AMC1302 高精度、±50mV 入力、強化絶縁型アンプ

1 特長

- シャント抵抗による電流測定用に最適化された ±50mV の入力電圧範囲
- 固定ゲイン:41
- 小さな DC 誤差:
  - オフセット誤差:±50µV (最大値)
  - オフセット・ドリフト:±0.8µV/℃ (最大値)
  - ゲイン誤差:±0.2% (最大値)
  - ゲイン・ドリフト:±35ppm/℃ (最大値)
  - 非線形性:0.03% (最大値)
- ハイサイド、ローサイドとも 3.3V または 5V で動作可能
- フェイルセーフ出力
- 高 CMTI:100kV/µs (最小値)
- 低 EMI、CISPR-11 および CISPR-25 規格に準拠
- 安全関連の認証:
  - DIN VDE V 0884-11 に準拠した強化絶縁耐圧 $7071V_{PK}$:2017-01
  - UL 1577 に準拠した絶縁耐圧:$5000V_{RMS}$ (1 分間)
- 拡張産業用温度範囲全体にわたって仕様を完全に規定:–40℃～+125℃

2 アプリケーション

- 次の用途における絶縁型電流センシング:
  - 保護リレー
  - モーター・ドライブ
  - 電源
  - 太陽光発電インバータ

3 概要

AMC1302 は高精度の絶縁型アンプで、磁気干渉に対して高い耐性のある絶縁バリアを使用し、入力側と出力側の回路を分離しています。この絶縁バリアは、VDE V 0884-11 および UL1577 に従って最大 $5kV_{RMS}$ の強化ガルバニック絶縁を達成していることが認証されており、最大 $1.5kV_{RMS}$ の使用電圧に対応しています。

この絶縁バリアは、異なる同相電圧レベルで動作するシステム領域を分離し、危険な電圧と損傷から低電圧側を保護します。

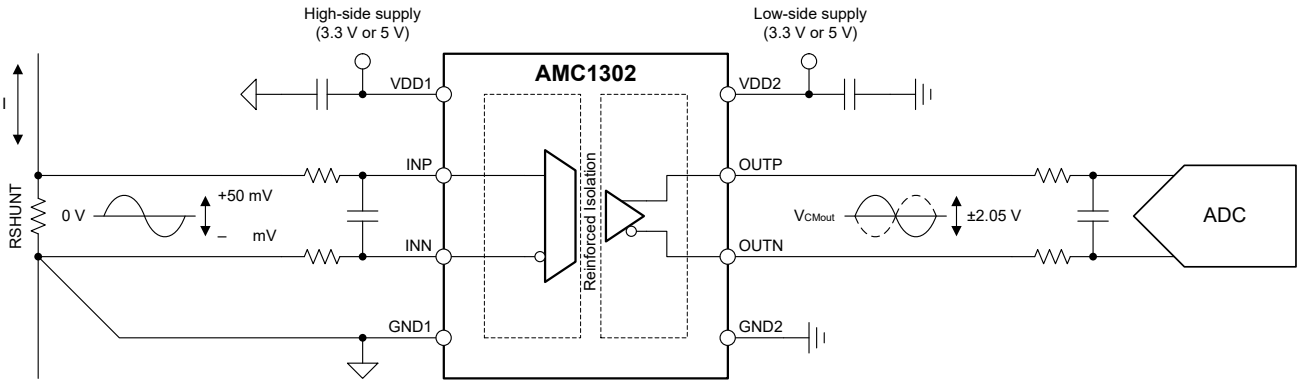
AMC1302 の入力は、低インピーダンスのシャント抵抗またはその他の信号レベルが小さい低インピーダンス電圧源と直接接続できるように最適化されています。優れた DC 精度と小さい温度ドリフトにより、車載用温度範囲全体 (–40℃～+125℃) にわたって、PFC 段、DC/DC コンバータ、AC モーター、サーボドライブの高精度電流制御に対応できます。

シャント喪失およびハイサイド電源喪失検出機能を内蔵しているため、システム・レベルの設計と診断が簡単に行えます。

製品情報(1)

部品番号	パッケージ	本体サイズ (公称)
AMC1302	SOIC (8)	5.85mm × 7.50mm

(1) 利用可能なすべてのパッケージについては、このデータシートの末尾にある注文情報を参照してください。



代表的なアプリケーション

Table of Contents

4 Revision History

資料番号末尾の英字は改訂を表しています。その改訂履歴は英語版に準じています。

Changes from Revision C (October 2019) to Revision D (June 2021) — **Page**

- *文書全体にわたって表、図、相互参照の採番方法を更新* ... 1
- Changed C_{IO} from ~1 pF to ~1.5 pF ... 6
- Changed V_{OS} from –100 µV / ±10 µV / 100 µV to –50 µV / ±2.5 µV / 50 µV (min / typ / max) ... 8
- Changed E_G from –0.3% / ±0.05% / 0.3% to –0.2% / ±0.04% / 0.2% (min / typ / max) ... 8
- Changed TCE_G from –50 ppm/°C / ±15 ppm/°C / 50 ppm/°C to –35 ppm/°C / ±3 ppm/°C / 35 ppm/°C (min / typ / max) ... 8
- Changed $V_{Failsafe}$ from –2.6 V / –2.5 V (typ / max) to –2.63 V / –2.57 V / –2.53 V (min / typ / max) ... 8
- Changed CMTI from 55 kV/µs / 80 kV/µs to 100 kV/µs / 150 kV/µs (min / typ) ... 8
- Changed $VDD1_{POR}$ from 1.75 V / 2.15 V / 2.7 V to 2.4 V / 2.6 V / 2.8 V (min / typ / max) ... 8
- Changed *Rise, Fall, and Delay Time Waveforms* image ... 9

Changes from Revision B (November 2018) to Revision C (October 2019) — **Page**

- 「特長」の「*安全関連の認証*」箇条書き項目の VDE 認証を DIN V VDE V 0884-11 (VDE V 0884-11) から *DIN VDE V 0884-11* に変更 ... 1

5 Pin Configuration and Functions

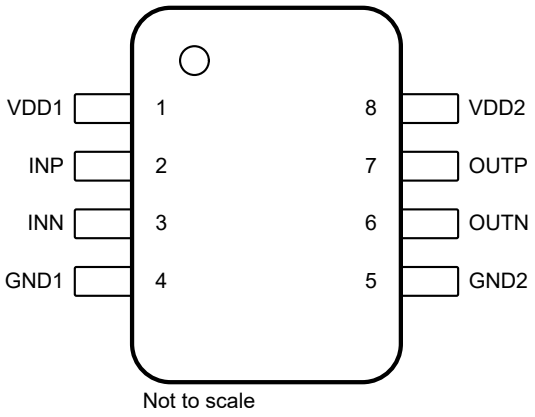


図 5-1. DWV Package, 8-Pin SOIC, Top View

表 5-1. Pin Functions

PIN		TYPE	DESCRIPTION
NO.	NAME		
1	VDD1	High-side power	High-side power supply.(1)
2	INP	Analog input	Noninverting analog input. Either INP or INN must have a DC current path to GND1 to define the common-mode input voltage.(2)
3	INN	Analog input	Inverting analog input. Either INP or INN must have a DC current path to GND1 to define the common-mode input voltage.(2)
4	GND1	High-side ground	High-side analog ground.
5	GND2	Low-side ground	Low-side analog ground.
6	OUTN	Analog output	Inverting analog output.
7	OUTP	Analog output	Noninverting analog output.
8	VDD2	Low-side power	Low-side power supply.(1)

(1) See the *Power Supply Recommendations* section for power-supply decoupling recommendations.
(2) See the *Layout* section for details.

6 Specifications

6.1 Absolute Maximum Ratings

over operating ambient temperature range (unless otherwise noted)(1)

		MIN	MAX	UNIT
Power-supply voltage	High-side VDD1 to GND1	–0.3	6.5	V
	Low-side VDD2 to GND2	–0.3	6.5	V
Analog input voltage	INP, INN	GND1 – 6	VDD1 + 0.5	V
Output voltage	OUTP, OUTN	GND2 – 0.5	VDD2 + 0.5	V
Input current	Continuous, any pin except power-supply pins	–10	10	mA
Temperature	Junction, T_J		150	°C
	Storage, T_{stg}	–65	150	

(1) Operation outside the *Absolute Maximum Ratings* may cause permanent device damage. Absolute Maximum Ratings do not imply functional operation of the device at these or any other conditions beyond those listed under *Recommended Operating Conditions*. If used outside the Recommended Operating Conditions but within the Absolute Maximum Ratings, the device may not be fully functional, and this may affect device reliability, functionality, performance, and shorten the device lifetime

6.2 ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001 (1)	±2000	V
		Charged device model (CDM), per JESD22-C101 (2)	±1000	

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

6.3 Recommended Operating Conditions

over operating ambient temperature range (unless otherwise noted)

			MIN	NOM	MAX	UNIT
POWER SUPPLY						
	High-side power supply	VDD1 to GND1	3	5	5.5	V
	Low-side power supply	VDD2 to GND2	3	3.3	5.5	V
ANALOG INPUT						
$V_{Clipping}$	Differential input voltage before clipping output	$V_{IN} = V_{INP} – V_{INN}$		±64		mV
V_{FSR}	Specified linear differential full-scale voltage	$V_{IN} = V_{INP} – V_{INN}$	–50		50	mV
V_{CM}	Operating common-mode input voltage	$(V_{INP} + V_{INN}) / 2$ to GND1	–0.032		VDD1 – 2.2	V
TEMPERATURE RANGE						
T_A	Specified ambient temperature		–55		125	°C

6.4 Thermal Information

THERMAL METRIC(1)		AMC1302 DWV (SOIC) 8 PINS	UNIT
$R_{\theta JA}$	Junction-to-ambient thermal resistance	85.4	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	26.8	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	43.5	°C/W
ψ_{JT}	Junction-to-top characterization parameter	4.8	°C/W
ψ_{JB}	Junction-to-board characterization parameter	41.2	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	n/a	°C/W

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

6.5 Power Ratings

PARAMETER		TEST CONDITIONS	VALUE	UNIT
P_D	Maximum power dissipation (both sides)	VDD1 = VDD2 = 5.5 V	99	mW
P_{D1}	Maximum power dissipation (high-side)	VDD1 = 3.6 V	31	mW
		VDD1 = 5.5 V	54	
P_{D2}	Maximum power dissipation (low-side)	VDD2 = 3.6 V	26	mW
		VDD2 = 5.5 V	45	

6.6 Insulation Specification

over operating ambient temperature range (unless otherwise noted)

PARAMETER		TEST CONDITIONS	VALUE	UNIT
GENERAL				
CLR	External clearance(1)	Shortest terminal-to-terminal distance through air	≥ 8.5	mm
CPG	External creepage(1)	Shortest terminal-to-terminal distance across the package surface	≥ 8.5	mm
DTI	Distance through the insulation	Minimum internal gap (internal clearance) of the double isolation (2 x 0.0105 mm)	≥ 0.021	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	Rated mains voltage ≤ 600 V_{RMS}	I -IV	
		Rated mains voltage ≤ 1000 V_{RMS}	I-III	
DIN V VDE 0884-11 (VDE V 0884-11): 2017-01(2)				
V_{IORM}	Maximum repetitive peak isolation voltage	AC voltage	2121	V_{PK}
V_{IOWM}	Maximum isolation working voltage	AC voltage (sine wave)	1500	V_{RMS}
		DC voltage	2121	V_{DC}
V_{IOTM}	Maximum transient isolation voltage	V_{TEST} = V_{IOTM}, t = 60 s (qualification test)	7071	V_{PK}
		V_{TEST} = V_{IOTM}, t = 1 s (100% production test)	8485	V_{PK}
V_{IOSM}	Maximum surge isolation voltage(1)	Test method per IEC 60065, 1.2/50 µs waveform, V_{TEST} = 1.6 × V_{IOSM} = 12800 V_{PK} (qualification)	8000	V_{PK}
q_{pd}	Apparent charge(3)	Method a: After I/O safety test subgroup 2/3, V_{ini} = V_{IOTM}, t_{ini} = 60 s; $V_{pd(m)}$ = 1.2 × V_{IORM} = 2545 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} = 3394 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} = 3977 V_{PK}, t_m = 1 s	≤ 5	
C_{IO}	Barrier capacitance, input to output(4)	V_{IO} = 0.4 × sin (2 πft), f = 1 MHz	~1.5	pF
R_{IO}	Insulation resistance, input to output(4)	V_{IO} = 500 V, T_A = 25°C	> 10^{12}	Ω
		V_{IO} = 500 V, 100°C ≤ T_A ≤ 125°C	> 10^{11}	
		V_{IO} = 500 V at T_S = 150°C	> 10^9	
	Pollution degree		2	
	Climatic category		55/125/21	
UL 1577				
V_{ISO}	Withstand isolation voltage	V_{TEST} = V_{ISO} = 5000 V_{RMS}, t = 60 s (qualification), V_{TEST} = 1.2 × V_{ISO} = 6000 V_{RMS}, t = 1 s (100% production)	5000	V_{RMS}

(1) Creepage and clearance requirements should be applied 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 do not reduce this distance. Creepage and clearance on a printed-circuit board become equal in certain cases. Techniques such as inserting grooves, ribs, or both on a printed-circuit board 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) Apparent charge is electrical discharge caused by a partial discharge (pd).
(4) All pins on each side of the barrier tied together creating a two-pin device.

