

QUAD CHANNEL M-LVDS RECEIVERS

Check for Samples: [SN65MLVD048](#)

FEATURES

- Low-Voltage Differential 30-Ω to 55-Ω Line Receivers for Signaling Rates⁽¹⁾ up to 250Mbps; Clock Frequencies up to 125MHz
- Type-1 Receiver Incorporates 25 mV of Input Threshold Hysteresis
- Type-2 Receiver Provides 100 mV Offset Threshold to Detect Open-Circuit and Idle-Bus Conditions
- Wide Receiver Input Common-Mode Voltage Range, -1 V to 3.4 V, Allows 2 V of Ground Noise
- Meets or Exceeds the M-LVDS Standard TIA/EIA-899 for Multipoint Topology
- High Input Impedance when $V_{CC} \leq 1.5V$
- Enhanced ESD Protection: 7 kV HBM on all pins
- 48-Pin 7 X 7 QFN (RGZ)

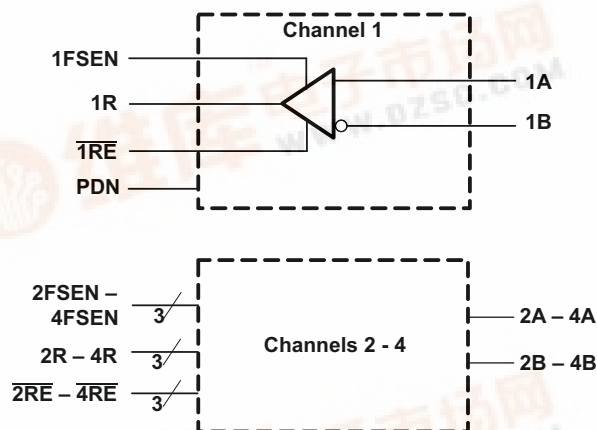
⁽¹⁾ The signaling rate of a line is the number of voltage transitions that are made per second, expressed in the units bps (bits per second).

APPLICATIONS

- Parallel Multipoint Data and Clock Transmission via Backplanes and Cables
- Cellular Base Stations
- Central Office Switches
- Network Switches and Routers

LOGIC DIAGRAM (POSITIVE LOGIC)

LOGIC DIAGRAM (POSITIVE LOGIC)
SN65MLVD048



DESCRIPTION

The SN65MLVD048 is a quad-channel M-LVDS receiver. This device is designed in full compliance with the TIA/EIA-899 (M-LVDS) standard, which is optimized to operate at signaling rates up to 250 Mbps. Each receiver channel is controlled by a receive enable (\overline{RE}). When \overline{RE} = low, the corresponding channel is enabled; when \overline{RE} = high, the corresponding channel is disabled.

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 25 mV of hysteresis to prevent output oscillations with loss of input; Type-2 receivers implement a failsafe by using an offset threshold. Receiver outputs are slew rate controlled to reduce EMI and crosstalk effects associated with large current surges.

The devices are characterized for operation from -40°C to 85°C.



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PRODUCTION DATA information is current as of publication date. Products conform to specifications per the terms of the Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.

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These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

PIN FUNCTIONS

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

RGZ PACKAGE (TOP VIEW)

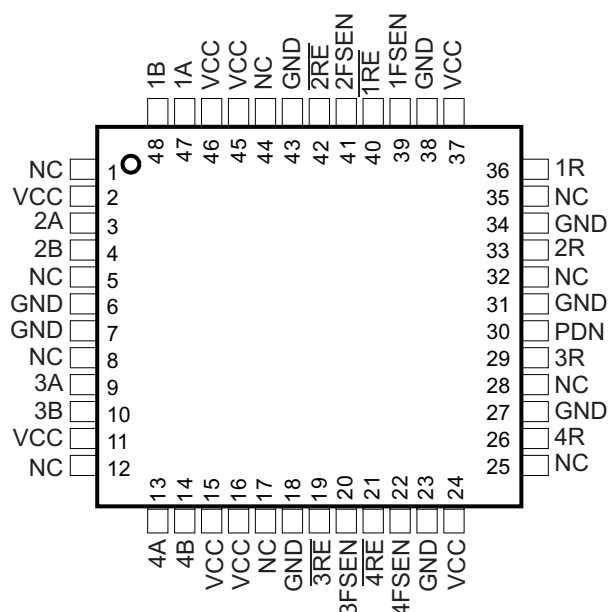


Table 1. DEVICE FUNCTION TABLE

INPUTS ⁽¹⁾				RECEIVER TYPE	OUTPUT ⁽¹⁾
$V_{ID} = V_A - V_B$	PDN	FSEN	\overline{RE}		R
$V_{ID} > 35\text{ mV}$	H	L	L	Type 1	H
$-35\text{ mV} \leq V_{ID} \leq 35\text{ mV}$	H	L	L	Type 1	?
$V_{ID} < -35\text{ mV}$	H	L	L	Type 1	L
$V_{ID} > 135\text{ mV}$	H	H	L	Type 2	H
$65\text{ mV} \leq V_{ID} \leq 135\text{ mV}$	H	H	L	Type 2	?
$V_{ID} < 65\text{ mV}$	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

ORDERING INFORMATION⁽¹⁾

PART NUMBER	FUNCTION	PART MARKING	PACKAGE / CARRIER
SN65MLVD048RGZR	M-LVDS Type 1 and 2 Receiver	MLVD048	48-Pin QFN / Tape and Reel
SN65MLVD048RGZT		MLVD048	48-Pin QFN / Small Tape and Reel

(1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI website at www.ti.com.

PACKAGE DISSIPATION RATINGS⁽¹⁾

PACKAGE	PCB TYPE	$T_A \leq 25^\circ\text{C}$ POWER RATING	DERATING FACTOR ⁽²⁾ ABOVE $T_A = 25^\circ\text{C}$	$T_A = 85^\circ\text{C}$ POWER RATING
48-Pin QFN (RGZ)	Low-K	1298 mW	12.98 mW/°C	519 mW
	High-K	3448 mW	34.48 mW/°C	1379 mW

(1) The thermal dissipations are in the consideration of soldering down the powerPAD without via on each type of boards.

(2) This is the inverse of the junction-to-ambient thermal resistance when board-mounted and with no air flow.

