

具有 $\pm 250\text{mV}$ 输入电压、 $3\mu\text{s}$ 延迟的增强隔离式 AMC1301-Q1 精密放大器

1 特性

- 符合汽车应用 标准
- 具有符合 AEC-Q100 的下列结果：
 - 温度等级： -40°C 至 125°C
 - 人体放电模式 (HBM) 静电放电 (ESD) 分类等级 2
 - 组件充电模式 (CDM) ESD 分类等级 C6
- 低偏移误差和漂移：
 - 25°C 时为 $\pm 200\mu\text{V}$, $\pm 3\mu\text{V}/^{\circ}\text{C}$
- 固定增益 = 8.2
- 超低增益误差和漂移：
 - 25°C 时为 $\pm 0.3\%$, $\pm 50\text{ppm}/^{\circ}\text{C}$
- 超低非线性度和漂移：
 - 0.03% , $1\text{ppm}/^{\circ}\text{C}$
- 高侧和低侧以 3.3V 电压运行
- 系统级诊断 特性
- 安全相关认证：
 - 7000V_{PK} 增强型隔离, 符合 DIN V VDE-V 0884-10 (VDE-V 0884-10): 2006-12 标准
 - 符合 UL 1577 标准且长达 1 分钟的 $5000\text{V}_{\text{RMS}}$ 隔离
 - CAN/CSA No. 5A 组件验收服务通知

2 应用

- 基于分流的电流感测或基于电阻分压器的电压感测输入：
 - 牵引逆变器
 - 板载充电器 (OBC)
 - 直流-直流转换器
 - 电池管理系统 (BMS)

3 说明

AMC1301-Q1 器件是一款隔离式精密放大器, 此放大器的输出与输入电路由抗电磁干扰性能极强的隔离层隔开。根据 VDE V 0884-10 和 UL1577 标准, 该隔离栅经认证可提供高达 7kV_{PEAK} 的增强型电流隔离。当与隔离电源配合使用时, 该器件可防止共模高电压线路上的噪声电流流入本地接地并干扰或损害敏感电路。

AMC1301-Q1 器件的输入针对直接连接分流电阻器或其他低电压等级信号源的情况进行了优化。该器件性能优异, 支持精确电流控制, 从而降低系统级功耗 (尤其在电机控制应用中) 并减少扭矩纹波。该器件 (AMC1301-Q1) 的集成共模过压和高侧电源电压缺失检测特性可简化系统级设计和诊断。

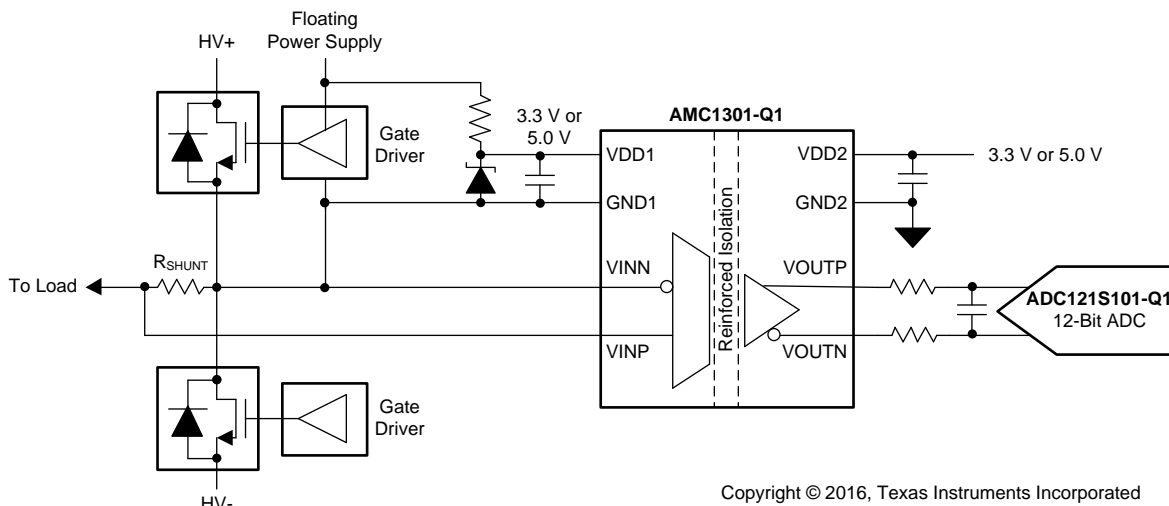
AMC1301-Q1 器件可提供宽体 8 引脚 SOIC (DWV) 封装。

器件信息⁽¹⁾

器件型号	封装	封装尺寸 (标称值)
AMC1301-Q1	SOIC (8)	5.85mm x 7.50mm

(1) 要了解所有可用封装, 请参阅数据表末尾的可订购产品附录。

简化电路原理图



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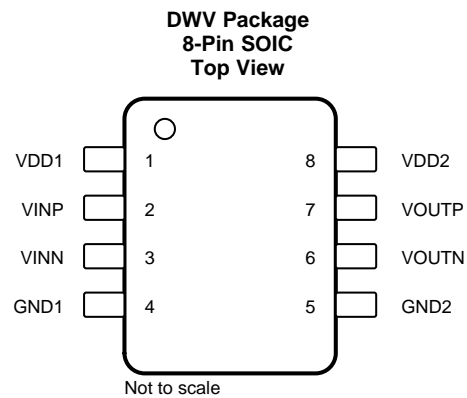
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4 修订历史记录

注：之前版本的页码可能与当前版本有所不同。

Changes from Original (April 2017) to Revision A	Page
• Changed maximum specification of <i>Supply voltage</i> row in <i>Absolute Maximum Ratings</i> table from 6.5 V to 7 V	4

5 Pin Configuration and Functions



Pin Functions

PIN		I/O	DESCRIPTION
NAME	NO.		
GND1	4	—	High-side analog ground
GND2	5	—	Low-side analog ground
VDD1	1	—	High-side power supply, 3.0 V to 5.5 V. See the Power Supply Recommendations section for decoupling recommendations.
VDD2	8	—	Low-side power supply, 3.0 V to 5.5 V. See the Power Supply Recommendations section for decoupling recommendations.
VINN	3	I	Inverting analog input
VINP	2	I	Noninverting analog input
VOUTN	6	O	Inverting analog output
VOUTP	7	O	Noninverting analog output

6 Specifications

6.1 Absolute Maximum Ratings⁽¹⁾

	MIN	MAX	UNIT
Supply voltage, VDD1 to GND1 or VDD2 to GND2	−0.3	7	V
Analog input voltage at VINP, VINN	GND1 − 6	VDD1 + 0.5	V
Input current to any pin except supply pins	−10	10	mA
Junction temperature, T _J		150	°C
Storage temperature, T _{stg}	−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.

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	±1000	

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

6.3 Recommended Operating Conditions

over operating ambient temperature range (unless otherwise noted)

		MIN	NOM	MAX	UNIT
VDD1	High-side supply voltage (VDD1 to GND1)	3.0	5.0	5.5	V
VDD2	Low-side supply voltage (VDD2 to GND2)	3.0	3.3	5.5	V
T _A	Operating ambient temperature	−40		125	°C

6.4 Thermal Information

THERMAL METRIC ⁽¹⁾		AMC1301-Q1	UNIT
		DWV (SOIC)	
		8 PINS	
R _{θJA}	Junction-to-ambient thermal resistance	110.1	°C/W
R _{θJC(top)}	Junction-to-case (top) thermal resistance	51.7	°C/W
R _{θJB}	Junction-to-board thermal resistance	66.4	°C/W
Ψ _{JT}	Junction-to-top characterization parameter	16.0	°C/W
Ψ _{JB}	Junction-to-board characterization parameter	64.5	°C/W
R _{θJC(bot)}	Junction-to-case (bottom) thermal resistance	N/A	°C/W

(1) For more information about traditional and new thermal metrics, see *Semiconductor and IC Package Thermal Metrics*, [SPRA953](#).

6.5 Power Ratings

PARAMETER		TEST CONDITIONS	VALUE	UNIT
P _D	Maximum power dissipation (both sides)	VDD1 = VDD2 = 5.5 V	81.4	mW
P _{D1}	Maximum power dissipation (high-side supply)		45.65	mW
P _{D2}	Maximum power dissipation (low-side supply)		35.75	mW

6.6 Insulation Specifications

over operating ambient temperature range (unless otherwise noted)

PARAMETER		TEST CONDITIONS	VALUE	UNIT
GENERAL				
CLR	External clearance ⁽¹⁾	Shortest pin-to-pin distance through air	≥ 9	mm
CPG	External creepage ⁽¹⁾	Shortest pin-to-pin distance across the package surface	≥ 9	mm
DTI	Distance through insulation	Minimum internal gap (internal clearance) of the double insulation (2 × 0.0135 mm)	≥ 0.027	mm
CTI	Comparative tracking index	DIN EN 60112 (VDE 0303-11); IEC 60112	≥ 600	V
	Material group	According to IEC 60664-1	I	
	Overvoltage category per IEC 60664-1	Rated mains voltage ≤ 300 V _{RMS}	I-IV	
		Rated mains voltage ≤ 600 V _{RMS}	I-III	
		Rated mains voltage ≤ 1000 V _{RMS}	I-II	
DIN V VDE V 0884-10 (VDE V 0884-10): 2006-12⁽²⁾				
V _{IORM}	Maximum repetitive peak isolation voltage	At ac voltage (bipolar)	1500	V _{PK}
V _{IOWM}	Maximum-rated isolation working voltage	At ac voltage (sine wave)	1000	V _{RMS}
		At dc voltage	1500	V _{DC}
V _{IOTM}	Maximum transient isolation voltage	V _{TEST} = V _{IOTM} , t = 60 s (qualification test)	7000	V _{PK}
		V _{TEST} = 1.2 × V _{IOTM} , t = 1 s (100% production test)	8400	
V _{IOSM}	Maximum surge isolation voltage ⁽³⁾	Test method per IEC 60065, 1.2/50-μs waveform, V _{TEST} = 1.6 × V _{IOSM} = 10000 V _{PK} (qualification)	6250	V _{PK}
q _{pd}	Apparent charge ⁽⁴⁾	Method a, after input/output safety test subgroup 2 / 3, V _{ini} = V _{IOTM} , t _{ini} = 60 s, V _{pd(m)} = 1.2 × V _{IORM} = 1800 V _{PK} , t _m = 10 s	≤ 5	pC
		Method a, after environmental tests subgroup 1, V _{ini} = V _{IOTM} , t _{ini} = 60 s, V _{pd(m)} = 1.6 × V _{IORM} = 2400 V _{PK} , t _m = 10 s	≤ 5	
		Method b1, at routine test (100% production) and preconditioning (type test), V _{ini} = V _{IOTM} , t _{ini} = 1 s, V _{pd(m)} = 1.875 × V _{IORM} = 2812.5 V _{PK} , t _m = 1 s	≤ 5	
C _{IO}	Barrier capacitance, input to output ⁽⁵⁾	V _{IO} = 0.5 V _{PP} at 1 MHz	1.2	pF
R _{IO}	Insulation resistance, input to output ⁽⁵⁾	V _{IO} = 500 V at T _S = 150°C	> 10 ⁹	Ω
	Pollution degree		2	
	Climatic category		40/125/21	
UL1577				
V _{ISO}	Withstand isolation voltage	V _{TEST} = V _{ISO} = 5000 V _{RMS} or 7000 V _{DC} , t = 60 s (qualification), V _{TEST} = 1.2 × V _{ISO} = 6000 V _{RMS} , t = 1 s (100% production test)	5000	V _{RMS}

- (1) Apply creepage and clearance requirements according to the specific equipment isolation standards of an application. Care must be taken to maintain the creepage and clearance distance of a board design to ensure that the mounting pads of the isolator on the printed circuit board (PCB) do not reduce this distance. Creepage and clearance on a PCB become equal in certain cases. Techniques such as inserting grooves and ribs on the PCB are used to help increase these specifications.
- (2) This coupler is suitable for *safe electrical insulation* only within the safety ratings. Compliance with the safety ratings shall be ensured by means of suitable protective circuits.
- (3) Testing is carried out in air or oil to determine the intrinsic surge immunity of the isolation barrier.
- (4) Apparent charge is electrical discharge caused by a partial discharge (pd).
- (5) All pins on each side of the barrier are tied together, creating a two-pin device.

