

### 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**
- Wide body, 16-lead SOIC package with >8 mm creepage**
- High temperature operation: 105°C**
- Safety and regulatory approvals**
  - UL recognition (pending)
  - 5000 V rms for 1 minute per UL 1577
  - CSA Component Acceptance Notice #5A
  - VDE Certificate of Conformity
  - DIN V VDE V 0884-10 (VDE V 0884-10): 2006-12
  - V<sub>IORM</sub> = 846 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**

### GENERAL DESCRIPTION

The ADuM2250/ADuM2251<sup>1</sup> are hot-swappable digital isolators with nonlatching bidirectional communication channels that are compatible with I<sup>2</sup>C<sup>®</sup> 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 ADuM2250 provides two bidirectional channels supporting a complete isolated I<sup>2</sup>C interface. The ADuM2251 provides one bidirectional channel and one unidirectional channel for those applications where a bidirectional clock is not required.

The ADuM2250/ADuM2251 contain hot-swap circuitry to prevent data glitches when an unpowered card is inserted onto an active bus.

These isolators are based on *iCoupler*<sup>®</sup> chip-scale transformer technology from Analog Devices, Inc. *iCoupler* is a magnetic isolation technology with performance, size, power consumption, and functional advantages compared to optocouplers. The ADuM2250/ADuM2251 integrate *iCoupler* channels with semiconductor circuitry to enable a complete, isolated I<sup>2</sup>C interface in a small form-factor package.

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

### FUNCTIONAL BLOCK DIAGRAMS

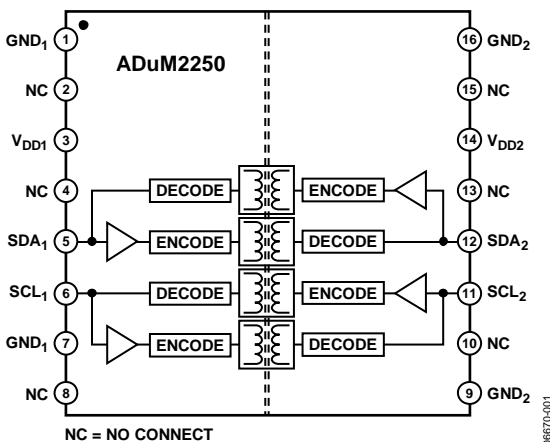


Figure 1. ADuM2250 Functional Block Diagram

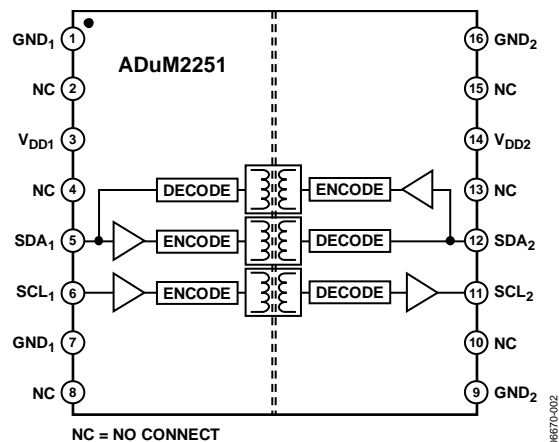


Figure 2. ADuM2251 Functional Block Diagram

### Rev. 0

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## REVISION HISTORY

4/07—Revision 0: Initial Version

## 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  $T_A = 25^\circ\text{C}$ ,  $V_{DD1} = 5\text{ V}$ , and  $V_{DD2} = 5\text{ V}$ , unless otherwise noted.

Table 1.

| Parameter  | Symbol                                   | Min                  | Typ  | Max                  | Unit          | Test Conditions   |
|--|--|----------------------|------|----------------------|---------------|---|
| ADuM2250   |  |                      |      |                      |               |   |
| 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            | $V_{DD2} = 3.3\text{ V}$  |
| ADuM2251   |  |                      |      |                      |               |   |
| 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                   | $\mu\text{A}$ | $V_{SDA1} = V_{DD1}, V_{SDA2} = V_{DD2},$<br>$V_{SCL1} = V_{DD1}, V_{SCL2} = V_{DD2}$ |
| SIDE 1 LOGIC LEVELS                                  |  |                      |      |                      |               |   |
| Logic Input Threshold <sup>1</sup>                   | $V_{SDA1IL}, V_{SCL1IL}$                 | 500                  |      | 700                  | mV            |   |
| Logic Low Output Voltages                            | $V_{SDA1OL}, V_{SCL1OL}$                 | 600                  |      | 900                  | mV            | $I_{SDA1} = I_{SCL1} = 3.0\text{ mA}$   |
|  |  | 600                  |      | 850                  | mV            | $I_{SDA1} = I_{SCL1} = 0.5\text{ mA}$   |
| 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                              | $V_{SDA2IL}, V_{SCL2IL}$                 |                      |      | $0.3 \times V_{DD2}$ | V             |   |
| Logic High Input Voltage                             | $V_{SDA2IH}, V_{SCL2IH}$                 | $0.7 \times V_{DD2}$ |      |                      | 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>  $\Delta V_{S1L} = V_{S1OL} - V_{S1IL}$ . This is the minimum difference between the output logic low level and the input logic low threshold within a given component. This ensures that there is no possibility of the part latching up the bus to which it is connected.

