General purpose input/output rail-to-rail low-power operational amplifiers

Features

- Operating range V_{CC} = 2.5 V to 6 V
- Rail-to-rail input and output
- Extended V_{icm} (V_{DD} - 0.2 V to V_{CC} + 0.2 V)
- Capable of driving a 32 Ω load resistor
- High stability: 500 pF
- Operating temperature range: -40 to 125 °C

Applications

- Battery powered applications
- Audio driver (headphone driver)
- Sensor signal conditioning
- Laptop/notebook computers

Description

The TSV358, TSV358A, TSV324, and TSV324A (dual and quad) devices are low voltage versions of the LM358 and LM324 commodity operational amplifiers. The TSV321 and TSV321A are the single version. All devices operate with voltages as low as 2.5 V and feature both I/O rail-to-rail.

The common mode input voltage extends 200 mV beyond the supply voltages at 25 °C while the output voltage swing is within 100 mV of each rail with a 600 Ω load resistor. At V_{CC} = 3 V, these devices offer 1.3 MHz of gain bandwidth product and provide high output current capability with a typical value of 80 mA.

These features make the TSV3xx and TSV3xxA family ideal for active filters, general purpose low voltage applications, and general purpose portable devices.

Pin connections (top view)

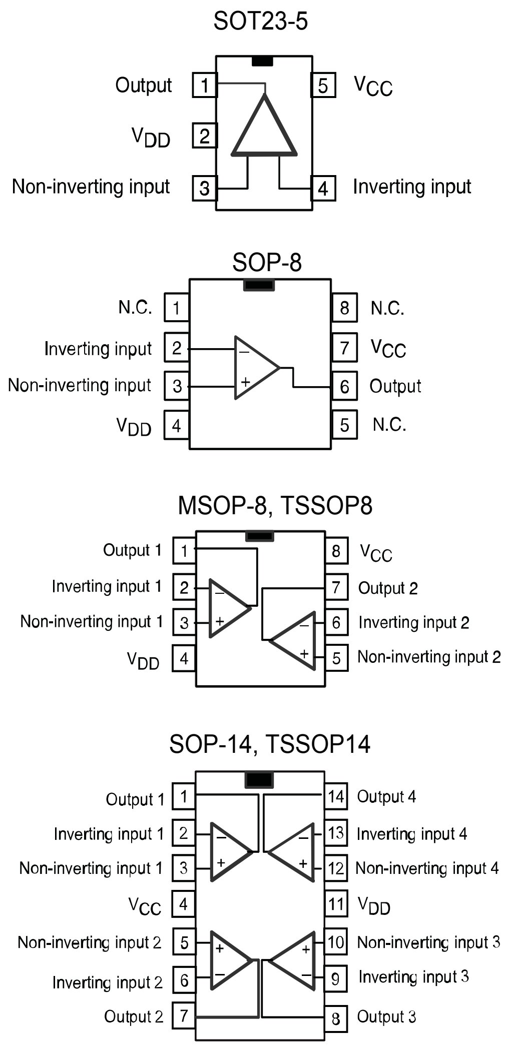


Table 1. Absolute maximum ratings

Symbol	Parameter		Value	Unit
V_{CC}	Supply voltage (1)		7	V
V_{id}	Differential input voltage (2)		±1	
V_{in}	Input voltage		V_{DD} -0.3 to V_{CC} +0.3	
T_{stg}	Storage temperature		-65 to +150	°C
T_j	Maximum junction temperature		150	
R_{thja}	Thermal resistance junction-to-ambient (3)	SOT23-5	250	°C/W
		SOP-8	125	
		MSOP-8	190	
		TSSOP8	120	
		SO14	105	
		TSSOP14	100	
R_{thjc}	Thermal resistance junction-to-case(3)	SOT23-5	81	
		SOP-8	40	
		MSOP-8	39	
		TSSOP8	37	
		SO14	31	
		TSSOP14	32	
ESD	HBM: human body model (4)		2	kV
	MM: machine model (5)		200	V
	CDM: charged device model (6)		1.5	kV
	Latch-up immunity		200	mA
	Lead temperature (soldering, 10 s)		250	°C
	Output short-circuit duration		See (7)	

1. All voltage values, except the differential voltage are with respect to the network terminal.
2. The differential voltage is the non-inverting input terminal with respect to the inverting input terminal. If V_{id} > ±1 V, the maximum input current must not exceed ±1 mA. When V_{id} > ±1 V, an input series resistor must be added to limit input current.
3. Short-circuits can cause excessive heating and destructive dissipation. R_{th} are typical values.
4. Human body model: 100 pF discharged through a 1.5 kΩ resistor between two pins of the device, done for all couples of pin combinations with other pins floating.
5. Machine model: a 200 pF capacitor is charged to the specified voltage, then discharged directly between two pins of the device with no external series resistor (internal resistor < 5 Ω), done for all couples of pin combinations with other pins floating.
6. Charged device model: all pins plus package are charged together to the specified voltage and then discharged directly to ground.
7. Short-circuits from the output to V_{CC} can cause excessive heating. The maximum output current is approximately 80 mA, independent of the magnitude of V_{CC}. Destructive dissipation can result from simultaneous short-circuits on all amplifiers.