6.7 Safety-Related Certifications

VDE	UL
Certified according to DIN VDE V 0884-11 (VDE V 0884-11): 2017-01, 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	Certificate number: E181974

6.8 Safety Limiting Values

Safety limiting(1) intends to minimize potential damage to the isolation barrier upon failure of input or output circuitry. A failure of the I/O can 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	$R_{\theta JA}$ = 85.4°C/W, VDDx = 5.5 V, T_J = 150°C, T_A = 25°C			266	mA
I_S	Safety input, output, or supply current	$R_{\theta JA}$ = 85.4°C/W, VDDx = 3.6 V, T_J = 150°C, T_A = 25°C			407	mA
P_S	Safety input, output, or total power	$R_{\theta JA}$ = 85.4°C/W, T_J = 150°C, T_A = 25°C			1464	mW
T_S	Maximum safety temperature				150	°C

(1) The maximum safety temperature, T_S, has the same value as the maximum junction temperature, T_J, specified for the device. The I_S and P_S parameters represent the safety current and safety power, respectively. Do not exceed the maximum limits of I_S and P_S. These limits vary with the ambient temperature, T_A.
The junction-to-air thermal resistance, $R_{\theta JA}$, in the Thermal Information table is that of a device installed on a high-K test board for leaded surface-mount packages. Use these equations to calculate the value for each parameter:
$T_J = T_A + R_{\theta JA} \times P$, where P is the power dissipated in the device.
$T_{J(max)} = T_S = T_A + R_{\theta JA} \times P_S$, where $T_{J(max)}$ is the maximum junction temperature.
$P_S = I_S \times VDD_{max}$, where VDD_{max} is the maximum supply voltage for high-side and low-side.

6.9 Electrical Characteristics

minimum and maximum specifications apply from T_A = – 55°C to +125°C, VDD1 = 3.0 V to 5.5 V, VDD2 = 3.0 V to 5.5 V, INP = – 50 mV to + 50 mV, and INN = GND1; typical specifications are at T_A = 25°C, VDD1 = 5 V, and VDD2 = 3.3 V (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
ANALOG INPUT						
V_{CMov}	Common-mode overvoltage detection level	(V_{INP} + V_{INN}) / 2 to GND1	VDD1 – 2			V
	Hysteresis of common-mode overvoltage detection level			60		mV
V_{OS}	Input offset voltage(1) (2)	T_A = 25°C, V_{INP} = V_{INN} = GND1	–50	±2.5	50	µV
TCV_{OS}	Input offset drift(1) (2) (3)		–0.8	±0.15	0.8	µV/°C
CMRR	Common-mode rejection ratio	f_{IN} = 0 Hz, $V_{CM\ min} \le V_{CM} \le V_{VCM\ max}$		–100		dB
		f_{IN} = 10 kHz, $V_{CM\ min} \le V_{CM} \le V_{CM\ max}$		–98		
C_{IN}	Single-ended input capacitance	INN = GND1, f_{IN} = 300 kHz		4		pF
C_{IND}	Differential input capacitance	f_{IN} = 300 kHz		2		
R_{IN}	Single-ended input resistance	INN = GND1		4.75		kΩ
R_{IND}	Differential input resistance			4.9		
I_{IB}	Input bias current	INP = INN = GND1; I_{IB} = (I_{IBP} + I_{IBN}) / 2	–48.5	–36	–28.5	uA
TCI_{IB}	Input bias current drift			±1.5		nA/°C
I_{IO}	Input offset current	I_{IO} = I_{IBP} – I_{IBN}		±10		nA
ANALOG OUTPUT						
	Nominal gain			41		
E_G	Gain error(1)	T_A = 25°C	–0.2%	±0.04%	0.2%	
TCE_G	Gain error drift(1) (4)		–35	±3	35	ppm/°C
	Nonlinearity(1)		–0.03%	±0.01%	0.03%	
	Nonlinearity drift			1		ppm/°C
THD	Total harmonic distortion	f_{IN} = 10 kHz		–85		dB
	Output noise	INP = INN = GND1, f_{IN} = 0 Hz, BW = 100 kHz brickwall filter		260		$µV_{RMS}$
SNR	Signal-to-noise ratio	f_{IN} = 1 kHz, BW = 10 kHz	80	84		dB
		f_{IN} = 10 kHz, BW = 100 kHz		70		
PSRR	Power-supply rejection ratio(2)	PSRR vs VDD1, at DC		–113		dB
		PSRR vs VDD1, 100-mV and 10-kHz ripple		–108		
		PSRR vs VDD2, at DC		–116		
		PSRR vs VDD2, 100-mV and 10-kHz ripple		–87		
V_{CMout}	Common-mode output voltage		1.39	1.44	1.49	V
$V_{CLIPout}$	Clipping differential output voltage	V_{OUT} = (V_{OUTP} – V_{OUTN}); $\lvert V_{IN}\rvert$ = $\lvert V_{INP} - V_{INN}\rvert$ > $\lvert V_{Clipping}\rvert$	–2.52	±2.49	2.52	V
$V_{Failsafe}$	Failsafe differential output voltage	$V_{CM} \ge V_{CMov}$, or VDD1 missing	–2.63	–2.57	–2.53	V
BW	Output bandwidth		220	280		kHz
R_{OUT}	Output resistance	On OUTP or OUTN		< 0.2		Ω
	Output short-circuit current	On OUTP or OUTN, sourcing or sinking, INN = INP = GND1, outputs shorted to either GND2 or VDD2		±14		mA
CMTI	Common-mode transient immunity	|GND1 – GND2| = 1 kV	100	150		kV/µs

6.9 Electrical Characteristics (continued)

minimum and maximum specifications apply from T_A = – 55°C to +125°C, VDD1 = 3.0 V to 5.5 V, VDD2 = 3.0 V to 5.5 V, INP = – 50 mV to + 50 mV, and INN = GND1; typical specifications are at T_A = 25°C, VDD1 = 5 V, and VDD2 = 3.3 V (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
POWER SUPPLY						
$VDD1_{POR}$	VDD1 power-on-reset threshold voltage	VDD1 falling	2.4	2.6	2.8	V
IDD1	High-side supply current	3.0 V ≤ VDD1 ≤ 3.6 V		6.2	8.5	mA
		4.5 V ≤ VDD1 ≤ 5.5 V		7.2	9.8	
IDD2	Low-side supply current	3.0 V ≤ VDD2 ≤ 3.6 V		5.3	7.2	
		4.5 V ≤ VDD2 ≤ 5.5 V		5.9	8.1	

(1) The typical value includes one standard deviation ("sigma") at nominal operating conditions.
(2) This parameter is input referred.
(3) Offset error temperature drift is calculated using the box method, as described by the following equation:
$TCV_{OS} = (Value_{MAX} - Value_{MIN}) / TempRange$
(4) Gain error temperature drift is calculated using the box method, as described by the following equation:
$TCE_G\ (ppm) = (Value_{MAX} - Value_{MIN}) / (Value_{(T=25°C)} \times TempRange) \times 10^6$

6.10 Switching Characteristics

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

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
t_r	Output signal rise time			1.5		µs
t_f	Output signal fall time			1.5		µs
	V_{INx} to V_{OUTx} signal delay (50% – 10%)	unfiltered output		1	1.5	µs
	V_{INx} to V_{OUTx} signal delay (50% – 50%)	unfiltered output		1.6	2.1	µs
	V_{INx} to V_{OUTx} signal delay (50% – 90%)	unfiltered output		2.5	3	µs
t_{AS}	Analog settling time	VDD1 step to 3.0 V with VDD2 ≥ 3.0 V, to OUTP and OUTN valid, 0.1% settling		500		µs