6.7 Safety-Related Certifications

VDE	UL
Certified according to DIN V VDE V 0884-10 (VDE V 0884-10): 2006-12, DIN EN 60950-1 (VDE 0805 Teil 1): 2014-08, and DIN EN 60065 (VDE 0860): 2005-11	Recognized under 1577 component recognition and CSA component acceptance NO 5 programs
Reinforced insulation	Single protection
Certificate number: 40040142	File number: E181974

6.8 Safety Limiting Values

Safety limiting intends to prevent potential damage to the isolation barrier upon failure of input or output (I/O) circuitry. A failure of the I/O may allow low resistance to ground or the supply and, without current limiting, dissipate sufficient power to overheat the die and damage the isolation barrier, potentially leading to secondary system failures.

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
I _S Safety input, output, or supply current	$\theta_{JA} = 110.1^{\circ}\text{C/W}$, $V_I = 5.5\text{ V}$, $T_J = 150^{\circ}\text{C}$, $T_A = 25^{\circ}\text{C}$			206	mA
	$\theta_{JA} = 110.1^{\circ}\text{C/W}$, $V_I = 3.6\text{ V}$, $T_J = 150^{\circ}\text{C}$, $T_A = 25^{\circ}\text{C}$			315	
P _S Safety input, output, or total power	$\theta_{JA} = 110.1^{\circ}\text{C/W}$, $T_J = 150^{\circ}\text{C}$, $T_A = 25^{\circ}\text{C}$			1135 ⁽¹⁾	mW
T _S Maximum safety temperature				150	°C

(1) Input, output, or the sum of input and output power must not exceed this value.

The maximum safety temperature is the maximum junction temperature specified for the device. The power dissipation and junction-to-air thermal impedance of the device installed in the application hardware determines the junction temperature. The assumed junction-to-air thermal resistance in the [Thermal Information](#) table is that of a device installed on a high-K test board for leaded surface-mount packages. The power is the recommended maximum input voltage times the current. The junction temperature is then the ambient temperature plus the power times the junction-to-air thermal resistance.

6.9 Electrical Characteristics

Minimum and maximum specifications apply from $T_A = -40^{\circ}\text{C}$ to $+125^{\circ}\text{C}$, $V_{DD1} = 3.0\text{ V}$ to 5.5 V , $V_{DD2} = 3.0\text{ V}$ to 5.5 V , $V_{INP} = -250\text{ mV}$ to $+250\text{ mV}$, and $V_{INN} = 0\text{ V}$. Typical specifications are at $T_A = 25^{\circ}\text{C}$, $V_{DD1} = 5\text{ V}$, and $V_{DD2} = 3.3\text{ V}$ (unless otherwise noted).

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
ANALOG INPUT					
V _{Clipping} Differential input voltage before clipping output	V _{INP} – V _{INN}		±302.7		mV
V _{F_{SR}} Specified linear differential full-scale	V _{INP} – V _{INN}	–250		250	mV
V _{CM} Specified common-mode input voltage	(V _{INP} + V _{INN}) / 2 to GND1	–0.16	V _{DD1} – 2.1		V
	Absolute common-mode input voltage ⁽¹⁾	–2		V _{DD1}	V
V _{CMov} Common-mode overvoltage detection level		V _{DD1} – 2			V
V _{OS} Input offset voltage	Initial, at $T_A = 25^{\circ}\text{C}$, V _{INP} = V _{INN} = GND1	–200	±50	200	μV
TCV _{OS} Input offset drift		–3	±1	3	μV/°C
CMRR Common-mode rejection ratio	$f_{IN} = 0\text{ Hz}$, $V_{CM\ min} \leq V_{CM} \leq V_{CM\ max}$		–93		dB
	$f_{IN} = 10\text{ kHz}$, $V_{CM\ min} \leq V_{CM} \leq V_{CM\ max}$		–93		
C _{IND} Differential input capacitance			1		pF
R _{IN} Single-ended input resistance	V _{INN} = GND1		18		kΩ
R _{IND} Differential input resistance			22		kΩ
I _{IB} Input bias current	V _{INP} = V _{INN} = GND1	–82	–60	–48	μA
TCI _{IB} Input bias current drift			1		nA/°C
BW _{IN} Input bandwidth			1000		kHz

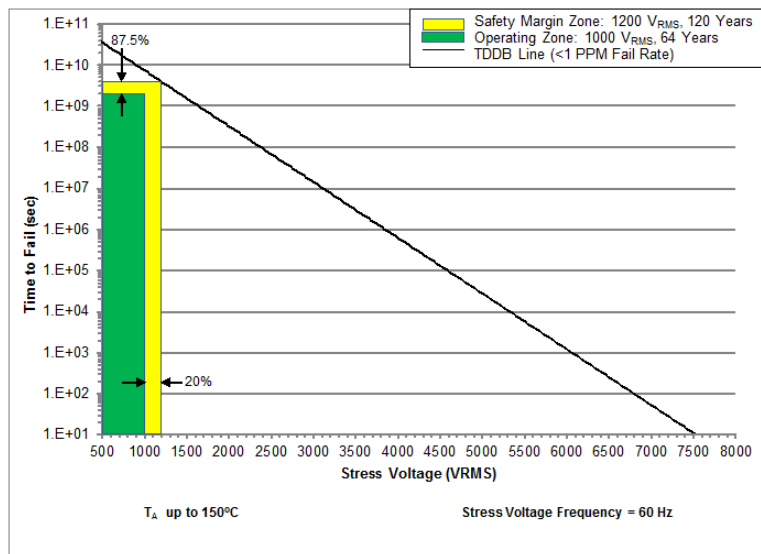
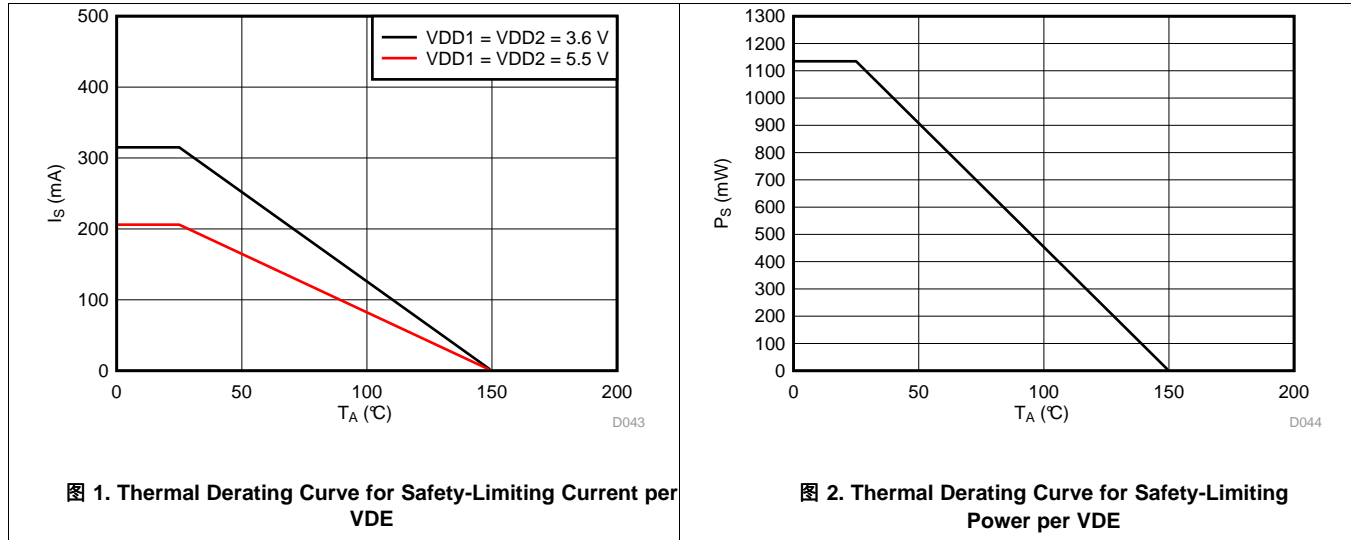
(1) Steady-state voltage supported by the device in case of a system failure. See specified common-mode input voltage V_{CM} for normal operation. Observe analog input voltage range as specified in [Absolute Maximum Ratings](#).

Electrical Characteristics (continued)

Minimum and maximum specifications apply from $T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$, $V_{DD1} = 3.0\text{ V}$ to 5.5 V , $V_{DD2} = 3.0\text{ V}$ to 5.5 V , $V_{INP} = -250\text{ mV}$ to $+250\text{ mV}$, and $V_{INN} = 0\text{ V}$. Typical specifications are at $T_A = 25^\circ\text{C}$, $V_{DD1} = 5\text{ V}$, and $V_{DD2} = 3.3\text{ V}$ (unless otherwise noted).

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
ANALOG OUTPUT						
	Nominal gain			8.2		
E_G	Gain error	Initial, at $T_A = 25^\circ\text{C}$	-0.3%	$\pm 0.05\%$	0.3%	
TCE_G	Gain error drift		-50	± 15	50	ppm/ $^\circ\text{C}$
	Nonlinearity		-0.03%	$\pm 0.01\%$	0.03%	
	Nonlinearity drift			1		ppm/ $^\circ\text{C}$
THD	Total harmonic distortion	$f_{IN} = 10\text{ kHz}$		-87		dB
	Output noise	$V_{INP} = V_{INN} = \text{GND1}$, $f_{IN} = 0\text{ Hz}$, $\text{BW} = 100\text{ kHz}$		220		μV_{RMS}
SNR	Signal-to-noise ratio	$f_{IN} = 1\text{ kHz}$, $\text{BW} = 10\text{ kHz}$	80	84		dB
		$f_{IN} = 10\text{ kHz}$, $\text{BW} = 100\text{ kHz}$		71		
PSRR	Power-supply rejection ratio	vs V_{DD1} , at dc		-94		dB
		vs V_{DD1} , 100-mV and 10-kHz ripple		-90		
		vs V_{DD2} , at dc		-100		
		vs V_{DD2} , 100-mV and 10-kHz ripple		-94		
t_r	Rise time	See Figure 45		2.0		μs
t_f	Fall time	See Figure 45		2.0		μs
	V_{IN} to V_{OUT} signal delay (50% – 10%)	See Figure 46 , unfiltered output		0.7	2.0	μs
	V_{IN} to V_{OUT} signal delay (50% – 50%)	See Figure 46 , unfiltered output		1.6	2.6	μs
	V_{IN} to V_{OUT} signal delay (50% – 90%)	See Figure 46 , unfiltered output		2.5	3.0	μs
CMTI	Common-mode transient immunity	$ \text{GND1} - \text{GND2} = 1\text{ kV}$	15			kV/ μs
V_{CMout}	Common-mode output voltage		1.39	1.44	1.49	V
	Output short-circuit current			± 13		mA
R_{OUT}	Output resistance	on V_{OUTP} or V_{OUTN}		< 0.2		Ω
BW	Output bandwidth		190	210		kHz
V_{FAILSAFE}	Failsafe differential output voltage	$V_{\text{CM}} \geq V_{\text{CMov}}$, or V_{DD1} missing	-2.563	-2.545		V
POWER SUPPLY						
I_{DD1}	High-side supply current	$3.0\text{ V} \leq V_{\text{DD1}} \leq 3.6\text{ V}$		5.0	6.9	mA
		$4.5\text{ V} \leq V_{\text{DD1}} \leq 5.5\text{ V}$		5.9	8.3	
I_{DD2}	Low-side supply current	$3.0\text{ V} \leq V_{\text{DD2}} \leq 3.6\text{ V}$		4.4	5.6	mA
		$4.5\text{ V} \leq V_{\text{DD2}} \leq 5.5\text{ V}$		4.8	6.5	
P_{DD1}	High-side power dissipation	$3.0\text{ V} \leq V_{\text{DD1}} \leq 3.6\text{ V}$		16.5	24.84	mW
		$4.5\text{ V} \leq V_{\text{DD1}} \leq 5.5\text{ V}$		29.5	45.65	
P_{DD2}	Low-side power dissipation	$3.0\text{ V} \leq V_{\text{DD2}} \leq 3.6\text{ V}$		14.52	20.16	mW
		$4.5\text{ V} \leq V_{\text{DD2}} \leq 5.5\text{ V}$		24	35.75	

6.10 Insulation Characteristics Curves



6.11 Typical Characteristics

at VDD1 = 5 V, VDD2 = 3.3 V, VINP = -250 mV to 250 mV, VINN = 0 V, and f_{IN} = 10 kHz (unless otherwise noted)

