

TXG404x-Q1 4-bit, $\pm 40V$ Ground-Level Translator

1 Features

- AEC-Q100 qualified for automotive applications
- Will be available in wettable flank QFN (RUC) package
- Supports DC ground shifts up to 40V
- AC Noise Rejection of $80V_{PP}$ up to 5MHz
- CMTI of $1kV/\mu s$
- Low Prop Delay ($<5ns$) and Ch-Ch Skew ($0.35ns$)
- Greater than 250Mbps
- Low power consumption (0.65mA per channel at 1Mbps, 1.8V)
- Fully configurable dual-rail design allows each port to operate from 1.71V to 5.5V
- 4, 2, 1 channel devices with multiple configurations will be available
- Two device variants:
 - TXG4041-Q1: 3 forward, 1 reverse
 - TXG4042-Q1: 2 forward, 2 reverse
- Supports V_{CC} disconnect feature (I/Os are forced into high-Z)
- Schmitt-trigger inputs allows for slow and noisy signals
- Inputs with integrated static pull-down resistors prevent channels from floating
- Operating temperature from $-40^{\circ}C$ to $+125^{\circ}C$
- Latch-up performance exceeds 100mA per JESD 78, class II
- ESD protection exceeds JESD 22
 - 4000V human-body model
 - 500V charged-device model
- Package options provided:
 - RUC (X2QFN-14)
 - DYY (SOT-14)
 - DBQ (QSOP-16)

2 Applications

- [Electric Power Steering](#)
- [Vehicle Control Unit](#)
- [Automotive Display](#)
- [Head Unit and Digital Cockpit](#)

3 Description

The TXG404x-Q1 is a 4-bit, fixed direction, non-galvanic based voltage and ground-level translator that can support both logic-level shifting between 1.71V to 5.5V and ground-level shifting up to $\pm 40V$. Compared to traditional level shifters, the TXG404x-Q1 family can solve the challenges of voltage translation across different ground levels. The [Simplified Diagram](#) shows a common use case where DC shift occurs between GNDA to GNDB due to parasitic resistance or capacitance.

V_{CCA} is referenced to GNDA and V_{CCB} is referenced to GNDB. Ax pins are referenced to V_{CCA} logic level while Bx pins are referenced to V_{CCB} logic levels. Both A port and B port can accept voltages from 1.71V to 5.5V. This device includes two enable pins that can place the respective outputs in a high-impedance state when the OE pin is connected to GND or left floating. In the event of input power or signal loss, the output is default low when OE is High (refer to [Table 7-1](#)). The leakage between GNDA and GNDB is $<30nA$ when V_{CC} to GND is shorted.

The TXG404x-Q1 device helps improve noise immunity and power sequencing across different ground domains while providing low power consumption, latency and channel-to-channel skew. It can suppress noise levels of $80V_{PP}$ up to 5MHz ([Figure 7-4](#)). This device can support multiple interfaces such as SPI, UART, GPIO, and I2S.

Package Information

PART NUMBER	PACKAGE ⁽¹⁾	BODY SIZE (NOM)
TXG4041-Q1 TXG4042-Q1	DYY (SOT-14)	4.20mm \times 2.00mm
	DBQ (QSOP-16)	4.90mm \times 3.90mm
	RUC (X2QFN-14)	2.00mm \times 2.00mm

(1) For all available packages, see the orderable addendum at the end of the data sheet.



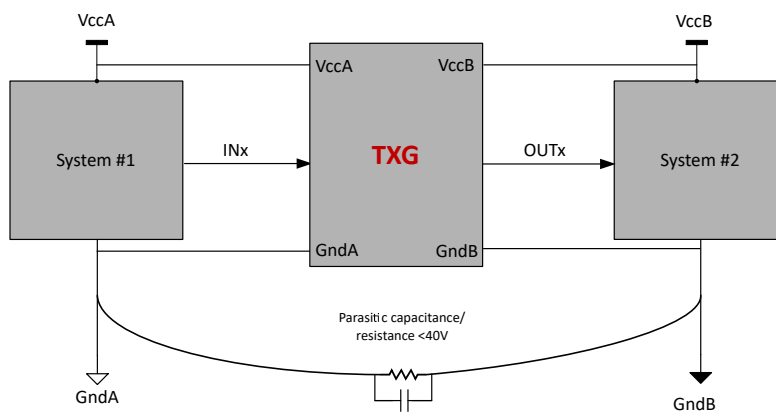
**Simplified Diagram**

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4 Pin Configuration and Functions

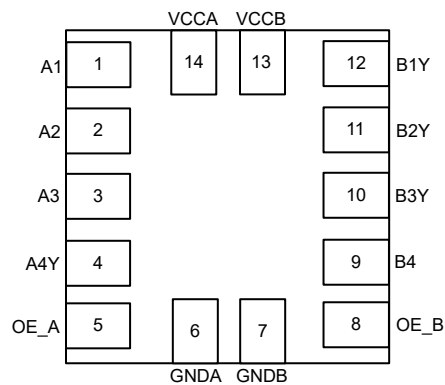


Figure 4-1. TXG4041-Q1 RUC Package 14-Pin X2QFN Top View

Table 4-1. TXG4041-Q1 RUC Pin Functions

PIN		I/O	DESCRIPTION
Name	TXG4041-Q1		
A1	1	I	Input A1. Referenced to V_{CCA}
A2	2	I	Input A2. Referenced to V_{CCA}
A3	3	I	Input A3. Referenced to V_{CCA}
A4Y	4	O	Output A4. Referenced to V_{CCA}
B1Y	12	O	Output B1. Referenced to V_{CCB}
B2Y	11	O	Output B2. Referenced to V_{CCB}
B3Y	10	O	Output B3. Referenced to V_{CCB}
B4	9	I	Input B4. Referenced to V_{CCB}
OE_A	5	I	Active-High Output Enable (A side). Pull to GND to place all outputs in high-impedance mode.
OE_B	8	I	Active-High Output Enable (B side). Pull to GND to place all outputs in high-impedance mode.
V_{CCA}	14	—	A side supply voltage. $1.71V \leq V_{CCA} \leq 5.5V$
V_{CCB}	13	—	B side supply voltage. $1.71V \leq V_{CCB} \leq 5.5V$
GNDA	6	—	Ground reference for V_{CCA}
GNDB	7	—	Ground reference for V_{CCB}

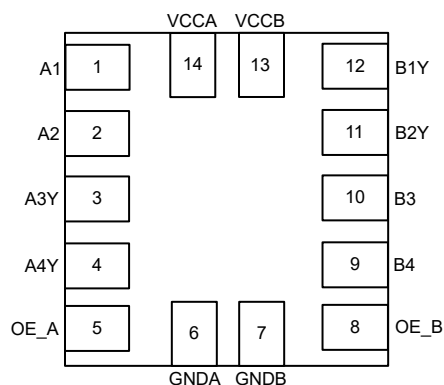


Figure 4-2. TXG4042-Q1 RUC Package 14-Pin X2QFN Top View

Table 4-2. TXG4042-Q1 RUC Pin Functions

PIN			
Name	TXG4042-Q1	I/O	DESCRIPTION
A1	1	I	Input A1. Referenced to V_{CCA}
A2	2	I	Input A2. Referenced to V_{CCA}
A3Y	3	O	Output A3. Referenced to V_{CCA}
A4Y	4	O	Output A4. Referenced to V_{CCA}
B1Y	12	O	Output B1. Referenced to V_{CCB}
B2Y	11	O	Output B2. Referenced to V_{CCB}
B3	10	I	Input B3. Referenced to V_{CCB}
B4	9	I	Input B4. Referenced to V_{CCA}
OE_A	5	I	Active-High Output Enable (A side). Pull to GND to place all outputs in high-impedance mode.
OE_B	8	I	Active-High Output Enable (B side). Pull to GND to place all outputs in high-impedance mode.
V_{CCA}	14	—	A side supply voltage. $1.71V \leq V_{CCA} \leq 5.5V$
V_{CCB}	13	—	B side supply voltage. $1.71V \leq V_{CCB} \leq 5.5V$
GNDA	6	—	Ground reference for V_{CCA}
GNDB	7	—	Ground reference for V_{CCB}

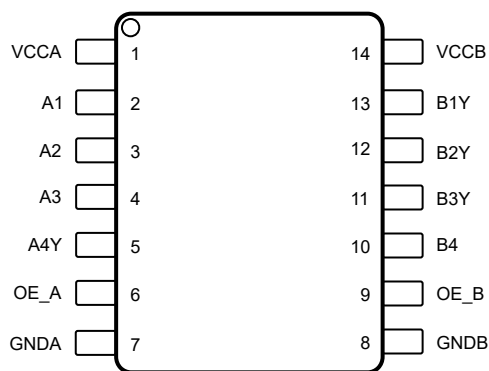


Figure 4-3. TXG4041-Q1 DYY 14-Pin SOT Top View

Table 4-3. TXG4041-Q1 DYY Pin Functions

PIN		I/O	DESCRIPTION
Name	TXG4041-Q1		
A1	2	I	Input A1. Referenced to V_{CCA}
A2	3	I	Input A2. Referenced to V_{CCA}
A3	4	I	Input A3. Referenced to V_{CCA}
A4Y	5	O	Output A4. Referenced to V_{CCA}
B1Y	13	O	Output B1. Referenced to V_{CCB}
B2Y	12	O	Output B2. Referenced to V_{CCB}
B3Y	11	O	Output B3. Referenced to V_{CCB}
B4	10	I	Input B4. Referenced to V_{CCB}
OE_A	6	I	Active-High Output Enable (A side). Pull to GND to place all outputs in high-impedance mode.
OE_B	9	I	Active-High Output Enable (B side). Pull to GND to place all outputs in high-impedance mode.
V_{CCA}	1	—	A side supply voltage. $1.71V \leq V_{CCA} \leq 5.5V$
V_{CCB}	14	—	B side supply voltage. $1.71V \leq V_{CCB} \leq 5.5V$
GNDA	7	—	Ground reference for V_{CCA}
GNDB	8	—	Ground reference for V_{CCB}

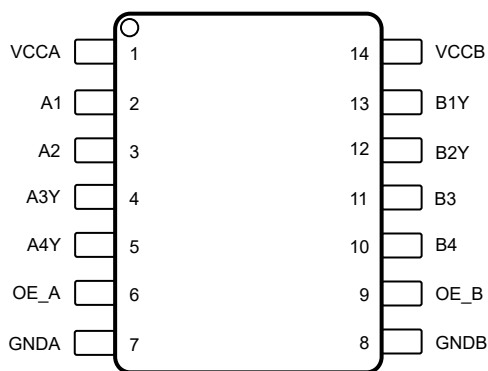


Figure 4-4. TXG4042-Q1 DYY 14-Pin SOT Top View

Table 4-4. TXG4042-Q1 DYY Pin Functions

PIN		I/O	DESCRIPTION
Name	TXG4042-Q1		
A1	2	I	Input A1. Referenced to V_{CCA}
A2	3	I	Input A2. Referenced to V_{CCA}
A3Y	4	O	Output A3. Referenced to V_{CCA}
A4Y	5	O	Output A4. Referenced to V_{CCA}
B1Y	13	O	Output B1. Referenced to V_{CCB}
B2Y	12	O	Output B2. Referenced to V_{CCB}
B3	11	I	Input B3. Referenced to V_{CCB}
B4	10	I	Input B4. Referenced to V_{CCA}
OE_A	6	I	Active-High Output Enable (A side). Pull to GND to place all outputs in high-impedance mode.
OE_B	9	I	Active-High Output Enable (B side). Pull to GND to place all outputs in high-impedance mode.
V_{CCA}	1	—	A side supply voltage. $1.71V \leq V_{CCA} \leq 5.5V$
V_{CCB}	14	—	B side supply voltage. $1.71V \leq V_{CCB} \leq 5.5V$
GNDA	7	—	Ground reference for V_{CCA}
GNDB	8	—	Ground reference for V_{CCB}

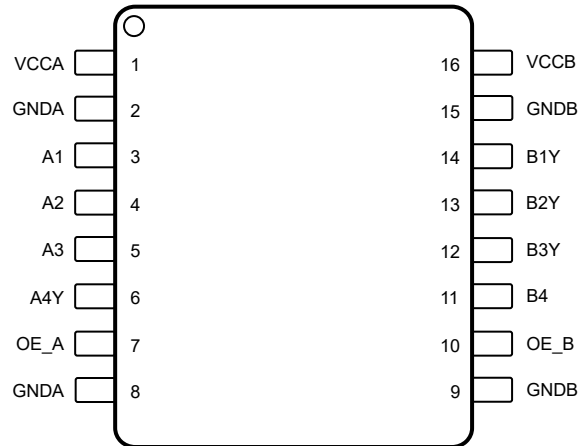


Figure 4-5. TXG4041-Q1 DBQ 16-Pin QSOP Top View

Table 4-5. TXG4041-Q1 DBQ Pin Functions

PIN		I/O	DESCRIPTION
Name	TXG4041-Q1		
A1	3	I	Input A1. Referenced to V_{CCA}
A2	4	I	Input A2. Referenced to V_{CCA}
A3	5	I	Input A3. Referenced to V_{CCA}
A4Y	6	O	Output A4. Referenced to V_{CCA}
B1Y	14	O	Output B1. Referenced to V_{CCB}
B2Y	13	O	Output B2. Referenced to V_{CCB}
B3Y	12	O	Output B3. Referenced to V_{CCB}
B4	11	I	Input B4. Referenced to V_{CCB}
OE_A	7	I	Active-High Output Enable (A side). Pull to GND to place all outputs in high-impedance mode.
OE_B	10	I	Active-High Output Enable (B side). Pull to GND to place all outputs in high-impedance mode.
V_{CCA}	1	—	A side supply voltage. $1.71V \leq V_{CCA} \leq 5.5V$
V_{CCB}	16	—	B side supply voltage. $1.71V \leq V_{CCB} \leq 5.5V$
GNDA	2, 8	—	Ground reference for V_{CCA}
GNDB	9, 15	—	Ground reference for V_{CCB}

