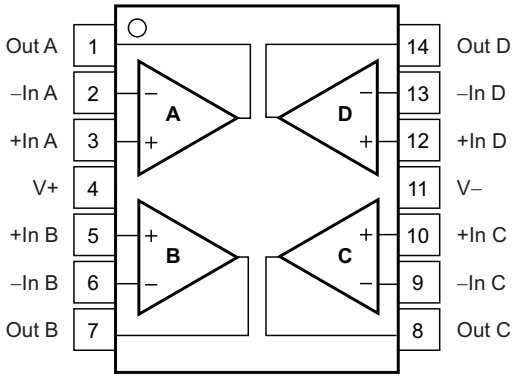
TLV3544-Q1 250MHz，轨至轨输入输出，用于汽车的CMOS 运算放大器

1 特性

- 符合汽车应用 要求
- 具有符合 AEC-Q100 标准的下列结果：
  - 器件温度等级 1：环境工作温度范围 T_A 为 –40°C 至 +125°C
  - 器件 HBM ESD 分类等级 1C
  - 器件 CDM ESD 分类等级 C3
- 单位增益带宽：250MHz
- 高带宽：100MHz GBW
- 高压摆率：150V/µs
- 低噪声：7.5nV/√Hz
- 轨至轨 I/O
- 高输出电流：> 100mA
- 出色的视频性能：
  - 差分增益：0.02%，差分相位：0.09°
  - 0.1dB 增益平坦度：40MHz
- 低输入偏置电流：3pA
- 静态电流：5.2mA
- 热关断
- 电源范围：2.5V 至 5.5V

简化图



2 应用

- 电流感应放大器
- 逆变器和电机控制
- 发动机管理
- 电池管理
- 导航和雷达系统
- 浓度传感器
- 盲点监测系统
- 短程到中程雷达
- 环视和倒车摄像头视频处理
- 用于送电传感器系统的汽车 SAR ADC 驱动器

3 说明

TLV3544-Q1 系列高速电压反馈 CMOS 运算放大器专为视频应用和其他需要宽带宽的 应用 而设计。这些器件单位增益稳定，可以输出大电流。差分增益为 0.02%，而差分相位为 0.09°。静态电流仅为每通道 4.9mA。

TLV3544-Q1 四通道运算放大器针对低至 2.5V (±1.25V) 和高达 5.5V (±2.75V) 的单电源或双电源供电运行进行了优化。共模输入范围超出电源供电范围。电源轨的输出摆幅在 100mV 以内，从而支持宽动态范围。

多通道版本具有完全独立的电路，可将串扰降到最低并彻底消除相互干扰。所有器件的额定扩展工作温度范围为 –40°C 至 +125°C。

器件信息(1)

器件型号	封装	封装尺寸（标称值）
TLV3544-Q1	薄型小外形尺寸封装 (TSSOP) (14)	5.00mm x 4.40mm

(1) 如需了解所有可用封装，请参阅数据表末尾的可订购产品附录。

目录

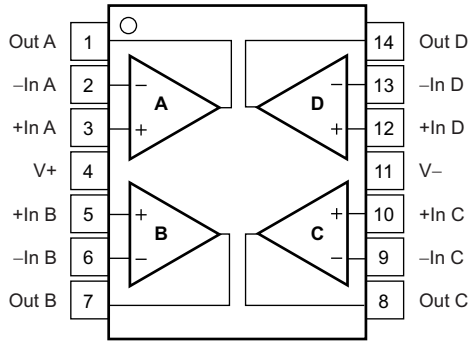
4 修订历史记录

注：之前版本的页码可能与当前版本有所不同。

日期	修订版本	说明
2017 年 10 月	*	初始发行版。

5 Pin Configuration and Functions

PW Package
14-Pin TSSOP
Top View



Pin Functions

PIN		I/O	DESCRIPTION
NAME	NO.		
–In A	2	I	Inverting input, channel A
+In A	3	I	Noninverting input, channel A
–In B	6	I	Inverting input, channel B
+In B	5	I	Noninverting input, channel B
–In C	9	I	Inverting input, channel C
+In C	10	I	Noninverting input, channel C
–In D	13	I	Inverting input, channel D
+In D	12	I	Noninverting input, channel D
Out A	1	O	Output, channel A
Out B	7	O	Output, channel B
Out C	8	O	Output, channel C
Out D	14	O	Output, channel D
V–	11	—	Negative (lowest) supply
V+	4	—	Positive (highest) supply

6 Specifications

6.1 Absolute Maximum Ratings

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

		MIN	MAX	UNIT
Voltage	Supply voltage, V+ to V−		7.5	V
	Signal input terminals(2)	(V−) − (0.5)	(V+) + 0.5	
Current	Signal input terminals(2)	–10	10	mA
	Output short circuit(3)	Continuous		
Temperature	Operating, T_A	–55	150	°C
	Junction, T_J		150	
	Storage, T_{stg}	–65	150	

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
(2) Input pins are diode-clamped to the power-supply rails. Input signals that can swing more than 0.5 V beyond the supply rails must be current limited to 10 mA or less.
(3) Short-circuit to ground, one amplifier per package.

6.2 ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human-body model (HBM), per AEC Q100-002(1)	±1000	V
		Charged-device model (CDM), per AEC Q100-011	±250	

(1) AEC Q100-002 indicates that HBM stressing shall be in accordance with the ANSI/ESDA/JEDEC JS-001 specification.

6.3 Recommended Operating Conditions

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

		MIN	MAX	UNIT
V_S	Supply voltage, V– to V+	2.5	5.5	V
	Specified temperature	–40	125	°C

6.4 Thermal Information: TLV3544-Q1

THERMAL METRIC		TLV3544-Q1 PW (TSSOP) 14 PINS	UNIT
$R_{\theta JA}$	Junction-to-ambient thermal resistance	92.6	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	27.5	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	33.6	°C/W
ψ_{JT}	Junction-to-top characterization parameter	1.9	°C/W
ψ_{JB}	Junction-to-board characterization parameter	33.1	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	—	°C/W

6.5 Electrical Characteristics: V_S = 2.7 V to 5.5 V Single-Supply

At T_A = 25°C, R_F = 0 Ω, R_L = 1 kΩ, and connected to V_S/2, unless otherwise noted.

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
OFFSET VOLTAGE						
V_{OS}	Input offset voltage	V_S = 5 V, at T_A = 25°C		±2	±10	mV
dV_{OS}/dT	Input offset voltage vs temperature	V_S = 5 V, at T_A = −40°C to +125°C		±4.5		µV/°C
PSRR	Input offset voltage vs power supply	V_S = 2.7 V to 5.5 V, V_{CM} = (V_S/2) − 0.55 V		±200	±800	µV/V
		V_S = 2.7 V to 5.5 V, V_{CM} = (V_S/2) − 0.55 V, at T_A = −40°C to +125°C			±900	
INPUT BIAS CURRENT						
I_B	Input bias current			3		pA
I_{OS}	Input offset current			±1		pA
NOISE						
e_n	Input voltage noise density	f = 1 MHz		7.5		nV/√Hz
i_n	Current noise density	f = 1 MHz		50		fA/√Hz
INPUT VOLTAGE RANGE						
V_{CM}	Common-mode voltage		(V−) − 0.1		(V+) + 0.1	V
CMRR	Common-mode rejection ratio	V_S = 5.5 V, –0.1 V < V_{CM} < 3.5 V, at T_A = 25°C	66	80		dB
		V_S = 5.5 V, –0.1 V < V_{CM} < 5.6 V, at T_A = 25°C	56	68		
INPUT IMPEDANCE						
	Differential			10^{13} || 2		Ω || pF
	Common-mode			10^{13} || 2		Ω || pF
OPEN-LOOP GAIN						
A_{OL}	Open-loop gain	V_S = 5.5 V, 0.3 V < V_O < 4.7 V, at T_A = 25°C	94	110		dB
		V_S = 5 V, 0.4 V < V_O < 4.6 V, at T_A = –40°C to +125°C	90			
FREQUENCY RESPONSE						
$f_{–3dB}$	Small-signal bandwidth	At G = +1, V_O = 100 mV_{PP}, R_F = 25 Ω		250		MHz
		At G = +2, V_O = 100 mV_{PP}		90		
GBW	Gain-bandwidth product	G = +10		100		MHz
$f_{0.1dB}$	Bandwidth for 0.1-dB gain flatness	At G = +2, V_O = 100 mV_{PP}		40		MHz
SR	Slew rate	V_S = 5 V, G = +1, 4-V step		150		V/µs
		V_S = 5 V, G = +1, 2-V step		130		
		V_S = 3 V, G = +1, 2-V step		110		
	Rise-and-fall time	At G = +1, V_O = 200 mV_{PP}, 10% to 90%		2		ns
		At G = +1, V_O = 2 V_{PP}, 10% to 90%		11		
	Settling time	0.1%, V_S = 5 V, G = +1, 2-V output step		30		ns
		0.01%, V_S = 5 V, G = +1, 2-V output step		60		
	Overload recovery time	V_{IN} × Gain = V_S		5		ns

Electrical Characteristics: V_S = 2.7 V to 5.5 V Single-Supply (continued)

At T_A = 25°C, R_F = 0 Ω, R_L = 1 kΩ, and connected to V_S/2, unless otherwise noted.

PARAMETER			TEST CONDITIONS	MIN	TYP	MAX	UNIT
FREQUENCY RESPONSE, continued							
	Harmonic distortion	Second harmonic	At G = +1, f = 1 MHz, V_O = 2 V_{PP}, R_L = 200 Ω, V_{CM} = 1.5 V		–75		dBc
		Third harmonic	At G = +1, f = 1 MHz, V_O = 2 V_{PP}, R_L = 200 Ω, V_{CM} = 1.5 V		–83		
	Differential gain error		NTSC, R_L = 150 Ω		0.02%		
	Differential phase error		NTSC, R_L = 150 Ω		0.09		°
	Channel-to-channel crosstalk	TLV3544-Q1	f = 5 MHz		–84		dB
OUTPUT							
	Voltage output swing from rail		V_S = 5 V, R_L = 1 kΩ, A_{OL} > 94 dB, at T_A = 25°C		0.1	0.3	V
I_O	Output current (1) (2)		V_S = 5 V	100			mA
			V_S = 3 V		50		mA
	Closed-loop output impedance		f < 100 kHz		0.05		Ω
R_O	Open-loop output resistance				35		Ω
POWER SUPPLY							
V_S	Specified voltage			2.7		5	V
	Operating voltage			2.5		5.5	
I_Q	Quiescent current (per amplifier)		At T_A = 25°C, V_S = 5 V, enabled, I_O = 0		5.2	6.5	mA
THERMAL SHUTDOWN – JUNCTION TEMPERATURE							
	Shutdown				160		°C
	Reset from shutdown				140		°C
THERMAL RANGE							
	Specified			–40		125	°C
	Operating			–55		150	°C
	Storage			–65		150	°C

(1) See typical characteristic curves, *Output Voltage Swing vs Output Current* (图 20 and 图 22).
(2) Specified by design.