# ADuM2250/ADuM2251

## 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  $T_A = 25^\circ\text{C}$ ,  $V_{DD1} = 5\text{ V}$ , and  $V_{DD2} = 5\text{ V}$ , unless otherwise noted. See Figure 3 for a timing test diagram.

**Table 2.**

| Parameter                                       | Symbol           | Min  | Typ | Max | Unit        | Test Conditions  |
|---|------------------|------|-----|-----|-------------|--|
| MAXIMUM FREQUENCY                               |                  | 1000 |     |     | kHz         |  |
| OUTPUT FALL TIME                                |                  |      |     |     |             |  |
| 5 V Operation                                   |                  |      |     |     |             | $4.5\text{ V} \leq V_{DD1}, V_{DD2} \leq 5.5\text{ V}, C_{L1} = 40\text{ pF}, R_1 = 1.6\text{ k}\Omega, C_{L2} = 400\text{ pF}, R_2 = 180\text{ }\Omega$ |
| Side 1 Output (0.9 $V_{DD1}$ to 0.9 V)          | $t_{r1}$         | 13   | 26  | 120 | ns          |  |
| Side 2 Output (0.9 $V_{DD2}$ to 0.1 $V_{DD2}$ ) | $t_{r2}$         | 32   | 52  | 120 | ns          |  |
| 3 V Operation                                   |                  |      |     |     |             | $3.0\text{ V} \leq V_{DD1}, V_{DD2} \leq 3.6\text{ V}, C_{L1} = 40\text{ pF}, R_1 = 1.0\text{ k}\Omega, C_{L2} = 400\text{ pF}, R_2 = 120\text{ }\Omega$ |
| Side 1 Output (0.9 $V_{DD1}$ to 0.9 V)          | $t_{r1}$         | 13   | 32  | 120 | ns          |  |
| Side 2 Output (0.9 $V_{DD2}$ to 0.1 $V_{DD2}$ ) | $t_{r2}$         | 32   | 61  | 120 | ns          |  |
| PROPAGATION DELAY                               |                  |      |     |     |             |  |
| 5 V Operation                                   |                  |      |     |     |             | $4.5\text{ V} \leq V_{DD1}, V_{DD2} \leq 5.5\text{ V}, C_{L1} = C_{L2} = 0\text{ pF}, R_1 = 1.6\text{ k}\Omega, R_2 = 180\text{ }\Omega$                 |
| 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                                   |                  |      |     |     |             | $3.0\text{ V} \leq V_{DD1}, V_{DD2} \leq 3.6\text{ V}, C_{L1} = C_{L2} = 0\text{ pF}, R_1 = 1.0\text{ k}\Omega, R_2 = 120\text{ }\Omega$                 |
| 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                                   |                  |      |     |     |             | $4.5\text{ V} \leq V_{DD1}, V_{DD2} \leq 5.5\text{ V}, C_{L1} = C_{L2} = 0\text{ pF}, R_1 = 1.6\text{ k}\Omega, R_2 = 180\text{ }\Omega$                 |
| 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                                   |                  |      |     |     |             | $3.0\text{ V} \leq V_{DD1}, V_{DD2} \leq 3.6\text{ V}, C_{L1} = C_{L2} = 0\text{ pF}, R_1 = 1.0\text{ k}\Omega, R_2 = 120\text{ }\Omega$                 |
| 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/ $\mu$ 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 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 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.

