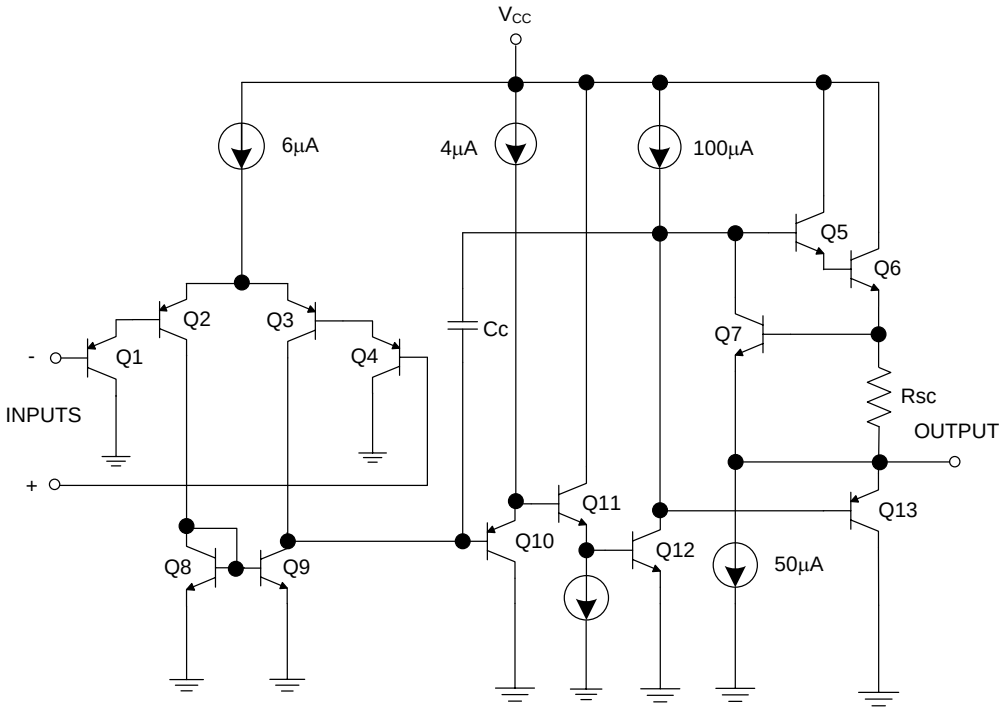
Functional Block Diagram



Each Amplifier

Pin Descriptions

LM2902, LM2902A		
Pin Name	**Pin Number**	**Function**
1OUT	1	Channel 1 Output
1IN-	2	Channel 1 Inverting Input
1IN+	3	Channel 1 Non-Inverting Input
V_{CC}	4	Chip Supply Voltage
2IN+	5	Channel 2 Non-Inverting Input
2IN-	6	Channel 2 Inverting Input
2OUT	7	Channel 2 Output
3OUT	8	Channel 3 Output
3IN-	9	Channel 3 Inverting Input
3IN+	10	Channel 3 Non-Inverting Input
GND	11	Ground
4IN+	12	Channel 4 Non-Inverting Input
4IN-	13	Channel 4 Inverting Input
4OUT	14	Channel 4 Output
LM2904, LM2904A		
1OUT	1	Channel 1 Output
1IN-	2	Channel 1 Inverting Input
1IN+	3	Channel 1 Non-Inverting Input
GND	4	Ground
2IN+	5	Channel 2 Non-Inverting Input
2IN-	6	Channel 2 Inverting Input
2OUT	7	Channel 2 Output
V_{CC}	8	Chip Supply Voltage

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Absolute Maximum Ratings (Note 4) (@T_A = +25°C, unless otherwise specified.)

Symbol	Parameter		Rating	Unit
V_{CC}	Supply Voltage		±18 or 36	V
V_{ID}	Differential Input Voltage		36	V
V_{IN}	Input Voltage		-0.3 to +36	V
θ_{JA}	Package Thermal Impedance (Note 5)	SO-8	115	°C/W
		MSOP-8	160	
		TSSOP-8	209	
		SO-14	91	
		TSSOP-14	133	
θ_{JC}	Package Thermal Impedance (Note 6)	SO-8	16	°C/W
		MSOP-8	20	
		TSSOP-8	47	
		SO-14	18	
		TSSOP-14	20	
—	Output Short-Circuit to GND (One Amplifier) (Note 7)	V_{CC} ≤ 15V and T_A = +25°C	Continuous	—
T_A	Operating Temperature Range		-40 to +125	°C
T_J	Operating Junction Temperature		+150	°C
T_{ST}	Storage Temperature Range		-65 to +150	°C
ESD	Human Body Mode ESD Protection (Note 8)		300	V
	Machine Mode ESD Protection		150	

Notes:
4. Stresses beyond those listed under *Absolute Maximum Ratings* can cause permanent damage to the device. These are stress ratings only; functional operation of the device at these or any other conditions beyond those indicated under recommended operating conditions is not implied. Exposure to absolute-maximum-rated conditions for extended periods can affect device reliability.
5. Maximum power dissipation is a function of $T_{J(max)}$, θ_{JA}, and T_A. The maximum allowable power dissipation at any allowable ambient temperature is $P_D = (T_{J(max)} - T_A)/\theta_{JA}$. Operating at the absolute maximum T_J of +150°C can affect reliability.
6. Maximum power dissipation is a function of $T_{J(max)}$, θ_{JC}, and T_A. The maximum allowable power dissipation at any allowable ambient temperature is $P_D = (T_{J(max)} - T_A)/\theta_{JA}$. Operating at the absolute maximum T_J of +150°C can affect reliability.
7. Short circuits from outputs to V_{CC} or ground can cause excessive heating and eventual destruction.
8. Human body model, 1.5kΩ in series with 100pF.

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Electrical Characteristics (Notes 12 & 13) (@ V_{CC} = +5.0V, T_A = +25°C, unless otherwise specified.)