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	\overline{RE} at 0 V, $C_L = 15\text{ pF}$, $V_{ID} = 400\text{ mV}$, 125 MHz			339	mW

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ABSOLUTE MAXIMUM RATINGS

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

			VALUE	UNIT
V _{CC}	Supply voltage range ⁽²⁾		−0.5 to 4	V
Input voltage range	\overline{RE} , FSEN		−0.5 to 4	V
	A or B		−1.8 to 4	V
Output voltage range	R		−0.3 to 4	V
Electrostatic discharge	Human-body model ⁽³⁾	All other pins	±7	kV
	Charged-device model ⁽⁴⁾	All pins	±1.5	kV

(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 EIA-JEDEC JESD22-C101D.

RECOMMENDED OPERATING CONDITIONS

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

		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
V _A or V _B	Voltage at any bus terminal	−1.4		3.8	V
V _{ID}	Magnitude of differential input voltage	0.05		V _{CC}	V
V _{IC}	Differential common-mode input voltage	−1		3.4	V
R _L	Differential load resistance	30	50		Ω
1/t _{UI}	Signaling rate			250	Mbps
T _A	Operating free-air temperature	−40		85	°C

DEVICE ELECTRICAL CHARACTERISTICS

over recommended operating conditions (unless otherwise noted)

PARAMETER	TEST CONDITIONS	MIN	TYP ⁽¹⁾	MAX	UNIT
I _{CC}	Supply current \overline{RE} at 0 V for all channels C _L = 15 pF, V _{ID} = 400 mV, 125 MHz		86	94	mA
Power down	PDN = L		0.75	1.5	mA

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

RECEIVER ELECTRICAL CHARACTERISTICS

over recommended operating conditions (unless otherwise noted)

PARAMETER			TEST CONDITIONS	MIN	TYP ⁽¹⁾	MAX	UNIT
V _{IT+}	Positive-going differential input voltage threshold	Type 1	See Table 2 and Table 3			35	mV
		Type 2				135	
V _{IT-}	Negative-going differential input voltage threshold	Type 1				–35	mV
		Type 2				65	
V _{HYS}	Differential input voltage hysteresis (V _{IT+} – V _{IT-})	Type 1				25	mV
		Type 2				0	
V _{OH}	High-level output voltage		I _{OH} = –8 mA	2.4			V
V _{OL}	Low-level output voltage		I _{OL} = 8 mA			0.4	V
I _{IH}	High-level input current		V _{IH} = 2 V to V _{CC}	–10			μA
I _{IL}	Low-level input current		V _{IL} = GND to 0.8 V	–10			μA
I _{OZ}	High-impedance output current		V _O = 0 V or V _{CC}	–10		15	μA
I _A or I _B	Receiver input current		One input (V _A or V _B) = –1.4 V or 3.8 V, Other input = 1.2 V	–20		20	μA
I _{AB}	Receiver differential input current (I _A – I _B)		V _A = V _B = –1.4 V or 3.8 V	–4		4	μA
I _{A(OFF)} or I _{B(OFF)}	Receiver input current		One input (V _A or V _B) = –1.4 V or 3.8 V, Other input = 1.2 V, V _{CC} = GND or 1.5 V	–32		32	μA
I _{AB(OFF)}	Receiver power-off differential input current (I _A – I _B)		V _A = V _B = –1.4 V or 3.8 V, V _{CC} = GND or 1.5 V	–4		4	μA
C _A or C _B	Input capacitance		V _I = 0.4sin(30E6πt) + 0.5V, ⁽²⁾ Other input at 1.2 V		5		pF
C _{AB}	Differential input capacitance		V _{AB} = 0.4sin(30E6πt) + 0.5 V ⁽²⁾			3	pF
C _{A/B}	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)

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RECEIVER SWITCHING CHARACTERISTICS

over recommended operating conditions (unless otherwise noted)

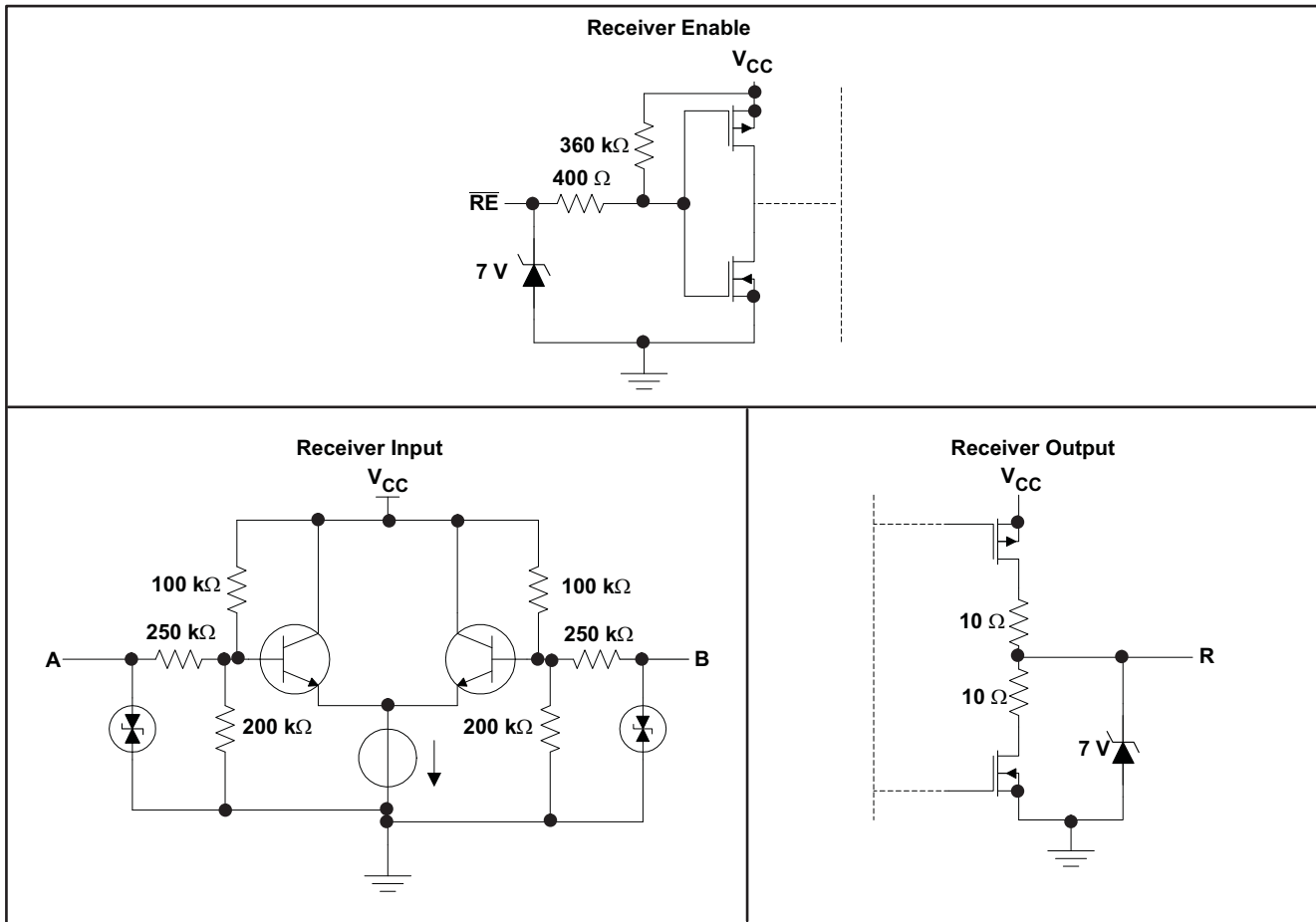
PARAMETER			TEST CONDITIONS	MIN	TYP ⁽¹⁾	MAX	UNIT
t _{PLH}	Propagation delay time, low-to-high-level output		C _L = 15 pF, See Figure 2	2		6	ns
t _{PHL}	Propagation delay time, high-to-low-level output			2		6	ns
t _r	Output signal rise time			1		2.3	
t _f	Output signal fall time			1		2.3	ns
t _{sk(p)}	Pulse skew (t _{PHL} – t _{PLH})	Type 1			35	270	ps
		Type 2			150	460	
t _{sk(pp)}	Part-to-part skew					800	ps
t _{jit(per)}	Period jitter, rms (1 standard deviation) ⁽²⁾		All channels switching, 125 MHz clock input ⁽³⁾ , See Figure 4			6	ps
t _{jit(c-c)}	Cycle-to-cycle jitter, rms ⁽²⁾					13	ps
t _{jit(det)}	Deterministic jitter ⁽²⁾	Type 1	All channels switching, 250 Mbps 2 ¹⁵ -1 PRBS input ⁽³⁾ , See Figure 4			800	ps
		Type 2				945	ps
t _{jit(ran)}	Random jitter ⁽²⁾	Type 1				9	ps
		Type 2				8	ps
t _{PZH}	Enable time, high-impedance-to-high-level output		C _L = 15 pF, See Figure 3			15	ns
t _{PZL}	Enable time, high-impedance-to-low-level output		C _L = 15 pF, See Figure 3			15	ns
t _{PHZ}	Disable time, high-level-to-high-impedance output		C _L = 15 pF, See Figure 3			10	ns
t _{PLZ}	Disable time, low-level-to-high-impedance output		C _L = 15 pF, See Figure 3			10	ns

