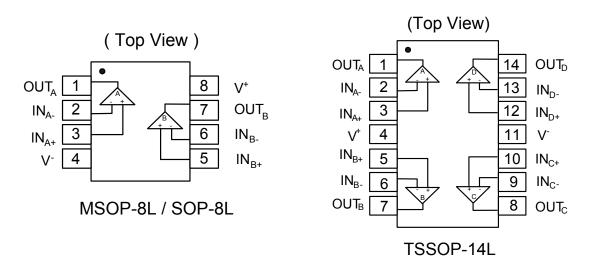


LOW VOLTAGE, RAIL-TO-RAIL INPUT AND OUTPUT DUAL/QUAD OPERATIONAL AMPLIFIERS

Pin Assignments



Absolute Maximum Ratings (Note 5)

Symbol	Description	Rating	Unit	
ESD HBM	Human Body Model ESD Protection	2000	V	
ESD MM	Machine Model ESD Protection	200	V	
	Differential Input Voltage	±Supply Voltage	V	
V ⁺ -V ⁻	Supply Voltage	5.5	V	
	Output Short Circuit to V ⁺	(Note 6)		
	Output Short Circuit to V ⁻	(Note 7)		
T _{ST}	Storage Temperature	-65 to 150	°C	
TJ	Maximum Junction Temperature	150	°C	

Operating Ratings (Note 5)

Symbol	Description	Rating	Unit
V ⁺ -V ⁻	Supply Voltage	2.5 to 5.5	V
T _A	Operating Ambient Temperature Range	-40 to +85	°C

Note: 5. Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is intended to be functional, but specific performance is not guaranteed. For guaranteed specifications and the test conditions, see the Electrical Characteristics.



LOW VOLTAGE, RAIL-TO-RAIL INPUT AND OUTPUT DUAL/QUAD OPERATIONAL AMPLIFIERS

Electrical Characteristics

2.7V DC Electrical Characteristics

Unless otherwise specified, all limits guaranteed for $T_A = 25^{\circ}C$, $V^+ = 2.7V$, $V^- = 0V$, $V_{CM} = 1.0V$, $V_O = V^+/2$ and $R_L > 1 M\Omega$.

Symbol	Parameter	Test Conditions	Min (Note 9)	Typ (Note 8)	Max (Note 9)	Unit
V _{os}	Input Offset Voltage			1.7	7	mV
TCVos	Input Offset Voltage Average Drift			5		µV/°C
I _B	Input Bias Current			10		nA
I _{os}	Input Offset Current			5	50	nA
CMRR	Common Mode Rejection Ratio	$0.3V \leq V_{\text{CM}} \leq 2.4V$	50	63		dB
PSRR	Power Supply Rejection Ratio	$2.7V \le V^+ \le 5V$ V _O = 1V	50	60		dB
V _{CM}	Input Common-Mode Voltage	For CMRR \geq 50dB	0.2		V ⁺ - 0.2	V
Vo	Output Swing	R _L = 10 kΩ to 1.35V	V ⁺ -100	V ⁺ -20 20	100	mV
I _S	Supply Current	APX358 Both amplifiers		190	340	μA
		APX324 All four amplifiers		340	680	μA

2.7V AC Electrical Characteristics

Unless otherwise specified, all limits guaranteed for $T_A = 25^{\circ}C$, $V^{+} = 2.7V$, $V^{-} = 0V$, $V_{CM} = 1.0V$, $V_{O} = V^{+}/2$ and $R_L > 1 M\Omega$.

Symbol	Parameter	Test Conditions	Min (Note 9)	Typ (Note 8)	Max (Note 9)	Unit
GBWP	Gain-Bandwidth Product	C _L = 200 pF		1		MHz
Φm	Phase Margin			60		Deg
Gm	Gain Margin			10		dB
en	Input-Referred Voltage Noise	f = 1 KHz		60		_ <mark>nV</mark> ₁√Hz



LOW VOLTAGE, RAIL-TO-RAIL INPUT AND OUTPUT DUAL/QUAD OPERATIONAL AMPLIFIERS

Electrical Characteristics (Continued)

5V DC Electrical Characteristics

Unless otherwise specified, all limits guaranteed for $T_A = 25^{\circ}C$, $V^{+} = 5V$, $V^{-} = 0V$, $V_{CM} = 2.0V$, $V_{O} = V^{+}/2$ and $R_L > 1 M\Omega$. **Boldface** limits apply at the temperature extremes.

