Triple- and Quad-Channel Unidirectional Digital Isolators

ADuM1310/ADuM1410

FEATURES

- Pb-free, 16-lead, wide body SOIC package
- Low power operation
  - 5 V operation
    - 1.0 mA per channel max @ 0 Mbps to 2 Mbps
    - 3.5 mA per channel max @ 10 Mbps
  - 3 V operation
    - 0.7 mA per channel max @ 0 Mbps to 2 Mbps
    - 2.1 mA per channel max @ 10 Mbps
- 3 V/5 V level translation
- High temperature operation: 105°C
- Up to 10 Mbps data rate (NRZ)
- Programmable default output state
- Safety and regulatory approvals
  - UL recognition: 2500 V rms for 1 minute per UL 1577
  - CSA component acceptance notice #5A
  - VDE certificate of conformity
    - DIN EN 60747-5-2 (VDE 0884 Part 2): 2003-01
    - DIN EN 60950 (VDE 0805): 2001-12; EN 60950: 2000
    - V_{IORM} = 560 V peak

APPLICATIONS

- General-purpose unidirectional multichannel isolation

GENERAL DESCRIPTION

The ADuM1310 and ADuM1410 are unidirectional triple- and quad-channel isolators based on Analog Devices' *i*Coupler® technology. Combining high speed CMOS and monolithic coreless transformer technology, these isolation components provide outstanding performance characteristics superior to alternatives such as optocoupler devices.

By avoiding the use of LEDs and photodiodes, *i*Coupler devices remove the design difficulties commonly associated with optocouplers. The typical optocoupler concerns regarding uncertain current transfer ratios, nonlinear transfer functions, and temperature and lifetime effects are eliminated with the simple *i*Coupler digital interfaces and stable performance characteristics. The need for external drivers and other discretes is eliminated with these *i*Coupler products. Furthermore, *i*Coupler devices run at one-tenth to one-sixth the power consumption of optocouplers at comparable signal data rates.

The ADuM1310 and ADuM1410 isolators provide three or four independent isolation channels at data rates up to 10 Mbps. Both models operate with the supply voltage of either side ranging from 2.7 V to 5.5 V, providing compatibility with lower voltage systems as well as enabling a voltage translation functionality across the isolation barrier. Each product also has a default output control pin with which the user can define the logic state the outputs are to take on in the absence of the input V_{DD1} power. Unlike other optocoupler alternatives, the ADuM1310 and ADuM1410 have a patented refresh feature that ensures dc correctness in the absence of input logic transitions and during power-up/power-down conditions.

FUNCTIONAL BLOCK DIAGRAMS

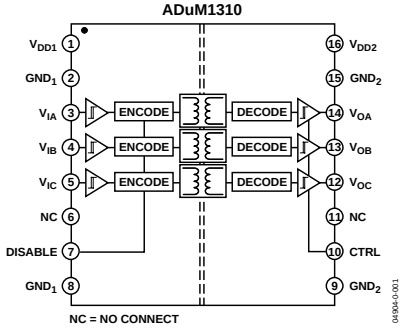

Figure 1.

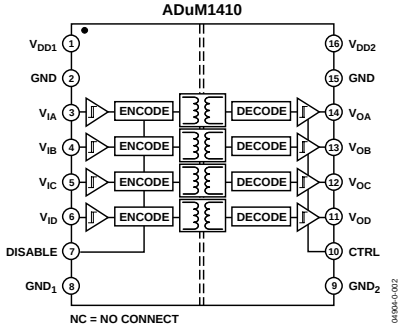

Figure 2.

Rev. C

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REVISION HISTORY

11/05—Rev. SpB to Rev. C

5/05—Rev. SpA to Rev. SpB
Changes to Table 6 9

10/04—Data Sheet Changed from Rev. Sp0 to Rev. SpA
Changes to Table 5 9

6/04—Revision Sp0: Initial Version

SPECIFICATIONS

ELECTRICAL CHARACTERISTICS—5 V OPERATION[1]

4.5 V ≤ V_{DD1} ≤ 5.5 V, 4.5 V ≤ V_{DD2} ≤ 5.5 V; all min/max specifications apply over the entire recommended operation range, unless otherwise noted; all typical specifications are at T_A = 25°C, V_{DD1} = V_{DD2} = 5 V.

Table 1.

Parameter	Symbol	Min	Typ	Max	Unit	Test Conditions
DC SPECIFICATIONS						
ADuM1310, Total Supply Current, Three Channels[2]						
V_{DD1} Supply Current, Quiescent	$I_{DD1 (Q)}$		2.4	3.2	mA	$V_{IA} = V_{IB} = V_{IC} = V_{ID} = 0$
V_{DD2} Supply Current, Quiescent	$I_{DD2 (Q)}$		1.2	1.6	mA	$V_{IA} = V_{IB} = V_{IC} = V_{ID} = 0$
V_{DD1} Supply Current, 10 Mbps Data Rate	$I_{DD1 (10)}$		6.6	9.0	mA	5 MHz logic signal frequency
V_{DD2} Supply Current, 10 Mbps Data Rate	$I_{DD2 (10)}$		2.1	3.0	mA	5 MHz logic signal frequency
ADuM1410, Total Supply Current, Four Channels[2]						
V_{DD1} Supply Current, Quiescent	$I_{DD1 (Q)}$		2.4	3.2	mA	$V_{IA} = V_{IB} = V_{IC} = V_{ID} = 0$
V_{DD2} Supply Current, Quiescent	$I_{DD2 (Q)}$		1.2	1.6	mA	$V_{IA} = V_{IB} = V_{IC} = V_{ID} = 0$
V_{DD1} Supply Current, 10 Mbps Data Rate	$I_{DD1 (10)}$		8.8	12	mA	5 MHz logic signal frequency
V_{DD2} Supply Current, 10 Mbps Data Rate	$I_{DD2 (10)}$		2.8	4.0	mA	5 MHz logic signal frequency
For All Models						
Input Currents	I_{IA}, I_{IB}, I_{IC}, I_{ID}, I_{CTRL}, $I_{DISABLE}$	−10	+0.01	+10	μA	0 ≤ V_{IA}, V_{IB}, V_{IC}, V_{ID}, $V_{DISABLE} \le V_{DD1}$, 0 ≤ $V_{CTRL} \le V_{DD2}$
Logic High Input Threshold	V_{IH}			2.0	V	
Logic Low Input Threshold	V_{IL}	0.8			V	
Logic High Output Voltages	V_{OAH}, V_{OBH}, V_{OCH}, V_{ODH}	V_{DD1}, V_{DD2} − 0.4	4.8		V	I_{Ox} = −4 mA, $V_{Ix} = V_{IxH}$
Logic Low Output Voltages	V_{OAL}, V_{OBL}, V_{OCL}, V_{ODL}		0.2	0.4	V	I_{Ox} = +4 mA, $V_{Ix} = V_{IxL}$
SWITCHING SPECIFICATIONS						
Minimum Pulse Width[3]	PW			100	ns	C_L = 15 pF, CMOS signal levels
Maximum Data Rate[4]		10			Mbps	C_L = 15 pF, CMOS signal levels
Propagation Delay[5]	t_{PHL}, t_{PLH}	20	30	50	ns	C_L = 15 pF, CMOS signal levels
Pulse Width Distortion, $\lvert t_{PLH} - t_{PHL} \rvert$[5]	PWD			5	ns	C_L = 15 pF, CMOS signal levels
Change vs. Temperature			5		ps/°C	C_L = 15 pF, CMOS signal levels
Propagation Delay Skew[6]	t_{PSK}			30	ns	C_L = 15 pF, CMOS signal levels
Channel-to-Channel Matching[7]	t_{PSKCD}			5	ns	C_L = 15 pF, CMOS signal levels
Output Rise/Fall Time (10% to 90%)	t_R/t_F		2.5		ns	C_L = 15 pF, CMOS signal levels
Common-Mode Transient Immunity at Logic High Output[8]	$\lvert CM_H \rvert$	25	35		kV/μs	$V_{Ix} = V_{DD1}/V_{DD2}$, V_{CM} = 1000 V, transient magnitude = 800 V
Common-Mode Transient Immunity at Logic Low Output[8]	$\lvert CM_L \rvert$	25	35		kV/μs	V_{Ix} = 0 V, V_{CM} = 1000 V, transient magnitude = 800 V
Refresh Rate	f_r		1.2		Mbps	
Input Enable Time[9]	t_{ENABLE}			2.0	μs	V_{IA}, V_{IB}, V_{IC}, V_{ID} = 0 or V_{DD1}
Input Disable Time[9]	$t_{DISABLE}$			5.0	μs	V_{IA}, V_{IB}, V_{IC}, V_{ID} = 0 or V_{DD1}
Input Dynamic Supply Current per Channel[10]	$I_{DDI (D)}$		0.19		mA/Mbps	
Output Dynamic Supply Current per Channel[10]	$I_{DDO (D)}$		0.05		mA/Mbps	