6.6 Typical Characteristics

At T_A = 25°C, V_S = 5 V, G = +1, R_F = 0 Ω, R_L = 1 kΩ, and connected to V_S/2, unless otherwise noted.

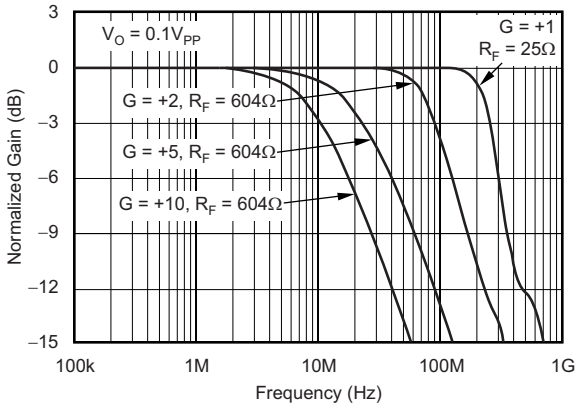


图 1. Noninverting Small-Signal Frequency Response

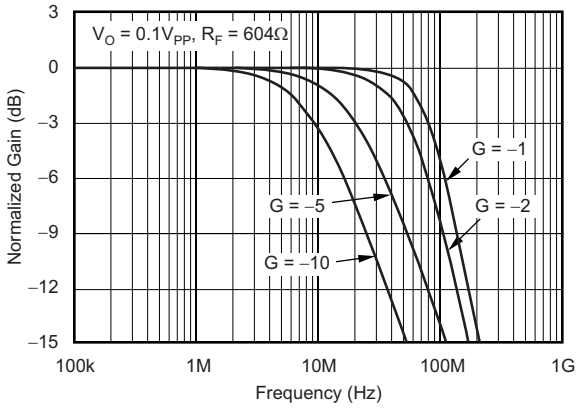


图 2. Inverting Small-Signal Frequency Response

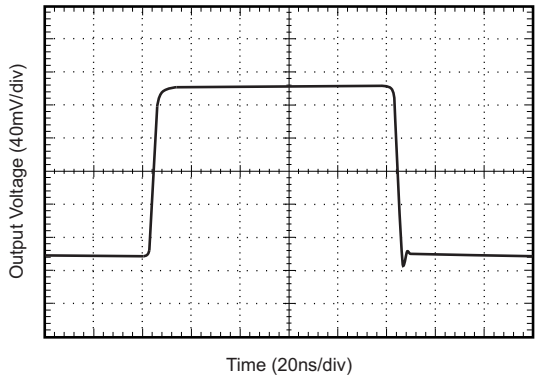


图 3. Noninverting Small-Signal Step Response

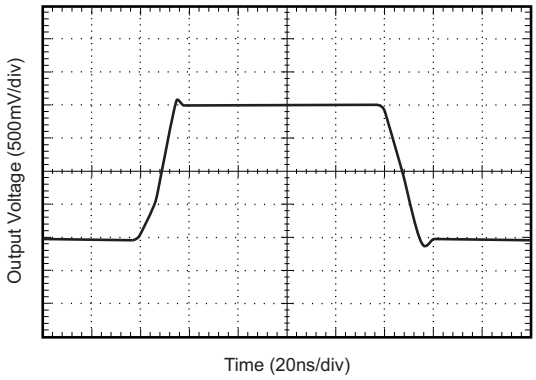


图 4. Noninverting Large-Signal Step Response

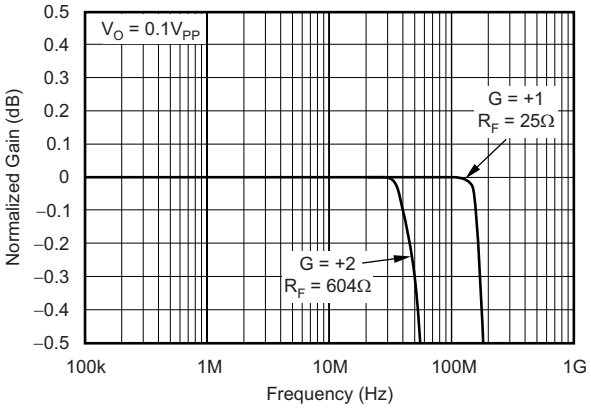


图 5. 0.1-dB Gain Flatness

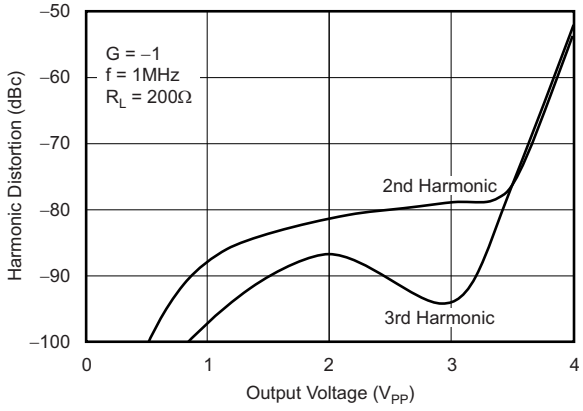


图 6. Harmonic Distortion vs Output Voltage

Typical Characteristics (接下页)

At T_A = 25°C, V_S = 5 V, G = +1, R_F = 0 Ω, R_L = 1 kΩ, and connected to V_S/2, unless otherwise noted.

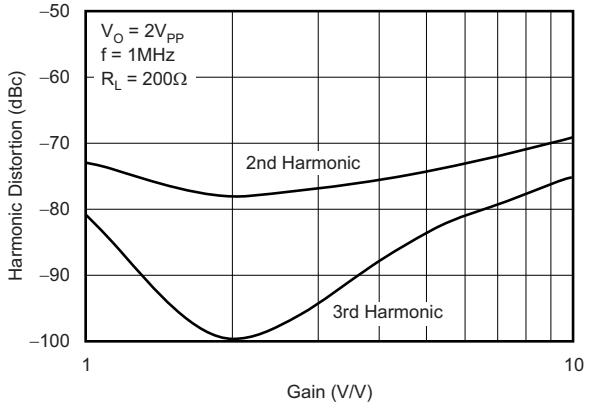


图 7. Harmonic Distortion vs Noninverting Gain

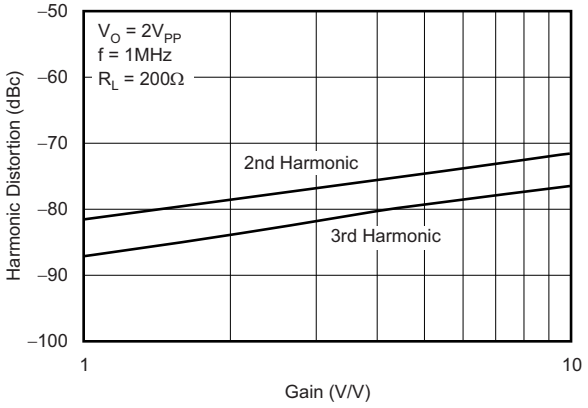


图 8. Harmonic Distortion vs Inverting Gain

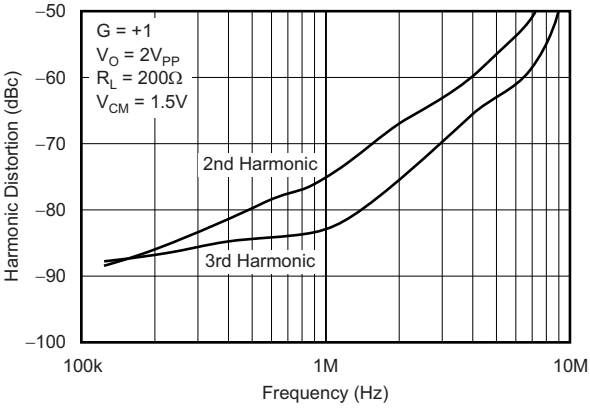


图 9. Harmonic Distortion vs Frequency

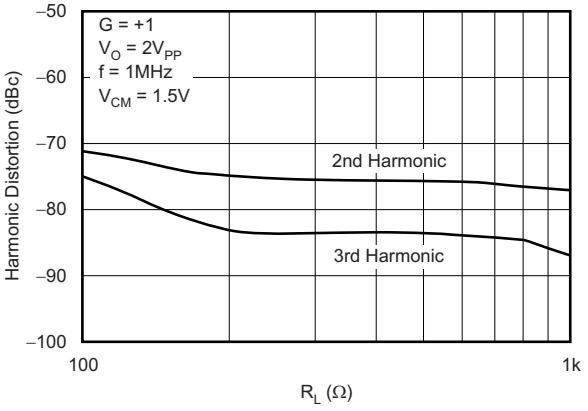


图 10. Harmonic Distortion vs Load Resistance

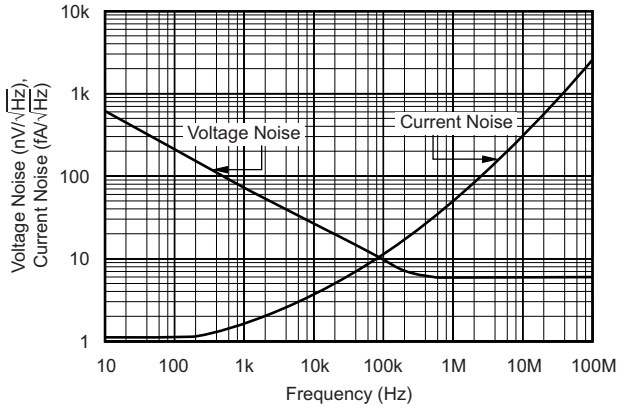


图 11. Input Voltage and Current Noise Spectral Density vs Frequency

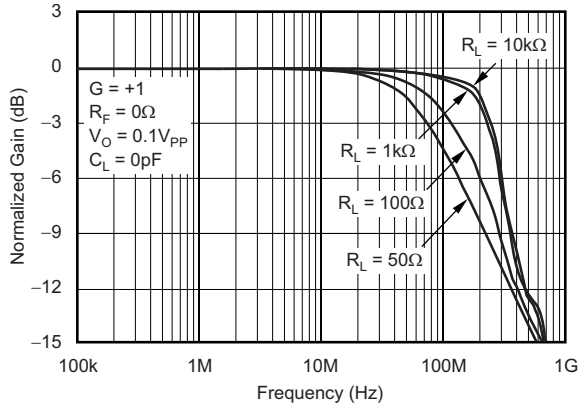


图 12. Frequency Response for Various R_L

Typical Characteristics (接下页)

At T_A = 25°C, V_S = 5 V, G = +1, R_F = 0 Ω, R_L = 1 kΩ, and connected to V_S/2, unless otherwise noted.