LM2902, LM2902A

Parameter		Conditions		T_A	Min	Typ	Max	Unit
V_{IO}	Input Offset Voltage	V_{IC} = V_{CMR} Min, V_O = 1.4V, V_{CC} = 5V to Max, R_S = 0Ω	Non-A Device	T_A = +25°C	—	2	7	mV
				Full Range	—	—	10	
			A-Suffix Device	T_A = +25°C	—	1	2	
				Full Range	—	—	4	
$\Delta V_{IO}/\Delta T$	Input Offset Voltage Temperature Drift	R_S = 0Ω		Full Range	—	7	—	µV/°C
I_B	Input Bias Current	I_{IN+} or I_{IN-} with OUT in Linear Range, V_{CMR} = 0V (Note 9)		T_A = +25°C	—	-20	-200	nA
				Full Range	—	—	-500	
I_{IO}	Input Offset Current	I_{IN+} - I_{IN-}, V_{CM} = 0V		T_A = +25°C	—	2	50	nA
				Full Range	—	—	150	
$\Delta I_{IO}/\Delta T$	Input Offset Current Temperature Drift	—		Full Range	—	10	—	pA/°C
V_{CMR}	Input Common-Mode Voltage Range	V_{CC} = 30V (Note 10)		T_A = +25°C	0 to V_{CC}-1.5	—	—	V
				Full Range	0 to V_{CC}-2.0	—	—	
I_{CC}	Supply Current (Four Amplifiers)	V_O = 0.5V_{CC}, No Load	V_{CC} = 30V	Full Range	—	1.0	3.0	mA
		V_O = 0.5V_{CC}, No Load	V_{CC} = 5V	Full Range	—	0.7	1.2	
A_V	Voltage Gain	V_{CC} = 15V, V_{OUT} = 1V to 11V, R_L ≥ 2kΩ		T_A = +25°C	25	100	—	V/mV
				Full Range	15	—	—	
CMRR	Common Mode Rejection Ratio	DC, V_{CMR} = 0V to V_{CC}-1.5V		T_A = +25°C	60	70	—	dB
PSRR	Power Supply Rejection Ratio	V_{CC} = 5V to 30V		T_A = +25°C	70	100	—	dB
—	Amplifier to Amplifier Coupling	f = 1kHz to 20kHz (Input Referred) (Note 11)		T_A = +25°C	—	-120	—	dB
I_{SINK}	Output Current	Sink	V_{IN}^- = 1V, V_{IN}^+ = 0V, V_{CC} = 15V, V_O = 200mV	T_A = +25°C	12	50	—	µA
			V_{IN}^- = 1V, V_{IN}^+ = 0V, V_{CC} = 15V, V_O = 15V	T_A = +25°C	10	20	—	mA
				Full Range	5	—	—	
I_{SOURCE}		Source	V_{IN}^+ = 1V, V_{IN}^- = 0V, V_{CC} = 15V, V_O = 0V	T_A = +25°C	-20	-40	-60	
				Full Range	-10	—	—	
I_{SC}	Short-Circuit to Ground	V_{CC} = 5V, GND = -5V, V_O = 0V		T_A = +25°C	—	±40	±60	mA
V_{OH}	High-Level Output Voltage Swing	R_L = 10kΩ		T_A = +25°C	—	V_{CC}-1.5	—	V
		V_{CC} = 30V	R_L = 2kΩ	Full Range	26	—	—	
			R_L ≥ 10kΩ		27	28	—	
V_{OL}	Low-Level Output Voltage Swing	R_L ≦ 10kΩ		Full Range	—	5	20	mV

AC Electrical Characteristics (Notes 12 & 13) (@ V_{CC} = ±15.0V, T_A = +25°C, unless otherwise specified.)

LM2902, LM2902A

Parameter		Conditions	Typ	Unit
SR	Slew Rate at Unity Gain	R_L = 1MΩ, C_L = 30pF, V_I = ±10V	0.3	V/µs
B1	Unity Gain Bandwidth	R_L = 1MΩ, C_L = 20pF	0.7	MHz
Vn	Equivalent Input Noise Voltage	R_S = 100Ω, V_I = 0V, f = 1kHz	40	nV/√Hz

Notes:
9. The direction of the input current is out of the IC due to the PNP input stage. This current is essentially constant, independent of the state of the output so no loading change exists on the input lines.
10. The input common-mode voltage of either input signal voltage should not be allowed to go negative by more than 0.3V (@ +25°C). The upper end of the common-mode voltage range is V_{CC} -1.5V (@ +25°C), but either or both inputs can go to +36V without damage, independent of the magnitude of V_{CC}.
11. Due to proximity of external components, insure that coupling is not originating via stray capacitance between these external parts. This typically can be detected as this type of capacitance increases at higher frequencies.
12. Typical values are all at T_A = +25°C conditions and 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.
13. All limits are guaranteed by testing or statistical analysis. Limits over the full temperature are guaranteed by design, but not tested in production.

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Electrical Characteristics (continued) (Notes 12 & 13) (@ V_{CC} = +5.0V, T_A = +25°C, unless otherwise specified.)

LM2904, LM2904A

Parameter		Conditions		T_A	Min	Typ	Max	Unit
V_{IO}	Input Offset Voltage	V_{IC} = V_{CMR} Min, V_O = 1.4V, V_{CC} = 5V to Max, R_S = 0Ω	Non-A Device	T_A = +25°C	—	2	7	mV
				Full Range	—	—	10	
			A-Suffix Device	T_A = +25°C	—	1	2	
				Full Range	—	—	4	
$\Delta V_{IO}/\Delta T$	Input Offset Voltage Temperature Drift	R_S = 0Ω		Full Range	—	7	—	µV/°C
I_B	Input Bias Current	I_{IN+} or I_{IN-} with OUT in Linear Range, V_{CMR} = 0V (Note 9)		T_A = +25°C	—	-20	-250	nA
				Full Range	—	—	-500	
I_{IO}	Input Offset Current	I_{IN+} - I_{IN-}, V_{CM} = 0V		T_A = +25°C	—	2	50	nA
				Full Range	—	—	150	
$\Delta I_{IO}/\Delta T$	Input Offset Current Temperature Drift	—		Full Range	—	10	—	pA/°C
V_{CMR}	Input Common-Mode Voltage Range	V_{CC} = 30V (Note 10)		T_A = +25°C	0 to V_{CC}-1.5	—	—	V
				Full Range	0 to V_{CC}-2.0	—	—	
I_{CC}	Supply Current (Two Amplifiers)	V_O = 0.5V_{CC}, No Load	V_{CC} = 30V	Full Range	—	0.7	2.0	mA
		V_O = 0.5V_{CC}, No Load	V_{CC} = 5V	Full Range	—	0.5	1.2	
A_V	Voltage Gain	V_{CC} = 15V, V_{OUT} = 1V to 11V, R_L ≥ 2kΩ		T_A = +25°C	25	100	—	V/mV
				Full Range	15	—	—	
CMRR	Common Mode Rejection Ratio	DC, V_{CMR} = 0V to V_{CC}-1.5V		T_A = +25°C	60	70	—	dB
PSRR	Power Supply Rejection Ratio	V_{CC} = 5V to 30V		T_A = +25°C	70	100	—	dB
—	Amplifier to Amplifier Coupling	f = 1kHz to 20kHz (Note 11)		T_A = +25°C	—	120	—	dB
I_{SINK}	Output Current	Sink	V_{IN}^- = 1V, V_{IN}^+ = 0V, V_{CC} = 15V, V_O = 200mV	T_A = +25°C	12	50	—	µA
			V_{IN}^- = 1V, V_{IN}^+ = 0V, V_{CC} = 15V, V_O = 15V	T_A = +25°C	10	20	—	mA
				Full Range	5	—	—	
I_{SOURCE}		Source	V_{IN}^+ = 1V, V_{IN}^- = 0V, V_{CC} = 15V, V_O = 0V	T_A = +25°C	-20	-40	-60	
				Full Range	-10	—	—	
I_{SC}	Short-Circuit to Ground	V_{CC} = 5V, GND = -5V, V_O = 0V		T_A = +25°C	—	±40	±60	mA
V_{OH}	High-Level Output Voltage Swing	R_L = 10kΩ		T_A = +25°C	V_{CC}-1.5	—	—	V
		V_{CC} = 30V	R_L = 2kΩ	Full Range	26	—	—	
			R_L ≥ 10kΩ		27	28	—	
V_{OL}	Low-Lever Output Voltage Swing	R_L ≦ 10kΩ		Full Range	—	5	20	mV