TEST CONDITIONS

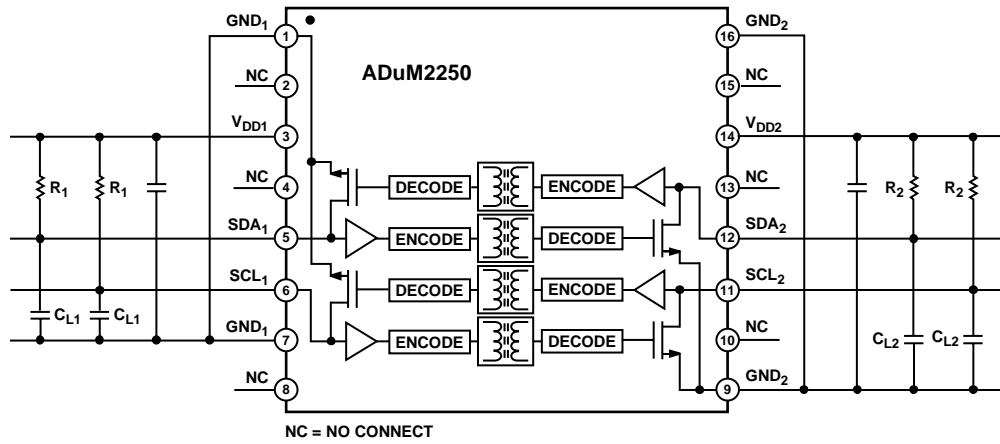


Figure 3. Timing Test Diagram

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# ADuM2250/ADuM2251

## PACKAGE CHARACTERISTICS

Table 3.

| Parameter                                  | Symbol           | Min | Typ              | Max | Unit | Test Conditions                                     |
|--|------------------|-----|------------------|-----|------|---|
| Resistance (Input to Output) <sup>1</sup>  | R <sub>I-O</sub> |     | 10 <sup>12</sup> |     | Ω    | f = 1 MHz   |
| Capacitance (Input to Output) <sup>1</sup> | C <sub>I-O</sub> |     | 2.2              |     | pF   |   |
| Input Capacitance                          | C <sub>i</sub>   |     | 4.0              |     | pF   | Thermocouple located at center of package underside |
| IC Junction-to-Ambient Thermal Resistance  | θ <sub>JA</sub>  |     | 45               |     | °C/W |   |

<sup>1</sup> The device is considered a 2-terminal device; Pin 1 to Pin 8 are shorted together, and Pin 9 to Pin 16 are shorted together.

## REGULATORY INFORMATION

The ADuM2250/ADuM2251 is approved by the following organizations.

Table 4.

| UL (Pending)   | CSA   | VDE  |
|--|---|--|
| Recognized under 1577 Component Recognition Program <sup>1</sup> | Approved under CSA Component Acceptance Notice #5A  | Certified according to DIN V VDE V 0884-10 (VDE V 0884-10): 2006-12 <sup>2</sup> |
| Double insulation, 5000 V rms isolation rating                   | Reinforced insulation per CSA 60950-1-03 and IEC 60950-1 600 V rms (848 V peak) maximum working voltage<br>Reinforced insulation per IEC 60601-1 250 V rms (353 V peak) maximum working voltage | Reinforced insulation, 846 V peak  |
| File E214100   | File 205078   | File 2471900-4880-0001   |

<sup>1</sup> In accordance with UL1577, each ADuM225x is proof tested by applying an insulation test voltage ≥ 6000 V rms for 1 second (current leakage detection limit = 10 μA).

<sup>2</sup> In accordance with DIN V VDE V 0884-10, each ADuM225x is proof tested by applying an insulation test voltage ≥ 1590 V peak for 1 sec (partial discharge detection limit = 5 pC). The \* marking branded on the component designates DIN V VDE V 0884-10 approval.

## INSULATION AND SAFETY-RELATED SPECIFICATIONS

Table 5.

| Parameter  | Symbol | Value     | Unit  | Conditions   |
|--|--------|-----------|-------|--|
| Rated Dielectric Insulation Voltage              |        | 5000      | V rms | 1-minute duration  |
| Minimum External Air Gap (Clearance)             | L(I01) | 7.46 min  | mm    | Measured from input terminals to output terminals, shortest distance through air     |
| Minimum External Tracking (Creepage)             | L(I02) | 8.10 min  | mm    | Measured from input terminals to output terminals, shortest distance path along body |
| Minimum Internal Gap (Internal Clearance)        |        | 0.017 min | mm    | Insulation distance through insulation   |
| Tracking Resistance (Comparative Tracking Index) | CTI    | >175      | V     | DIN IEC 112/VDE 0303 Part 1  |
| Isolation Group                                  |        | IIIa      |       | Material Group (DIN VDE 0110, 1/89, Table 1)   |

**DIN V VDE V 0884-10 (VDE V 0884-10) INSULATION CHARACTERISTICS**

Note that the \* marking on the package denotes DIN V VDE V 0884-10 approval for a 848 V peak working voltage. This isolator is suitable for reinforced isolation only within the safety limit data. Maintenance of the safety data is ensured by protective circuits.