Table 2. Operating conditions

Symbol	Parameter		Value	Unit
V_{CC}	Supply voltage		2.5 to 6	V
V_{icm}	Common mode input voltage range	T_{amb} = 25 °C, 2.5 ≤ V_{CC} ≤ 6 V	V_{DD} - 0.2 to V_{CC} + 0.2	V
		T_{min} < T_{amb} < T_{max}, 2.5 ≤ V_{CC} ≤ 5.5 V	V_{DD} to V_{CC}	
T_{oper}	Operating free air temperature range		-40 to + 125	°C

Table 3. Electrical characteristics at V_{CC} = +3 V, V_{DD} = 0 V, R_L, C_L connected to V_{CC}/2, and T_{amb} = 25 °C (unless otherwise specified)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V_{io}	Input offset voltage	V_{icm} = V_{out} = V_{CC} /2				mV
		TSV321/358/324		0.2	3	
		T_{min} ≤ T_{amb} ≤ T_{max}			6	
		TSV321A/358A/324A		0.1	1	
		T_{min} ≤ T_{amb} ≤ T_{max}			3	
$\Delta V_{io}/\Delta T$	Input offset voltage drift			2		μV/°C
I_{io}	Input offset current	V_{icm} = V_{out} = V_{CC} /2 (1)		3	30	nA
		T_{min} ≤ T_{amb} ≤ T_{max}			60	
I_{ib}	Input bias current	V_{icm} = V_{out} = V_{CC} /2(1)		40	125	
		T_{min} ≤ T_{amb} ≤ T_{max}			150	
CMR	Common mode rejection ratio 20 log ($\Delta V_{ic}/\Delta V_{io}$)	0 ≤ V_{icm} ≤ V_{CC}, V_{out} = V_{CC} /2	60	80		dB
A_{vd}	Large signal voltage gain	V_{out} = 0.5 V to 2.5 V, R_L = 2 kΩ	80	92		
		V_{out} = 0.5 V to 2.5 V, R_L = 600 Ω	74	95		
V_{OH}	High level output voltage, V_{OH} = V_{out}	V_{id} = 100 mV, R_L = 2 kΩ	2.82	2.95		V
		V_{id} = 100 mV, R_L = 600 Ω	2.80	2.95		
		V_{id} = 100 mV, T_{min} ≤ T_{amb} ≤ T_{max}, R_L = 2 kΩ	2.82			
		V_{id} = 100 mV, T_{min} ≤ T_{amb} ≤ T_{max}, R_L = 600 Ω	2.80			
V_{OL}	Low level output voltage	V_{id} = -100 mV, R_L = 2 kΩ		88	120	mV
		V_{id} = -100 mV, R_L = 600 Ω		115	160	
		V_{id} = -100 mV, T_{min} ≤ T_{amb} ≤ T_{max}, R_L = 2 kΩ			120	
		V_{id} = -100 mV, T_{min} ≤ T_{amb} ≤ T_{max}, R_L = 600 Ω			160	
I_o	Output source current	V_{id} = 100 mV, V_O = V_{DD}	20	80		mA
	Output sink current	V_{id} = -100 mV, V_O = V_{CC}	20	80		
I_{CC}	Supply current (per amplifier)	A_{VCL} = 1, no load		420	650	μA
		T_{min} ≤ T_{amb} ≤ T_{max}			690	
GBP	Gain bandwidth product	R_L = 10 kΩ, C_L = 100 pF, f = 100 kHz	1	1.3		MHz
SR	Slew rate	R_L = 10 kΩ, C_L = 100 pF	0.42	0.6		V/μs
ϕm	Phase margin	C_L = 100 pF		53		Degrees
en	Input voltage noise			27		nV/√ Hz
THD	Total harmonic distortion			0.01		%