6.11 Timing Diagram

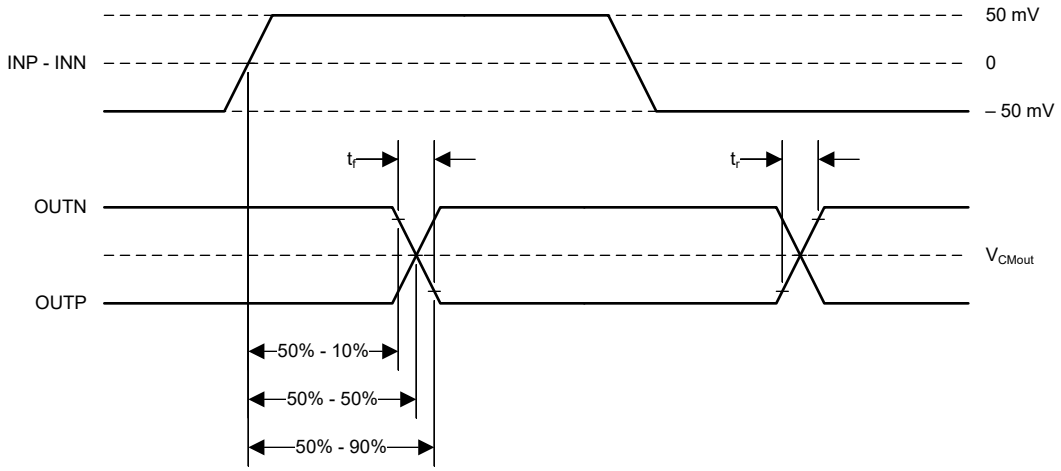


図 6-1. Rise, Fall, and Delay Time Waveforms

6.12 Insulation Characteristics Curves

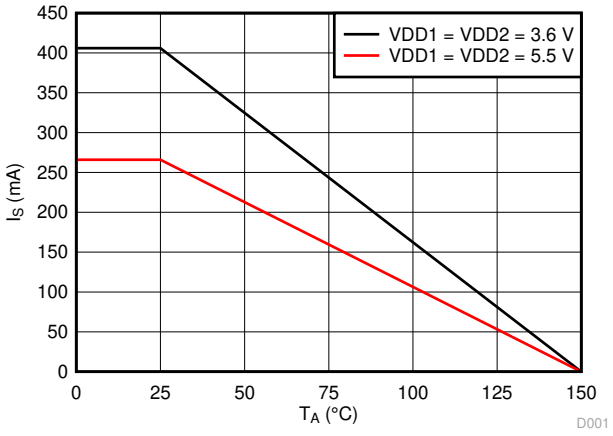


図 6-2. Thermal Derating Curve for Safety-Limiting Current per VDE

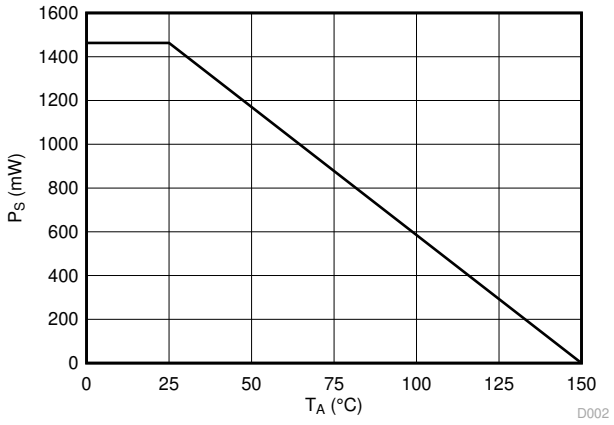
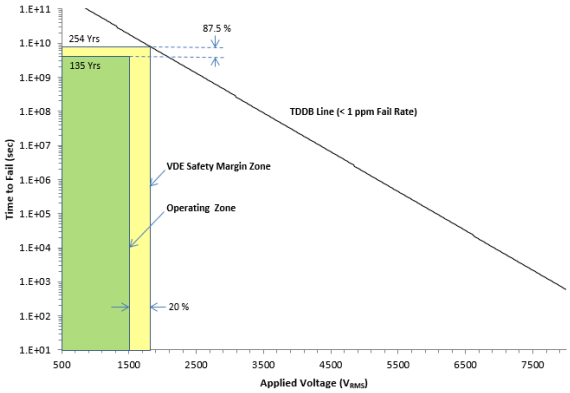


図 6-3. Thermal Derating Curve for Safety-Limiting Power per VDE



T_A up to 150°C, stress-voltage frequency = 60 Hz, isolation working voltage = 1500 V_{RMS}, operating lifetime = 135 years

図 6-4. Reinforced Isolation Capacitor Lifetime Projection

6.13 Typical Characteristics

at T_A = 25°C, VDD1 = 5 V, VDD2 = 3.3 V, INP = –50 mV to 50 mV, INN = GND1, and f_{IN} = 10 kHz (unless otherwise noted)

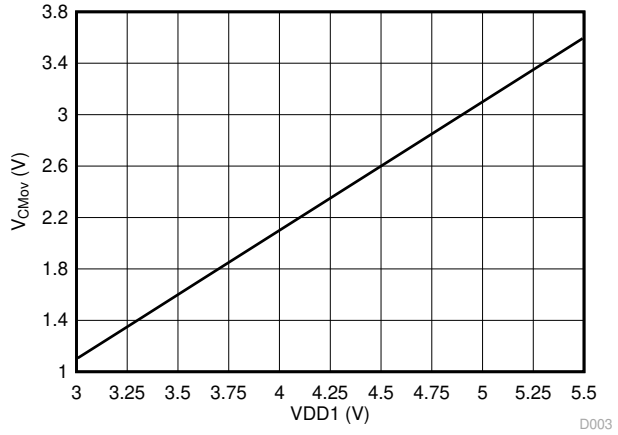


図 6-5. Common-Mode Overvoltage Detection Level vs High-Side Supply Voltage

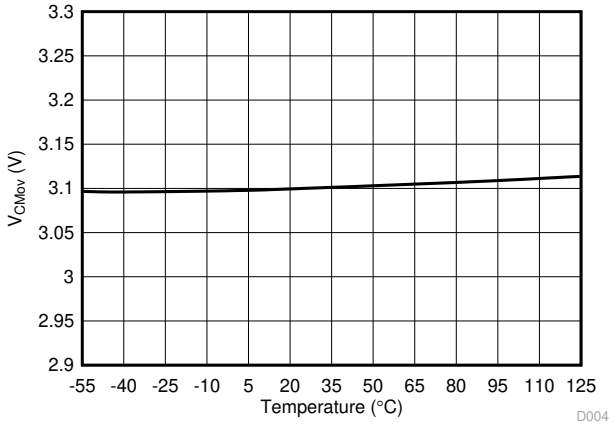


図 6-6. Common-Mode Overvoltage Detection Level vs Temperature

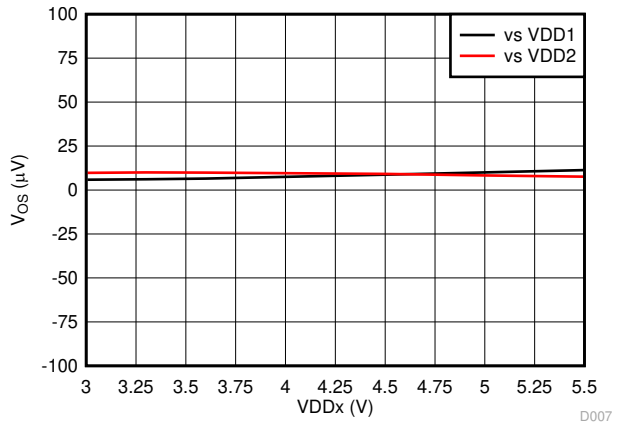


図 6-7. Input Offset Voltage vs Supply Voltage

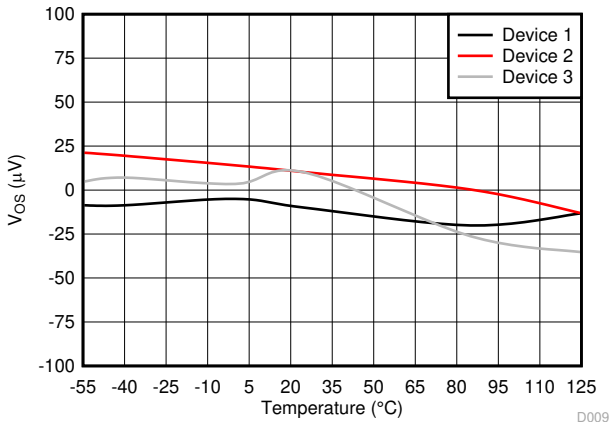


図 6-8. Input Offset Voltage vs Temperature

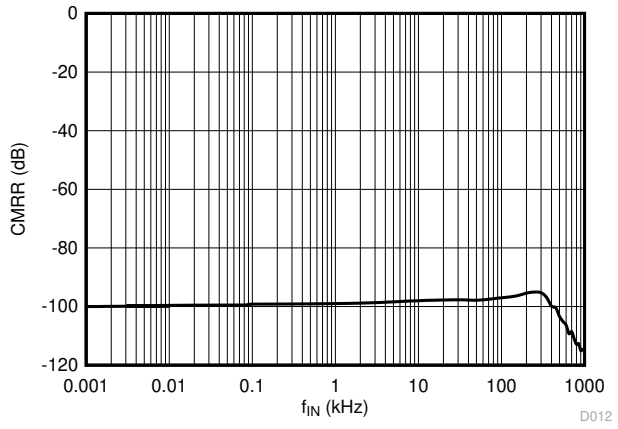


図 6-9. Common-Mode Rejection Ratio vs Input Frequency

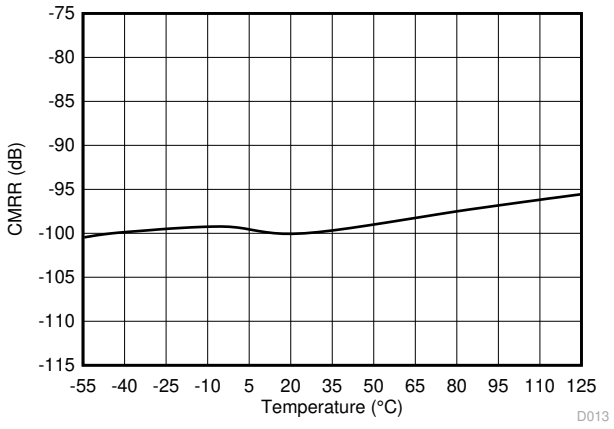


図 6-10. Common-Mode Rejection Ratio vs Temperature

6.13 Typical Characteristics (continued)

at T_A = 25°C, VDD1 = 5 V, VDD2 = 3.3 V, INP = –50 mV to 50 mV, INN = GND1, and f_{IN} = 10 kHz (unless otherwise noted)