[1] All voltages are relative to their respective ground.
[2] Supply current values are for all four channels combined running at identical data rates. Output supply current values are specified with no output load present. The supply current associated with an individual channel operating at a given data rate can be calculated as described in the Power Consumption section. See Figure 6 through Figure 8 for information on the per-channel supply current as a function of the data rate for unloaded and loaded conditions. See Figure 9 through Figure 12 for total I_{DD1} and I_{DD2} supply currents as a function of the data rate for the ADuM1310/ADuM1410 channel configurations.
[3] The minimum pulse width is the shortest pulse width at which the specified pulse width distortion is guaranteed.
[4] The maximum data rate is the fastest data rate at which the specified pulse width distortion is guaranteed.
[5] t_{PHL} propagation delay is measured from the 50% level of the falling edge of the V_{Ix} signal to the 50% level of the falling edge of the V_{Ox} signal. t_{PLH} propagation delay is measured from the 50% level of the rising edge of the V_{Ix} signal to the 50% level of the rising edge of the V_{Ox} signal.
[6] t_{PSK} is the magnitude of the worst-case difference in t_{PHL} and/or t_{PLH} that is measured between units at the same operating temperature, supply voltages, and output load within the recommended operating conditions.
[7] Channel-to-channel matching is the absolute value of the difference in propagation delays between any two channels within the same component.
[8] 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 $V_O < 0.8$ 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.
[9] Input enable time is the duration from when $V_{DISABLE}$ is set low until the output states are guaranteed to match the input states in the absence of any input data logic transitions. If an input data logic transition within a given channel does occur within this time interval, the output of that channel reaches the correct state within the much shorter duration as determined by the propagation delay specifications within this data sheet. Input disable time is the duration from when $V_{DISABLE}$ is set high until the output states are guaranteed to reach their programmed output levels, as determined by the CTRL logic state (see Table 10).
[10] Dynamic supply current is the incremental amount of supply current required for a 1 Mbps increase in the signal data rate. See Figure 6 through Figure 8 for information on the per-channel supply current for unloaded and loaded conditions. See the Power Consumption section for guidance on calculating the per-channel supply current for a given data rate.

ELECTRICAL CHARACTERISTICS—3 V OPERATION[1]

2.7 V ≤ V_{DD1} ≤ 3.6 V, 2.7 V ≤ V_{DD2} ≤ 3.6 V; all min/max specifications apply over the entire recommended operation range, unless otherwise noted; all typical specifications are at T_A = 25°C, V_{DD1} = V_{DD2} = 3.0 V.

Table 2.

Parameter	Symbol	Min	Typ	Max	Unit	Test Conditions
DC SPECIFICATIONS						
ADuM1310, Total Supply Current, Three Channels[2]						
V_{DD1} Supply Current, Quiescent	$I_{DD1 (Q)}$		1.2	1.6	mA	$V_{IA} = V_{IB} = V_{IC} = V_{ID} = 0$
V_{DD2} Supply Current, Quiescent	$I_{DD2 (Q)}$		0.8	1.0	mA	$V_{IA} = V_{IB} = V_{IC} = V_{ID} = 0$
V_{DD1} Supply Current, 10 Mbps Data Rate	$I_{DD1 (10)}$		3.4	4.9	mA	5 MHz logic signal frequency
V_{DD2} Supply Current, 10 Mbps Data Rate	$I_{DD2 (10)}$		1.1	1.3	mA	5 MHz logic signal frequency
ADuM1410, Total Supply Current, Four Channels[2]						
V_{DD1} Supply Current, Quiescent	$I_{DD1 (Q)}$		1.2	1.6	mA	$V_{IA} = V_{IB} = V_{IC} = V_{ID} = 0$
V_{DD2} Supply Current, Quiescent	$I_{DD2 (Q)}$		0.8	1.0	mA	$V_{IA} = V_{IB} = V_{IC} = V_{ID} = 0$
V_{DD1} Supply Current, 10 Mbps Data Rate	$I_{DD1 (10)}$		4.5	6.5	mA	5 MHz logic signal frequency
V_{DD2} Supply Current, 10 Mbps Data Rate	$I_{DD2 (10)}$		1.4	1.8	mA	5 MHz logic signal frequency
For All Models						
Input Currents	I_{IA}, I_{IB}, I_{IC}, I_{ID}, I_{CTRL}, $I_{DISABLE}$	−10	+0.01	+10	µA	$0 \le V_{IA}, V_{IB}, V_{IC}, V_{ID}, V_{DISABLE} \le V_{DD1}$, $0 \le V_{CTRL} \le V_{DD2}$
Logic High Input Threshold	V_{IH}			1.6	V	
Logic Low Input Threshold	V_{IL}	0.4			V	
Logic High Output Voltages	V_{OAH}, V_{OBH}, V_{OCH}, V_{ODH}	V_{DD1}, V_{DD2} − 0.4	2.8		V	I_{Ox} = −4 mA, $V_{Ix} = V_{IxH}$
Logic Low Output Voltages	V_{OAL}, V_{OBL}, V_{OCL}, V_{ODL}		0.2	0.4	V	I_{Ox} = +4 mA, $V_{Ix} = V_{IxL}$
SWITCHING SPECIFICATIONS						
Minimum Pulse Width[3]	PW			100	ns	C_L = 15 pF, CMOS signal levels
Maximum Data Rate[4]		10			Mbps	C_L = 15 pF, CMOS signal levels
Propagation Delay[5]	t_{PHL}, t_{PLH}	20	30	50	ns	C_L = 15 pF, CMOS signal levels
Pulse Width Distortion, $\lvert t_{PLH} - t_{PHL} \rvert$[5]	PWD			5	ns	C_L = 15 pF, CMOS signal levels
Change vs. Temperature			5		ps/°C	C_L = 15 pF, CMOS signal levels
Propagation Delay Skew (Equal Temperature)[6]	t_{PSK}			30	ns	C_L = 15 pF, CMOS signal levels
Channel-to-Channel Matching[7]	t_{PSKCD}			5	ns	C_L = 15 pF, CMOS signal levels
Output Rise/Fall Time (10% to 90%)	t_R/t_F		2.5		ns	C_L = 15 pF, CMOS signal levels
Common-Mode Transient Immunity at Logic High Output[8]	$\lvert CM_H \rvert$	25	35		kV/µs	$V_{Ix} = V_{DD1}/V_{DD2}$, V_{CM} = 1000 V, transient magnitude = 800 V
Common-Mode Transient Immunity at Logic Low Output[8]	$\lvert CM_L \rvert$	25	35		kV/µs	V_{Ix} = 0 V, V_{CM} = 1000 V, transient magnitude = 800 V
Refresh Rate	f_r		1.1		Mbps	
Input Enable Time[9]	t_{ENABLE}			2.0	µs	$V_{IA}, V_{IB}, V_{IC}, V_{ID}$ = 0 or V_{DD1}
Input Disable Time[9]	$t_{DISABLE}$			5.0	µs	$V_{IA}, V_{IB}, V_{IC}, V_{ID}$ = 0 or V_{DD1}
Input Dynamic Supply Current per Channel[10]	$I_{DDI (D)}$		0.10		mA/Mbps	
Output Dynamic Supply Current per Channel[10]	$I_{DDO (D)}$		0.03		mA/Mbps	

