

### FEATURES

- ▶ Bidirectional I<sup>2</sup>C communication
- ▶ Open-drain interfaces
- ▶ Suitable for hot swap applications
- ▶ 30 mA current sink capability
- ▶ 1000 kHz operation
- ▶ 3.0 V to 5.5 V supply/logic levels
- ▶ 8-lead, RoHS compliant SOIC package
- ▶ High temperature operation: 125°C
- ▶ Qualified for automotive applications
- ▶ Safety and regulatory approvals
  - ▶ UL 1577
    - ▶  $V_{ISO} = 2500 V_{RMS}$  for 1 minute
  - ▶ IEC / EN / CSA 62368-1
  - ▶ IEC / CSA 61010-1
  - ▶ CQC GB4943.1
  - ▶ DIN EN IEC 60747-17 (VDE 0884-17)
    - ▶  $V_{IORM} = 560 V_{PEAK}$

### APPLICATIONS

- ▶ Isolated I<sup>2</sup>C, SMBus, or PMBus interfaces
- ▶ Multilevel I<sup>2</sup>C interfaces
- ▶ Power supplies
- ▶ Networking
- ▶ Power over Ethernet
- ▶ Hybrid electric vehicle battery management

### GENERAL DESCRIPTION

The ADuM1250/ADuM1251<sup>1</sup> are hot swappable digital isolators with nonlatching, bidirectional communication channels that are compatible with I<sup>2</sup>C interfaces. This eliminates the need for splitting I<sup>2</sup>C signals into separate transmit and receive signals for use with standalone optocouplers.

The ADuM1250 provides two bidirectional channels, supporting a complete isolated I<sup>2</sup>C interface. The ADuM1251 provides one bidirectional channel and one unidirectional channel for applications where a bidirectional clock is not required.

Both the ADuM1250 and the ADuM1251 contain hot swap circuitry to prevent glitching data when an unpowered card is inserted onto an active bus.

### FUNCTIONAL BLOCK DIAGRAMS

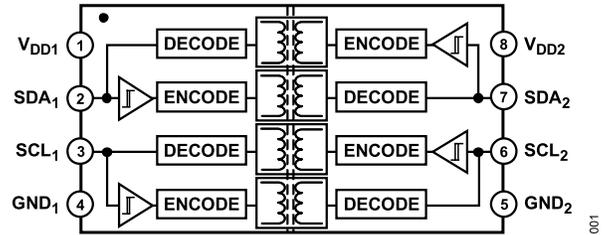


Figure 1. ADuM1250

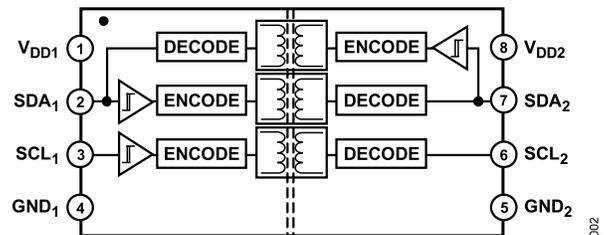


Figure 2. ADuM1251

These isolators are based on the *iCoupler*<sup>®</sup> chip scale transformer technology from Analog Devices, Inc. *iCoupler* is a magnetic isolation technology with functional, performance, size, and power consumption advantages as compared to optocouplers. With the ADuM1250/ADuM1251, *iCoupler* channels can be integrated with semiconductor circuitry, which enables a complete isolated I<sup>2</sup>C interface to be implemented in a small form factor.

<sup>1</sup> Protected by U.S. Patents 5,952,849; 6,873,065; and 7,075,329.

**TABLE OF CONTENTS**

Features.....	1	ESD Caution.....	8
Applications.....	1	Pin Configuration and Function Descriptions.....	9
Functional Block Diagrams.....	1	Test Conditions.....	10
General Description.....	1	Applications Information.....	11
Specifications.....	3	Functional Description.....	11
Electrical Characteristics.....	3	Startup.....	11
Package Characteristics.....	5	Typical Application Diagram.....	11
Regulatory Information.....	5	Capacitive Load at Low Speeds.....	12
Insulation and Safety Related Specifications.....	6	Magnetic Field Immunity.....	13
DIN EN IEC 60747-17 (VDE 0884-17)		Outline Dimensions.....	14
Insulation Characteristics.....	6	Ordering Guide.....	14
Recommended Operating Conditions.....	7	Evaluation Boards.....	14
Absolute Maximum Ratings.....	8	Automotive Products.....	14

**REVISION HISTORY****5/2025—Rev. J to Rev. K**

Changes to Features Section.....	1
Changes to Regulatory Information Section.....	5
Replaced Table 4.....	5
Changes to Table 5.....	6
Changed DIN VDE V 0884-11:2017-01 Insulation Characteristics Section to DIN EN IEC 60747-17 (VDE 0884-17) Insulation Characteristics Section.....	6
Changes to DIN EN IEC 60747-17 (VDE 0884-17) Insulation Characteristics Section and Table 6.....	6
Changes to Figure 3 Caption.....	7

**4/2023—Rev. I to Rev. J**

Changes to Features Section.....	1
Changes to Regulatory Information Section and Table 4.....	5
Changes to Table 5.....	6
Changed DIN VDE V 0884-10 (VDE V 0884-10) Insulation Characteristics Section to DIN VDE V 0884-11:2017-01 Insulation Characteristics Section.....	6
Changes to DIN VDE V 0884-11:2017-01 Insulation Characteristics Section and Table 6.....	6
Changes to Figure 3 Caption.....	7
Changes to Table 7.....	7
Changes to Table 8.....	8
Changes to Typical Application Diagram Section.....	11
Added Evaluation Boards Section.....	14

## SPECIFICATIONS

## ELECTRICAL CHARACTERISTICS

## DC Specifications

All voltages are relative to their respective ground. All minimum/maximum specifications apply over the entire recommended operating range, unless otherwise noted. All typical specifications are at  $T_A = 25^\circ\text{C}$ ,  $V_{DD1} = 3.3\text{ V}$  or  $5\text{ V}$ , and  $V_{DD2} = 3.3\text{ V}$  or  $5\text{ V}$ , unless otherwise noted.

