SN74AVC16T245-Q1 16-Bit Dual-Supply Bus Transceiver With Configurable Voltage Translation and 3-State Outputs

1 Features

- Qualified for Automotive Applications
- AEC-Q100 Qualified With the Following Results:
  - Device Temperature Grade 1: –40°C to 125°C Ambient Operating Temperature Range
  - Device HBM ESD Classification Level H3B (JESD 22 A114-A)
  - Device CDM ESD Classification Level C5 (JESD 22 C101)
- Control Inputs V_{IH}/V_{IL} Levels Are Referenced to V_{CCA} Voltage
- V_{CC} Isolation Feature – If Either V_{CC} Input is at GND, Both Ports Are in the High-Impedance State
- Fully Configurable Dual-Rail Design Allows Each Port to Operate Over the Full 1.2V to 3.6V Power-Supply Range
- I_{off} Supports Partial-Power-Down Mode Operation
- I/Os Are 4.6V Tolerant
- Maximum Data Rates
  - 380Mbps (1.8V to 3.3V Translation)
  - 200Mbps (<1.8V to 3.3V Translation)
  - 200Mbps (Translate to 2.5V or 1.8V)
  - 150Mbps (Translate to 1.5V)
  - 100Mbps (Translate to 1.2V)
- Latch-Up Performance Exceeds 100mA Per JESD 78, Class II

2 Applications

- Telematics
- Clusters
- Head Units
- Navigation Systems

3 Description

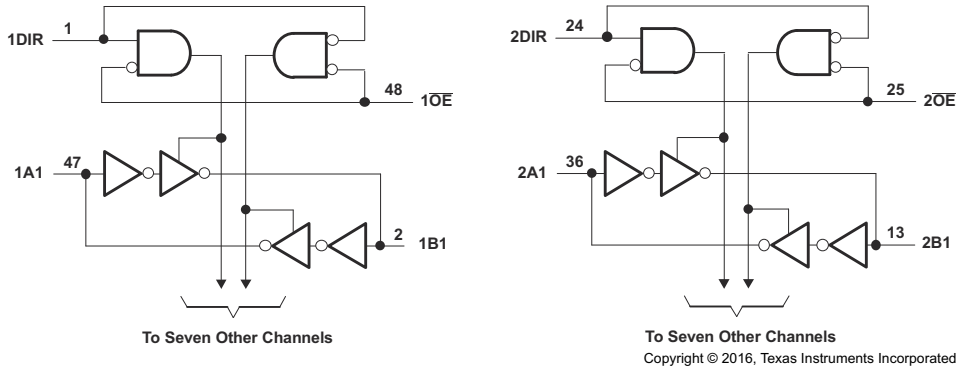
The SN74AVC16T245-Q1 is a 16-bit noninverting bus transceiver that uses two separate configurable power-supply rails. The SN74AVC16T245-Q1 is optimized to operate with V_{CCA} or V_{CCB} set at 1.4V to 3.6V. It is operational with V_{CCA} or V_{CCB} as low as 1.2V. The A port is designed to track V_{CCA}. V_{CCA} accepts any supply voltage from 1.2V to 3.6V. The B port is designed to track V_{CCB}. V_{CCB} accepts any supply voltage from 1.2V to 3.6V. This allows for universal low-voltage bidirectional translation between any of the 1.2V, 1.5V, 1.8V, 2.5V, and 3.3V voltage nodes.

The SN74AVC16T245-Q1 is designed for asynchronous communication between data buses. The device transmits data from the A bus to the B bus or from the B bus to the A bus, depending on the logic level at the direction-control (DIR) input. The output-enable ($\overline{OE}$) input can be used to disable the outputs so the buses effectively are isolated.

Device Information

PART NUMBER	PACKAGE(1)	BODY SIZE (NOM)
SN74AVC16T245-Q1	TVSOP (48)	9.70mm × 4.40mm

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



Logic Diagram (Positive Logic)

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4 Description (continued)

The SN74AVC16T245-Q1 is designed so that the control pins (1DIR, 2DIR, 1 $\overline{OE}$, and 2 $\overline{OE}$) are supplied by V_{CCA}.

This device is fully specified for partial-power-down applications using I_{off}. The I_{off} circuitry disables the outputs, preventing damaging current backflow through the device when it is powered down.

The V_{CC} isolation feature ensures that if either V_{CC} input is at GND, both ports are in the high-impedance state.

To ensure the high-impedance state during power up or power down, $\overline{OE}$ must be tied to V_{CC} through a pullup resistor; the minimum value of the resistor is determined by the current-sinking capability of the driver.

5 Pin Configuration and Functions

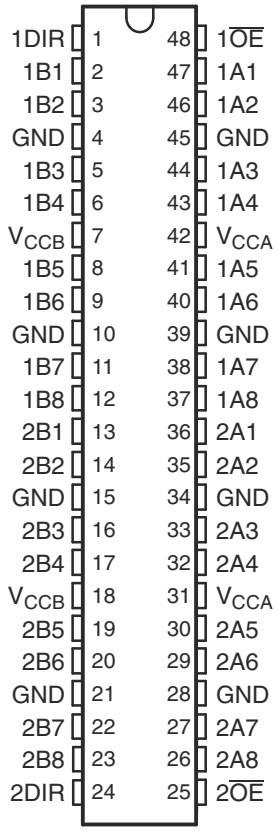


Figure 5-1. DGV Package 48-Pin TVSOP Top View

Table 5-1. Pin Functions

PIN		I/O	DESCRIPTION
NAME	NO.		
1A1	47	I/O	Input and output. Referenced to V_{CCA}
1A2	46		
1A3	44		
1A4	43		
1A5	41		
1A6	40		
1A7	38		
1A8	37		
1B1	2	I/O	Input and output. Referenced to V_{CCB}
1B2	3		
1B3	5		
1B4	6		
1B5	8		
1B6	9		
1B7	11		
1B8	12		

Table 5-1. Pin Functions (continued)

PIN		I/O	DESCRIPTION
NAME	NO.		
2A1	36	I/O	Input and output. Referenced to V_{CCA}
2A2	35		
2A3	33		
2A4	32		
2A5	30		
2A6	29		
2A7	27		
2A8	26		
2B1	13	I/O	Input and output. Referenced to V_{CCB}
2B2	14		
2B3	16		
2B4	17		
2B5	19		
2B6	20		
2B7	22		
2B8	23		
1DIR	1	I	Direction-control signal
2DIR	24		
1 $\overline{OE}$	48	—	Tri-State output-mode enables. Pull $\overline{OE}$ high to place all outputs in Tri-State mode. Referenced to V_{CCA}
2 $\overline{OE}$	25		
GND	4, 10, 15, 21, 45, 39, 34, 28	—	Ground
V_{CCA}	42, 31	—	A-port supply voltage. 1.2 V ≤ V_{CCB} ≤ 3.6 V
V_{CCB}	7, 18	—	B-port supply voltage. 1.2 V ≤ V_{CCB} ≤ 3.6 V

6 Specifications

6.1 Absolute Maximum Ratings

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

			MIN	MAX	UNIT
V_{CCA} V_{CCB}	Supply voltage		–0.5	4.6	V
V_I	Input voltage (2)	I/O ports (A port)	–0.5	4.6	V
		I/O ports (B port)	–0.5	4.6	
		Control inputs	–0.5	4.6	
V_O	Voltage applied to any output in the high-impedance or power-off state(2)	A port	–0.5	4.6	V
		B port	–0.5	4.6	
V_O	Voltage applied to any output in the high or low state(2) (3)	A port	–0.5	V_{CCA} + 0.5	V
		B port	–0.5	V_{CCB} + 0.5	
I_{IK}	Input clamp current	V_I < 0		–50	mA
I_{OK}	Output clamp current	V_O < 0		–50	mA
I_O	Continuous output current			±50	mA
	Continuous current through each V_{CCA}, V_{CCB}, and GND			±100	mA
T_{stg}	Storage temperature		–65	150	°C

(1) Stresses beyond those listed under *Absolute Maximum Ratings* 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 *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods 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 4.6 V maximum if the output current rating is observed.