1. Maximum values include unavoidable inaccuracies of the industrial tests.

Table 4. Electrical characteristics at V_{CC} = +5 V, V_{DD} = 0 V, R_L, C_L connected to $V_{CC}/2$, and T_{amb} = 25 °C (unless otherwise specified)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V_{io}	Input offset voltage	$V_{icm} = V_{out} = V_{CC}/2$				mV
		TSV321/358/324		0.2	3	
		$T_{min} \le T_{amb} \le T_{max}$			6	
		TSV321A/358A/324A		0.1	1	
		$T_{min} \le T_{amb} \le T_{max}$			3	
$\Delta V_{io}/\Delta T$	Input offset voltage drift			2		μV/°C
I_{io}	Input offset current	$V_{icm} = V_{out} = V_{CC}/2$ (1)		3	30	nA
		$T_{min} \le T_{amb} \le T_{max}$			60	
I_{ib}	Input bias current	$V_{icm} = V_{out} = V_{CC}/2$(1)		70	130	
		$T_{min} \le T_{amb} \le T_{max}$			150	
CMR	Common mode rejection ratio 20 log ($\Delta V_{ic}/\Delta V_{io}$)	$0 \le V_{icm} \le V_{CC}$, $V_{out} = V_{CC}/2$	65	85		dB
SVR	Supply voltage rejection ratio 20 log ($\Delta V_{CC}/\Delta V_{io}$)	V_{CC} = 2.5 V to 5 V	70	90		
A_{vd}	Large signal voltage gain	V_{out} = 0.5 V to 4.5 V, R_L = 2 kΩ	83	92		
		V_{out} = 0.5 V to 4.5 V, R_L = 600 Ω	77	85		
V_{OH}	High level output voltage, $V_{OH} = V_{out}$	V_{id} = 100 mV, R_L = 2 kΩ	4.80	4.95		V
		V_{id} = 100 mV, R_L = 600 Ω	4.75	4.90		
		V_{id} = 100 mV, $T_{min} \le T_{amb} \le T_{max}$, R_L = 2 kΩ	4.80			
		V_{id} = 100 mV, $T_{min} \le T_{amb} \le T_{max}$, R_L = 600 Ω	4.75			
V_{OL}	Low level output voltage	V_{id} = -100 mV, R_L = 2 kΩ		88	130	mV
		V_{id} = -100 mV, R_L = 600 Ω		115	188	
		V_{id} = -100 mV, $T_{min} \le T_{amb} \le T_{max}$, R_L = 2 kΩ			130	
		V_{id} = -100 mV, $T_{min} \le T_{amb} \le T_{max}$, R_L = 600 Ω			188	
I_o	Output source current	V_{id} = 100 mV, $V_O = V_{DD}$	20	80		mA
	Output sink current	V_{id} = -100 mV, $V_O = V_{CC}$	20	80		
I_{CC}	Supply current (per amplifier)	A_{VCL} = 1, no load		500	835	μA
		$T_{min} \le T_{amb} \le T_{max}$			875	
GBP	Gain bandwidth product	R_L = 10 kΩ, C_L = 100 pF, f = 100 kHz	1	1.4		MHz
SR	Slew rate	R_L = 10 kΩ, C_L = 100 pF	0.42	0.6		V/μs
ϕm	Phase margin	C_L = 100 pF		55		Degrees
en	Input voltage noise			27		nV/√ Hz
THD	Total harmonic distortion			0.01		%

