OPAx365-Q1 50-MHz Low-Distortion High-CMRR Rail-to-Rail I/O, Single-Supply Operational Amplifiers

1 Features

- Qualified for Automotive Applications
- AEC-Q100 Qualified with the Following Results:
  - Device Temperature Grade 1: –40°C to 125°C Ambient Operating Temperature Range
  - Device HBM ESD Classification Level H2
  - Device CDM ESD Classification Level C3B
- OPA2365-Q1 Functional Safety-Capable:
  - Documentation Available to Aid Functional Safety System Design
- Gain Bandwidth: 50 MHz
- Zero-Crossover Distortion Topology
  - Excellent THD+N: 0.0004%
  - CMRR: 100 dB (Minimum)
  - Rail-to-Rail Input and Output
  - Input 100 mV Beyond Supply Rail
- Low Noise: 4.5 nV/√Hz at 100 kHz
- Slew Rate: 25 V/µs
- Fast Settling: 0.3 µs to 0.01%
- Precision
  - Low Offset: 100 µV
  - Low Input Bias Current: 0.2 pA
- 2.2-V to 5.5-V Operation

2 Applications

- Automotive
- ADAS
- HEV/EV and Powertrain
- Body and Lighting
- Blind Spot Detection
- Engine Control Units
- DC-DC Converters
- Short to Mid Range Radars
- Collision Warning
- Industrial
- Heads Up Display

3 Description

The OPAx365-Q1 zero-crossover family, rail-to-rail, high-performance, CMOS operational amplifiers are optimized for very low voltage, single-supply applications. Rail-to-rail input/output, low noise (4.5 nV/√Hz) and high speed operation (50-MHz gain bandwidth) make these devices ideal for driving sampling data converters (such as the ADS7822-Q1 or the ADS1115-Q1), specifically in short to mid-range radar applications. The OPAx356-Q1 family of operational amplifiers are also well-suited for HEV/EV and Powertrain applications in DC-DC converters and as transmission control in engine control units.

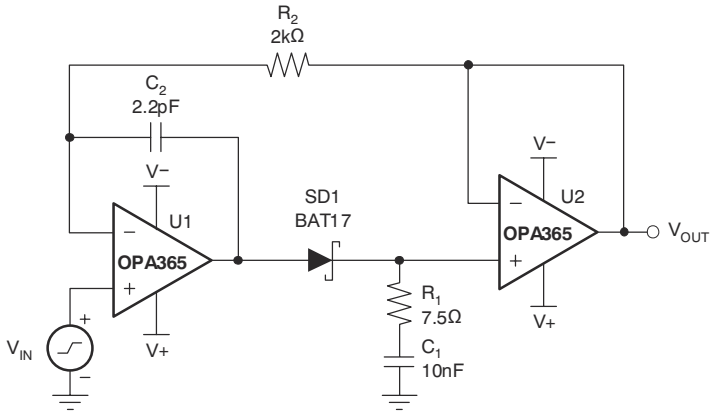
Special features include an excellent common-mode rejection ratio (CMRR), no input stage crossover distortion, high input impedance, and rail-to-rail input and output swing. The input common-mode range includes both the negative and positive supplies. The output voltage swing is within 10 mV of the rails.

The OPA365-Q1 (single version) is available in the 5-pin SOT-23 package. The OPA2365-Q1 (dual version) is available in the 8-pin SOIC package. All versions are specified for operation from −40°C to 125°C. Single and dual versions have identical specifications for maximum design flexibility.

Device Information (1)

PART NUMBER	PACKAGE	BODY SIZE (NOM)
OPA2365-Q1	SOIC (8)	4.90 mm × 3.91 mm
OPA365-Q1	SOT-23 (5)	2.90 mm × 1.60 mm

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



Fast-Settling Peak Detector

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4 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision D (December 2015) to Revision E (November 2020)	Page
• Updated the numbering format for tables, figures, and cross-references throughout the document	1
• Added Functional Safety-Capable - Documentation information to the *Features* section	1
• Updated *Related Documentation* section	22

Changes from Revision C (April 2012) to Revision D (December 2015)	Page
• Added *ESD Ratings* table, *Feature Description* section, *Device Functional Modes*, *Application and Implementation* section, *Power Supply Recommendations* section, *Layout* section, *Device and Documentation Support* section, and *Mechanical, Packaging, and Orderable Information* section	1

Changes from Revision B (January 2012) to Revision C (April 2012)	Page
• Added another row with V_{OS} for OPA2365-Q1 only	5
• Changed I_Q upper limit to 5.3 from 5.5	5

5 Pin Configuration and Functions

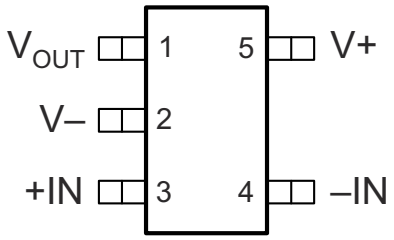


Figure 5-1. DBV Package 5-Pin SOT-23 Top View

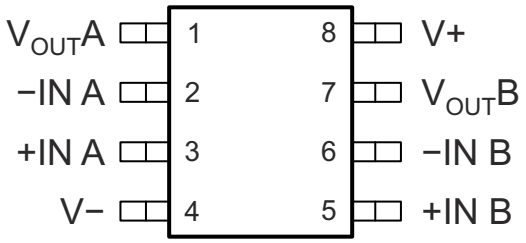


Figure 5-2. D Package 8-Pin SOIC Top View

Table 5-1. Pin Functions

PIN			I/O	DESCRIPTION
NAME	SOT-23	SOIC		
+IN	3	—	I	Noninverting input
–IN	4	—	I	Inverting input
+IN A	—	3	I	Noninverting input
–IN A	—	2	I	Inverting input
+IN B	—	5	I	Noninverting input
–IN B	—	6	I	Inverting input
V+	5	8	I	Positive (highest) supply
V–	4	4	I	Negative (lowest) supply
V_{OUT}	I	—	O	Output
V_{OUT}A	—	1	O	Output
V_{OUT}B	—	7	O	Output

6 Specifications

6.1 Absolute Maximum Ratings

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

		MIN	MAX	UNIT
V_{CC}	Supply voltage		5.5	V
V_I	Signal input terminals, voltage(2)	(V−) − 0.5	(V+) + 0.5	V
I_I	Signal input terminals, current(2)	–10	10	mA
t_{OSC}	Output short-circuit duration(3)	Continuous		
T_{OP}	Operating temperature	–40	150	°C
T_J	Junction temperature		150	°C
T_{stg}	Storage temperature	–65	150	°C

(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 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 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)	±2000	V
		Charged-device model (CDM), per AEC Q100-011	±750	

(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	NOM	MAX	UNIT
V_S	Supply voltage V– to V+	2.2	3.3	5.5	V
T_A	Operating free-air temperature	–40	25	125	°C

6.4 Thermal Information

THERMAL METRIC(1)		OPA2365-Q1 D (SOIC) 8 PINS	OPA365-Q1 DBV (SOT-23) 5 PINS	UNIT
$R_{\theta JA}$	Junction-to-ambient thermal resistance	115.5	208.8	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	60.1	123.7	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	56.9	54.6	°C/W
ψ_{JT}	Junction-to-top characterization parameter	9.5	37.2	°C/W
ψ_{JB}	Junction-to-board characterization parameter	56.3	36.3	°C/W

(1) For more information about traditional and new thermal metrics, see the *Semiconductor and IC Package Thermal Metrics* application report, SPRA953.

6.5 Electrical Characteristics

V_S = 2.2 V to 5.5 V, R_L = 10 kΩ connected to V_S/2, V_{CM} = V_S/2, and V_{OUT} = V_S/2 (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T_A [1]	MIN	TYP	MAX	UNIT
OFFSET VOLTAGE							
V_{OS}	Input offset voltage		25°C		100	200	µV
V_{OS} [3]	Input offset voltage		25°C		100	230	µV
dV_{OS}/ dT	Input offset voltage drift		Full range		1		µV/°C
PSRR	Input offset voltage vs power supply	V_S = 2.2 V to 5.5 V	Full range		10	100	µV/V
	Channel separation, DC		25°C		0.2		µV/V
INPUT BIAS CURRENT							
I_B	Input bias current		25°C		±0.2	±10	pA
			Full range		See *Section 6.6*		
I_{OS}	Input offset current		25°C		±0.2	±10	pA
NOISE							
e_n	Input voltage noise	f = 0.1 Hz to 10 Hz	25°C		5		μV_{PP}
e_n	Input voltage noise density	f = 100 kHz	25°C		4.5		nV/√Hz
i_n	Input current noise density	f = 10 kHz	25°C		4		fA/√Hz
INPUT VOLTAGE RANGE							
V_{CM}	Common-mode voltage		25°C	(V-) – 0.1		(V+) + 0.1	V
CMRR	Common-mode rejection ratio	(V-) – 0.1 V ≤ V_{CM} ≤ (V+) + 0.1 V	Full range	100	120		dB
INPUT CAPACITANCE							
	Differential		25°C		6		pF
	Common-mode		25°C		2		pF
OPEN-LOOP GAIN							
A_{OL}	Open-loop voltage gain	R_L = 10 kΩ, 100 mV < V_O < (V+) – 100 mV	Full range	100	120		dB
		R_L = 600 Ω, 200 mV < V_O < (V+) – 200 mV	25°C	100	120		
		R_L = 600 Ω, 200 mV < V_O < (V+) – 200 mV	Full range	94			
FREQUENCY RESPONSE							
GBW	Gain-bandwidth product		25°C		50		MHz
SR	Slew rate	V_S = 5 V, G = 1	25°C		25		V/µs
t_S	Settling time	0.1%, V_S = 5 V, 4-V Step, G = 1	25°C		200		ns
		0.01%, V_S = 5 V, 4-V Step, G = 1	25°C		300		
	Overload recovery time	V_S = 5 V, V_{IN} × Gain > V_S	25°C		< 0.1		µs
THD+N	Total harmonic distortion + noise[2]	V_S = 5 V, R_L = 600 Ω, V_O = 4 VPP, G = 1, f = 1 kHz	25°C		0.0004%		
OUTPUT							
	Voltage output swing from rail	R_L = 10 kΩ, V_S = 5.5 V	Full range		10	20	mV
I_{SC}	Short-circuit current		25°C		±65		mA
C_L	Capacitive load drive		25°C		See *Section 6.6*		
	Open-loop output impedance	f = 1 MHz, I_O = 0	25°C		30		Ω
POWER SUPPLY							
V_S	Specified voltage		25°C	2.2		5.5	V
I_Q	Quiescent current per amplifier	I_O = 0	25°C		4.6	5	mA
			Full range			5.3	

