

2.5V/3.3V, 5 Gb/s Multi Level Clock/Data Input to CML Driver / Receiver / Buffer/Translator with Internal Termination

Description

The NB4L16M is a differential driver/receiver/buffer/translator which can accept LVPECL, LVDS, CML, HSTL, LVCMOS/LVTTL and produce 400 mV CML output. The device is capable of receiving, buffering, and translating a clock or data signal that is as small as 75 mV operating up to 3.5 GHz or 5.0 Gb/s, respectively. As such, it is ideal for SONET, GigE, Fiber Channel and backplane applications (see Table 6 and Figures 20, 21 22, and 23).

Differential inputs incorporate internal 50 Ω termination resistors and accept LVPECL (Positive ECL), LVTTL/LVCMOS, CML, HSTL or LVDS. The differential 16 mA CML output provides matching internal 50 Ω termination, and 400 mV output swing when externally receiver terminated, 50 Ω to V_{CC} (see Figure 19). These features provide transmission line termination on chip, at the receiver and driver end, eliminating any use of additional external components.

The V_{BB} , an internally generated voltage supply, is available to this device only. For single-ended input configuration, the unused complementary differential input is connected to V_{BB} as a switching reference voltage. The V_{BB} reference output can be used also to re-bias capacitor coupled differential or single-ended output signals. For the capacitor coupled input signals, V_{BB} should be connected to the V_{TD} pin and bypassed to ground with a 0.01 μ F capacitor. When not used V_{BB} should be left open.

This device is housed in a 3x3 mm 16 pin QFN package. Application notes, models, and support documentation are available at www.onsemi.com.

Features

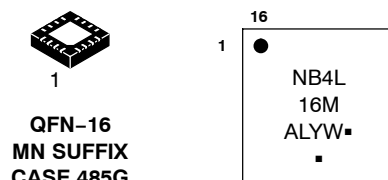
- Maximum Input Clock Frequency up to 3.5 GHz
- Maximum Input Data Rate up to 5.0 Gb/s
- < 0.7 ps Maximum Clock RMS Jitter
- < 10 ps Maximum Data Dependent Jitter at 2.5 Gb/s
- 220 ps Typical Propagation Delay
- 60 ps Typical Rise and Fall Times
- CML Output with Operating Range:
 $V_{CC} = 2.375$ V to 3.6 V with $V_{EE} = 0$ V
- CML Output Level (400 mV Peak-to-Peak Output),
Differential Output Only
- 50 Ω Internal Input and Output Termination Resistors
- Functionally Compatible with Existing 2.5 V / 3.3 V LVEL, LVEP, EP, and SG Devices
- Pb-Free Packages are Available



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MARKING DIAGRAM*



A	= Assembly Location
L	= Wafer Lot
Y	= Year
W	= Work Week
▪	= Pb-Free Package

(Note: Microdot may be in either location)

*For additional marking information, refer to Application Note AND8002/D.

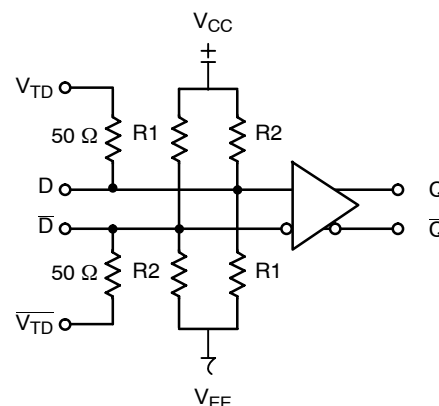


Figure 1. Functional Block Diagram

ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 11 of this data sheet.

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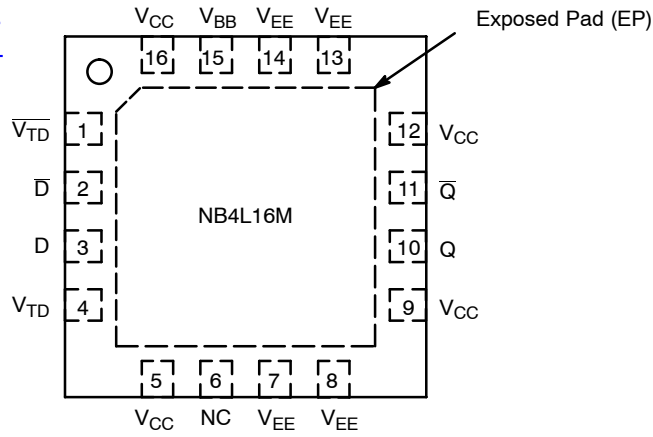