**Table 6.**

| Description  | Conditions  | Symbol     | Characteristic                | Unit               |
|--|---|------------|-------------------------------|--------------------|
| Installation Classification per DIN VDE 0110<br>For Rated Mains Voltage $\leq 300$ V rms<br>For Rated Mains Voltage $\leq 450$ V rms<br>For Rated Mains Voltage $\leq 600$ V rms |   |            | I to IV<br>I to II<br>I to II |                    |
| Climatic Classification  |   |            | 40/105/21                     |                    |
| Pollution Degree (DIN VDE 0110, Table 1)   |   |            | 2                             |                    |
| Maximum Working Insulation Voltage   |   | $V_{IORM}$ | 846                           | V peak             |
| Input-to-Output Test Voltage, Method b1  | $V_{IORM} \times 1.875 = V_{PR}$ , 100% production test, $t_m = 1$ sec,<br>partial discharge $< 5$ pC | $V_{PR}$   | 1590                          | V peak             |
| Input-to-Output Test Voltage, Method a   |   | $V_{PR}$   |                               |                    |
| After Environmental Tests Subgroup 1   | $V_{IORM} \times 1.6 = V_{PR}$ , $t_m = 60$ sec, partial discharge $< 5$ pC                           |            | 1375                          | V peak             |
| After Input and/or Safety Test Subgroup 2<br>and Subgroup 3  | $V_{IORM} \times 1.2 = V_{PR}$ , $t_m = 60$ sec, partial discharge $< 5$ pC                           |            | 1018                          | V peak             |
| Highest Allowable Overvoltage  | Transient overvoltage, $t_{TR} = 10$ seconds  | $V_{TR}$   | 6000                          | V peak             |
| Safety-Limiting Values   | Maximum value allowed in the event of a failure;<br>see Figure 4                                      |            |                               |                    |
| Case Temperature   |   | $T_S$      | 150                           | $^{\circ}\text{C}$ |
| Supply Current   | $I_{DD1} + I_{DD2}$   | $I_S$      | 555                           | mA                 |
| Insulation Resistance at $T_S$   | $V_{IO} = 500$ V  | $R_S$      | $>10^9$                       | $\Omega$           |

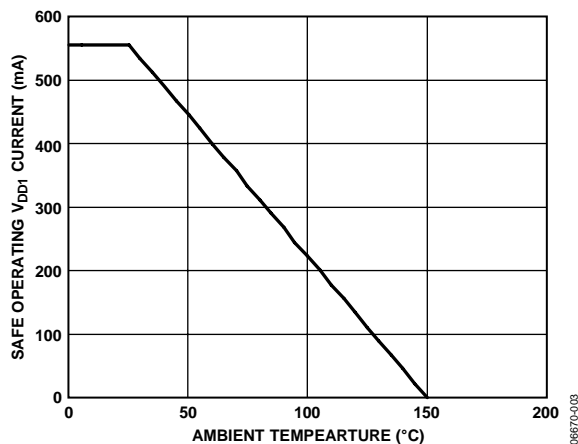


Figure 4. Thermal Derating Curve, Dependence of Safety-Limiting Values on Case Temperature, per DIN V VDE V 0884-10

**RECOMMENDED OPERATING CONDITIONS****Table 7.**

| Parameter                     | Symbol  | Min | Max  | Unit               |
|-------------------------------|---|-----|------|--------------------|
| Operating Temperature         | $T_A$   | -40 | +105 | $^{\circ}\text{C}$ |
| Supply Voltages <sup>1</sup>  | $V_{DD1}, V_{DD2}$                            | 3.0 | 5.5  | V                  |
| Input/Output Signal Voltage   | $V_{SDA1}, V_{SCL1},$<br>$V_{SDA2}, V_{SCL2}$ |     | 5.5  | V                  |
| Capacitive Load, Side 1       | $C_{L1}$                                      |     | 40   | pF                 |
| Capacitive Load, Side 2       | $C_{L2}$                                      |     | 400  | pF                 |
| Static Output Loading, Side 1 | $I_{SDA1}, I_{SCL1}$                          | 0.5 | 3    | mA                 |
| Static Output Loading, Side 2 | $I_{SDA2}, I_{SCL2}$                          | 0.5 | 30   | mA                 |

<sup>1</sup> All voltages are relative to their respective ground. See the Applications Information section for data on immunity to external magnetic fields.