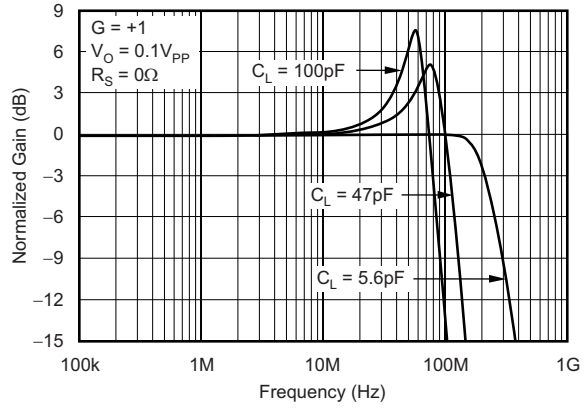


图 13. Frequency Response for Various C_L

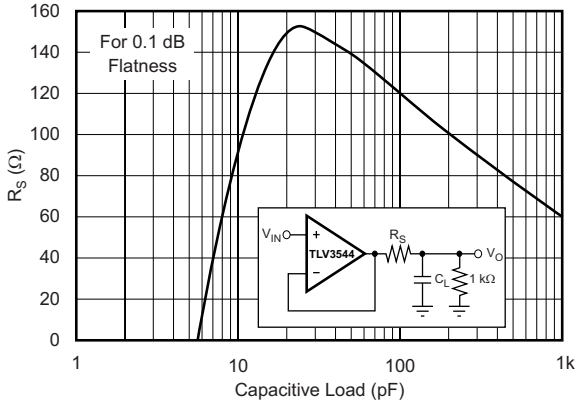


图 14. Recommended R_S vs Capacitive Load

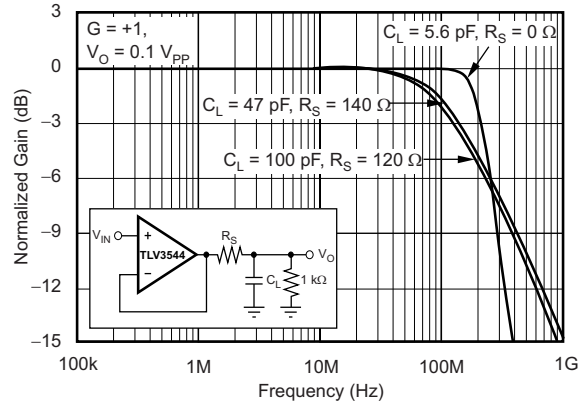


图 15. Frequency Response vs Capacitive Load

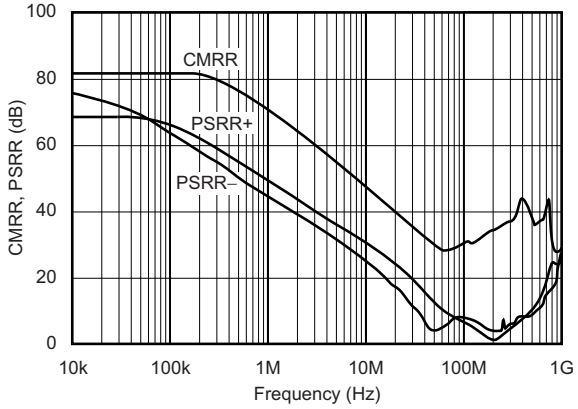


图 16. Common-Mode Rejection Ratio and Power-Supply Rejection Ratio vs Frequency

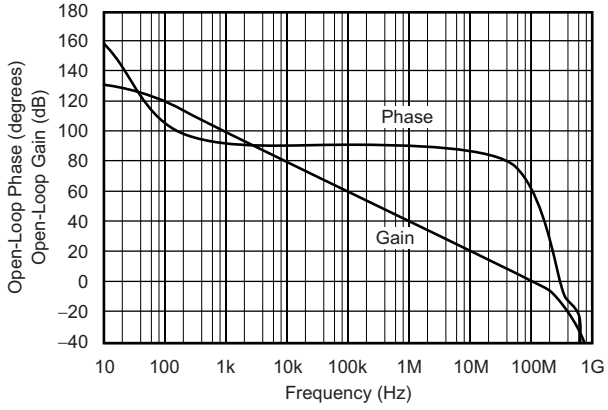


图 17. Open-Loop Gain and Phase

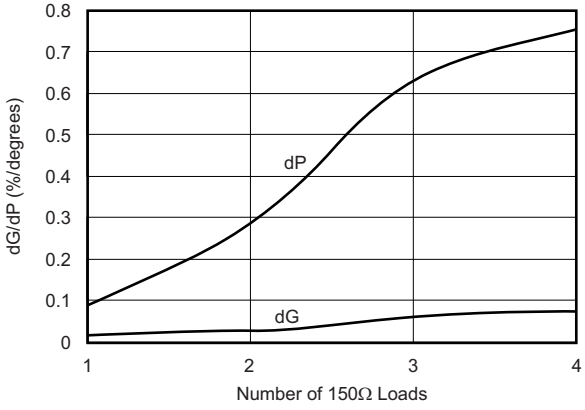


图 18. Composite Video Differential Gain and Phase

Typical Characteristics (接下页)

At T_A = 25°C, V_S = 5 V, G = +1, R_F = 0 Ω, R_L = 1 kΩ, and connected to V_S/2, unless otherwise noted.

