

#### features

- Multi-Rate Operation from 155 Mbps Up to 3.3 Gbps
- 106-mW Power Consumption
- Input Offset Cancellation
- High Input Dynamic Range
- Output Disable
- Output Polarity Select
- CML Data Outputs
- Receive Signals Strength Indicator (RSSI)
- Loss of Signal Detection

- Single 3.3-V Supply
- Surface Mount Small Footprint 3 mm × 3 mm 16-Pin QFN Package

#### applications

- SONET/SDH Transmission Systems at OC3, OC12, OC24, OC48
- 1.0625-Gbps and 2.125-Gbps Fibre Channel Receivers
- Gigabit Ethernet Receivers

#### description

The ONET3301PA is a versatile high-speed limiting amplifier for multiple fiber optic applications with data rates up to 3.3 Gbps.

This device provides a gain of about 50 dB, which ensures a fully differential output swing for input signals as low as 3 mV<sub>p-p</sub>.

The high input signal dynamic range ensures low jitter output signals even when overdriven with input signal swings as high as 1200 mV<sub>p-p</sub>.

The ONET3301PA comprises a loss of signals detection, as well as a received signal strength indicator.

The ONET3301PA is available in a small footprint 3 mm × 3 mm 16-pin QFN package and requires a single 3.3-V supply.

This power efficient limiting amplifier dissipates less than 106 mW typical. It is characterized for operation from –40°C to 85°C.

#### available options

T <sub>A</sub>	PACKAGED DEVICE	FEATURES
–40°C to 85°C	ONET3301PARGT	16-pin 3 mm x 3 mm QFN, tube
–40°C to 85°C	ONET3301PARGTR	16-pin 3 mm x 3 mm QFN, tape and reel



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# ONET3301PA

## 155-Mbps TO 3.3-Gbps LIMITING AMPLIFIER

SLLS603B – MARCH 2004 – REVISED DECEMBER 2004

### block diagram

A simplified block diagram of the ONET3301PA is shown in Figure 1.

This compact, low power 3.3-Gbps limiting amplifier consists of a high-speed data path with offset cancellation block, a loss of signal and RSSI detection block, and a bandgap voltage reference and bias current generation block.

The limiting amplifier requires a single 3.3-V supply voltage. All circuit parts are described in detail below.

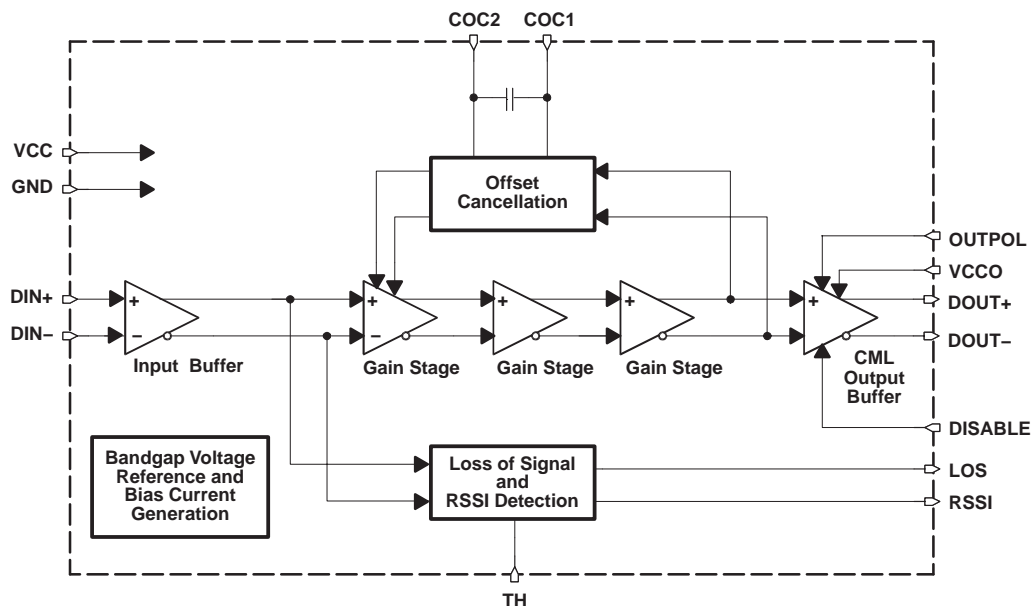


Figure 1. Block Diagram

### high-speed data path

The high-speed data signal is applied to the data path by means of the input signal pins DIN+/DIN-. The data path consists of the input stage with  $2 \times 50\text{-}\Omega$  on-chip line termination to VCC, three gain stages, which provide the required typical gain of about 50 dB and a CML output stage. The amplified data output signal is available at the output pins DOUT+/DOUT-, which provide  $2 \times 50\text{-}\Omega$  back-termination to VCCO. The output stage also includes a data polarity switching function, which is controlled by the OUTPOL input and a disable function, controlled by the signal applied to the DISABLE input pin.