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

(2) Jitter is ensured by design and characterization. Stimulus jitter has been subtracted from the numbers.

(3) $t_r = t_f = 0.5\text{ ns}$ (10% to 90%)

EQUIVALENT INPUT AND OUTPUT SCHEMATIC DIAGRAMS



PARAMETER MEASUREMENT INFORMATION

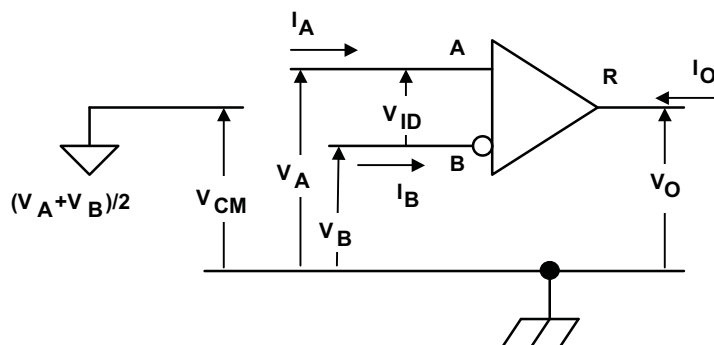


Figure 1. Receiver Voltage and Current Definitions

Table 2. Type-1 Receiver Input Threshold Test Voltages

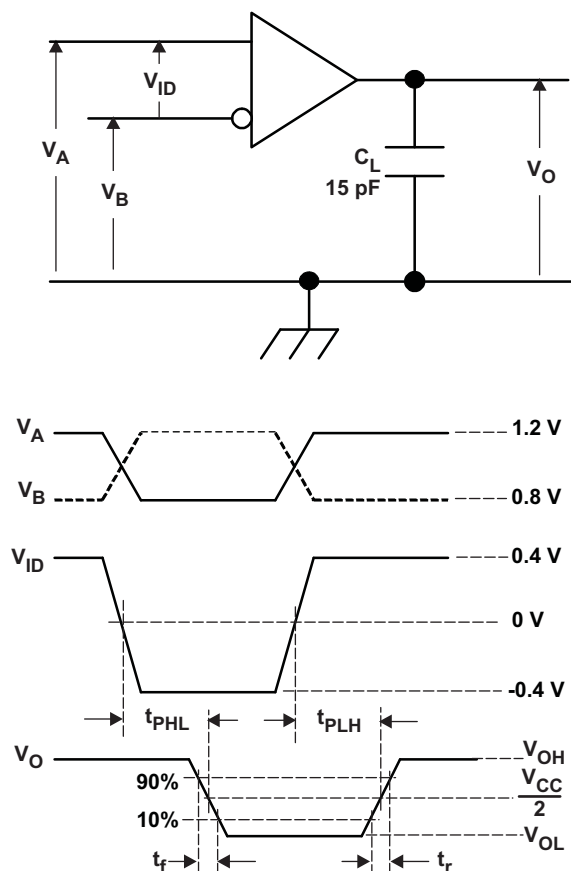
APPLIED VOLTAGES		RESULTING DIFFERENTIAL INPUT VOLTAGE	RESULTING COMMON-MODE INPUT VOLTAGE	RECEIVER OUTPUT ⁽¹⁾
V_{IA}	V_{IB}	V_{ID}	V_{IC}	
2.400	0.000	2.400	1.200	H
0.000	2.400	-2.400	1.200	L
3.400	3.365	0.035	3.3825	H
3.365	3.400	-0.035	3.3825	L
-0.965	-1	0.035	-0.9825	H
-1	-0.965	-0.035	-0.9825	L