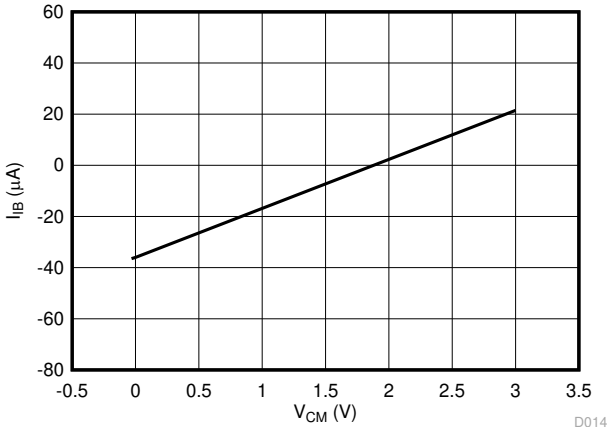


図 6-11. Input Bias Current vs Common-Mode Input Voltage

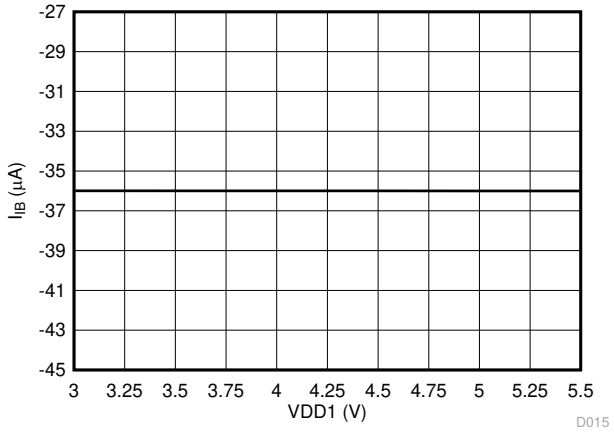


図 6-12. Input Bias Current vs High-Side Supply Voltage

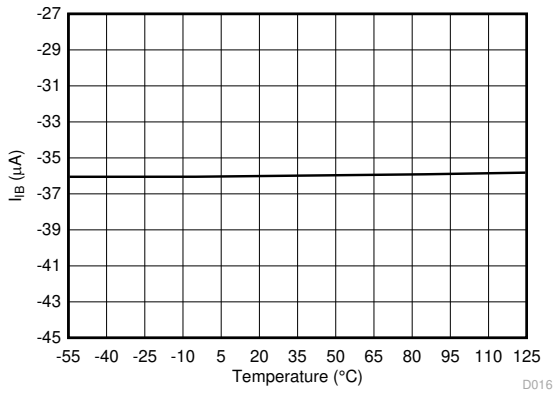


図 6-13. Input Bias Current vs Temperature

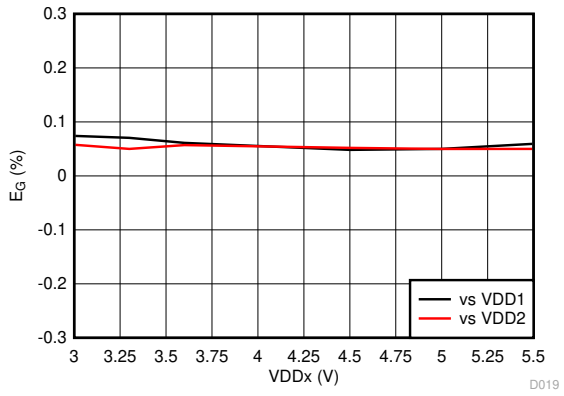


図 6-14. Gain Error vs Supply Voltage

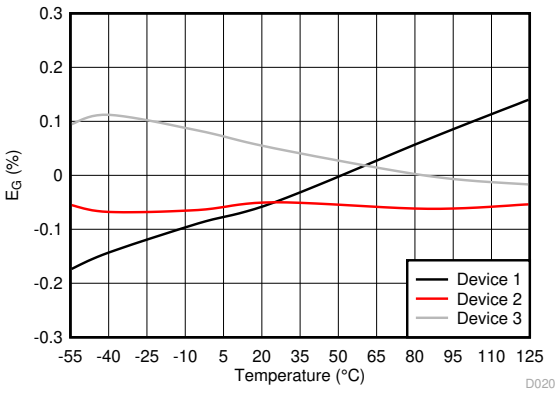


図 6-15. Gain Error vs Temperature

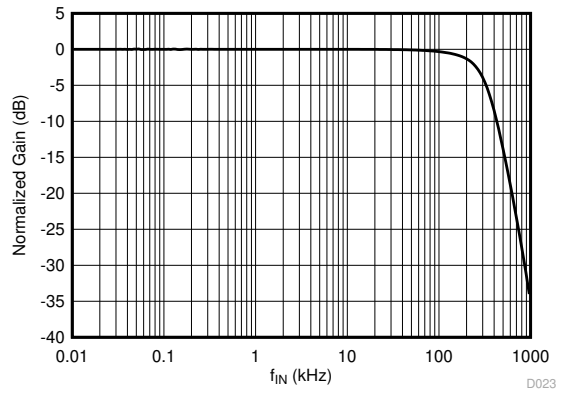


図 6-16. Normalized Gain vs Input Frequency

6.13 Typical Characteristics (continued)

at T_A = 25°C, VDD1 = 5 V, VDD2 = 3.3 V, INP = –50 mV to 50 mV, INN = GND1, and f_{IN} = 10 kHz (unless otherwise noted)

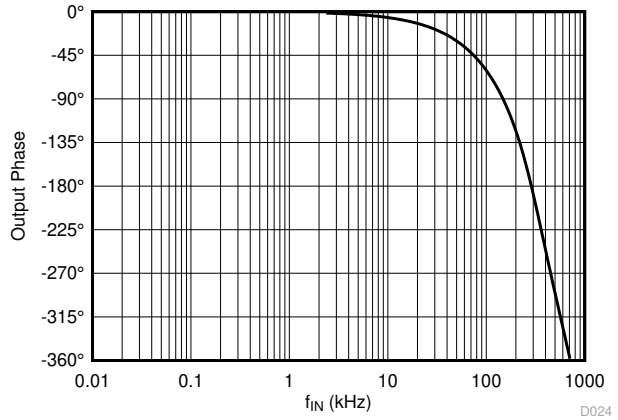


図 6-17. Output Phase vs Input Frequency

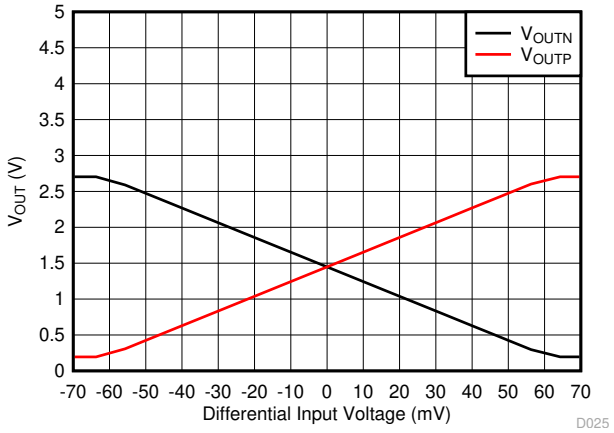


図 6-18. Output Voltage vs Input Voltage

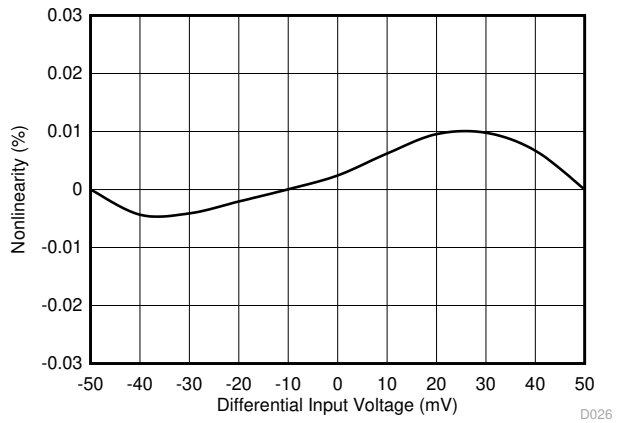


図 6-19. Nonlinearity vs Input Voltage

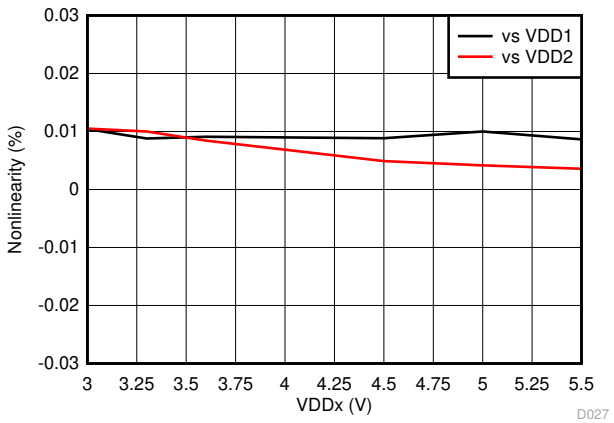


図 6-20. Nonlinearity vs Supply Voltage

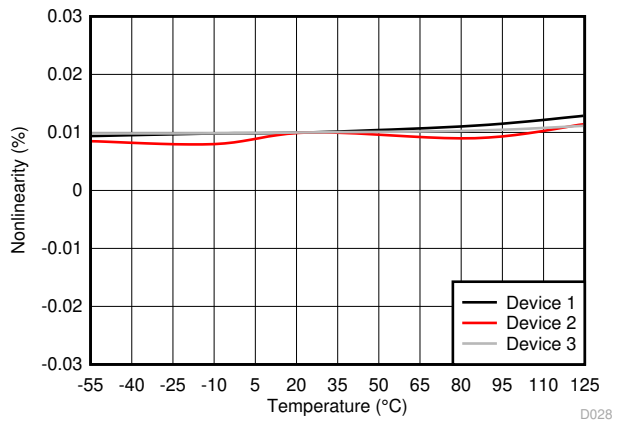


図 6-21. Nonlinearity vs Temperature

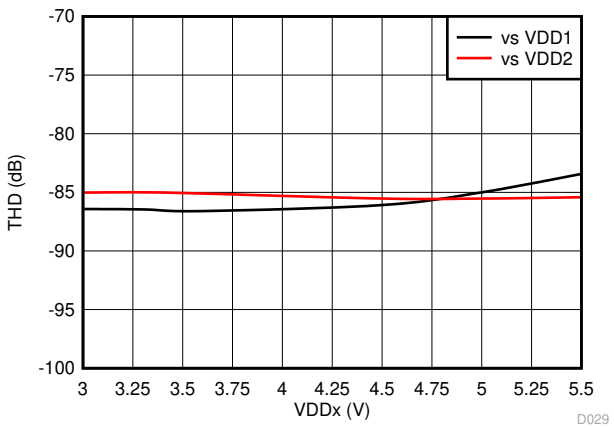


図 6-22. Total Harmonic Distortion vs Supply Voltage

6.13 Typical Characteristics (continued)

at T_A = 25°C, VDD1 = 5 V, VDD2 = 3.3 V, INP = –50 mV to 50 mV, INN = GND1, and f_{IN} = 10 kHz (unless otherwise noted)