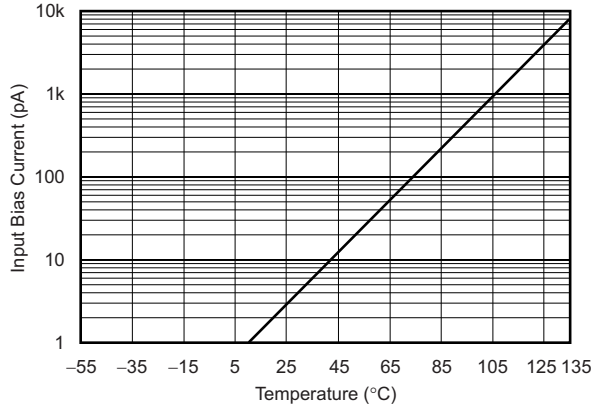


图 19. Input Bias Current vs Temperature

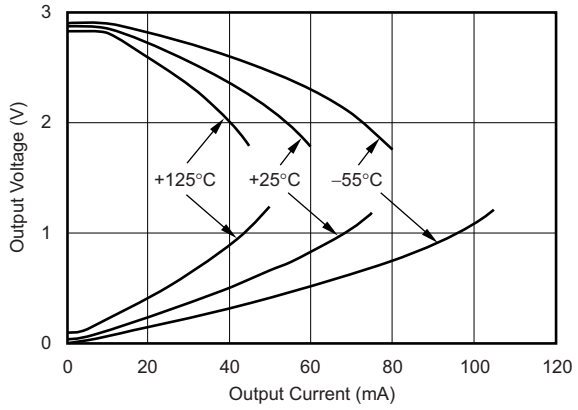


图 20. Output Voltage Swing vs Output Current for V_S = 3 V

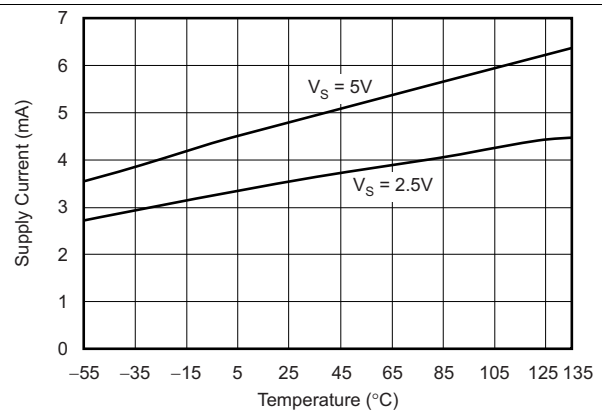


图 21. Supply Current vs Temperature

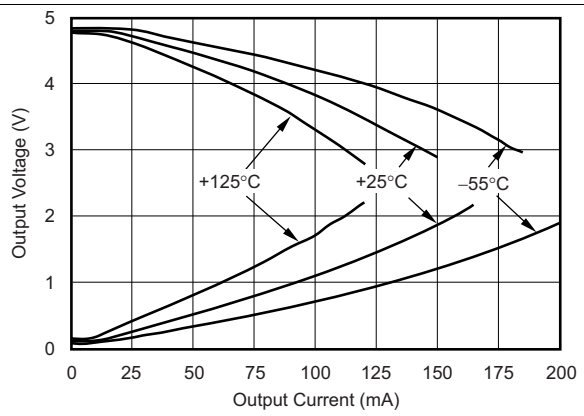


图 22. Output Voltage Swing vs Output Current for V_S = 5 V

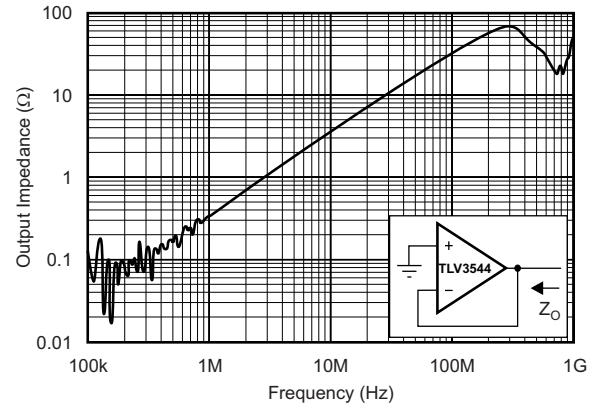


图 23. Closed-Loop Output Impedance vs Frequency

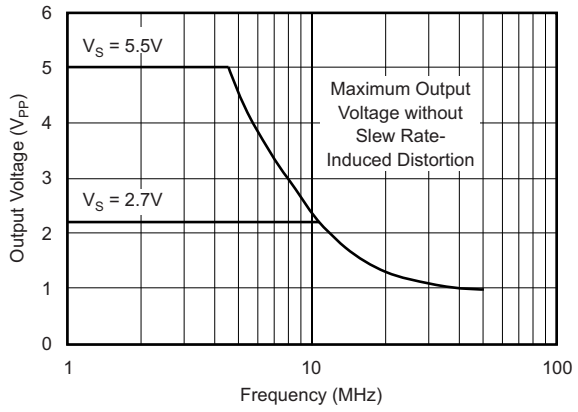


图 24. Maximum Output Voltage vs Frequency

Typical Characteristics (接下页)

At T_A = 25°C, V_S = 5 V, G = +1, R_F = 0 Ω, R_L = 1 kΩ, and connected to V_S/2, unless otherwise noted.

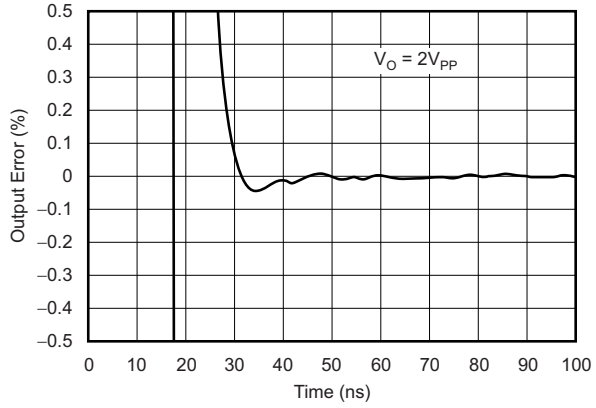


图 25. Output Settling Time to 0.1%

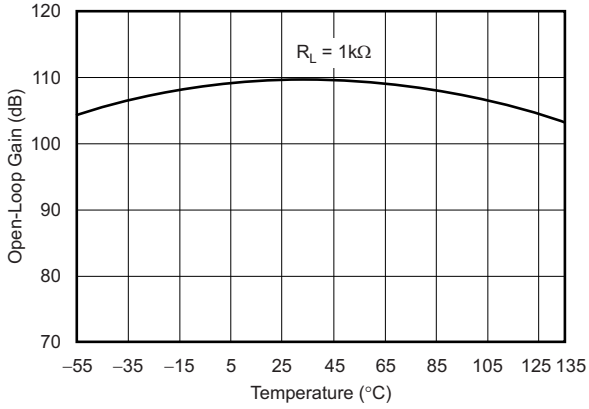


图 26. Open-Loop Gain vs Temperature

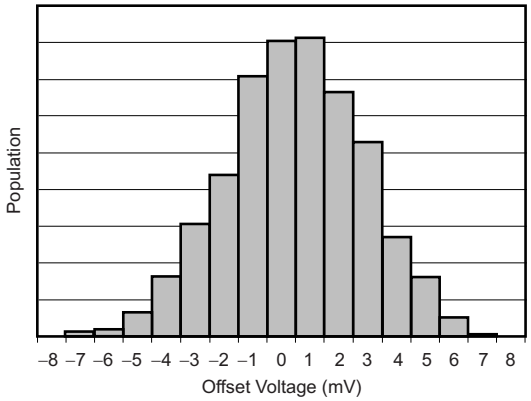


图 27. Offset Voltage Production Distribution

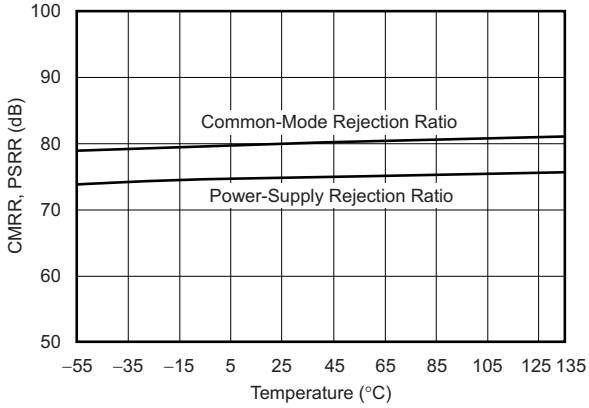


图 28. Common-Mode Rejection Ratio and Power-Supply Rejection Ratio vs Temperature

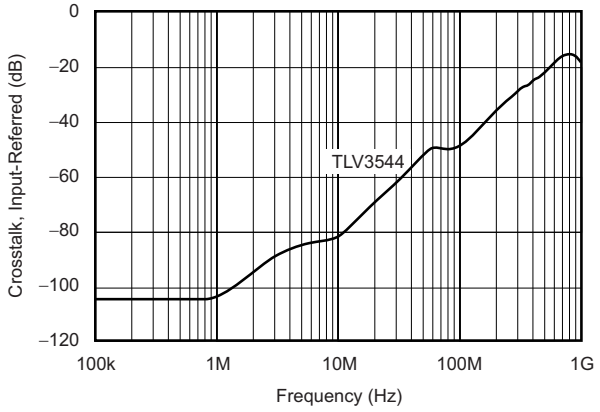


图 29. Channel-to-Channel Crosstalk

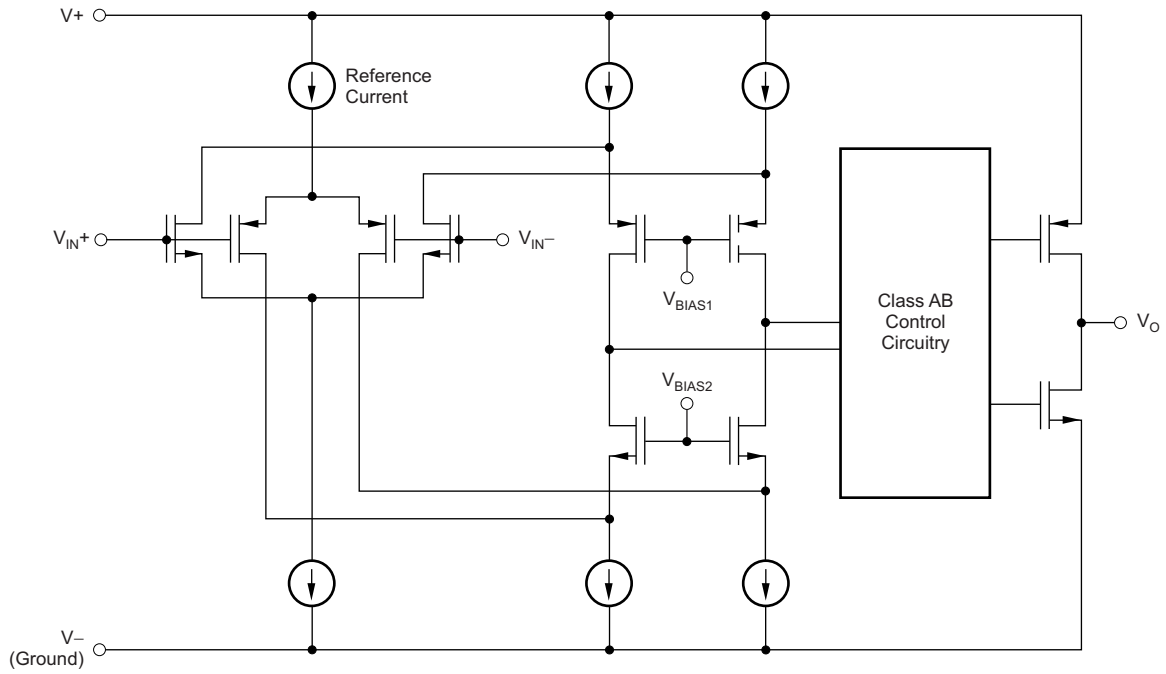
7 Detailed Description

7.1 Overview

The TLV3544-Q1 is a quad-channel CMOS, rail-to-rail I/O, high-speed, voltage-feedback operational amplifier designed for video, high-speed, and other applications.

The amplifier features a 100-MHz gain bandwidth and 150-V/µs slew rate, but it is unity-gain stable and can be operated as a +1-V/V voltage follower.

7.2 Functional Block Diagram



7.3 Feature Description

7.3.1 TLV3544-Q1 Comparison

表 1 lists several members of the device family that includes the TLV3544-Q1.

表 1. Device Family Comparison

FEATURES	PRODUCT
Shutdown Version of TLV3544 Family	OPAx357
200-MHz GBW, Rail-to-Rail Output, CMOS, Shutdown	OPAx355
200-MHz GBW, Rail-to-Rail Output, CMOS	OPAx356
38-MHz GBW, Rail-to-Rail Input/Output, CMOS	OPAx350/OPAx353
75-MHz BW G = 2, Rail-to-Rail Output	OPA2631
150-MHz BW G = 2, Rail-to-Rail Output	OPA2634
100-MHz BW, Differential Input/Output, 3.3-V Supply	THS412x

7.3.2 Operating Voltage

The TLV3544-Q1 is specified over a power-supply range of 2.7 V to 5.5 V (±1.35 V to ±2.75 V). However, the supply voltage may range from 2.5 V to 5.5 V (±1.25 V to ±2.75 V).