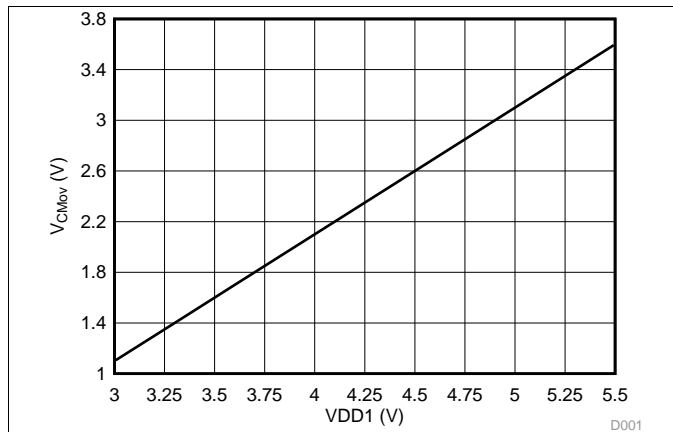


图 4. Common-Mode Overtolerance Detection Level vs High-Side Supply Voltage

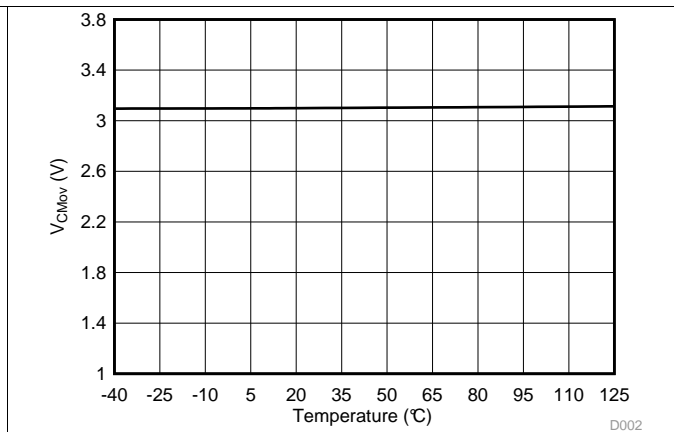


图 5. Common-Mode Overtolerance Detection Level vs Temperature

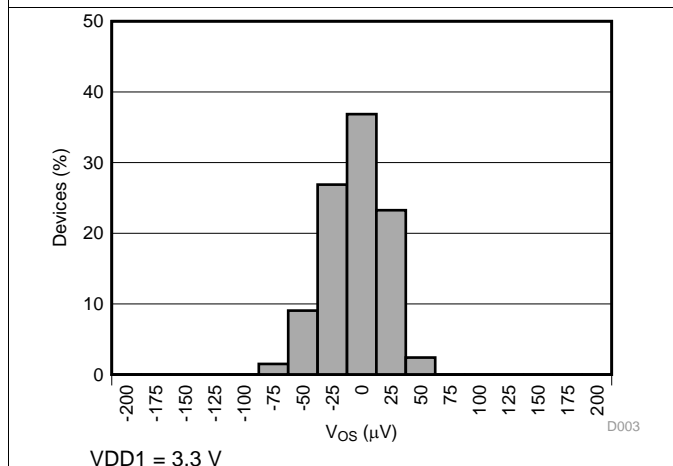


图 6. Input Offset Voltage Histogram

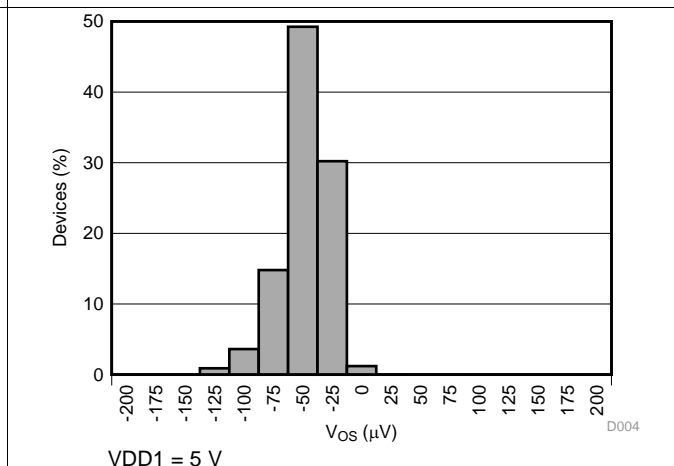


图 7. Input Offset Voltage Histogram

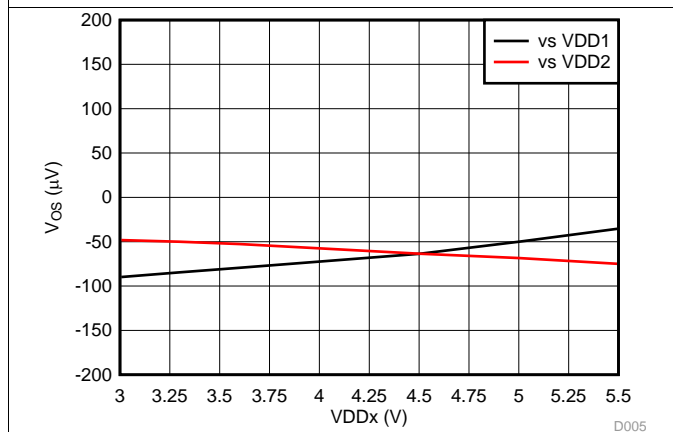


图 8. Input Offset Voltage vs Supply Voltage

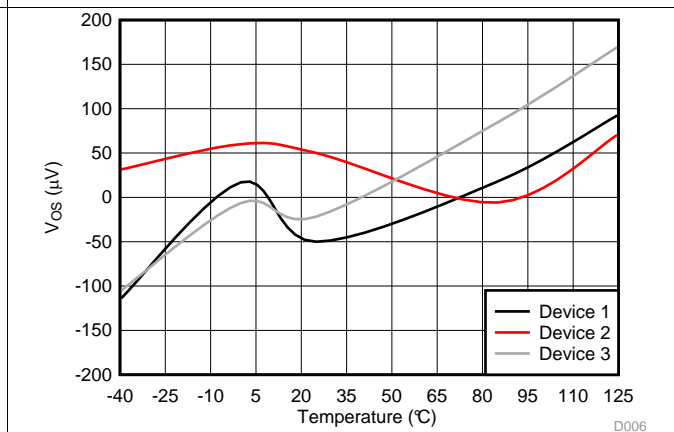
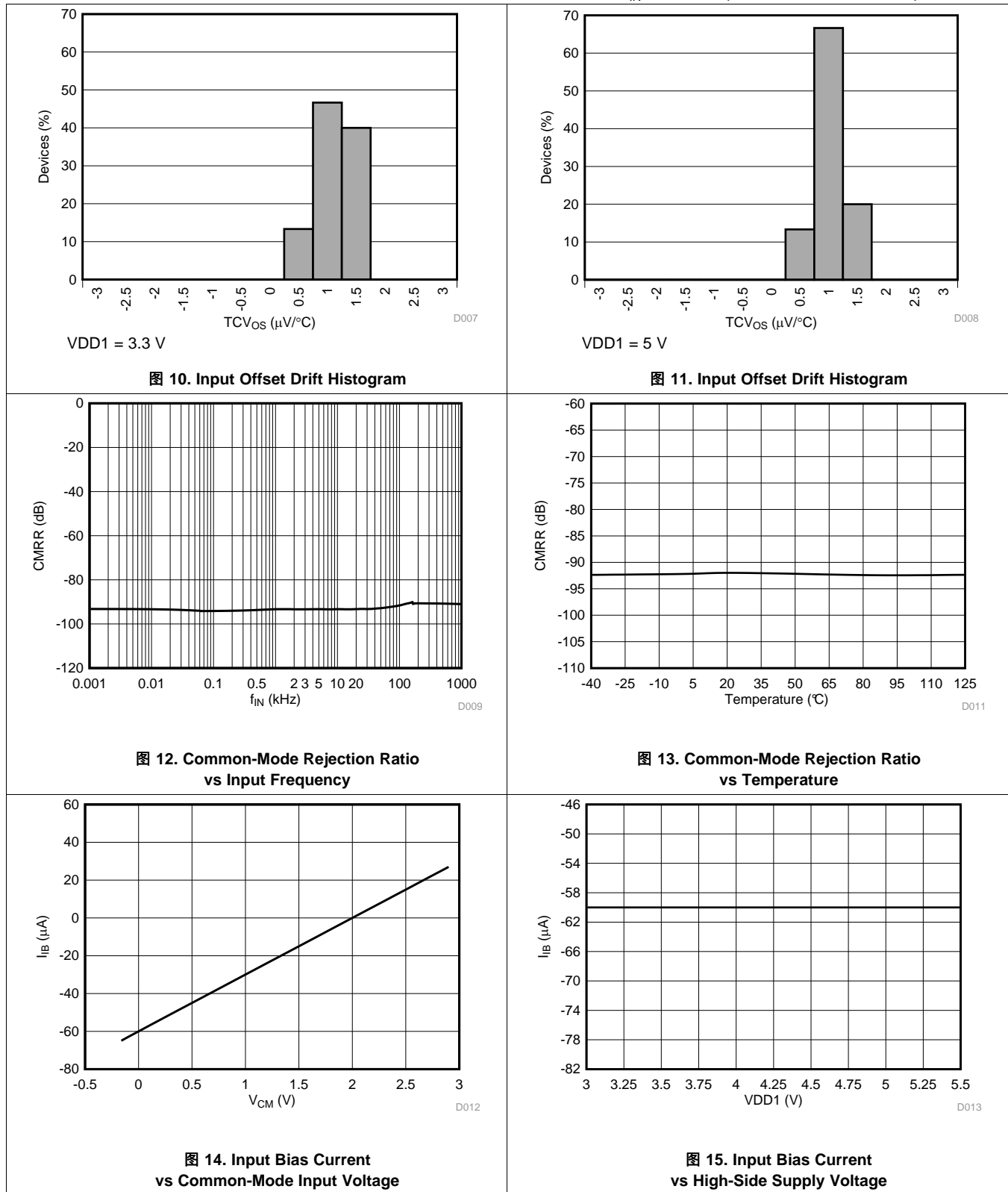


图 9. Input Offset Voltage vs Temperature

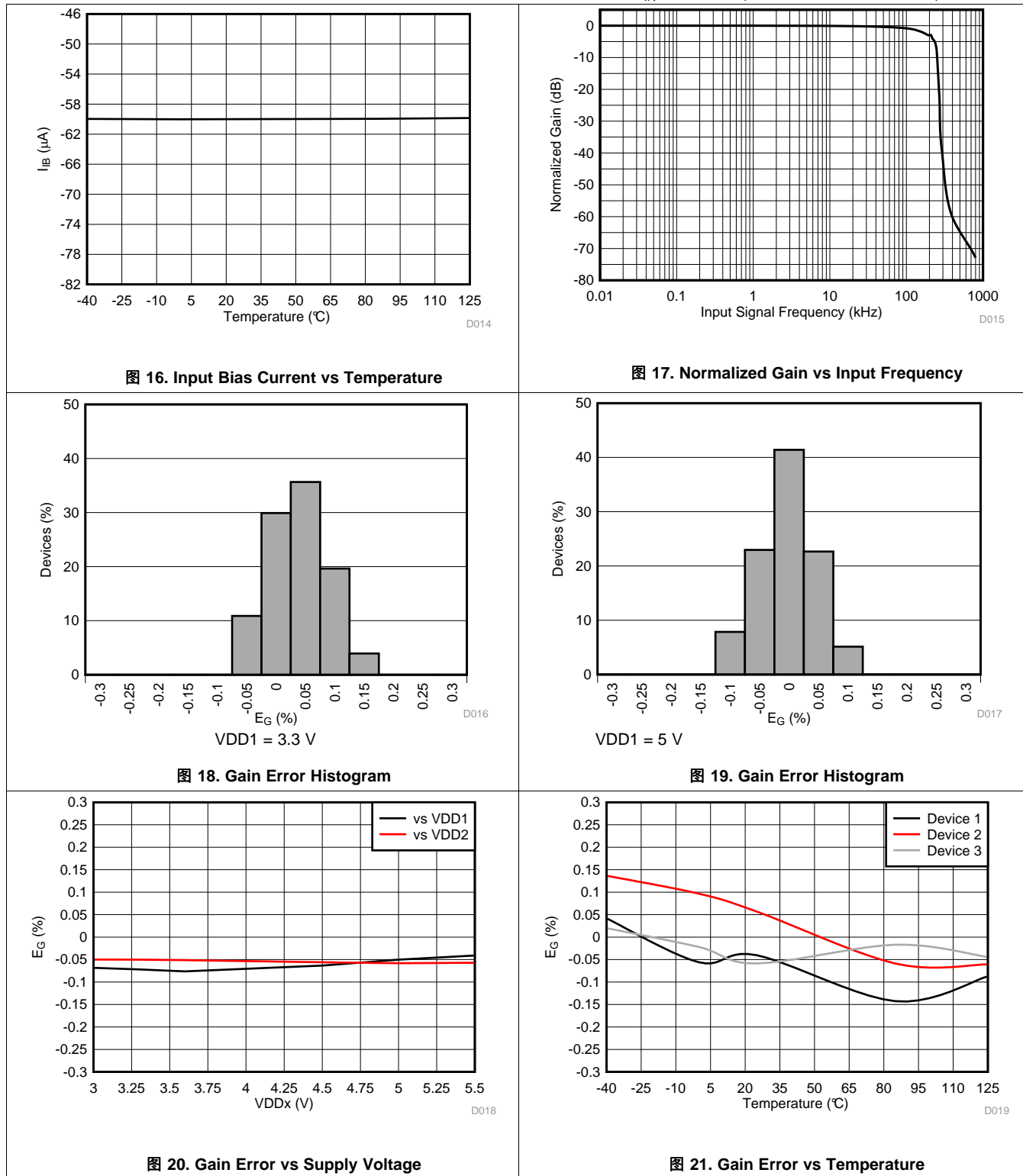
Typical Characteristics (接下页)