6.2 ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001(1)	±8000	V
		Charged-device model (CDM), per JEDEC specification JESD22-C101	±1000	
		Machine model (MM), per JEDEC specification JESD22-A115-A	±200	

(1) AEC Q100-002 indicates that HBM stressing shall be in accordance with the ANSI/ESDA/JEDEC JS-001 specification.

6.3 Recommended Operating Conditions

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

			V_{CCI}	V_{CCO}	MIN	MAX	UNIT
V_{CCA}, V_{CCB}	Supply voltage				1.2	3.6	V
V_{IH}	High-level input voltage	Data inputs(4)	1.2 V to 1.95 V		V_{CCI} × 0.65		V
			1.95 V to 2.7 V		1.6		
			2.7 V to 3.6 V		2		
V_{IL}	Low-level input voltage	Data inputs(4)	1.2 V to 1.95 V			V_{CCI} × 0.35	V
			1.95 V to 2.7 V			0.7	
			2.7 V to 3.6 V			0.8	
V_{IH}	High-level input voltage	DIR (referenced to V_{CCA})(5)	1.2 V to 1.95 V		V_{CCA} × 0.65		V
			1.95 V to 2.7 V		1.6		
			2.7 V to 3.6 V		2		
V_{IL}	Low-level input voltage	DIR (referenced to V_{CCA})(5)	1.2 V to 1.95 V			V_{CCA} × 0.35	V
			1.95 V to 2.7 V			0.7	
			2.7 V to 3.6 V			0.8	
V_I	Input voltage				0	3.6	V
V_O	Output voltage	Active state			0	V_{CCO}	V
		3-state			0	3.6	
I_{OH}	High-level output current			1.2 V		–3	mA
				1.4 V to 1.6 V		–6	
				1.65 V to 1.95 V		–8	
				2.3 V to 2.7 V		–9	
				3 V to 3.6 V		–12	
I_{OL}	Low-level output current			1.2 V		3	mA
				1.4 V to 1.6 V		6	
				1.65 V to 1.95 V		8	
				2.3 V to 2.7 V		9	
				3 V to 3.6 V		12	
Δt/Δv	Input transition rise or fall rate					5	ns/V
T_A	Operating free-air temperature				–40	125	°C

(1) V_{CCI} is the V_{CC} associated with the data input port.
(2) V_{CCO} is the V_{CC} associated with the output port.
(3) All unused data inputs of the device must be held at V_{CCI} or GND to ensure proper device operation. See *Implications of Slow or Floating CMOS Inputs*.
(4) For V_{CCI} values not specified in the data sheet, V_{IH} min = V_{CCI} × 0.7 V, V_{IL} max = V_{CCI} × 0.3 V.
(5) For V_{CCA} values not specified in the data sheet, V_{IH} min = V_{CCA} × 0.7 V, V_{IL} max = V_{CCA} × 0.3 V.

6.4 Thermal Information

THERMAL METRIC(1)		SN74AVC16T245-Q1 DGV (TVSOP) 48 PINS	UNIT
$R_{\theta JA}$	Junction-to-ambient thermal resistance	77.2	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	31.4	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	39.5	°C/W
ψ_{JT}	Junction-to-top characterization parameter	3.5	°C/W
ψ_{JB}	Junction-to-board characterization parameter	39	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	N/A	°C/W

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

6.5 Electrical Characteristics

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

PARAMETER		TEST CONDITIONS		V_{CCA}	V_{CCB}	T_A	MIN	TYP	MAX	UNIT
V_{OH}		I_{OH} = –100 µA	V_I= V_{IH}	1.2 V to 3.6 V	1.2 V to 3.6 V	T_A = –40°C to 125°C	V_{CCO} – 0.2			V
		I_{OH} = –3 mA		1.2 V	1.2 V	T_A = 25°C		0.95		
		I_{OH} = –6 mA		1.4 V	1.4 V	T_A = –40°C to 125°C	1			
		I_{OH} = –8 mA		1.65 V	1.65 V	T_A = –40°C to 125°C	1.15			
		I_{OH} = –9 mA		2.3 V	2.3 V	T_A = –40°C to 125°C	1.75			
		I_{OH} = –12 mA		3 V	3 V	T_A = –40°C to 125°C	2.3			
V_{OL}		I_{OL} = 100 µA	V_I= V_{IL}	1.2 V to 3.6 V	1.2 V to 3.6 V	T_A = –40°C to 125°C			0.2	V
		I_{OL} = 3 mA		1.2 V	1.2 V	T_A = 25°C		0.15		
		I_{OL} = 6 mA		1.4 V	1.4 V	T_A = –40°C to 125°C			0.4	
		I_{OL} = 8 mA		1.65 V	1.65 V	T_A = –40°C to 125°C			0.45	
		I_{OL} = 9 mA		2.3 V	2.3 V	T_A = –40°C to 125°C			0.55	
		I_{OL} = 12 mA		3 V	3 V	T_A = –40°C to 125°C			0.7	
I_I	Control inputs	V_I = V_{CCA} or GND		1.2 V to 3.6 V	1.2 V to 3.6 V	T_A = 25°C		±0.025	±0.25	µA
						T_A = –40°C to 125°C			±2	
I_{off}	A or B port	V_I or V_O= 0 to 3.6 V		0 V	0 to 3.6 V	T_A = 25°C		±0.1	±2.5	µA
						T_A = –40°C to 125°C			±10	
	A or B port			0 to 3.6 V	0 V	T_A = 25°C		±0.5	±2.5	
						T_A = –40°C to 125°C			±10	
I_{OZ} (1)	A or B port	V_O = V_{CCO} or GND, V_I= V_{CCI} or GND, $\overline{OE}$ =V_{IH}		3.6 V	3.6 V	T_A = 25°C		±0.5	±2.5	µA
						T_A = –40°C to 125°C			±10	
I_{CCA}		V_I = V_{CCI} or GND, I_O = 0		1.2 V to 3.6 V	1.2 V to 3.6 V	T_A = –40°C to 125°C			30	µA
				0 V	3.6 V	T_A = –40°C to 125°C			–40	
				3.6 V	0 V	T_A = –40°C to 125°C			30	
I_{CCB}		V_I = V_{CCI} or GND, I_O = 0		1.2 V to 3.6 V	1.2 V to 3.6 V	T_A = –40°C to 125°C			30	µA
				0 V	3.6 V	T_A = –40°C to 125°C			30	
				3.6 V	0 V	T_A = –40°C to 125°C			–40	
I_{CCA}+ I_{CCB}		V_I = V_{CCI} or GND, I_O = 0		1.2 V to 3.6 V	1.2 V to 3.6 V	T_A = –40°C to 125°C			60	µA
C_i	Control inputs	V_I = 3.3 V or GND		3.3 V	3.3 V	T_A = 25°C		3.5		pF
C_{io}	A or B port	V_O = 3.3 V or GND		3.3 V	3.3 V	T_A = 25°C		7		pF

(1) For I/O ports, the parameter I_{OZ} includes the input leakage current.
(2) V_{CCO} is the V_{CC} associated with the output port.
(3) V_{CCI} is the V_{CC} associated with the input port.