CAUTION

Supply voltages higher than 7.5 V (absolute maximum) can permanently damage the amplifier.

Parameters that vary over supply voltage or temperature are shown in *Typical Characteristics* of this data sheet.

7.3.3 Rail-to-Rail Input

The specified input common-mode voltage range of the TLV3544-Q1 extends 100 mV beyond the supply rails. This extended range is achieved with a complementary input stage—an N-channel input differential pair in parallel with a P-channel differential pair, as shown in the *Functional Block Diagram*. The N-channel pair is active for input voltages close to the positive rail, typically (V+) − 1.2 V to 100 mV above the positive supply, while the P-channel pair is on for inputs from 100 mV below the negative supply to approximately (V+) − 1.2 V. There is a small transition region, typically (V+) − 1.5 V to (V+) − 0.9 V, in which both pairs are on. This 600-mV transition region can vary ±500 mV with process variation. Thus, the transition region (both input stages on) can range from (V+) − 2 V to (V+) − 1.5 V on the low end, up to (V+) − 0.9 V to (V+) − 0.4 V on the high end.

A double-folded cascode adds the signal from the two input pairs and presents a differential signal to the class AB output stage.

7.3.4 Rail-to-Rail Output

A class AB output stage with common-source transistors is used to achieve rail-to-rail output. For high-impedance loads (> 200 Ω), the output voltage swing is typically 100 mV from the supply rails. With 10-Ω loads, a useful output swing can be achieved while maintaining high open-loop gain. See the typical characteristic curves, *Output Voltage Swing vs Output Current* (图 20 and 图 22).

7.3.5 Output Drive

The TLV3544-Q1 output stage can supply a continuous output current of ±100 mA and yet provide approximately 2.7 V of output swing on a 5-V supply, as shown in 图 30. For maximum reliability, TI does not recommend running a continuous DC current in excess of ±100 mA. Refer to the typical characteristic curves, *Output Voltage Swing vs Output Current* (图 20 and 图 22). For supplying continuous output currents greater than ±100 mA, the TLV3544-Q1 may be operated in parallel, as shown in 图 31.

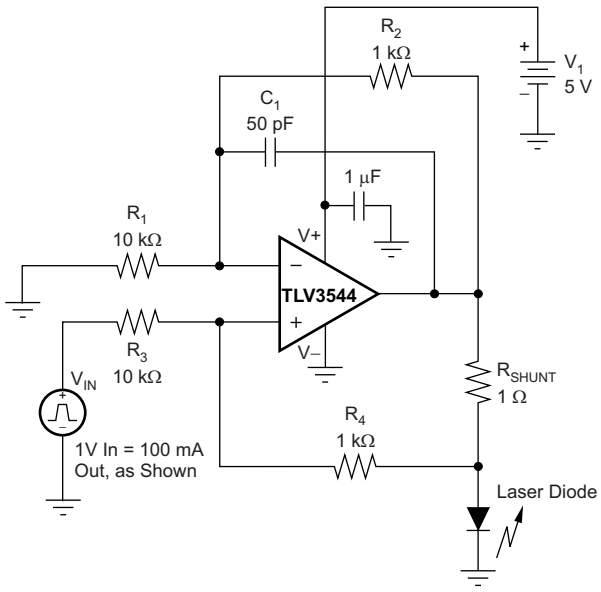


图 30. Laser Diode Driver

The TLV3544-Q1 provides peak currents up to 200 mA, which corresponds to the typical short-circuit current. Therefore, an on-chip thermal shutdown circuit is provided to protect the TLV3544-Q1 from dangerously high junction temperatures. At 160°C, the protection circuit shuts down the amplifier. Normal operation resumes when the junction temperature cools to below 140°C.

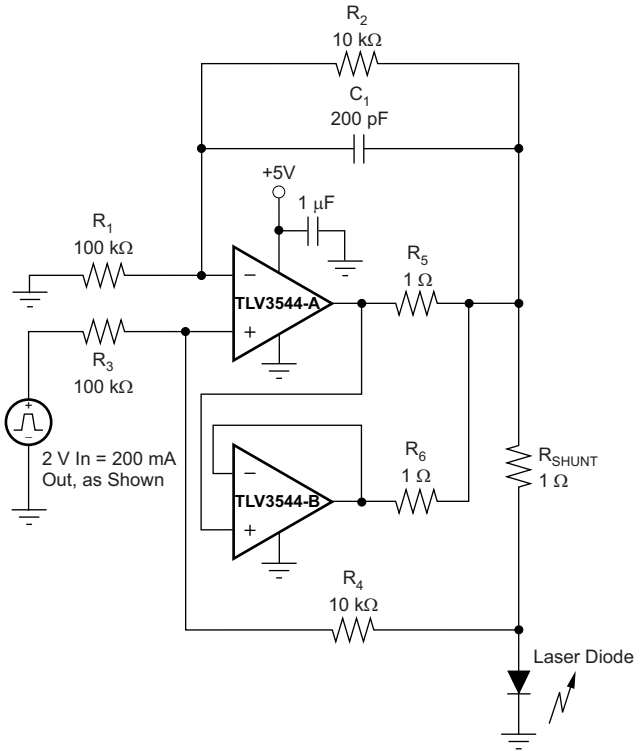


图 31. Parallel Operation

7.3.6 Video

The TLV3544-Q1 output stage is capable of driving standard back-terminated 75-Ω video cables, as shown in 图 32. By back-terminating a transmission line, it does not exhibit a capacitive load to its driver. A properly back-terminated 75-Ω cable does not appear as capacitance; it presents only a 150-Ω resistive load to the TLV3544-Q1 output.

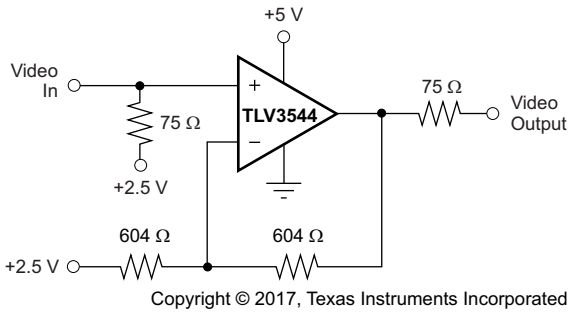
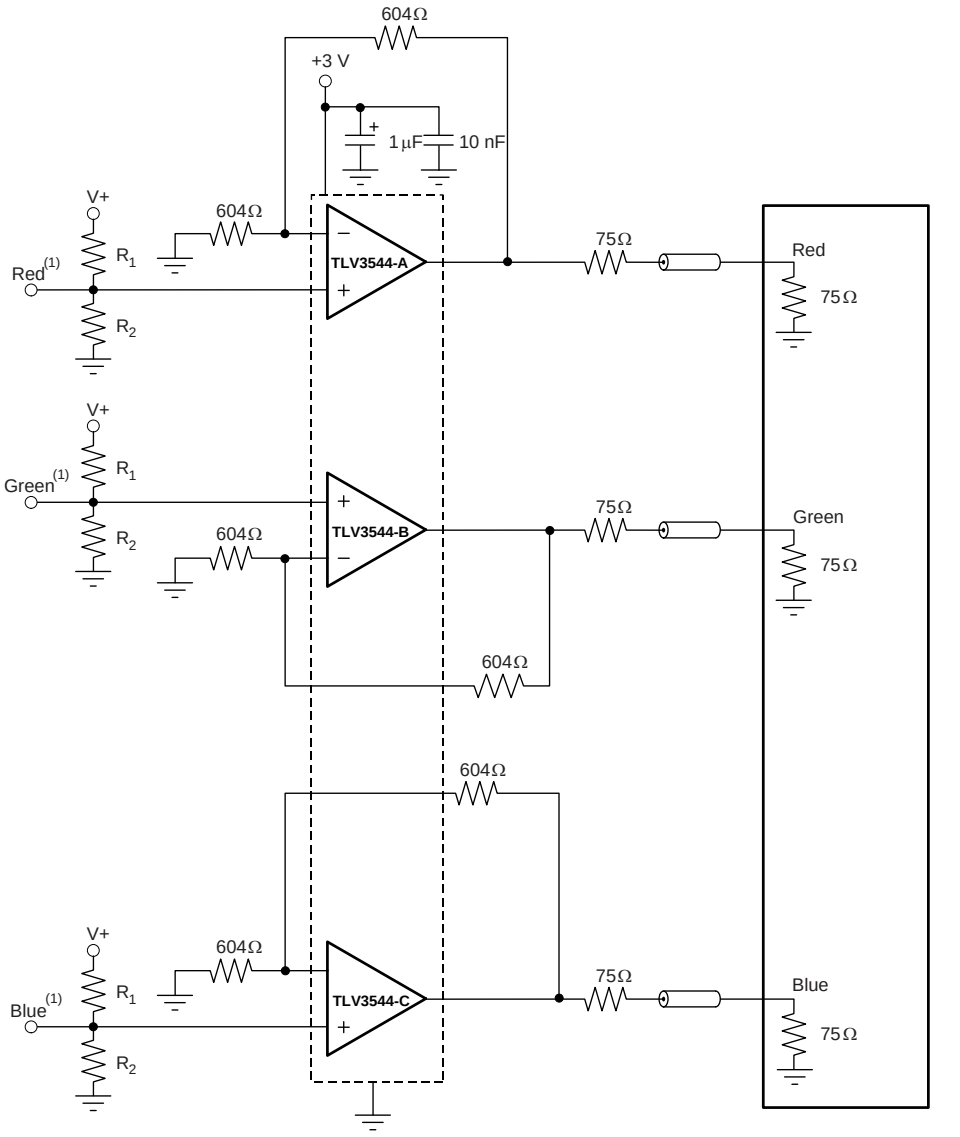


图 32. Single-Supply Video Line Driver

The TLV3544-Q1 can be used as an amplifier for RGB graphic signals, which have a voltage of zero at the video black level, by offsetting and AC-coupling the signal. See 图 33.



(1) Source video signal offset 300 mV above ground to accommodate op amp swing−to−ground capability.