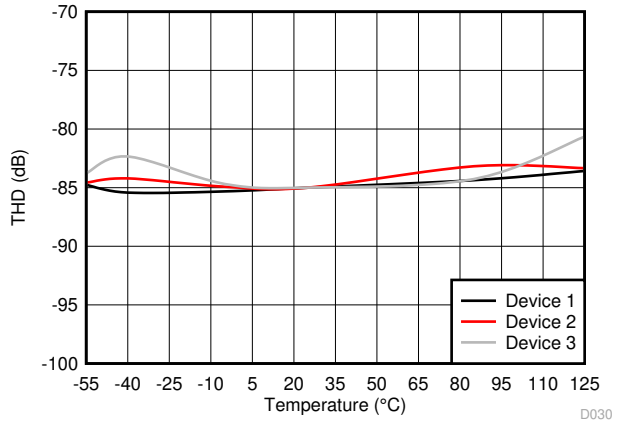


図 6-23. Total Harmonic Distortion vs Temperature

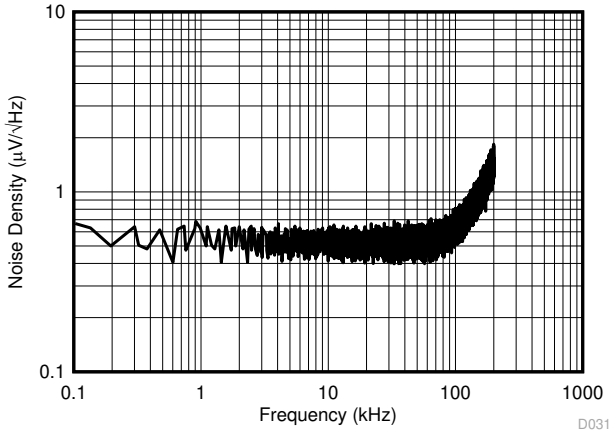


図 6-24. Output Noise Density vs Frequency

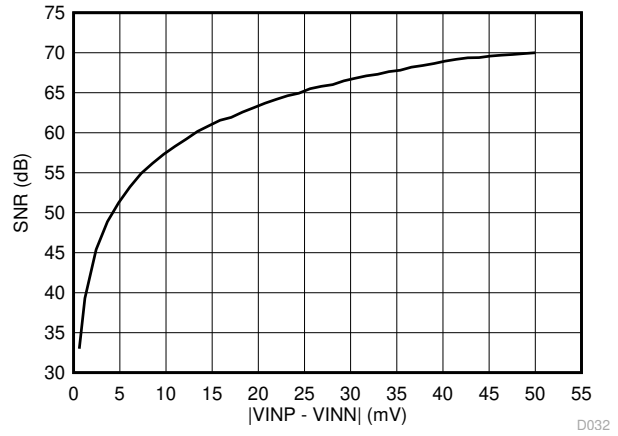


図 6-25. Signal-to-Noise Ratio vs Input Voltage

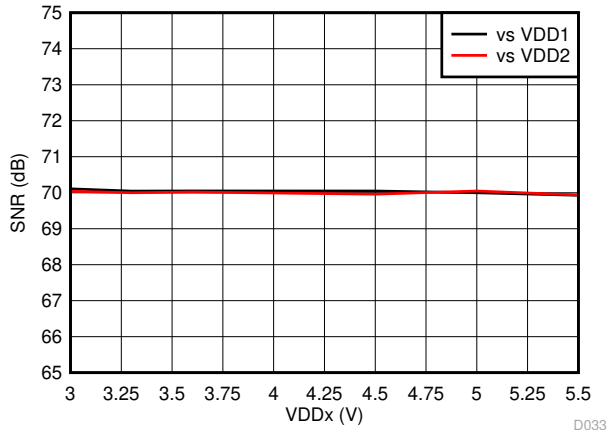


図 6-26. Signal-to-Noise Ratio vs Supply Voltage

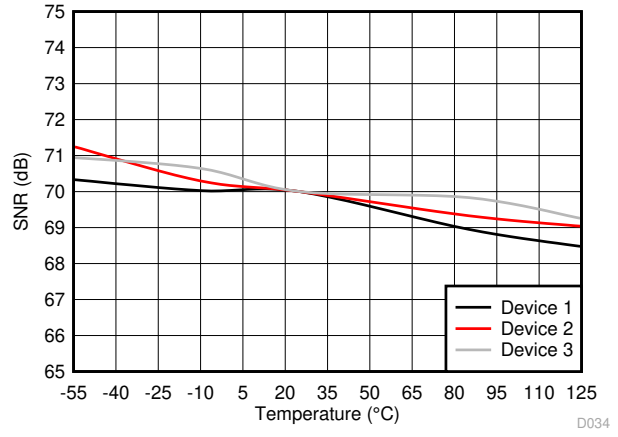


図 6-27. Signal-to-Noise Ratio vs Temperature

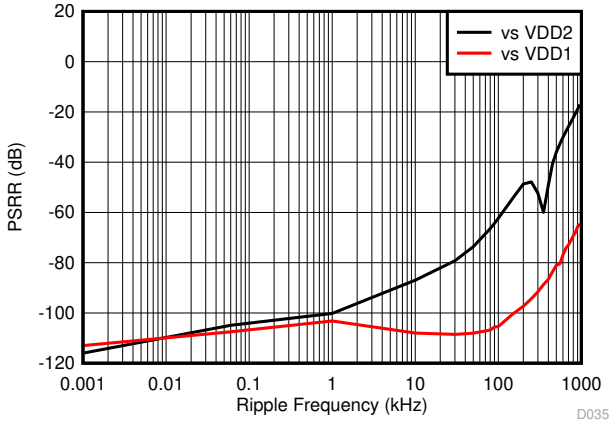


図 6-28. Power-Supply Rejection Ratio vs Ripple Frequency

6.13 Typical Characteristics (continued)

at T_A = 25°C, VDD1 = 5 V, VDD2 = 3.3 V, INP = –50 mV to 50 mV, INN = GND1, and f_{IN} = 10 kHz (unless otherwise noted)

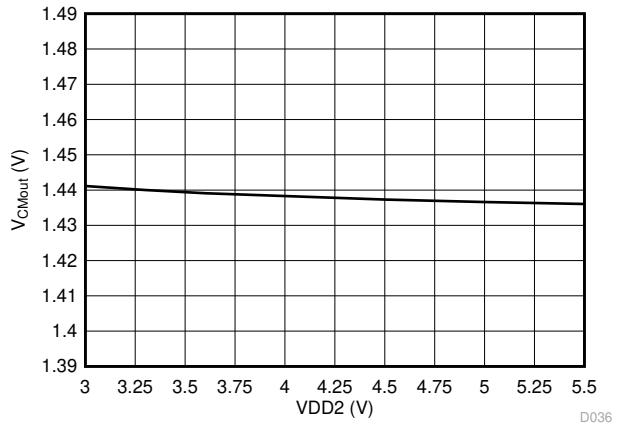


図 6-29. Output Common-Mode Voltage vs Low-Side Supply Voltage

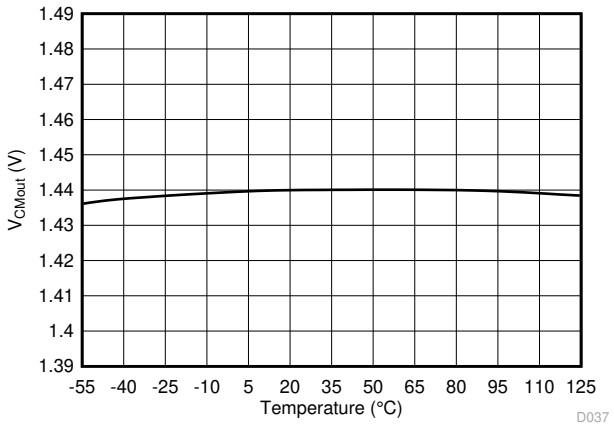


図 6-30. Output Common-Mode Voltage vs Temperature

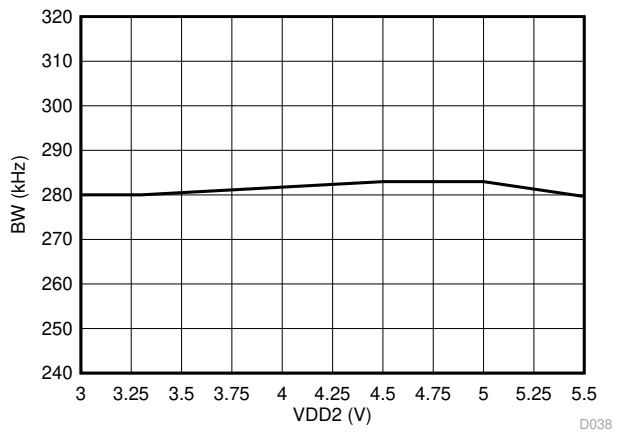


図 6-31. Output Bandwidth vs Low-Side Supply Voltage

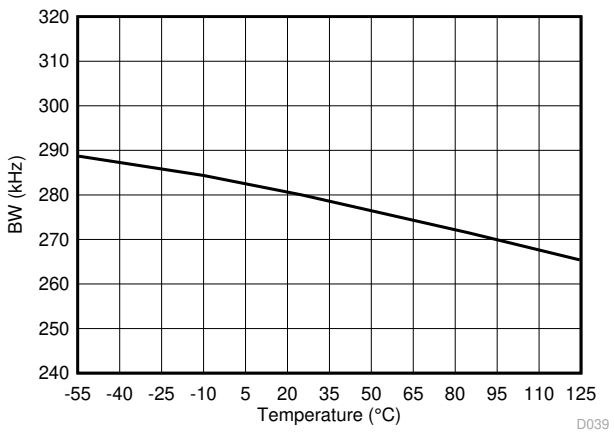


図 6-32. Output Bandwidth vs Temperature

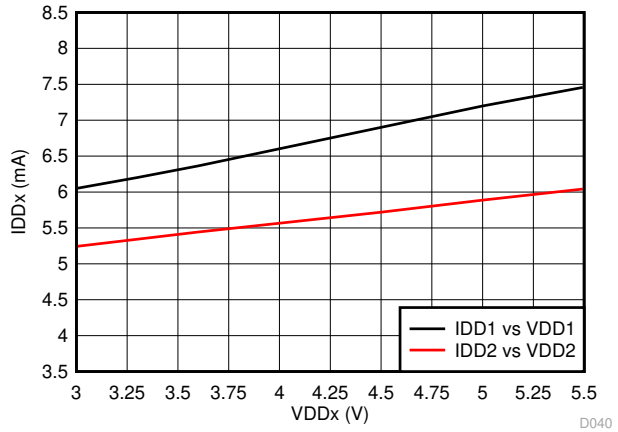


図 6-33. Supply Current vs Supply Voltage

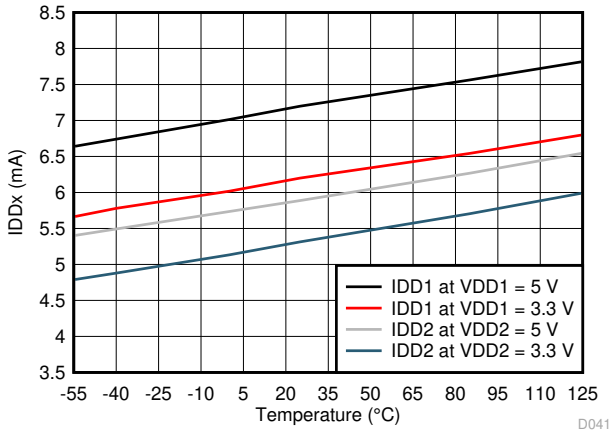


図 6-34. Supply Current vs Temperature

6.13 Typical Characteristics (continued)

at T_A = 25°C, VDD1 = 5 V, VDD2 = 3.3 V, INP = –50 mV to 50 mV, INN = GND1, and f_{IN} = 10 kHz (unless otherwise noted)