V_S = 2.2 V to 5.5 V, R_L = 10 kΩ connected to $V_S/2$, $V_{CM} = V_S/2$, and $V_{OUT} = V_S/2$ (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T_A (1)	MIN	TYP	MAX	UNIT
TEMPERATURE RANGE							
	Specified		25°C	–40		125	°C
θ_{JA}	Thermal resistance	SOT23-5	25°C				°C/W
		SO-8	25°C		200		

(1) Full range T_A = −40°C to 125°C
(2) Third-order filter, bandwidth 80 kHz at −3 dB.
(3) For OPA2365-Q1 only

6.6 Typical Characteristics

T_A = 25°C, V_S = 5 V, C_L = 0 pF (unless otherwise noted)

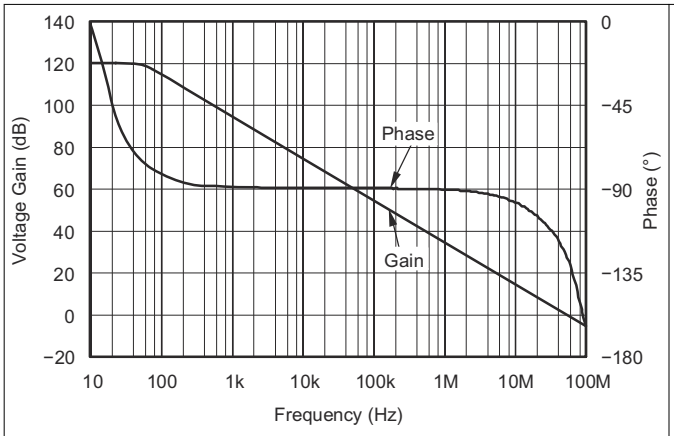


Figure 6-1. Open-Loop Gain and Phase vs Frequency

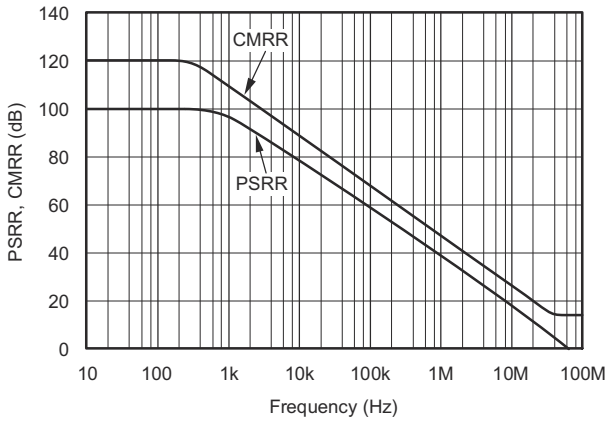


Figure 6-2. Power Supply and Common Mode Rejection Ratio vs Frequency

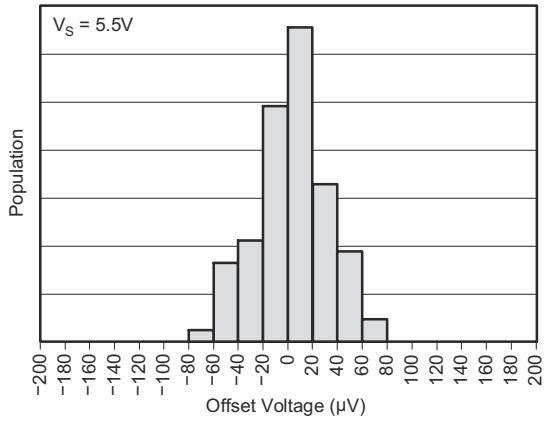


Figure 6-3. Offset Voltage Production Distribution

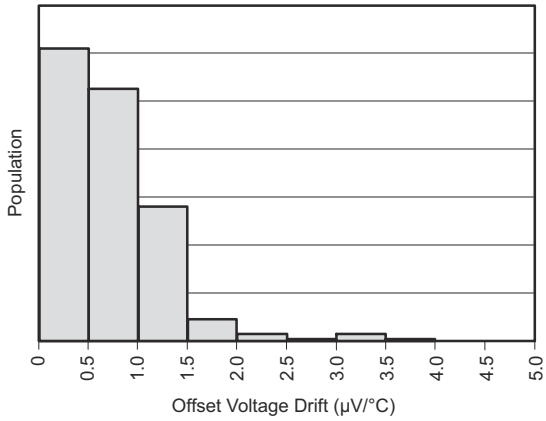


Figure 6-4. Offset Voltage Drift Production Distribution

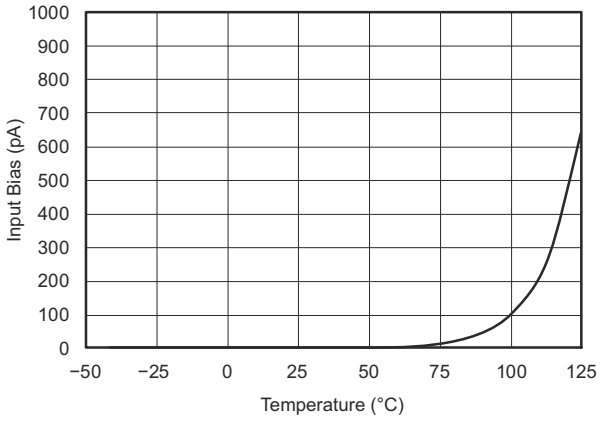


Figure 6-5. Input Bias Current vs Temperature

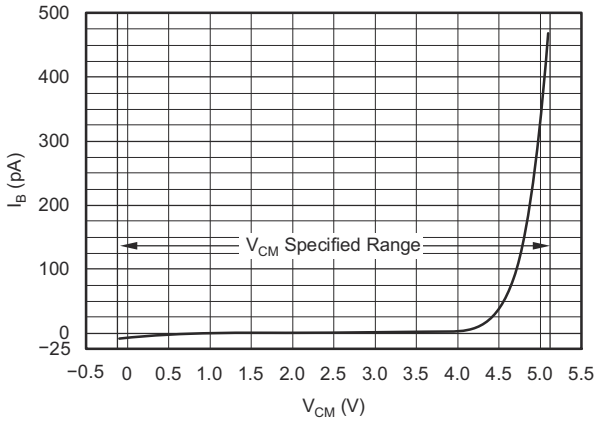


Figure 6-6. Input Bias Current vs Common Mode Voltage

6.6 Typical Characteristics (continued)

T_A = 25°C, V_S = 5 V, C_L = 0 pF (unless otherwise noted)