图 33. RGB Cable Driver

7.3.7 Driving Analog-to-Digital converters

The TLV3544-Q1 series op amps offer 60 ns of settling time to 0.01%, making them a good choice for driving high- and medium-speed sampling A/D converters and reference circuits. The TLV3544-Q1 provides an effective means of buffering the A/D converter input capacitance and resulting charge injection while providing signal gain. For applications requiring high DC accuracy, the OPA350 series is recommended.

图 34 illustrates the TLV3544-Q1 driving an A/D converter. With the TLV3544-Q1 in an inverting configuration, a capacitor across the feedback resistor can be used to filter high-frequency noise in the signal.

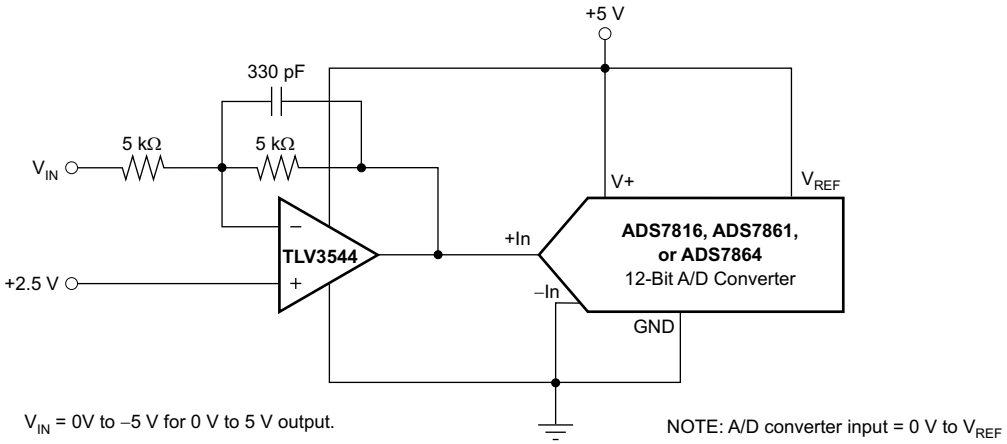


图 34. The TLV3544-Q1 in Inverting Configuration Driving the ADS7816

7.3.8 Capacitive Load and Stability

The TLV3544-Q1 series op amps can drive a wide range of capacitive loads. However, all op amps under certain conditions may become unstable. Op amp configuration, gain, and load value are just a few of the factors to consider when determining stability. An op amp in unity-gain configuration is most susceptible to the effects of capacitive loading. The capacitive load reacts with the device output resistance, along with any additional load resistance, to create a pole in the small-signal response that degrades the phase margin. Refer to the typical characteristic curve, *Frequency Response for Various C_L* (图 13) for details.

The TLV3544-Q1 topology enhances its ability to drive capacitive loads. In unity gain, these op amps perform well with large capacitive loads. Refer to the typical characteristic curves, *Recommended R_S vs Capacitive Load* (图 14) and *Frequency Response vs Capacitive Load* (图 15) for details.

One method of improving capacitive load drive in the unity-gain configuration is to insert a 10-Ω to 20-Ω resistor in series with the output, as shown in 图 35. This configuration significantly reduces ringing with large capacitive loads—see the typical characteristic curve, *Frequency Response vs Capacitive Load* (图 15). However, if there is a resistive load in parallel with the capacitive load, R_S creates a voltage divider. This voltage division introduces a DC error at the output and slightly reduces output swing. This error may be insignificant. For instance, with R_L = 10 kΩ and R_S = 20 Ω, there is approximately a 0.2% error at the output.

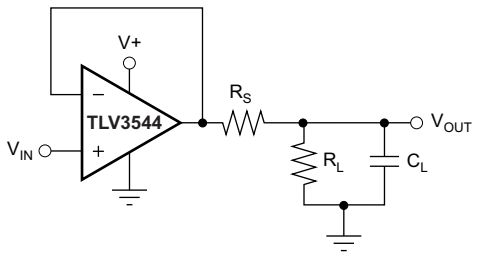


图 35. Series Resistor in Unity-Gain Configuration Improves Capacitive Load Drive

7.3.9 Wideband Transimpedance Amplifier

Wide bandwidth, low input bias current, low input voltage, and current noise make the TLV3544-Q1 an ideal wideband photodiode transimpedance amplifier for low-voltage single-supply applications. Low-voltage noise is important because photodiode capacitance causes the effective noise gain of the circuit to increase at high frequency.

The key elements to a transimpedance design, as shown in 图 36, are the expected diode capacitance [including the parasitic input common-mode and differential-mode input capacitance (2 + 2) pF for the TLV3544-Q1], the desired transimpedance gain (R_F), and the Gain-Bandwidth Product (GBW) for the TLV3544-Q1 (100 MHz typical). With these three variables set, the feedback capacitor value (C_F) may be set to control the frequency response.

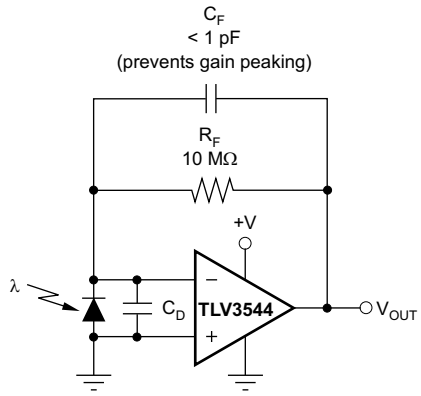


图 36. Transimpedance Amplifier

To achieve a maximally flat, second-order, Butterworth frequency response, the feedback pole must be set as shown in 公式 1:

$$\frac{1}{2\pi R_F C_F} = \sqrt{\frac{GBP}{4\pi R_F C_D}} \quad (1)$$

Typical surface-mount resistors have a parasitic capacitance of approximately 0.2 pF that must be deducted from the calculated feedback capacitance value. Bandwidth is calculated by 公式 2:

$$f_{-3dB} = \sqrt{\frac{GBP}{2\pi R_F C_D}} \text{ Hz} \quad (2)$$

For even higher transimpedance bandwidth, the high-speed CMOS OPA355 (200-MHz GBW) or the OPA655 (400-MHz GBW) may be used.

7.4 Device Functional Modes

The TLV3544-Q1 is powered on when the supply is connected. The devices can be operated as single-supply operational amplifiers or dual-supply amplifiers depending on the application. The devices can also be used with asymmetrical supplies as long as the differential voltage (V– to V+) is at least 1.8 V and no greater than 5.5 V (example: V– set to –3.5 V and V+ set to 1.5 V).

8 Application and Implementation

注

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

8.1 Application Information

The TLV3544-Q1 is a CMOS, rail-to-rail I/O, high-speed, voltage-feedback operational amplifier designed for video, high-speed, and other applications. The amplifier features a 100-MHz gain bandwidth, and 150-V/µs slew rate, but it is unity-gain stable and can be operated as a 1-V/V voltage follower.

8.2 Typical Application

Wide gain bandwidth, low input bias current, low input voltage, and current noise make the TLV3544-Q1 an ideal wideband photodiode transimpedance amplifier. Low-voltage noise is important because photodiode capacitance causes the effective noise gain of the circuit to increase at high frequency. The key elements to a transimpedance design, as shown in 图 37, are the expected diode capacitance, which include the parasitic input common-mode and differential-mode input capacitance; the desired transimpedance gain; and the gain-bandwidth (GBW) for the TLV3544-Q1 (20 MHz). With these three variables set, the feedback capacitor value can be set to control the frequency response. Feedback capacitance includes the stray capacitance of, which is 0.2 pF for a typical surface-mount resistor.

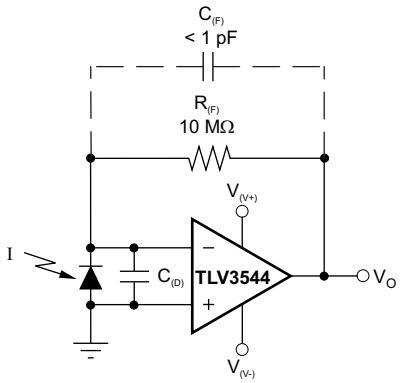


图 37. Dual-Supply Transimpedance Amplifier

8.2.1 Design Requirements

For this design example, use the parameters listed in 表 2 as the input parameters.

表 2. Design Parameters

PARAMETER	EXAMPLE VALUE
Supply voltage, $V_{(V+)}$	2.5 V
Supply voltage, $V_{(V-)}$	–2.5 V

$C_{(F)}$ is optional to prevent gain peaking. $C_{(F)}$ includes the stray capacitance of $R_{(F)}$.

8.2.2 Detailed Design Procedure

To achieve a maximally-flat, second-order Butterworth frequency response, set the feedback pole using 公式 3.

$$\frac{1}{2 \times \pi \times R_{(F)} \times C_{(F)}} = \sqrt{\frac{GBW}{4 \times \pi \times R_{(F)} \times C_{(D)}}} \quad (3)$$

Calculate the bandwidth using 公式 4.

$$f_{(-3\ dB)} = \sqrt{\frac{GBW}{2 \times \pi \times R_{(F)} \times C_{(D)}}} \quad (4)$$

8.2.2.1 Optimizing the Transimpedance Circuit

To achieve the best performance, components must be selected according to the following guidelines:

1. For lowest noise, select $R_{(F)}$ to create the total required gain. Using a lower value for $R_{(F)}$ and adding gain after the transimpedance amplifier generally produces poorer noise performance. The noise produced by $R_{(F)}$ increases with the square-root of $R_{(F)}$, whereas the signal increases linearly. Therefore, signal-to-noise ratio improves when all the required gain is placed in the transimpedance stage.

2. Minimize photodiode capacitance and stray capacitance at the summing junction (inverting input). This capacitance causes the voltage noise of the op amp to be amplified (increasing amplification at high frequency). Using a low-noise voltage source to reverse-bias a photodiode can significantly reduce the capacitance. Smaller photodiodes have lower capacitance. Use optics to concentrate light on a small photodiode.

3. Noise increases with increased bandwidth. Limit the circuit bandwidth to only that required. Use a capacitor across the $R_{(F)}$ to limit bandwidth, even if not required for stability.

4. Circuit board leakage can degrade the performance of an otherwise well-designed amplifier. Clean the circuit board carefully. A circuit board guard trace that encircles the summing junction and is driven at the same voltage can help control leakage.

