TPH2501/TPH2502/TPH2503 /TPH2504

250MHz, Precision, Rail-to-Rail I/O, CMOS Op-amps

Features

- **Unity-Gain Bandwidth: 250MHz**
- **Gain Bandwidth Product: 120MHz**
- **High Slew Rate: 180V/μs**
- **Offset Voltage: 2mV Max.**
- **Low Noise: 6.5nV/√Hz**
- **Rail-to-Rail Input and Output**
- **High Output Current: > 100mA**
- **Excellent Video Performance:**
  Diff Gain: 0.02%, Diff Phase: 0.3°
  0.1dB Gain Flatness: 25MHz
- **Low Input Bias Current: 0.3pA**
- **Thermal Shutdown**
- **Supply Range: 2.5V to 5.5V**
- **Operating Temperature Range: –40°C to 125°C**

Applications

- Low Voltage, High Frequency Signal Processing
- Video Processing
- Optical Networking, Tunable Lasers
- Photodiode Trans-impedance
- Barcode Scanner
- Fast Current Sensing Amplifiers

Description

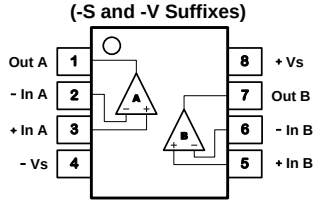
The TPH2501/3, THP2502, TPH2504 are single, dual, quad low power, high speed unity gain stable rail-to-rail input/output operational amplifiers. On only 6.5mA of supply current they feature an impressive 250MHz gain-bandwidth product, 180V/μs slew rate and a low 6.5nV/√Hz of input-referred noise, TPH2503 offers a shutdown current of only 1μA. The combination of high bandwidth, high slew rate, low power consumption and low broadband noise makes these amplifiers unique among rail-to-rail input/output op amps with similar supply currents. They are ideal for lower supply voltage high speed signal conditioning systems.

The TPH2501 family maintains high efficiency performance from supply voltage levels of 2.5V to 5.5V and is fully specified at supplies of 2.7V and 5.0V. The TPH2501 family can be used as a plug-in replacement for many commercially available op amps to reduce power or to improve I/O range and performance.

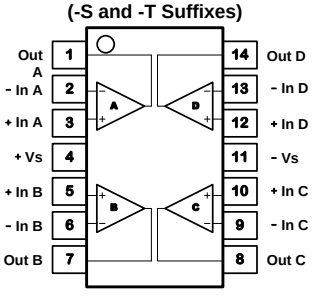
The TPH2501 is single channel version available in 5-pin SOT23 package. The TPH2502 is dual channel version available in 8-pin SOP and MSOP packages. The TPH2503 is in 6-pin SOT23 package with shutdown function. The TPH2504 is quad channel version available in 14-pin SOP and TSSOP packages.

Pin Configuration (Top View)

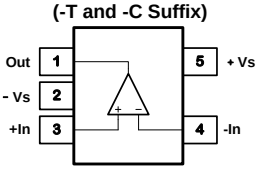
TPH2502
8-Pin SOP/MSOP
(-S and -V Suffixes)



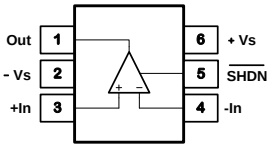
TPH2504
14-Pin SOP/TSSOP
(-S and -T Suffixes)



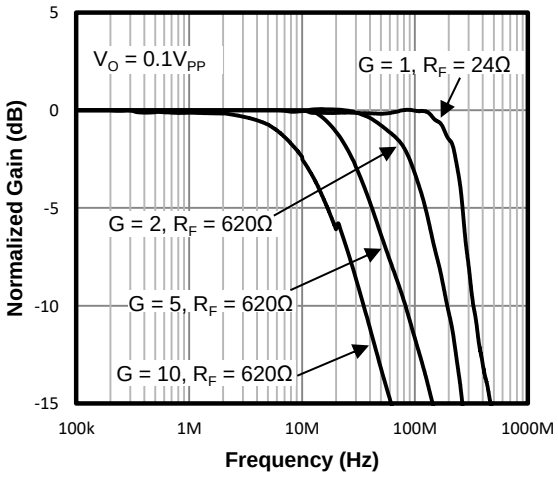
TPH2501
5-Pin SOT23/SC-70
(-T and -C Suffix)



TPH2503
6-Pin SOT23/SC-70
(-T and -C Suffix)



Noninverting Small−Signal Frequency Response



Order Number	Package	MSL	Transport Media, Quantity	Marking Information
TPH2501-TR	5-Pin SOT23	MSL 3	Tape and Reel, 3,000	501
TPH2502-SR	8-Pin SOP	MSL 3	Tape and Reel, 4,000	TPH2502
TPH2502-VR	8-Pin MSOP	MSL 3	Tape and Reel, 3,000	TPH2502
TPH2503-TR	6-Pin SOT23	MSL 3	Tape and Reel, 3,000	503
TPH2504-SR	14-Pin SOP	MSL 3	Tape and Reel, 2,500	TPH2504
TPH2504-TR	14-Pin TSSOP	MSL 3	Tape and Reel, 3,000	TPH2504

Absolute Maximum Ratings Note 1

Supply Voltage: $V^+ - V^-$ Note 2.....7.0V
Input Voltage..... V^- – 0.3 to V^+ + 0.3
Input Current: +IN, –IN Note 3..... ±20Ma
Output Current: OUT..... ±160Ma
Output Short-Circuit Duration Note 4..... Infinite

Current at Supply Pins……..... ±60Ma
Operating Temperature Range.....–40°C to 125°C
Maximum Junction Temperature..... 150°C
Storage Temperature Range..... –65°C to 150°C
Lead Temperature (Soldering, 10 sec) ..... 260°C

Note 1: Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. Exposure to any Absolute Maximum Rating condition for extended periods may affect device reliability and lifetime.

Note 2: The op amp supplies must be established simultaneously, with, or before, the application of any input signals.

Note 3: The inputs are protected by ESD protection diodes to each power supply. If the input extends more than 500Mv beyond the power supply, the input current should be limited to less than 10Ma.

Note 4: A heat sink may be required to keep the junction temperature below the absolute maximum. This depends on the power supply voltage and how many amplifiers are shorted. Thermal resistance varies with the amount of PC board metal connected to the package. The specified values are for short traces connected to the leads.

ESD, Electrostatic Discharge Protection

Symbol	Parameter	Condition	Minimum Level	Unit
HBM	Human Body Model ESD	ANSI/ESDA/JEDEC JS-001	2	kV
CDM	Charged Device Model ESD	ANSI/ESDA/JEDEC JS-002	1	kV

Thermal Resistance

Package Type	θ_{JA}	θ_{JC}	Unit
5-Pin SOT23	250	81	°C/W
6-Pin SOT23	170	130	°C/W
8-Pin SOP	158	43	°C/W
8-Pin MSOP	210	45	°C/W
14-Pin SOP	120	36	°C/W
14-Pin TSSOP	180	35	°C/W

Electrical Characteristics

The specifications are at T_A = +25°C, R_F = 0Ω, R_L = 1Kω, and connected to V_S/2, Unless otherwise noted.