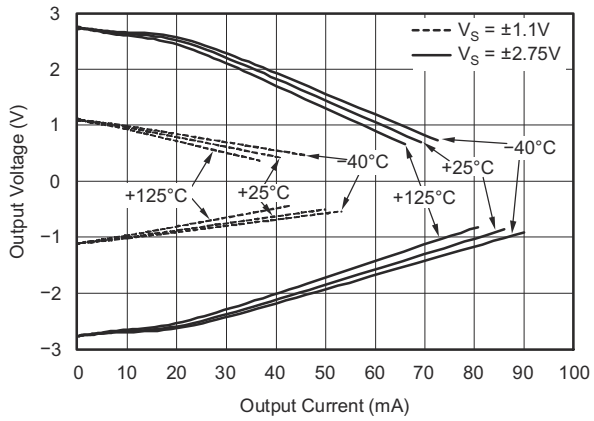


Figure 6-7. OPA365-Q1 Output Voltage vs Output Current

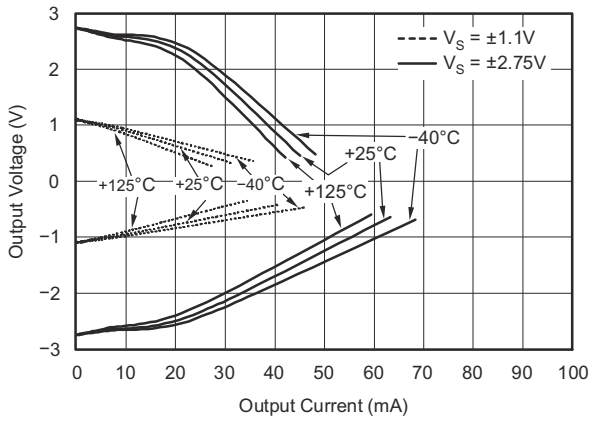


Figure 6-8. OPA2365-Q1 Output Voltage Swing vs Output Current

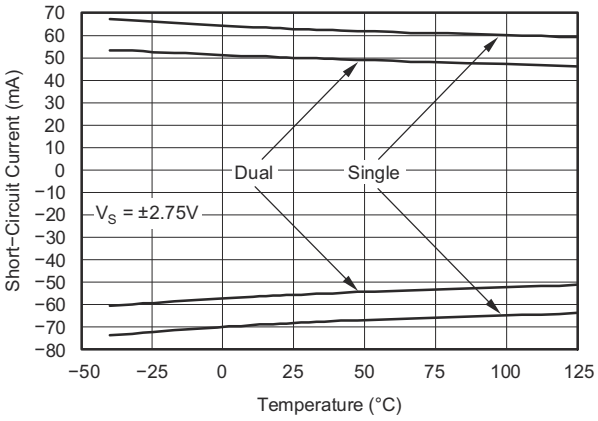


Figure 6-9. Short-Circuit Current vs Temperature

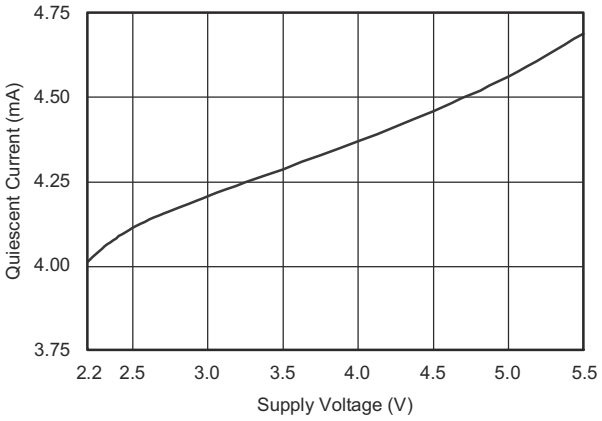


Figure 6-10. Quiescent Current vs Supply Voltage

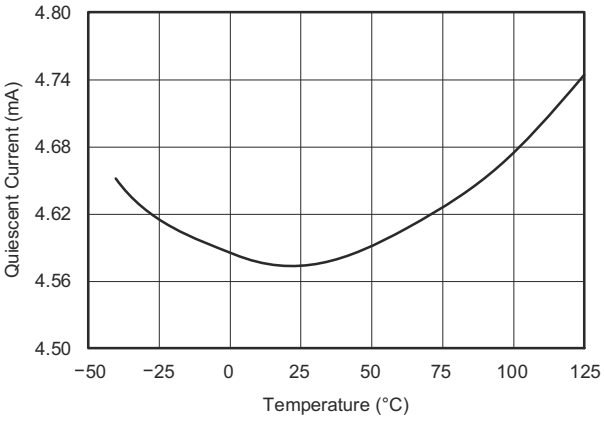


Figure 6-11. Quiescent Current vs Temperature

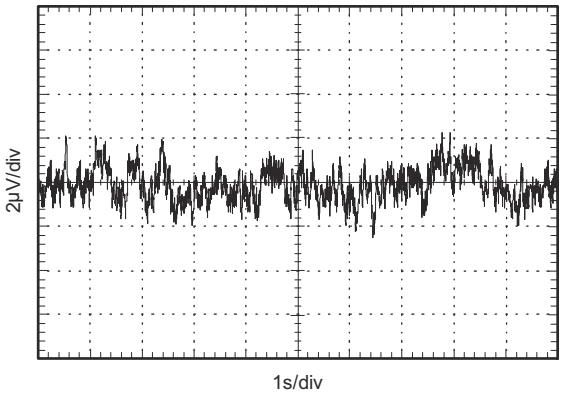


Figure 6-12. 0.1-Hz to 10-Hz Input Voltage Noise

6.6 Typical Characteristics (continued)

T_A = 25°C, V_S = 5 V, C_L = 0 pF (unless otherwise noted)

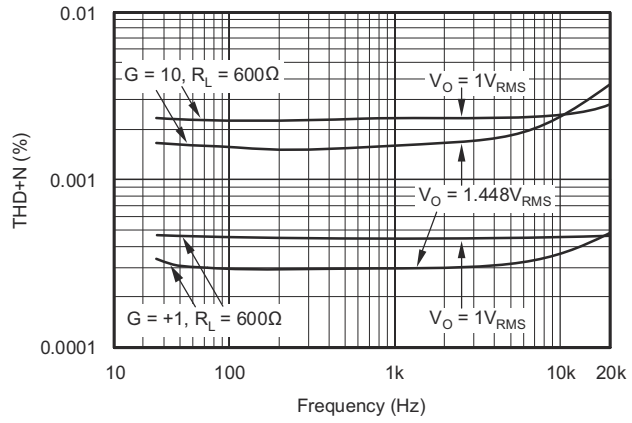


Figure 6-13. Total Harmonic Distortion + Noise vs Frequency

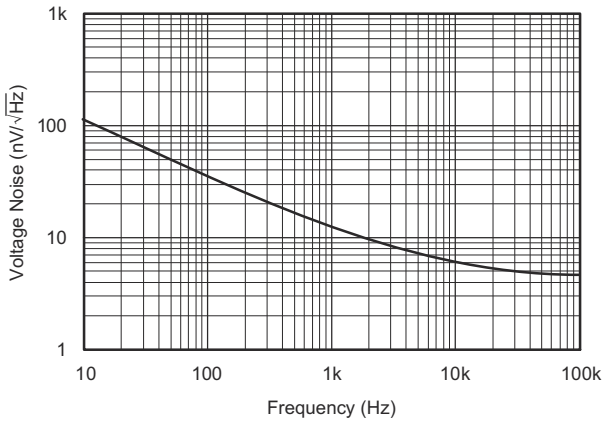


Figure 6-14. Input Voltage Noise Spectral Density

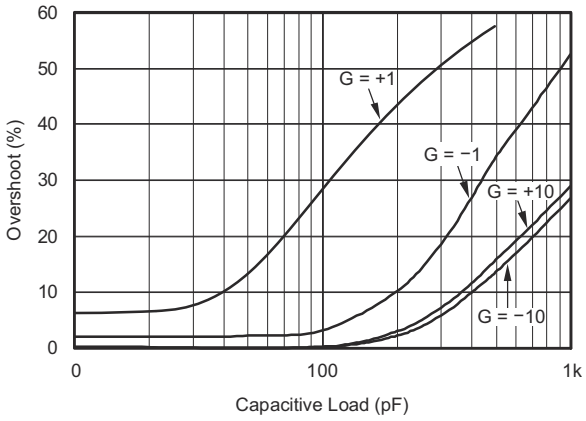


Figure 6-15. Overshoot vs Capacitive Load

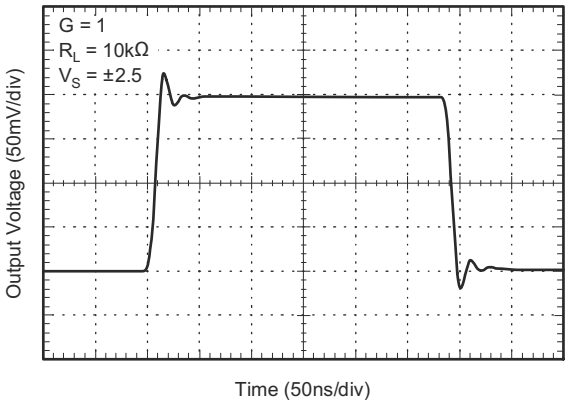


Figure 6-16. Small-Signal Step Response

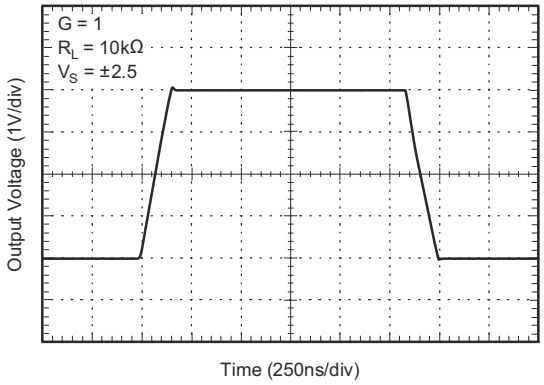


Figure 6-17. Large-Signal Step Response

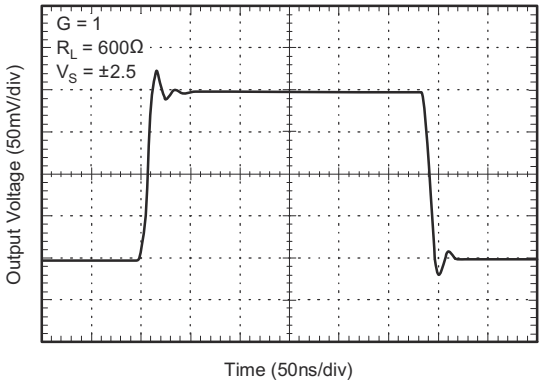


Figure 6-18. Small-Signal Step Response

6.6 Typical Characteristics (continued)

T_A = 25°C, V_S = 5 V, C_L = 0 pF (unless otherwise noted)

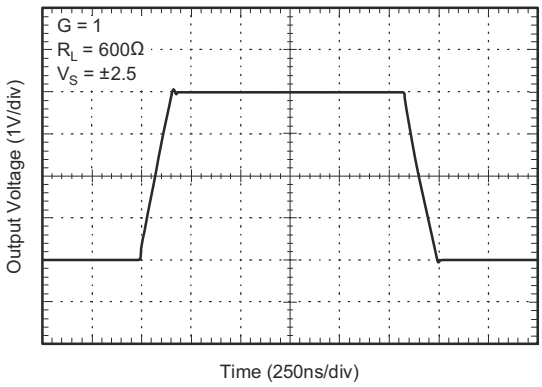


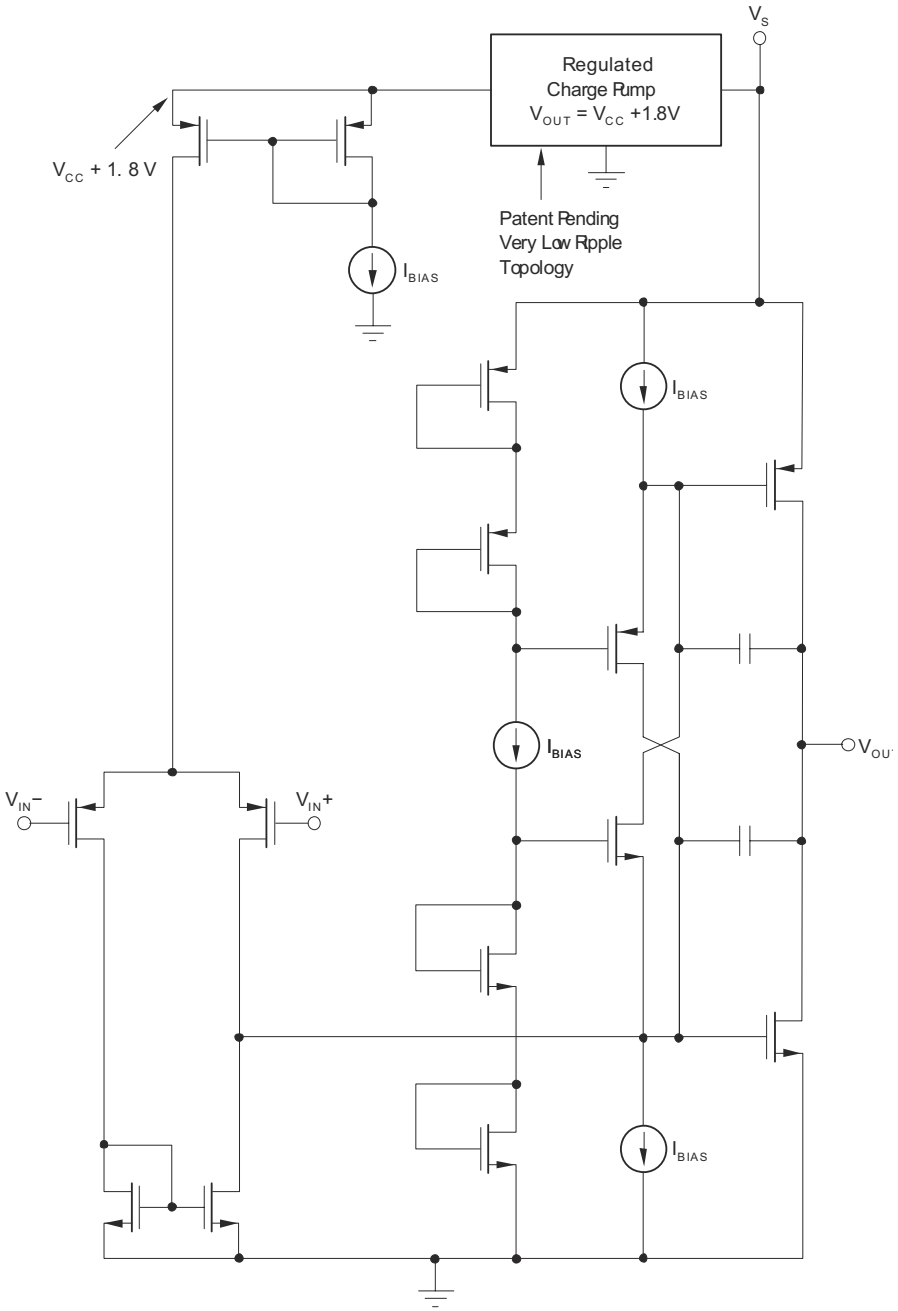
Figure 6-19. Large-Signal Step Response

7 Detailed Description

7.1 Overview

The OPAx365-Q1 zero-crossover family of rail-to-rail, high-performance, CMOS operational amplifiers are optimized for very low voltage, single-supply applications. Their rail-to-rail input and output, low-noise (4.5 nV/√Hz), and high-speed operation (50-MHz gain bandwidth) make these devices ideal for driving sampling analog-to-digital converters (ADCs). Applications include audio, signal conditioning, and sensor amplification. The high-gain bandwidth of 50 MHz makes this family suited for amplifying low signal levels and high frequency such as radar signal processing .