Figure 2. Pin Configuration (Top View)

Table 1. PIN DESCRIPTION

Pin	Name	I/O	Description
1	$\overline{V_{TD}}$	–	Internal 50 Ω termination pin. See Table 4 (Note 1).
2	$\overline{D}$	LVPECL, CML, HSTL, LVCMOS, LVDS, LVTTTL Input	Inverted differential input. Internal 36.5 k Ω to V_{CC} and 73 k Ω to V_{EE} (Note 1).
3	D	LVPECL, CML, HSTL, LVCMOS, LVDS, LVTTTL Input	Noninverted differential input. Internal 73 k Ω to V_{CC} and 36.5 k Ω to V_{EE} (Note 1).
4	V_{TD}	–	Internal 50 Ω termination pin. See Table 4. (Note 1)
15	V_{BB}	–	Internally generated reference voltage supply.
6	NC		No Connect pin. The No Connect (NC) pin is electrically connected to the die and MUST be left open.
10	Q	CML Output	Noninverted differential output. Typically receiver terminated with 50 Ω resistor to V_{CC} .
11	$\overline{Q}$	CML Output	Inverted differential output. Typically receiver terminated with 50 Ω resistor to V_{CC} .
7, 8, 13, 14	V_{EE}	–	Negative supply voltage
5, 9, 12, 16	V_{CC}	–	Positive supply voltage
–	EP	–	Exposed pad (EP). EP on the package bottom is thermally connected to the die for improved heat transfer out of the package. The pad is not electrically connected to the die, but is recommended to be soldered to V_{EE} on the PC Board.

1. In the differential configuration when the input termination pins (V_{TD} , $\overline{V_{TD}}$) are connected to a common termination voltage and if no signal is applied on D/ $\overline{D}$ input then the device will be susceptible to self-oscillation.

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Table 2. ATTRIBUTES

Characteristics		Value	
Input Default State Resistors	R1 R2	37.5 kΩ 73 kΩ	
ESD Protection	Human Body Model Machine Model Charged Device Model	> 2 kV > 200 V > 1 kV	
Moisture Sensitivity (Note 2)		Pb Pkg	Pb-Free Pkg
	QFN-16	Level 1	Level 1
Flammability Rating	Oxygen Index: 28 to 34	UL 94 V-0 @ 0.125 in	
Transistor Count		157	
Meets or exceeds JEDEC Spec EIA/JESD78 IC Latchup Test			

2. For additional information, see Application Note AND8003/D.

Table 3. MAXIMUM RATINGS

Symbol	Parameter	Condition 1	Condition 2	Rating	Unit
V_{CC}	Positive Power Supply	$V_{EE} = 0 \text{ V}$		6	V
V_{EE}	Negative Power Supply	$V_{CC} = 0 \text{ V}$		-6	V
V_I	Positive Input Negative Input	$V_{EE} = 0 \text{ V}$ $V_{CC} = 0 \text{ V}$	$V_I = V_{CC}$ $V_I = V_{EE}$	6 -6	V V
V_{INPP}	Differential Input Voltage	$ D - \bar{D} $		$ V_{CC} - V_{EE} $	V
I_{IN}	Input Current Through R_T (50 Ω Resistor)	Static Surge		45 80	mA mA
I_{OUT}	Output Current	Continuous Surge		25 50	mA mA
I_{BB}	V_{BB} Sink/Source			± 0.5	mA
T_A	Operating Temperature Range			-40 to +85	$^{\circ}\text{C}$
T_{stg}	Storage Temperature Range			-65 to +150	$^{\circ}\text{C}$
θ_{JA}	Thermal Resistance (Junction-to-Ambient) (Note 3)	0 lfpm 500 lfpm	QFN-16 QFN-16	42 35	$^{\circ}\text{C}/\text{W}$ $^{\circ}\text{C}/\text{W}$
θ_{JC}	Thermal Resistance (Junction-to-Case)	1S2P (Note 3)	QFN-16	4	$^{\circ}\text{C}/\text{W}$
T_{sol}	Wave Solder Pb Pb-Free			265 265	$^{\circ}\text{C}$

Maximum ratings are those values beyond which device damage can occur. Maximum ratings applied to the device are individual stress limit values (not normal operating conditions) and are not valid simultaneously. If these limits are exceeded, device functional operation is not implied, damage may occur and reliability may be affected.