6.6 Switching Characteristics: V_{CCA}= 1.2 V

over recommended operating free-air temperature range, V_{CCA} = 1.2 V (see Figure 7-1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V_{CCB} = 1.2 V			V_{CCB} = 1.5 V			V_{CCB} = 1.8 V			V_{CCB} = 2.5 V			V_{CCB} = 3.3 V			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
t_{PLH}	A	B		4.1			3.3			3			2.8			3.2		ns
t_{PHL}				4.1			3.3			3			2.8			3.2		
t_{PLH}	B	A		4.4			4			3.8			3.6			3.5		ns
t_{PHL}				4.4			4			3.8			3.6			3.5		
t_{PZH}	$\overline{OE}$	A		6.4			6.4			6.4			6.4			6.4		ns
t_{PZL}				6.4			6.4			6.4			6.4			6.4		
t_{PZH}	$\overline{OE}$	B		6			4.6			4			3.4			3.2		ns
t_{PZL}				6			4.6			4			3.4			3.2		
t_{PHZ}	$\overline{OE}$	A		6.6			6.6			6.6			6.6			6.8		ns
t_{PLZ}				6.6			6.6			6.6			6.6			6.8		
t_{PHZ}	$\overline{OE}$	B		6			4.9			4.9			4.2			5.3		ns
t_{PLZ}				6			4.9			4.9			4.2			5.3		

6.7 Switching Characteristics: V_{CCA}= 1.5 V ± 0.1 V

over recommended operating free-air temperature range, V_{CCA} = 1.5 V ± 0.1 V (see Figure 7-1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V_{CCB} = 1.2 V			V_{CCB} = 1.5 V ± 0.1 V			V_{CCB} = 1.8 V ± 0.15 V			V_{CCB} = 2.5 V ± 0.2 V			V_{CCB} = 3.3 V ± 0.3 V			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
t_{PLH}	A	B		3.6		0.5		9.2	0.5		8.2	0.5		7.1	0.5		6.7	ns
t_{PHL}				3.6		0.5		9.2	0.5		8.2	0.5		7.1	0.5		6.7	
t_{PLH}	B	A		3.3		0.5		9.2	0.5		8.9	0.5		8.6	0.5		8.5	ns
t_{PHL}				3.3		0.5		9.2	0.5		8.9	0.5		8.6	0.5		8.5	
t_{PZH}	$\overline{OE}$	A		4.3		0.5		13.1	0.5		13.1	0.5		13.1	0.5		13.1	ns
t_{PZL}				4.3		0.5		13.1	0.5		13.1	0.5		13.1	0.5		13.1	
t_{PZH}	$\overline{OE}$	B		5.6		0.5		13.1	0.5		11.1	0.5		8.9	0.5		8.2	ns
t_{PZL}				5.6		0.5		13.1	0.5		11.1	0.5		8.9	0.5		8.2	
t_{PHZ}	$\overline{OE}$	A		4.5		0.5		12.1	0.5		12.1	0.5		12.1	0.5		12.1	ns
t_{PLZ}				4.5		0.5		12.1	0.5		12.1	0.5		12.1	0.5		12.1	
t_{PHZ}	$\overline{OE}$	B		5.5		0.5		11.7	0.5		10.5	0.5		9.5	0.5		9.3	ns
t_{PLZ}				5.5		0.5		11.7	0.5		10.5	0.5		9.5	0.5		9.3	

6.8 Switching Characteristics: V_{CCA}= 1.8 V ± 0.15 V

over recommended operating free-air temperature range, V_{CCA} = 1.8 V ± 0.15 V (see Figure 7-1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V_{CCB} = 1.2 V			V_{CCB} = 1.5 V ± 0.1 V			V_{CCB} = 1.8 V ± 0.15 V			V_{CCB} = 2.5 V ± 0.2 V			V_{CCB} = 3.3 V ± 0.3 V			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
t_{PLH}	A	B		3.4		0.5		8.9	0.5		7.8	0.5		6.7	0.5		6.3	ns
t_{PHL}				3.4		0.5		8.9	0.5		7.8	0.5		6.7	0.5		6.3	
t_{PLH}	B	A		3		0.5		8.2	0.5		7.8	0.5		7.5	0.5		7.4	ns
t_{PHL}				3		0.5		8.2	0.5		7.8	0.5		7.5	0.5		7.4	
t_{PZH}	$\overline{OE}$	A		3.4		0.5		10.8	0.5		10.8	0.5		10.8	0.5		10.8	ns
t_{PZL}				3.4		0.5		10.8	0.5		10.8	0.5		10.8	0.5		10.8	
t_{PZH}	$\overline{OE}$	B		5.4		0.5		12.2	0.5		10.4	0.5		8.3	0.5		7.5	ns
t_{PZL}				5.4		0.5		12.2	0.5		10.4	0.5		8.3	0.5		7.5	
t_{PHZ}	$\overline{OE}$	A		4.2		0.5		10.7	0.5		10.7	0.5		10.7	0.5		10.7	ns
t_{PLZ}				4.2		0.5		10.7	0.5		10.7	0.5		10.7	0.5		10.7	
t_{PHZ}	$\overline{OE}$	B		5.2		0.5		11.4	0.5		8.9	0.5		8.9	0.5		8.7	ns
t_{PLZ}				5.2		0.5		11.4	0.5		8.9	0.5		8.9	0.5		8.7	

6.9 Switching Characteristics: V_{CCA}= 2.5 V ± 0.2 V

over recommended operating free-air temperature range, V_{CCA} = 2.5 V ± 0.2 V (see Figure 7-1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V_{CCB} = 1.2 V			V_{CCB} = 1.5 V ± 0.1 V			V_{CCB} = 1.8 V ± 0.15 V			V_{CCB} = 2.5 V ± 0.2 V			V_{CCB} = 3.3 V ± 0.3 V			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
t_{PLH}	A	B		3.2		0.5		9.6	0.5		7.5	0.5		6.3	0.5		5.8	ns
t_{PHL}				3.2		0.5		8.6	0.5		7.5	0.5		6.3	0.5		5.8	
t_{PLH}	B	A		2.6		0.5		7.1	0.5		6.7	0.5		6.3	0.5		6.2	ns
t_{PHL}				2.6		0.5		7.1	0.5		6.7	0.5		6.3	0.5		6.2	
t_{PZH}	$\overline{OE}$	A		2.5		0.5		8.3	0.5		8.3	0.5		8.3	0.5		8.3	ns
t_{PZL}				2.5		0.5		8.3	0.5		8.3	0.5		8.3	0.5		8.3	
t_{PZH}	$\overline{OE}$	B		5.2		0.5		12.4	0.5		10.3	0.5		8.1	0.5		7.5	ns
t_{PZL}				5.2		0.5		12.4	0.5		10.3	0.5		8.1	0.5		7.5	
t_{PHZ}	$\overline{OE}$	A		3		0.5		9.1	0.5		9.1	0.5		9.1	0.5		9.1	ns
t_{PLZ}				3		0.5		9.1	0.5		9.1	0.5		9.1	0.5		9.1	
t_{PHZ}	$\overline{OE}$	B		5		0.5		10.9	0.5		9.6	0.5		9.1	0.5		8.2	ns
t_{PLZ}				5		0.5		10.9	0.5		9.6	0.5		9.1	0.5		8.2	

6.10 Switching Characteristics: V_{CCA}= 3.3 V ± 0.3 V

over recommended operating free-air temperature range, V_{CCA} = 3.3 V ± 0.3 V (see Figure 7-1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V_{CCB} = 1.2 V			V_{CCB} = 1.5 V ± 0.1 V			V_{CCB} = 1.8 V ± 0.15 V			V_{CCB} = 2.5 V ± 0.2 V			V_{CCB} = 3.3 V ± 0.3 V			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
t_{PLH}	A	B		3.2		0.5		8.5	0.5		7.4	0.5		6.2	0.5		5.7	ns
t_{PHL}				3.2		0.5		8.5	0.5		7.4	0.5		6.2	0.5		5.7	
t_{PLH}	B	A		2.8		0.5		6.7	0.5		6.3	0.5		5.8	0.5		5.7	ns
t_{PHL}				2.8		0.5		6.7	0.5		6.3	0.5		5.8	0.5		5.7	
t_{PZH}	$\overline{OE}$	A		2.2		0.5		7.3	0.5		7.2	0.5		7.1	0.5		7	ns
t_{PZL}				2.2		0.5		7.3	0.5		7.2	0.5		7.1	0.5		7	
t_{PZH}	$\overline{OE}$	B		5.1		0.5		12.3	0.5		10.2	0.5		7.9	0.5		7	ns
t_{PZL}				5.1		0.5		12.3	0.5		10.2	0.5		7.9	0.5		7	
t_{PHZ}	$\overline{OE}$	A		3.4		0.5		8	0.5		8	0.5		8	0.5		8	ns
t_{PLZ}				3.4		0.5		8	0.5		8	0.5		8	0.5		8	
t_{PHZ}	$\overline{OE}$	B		4.9		0.5		10.7	0.5		9.5	0.5		8.2	0.5		8	ns
t_{PLZ}				4.9		0.5		10.7	0.5		9.5	0.5		8.2	0.5		8	