7.2 Functional Block Diagram



7.3 Feature Description

7.3.1 Operating Characteristics

The OPA365-Q1 amplifier parameters are fully specified from 2.2 V to 5.5 V. Many of the specifications apply from −40°C to 125°C. Parameters that can exhibit significant variance with regard to operating voltage or temperature are presented in *Section 6.6*.

7.3.2 Basic Amplifier Configurations

As with other single-supply operational amplifiers, the OPA365-Q1 may be operated with either a single supply or dual supplies (see Figure 7-1). A typical dual-supply connection is shown in Figure 7-1, which is accompanied by a single-supply connection. The OPA365-Q1 device is configured as a basic inverting amplifier with a gain of −10 V/V. The dual-supply connection has an output voltage centered on zero, while the single− supply connection has an output centered on the common-mode voltage V_{CM}. For the circuit shown, this voltage is 1.5 V, but may be any value within the common-mode input voltage range. The OPA365-Q1 V_{CM} range extends 100 mV beyond the power-supply rails.

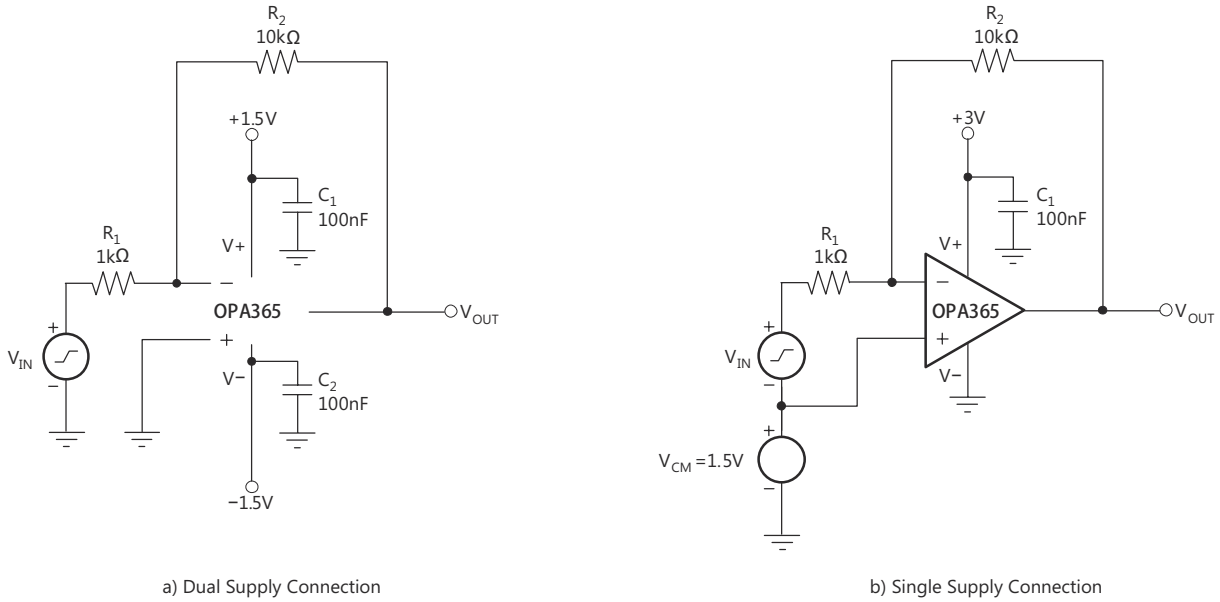


Figure 7-1. Basic Circuit Connections

Figure 7-2 shows a single-supply, electret microphone application where V_{CM} is provided by a resistive divider. The divider also provides the bias voltage for the electret element.

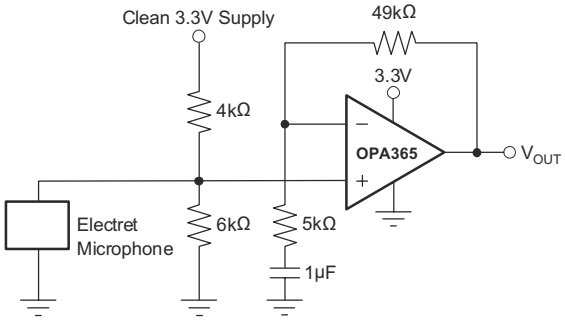


Figure 7-2. Microphone Preamplifier

7.3.3 Input and ESD Protection

The OPA365-Q1 device 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, provided that the current is limited to 10 mA as stated in the *Section 6.1*. Figure 7-3 shows how a series input resistor may be added to the driven input to limit the input current. The added resistor contributes thermal noise at the amplifier input and its value should be kept to the minimum in noise-sensitive applications.

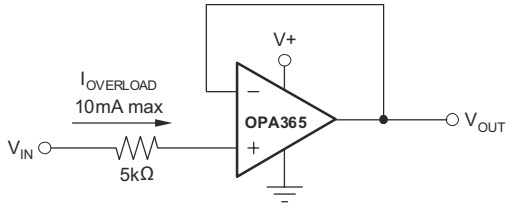


Figure 7-3. Input Current Protection

7.3.4 Rail-to-Rail Input

The OPA365-Q1 product family features true rail-to-rail input operation, with supply voltages as low as ±1.1 V (2.2 V). A unique zero-crossover input topology eliminates the input offset transition region typical of many rail-to-rail, complementary stage operational amplifiers. This topology also allows the OPA365-Q1 device to provide superior common-mode performance over the entire input range, which extends 100 mV beyond both power-supply rails, as shown in Figure 7-4. When driving ADCs, the highly linear VCM range of the OPA365-Q1 device assures that the operational amplifier/ADC system linearity performance is not compromised.

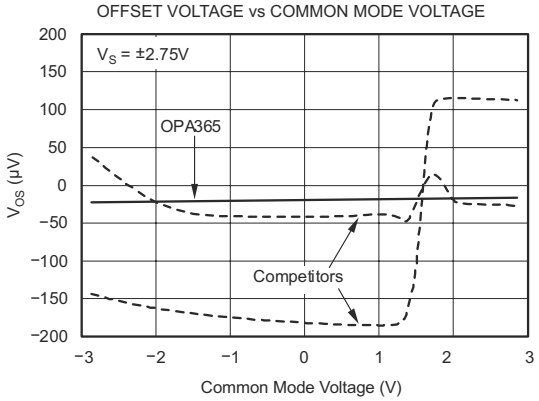


Figure 7-4. OPA365-Q1 Has Linear Offset Over the Entire Common-Mode Range

7.4 Device Functional Modes

The OPAx365-Q1 family of devices is powered on when the supply is connected. The device can be operated as a single-supply operational amplifier or a dual-supply amplifier depending on the application.

8 Application and Implementation

Note

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

8.1.1 Capacitive Loads

The OPA365-Q1 device may be used in applications where driving a capacitive load is required. As with all operational amplifiers, there may be specific instances where the OPA365-Q1 device can become unstable, leading to oscillation. The particular operational amplifier circuit configuration, layout, gain and output loading are some of the factors to consider when establishing whether an amplifier will be stable in operation. An operational amplifier in the unity-gain (1 V/V) buffer configuration and driving a capacitive load exhibits a greater tendency to be unstable than an amplifier operated at a higher noise gain. The capacitive load, in conjunction with the operational amplifier output resistance, creates a pole within the feedback loop that degrades the phase margin. The degradation of the phase margin increases as the capacitive loading increases.

When operating in the unity-gain configuration, the OPA365-Q1 device remains stable with a pure capacitive load up to approximately 1 nF. The equivalent series resistance (ESR) of some very large capacitors (C_L > 1 µF) is sufficient to alter the phase characteristics in the feedback loop such that the amplifier remains stable. Increasing the amplifier closed-loop gain allows the amplifier to drive increasingly larger capacitance. This increased capability is evident when observing the overshoot response of the amplifier at higher voltage gains. See Figure 6-15.

One technique for increasing the capacitive load drive capability of the amplifier operating in unity gain is to insert a small resistor, typically 10 Ω to 20 Ω, in series with the output; see Figure 8-1. This resistor significantly reduces the overshoot and ringing associated with large capacitive loads. A possible problem with this technique is that a voltage divider is created with the added series resistor and any resistor connected in parallel with the capacitive load. The voltage divider introduces a gain error at the output that reduces the output swing. The error contributed by the voltage divider may be insignificant. For instance, with a load resistance, R_L = 10 kΩ, and R_S = 20 Ω, the gain error is only about 0.2%. However, when R_L is decreased to 600 Ω, which the OPA365-Q1 device is able to drive, the error increases to 7.5%.

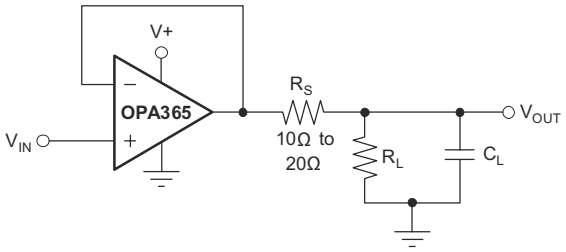


Figure 8-1. Improving Capacitive Load Drive

8.1.2 Achieving an Output Level of Zero Volts (0 V)

Certain single-supply applications require the operational amplifier output to swing from 0 V to a positive full-scale voltage and have high accuracy. An example is an operational amplifier employed to drive a single-supply ADC having an input range from 0 V to 5 V. Rail-to-rail output amplifiers with very light output loading may achieve an output level within millivolts of 0 V (or $+V_S$ at the high end), but not 0 V. Furthermore, the deviation from 0 V only becomes greater as the load current required increases. This increased deviation is a result of limitations of the CMOS output stage.