Table 1.

Parameter	Symbol	Min	Typ	Max	Unit	Test Conditions/Comments
ADuM1250						
Input Supply Current, Side 1, 5 V	$I_{DD1}$		2.8	5.0	mA	$V_{DD1} = 5\text{ V}$
Input Supply Current, Side 2, 5 V	$I_{DD2}$		2.7	5.0	mA	$V_{DD2} = 5\text{ V}$
Input Supply Current, Side 1, 3.3 V	$I_{DD1}$		1.9	3.0	mA	$V_{DD1} = 3.3\text{ V}$
Input Supply Current, Side 2, 3.3 V	$I_{DD2}$		1.7	3.0	mA	$V_{DD2} = 3.3\text{ V}$
ADuM1251						
Input Supply Current, Side 1, 5 V	$I_{DD1}$		2.8	6.0	mA	$V_{DD1} = 5\text{ V}$
Input Supply Current, Side 2, 5 V	$I_{DD2}$		2.5	4.7	mA	$V_{DD2} = 5\text{ V}$
Input Supply Current, Side 1, 3.3 V	$I_{DD1}$		1.8	3.0	mA	$V_{DD1} = 3.3\text{ V}$
Input Supply Current, Side 2, 3.3 V	$I_{DD2}$		1.6	2.8	mA	$V_{DD2} = 3.3\text{ V}$
LEAKAGE CURRENTS	$I_{SDA1}, I_{SDA2},$ $I_{SCL1}, I_{SCL2}$		0.01	10	$\mu\text{A}$	$V_{SDA1} = V_{DD1}, V_{SDA2} = V_{DD2},$ $V_{SCL1} = V_{DD1}, V_{SCL2} = V_{DD2}$
SIDE 1 LOGIC LEVELS						
Logic Input Threshold <sup>1</sup>	$V_{SDA1T}, V_{SCL1T}$	500		700	mV	
Logic Low Output Voltages	$V_{SDA1OL}, V_{SCL1OL}$	600		900	mV	$I_{SDA1} = I_{SCL1} = 3.0\text{ mA}$ $I_{SDA1} = I_{SCL1} = 0.5\text{ mA}$
		600		850	mV	
Input/Output Logic Low Level Difference <sup>2</sup>	$\Delta V_{SDA1}, \Delta V_{SCL1}$	50			mV	
SIDE 2 LOGIC LEVELS						
Logic Low Input Voltage	$V_{SDA2IL}, V_{SCL2IL}$			$0.3 V_{DD2}$	V	
Logic High Input Voltage	$V_{SDA2IH}, V_{SCL2IH}$	$0.7 V_{DD2}$			V	
Logic Low Output Voltage	$V_{SDA2OL}, V_{SCL2OL}$			400	mV	$I_{SDA2} = I_{SCL2} = 30\text{ mA}$

<sup>1</sup>  $V_{IL} < 0.5\text{ V}$ ,  $V_{IH} > 0.7\text{ V}$ .

<sup>2</sup>  $\Delta V_{S1} = V_{S1OL} - V_{S1T}$ . This is the minimum difference between the output logic low level and the input logic threshold within a given component. This ensures that there is no possibility of the part latching up the bus to which it is connected.

## SPECIFICATIONS

## AC Specifications

All voltages are relative to their respective ground. All minimum/maximum specifications apply over the entire recommended operating range, unless otherwise noted. All typical specifications are at  $T_A = 25^\circ\text{C}$ ,  $V_{DD1} = 3.3\text{ V}$  or  $5\text{ V}$ , and  $V_{DD2} = 3.3\text{ V}$  or  $5\text{ V}$ , unless otherwise noted. Refer to Figure 5.

Table 2.