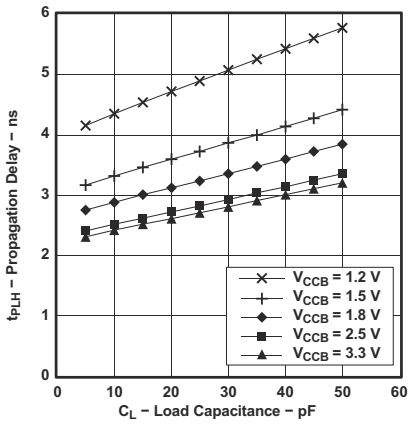
6.11 Operating Characteristics

T_A= 25°C

PARAMETER			TEST CONDITIONS	V_{CCA} = V_{CCB}= 1.2 V			V_{CCA} = V_{CCB}= 1.5 V			V_{CCA} = V_{CCB}= 1.8 V			V_{CCA} = V_{CCB}= 2.5 V			V_{CCA} = V_{CCB}= 3.3 V			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
C_{pdA} (1)	A to B	Outputs enabled	C_L = 0, f = 10 MHz, t_r = t_f = 1 ns		1			1			1			1			2	pF
		Outputs disabled			1			1			1			1			1	
	B to A	Outputs enabled			13			13			14			15			16	
		Outputs disabled			1			1			1			1			1	
C_{pdB} (1)	A to B	Outputs enabled	C_L = 0, f = 10 MHz, t_r = t_f = 1 ns		13			13			14			15			16	pF
		Outputs disabled			1			1			1			1			1	
	B to A	Outputs enabled			1			1			1			1			2	
		Outputs disabled			1			1			1			1			1	

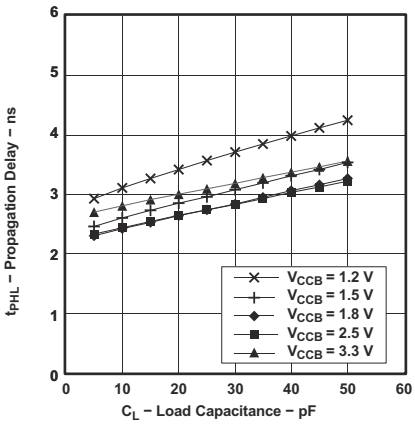
(1) Power dissipation capacitance per transceiver

6.12 Typical Characteristics



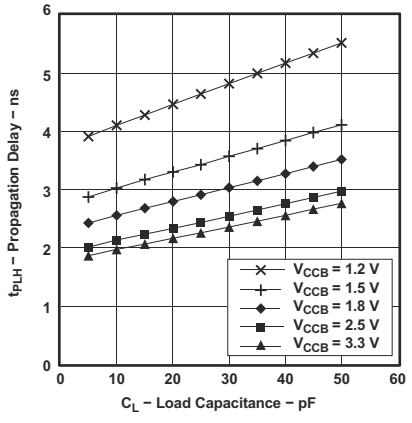
V_{CCA} = 1.2 V

Figure 6-1. Typical Propagation Delay t_{PLH} (A to B) vs Load Capacitance



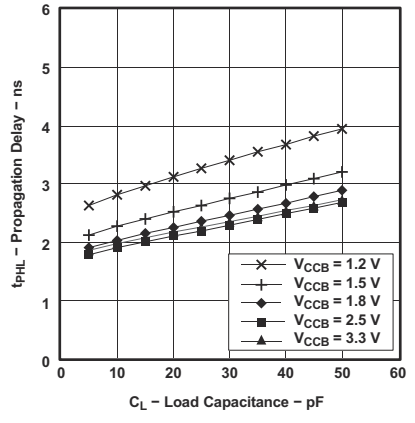
V_{CCA} = 1.2 V

Figure 6-2. Typical Propagation Delay t_{PHL} (A to B) vs Load Capacitance



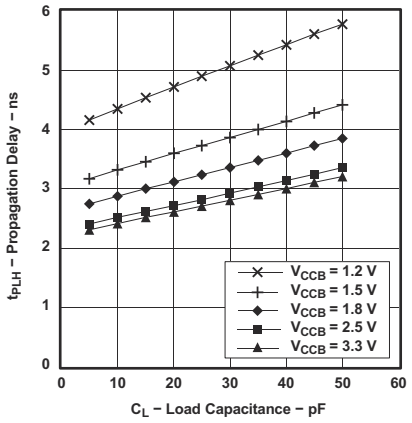
V_{CCA} = 1.5 V

Figure 6-3. Typical Propagation Delay t_{PLH} (A to B) vs Load Capacitance



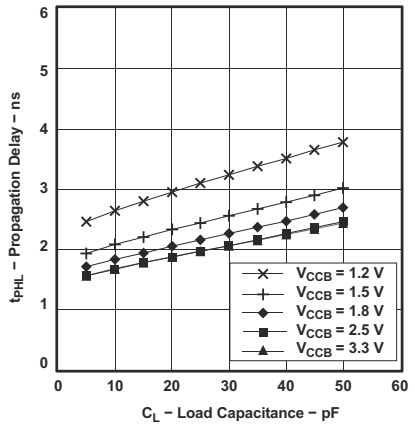
V_{CCA} = 1.5 V

Figure 6-4. Typical Propagation Delay t_{PHL} (A to B) vs Load Capacitance



V_{CCA} = 1.8 V

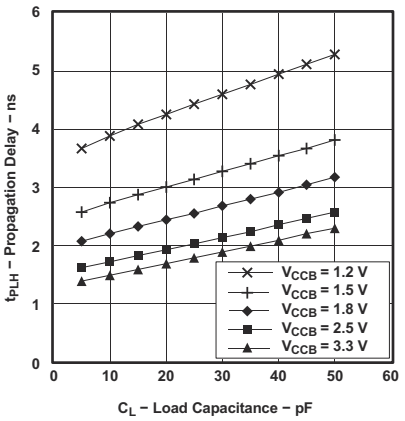
Figure 6-5. Typical Propagation Delay t_{PLH} (A to B) vs Load Capacitance



V_{CCA} = 1.8 V

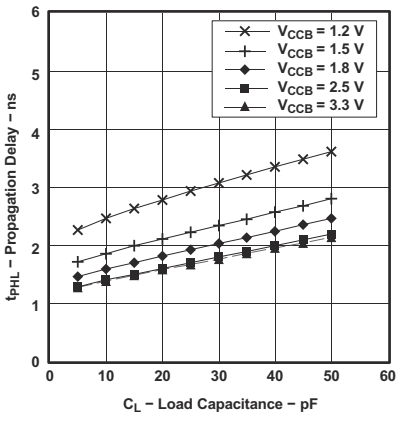
Figure 6-6. Typical Propagation Delay t_{PHL} (A to B) vs Load Capacitance