An offset cancellation compensates inevitable internal offset voltages and thus ensures proper operation even for small input data signals.

The low frequency cutoff is as low as 45 kHz with the built-in filter capacitor.

For applications, which require even lower cutoff frequencies, an additional external filter capacitor may be connected to the COC1/COC2 pins.

### loss of signal and RSSI detection

The output signal of the input buffer is monitored by the loss of signal and RSSI detection circuitry. In this block a signal is generated, which is linear proportional to the input amplitude over a wide input voltage range. This signal is available at the RSSI output pin.

Furthermore, this circuit block compares the input signal to a threshold, which can be programmed by means of an external resistor connected to the TH pin. If the input signal falls below the specified threshold, a loss of signal is indicated at the LOS pin.

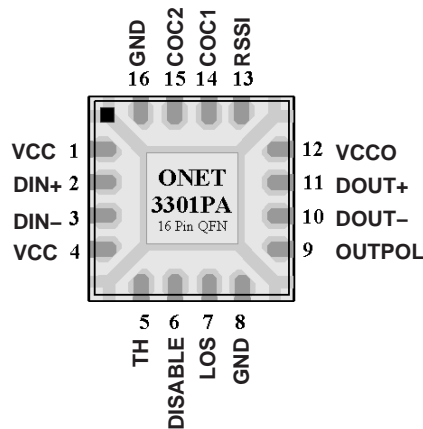
## bandgap voltage and bias generation

The ONET3301PA limiting amplifier is supplied by a single 3.3-V  $\pm 10\%$  supply voltage connected to the VCC and VCCO pins. This voltage is referred to ground (GND).

An on-chip bandgap voltage circuitry generates a supply voltage independent reference from which all other internally required voltages and bias currents are derived.

## package

For the ONET3301PA, a small footprint 3 mm  $\times$  3 mm 16-pin QFN package is used with a lead pitch of 0,5 mm. The pin out is shown in Figure 2.



**Figure 2. Pinout of ONET3301PA in a 3 mm  $\times$  3 mm 16-Pin QFN Package**

## terminal functions

The following table shows a pin description for the ONET3301PA in a 3 mm  $\times$  3 mm 16-pin QFN package.

TERMINAL		TYPE	DESCRIPTION
NAME	NO.		
VCC	1, 4	Supply	3.3-V $\pm 10\%$ supply voltage
DIN+	2	Analog in	Noninverted data input. On-chip 50- $\Omega$ terminated to VCC
DIN-	3	Analog in	Inverted data input. On-chip 50- $\Omega$ terminated to VCC
TH	5	Analog in	LOS threshold adjustment with resistor to GND.
DISABLE	6	CMOS in	Disables CML output stage when set to high level.
LOS	7	CMOS out	High level indicates that the input signal amplitude is below the programmed threshold level.
GND	8, 16, EP	Supply	Circuit ground. Exposed die pad (EP) must be grounded.
OUTPOL	9	CMOS in	Output data signal polarity select (internally pulled up): Setting to high level or leaving pin open selects normal polarity. Low level selects inverted polarity.
DOUT-	10	CML out	Inverted data output. On-chip 50- $\Omega$ back-terminated to VCCO
DOUT+	11	CML out	Noninverted data output. On-chip 50- $\Omega$ back-terminated to VCCO
VCCO	12	Supply	3.3-V $\pm 10\%$ supply voltage for output stage
RSSI	13	Analog out	Analog output voltage proportional to the input data amplitude. Indicates the strength of the received signal (RSSI).
COC1	14	Analog	Offset cancellation filter capacitor terminal 1. Connect an additional filter capacitor between this pin and COC2 (pin 15). To disable the offset cancellation loop connect COC1 and COC2 (pins 14 and 15).
COC2	15	Analog	Offset cancellation filter capacitor terminal 2. Connect an additional filter capacitor between this pin and COC1 (pin 14). To disable the offset cancellation loop connect COC1 and COC2 (pins 14 and 15).