When a pulldown resistor is connected from the amplifier output to a negative voltage source, the OPA365-Q1 can achieve an output level of 0 V, and even a few millivolts below 0 V. Below this limit, nonlinearity and limiting conditions become evident. Figure 8-2 illustrates a circuit using this technique.

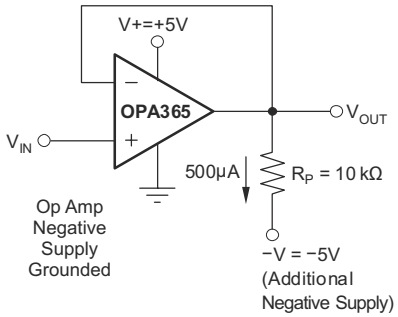


Figure 8-2. Swing-to-Ground

A pulldown current of approximately 500 µA is required when OPA365-Q1 is connected as a unity-gain buffer. A practical termination voltage (V_{NEG}) is −5 V, but other convenient negative voltages also may be used. The pulldown resistor R_L is calculated from $R_L = [(V_O - V_{NEG})/(500\ \mu A)]$. Using a minimum output voltage (V_O) of 0 V, $R_L = [0\ V-(-5V)]/(500\ \mu A)] = 10\ k\Omega$. Keep in mind that lower termination voltages result in smaller pulldown resistors that load the output during positive output voltage excursions.

This technique does not work with all operational amplifier, and should only be applied to operational amplifiers, such as the OPA365-Q1, that have been specifically designed to operate in this manner. Also, operating the OPA365-Q1 output at 0 V changes the output stage operating conditions, resulting in somewhat lower open-loop gain and bandwidth. Keep these precautions in mind when driving a capacitive load because these conditions can affect circuit transient response and stability.

8.1.3 Active Filtering

The OPA365-Q1 device is well-suited for active filter applications requiring a wide bandwidth, fast slew rate, low-noise, and single-supply operational amplifier. Figure 8-3 shows a 500 kHz, 2nd-order, low-pass filter utilizing the multiple-feedback (MFB) topology. The components have been selected to provide a maximally-flat Butterworth response. Beyond the cutoff frequency, roll-off is −40 dB/dec. The Butterworth response is ideal for applications requiring predictable gain characteristics such as the anti-aliasing filter used ahead of an ADC.

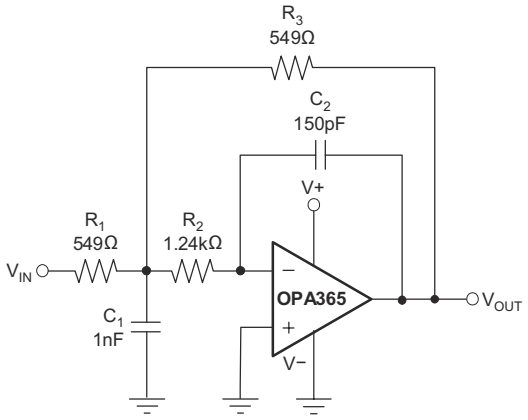


Figure 8-3. Second-Order Butterworth 500-kHz Low-Pass Filter

One point to observe when considering the MFB filter is that the output is inverted, relative to the input. If this inversion is not required, or not desired, a noninverting output can be achieved through one of these options:

1. adding an inverting amplifier;
2. adding an additional 2nd-order MFB stage;
3. using a noninverting filter topology such as the Sallen-Key (shown in Figure 8-4).

MFB and Sallen-Key, low-pass and high-pass filter synthesis is quickly accomplished using TI's FilterPro program. This software is available as a free download at www.ti.com.

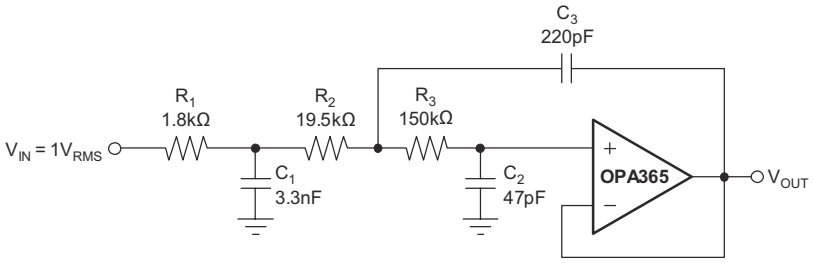


Figure 8-4. Configured as a 3-Pole, 20 kHz, Sallen-Key Filter

8.1.4 Driving an ADS7822-Q1 Analog-to-Digital Converter

The OPAx365-Q1 operational amplifiers are optimized for driving medium to high speed sampling A/D converters. The OPAx365-Q1 op amps buffer the A/D's input capacitance and resulting charge injection while providing signal gain. Figure 8-5 shows the OPAx365-Q1 in a basic noninverting configuration driving the ADS7822-Q1. The ADS7822-Q1 is a 12-bit, micro-power sampling converter in the MSOP-8 package. When used with the low-power, miniature packages of the OPAx365-Q1, the combination is ideal for space-limited, low power applications. In this configuration, an RC network at the A/D's input can be used to filter charge injection.

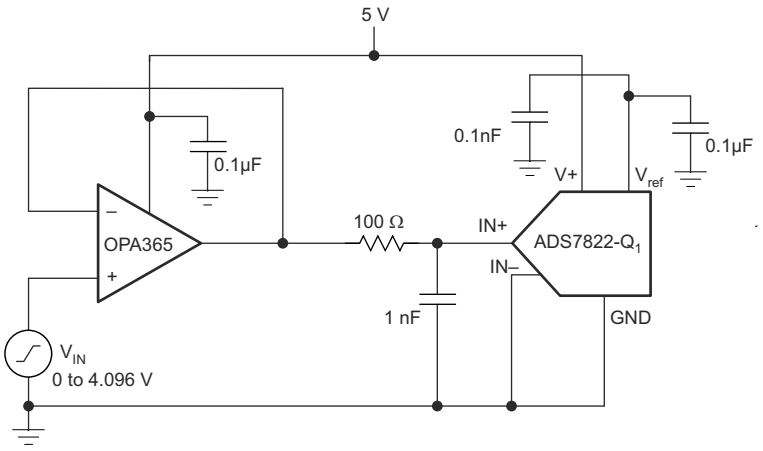


Figure 8-5. Driving the ADS7822-Q1

8.1.5 Driving ADS1115-Q1 Analog-to-Digital Converter

Some applications such as mutli-channels mid range radar need selection between channels. OPA2365-Q1 combined with ADS1115-Q1 fit very well for 2 channels radar selection. The circuit in Figure 8-6 shows the same band pass filter but the components can be modified for different desired band pass.

The DAS1115-Q1 inputs are set as differential. the inputs accept up the ±2 V. The OPA2365-Q1 flat gain is 100 so the input signal peak is 20 mV.

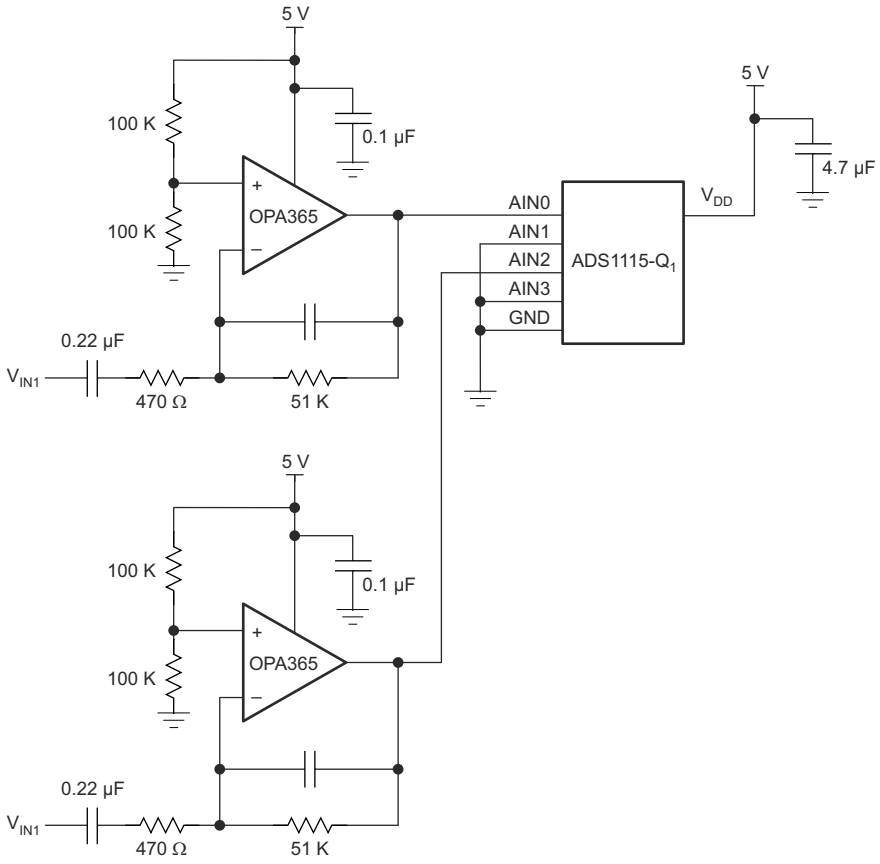


Figure 8-6. Driving the ADS1115-Q1

8.2 Typical Application

8.2.1 Fast Settling Peak Detector

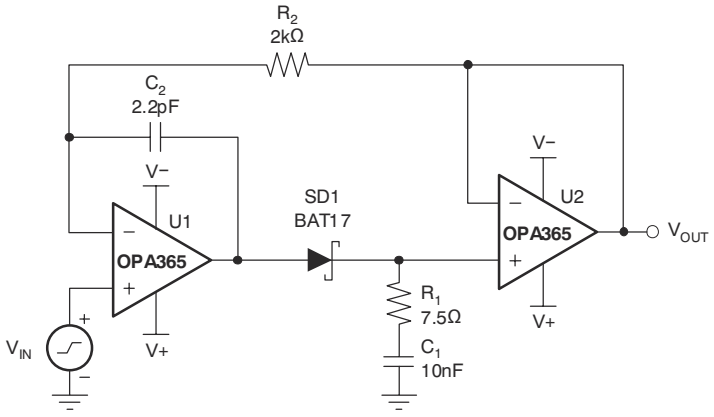


Figure 8-7. Fast Settling Peak Detector Schematic

Some applications require peak signal measurement. High unity gain bandwidth, wide supply voltage range, rail-to-rail input and output, and very low input bias current make the OPA2365-Q1 device very suitable for a peak detector circuit.