AC Electrical Characteristics (Notes 12 & 13) (@ V_{CC} = ±15.0V, T_A = +25°C, unless otherwise specified.)

LM2904, LM2904A

Parameter		Conditions	Typ	Unit
SR	Slew Rate at Unity Gain	R_L = 1MΩ, C_L = 30pF, V_I = ±10V	0.3	V/µs
B1	Unity Gain Bandwidth	R_L = 1MΩ, C_L = 20pF	0.7	MHz
Vn	Equivalent Input Noise Voltage	R_S = 100Ω, V_I = 0V, f = 1kHz	40	nV/√Hz

Notes:
9. The direction of the input current is out of the IC due to the PNP input stage. This current is essentially constant, independent of the state of the output so no loading change exists on the input lines.
10. The input common-mode voltage of either input signal voltage should not be allowed to go negative by more than 0.3V (@ +25°C). The upper end of the common-mode voltage range is V_{CC}-1.5V (@ +25°C), but either or both inputs can go to +36V without damage, independent of the magnitude of V_{CC}.
11. Due to proximity of external components, insure that coupling is not originating via stray capacitance between these external parts. This typically can be detected as this type of capacitance increases at higher frequencies.
12. Typical values are all at T_A = +25°C conditions and 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.
13. All limits are guaranteed by testing or statistical analysis. Limits over the full temperature are guaranteed by design, but not tested in production.

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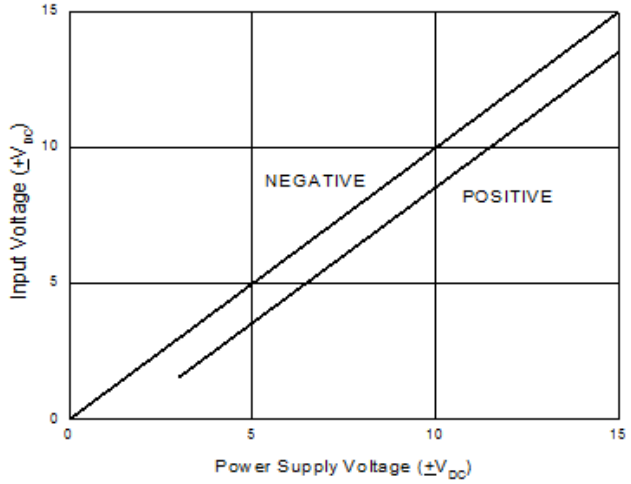
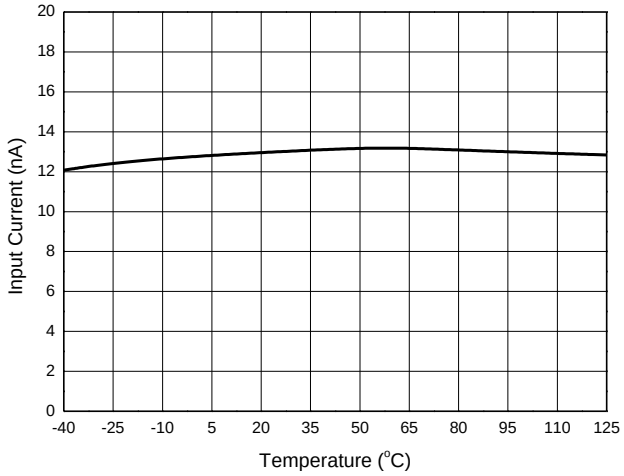
Performance Characteristics