Parameter	Symbol	Min	Typ	Max	Unit	Test Conditions/Comments
MAXIMUM FREQUENCY		1000			kHz	
OUTPUT FALL TIME						
5 V Operation						$4.5\text{ V} \leq V_{DD1}$ , $V_{DD2} \leq 5.5\text{ V}$ , $C_{L1} = 40\text{ pF}$ , $R1 = 1.6\text{ k}\Omega$ , $C_{L2} = 400\text{ pF}$ , $R2 = 180\text{ }\Omega$
Side 1 Output ( $0.9 V_{DD1}$ to $0.9\text{ V}$ )	$t_{f1}$	13	26	120	ns	
Side 2 Output ( $0.9 V_{DD2}$ to $0.1 V_{DD2}$ )	$t_{f2}$	32	52	120	ns	
3 V Operation						$3.0\text{ V} \leq V_{DD1}$ , $V_{DD2} \leq 3.6\text{ V}$ , $C_{L1} = 40\text{ pF}$ , $R1 = 1.0\text{ k}\Omega$ , $C_{L2} = 400\text{ pF}$ , $R2 = 120\text{ }\Omega$
Side 1 Output ( $0.9 V_{DD1}$ to $0.9\text{ V}$ )	$t_{f1}$	13	32	120	ns	
Side 2 Output ( $0.9 V_{DD2}$ to $0.1 V_{DD2}$ )	$t_{f2}$	32	61	120	ns	
PROPAGATION DELAY						
5 V Operation						$4.5 \leq V_{DD1}$ , $V_{DD2} \leq 5.5\text{ V}$ , $C_{L1} = C_{L2} = 0\text{ pF}$ , $R1 = 1.6\text{ k}\Omega$ , $R2 = 180\text{ }\Omega$
Side 1 to Side 2, Rising Edge <sup>1</sup>	$t_{PLH12}$		95	130	ns	
Side 1 to Side 2, Falling Edge <sup>2</sup>	$t_{PHL12}$		162	275	ns	
Side 2 to Side 1, Rising Edge <sup>3</sup>	$t_{PLH21}$		31	70	ns	
Side 2 to Side 1, Falling Edge <sup>4</sup>	$t_{PHL21}$		85	155	ns	
3 V Operation						$3.0\text{ V} \leq V_{DD1}$ , $V_{DD2} \leq 3.6\text{ V}$ , $C_{L1} = C_{L2} = 0\text{ pF}$ , $R1 = 1.0\text{ k}\Omega$ , $R2 = 120\text{ }\Omega$
Side 1 to Side 2, Rising Edge <sup>1</sup>	$t_{PLH12}$		82	125	ns	
Side 1 to Side 2, Falling Edge <sup>2</sup>	$t_{PHL12}$		196	340	ns	
Side 2 to Side 1, Rising Edge <sup>3</sup>	$t_{PLH21}$		32	75	ns	
Side 2 to Side 1, Falling Edge <sup>4</sup>	$t_{PHL21}$		110	210	ns	
PULSE WIDTH DISTORTION						
5 V Operation						$4.5\text{ V} \leq V_{DD1}$ , $V_{DD2} \leq 5.5\text{ V}$ , $C_{L1} = C_{L2} = 0\text{ pF}$ , $R1 = 1.6\text{ k}\Omega$ , $R2 = 180\text{ }\Omega$
Side 1 to Side 2, $ t_{PLH12} - t_{PHL12} $	$PWD_{12}$		67	145	ns	
Side 2 to Side 1, $ t_{PLH21} - t_{PHL21} $	$PWD_{21}$		54	85	ns	
3 V Operation						$3.0\text{ V} \leq V_{DD1}$ , $V_{DD2} \leq 3.6\text{ V}$ , $C_{L1} = C_{L2} = 0\text{ pF}$ , $R1 = 1.0\text{ k}\Omega$ , $R2 = 120\text{ }\Omega$
Side 1 to Side 2, $ t_{PLH12} - t_{PHL12} $	$PWD_{12}$		114	215	ns	
Side 2 to Side 1, $ t_{PLH21} - t_{PHL21} $	$PWD_{21}$		77	135	ns	
COMMON-MODE TRANSIENT IMMUNITY <sup>5</sup>	$ CM_H $ , $ CM_L $	25	35		kV/ $\mu\text{s}$	

<sup>1</sup>  $t_{PLH12}$  propagation delay is measured from the Side 1 input logic threshold to an output value of  $0.7 V_{DD2}$ .

<sup>2</sup>  $t_{PHL12}$  propagation delay is measured from the Side 1 input logic threshold to an output value of  $0.4\text{ V}$ .

<sup>3</sup>  $t_{PLH21}$  propagation delay is measured from the Side 2 input logic threshold to an output value of  $0.7 V_{DD1}$ .

<sup>4</sup>  $t_{PHL21}$  propagation delay is measured from the Side 2 input logic threshold to an output value of  $0.9\text{ V}$ .

<sup>5</sup>  $CM_H$  is the maximum common-mode voltage slew rate that can be sustained while maintaining  $V_O > 0.8 V_{DD2}$ .  $CM_L$  is the maximum common-mode voltage slew rate that can be sustained while maintaining  $V_O < 0.8\text{ V}$ . The common-mode voltage slew rates apply to both rising and falling common-mode voltage edges. The transient magnitude is the range over which the common mode is slewed.

## SPECIFICATIONS

## PACKAGE CHARACTERISTICS

Table 3.

Parameter	Symbol	Min	Typ	Max	Unit	Test Conditions/Comments
Resistance (Input to Output) <sup>1</sup>	$R_{I-O}$		10 <sup>12</sup>		$\Omega$	
Capacitance (Input to Output) <sup>1</sup>	$C_{I-O}$		1.0		pF	f = 1 MHz
Input Capacitance	$C_I$		4.0		pF	
IC Junction to Case Thermal Resistance, Side 1	$\theta_{JCI}$		46		$^{\circ}\text{C}/\text{W}$	Thermocouple located at center of package underside
IC Junction to Case Thermal Resistance, Side 2	$\theta_{JCO}$		41		$^{\circ}\text{C}/\text{W}$	

<sup>1</sup> The device is considered a 2-terminal device; Pin 1 through Pin 4 are shorted together, and Pin 5 through Pin 8 are shorted together.

## REGULATORY INFORMATION

The ADuM1250/ADuM1251 certification approvals are listed in Table 4. Certifications available at [Safety and Regulatory Certifications for Digital Isolation](#).

Table 4.

