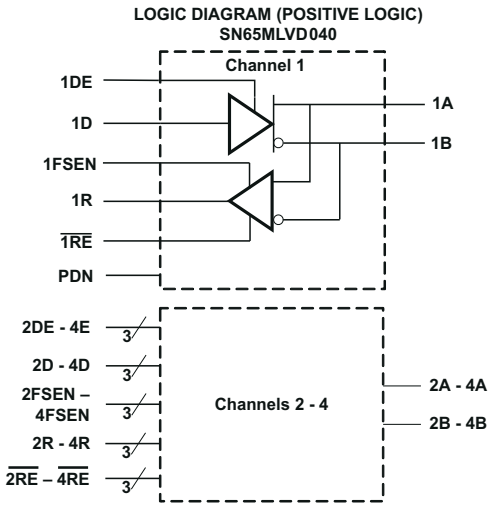
SN65MLVD040 4-Channel Half-Duplex M-LVDS Line Transceivers

1 Features

- Low-Voltage Differential 30Ω to 55Ω Line Drivers and Receivers for Signaling Rates(1) Up to 250Mbps; Clock Frequencies Up to 125MHz
- Meets or Exceeds the M-LVDS Standard TIA/EIA-899 for Multipoint Data Interchange
- Controlled Driver Output Voltage Transition Times for Improved Signal Quality
- –1V to 3.4V Common-Mode Voltage Range Allows Data Transfer With 2V of Ground Noise
- Bus Pins High Impedance When Driver Disabled or V_{CC} ≤ 1.5V
- Independent Enables for each Driver and Receiver
- Enhanced ESD Protection: 7kV HBM on all Pins
- 48 pin 7 X 7 QFN (RGZ)
- M-LVDS Bus Power Up/Down Glitch Free

2 Applications

- Parallel Multipoint Data and Clock Transmission Via Backplanes and Cables
- Low-Power High-Speed Short-Reach Alternative to TIA/EIA-485
- Cellular Base Stations
- Central-Office Switches
- Network Switches and Routers



A. The signaling rate of a line, is the number of voltage transitions that are made per second expressed in the units bps (bits per second)

3 Description

The SN65MLVD040 provides four half-duplex transceivers for transmitting and receiving Multipoint-Low-Voltage Differential Signals in full compliance with the TIA/EIA-899 (M-LVDS) standard, which are optimized to operate at signaling rates up to 250Mbps. The driver outputs have been designed to support multipoint buses presenting loads as low as 30Ω and incorporates controlled transition times to allow for stubs off of the backplane transmission line.

The M-LVDS standard defines two types of receivers, designated as Type-1 and Type-2. Type-1 receivers have thresholds centered about zero with 25mV of hysteresis to prevent output oscillations with loss of input; Type-2 receivers implement a failsafe by using an offset threshold. The xFSEN pins is used to select the Type-1 and Type-2 receiver for each of the channels. In addition, the driver rise and fall times are between 1ns and 2ns, complying with the M-LVDS standard to provide operation at 250Mbps while also accommodating stubs on the bus. Receiver outputs are slew rate controlled to reduce EMI and crosstalk effects associated with large current surges. The M-LVDS standard allows for 32 nodes on the bus providing a high-speed replacement for RS-485 where lower common-mode can be tolerated or when higher signaling rates are needed.

The driver logic inputs and the receiver logic outputs are on separate pins rather than tied together as in some transceiver designs. The drivers have separate enables (DE) and so does the receivers ($\overline{RE}$). This arrangement of separate logic inputs, logic outputs, and enable pins allows for a listen-while-talking operation. The devices are characterized for operation from –40°C to 85°C.

Package Information

PART NUMBER	PACKAGE (1)	PACKAGE SIZE
SN65MLVD040RGZR	VQFN (RGZ)	7 x 7, 0.5mm pitch
SN65MLVD040RGZT	VQFN (RGZ)	7 x 7, 0.5mm pitch

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

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4 Pin Configuration and Functions

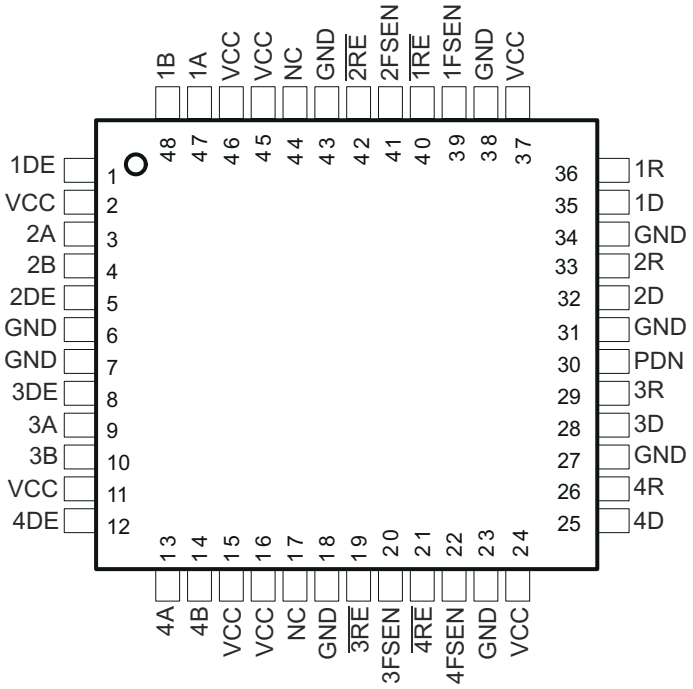


Figure 4-1. RGZ Package (Top View)

Table 4-1. Pin Functions

PIN		I/O	DESCRIPTION
NAME	NO.		
1D–4D	35, 32, 28, 25	I	Data inputs for drivers
1R–4R	36, 33, 29, 26	O	Data output for receivers
1A–4A	47, 3, 9, 13	Bus I/O	M-LVDS bus non-inverting input/output
1B–4B	48, 4, 10, 14	Bus I/O	M-LVDS bus inverting input/output
GND	6, 7, 18, 23, 27, 31, 34, 38, 43		Circuit ground. **ALL GND pins must be connected to ground.**
V_{CC}	2, 11, 15, 16, 24, 37, 45, 46		Supply voltage. **ALL VCC pins must be connected to supply.**
$\overline{1RE}$– $\overline{4RE}$	40, 42, 19, 21	I	Receiver enable, active low, enable individual receivers. When this pin is left floating, internally this pin will be pulled to logic HIGH.
1DE–4DE	1, 5, 8, 12	I	Driver enable, active high, individual enables the drivers. When this pin is left floating, internally this pin will be pulled to logic LOW.
1FSEN–4FSEN	39, 41, 20, 22	I	Failsafe enable pin. When this pin is left floating, internally this pin will be pulled to logic HIGH. This pin enables the Type 2 receiver for the respective channel. xFSEN = L → Type 1 receiver inputs xFSEN = H → Type 2 receiver inputs
PDN	30	I	Power Down pin. When this pin is left floating, internally this pin will be pulled to logic LOW. When PDN is HIGH, the device is powered up. When PDN is LOW, the device overrides all other control and powers down. All outputs are Hi-Z.
NC	17		Not Connected
NC	44		Not Connected. Internal TI Test pin. This pin must be left unconnected.
PowerPAD™	–		Connected to GND

Table 4-2. Device Function Tables

RECEIVER							DRIVER			
INPUTS[1]				RECEIVER TYPE	OUTPUT[1]		INPUTS[1]		OUTPUTS[1]	
$V_{ID} = V_A – V_B$	PDN	FSEN	$\overline{RE}$		R		D	DE	A	B
V_{ID} > 35 mV	H	L	L	Type 1	H		L	H	L	H
–35 mV ≤ V_{ID} ≤ 35 mV	H	L	L	Type 1	?		H	H	H	L
V_{ID} < 35 mV	H	L	L	Type 1	L		OPEN	H	L	H
							X	OPEN	Z	Z
V_{ID} > 135 mV	H	H	L	Type 2	H		X	L	Z	Z
65 mV ≤ V_{ID} ≤ 135 mV	H	H	L	Type 2	?					
V_{ID} < 65 mV	H	H	L	Type 2	L					
Open Circuit	H	L	L	Type 1	?					
Open Circuit	H	H	L	Type 2	L					
X	H	X	H	X	Z					
X	H	X	OPEN	X	Z					
X	L	X	X	X	Z					

(1) H=high level, L=low level, Z=high impedance, X=Don't care, ?=indeterminate

5 Specifications

5.1 Absolute Maximum Ratings

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

			SN65MLVD040
Supply voltage range(2), V_{CC}			–0.5 V to 4 V
Input voltage range	D, DE, $\overline{RE}$, FSEN		–0.5 V to 4 V
	A, B		–1.8 V to 4 V
Output voltage range	R		–0.3 V to 4 V
	A, or B		–1.8 V to 4 V
Electrostatic discharge	Human Body Model(3)	All pins	±7 kV
	Charged-Device Model(4)	All pins	±1500 V
Storage temperature range			–65°C to 150°C

(1) Stresses beyond those listed under *absolute maximum ratings* may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under *recommended operating conditions* is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
(2) All voltage values, except differential I/O bus voltages, are with respect to network ground terminal.
(3) Tested in accordance with JEDEC Standard 22, Test Method A114-E. Bus pin stressed with respect to a common connection of GND and V_{CC}
(4) Tested in accordance with JEDEC Standard 22, Test Method C101-D.

5.2 Reccommended Operationg Conditions

		MIN	NOM	MAX	UNIT
V_{CC}	Supply voltage	3	3.3	3.6	V
V_{IH}	High-level input voltage	2		V_{CC}	V
V_{IL}	Low-level input voltage	GND		0.8	V
	Voltage at any bus terminal V_A or V_B	–1.4		3.8	V
$\|V_{ID}\|$	Magnitude of differential input voltage	0.05		V_{CC}	V
T_A	Operating free-air temperature	–40		85	°C
	Maximum junction temperature			140	°C

5.3 Thermal Characteristics

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$R_{\theta JB}$	Junction-to-board thermal resistance			9		°C/W
$R_{\theta JC}$	Junction-to-case thermal resistance			20		°C/W
$R_{\theta JP}$	Junction-to-pad thermal resistance			1.37		°C/W
P_D	Device power dissipation (See typical curves for additional information)	$\overline{RE}$at 0 V, DE at 0 V, C_L = 15 pF, V_{ID} = 400 mW, 125 MHz, All others open			382	mW

5.4 Package Dissipation Ratings

PACKAGE	PCB JEDEC STANDARD	$T_A \le 25°C$ POWER RATING	DERATING FACTOR(1) ABOVE T_A = 25°C	T_A = 85°C POWER RATING
RGZ	Low-K(2)	1298 mW	12.98 mW/°C	519 mW
RGZ	High-K(3)	3448 mW	34.48 mW/°C	1379 mW

(1) This is the inverse of the junction-to-ambient thermal resistance when board mounted and with no air flow.
(2) In accordance with the Low-K thermal metric definitions of EIA/JESD51-3.
(3) In accordance with the High-K thermal metric definitions of EIA/JESD51-7.

5.5 Device Electrical Characteristics

over recommended operating conditions unless otherwise noted

PARAMETER			TEST CONDITIONS	MIN	TYP(1)	MAX	UNIT
I_{CC}	Supply current	Driver only	$\overline{RE}$ and DE at V_{CC}, R_L = 50 Ω, 125MHz, All others open			76	mA
		Both disabled	$\overline{RE}$ at V_{CC}, DE at 0 V, R_L = No Load, 125MHz, All others open			10	
		Both enabled	$\overline{RE}$at 0 V, DE at V_{CC}, R_L = 50 Ω, C_L = 15 pF, All others open, 125MHz, No external RX stimulus			165	
		Receiver only	$\overline{RE}$at 0 V, DE at 0 V, C_L = 15 pF, V_{ID} = 400 mV, 125 MHz, All others open			100	
	Power down	PDN = L				5	mA

(1) All typical values are at 25°C and with a 3.3-V supply voltage.