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

Table 3. Type-2 Receiver Input Threshold Test Voltages

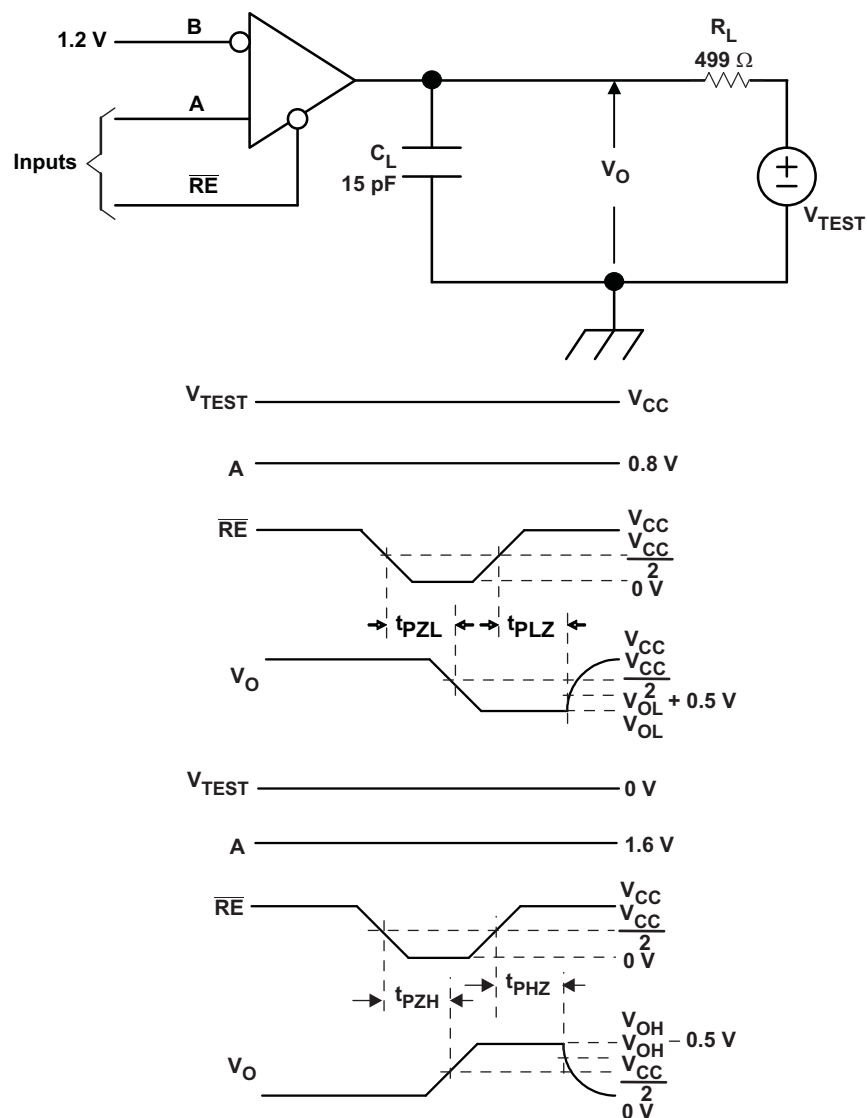
APPLIED VOLTAGES		RESULTING DIFFERENTIAL INPUT VOLTAGE	RESULTING COMMON-MODE INPUT VOLTAGE	RECEIVER OUTPUT ⁽¹⁾
V_{IA}	V_{IB}	V_{ID}	V_{IC}	
2.400	0.000	2.400	1.200	H
0.000	2.400	-2.400	1.200	L
3.400	3.265	0.135	3.3325	H
3.4000	3.335	0.05065	3.3675	L
-0.865	-1	0.135	-0.9325	H
-0.935	-1	0.065	-0.9675	L

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



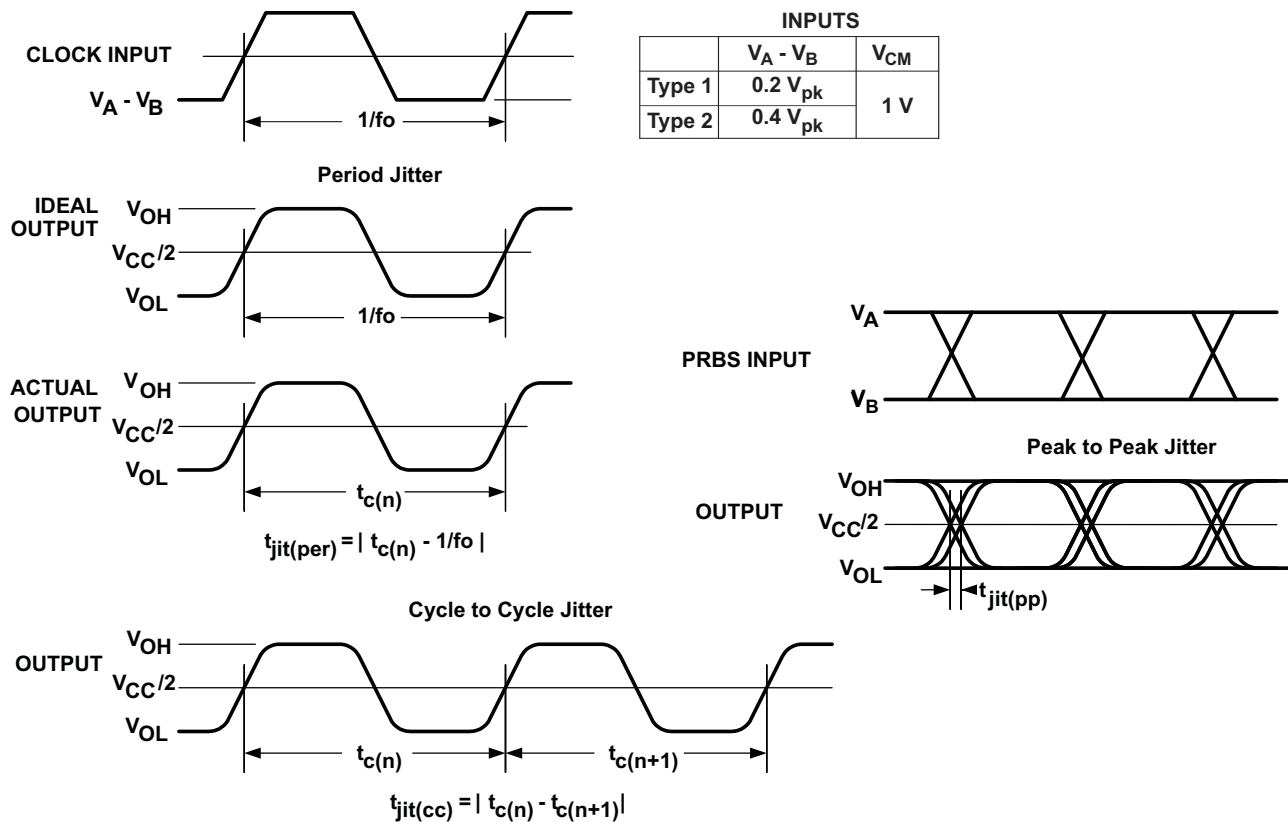
- A. All input pulses are supplied by a generator having the following characteristics: t_f or $t_r \leq 1$ ns, Frequency = 1 MHz, duty cycle = $50 \pm 5\%$. C_L is a combination of a 20%-tolerance, low-loss ceramic, surface-mount capacitor and fixture capacitance within 2 cm of the D.U.T.
- B. The measurement is made on test equipment with a -3dB bandwidth of at least 1 GHz.