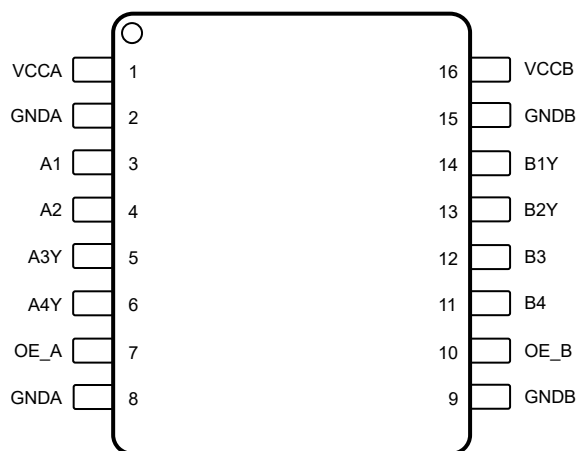


Figure 4-6. TXG4042-Q1 DBQ 16-Pin QSOP Top View

Table 4-6. TXG4042-Q1 DBQ Pin Functions

PIN		I/O	DESCRIPTION
Name	TXG4042-Q1		
A1	3	I	Input A1. Referenced to V_{CCA}
A2	4	I	Input A2. Referenced to V_{CCA}
A3Y	5	O	Output A3. Referenced to V_{CCA}
A4Y	6	O	Output A4. Referenced to V_{CCA}
B1Y	14	O	Output B1. Referenced to V_{CCB}
B2Y	13	O	Output B2. Referenced to V_{CCB}
B3	12	I	Input B3. Referenced to V_{CCB}
B4	11	I	Input B4. Referenced to V_{CCB}
OE_A	7	I	Active-High Output Enable (A side). Pull to GND to place all outputs in high-impedance mode.
OE_B	10	I	Active-High Output Enable (B side). Pull to GND to place all outputs in high-impedance mode.
V_{CCA}	1	—	A side supply voltage. $1.71V \leq V_{CCA} \leq 5.5V$
V_{CCB}	16	—	B side supply voltage. $1.71V \leq V_{CCB} \leq 5.5V$
GNDA	2, 8	—	Ground reference for V_{CCA}
GNDB	9, 15	—	Ground reference for V_{CCB}

5 Specifications

5.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)⁽¹⁾

			MIN	MAX	UNIT
V_{CCA} to V_{GNDA}	Supply voltage A to Ground voltage A		–0.5	6.5	V
V_{CCB} to V_{GNDB}	Supply voltage B to Ground voltage B		–0.5	6.5	V
V_{GNDA} to V_{GNDB}	Voltage between GNDA and GNDB		–45	45	V
V_I	Input Voltage ⁽²⁾	I/O Ports (A Port) to V_{GNDA}	–0.5	6.5	V
		I/O Ports (B Port) to V_{GNDB}	–0.5	6.5	
		OE	–0.5	6.5	V
V_O	Voltage applied to any output in the high-impedance or power-off state ⁽²⁾	A Port to V_{GNDA}	–0.5	6.5	V
		B Port to V_{GNDB}	–0.5	6.5	
V_O	Voltage applied to any output in the high or low state ^{(2) (3)}	A Port to V_{GNDA}	–0.5	6.5	V
		B Port to V_{GNDB}	–0.5	6.5	
I_{IK}	Input clamp current	$V_I < 0$	–20		mA
I_{OK}	Output clamp current	$V_O < 0$	–20		mA
I_O	Continuous output current		–16	16	mA
	Continuous current through V_{CCx} or $GNDx$		–64	64	mA
T_J	Junction Temperature			150	°C
T_{stg}	Storage temperature		–65	150	°C

- (1) Stresses beyond those listed under [Section 5.1](#) may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under [Section 5.3](#) Exposure beyond the limits listed in [Section 5.3](#) may affect device reliability.
- (2) The input voltage and output negative-voltage ratings may be exceeded if the input and output current ratings are observed.
- (3) The output positive-voltage rating may be exceeded up to 6.5V maximum if the output current rating is observed.

5.2 ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001 ⁽¹⁾	±4000	V
		Charged device model (CDM), per ANSI/ESDA/JEDEC JS-002 ⁽²⁾	±500	

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

5.3 Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted) ⁽¹⁾ ⁽²⁾ ⁽³⁾

		MIN	TYP	MAX	UNIT
V _{CCA}	Supply voltage A - Relative to GNDA	1.71		5.5	V
V _{CCB}	Supply voltage B - Relative to GNDB	1.71		5.5	V
V _{GNDA} to V _{GNDB}	Voltage between GNDA and GNDB	-40		40	V
I _{OH}	High-level output current	V _{CCO} = 1.71V	-4.5		mA
		V _{CCO} = 2.3V	-8		
		V _{CCO} = 3V	-10		
		V _{CCO} = 4.5V	-12		
I _{OL}	Low-level output current	V _{CCO} = 1.71V		4.5	mA
		V _{CCO} = 2.3V		8	
		V _{CCO} = 3V		10	
		V _{CCO} = 4.5V		12	
V _I	Input voltage - Relative to GNDx	0		5.5	V
V _O	Output voltage - Relative to GNDx	0		V _{CCO}	V
T _A	Operating free-air temperature	-40		125	°C

- (1) V_{CCI} is the V_{CC} associated with the input port.
(2) V_{CCO} is the V_{CC} associated with the output port.
(3) All control inputs and data I/Os of this device have weak pulldowns to ensure the line is not floating when undefined external to the device. The input leakage from these weak pulldowns is defined by the I_I specification indicated under Electrical Characteristics.

5.4 Thermal Information

THERMAL METRIC ⁽¹⁾		TXGx041 and TXGx042			UNIT
		DYY (SOT)	RUC (X2QFN)	DBQ (QSOP)	
		14 PINS	14 PINS	16 PINS	
R _{θJA}	Junction-to-ambient thermal resistance	128.4	99.7	143.1	°C/W
R _{θJC(top)}	Junction-to-case (top) thermal resistance	52.4	57.9	82.3	°C/W
R _{θJB}	Junction-to-board thermal resistance	58.5	51.9	46.9	°C/W
Y _{JT}	Junction-to-top characterization parameter	2.7	8.1	1.2	°C/W
Y _{JB}	Junction-to-board characterization parameter	51.9	57.2	81.9	°C/W

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

5.5 Electrical Characteristics

over operating free-air temperature range (unless otherwise noted)^{(1) (2)}

PARAMETER		TEST CONDITIONS	V _{CCA}	V _{CCB}	Operating free-air temperature (T _A)			UNIT
					–40°C to 125°C			
					MIN	TYP	MAX	
V _{OH}	High-level output voltage ⁽³⁾	I _{OH} = –4.5mA	1.71V	1.71V	1.5			V
		I _{OH} = –8mA	2.3V	2.3V	2.0			
		I _{OH} = –10mA	3V	3V	2.6			
		I _{OH} = –12mA	4.5V	4.5V	4.0			
V _{OL}	Low-level output voltage ⁽⁴⁾	I _{OL} = 4.5mA	1.71V	1.71V	0.18			V
		I _{OL} = 8mA	2.3V	2.3V	0.33			
		I _{OL} = 10mA	3V	3V	0.41			
		I _{OL} = 12mA	4.5V	4.5V	0.49			
V _{T+}	Positive-going input-threshold voltage	Data Inputs (Ax, Bx) (Referenced to V _{CCI})	1.71V	1.71V	1.14			V
			2.3V	2.3V	1.42			
			3V	3V	1.74			
			4.5V	4.5V	2.47			
			5.5V	5.5V	2.97			
V _{T+}	Positive-going input-threshold voltage	OE (Referenced to V _{CCA} or V _{CCB})	1.71V	1.71V	1.12			V
			2.3V	2.3V	1.42			
			3V	3V	1.73			
			4.5V	4.5V	2.47			
			5.5V	5.5V	2.94			
V _{T–}	Negative-going input-threshold voltage	Data Inputs (Ax, Bx) (Referenced to V _{CCI})	1.71V	1.71V	0.52			V
			2.3V	2.3V	0.76			
			3V	3V	1.09			
			4.5V	4.5V	1.77			
			5.5V	5.5V	2.28			
V _{T–}	Negative-going input-threshold voltage	OE (Referenced to V _{CCA} or V _{CCB})	1.71V	1.71V	0.46			V
			2.3V	2.3V	0.76			
			3V	3V	1.04			
			4.5V	4.5V	1.86			
			5.5V	5.5V	2.5			
ΔV _T	Input-threshold hysteresis (V _{T+} – V _{T–})	Data Inputs (Ax, Bx) (Referenced to V _{CCI})	1.71V	1.71V	0.24		0.54	V
			2.3V	2.3V	0.29		0.60	
			3V	3V	0.33		0.54	
			4.5V	4.5V	0.38		0.82	
			5.5V	5.5V	0.37		0.96	
ΔV _T	Input-threshold hysteresis (V _{T+} – V _{T–})	OE (Referenced to V _{CCA} or V _{CCB})	1.71V	1.71V	0.24		0.45	V
			2.3V	2.3V	0.28		0.58	
			3V	3V	0.32		0.54	
			4.5V	4.5V	0.35		0.58	
			5.5V	5.5V	0.39		0.62	
I _I	Input leakage current	Data Inputs (Ax, Bx) V _I = V _{CCI} or GND	1.71V – 5.5V	1.71V – 5.5V	1.6			μA

over operating free-air temperature range (unless otherwise noted)^{(1) (2)}

PARAMETER		TEST CONDITIONS	V _{CCA}	V _{CCB}	Operating free-air temperature (T _A)			UNIT
					–40°C to 125°C			
					MIN	TYP	MAX	
I _{off-float}	Floating supply Partial power down current	A Port or B Port V _I = GND	Floating ⁽⁵⁾	0V - 5.5V	–2.5	2.5	μA	
			0V - 5.5V	Floating ⁽⁵⁾	–2.5	2.5		
I _O	Tri-state output Output current	A or B Port: V _I = V _{CCA} or V _{GNDA} OE = GND	1.71V – 5.5V	1.1V – 5.5V	–5	5	μA	
C _i	Control Input Capacitance	V _I = 3.3V or V _{GNDA}	3.3V	3.3V	2		pF	
C _{io}	Data I/O Capacitance	OE = GND, V _O = 1.71V DC +1MHz -16dBm sine wave	3.3V	3.3V	5		pF	
C _{GND}	Cap between grounds	All channels combined (V _{CC} both sides are powered on)			49		pF	
		All channels combined (V _{CC} to GND shorted)			54		pF	
Leakage	Current Leakage between GndA to GndB	All channels combined (V _{CC} to GND shorted)	1.71V – 5.5V	1.71V – 5.5V	45		nA	
		All channels combined (V _{CC} both sides are powered on and inputs are all low)	1.71V – 5.5V	1.71V – 5.5V	45		nA	
		All channels combined (V _{CC} both sides are powered on and inputs are all high)	1.71V – 5.5V	1.71V – 5.5V	33		μA	
CMTI	Common Mode Transient Immunity	Input toggling at 100Mbps Ground shift up to 40V	1.71V – 5.5V	1.71V – 5.5V	1		kV/μs	
V _{UVLO+}	Positive-Going Undervoltage Lockout Voltage	A Supply	1.71V – 5.5V		1.55		V	
		B Supply		1.71V – 5.5V	1.55			
V _{UVLO-}	Negative-Going Undervoltage Lockout Voltage	A Supply	1.71V – 5.5V		1.36		V	
		B Supply		1.71V – 5.5V	1.36			
V _{UVLO_Hys}	Undervoltage Lockout Hysteresis	A Supply	1.71V – 5.5V		36	147	mV	
		B Supply		1.71V – 5.5V	36	147		

(1) V_{CCI} is the V_{CC} associated with the input port and referenced to GND_A

(2) V_{CCO} is the V_{CC} associated with the output port and referenced to GND_B

(3) Tested at V_I = V_{T+(MAX)}

(4) Tested at V_I = V_{T-(MIN)}

(5) Floating is defined as a node that is both not actively driven by an external device and has leakage not exceeding 10nA