5.6 Driver Electrical Characteristics

over recommended operating conditions unless otherwise noted

PARAMETER		TEST CONDITIONS	MIN(1)	TYP(2)	MAX	UNIT
$\lvert V_{AB}\rvert$	Differential output voltage magnitude (A, B)	See Figure 6-2	480		650	mV
$\Delta\lvert V_{AB}\rvert$	Change in differential output voltage magnitude between logic states (A, B)		–50		50	mV
$V_{OS(SS)}$	Steady-state common-mode output voltage (A, B)	See Figure 6-3	0.7		1.1	V
$\Delta V_{OS(SS)}$	Change in steady-state common-mode output voltage between logic states (A, B)		–50		50	mV
$V_{OS(PP)}$	Peak-to-peak common-mode output voltage (A, B)				150	mV
$V_{A(OC)}$	Maximum steady-state open-circuit output voltage (A, B)	See Figure 6-7	0		2.4	V
$V_{B(OC)}$	Maximum steady-state open-circuit output voltage (A, B)		0		2.4	V
$V_{P(H)}$	Voltage overshoot, low-to-high level output (A, B)	See Figure 6-5			1.2 V_{SS}	V
$V_{P(L)}$	Voltage overshoot, high-to-low level output (A, B)		–0.2 V_{SS}			V
I_{IH}	High-level input current (D, DE)	V_{IH} = 2 V to V_{CC}			10	µA
I_{IL}	Low-level input current (D, DE)	V_{IL} = GND to 0.8 V			10	µA
$\lvert I_{OS}\rvert$	Differential short-circuit output current magnitude (A, B)	See Figure 6-4			24	mA
C_I	Input capacitance (D, DE)	V_I = 0.4 sin(30E6πt) + 0.5 V (3)		5		pF

(1) The algebraic convention, in which the least positive (most negative) limit is designated as minimum is used in this data sheet.
(2) All typical values are at 25°C and with a 3.3-V supply voltage.
(3) HP4194A impedance analyzer (or equivalent)

5.7 Reciver Electrical Charecteristics

over recommended operating conditions unless otherwise noted

PARAMETER			TEST CONDITIONS	MIN	TYP(1)	MAX	UNIT
V_{IT+}	Positive-going differential input voltage threshold (A, B)	Type 1	See Table 6-1 and Table 6-2			35	mV
		Type 2				135	
$V_{IT–}$	Negative-going differential input voltage threshold (A, B)	Type 1		–35			mV
		Type 2		65			
V_{HYS}	Differential input voltage hysteresis, ($V_{IT+} – V_{IT–}$) (A, B)	Type 1			25		mV
		Type 2			0		
V_{OH}	High-level output voltage (R)		I_{OH} = –8 mA	2.4			V
V_{OL}	Low-level output voltage (R)		I_{OL} = 8 mA			0.4	V
I_{IH}	High-level input current ($\overline{RE}$)		V_{IH} = 2 V to V_{CC}	–10			µA
I_{IL}	Low-level input current ($\overline{RE}$)		V_{IL} = GND to 0.8 V	–10			µA
I_{OZ}	High-impedance output current (R)		V_O = 0 V or V_{CC}	–10		15	µA

(1) All typical values are at 25°C and with a 3.3-V supply voltage.

5.8 Bus Input and Output Electrical Characteristics

over recommended operating conditions unless otherwise noted

PARAMETER		TEST CONDITIONS			MIN	TYP(1)	MAX	UNIT
I_A	Receiver or transceiver with driver disabled input current	V_A = 3.8 V,	V_B = 1.2 V				32	µA
		V_A = –1.4 V,	V_B = 1.2 V		–32			
I_B	Receiver or transceiver with driver disabled input current	V_B = 3.8 V,	V_A = 1.2 V				32	µA
		V_B = –1.4 V,	V_A = 1.2 V		–32			
I_{AB}	Receiver or transceiver with driver disabled differential input current ($I_A – I_B$)	$V_A = V_B$,	1.4 ≤ V_A ≤ 3.8 V		–4		4	µA
$I_{A(OFF)}$	Receiver or transceiver power-off input current	V_A = 3.8 V,	V_B = 1.2 V,	0 V ≤ V_{CC}≤ 1.5 V			32	µA
		V_A = –1.4 V,	V_B= 1.2 V,	0 V ≤ V_{CC}≤ 1.5 V	–32			
$I_{B(OFF)}$	Receiver or transceiver power-off input current	V_B = 3.8 V,	V_A = 1.2 V,	0 V ≤ V_{CC}≤ 1.5 V			32	µA
		V_B = –1.4 V,	V_A = 1.2 V,	0 V ≤ V_{CC}≤ 1.5 V	–32			
$I_{AB(OFF)}$	Receiver input or transceiver power-off differential input current ($I_{A(off)} – I_{B(off)}$)	$V_A = V_B$, 0 V ≤ V_{CC} ≤ 1.5 V, –1.4 ≤ V_A ≤ 3.8 V			–4		4	µA
C_A	Transceiver with driver disabled input capacitance	V_A = 0.4 sin (30E6πt) + 0.5 V(2),	V_B = 1.2 V			5		pF
C_B	Transceiver with driver disabled input capacitance	V_B = 0.4 sin (30E6πt) + 0.5 V(2),	V_A = 1.2 V			5		pF
C_{AB}	Transceiver with driver disabled differential input capacitance	V_{AB} = 0.4 sin (30E6πt)V(2)					3	pF
$C_{A/B}$	Transceiver with driver disabled input capacitance balance, (C_A/C_B)				0.99		1.01	

(1) All typical values are at 25°C and with a 3.3-V supply voltage.
(2) HP4194A impedance analyzer (or equivalent)

5.9 Driver Switching Characterisitics

over recommended operating conditions unless otherwise noted

PARAMETER		TEST CONDITIONS	MIN	TYP(1)	MAX	UNIT
t_{pLH}	Propagation delay time, low-to-high-level output	See Figure 6-5	1.3	1.9	2.4	ns
t_{pHL}	Propagation delay time, high-to-low-level output		1.3	1.9	2.4	ns
t_r	Differential output signal rise time		0.9		2	ns
t_f	Differential output signal fall time		0.9		2.2	ns
$t_{sk(o)}$	Output skew				200	ps
$t_{sk(p)}$	Pulse skew ($\lvert t_{PHL} - t_{PLH} \rvert$)				150	ps
$t_{sk(pp)}$	Part-to-part skew (2)				300	ps
$t_{jit(per)}$	Period jitter, rms (1 standard deviation)(3)	All channels switching, 125 MHz clock input(4), see Figure 6-8			2	ps
$t_{jit(c-c)}$	Cycle-to-cycle jitter, rms(3)				9	ps
$t_{jit(det)}$	Deterministic jitter(3)	All channels switching, 250 Mbps 2^{15}–1 PRBS input(4), see Figure 6-8			290	ps
$t_{jit(r)}$	Random jitter(3)				4	ps
t_{PZH}	Enable time, high-impedance-to-high-level output	See Figure 6-6			7	ns
t_{PZL}	Enable time, high-impedance-to-low-level output				7	ns
t_{PHZ}	Disable time, high-level-to-high-impedance output				7	ns
t_{PLZ}	Disable time, low-level-to-high-impedance output				7	ns

(1) All typical values are at 25°C and with a 3.3-V supply voltage.
(2) $t_{sk(pp)}$ is the magnitude of the time difference in propagation delay times between any specified terminals of two devices when both devices operate with the same supply voltages, at the same temperature, and have identical packages and test circuits.
(3) Jitter is ensured by design and characterization. Stimulus jitter has been subtracted from the numbers.
(4) $t_r = t_f = 0.5$ ns (10% to 90%)

5.10 Reciever Switching Charecteristics

over recommended operating conditions unless otherwise noted

PARAMETER			TEST CONDITIONS	MIN	TYP(1)	MAX	UNIT
t_{pLH}	Propagation delay time, low-to-high-level output		C_L = 15 pF, See Figure 6-10	2.5	4.5	6	ns
t_{pHL}	Propagation delay time, high-to-low-level output			2.5	4.5	6	ns
t_r	Output signal rise time			1.4		2.35	ns
t_f	Output signal fall time			1.4		2.35	ns
$t_{sk(o)}$	Output skew					350	ps
$t_{sk(p)}$	Pulse skew ($\lvert t_{PHL} - t_{PLH} \rvert$)	Type 1			35	210	ps
		Type 2			150	470	
$t_{sk(pp)}$	Part-to-part skew(2)					800	ps
$t_{jit(per)}$	Period jitter, rms (1 standard deviation)(3)		All channels switching, 125 MHz clock input(4), See Figure 6-12			6	ps
$t_{jit(c-c)}$	Cycle-to-cycle jitter, rms(3)					13	ps
$t_{jit(det)}$	Deterministic jitter(3)	Type 1	All channels switching, 250 Mbps 2^{15}–1 PRBS input(4),See Figure 6-12			800	ps
		Type 2				945	ps
$t_{jit(r)}$	Random jitter (3)	Type 1				9	ps
		Type 2				8	ps
t_{PZH}	Enable time, high-impedance-to-high-level output		C_L = 15 pF, See Figure 6-11			15	ns
t_{PZL}	Enable time, high-impedance-to-low-level output					15	ns
t_{PHZ}	Disable time, high-level-to-high-impedance output					10	ns
t_{PLZ}	Disable time, low-level-to-high-impedance output					10	ns

(1) All typical values are at 25°C and with a 3.3-V supply voltage.
(2) $t_{sk(pp)}$ is the magnitude of the time difference in propagation delay times between any specified terminals of two devices when both devices operate with the same supply voltages, at the same temperature, and have identical packages and test circuits.
(3) Jitter is ensured by design and characterization. Stimulus jitter has been subtracted from the numbers.
(4) $t_r = t_f$ = 0.5 ns (10% to 90%)