## ABSOLUTE MAXIMUM RATINGS

$T_A = 25^\circ\text{C}$ , unless otherwise noted.

**Table 8.**

| Parameter                                    | Symbol               | Min  | Max             | Unit              |
|--|----------------------|------|-----------------|-------------------|
| Storage Temperature                          | $T_{ST}$             | -65  | +150            | $^\circ\text{C}$  |
| Ambient Operating Temperature                | $T_A$                | -40  | +105            | $^\circ\text{C}$  |
| Supply Voltages <sup>1</sup>                 | $V_{DD1}, V_{DD2}$   | -0.5 | +7.0            | V                 |
| Input/Output Voltage, <sup>1</sup> Side 1    | $V_{SDA1}, V_{SCL1}$ | -0.5 | $V_{DD1} + 0.5$ | V                 |
| Input/Output Voltage, <sup>1</sup> Side 2    | $V_{SDA2}, V_{SCL2}$ | -0.5 | $V_{DD2} + 0.5$ | V                 |
| Average Output Current, per Pin <sup>2</sup> | $I_{O1}$             | -18  | +18             | mA                |
| Average Output Current, per Pin <sup>2</sup> | $I_{O2}$             | -100 | +100            | mA                |
| Common-Mode Transients <sup>3</sup>          |                      | -100 | +100            | kV/ $\mu\text{s}$ |

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

<sup>2</sup> See Figure 4 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 above those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only; functional operation of the device at these or any other conditions above those indicated in the operational section of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

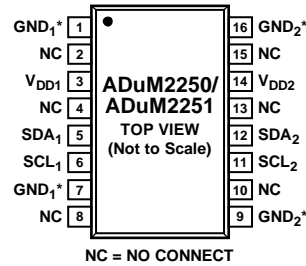
### ESD CAUTION



**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



NC = NO CONNECT

\*PIN 1 AND PIN 7 ARE INTERNALLY CONNECTED. CONNECTING BOTH TO GND<sub>1</sub> IS RECOMMENDED. PIN 9 AND PIN 16 ARE INTERNALLY CONNECTED. CONNECTING BOTH TO GND<sub>2</sub> IS RECOMMENDED.

09670-004

Figure 5. Pin Configuration

Table 9. ADuM2250 Pin Function Descriptions

| Pin No. | Mnemonic         | Description  |
|---------|------------------|--|
| 1       | GND <sub>1</sub> | Ground 1. Ground reference for Isolator Side 1.          |
| 2       | NC               | No Connect.  |
| 3       | V <sub>DD1</sub> | Supply Voltage, 3.0 V to 5.5 V.                          |
| 4       | NC               | No Connect.  |
| 5       | SDA <sub>1</sub> | Data Input/Output, Side 1.                               |
| 6       | SCL <sub>1</sub> | Clock Input/Output, Side 1.                              |
| 7       | GND <sub>1</sub> | Ground 1. Ground reference for Isolator Side 1.          |
| 8       | NC               | No Connect.  |
| 9       | GND <sub>2</sub> | Ground 2. Isolated ground reference for Isolator Side 2. |
| 10      | NC               | No Connect.  |
| 11      | SCL <sub>2</sub> | Clock Input/Output, Side 2.                              |
| 12      | SDA <sub>2</sub> | Data Input/Output, Side 2.                               |
| 13      | NC               | No Connect.  |
| 14      | V <sub>DD2</sub> | Supply Voltage, 3.0 V to 5.5 V.                          |
| 15      | NC               | No Connect.  |
| 16      | GND <sub>2</sub> | Ground 2. Isolated ground reference for Isolator Side 2. |