Figure 2. Receiver Timing Test Circuit and Waveforms



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

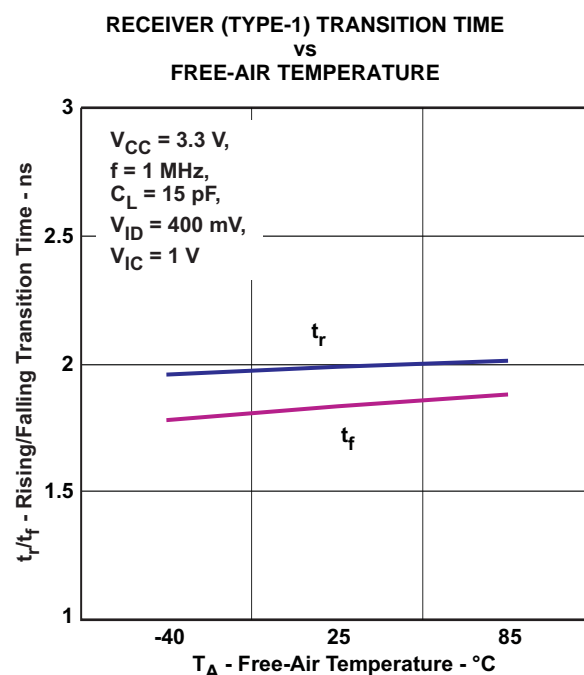
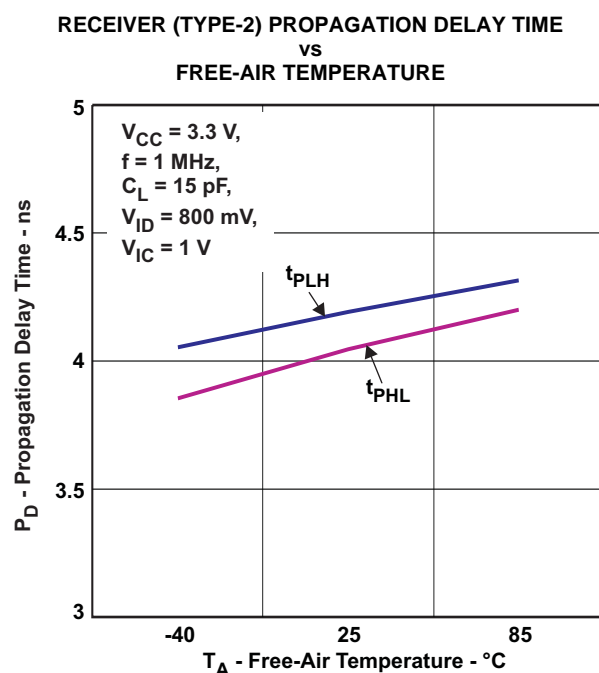
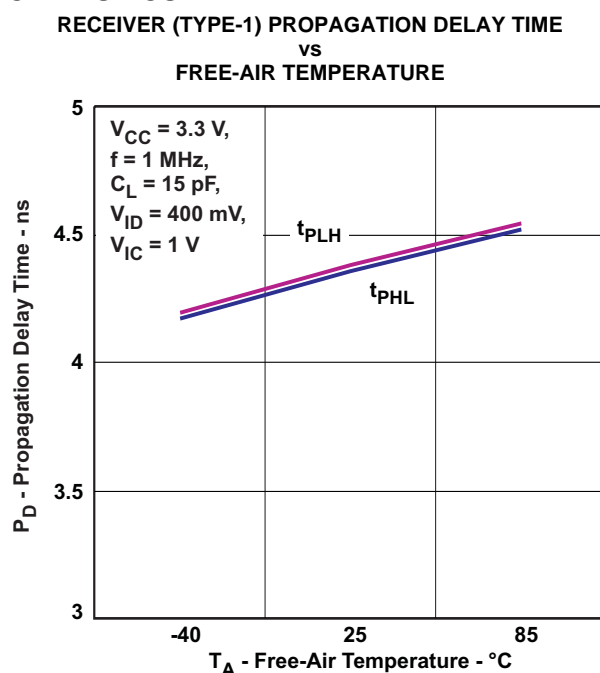
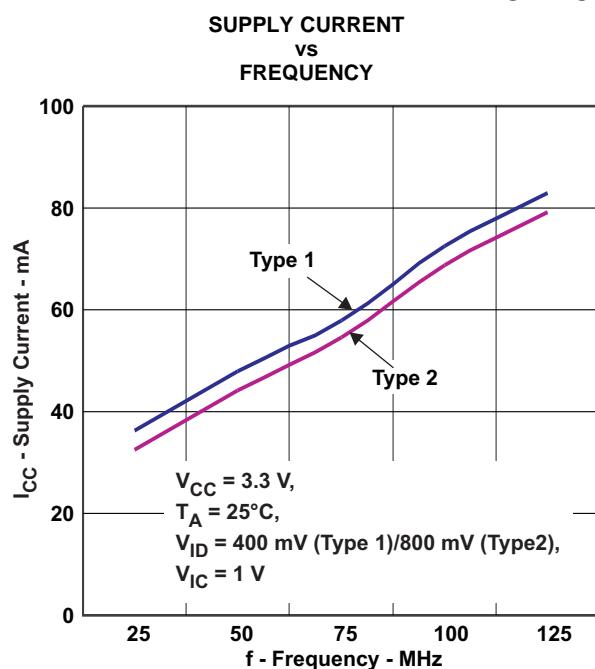
Figure 3. Receiver Enable/Disable Time Test Circuit and Waveforms



