Dual Operational Amplifier

FEATURES

- **Unity-gain bandwidth:1.1MHZ**
- **Low input offset voltage:2mV (Typical)**
- **Supply Range: 3V to 36V**
- **Quiescent current:350uA per amplifier**
- **Low input bias current: 20nA (Typical)**
- **Common-mode input voltage range includes ground**
- **Output Swing:0V~Vcc-1.5V**
- **SPECIFIED UP TO +85°C**
- ***Micro* SIZE PACKAGES: SOIC-8(SOP8)**

APPLICATIONS

- **SENSORS**
- **PHOTODIODE AMPLIFICATION**
- **ACTIVE FILTERS**
- **TEST EQUIPMENT**
- **DRIVING A/D CONVERTERS**

DESCRIPTION

The LM358 include two high-voltage(36-V) operational amplifiers. These devices provide outstanding value for Cost sensitive applications, with features including low offset 2mV(Typical),Common-mode input range to ground. the LM358 simplify circuit design with enhanced features such as unity-gain stability, lower quiescent current of 350uA per amplifier (Typical).

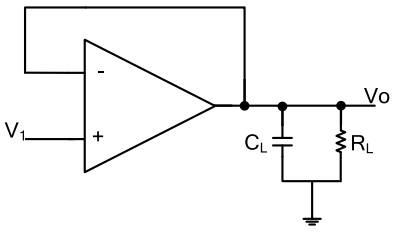
The LM358 amplifier are specified at the full temperature range of −40°C to +85°C under single or dual power supplies of 3V to 36V.

Device Information (1)

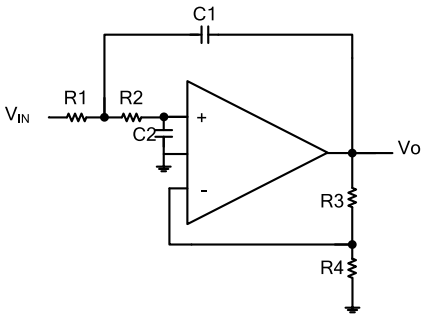
PART NUMBER	PACKAGE	BODY SIZE(NOM)
LM321	SOT23-5	2.90mm x 1.60mm
LM358	SOIC-8	4.90mm x 3.90mm
LM324	SOIC-14	8.65mm x 3.90mm
	TSSOP-14	5.00mm x 4.40mm

(1) For all available packages, see the orderable addendum at the end of the data sheet.

Typical applications

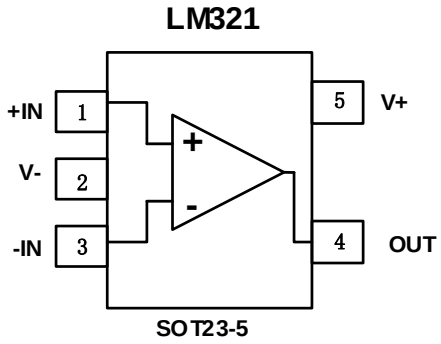


Unity-Gain Amplifier



DC Coupled Low-Pass RC Active Filter

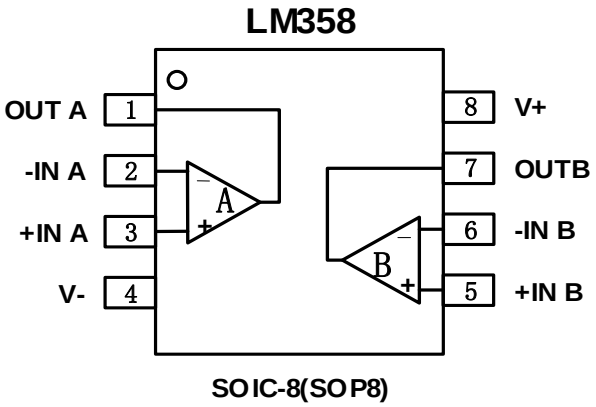
Pin Configuration and Functions (Top View)



Pin Description

NAME	PIN	I/O	DESCRIPTION
	LM321		
	SOT23-5		
+IN	1	I	Positive (noninverting) input
V-	2	-	Negative (lowest) power supply
-IN	3	I	Negative (inverting) input
OUT	4	O	Output
V+	5	-	Positive (highest) power supply

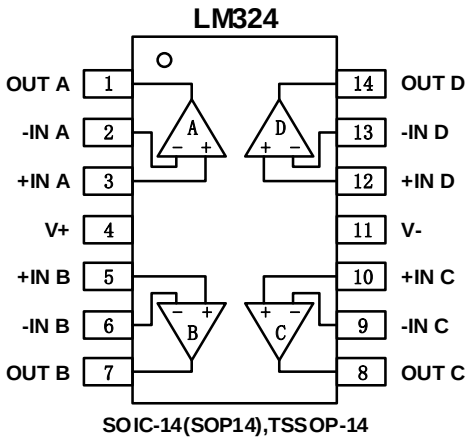
Pin Configuration and Functions (Top View)