[1] All voltages are relative to their respective ground.
[2] Supply current values are for all four channels combined running at identical data rates. Output supply current values are specified with no output load present. The supply current associated with an individual channel operating at a given data rate can be calculated as described in the Power Consumption section. See Figure 6 through Figure 8 for information on the per-channel supply current as a function of the data rate for unloaded and loaded conditions. See Figure 9 through Figure 12 for total I_{DD1} and I_{DD2} supply currents as a function of the data rate for the ADuM1310/ADuM1410 channel configurations.
[3] The minimum pulse width is the shortest pulse width at which the specified pulse width distortion is guaranteed.
[4] The maximum data rate is the fastest data rate at which the specified pulse width distortion is guaranteed.
[5] t_{PHL} propagation delay is measured from the 50% level of the falling edge of the V_{Ix} signal to the 50% level of the falling edge of the V_{Ox} signal. t_{PLH} propagation delay is measured from the 50% level of the rising edge of the V_{Ix} signal to the 50% level of the rising edge of the V_{Ox} signal.
[6] t_{PSK} is the magnitude of the worst-case difference in t_{PHL} and/or t_{PLH} that is measured between units at the same operating temperature, supply voltages, and output load within the recommended operating conditions.
[7] Channel-to-channel matching is the absolute value of the difference in propagation delays between any two channels within the same component.
[8] 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 $V_O < 0.8$ 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.
[9] Input enable time is the duration from when $V_{DISABLE}$ is set low until the output states are guaranteed to match the input states in the absence of any input data logic transitions. If an input data logic transition within a given channel does occur within this time interval, the output of that channel reaches the correct state within the much shorter duration as determined by the propagation delay specifications within this data sheet. Input disable time is the duration from when $V_{DISABLE}$ is set high until the output states are guaranteed to reach their programmed output levels, as determined by the CTRL logic state (see Table 10).
[10] Dynamic supply current is the incremental amount of supply current required for a 1 Mbps increase in signal data rate. See Figure 6 through Figure 8 for information on the per-channel supply current for unloaded and loaded conditions. See the Power Consumption section for guidance on calculating the per-channel supply current for a given data rate.

ELECTRICAL CHARACTERISTICS—MIXED 5 V/3 V OR 3 V/5 V OPERATION[1]

5 V/3 V operation: 4.5 V ≤ V_{DD1} ≤ 5.5 V, 2.7 V ≤ V_{DD2} ≤ 3.6 V; 3 V/5 V operation: 2.7 V ≤ V_{DD1} ≤ 3.6 V, 4.5 V ≤ V_{DD2} ≤ 5.5 V; all min/max specifications apply over the entire recommended operation range, unless otherwise noted; all typical specifications are at T_A = 25°C; V_{DD1} = 3.0 V, V_{DD2} = 5 V; or V_{DD1} = 5 V, V_{DD2} = 3.0 V.

Table 3.

Parameter	Symbol	Min	Typ	Max	Unit	Test Conditions
DC SPECIFICATIONS						
ADuM1310, Total Supply Current, Three Channels[2]						
V_{DD1} Supply Current, Quiescent	$I_{DDI (Q)}$					
5 V/3 V Operation			2.4	3.2	mA	$V_{IA} = V_{IB} = V_{IC} = V_{ID} = 0$
3 V/5 V Operation			1.2	1.6	mA	$V_{IA} = V_{IB} = V_{IC} = V_{ID} = 0$
V_{DD2} Supply Current, Quiescent	$I_{DDO (Q)}$					
5 V/3 V Operation			0.8	1.0	mA	$V_{IA} = V_{IB} = V_{IC} = V_{ID} = 0$
3 V/5 V Operation			1.2	1.6	mA	$V_{IA} = V_{IB} = V_{IC} = V_{ID} = 0$
V_{DD1} Supply Current, 10 Mbps Data Rate	$I_{DD1 (10)}$					
5 V/3 V Operation			6.5	8.2	mA	5 MHz logic signal frequency
3 V/5 V Operation			3.4	4.9	mA	5 MHz logic signal frequency
V_{DD2} Supply Current, 10 Mbps Data Rate	$I_{DD2 (10)}$					
5 V/3 V Operation			1.1	1.3	mA	5 MHz logic signal frequency
3 V/5 V Operation			1.9	2.2	mA	5 MHz logic signal frequency
ADuM1410, Total Supply Current, Four Channels[2]						
V_{DD1} Supply Current, Quiescent	$I_{DDI (Q)}$					
5 V/3 V Operation			2.4	3.2	mA	$V_{IA} = V_{IB} = V_{IC} = V_{ID} = 0$
3 V/5 V Operation			1.2	1.6	mA	$V_{IA} = V_{IB} = V_{IC} = V_{ID} = 0$
V_{DD2} Supply Current, Quiescent	$I_{DDO (Q)}$					
5 V/3 V Operation			0.8	1.0	mA	$V_{IA} = V_{IB} = V_{IC} = V_{ID} = 0$
3 V/5 V Operation			1.2	1.6	mA	$V_{IA} = V_{IB} = V_{IC} = V_{ID} = 0$
V_{DD1} Supply Current, 10 Mbps Data Rate	$I_{DD1 (10)}$					
5 V/3 V Operation			8.6	11	mA	5 MHz logic signal frequency
3 V/5 V Operation			3.4	6.5	mA	5 MHz logic signal frequency
V_{DD2} Supply Current, 10 Mbps Data Rate	$I_{DD2 (10)}$					
5 V/3 V Operation			1.4	1.8	mA	5 MHz logic signal frequency
3 V/5 V Operation			2.6	3.0	mA	5 MHz logic signal frequency
For All Models						
Input Currents	I_{IA}, I_{IB}, I_{IC}, I_{ID}, I_{CTRL}, $I_{DISABLE}$	−10	+0.01	+10	µA	$0 \le V_{IA}, V_{IB}, V_{IC}, V_{ID}, V_{DISABLE} \le V_{DD1}$, $0 \le V_{CTRL} \le V_{DD2}$
Logic High Input Threshold	V_{IH}					
5 V/3 V Operation				2.0	V	
3 V/5 V Operation				1.6	V	
Logic Low Input Threshold	V_{IL}					
5 V/3 V Operation		0.8			V	
3 V/5 V Operation		0.4			V	
Logic High Output Voltages	V_{OAH}, V_{OBH}, V_{OCH}, V_{ODH}	V_{DD1}/ V_{DD2} − 0.4	V_{DD1}/ V_{DD2} − 0.2		V	I_{Ox} = −4 µA, $V_{Ix} = V_{IxH}$
Logic Low Output Voltages	V_{OAL}, V_{OBL}, V_{OCL}, V_{ODL}		0.2	0.4	V	I_{Ox} = +4 µA, $V_{Ix} = V_{IxL}$