5.11 Typical Characteristics

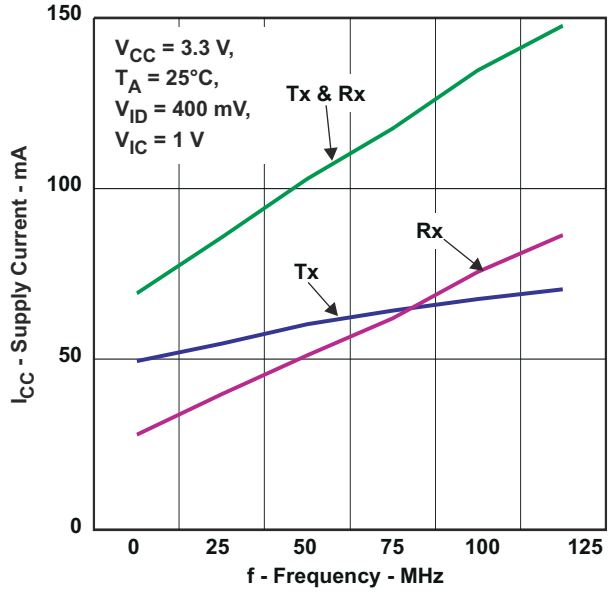


Figure 5-1. Supply Current vs Frequency

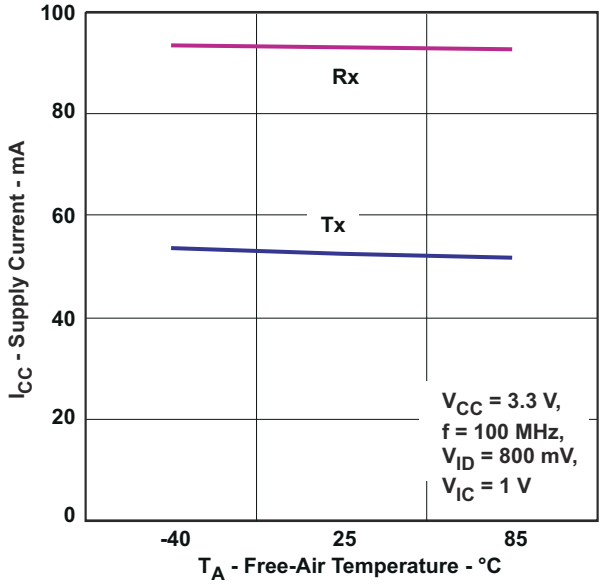


Figure 5-2. Supply Current vs Free-air Temperature

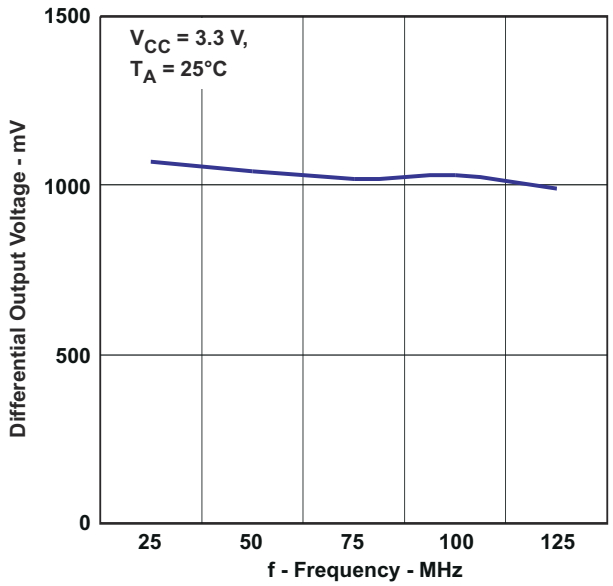


Figure 5-3. Differntial Output Voltage vs Frequency

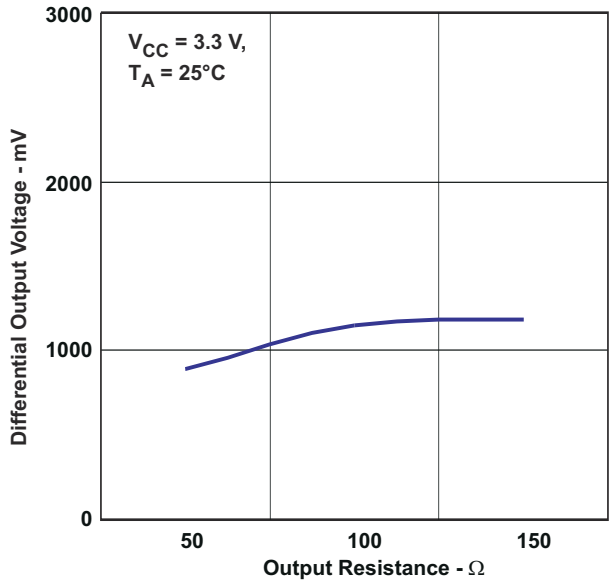


Figure 5-4. Differential Output Voltage vs Frequency

5.11 Typical Characteristics (continued)

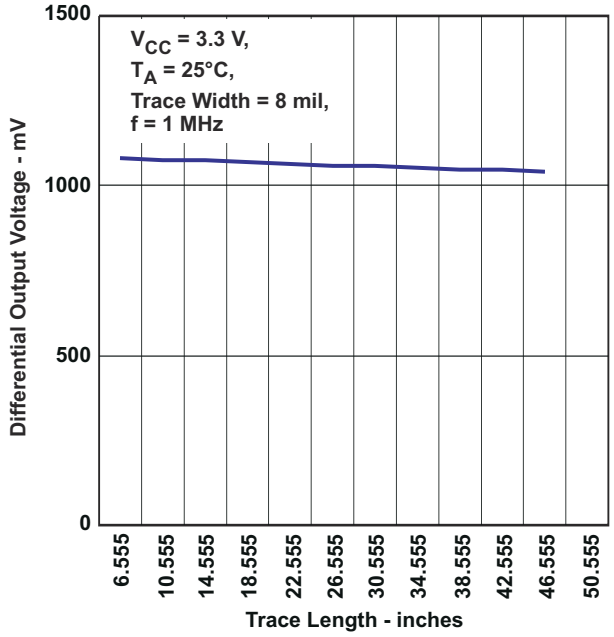


Figure 5-5. Differential Output Voltage vs Trace Length

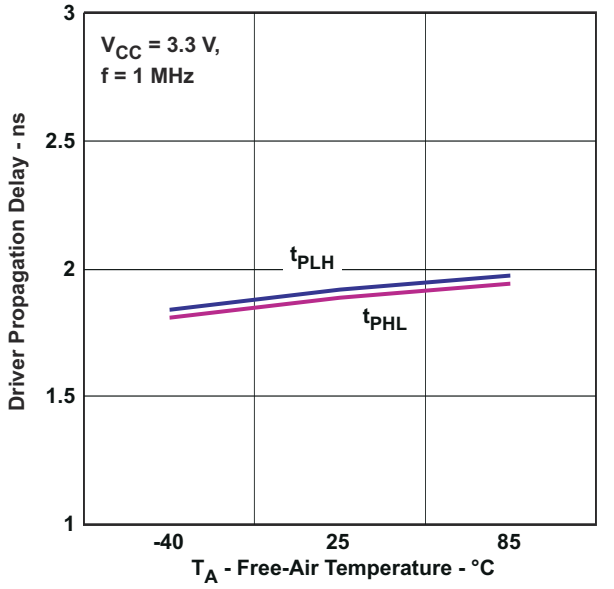


Figure 5-6. Driver Propagation Delay vs Free-Air Temperature

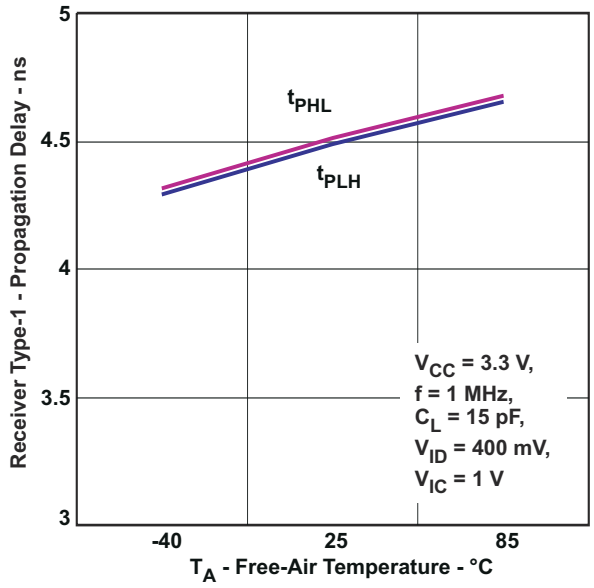


Figure 5-7. Receiver Type-1 Propagation Delay vs Free-air Temperature

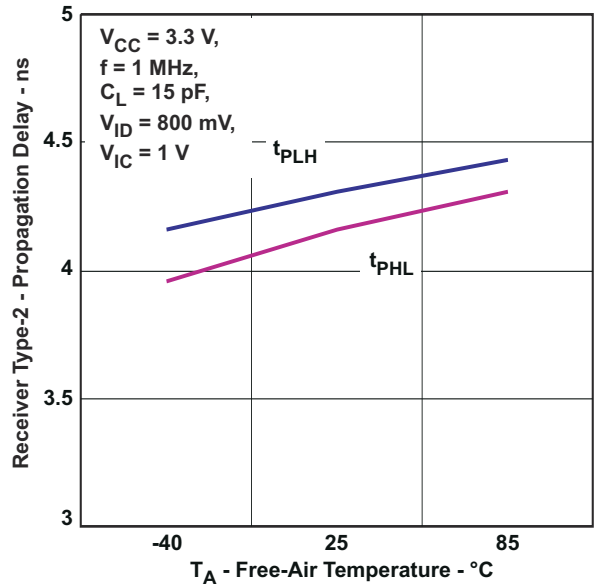


Figure 5-8. Receiver Type-2 Propagation Delay vs Free-air Temperature

5.11 Typical Characteristics (continued)

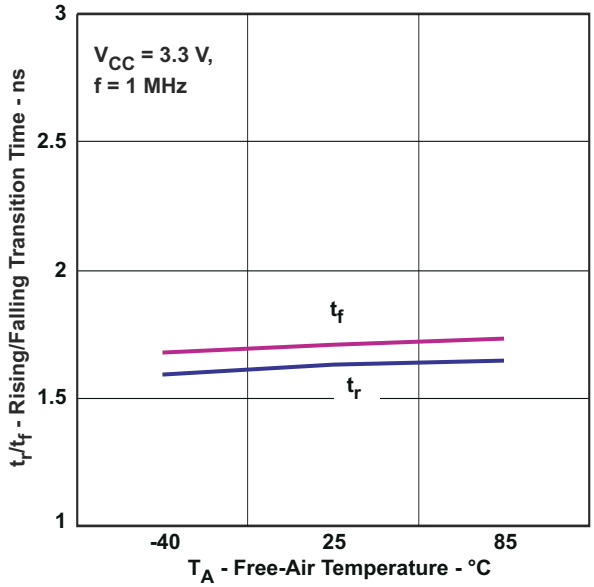


Figure 5-9. Driver Transition Time vs Free-air Temperature

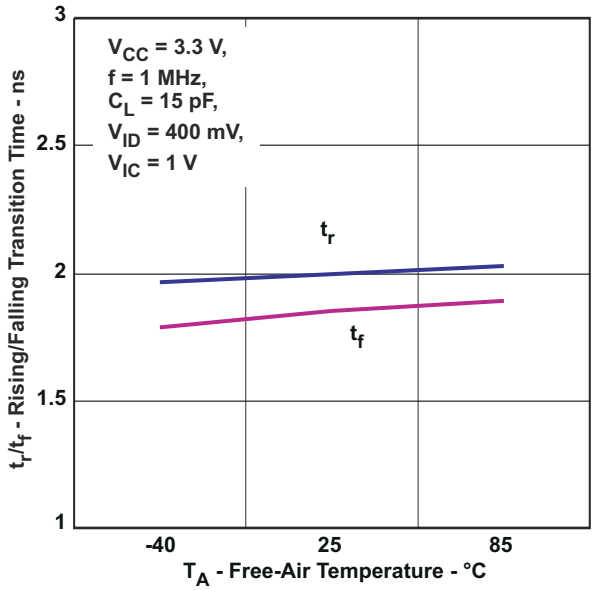


Figure 5-10. Type-1 Reciver Transition Time vs Free-Air Temperature

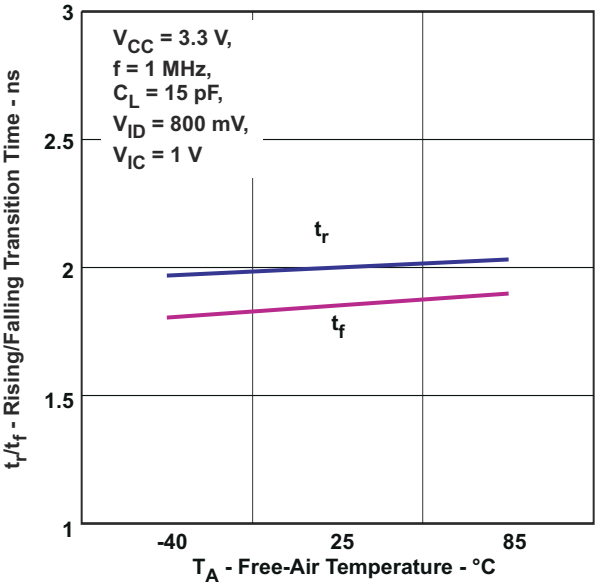


Figure 5-11. Type-2 Reciver Transition Time vs Free-Air Temperature

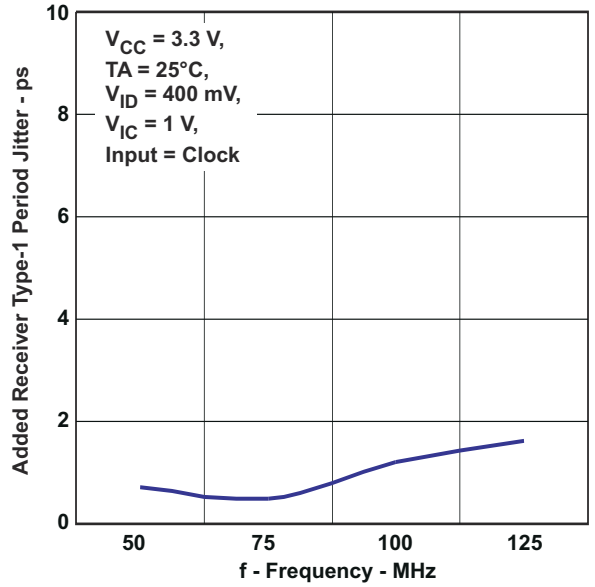


Figure 5-12. Added Reciver Type-1 Period Jitter vs Frequency

5.11 Typical Characteristics (continued)

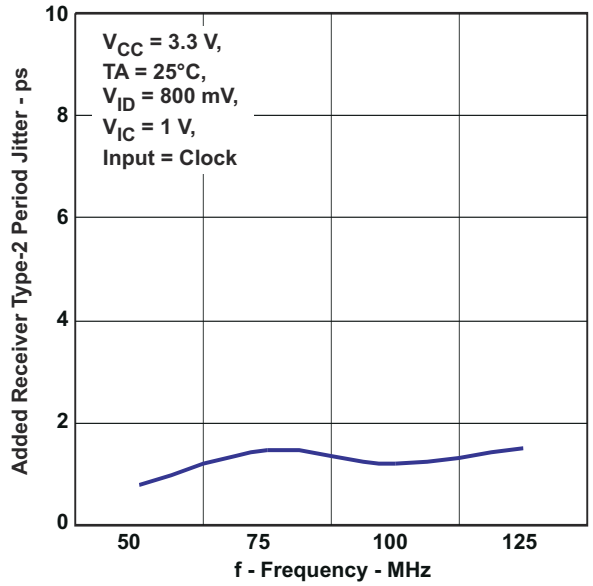