# ONET3301PA

## 155-Mbps TO 3.3-Gbps LIMITING AMPLIFIER

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### absolute maximum ratings

over operating free-air temperature range unless otherwise noted†

		VALUE	UNIT
$V_{CC}, V_{CCO}$	Supply voltage, See Note 1	–0.3 to 4	V
$V_{DIN+}, V_{DIN-}$	Voltage at DIN+, DIN–, See Note 1	0.5 to 4	V
$V_{TH}, V_{DISABLE}, V_{LOS}, V_{OUTPOL}, V_{DOUT+}, V_{DOUT-}, V_{RSSI}, V_{COC1}, V_{COC2}$	Voltage at TH, DISABLE, LOS, OUTPOL, DOUT+, DOUT–, RSSI, COC1, and COC2, See Note 1	–0.3 to 4	V
$V_{COC\_DIFF}$	Differential voltage between COC1 and COC2	±1	V
$V_{DIN\_DIFF}$	Differential voltage between DIN+ and DIN–	±2.5	V
$I_{LOS}$	Current into LOS	–1 to 9	mA
$I_{DIN+}, I_{DIN-}, I_{DOUT+}, I_{DOUT-}$	Continuous current at inputs and outputs	–25 to 25	mA
ESD	ESD rating at all pins except VCCO	3	kV (HBM)
	ESD rating at VCCO	1.1	
$T_{J(max)}$	Maximum junction temperature	125	°C
$T_{stg}$	Storage temperature range	–65 to 85	°C
$T_A$	Characterized free-air operating temperature range	–40 to 85	°C
$T_L$	Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds	260	°C

† 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.

NOTE 1: All voltage values are with respect to network ground terminal.

### recommended operating conditions

	MIN	TYP	MAX	UNIT
Supply voltage, $V_{CC}, V_{CCO}$	3	3.3	3.6	V
Operating free-air temperature, $T_A$	–40		85	°C

### dc electrical characteristics

over recommended operating conditions (unless otherwise noted), typical operating condition is at  $V_{CC} = 3.3\text{ V}$  and  $T_A = 25^\circ\text{C}$

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
$V_{CC}, V_{CCO}$ Supply voltage		3	3.3	3.6	V
$I_{CC}$ Supply current	DISABLE = low (excludes CML output current)		32	40	mA
$V_{OD}$ Differential data output voltage swing	DISABLE = high		0.25	10	mV <sub>p-p</sub>
	DISABLE = low	600	780	1200	mV <sub>p-p</sub>
$r_{IN}, r_{OUT}$ Data input/output resistance	Single ended		50		$\Omega$
RSSI output voltage	Input = 2 mV <sub>p-p</sub> , $R_{RSSI} \geq 10\text{ k}\Omega$		100		mV
	Input = 80 mV <sub>p-p</sub> , $R_{RSSI} \geq 10\text{ k}\Omega$		2800		
RSSI linearity	20-dB input signal, $V_{IN} \leq 80\text{ mVpp}$		$\pm 3\%$	$\pm 8\%$	
$V_{(IN\_MIN)}$ Data input sensitivity	BER < $10^{-10}$		3	5	mV <sub>p-p</sub>
$V_{(IN\_MAX)}$ Data input overload		1200			mV <sub>p-p</sub>
CMOS input high voltage		2.1			V
CMOS input low voltage				0.6	V
LOS high voltage	$I_{SINK} = -30\text{ }\mu\text{A}$	2.4			V
LOS low voltage	$I_{SOURCE} = 1\text{ mA}$			0.4	V
LOS hysteresis	$2^{23}-1$ PRBS (at 2.5 Gbps and 155 Mbps)	2.5	4.5		dB
$V_{TH}$ LOS assert threshold range	$2^{23}-1$ PRBS (at 2.5 Gbps and 155 Mbps)		5–40		mV <sub>p-p</sub>

### ac electrical characteristics

over recommended operating conditions (unless otherwise noted), typical operating condition is at  $V_{CC} = 3.3\text{ V}$  and  $T_A = 25^\circ\text{C}$

