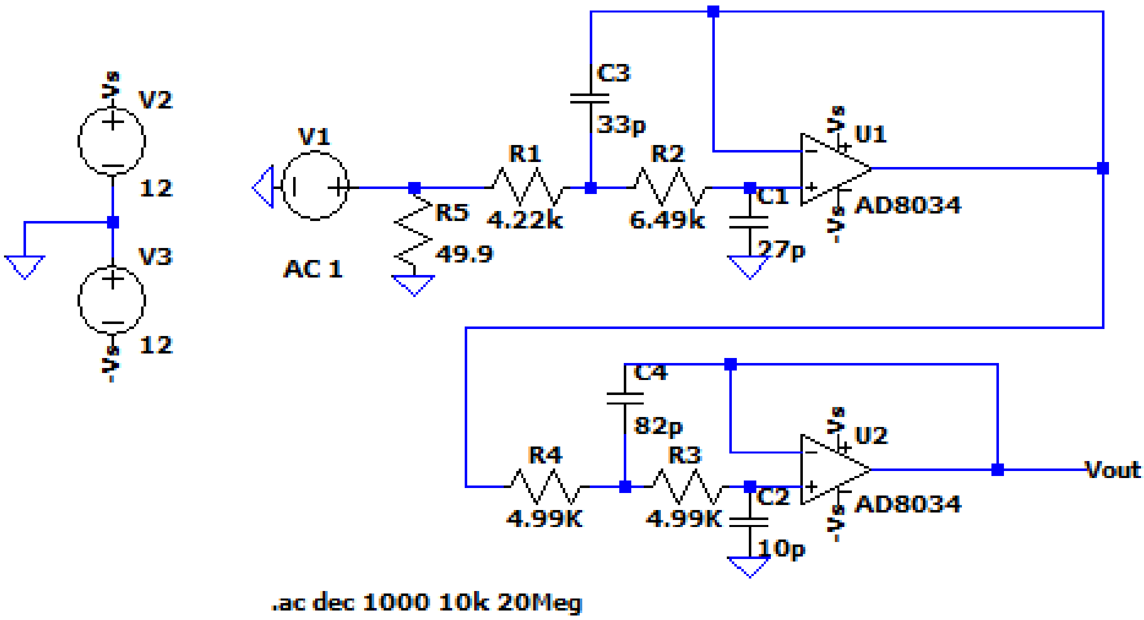
1. For the unity gain follower, the output voltage is clipped at peak values as compared to the input voltage.
2. Clipping occurs at both positive and negative cycles as the supply voltage is dual supply voltage with equal magnitude.

Application Circuits:

4-pole Cascade Sallen-Key Filter

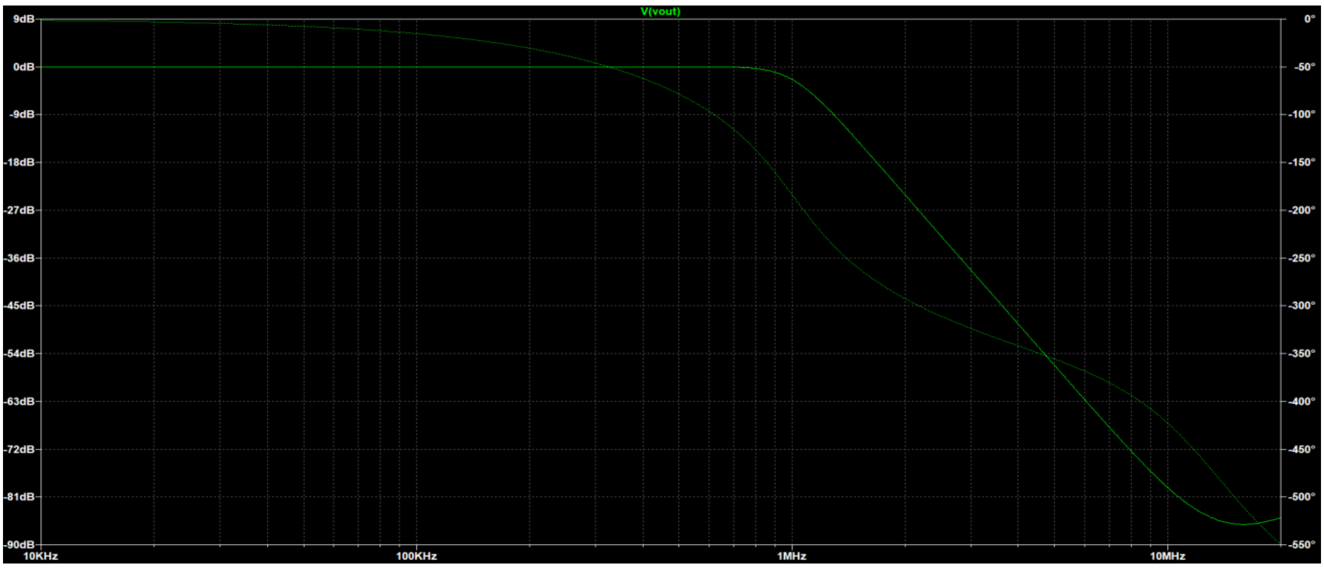
The Sallen-Key topology is the least dependent on the active device, requiring that the bandwidth be flat to beyond the stopband frequency because it is used simply as a gain block. In the case of high Q filter stages, the peaking must not exceed the open loop bandwidth and the linear input range of the amplifier.

LTSpice Circuit Diagram:



Circuit diagram of a 4-pole cascaded Sallen Key filter constructed using AD8034.

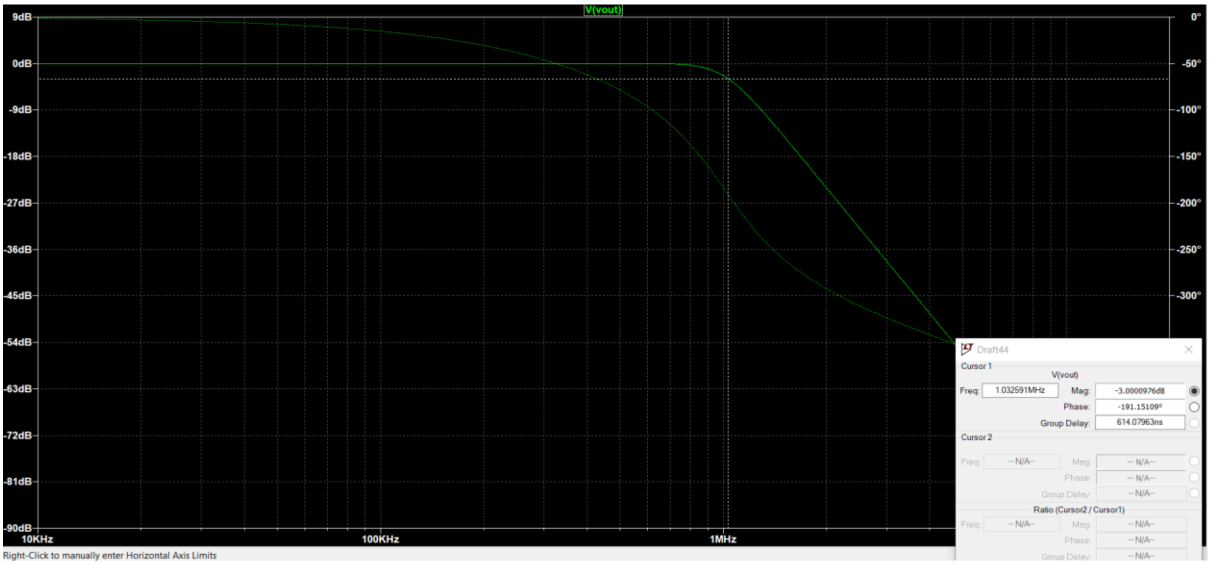
LTSpice Output:



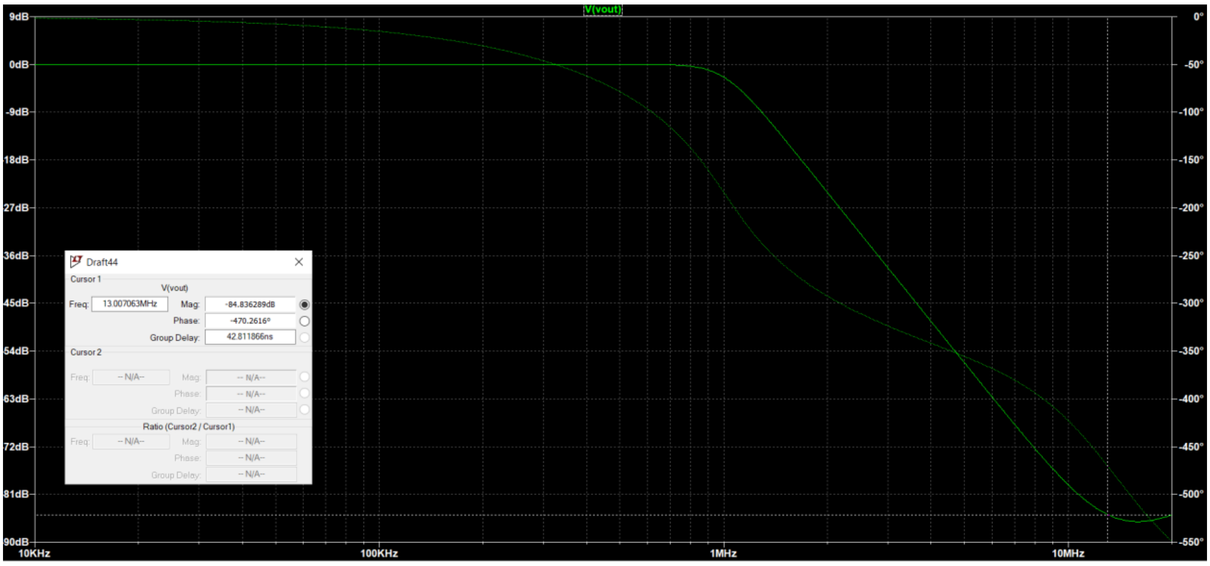
Inference:

1. The output curve is similar to a low pass filter.
2. As frequency increases the gain decreases rapidly.
3. Attenuation occurs at higher frequencies.
4. The output obtained from simulation is little bit different from the output in the datasheet as in the simulation the source, capacitor and resistors are taken as ideal.

Cut-off frequency at -3dB:

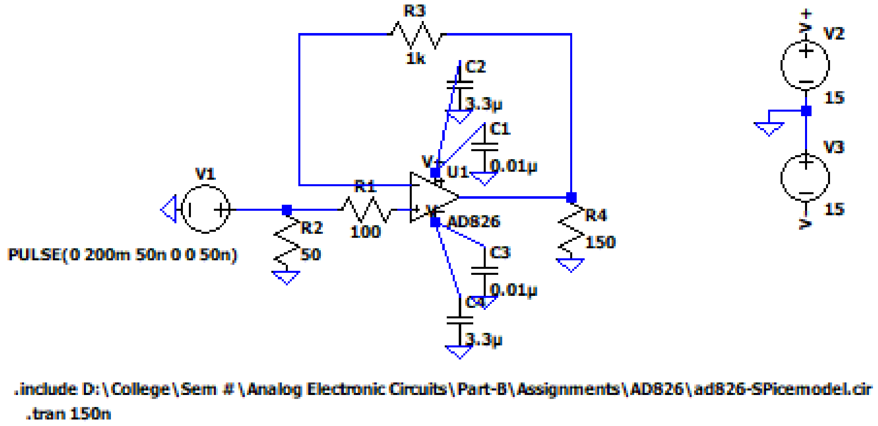


1. The cut-off frequency of the above filter is close to 1MHz and is same as given in datasheet.

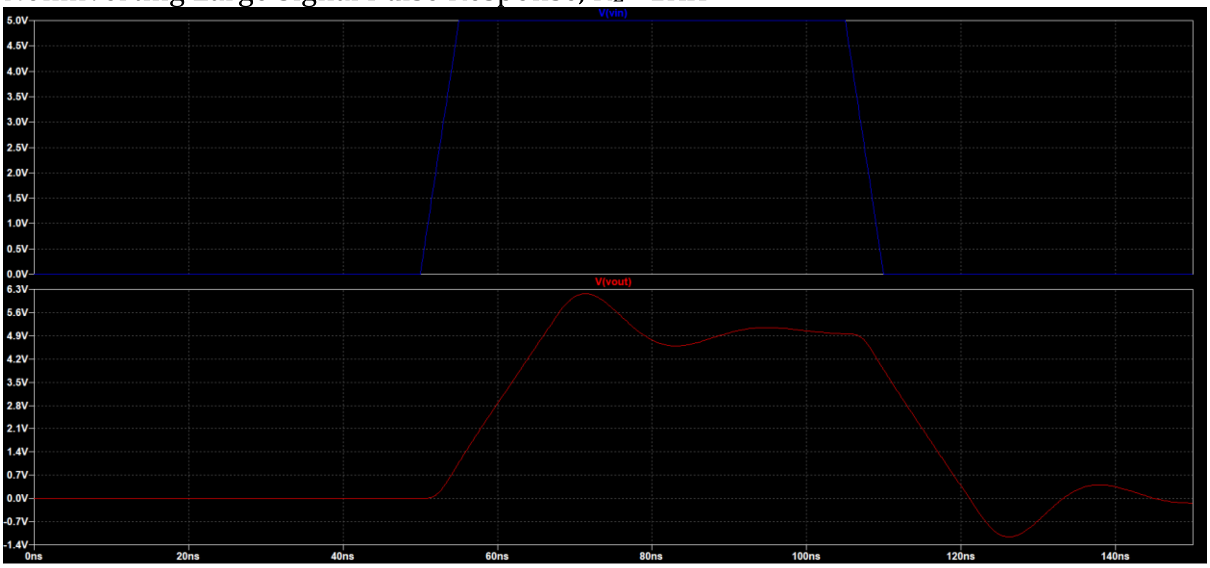


2. We can see that at -84dB the gain starts to increase and then it again decreases and the cycle goes on, this is the start of attenuation.
3. The stop band attenuation given in the datasheet is above 80dB which is close to our simulation.