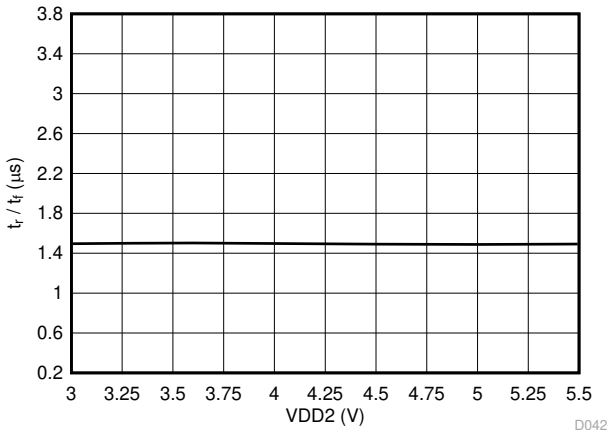


図 6-35. Output Rise and Fall Time vs Low-Side Supply Voltage

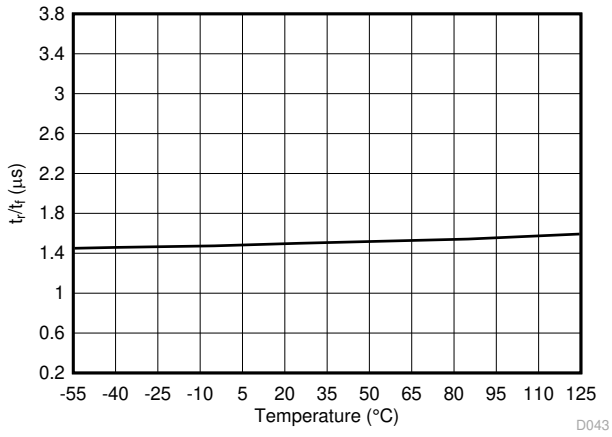


図 6-36. Output Rise and Fall Time vs Temperature

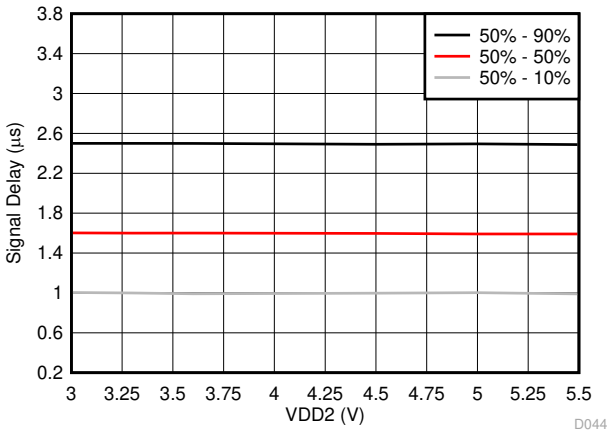


図 6-37. V_{IN} to V_{OUT} Signal Delay vs Low-Side Supply Voltage

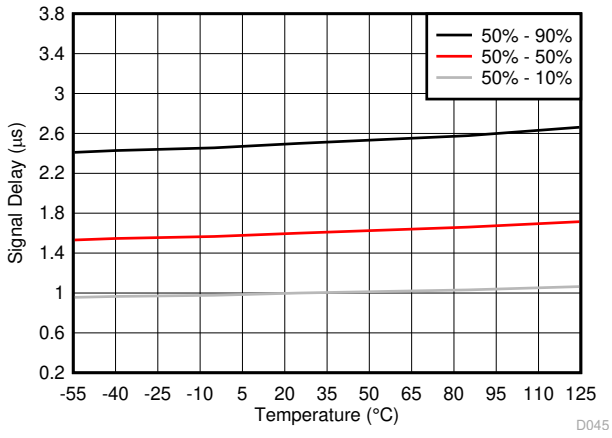


図 6-38. V_{IN} to V_{OUT} Signal Delay vs Temperature

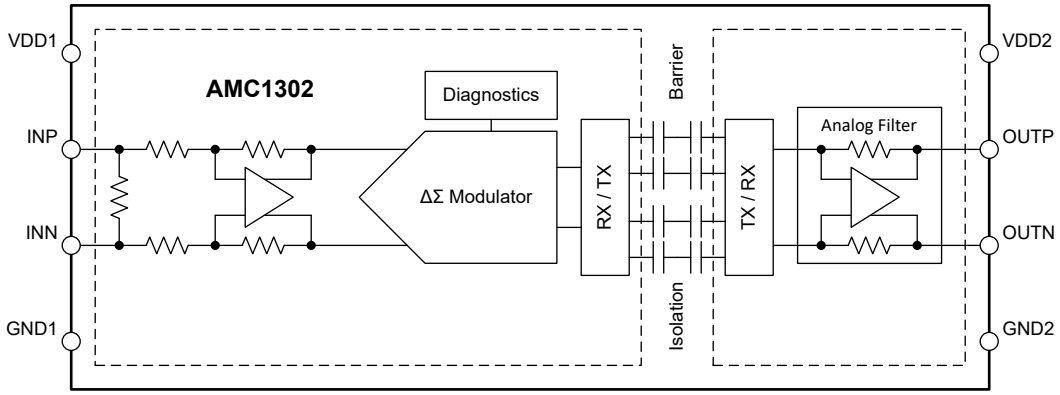
7 Detailed Description

7.1 Overview

The AMC1302 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 (ΔΣ) modulator. The modulator converts the analog input signal into a digital bitstream that is transferred across the isolation barrier that separates the high-side from the low-side. On the low-side, the received bitstream is processed by a fourth-order analog filter that outputs a differential signal at the OUTP and OUTN pins that is proportional to the input signal.

The SiO_2-based, capacitive isolation barrier supports a high level of magnetic field immunity, as described in the *ISO72x Digital Isolator Magnetic-Field Immunity* application report. The digital modulation used in the AMC1302 to transmit data across the isolation barrier, and the isolation barrier characteristics itself, result in high reliability and common-mode transient immunity.

7.2 Functional Block Diagram



7.3 Feature Description

7.3.1 Analog Input

The differential amplifier input stage of the AMC1302 feeds a second-order, switched-capacitor, feed-forward ΔΣ modulator. The gain of the differential amplifier is set by internal precision resistors with a differential input impedance of R_{IND}. The modulator converts the analog input signal into a bitstream that is transferred across the isolation barrier, as described in the *Isolation Channel Signal Transmission* section.

There are two restrictions on the analog input signals INP and INN. First, if the input voltages V_{INP} or V_{INN} exceed the range specified in the *Absolute Maximum Ratings* table, the input currents must be limited to the absolute maximum value, because the electrostatic discharge (ESD) protection turns on. In addition, the linearity and parametric performance of the device are ensured only when the analog input voltage remains within the linear full-scale range (V_{FSR}) and within the common-mode input voltage range (V_{CM}) as specified in the *Recommended Operating Conditions* table.

7.3.2 Isolation Channel Signal Transmission

The AMC1302 uses an on-off keying (OOK) modulation scheme, as shown in 図 7-1, to transmit the modulator output bitstream across the SiO_2-based isolation barrier. The transmit driver (TX) shown in the *Functional Block Diagram* transmits an internally-generated, high-frequency carrier across the isolation barrier to represent a digital *one* and does not send a signal to represent a digital *zero*. The nominal frequency of the carrier used inside the AMC1302 is 480 MHz.

The receiver (RX) on the other side of the isolation barrier recovers and demodulates the signal and provides the input to the 4th-order analog filter. The AMC1302 transmission channel is optimized to achieve the highest level of common-mode transient immunity (CMTI) and lowest level of radiated emissions caused by the high-frequency carrier and RX/TX buffer switching.

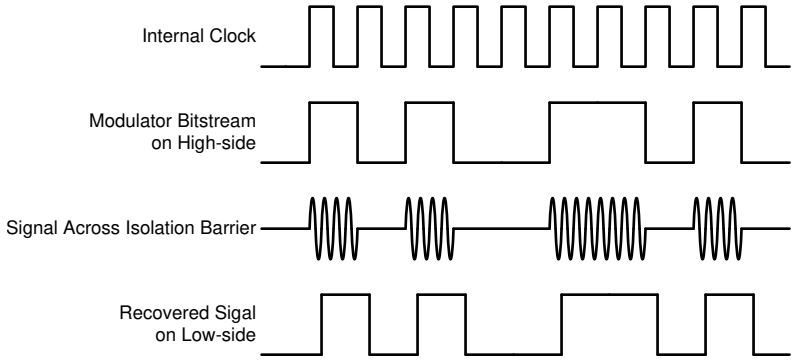


図 7-1. OOK-Based Modulation Scheme

7.3.3 Analog Output

The AMC1302 offers a differential analog output comprised of the OUTP and OUTN pins. For differential input voltages ($V_{INP} – V_{INN}$) in the range from –50 mV to 50 mV, the device provides a linear response with a nominal gain of 41. For example, for a differential input voltage of 50 mV, the differential output voltage ($V_{OUTP} – V_{OUTN}$) is 2.05 V. At zero input (INP shorted to INN), both pins output the same common-mode output voltage V_{CMout}, as specified in the *Electrical Characteristics* table. For absolute differential input voltages greater than 50 mV but less than 64 mV, the differential output voltage continues to increase in magnitude but with reduced linearity performance. The outputs saturate at a differential output voltage of $V_{CLIPout}$, as shown in 図 7-2, if the differential input voltage exceeds the $V_{Clipping}$ value.

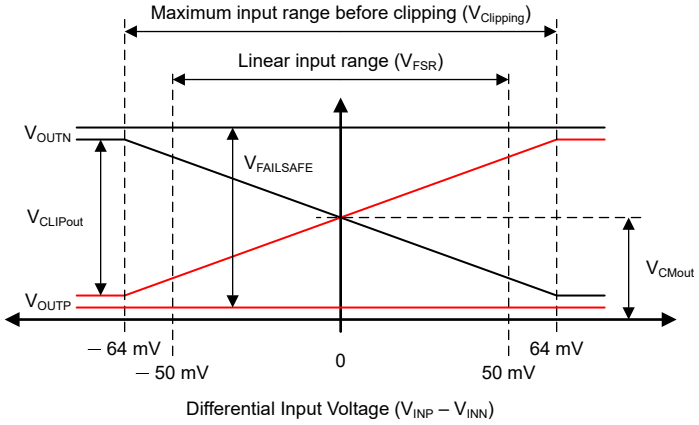


図 7-2. Output Behavior of the AMC1302

The AMC1302 offers a fail-safe feature that simplifies diagnostics on system level. 図 7-2 shows the fail-safe mode, in which the AMC1302 outputs a negative differential output voltage that does not occur under normal operating conditions. The fail-safe output is active in two cases:

- When the high-side supply is missing or below the $VDD1_{UV}$ threshold
- When the common-mode input voltage, that is $V_{CM} = (V_{INP} + V_{INN}) / 2$, exceeds the common-mode overvoltage detection level V_{CMov}

Use the maximum $V_{FAILSAFE}$ voltage specified in the *Electrical Characteristics* table as a reference value for fail-safe detection on system level.

7.4 Device Functional Modes

The AMC1302 is operational when the power supplies VDD1 and VDD2 are applied, as specified in the *Recommended Operating Conditions* table.

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, as well as validating and testing their design implementation to confirm system functionality.

8.1 Application Information

The low analog input voltage range, excellent accuracy, and low temperature drift make the a high-performance solution for industrial applications where shunt-based current sensing in the presence of high common-mode voltage levels is required.

8.2 Typical Application

The AMC1302 is ideally suited for shunt-based current sensing applications where accurate current monitoring is required in the presence of high common-mode voltages.

図 8-1 shows the AMC1302 in a typical application. The load current flowing through an external shunt resistor RSHUNT produces a voltage drop that is sensed by the AMC1302. The AMC1302 digitizes the analog input signal on the high-side, transfers the data across the isolation barrier to the low-side, reconstructs the analog signal, and presents that signal as a differential voltage on the output pins.

The differential input, differential output, and the high common-mode transient immunity (CMTI) of the AMC1302 ensure reliable and accurate operation even in high-noise environments.

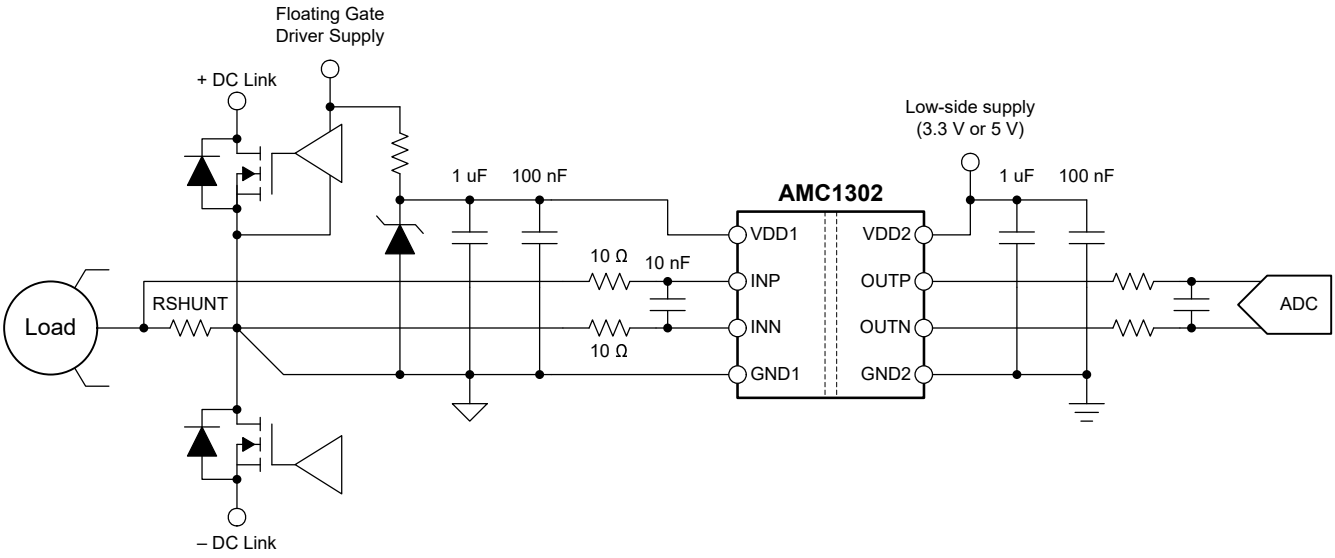


図 8-1. Using the AMC1302 for Current Sensing in a Typical Application

8.2.1 Design Requirements

表 8-1 lists the parameters for this typical application.

表 8-1. 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 RSHUNT for a linear response	±50 mV (maximum)
Signal delay (50% V_{IN} to 90% OUTP, OUTN)	3 µs (maximum)

8.2.2 Detailed Design Procedure

In 図 8-1, the high-side power supply (VDD1) for the AMC1302 is derived from the floating power supply of the upper gate driver.