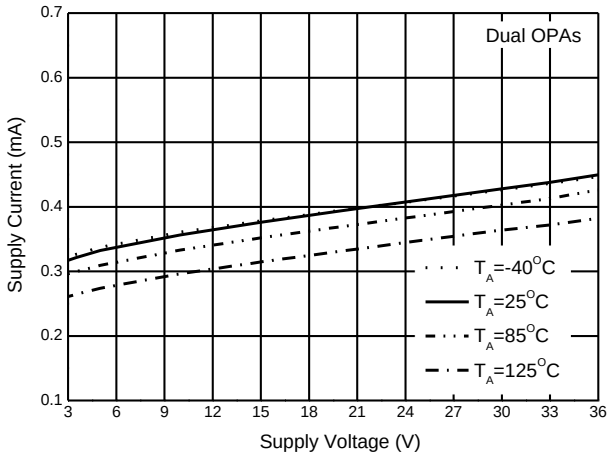
Input Voltage Range



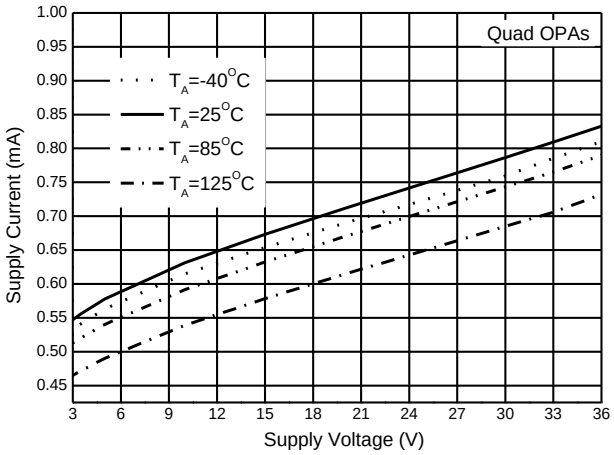
Input Current



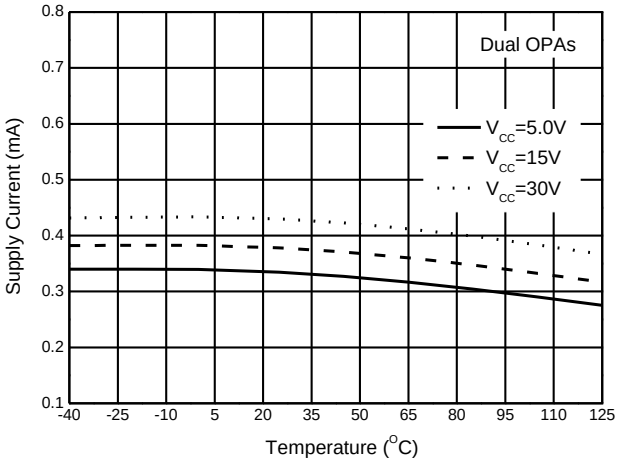
Supply Current vs. Supply Voltage (LM2904/LM2904A)



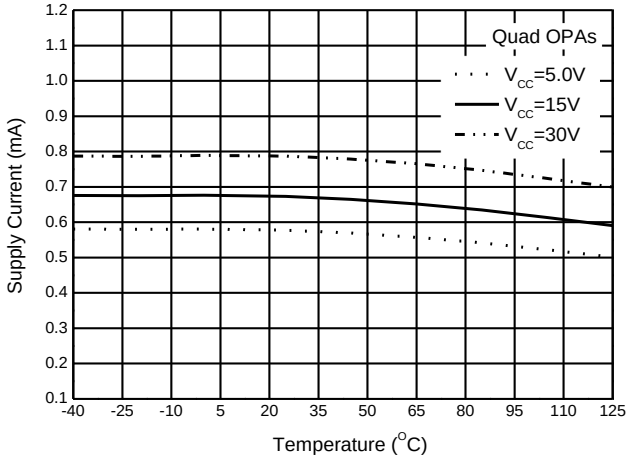
Supply Current vs. Supply Voltage (LM2902/LM2902A)



Supply Current vs. Temperature (LM2904/LM2904A)



Supply Current vs. Temperature (LM2902/LM2902A)



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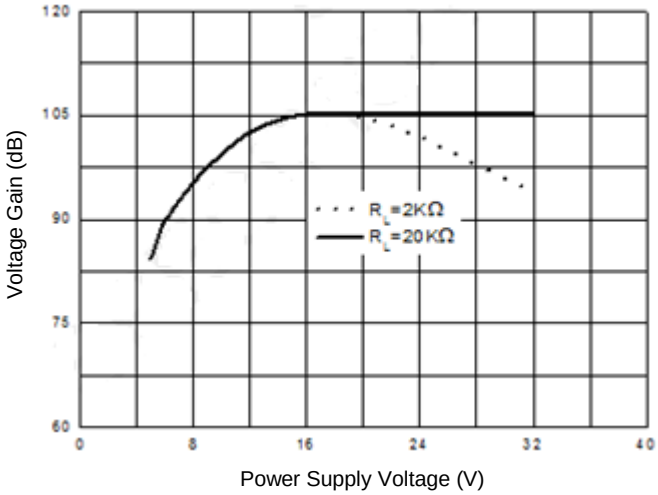
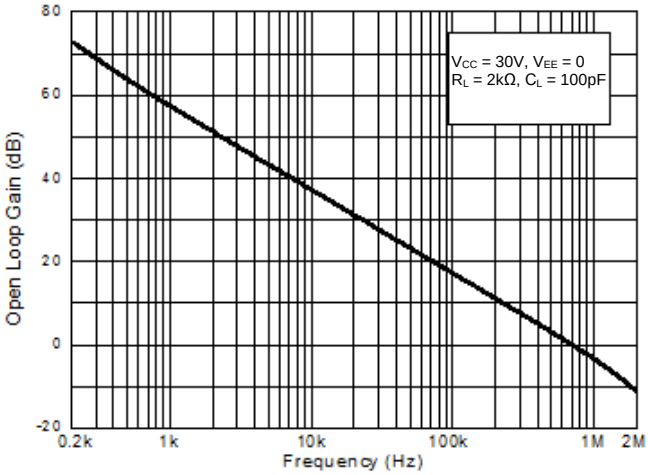
Performance Characteristics (continued)