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

Figure 4. Receiver Jitter Measurement Waveforms

TYPICAL CHARACTERISTICS



TYPICAL CHARACTERISTICS (continued)

RECEIVER (TYPE-2) TRANSITION TIME
vs
FREE-AIR TEMPERATURE

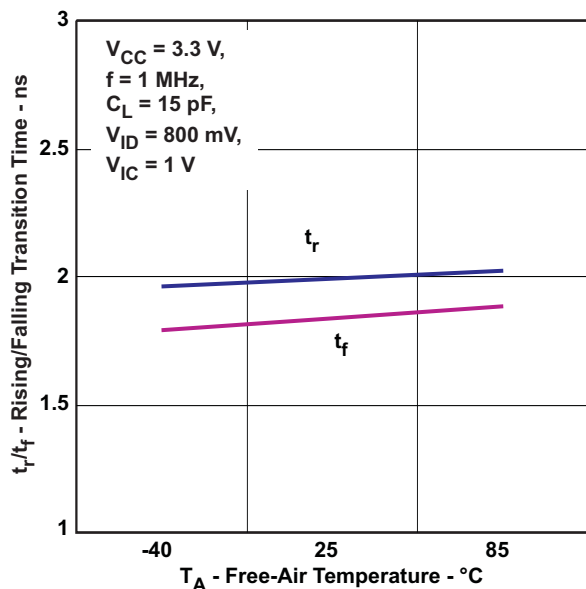


Figure 9.

RECEIVER (TYPE-1) TRANSITION TIME
vs
OUTPUT LOAD CAPACITOR

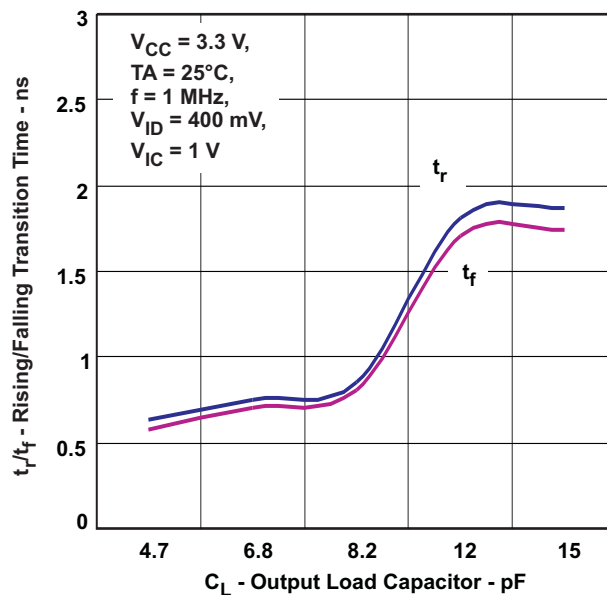


Figure 10.

RECEIVER (TYPE-2) TRANSITION TIME
vs
OUTPUT LOAD CAPACITOR

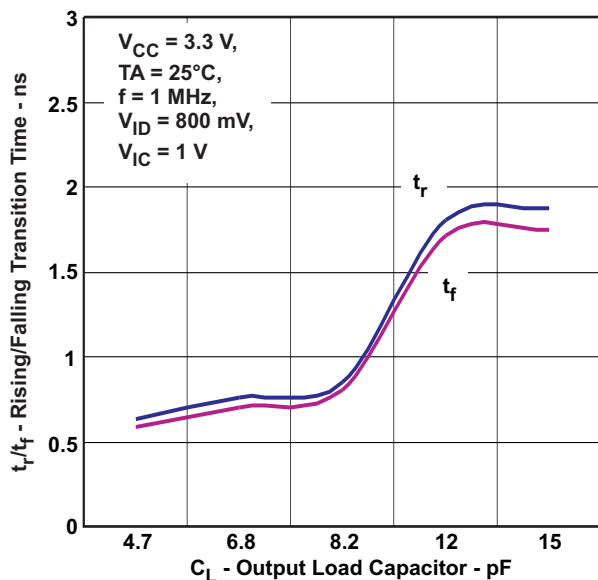


Figure 11.

ADDED RECEIVER PEAK-TO-PEAK JITTER
vs
SIGNALLING RATE

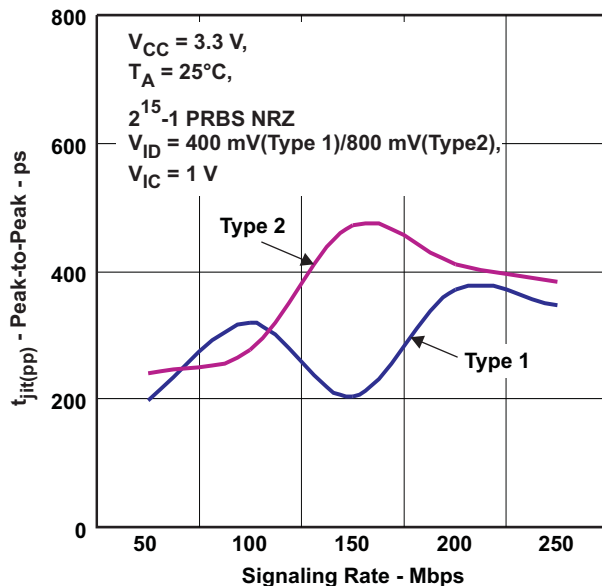


Figure 12.

TYPICAL CHARACTERISTICS (continued)

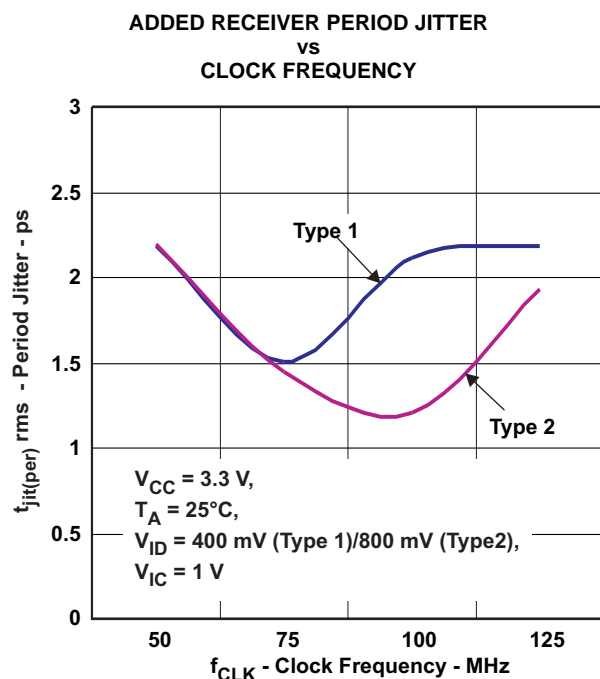


Figure 13.