Figure 5-13. Added Reciver Type-2 Periods Jitter vs Frequency

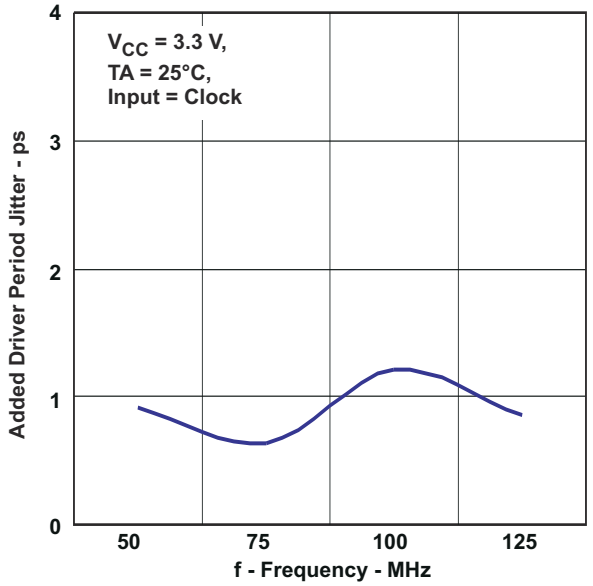


Figure 5-14. Added Period Driver Jitter vs Frequency

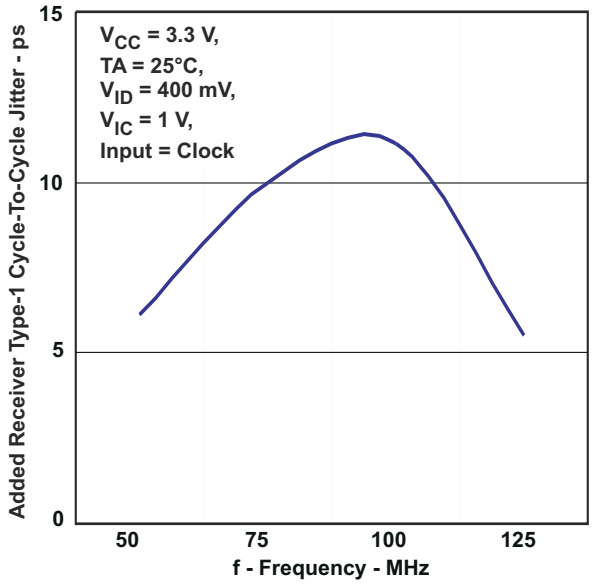


Figure 5-15. Added Reciver Type-1 Cycle-to-Cycle Jitter vs Frequency

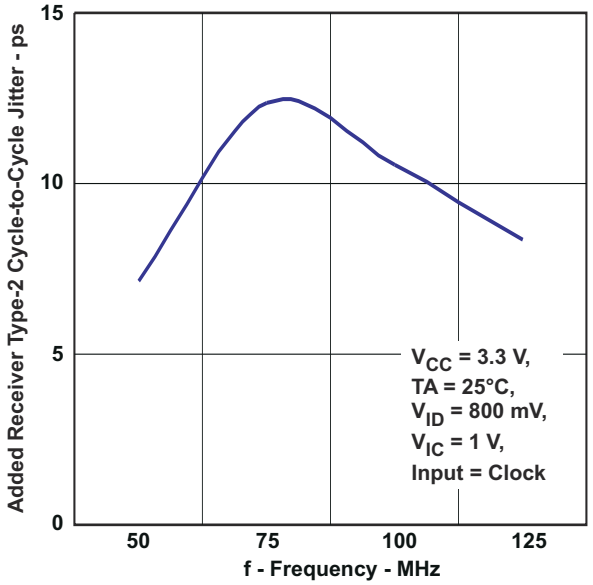


Figure 5-16. Added Reciver Type-2 Cycle-to-Cycle Jitter vs Frequency

5.11 Typical Characteristics (continued)

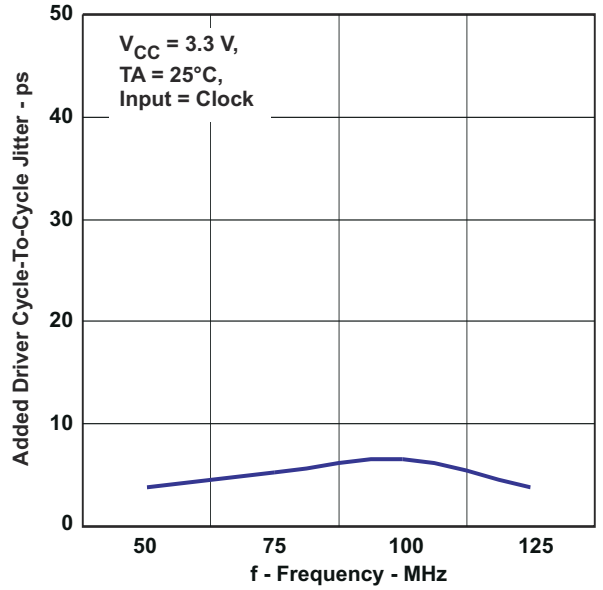


Figure 5-17. Added Driver Cycle-to-Cylce Jitter vs Frequency

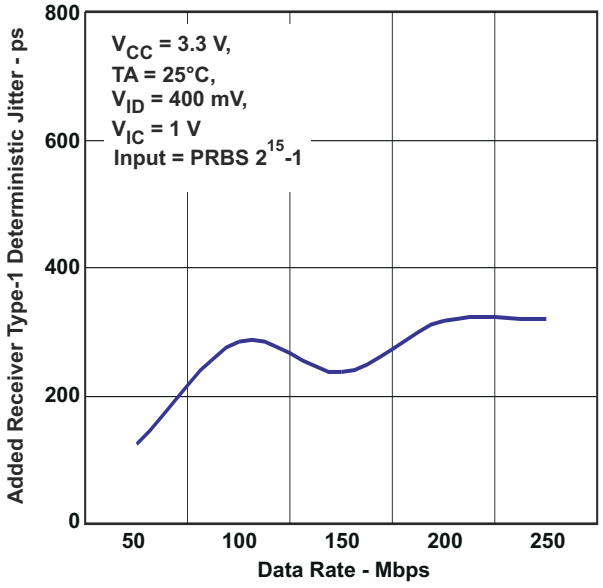


Figure 5-18. Added Reciver Type-1 Deterministic Jitter vs Data Rate

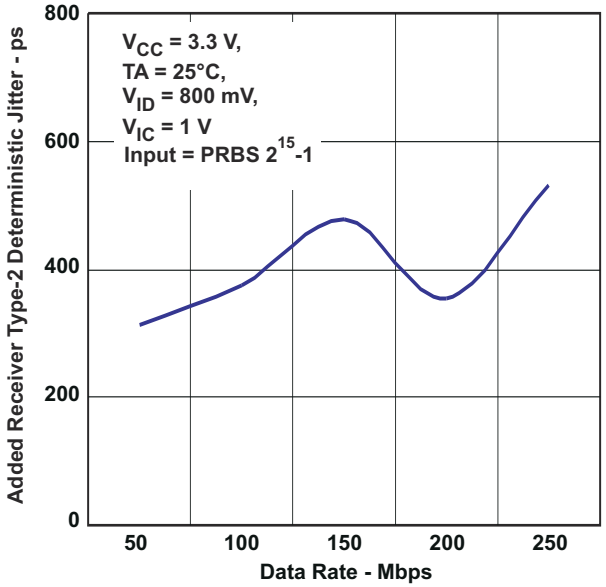


Figure 5-19. Added Reciver Type-1 Deterministic Jitter vs Data Rate

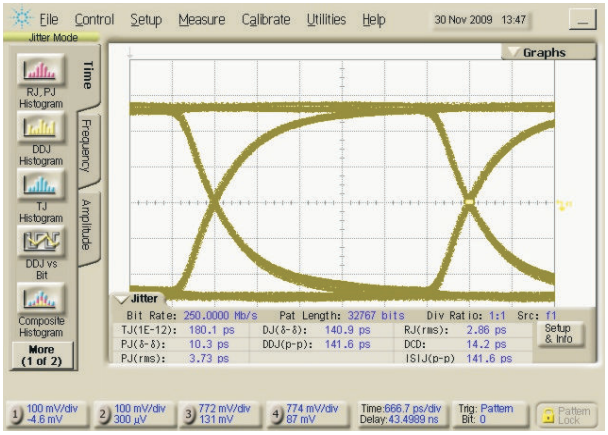


Figure 5-20. Driver Output Eye Pattern 250 Mbps, 2^{15}–1 PRBS, V_{CC} = 3.3 V

5.11 Typical Characteristics (continued)

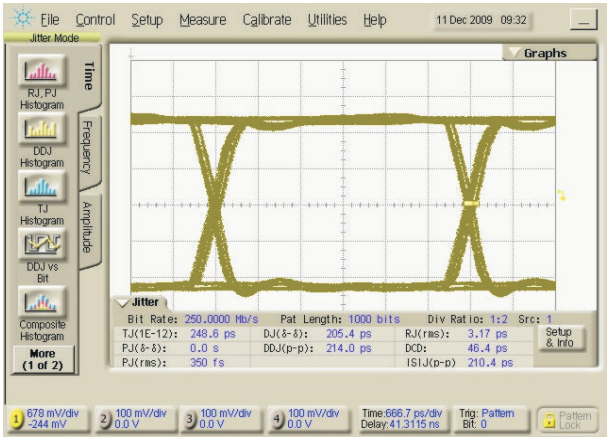


Figure 5-21. Reciver Output Eye Pattern 250 Mbps, 2^{15}–1 PRBS, V_{CC} = 3.3 V|V_{ID}| = 400 mV_{PP}, V_{IC} = 1 V

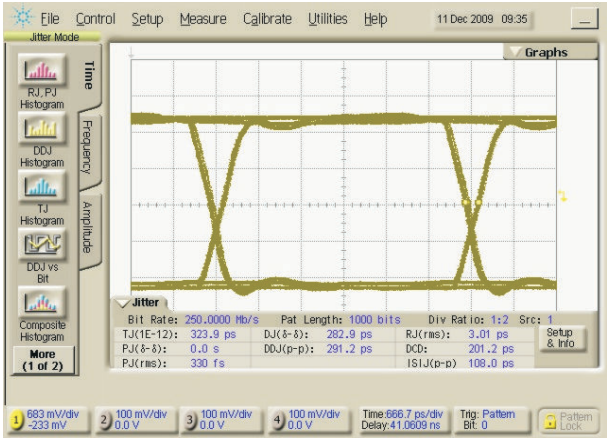


Figure 5-22. Reciver Output Eye Pattern 250 Mbps, 2^{15}–1 PRBS, V_{CC} = 3.3 V|V_{ID}| = 800 mV_{PP}, V_{IC} = 1 V

6 Paramater Measurement Information

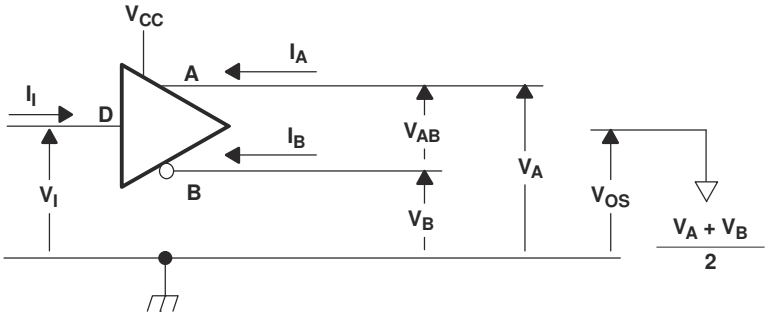
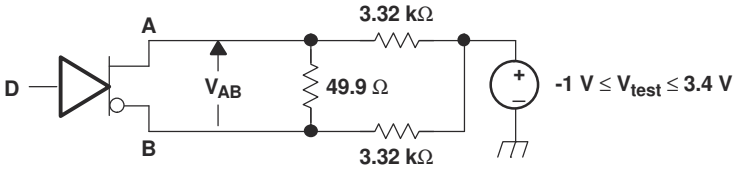
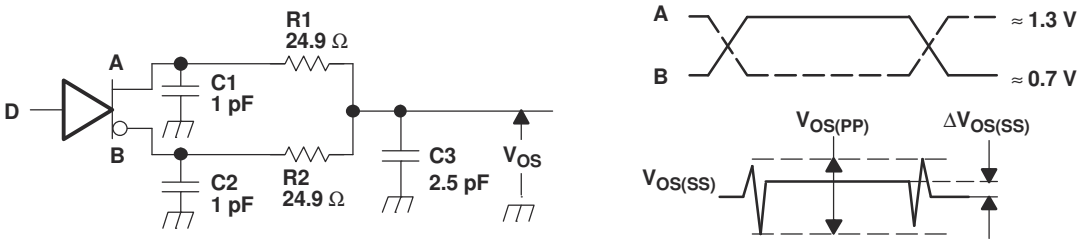


Figure 6-1. Driver Voltage and Current Definitions



All resistors are 1% tolerance.