Parameter	Symbol	Min	Typ	Max	Unit	Test Conditions
SWITCHING SPECIFICATIONS						
Minimum Pulse Width[3]	PW			100	ns	C_L = 15 pF, CMOS signal levels
Maximum Data Rate[4]		10			Mbps	C_L = 15 pF, CMOS signal levels
Propagation Delay[5]	t_{PHL}, t_{PLH}	20	30	50	ns	C_L = 15 pF, CMOS signal levels
Pulse Width Distortion, $\|t_{PLH} - t_{PHL}\|$[5]	PWD			5	ns	C_L = 15 pF, CMOS signal levels
Change vs. Temperature			5			
Propagation Delay Skew[6]	t_{PSK}			30	ns	C_L = 15 pF, CMOS signal levels
Channel-to-Channel Matching[7]	t_{PSKCD}			5	ns	C_L = 15 pF, CMOS signal levels
Output Rise/Fall Time (10% to 90%)	t_R/t_f					C_L = 15 pF, CMOS signal levels
5 V/3 V Operation			3.0		ns	
3 V/5 V Operation			2.5		ns	
Common-Mode Transient Immunity at Logic High Output[8]	$\|CM_H\|$	25	35		kV/µs	$V_{Ix} = V_{DD1}/V_{DD2}$, V_{CM} = 1000 V, transient magnitude = 800 V
Common-Mode Transient Immunity at Logic Low Output[8]	$\|CM_L\|$	25	35		kV/µs	V_{Ix} = 0 V, V_{CM} = 1000 V, transient magnitude = 800 V
Refresh Rate	f_r					
5 V/3 V Operation			1.2		Mbps	
3 V/5 V Operation			1.1		Mbps	
Input Enable Time[9]	t_{ENABLE}			2.0	µs	V_{IA}, V_{IB}, V_{IC}, V_{ID} = 0 or V_{DD1}
Input Disable Time[9]	$t_{DISABLE}$			5.0	µs	V_{IA}, V_{IB}, V_{IC}, V_{ID} = 0 or V_{DD1}
Input Dynamic Supply Current per Channel[10]	$I_{DDI (D)}$					
5 V/3 V Operation			0.19		mA/Mbps	
3 V/5 V Operation			0.10		mA/Mbps	
Output Dynamic Supply Current per Channel[10]	$I_{DDI (D)}$					
5 V/3 V Operation			0.03		mA/Mbps	
3 V/5 V Operation			0.05		mA/Mbps	

[1] All voltages are relative to their respective ground.

[2] Supply current values are for all channels combined running at identical data rates. Output supply current values are specified with no output load present. The supply current associated with an individual channel operating at a given data rate can be calculated as described in the Power Consumption section. See Figure 6 through Figure 8 for information on the per-channel supply current as a function of the data rate for unloaded and loaded conditions. See Figure 9 through Figure 12 for total I_{DD1} and I_{DD2} supply currents as a function of the data rate for the ADuM1310/ADuM1410.

[3] The minimum pulse width is the shortest pulse width at which the specified pulse width distortion is guaranteed.

[4] The maximum data rate is the fastest data rate at which the specified pulse width distortion is guaranteed.

[5] t_{PHL} propagation delay is measured from the 50% level of the falling edge of the V_{Ix} signal to the 50% level of the falling edge of the V_{Ox} signal. t_{PLH} propagation delay is measured from the 50% level of the rising edge of the V_{Ix} signal to the 50% level of the rising edge of the V_{Ox} signal.

[6] t_{PSK} is the magnitude of the worst-case difference in t_{PHL} and/or t_{PLH} that is measured between units at the same operating temperature, supply voltages, and output load within the recommended operating conditions.

[7] Channel-to-channel matching is the absolute value of the difference in propagation delays between any two channels within the same component.

[8] 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 $V_O < 0.8$ 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.

[9] Input enable time is the duration from when $V_{DISABLE}$ is set low until the output states are guaranteed to match the input states in the absence of any input data logic transitions. If an input data logic transition within a given channel does occur within this time interval, the output of that channel reaches the correct state within the much shorter duration as determined by the propagation delay specifications within this data sheet. Input disable time is the duration from when $V_{DISABLE}$ is set high until the output states are guaranteed to reach their programmed output levels, as determined by the CTRL logic state (see Truth Table – Table 10).

[10] Dynamic supply current is the incremental amount of supply current required for a 1 Mbps increase in signal data rate. See Figure 6 through Figure 8 for information on the per-channel supply current for unloaded and loaded conditions. See the Power Consumption section for guidance on calculating the per-channel supply current for a given data rate.

PACKAGE CHARACTERISTICS

Table 4.

Parameter	Symbol	Min	Typ	Max	Unit	Test Conditions
Resistance (Input-Output)[1]	R_{I-O}		10^{12}		Ω	
Capacitance (Input-Output)[2]	C_{I-O}		2.2		pF	f = 1 MHz
Input Capacitance[2]	C_I		4.0		pF	
IC Junction-to-Case Thermal Resistance, Side 1	θ_{JCI}		33		°C/W	Thermocouple located at center of package underside
IC Junction-to-Case Thermal Resistance, Side 2	θ_{JCO}		28		°C/W	Thermocouple located at center of package underside

[1] Device considered a 2-terminal device. Pin 1, Pin 2, Pin 3, Pin 4, Pin 5, Pin 6, Pin 7, and Pin 8 shorted together and Pin 9, Pin 10, Pin 11, Pin 12, Pin 13, Pin 14, Pin 15, and Pin 16 shorted together.
[2] Input capacitance is from any input data pin to ground.

REGULATORY INFORMATION

The ADuM1x10 is approved by the following organizations.

Table 5.

UL[1]	CSA	VDE[2]
Recognized under 1577 Component Recognition Program	Approved under CSA Component Acceptance Notice #5A	Certified according to: DIN EN 60747-5-2 (VDE 0884 Part 2): 2003-01 DIN EN 60950 (VDE 0805): 2001-12; EN 60950: 2000

[1] In accordance with UL1577, each ADuM1310 and ADuM1410 is proof tested by applying an insulation test voltage ≥3000 V rms for 1 second (current leakage detection limit = 5 μA).
[2] In accordance with DIN EN 60747-5-2, each ADuM1310 and ADuM1410 is proof tested by applying an insulation test voltage ≥1050 V peak for 1 second (partial discharge detection limit = 5 pC).

INSULATION AND SAFETY-RELATED SPECIFICATIONS

Table 6.

Parameter	Symbol	Value	Unit	Conditions
Rated Dielectric Insulation Voltage		2500	V rms	1-minute duration
Minimum External Air Gap (Clearance)	L(I01)	7.7 min	mm	Measured from input terminals to output terminals, shortest distance through air
Minimum External Tracking (Creepage)	L(I02)	8.1 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 EN 60747-5-2 (VDE 0884 PART 2) INSULATION CHARACTERISTICS

Table 7.