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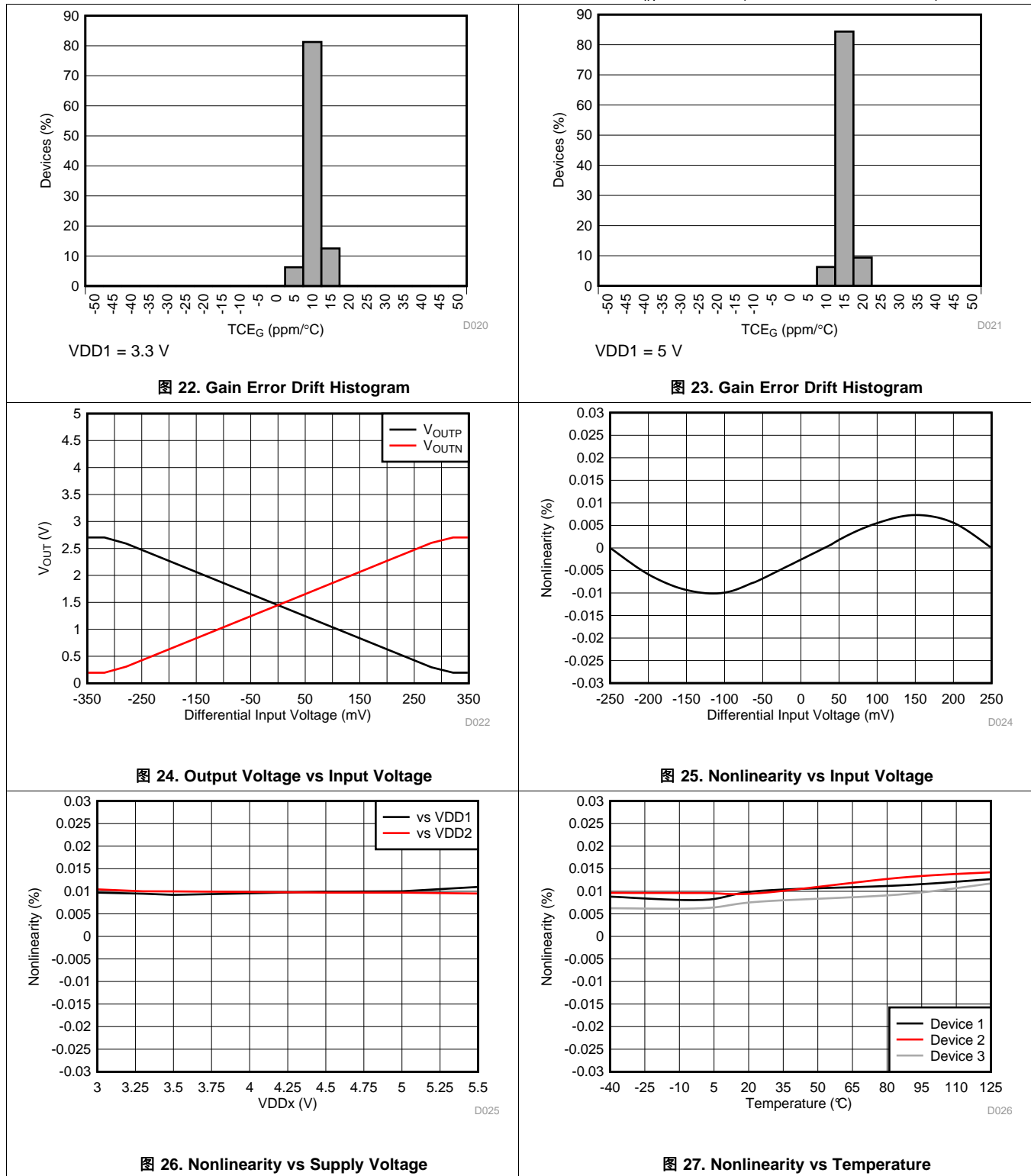
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Typical Characteristics (接下页)

at VDD1 = 5 V, VDD2 = 3.3 V, VINP = -250 mV to 250 mV, VINN = 0 V, and $f_{IN} = 10$ kHz (unless otherwise noted)

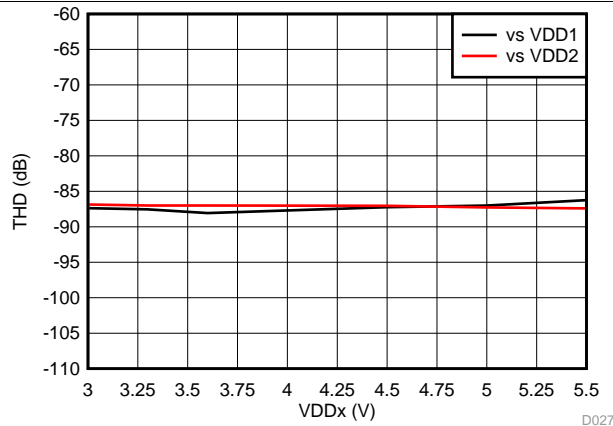


图 28. Total Harmonic Distortion vs Supply Voltage

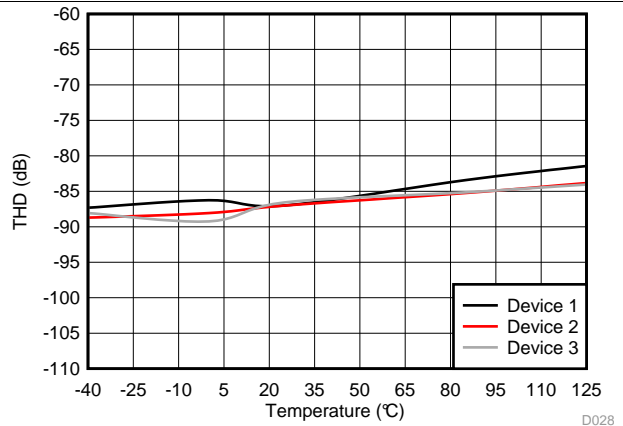


图 29. Total Harmonic Distortion vs Temperature

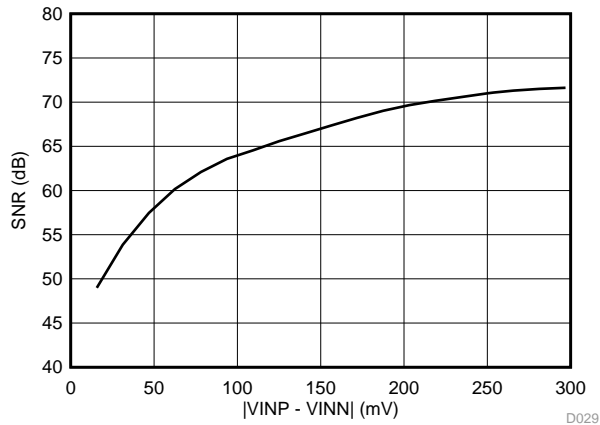


图 30. Signal-to-Noise Ratio vs Input Voltage

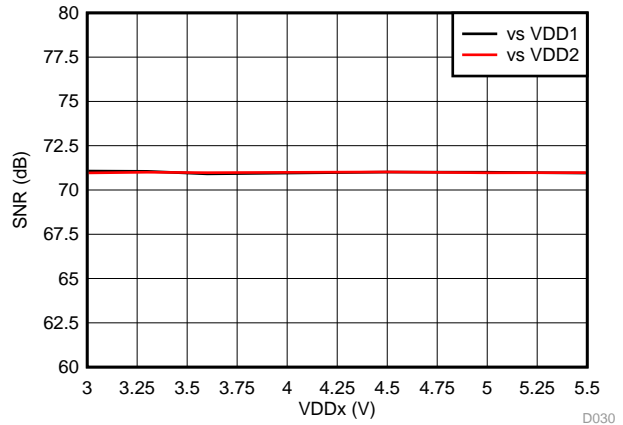


图 31. Signal-to-Noise Ratio vs Supply Voltage

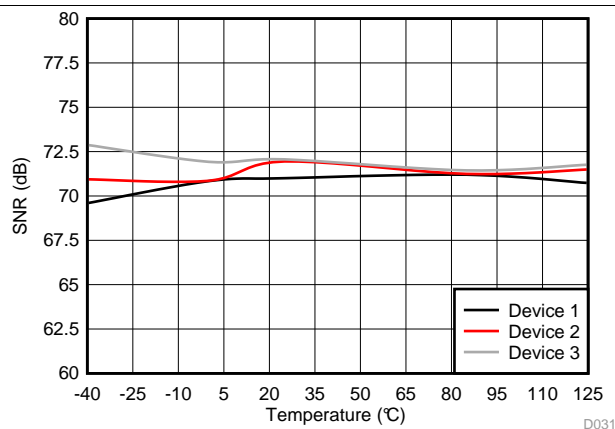


图 32. Signal-to-Noise Ratio vs Temperature

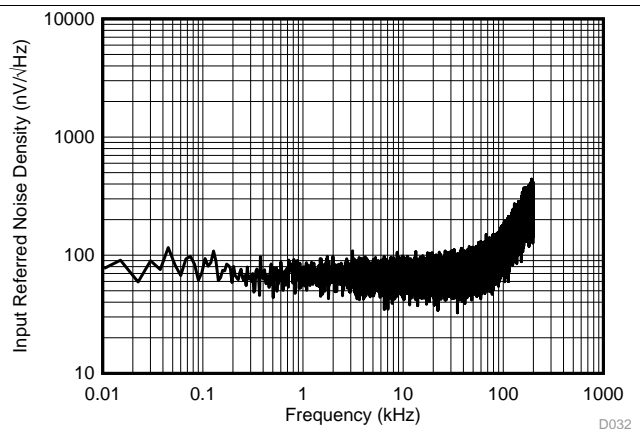


图 33. Input-Referred Noise Density vs Frequency

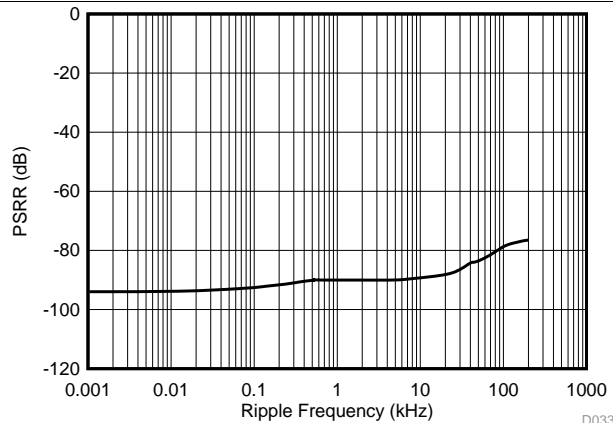
AMC1301-Q1

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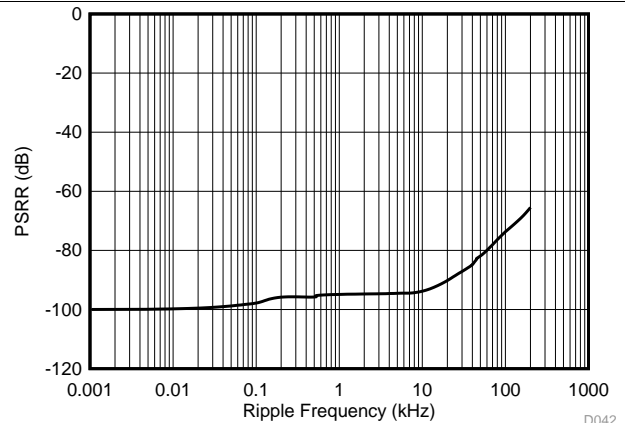
Typical Characteristics (接下页)