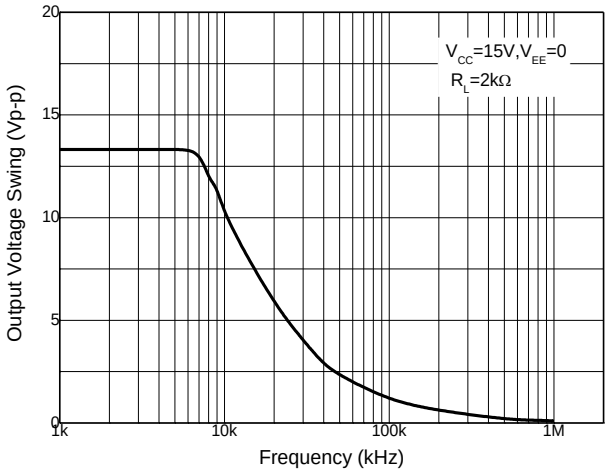
Voltage Gain



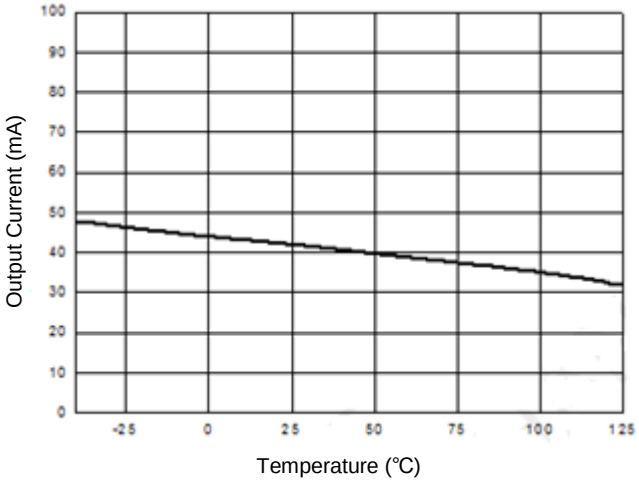
Open Loop Frequency Response



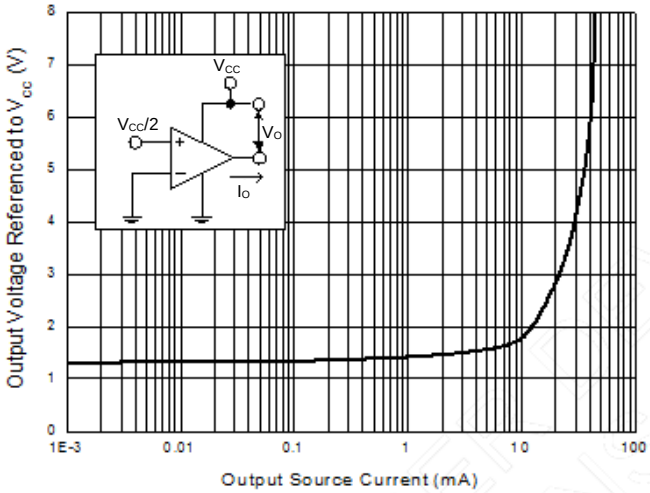
Large Signal Frequency Response



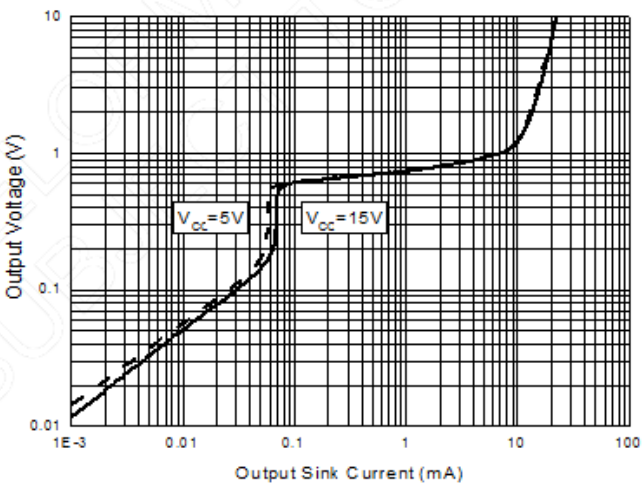
Current Limit



Output Characteristics: Current Sourcing



Output Characteristics: Current Sinking



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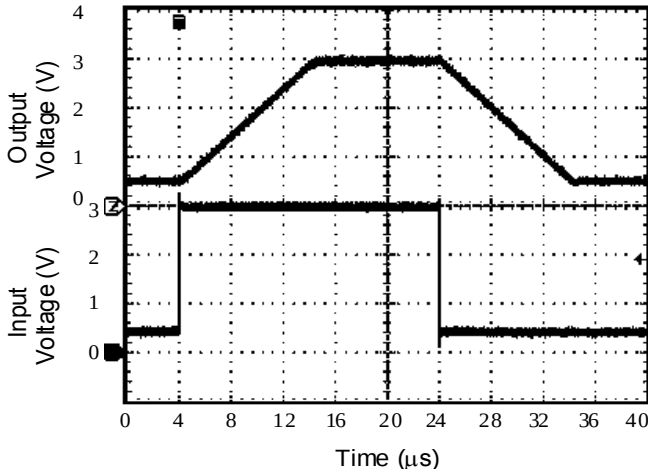
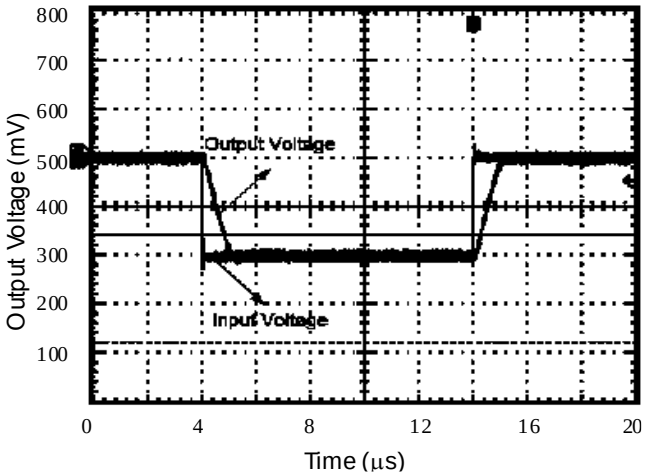
Performance Characteristics (continued)

Voltage Follower Pulse Response



Voltage Follower Pulse Response (Small Signal)



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Application Information

General Information

The LM2902/LM2904 series are op amps which operate with only a single power supply voltage, have true-differential inputs, and remain in the linear mode with an input common-mode voltage of $0V_{DC}$. These amplifiers operate over a wide range of power supply voltage with little change in performance characteristics. At +25°C amplifier operation is possible down to a minimum supply voltage of $2.3V_{DC}$.

Precautions should be taken to insure that the power supply for the integrated circuit never becomes reversed in polarity or that the unit is not inadvertently installed backwards in a test socket as an unlimited current surge through the resulting forward diode within the IC could cause fusing of the internal conductors and result in a destroyed unit.

Large differential input voltages can be easily accommodated and, as input differential voltage protection diodes are not needed, no large input currents result from large differential input voltages. The differential input voltage may be larger than V^+ without damaging the device. Protection should be provided to prevent the input voltages from going negative more than $-0.3V_{DC}$ (@ +25°C). An input clamp diode with a resistor to the IC input terminal can be used.

To reduce the power supply current drain, the amplifiers have a Class A output stage for small signal levels which converts to Class B in a large signal mode. These allow the amplifiers to both source and sink large output currents. Therefore both NPN and PNP external current boost transistors can be used to extend the power capability of the basic amplifiers. The output voltage needs to raise approximately 1 diode drop above ground to bias the on-chip vertical PNP transistor for output current sinking applications.

For AC applications, where the load is capacitive coupled to the output of the amplifier, a resistor should be used, from the output of the amplifier to ground to increase the Class A bias current and prevent crossover distortion. Where the load is directly coupled, as in DC applications, there is no crossover distortion.

Capacitive loads which are applied directly to the output of the amplifier reduce the loop stability margin. Values of 50pF can be accommodated using the worst-case non-inverting unity gain connection. Large closed loop gains or resistive isolation should be used if larger load capacitance must be driven by the amplifier.