The floating ground reference (GND1) is derived from the end of the shunt resistor that is connected to the negative input of the AMC1302 (INN). If a four-pin shunt is used, the inputs of the AMC1302 are connected to the inner leads and GND1 is connected to the outer lead on the INN-side of the shunt. To minimize offset and improve accuracy, route the ground connection as a separate trace that connects directly to the shunt resistor rather than shorting GND1 to INN directly at the input to the device. See the *Layout* section for more details.

8.2.2.1 Shunt Resistor Sizing

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

Consider the following two restrictions when selecting the value of the shunt resistor, RSHUNT:

- The voltage drop caused by the nominal current range must not exceed the recommended differential input voltage range for a linear response: $|V_{SHUNT}| \leq |V_{FSR}|$
- The voltage drop caused by the maximum allowed overcurrent must not exceed the input voltage that causes a clipping output: $|V_{SHUNT}| \leq |V_{Clipping}|$

8.2.2.2 Input Filter Design

TI recommends placing an RC-filter in front of the isolated amplifier to improve signal-to-noise performance of the signal path. Design the input filter such that:

- The cutoff frequency of the filter is at least one order of magnitude lower than the sampling frequency (20 MHz) of the ΔΣ modulator
- The input bias current does not generate significant voltage drop across the DC impedance of the input filter
- The impedances measured from the analog inputs are equal

For most applications, the structure shown in 図 8-2 achieves excellent performance.

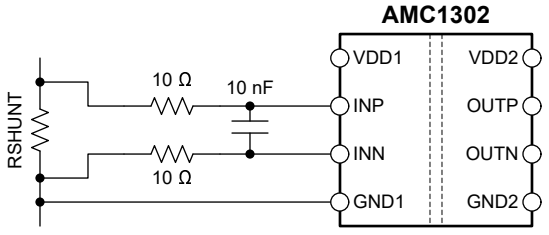


図 8-2. Differential Input Filter

8.2.2.3 Differential to Single-Ended Output Conversion

図 8-3 shows an example of a TLV6001-based signal conversion and filter circuit for systems using single-ended-input ADCs to convert the analog output voltage into digital. With R1 = R2 = R3 = R4, the output voltage equals (V_{OUTP} – V_{OUTN}) + V_{REF}. Tailor the bandwidth of this filter stage to the bandwidth requirement of the system. For most applications, R1 = R2 = R3 = R4 = 3.3 kΩ and C1 = C2 = 330 pF yields good performance.

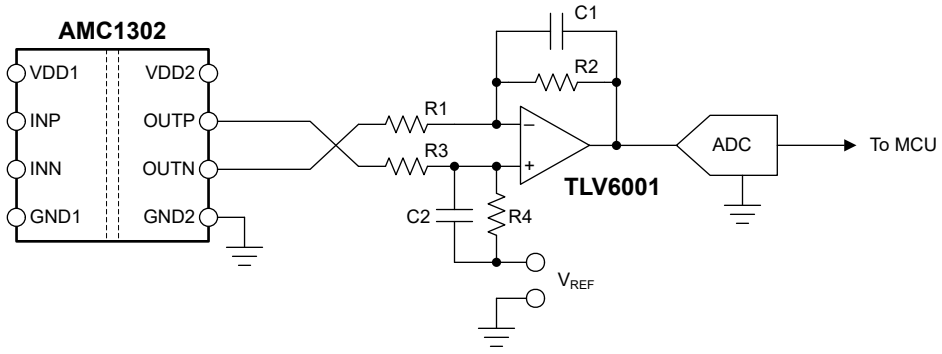


図 8-3. Connecting the AMC1302 Output to a Single-Ended Input ADC

For more information on the general procedure to design the filtering and driving stages of SAR ADCs, see the *18-Bit, 1MSPS Data Acquisition Block (DAQ) Optimized for Lowest Distortion and Noise* and *18-Bit Data Acquisition Block (DAQ) Optimized for Lowest Power* reference guides, available for download at www.ti.com.

8.2.3 Application Curve

One important aspect of power-stage design is the effective detection of an overcurrent condition to protect the switching devices and passive components from damage. To power off the system quickly in the event of an overcurrent condition, a low delay caused by the isolated amplifier is required. 図 8-4 shows the typical full-scale step response of the AMC1302.

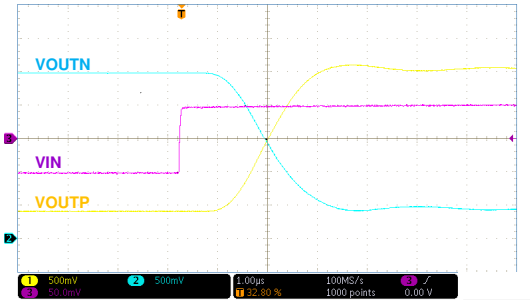


図 8-4. Step Response of the AMC1302

8.3 What to Do and What Not to Do

Do not leave the inputs of the AMC1302 unconnected (floating) when the device is powered up. If the device inputs are left floating, the input bias current may drive the inputs to a positive value that exceeds the operating common-mode input voltage and the device outputs the fail-safe voltage as described in the *Analog Output* section.

Connect the high-side ground (GND1) to INN, either by a hard short or through a resistive path. A DC current path between INN and GND1 is required to define the input common-mode voltage. Do not exceed the input common-mode range as specified in the *Recommended Operating Conditions* table. For best accuracy, route the ground connection as a separate trace that connects directly to the shunt resistor rather than shorting GND1 to INN directly at the input to the device. See the *Layout* section for more details.

9 Power Supply Recommendations

The AMC1302 does not require any specific power up sequencing. The high-side power-supply (VDD1) is decoupled with a low-ESR 100-nF capacitor (C1) parallel to a low-ESR 1-µF capacitor (C2). The low-side power supply (VDD2) is equally decoupled with a low-ESR 100-nF capacitor (C3) parallel to a low-ESR 1-µF capacitor (C4). Place all four capacitors (C1, C2, C3, and C4) as close to the device as possible.

The ground reference for the high-side (GND1) is derived from the end of the shunt resistor, which is connected to the negative input (INN) of the device. For best DC accuracy, use a separate trace (as shown in 図 9-1) to make this connection instead of shorting GND1 to INN directly at the device input. If a four-terminal shunt is used, the device inputs are connected to the inner leads and GND1 is connected to the outer lead on the INN-side of the shunt.

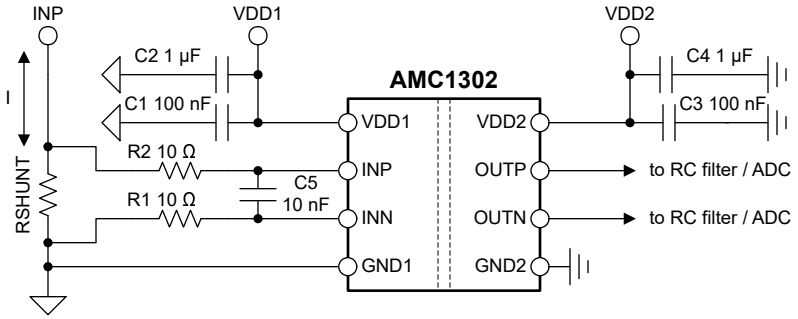


図 9-1. Decoupling of the AMC1302

Capacitors must provide adequate effective capacitance under the applicable DC bias conditions they experience in the application. Multilayer ceramic capacitors (MLCCs) typically exhibit only a fraction of their nominal capacitance under real-world conditions and this factor must be taken into consideration when selecting these capacitors. This problem is especially acute in low-profile capacitors, in which the dielectric field strength is higher than in taller components. Reputable capacitor manufacturers provide capacitance versus DC bias curves that greatly simplify component selection.

10 Layout

10.1 Layout Guidelines

図 10-1 shows a layout recommendation with the critical placement of the decoupling capacitors (as close as possible to the AMC1302 supply pins) and placement of the other components required by the device. For best performance, place the shunt resistor close to the INP and INN inputs of the AMC1302 and keep the layout of both connections symmetrical.

10.2 Layout Example

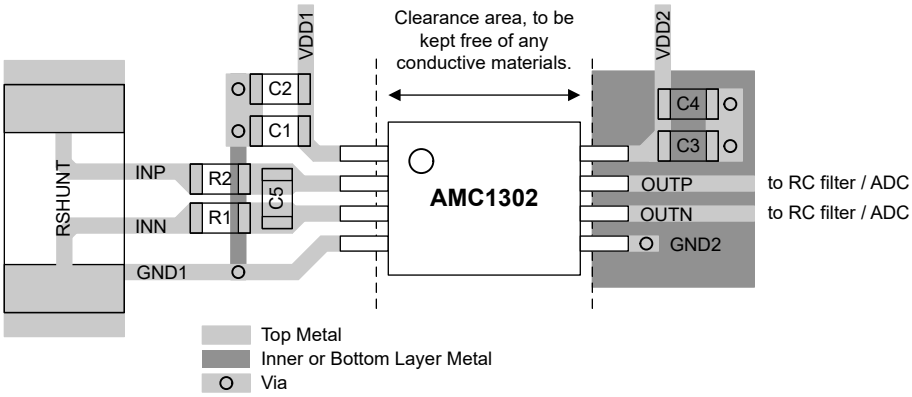


図 10-1. Recommended Layout of the AMC1302

11 Device and Documentation Support

11.1 Documentation Support

11.1.1 Related Documentation

For related documentation, see the following:

- Texas Instruments, *Isolation Glossary* application report
- Texas Instruments, *Semiconductor and IC Package Thermal Metrics* application report
- Texas Instruments, *ISO72x Digital Isolator Magnetic-Field Immunity* application report
- Texas Instruments, *TLV600x Low-Power, Rail-to-Rail In/Out, 1-MHz Operational Amplifier for Cost-Sensitive Systems* data sheet
- Texas Instruments, *18-Bit, 1-MSPS Data Acquisition Block (DAQ) Optimized for Lowest Distortion and Noise* reference guide
- Texas Instruments, *18-Bit, 1-MSPS Data Acquisition Block (DAQ) Optimized for Lowest Power* reference guide
- Texas Instruments, *Isolated Amplifier Voltage Sensing Excel Calculator* design tool

11.2 Trademarks

すべての商標は、それぞれの所有者に帰属します。

11.3 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.

11.4 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.

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
AMC1302DWV	ACTIVE	SOIC	DWV	8	64	RoHS & Green	NIPDAU	Level-3-260C-168 HR	-55 to 125	AMC1302	Samples
AMC1302DWVR	ACTIVE	SOIC	DWV	8	1000	RoHS & Green	NIPDAU	Level-3-260C-168 HR	-55 to 125	AMC1302	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.

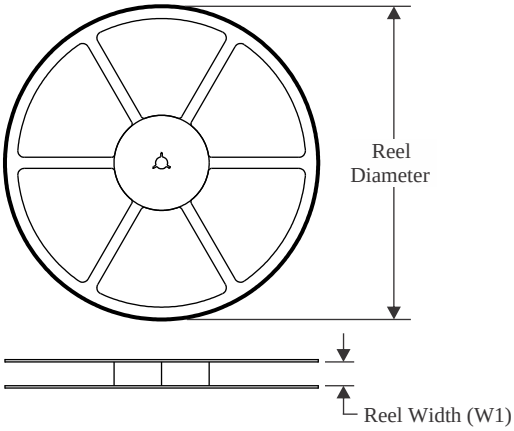
(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(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.