3. JEDEC standard multilayer board – 1S2P (1 signal, 2 power) with 8 filled thermal vias under exposed pad.

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Table 4. DC CHARACTERISTICS: CLOCK INPUTS, CML OUTPUTS $V_{CC} = 2.375 \text{ V to } 3.8 \text{ V}$, $V_{EE} = 0 \text{ V}$, $T_A = -40^\circ\text{C to } +85^\circ\text{C}$

Symbol	Characteristic	Min	Typ	Max	Unit
I_{CC}	Power Supply Current (Inputs and Outputs Open)	30	45	55	mA
V_{OH}	Output HIGH Voltage (Note 4)	$V_{CC} - 40$	$V_{CC} - 10$	V_{CC}	mV
V_{OL}	Output LOW Voltage (Note 4)	$V_{CC} - 500$	$V_{CC} - 400$	$V_{CC} - 300$	mV

DIFFERENTIAL INPUT DRIVEN SINGLE-ENDED (Figures 15 and 17)

V_{TH}	Input Threshold Reference Voltage Range (Note 6)	1050		$V_{CC} - 150$	mV
V_{IH}	Single-ended Input HIGH Voltage	$V_{th} + 150$		V_{CC}	mV
V_{IL}	Single-ended Input LOW Voltage	V_{EE}		$V_{th} - 150$	mV
V_{BB}	Internally Generated Reference Voltage Supply (Loaded with $-100 \mu\text{A}$)	$V_{CC} - 1500$	$V_{CC} - 1400$	$V_{CC} - 1300$	mV

DIFFERENTIAL INPUTS DRIVEN DIFFERENTIALLY (Figures 16 and 18)

V_{IHD}	Differential Input HIGH Voltage	1200		V_{CC}	mV
V_{ILD}	Differential Input LOW Voltage	V_{EE}		$V_{CC} - 150$	mV
V_{CMR}	Input Common Mode Range (Differential Configuration)	1125		$V_{CC} - 75$	mV
V_{ID}	Differential Input Voltage ($V_{IHD} - V_{ILD}$)	150		$V_{CC} - V_{EE}$	mV
I_{IH}	Input HIGH Current (VTD/VTD Open)	$\begin{matrix} D \\ \overline{D} \end{matrix}$ 0 0	$\begin{matrix} 100 \\ 50 \end{matrix}$	$\begin{matrix} 150 \\ 100 \end{matrix}$	μA
I_{IL}	Input LOW Current (VTD/VTD Open)	$\begin{matrix} D \\ \overline{D} \end{matrix}$ -100 -150	$\begin{matrix} -50 \\ -100 \end{matrix}$	$\begin{matrix} 0 \\ 0 \end{matrix}$	μA
R_{TIN}	Internal Input Termination Resistor	40	50	60	Ω
R_{TOUT}	Internal Output Termination Resistor	40	50	60	Ω
R_{Temp} Coef	Internal I/O Termination Resistor Temperature Coefficient		16		$\text{m}\Omega/^\circ\text{C}$

NOTE: Device will meet the specifications after thermal equilibrium has been established when mounted in a test socket or printed circuit board with maintained transverse airflow greater than 500 lfm. Electrical parameters are guaranteed only over the declared operating temperature range. Functional operation of the device exceeding these conditions is not implied. Device specification limit values are applied individually under normal operating conditions and not valid simultaneously.

- CML outputs require 50 Ω receiver termination resistors to V_{CC} for proper operation. See Figure 14.
- Input and output parameters vary 1:1 with V_{CC} .
- V_{th} is applied to the complementary input when operating in single-ended mode.
- V_{CMR} min varies 1:1 with V_{EE} ; V_{CMRmax} varies 1:1 with V_{CC} . The V_{CMR} range is referenced to the most positive side of the differential input signal.