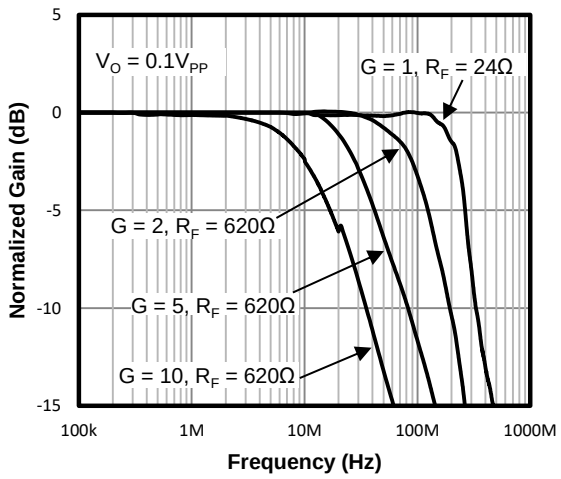
SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
V_{OS}	Input Offset Voltage	V_{CM} = V_{DD}/2	-2		+2	mV
		V_{CM} = V_{DD}/2, -40°C to 125°C	-5		+5	mV
V_{OS} TC	Input Offset Voltage Drift	-40°C to 125°C		10		uV/°C
I_B	Input Bias Current	T_A = 27 °C		3		pA
		T_A = 85 °C		150		pA
		T_A = 125 °C		300		pA
I_{OS}	Input Offset Current			3		pA
e_n	Input Voltage Noise Density	f = 1MHz		6.5		nV/√Hz
i_n	Input Current Noise	f = 1MHz		50		fA/√Hz
C_{IN}	Input Capacitance	Differential Common Mode		2.7 1		pF
CMRR	Common Mode Rejection Ratio	V_{CM} = 0.7V to 3.7V, V_S = 5.4V	65	85		dB
CMRR	Common Mode Rejection Ratio	V_{CM} = 0V to 3V, V_S = 5V	65	85		dB
		V_{CM} = 0V to 3V, V_S = 5V, -40°C to 125°C	45			dB
V_{CM}	Common-mode Input Voltage Range		V^- -0.1		V^+-0.1	V
PSRR	Power Supply Rejection Ratio	V_S = 2.5V to 5.5V	70	120		dB
		V_S = 2.5V to 5.5V, -40°C to 125°C	65			dB
A_{VOL}	Open-Loop Large Signal Gain	R_{LOAD} = 2Kω	85	110		dB
		R_{LOAD} = 2Kω, -40°C to 125°C	75			dB
Frequency Response						
f_{-3dB}	Small-Signal Bandwidth	G = +1, V_O = 100mV_{PP}, R_F = 25Ω		250		MHz
		G = +2, V_O = 100mV_{PP}		90		MHz
GBW	Gain-Bandwidth Product	G = +10		120		MHz
$f_{0.1dB}$	Bandwidth for 0.1dB Gain Flatness	G = +2, V_O = 100mV_{PP}		25		MHz
SR	Slew Rate	V_S = +5V, G = +1, 4V Step		200		V/μs
		V_S = +5V, G = +1, 2V Step		180		V/μs
		V_S = +3V, G = +1, 2V Step		160		V/μs
t_F	Rise-and-fAll Time	G = +1, V_O = 200mV_{PP}, 10% to 90%		2		ns
		G = +1, V_O = 2V_{PP}, 10% to 90%		7		ns
t_S	Settling Time, 0.1%	V_S = +5V, G = +1, 2V Output Step		25		ns
	Settling Time, 0.01%			40		ns
t_R	Overload Recovery Time	V_{IN} * Gain = V_S		50		ns
HD2	Harmonic Distortion, 2nd-Harmonic	G = +1, f = 1MHz, V_O = 2V_{PP}, R_L = 200Ω, V_{CM} = 1.5V		-78		dBc
HD3	Harmonic Distortion, 3rd-Harmonic	G = +1, f = 1MHz, V_O = 2V_{PP}, R_L = 200Ω, V_{CM} = 1.5V		-90		dBc
GE	Differential Gain Error	NTSC, R_L = 150Ω		0.02		%
PE	Differential Phase Error	NTSC, R_L = 150Ω		0.3		degrees
X_{talk}	Channel-to-Channel Crosstalk TPH2502	f = 5MHz		-100		dB

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
	Channel-to-Channel Crosstalk TPH2504			-84		dB
V_{OL}, V_{OH}	Output Swing from Supply Rail	R_{LOAD} = 100Kω		2	30	mV
		R_{LOAD} = 100Kω, -40°C to 125°C			35	mV
R_I	Input Impedance	Differential		10^{13} || 2		Ω || pF
		Common-Mode		10^{13} || 2		Ω || pF
R_{OUT}	Closed-Loop Output Impedance	G = 1, f =1kHz, I_{OUT} = 0		0.01		Ω
R_O	Open-Loop Output Impedance	f = 1kHz, I_{OUT} = 0		21		Ω
I_{SC}	Output Short-Circuit Current	Sink current	100	160		mA
		Source current	100	290		mA
V_{DD}	Supply Voltage		2.5		5.5	V
I_Q	Quiescent Current per Amplifier	TPH2501		8	10	mA
		TPH2501, -40°C to 125°C			15	mA
		TPH2502, TPH2504		6.5	7.5	mA
		TPH2502, TPH2504, -40°C to 125°C			12	mA
I_{SD}	Shutdown Current(TPH2503)			30		uA
	Input Logic High of Shuntdown		1.6			V
	Input Logic Low of Shuntdown				0.6	V

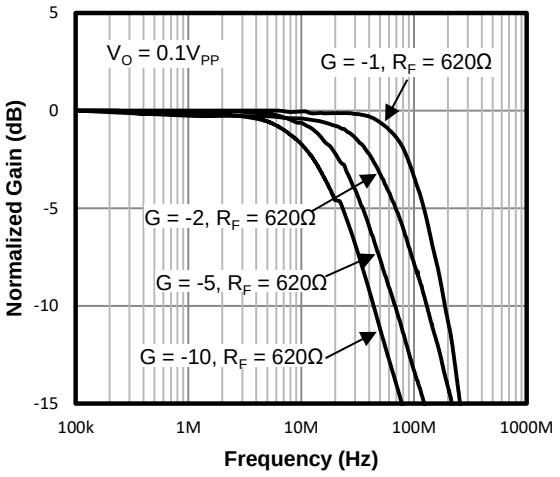
Typical Performance Characteristics

V_S = 5V, G = +1, R_F = 0Ω, R_L = 1KΩ, and connected to V_S/2, unless otherwise specified.