5.6 Supply Current

over operating free-air temperature range (unless otherwise noted)^{(1) (2)}

PARAMETER		TEST CONDITIONS	V _{CCA}	V _{CCB}	Operating free-air temperature (T _A)			UNIT
					−40°C to 125°C			
					MIN	TYP	MAX	
TXGx041								
I _{CCA}	V _{CCA} supply current	V _I = V _{CCI} or GND I _O = 0	1.71V – 5.5V	1.71V – 5.5V	546	1220	μA	
			0V	5.5V	-3	13		
			5.5V	0V	509	1050		
		V _I = GND I _O = 0	5.5V	Floating ⁽³⁾	509	1050		
I _{CCB}	V _{CCB} supply current	V _I = V _{CCI} or GND I _O = 0	1.71V – 5.5V	1.71V – 5.5V	750	1836	μA	
			0V	5.5V	654	1350		
			5.5V	0V	-3	36		
		V _I = GND I _O = 0	Floating ⁽³⁾	5.5V	656	1350		
I _{CCA} + I _{CCB}	Supply Current - Disable	EN = 0	1.8V	1.8V	1.9	3.1	mA	
			2.5V	2.5V	1.9	3.1		
			3.3V	3.3V	2.0	3.1		
			5V	5V	2.1	3.3		
I _{CCA} + I _{CCB}	Supply Current - DC Signal	V _I = V _{CCI}	1.8V	1.8V	1	2.65	mA	
			2.5V	2.5V	1.3	2.7		
			3.3V	3.3V	1.3	2.8		
			5V	5V	1.4	3.1		
		V _I = GND	1.8V	1.8V	1.2	2.7		
			2.5V	2.5V	1.3	2.7		
			3.3V	3.3V	1.3	2.8		
			5V	5V	1.4	3.1		

over operating free-air temperature range (unless otherwise noted)^{(1) (2)}

PARAMETER		TEST CONDITIONS	V _{CCA}	V _{CCB}	Operating free-air temperature (T _A)		UNIT
					−40°C to 125°C		
					MIN	TYP	
I _{CCA} + I _{CCB}	Supply Current - AC Signal	All channels switching with square wave clock input; C _L = 15pF, 1Mbps	1.8V	1.8V	1.5	2.6	mA
			2.5V	2.5V	1.6	2.7	
			3.3V	3.3V	1.6	2.8	
			5V	5V	1.9	3.3	
		All channels switching with square wave clock input; C _L = 15pF, 50Mbps	1.8V	1.8V	9.2	12.1	
			2.5V	2.5V	10.8	14	
			3.3V	3.3V	12.4	16.2	
			5V	5V	17.6	20.6	
		All channels switching with square wave clock input; C _L = 15pF, 100Mbps	1.8V	1.8V	16.5	20.1	
			2.5V	2.5V	20.2	24.7	
			3.3V	3.3V	24.1	29	
			5V	5V	35	38	
TXGx042							
I _{CCA}	V _{CCA} supply current	V _I = V _{CCI} or GND I _O = 0	1.71V – 5.5V	1.71V – 5.5V	547	1365	μA
			0V	5.5V	-2.6	25	
			5.5V	0V	625	1052	
		V _I = GND I _O = 0	5.5V	Floating ⁽³⁾	625	1052	
I _{CCB}	V _{CCB} supply current	V _I = V _{CCI} or GND I _O = 0	1.71V – 5.5V	1.71V – 5.5V	753	1692	μA
			0V	5.5V	819	1380	
			5.5V	0V	-2.4	25	
		V _I = GND I _O = 0	Floating ⁽³⁾	5.5V	823	1380	
I _{CCA} + I _{CCB}	Supply Current - Disable	EN = 0	1.8V	1.8V	1.9	3.1	mA
			2.5V	2.5V	1.9	3.1	
			3.3V	3.3V	2	3.1	
			5V	5V	2.1	3.3	

over operating free-air temperature range (unless otherwise noted)^{(1) (2)}

PARAMETER		TEST CONDITIONS	V _{CCA}	V _{CCB}	Operating free-air temperature (T _A)			UNIT
					−40°C to 125°C			
					MIN	TYP	MAX	
I _{CCA} + I _{CCB}	Supply Current - DC Signal	V _I = V _{CCI}	1.8V	1.8V	1.2	2.7	mA	
			2.5V	2.5V	1.3	2.6		
			3.3V	3.3V	1.3	2.7		
			5V	5V	1.4	3.1		
		V _I = GND	1.8V	1.8V	1.2	2.7		
			2.5V	2.5V	1.3	2.6		
			3.3V	3.3V	1.3	2.7		
			5V	5V	1.4	3.1		
I _{CCA} + I _{CCB}	Supply Current - AC Signal	All channels switching with square wave clock input; C _L = 15pF, 1Mbps	1.8V	1.8V	1.5	2.6	mA	
			2.5V	2.5V	1.6	2.7		
			3.3V	3.3V	1.6	2.8		
			5V	5V	1.9	3.3		
		All channels switching with square wave clock input; C _L = 15pF, 50Mbps	1.8V	1.8V	9.5	12.9		
			2.5V	2.5V	10.6	13.9		
			3.3V	3.3V	12.9	15.9		
			5V	5V	17.7	20.8		
		All channels switching with square wave clock input; C _L = 15pF, 100Mbps	1.8V	1.8V	16.5	20		
			2.5V	2.5V	20.5	25.2		
			3.3V	3.3V	24.4	28.7		
			5V	5V	34.9	38.4		

- (1) V_{CCI} is the V_{CC} associated with the input port
 (2) V_{CCO} is the V_{CC} associated with the output port
 (3) Floating is defined as a node that is both not actively driven by an external device and has leakage not exceeding 10nA

5.7 Switching Characteristics, $V_{CCA} = 1.8 \pm 0.15V$

PARAMETER		TEST CONDITIONS	FROM	TO	TEMPERATURE	B-Port Supply Voltage (V _{CCB})												UNIT
						1.8 ± 0.15V			2.5 ± 0.2V			3.3 ± 0.3V			5.0 ± 0.5V			
						MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
t _{pd}	Propagation delay	1Mbps all 4 channels toggling	A	B	-40°C to 85°C	3	7.4	3	7.5	3.1	7.5	3.1	7.9	ns				
			A	B	-40°C to 125°C	3	7.8	3	7.8	3.1	7.9	3.1	8.4					
			B	A	-40°C to 85°C	3	7.4	2.8	5.8	2.8	5.2	2.8	4.9					
			B	A	-40°C to 125°C	3	7.8	2.8	6.1	2.8	5.5	2.8	5.2					
t _{dis}	Disable time		OE	A	-40°C to 85°C	16.1	35	16.1	35	16.1	35	16.1	35	ns				
			OE	A	-40°C to 125°C	16.1	35.6	16.1	35.5	16.1	35.6	16.1	35.6					
			OE	B	-40°C to 85°C	17.6	40.9	12.6	28.2	14.7	27.4	10	18.8					
			OE	B	-40°C to 125°C	17.6	42	12.6	29.1	14.7	28	10	19.3					
t _{en}	Enable time		OE	A	-40°C to 85°C	5.4	18.1	5.4	18.1	5.4	18.1	5.4	18.1	ns				
			OE	A	-40°C to 125°C	5.4	18.9	5.4	18.8	5.4	18.9	5.4	18.8					
			OE	B	-40°C to 85°C	7.5	26.5	5.5	15.3	4.5	11	3.8	7.9					
			OE	B	-40°C to 125°C	7.9	27.5	5.5	16.3	4.5	11.8	3.8	8.4					
PWD	Pulse width distortion	t _{phl} - t _{plh}	A	B	-40°C to 85°C	0.7	1.5	0.6	1.4	0.6	1.3	0.5	1.2	ns				
			A	B	-40°C to 125°C	0.7	1.5	0.6	1.4	0.6	1.3	0.5	1.2					
			B	A	-40°C to 85°C	0.7	1.5	0.6	1.4	0.6	1.3	0.5	1.2					
			B	A	-40°C to 125°C	0.7	1.5	0.6	1.4	0.6	1.3	0.5	1.2					
t _r	Output signal rise time		A	B	-40°C to 85°C	0.6	1.1	0.5	1.2	0.5	1.5	0.6	1.8	ns				
			A	B	-40°C to 125°C	0.6	1.3	0.5	1.5	0.5	1.6	0.6	1.9					
			B	A	-40°C to 85°C	0.5	0.9	0.5	1	0.5	0.9	0.5	0.9					
			B	A	-40°C to 125°C	0.5	1	0.5	1.1	0.5	1	0.5	1.1					
t _f	Output signal fall time		A	B	-40°C to 85°C	0.5	1.3	0.5	1.6	0.5	1.6	0.6	1.9	ns				
			A	B	-40°C to 125°C	0.5	1.6	0.5	1.8	0.5	1.9	0.6	2.2					
			B	A	-40°C to 85°C	0.5	1.1	0.5	1.1	0.5	1.1	0.5	1.1					
			B	A	-40°C to 125°C	0.5	1.4	0.5	1.5	0.5	1.4	0.5	1.4					
t _{DO}	Default output delay time from input power loss	Measured from the time V _{CC} goes below 1.36V			-40°C to 85°C		8.4		8.3		8.2		8	μs				
					-40°C to 125°C		8.4		8.3		8.2		8					
t _{PU}	Time from ULVO to valid output data				-40°C to 85°C		66.8		66.8		66.8		66.9	μs				
					-40°C to 125°C		66.8		66.8		66.8		66.9					

ADVANCE INFORMATION

5.8 Switching Characteristics, $V_{CCA} = 2.5 \pm 0.2V$

PARAMETER		TEST CONDITIONS	FROM	TO	TEMPERATURE	B-Port Supply Voltage (V _{CCB})												UNIT
						1.8 ± 0.15V			2.5 ± 0.2V			3.3 ± 0.3V			5.0 ± 0.5V			
						MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
t _{pd}	Propagation delay	1Mbps all 4 channels toggling	A	B	-40°C to 85°C	2.9		5.9	2.9		5.9	2.9		6	3		6.2	ns
			A	B	-40°C to 125°C	2.9		6.1	2.9		6.2	2.9		6.3	3		6.6	
			B	A	-40°C to 85°C	3		7.4	2.9		5.9	2.8		5.2	2.8		5	
			B	A	-40°C to 125°C	3		7.8	2.9		6.2	2.8		5.6	2.8		5.4	
t _{dis}	Disable time		OE	A	-40°C to 85°C	11.6		24.7	11.6		24.7	11.6		24.7	11.6		24.7	ns
			OE	A	-40°C to 125°C	11.6		25.2	11.6		25.2	11.6		25.2	11.6		25.2	
			OE	B	-40°C to 85°C	17.6		40.9	12.6		28.3	14.7		27.4	10.1		18.8	
			OE	B	-40°C to 125°C	17.6		41.9	12.6		29.1	14.7		28	10.1		19.3	
t _{en}	Enable time		OE	A	-40°C to 85°C	3.8		10.9	3.8		10.9	3.8		10.9	3.8		10.9	ns
			OE	A	-40°C to 125°C	3.8		11.6	3.8		11.6	3.8		11.6	3.8		11.6	
			OE	B	-40°C to 85°C	7.5		26.5	5.5		15.3	4.5		11	3.8		7.8	
			OE	B	-40°C to 125°C	7.9		27.5	5.5		16.3	4.5		11.8	3.8		8.4	
PWD	Pulse width distortion	t _{phl} - t _{plh}	A	B	-40°C to 85°C	0.1		0.6	0.1		0.57	0.002		0.56	0.002		0.48	ns
			A	B	-40°C to 125°C	0.1		0.6	0.1		0.57	0.002		0.56	0.002		0.48	
			B	A	-40°C to 85°C	0.1		0.6	0.1		0.57	0.002		0.56	0.002		0.48	
			B	A	-40°C to 125°C	0.1		0.6	0.1		0.57	0.002		0.56	0.002		0.48	
t _r	Output signal rise time		A	B	-40°C to 85°C	0.6		1.1	0.5		1.2	0.5		1.5	0.6		1.8	ns
			A	B	-40°C to 125°C	0.6		1.3	0.5		1.4	0.5		1.7	0.6		1.9	
			B	A	-40°C to 85°C	0.5		1	0.5		1	0.5		1	0.5		1	
			B	A	-40°C to 125°C	0.5		1.1	0.5		1.2	0.5		1.2	0.5		1.1	
tf	Output signal fall time		A	B	-40°C to 85°C	0.5		1.2	0.5		1.5	0.5		1.7	0.5		1.9	ns
			A	B	-40°C to 125°C	0.5		1.6	0.5		1.7	0.5		1.8	0.5		2.1	
			B	A	-40°C to 85°C	0.5		1.3	0.5		1.3	0.5		1.4	0.5		1.3	
			B	A	-40°C to 125°C	0.5		1.5	0.5		1.5	0.5		1.5	0.5		1.6	
t _{DO}	Default output delay time from input power loss	Measured from the time V _{CC} goes below 1.36V			-40°C to 85°C			8.1			8.1			8			7.8	μs
					-40°C to 125°C			8.1			8.1			8			7.8	
t _{PU}	Time from ULVO to valid output data				-40°C to 85°C			71.3			71.3			71.3			71.3	μs
					-40°C to 125°C			71.3			71.3			71.3			71.3	