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Table 5. AC CHARACTERISTICS $V_{CC} = 2.375\text{ V to }3.8\text{ V}$, $V_{EE} = 0\text{ V}$; (Note 8)

Symbol	Characteristic	-40°C			25°C			85°C			Unit
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
V_{OUTPP}	Output Voltage Amplitude (@ $V_{INPPmin}$) $f_{in} \leq 3.5\text{ GHz}$ (Figures 3 and 4) $f_{in} \leq 4.5\text{ GHz}$	280 150	400 300		280 150	400 300		280 150	400 300		mV
f_{DATA}	Maximum Operating Data Rate	3.5	5.0		3.5	5.0		3.5	5.0		Gb/s
t_{PLH} , t_{PHL}	Propagation Delay to Output Differential @ 0.5 GHz (Figure 6)	175	215	265	175	220	265	175	225	265	ps
t_{SKEW}	Duty Cycle Skew (Note 9) Device-to-Device Skew (Note 13)		2.0 6.0	10 90		2.0 6.0	10 90		2.0 6.0	10 90	ps
t_{JITTER}	RMS Random Clock Jitter (Note 11) $f_{in} \leq 4.5\text{ GHz}$ Peak-to-Peak Data Dependent Jitter (Note 12) $f_{DATA} = 2.5\text{ Gb/s}$ $f_{DATA} = 3.5\text{ Gb/s}$ $f_{DATA} = 5.0\text{ Gb/s}$		0.2 1.5 2.0 9.0	0.7 10 12 25		0.2 1.5 2.0 9.0	0.7 10 12 25		0.2 1.5 2.0 9.0	0.7 10 12 25	ps
V_{INPP}	Input Voltage Swing/Sensitivity (Differential Configuration) (Note 10)	75		V_{CC} $-V_{EE}$	75		V_{CC} $-V_{EE}$	75	V_{CC} $-V_{EE}$		mV
t_r t_f	Output Rise/Fall Times @ 0.5 GHz (Figure 5) (20% – 80%)		60	90		60	90		60	90	ps

NOTE: Device will meet the specifications after thermal equilibrium has been established when mounted in a test socket or printed circuit board with maintained transverse airflow greater than 500 lfm. Electrical parameters are guaranteed only over the declared operating temperature range. Functional operation of the device exceeding these conditions is not implied. Device specification limit values are applied individually under normal operating conditions and not valid simultaneously.

8. Measured by forcing $V_{INPP}(MIN)$ from a 50% duty cycle clock source. All loading with an external $R_L = 50\ \Omega$ to V_{CC} . Input edge rates 40 ps (20% – 80%). See Figure 12 and 14.
9. Duty cycle skew is measured between differential outputs using the deviations of the sum of T_{pw-} and T_{pw+} @ 0.5 GHz.
10. $V_{INPP}(MAX)$ cannot exceed $V_{CC} - V_{EE}$. Input voltage swing is a single-ended measurement operating in differential mode. See Figure 11.
11. Additive RMS jitter with 50% duty cycle input clock signal.
12. Additive peak-to-peak data dependent jitter with NRZ input data signal, PRBS 2²³-1 and K28.7 pattern. See Figures 7, 8, 9, 10, 11 and 12.
13. Device-to-device skew is measured between outputs under identical transition @ 0.5 GHz.

TYPICAL OPERATING CHARACTERISTICS

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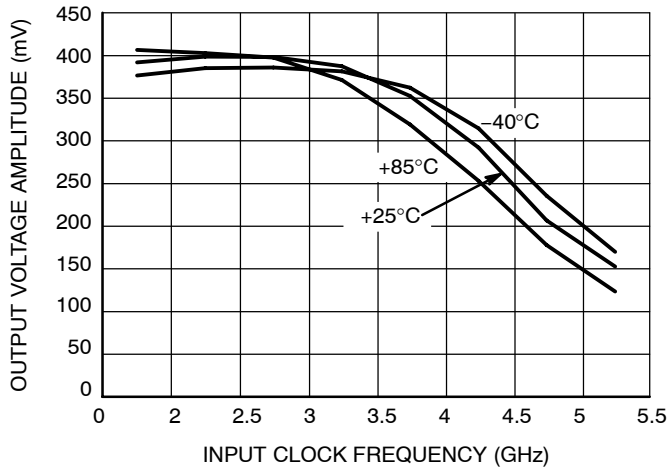