The bias network of the LM2902/LM2904 series establishes a quiescent current which is independent of the magnitude of the power supply voltage over the range of $3V_{DC}$ to $30V_{DC}$.

Output short circuits either to ground or to the positive power supply should be of short time duration. Units can be destroyed, not as a result of the short circuit current causing metal fusing, but rather due to the large increase in IC chip dissipation which will cause eventual failure due to excessive function temperatures. Putting direct short-circuits on more than one amplifier at a time will increase the total IC power dissipation to destructive levels, if not properly protected with external dissipation limiting resistors in series with the output leads of the amplifiers. The larger value of output source current which is available at +25°C provides a larger output current capability at elevated temperatures (see Performance Characteristics) than a standard IC op amp.

The circuits presented in the section on typical applications emphasize operation on only a single power supply voltage. If complementary power supplies are available, all of the standard op amp circuits can be used. In general, introducing a pseudo-ground (a bias voltage reference of $V_{CC}/2$) will allow operation above and below this value in single power supply systems. Many application circuits are shown which take advantage of the wide input common-mode voltage range which includes ground. In most cases, input biasing is not required and input voltages which range to ground can easily be accommodated.

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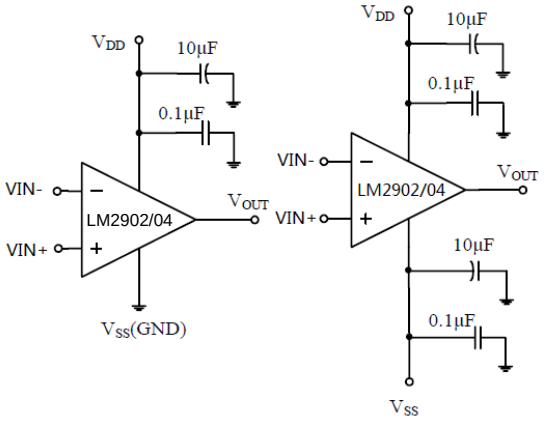
Application Information (continued)

Power Supply Bypassing and Layout

The LM2902/LM2904 operate both single supply voltage range 3V to 36V or dual supply voltage ±1.5V to ±18V.

As with any operation amplifier, proper supply bypassing is critical for low noise performance and high power supply rejection. For single supply operation system, a minimum 0.1µF bypass capacitor should be recommended to place as close as possible between the V_{CC} Pin and GND. For dual supply operation, both the positive supply pin and negative supply pin should be bypassed to ground with a separate 0.1µF ceramic capacitor. 2.2µF tantalum capacitor can be added for better performance. Keep the length of leads and traces that connect capacitors between the LM2902/LM2904 power supply pin and ground as short as possible.



Amplifier with Bypass Capacitors

Ordering Information (Note 14)

LM290X X XXX - 13

Channel	Grade	Package	Packing
2 : Quad 4 : Dual	Blank : Normal A : Low V_{IO}	T14 : TSSOP-14 S14 : SO-14 S : SO-8 M8 : MSOP-8 TH : TSSOP-8	13 : Tape & Reel

Part Number	Package Code	Packaging	13" Tape and Reel	
			Quantity	Part Number Suffix
LM2902T14-13	T14	TSSOP-14	2,500/Tape & Reel	-13
LM2902AT14-13	T14	TSSOP-14	2,500/Tape & Reel	-13
LM2902S14-13	S14	SO-14	2,500/Tape & Reel	-13
LM2902AS14-13	S14	SO-14	2,500/Tape & Reel	-13
LM2904S-13	S	SO-8	2,500/Tape & Reel	-13
LM2904AS-13	S	SO-8	2,500/Tape & Reel	-13
LM2904AM8-13	M8	MSOP-8	2,500/Tape & Reel	-13
LM2904M8-13	M8	MSOP-8	2,500/Tape & Reel	-13
LM2904ATH-13	TH	TSSOP-8	2,500/Tape & Reel	-13
LM2904TH-13	TH	TSSOP-8	2,500/Tape & Reel	-13

Note: 14. For packaging details, go to our website at https://www.diodes.com/design/support/packaging/diodes-packaging/.

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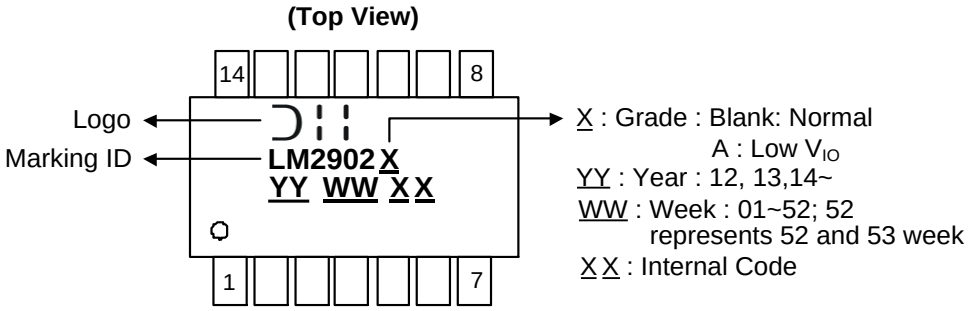
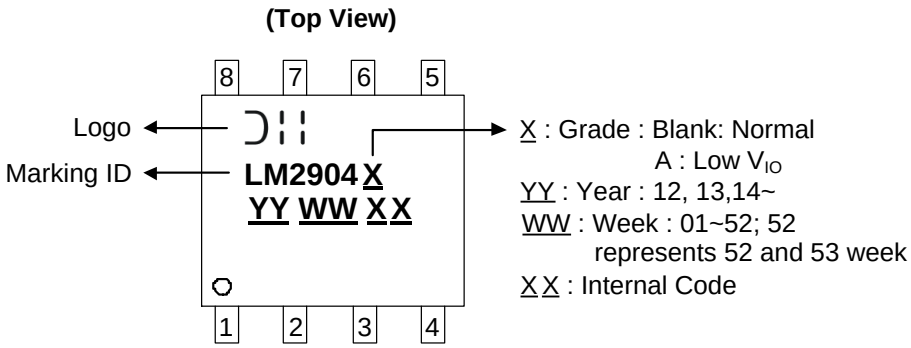
Marking Information