5.9 Switching Characteristics, $V_{CCA} = 3.3 \pm 0.3V$

PARAMETER		TEST CONDITIONS	FROM	TO	TEMPERATURE	B-Port Supply Voltage (V _{CCB})												UNIT
						1.8 ± 0.15V			2.5 ± 0.2V			3.3 ± 0.3V			5.0 ± 0.5V			
						MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
t _{pd}	Propagation delay	1Mbps all 4 channels toggling	A	B	-40°C to 85°C	2.9	5.2	2.9	5.3	2.8	5.4	3	5.7	ns				
			A	B	-40°C to 125°C	2.9	5.5	2.9	5.6	2.8	5.8	3	6.1					
			B	A	-40°C to 85°C	3	7.5	2.9	5.9	2.8	5.3	2.8	5.1					
			B	A	-40°C to 125°C	3	7.9	2.9	6.3	2.8	5.7	2.8	5.5					
t _{dis}	Disable time		OE	A	-40°C to 85°C	13.9	25.3	13.8	25.3	13.8	25.3	13.8	25.3	ns				
			OE	A	-40°C to 125°C	13.9	25.7	13.8	25.7	13.8	25.7	13.8	25.7					
			OE	B	-40°C to 85°C	17.6	40.9	12.6	28.2	14.7	27.4	10.1	18.8					
			OE	B	-40°C to 125°C	17.6	41.9	12.6	29	14.7	28	10.1	19.3					
t _{en}	Enable time		OE	A	-40°C to 85°C	3	8	3.1	8	3.1	8	3	8	ns				
			OE	A	-40°C to 125°C	3	8.5	3.1	8.5	3.1	8.6	3	8.5					
			OE	B	-40°C to 85°C	7.5	26.5	5.5	15.3	4.5	11	3.8	7.8					
			OE	B	-40°C to 125°C	8	27.5	5.5	16.3	4.5	11.8	3.8	8.4					
PWD	Pulse width distortion	t _{phl} - t _{plh}	A	B	-40°C to 85°C	0.006	0.37	0.002	0.37	0.001	0.34	0	0.36	ns				
			A	B	-40°C to 125°C	0.006	0.37	0.002	0.37	0.001	0.34	0	0.36					
			B	A	-40°C to 85°C	0.006	0.37	0.002	0.37	0.001	0.34	0	0.36					
			B	A	-40°C to 125°C	0.006	0.37	0.002	0.37	0.001	0.34	0	0.36					
t _r	Output signal rise time		A	B	-40°C to 85°C	0.6	1.1	0.6	1.2	0.5	1.5	0.6	1.8	ns				
			A	B	-40°C to 125°C	0.6	1.3	0.6	1.5	0.5	1.7	0.6	1.9					
			B	A	-40°C to 85°C	0.6	1.1	0.6	1.2	0.5	1.5	0.6	1.8					
			B	A	-40°C to 125°C	0.6	1.3	0.6	1.5	0.5	1.7	0.6	1.9					
t _f	Output signal fall time		A	B	-40°C to 85°C	0.5	1.2	0.5	1.6	0.5	1.6	0.6	1.9	ns				
			A	B	-40°C to 125°C	0.5	1.7	0.5	1.7	0.5	1.8	0.6	2.1					
			B	A	-40°C to 85°C	0.5	1.4	0.5	1.5	0.5	1.4	0.5	1.5					
			B	A	-40°C to 125°C	0.5	1.7	0.5	1.7	0.5	1.7	0.5	1.6					
t _{DO}	Default output delay time from input power loss	Measured from the time V _{CC} goes below 1.36V			-40°C to 85°C		8		7.9		7.9		7.7	μs				
					-40°C to 125°C		8		7.9		7.9		7.7	μs				
t _{PU}	Time from ULVO to valid output data				-40°C to 85°C		79.1		79.1		79.1		79.1	μs				
					-40°C to 125°C		79.1		79.1		79.1		79.1	μs				

ADVANCE INFORMATION

5.10 Switching Characteristics, $V_{CCA} = 5.0 \pm 0.5V$

PARAMETER		TEST CONDITIONS	FROM	TO	TEMPERATURE	B-Port Supply Voltage (V _{CCB})												UNIT
						1.8 ± 0.15V			2.5 ± 0.2V			3.3 ± 0.3V			5.0 ± 0.5V			
						MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
t _{pd}	Propagation delay	1Mbps all 4 channels toggling	A	B	-40°C to 85°C	2.8	5	2.8	5	2.9	5.2	2.9	5.5	ns				
			A	B	-40°C to 125°C	2.8	5.3	2.8	5.3	2.9	5.6	2.9	5.9					
			B	A	-40°C to 85°C	3.1	7.8	3	6.3	2.9	5.7	2.8	5.6					
			B	A	-40°C to 125°C	3.1	8.3	3	6.6	2.9	6.1	2.8	5.8					
t _{dis}	Disable time		OE	A	-40°C to 85°C	9.4	17.4	9.4	17.4	9.4	17.4	9.4	17.4	ns				
			OE	A	-40°C to 125°C	9.4	17.7	9.4	17.7	9.4	17.7	9.4	17.7					
			OE	B	-40°C to 85°C	17.7	40.9	12.6	28.3	14.7	27.4	10.1	18.8					
			OE	B	-40°C to 125°C	17.7	41.9	12.6	29.1	14.7	28	10.1	19.4					
t _{en}	Enable time		OE	A	-40°C to 85°C	2.5	5.9	2.5	5.9	2.5	5.9	2.5	5.9	ns				
			OE	A	-40°C to 125°C	2.5	6.3	2.5	6.3	2.5	6.3	2.5	6.3					
			OE	B	-40°C to 85°C	7.5	26.5	5.5	15.3	4.5	11	3.8	7.8					
			OE	B	-40°C to 125°C	8	27.5	5.5	16.3	4.5	11.8	3.8	8.4					
PWD	Pulse width distortion	t _{phl} - t _{plh}	A	B	-40°C to 85°C	0	0.2	0	0.3	0.003	0.4	0.011	0.7	ns				
			A	B	-40°C to 125°C	0	0.2	0	0.3	0.003	0.4	0.011	0.7					
			B	A	-40°C to 85°C	0	0.2	0	0.3	0.003	0.4	0.011	0.7					
			B	A	-40°C to 125°C	0	0.2	0	0.3	0.003	0.4	0.011	0.7					
t _r	Output signal rise time		A	B	-40°C to 85°C	0.6	1.1	0.5	1.1	0.5	1.6	0.6	1.8	ns				
			A	B	-40°C to 125°C	0.6	1.3	0.5	1.5	0.5	1.7	0.6	1.9					
			B	A	-40°C to 85°C	0.5	1.6	0.5	1.6	0.5	1.7	0.5	1.7					
			B	A	-40°C to 125°C	0.5	1.7	0.5	1.7	0.5	1.8	0.5	1.7					
tf	Output signal fall time		A	B	-40°C to 85°C	0.5	1.4	0.4	1.6	0.5	1.8	0.6	1.9	ns				
			A	B	-40°C to 125°C	0.5	1.7	0.5	1.7	0.5	1.8	0.6	2.2					
			B	A	-40°C to 85°C	0.5	1.4	0.5	1.6	0.5	1.8	0.6	1.9					
			B	A	-40°C to 125°C	0.5	1.7	0.5	1.7	0.5	1.8	0.6	2.2					
t _{DO}	Default output delay time from input power loss	Measured from the time V _{CC} goes below 1.36V			-40°C to 85°C		7.9		7.8		7.7		7.6	µs				
					-40°C to 125°C		7.9		7.8		7.7		7.6					
t _{PU}	Time from ULVO to valid output data				-40°C to 85°C		98.3		98.3		98.3		98.3	µs				
					-40°C to 125°C		98.3		98.3		98.3		98.3					

5.11 Switching Characteristics: T_{sk} , T_{MAX}

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

PARAMETER	TEST CONDITIONS		V _{CCI}	V _{CCO}	Operating free-air temperature (T _A)			UNIT
					-40°C to 125°C			
					MIN	TYP	MAX	
T _{MAX} - Maximum Data Rate	50% Duty Cycle Input One channel switching 20% of pulse > 0.7*V _{CCO} 20% of pulse < 0.3*V _{CCO}	No Translation	1.65V - 1.95V	1.65V - 1.95V	264		Mbps	
			2.3V - 2.7V	2.3V - 2.7V	264		Mbps	
			3.0V - 3.6V	3.0V - 3.6V	176		Mbps	
			4.5V - 5.5V	4.5V - 5.5V	176		Mbps	
T _{MAX} - Maximum Data Rate	50% Duty Cycle Input One channel switching 20% of pulse > 0.7*V _{CCO} 20% of pulse < 0.3*V _{CCO}	Up Translation	1.65V - 1.95V	2.3V - 2.7V	264		Mbps	
			1.65V - 1.95V	3.0V - 3.6V	264		Mbps	
			1.65V - 1.95V	4.5V - 5.5V	264		Mbps	
			2.3V - 2.7V	3.0V - 3.6V	264		Mbps	
			2.3V - 2.7V	4.5V - 5.5V	220		Mbps	
			3.0V - 3.6V	4.5V - 5.5V	176		Mbps	
T _{MAX} - Maximum Data Rate	50% Duty Cycle Input One channel switching 20% of pulse > 0.7*V _{CCO} 20% of pulse < 0.3*V _{CCO}	Down Translation	2.3V - 2.7V	1.65V - 1.95V	285		Mbps	
			3.0V - 3.6V	2.3V - 2.7V	220		Mbps	
			3.0V - 3.6V	1.65V - 1.95V	220		Mbps	
			4.5V - 5.5V	3.0V - 3.6V	176		Mbps	
			4.5V - 5.5V	2.3V - 2.7V	220		Mbps	
			4.5V - 5.5V	1.65V - 1.95V	220		Mbps	
t _{sk} - Output skew	Timing skew between any switching outputs on the rising or falling edge (same direction channels)	No Translation	1.65V - 1.95V	1.65V - 1.95V			0.35	ns
			2.3V - 2.7V	2.3V - 2.7V			0.35	ns
			3.0V - 3.6V	3.0V - 3.6V			0.35	ns
			4.5V - 5.5V	4.5V - 5.5V			0.35	ns
t _{sk} - Output skew	Timing skew between any switching outputs on the rising or falling edge (same direction channels)	Up Translation	1.65V - 1.95V	2.3V - 2.7V			0.35	ns
			1.65V - 1.95V	3.0V - 3.6V			0.35	ns
			1.65V - 1.95V	4.5V - 5.5V			0.35	ns
			2.3V - 2.7V	3.0V - 3.6V			0.35	ns
			2.3V - 2.7V	4.5V - 5.5V			0.35	ns
			3.0V - 3.6V	4.5V - 5.5V			0.35	ns

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

PARAMETER	TEST CONDITIONS		V _{CCI}	V _{CCO}	Operating free-air temperature (T _A)			UNIT
					-40°C to 125°C			
					MIN	TYP	MAX	
t _{sk} - Output skew	Timing skew between any switching outputs on the rising or falling edge (same direction channels)	Down Translation	2.3V - 2.7V	1.65V - 1.95V	0.35			ns
			3.0V - 3.6V	2.3V - 2.7V	0.35			ns
			3.0V - 3.6V	1.65V - 1.95V	0.35			ns
			4.5V - 5.5V	3.0V - 3.6V	0.35			ns
			4.5V - 5.5V	2.3V - 2.7V	0.35			ns
			4.5V - 5.5V	1.65V - 1.95V	0.35			ns

5.12 Typical Characteristics

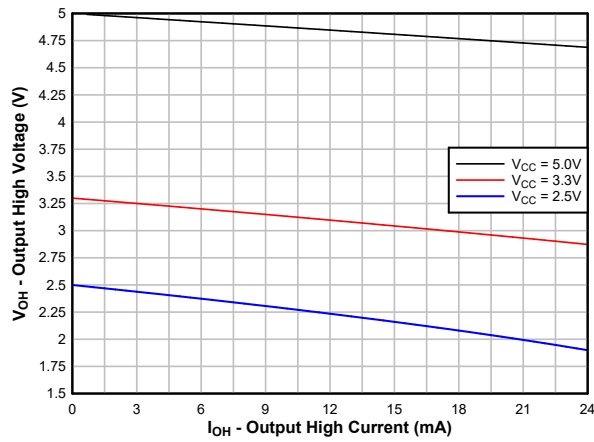


Figure 5-1. Typical ($T_A=25^\circ\text{C}$) Output High Voltage (V_{OH}) vs Source Current (I_{OH})

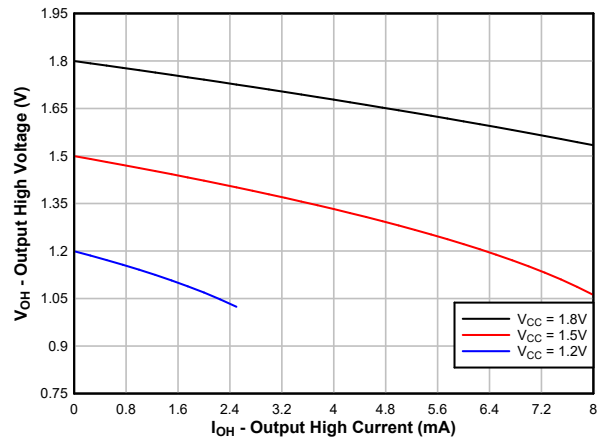


Figure 5-2. Typical ($T_A=25^\circ\text{C}$) Output High Voltage (V_{OH}) vs Source Current (I_{OH})

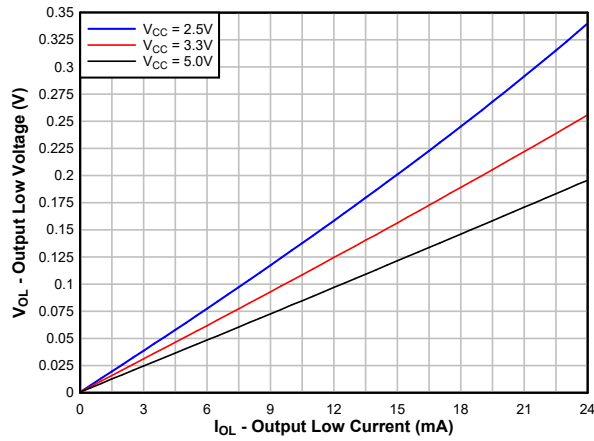


Figure 5-3. Typical ($T_A=25^\circ\text{C}$) Output Low Voltage (V_{OL}) vs Sink Current (I_{OL})

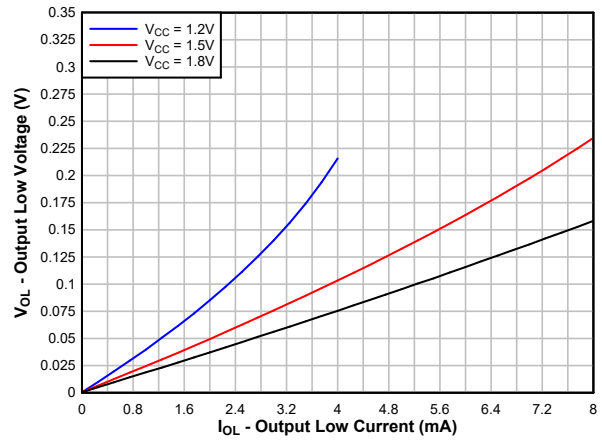


Figure 5-4. Typical ($T_A=25^\circ\text{C}$) Output Low Voltage (V_{OL}) vs Sink Current (I_{OL})