Figure 6-2. Differential Output Voltage Test Circuit



A. All input pulses are supplied by a generator having the following characteristics: t_r or t_f ≤ 1 ns, pulse frequency = 1 MHz, duty cycle = 50 ±5%.
B. C1, C2 and C3 include instrumentation and fixture capacitance within 2 cm of the D.U.T. and are ±20%.
C. R1 and R2 are metal film, surface mount, ±1%, and located within 2 cm of the D.U.T.
D. The measurement of $V_{OS(PP)}$ is made on test equipment with a –3 dB bandwidth of at least 1 GHz.

Figure 6-3. Test Circuit and Definitions for the Driver Common-Mode Output Voltage

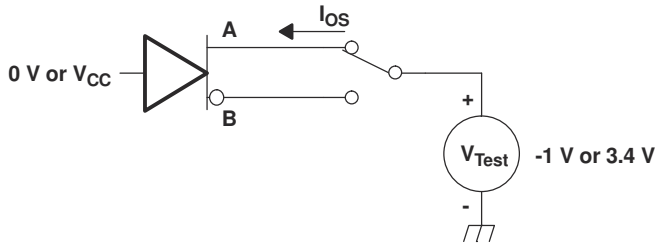
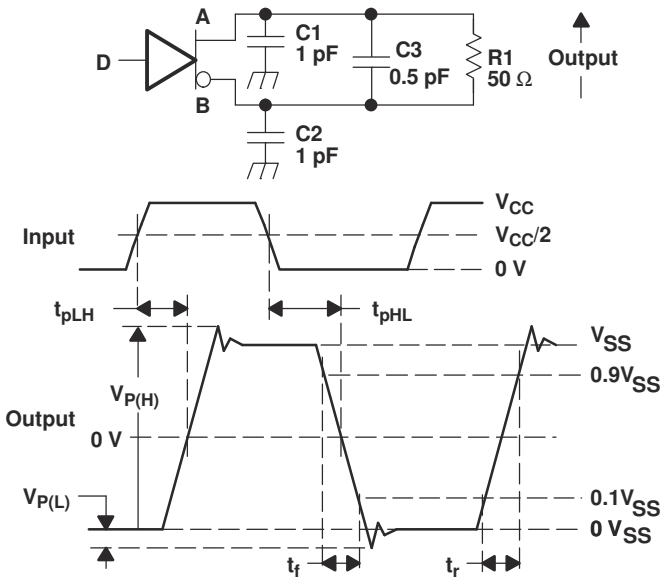
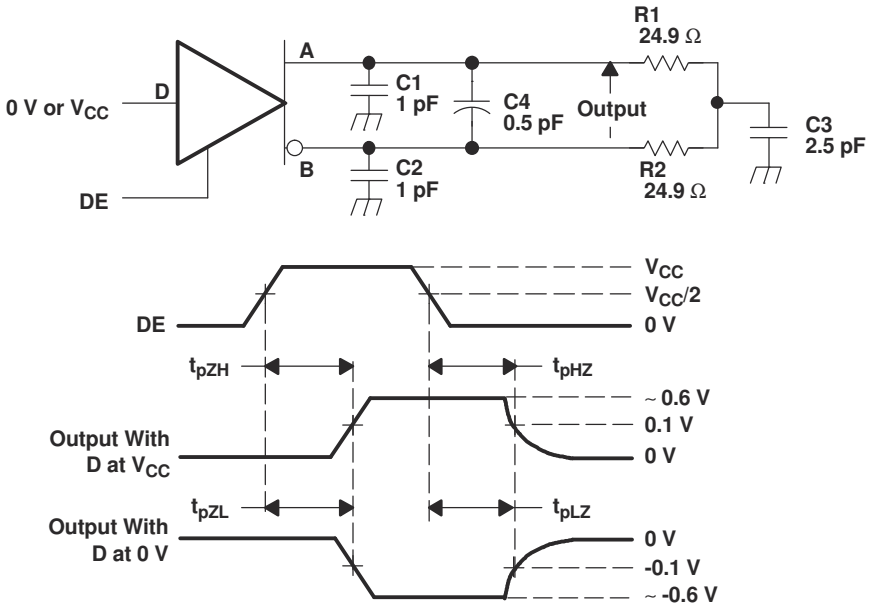


Figure 6-4. Driver Short-Circuit Test Circuit



A. All input pulses are supplied by a generator having the following characteristics: t_r or t_f ≤ 1 ns, frequency = 1 MHz, duty cycle = 50 ±5%.
B. C1, C2, and C3 include instrumentation and fixture capacitance within 2 cm of the D.U.T. and are ±20%.
C. R1 is a metal film, surface mount, and 1% tolerance and located within 2 cm of the D.U.T.
D. The measurement is made on test equipment with a –3 dB bandwidth of at least 1 GHz.

Figure 6-5. Driver Test Circuit, Timing, and Voltage Definitions for the Differential Output Signal



A. All input pulses are supplied by a generator having the following characteristics: t_r or t_f ≤ 1 ns, frequency = 1 MHz, duty cycle = 50 ±5%.
B. C1, C2, C3, and C4 includes instrumentation and fixture capacitance within 2 cm of the D.U.T. and are ±20%.
C. R1 and R2 are metal film, surface mount, and 1% tolerance and located within 2 cm of the D.U.T.
D. The measurement is made on test equipment with a –3 dB bandwidth of at least 1 GHz.

Figure 6-6. Driver Enable and Disable Time Circuit and Definitions

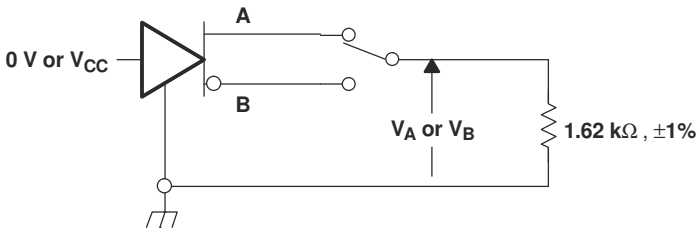
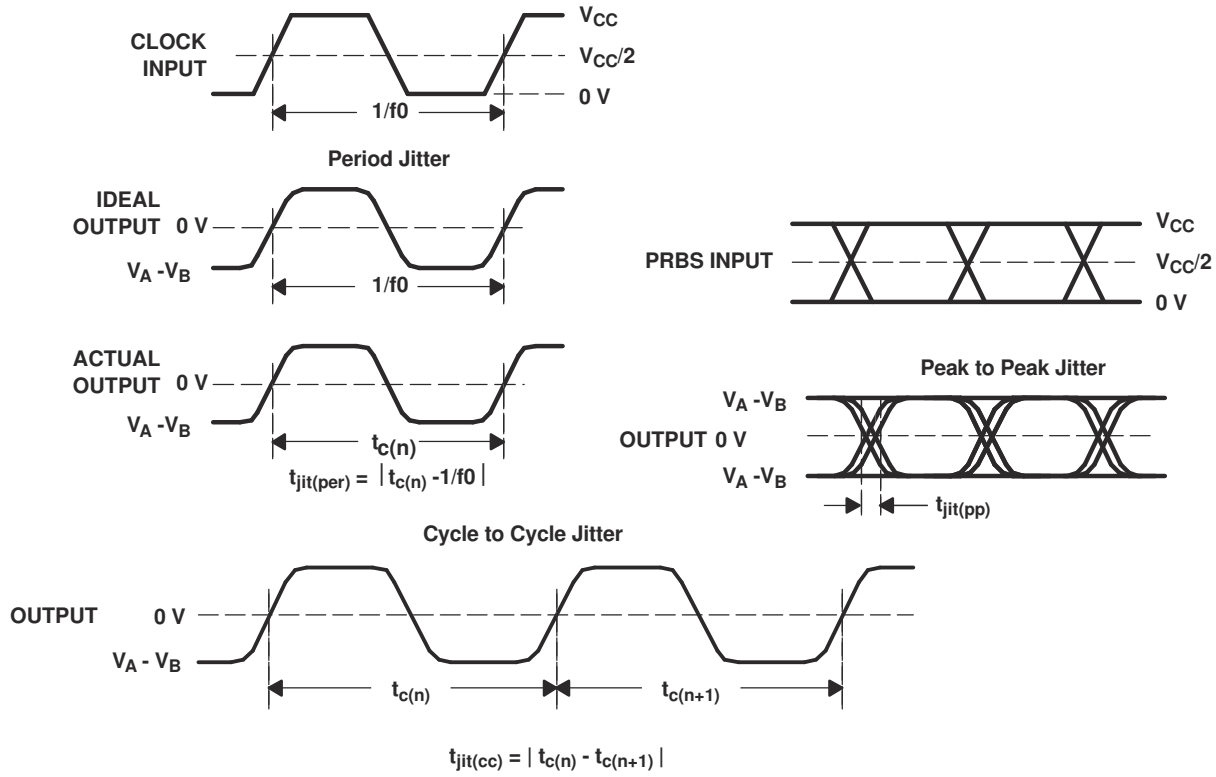


Figure 6-7. Maximum Steady State Output Voltage



A. All input pulses are supplied by the Agilent 81250 Parallel BERT Stimulus System with plug-in E4832A.
B. The cycle-to-cycle measurement is made on a TEK TDS6604 running TDSJIT3 application software.
C. All other jitter measurements are made with an Agilent Infiniium DCA-J 86100C Digital Communications Analyzer.
D. Period jitter and cycle-to-cycle jitter are measured using a 125 MHz 50 ±1% duty cycle clock input. Measured over 75K samples.
E. Deterministic jitter and random jitter are measured using a 250 Mbps 2^{15}–1 PRBS input. Measured over BER = 10^{-12}

Figure 6-8. Driver Jitter Measurement Waveforms

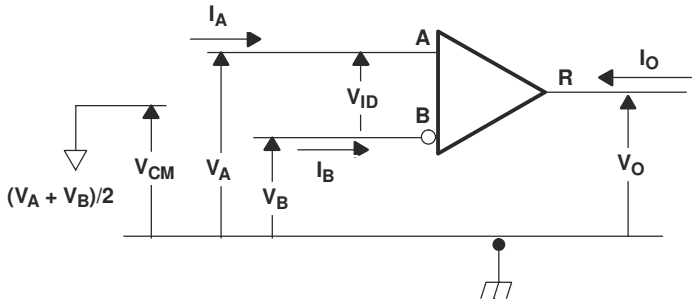


Figure 6-9. Receiver Voltage and Current Definitions

Table 6-1. Type-1 Receiver Input Threshold Test Voltages

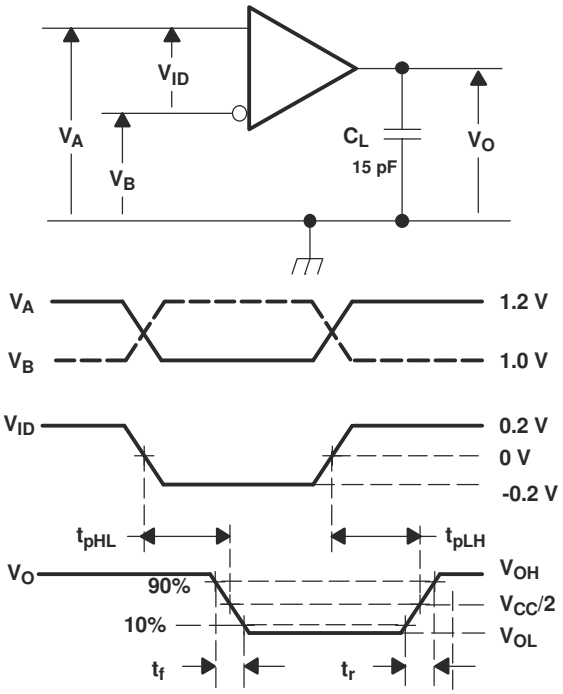
APPLIED VOLTAGES		RESULTING DIFFERENTIAL INPUT VOLTAGE	RESULTING COMMON-MODE INPUT VOLTAGE	RECEIVER OUTPUT(1)
V_{IA}	V_{IB}	V_{ID}	V_{IC}	
2.400	0.000	2.400	1.200	H
0.000	2.400	–2.400	1.200	L
3.400	3.365	0.035	3.3825	H
3.365	3.400	–0.035	3.3825	L
–0.965	–1	0.035	–0.9825	H
–1	–0.965	–0.035	–0.9825	L