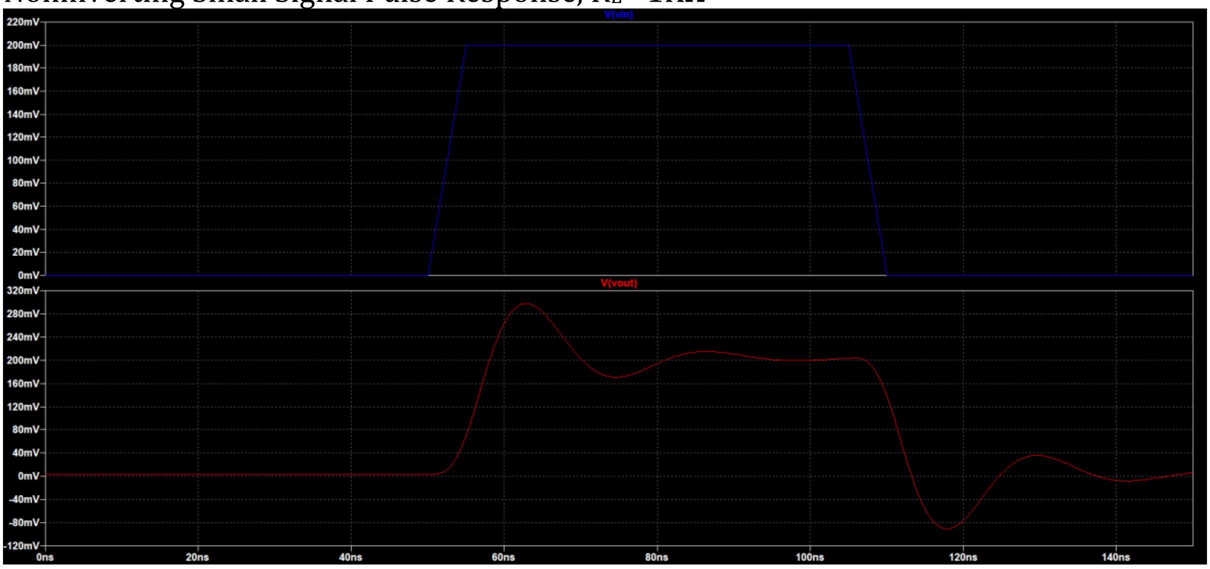
Non-inverting Amplifier Configuration



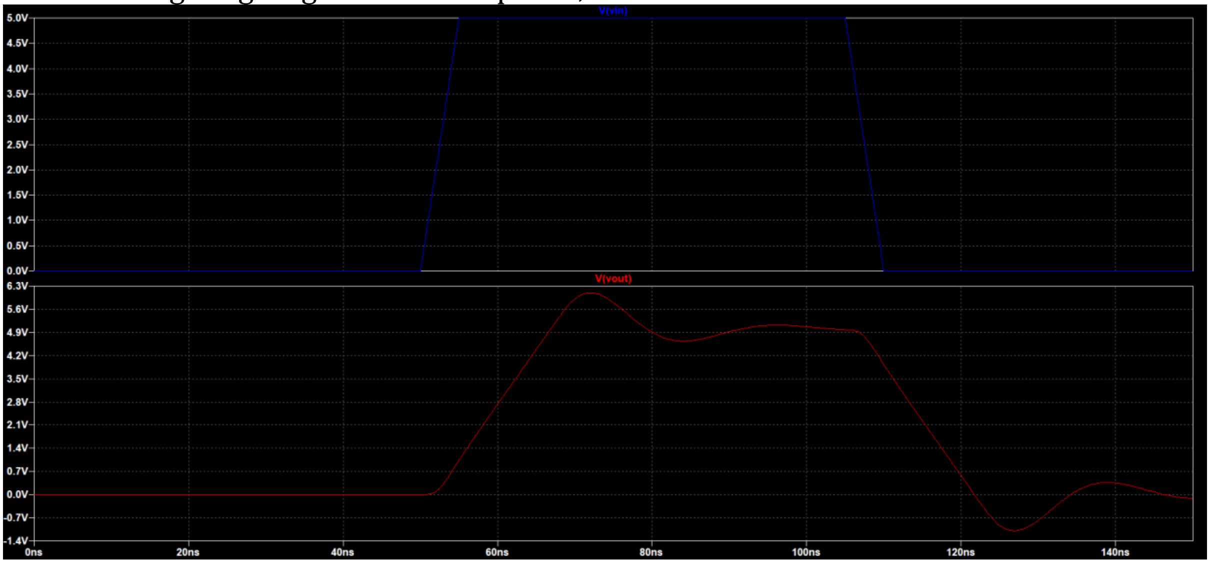
Noninverting Large Signal Pulse Response, R_L =1KΩ