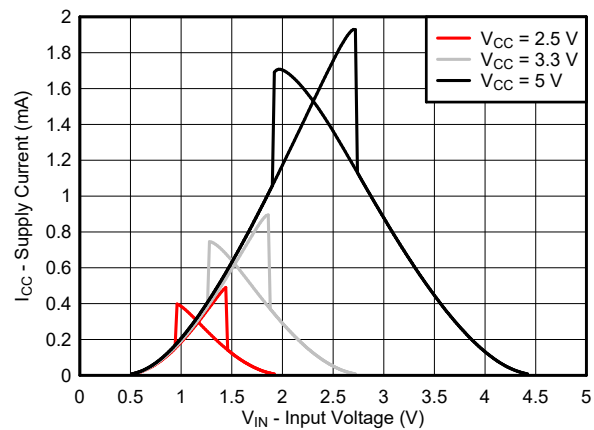


Figure 5-5. Typical ($T_A=25^\circ\text{C}$) Supply Current (I_{CC}) vs Input Voltage (V_{IN})

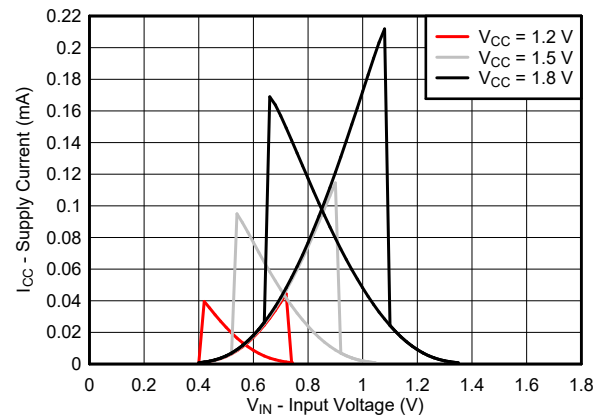


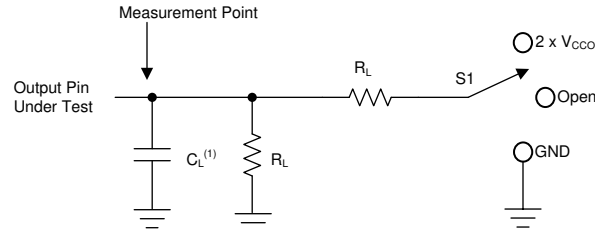
Figure 5-6. Typical ($T_A=25^\circ\text{C}$) Supply Current (I_{CC}) vs Input Voltage (V_{IN})

6 Parameter Measurement Information

6.1 Load Circuit and Voltage Waveforms

Unless otherwise noted, generators supply all input pulses that have the following characteristics:

- $f = 1\text{MHz}$
- $Z_O = 50\Omega$
- $\Delta t/\Delta V \leq 1\text{ns/V}$

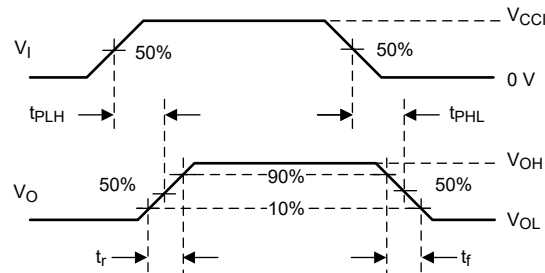


A. C_L includes probe and jig capacitance.

Figure 6-1. Load Circuit

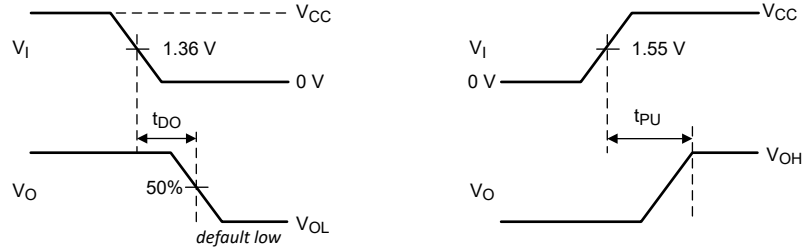
Table 6-1. Load Circuit Conditions

Parameter	V_{CCO}	R_L	C_L	S_1	V_{TP}
t_{pd} Propagation (delay) time	1.71V – 5.5V	10k Ω	15pF	Open	N/A
t_{en}, t_{dis} Enable time, disable time	1.71V – 2.7V	10k Ω	15pF	$2 \times V_{CCO}$	0.15V
	3.0V – 5.5V	10k Ω	15pF	$2 \times V_{CCO}$	0.3V
t_{en}, t_{dis} Enable time, disable time	1.71V – 2.7V	10k Ω	15pF	GND	0.15V
	3.0V – 5.5V	10k Ω	15pF	GND	0.3V



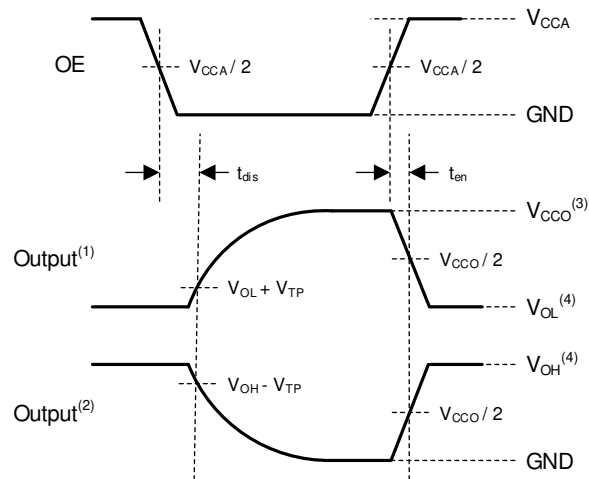
1. V_{CCI} is the supply pin associated with the input port.
2. V_{OH} and V_{OL} are typical output voltage levels that occur with specified R_L , C_L , and S_1

Figure 6-2. Switching Characteristics Voltage Waveforms



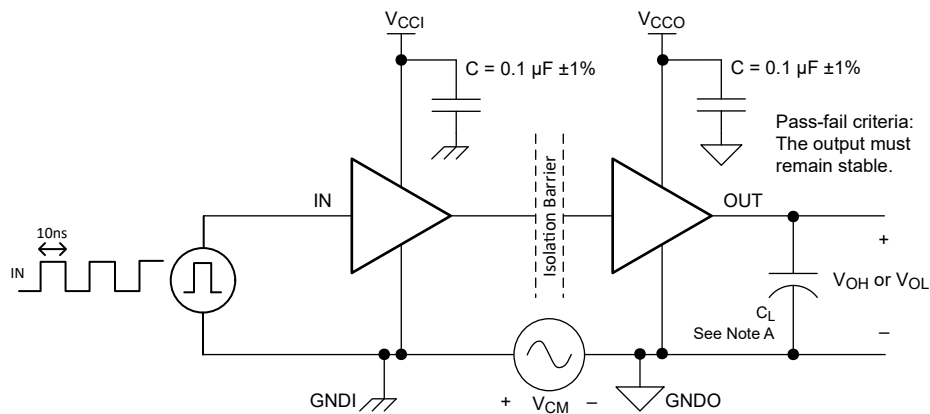
1. V_{CCI} is the supply pin associated with the input port.
2. V_{OH} and V_{OL} are typical output voltage levels that occur with specified R_L , C_L , and S_1 .

Figure 6-3. Default Output Delay Time & Time from UVLO to Valid Output Voltage Waveform



1. Output waveform on the condition that input is driven to a valid Logic Low.
2. Output waveform on the condition that input is driven to a valid Logic High.
3. V_{CCO} is the supply pin associated with the output port.
4. V_{OH} and V_{OL} are typical output voltage levels with specified R_L , C_L , and S_1 .

Figure 6-4. Enable Time And Disable Time



1. $C_L = 15\text{pF}$ and includes instrumentation and fixture capacitance within $\pm 20\%$.

Figure 6-5. Common-Mode Transient Immunity Test Circuit

7 Detailed Description

7.1 Overview

The TXG404x-Q1 is a 4-bit ground-level translator that uses two individually configurable power-supply rails which allows it to translate across two different power domains. The device is operational with V_{CCA} and V_{CCB} supplies as low as 1.71V and as high as 5.5V. The A port is designed to track V_{CCA} and the B port is designed to track V_{CCB} . In addition to I/O level shifting, this translator can support a difference of -10V to +10V between GNDA and GNDB. V_{CCA} is referenced to GNDA and V_{CCB} is referenced to GNDB.

The TXG404x-Q1 device is designed for asynchronous communication between data buses, and transmits data with fixed direction from the A bus to the B bus on some channels and from the B bus to the A bus on the remaining channels. The output-enable input (OE) is used to disable the outputs so the buses are effectively isolated. The OE_A pin is referenced to V_{CCA} and OE_B pin is referenced to V_{CCB} . The OE pin can be left floating or externally pulled down to ground to keep the translator outputs in a high-impedance state during power-up or power-down.

The V_{CC} disconnect feature ensures that if V_{CC} is disconnected with the complementary supply within recommended operating conditions, outputs are disabled and set to the high-impedance state while the supply current is maintained. The $I_{off-float}$ circuitry ensures that no excessive current is drawn from or sourced into an input or output while the supply is floating.

Glitch-free power supply sequencing allows either supply rail to be powered on or off in any order while providing robust power sequencing performance.

7.2 Functional Block Diagram

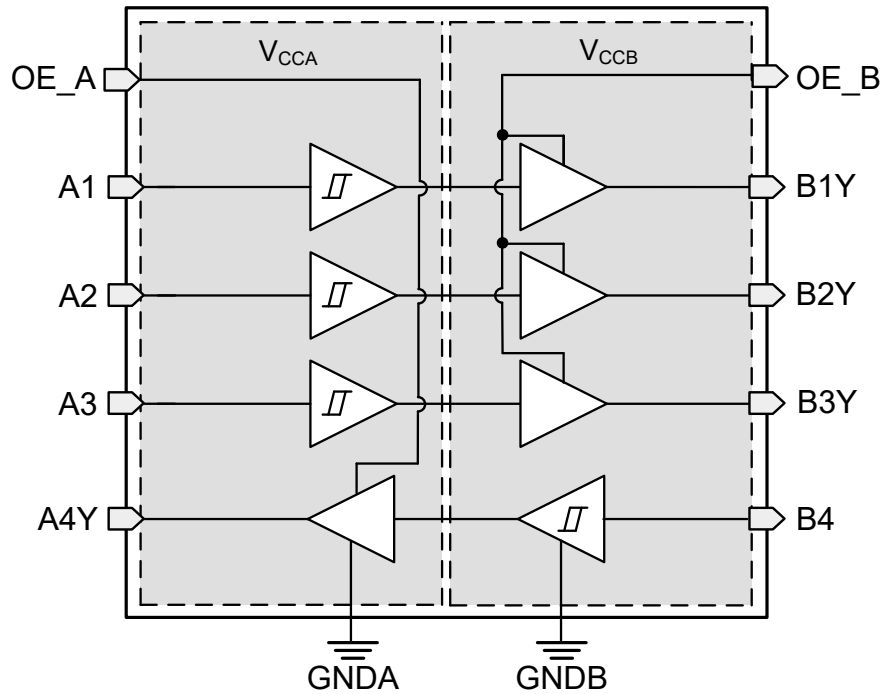


Figure 7-1. TXG4041-Q1 Functional Block Diagram

7.3 Feature Description

7.3.1 CMOS Schmitt-Trigger Inputs with Integrated Pulldowns

Standard CMOS inputs are high impedance and are typically modeled as a resistor in parallel with the input capacitance given in the *Electrical Characteristics*. The worst case resistance is calculated with the maximum input voltage, given in the *Absolute Maximum Ratings*, and the maximum input leakage current, given in the *Electrical Characteristics*, using ohm's law ($R = V \div I$).

The Schmitt-trigger input architecture provides hysteresis as defined by ΔV_T in the *Electrical Characteristics*, which makes this device extremely tolerant to slow or noisy inputs. Driving the inputs slowly will increase dynamic current consumption of the device. See Understanding Schmitt Triggers for additional information regarding Schmitt-trigger inputs.

7.3.1.1 Inputs with Integrated Static Pull-Down Resistors

This device has 5 M Ω typical integrated weak pull-downs for each input. This feature allows all inputs to be left floating without the concern for unstable outputs or increased current consumption. This also helps to reduce external component count for applications where not all channels are used or need to be fixed low. If an external pull-up is required, it should be no larger than 1 M Ω to avoid contention with the 5 M Ω internal pull-down.

7.3.2 Balanced High-Drive CMOS Push-Pull Outputs

A balanced output allows the device to sink and source similar currents. The high drive capability of this device creates fast edges into light loads, so routing and load conditions should be considered to prevent ringing. Additionally, the outputs of this device are capable of driving larger currents than the device can sustain without being damaged. *Absolute Maximum Ratings* defines the electrical and thermal limits that must be followed at all times.

7.3.3 V_{CC} Disconnect

The outputs for this device are disabled and enter a high-impedance state when either supply is left floating (disconnected), and with the complementary supply within recommended operating conditions. It is recommended that the inputs are kept low before floating (disconnecting) either supply.

The $I_{CCX(floating)}$ in the *Electrical Characteristics* specifies the maximum supply current. The $I_{off(float)}$ in the *Electrical Characteristics* specifies the maximum leakage into or out of any input or output pin on the device.