Pin Description

NAME	PIN	I/O	DESCRIPTION
	SOIC-8(SOP8)		
-INA	2	I	Inverting input, channel A
+INA	3	I	Noninverting input, channel A
-INB	6	I	Inverting input, channel B
+INB	5	I	Noninverting input, channel B
OUTA	1	O	Output, channel A
OUTB	7	O	Output, channel B
V-	4	-	Negative (lowest) power supply or ground (for single supply operation)
V+	8	-	Positive (highest) power supply

Pin Configuration and Functions (Top View)



SOIC-14(SOP14),TSSOP-14

Pin Description

NAME	PIN SOIC-14(SOP14)/TSSOP-14	I/O	DESCRIPTION
-INA	2	I	Inverting input, channel A
+INA	3	I	Noninverting input, channel A
-INB	6	I	Inverting input, channel B
+INB	5	I	Noninverting input, channel B
-INC	9	I	Inverting input, channel C
+INC	10	I	Noninverting input, channel C
-IND	13	I	Inverting input, channel D
+IND	12	I	Noninverting input, channel D
OUTA	1	O	Output, channel A
OUTB	7	O	Output, channel B
OUTC	8	O	Output, channel C
OUTD	14	O	Output, channel D
V-	11	-	Negative (lowest) power supply
V+	4	-	Positive (highest) power supply

SPECIFICATIONS

Absolute Maximum Ratings

Over operating free-air temperature range (unless otherwise noted) (1)

		MIN	MAX	UNIT
Voltage	Supply, Vs=(V+) - (V-)		40	V
	Signal input pin (2)	(V-)-0.5	(V+) +0.5	
	Signal output pin (3)	(V-)-0.5	(V+) +0.5	
Current	Signal input pin (2)	-10	10	mA
	Signal output pin (3)	-55	55	mA
	Output short-circuit (4)	Continuous		
Temperature	Operating range, T_A	-40	85	°C
	Junction, T_J		150	
	Storage, T_{stg}	-55	150	

(1) Stresses above these ratings may cause permanent damage. Exposure to absolute maximum conditions for extended periods may degrade device reliability. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those specified is not implied.
(2) Input terminals are diode-clamped to the power-supply rails. Input signals that can swing more than 0.5V beyond the supply rails should be current-limited to 10mA or less.
(3) Output terminals are diode-clamped to the power-supply rails. Output signals that can swing more than 0.5V beyond the supply rails should be current-limited to ±55mA or less.
(4) Short-circuit to ground, one amplifier per package.

ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human-body model (HBM)	3000	V
		Machine Model (MM)	200	

Recommended Operating Conditions

Over operating free-air temperature range (unless otherwise noted)

		MIN	NOM	MAX	UNIT
Supply voltage，Vs= (V+) - (V-)	Single-supply	3		36	V
	Dual-supply	±1.5		±18	

Thermal Information:

THERMAL METRIC (1)		LM321	LM358	LM324		UNIT
		5PINS	8PINS	14PINS		
		SOT23-5	SOIC-8	SOIC-14	TSSOP-14	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	273.8	124.7	**83.8**	120.8	°C/W
$R_{\theta JC(top)}$	Junction-to-case(top) thermal resistance	126.8	66.9	70.7	34.3	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	85.9	67.9	59.5	62.8	°C/W
Ψ_{JT}	Junction-to-top characterization parameter	10.9	19.2	11.6	1	°C/W
Ψ_{JB}	Junction-to-board characterization parameter	84.9	67.2	37.7	56.5	°C/W
$R_{\theta JC(bot)}$	Junction-to-case(bottom) thermal resistance	N/A	N/A	N/A	N/A	°C/W

PACKAGE/ORDERING INFORMATION

Orderable Device	Package Type	Pin	Channel	Op Temp(°C)	Device Marking	Package Qty
LM321BXF	SOT23-5	5	1	-40℃~85℃	LM321B	Tape and Reel,3000
LM358XK	SOIC-8(SOP8)	8	1	-40℃~85℃	LM358	Tape and Reel,2500
LM324XP	SOIC-14(SOP14)	14	4	-40℃~85℃	LM324	Tape and Reel,2500
LM324XQ	TSSOP-14	14	4	-40℃~85℃	LM324	Tape and Reel,3000

ELECTRICAL CHARACTERISTICS

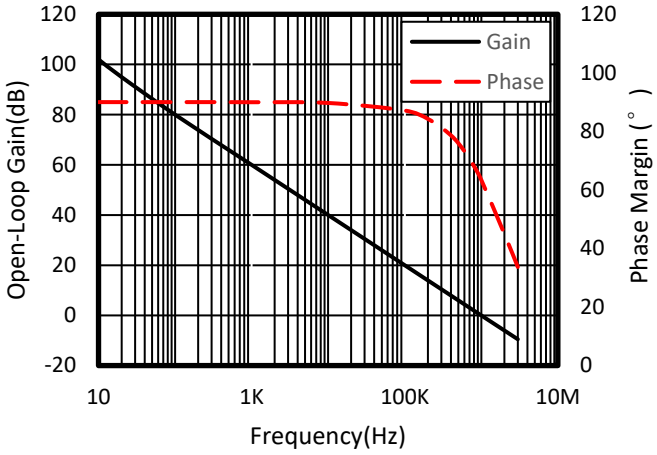
(At T_A = +25°C, Vs=5V, R_L = 10kΩ connected to V_S/2, and V_{OUT} = V_S/2, unless otherwise noted.)