UL	CSA	CQC	VDE	TUV
UL 1577 <sup>1</sup>	IEC / EN / CSA 62368-1	CQC GB4943.1	DIN EN IEC 60747-17 (VDE 0884-17) <sup>2</sup>	EN / UL 60950-1
Single Protection, 2500 V <sub>RMS</sub>	Basic insulation, 400 V <sub>RMS</sub> Reinforced insulation, 150 V <sub>RMS</sub> IEC / CSA 61010-1 Basic insulation, 300 V <sub>RMS</sub> Reinforced insulation, 150 V <sub>RMS</sub>	Basic insulation, 400 V <sub>RMS</sub> Reinforced insulation, 150 V <sub>RMS</sub>	Reinforced insulation, 560 V <sub>PEAK</sub>	Basic insulation, 400 V <sub>RMS</sub> Reinforced insulation, 200 V <sub>RMS</sub>
File E214100	File No. 205078	Certificate No. CQC14001108691	Certificate No. 40011599	Certificate No. U8V 16 05 56232 017

<sup>1</sup> In accordance with UL 1577, each ADuM1250/ADuM1251 is proof-tested by applying an insulation test voltage  $\geq 3000$  V<sub>RMS</sub> for 1 second (curemt leakage detection limit = 5  $\mu\text{A}$ ).

<sup>2</sup> In accordance with DIN EN IEC 60747-17 (VDE 0884-17), each ADuM1250/ADuM1251 is proof-tested by applying an insulation test voltage  $\geq 1050$  V<sub>PEAK</sub> for 1 second (partial discharge detection limit = 5 pC). The asterisk (\*) marked on the component designates DIN EN IEC 60747-17 (VDE 0884-17) approval.

## SPECIFICATIONS

## INSULATION AND SAFETY RELATED SPECIFICATIONS

Table 5.

Parameter	Symbol	Value	Unit	Test Conditions/Comments
Rated Dielectric Insulation Voltage		2500	V <sub>RMS</sub>	1-minute duration
Minimum External Air Gap (Clearance) <sup>1,2</sup>	L(I01)	4.0	mm	Measured from input terminals to output terminals, shortest distance through air
Minimum External Tracking (Creepage) <sup>1</sup>	L(I02)	4.0	mm	Measured from input terminals to output terminals, shortest distance path along body
Minimum Internal Gap (Internal Clearance)		18	µm	Insulation distance through insulation
Tracking Resistance (Comparative Tracking Index) <sup>3</sup>	CTI	>400	V	DIN EN 60112 (VDE 0303 Part 11):2010-05
Material Group		II		Material Group (DIN VDE 0110, 1/89, Table 1)
Maximum Working Voltage Compatible with 50 Year Service Life	V <sub>IORM</sub>	560	V <sub>PEAK</sub>	Continuous peak voltage across the isolation barrier

<sup>1</sup> In accordance with IEC 62368-1 / IEC 60601-1 guidelines for the measurement of creepage and clearance distances for a pollution degree of 2 and altitudes ≤2000 m.

<sup>2</sup> Consideration must be given to pad layout to ensure the minimum required distance for clearance is maintained.

<sup>3</sup> CTI rating for the ADuM1250/ADuM1251 is >400 V and a Material Group II isolation group.

## DIN EN IEC 60747-17 (VDE 0884-17) INSULATION CHARACTERISTICS

This isolator is suitable for reinforced isolation only within the safety limit data. Maintenance of the safety data is ensured by protective circuits. The asterisk (\*) marking on the package denotes DIN EN IEC 60747-17 (VDE 0884-17) approval.

Table 6.

Description	Test Conditions/Comments	Symbol	Characteristic	Unit
Installation Classification per DIN VDE 0110				
For Rated Mains Voltage ≤ 150 V <sub>RMS</sub>			I to IV	
For Rated Mains Voltage ≤ 300 V <sub>RMS</sub>			I to III	
For Rated Mains Voltage ≤ 400 V <sub>RMS</sub>			I to II	
Climatic Classification	A grade		40/105/21	
	S, W grades		40/125/21	
Pollution Degree per DIN VDE 0110, Table 1			2	
Maximum Repetitive Isolation Voltage		V <sub>IORM</sub>	560	V <sub>PEAK</sub>
Maximum Working Insulation Voltage		V <sub>IOWM</sub>	396	V <sub>RMS</sub>
Input to Output Test Voltage, Method B1	V <sub>IORM</sub> × 1.875 = V <sub>PR</sub> , 100% production test, t <sub>m</sub> = 1 sec, partial discharge < 5 pC	V <sub>PR</sub>	1050	V <sub>PEAK</sub>
Input to Output Test Voltage, Method A	V <sub>IORM</sub> × 1.6 = V <sub>PR</sub> , t <sub>m</sub> = 60 sec, partial discharge < 5 pC	V <sub>PR</sub>		
After Environmental Tests Subgroup 1			896	V <sub>PEAK</sub>
After Input and/or Safety Tests Subgroup 2 and Subgroup 3	V <sub>IORM</sub> × 1.2 = V <sub>PR</sub> , t <sub>m</sub> = 60 sec, partial discharge < 5 pC		672	V <sub>PEAK</sub>
Maximum Transient Isolation Voltage	V <sub>TEST</sub> = 1.2 × V <sub>IOTM</sub> , t = 1 sec (100% production)	V <sub>IOTM</sub>	4000	V <sub>PEAK</sub>
Maximum Impulse Voltage	Surge voltage in air, waveform per IEC 61000-4-5	V <sub>IMP</sub>	4000	V <sub>PEAK</sub>
Maximum Surge Isolation Voltage	V <sub>TEST</sub> ≥ 1.3 × V <sub>IMP</sub> (sample test), Tested in oil, waveform per IEC 61000-4-5	V <sub>IOSM</sub>	6250	V <sub>PEAK</sub>
Safety Limiting Values	Maximum value allowed in the event of a failure (see Figure 3)			
Case Temperature		T <sub>S</sub>	150	°C
V <sub>DD1</sub> + V <sub>DD2</sub> Current		I <sub>TMAX</sub>	212	mA
Insulation Resistance at T <sub>S</sub>	V <sub>IO</sub> = 500 V	R <sub>S</sub>	>10 <sup>9</sup>	Ω