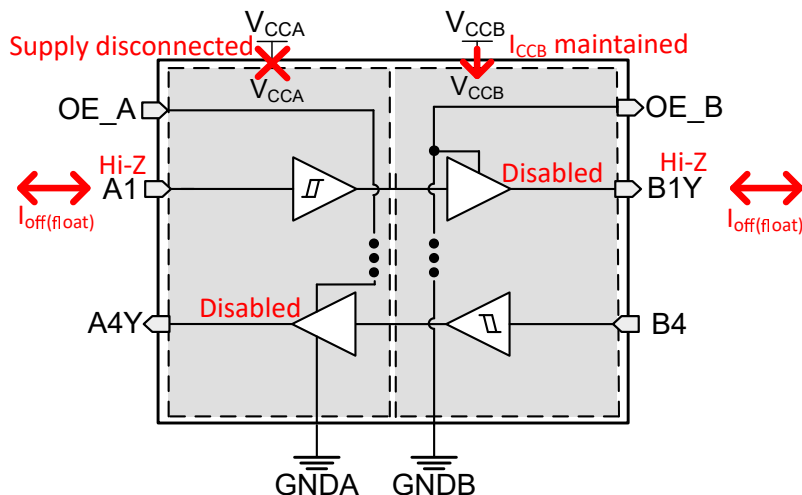


Figure 7-2. V_{CC} Disconnect Feature

7.3.4 Over-Voltage Tolerant Inputs

Input signals to this device can be driven above the supply voltage so long as they remain below the maximum input voltage value specified in the *Recommended Operating Conditions*.

7.3.5 Glitch-Free Power Supply Sequencing

Either supply rail may be powered on or off in any order without producing a glitch on the inputs or outputs (that is, where the output erroneously transitions to VCC when it should be held low or vice versa). Glitches of this nature can be misinterpreted by a peripheral as a valid data bit, which could trigger a false device reset of the peripheral, a false device configuration of the peripheral, or even a false data initialization by the peripheral.

7.3.6 Negative Clamping Diodes

depicts the inputs and outputs to this device that have negative clamping diodes.

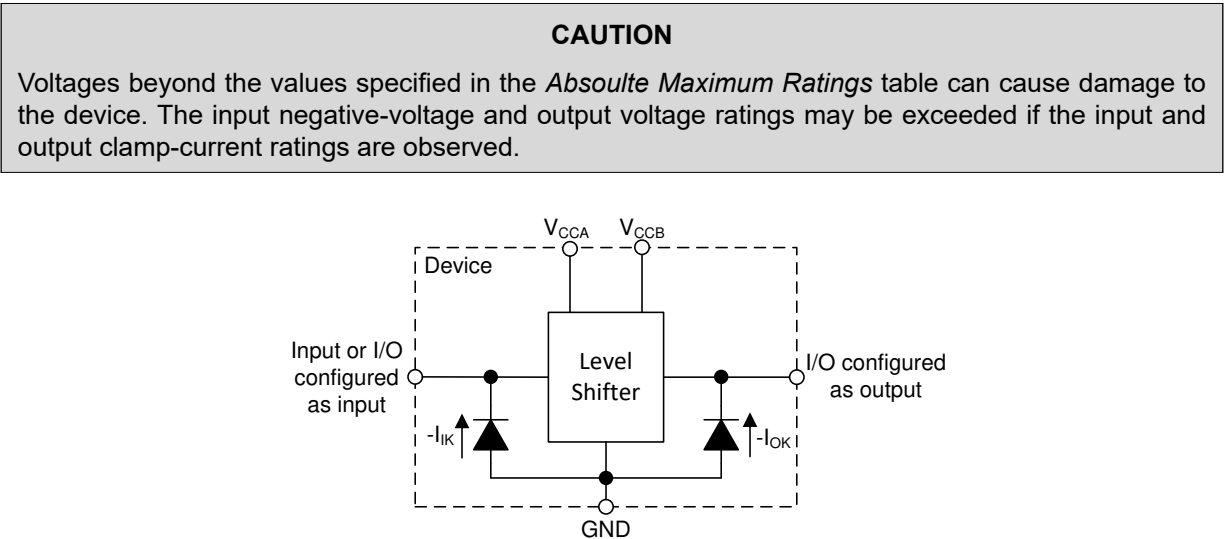


Figure 7-3. Electrical Placement of Clamping Diodes for Each Input and Output

7.3.7 Fully Configurable Dual-Rail Design

The V_{CCA} and V_{CCB} pins can be supplied at any voltage from 1.71V to 5.5V, making the device suitable for translating between any of the voltage nodes (1.8V, 3.3V, and 5.0V).

7.3.8 Supports High-Speed Translation

The TXG404x-Q1 device can support high data-rate applications. The translated signal data rate can be up to 250Mbps when the signal is translated from 1.71V to 5.5V.

7.3.9 AC Noise Rejection

TXG404x-Q1 supports I/O voltage translation in environments with noisy grounds. The plot below illustrates the amount of noise that GNDA and GNDB can reject in terms peak-to-peak voltage over frequency without disrupting communication between two systems. As an example, [Figure 7-5](#) below shows GNDA with a ground bounce of $2V_{PP}$ at 10kHz but still effectively translating 5V to 2.5V without any degradation.

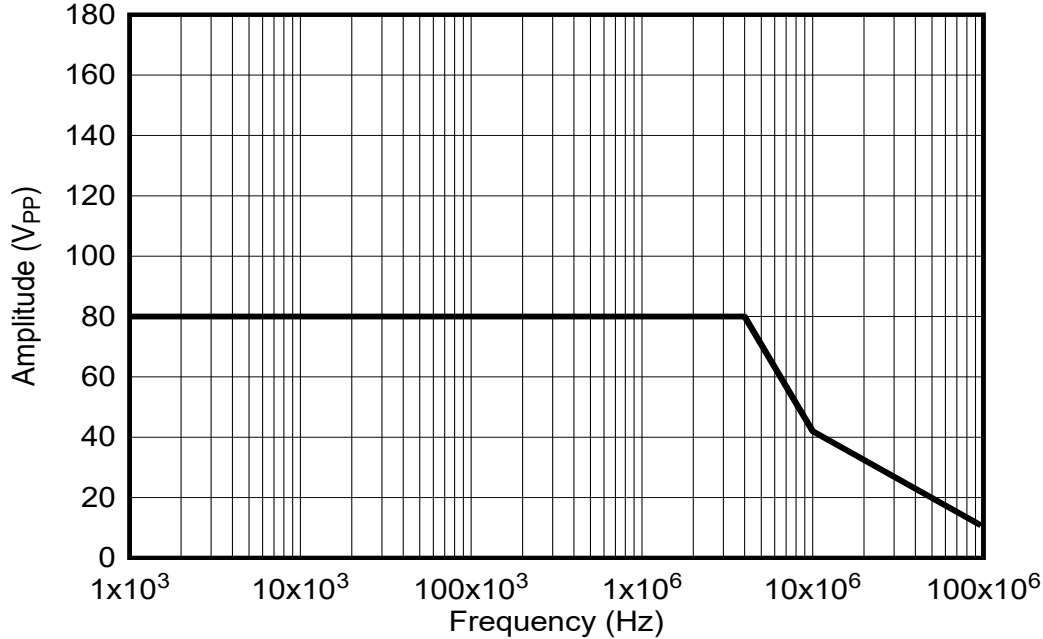
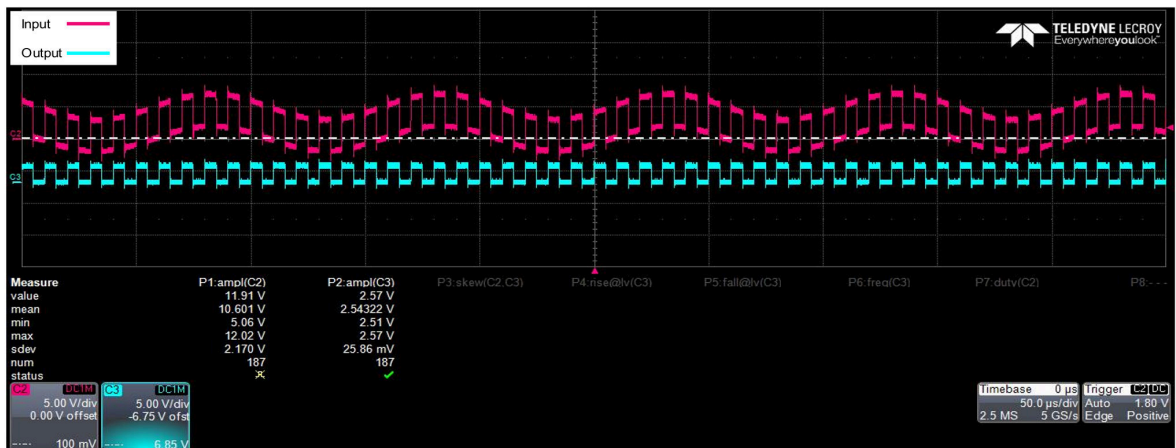


Figure 7-4. AC Noise Rejection Plot

Voltage:
 $V_{CCA} = 5V$
 $V_{CCB} = 2.5V$



*Note: Offset voltage on the output to show both signals side-by-side

Figure 7-5. Waveform showing 5V to 2.5V I/O translation with AC Ground Noise of $2V_{PP}$ at 10kHz

7.4 Device Functional Modes

Table 7-1. Function Table

Power Supply ⁽¹⁾		Control Inputs	Port Status	
VCCI	VCCO	OE	Input	Output
PU	PU	H	H	H
PU	PU	H	L	L
PU	PU	L or Open	X	Hi-Z
PU	PU	H	Open	L
PD	PU	H	X	L
X	PU	L or Open	X	High-Z
X	PU	H	X	L
X	PD	X	X	Undetermined

(1) In the table above: PU = Powered Up; PD = Powered Down; X = Irrelevant; H = High Level; L = Low Level; Open = Floating

8 Application and Implementation

Note

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes, as well as validating and testing their design implementation to confirm system functionality.

8.1 Application Information

The TXG404x-Q1 is used for level translation, enabling communication between devices or systems operating at different interface and ground voltages. The TXG404x-Q1 device is ideal for use in applications where a push-pull driver is connected to the data inputs. [Figure 8-1](#) is an example of two systems that translate from 1.8V to 3.3V across an SPI interface while also experiencing a ground shift of 5V. The ground shift occurs due to the parasitic resistance of the cable used to connect the 48V battery ground and 12V battery ground to the chassis of the car. The TXG404x-Q1 device is ideal for use in applications where a push-pull driver is connected to the data inputs.

8.2 Typical Application

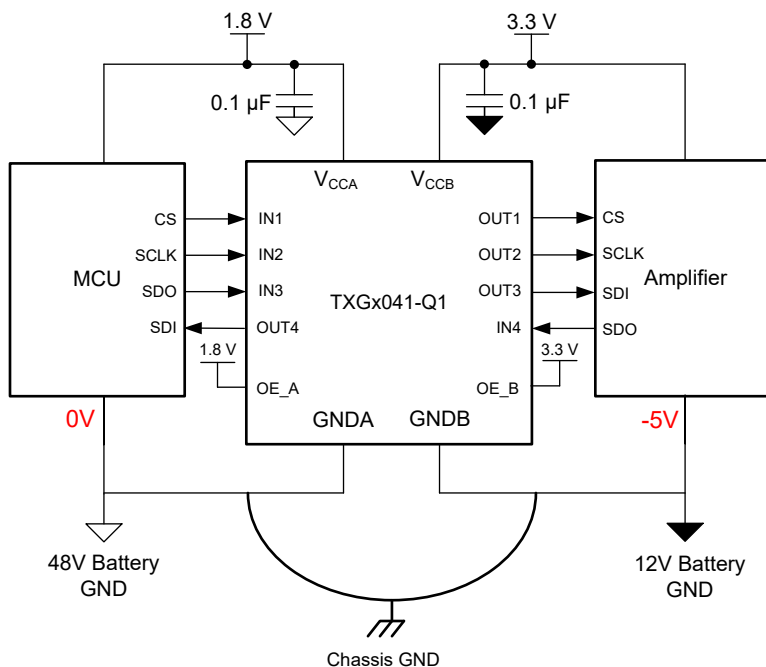


Figure 8-1. TXG404x-Q1 in Automotive

8.2.1 Design Requirements

Use the parameters listed in [Table 8-1](#) for this design example.