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Low frequency –3-dB bandwidth	$C_{OC} = \text{open}$		45	70	kHz
	$C_{OC} = 2.2\text{ nF}$		0.8		
Data rate		3.3			Gb/s
$v_{NI}$ Input referred noise			180		$\mu\text{VRMS}$
DJ Deterministic jitter, See Note 2	K28.5 pattern at 3.3 Gbps		8.5	25	ps <sub>p-p</sub>
	$2^{23}-1$ PRBS equivalent pattern at 2.7 Gbps		9.3	30	
	K28.5 pattern at 2.1 Gbps		7.8	25	
	$2^{23}-1$ PRBS equivalent pattern at 155 Mbps		25	50	
RJ Random jitter	Input = 5 mVpp		6.5		ps <sub>RMS</sub>
	Input = 10 mVpp		3		
$t_r$ Output rise time	20% to 80%		60	85	ps
$t_f$ Output fall time	20% to 80%		60	85	ps
PSNR Power supply noise rejection	$f < 2\text{ MHz}$	26			dB
$t_{DIS}$ Disable response time			20		ns
$t_{LOS}$ LOS assert/deassert time		2		100	$\mu\text{s}$

NOTE 2: Deterministic jitter does not include pulse-width distortion due to residual small output offset voltage.

# ONET3301PA

## 155-Mbps TO 3.3-Gbps LIMITING AMPLIFIER

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### APPLICATION INFORMATION

Figure 3 shows the ONET3301PA connected with an ac-coupled interface to the data signal source as well as to the output load.

Besides the ac-coupling capacitors,  $C_1$  through  $C_4$  in the input and output data signal lines, the only required external component is the LOS threshold setting resistor  $R_{TH}$ . In addition, an optional external filter capacitor ( $C_{OC}$ ) may be used if a low cutoff frequency is desired.