at VDD1 = 5 V, VDD2 = 3.3 V, VINP = -250 mV to 250 mV, VINN = 0 V, and f_{IN} = 10 kHz (unless otherwise noted)



vs VDD1

图 34. Power-Supply Rejection Ratio vs Ripple Frequency



vs VDD2

图 35. Power-Supply Rejection Ratio vs Ripple Frequency

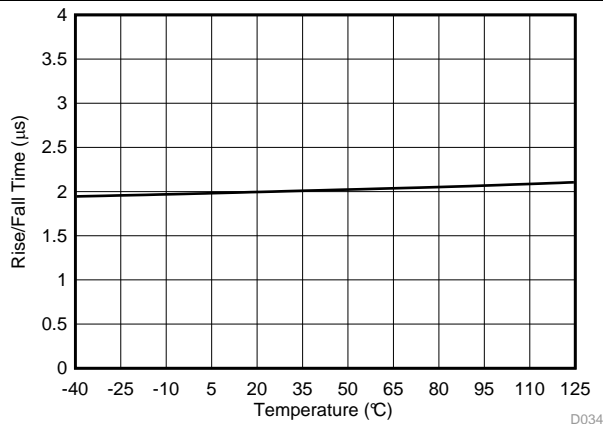


图 36. Output Rise and Fall Time vs Temperature

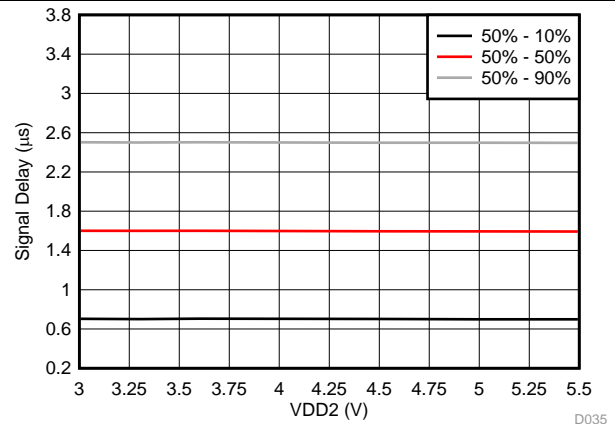


图 37. V_{IN} to V_{OUT} Signal Delay vs Low-Side Supply Voltage

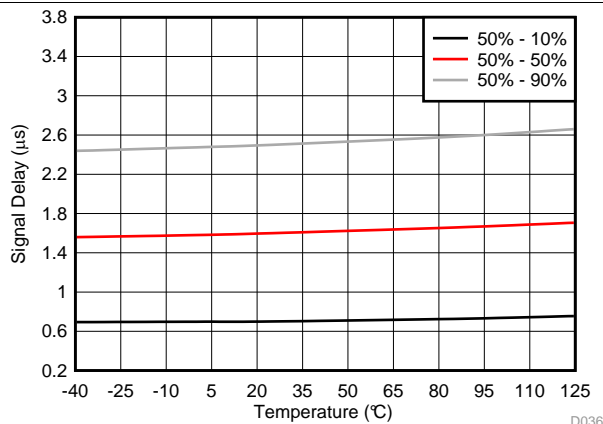


图 38. V_{IN} to V_{OUT} Signal Delay vs Temperature

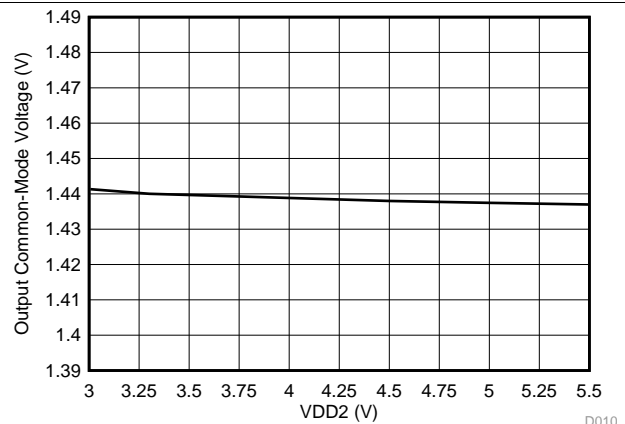


图 39. Output Common-Mode Voltage vs Low-Side Supply Voltage

Typical Characteristics (接下页)

at VDD1 = 5 V, VDD2 = 3.3 V, VINP = -250 mV to 250 mV, VINN = 0 V, and f_{IN} = 10 kHz (unless otherwise noted)