Description	Symbol	Characteristic	Unit
Installation Classification per DIN VDE 0110			
For Rated Mains Voltage ≤150 V rms		I–IV	
For Rated Mains Voltage ≤300 V rms		I–III	
For Rated Mains Voltage ≤400 V rms		I–II	
Climatic Classification		40/105/21	
Pollution Degree (DIN VDE 0110, Table 1)		2	
Maximum Working Insulation Voltage	V_{IORM}	560	V peak
Input to Output Test Voltage, Method b1	V_{PR}	1050	V peak
$V_{IORM} \times 1.875 = V_{PR}$, 100% Production Test, t_m = 1 sec, Partial Discharge <5 pC			
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		896	V peak
After Input and/or Safety Test Subgroup 2/3			
$V_{IORM} \times 1.2 = V_{PR}$, t_m = 60 sec, Partial Discharge <5 pC		672	V peak
Highest Allowable Overvoltage (Transient Overvoltage, t_{TR} = 10 sec)	V_{TR}	4000	V peak
Safety-Limiting Values (maximum value allowed in the event of a failure; see Figure 3)			
Case Temperature	T_S	150	°C
Side 1 Current	I_{S1}	265	mA
Side 2 Current	I_{S2}	335	mA
Insulation Resistance at T_S, V_{IO} = 500 V	R_S	$>10^9$	Ω

This isolator is suitable for basic electrical isolation only within the safety limit data. Maintenance of the safety data shall be ensured by means of protective circuits. The * marking on packages denotes DIN EN 60747-5-2 approval for 560 V peak working voltage.

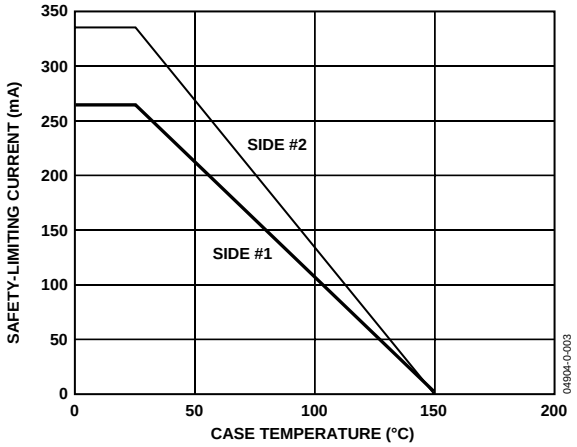


Figure 3. Thermal Derating Curve, Dependence of Safety-Limiting Values with Case Temperature per DIN EN 60747-5-2

RECOMMENDED OPERATING CONDITIONS

Table 8.

Parameter	Symbol	Min	Max	Unit
Operating Temperature	T_A	−40	+105	°C
Supply Voltages[1]	V_{DD1}, V_{DD2}	2.7	5.5	V
Input Signal Rise and Fall Times			1.0	ms

[1] All voltages are relative to their respective ground. See the DC Correctness and Magnetic Field Immunity section for information on immunity to external magnetic fields.

ABSOLUTE MAXIMUM RATINGS

Ambient temperature = 25°C, unless otherwise noted.

Table 9.

Parameter	Symbol	Min	Max	Unit
Storage Temperature	T_{ST}	–65	+150	°C
Ambient Operating Temperature	T_A	–40	+105	°C
Supply Voltages[1]	V_{DD1}, V_{DD2}	–0.5	+6.5	V
Input Voltage[1, 2]	V_{IA}, V_{IB}, V_{IC}, V_{ID}, V_{CTRL}	–0.5	V_{DDI} + 0.5	V
Output Voltage[1, 2]	V_{OA}, V_{OB}, V_{OC}, V_{OD}	–0.5	V_{DDO} + 0.5	V
Average Output Current per Pin[3]				
Side 1	I_{O1}	–18	+18	mA
Side 2	I_{O2}	–22	+22	mA
Common-Mode Transients[4]		–100	+100	kV/µs

[1] All voltages are relative to their respective ground.
[2] V_{DDI} and V_{DDO} refer to the supply voltages on the input and output sides of a given channel, respectively.
[3] See Figure 3 for maximum rated current values for various temperatures.
[4] Refers to common-mode transients across the insulation barrier. Common-mode transients exceeding the Absolute Maximum Ratings can 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 listed in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions may affect device reliability.

Table 10. Truth Table (Positive Logic)

V_{IX} Input[1]	CTRL Input	$V_{DISABLE}$ State	V_{DD1} State[1]	V_{DD2} State[1]	V_{OX} Output[1]	Notes
H	X	L or NC	Powered	Powered	H	Normal operation, data is high.
L	X	L or NC	Powered	Powered	L	Normal operation, data is low.
X	H or NC	H	X	Powered	H	Inputs disabled. Outputs are in the default state as determined by CTRL.
X	L	H	X	Powered	L	Inputs disabled. Outputs are in the default state as determined by CTRL.
X	H or NC	X	Unpowered	Powered	H	Input unpowered. Outputs are in the default state as determined by CTRL. Outputs return to input state within 1 µs of V_{DD1} power restoration. See the Power-Up/Power-Down Considerations section for more details.
X	L	X	Unpowered	Powered	L	Input unpowered. Outputs are in the default state as determined by CTRL. Outputs return to input state within 1 µs of V_{DD1} power restoration. See the Power-Up/Power-Down Considerations section for more details.
X	X	X	Powered	Unpowered	Z	Output unpowered. Output pins are in high impedance state. Outputs return to input state within 1 µs of V_{DD2} power restoration. See the Power-Up/Power-Down Considerations section for more details.

[1] V_{IX} and V_{OX} refer to the input and output signals of a given channel (A, B, C, or D).

ESD CAUTION

ESD (electrostatic discharge) sensitive device. Electrostatic charges as high as 4000 V readily accumulate on the human body and test equipment and can discharge without detection. Although this product features proprietary ESD protection circuitry, permanent damage may occur on devices subjected to high energy electrostatic discharges. Therefore, proper ESD precautions are recommended to avoid performance degradation or loss of functionality.

PIN CONFIGURATIONS AND FUNCTION DESCRIPTIONS

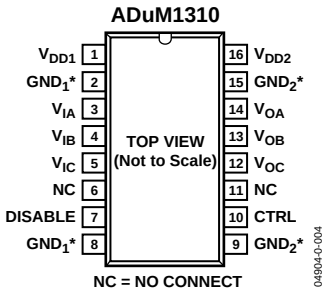


Figure 4. ADuM1310 Pin Configuration

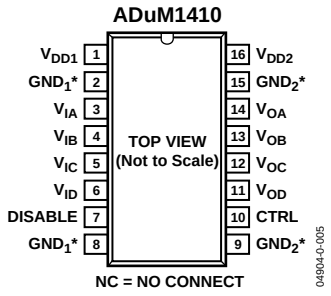


Figure 5. ADuM1410 Pin Configuration

***Pin 2 and Pin 8 are internally connected. Connecting both to GND_1 is recommended. Pin 9 and Pin 15 are internally connected. Connecting both to GND_2 is recommended.**

Table 11. ADuM1310 Pin Function Descriptions

Pin No.	Mnemonic	Description
1	V_{DD1}	Supply Voltage for Isolator Side 1, 2.7 V to 5.5 V.
2	GND_1	Ground 1. Ground reference for Isolator Side 1.
3	V_{IA}	Logic Input A.
4	V_{IB}	Logic Input B.
5	V_{IC}	Logic Input C.
6	NC	No Connect.
7	DISABLE	Input Disable. Disables the isolator inputs and refreshes. Outputs take on logic state determined by CTRL.
8	GND_1	Ground 1. Ground reference for Isolator Side 1.
9	GND_2	Ground 2. Ground reference for Isolator Side 2.
10	CTRL	Default Output Control. Controls the logic state the outputs take on when the input power is off. V_{OA}, V_{OB}, V_{OC}, and V_{OD} outputs are high when CTRL is high or disconnected and V_{DD1} is off. V_{OA}, V_{OB}, V_{OC}, and V_{OD} outputs are low when CTRL is low and V_{DD1} is off. When V_{DD1} power is on, this pin has no effect.
11	NC	No Connect.
12	V_{OC}	Logic Output C.
13	V_{OB}	Logic Output B.
14	V_{OA}	Logic Output A.
15	GND_2	Ground 2. Ground reference for Isolator Side 2.
16	V_{DD2}	Supply Voltage for Isolator Side 1, 2.7 V to 5.5 V.