(1) H= high level, L = low level, output state assumes receiver is enabled ($\overline{RE}$ = L)

Table 6-2. Type-2 Receiver Input Threshold Test Voltages

APPLIED VOLTAGES		RESULTING DIFFERENTIAL INPUT VOLTAGE	RESULTING COMMON-MODE INPUT VOLTAGE	RECEIVER OUTPUT(1)
V_{IA}	V_{IB}	V_{ID}	V_{IC}	
2.400	0.000	2.400	1.200	H
0.000	2.400	–2.400	1.200	L
3.400	3.265	0.135	3.3325	H
3.4000	3.335	0.065	3.3675	L
–0.865	–1	0.135	–0.9325	H
–0.935	–1	0.065	–0.9675	L

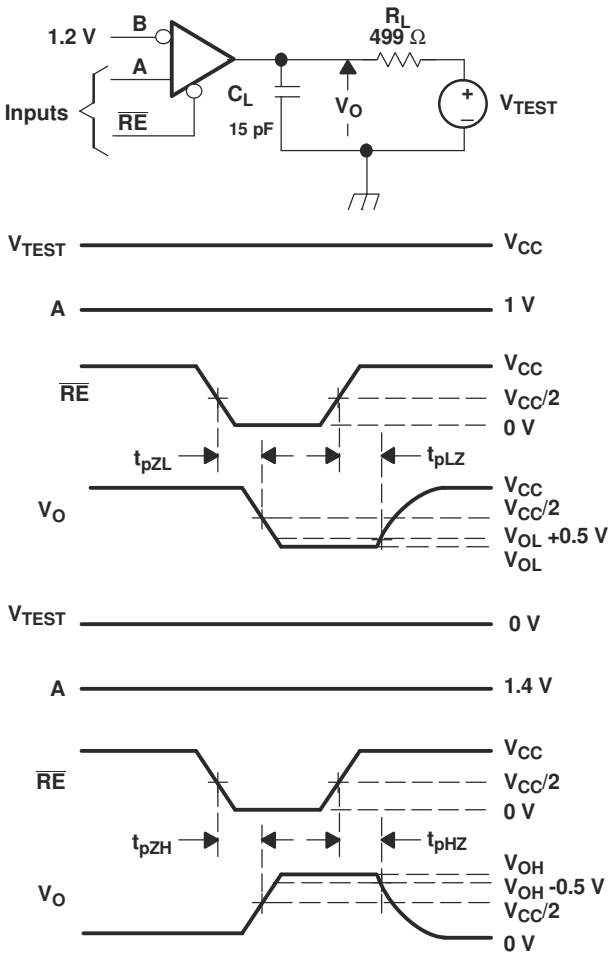
(1) H= high level, L = low level, output state assumes receiver is enabled ($\overline{RE}$ = L)



A. All input pulses are supplied by a generator having the following characteristics: t_r or t_f ≤ 1 ns, frequency = 1 MHz, duty cycle = 50 ±5%. C_L is a combination of a 20%-tolerance, low-loss ceramic, surface-mount capacitor and fixture capacitance within 2 cm of the D.U.T.

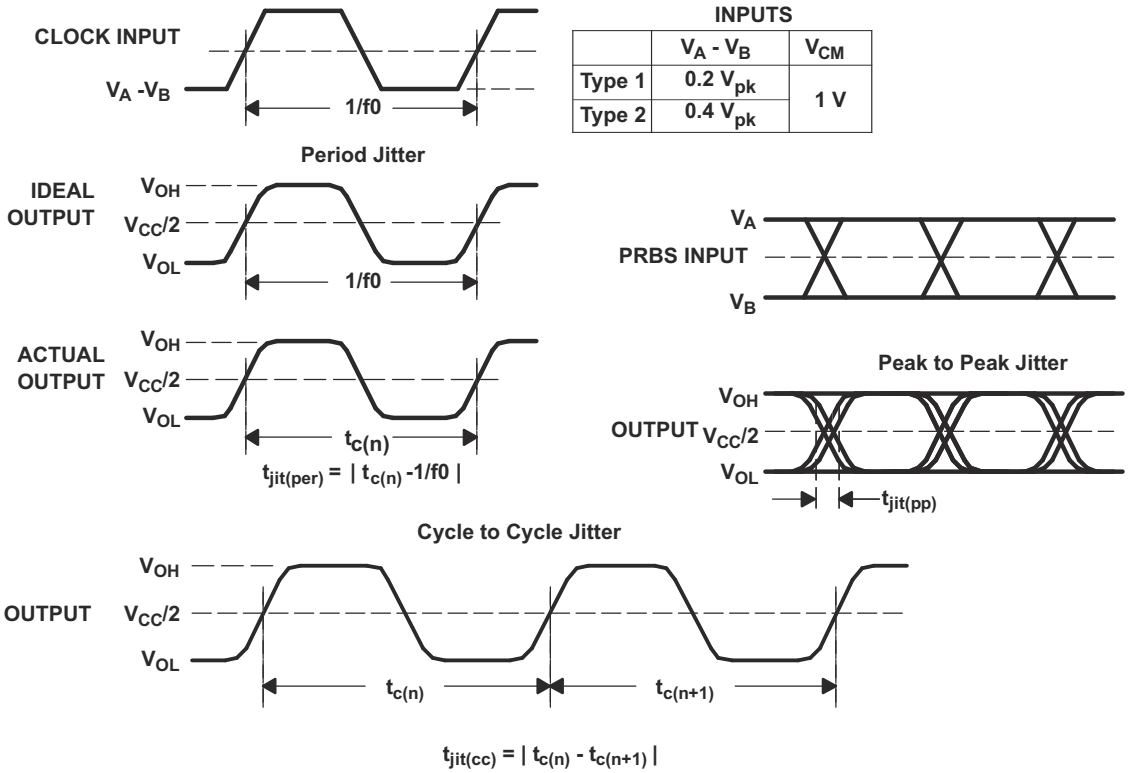
B. The measurement is made on test equipment with a –3 dB bandwidth of at least 1 GHz.

Figure 6-10. Receiver Timing Test Circuit and Waveforms



A. All input pulses are supplied by a generator having the following characteristics: t_r or t_f≤ 1 ns, frequency = 1 MHz, duty cycle = 50 ± 5%.
B. R_L is 1% tolerance, metal film, surface mount, and located within 2 cm of the D.U.T.
C. C_L is the instrumentation and fixture capacitance within 2 cm of the DUT and ±20%. The measurement is made on test equipment with a –3 dB bandwidth of at least 1 GHz.

Figure 6-11. Receiver Enable/Disable Time Test Circuit and Waveforms

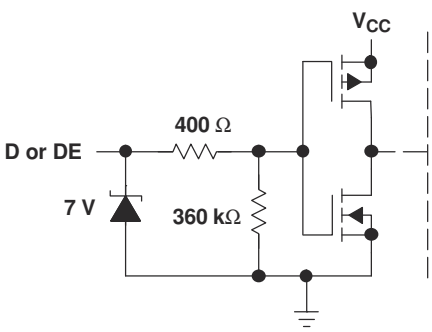


A. All input pulses are supplied by the Agilent 81250 Parallel BERT Stimulus System with plug-in E4832A.
B. The cycle-to-cycle measurement is made on a TEK TDS6604 running TDSJIT3 application software.
C. All other jitter measurements are made with an Agilent Infiniium DCA-J 86100C Digital Communications Analyzer.
D. Period jitter and cycle-to-cycle jitter are measured using a 125 MHz 50 ±1% duty cycle clock input. Measured over 75K samples.
E. Deterministic jitter and random jitter are measured using a 250 Mbps 2^{15}–1 PRBS input. Measured over BER = 10^{-12}

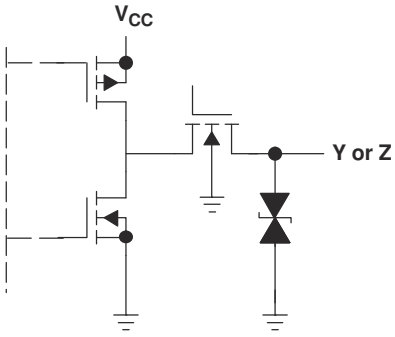
Figure 6-12. Receiver Jitter Measurement Waveforms

6.1 Equivalent Input and Output Schematic Diagrams

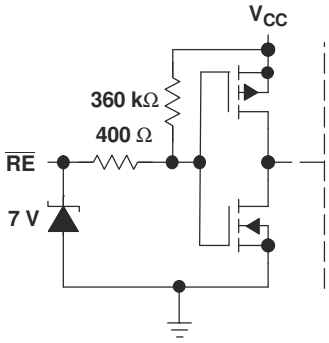
DRIVER INPUT AND DRIVER ENABLE



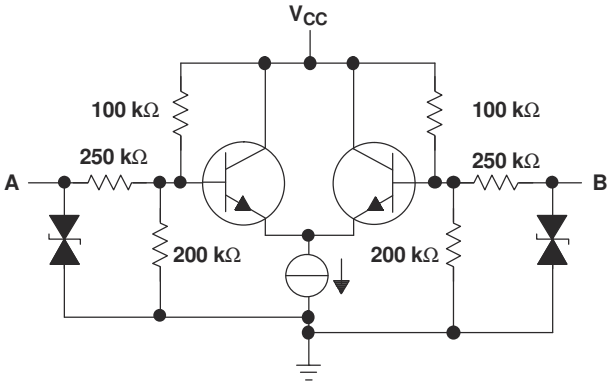
DRIVER OUTPUT



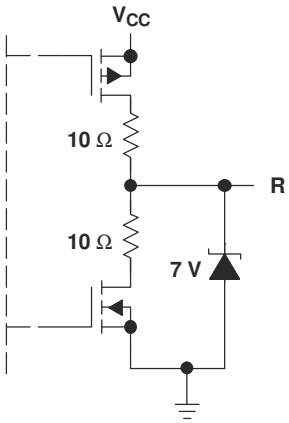
RECEIVER ENABLE



RECEIVER INPUT



RECEIVER OUTPUT



7 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.

7.1 Application Information

7.1.1 Source Synchronous System Clock (SSSC)

There are two approaches to transmit data in a synchronous system: centralized synchronous system clock (CSSC) and source synchronous system clock (SSSC). CSSC systems synchronize data transmission between different modules using a clock signal from a centralized source. The key requirement for a CSSC system is for data transmission and reception to complete during a single clock cycle. The maximum operating frequency is the inverse of the shortest clock cycle for which valid data transmission and reception can be ensured. SSSC systems achieve higher operating frequencies by sending clock and data signals together to eliminate the flight time on the transmission media, backplane, or cables. In SSSC systems, the maximum operating frequency is limited by the cumulated skews that can exist between clock and data. The absolute flight time of data on the backplane does not provide a limitation on the operating frequency as it does with CSSC.

The SN65MLVD082 can be designed for interfacing the data and clock to support source synchronous system clock (SSSC) operation. It is specified for transmitting data up to 250 Mbps and clock frequencies up to 125 MHz. Figure 7-1 shows an example of a SSSC architecture supported by M-LVDS transceivers. The SN65MLVD206, a single channel transceiver, transmits the main system clock between modules. A retiming unit is then applied to the main system clock to generate a local clock for subsystem synchronization processing. System operating data (or control) and subsystem clock signals are generated from the data processing unit, such as a microprocessor, FPGA, or ASIC, on module 1, and sent to slave modules through the SN65MLVD082. Such design configurations are common while transmitting parallel control data over the backplane with a higher SSSC subsystem clock frequency. The subsystem clock frequency is aligned with the operating frequencies of the data processing unit to synchronize data transmission between different units.