PARAMETER		CONDITIONS	T_J	LM358			UNITS
				MIN	TYP	MAX	
POWER SUPPLY							
Vs	Operating Voltage Range		25°C	3		36	V
IQ	Quiescent Current/Amplifier	Vs=5V, Io=0mA	-40°C to 85C		420		uA
		Vs=30V, Io=0mA			650		
PSRR	Power-Supply Rejection Ratio	Vs=5V to 30V	25°C	70	100		dB
			-40°C to 85°C	60			
INPUT							
Vos	Input Offset Voltage	V_{CM}= V_S/2	25°C	-5	±2	5	mV
			-40°C to 85C			7	
Vos Tc	Input Offset Voltage Average Drift	-40°C to 85°C			7		uV/°C
IB	Input Bias Current	V_{CM}=0V	25°C		20	150	nA
			-40°C to 85C			200	
I_{OS}	Input Offset Current	V_{CM}=0V	25°C		5	30	nA
			-40°C to 85C			100	
V_{CM}	Common-Mode Voltage Range	Vs= 30V	25°C	0		Vcc-1.5	V
CMRR	Common-Mode Rejection Ratio	Vs= 5V, V_{CM}=0V to (Vcc-1.5)V	25°C	60	80		dB
			-40°C to 85°C	60			
OUTPUT							
A_{OL}	Open-Loop Voltage Gain	Vs=15V, R_L=2KΩ, Vo=1V to 11V	25°C	85	100		dB
			-40°C to 85°C	80			
		Vs=15V, R_L=10KΩ, Vo= 1V to 11V	25°C	83	96		
			-40°C to 85°C	78			
V_{OH}	Output Swing From Rail	Vs=30V, R_L=2KΩ	25°C	26			V
			-40°C to 85°C	26			
		Vs=30V, R_L=10KΩ	25°C	27	28		
			-40°C to 85°C	27			
V_{OL}		Vs=5V, R_L=10KΩ	25°C		0.5	10	mV
			-40°C to 85°C			20	
I_{SOURCE}	Output current	V_S=15V, V_{IN+}=1V, V_{IN-}=0V, Vo=2V	25°C	20	40		mA
			-40°C to 85°C	20			
I_{SINK}		V_S=15V, V_{IN-}=1V, V_{IN+}=0V, Vo=2V	25°C	10	15		mA
			-40°C to 85°C	5			
		V_S=15V, V_{IN-}=1V, V_{IN+}=0V, Vo=0.2V	25°C		50		uA
I_{SC}	Short-circuit current	V_S=15V, Vo=0V	25°C		40	60	mA
FREQUENCY RESPONSE							
SR	Slew Rate	G=+1, C_L=100pF	25°C		0.35		V/us
GBP	Gain-Bandwidth Product		25°C		1.1		MHz
PM	Phase Margin		25°C		56		°
ts	Setting Time,0.1%	V_S=5V, G=+1, C_L=100pF,Step=2V	25°C		22		us
t_{OR}	Overload Recovery Time	V_{IN}·Gain≥V_S, G=-100	25°C		10		us
NOISE							
En	Input Voltage Noise	f = 0.1Hz to 10Hz, Vs=5V	25°C		0.9		uVpp
en	Input Voltage Noise Density	f = 1KHz	25°C		40		nV/√Hz

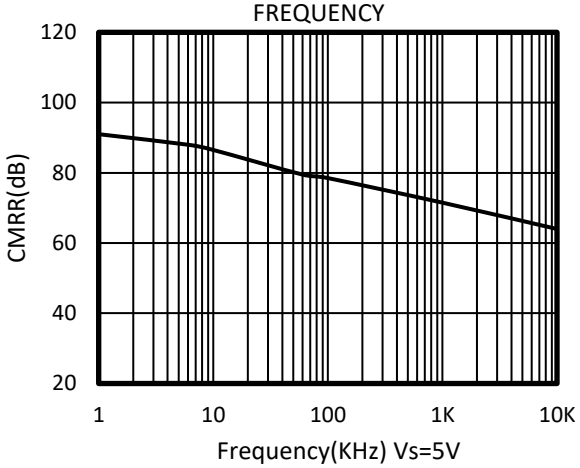
TYPICAL CHARACTERISTICS

At T_A = +25°C, Vs= 36 V (±18 V), R_L = 10kΩ connected to $V_S/2$, V_{OUT} = $V_S/2$, unless otherwise noted.