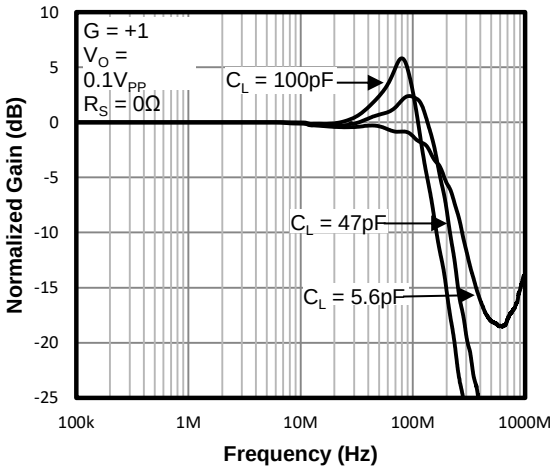
Noninverting Small−Signal Frequency Response



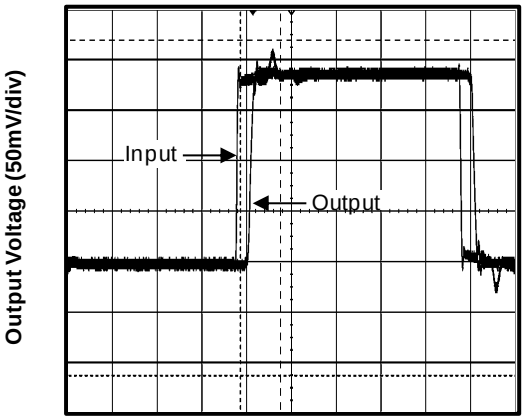
Inverting Small−Signal Frequency Response



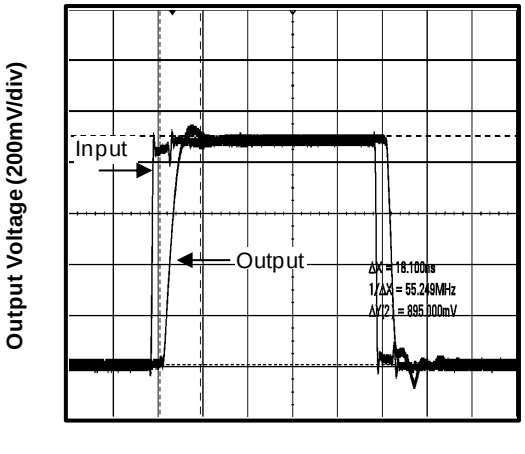
Frequency Response for Various C_L



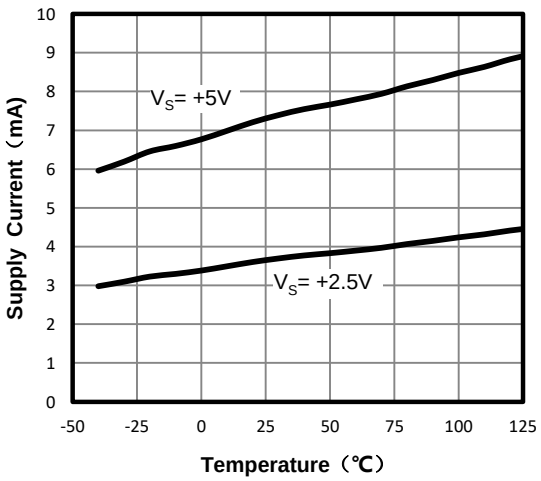
Noninverting Small−Signal Step Response



Inverting Large-Signal Step Response



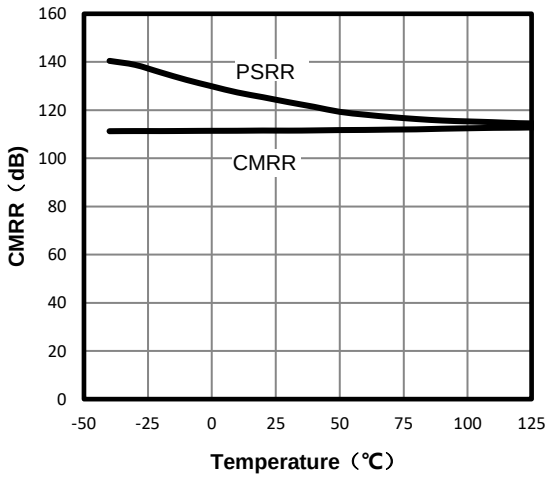
Quiescent Current vs. Temperature



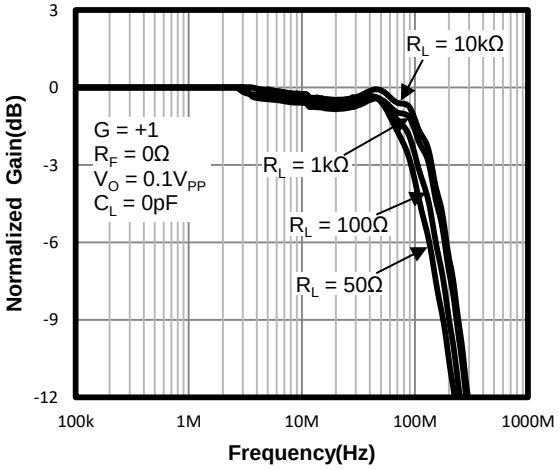
Typical Performance Characteristics

V_S = 5V, G = +1, R_F = 0Ω, R_L = 1Kω, and connected to V_S/2, unless otherwise specified.