8.2.1.1 Design Requirements

Use the following design parameters for this application:

- Supply voltage: 2.2 V to 5 V
- Input signal: 0 V to 4.5 V
- Input signal frequency: 0 MHz to 1 MHz

8.2.1.2 Detailed Design Procedure

The circuit in Figure 8-7 detects the peak of an input signal and generates a DC output equal to the peak level VOUT = VINpeak. The capacitor C1 is charged through the SD1 diode and limiting resistor R1. The only discharging path for C1 is the OPA2365-Q1 very high input impedance. This allows the peak detection of low frequency and low-duty cycle signal.

8.2.1.3 Application Curves

Figure 8-8. Supply Voltage 2.2 V, Peak Signal 1 V

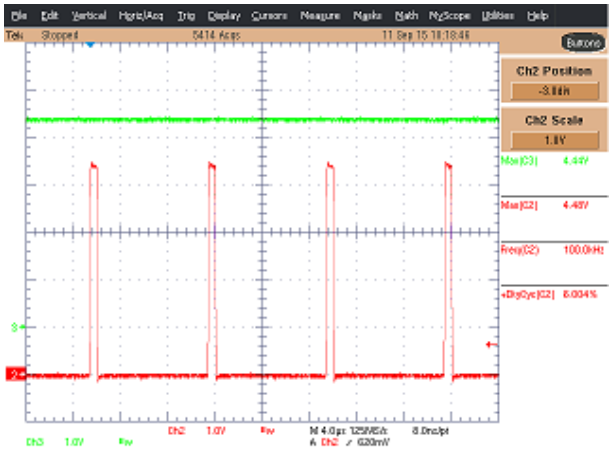


Figure 8-9. Supply Voltage 5 V Peak Signal 4.5 V

8.2.2 Bandpass Filter 1.5 kHz to 160 kHz and 40-db Flat Gain

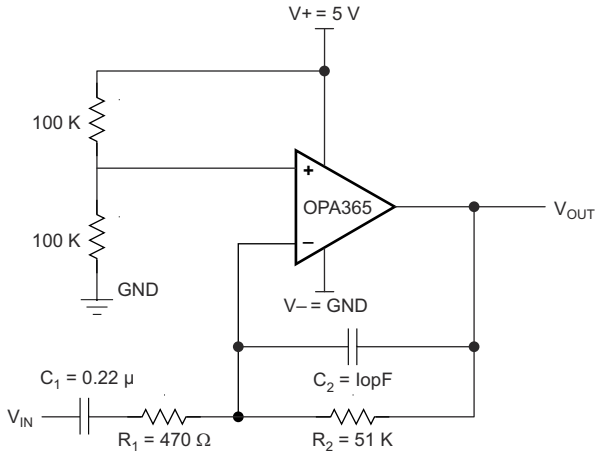


Figure 8-10. Bandpass Filter 1.5 kHz to 160 kHz and 40-db Flat Gain Schematic

8.2.2.1 Design Requirements

Use the following design parameters for this application:

- Supply voltage: 2.2 V to 5 V
- Input signal: 0 V to 25 mV
- Input signal frequency: 0 MHz to 1 MHz

8.2.2.2 Detailed Design Procedure

Some applications need bandpass filter–that is, radar or audio signal precessing. The cross over frequencies and flat gain can be adjusted by changing the resistors and capacitors value according to applications.

The circuit is designed for 5-V supply and 20-mV input signal. With a flat gain of 100 dB or 40 dB, the peak output signal is 2 V. The reference signal is at half way of 5 V, which is 2.5 V.

$$\text{The transfer function or gain} = \frac{V_{out}}{V_{in}} = -\frac{R_2C_1S}{(1+R_1C_1S)(1+R_2C_2S)} \quad (1)$$

$$\text{A zero at} = \frac{1}{2\pi R_2C_1} = 14.2\,\text{Hz} \quad (2)$$

$$\text{A pole at} = \frac{1}{2\pi R_1C_1} = 1.54\,\text{KHz} \quad (3)$$

$$\text{A pole at} = \frac{1}{2\pi R_2C_2} = 156\,\text{KHz} \quad (4)$$

Flat Gain of 100 or 40 dB between 1.54 kHz and 156 kHz (5)

20 db/decade below 1.54 KHz (6)

–20 dB/decade above 156 kHz (7)

Bandpass between 1.54 kHz and 156 kHz (8)

8.2.2.3 Application Curves

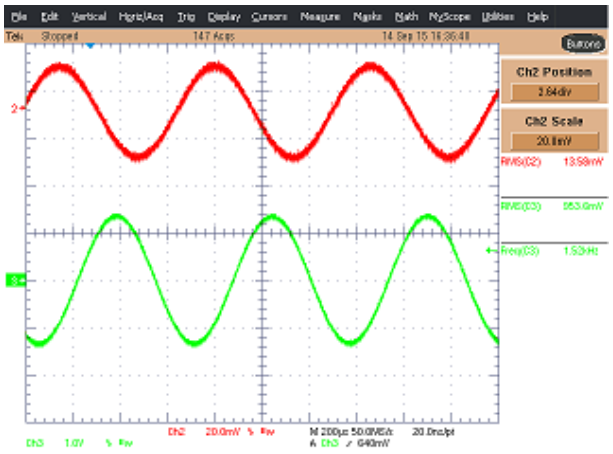


Figure 8-11. Gain Is –3 dB Below the Flat Gain at 1.5 kHz

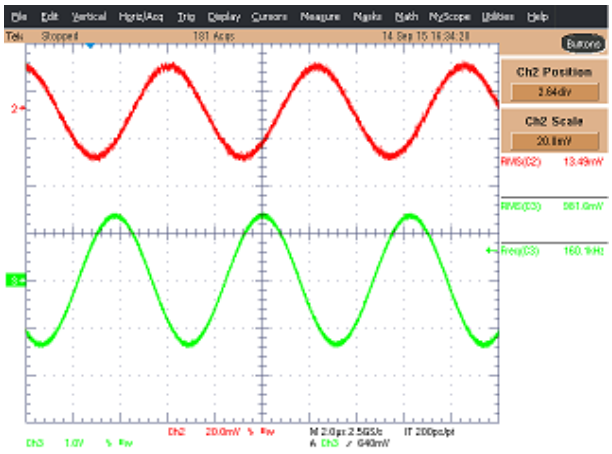


Figure 8-12. Gain Is –3 dB Above the Flat Gain at 160 kHz

9 Power Supply Recommendations

The OPAx365-Q1 family of devices is specified for operation from 2.2 V to 5.5 V (±1.1 V to ±2.75 V); many specifications apply from –40°C to 125°C. The *Section 6.6* presents parameters that can exhibit significant variance with regard to operating voltage or temperature.

CAUTION

Supply voltages larger than 7 V can permanently damage the device (see *Section 6.1*).

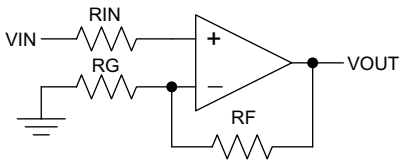
Place 0.1-µF bypass capacitors close to the power-supply pins to reduce errors coupling in from noisy or high impedance power supplies. For more detailed information on bypass capacitor placement, see *Section 10.1*.

10 Layout

10.1 Layout Guidelines

The OPA365-Q1 is a wideband amplifier. To realize the full operational performance of the device, good high-frequency printed-circuit-board (PCB) layout practices are required. Low-loss 0.1-µF bypass capacitors must be connected between each supply pin and ground as close to the device as possible. The bypass capacitor traces should be designed for minimum inductance.

10.2 Layout Example



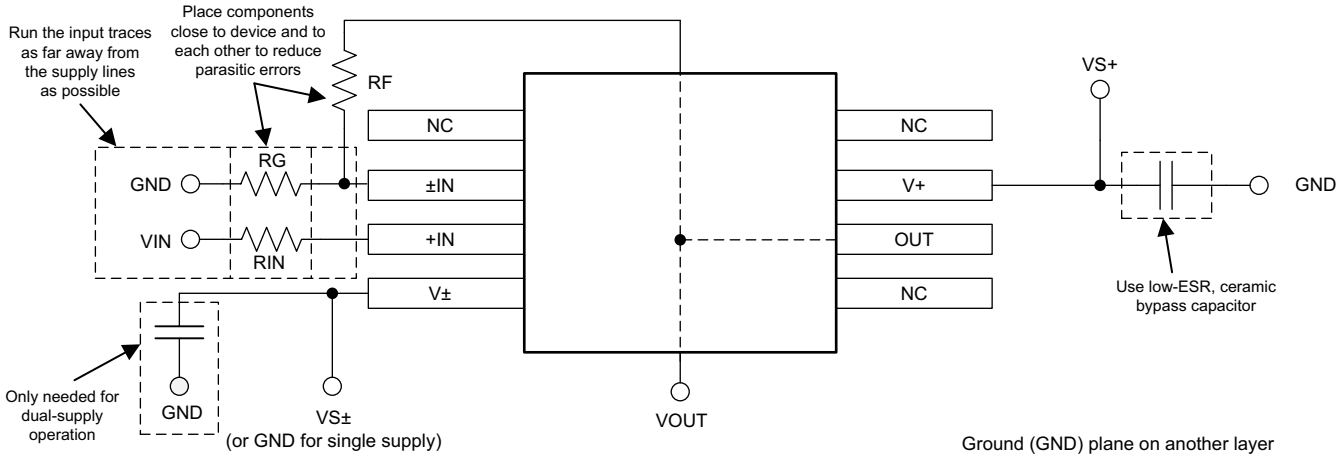


Figure 10-1. Layout Recommendation

11 Device and Documentation Support

11.1 Documentation Support

11.1.1 Related Documentation

Texas Instruments, ADS1258 16-Channel, 24-Bit Analog-to-Digital Converter data sheet

11.2 Support Resources

TI E2E™ support forums are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

Linked content is provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's Terms of Use.