Table 10. ADuM2251 Pin Function Descriptions

| Pin No. | Mnemonic         | Description  |
|---------|------------------|--|
| 1       | GND <sub>1</sub> | Ground 1. Ground reference for Isolator Side 1.          |
| 2       | NC               | No Connect.  |
| 3       | V <sub>DD1</sub> | Supply Voltage, 3.0 V to 5.5 V.                          |
| 4       | NC               | No Connect.  |
| 5       | SDA <sub>1</sub> | Data Input/Output, Side 1.                               |
| 6       | SCL <sub>1</sub> | Clock Input, Side 1.                                     |
| 7       | GND <sub>1</sub> | Ground 1. Ground reference for Isolator Side 1.          |
| 8       | NC               | No Connect.  |
| 9       | GND <sub>2</sub> | Ground 2. Isolated ground reference for Isolator Side 2. |
| 10      | NC               | No Connect.  |
| 11      | SCL <sub>2</sub> | Clock Output, Side 2.                                    |
| 12      | SDA <sub>2</sub> | Data Input/Output, Side 2.                               |
| 13      | NC               | No Connect.  |
| 14      | V <sub>DD2</sub> | Supply Voltage, 3.0 V to 5.5 V.                          |
| 15      | NC               | No Connect.  |
| 16      | GND <sub>2</sub> | Ground 2. Isolated ground reference for Isolator Side 2. |

# ADuM2250/ADuM2251

## APPLICATIONS INFORMATION

### FUNCTIONAL DESCRIPTION

The ADuM2250/ADuM2251 interface on each side to I<sup>2</sup>C signals. Internally, the bidirectional I<sup>2</sup>C signals are split into two unidirectional channels communicating in opposite directions via dedicated iCoupler isolation channels. One channel of each pair (the Side 1 input of each I/O pin in Figure 6) implements a special input buffer and output driver that can differentiate between externally generated inputs and its own output signals. It only transfers externally generated input signals to the corresponding Side 2 data or clock 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 side causes the corresponding I/O pin across the coupler to be pulled low enough to comply with the logic low threshold requirements of other I<sup>2</sup>C devices on the bus. Bus contention and latch-up is avoided by guaranteeing that the input low threshold at SDA<sub>1</sub> or SCL<sub>1</sub> is 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 by latching the state.

Because the Side 2 logic levels/thresholds and drive capabilities comply fully with standard I<sup>2</sup>C values, multiple ADuM2250/ADuM2251 devices connected to a bus by their Side 2 pins can communicate with each other and with other devices having I<sup>2</sup>C compatibility as shown in Figure 7. Note the distinction 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 or drive capability 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 and drive capability of a component fully meet the requirements of the I<sup>2</sup>C specification.

Because the Side 1 pin has a modified output level/input threshold, Side 1 of the ADuM2250/ADuM2251 can only communicate with devices fully compliant with the I<sup>2</sup>C standard. In other words, Side 2 of the ADuM2250/ADuM2251 is I<sup>2</sup>C-compliant while Side 1 is only I<sup>2</sup>C-compatible.

The Side 1 I/O pins must not be connected to other I<sup>2</sup>C buffers that implement a similar scheme of dual I/O threshold detection. This latch-up prevention scheme is implemented in several popular I<sup>2</sup>C level shifting and bus extension products currently available from Analog Devices and other manufacturers. Care should be taken to review the data sheet of potential I<sup>2</sup>C bus buffering products to ensure that only one

buffer on a bus segment implements a dual threshold scheme. A bus segment is a portion of the I<sup>2</sup>C bus that is isolated from other portions of the bus by galvanic isolation, bus extenders, or level shifting buffers. Table 11 shows how multiple ADuM2250/ADuM2251 components can coexist on a bus as long as two Side 1 buffers are not connected to the same bus segment.

**Table 11. ADuM225x Buffer Compatibility**

|        | Side 1 | Side 2 |
|--------|--------|--------|
| Side 1 | No     | Yes    |
| Side 2 | Yes    | Yes    |

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 I/O pins have open-collector outputs whose high levels are set via pull-up resistors to their respective supply voltages.