6.12 Typical Characteristics (continued)



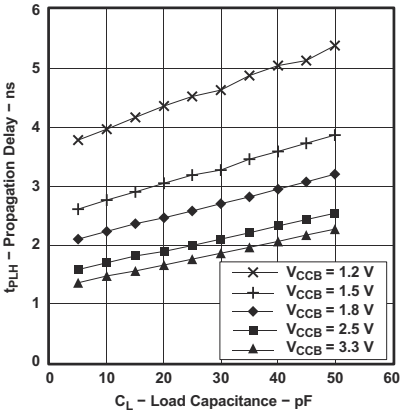
V_{CCA} = 2.5 V

Figure 6-7. Typical Propagation Delay t_{PLH} (A to B) vs Load Capacitance



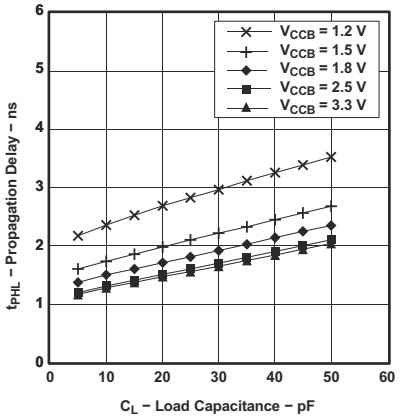
V_{CCA} = 2.5 V

Figure 6-8. Typical Propagation Delay t_{PHL} (A to B) vs Load Capacitance



V_{CCA} = 3.3 V

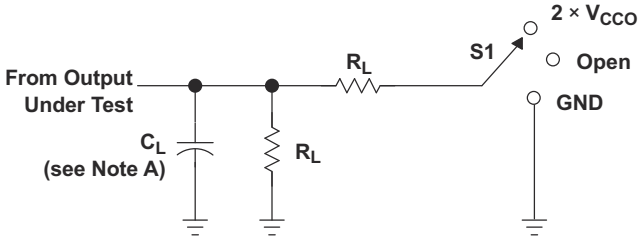
Figure 6-9. Typical Propagation Delay t_{PLH} (A to B) vs Load Capacitance



V_{CCA} = 3.3 V

Figure 6-10. Typical Propagation Delay t_{PHL} (A to B) vs Load Capacitance

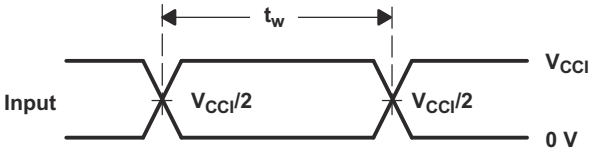
7 Parameter Measurement Information



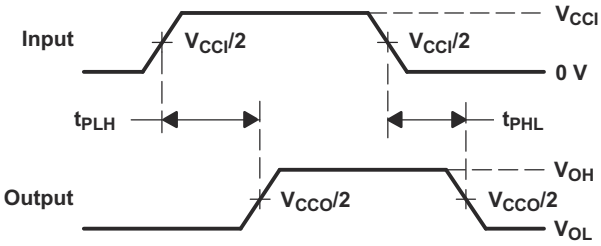
LOAD CIRCUIT

TEST	S1
t_{pd} t_{PLZ}/t_{PZL} t_{PHZ}/t_{PZH}	Open 2 × V_{CCO} GND

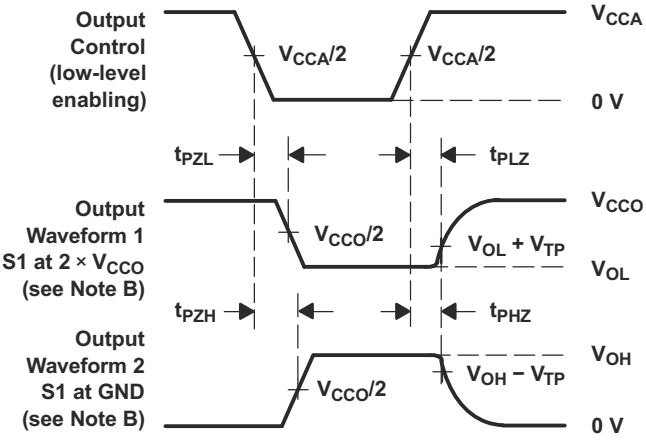
V_{CCO}	C_L	R_L	V_{TP}
1.2 V	15 pF	2 kΩ	0.1 V
1.5 V ± 0.1 V	15 pF	2 kΩ	0.1 V
1.8 V ± 0.15 V	15 pF	2 kΩ	0.15 V
2.5 V ± 0.2 V	15 pF	2 kΩ	0.15 V
3.3 V ± 0.3 V	15 pF	2 kΩ	0.3 V



VOLTAGE WAVEFORMS
PULSE DURATION



VOLTAGE WAVEFORMS
PROPAGATION DELAY TIMES



VOLTAGE WAVEFORMS
ENABLE AND DISABLE TIMES

NOTES: A. C_L includes probe and jig capacitance.
B. Waveform 1 is for an output with internal conditions such that the output is low, except when disabled by the output control. Waveform 2 is for an output with internal conditions such that the output is high, except when disabled by the output control.
C. All input pulses are supplied by generators having the following characteristics: PRR ≤ 10 MHz, Z_O = 50 Ω, dv/dt ≥ 1 V/ns.
D. The outputs are measured one at a time, with one transition per measurement.
E. t_{PLZ} and t_{PHZ} are the same as t_{dis}.
F. t_{PZL} and t_{PZH} are the same as t_{en}.
G. t_{PLH} and t_{PHL} are the same as t_{pd}.
H. V_{CCI} is the V_{CC} associated with the input port.
I. V_{CCO} is the V_{CC} associated with the output port.

Figure 7-1. Load Circuit and Voltage Waveforms

8 Detailed Description

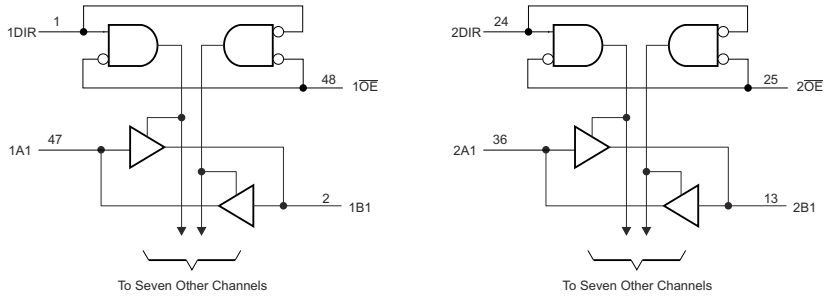
8.1 Overview

The SN74AVC16T245-Q1 is a 16-bit, dual-supply, noninverting, bidirectional voltage level translation. Pins A and control pins (DIR and $\overline{OE}$) are supported by V_{CCA} and B pins are supported by V_{CCB}. The A port can accept I/O voltages ranging from 1.2 V to 3.6 V, while the B port can accept I/O voltages from 1.2 V to 3.6 V. A high on DIR allows data transmission from A to B and a low on DIR allows data transmission from B to A when $\overline{OE}$ is set to low. When $\overline{OE}$ is set to high, both A and B are in the high-impedance state.

This device is fully specified for partial-power-down applications using off output current (I_{off}).

The V_{CC} isolation feature ensures that if either V_{CC} input is at GND, both ports are put in a high-impedance state.

8.2 Functional Block Diagram



8.3 Feature Description

8.3.1 Fully Configurable Dual-Rail Design Allows Each Port to Operate Over the Full 1.2-V to 3.6-V Power-Supply Range

Both V_{CCA} and V_{CCB} can be supplied at any voltage from 1.2 V to 3.6 V, making the device suitable for translating between any of the low voltage nodes (1.2 V, 1.8 V, 2.5 V, and 3.3 V).

8.3.2 Partial-Power-Down Mode Operation

This device is fully specified for partial-power-down applications using off output current (I_{off}). The I_{off} circuitry prevents backflow current by disabling I/O output circuits when device is in partial power-down mode.

8.3.3 V_{CC} Isolation

The V_{CC} isolation feature ensures that if either V_{CCA} or V_{CCB} are at GND, both ports are in a high-impedance state (I_{OZ} shown in *Section 6.5*). This prevents false logic levels from being presented to either bus.

8.4 Device Functional Modes

The SN74AVC16T245-Q1 is a voltage level translator that can operate from 1.2 V to 3.6 V (V_{CCA}) and 1.2 V to 3.6 V (V_{CCB}). The signal translation between 1.2 V and 3.6 V requires direction control and output enable control. When $\overline{OE}$ is low and DIR is high, data transmission is from A to B. When $\overline{OE}$ is low and DIR is low, data transmission is from B to A. When $\overline{OE}$ is high, both output ports will be high-impedance. Table 8-1 lists the functions.