Symbol	Parameter	Test Conditions	Min (Note 9)	Typ (Note 8)	Max (Note 9)	Unit
V _{OS}	Input Offset Voltage			1.7	7 9	mV
TCV _{os}	Input Offset Voltage Average Drift			5		µV/°C
I _B	Input Bias Current			15	250 500	nA
I _{OS}	Input Offset Current			5	50 150	nA
CMRR	Common Mode Rejection Ratio	$0.3V \leq V_{CM} \leq 4.7V$	50	65		dB
PSRR	Power Supply Rejection Ratio	$\begin{array}{l} 2.7V \leq V^{*} \leq 5V \\ V_{O} = 1V, V_{CM} = 1V \end{array}$	50	60		dB
V _{CM}	Input Common-Mode Voltage	For CMRR \geq 50dB	0.2		V ⁺ -0.2	V
A _V	Large Signal Voltage Gain (Note 10)	R _L = 2 kΩ	15 10	100		V/mV
	Output Swing	$R_L = 2 k\Omega$ to 2.5V	V ⁺ -300 V⁺ -400	V ⁺ -50		mV
N/				50	300 400	mV
Vo		$R_L = 10 \text{ k}\Omega \text{ to } 2.5 \text{V}$	V ⁺ -100 V⁺ -200	V ⁺ -10		mV
				10	180 280	mV
1	Output Short Circuit Current	Sourcing, V ₀ = 0V	5	60		mA
Ι _ο			10	90		mA
۱ _S	Supply Current	APX358 Both amplifiers		190	340 600	μA
		APX324 All four amplifiers		340	680 1100	μA
θ_{JA}	Thermal Resistance Junction-to-Ambient	MSOP-8L (Note 12)		203		°C/W
		SOP-8L (Note 12)		150		°C/W
		TSSOP-14L (Note 12)		100		°C/W



LOW VOLTAGE, RAIL-TO-RAIL INPUT AND OUTPUT **DUAL/QUAD OPERATIONAL AMPLIFIERS**

Electrical Characteristics (Continued)

5V AC Electrical Characteristics

Unless otherwise specified, all limits guaranteed for $T_A = 25^{\circ}C$, $V^{+} = 5V$, $V^{-} = 0V$, $V_{CM} = 2.0V$, $VO = V^{+}/2$ and R_L > 1 M Ω . **Boldface** limits apply at the temperature extremes.

Symbol	Parameter	Test Conditions	Min (Note 9)	Typ (Note 8)	Max (Note 9)	Unit
SR	Slew Rate	(Note 11)		1		V/µs
GBWP	Gain-Bandwidth Product	C _L = 200 pF		1		MHz
Φ_{m}	Phase Margin			60		Deg
G _m	Gain Margin			10		dB
e _n	Input-Referred Voltage Noise	f = 1 KHz		55		<u>nV</u> √Hz

Note:

 Shorting output to V+ will adversely affect reliability.
Shorting output to V- will adversely affect reliability.
Typical values represent the most likely parametric norm as determined at the time of characterization. Actual typical values may vary over time and will also depend on the application and configuration. The typical values are not tested and are not guaranteed on shipped production material.

9. All limits are guaranteed by testing or statistical analysis.

10. RL is connected to V-. The output voltage is 0.5V \leq VO \leq 4.5V.

Connected as voltage follower with 3V step input. Number specified is the slower of the positive and negative slew rates.
All numbers are typical, and apply for packages soldered directly onto a PC board in still air.