Figure 3. Output Voltage Amplitude (V_{OUTPP}) vs. Input Clock Frequency (f_{IN}) and Temperature at 3.3 V Power Supply

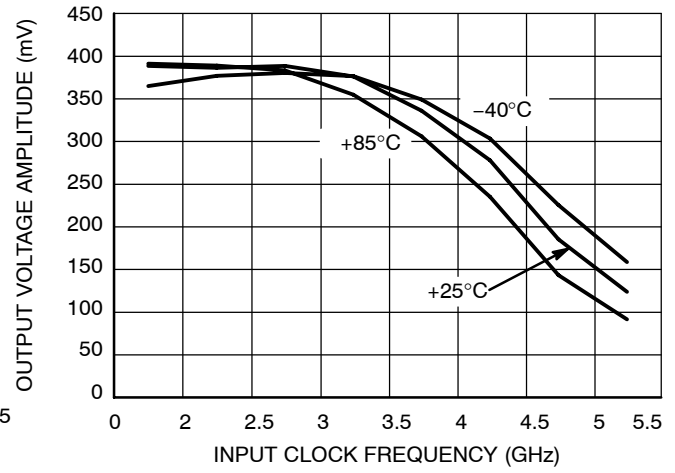


Figure 4. Output Voltage Amplitude (V_{OUTPP}) vs Input Clock Frequency (f_{IN}) and Temperature at 2.5 V Power Supply

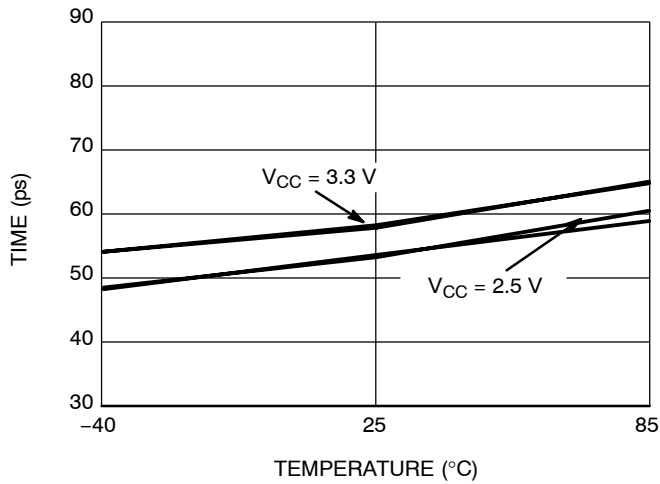


Figure 5. Rise/Fall Time vs Temperature and Power Supply

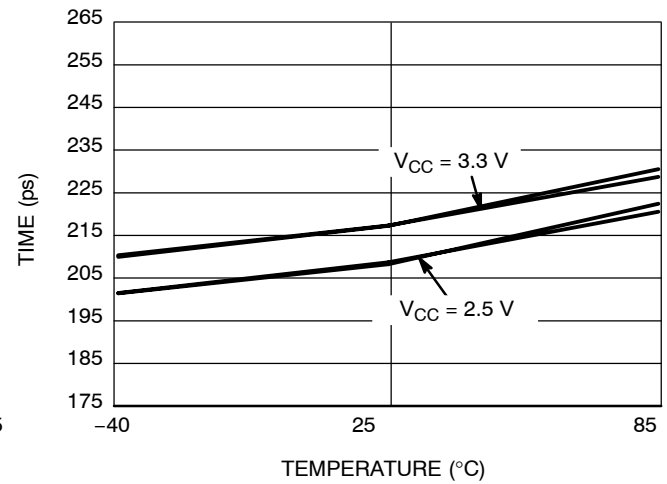


Figure 6. Propagation Delay vs Temperature and Power Supply

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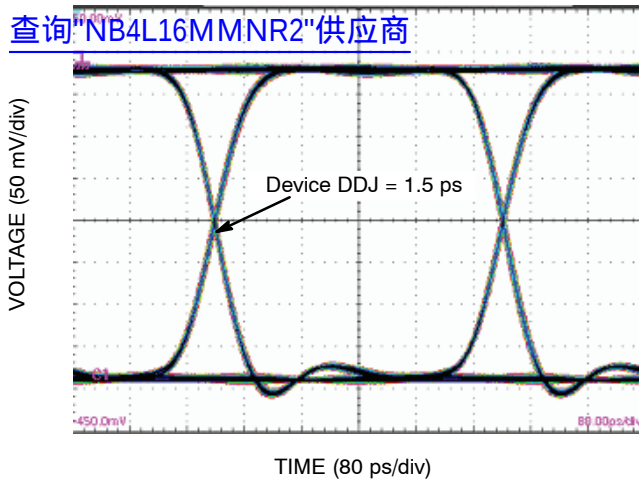