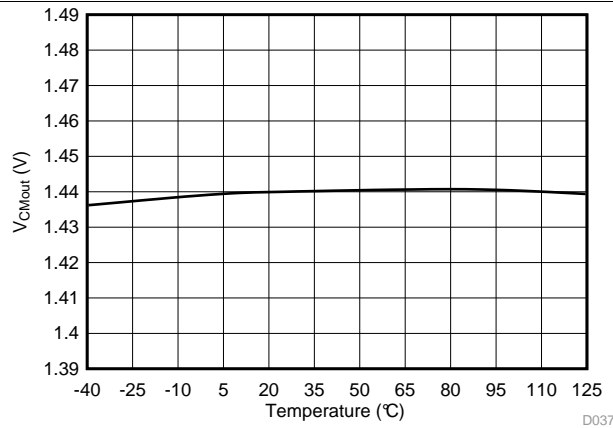


图 40. Output Common-Mode Voltage vs Temperature

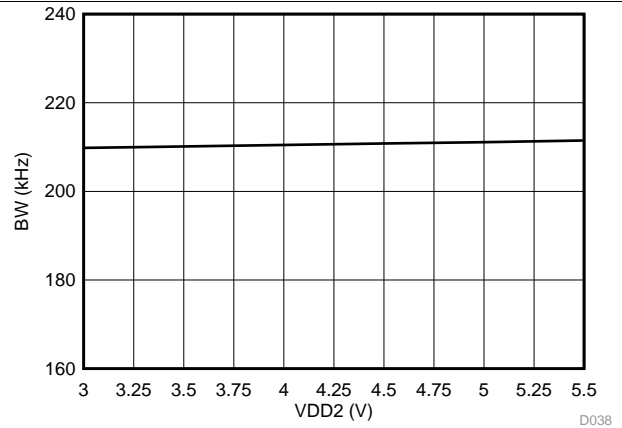


图 41. Output Bandwidth vs Low-Side Supply Voltage

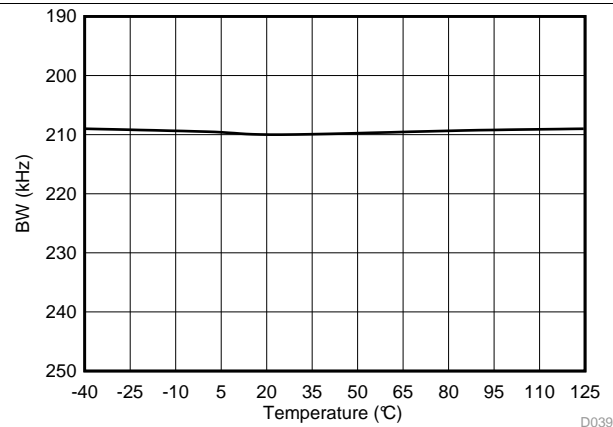


图 42. Output Bandwidth vs Temperature

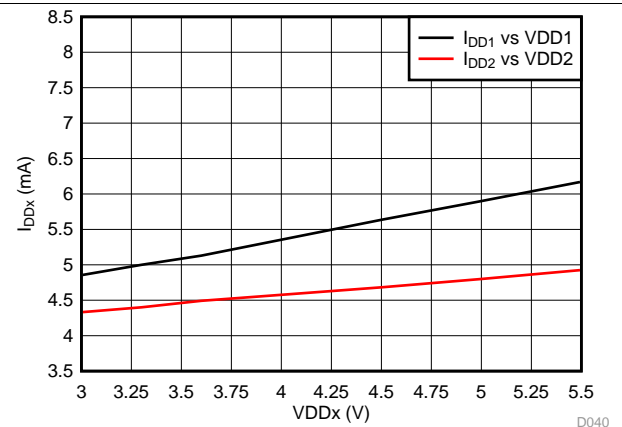


图 43. Supply Current vs Supply Voltage

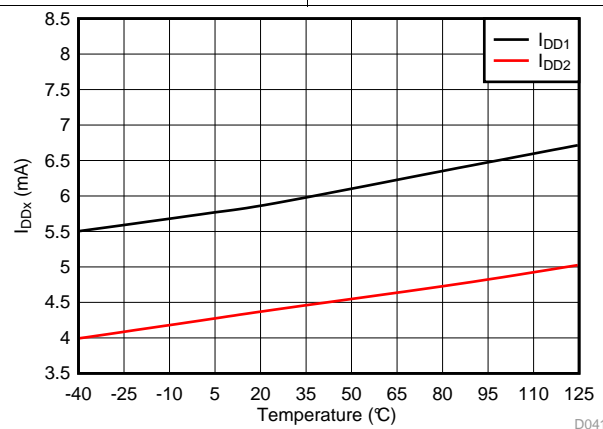


图 44. Supply Current vs Temperature

7 Parameter Measurement Information

7.1 Timing Diagrams

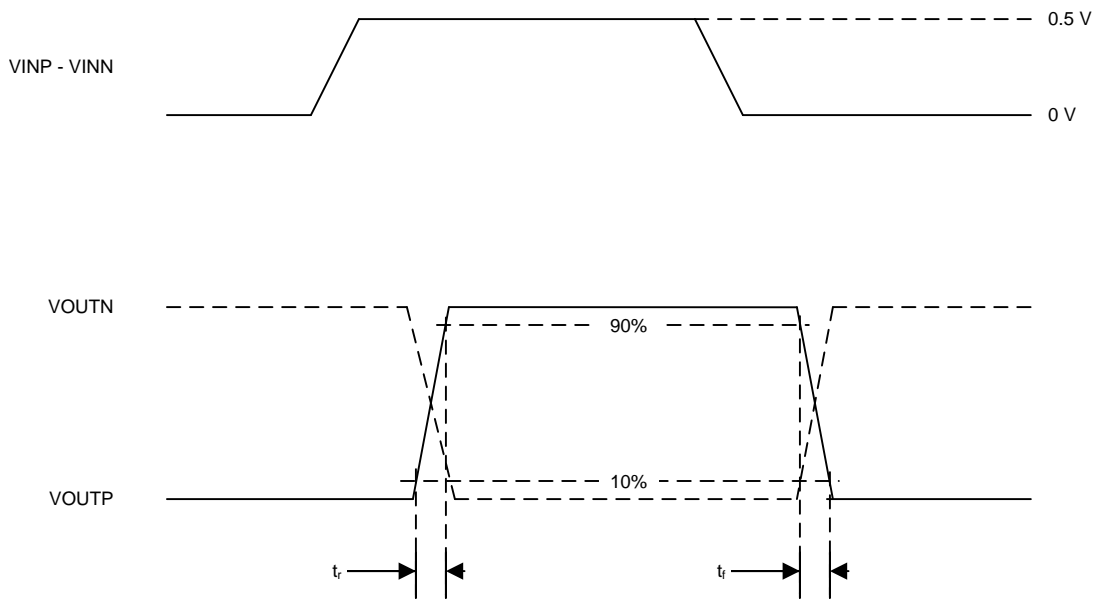


图 45. Rise and Fall Time Test Waveforms

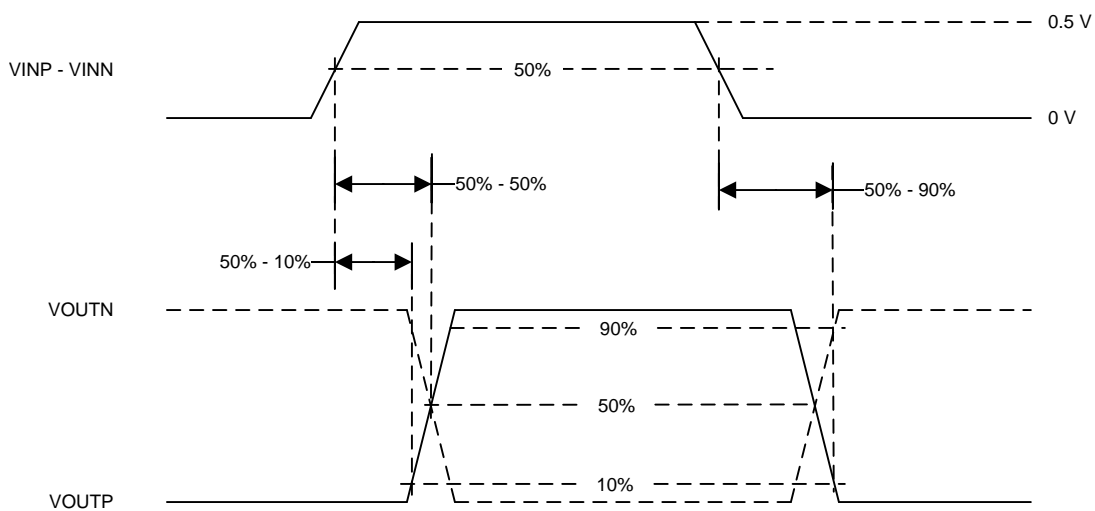


图 46. Delay Time Test Waveforms

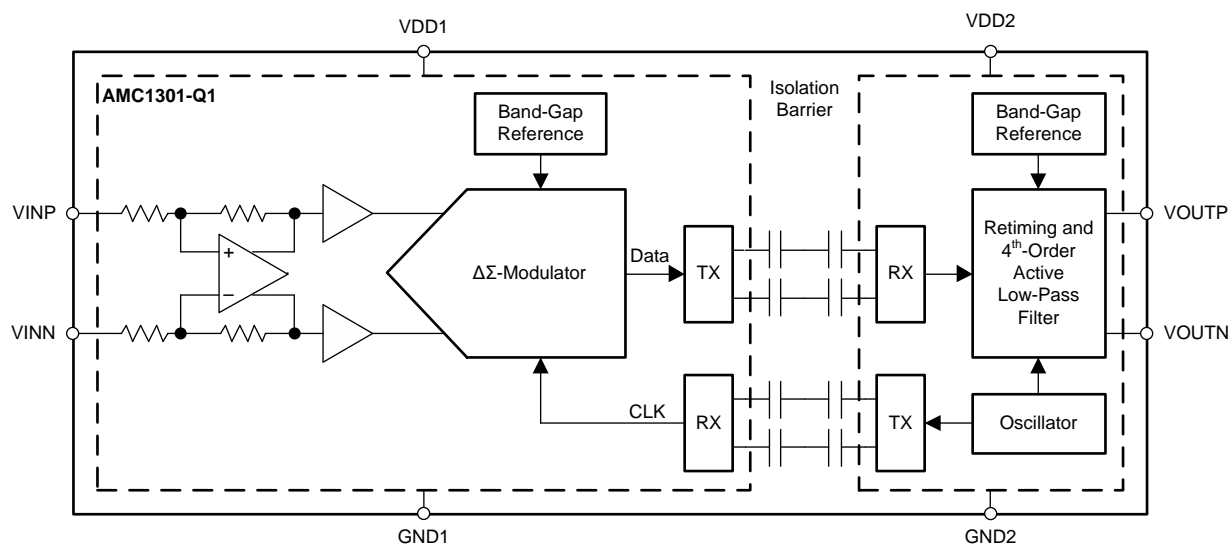
8 Detailed Description

8.1 Overview

The AMC1301-Q1 device is a fully-differential, precision, isolated amplifier. The input stage of the device consists of a fully-differential amplifier that drives a second-order, delta-sigma ($\Delta\Sigma$) modulator. The modulator uses the internal voltage reference and clock generator to convert the analog input signal to a digital bitstream. The drivers (called TX in the [Functional Block Diagram](#)) transfer the output of the modulator across the isolation barrier that separates the high-side and low-side voltage domains. The received bitstream and clock are synchronized and processed by a fourth-order analog filter on the low-side and presented as a differential output of the device, as shown in the [Functional Block Diagram](#).

The SiO₂-based, double-capacitive isolation barrier supports a high level of magnetic field immunity, as described in [ISO72x Digital Isolator Magnetic-Field Immunity](#). The digital modulation used in the AMC1301-Q1 device and the isolation barrier characteristics result in high reliability and common-mode transient immunity.

8.2 Functional Block Diagram



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8.3 Feature Description

8.3.1 Analog Input

The AMC1301-Q1 device incorporates front-end circuitry that contains a fully-differential amplifier followed by a $\Delta\Sigma$ modulator sampling stage. The gain of the differential amplifier is set by internal precision resistors to a factor of 4 with a differential input impedance of 22 k Ω . Consider the input impedance of the AMC1301-Q1 device in designs with high-impedance signal sources that may cause degradation of gain and offset specifications. The importance of this effect, however, depends on the desired system performance.

Additionally, the input bias current caused by the internal common-mode voltage at the output of the differential amplifier causes an offset that is dependent on the actual amplitude of the input signal. See the [Isolated Voltage Sensing](#) section for more details on reducing this effect.

There are two restrictions on the analog input signals (VINP and VINN). First, if the input voltage exceeds the range GND1 – 6 V to VDD1 + 0.5 V, then the input current must be limited to 10 mA because the device input electrostatic discharge (ESD) protection turns on. In addition, the linearity and noise performance of the device are ensured only when the analog input voltage remains within the specified linear full-scale range (FSR) and within the specified common-mode input voltage range.

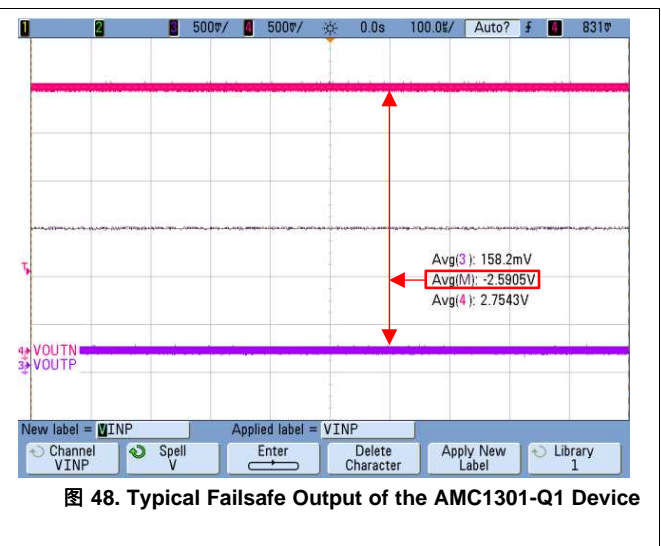
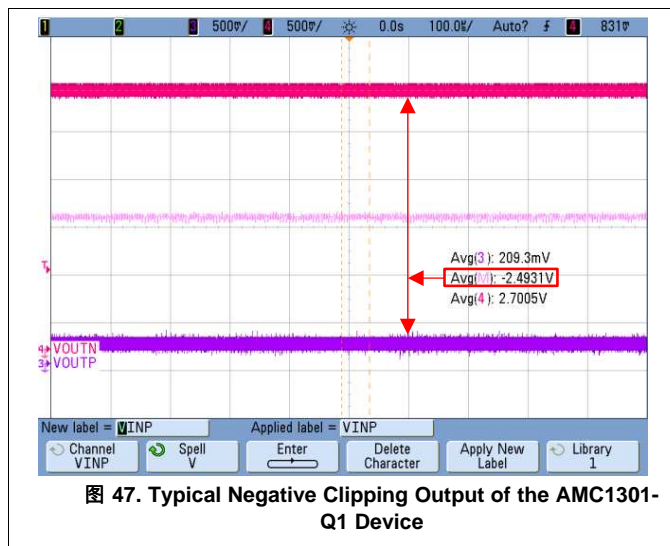
Feature Description (接下页)

8.3.2 Fail-Safe Output

The AMC1301-Q1 device offers a fail-safe output that simplifies diagnostics on system level. The fail-safe output is active in two cases:

- When the high-side supply VDD1 of the AMC1301-Q1 device is missing, or
- When the common-mode input voltage, that is $V_{CM} = (VINP + VINN) / 2$, exceeds the minimum common-mode over-voltage detection level V_{CMov} of $VDD1 - 2\text{ V}$.

The fail-safe output of the AMC1301-Q1 device is a negative differential output voltage value that differs from the negative clipping output voltage, as shown in 图 47 and 图 48. As a reference value for the fail-safe detection on a system level, use the $V_{FAILSAFE}$ maximum value of -2.545 V .



8.4 Device Functional Modes

The AMC1301-Q1 device is operational when the power supplies VDD1 and VDD2 are applied, as specified in [Recommended Operating Conditions](#).

9 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.

9.1 Application Information

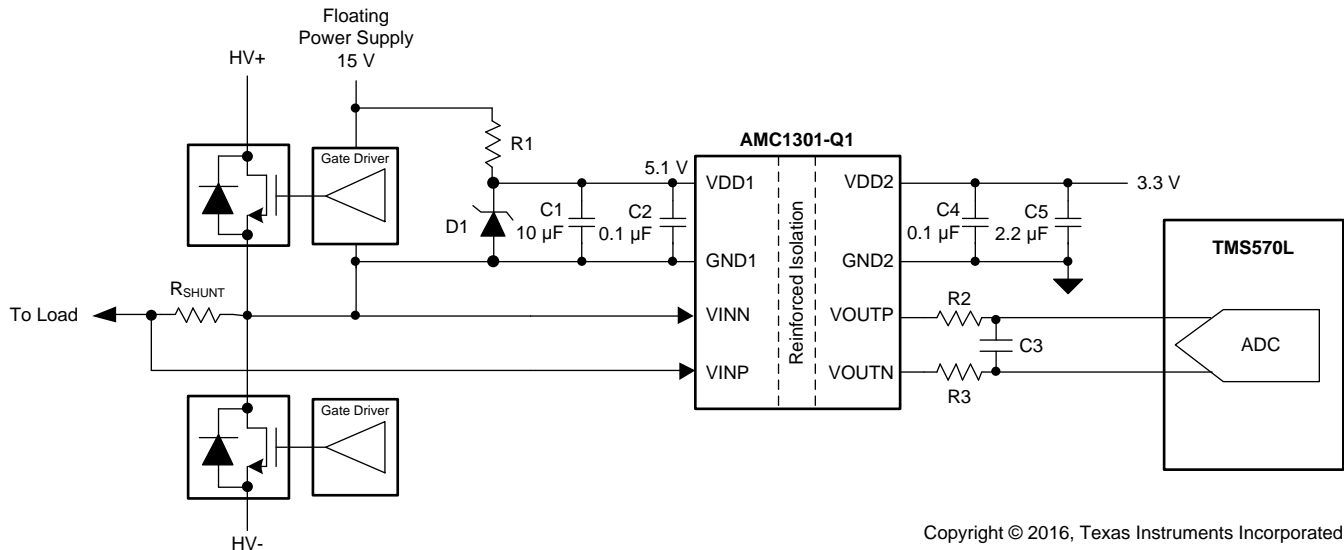
The AMC1301-Q1 device offers unique linearity, high input common-mode and power-supply rejection, low ac and dc errors, and low temperature drift. These features make the AMC1301-Q1 device a robust, high-performance, isolated amplifier for automotive applications where high voltage isolation is required.

9.2 Typical Applications

9.2.1 Traction Inverter Application

图 49 shows a typical operation of the AMC1301-Q1 device for current sensing in a traction inverter application. Phase current measurement is done through the shunt resistor, R_{SHUNT} (in this case, a two-pin shunt). The differential input and the high common-mode transient immunity of the AMC1301-Q1 device ensure reliable and accurate operation even in high-noise environments (such as the power stage of the traction inverter).

Additionally, the AMC1301-Q1 device may also be used for isolated voltage measurement of the dc-link, as described in [Isolated Voltage Sensing](#).



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图 49. Using the AMC1301-Q1 Device for Current Sensing in Traction Inverters

Typical Applications (接下页)

9.2.1.1 Design Requirements

表 1 lists the parameters for the typical application in 图 49.

表 1. Design Requirements

PARAMETER	VALUE
High-side supply voltage	3.3 V or 5 V
Low-side supply voltage	3.3 V or 5 V
Voltage drop across the shunt for a linear response	± 250 mV (maximum)

9.2.1.2 Detailed Design Procedure

The high-side power supply (VDD1) for the AMC1301-Q1 device is derived from the power supply of the upper gate driver. Further details are provided in the [Power Supply Recommendations](#) section.