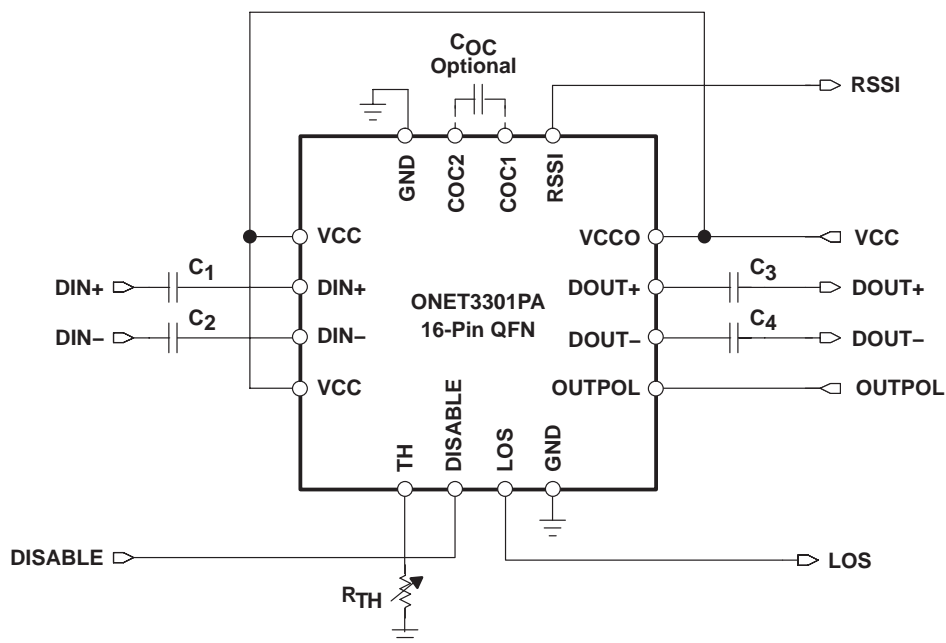
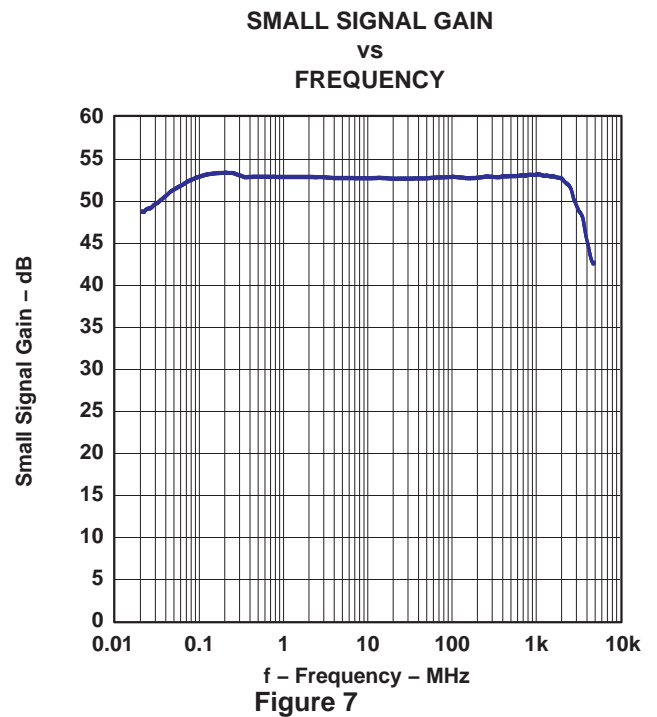
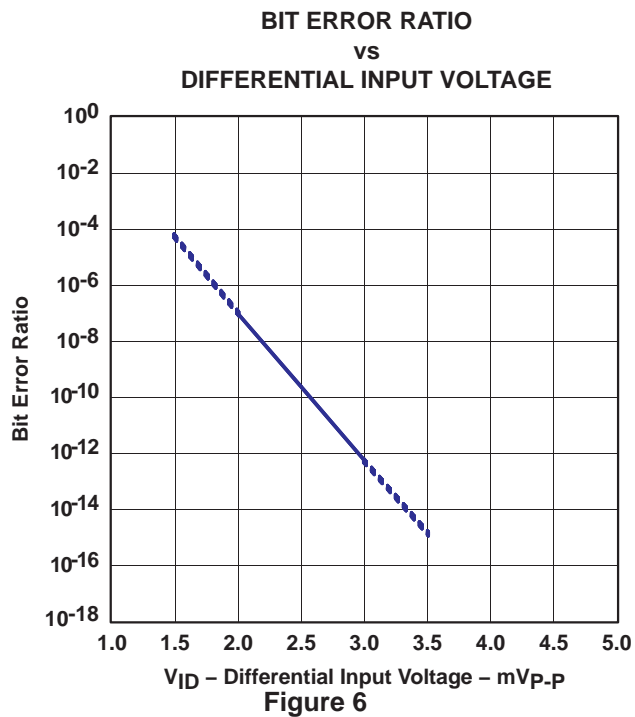