Figure 7. Typical Output Waveform at 2.488 Gb/s with PRBS $2^{23}-1$ ($V_{INPP} = 75$ mV; Input Signal DDJ = 12 ps)

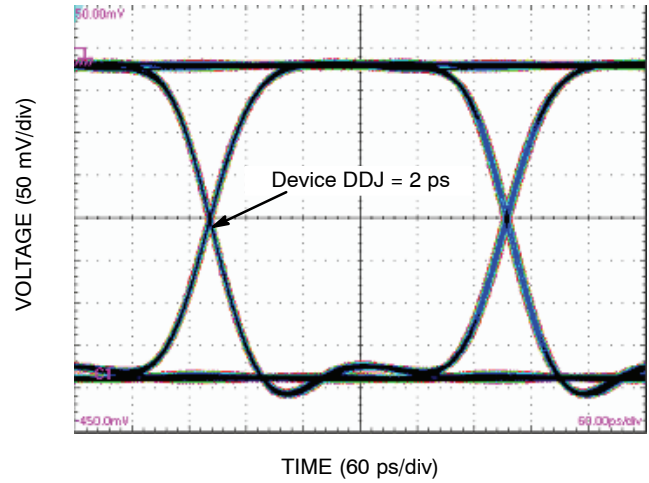


Figure 8. Typical Output Waveform at 3.2 Gb/s with PRBS $2^{23}-1$ ($V_{INPP} = 75$ mV; Input Signal DDJ = 12 ps)

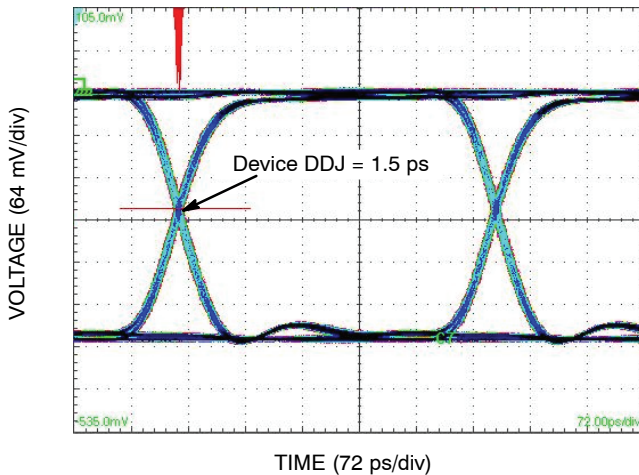


Figure 9. Typical Output Waveform at 2.488 Gb/s with PRBS $2^{23}-1$ ($V_{INPP} = 400$ mV; Input Signal DDJ = 12 ps)

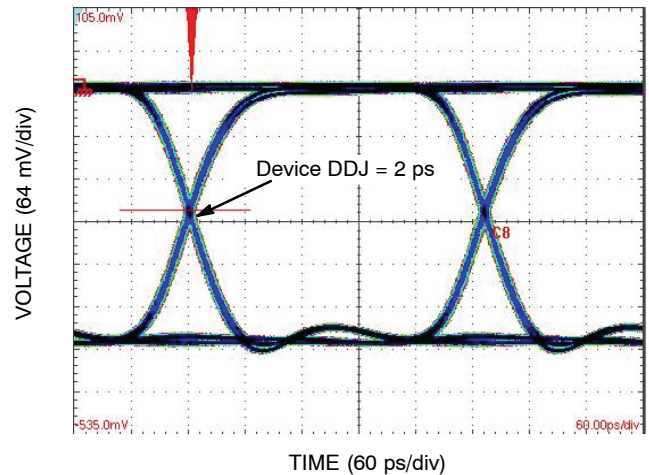


Figure 10. Typical Output Waveform at 3.2 Gb/s with PRBS $2^{23}-1$ ($V_{INPP} = 400$ mV; Input Signal DDJ = 12 ps)