Table 12. ADuM1410 Pin Function Descriptions

Pin No.	Mnemonic	Description
1	V_{DD1}	Supply Voltage for Isolator Side 1, 2.7 V to 5.5 V.
2	GND_1	Ground 1. Ground reference for isolator Side 1.
3	V_{IA}	Logic Input A.
4	V_{IB}	Logic Input B.
5	V_{IC}	Logic Input C.
6	V_{ID}	Logic Input D.
7	DISABLE	Input Disable. Disables the isolator inputs and refreshes. Outputs take on logic state determined by CTRL.
8	GND_1	Ground 1. Ground reference for Isolator Side 1.
9	GND_2	Ground 2. Ground reference for Isolator Side 2.
10	CTRL	Default Output Control. Controls the logic state the outputs take on when the input power is off. V_{OA}, V_{OB}, V_{OC}, and V_{OD} outputs are high when CTRL is high or disconnected and V_{DD1} is off. V_{OA}, V_{OB}, V_{OC}, and V_{OD} outputs are low when CTRL is low and V_{DD1} is off. When V_{DD1} power is on, this pin has no effect.
11	V_{OD}	Logic Output D.
12	V_{OC}	Logic Output C.
13	V_{OB}	Logic Output B.
14	V_{OA}	Logic Output A.
15	GND_2	Ground 2. Ground reference for Isolator Side 2.
16	V_{DD2}	Supply Voltage for Isolator Side 2, 2.7 V to 5.5 V.

TYPICAL PERFORMANCE CHARACTERISTICS

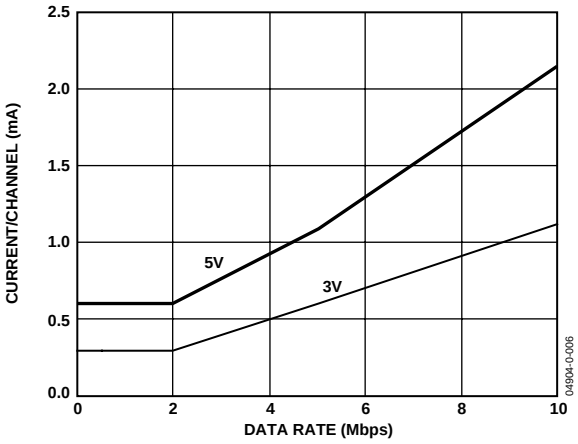


Figure 6. Typical Input Supply Current per Channel vs. Data Rate for 5 V and 3 V Operation

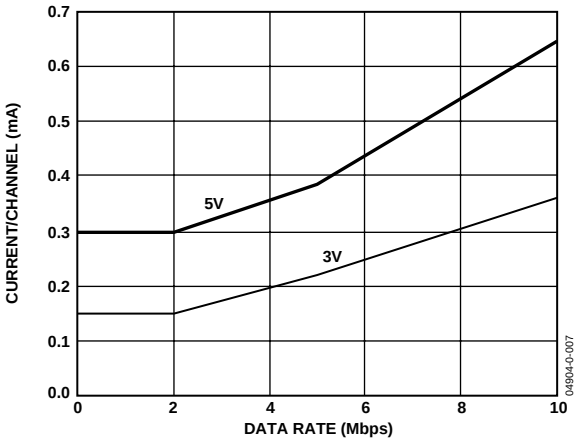


Figure 7. Typical Output Supply Current per Channel vs. Data Rate for 5 V and 3 V Operation (No Output Load)

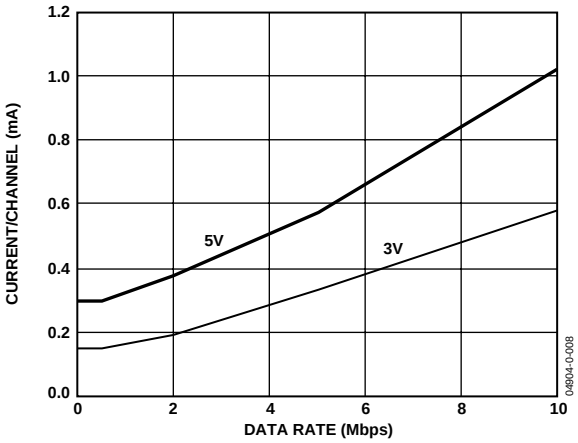


Figure 8. Typical Output Supply Current per Channel vs. Data Rate for 5 V and 3 V Operation (15 pF Output Load)

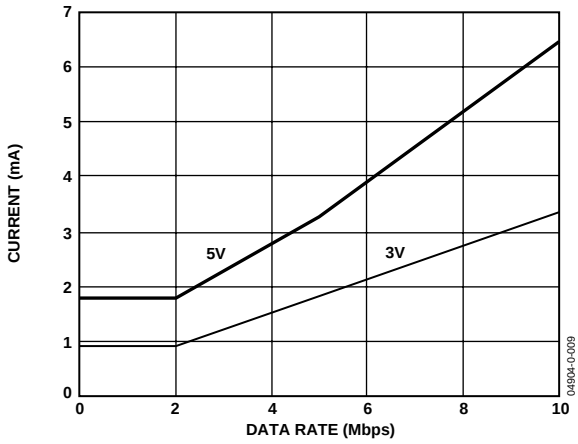


Figure 9. Typical ADuM1310 V_{DD1} Supply Current vs. Data Rate for 5 V and 3 V Operation

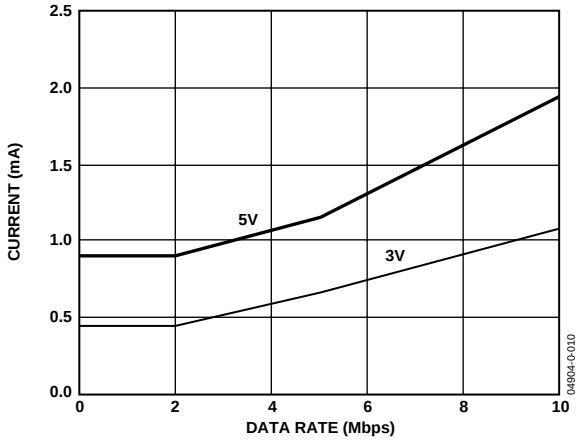


Figure 10. Typical ADuM1310 V_{DD2} Supply Current vs. Data Rate for 5 V and 3 V Operation