## SPECIFICATIONS

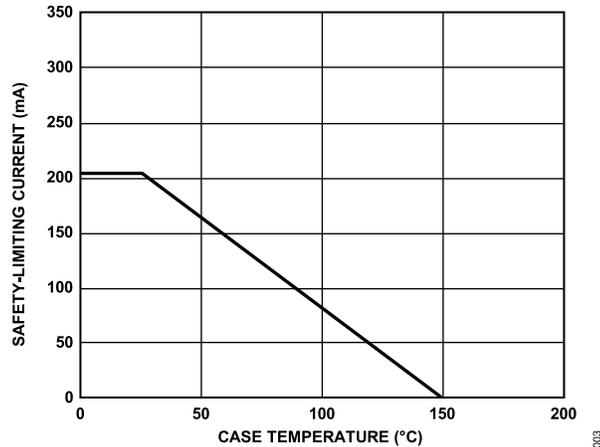


Figure 3. Thermal Derating Curve, Dependence of Safety-Limiting Values on Case Temperature, per DIN EN IEC 60747-17 (VDE 0884-17)

## RECOMMENDED OPERATING CONDITIONS

Table 7.

Parameter	Rating
Operating Temperature ( $T_A$ )	
A Grade	-40°C to +105°C
S, W Grades	-40°C to +125°C
Supply Voltages <sup>1</sup>	
$V_{DD1}$	3.0 V to 5.5 V
$V_{DD2}$	3.0 V to 5.5 V
Input/Output Signal Voltage ( $V_{SDA1}$ , $V_{SCL1}$ , $V_{SDA2}$ , $V_{SCL2}$ )	5.5 V
Capacitive Load	
Side 1 ( $C_{L1}$ )	40 pF
Side 2 ( $C_{L2}$ )	400 pF
Static Output Loading	
Side 1 ( $I_{SDA1}$ , $I_{SCL1}$ )	0.5 mA to 3 mA
Side 2 ( $I_{SDA2}$ , $I_{SCL2}$ )	0.5 mA to 30 mA

<sup>1</sup> All voltages are relative to their respective ground. See the [Magnetic Field Immunity](#) section for information about immunity to external magnetic fields.

**ABSOLUTE MAXIMUM RATINGS**

Ambient temperature = 25°C, unless otherwise noted.

**Table 8.**

Parameter	Rating
Storage Temperature ( $T_{ST}$ )	-55°C to +150°C
Ambient Operating Temperature ( $T_A$ )	
A Grade	-40°C to +105°C
S, W Grades	-40°C to +125°C
Supply Voltages <sup>1</sup>	
$V_{DD1}$ to GND <sub>1</sub>	-0.5 V to +7.0 V
$V_{DD2}$ to GND <sub>2</sub>	-0.5 V to +7.0 V
Input/Output Voltage	
Side 1 ( $V_{SDA1}$ , $V_{SCL1}$ ) <sup>2</sup>	-0.5 V to $V_{DD1} + 0.5$ V
Side 2 ( $V_{SDA2}$ , $V_{SCL2}$ ) <sup>2</sup>	-0.5 V to +7.0 V
Average Output Current per Pin <sup>2</sup>	
Side 1 ( $I_{O1}$ )	±18 mA
Side 2 ( $I_{O2}$ )	±100 mA
Common-Mode Transients <sup>3</sup>	-100 kV/μs to +100 kV/μs

<sup>1</sup> All voltages are relative to their respective ground.

- <sup>2</sup> See Figure 3 for maximum rated current values for various temperatures.
- <sup>3</sup> Refers to common-mode transients across the insulation barrier. Common-mode transients exceeding the absolute maximum rating may cause latch-up or permanent damage.

Stresses at or above those listed under Absolute Maximum Ratings may cause permanent damage to the product. This is a stress rating only; functional operation of the product at these or any other conditions above those indicated in the operational section of this specification is not implied. Operation beyond the maximum operating conditions for extended periods may affect product reliability.

**ESD CAUTION**

**ESD (electrostatic discharge) sensitive device.** Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

## PIN CONFIGURATION AND FUNCTION DESCRIPTIONS

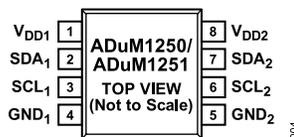


Figure 4. ADuM1250/ADuM1251 Pin Configuration

Table 9. ADuM1250 Pin Function Descriptions

Pin No.	Mnemonic	Description
1	V <sub>DD1</sub>	Supply Voltage, 3.0 V to 5.5 V.
2	SDA <sub>1</sub>	Data Input/Output, Side 1.
3	SCL <sub>1</sub>	Clock Input/Output, Side 1.
4	GND <sub>1</sub>	Ground 1. Ground reference for Isolator Side 1.
5	GND <sub>2</sub>	Ground 2. Isolated ground reference for Isolator Side 2.
6	SCL <sub>2</sub>	Clock Input/Output, Side 2.
7	SDA <sub>2</sub>	Data Input/Output, Side 2.
8	V <sub>DD2</sub>	Supply Voltage, 3.0 V to 5.5 V.