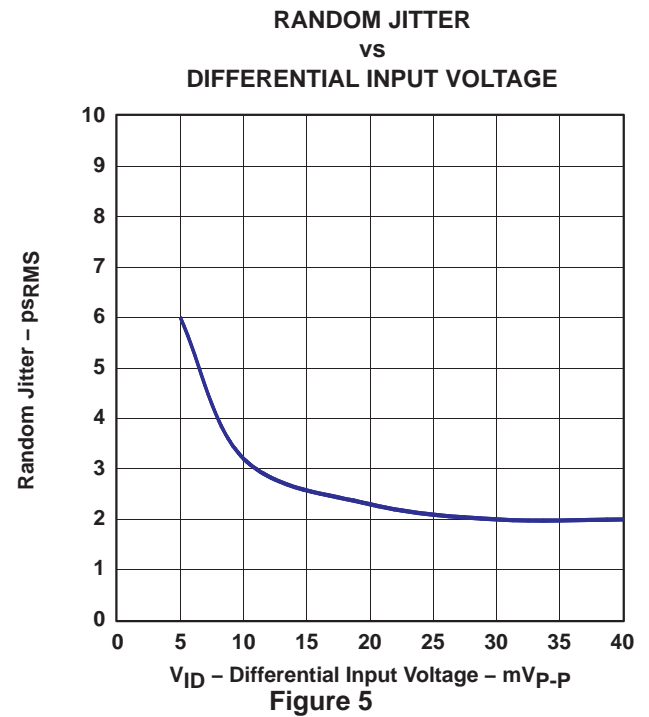
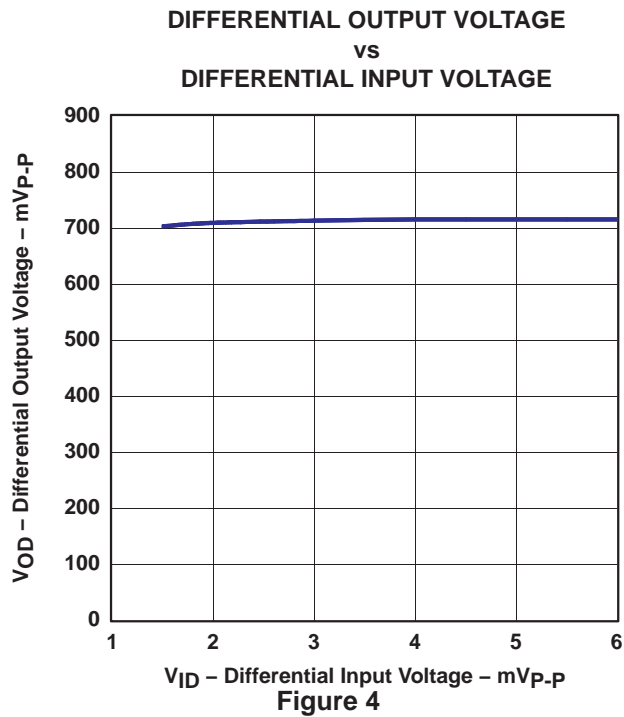
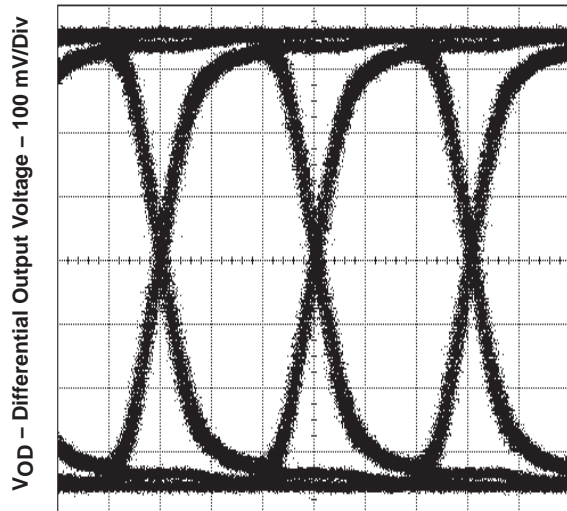