The floating ground reference (GND1) is derived from one of the ends of the shunt resistor that is connected to the negative input of the AMC1301-Q1 device (VINN). If a four-pin shunt is used, the inputs of the AMC1301-Q1 device are connected to the inner leads and GND1 is connected to one of the outer shunt leads.

Use Ohm's Law to calculate the voltage drop across the shunt resistor (V_{SHUNT}) for the desired measured current: $V_{SHUNT} = I \times R_{SHUNT}$.

Consider the following two restrictions to choose the proper value of the shunt resistor R_{SHUNT} :

- The voltage drop caused by the nominal current range must not exceed the recommended differential input voltage range: $V_{SHUNT} \leq \pm 250 \text{ mV}$
- The voltage drop caused by the maximum allowed overcurrent must not exceed the input voltage that causes a clipping output: $V_{SHUNT} \leq V_{Clipping}$

For best performance, use an RC filter (components R_2 , R_3 , and C_3 in 图 49) to minimize the noise of the differential output signal. Tailor the bandwidth of this RC filter to the bandwidth requirement of the system. TI recommends an NP0-type capacitor to be used for C_3 .

For more information on the general procedure to design the filtering and driving stages of SAR ADCs, consult the TI Precision Designs [18-Bit, 1MSPS Data Acquisition Block \(DAQ\) Optimized for Lowest Distortion and Noise](#) (SLAU515) and [18-Bit Data Acquisition Block \(DAQ\) Optimized for Lowest Power](#) (SLAU513), available for download at www.ti.com.

9.2.1.3 Application Curves

In traction inverter applications, the power switches must be protected in case of an overcurrent condition. To allow for fast powering off of the system, a low delay caused by the isolated amplifier is required. 图 50 shows the typical full-scale step response of the AMC1301-Q1 device. Consider the delay of the required window comparator and the MCU to calculate the overall response time of the system.



图 50. Step Response of the AMC1301-Q1 Device

The high linearity and low temperature drift of offset and gain errors of the AMC1301-Q1 device, as shown in 图 51, allows design of motor drives with low torque ripple.

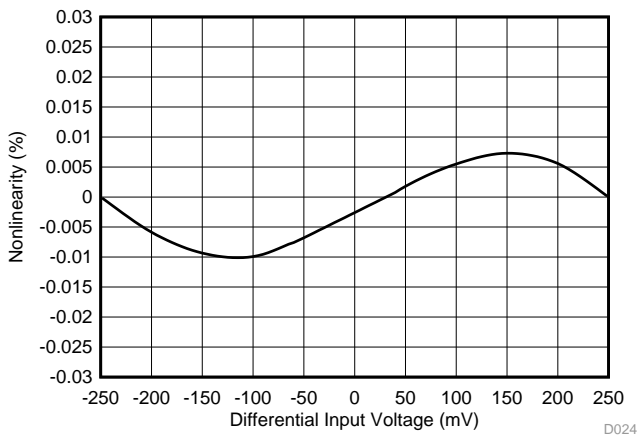
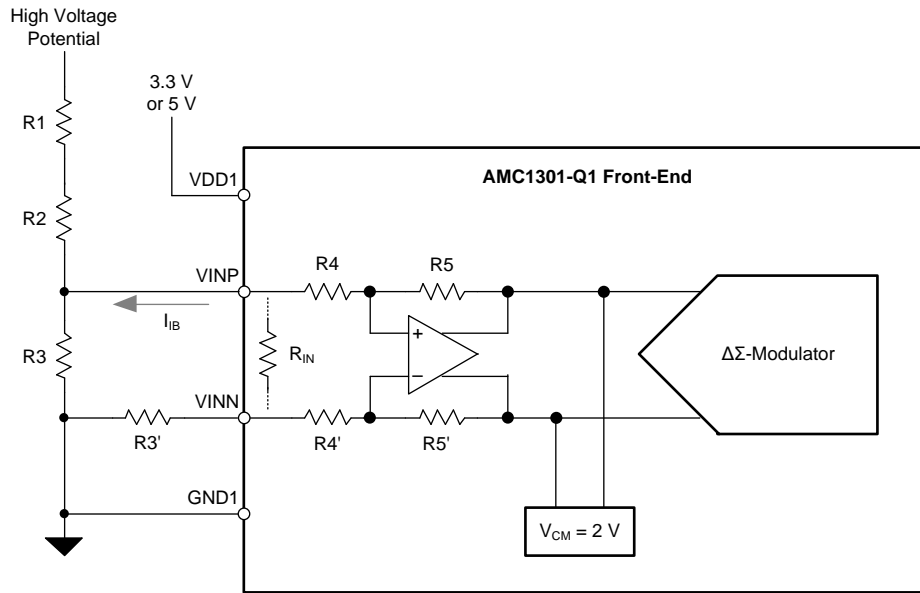


图 51. Typical Nonlinearity of the AMC1301-Q1 Device

9.2.2 Isolated Voltage Sensing

The AMC1301-Q1 device is optimized for usage in current-sensing applications using low-impedance shunts. However, the device may also be used in isolated voltage-sensing applications if the effect of the (usually higher) impedance of the resistor divider used in this case is considered.



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图 52. Using the AMC1301-Q1 Device for Isolated Voltage Sensing

9.2.2.1 Design Requirements

图 52 shows a simplified circuit typically used in high-voltage sensing applications. The high-impedance resistors (R1 and R2) dominate the current value that flows through the resistive divider. The resistance of the sensing resistor R3 is chosen to meet the input voltage range of the AMC1301-Q1 device. This resistor and the input impedance of the device ($R_{IN} = 18\text{ k}\Omega$) also create a voltage divider that results in an additional gain error. With the assumption of R1 and R2 having a considerably higher value than R3 and omitting R3' for the moment, the resulting total gain error is estimated using 公式 1, with E_G being the initial gain error of the AMC1301-Q1 device.

$$|E_{G_{tot}}| = |E_G| + \frac{R_3}{R_{IN}} \quad (1)$$

This gain error may be easily minimized during the initial system-level gain calibration procedure.

9.2.2.2 Detailed Design Procedure

As indicated in 图 52, the output of the integrated differential amplifier is internally biased to a common-mode voltage of 2 V. This voltage results in a bias current I_{IB} through the resistive network R4 and R5 (or R4' and R5') used for setting the gain of the amplifier. The value of this current is specified in the [Pin Configuration and Functions](#) section. This bias current generates additional offset and gain errors that depend on the value of the resistor R3. Because the value of this bias current depends on the actual common-mode amplitude of the input signal (as shown in 图 53), the initial system offset calibration eliminates the offset but not the gain error component. Therefore, in systems with high accuracy requirements, a series resistor is recommended to be used at the negative input (VINN) of the AMC1301-Q1 device with a value equal to the shunt resistor R3 (that is, $R3' = R3$ in 图 52) to eliminate the effect of the bias current.

This additional series resistor (R3') influences the gain error of the circuit. The effect is calculated using 公式 2 with $R4 = R4' = 12.5\text{ k}\Omega$. The effect of the internal resistors $R5 = R5'$ cancels in this calculation.

$$E_G(\%) = \left(1 - \frac{R4}{R4' + R3'}\right) * 100\% \quad (2)$$

9.2.2.3 Application Curve

图 53 shows the dependency of the input bias current on the common-mode voltage at the input of the AMC1301-Q1 device.

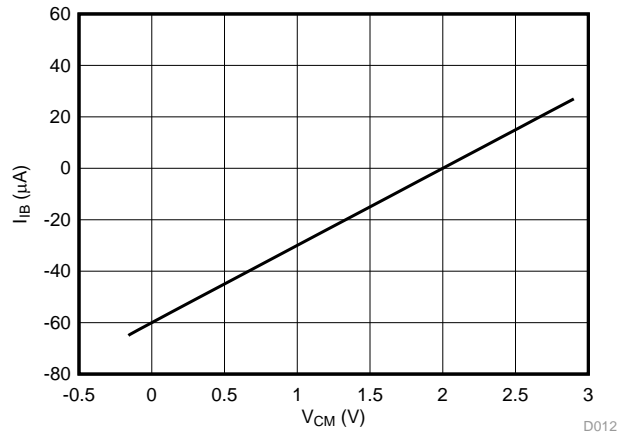


图 53. Input Current vs Input Common-Mode Voltage

9.3 Do's and Don'ts

Do not leave the inputs of the AMC1301-Q1 device unconnected (floating) when the device is powered up. If both device inputs are left floating, the input bias current drives them to the output common-mode of the analog front-end of approximately 2 V. If the high-side supply voltage V_{DD1} is below 4 V, the internal common-mode overvoltage detector turns on and the output functions as described in the [Fail-Safe Output](#) section, which may lead to an undesired reaction on the system level.

10 Power Supply Recommendations

In a typical traction inverter application, the high-side power supply (VDD1) for the device is derived from the floating power supply of the upper gate driver. For lowest cost, a Zener diode may be used to limit the voltage to 5 V (or 3.3 V, depending on the design) $\pm 10\%$. Alternatively a low-cost, low-dropout (LDO) regulator (for example, the [LP2951-XX-Q1](#)) may be used to minimize noise on the power supply. TI recommends a low-ESR decoupling capacitor of 0.1 μF to filter this power-supply path. Place this capacitor (C_2 in [图 54](#)) as close as possible to the VDD1 pin of the AMC1301-Q1 device for best performance. If better filtering is required, an additional 10- μF capacitor may be used. The floating ground reference (GND1) is derived from the end of the shunt resistor, which is connected to the negative input (VINN) of the device. If a four-pin shunt is used, the device inputs are connected to the inner leads, and GND1 is connected to one of the outer leads of the shunt.

To decouple the digital power supply on the controller side, use a 0.1- μF capacitor placed as close to the VDD2 pin of the AMC1301-Q1 device as possible, followed by an additional capacitor from 1 μF to 10 μF .