Table 8-1. Function Table (Each 16-Bit Section)

CONTROL INPUTS		OUTPUT CIRCUITS		OPERATION
$\overline{OE}$	DIR	A PORT	B PORT	
L	L	Enabled	Hi-Z	B data to A bus
L	H	Hi-Z	Enabled	A data to B bus
H	X	Hi-Z	Hi-Z	Isolation

9 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. Customers should validate and test their design implementation to confirm system functionality.

9.1 Application Information

The SN74AVC16T245-Q1 device can be used in level-shifting applications for interfacing devices and addressing mixed voltage incompatibility. The SN74AVC16T245-Q1 device is ideal for data transmission where direction is different for each channel.

9.1.1 Enable Times

Calculate the enable times for the SN74AVC16T45 using the following formulas:

$$t_{PZH}\ (\text{DIR to A}) = t_{PLZ}\ (\text{DIR to B}) + t_{PLH}\ (\text{B to A}) \quad (1)$$

$$t_{PZL}\ (\text{DIR to A}) = t_{PHZ}\ (\text{DIR to B}) + t_{PHL}\ (\text{B to A}) \quad (2)$$

$$t_{PZH}\ (\text{DIR to B}) = t_{PLZ}\ (\text{DIR to A}) + t_{PLH}\ (\text{A to B}) \quad (3)$$

$$t_{PZL}\ (\text{DIR to B}) = t_{PHZ}\ (\text{DIR to A}) + t_{PHL}\ (\text{A to B}) \quad (4)$$

In a bidirectional application, these enable times provide the maximum delay from the time the DIR bit is switched until an output is expected. For example, if the SN74AVC16T245-Q1 initially is transmitting from A to B, then the DIR bit is switched; the B port of the device must be disabled before presenting it with an input. After the B port has been disabled, an input signal applied to it appears on the corresponding A port after the specified propagation delay.

9.2 Typical Application

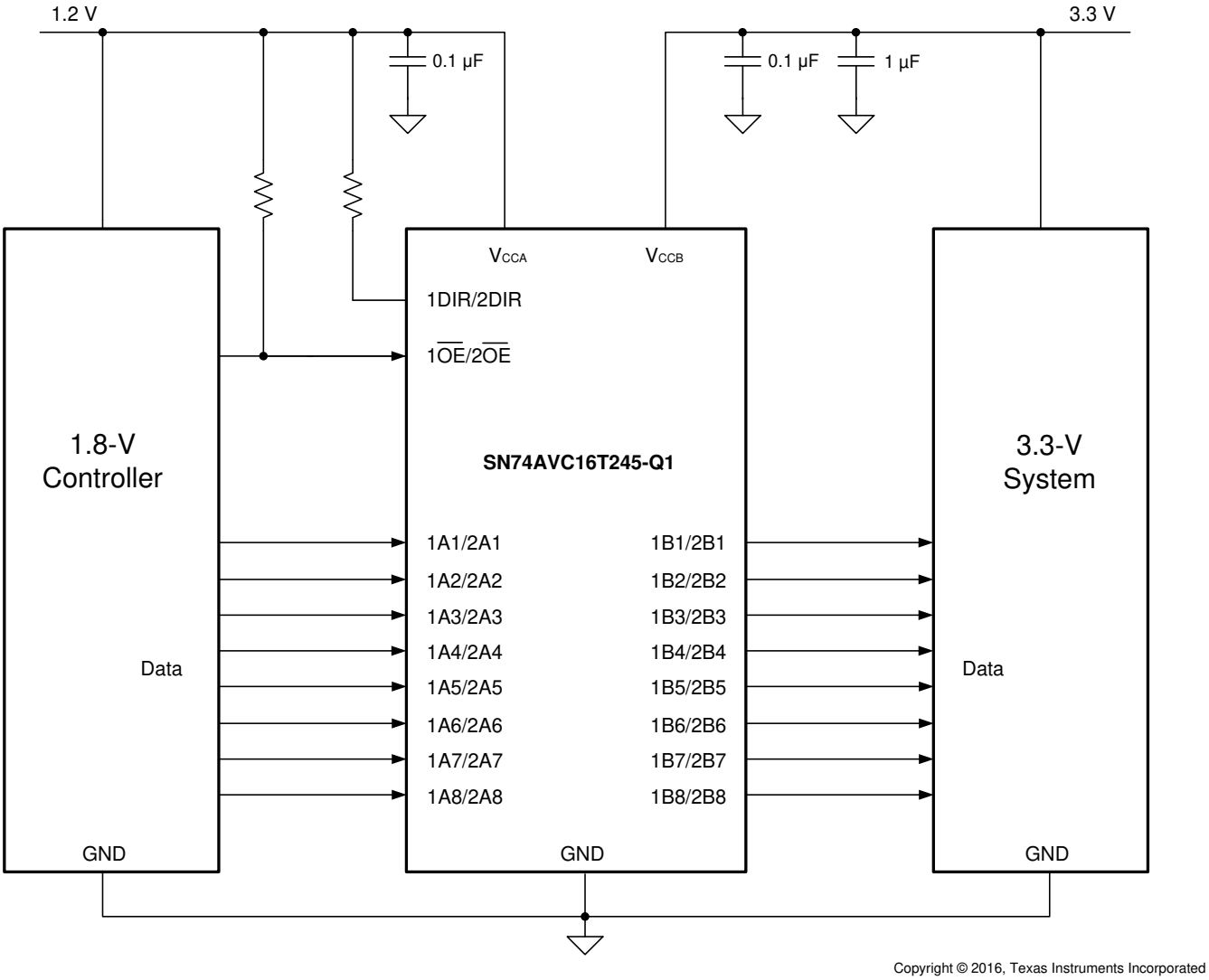


Figure 9-1. Typical Application Schematic

9.2.1 Design Requirements

This device uses drivers which are enabled depending on the state of the DIR pin. The designer must know the intended flow of data and take care not to violate any of the high or low logic levels. Unused data inputs must not be floating, as this can cause excessive internal leakage on the input CMOS structure. Tie any unused input and output ports directly to ground.

For this design example, use the parameters listed in Table 9-1.

Table 9-1. Design Parameters

DESIGN PARAMETER	EXAMPLE VALUE
Input voltage range	1.2 V
Output voltage range	3.3 V

9.2.2 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 SN74AVC16T245-Q1 device to determine the input voltage range. For a valid logic high the value must exceed the V_{IH} of the input port. For a valid logic low the value must be less than the V_{IL} of the input port.
- Output voltage range
  - Use the supply voltage of the device that the SN74AVC16T245-Q1 device is driving to determine the output voltage range.

9.2.3 Application Curve

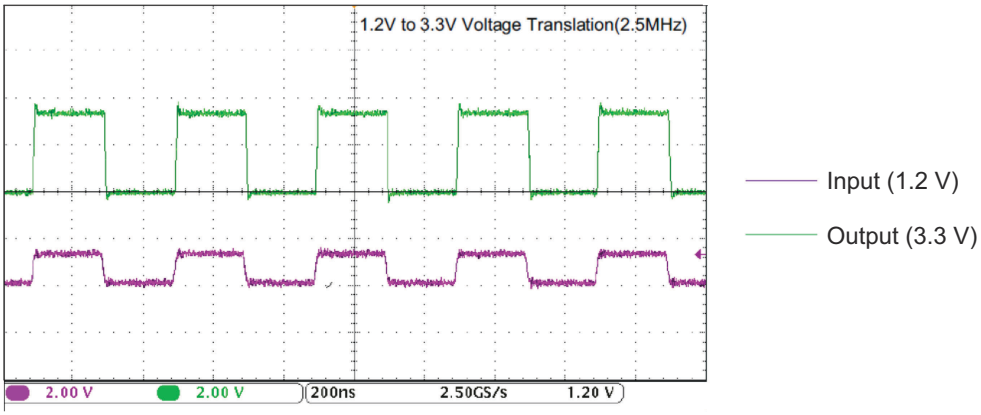


Figure 9-2. Translation Up (1.2 V to 3.3 V) at 2.5 MHz

10 Power Supply Recommendations

The SN74AVC16T245-Q1 device uses two separate configurable power-supply rails, V_{CCA} and V_{CCB}. V_{CCA} accepts any supply voltage from 1.2 V to 3.6 V and V_{CCB} accepts any supply voltage from 1.2 V to 3.6 V. The A port and B port are designed to track V_{CCA} and V_{CCB}, respectively, allowing for low-voltage bidirectional translation between any of the 1.2-V, 1.5-V, 1.8-V, 2.5-V, and 3.3-V voltage nodes.