Figure 3. Basic Application Circuit With AC-Coupled I/Os

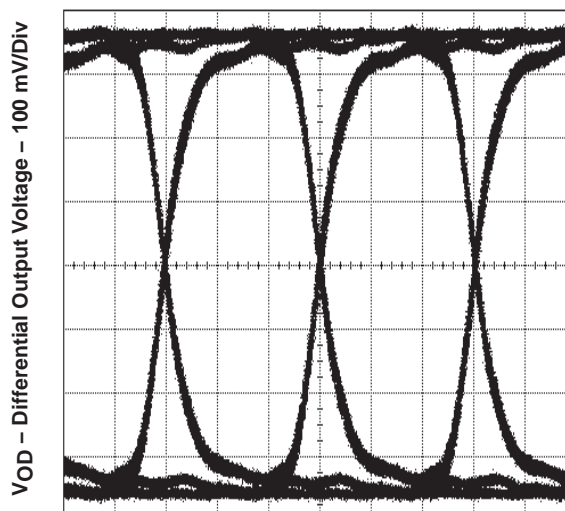


**OUTPUT EYE-DIAGRAM AT 3.3 GBPS AND  
MINIMUM INPUT VOLTAGE (1200 mV<sub>p-p</sub>)**



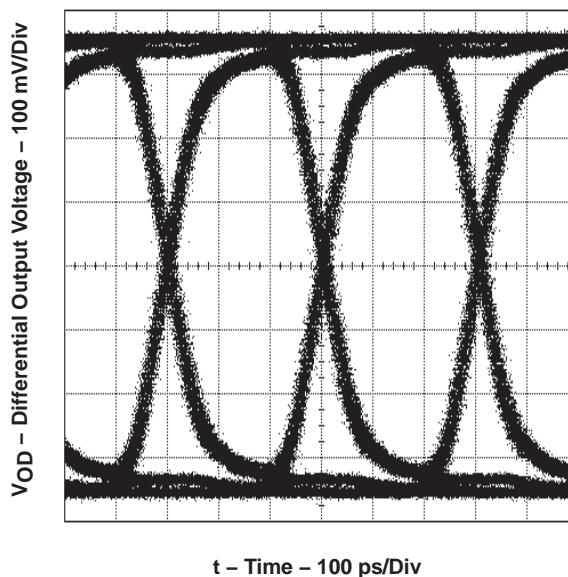
**Figure 8**

**OUTPUT EYE-DIAGRAM AT 3.3 GBPS AND  
MAXIMUM INPUT VOLTAGE (1200 mV<sub>p-p</sub>)**



**Figure 9**

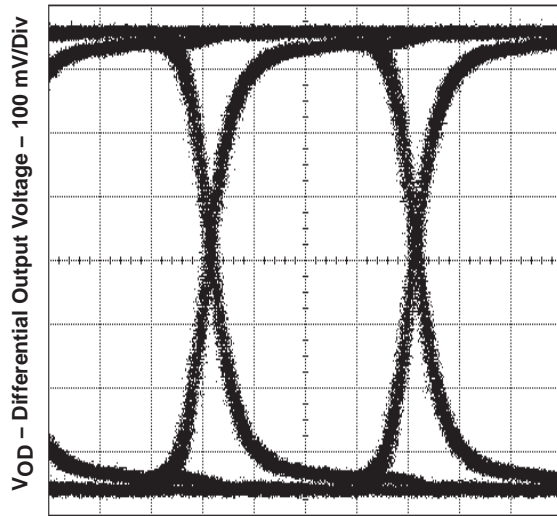
**OUTPUT EYE-DIAGRAM AT  
3.3 GBPS AND 85°C MINIMUM  
INPUT VOLTAGE (5 mV<sub>p-p</sub>)**



**Figure 10**



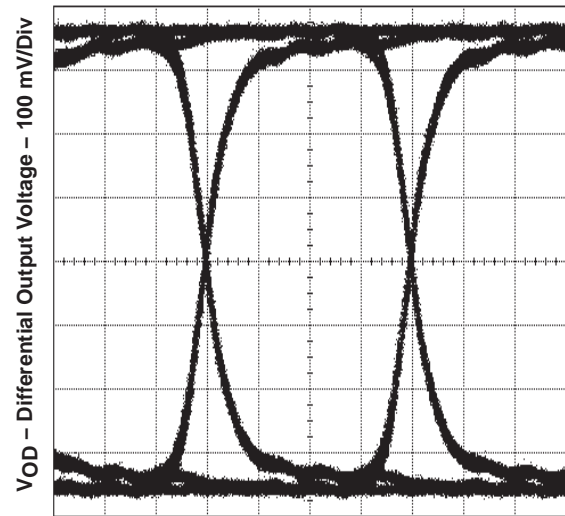
**OUTPUT EYE-DIAGRAM AT 2.5 GBPS AND  
 MINIMUM INPUT VOLTAGE (5 mV<sub>p-p</sub>)**



t - Time - 100 ps/Div

**Figure 11**

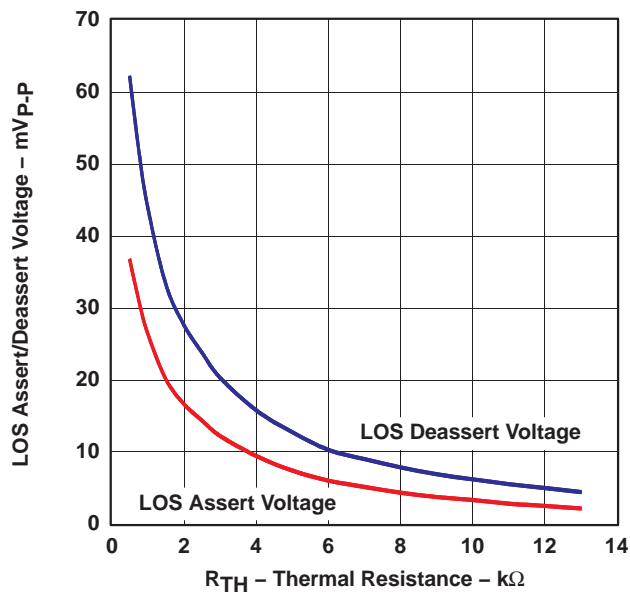
**OUTPUT EYE-DIAGRAM AT 2.5 GBPS AND  
 MAXIMUM INPUT VOLTAGE (1200 mV<sub>p-p</sub>)**