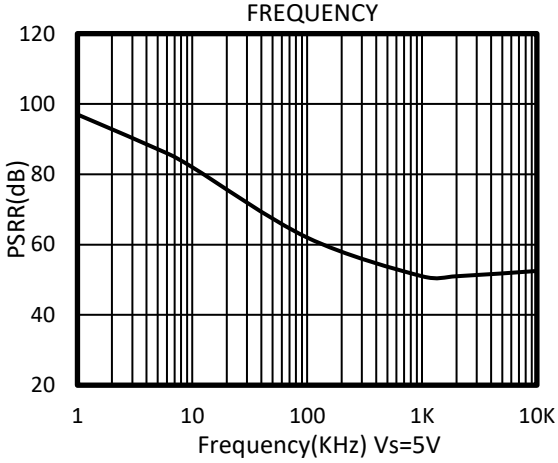
OPEN−LOOP GAIN AND PHASE vs FREQUENCY



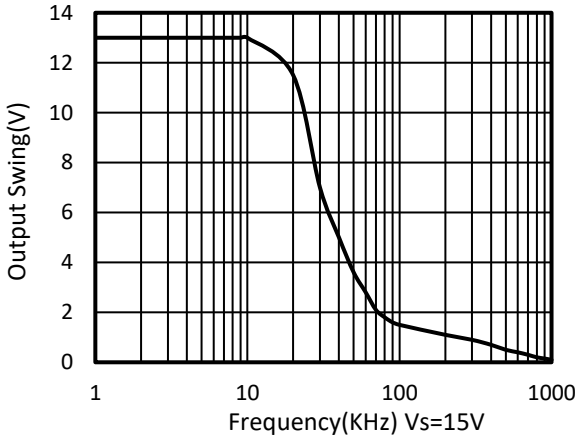
COMMON−MODE REJECTION RATIO vs FREQUENCY



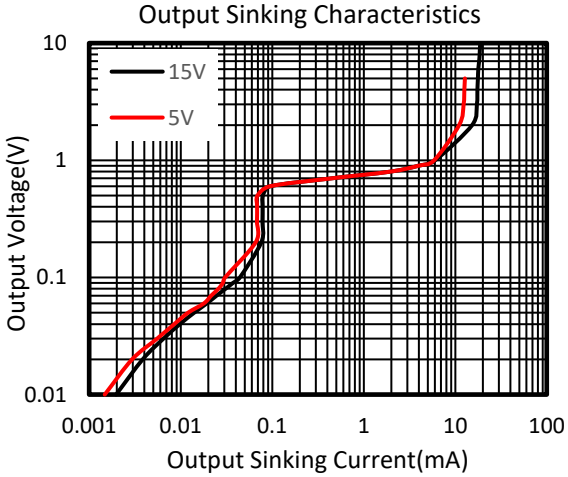
POWER−SUPPLY REJECTION RATIO vs FREQUENCY