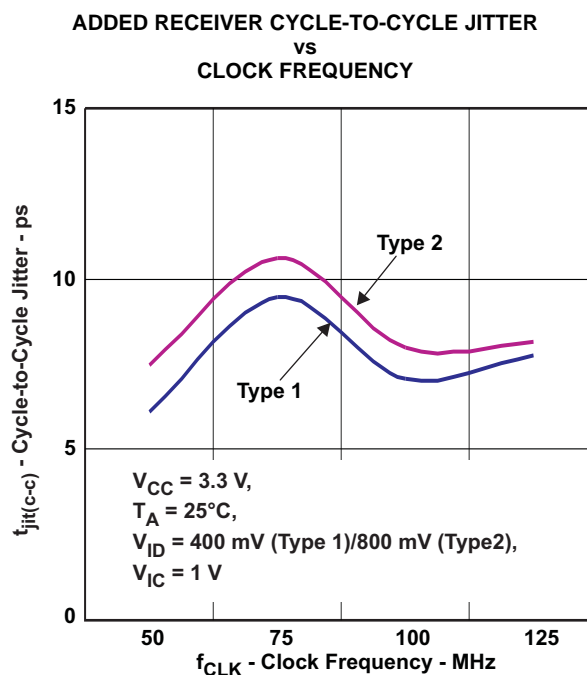


Figure 14.

EYE PATTERNS

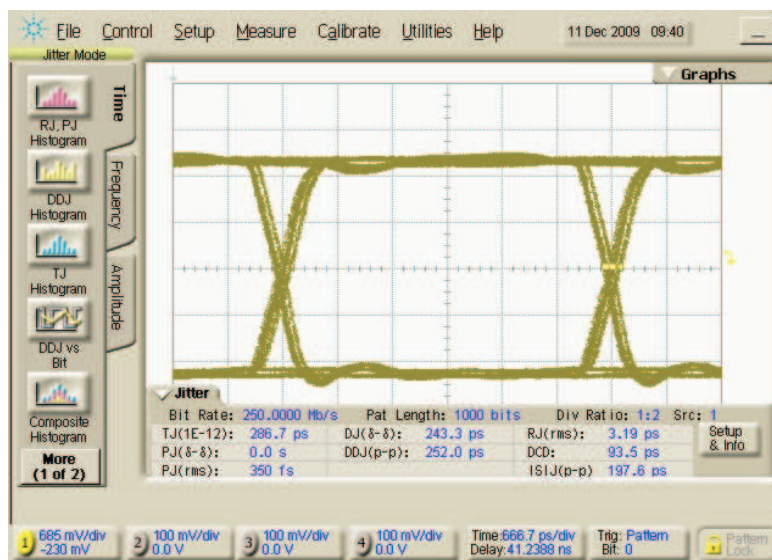


Figure 15. SN65MLVD048 Output ($V_{CC} = 3.3$ V, $V_{ID} = 400$ mV) 250 Mbps $2^{15}-1$ PRBS, Receiver Type 1

TYPICAL CHARACTERISTICS (continued)

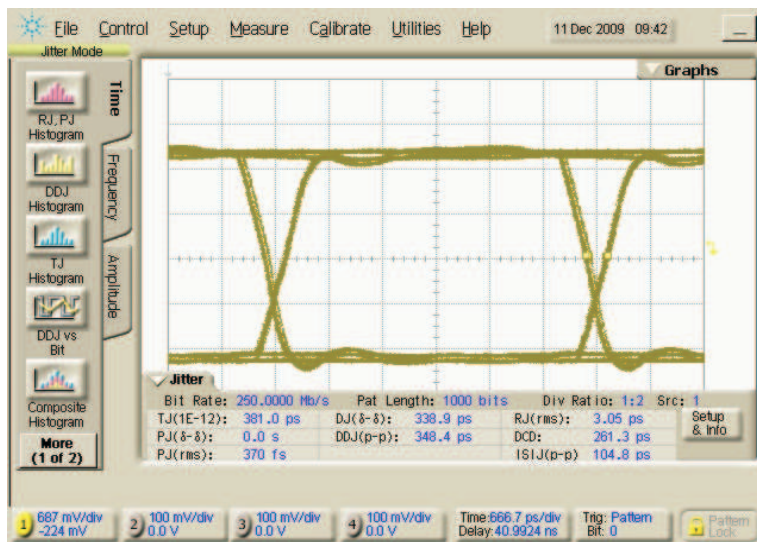


Figure 16. SN65MLVD048 Output ($V_{CC} = 3.3\text{ V}$, $V_{ID} = 800\text{ mV}$) 250 Mbps $2^{15}-1$ PRBS, Receiver Type 2

PACKAGING INFORMATION

Orderable Device	Status ⁽¹⁾	Package Type	Package Drawing	Pins	Package Qty	Eco Plan ⁽²⁾	Lead/Ball Finish	MSL Peak Temp ⁽³⁾
SN65MLVD048RGZR	ACTIVE	VQFN	RGZ	48	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR
SN65MLVD048RGZT	ACTIVE	VQFN	RGZ	48	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR

⁽¹⁾ The marketing status values are defined as follows:

ACTIVE: Product device recommended for new designs.

LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

PREVIEW: Device has been announced but is not in production. Samples may or may not be available.

OBsolete: TI has discontinued the production of the device.

⁽²⁾ Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

TBD: The Pb-Free/Green conversion plan has not been defined.

Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

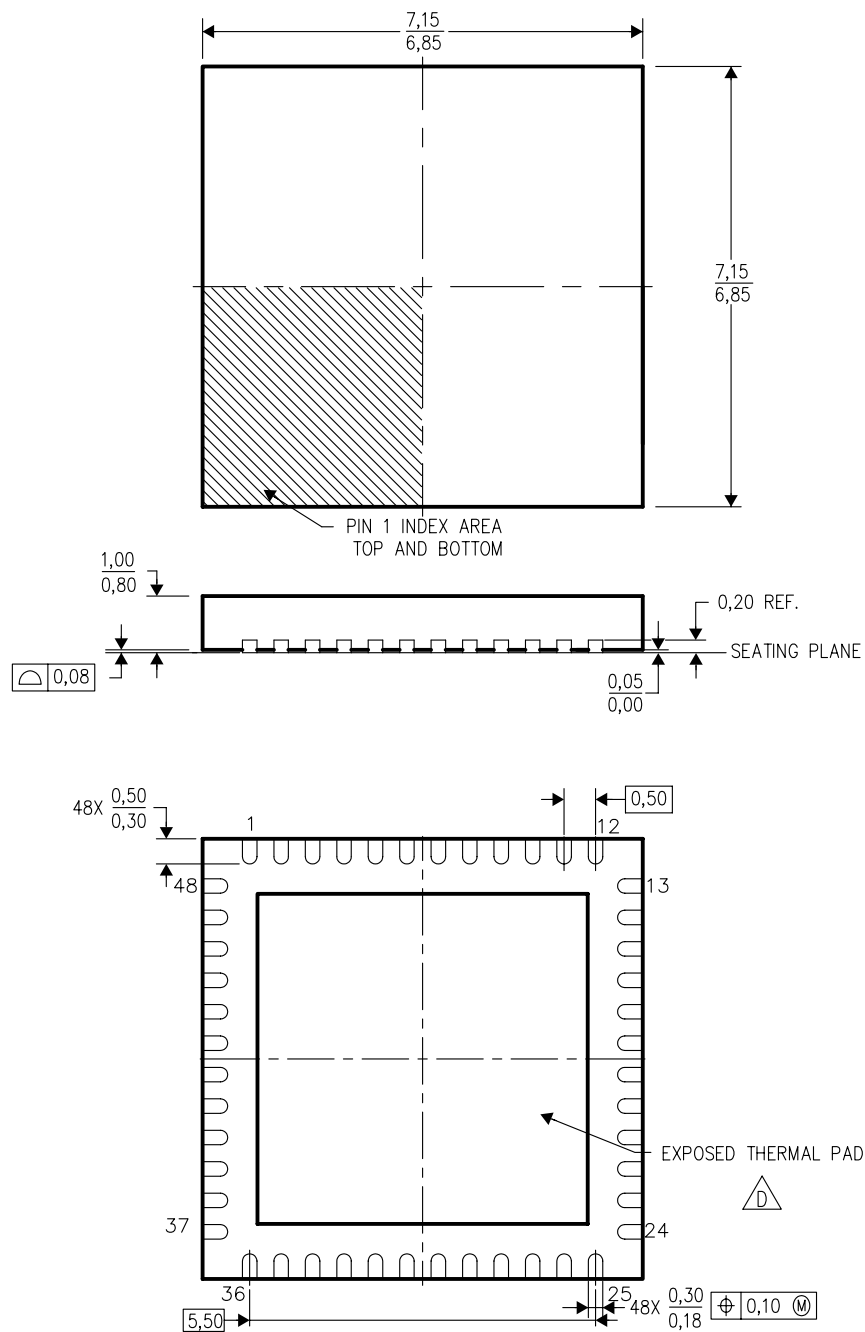
⁽³⁾ MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

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
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RGZ (S-PQFP-N48)

PLASTIC QUAD FLATPACK



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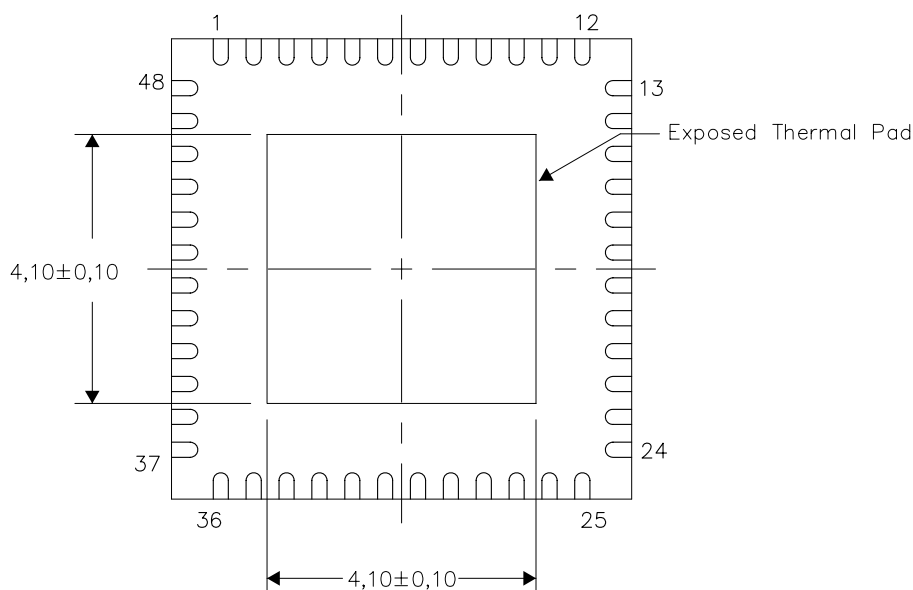
- NOTES:
- A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
 - B. This drawing is subject to change without notice.
 - C. Quad Flatpack, No-leads (QFN) package configuration.
 -  D. The package thermal pad must be soldered to the board for thermal and mechanical performance. See the Product Data Sheet for details regarding the exposed thermal pad dimensions.
 - E. Falls within JEDEC MO-220.

THERMAL INFORMATION

This package incorporates an exposed thermal pad that is designed to be attached directly to an external heatsink. The thermal pad must be soldered directly to the printed circuit board (PCB). After soldering, the PCB can be used as a heatsink. In addition, through the use of thermal vias, the thermal pad can be attached directly to the appropriate copper plane shown in the electrical schematic for the device, or alternatively, can be attached to a special heatsink structure designed into the PCB. This design optimizes the heat transfer from the integrated circuit (IC).

For information on the Quad Flatpack No-Lead (QFN) package and its advantages, refer to Application Report, QFN/SON PCB Attachment, Texas Instruments Literature No. SLUA271. This document is available at www.ti.com.

The exposed thermal pad dimensions for this package are shown in the following illustration.

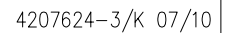


Bottom View

NOTE: All linear dimensions are in millimeters

Exposed Thermal Pad Dimensions

PLASTIC QUAD FLATPACK NO-LEAD



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