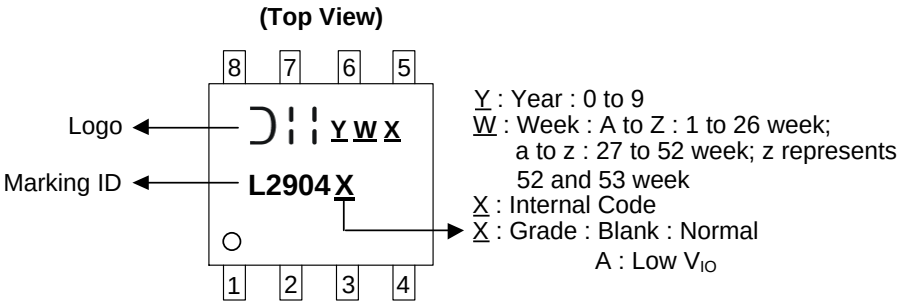
(1) TSSOP-14 and SO-14



(2) SO-8



(3) MSOP-8 and TSSOP-8



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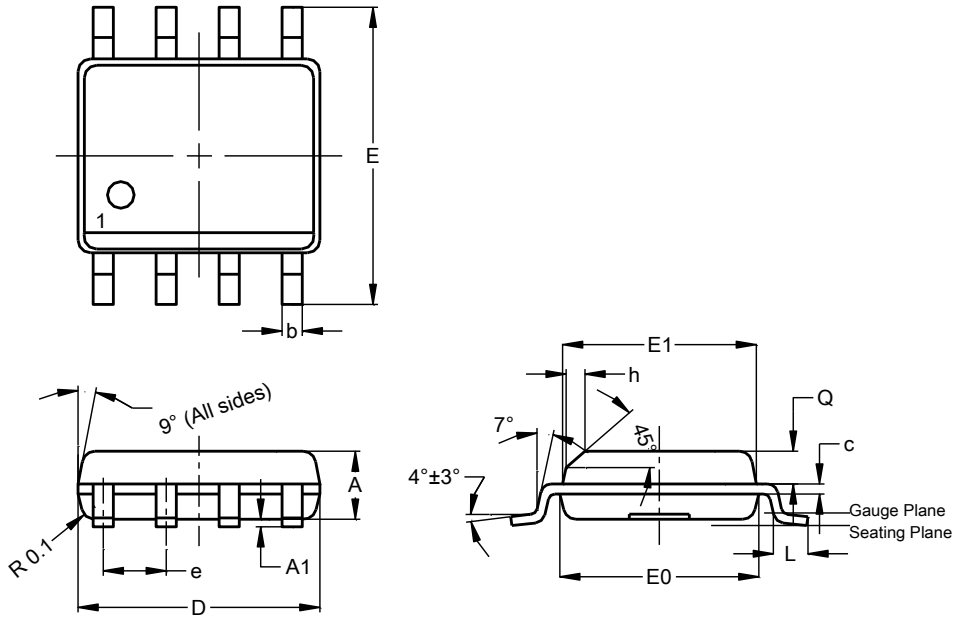
Package Outline Dimensions

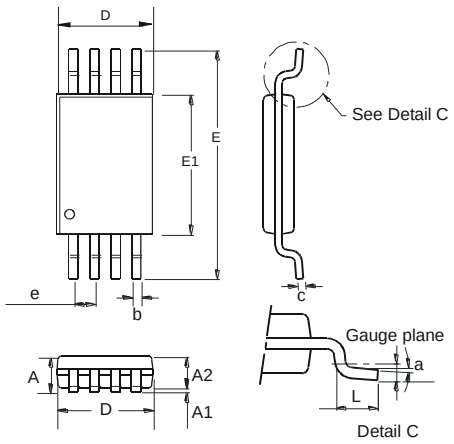
Please see http://www.diodes.com/package-outlines.html for the latest version.

(1) Package Type: SO-8



SO-8			
Dim	**Min**	**Max**	**Typ**
A	1.40	1.50	1.45
A1	0.10	0.20	0.15
b	0.30	0.50	0.40
c	0.15	0.25	0.20
D	4.85	4.95	4.90
E	5.90	6.10	6.00
E1	3.80	3.90	3.85
E0	3.85	3.95	3.90
e	--	--	1.27
h	-	--	0.35
L	0.62	0.82	0.72
Q	0.60	0.70	0.65
All Dimensions in mm			

(2) Package Type: TSSOP-8



TSSOP-8			
Dim	**Min**	**Max**	**Typ**
a	0.09	–	–
A	–	1.20	–
A1	0.05	0.15	–
A2	0.825	1.025	0.925
b	0.19	0.30	–
c	0.09	0.20	–
D	2.90	3.10	3.025
e	–	–	0.65
E	–	–	6.40
E1	4.30	4.50	4.425
L	0.45	0.75	0.60
All Dimensions in mm			

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Package Outline Dimensions (continued)

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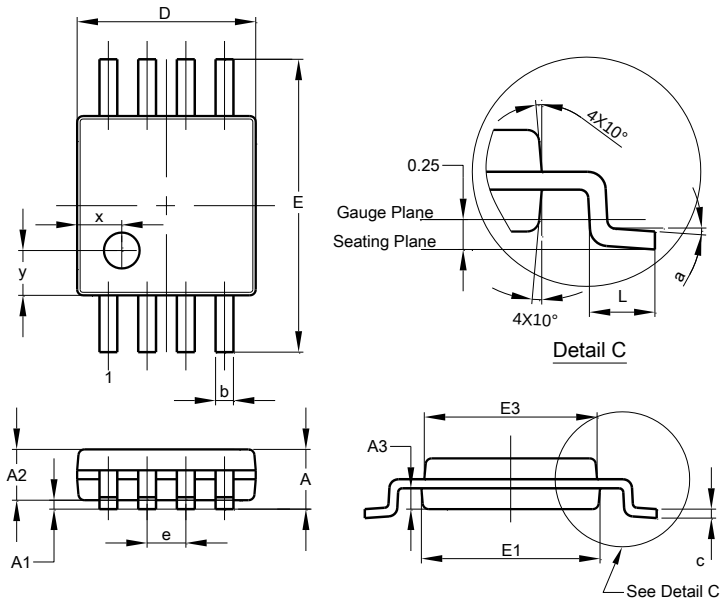
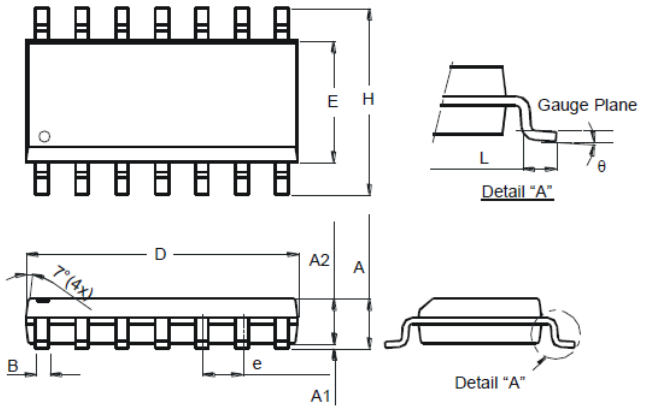
(3) Package Type:MSOP-8