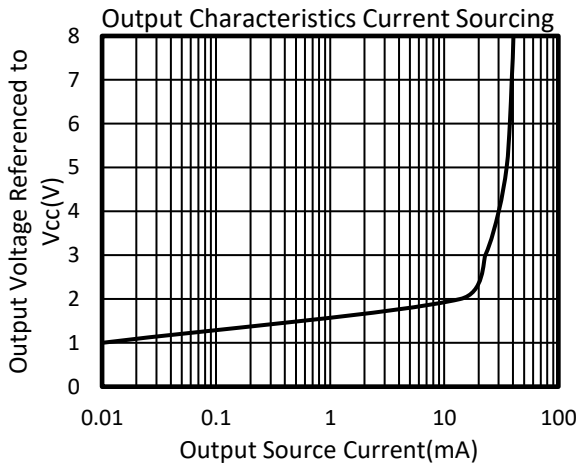
Maximum Output Voltage vs Frequency



Output Sinking Characteristics

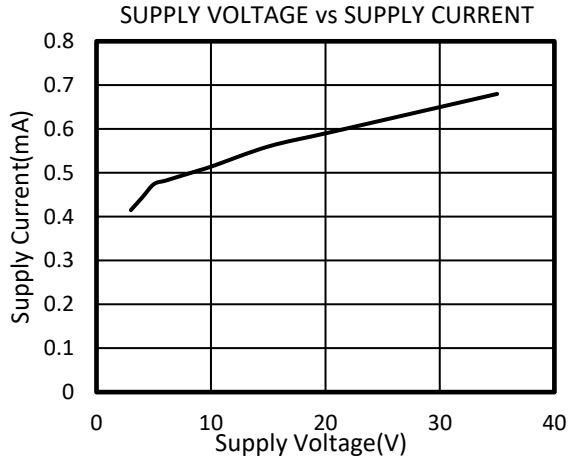


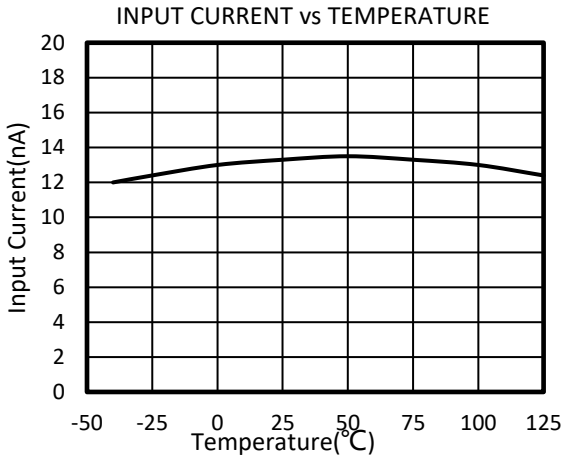
Output Characteristics Current Sourcing

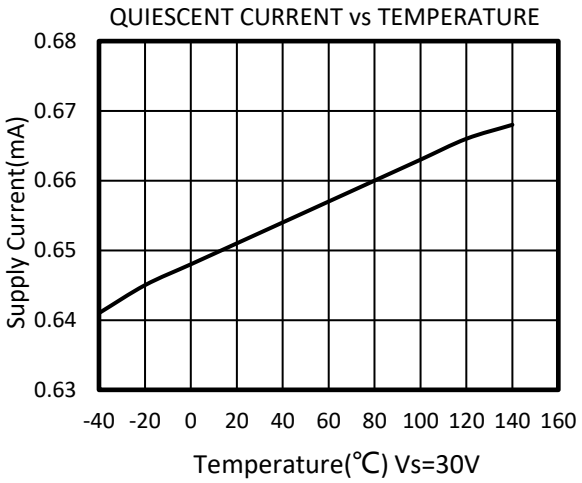


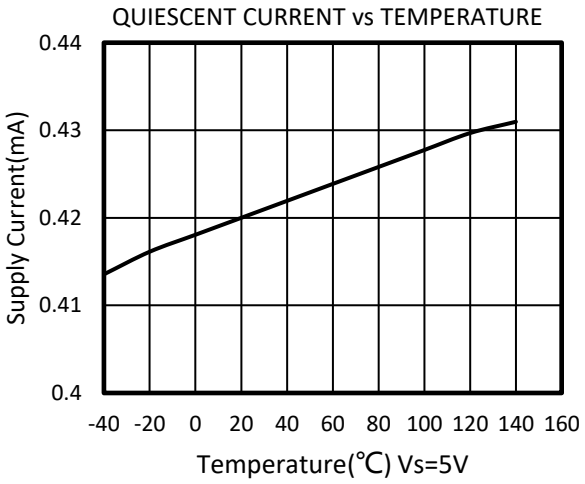
TYPICAL CHARACTERISTICS

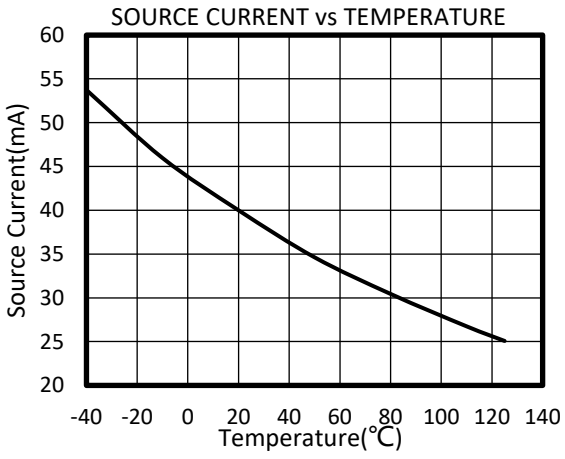
At T_A = +25°C, Vs= 36 V (±18 V), R_L = 10kΩ connected to $V_S/2$, V_{OUT} = $V_S/2$, unless otherwise noted.

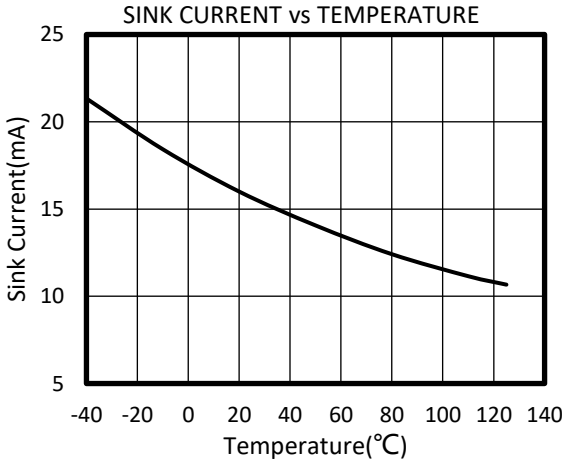








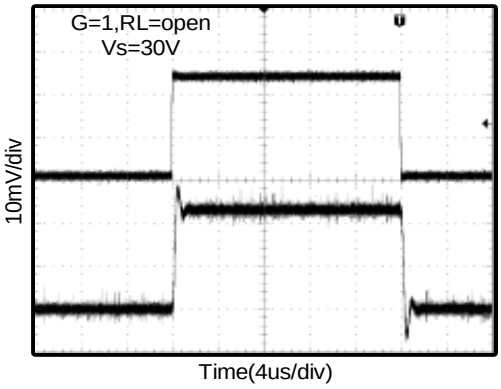




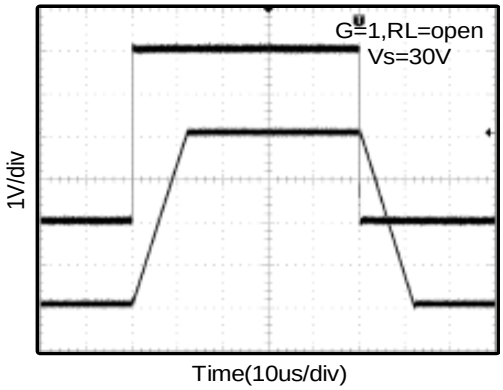
TYPICAL CHARACTERISTICS

At T_A = +25°C, Vs= 36 V (±18 V), R_L = 10kΩ connected to $V_S/2$, V_{OUT} = $V_S/2$, unless otherwise noted.