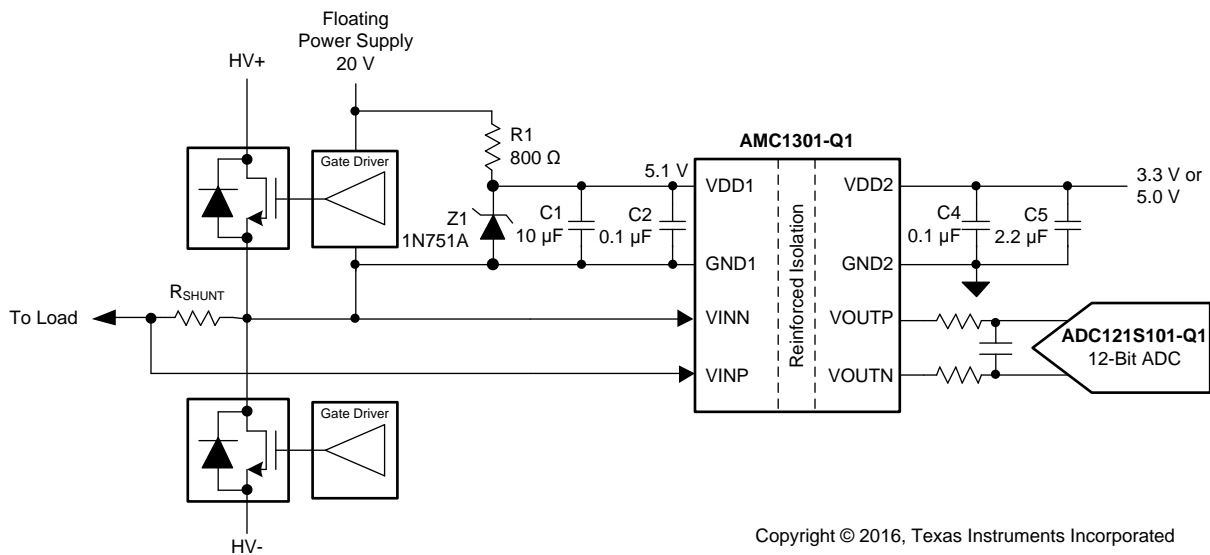


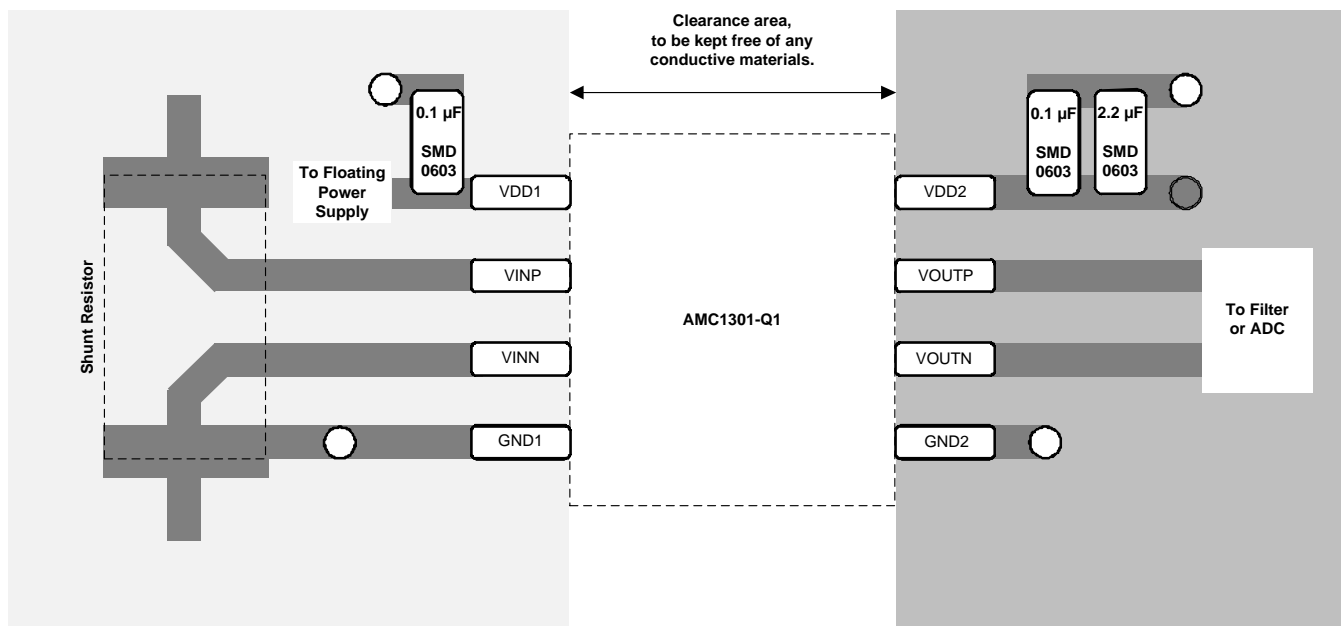
图 54. Zener-Diode-Based, High-Side Power Supply

11 Layout

11.1 Layout Guidelines

A layout recommendation showing the critical placement of the decoupling capacitors (as close as possible to the AMC1301-Q1 device) and placement of the other components required by the device is shown in 图 55. For best performance, place the shunt resistor close to the VINP and VINN inputs of the AMC1301-Q1 device and keep the layout of both connections symmetrical.

11.2 Layout Example



LEGEND

- Copper Pour and Traces
- High-Side Area
- Low-Side Area
- Via to Ground Plane
- Via to Supply Plane

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图 55. Recommended Layout of the AMC1301-Q1 Device

12 器件和文档支持

12.1 文档支持

12.1.1 相关文档

相关文档如下：

- [隔离相关术语](#)
- [《ADC121S101-Q1 单通道、0.5 至 1Msps、12 位模数转换器》](#)
- [《具有关断功能的 LP2951-xx-Q1 可调微功耗电压稳压器》](#)
- [《TMS570LS0232 16 和 32 位 RISC 闪存微控制器》](#)
- [《ISO72x 数字隔离器磁场抗扰度》](#)
- [《针对最低失真和最低噪声进行优化的 18 位 1MSPS 数据采集模块 \(DAQ\)》](#)
- [《针对最低功耗进行优化的 18 位 1MSPS 数据采集模块 \(DAQ\)》](#)

12.2 接收文档更新通知

要接收文档更新通知，请导航至 ti.com 上的器件产品文件夹。请单击右上角的 [通知我](#) 进行注册，即可收到任意产品信息更改每周摘要。有关更改的详细信息，请查看任意已修订文档中包含的修订历史记录。

12.3 社区资源

The following links connect to TI community resources. Linked contents are 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](#).

TI E2E™ Online Community *TI's Engineer-to-Engineer (E2E) Community*. Created to foster collaboration among engineers. At e2e.ti.com, you can ask questions, share knowledge, explore ideas and help solve problems with fellow engineers.

Design Support *TI's Design Support* Quickly find helpful E2E forums along with design support tools and contact information for technical support.

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ESD 的损坏小至导致微小的性能降级，大至整个器件故障。精密的集成电路可能更容易受到损坏，这是因为非常细微的参数更改都可能会导致器件与其发布的规格不相符。

12.6 Glossary



[SLYZ022](#) — *TI Glossary*.

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

13 机械、封装和可订购信息

以下页面包括机械、封装和可订购信息。这些信息是指定器件的最新可用数据。这些数据发生变化时，我们可能不会另行通知或修订此文档。如欲获取此产品说明书的浏览器版本，请参见左侧的导航栏。

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
AMC1301QDWVQ1	ACTIVE	SOIC	DWV	8	64	RoHS & Green	NIPDAU	Level-3-260C-168 HR	-40 to 125	1301Q1	
AMC1301QDWVRQ1	ACTIVE	SOIC	DWV	8	1000	RoHS & Green	NIPDAU	Level-3-260C-168 HR	-40 to 125	1301Q1	

(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.

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OTHER QUALIFIED VERSIONS OF AMC1301-Q1 :

- Catalog : [AMC1301](#)

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product

TAPE AND REEL INFORMATION

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
AMC1301QDWVRQ1	SOIC	DWV	8	1000	330.0	16.4	12.05	6.15	3.3	16.0	16.0	Q1

TAPE AND REEL BOX DIMENSIONS


*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
AMC1301QDWVRQ1	SOIC	DWV	8	1000	350.0	350.0	43.0

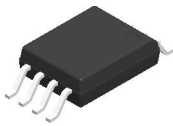
TUBE


*All dimensions are nominal

Device	Package Name	Package Type	Pins	SPQ	L (mm)	W (mm)	T (μm)	B (mm)
AMC1301QDWVQ1	DWV	SOIC	8	64	505.46	13.94	4826	6.6

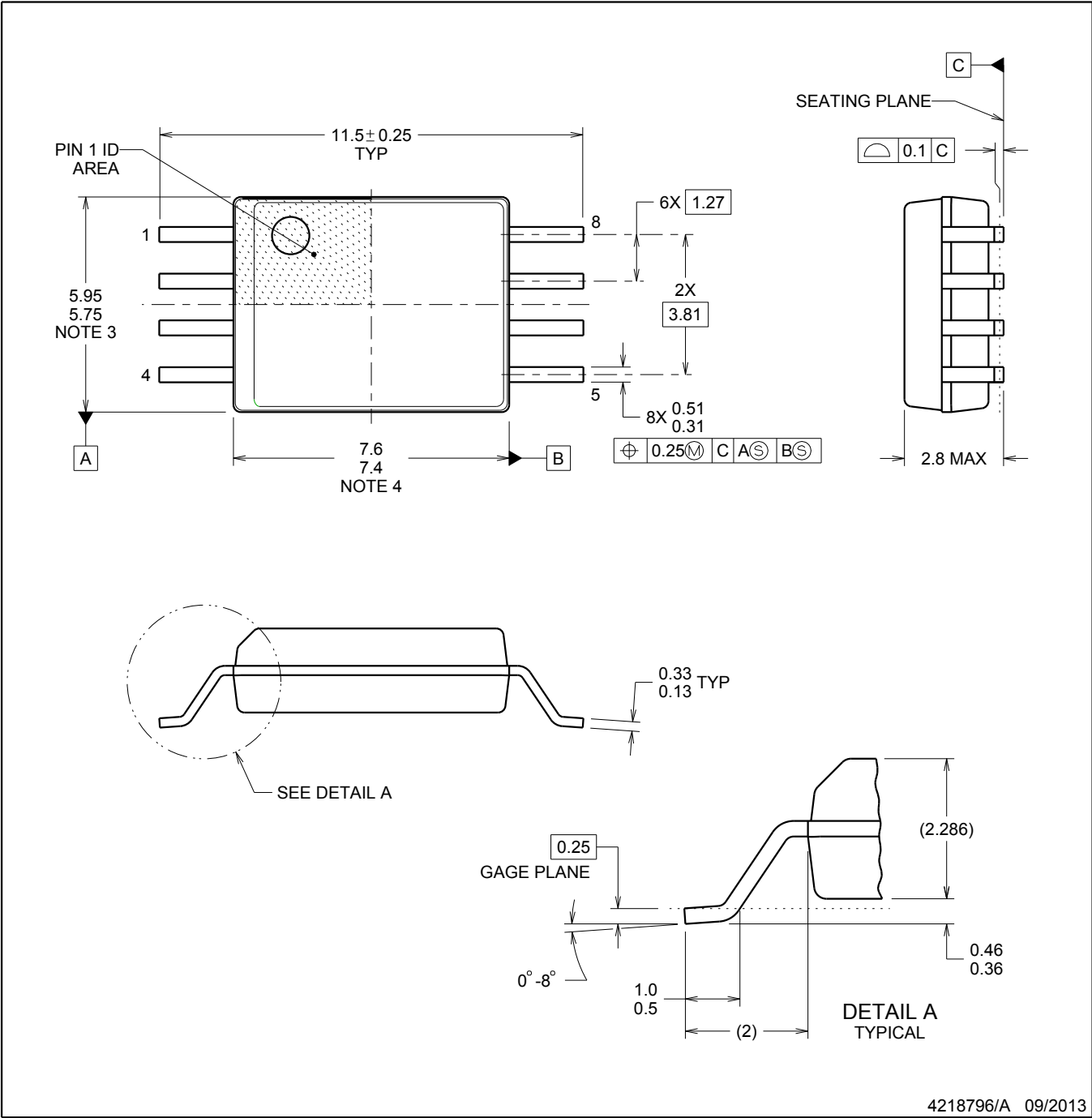
PACKAGE OUTLINE

DWV0008A



SOIC - 2.8 mm max height

SOIC



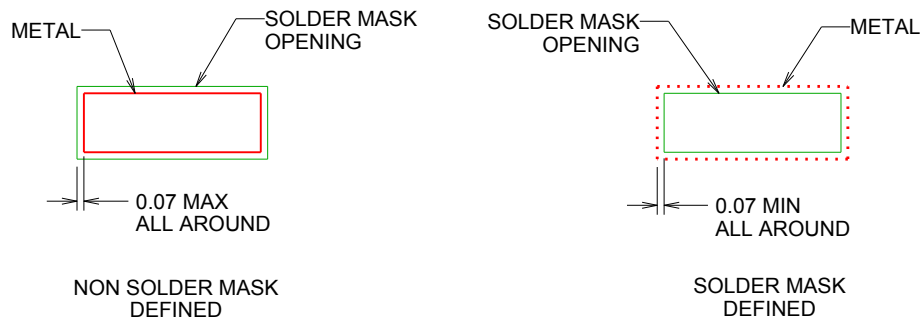
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NOTES:

1. All linear dimensions are in millimeters. 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.



LAND PATTERN EXAMPLE
9.1 mm NOMINAL CLEARANCE/CREEPAGE
SCALE:6X

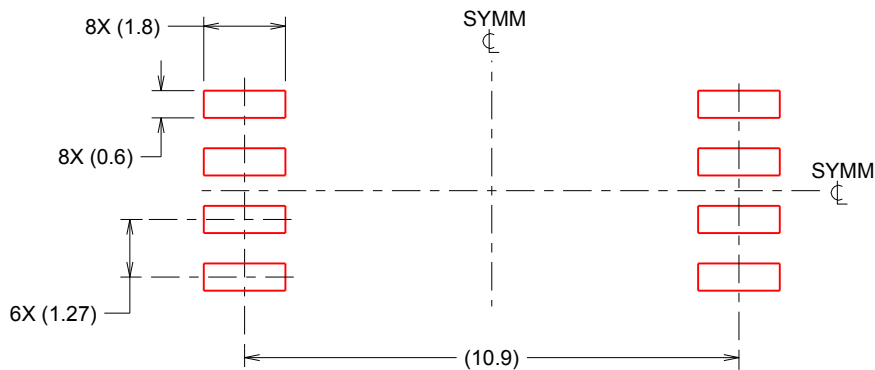


SOLDER MASK DETAILS

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NOTES: (continued)

- 5. Publication IPC-7351 may have alternate designs.
- 6. 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:6X

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NOTES: (continued)

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

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