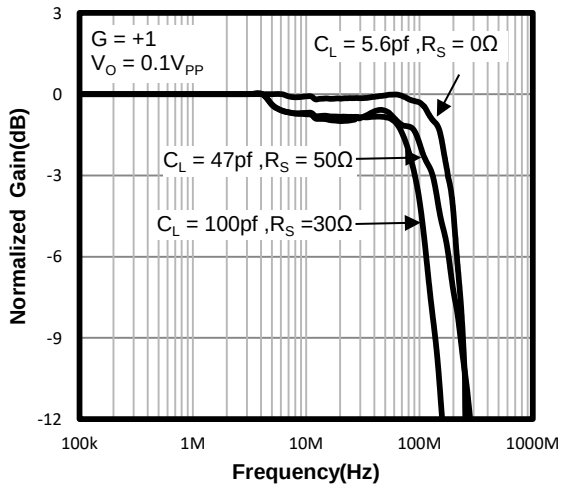
CMRR and PSRR Vs. Temperature



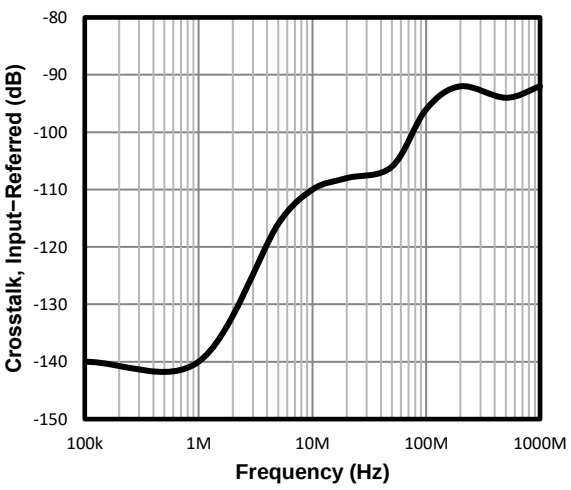
Frequency Response For Various R_L



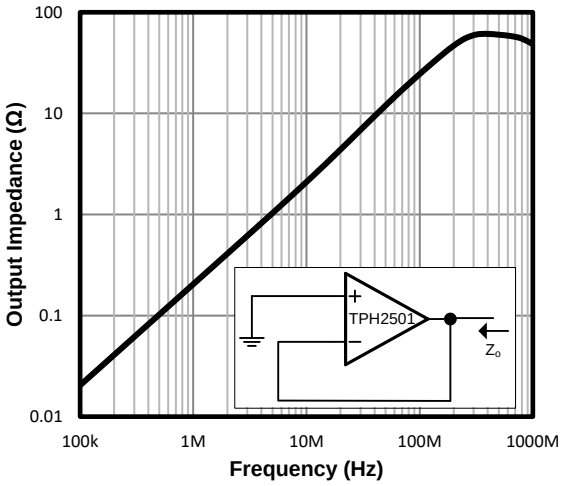
Frequency Response Vs. Capacitive Load



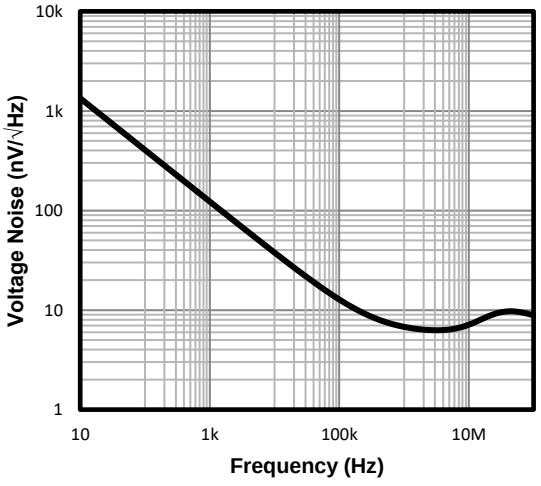
Channel-To-Channel Crosstalk



Closed-Loop Output Impedance Vs. Frequency



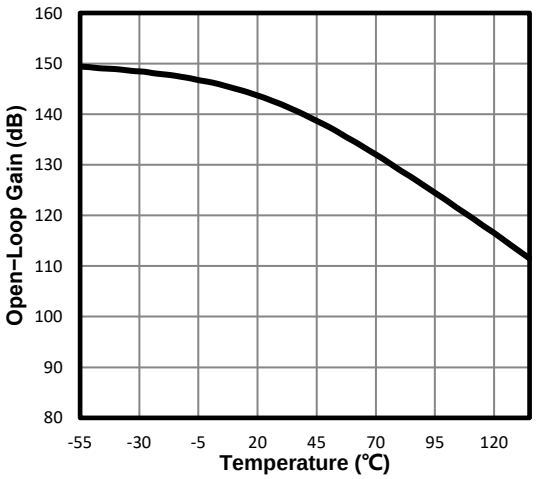
Voltage Spectral Density Vs. Frequency



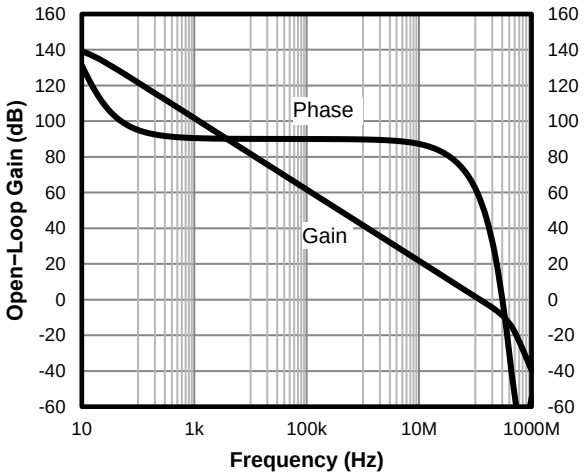
Typical Performance Characteristics

V_S = 5V, G = +1, R_F = 0Ω, R_L = 1Kω, and connected to V_S/2, unless otherwise specified.

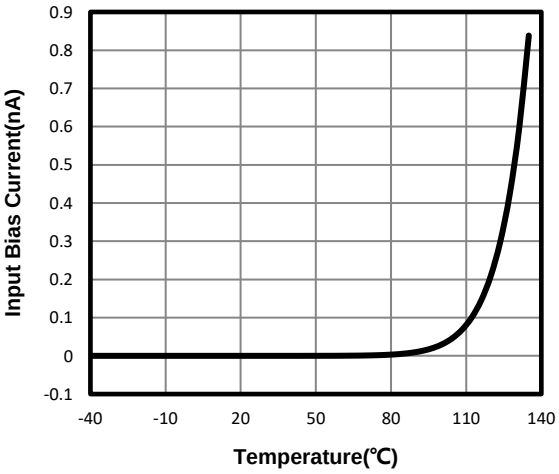
Open Loop Gain Vs. Temperature



Open Loop Gain And Phase



Input Bias Current Vs. Temperature



Pin Functions

-IN: Inverting Input of the Amplifier.

+IN: Non-Inverting Input of Amplifier.

OUT: Amplifier Output. The voltage range extends to within Mv of each supply rail.

V+ or +V_S: Positive Power Supply. Typically the voltage is from 2.5V to 5.5V. Split supplies are possible as long as the voltage between V+ and V– is between 2.5V and 5.5V. A bypass capacitor of 0.1Mf as close to the part as possible should be used between power supply pins or between supply pins and ground.

V- or –V_S: Negative Power Supply. It is normally tied to ground. It can also be tied to a voltage other than ground as long as the voltage between V_+ and V_- is from 2.5V to 5.5V. If it is not connected to ground, bypass it with a capacitor of 0.1Mf as close to the part as possible.

$\overline{SHDN}$: High on this pin logic low to shut down the device. Range: Logic high enables the device and logic low shut down the device. **This pin defaults to logic high if left open.**

Operation

The TPH2501,TPH2502,TPH2504 is a CMOS, rail-to-rail I/O, high-speed, voltage-feedback operational amplifier designed for video, high-speed, and other applications. It is available as a single, dual, or quad op amp. The amplifier features a 250MHz gain bandwidth, and 180V/μs slew rate, but it is unity-gain stable and can be operated as a +1V/V voltage follower. The TPH2501/TPH2502/TPH2504 is specified over a power-supply range of +2.7V to +5.5V (±1.35V to ±2.75V). However, the supply voltage may range from +2.5V to +5.5V (±1.25V to ±2.75V). Supply voltages higher than 7.5V (absolute maximum) can permanently damage the amplifier. Parameters that vary over supply voltage or temperature are shown in the typical characteristics section of this datasheet.

Applications Information

Power On Requirement

Generally the high speed amplifier(>100MHz GBW) has larger Vos as the input transistors has small size to get the lower input capacitance for high speed, the small size input transistors bring to large Vos for the mismatch of input transistor pair. The high speed amplifier has normally >±5mV Vos, comparing to low speed amplifier has maximum ±3mV Vos with larger input transistors.

The TPH250x amplifier use internal calibration block to achieve ±2mV Vos, which is better than most of high speed amplifiers. To guarantee the calibration block works properly, good power on of the amplifier power supply is recommended:

- Fast power on time to produce the power on reset signal of calibration block. The maximum value of power on time is 1ms.
- Avoid the voltage glitch reaching in 0.4V to 1V range on power supply. For example, power supply drop to 0.5V then recovery to 5V may cause error of calibration block.

If the power on signal is not good, the amplifier has probability to enter an unexpected status.

Rail-to-Rail Inputs and Outputs

The TPH2501,TPH2502,TPH2504 op amps are designed to be immune to phase reversal when the input pins exceed the supply voltages, therefore providing further in-system stability and predictability. Figure 1 shows the input voltage exceeding the supply voltage without any phase reversal.