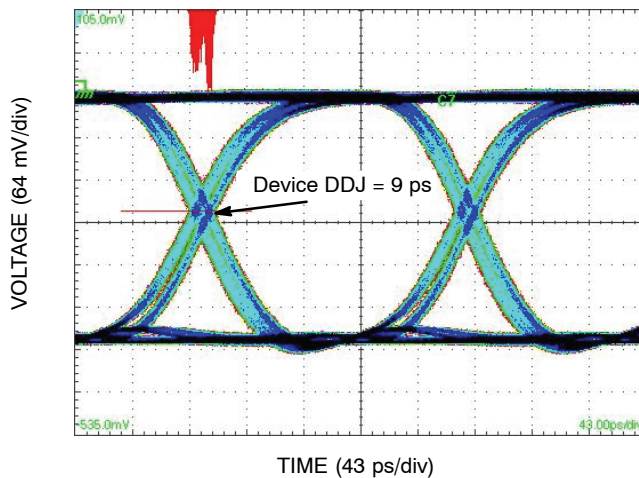


Figure 11. Typical Output Waveform at 5 Gb/s with PRBS $2^{23}-1$ ($V_{INPP} = 400$ mV; Input Signal DDJ = 13 ps)

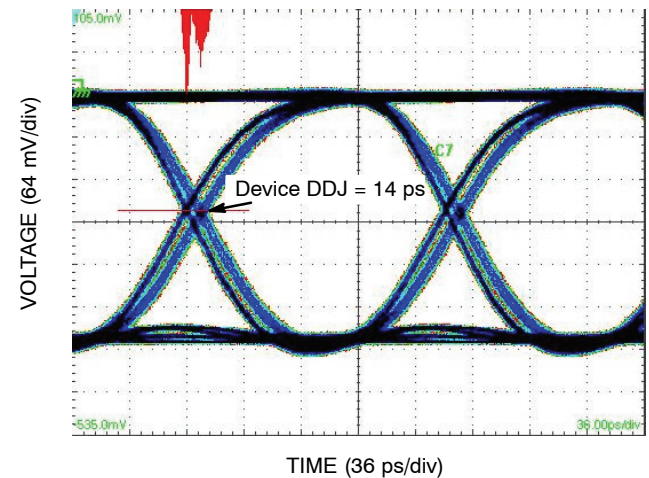


Figure 12. Typical Output Waveform at 6.125 Gb/s with PRBS $2^{23}-1$ ($V_{INPP} = 400$ mV; Input Signal DDJ = 15 ps)

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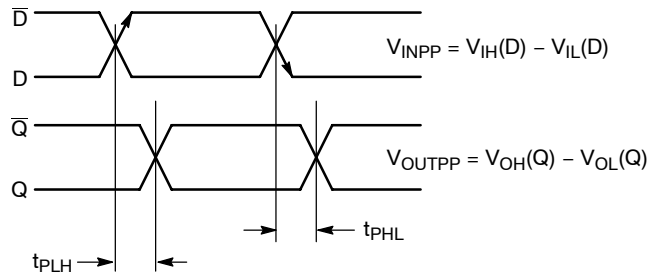