11.3 Trademarks

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

11.4 Electrostatic Discharge Caution

This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

11.5 Glossary

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

12 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

10-Dec-2020

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
OPA2365AQDRQ1	ACTIVE	SOIC	D	8	2500	RoHS & Green	NIPDAU	Level-3-260C-168 HR	-40 to 125	O2365Q	Samples
OPA365AQDBVRQ1	ACTIVE	SOT-23	DBV	5	3000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	OTNQ	Samples

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".
RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.
Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead finish/Ball material - Orderable Devices 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.

OTHER QUALIFIED VERSIONS OF OPA2365-Q1, OPA365-Q1 :

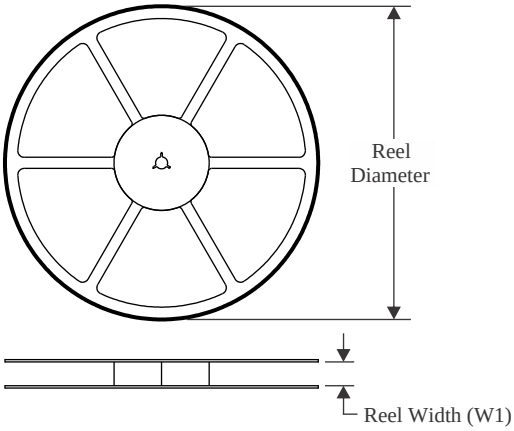
- Catalog: OPA2365, OPA365
- Enhanced Product: OPA365-EP

NOTE: Qualified Version Definitions:

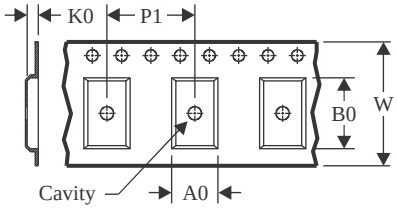
- Catalog - TI's standard catalog product
- Enhanced Product - Supports Defense, Aerospace and Medical Applications

TAPE AND REEL INFORMATION

REEL DIMENSIONS

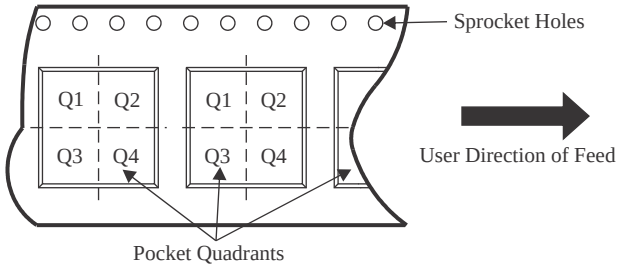


TAPE DIMENSIONS



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



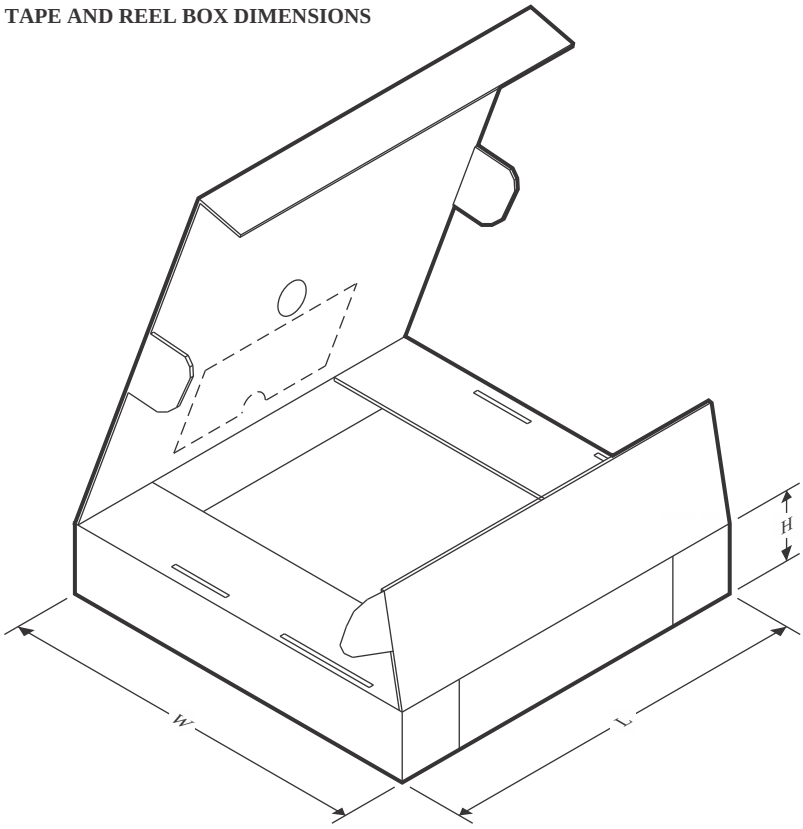
*All dimensions are nominal

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
OPA2365AQDRQ1	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
OPA365AQDBVRQ1	SOT-23	DBV	5	3000	179.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3

PACKAGE MATERIALS INFORMATION

3-Jun-2022

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

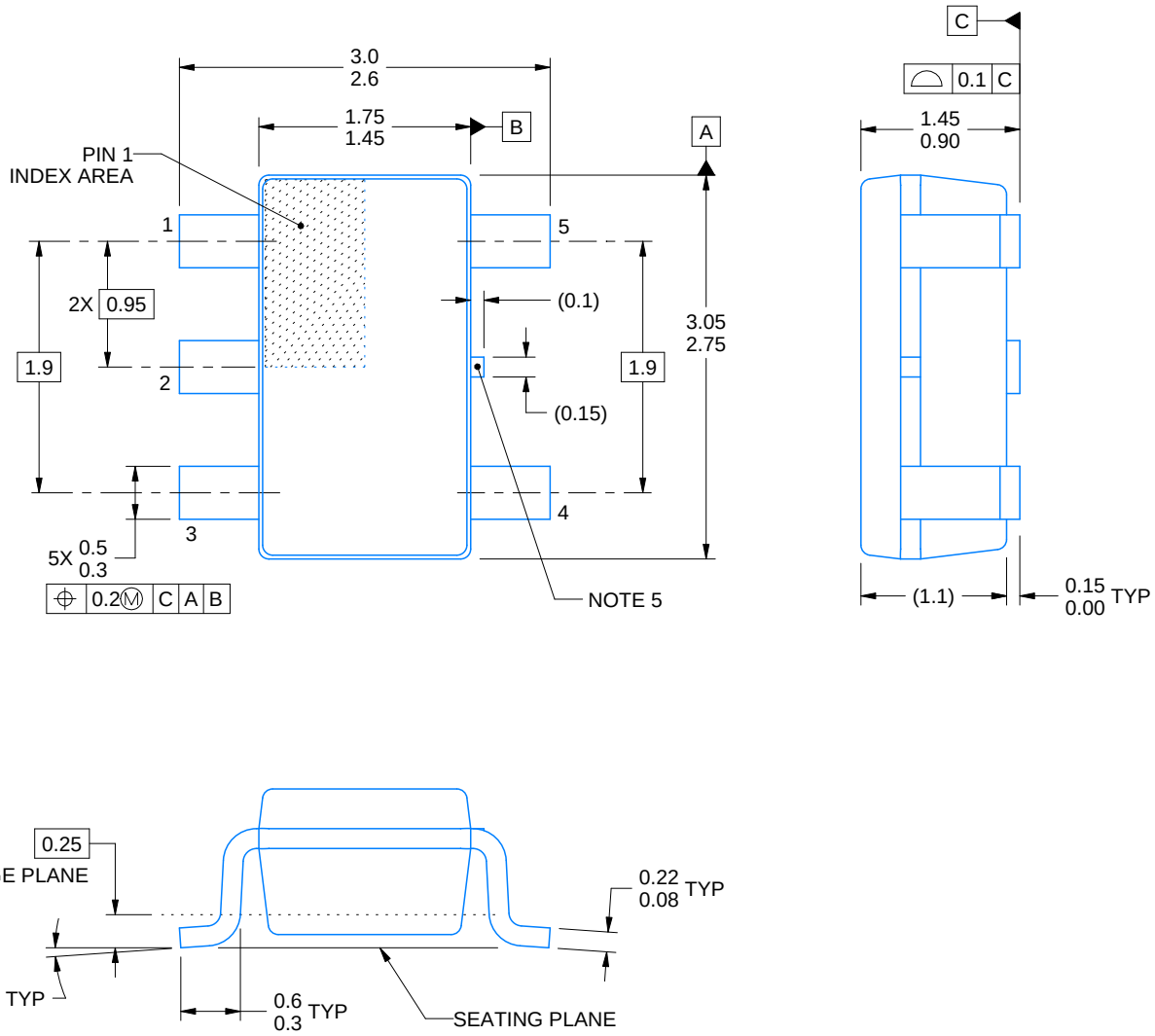
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
OPA2365AQDRQ1	SOIC	D	8	2500	356.0	356.0	35.0
OPA365AQDBVRQ1	SOT-23	DBV	5	3000	200.0	183.0	25.0

PACKAGE OUTLINE

DBV0005A

SOT-23 - 1.45 mm max height

SMALL OUTLINE TRANSISTOR



4214839/G 03/2023

NOTES:

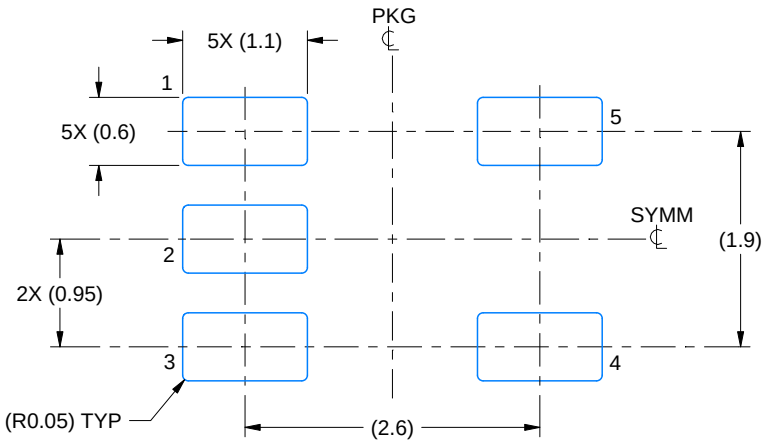
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. Refernce JEDEC MO-178.
4. Body dimensions do not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.25 mm per side.
5. Support pin may differ or may not be present.