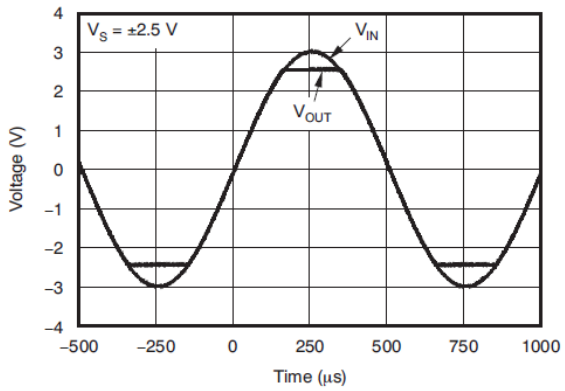


Figure 1. No Phase Reversal

Choice of Feedback Resistor and Gain Bandwidth Product

For applications that require a gain of +1, no feedback resistor is required. Just short the output pin to the inverting input pin. For gains greater than +1, the feedback resistor forms a pole with the parasitic capacitance at the inverting input. As this pole becomes smaller, the amplifier's phase margin is reduced. This causes ringing in the time domain and peaking in the frequency domain. Therefore, R_F has some maximum value that should not be exceeded for optimum performance. If a large value of R_F must be used, a small capacitor in the few Pico farad range in parallel with R_F can help to reduce the ringing and peaking at the expense of reducing the bandwidth. As far as the output stage of the amplifier is concerned, the output stage is also a gain stage with the load. R_F and R_G appear in parallel with R_L for gains other than +1. As this combination gets smaller, the bandwidth falls off. Consequently, R_F also has a minimum value that should not be exceeded for optimum performance. For gain of +1, R_F=0 is optimum. For the gains other than +1, optimum response is obtained with R_F between 300Ω to 1Kω.

The TPH2501, TPH2502 and TPH2504 have a gain bandwidth product of 120MHz. For gains ⩾5, its bandwidth can be predicted by the following equation:

$$\text{Gain} \times \text{BW} = 120\text{MHz}$$

Video Performance

For good video performance, an amplifier is required to maintain the same output impedance and the same frequency response as DC levels are changed at the output. This is especially difficult when driving a standard video load of 150Ω, because the change in output current with DC level. Special circuitry has been incorporated in the TPH2501, TPH2502 and TPH2504 to reduce the variation of the output impedance with the current output. This results in Dg and Dp specifications of 0.03% and 0.3°, while driving 150Ω at a gain of 2. Driving high impedance loads would give a similar or better Dg and Dp performance.

Driving Capacitive Loads and Cables

The TPH2501, TPH2502 and TPH2504 can drive 10Pf loads in parallel with 1Kω with less than 5Db of peaking at gain of +1. If less peaking is desired in applications, a small series resistor (usually between 5Ω to 50Ω) can be placed in series with the output to eliminate most peaking. However, this will reduce the gain slightly. If the gain setting is greater than 1, the gain resistor R_G can then be chosen to make up for any gain loss which may be created by the additional series resistor at the output. When used as a cable driver, double termination is always recommended for reflection-

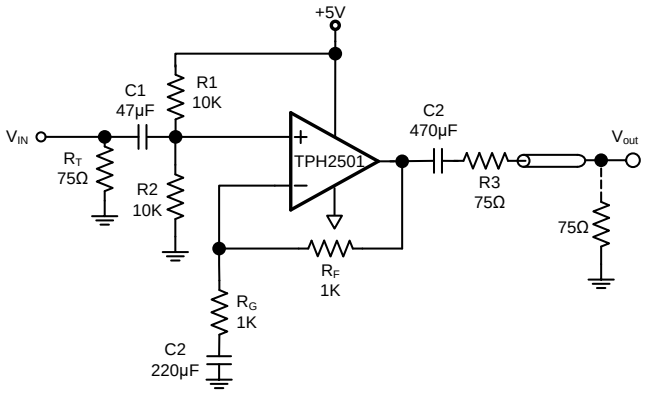
free performance. For those applications, a back-termination series resistor at the amplifier's output will isolate the amplifier from the cable and allow extensive capacitive drive. However, other applications may have high capacitive loads without a back-termination resistor. Again, a small series resistor at the output can help to reduce peaking.

Output Drive Capability

The TPH2501,TPH2502 and TPH2504 output stage can supply a continuous output current of ±100Ma and still provide approximately 2.7V of output swing on a 5V supply. For maximum reliability, it is not recommended to run a continuous DC current in excess of ±100Ma. Refer to the typical characteristic curve Output Voltage Swing vs Output Current. For supplying continuous output currents greater than ±100Ma, the TPH250x may be operated in parallel. The TPH250x will provide peak currents up to 200Ma, which corresponds to the typical short-circuit current. Therefore, an on-chip thermal shutdown circuit is provided to protect the TPH250x from dangerously high junction temperatures. At 160°C, the protection circuit will shut down the amplifier. Normal operation will resume when the junction temperature cools to below 140°C.

Single Supply Video Line Driver

The TPH2501, TPH2502 and TPH2504 are wideband rail-to-rail output op amplifiers with large output current, excellent Dg, Dp, and low distortion that allow them to drive video signals in low supply applications. Figure 2 is the single supply non-inverting video line driver configuration inverting video ling driver configuration. The signal is AC coupled by C1. R1 and R2 are used to level shift the input and output to provide the largest output swing. RF and RG set the AC gain. C2 isolates the virtual ground potential. RT and R3 are the termination resistors for the line. C1, C2 and C3 are selected big enough to minimize the droop of the luminance signal.



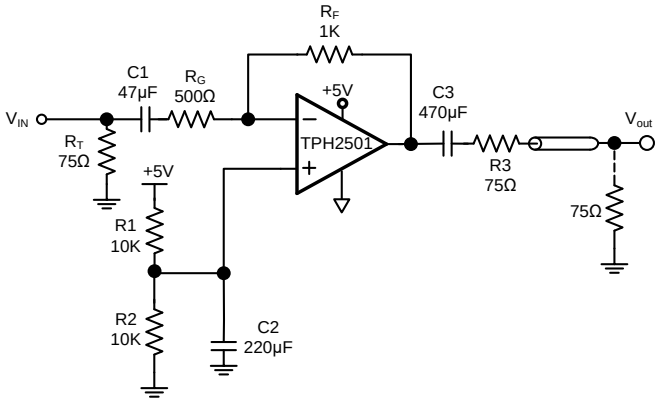


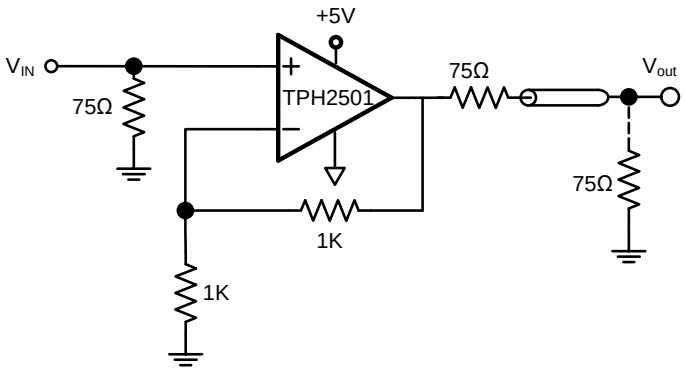
Figure 2. 5V Single Supply Non-Inverting and Inverting Video Line Driver

Power Supply Bypassing and Printed Circuit Board Layout

As with any high frequency device, a good printed circuit board layout is necessary for optimum performance. Lead lengths should be as sort as possible. The power supply pin must be well bypassed to reduce the risk of oscillation. For normal single supply operation, where the V_S- pin is connected to the ground plane, a single 4.7Mf tantalum capacitor in parallel with a 0.1Mf ceramic capacitor from V_S+ to GND will suffice. This same capacitor combination should be placed at each supply pin to ground if split supplies are to be used. In this case, the V_S- pin becomes the negative supply rail. For good AC performance, parasitic capacitance should be kept to a minimum. Use of wire wound resistors should be avoided because of their additional series inductance. Use of sockets should also be avoided if possible. Sockets add parasitic inductance and capacitance that can result in compromised performance. Minimizing parasitic capacitance at the amplifier's inverting input pin is very important. The feedback resistor should be placed very close to the inverting input pin. Strip line design techniques are recommended for the signal traces.