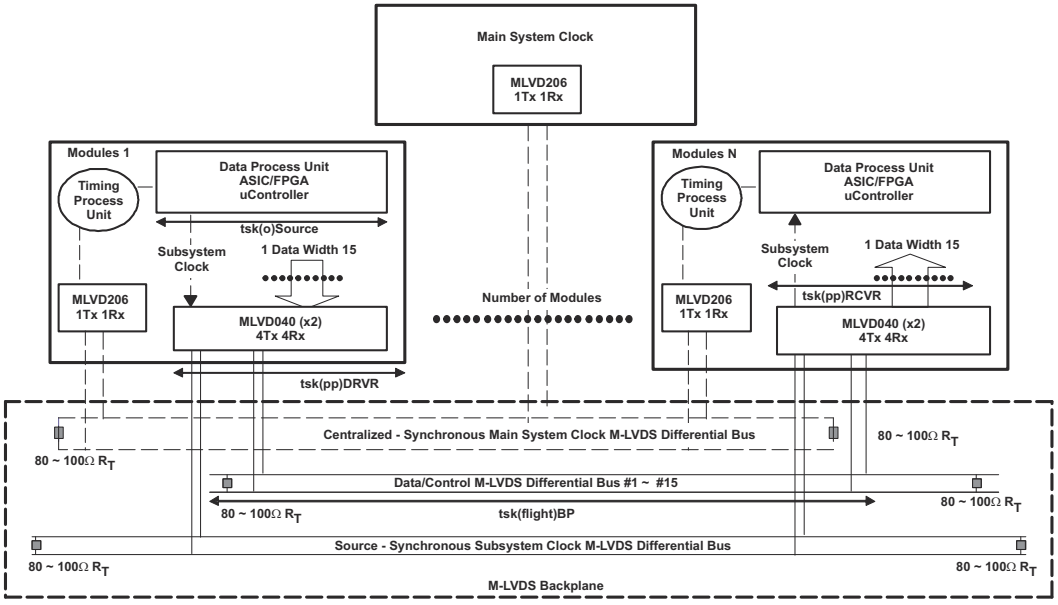


Figure 7-1. Using Differential M-LVDS to Perform Source Synchronous System Clock Distribution

The maximum SSSC frequencies in a transparent mode can be calculated with Equation 1:

$$f_{max(clk)} < 1/[\ t_{sk(o)Source} + t_{sk(pp)DRVR} + t_{sk(flight)BP} + t_{sk(pp)RCVR} \quad (1)$$

Setup time and hold time on the receiver side are decided by the data processing unit, FPGA, or ASIC in this example. By considering data passes through the transceiver only, the general calculation result is 238 MHz when using the following data:

$t_{sk(o)Source}$ = 2 ns – Output skew of data processing unit; any skew between data bits, or clock and data bits

$t_{sk(pp)DRVR}$ = 0.6 ns – Driver part-to-part skew of the SN65MLVD040

$t_{sk(flight)BP}$ = 0.4 ns – Skew of propagation delay on the backplane between data and clock

$t_{sk(pp)RCVR}$ = 1 ns – Receiver part-to-part skew of the SN65MLVD040

The 238-MHz maximum operating speed calculated above was determined based on data and clock skews only. Another important consideration when calculating the maximum operating speed is output transition time. Transition-time-limited operating speed is calculated from Equation 2:

$$f = 45\% \times \frac{1}{2 \times t_{transition}} \quad (2)$$

Using the typical transition time of the SN65MLVD040 of 1.4 ns, a transition-time-limited operating frequency of 170 MHz can be supported.

In addition to the high operating frequencies of SSSC that can be ensured, the SN65MLVD040 presents other benefits as other M-LVDS bus transceivers can provide:

- Robust system operation due to common mode noise cancellation using a low voltage differential receiver
- Low EMI radiation noise due to differential signaling improves signal integrity through the backplane
- A singly terminated transmission line is easy to design and implement
- Low power consumption in both active and idle modes minimizes thermal concerns on each module

In dense backplane design, these benefits are important for improving the performance of the whole system.

7.1.1.1 Live Insertion/Glitch-Free Power Up/Down

The SN65MLVD040 family of products offered by Texas Instruments provides a glitch-free powerup/down feature that prevents the M-LVDS outputs of the device from turning on during a powerup or powerdown event. This is especially important in live insertion applications, when a device is physically connected to an M-LVDS multipoint bus and V_{CC} is ramping.

While the M-LVDS interface for these devices is glitch free on powerup/down, the receiver output structure is not. Figure 7-2 shows the performance of the receiver output pin, R (CHANNEL 2), as V_{CC} (CHANNEL 1) is ramped.

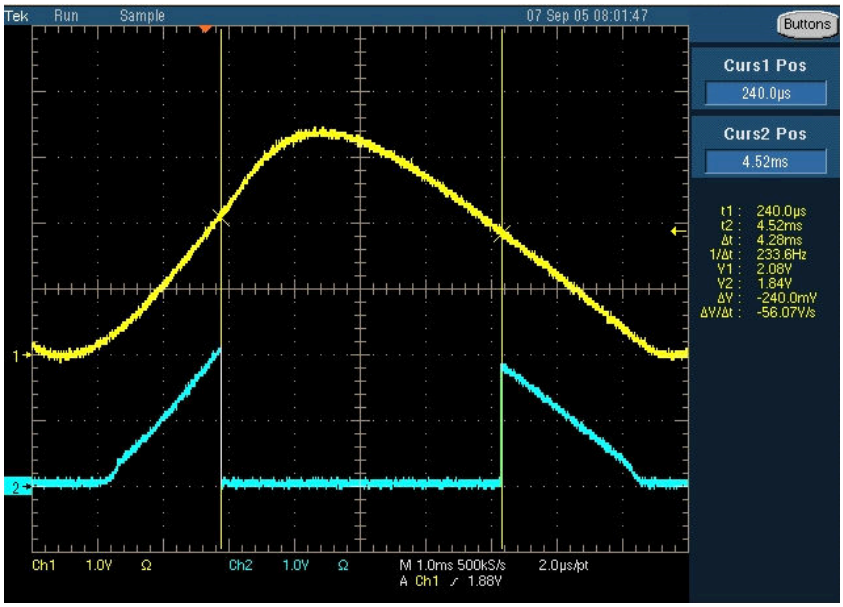


Figure 7-2. M-LVDS Receiver Output: V_{CC} (CHANNEL 1), R Pin (CHANNEL 2)

The glitch on the R pin is independent of the $\overline{RE}$ voltage. Any complications or issues from this glitch are resolved in power sequencing or system requirements that suspend operation until V_{CC} has reached a steady state value.

8 Device and Documentation Support

TI offers an extensive line of development tools. Tools and software to evaluate the performance of the device, generate code, and develop solutions are listed below.

8.1 Documentation Support

8.2 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.

8.3 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.

8.4 Trademarks

PowerPAD™ and TI E2E™ are trademarks of Texas Instruments.
All trademarks are the property of their respective owners.

8.5 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.

8.6 Glossary

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

9 Revision History

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

Changes from Revision * (Febuary 2010) to Revision A (March 2024)	Page
• Updated the numbering format for tables, figures, and cross-references throught the document.....	1

10 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)
SN65MLVD040RGZR	Active	Production	VQFN (RGZ) | 48	2500 | LARGE T&R	Yes	NIPDAU	Level-3-260C-168 HR	-40 to 85	MLVD040
SN65MLVD040RGZR.B	Active	Production	VQFN (RGZ) | 48	2500 | LARGE T&R	Yes	NIPDAU	Level-3-260C-168 HR	-40 to 85	MLVD040
SN65MLVD040RGZT	Active	Production	VQFN (RGZ) | 48	250 | SMALL T&R	Yes	NIPDAU	Level-3-260C-168 HR	-40 to 85	MLVD040
SN65MLVD040RGZT.B	Active	Production	VQFN (RGZ) | 48	250 | SMALL T&R	Yes	NIPDAU	Level-3-260C-168 HR	-40 to 85	MLVD040
SN65MLVD040RGZTG4	Active	Production	VQFN (RGZ) | 48	250 | SMALL T&R	Yes	NIPDAU	Level-3-260C-168 HR	-40 to 85	MLVD040
SN65MLVD040RGZTG4.B	Active	Production	VQFN (RGZ) | 48	250 | SMALL T&R	Yes	NIPDAU	Level-3-260C-168 HR	-40 to 85	MLVD040

(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.

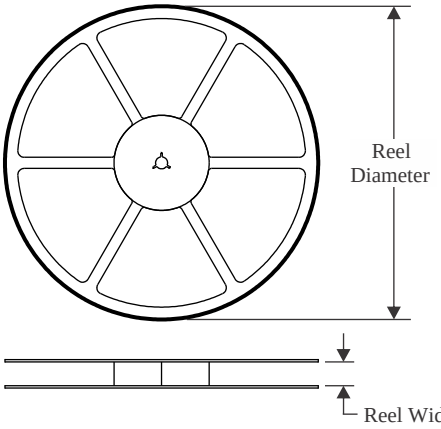
(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will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

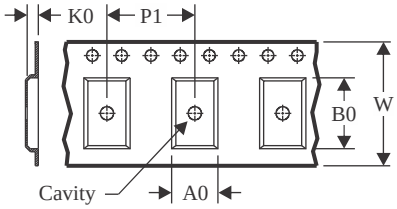
Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

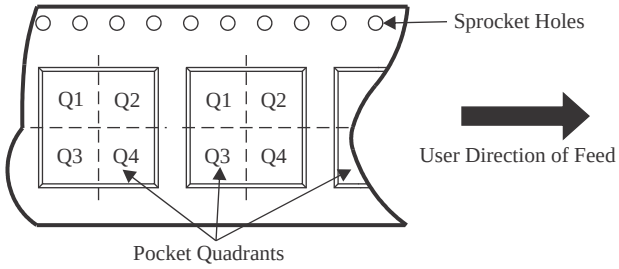


TAPE DIMENSIONS



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

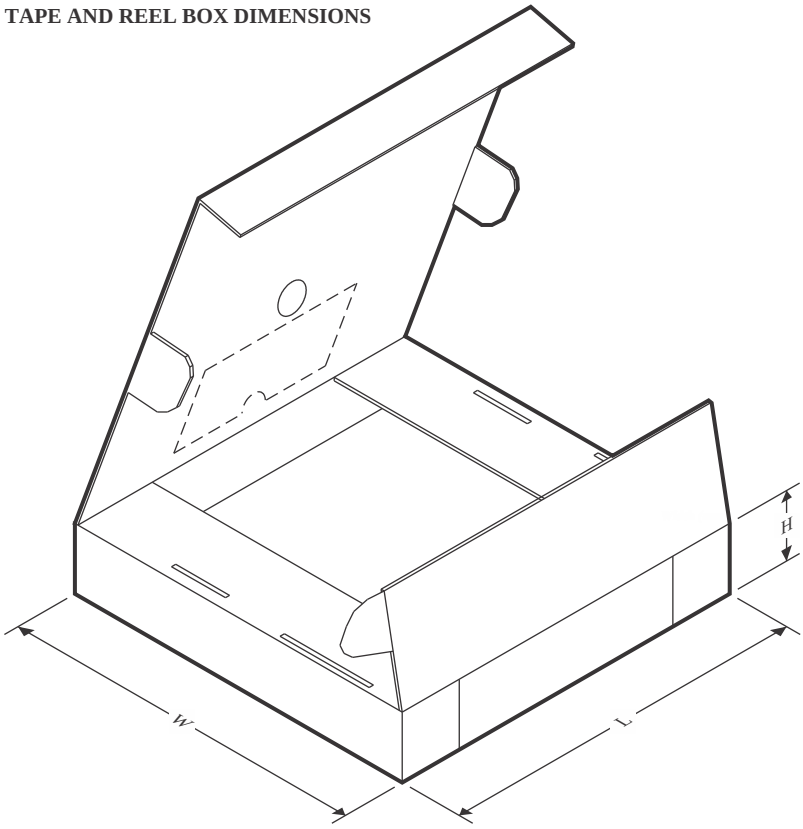
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
SN65MLVD040RGZR	VQFN	RGZ	48	2500	330.0	16.4	7.3	7.3	1.5	12.0	16.0	Q2
SN65MLVD040RGZT	VQFN	RGZ	48	250	180.0	16.4	7.3	7.3	1.5	12.0	16.0	Q2
SN65MLVD040RGZTG4	VQFN	RGZ	48	250	180.0	16.4	7.3	7.3	1.5	12.0	16.0	Q2

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
SN65MLVD040RGZR	VQFN	RGZ	48	2500	353.0	353.0	32.0
SN65MLVD040RGZT	VQFN	RGZ	48	250	213.0	191.0	35.0
SN65MLVD040RGZTG4	VQFN	RGZ	48	250	213.0	191.0	35.0

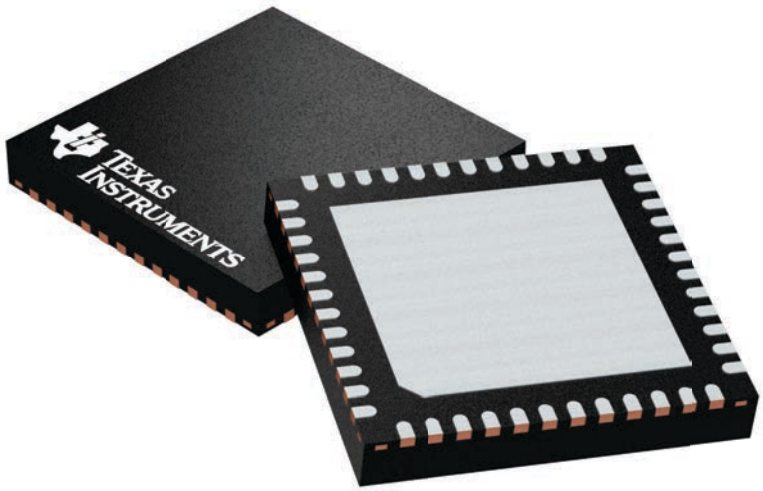
GENERIC PACKAGE VIEW

RGZ 48

VQFN - 1 mm max height

7 x 7, 0.5 mm pitch

PLASTIC QUADFLAT PACK- NO LEAD



Images above are just a representation of the package family, actual package may vary.
Refer to the product data sheet for package details.