1. Maximum values include unavoidable inaccuracies of the industrial tests.

Figure 1. Supply current/amplifier vs. supply voltage

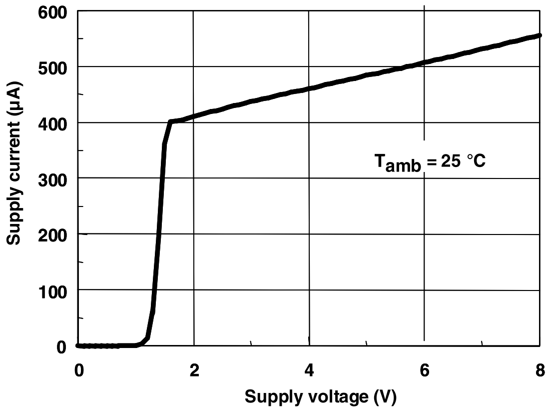


Figure 2. Supply current/amplifier vs. temperature

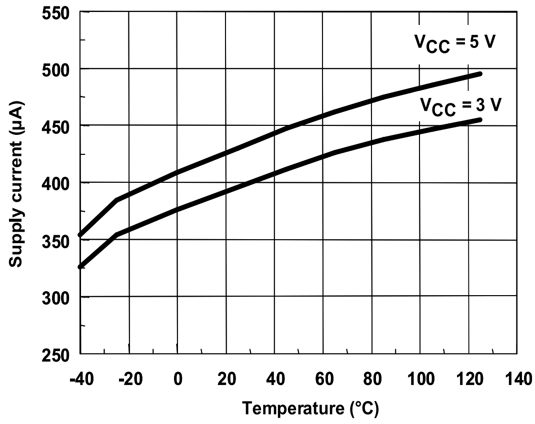


Figure 3. Output power vs. supply voltage

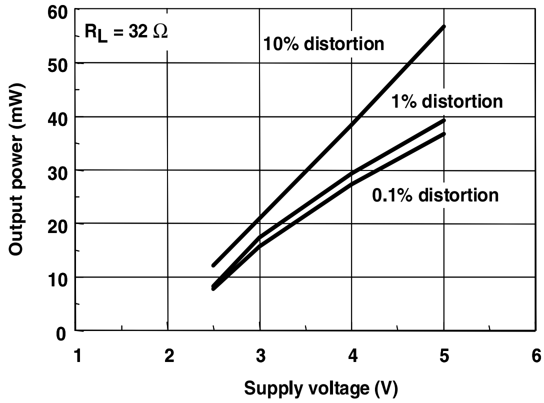


Figure 4. Input offset voltage drift vs. temperature

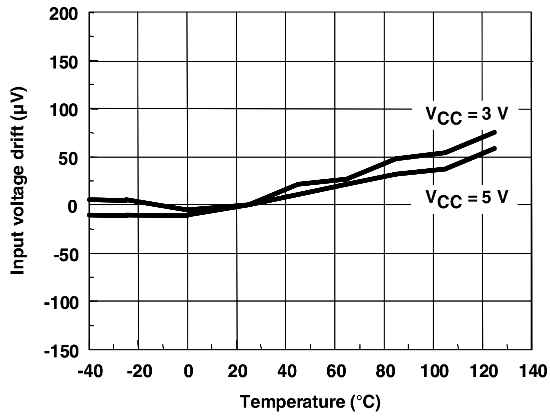


Figure 5. Input bias current vs. temperature

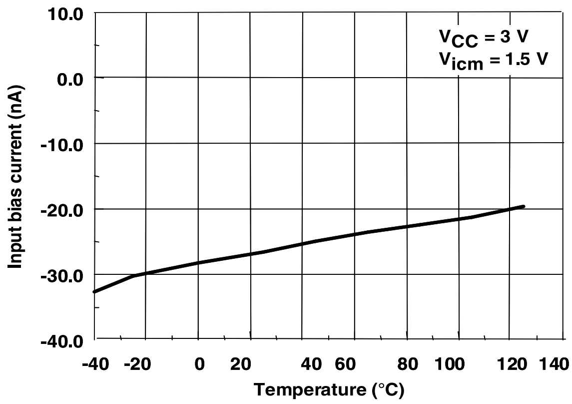
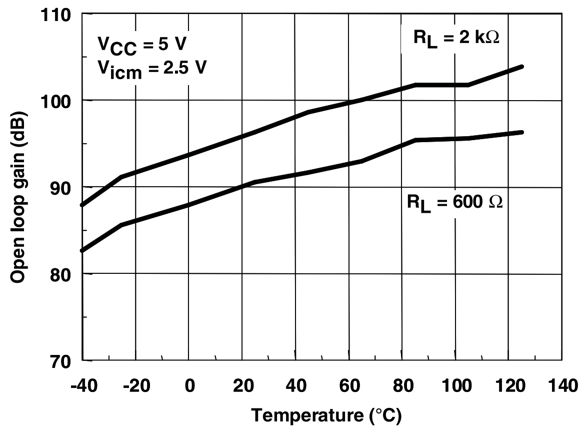