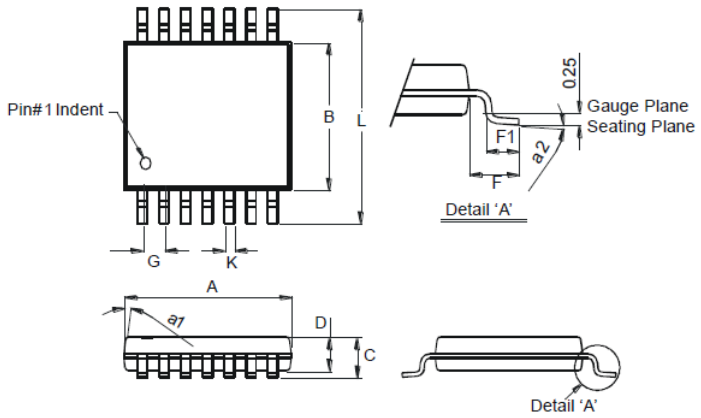
MSOP-8			
Dim	**Min**	**Max**	**Typ**
A	-	1.10	-
A1	0.05	0.15	0.10
A2	0.75	0.95	0.86
A3	0.29	0.49	0.39
b	0.22	0.38	0.30
c	0.08	0.23	0.15
D	2.90	3.10	3.00
E	4.70	5.10	4.90
E1	2.90	3.10	3.00
E3	2.85	3.05	2.95
e	-	-	0.65
L	0.40	0.80	0.60
a	0°	8°	4°
x	-	-	0.750
y	-	-	0.750
All Dimensions in mm			

(4) Package Type: SO-14



SO-14		
Dim	**Min**	**Max**
A	1.47	1.73
A1	0.10	0.25
A2	1.45 Typ	
B	0.33	0.51
D	8.53	8.74
E	3.80	3.99
e	1.27 Typ	
H	5.80	6.20
L	0.38	1.27
θ	0°	8°
All Dimensions in mm		

(5) Package Type: TSSOP-14



TSSOP-14		
Dim	**Min**	**Max**
a1	7° (4X)	
a2	0°	8°
A	4.9	5.10
B	4.30	4.50
C	-	1.2
D	0.8	1.05
F	1.00 Typ	
F1	0.45	0.75
G	0.65 Typ	
K	0.19	0.30
L	6.40 Typ	
All Dimensions in mm		

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Suggested Pad Layout

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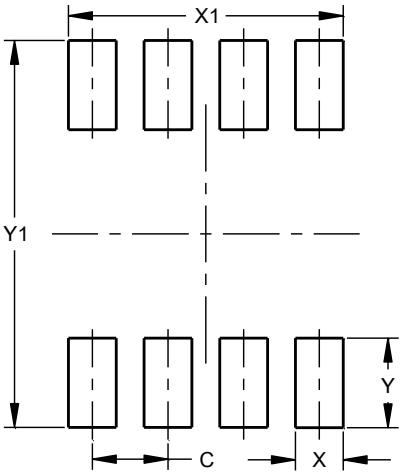
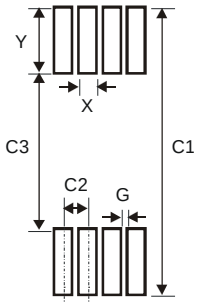
(1) Package Type: SO-8



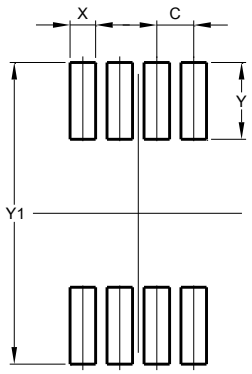
Dimensions	Value (in mm)
C	1.27
X	0.802
X1	4.612
Y	1.505
Y1	6.50

(2) Package Type: TSSOP-8



Dimensions	Value (in mm)
X	0.45
Y	1.78
C1	7.72
C2	0.65
C3	4.16
G	0.20

(3) Package Type: MSOP-8



Dimensions	Value (in mm)
C	0.650
X	0.450
Y	1.350
Y1	5.300

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Suggested Pad Layout (continued)

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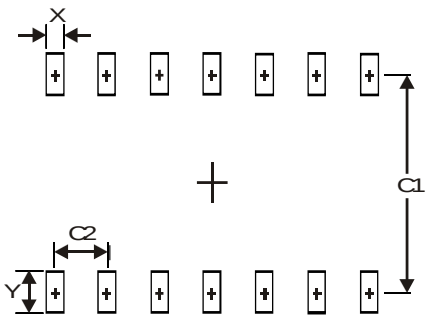
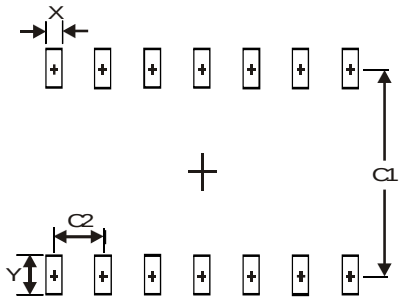
(4) Package Type: SO-14



Dimensions	Value (in mm)
X	0.60
Y	1.50
C1	5.4
C2	1.27

(5) Package Type: TSSOP-14



Dimensions	Value (in mm)
X	0.45
Y	1.45
C1	5.9
C2	0.65

Mechanical Data

- Moisture Sensitivity:
  - MSOP-8, TSSOP-8: Level 1 per J-STD-020
  - SO-8, SO-14, TSSOP-14: Level 3 per J-STD-020
- Terminals: Finish - Mate Tin Plated Leads, Solderable per MIL-STD-202, Method 208 e3
- Weight:
  - SO-8: 0.074 grams (Approximate)
  - TSSOP-8: 0.041 grams (Approximate)
  - MSOP-8: 0.027 grams (Approximate)
  - SO-14: 0.142 grams (Approximate)
  - TSSOP-14: 0.052 grams (Approximate)

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