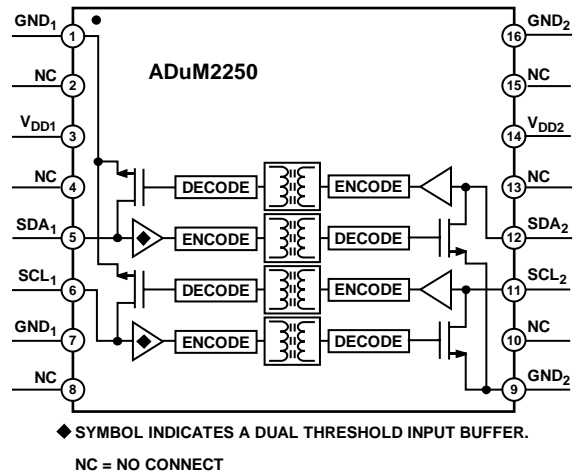


Figure 6. ADuM2250 Block Diagram

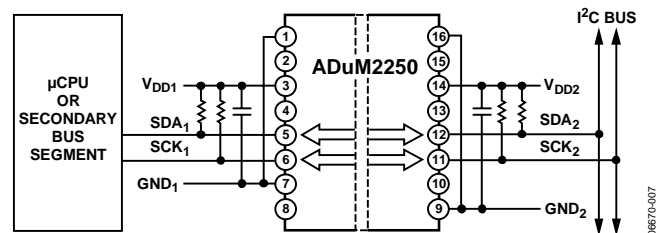


Figure 7. Typical Isolated I<sup>2</sup>C Interface Using ADuM2250

## STARTUP

Both the  $V_{DD1}$  and  $V_{DD2}$  supplies have an under voltage lockout feature that prevents the signal channels from operating unless certain criteria is met. This feature is to avoid the possibility of input logic low signals from pulling down the I<sup>2</sup>C bus inadvertently during power-up/power-down.

Criteria that must be met for the signal channels to be enabled are as follows:

- Both supplies must be at least 2.5 V.
- At least 40  $\mu$ s must elapse after both supplies exceed the internal start-up threshold of 2.0 V.

Until both of these criteria are met for both supplies, the ADuM2250/ADuM2251 outputs are pulled high thereby ensuring a startup that avoids any disturbances on the bus. Figure 8 and Figure 9 illustrate the supply conditions for fast and slow input supply slew rates.

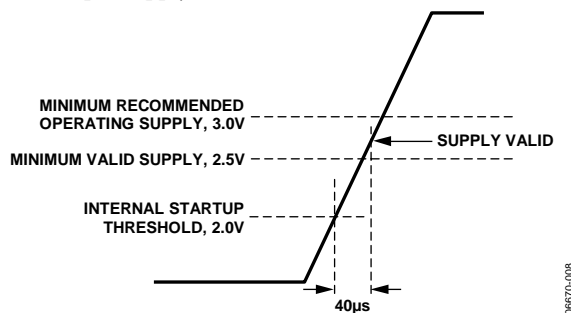


Figure 8. Start-Up Condition, Supply Slew Rate < 12.5 V/ms

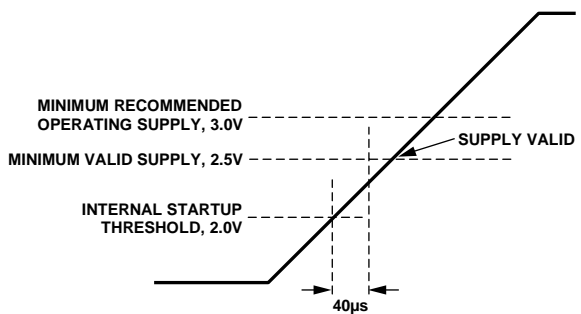


Figure 9. Start-Up Condition, Supply Slew Rate > 12.5 V/ms

## MAGNETIC FIELD IMMUNITY

The ADuM2250/ADuM2251 are extremely immune to external magnetic fields. The limitation on the magnetic field immunity of the ADuM2250/ADuM2251 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 ADuM2250/ADuM2251 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 about 0.5 V, therefore establishing a 0.5 V margin in which induced voltages can be tolerated. The voltage induced across the receiving coil is given by

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

where:

$\beta$  is the magnetic flux density (gauss).

$r_n$  is the radius of the nth turn in the receiving coil (cm).

$N$  is the number of turns in the receiving coil.

Given the geometry of the receiving coil in the ADuM2250/ADuM2251 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.

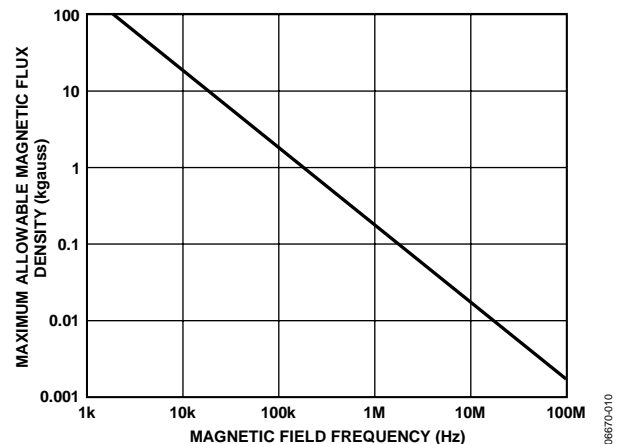


Figure 10. Maximum Allowable External Magnetic Flux Density

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 is about 50% of the sensing threshold and does not cause a faulty output transition. Similarly, if such an event were to occur during a transmitted pulse (and had the worst-case polarity), it would reduce the received pulse from >1.0 V to 0.75 V (still well above the 0.5 V sensing threshold of the decoder).