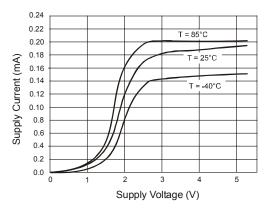


LOW VOLTAGE, RAIL-TO-RAIL INPUT AND OUTPUT DUAL/QUAD OPERATIONAL AMPLIFIERS

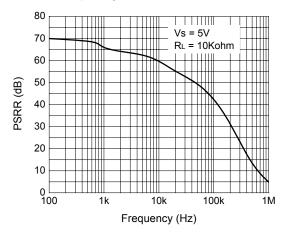
Typical Performance Characteristics

Unless otherwise specified, Vs=+5V, single supply, T_A=25°C

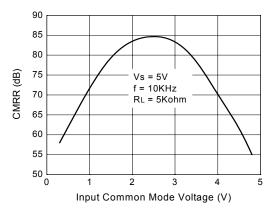
Supply Current vs. Supply Voltage



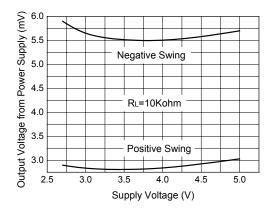
PSRR vs. Frequency



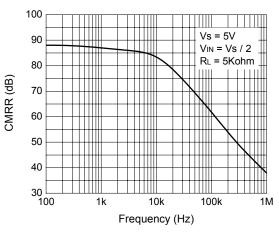


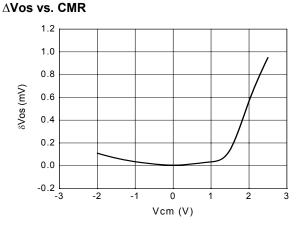


Output Voltage Swing vs. Supply Voltage









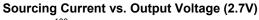
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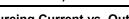
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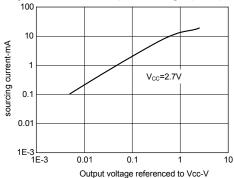


LOW VOLTAGE, RAIL-TO-RAIL INPUT AND OUTPUT **DUAL/QUAD OPERATIONAL AMPLIFIERS**

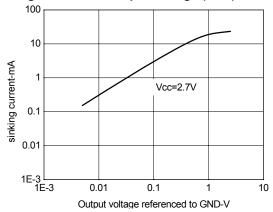
Typical Performance Characteristics (Continued)

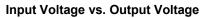


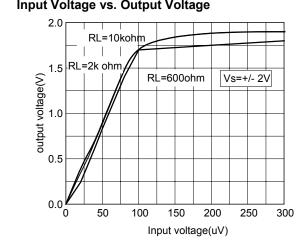


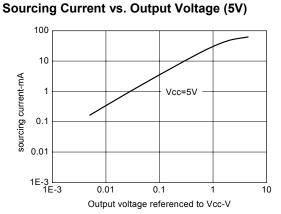


Sinking Current vs. Output Voltage (2.7V)

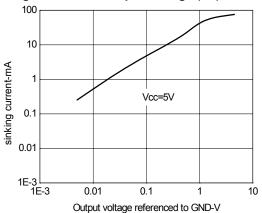








Sinking Current vs. Output Voltage (5V)



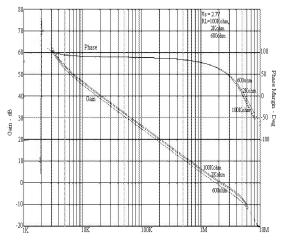


LOW VOLTAGE, RAIL-TO-RAIL INPUT AND OUTPUT DUAL/QUAD OPERATIONAL AMPLIFIERS

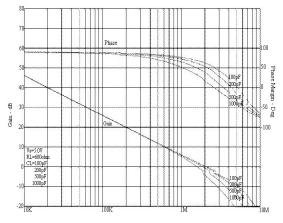
Typical Performance Characteristics (continued)

Frequency Response vs. Resistive Load (2.7V)

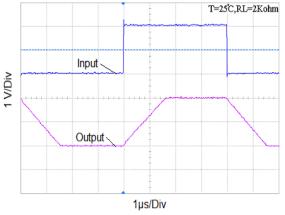
Frequency Response vs. Resistive Load (5V)

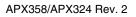


Frequency Response vs. Capacitive Load (2.7V)