Figure 6. Open loop gain vs. temperature at V_{CC} = 5 V



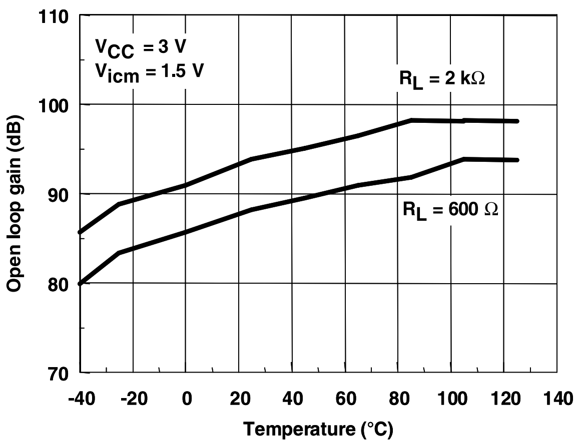


Figure 7. Open loop gain vs. temperature at V_{CC} = 3 V

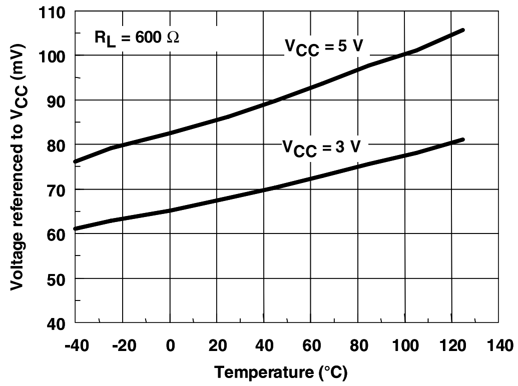


Figure 8. High level output voltage vs. temperature

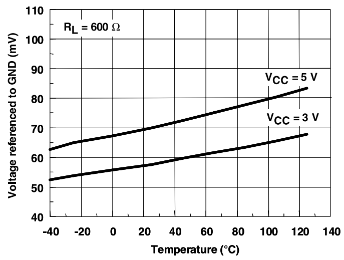


Figure 9. Low level output voltage vs. temperature

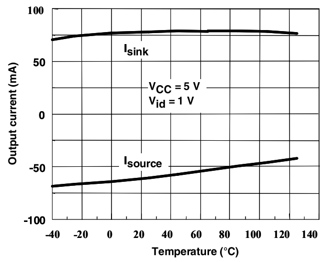


Figure 10. Output current vs. temperature at V_{CC} = 5 V

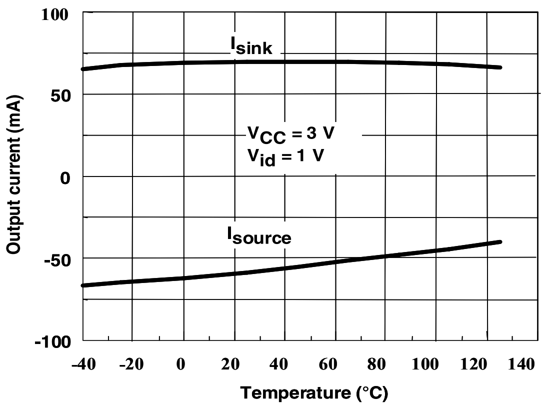


Figure 11. Output current vs. temperature at V_{CC} = 3 V

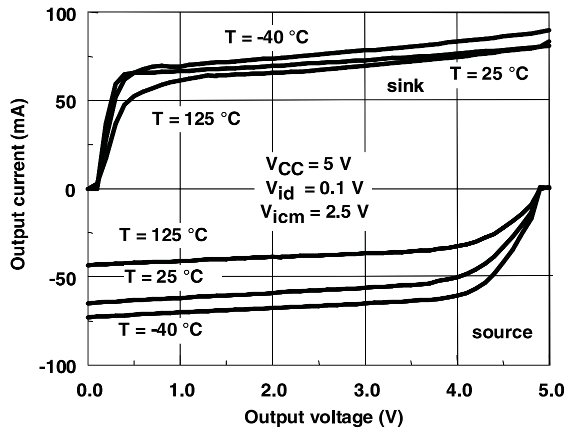