Table 10. ADuM1251 Pin Function Descriptions

Pin No.	Mnemonic	Description
1	V <sub>DD1</sub>	Supply Voltage, 3.0 V to 5.5 V.
2	SDA <sub>1</sub>	Data Input/Output, Side 1.
3	SCL <sub>1</sub>	Clock Input, Side 1.
4	GND <sub>1</sub>	Ground 1. Ground reference for Isolator Side 1.
5	GND <sub>2</sub>	Ground 2. Isolated ground reference for Isolator Side 2.
6	SCL <sub>2</sub>	Clock Output, Side 2.
7	SDA <sub>2</sub>	Data Input/Output, Side 2.
8	V <sub>DD2</sub>	Supply Voltage, 3.0 V to 5.5 V.

TEST CONDITIONS

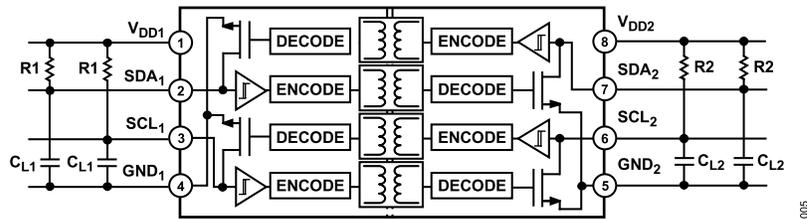


Figure 5. Timing Test Diagram

## APPLICATIONS INFORMATION

## FUNCTIONAL DESCRIPTION

The ADuM1250/ADuM1251 interface on each side to a bidirectional I<sup>2</sup>C signal. Internally, the I<sup>2</sup>C interface is split into two unidirectional channels communicating in opposing directions via a dedicated iCoupler isolation channel for each. One channel (the bottom channel of each channel pair shown in Figure 6) senses the voltage state of the Side 1 I<sup>2</sup>C pin and transmits its state to its respective Side 2 I<sup>2</sup>C pin.

Both the Side 1 and the Side 2 I<sup>2</sup>C pins are designed to interface to an I<sup>2</sup>C bus operating in the 3.0 V to 5.5 V range. A logic low on either pin causes the opposite pin to be pulled low enough to comply with the logic low threshold requirements of other I<sup>2</sup>C devices on the bus. Avoidance of I<sup>2</sup>C bus contention is ensured by an input low threshold at SDA<sub>1</sub> or SCL<sub>1</sub> guaranteed to be at least 50 mV less than the output low signal at the same pin. This prevents an output logic low at Side 1 being transmitted back to Side 2 and pulling down the I<sup>2</sup>C bus.

Because the Side 2 logic levels/thresholds are standard I<sup>2</sup>C values, multiple ADuM1250/ADuM1251 devices connected to a bus by their Side 2 pins can communicate with each other and with other I<sup>2</sup>C compatible devices. A distinction is made between I<sup>2</sup>C compatibility and I<sup>2</sup>C compliance. I<sup>2</sup>C compatibility refers to situations in which the logic levels of a component do not necessarily meet the requirements of the I<sup>2</sup>C specification but still allow the component to communicate with an I<sup>2</sup>C compliant device. I<sup>2</sup>C compliance refers to situations in which the logic levels of a component meet the requirements of the I<sup>2</sup>C specification.

However, because the Side 1 pin has a modified output level/ input threshold, this side of the ADuM1250/ADuM1251 can communicate only with devices that conform to the I<sup>2</sup>C standard. In other words, Side 2 of the ADuM1250/ADuM1251 is I<sup>2</sup>C compliant, whereas Side 1 is only I<sup>2</sup>C compatible.

The output logic low levels are independent of the V<sub>DD1</sub> and V<sub>DD2</sub> voltages. The input logic low threshold at Side 1 is also independent of V<sub>DD1</sub>. However, the input logic low threshold at Side 2 is designed to be at 0.3 V<sub>DD2</sub>, consistent with I<sup>2</sup>C requirements. The Side 1 and Side 2 pins have open-collector outputs whose high levels are set via pull-up resistors to their respective supply voltages.

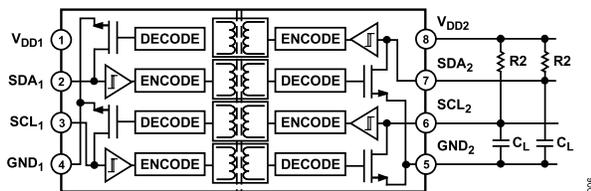


Figure 6. ADuM1250 Block Diagram

## STARTUP

Both the V<sub>DD1</sub> and V<sub>DD2</sub> supplies have an undervoltage lockout feature to prevent the signal channels from operating unless certain criteria are met. This feature prevents input logic low signals from pulling down the I<sup>2</sup>C bus inadvertently during power-up/power-down.

For the signal channels to be enabled, the following two criteria must be met:

- ▶ Both supplies must be at least 2.5 V.
- ▶ At least 40 μs must elapse after both supplies exceed the internal startup threshold of 2.0 V.

Until both criteria are met for both supplies, the ADuM1250/ADuM1251 outputs are pulled high, ensuring a startup that avoids any disturbances on the bus. Figure 7 and Figure 8 illustrate the supply conditions for fast and slow input supply slew rates.