Non-Inverting Large Signal Pulse Response

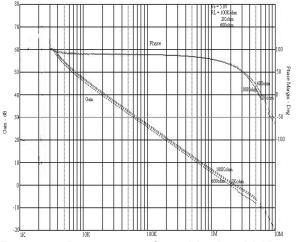




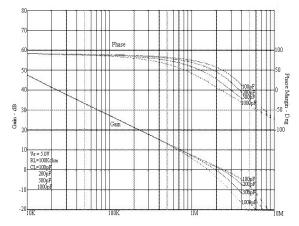
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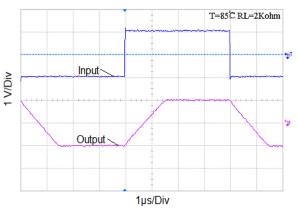
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Frequency Response vs. Capacitive Load (5V)



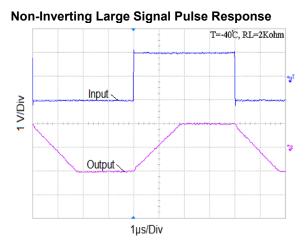
Non-Inverting Large Signal Pulse Response



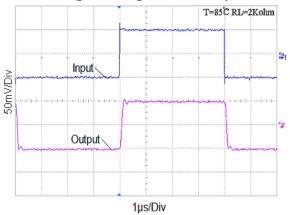


LOW VOLTAGE, RAIL-TO-RAIL INPUT AND OUTPUT DUAL/QUAD OPERATIONAL AMPLIFIERS

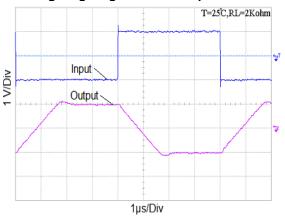
Typical Performance Characteristics (continued)

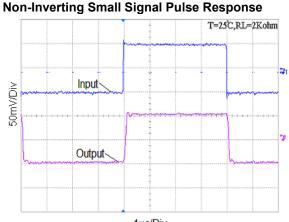


Non-Inverting Small Signal Pulse Response



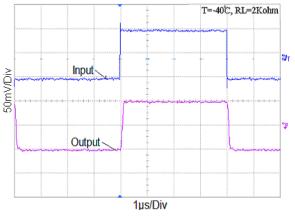
Inverting Large Signal Pulse Response

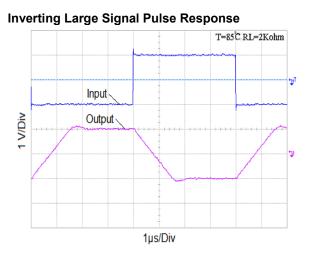




1µs/Div

Non-Inverting Small Signal Pulse Response





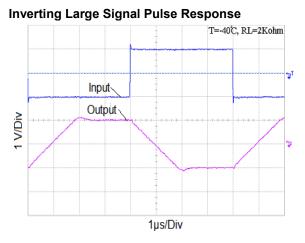
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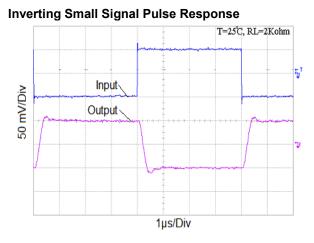
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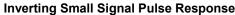


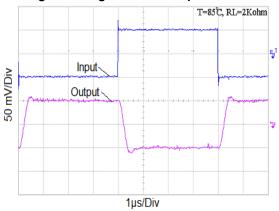
LOW VOLTAGE, RAIL-TO-RAIL INPUT AND OUTPUT DUAL/QUAD OPERATIONAL AMPLIFIERS

Typical Performance Characteristics (Continued)