8.2.3 Application Curve

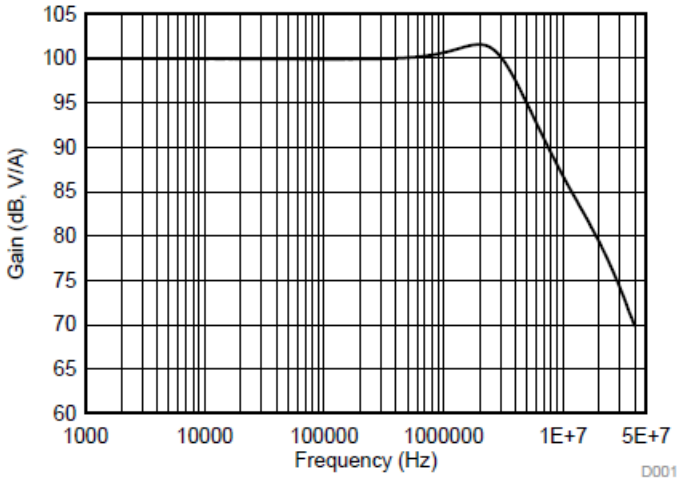


图 38. AC Transfer Function

9 Power Supply Recommendations

The TLV3544-Q1 is specified for operation from 2.5 V to 5.5 V (±1.25 to ±2.75 V); many specifications apply from –40°C to +125°C. Parameters that can exhibit significant variance with regard to operating voltage or temperature are shown *Typical Characteristics*.

Place 0.1-µF bypass capacitors close to the power-supply pins to reduce errors coupling in from noisy or high impedance power supplies. For more detailed information on bypass capacitor placement, see *Layout Guidelines*.

10 Layout

10.1 Layout Guidelines

Good high-frequency printed-circuit board (PCB) layout techniques must be employed for the TLV3544-Q1. Generous use of ground planes, short and direct signal traces, and a suitable bypass capacitor located at the V+ pin assure clean, stable operation. Large areas of copper also provides a means of dissipating heat that is generated in normal operation.

TI does not recommend using sockets with any high-speed amplifier.

A 10-nF ceramic bypass capacitor is the minimum recommended value; adding a 1-µF or larger tantalum capacitor in parallel can be beneficial when driving a low-resistance load. Providing adequate bypass capacitance is essential to achieving very low harmonic and intermodulation distortion.

10.2 Layout Example

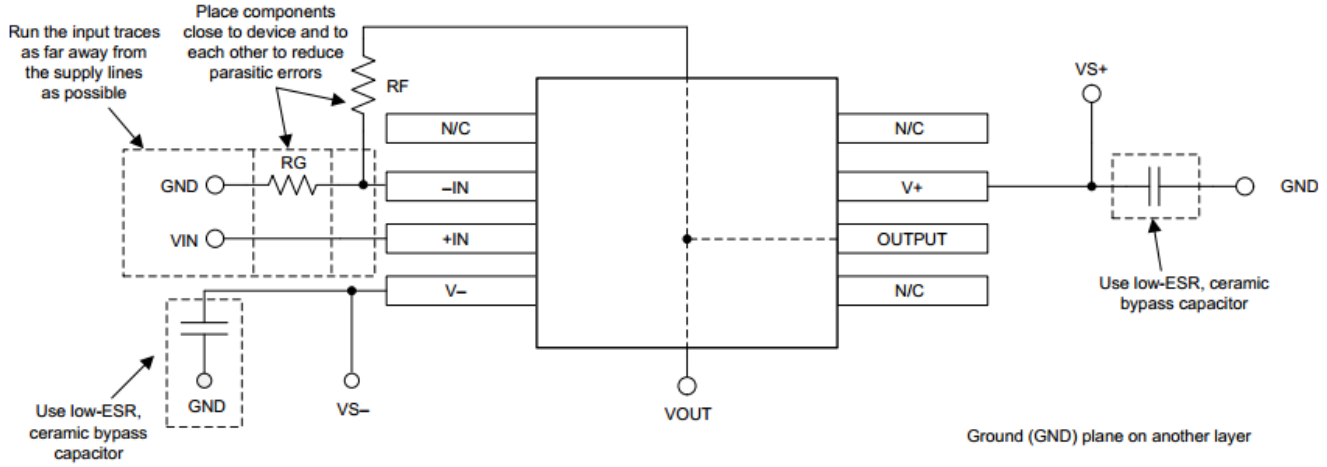


图 39. Operational Amplifier Board Layout for Noninverting Configuration

10.3 Power Dissipation

Power dissipation depends on power-supply voltage, signal and load conditions. With DC signals, power dissipation is equal to the product of output current times the voltage across the conducting output transistor, $V_S - V_O$. Power dissipation can be minimized by using the lowest possible power-supply voltage necessary to assure the required output voltage swing.

For resistive loads, the maximum power dissipation occurs at a DC output voltage of one-half the power-supply voltage. Dissipation with AC signals is lower. AB-039 *Power Amplifier Stress and Power Handling Limitations* explains how to calculate or measure power dissipation with unusual signals and loads, and can be found at www.ti.com.

Power Dissipation (接下页)

Any tendency to activate the thermal protection circuit indicates excessive power dissipation or an inadequate heatsink. For reliable operation, junction temperature must be limited to 150°C, maximum. To estimate the margin of safety in a complete design, increase the ambient temperature until the thermal protection is triggered at 160°C. The thermal protection should trigger more than 35°C above the maximum expected ambient condition of the application.

11 器件和文档支持

11.1 文档支持

相关文档请参见以下部分：

- *《ADS8326 16 位、2.7V 至 5.5V 高速微功耗采样模数转换器》*
- *《电路板布局布线技巧》*
- *《用直观方式补偿跨阻放大器》*
- *《FilterPro™ 用户指南》*
- *《高速运算放大器噪声分析》*
- *《OPA380 和 OPA2380 精密高速跨阻放大器》*
- *《具有关闭功能的 OPA355、OPA2355 和 OPA3355 200MHz CMOS 运算放大器》*
- *《OPA656 宽带单位增益稳定 FET 输入运算放大器》*
- *《功率放大器应力和功率处理限制》*
- *《PowerPAD 热增强型封装》*

11.2 接收文档更新通知

要接收文档更新通知，请转至 TI.com 上的器件产品文件夹。单击右上角的*通知我* 进行注册，即可每周接收产品信息更改摘要。有关更改的详细信息，请查看任何已修订文档中包含的修订历史记录。

11.3 社区资源

下列链接提供到 TI 社区资源的连接。链接的内容由各个分销商“按照原样”提供。这些内容并不构成 TI 技术规范，并且不一定反映 TI 的观点；请参阅 TI 的 《使用条款》。

TI E2E™ 在线社区 ***TI 的工程师对工程师 (E2E) 社区。*** 此社区的创建目的在于促进工程师之间的协作。在 e2e.ti.com 中，您可以咨询问题、分享知识、拓展思路并与同行工程师一道帮助解决问题。

设计支持 ***TI 参考设计支持*** 可帮助您快速查找有帮助的 E2E 论坛、设计支持工具以及技术支持的联系信息。

11.4 商标

E2E is a trademark of Texas Instruments.
All other trademarks are the property of their respective owners.

11.5 静电放电警告

这些装置包含有限的内置 ESD 保护。 存储或装卸时，应将导线一起截短或将装置放置于导电泡棉中，以防止 MOS 门极遭受静电损伤。

11.6 Glossary

SLYZ022 — *TI Glossary*.

This glossary lists and explains terms, acronyms, and definitions.

12 机械、封装和可订购信息

以下页面包含机械、封装和可订购信息。这些信息是指定器件的最新可用数据。这些数据如有变更，恕不另行通知和修订此文档。如欲获取此数据表的浏览器版本，请参阅左侧的导航。

PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package | Pins	Package qty | Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
TLV3544QPWRQ1	Active	Production	TSSOP (PW) | 14	2000 | LARGE T&R	Yes	NIPDAU	Level-3-260C-168 HR	-40 to 125	3544Q1
TLV3544QPWRQ1.B	Active	Production	TSSOP (PW) | 14	2000 | LARGE T&R	Yes	NIPDAU	Level-3-260C-168 HR	-40 to 125	3544Q1

(1) **Status:** For more details on status, see our product life cycle.

(2) **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

(3) **RoHS values:** Yes, No, RoHS Exempt. See the TI RoHS Statement for additional information and value definition.

(4) **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

(6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

OTHER QUALIFIED VERSIONS OF TLV3544-Q1 :

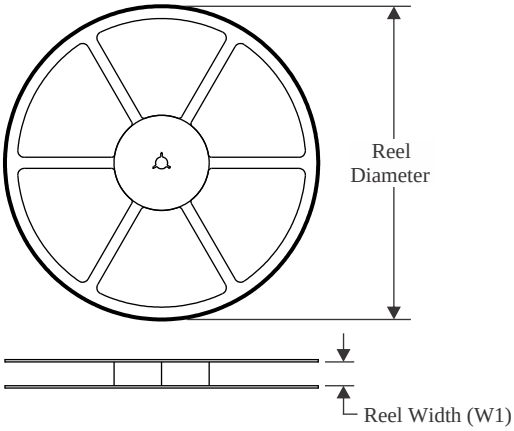
- Catalog : TLV3544

NOTE: Qualified Version Definitions:

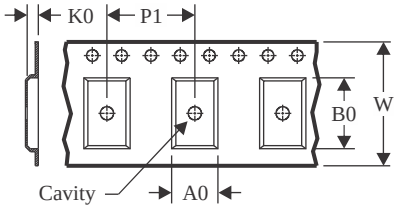
- Catalog - TI's standard catalog product