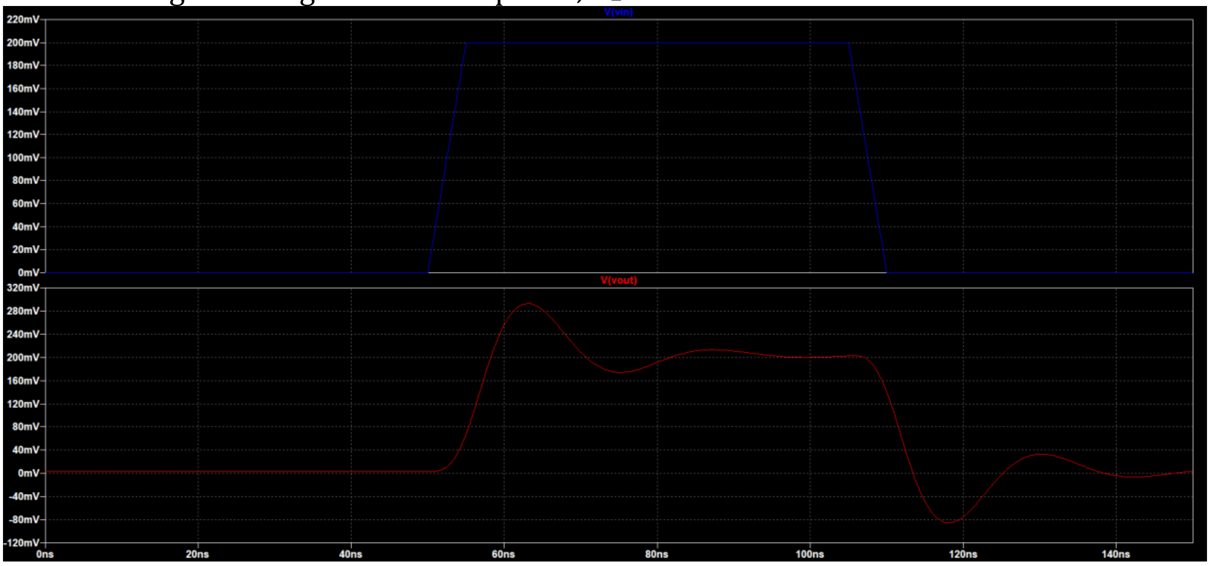
Noninverting Small Signal Pulse Response, R_L =1KΩ



Noninverting Large Signal Pulse Response, R_L =150Ω



Noninverting Small Signal Pulse Response, R_L =150Ω



Inference:

1. The distortion in the output waveform is due to the settling time of the Opamp.
2. The graphs obtained from simulation are similar to that given in the datasheet.
3. We can observe the distortion at the transient points of the output and input curve, as the Opamp takes some time to settle the output voltage.

Conclusion

Overall Comparison

	Maximum Typical Values		
Parameter	**AD826**	**AD8034**	**Preference**
DYNAMIC PERFORMANCE			
Bandwidth	50MHz, Unity Gain Bandwidth	80MHz, -3dB bandwidth (G=+1)	Should be high for high speed applications
Slew Rate	350 V/µs	80 V/µs	Should be high for high speed applications
Settling time to 0.1%	70ns	225ns	Should be low for high speed applications
DC PERFORMANCE			
Input Offset Voltage	0.5mV(typical)	1mV(typical)	Should be low for good DC performance
Input Bias Current	3.3 µA	50pA	Should be low for good DC performance
Open Loop Gain	6mV/V or 6000V/V	96dB or 63095.73445V/V	Should be high for good DC performance
INPUT CHARACTERISTICS			
Common-Mode Rejection Ratio	100dB	100dB	Should be high for excellent noise rejection
OUTPUT CHARACTERISTICS			
Output Voltage Swing	±13.7 (V_S=±15V, R_L=1KΩ)	±11.84 (V_S=±12V, R_L=1KΩ)	Should be less to avoid clipping
Short Circuit Current	90mA	60mA	Should be less
POWER SUPPLY			
Operating Range	±18	24	Should be high when dealing with high outputs to avoid clipping
PSRR	86	-100	High rejection should be there
TEMPERATURE RANGE			
Storage Temperature	-65°C to +125°C	-65°C to +125°C	Higher operating temperature range are good for working in different and extreme enviroments
Operating Temperature	-40°C to +80°C	-40°C to +85°C	

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