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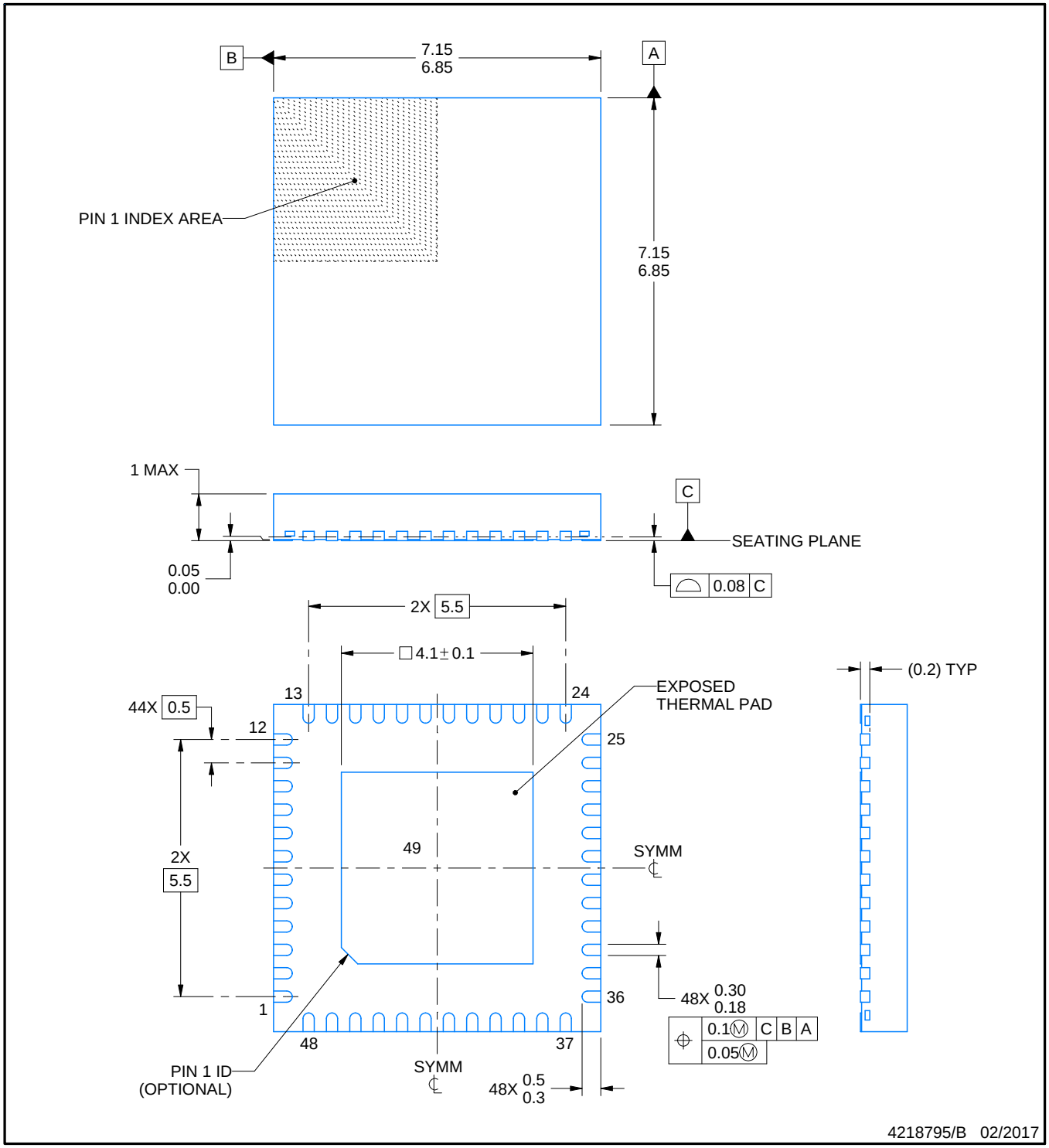
RGZ0048B

PACKAGE OUTLINE

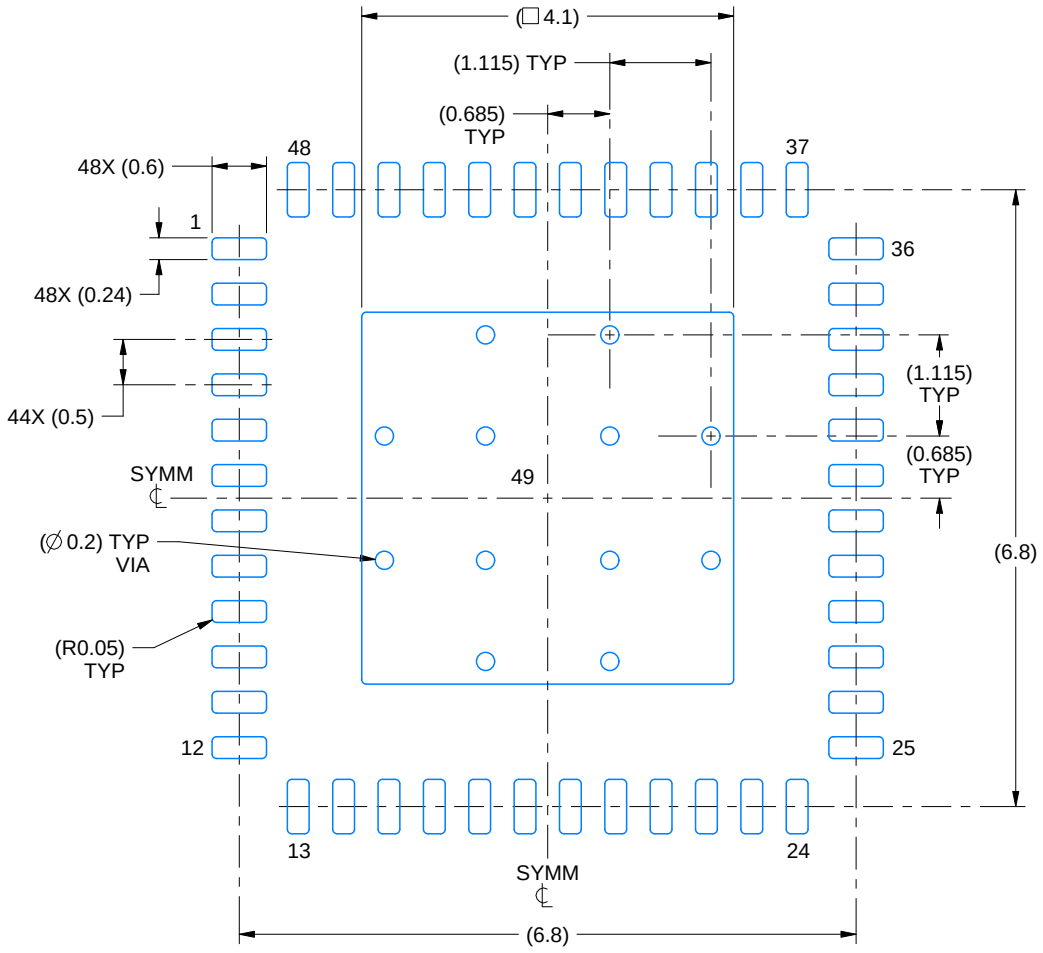
VQFN - 1 mm max height

PLASTIC QUAD FLATPACK - NO LEAD

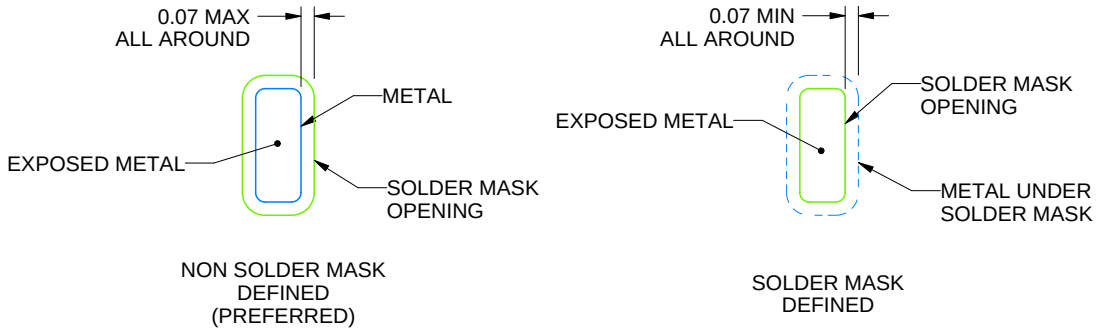


NOTES:

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. The package thermal pad must be soldered to the printed circuit board for thermal and mechanical performance.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:12X



SOLDER MASK DETAILS

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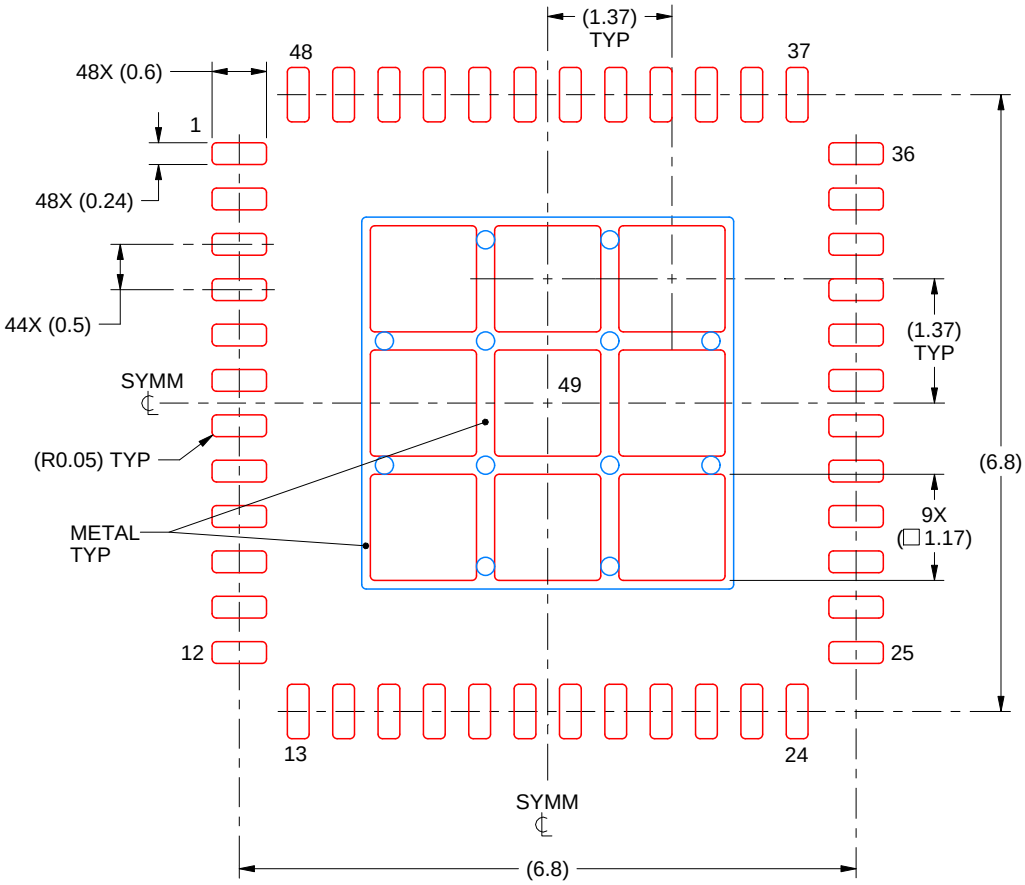
NOTES: (continued)

4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 (www.ti.com/lit/slua271).
5. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL

EXPOSED PAD 49
73% PRINTED SOLDER COVERAGE BY AREA UNDER PACKAGE
SCALE:12X

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NOTES: (continued)

6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.

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