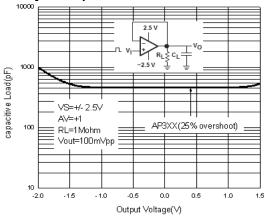




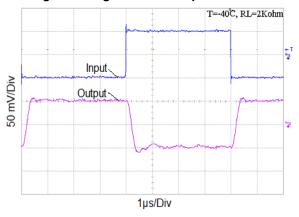




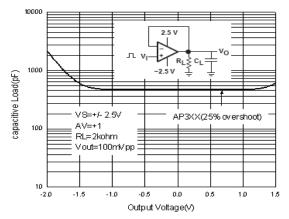




Inverting Small Signal Pulse Response







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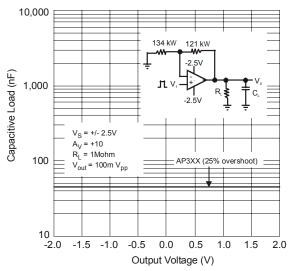
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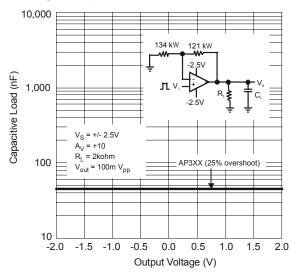
LOW VOLTAGE, RAIL-TO-RAIL INPUT AND OUTPUT DUAL/QUAD OPERATIONAL AMPLIFIERS

Typical Performance Characteristics (Continued)

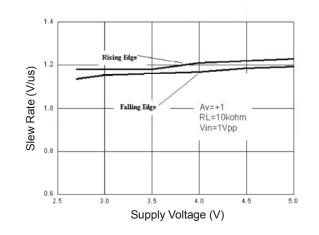
Stability vs. Capacitive Load



Stability vs. Capacitive Load



Slew Rate vs. Supply Voltage

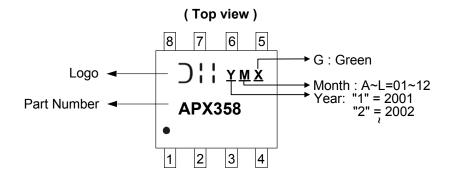




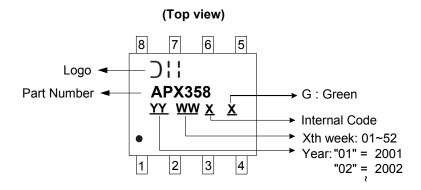
LOW VOLTAGE, RAIL-TO-RAIL INPUT AND OUTPUT DUAL/QUAD OPERATIONAL AMPLIFIERS

Marking Information

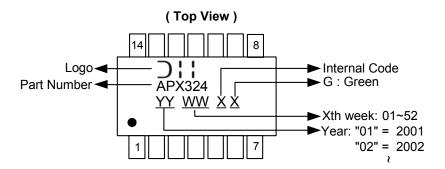
(1) MSOP-8L



(2) SOP-8L



(3) TSSOP-14L

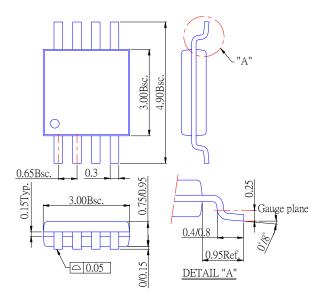




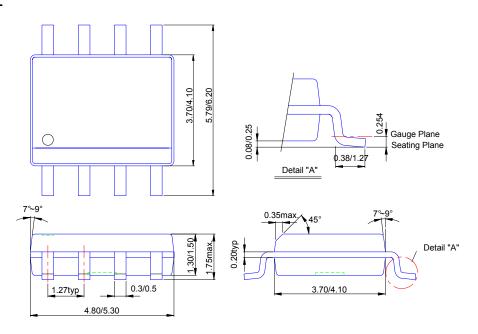
LOW VOLTAGE, RAIL-TO-RAIL INPUT AND OUTPUT DUAL/QUAD OPERATIONAL AMPLIFIERS

Package Information (All Dimensions in mm)

(1) MSOP-8L



(2) SOP-8L



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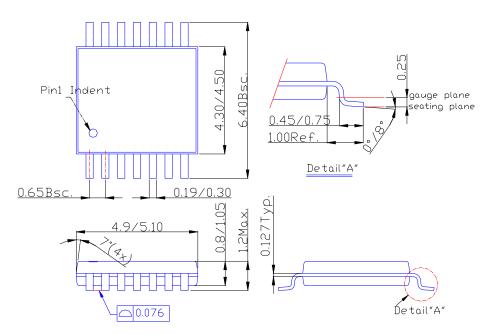
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Package Information (Continued)

(3) TSSOP-14L



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