The output-enable $\overline{OE}$ input circuit is designed so that it is supplied by V_{CCA} and when the $\overline{OE}$ input is high, all outputs are placed in the high-impedance state. To ensure the high-impedance state of the outputs during power up or power down, the $\overline{OE}$ input pin must be tied to V_{CCA} through a pullup resistor and must not be enabled until V_{CCA} and V_{CCB} are fully ramped and stable. The minimum value of the pullup resistor to V_{CCA} is determined by the current-sinking capability of the driver.

11 Layout

11.1 Layout Guidelines

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

- Bypass capacitors must be used on power supplies.
- Short trace lengths must be used to avoid excessive loading.
- Placing pads on the signal paths for loading capacitors or pullup resistors to help adjust rise and fall times of signals depending on the system requirements.

11.2 Layout Example

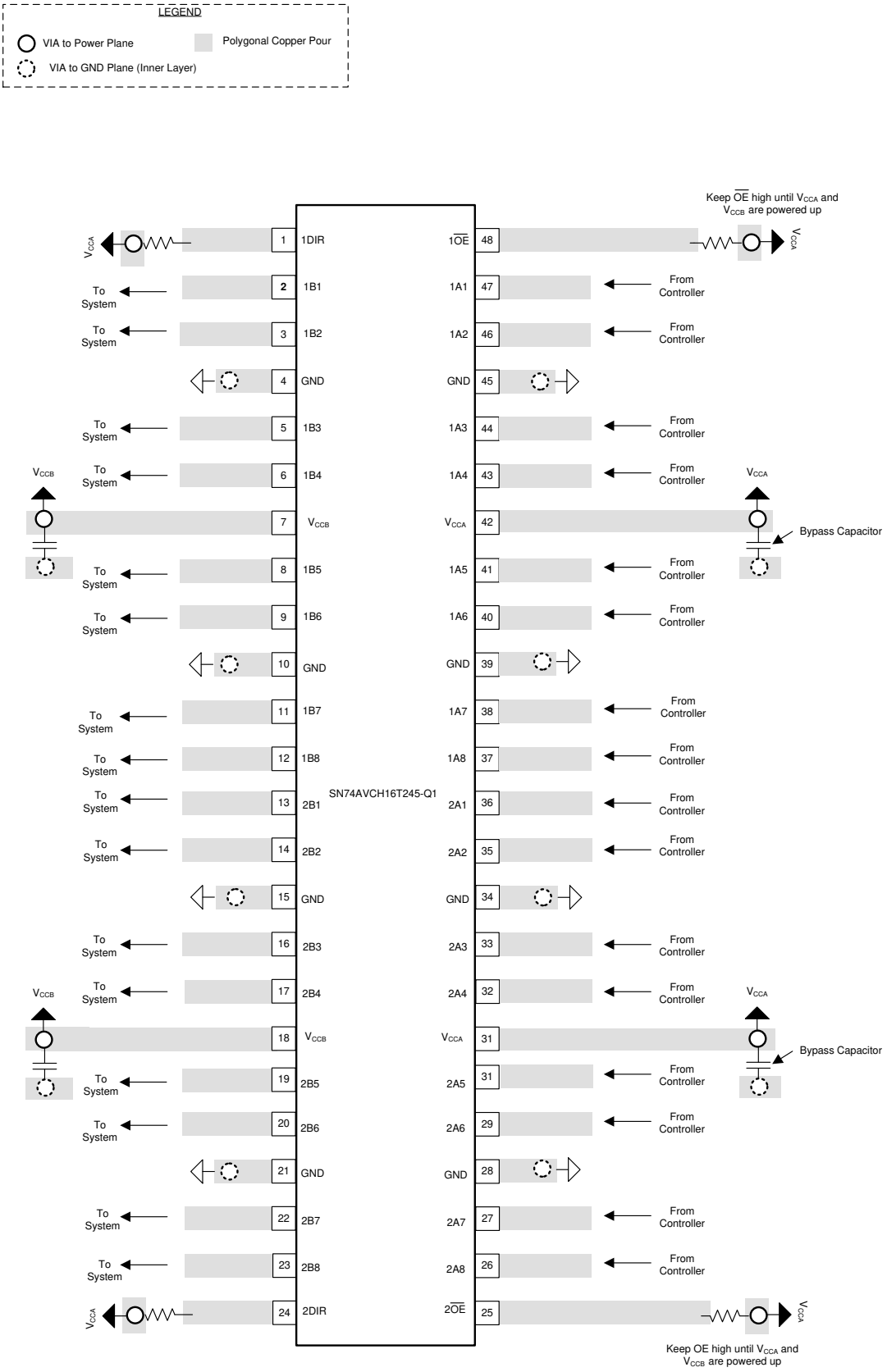


Figure 11-1. Recommended Layout Example

12 Device and Documentation Support

12.1 Documentation Support

12.1.1 Related Documentation

For related documentation see the following:

- *CMOS Power Consumption and Cpd Calculation*
- *IC Package Thermal Metrics application report*
- *Implications of Slow or Floating CMOS Inputs*

12.2 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on 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.

12.3 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.

Linked content is provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's Terms of Use.

12.4 Trademarks

TI E2E™ is a trademark of Texas Instruments.
All trademarks are the property of their respective owners.

12.5 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.

12.6 Glossary

TI Glossary	This glossary lists and explains terms, acronyms, and definitions.

13 Revision History

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

Changes from Revision A (February 2016) to Revision B (March 2024)	Page
• Updated the numbering format for tables, figures, and cross-references throughout the document	1

Changes from Revision * (September 2008) to Revision A (February 2016)	Page
• Added *ESD Ratings* table, *Feature Description* section, *Device Functional Modes*, *Application and Implementation* section, *Power Supply Recommendations*section,*Layout* section, *Device and Documentation Support*section, and*Mechanical, Packaging, and Orderable Information* section	1
• Deleted *Ordering Information* table; see the POA at the end of the data sheet	1
• Deleted Overvoltage-Tolerant Inputs/Outputs Allow Mixed- Voltage-Mode Data Communications bullet from *Features*	1
• Deleted ESD Protection Exceeds JESD 22 from *Features*	1
• Changed the *Thermal Information* table	7

14 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)
CAVC16T245QDGVRQ1	Active	Production	TVSOP (DGV) | 48	2000 | LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	WF245Q
CAVC16T245QDGVRQ1.B	Active	Production	TVSOP (DGV) | 48	2000 | LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	WF245Q

(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.