Figure 12. Output current vs. output voltage at V_{CC} = 5 V

Figure 13. Output current vs. output voltage at V_{CC} = 3 V

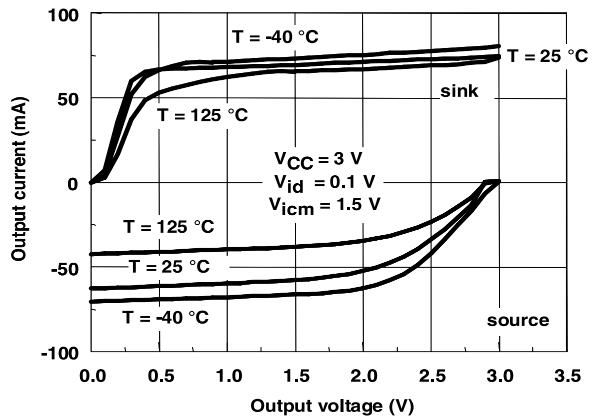


Figure 14. Gain and phase vs. frequency at V_{CC} = 5 V

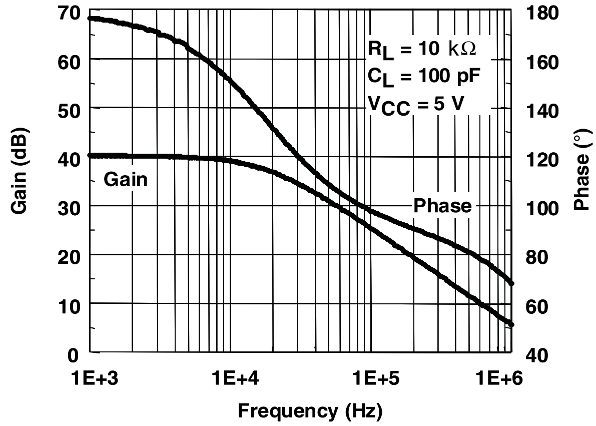


Figure 15. Gain and phase vs. frequency at V_{CC} = 3 V

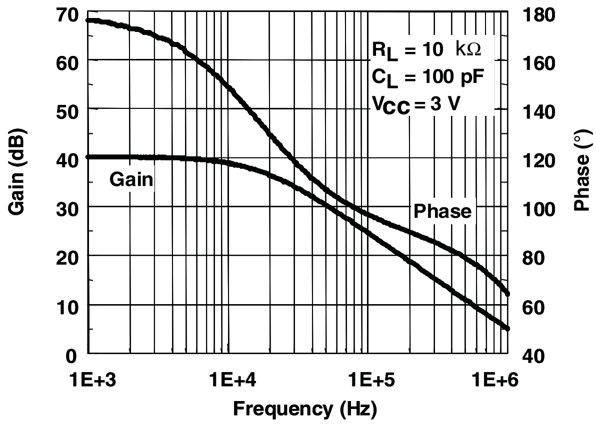


Figure 16. Slew rate vs. temperature at V_{CC} = 5 V

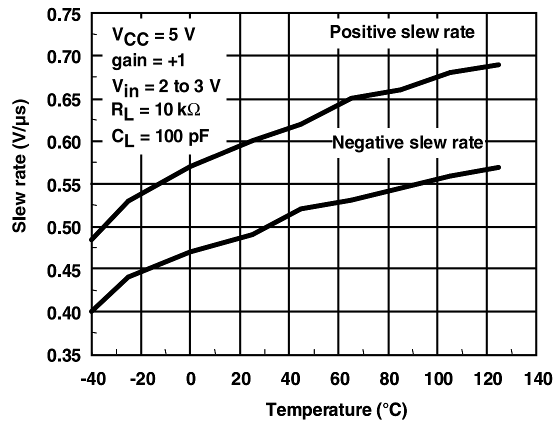


Figure 17. Slew rate vs. temperature at V_{CC} = 3 V

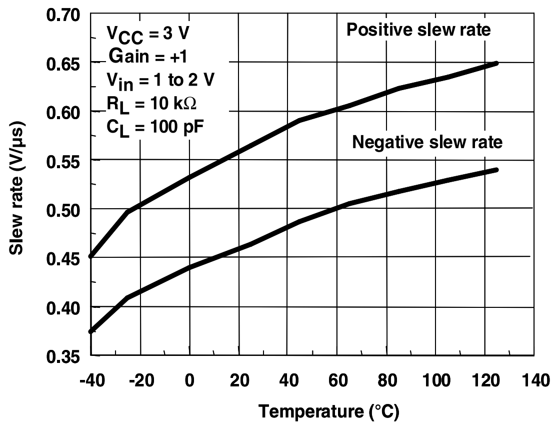
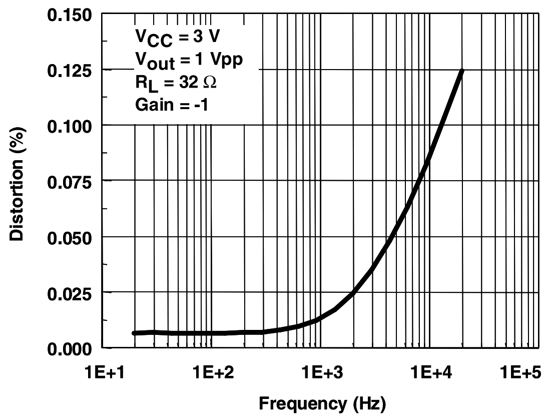
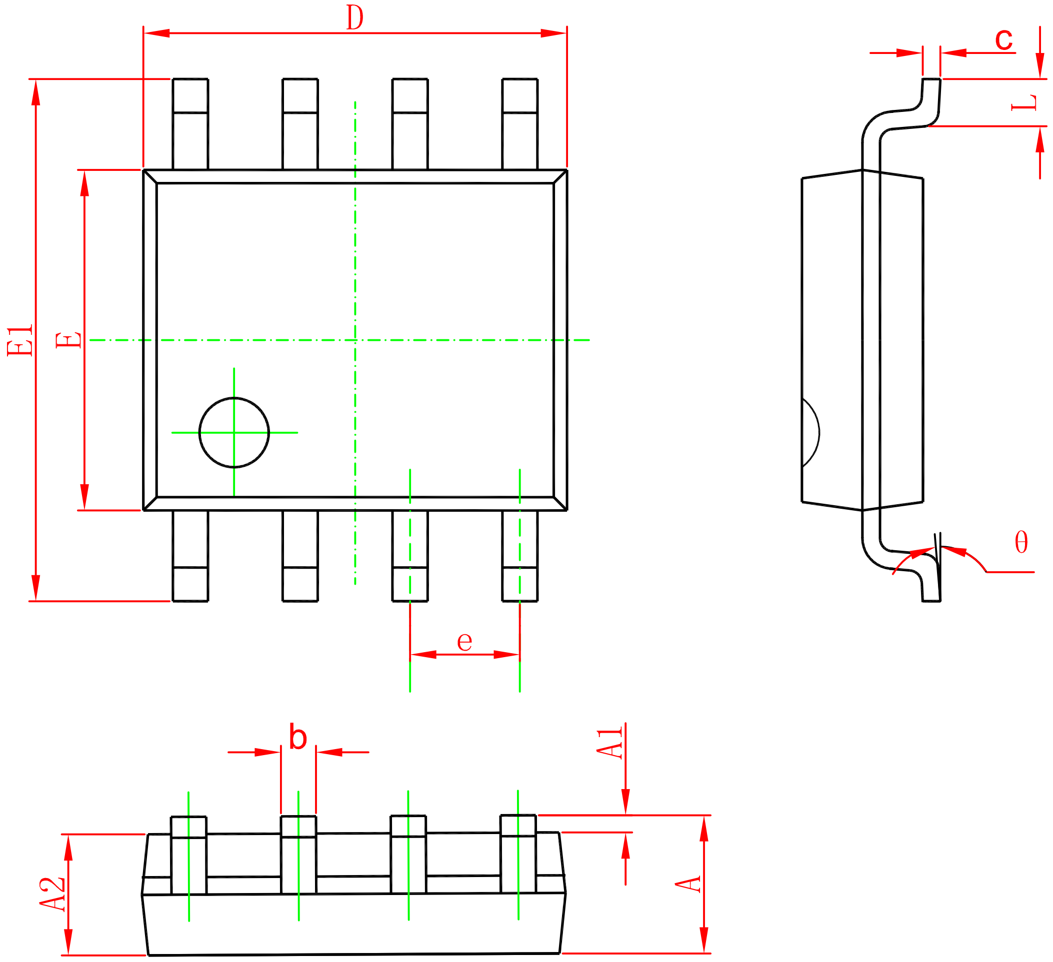