Video Sync Pulse Remover

Many CMOS analog to digital converters have a parasitic latch up problem when subjected to negative input voltage levels. Since the sync tip contains no useful video information and it is a negative going pulse, we can chop it off. Figure 29 shows a gain of 2 connections. Figure 3 shows the complete input video signal applied at the input, as well as the output signal with the negative going sync pulse removed.



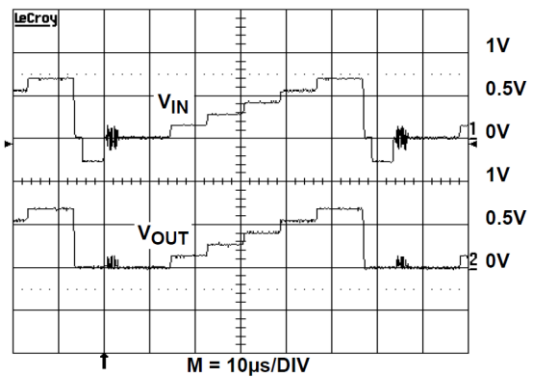


Figure 3. Sync Pulse Remover and Waveform

Input ESD Diode Protection

The TPH250x incorporates internal electrostatic discharge (ESD) protection circuits on all pins. In the case of input and output pins, this protection primarily consists of current-steering diodes connected between the input and power-supply pins. These ESD protection diodes also provide in-circuit input overdrive protection, as long as the current is limited to 20 Ma as stated in the Absolute Maximum Ratings table. Many input signals are inherently current-limited to less than 20 Ma; therefore, a limiting resistor is not required. Figure 4 shows how a series input resistor (R_S) may be added to the driven input to limit the input current. The added resistor contributes thermal noise at the amplifier input and the value should be kept to the minimum in noise-sensitive applications.

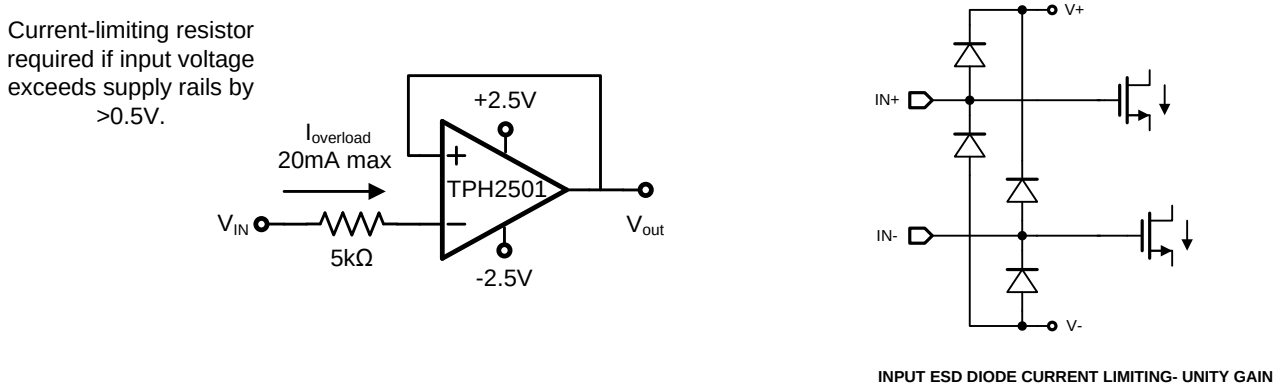
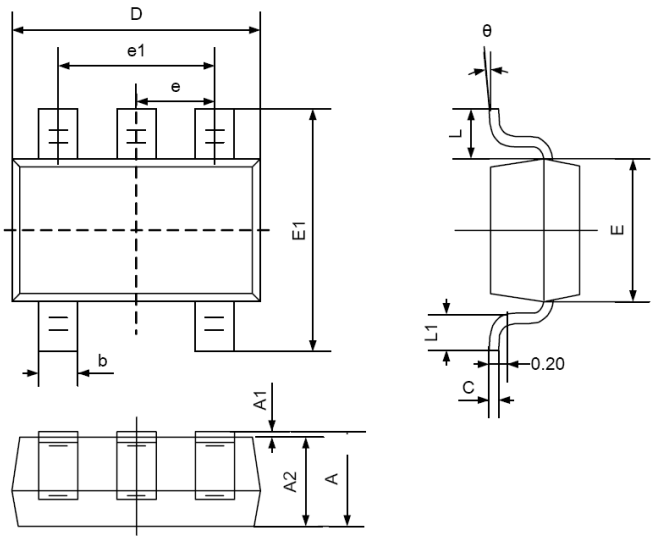


Figure 4. Input ESD Diode

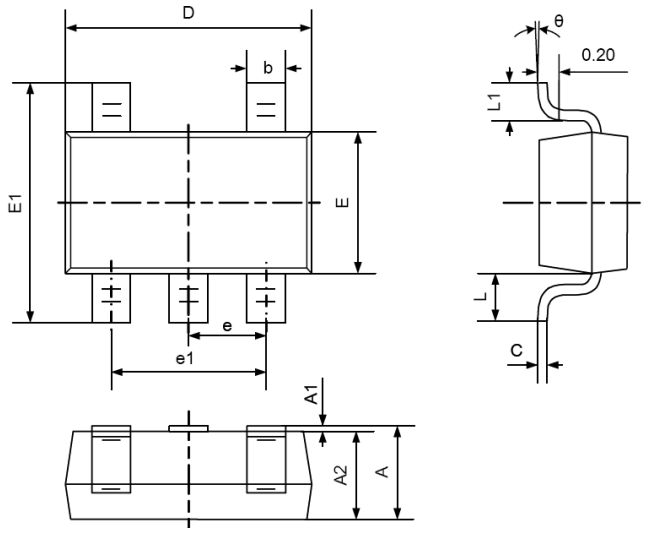
Package Outline Dimensions

SC70-5 /SOT-353



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0.900	1.100	0.035	0.043
A1	0.000	0.100	0.000	0.004
A2	0.900	1.000	0.035	0.039
b	0.150	0.350	0.006	0.014
C	0.080	0.150	0.003	0.006
D	2.000	2.200	0.079	0.087
E	1.150	1.350	0.045	0.053
E1	2.150	2.450	0.085	0.096
e	0.650TYP		0.026TYP	
e1	1.200	1.400	0.047	0.055
L	0.525REF		0.021REF	
L1	0.260	0.460	0.010	0.018
θ	0°	8°	0°	8°