# ADuM2250/ADuM2251

The preceding magnetic flux density values correspond to specific current magnitudes at given distances away from the ADuM2250/ADuM2251 transformers. Figure 11 expresses these allowable current magnitudes as a function of frequency for selected distances. As seen, the ADuM2250/ADuM2251 is extremely immune and can be affected only by extremely large currents operated at high frequency and very close to the component. For the 1 MHz example, place a 0.5 kA current 5 mm away from the ADuM2250/ADuM2251 to affect the operation of the component.

Note that at combinations of strong magnetic fields and high frequencies, any loops formed by printed circuit board traces could induce sufficiently large error voltages to trigger the threshold of succeeding circuitry. Care should be taken in the layout of such traces to avoid this possibility.

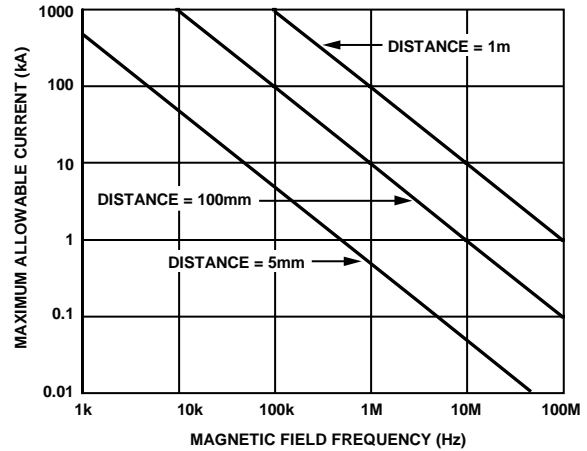
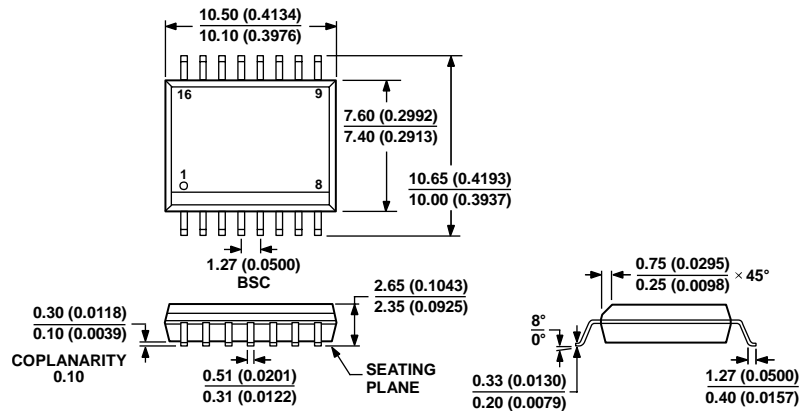


Figure 11. Maximum Allowable Current for Various Current-to-ADuM2250/ADuM2251 Spacings

06870-011

## OUTLINE DIMENSIONS



COMPLIANT TO JEDEC STANDARDS MS-013-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.

Figure 12. 16-Lead Standard Small Outline Package [SOIC\_W]  
Wide Body (RW-16)  
Dimensions shown in millimeters (inches)

03/07/09-B

## ORDERING GUIDE

| Model                        | Number of Inputs, V <sub>DD1</sub> Side | Number of Inputs, V <sub>DD2</sub> Side | Maximum Data Rate (Mbps) | Temperature Range | Package Description      | Package Option |
|------------------------------|---|---|--------------------------|-------------------|--------------------------|----------------|
| ADuM2250ARWZ <sup>1</sup>    | 2                                       | 2                                       | 1                        | -40°C to +105°C   | 16-Lead SOIC_W           | RW-16          |
| ADuM2250ARWZ-RL <sup>1</sup> | 2                                       | 2                                       | 1                        | -40°C to +105°C   | 16-Lead SOIC_W, 13" Reel | RW-16          |
| ADuM2251ARWZ <sup>1</sup>    | 2                                       | 1                                       | 1                        | -40°C to +105°C   | 16-Lead SOIC_W           | RW-16          |
| ADuM2251ARWZ-RL <sup>1</sup> | 2                                       | 1                                       | 1                        | -40°C to +105°C   | 16-Lead SOIC_W, 13" Reel | RW-16          |

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

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