Table 8-1. Design Parameters

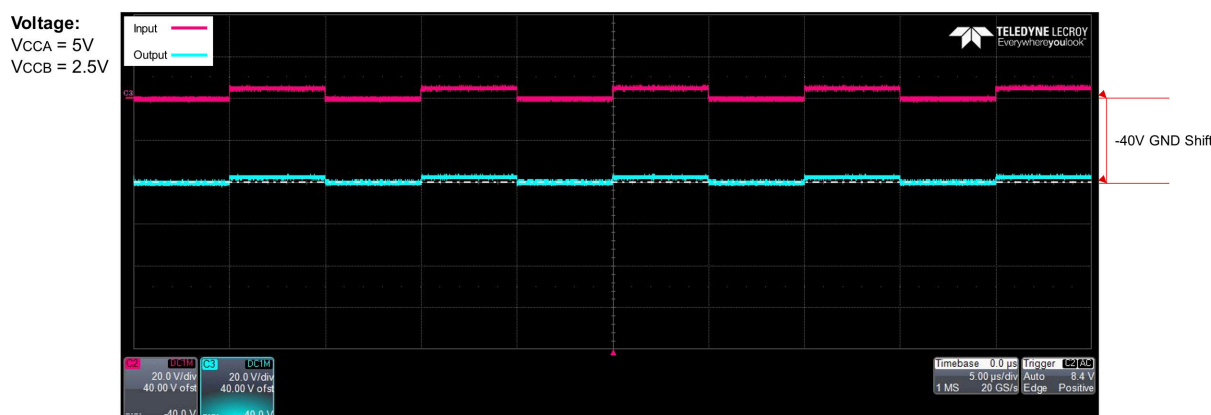
DESIGN PARAMETERS	EXAMPLE VALUES
Input voltage range	1.71V to 5.5V
Output voltage range	1.71V to 5.5V

8.2.2 Detailed Design Procedure

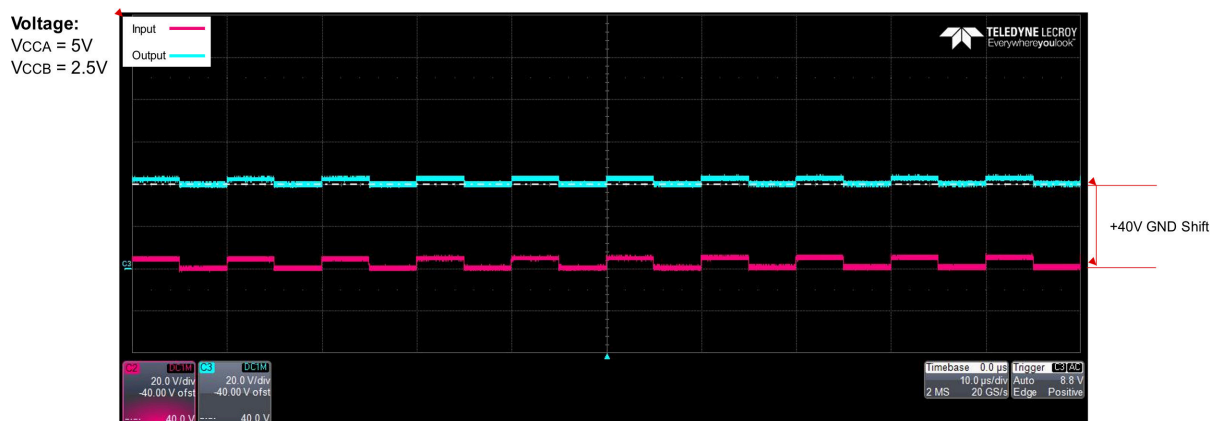
To begin the design process, determine the following:

- Input voltage range
 - Use the supply voltage of the device that is driving the TXG404x-Q1 device to determine the input voltage range. For a valid logic-high, the value must exceed the positive-going input-threshold voltage (V_{T+}) of the input port. For a valid logic low the value must be less than the negative-going input-threshold voltage (V_{T-}) of the input port.
- Output voltage range
 - Use the supply voltage of the device that the TXG404x-Q1 device is driving to determine the output voltage range.

8.2.3 Application Curve



*Note: All signals have a +40V offset to show negative ground shift



*Note: All signals have a -40V offset to show positive ground shift

Figure 8-2. Waveform showing -40V (top) and +40V (bottom) Ground Shift with 2.25V to 5V I/O Translation

8.3 Power Supply Recommendations

Always apply a ground reference to the GND pins first. This device is designed for glitch free power sequencing without any supply sequencing requirements such as ramp order or ramp rate. Please make sure the difference between VCC and GND remains at 6.5V max at all times.

8.4 Layout

8.4.1 Layout Guidelines

To ensure reliability of the device, following common printed-circuit board layout guidelines are recommended:

- Use bypass capacitors on the power supply pins and place them as close to the device as possible. A 0.1µF capacitor is recommended, but transient performance can be improved by having 1µF and 0.1µF capacitors in parallel as bypass capacitors.
- The high drive capability of this device creates fast edges into light loads so routing and load conditions should be considered to prevent ringing.
- A 0.1µF capacitor can be added between GNDA and GNDB to improve performances of CMTI.

8.4.2 Layout Example

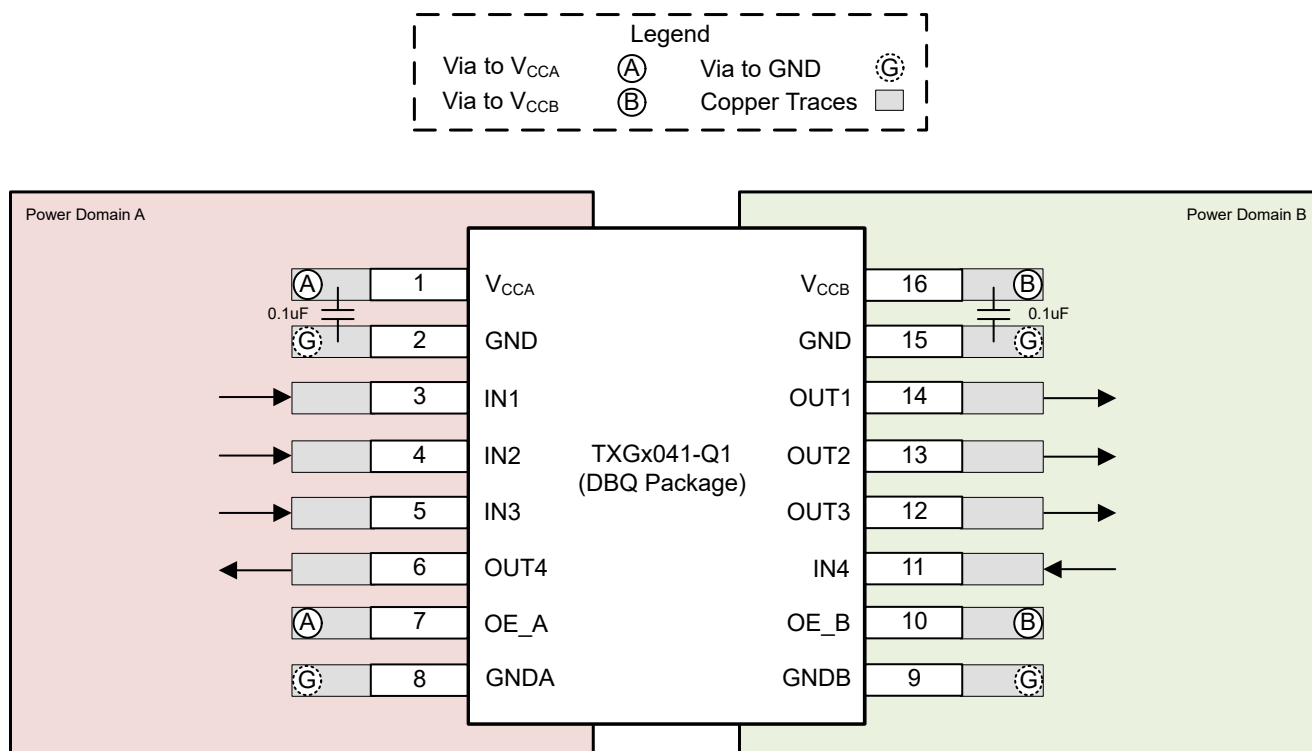


Figure 8-3. Layout Example

9 Device and Documentation Support

9.1 Documentation Support

9.1.1 Related Documentation

For related documentation, see the following:

- Texas Instruments, [Understanding Schmitt Triggers application report](#)
- Texas Instruments, [CMOS Power Consumption and \$C_{pd}\$ Calculation application report](#)

9.2 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on [ti.com](https://www.ti.com). Click on *Notifications* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

9.3 Support Resources

[TI E2E™ support forums](#) are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

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9.4 Trademarks

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9.5 Electrostatic Discharge Caution



This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

9.6 Glossary

[TI Glossary](#) This glossary lists and explains terms, acronyms, and definitions.

10 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision * (February 2025) to Revision A (April 2025) Page

- Added DBQ and DYY packages..... [1](#)

DATE	REVISION	NOTES
February 2025	*	Initial APL Release

11 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package Pins	Package qty Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
PTXG4041QDBQRQ1	Active	Preproduction	SSOP (DBQ) 16	3000 LARGE T&R	-	Call TI	Call TI	-40 to 125	
PTXG4041QDYRQ1	Active	Preproduction	SOT-23-THIN (DYY) 14	3000 LARGE T&R	-	Call TI	Call TI	-40 to 125	
PTXG4041QRUCRQ1	Active	Preproduction	QFN (RUC) 14	3000 LARGE T&R	-	Call TI	Call TI	-40 to 125	
PTXG4041QRUCRQ1.A	Active	Preproduction	QFN (RUC) 14	3000 LARGE T&R	-	Call TI	Call TI	-40 to 125	
PTXG4042QDBQRQ1	Active	Preproduction	SSOP (DBQ) 16	3000 LARGE T&R	-	Call TI	Call TI	-40 to 125	
PTXG4042QDYRQ1	Active	Preproduction	SOT-23-THIN (DYY) 14	3000 LARGE T&R	-	Call TI	Call TI	-40 to 125	
PTXG4042QRUCRQ1	Active	Preproduction	QFN (RUC) 14	3000 LARGE T&R	-	Call TI	Call TI	-40 to 125	
PTXG4042QRUCRQ1.A	Active	Preproduction	QFN (RUC) 14	3000 LARGE T&R	-	Call TI	Call TI	-40 to 125	

⁽¹⁾ **Status:** For more details on status, see our [product life cycle](#).

⁽²⁾ **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

⁽³⁾ **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.

⁽⁴⁾ **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

⁽⁵⁾ **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

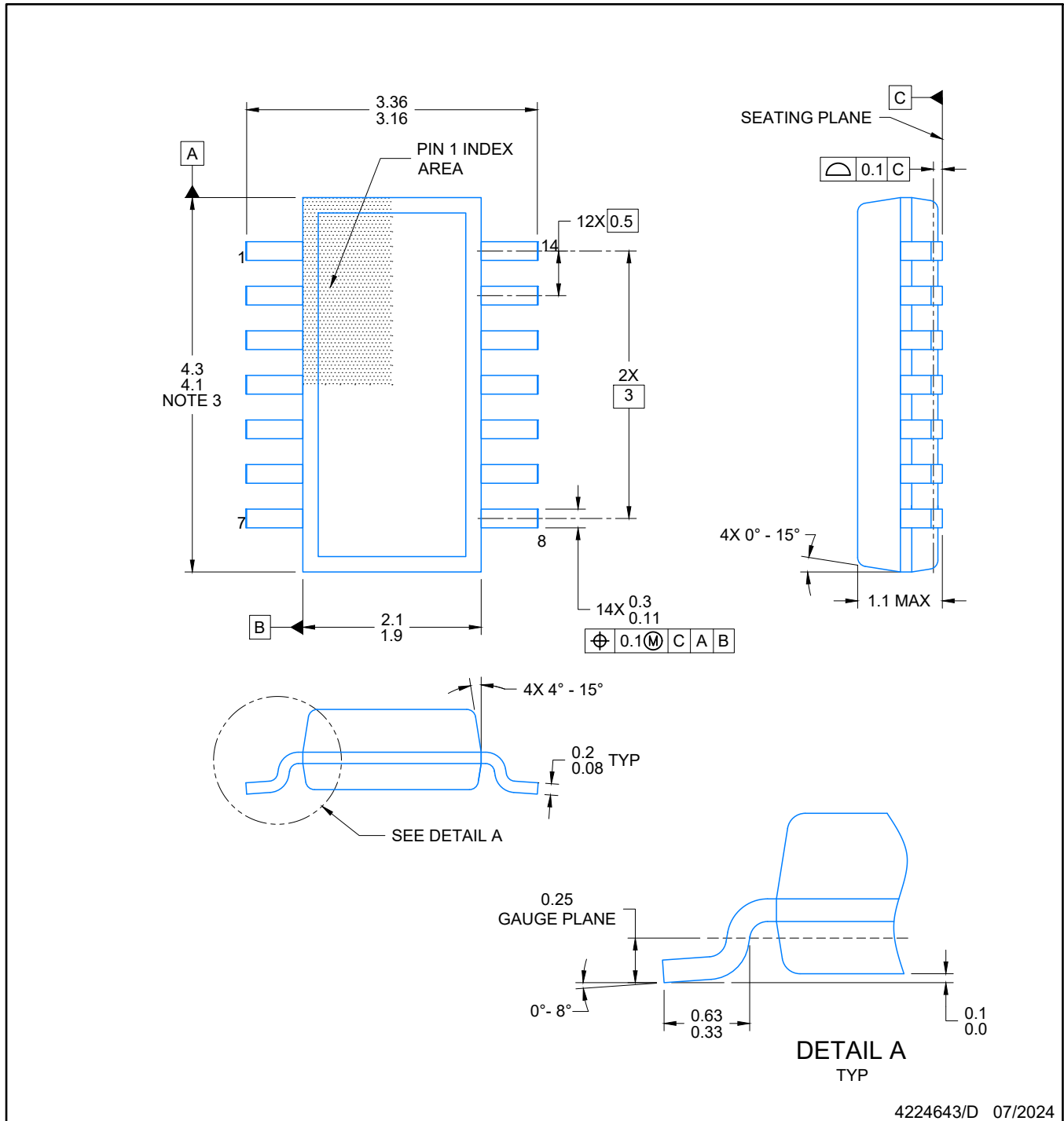
⁽⁶⁾ **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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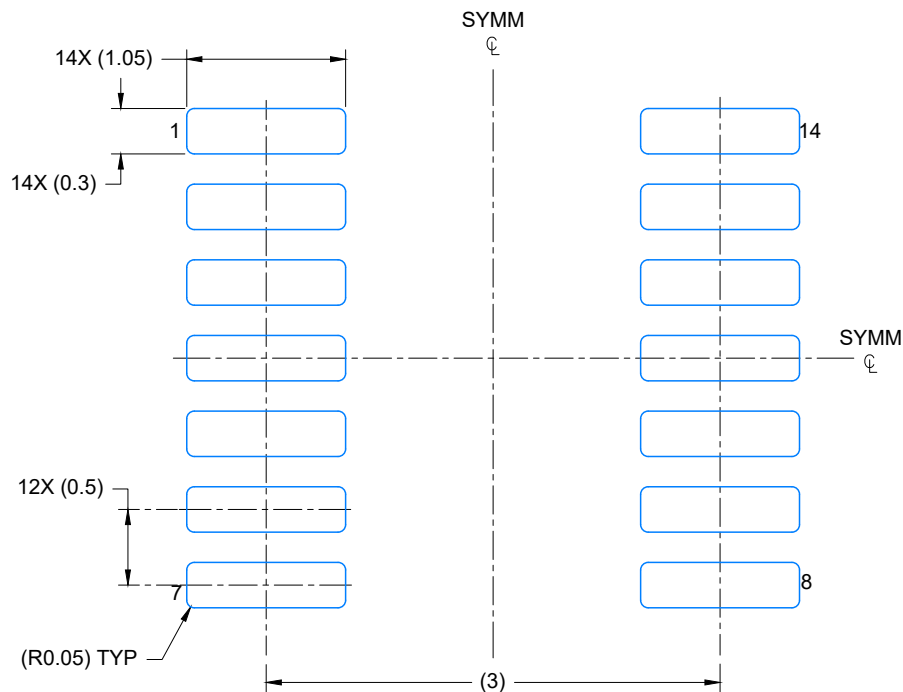
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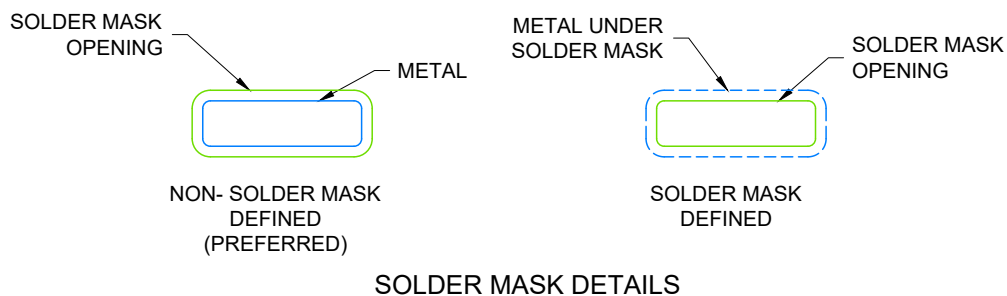
4224643/D 07/2024

NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 per side.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.50 per side.
5. Reference JEDEC Registration MO-345, Variation AB



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 20X



4224643/D 07/2024

NOTES: (continued)

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



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE: 20X

4224643/D 07/2024

NOTES: (continued)

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

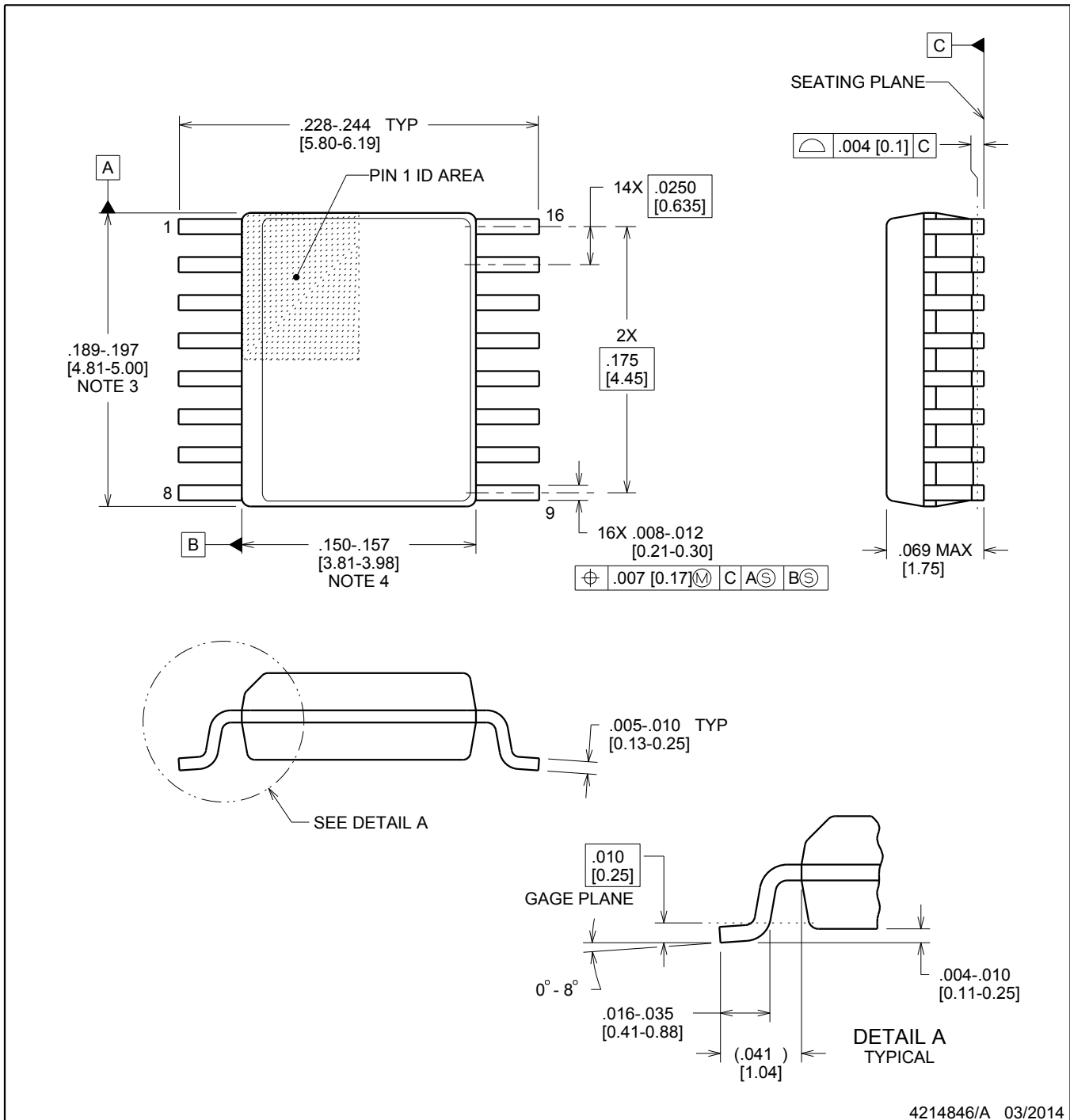


DBQ0016A

PACKAGE OUTLINE

SSOP - 1.75 mm max height

SHRINK SMALL-OUTLINE PACKAGE



4214846/A 03/2014

NOTES:

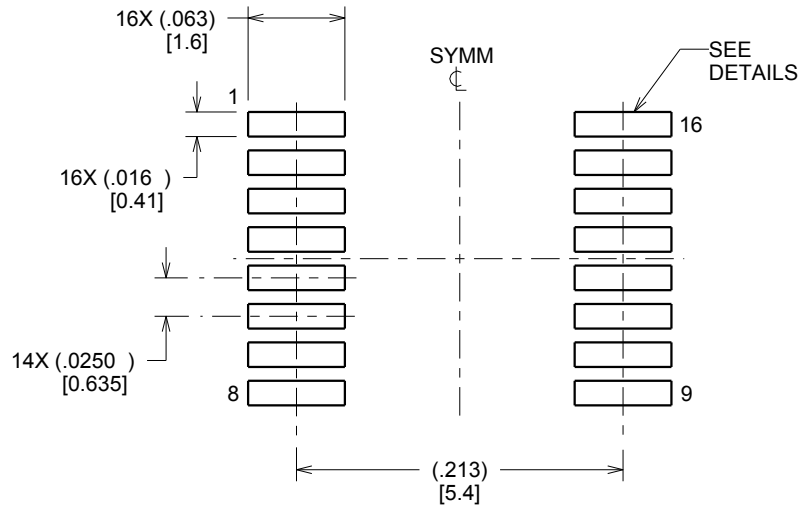
- Linear dimensions are in inches [millimeters]. Dimensions in parenthesis are for reference only. Controlling dimensions are in inches. Dimensioning and tolerancing per ASME Y14.5M.
- This drawing is subject to change without notice.
- This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed .006 inch, per side.
- This dimension does not include interlead flash.
- Reference JEDEC registration MO-137, variation AB.

EXAMPLE BOARD LAYOUT

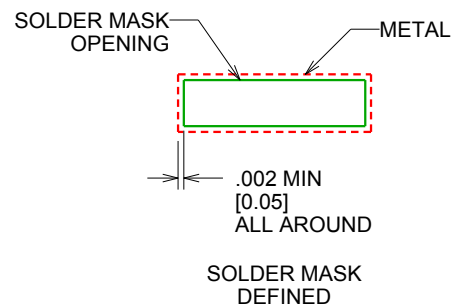
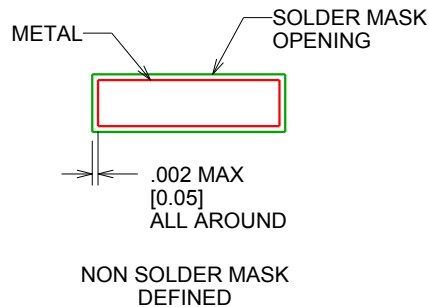
DBQ0016A

SSOP - 1.75 mm max height

SHRINK SMALL-OUTLINE PACKAGE



LAND PATTERN EXAMPLE
SCALE:8X



SOLDER MASK DETAILS

4214846/A 03/2014

NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.

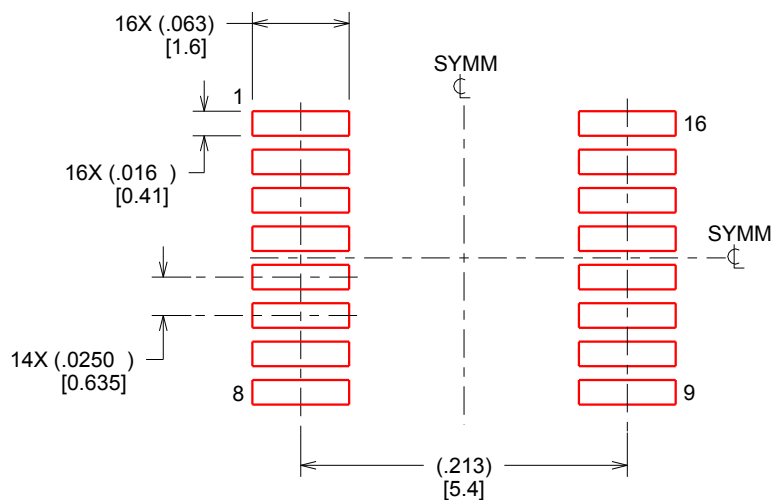
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

EXAMPLE STENCIL DESIGN

DBQ0016A

SSOP - 1.75 mm max height

SHRINK SMALL-OUTLINE PACKAGE



SOLDER PASTE EXAMPLE
BASED ON .005 INCH [0.127 MM] THICK STENCIL
SCALE:8X

4214846/A 03/2014

NOTES: (continued)

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

GENERIC PACKAGE VIEW

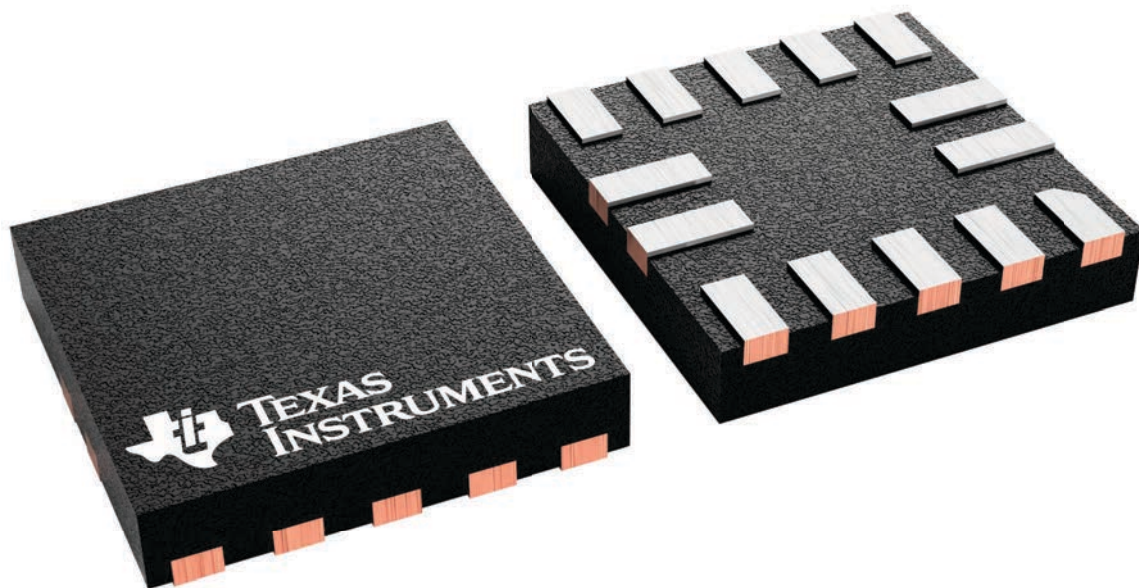
RUC 14

X2QFN - 0.4 mm max height

2 x 2, 0.4 mm pitch

PLASTIC QUAD FLATPACK - NO LEAD

This image is a representation of the package family, actual package may vary.
Refer to the product data sheet for package details.



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