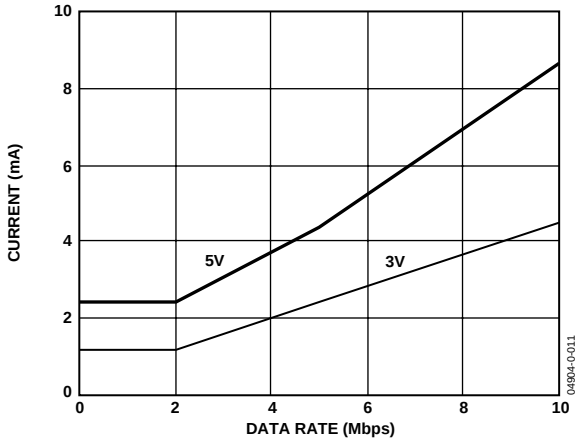


Figure 11. Typical ADuM1410 V_{DD1} Supply Current vs. Data Rate for 5 V and 3 V Operation

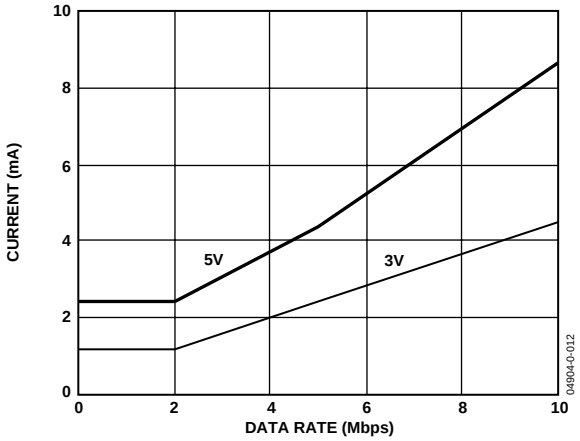


Figure 12. Typical ADuM1410 V_{DD2} Supply Current vs. Data Rate for 5 V and 3 V Operation

APPLICATION INFORMATION

PC BOARD LAYOUT

The ADuM1x10 digital isolator requires no external interface circuitry for the logic interfaces. Power supply bypassing is strongly recommended at the input and output supply pins (see Figure 13). Bypass capacitors are most conveniently connected between Pin 1 and Pin 2 for V_{DD1} and between Pin 15 and Pin 16 for V_{DD2}. The capacitor value should be between 0.01 µF and 0.1 µF. The total lead length between both ends of the capacitor and the input power supply pin should not exceed 20 mm. Bypassing between Pin 1 and Pin 8 and between Pin 9 and Pin 16 should also be considered unless the ground pair on each package side is connected close to the package.

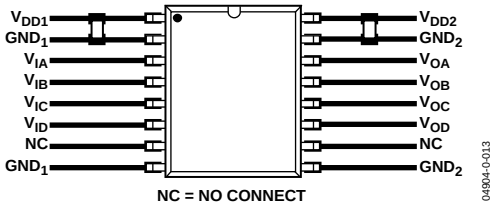


Figure 13. Recommended Printed Circuit Board Layout

PROPAGATION DELAY-RELATED PARAMETERS

Propagation delay is a parameter that describes the length of time it takes for a logic signal to propagate through a component. The propagation delay to a logic low output can differ from the propagation delay to a logic high output.

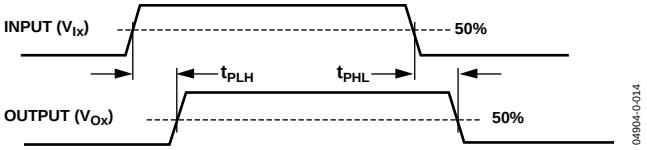


Figure 14. Propagation Delay Parameters

Pulse width distortion is the maximum difference between these two propagation delay values and is an indication of how accurately the input signal's timing is preserved.

Channel-to-channel matching refers to the maximum amount the propagation delay differs between channels within a single ADuM1x10 component.

Propagation delay skew refers to the maximum amount the propagation delay differs among multiple ADuM1x10 components operated under the same conditions.

DC CORRECTNESS AND MAGNETIC FIELD IMMUNITY

Positive and negative logic transitions at the isolator input cause narrow (~1 ns) pulses to be sent via the transformer to the decoder. The decoder is bistable, and is, therefore, either set or reset by the pulses indicating input logic transitions. In the absence of logic transitions at the input for more than 2 µs, a periodic set of refresh pulses indicative of the correct input state are sent to ensure dc correctness at the output. If the decoder receives no pulses for more than about 5 µs, the input side is assumed to be unpowered or nonfunctional, in which case the isolator output is forced to a default state (see Table 10) by the watchdog timer circuit.

The limitation on the device's magnetic field immunity is set by the condition in which induced voltage in the transformer's receiving coil is sufficiently large to either falsely set or reset the decoder. The analysis below defines such conditions. The ADuM1x10's 3 V operating condition 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 of 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

$$V = (-d\beta/dt)\Sigma\prod r_n^2; \; n = 1, 2, \ldots, N$$

where:

β is the magnetic flux density (gauss).
N is the number of turns in the receiving coil.
r_n is the radius of the n^{th} turn in the receiving coil (cm).

Given the geometry of the receiving coil in the ADuM1x10 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 15.

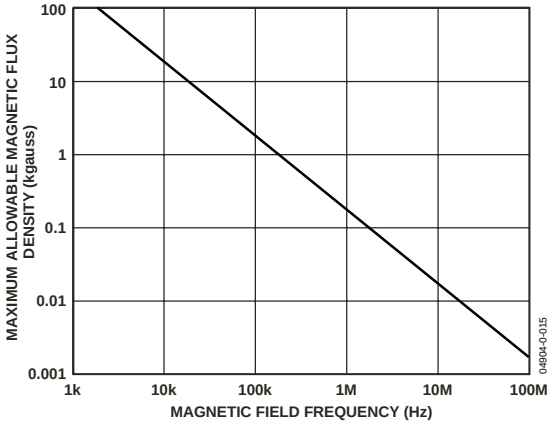


Figure 15. Maximum Allowable External Magnetic Flux Density

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 occurred during a transmitted pulse (and was of 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.

The preceding magnetic flux density values correspond to specific current magnitudes at given distances away from the ADuM1x10 transformers. Figure 16 expresses these allowable current magnitudes as a function of frequency for selected distances. As can be seen, the ADuM1x10 is 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 noted, one would have to place a 0.5 kA current 5 mm away from the ADuM1x10 to affect the component's operation.

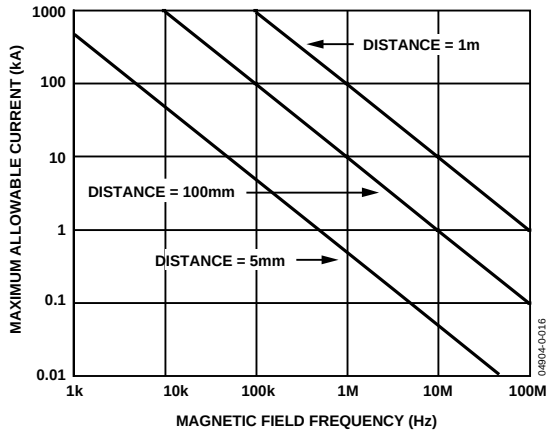


Figure 16. Maximum Allowable Current for Various Current to ADuM1x10 Spacings

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

POWER CONSUMPTION

The supply current at a given channel of the ADuM1x10 isolator is a function of the supply voltage, the channel's data rate, and the channel's output load.