EXAMPLE BOARD LAYOUT

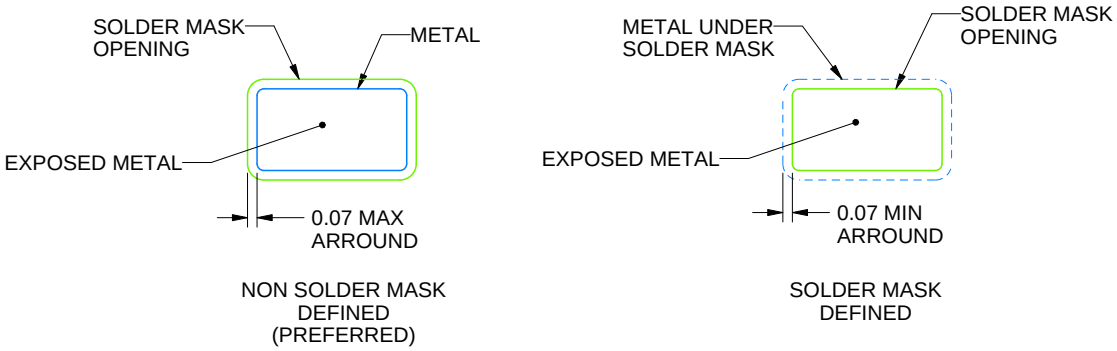
DBV0005A

SOT-23 - 1.45 mm max height

SMALL OUTLINE TRANSISTOR



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:15X



SOLDER MASK DETAILS

4214839/G 03/2023

NOTES: (continued)

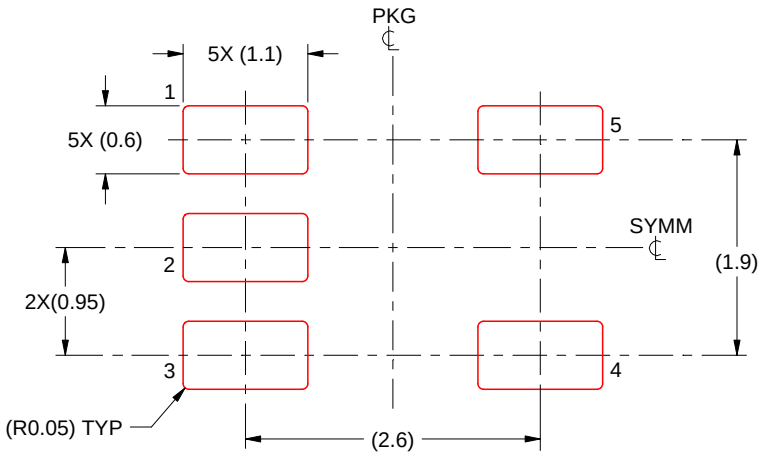
6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

EXAMPLE STENCIL DESIGN

DBV0005A

SOT-23 - 1.45 mm max height

SMALL OUTLINE TRANSISTOR



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE:15X

4214839/G 03/2023

NOTES: (continued)

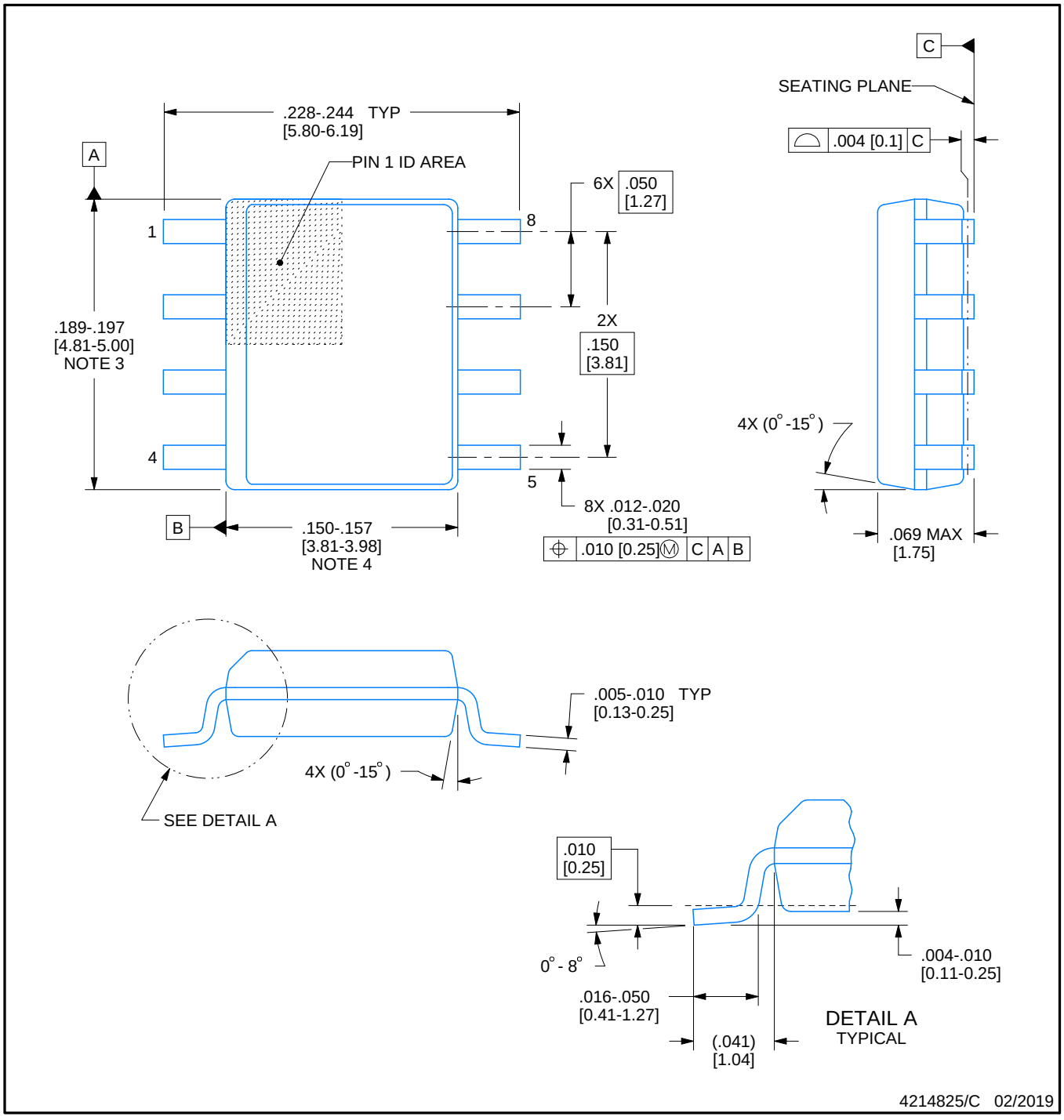
8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

PACKAGE OUTLINE

D0008A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



NOTES:

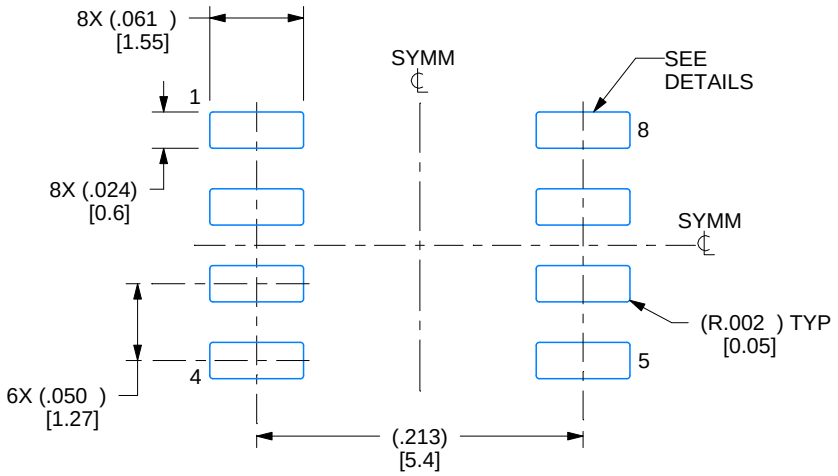
1. Linear dimensions are in inches [millimeters]. Dimensions in parenthesis are for reference only. Controlling dimensions are in inches. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed .006 [0.15] per side.
4. This dimension does not include interlead flash.
5. Reference JEDEC registration MS-012, variation AA.

EXAMPLE BOARD LAYOUT

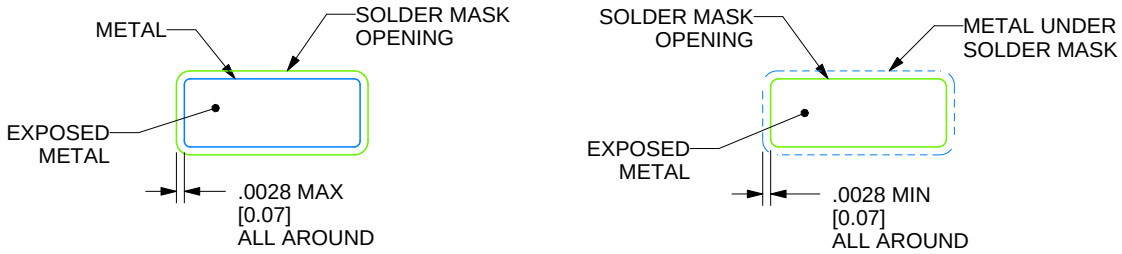
D0008A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:8X



SOLDER MASK DETAILS

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NOTES: (continued)

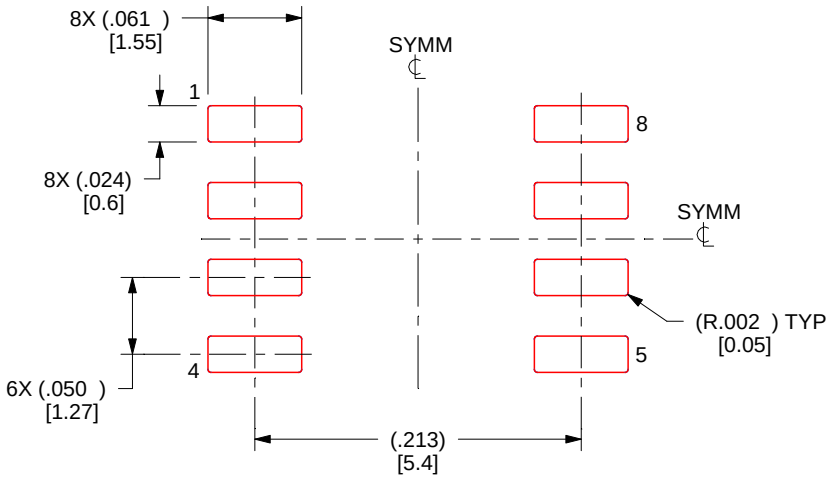
6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

EXAMPLE STENCIL DESIGN

D0008A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



SOLDER PASTE EXAMPLE
BASED ON .005 INCH [0.125 MM] THICK STENCIL
SCALE:8X

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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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Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265