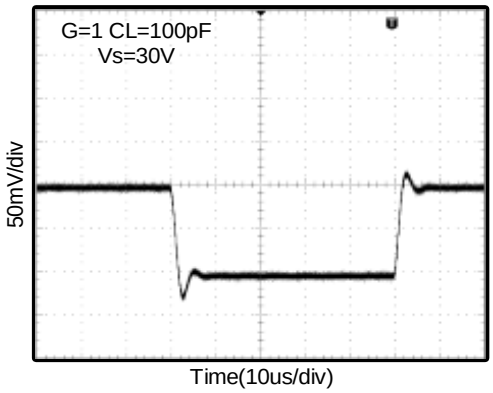
SMALL-SIGNAL STEP RESPONSE



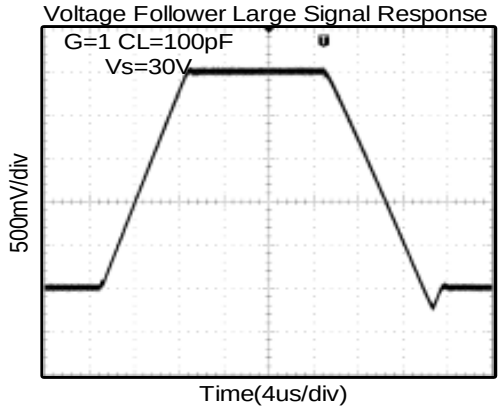
LARGE-SIGNAL STEP RESPONSE



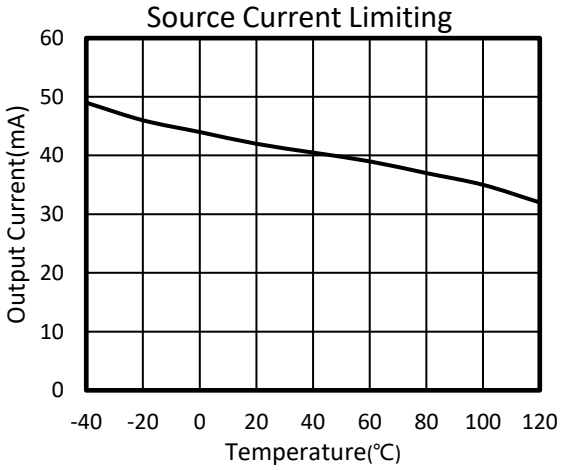
Voltage Follower Small Signal Response



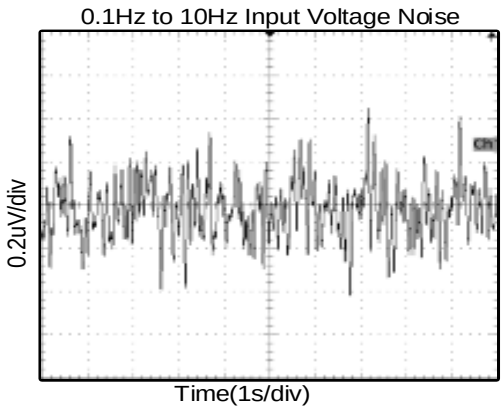
Voltage Follower Large Signal Response



Source Current Limiting



0.1Hz to 10Hz Input Voltage Noise



LAYOUT

Layout Guidelines

Attention to good layout practices is always recommended. Keep traces short. When possible, use a PCB ground plane with surface-mount components placed as close to the device pins as possible. Place a 0.1uF capacitor closely across the supply pins.

These guidelines should be applied throughout the analog circuit to improve performance and provide benefits such as reducing the EMI susceptibility.