Figure 18. Distortion vs. frequency

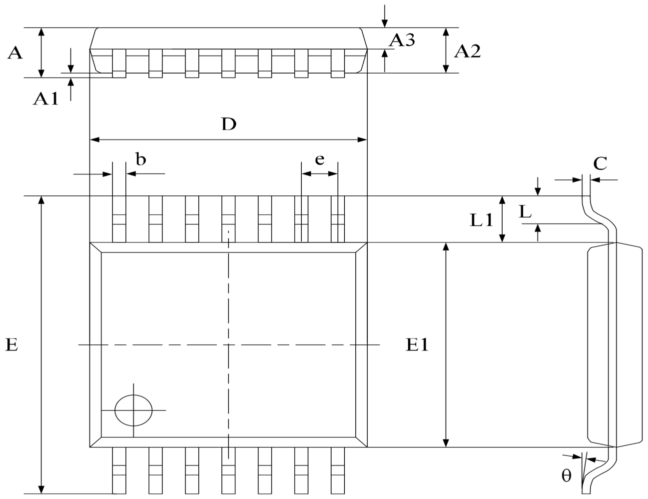


SOP-8



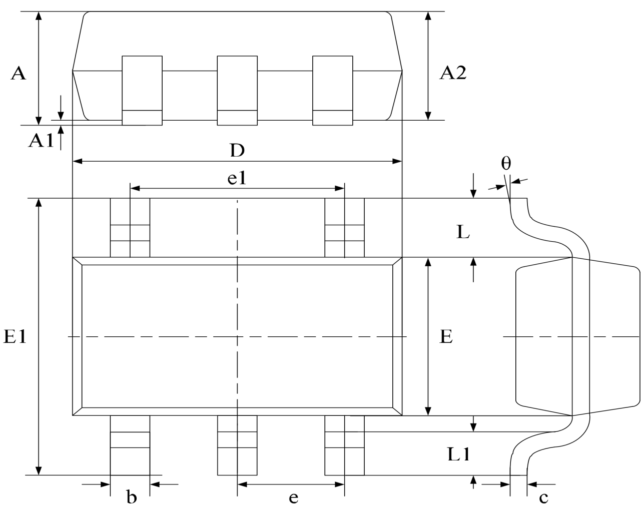
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.006	0.010
D	4.700	5.100	0.185	0.200
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.270(BSC)		0.050(BSC)	
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°