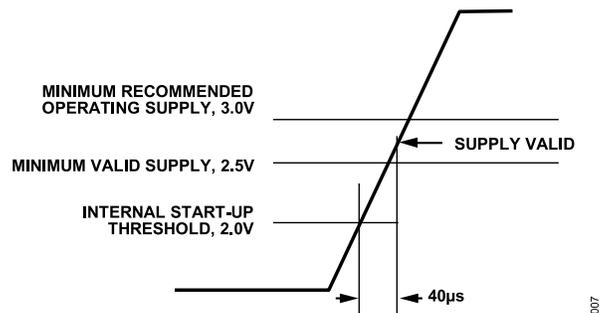


Figure 7. Start-Up Condition, Supply Slew Rate > 12.5 V/ms

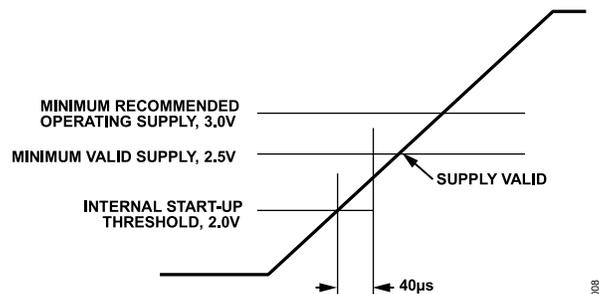


Figure 8. Start-Up Condition, Supply Slew Rate < 12.5 V/ms

## TYPICAL APPLICATION DIAGRAM

Figure 9 shows a typical application circuit including the pull-up resistors required for both Side 1 and Side 2 buses. Bypass capacitors with values from 0.01 μF to 0.1 μF are required between V<sub>DD1</sub> and GND<sub>1</sub> and between V<sub>DD2</sub> and GND<sub>2</sub>. The 200 Ω resistor shown in Figure 9 is required for latch-up immunity when hot plugging if the ambient temperature is between 105°C and 125°C, and must be placed on the side being hot plugged. Use 200 Ω for 5 V V<sub>DD1</sub> and 91 Ω for 3.3 V V<sub>DD1</sub>.

APPLICATIONS INFORMATION

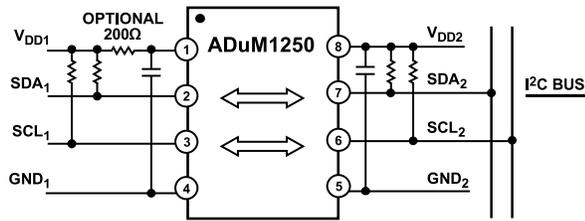


Figure 9. Typical Isolated I<sup>2</sup>C Interface Using the ADuM1250

CAPACITIVE LOAD AT LOW SPEEDS

The ADuM1250/ADuM1251 are designed for operation at speeds up to 1 Mbps. Due to the limited current available on Side 1,

operation at 1 Mbps limits the capacitance that can be driven at the minimum pull-up value to 40 pF.

Most applications operate at 100 kbps in standard mode or 400 kbps in fast mode. At these lower operating speeds, the limitation on the load capacitance can be significantly relaxed. Table 11 shows the maximum capacitance at minimum pull-up values for standard and fast operating modes. If larger values for the pull up resistor are used, the maximum supported capacitance must be scaled down proportionately so that the rise time does not increase beyond the values required by the standard.

Table 11. Side 1 Maximum Load Conditions

Maximum Capacitive Load for Side 1						
Mode	V <sub>DD1</sub>	Data Rate (kbps)	t <sub>r</sub> (ns)	t <sub>f</sub> (ns)	R <sub>1</sub> (Ω)	C <sub>L1</sub> (pF)
Standard	5	100	1000	187	1600	484
Fast	5	400	300	172	1600	120
Standard	3.3	100	1000	270	1000	771
Fast	3.3	400	300	235	1000	188

APPLICATIONS INFORMATION

MAGNETIC FIELD IMMUNITY

The ADuM1250/ADuM1251 are extremely immune to external magnetic fields. The limitation on the magnetic field immunity of the ADuM1250/ADuM1251 is set by the condition in which induced voltage in the receiving coil of the transformer is sufficiently large to either falsely set or reset the decoder. The following analysis defines the conditions under which this may occur. The 3 V operating condition of the ADuM1250/ADuM1251 is examined because it represents the most susceptible mode of operation.

The pulses at the transformer output have an amplitude greater than 1.0 V. The decoder has a sensing threshold at approximately 0.5 V, thus establishing a 0.5 V margin in which induced voltages can be tolerated. The voltage induced across the receiving coil is given by

$$V = (-d\beta/dt) \sum \pi r_n^2; n = 1, 2, \dots, N \tag{1}$$

where:

- $\beta$  is the magnetic flux density (gauss).
- $r_n$  is the radius of the  $n^{\text{th}}$  turn in the receiving coil (cm).
- $N$  is the total number of turns in the receiving coil.

Given the geometry of the receiving coil in the ADuM1250 and the ADuM1251 and an imposed requirement that the induced voltage be, at most, 50% of the 0.5 V margin at the decoder, a maximum allowable magnetic field is calculated as shown in Figure 10.

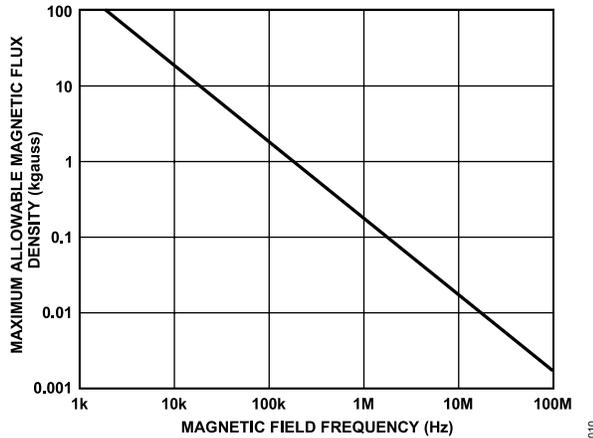


Figure 10. Maximum Allowable External Magnetic Flux Density

For example, at a magnetic field frequency of 1 MHz, the maximum allowable magnetic field of 0.2 kgauss induces a voltage of 0.25 V at the receiving coil. This voltage is approximately 50% of the sensing threshold and does not cause a faulty output transition. Similarly, if such an event occurs during a transmitted pulse (and is of the worst-case polarity), it reduces the received pulse from >1.0 V to 0.75 V, still well above the 0.5 V sensing threshold of the decoder.