t - Time - 100 ps/Div

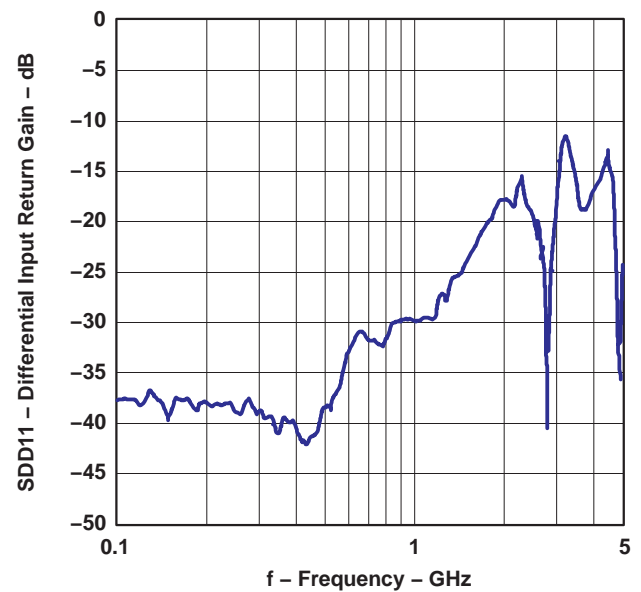
**Figure 12**

**LOS ASSERT/DEASSERT VOLTAGE  
 VS  
 EXTERNAL RESISTANCE R<sub>TH</sub>**



**Figure 13**

**DIFFERENTIAL INPUT RETURN GAIN  
 VS  
 FREQUENCY**



**Figure 14**

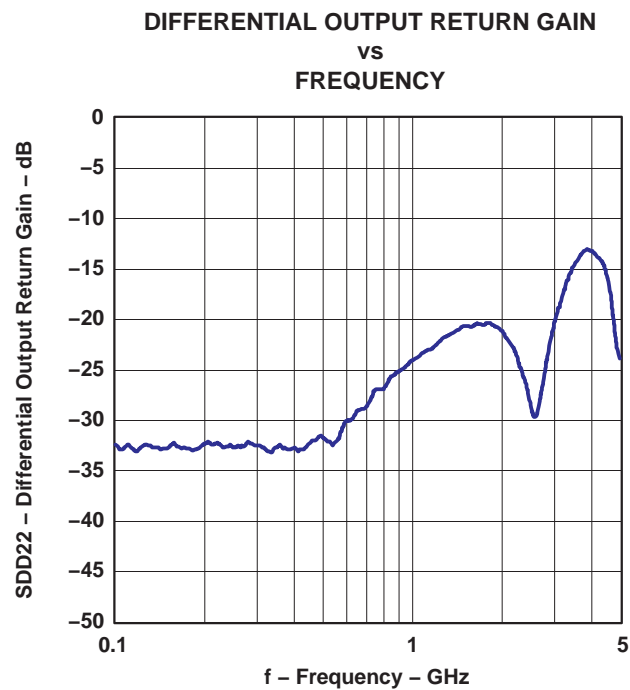


Figure 15

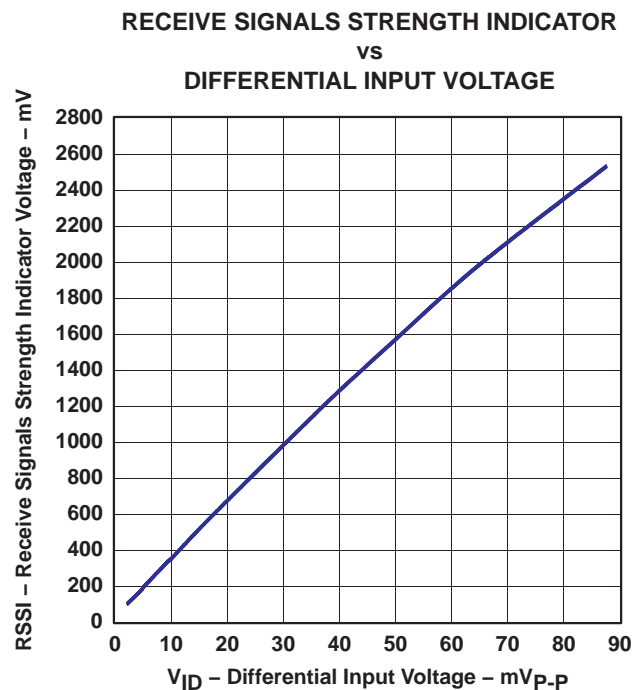


Figure 16

## PACKAGING INFORMATION

Orderable Device	Status <sup>(1)</sup>	Package Type	Package Drawing	Pins	Package Qty	Eco Plan <sup>(2)</sup>	Lead/Ball Finish	MSL Peak Temp <sup>(3)</sup>
ONET3301PARGT	ACTIVE	QFN	RGT	16	121	None	CU NIPDAU	Level-2-220C-1 YEAR

<sup>(1)</sup> 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.

<sup>(2)</sup> Eco Plan - May not be currently available - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

**None:** Not yet available Lead (Pb-Free).

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

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