TSSOP-14



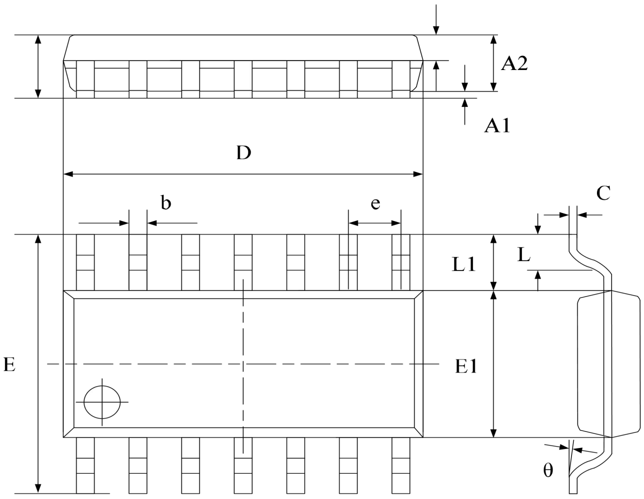
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	-	1.200	-	0.0472
A1	0.050	0.150	0.002	0.006
A2	0.900	1.050	0.037	0.043
A3	0.390	0.490	0.016	0.020
b	0.200	0.290	0.008	0.012
C	0.130	0.180	0.005	0.007
D	4.860	5.060	0.198	0.207
E	6.200	6.600	0.253	0.269
E1	4.300	4.500	0.176	0.184
e	0.650 typ.		0.0256 typ.	
L1	1.000 ref.		0.0393 ref.	
L	0.450	0.750	0.018	0.031
θ	0°	8°	0°	8°

SOT23-5



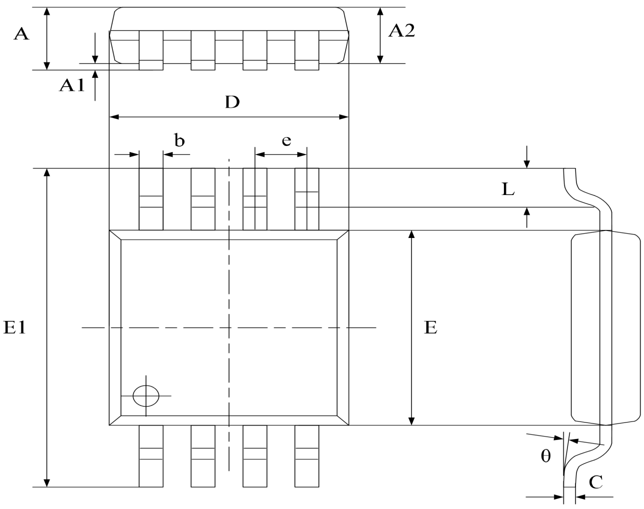
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.040	1.350	0.042	0.055
A1	0.040	0.150	0.002	0.006
A2	1.000	1.200	0.041	0.049
b	0.380	0.480	0.015	0.020
c	0.110	0.210	0.004	0.009
D	2.720	3.120	0.111	0.127
E	1.400	1.800	0.057	0.073
E1	2.600	3.000	0.106	0.122
e	0.950 typ.		0.037 typ.	
e1	1.900 typ.		0.078 typ.	
L	0.700 ref.		0.028 ref.	
L1	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°

SOP-14



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.450	1.850	0.059	0.076
A1	0.100	0.300	0.004	0.012
A2	1.350	1.550	0.055	0.063
A3	0.550	0.750	0.022	0.031
b	0.406typ.		0.017typ.	
C	0.203typ.		0.008typ.	
D	8.630	8.830	0.352	0.360
E	5.840	6.240	0.238	0.255
E1	3.850	4.050	0.157	0.165
e	1.270 typ.		0.050 typ.	
L1	1.040 ref.		0.041 ref.	
L	0.350	0.750	0.014	0.031
θ	2°	8°	2°	8°

MSOP-8



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0.800	1.100	0.033	0.045
A1	0.050	0.150	0.002	0.006
A2	0.750	0.950	0.031	0.039
b	0.290	0.380	0.012	0.016
C	0.150	0.200	0.006	0.008
D	2.900	3.100	0.118	0.127
E	2.900	3.100	0.118	0.127
E1	4.700	5.100	0.192	0.208
e	0.650typ.		0.026typ.	
L	0.400	0.700	0.016	0.029
θ	0°	8°	0°	8°

Ordering information

Order code	Package	Baseqty	Deliverymode	Marking
UMW TSV321RAILT	SOT23-5	3000	Tape and reel	K178
UMW TSV321RILT	SOT23-5	3000	Tape and reel	K174
UMW TSV358AIST	MSOP-8	3000	Tape and reel	K184
UMW TSV358IST	MSOP-8	3000	Tape and reel	K175
UMW TSV358IPT	TSSOP-8	3000	Tape and reel	V358I
UMW TSV358AIDT	SOP-8	3000	Tape and reel	V358AI
UMW TSV358IDT	SOP-8	3000	Tape and reel	V358ID
UMW TSV324IPT	TSSOP14	3000	Tape and reel	V324IP
UMW TSV324IDT	SOP-14	3000	Tape and reel	V324ID