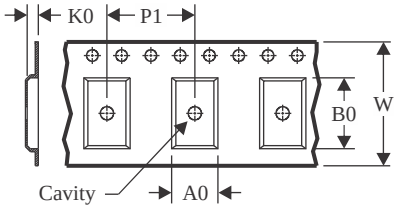
(6) Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

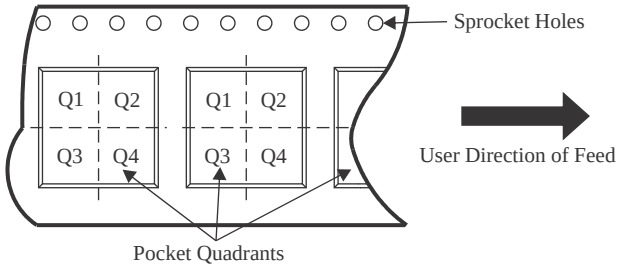


TAPE DIMENSIONS



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

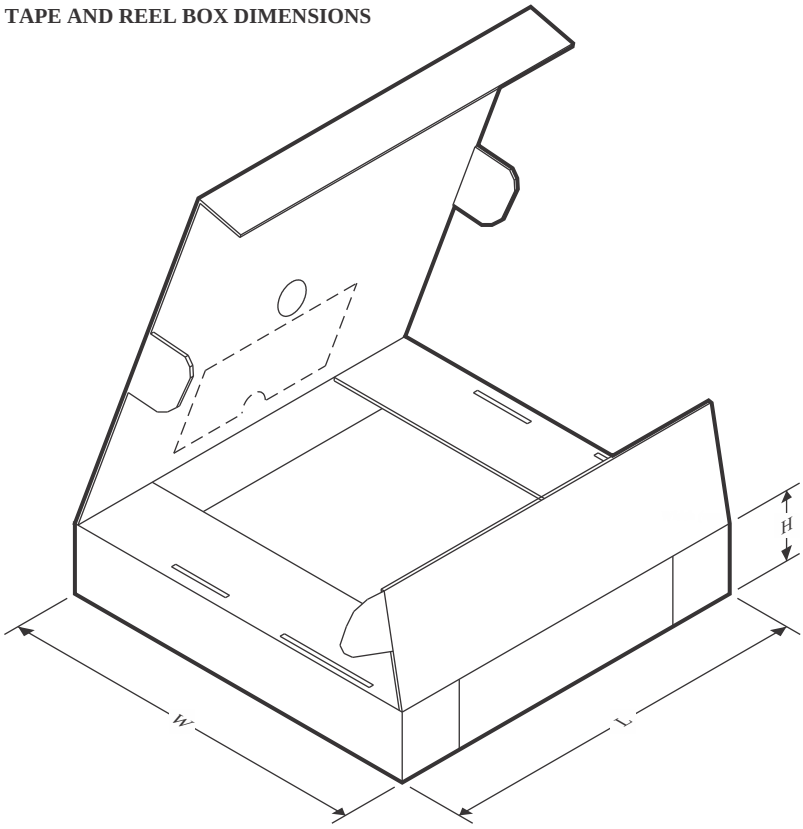
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
AMC1302DWVR	SOIC	DWV	8	1000	330.0	16.4	12.05	6.15	3.3	16.0	16.0	Q1

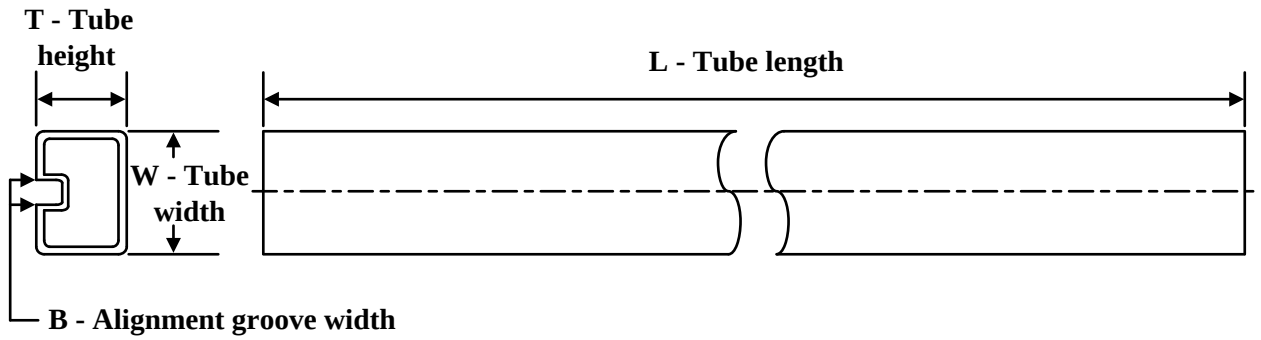
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

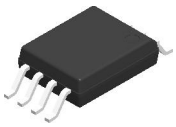
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
AMC1302DWVR	SOIC	DWV	8	1000	350.0	350.0	43.0

TUBE



*All dimensions are nominal

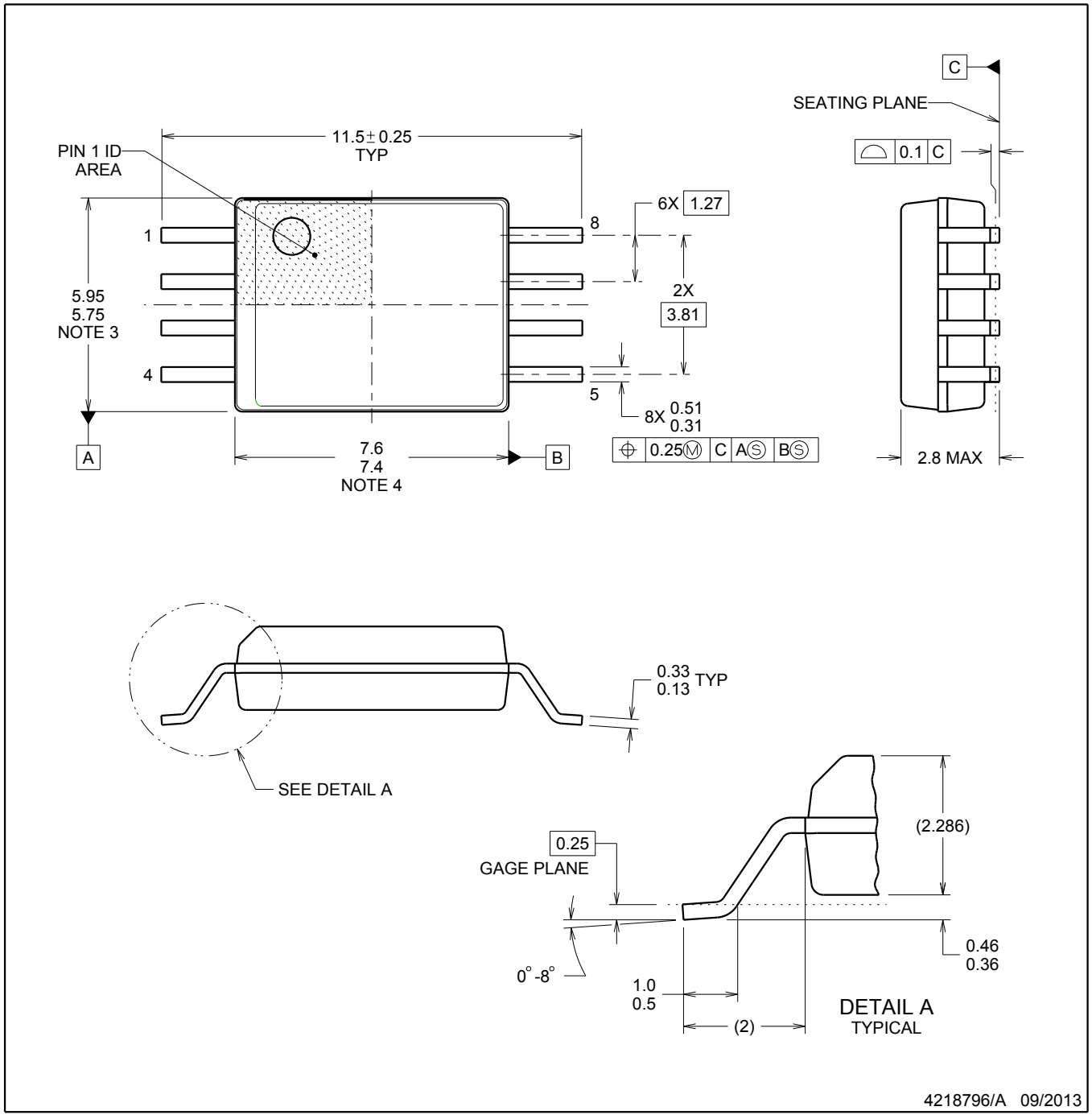
Device	Package Name	Package Type	Pins	SPQ	L (mm)	W (mm)	T (µm)	B (mm)
AMC1302DWV	DWV	SOIC	8	64	505.46	13.94	4826	6.6



DWV0008A

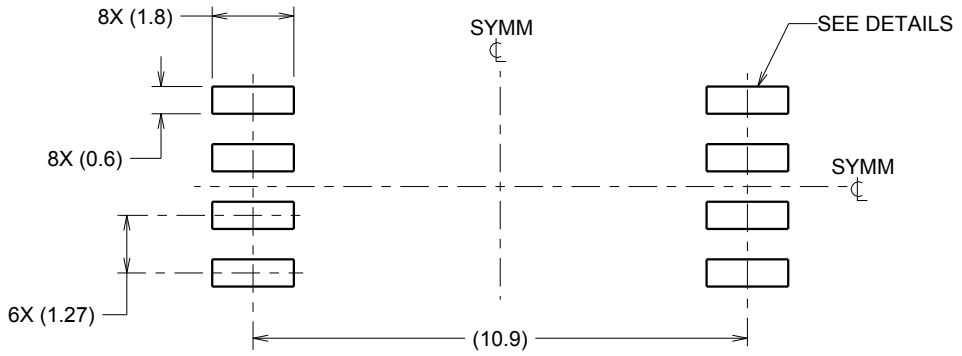
SOIC - 2.8 mm max height

SOIC

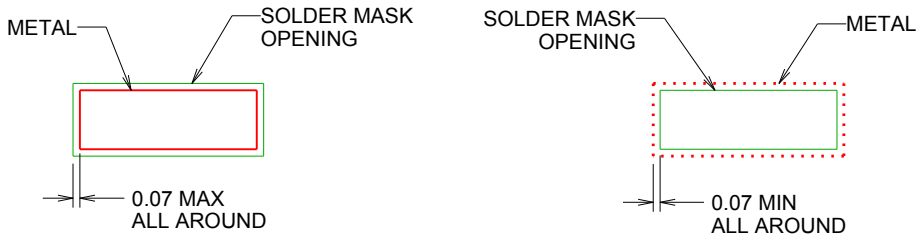


NOTES:

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

4218796/A 09/2013

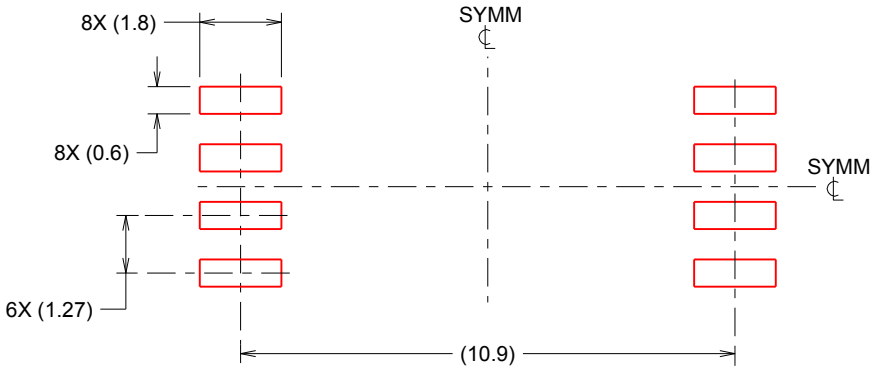
NOTES: (continued)

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

DWV0008A

SOIC - 2.8 mm max height

SOIC



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE:6X

4218796/A 09/2013

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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