Layout Example

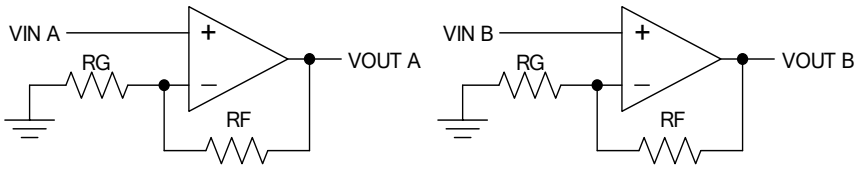


Figure 1. Schematic Representation

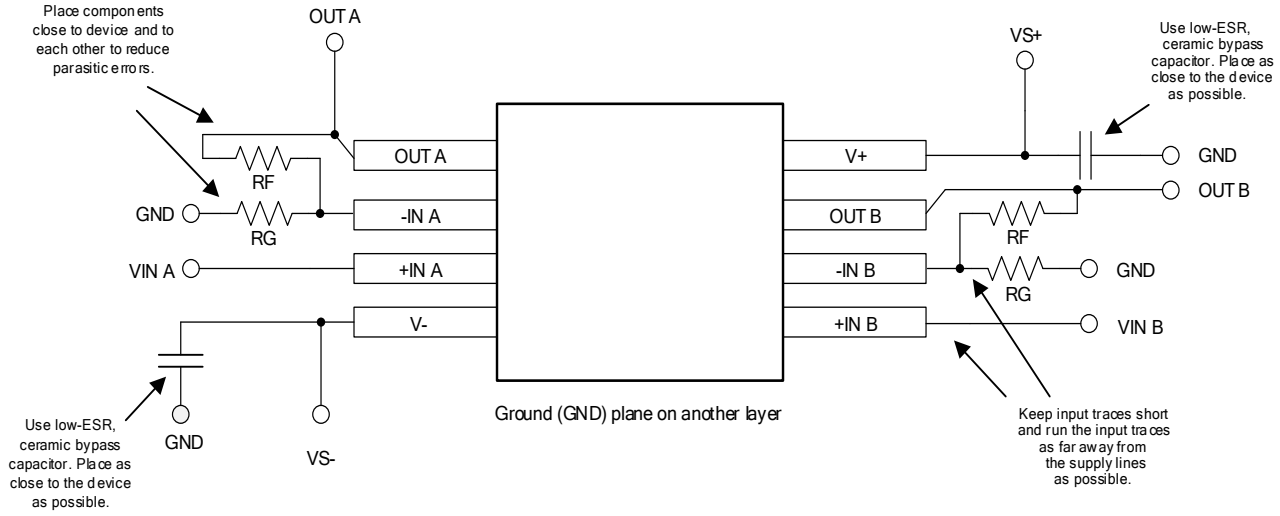
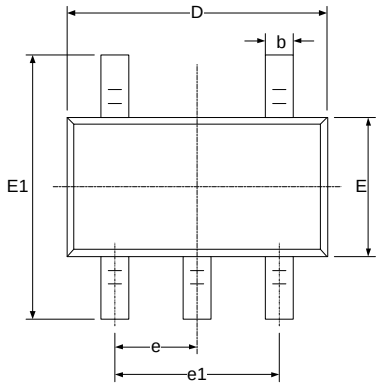
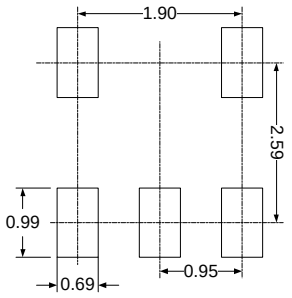


Figure 2. Layout Example

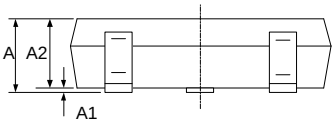
PACKAGE OUTLINE DIMENSIONS

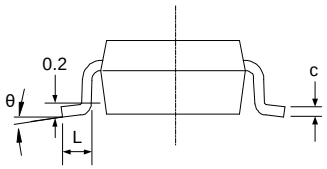
SOT23-5





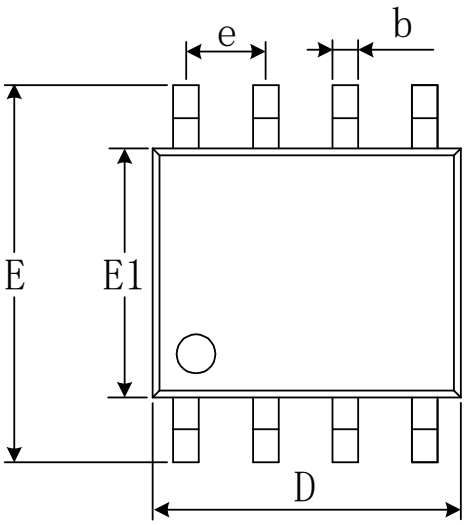
RECOMMENDED LAND PATTERN (Unit: mm)

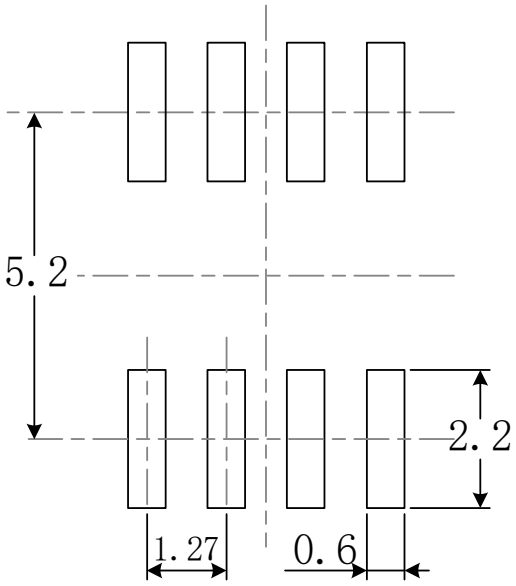




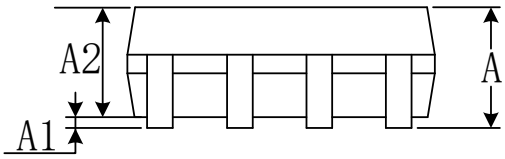
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950(BSC)		0.037(BSC)	
e1	1.800	2.000	0.071	0.079
L	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°

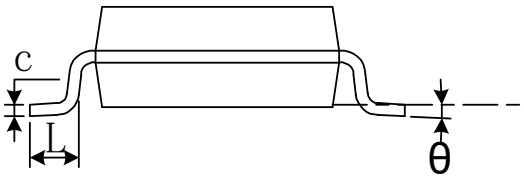
SOIC-8(SOP8)