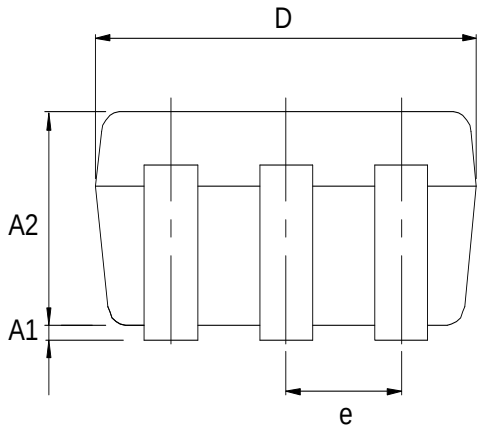
SOT23-5

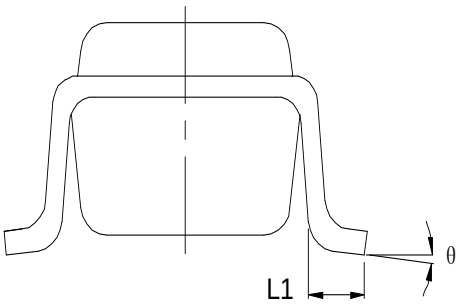


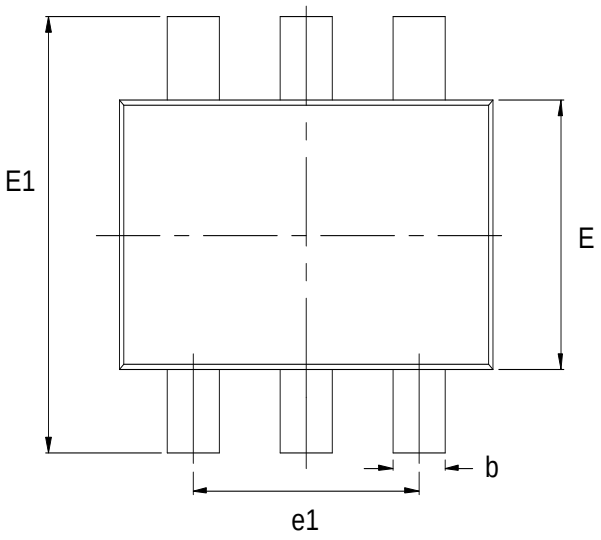
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.400	0.012	0.016
C	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950TYP		0.037TYP	
e1	1.800	2.000	0.071	0.079
L	0.700REF		0.028REF	
L1	0.300	0.460	0.012	0.024
θ	0°	8°	0°	8°

Package Outline Dimensions

SOT23-6



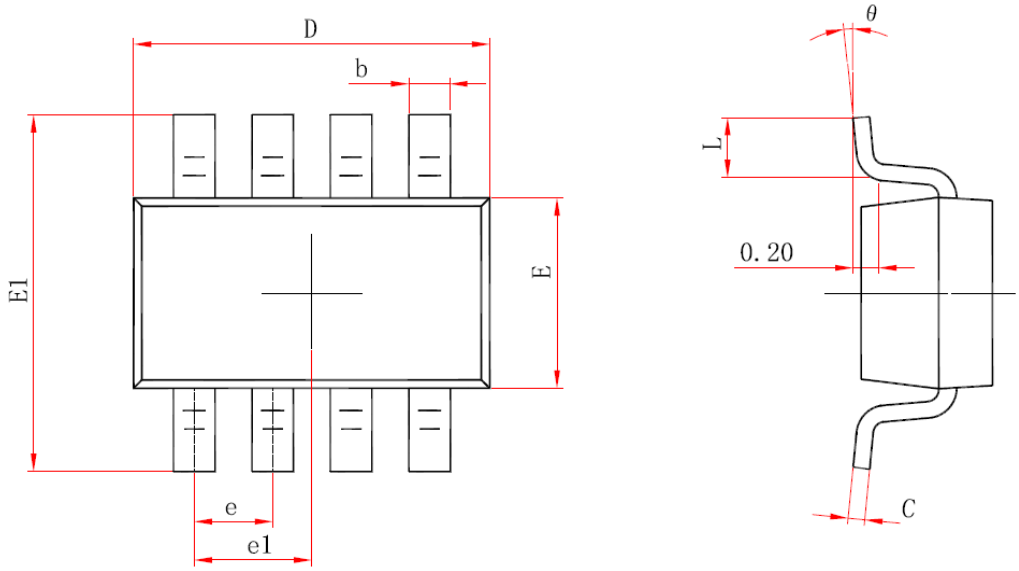


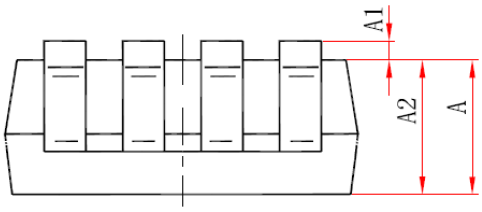


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.400	0.012	0.016
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950TYP		0.037TYP	
e1	1.800	2.000	0.071	0.079
L1	0.300	0.460	0.012	0.024
θ	0°	8°	0°	8°

Package Outline Dimensions

SOT-23-8

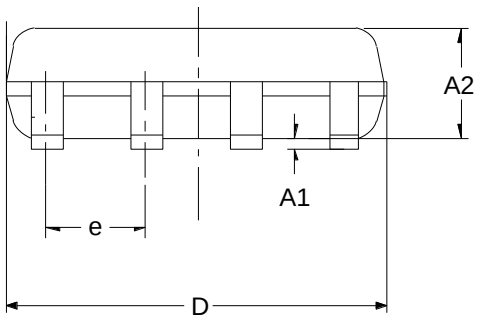


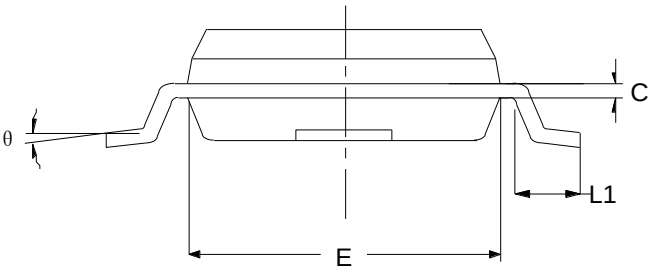


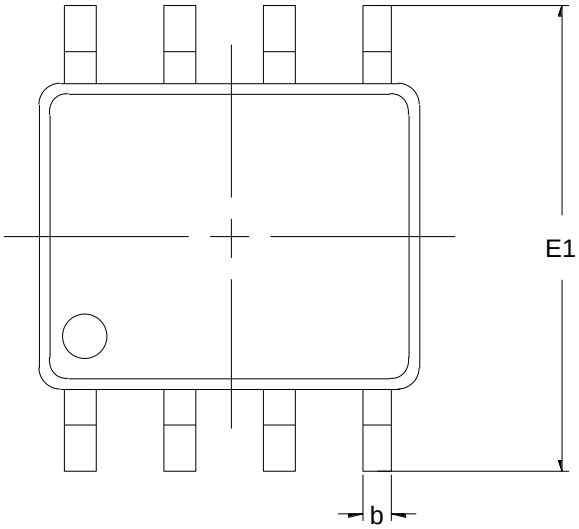
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
e	0.65（BSC）		0.026(BSC)	
e1	0.975（BSC）		0.038(BSC)	
L	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°