OTHER QUALIFIED VERSIONS OF SN74AVC16T245-Q1 :

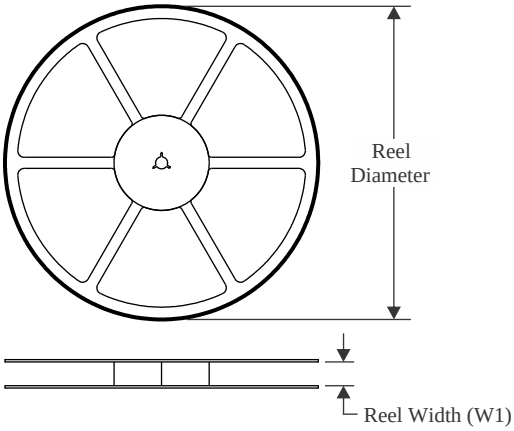
- Catalog : SN74AVC16T245

NOTE: Qualified Version Definitions:

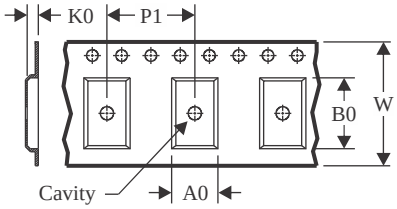
- Catalog - TI's standard catalog product

TAPE AND REEL INFORMATION

REEL DIMENSIONS

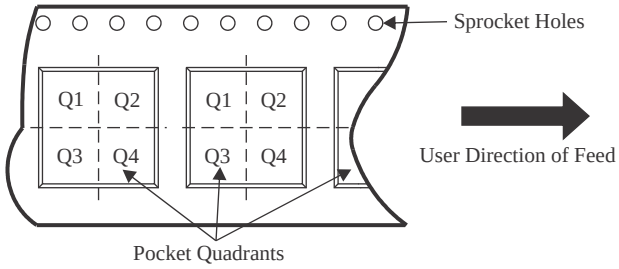


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

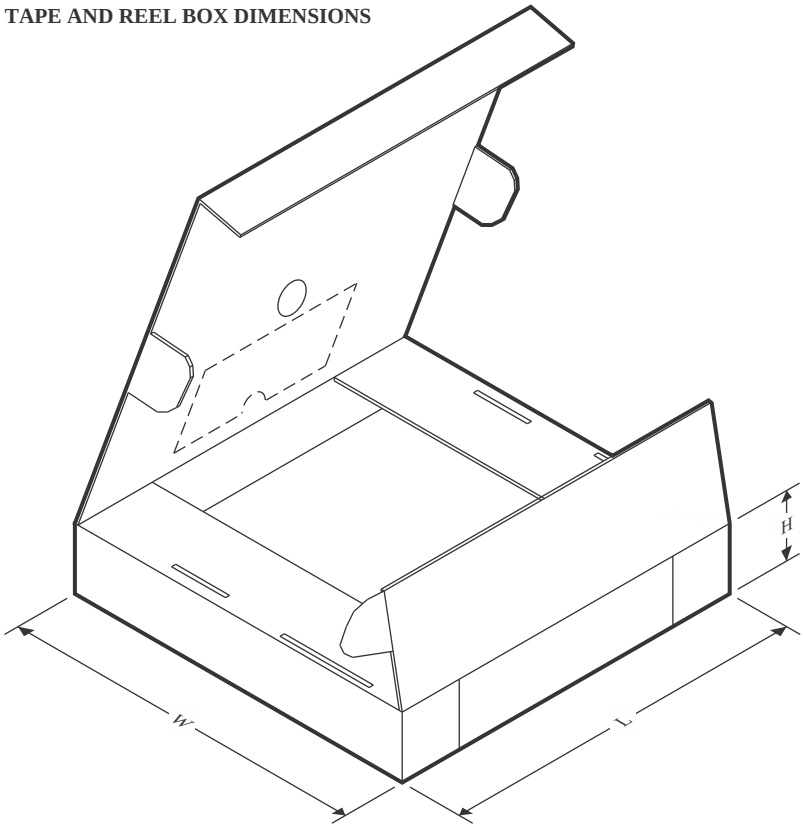
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
CAVC16T245QDGVRQ1	TVSOP	DGV	48	2000	330.0	16.4	7.1	10.2	1.6	12.0	16.0	Q1

TAPE AND REEL BOX DIMENSIONS

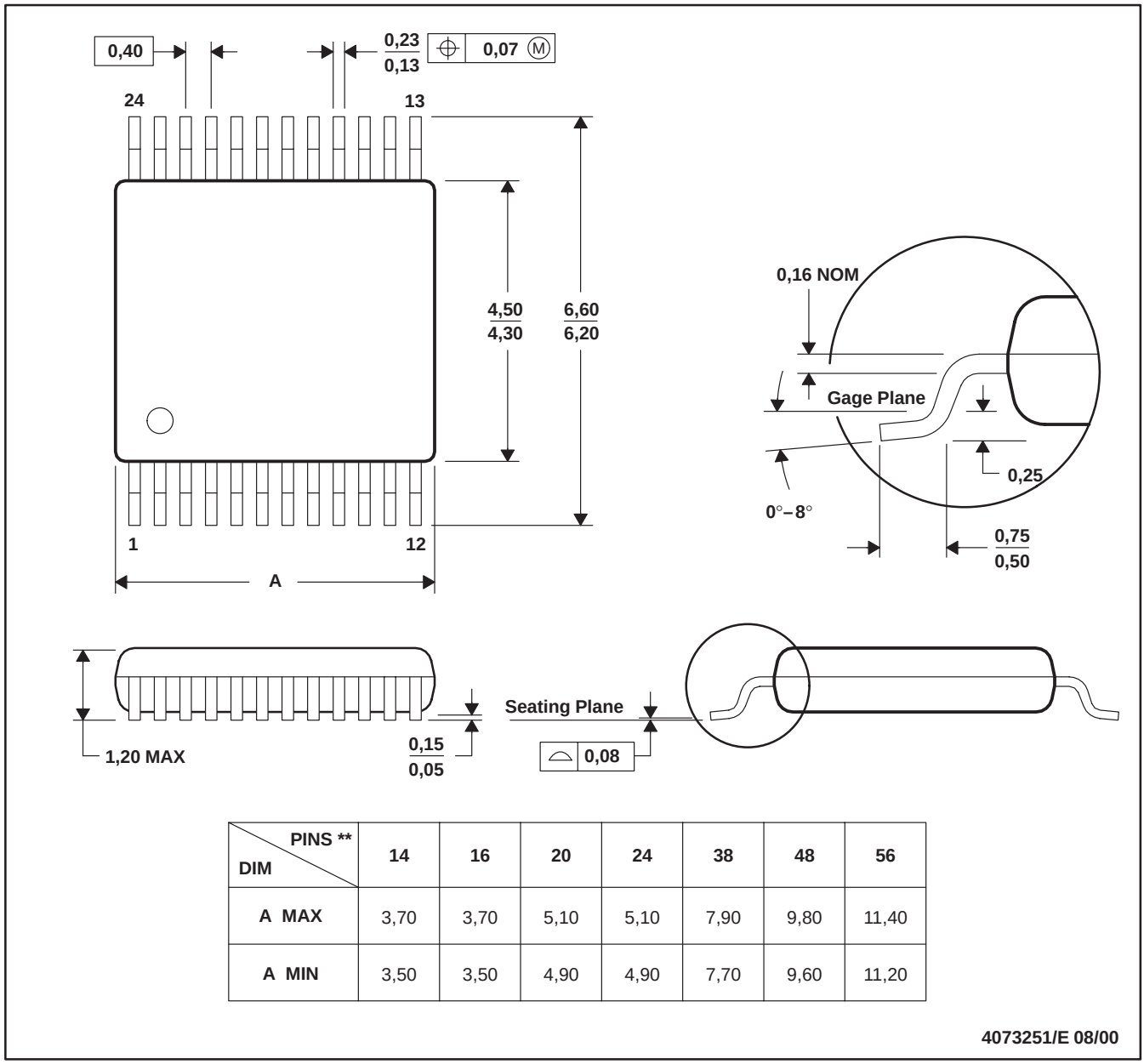


*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
CAVC16T245QDGVRQ1	TVSOP	DGV	48	2000	353.0	353.0	32.0

DGV (R-PDSO-G)** **PLASTIC SMALL-OUTLINE**

24 PINS SHOWN



DIM \ PINS **	14	16	20	24	38	48	56
A MAX	3,70	3,70	5,10	5,10	7,90	9,80	11,40
A MIN	3,50	3,50	4,90	4,90	7,70	9,60	11,20

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NOTES: A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion, not to exceed 0,15 per side.
D. Falls within JEDEC: 24/48 Pins – MO-153
14/16/20/56 Pins – MO-194

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