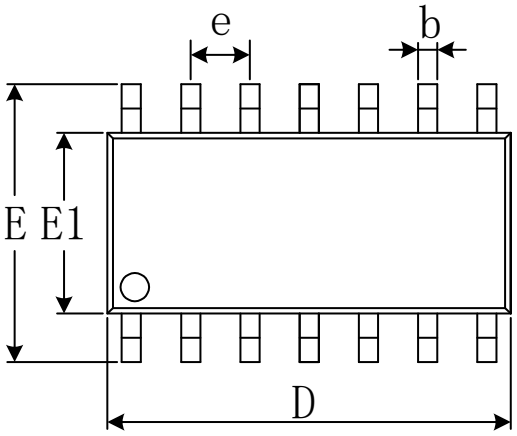
RECOMMENDED LAND PATTERN (Unit: mm)

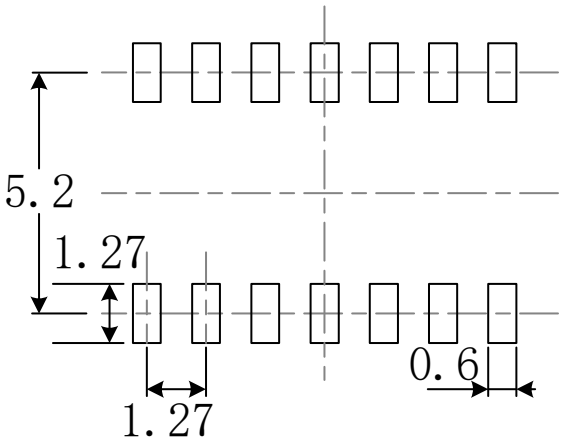




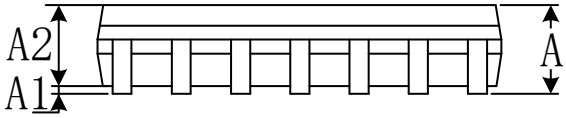
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.007	0.010
D	4.800	5.000	0.189	0.197
e	1.270(BSC)		0.050(BSC)	
E	5.800	6.200	0.228	0.244
E1	3.800	4.000	0.150	0.157
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°

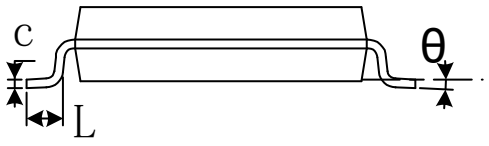
SOIC-14(SOP14)





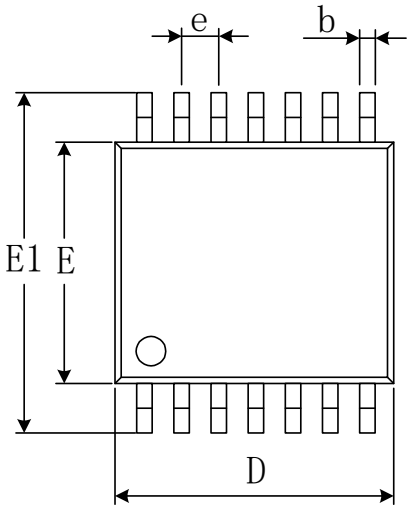
RECOMMENDED LAND PATTERN (Unit: mm)

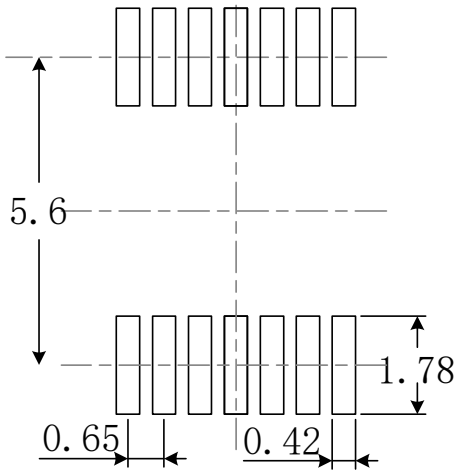




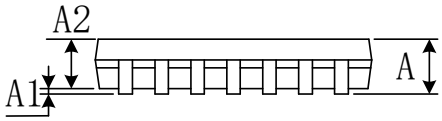
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.310	0.510	0.012	0.020
c	0.100	0.250	0.004	0.010
D	8.450	8.850	0.333	0.348
e	1.270(BSC)		0.050(BSC)	
E	5.800	6.200	0.228	0.244
E1	3.800	4.000	0.150	0.157
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°

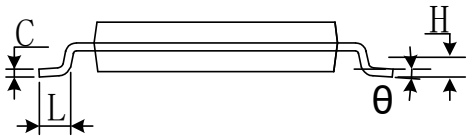
TSSOP-14





RECOMMENDED LAND PATTERN (Unit: mm)





Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A		1.200		0.047
A1	0.050	0.150	0.002	0.006
A2	0.800	1.050	0.031	0.041
b	0.190	0.300	0.007	0.012
c	0.090	0.200	0.004	0.008
D	4.860	5.100	0.191	0.201
E	4.300	4.500	0.169	0.177
E1	6.250	6.550	0.246	0.258
e	0.650(BSC)		0.026(BSC)	
L	0.500	0.700	0.020	0.028
H	0.25(TYP)		0.01(TYP)	
θ	1°	7°	1°	7°

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