For each input channel, the supply current is given by

$$I_{DDI} = I_{DDI\,(Q)} \qquad f \le 0.5f_r$$

$$I_{DDI} = I_{DDI\,(D)} \times (2f - f_r) + I_{DDI\,(Q)} \qquad f > 0.5f_r$$

For each output channel, the supply current is given by

$$I_{DDO} = I_{DDO\,(Q)} \qquad f \le 0.5f_r$$

$$I_{DDO} = (I_{DDO\,(D)} + C_L V_{DDO}) \times (2f - f_r) + I_{DDO\,(Q)} \qquad f > 0.5f_r$$

where:

$I_{DDI\,(D)}$, $I_{DDO\,(D)}$ are the input and output dynamic supply currents per channel (mA/Mbps).

C_L is the output load capacitance (pF).

V_{DDO} is the output supply voltage (V).

f is the input logic signal frequency (Hz, half of the input data rate, NRZ signaling).

f_r is the input stage refresh rate (bps).

$I_{DDI\,(Q)}$, $I_{DDO\,(Q)}$ are the specified input and output quiescent supply currents (mA).

To calculate the total I_{DD1} and I_{DD2} supply current, the supply currents for each input and output channel corresponding to I_{DD1} and I_{DD2} are calculated and totaled. Figure 6 and Figure 7 provide per-channel supply currents as a function of the data rate for an unloaded output condition. Figure 8 provides per-channel supply current as a function of the data rate for a 15 pF output condition. Figure 9 through Figure 12 provide total I_{DD1} and I_{DD2} supply current as a function of the data rate for ADuM1310/ADuM1410 products.

POWER-UP/POWER-DOWN CONSIDERATIONS

Given that the ADuM1310/ADuM1410 have separate supplies on either side of the isolation barrier, the power-up and power-down characteristics relative to each supply voltage need to be considered individually.

As shown in Table 10, when V_{DD1} input power is off, the ADuM1310/ADuM1410 outputs take on a default condition as determined by the state of the CTRL pin. As the V_{DD1} supply is increased/decreased, the output of each channel transitions from/to the default condition to/from the state matching its respective signals (see Figure 17 and Figure 18).

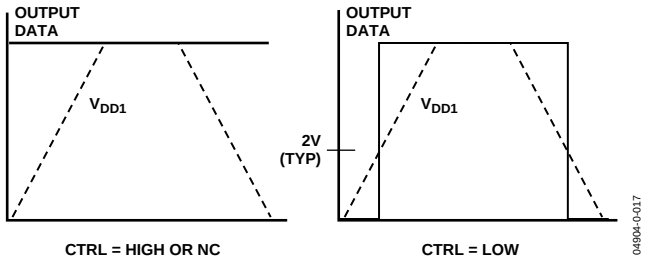


Figure 17. V_{DD1} Power-Up/Power-Down Characteristics, Input Data = High

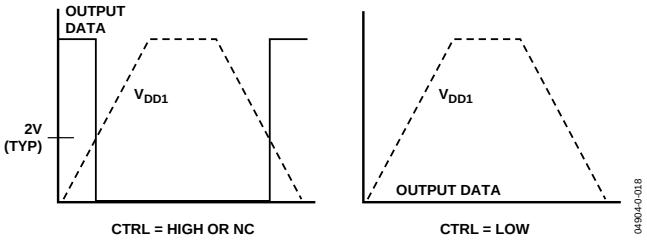


Figure 18. V_{DD1} Power-Up/Power-Down Characteristics, Input Data = Low

When V_{DD1} crosses the threshold for activating the refresh circuit (approximately 2 V), there can be a delay of up to 2 µs before the output is updated to the correct state depending on the timing of the next refresh pulse. When V_{DD1} is reduced from an on state below the 2 V threshold, there can be a delay of up to 5 µs before the output takes on its default state determined by the CTRL signal. This corresponds to the duration that the watchdog timer circuit at the input is designed to wait before triggering an output default state.

When the V_{DD2} output supply is below the level at which the ADuM1310/ADuM1410's output transistors are biased (about 1 V), the outputs take on a high impedance state. When V_{DD2} is above a value of about 2 V, each channel's output takes on a state matching that of its respective input. Between the values of 1 V and 2 V, the outputs are set low. This behavior is shown in Figure 19 and Figure 20.

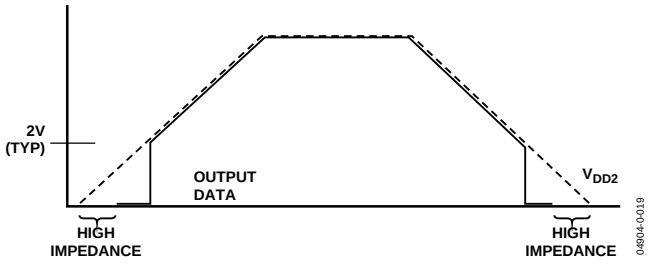


Figure 19. V_{DD2} Power-Up/Power-Down Characteristics, Input Data = High

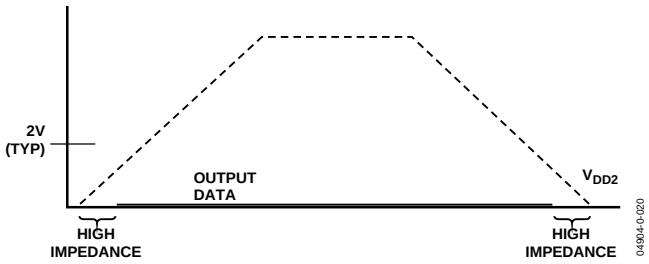
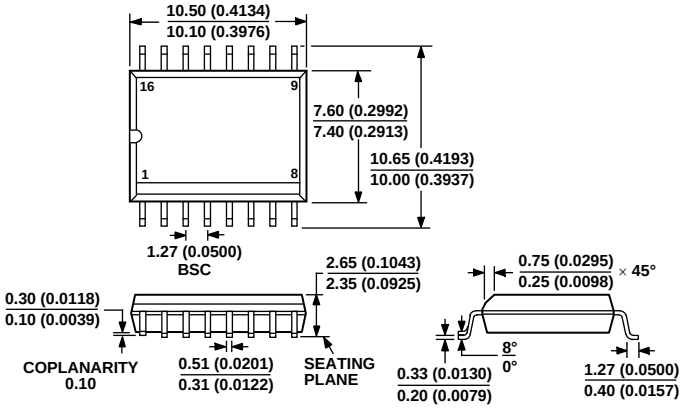


Figure 20. V_{DD2} Power-Up/Power-Down Characteristics, Input Data = Low

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 21. 16-Lead Standard Small Outline Package [SOIC_W]
Wide Body (RW-16)
Dimensions shown in millimeters and (inches)

ORDERING GUIDE

Model	Number of Channels	Maximum Data Rate (Mbps)	Temperature Range	Package Description	Package Option
ADuM1310BRWZ[1]	3	10	−40°C to +105°C	16-Lead Wide Body SOIC_W	RW-16
ADuM1310BRWZ-RL[1, 2]	3	10	−40°C to +105°C	16-Lead Wide Body SOIC_W	RW-16
ADuM1410BRWZ[1]	4	10	−40°C to +105°C	16-Lead Wide Body SOIC_W	RW-16
ADuM1410BRWZ-RL[1, 2]	4	10	−40°C to +105°C	16-Lead Wide Body SOIC_W	RW-16

[1] Z = Pb-free part.
[2] The addition of an -RL suffix designates a 13-inch (1,000 units) tape and reel option.

NOTES

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