The preceding magnetic flux density values correspond to specific current magnitudes at given distances away from the ADuM1250/ADuM1251 transformers. Figure 11 expresses these allowable current magnitudes as a function of frequency for selected distances. As shown in Figure 11 the ADuM1250/ADuM1251 are extremely immune and can be affected only by extremely large currents operated at high frequency very close to the component. For the 1 MHz example, a 0.5 kA current placed 5 mm away from the ADuM1250/ADuM1251 is required to affect the operation of the component.

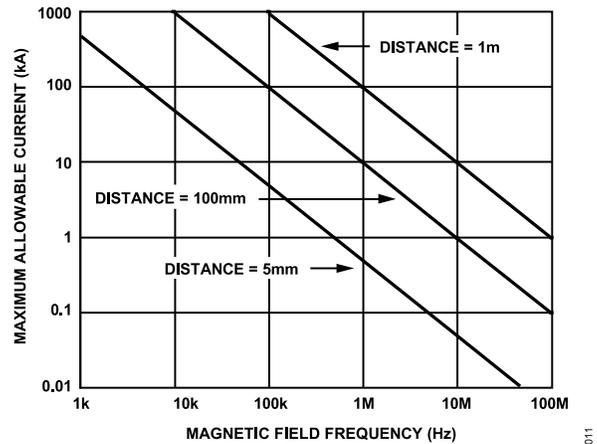
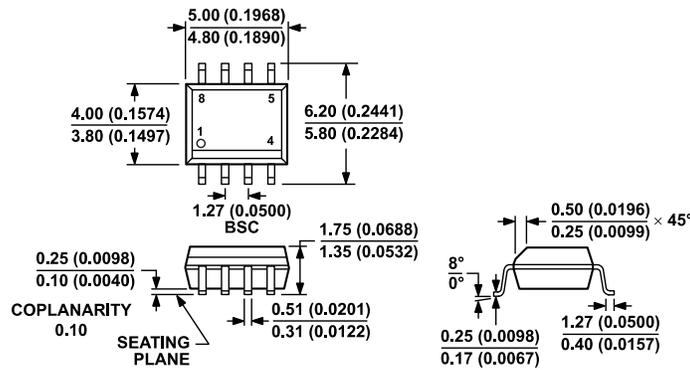


Figure 11. Maximum Allowable Current for Various Current-to-ADuM1250/ADuM1251 Spacings

Note that at combinations of strong magnetic field and high frequency, any loops formed by PCB traces can induce error voltages sufficiently large to trigger the thresholds of succeeding circuitry. Exercise care in the layout of such traces to avoid this possibility.

OUTLINE DIMENSIONS



COMPLIANT TO JEDEC STANDARDS MS-012-AA  
 CONTROLLING DIMENSIONS ARE IN MILLIMETERS; INCH DIMENSIONS  
 (IN PARENTHESES) ARE ROUNDED-OFF MILLIMETER EQUIVALENTS FOR  
 REFERENCE ONLY AND ARE NOT APPROPRIATE FOR USE IN DESIGN.

012407-A

Figure 12. 8-Lead Standard Small Outline Package [SOIC\_N]  
 Narrow Body  
 (R-8)

Dimensions shown in millimeters and (inches)

ORDERING GUIDE

Model <sup>1, 2</sup>	Temperature Range	Package Description	Packing Quantity	Package Option
ADUM1250ARZ	-40°C to +105°C	8-Lead SOIC	Tube, 98	R-8
ADUM1250ARZ-RL7	-40°C to +105°C	8-Lead SOIC	Reel, 1000	R-8
ADUM1250SRZ	-40°C to +125°C	8-Lead SOIC	Tube, 98	R-8
ADUM1250SRZ-RL7	-40°C to +125°C	8-Lead SOIC	Reel, 1000	R-8
ADUM1250WSRZ	-40°C to +125°C	8-Lead SOIC	Tube, 98	R-8
ADUM1250WSRZ-RL7	-40°C to +125°C	8-Lead SOIC	Reel, 1000	R-8
ADUM1251ARZ	-40°C to +105°C	8-Lead SOIC	Tube, 98	R-8
ADUM1251ARZ-RL7	-40°C to +105°C	8-Lead SOIC	Reel, 1000	R-8
ADUM1251WARZ	-40°C to +125°C	8-Lead SOIC	Tube, 98	R-8
ADUM1251WARZ-RL7	-40°C to +125°C	8-Lead SOIC	Reel, 1000	R-8

<sup>1</sup> Z = RoHS Compliant Part.

<sup>2</sup> W = Qualified for Automotive Applications.

EVALUATION BOARDS

Model <sup>1</sup>	Description
EVAL-ADuM1250EBZ	Evaluation Board

<sup>1</sup> EVAL-ADuM1250EBZ is RoHS compliant.

AUTOMOTIVE PRODUCTS

The ADuM1250W and ADuM1251W models are available with controlled manufacturing to support the quality and reliability requirements of automotive applications. Note that these automotive models may have specifications that differ from the commercial models; therefore, designers should review the [Specifications](#) section of this data sheet carefully. Only the automotive grade products shown are available for use in automotive applications. Contact your local Analog Devices account representative for specific product ordering information and to obtain the specific Automotive Reliability reports for these models.

I<sup>2</sup>C refers to a communications protocol originally developed by Philips Semiconductors (now NXP Semiconductors).