TAPE AND REEL INFORMATION

REEL DIMENSIONS

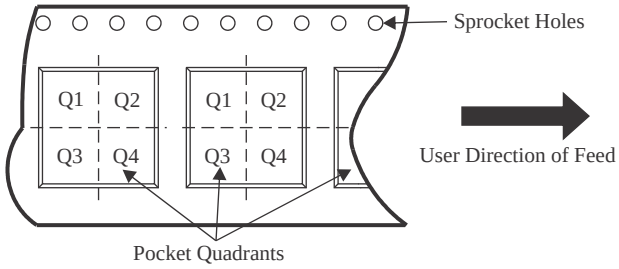


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

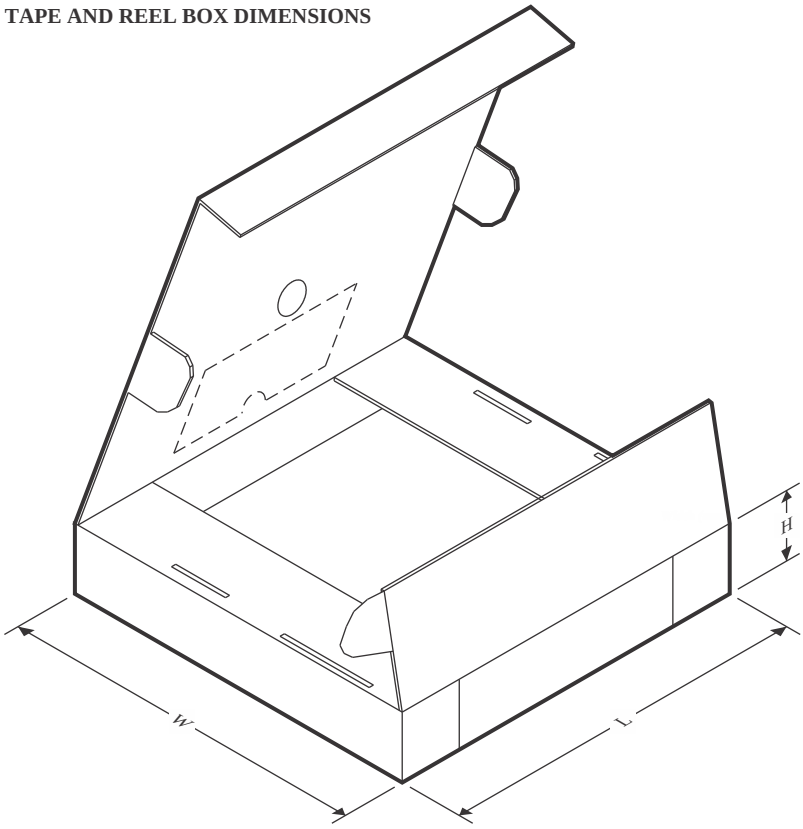
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
TLV3544QPWRQ1	TSSOP	PW	14	2000	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

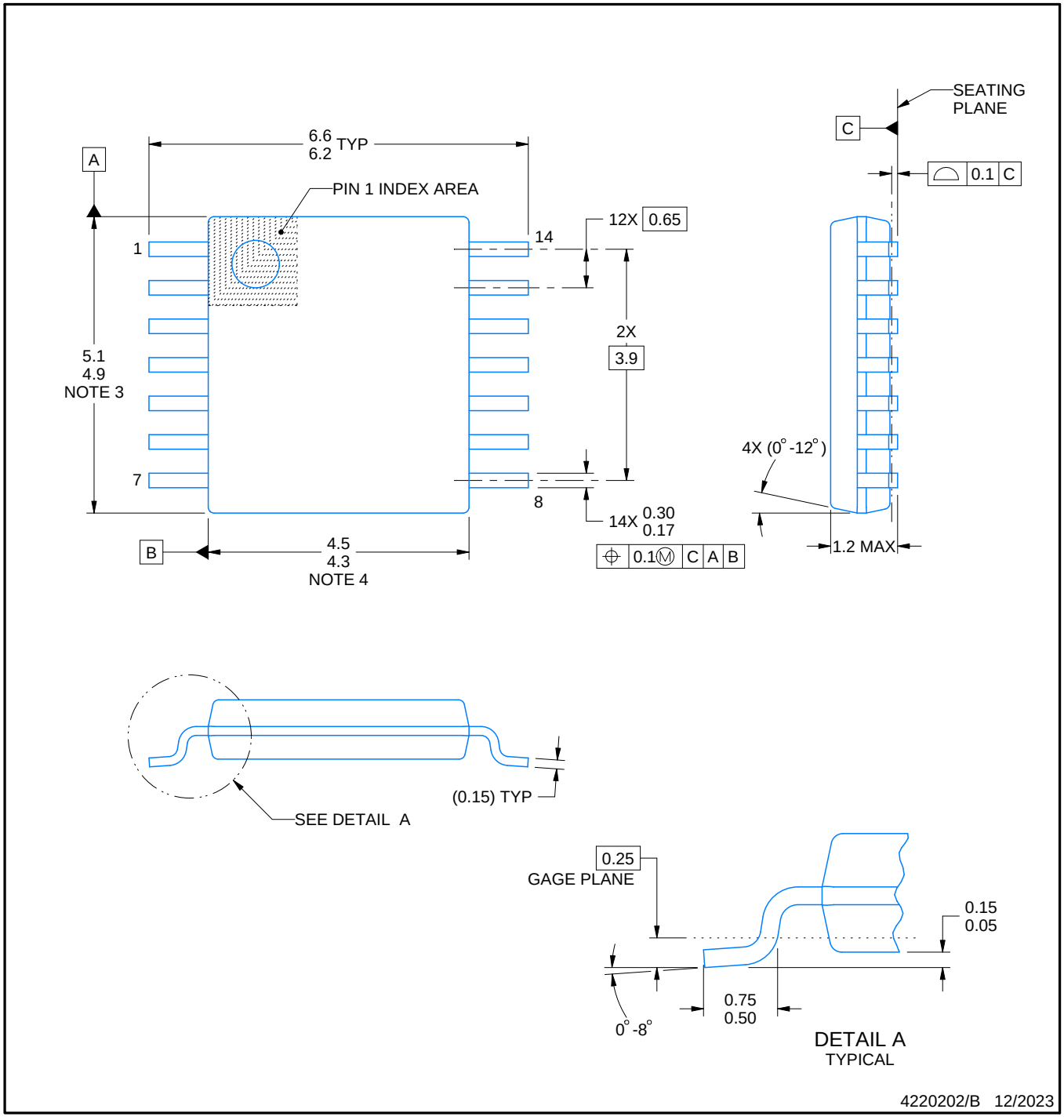
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TLV3544QPWRQ1	TSSOP	PW	14	2000	353.0	353.0	32.0

PACKAGE OUTLINE

PW0014A

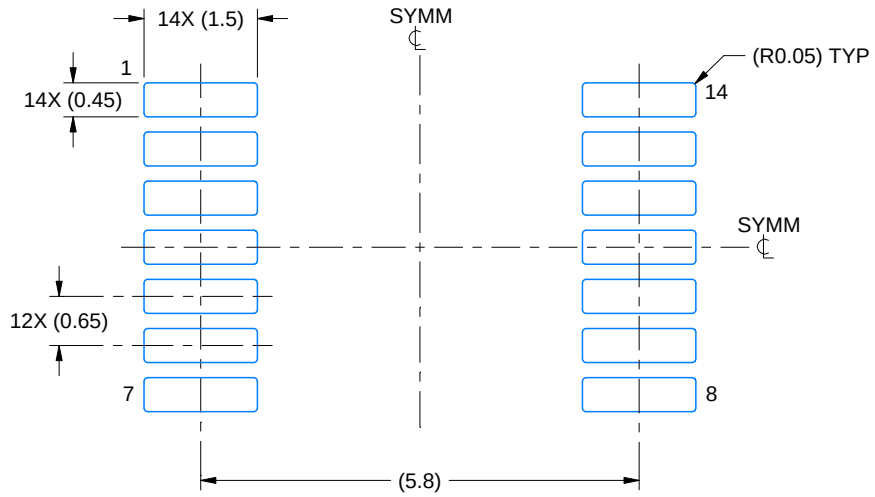
TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE

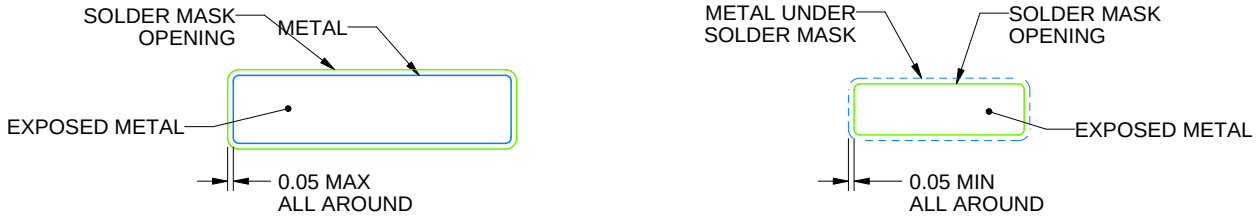


NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.25 mm per side.
5. Reference JEDEC registration MO-153.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 10X



SOLDER MASK DETAILS

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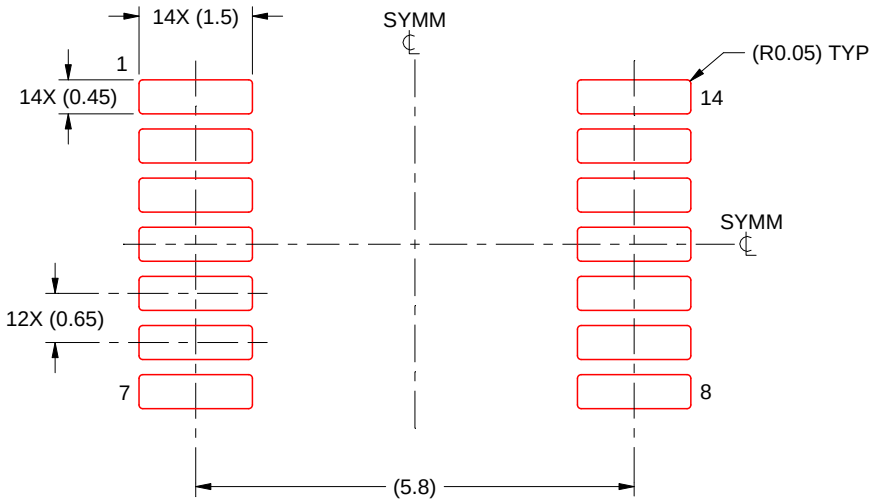
NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE: 10X

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NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

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