Package Outline Dimensions

SOP-8



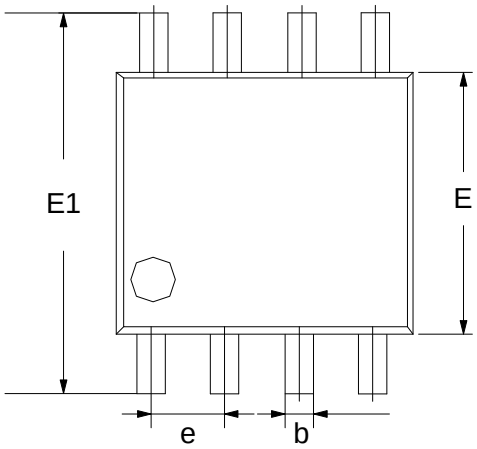


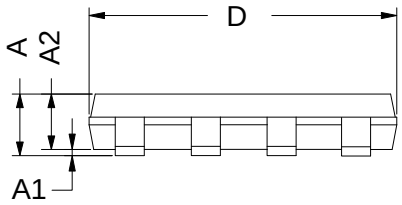


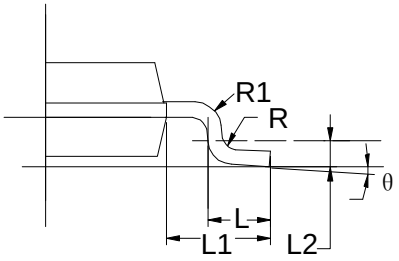
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
C	0.190	0.250	0.007	0.010
D	4.780	5.000	0.188	0.197
E	3.800	4.000	0.150	0.157
E1	5.800	6.300	0.228	0.248
e	1.270 TYP		0.050 TYP	
L1	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°

Package Outline Dimensions

MSOP-8



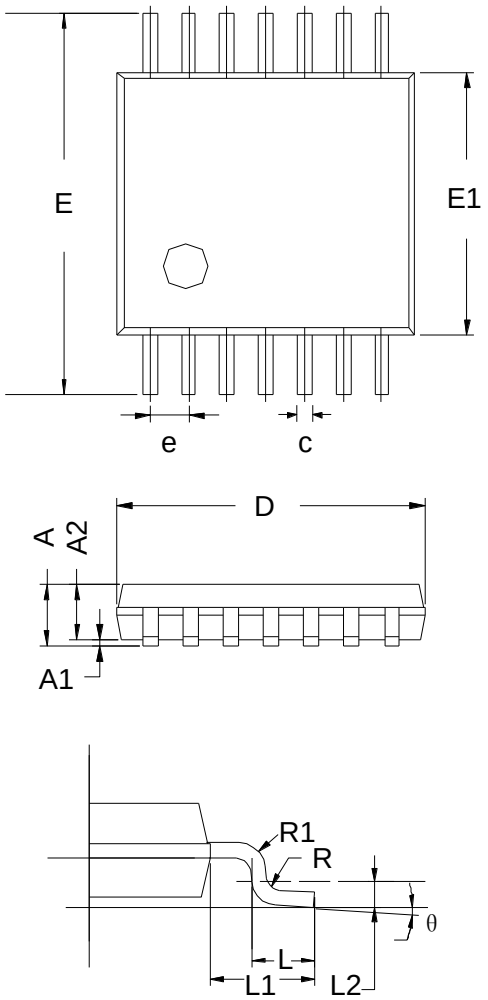




Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0.800	1.200	0.031	0.047
A1	0.000	0.200	0.000	0.008
A2	0.760	0.970	0.030	0.038
b	0.30 TYP		0.012 TYP	
C	0.15 TYP		0.006 TYP	
D	2.900	3.100	0.114	0.122
e	0.65 TYP		0.026	
E	2.900	3.100	0.114	0.122
E1	4.700	5.100	0.185	0.201
L1	0.410	0.650	0.016	0.026
θ	0°	6°	0°	6°

Package Outline Dimensions

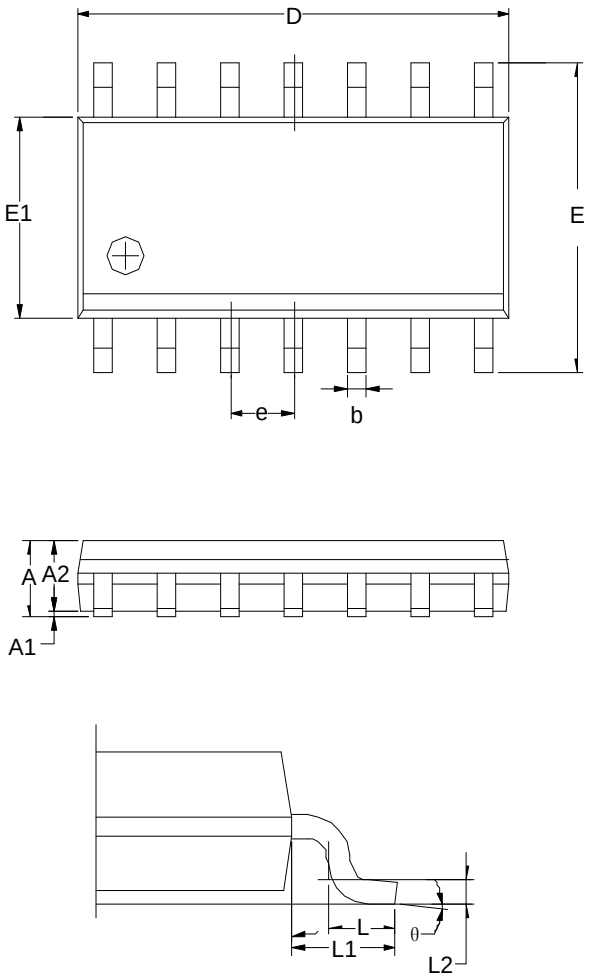
TSSOP-14



Symbol	Dimensions In Millimeters		
	MIN	TYP	MAX
A	-	-	1.20
A1	0.05	-	0.15
A2	0.90	1.00	1.05
b	0.20	-	0.28
c	0.10	-	0.19
D	4.86	4.96	5.06
E	6.20	6.40	6.60
E1	4.30	4.40	4.50
e	0.65 BSC		
L	0.45	0.60	0.75
L1	1.00 REF		
L2	0.25 BSC		
R	0.09	-	-
θ	0°	-	8°

Package Outline Dimensions

SOP-14



Symbol	Dimensions In Millimeters		
	MIN	TYP	MAX
A	1.35	1.60	1.75
A1	0.10	0.15	0.25
A2	1.25	1.45	1.65
b	0.36		0.49
D	8.53	8.63	8.73
E	5.80	6.00	6.20
E1	3.80	3.90	4.00
e	1.27 BSC		
L	0.45	0.60	0.80
L1	1.04 REF		
L2	0.25 BSC		
θ	0°		8°

Revision History

2018/8/20	Rev B	Update Full Temperature Specification
2018/12/25	Rev B01	Correct Mark of TPH2501L1-TR: “501”->“50L”. Add Power On Requirement in Application Information.
2019/11/14	Rev B02	Correct the typo error in Input Bias Current Vs. Temperature: Unit “pA” -> “nA”; Add input logic voltage of shut down.
2019/12/16	Rev B03	Correct the typo error in TPH2503 pin configuration on page1.
2022/4/29	Rev B.4	Update order information