Figure 13. AC Reference Measurement

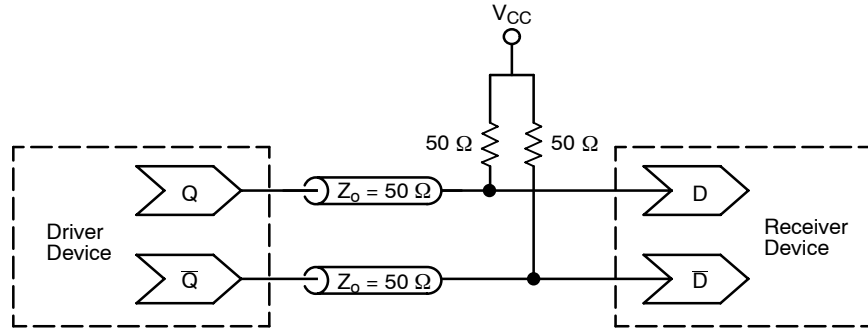


Figure 14. Typical Termination for Output Driver and Device Evaluation

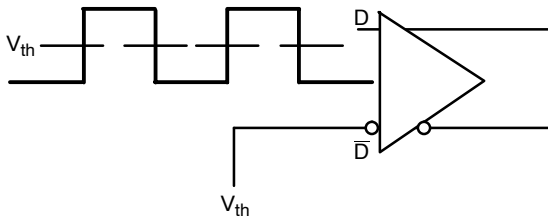


Figure 15. Differential Input Driven Single-Ended

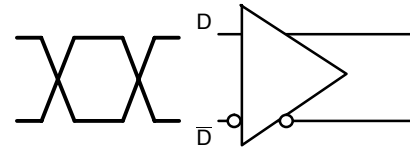


Figure 16. Differential Inputs Driven Differentially

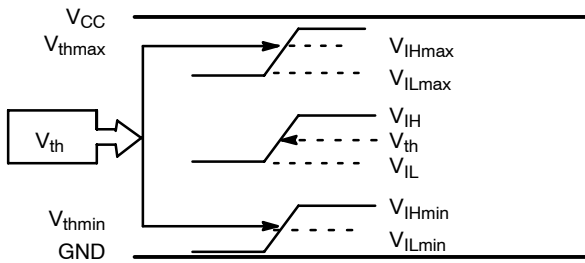


Figure 17. V_{th} Diagram

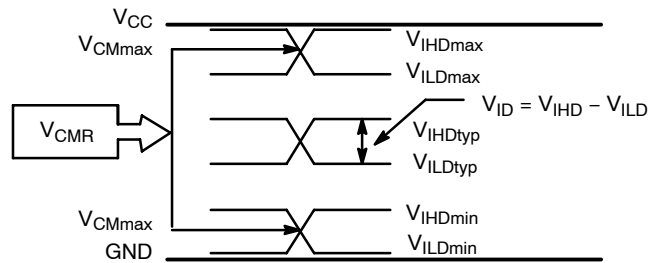


Figure 18. V_{CM} Diagram

NOTE: $V_{EE} \leq V_{IN} \leq V_{CC}$; $V_{IH} > V_{IL}$

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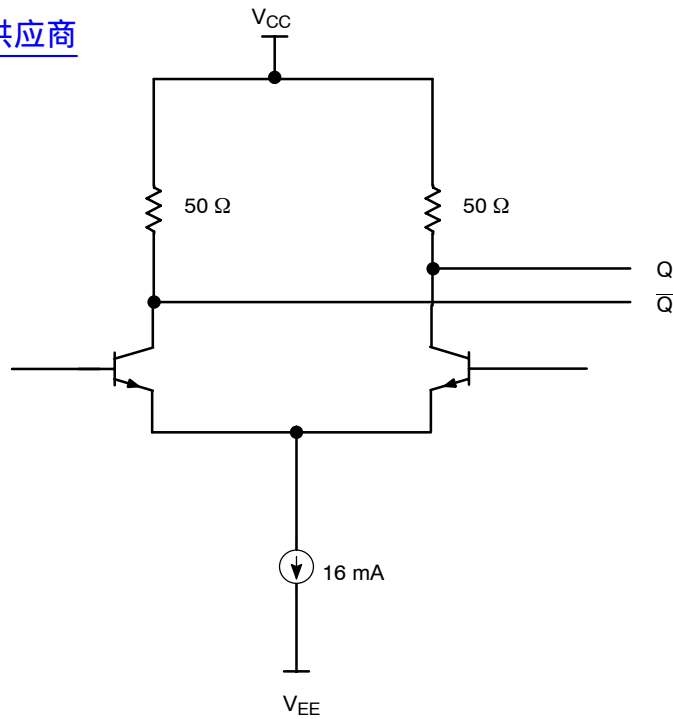


Figure 19. CML Output Structure

Table 6. INTERFACING OPTIONS

INTERFACING OPTIONS	CONNECTIONS
CML	Connect V_{TD} and $\overline{V_{TD}}$ to V_{CC}
LVDS	Connect V_{TD} and $\overline{V_{TD}}$ Together
AC-COUPLED	Bias V_{TD} and $\overline{V_{TD}}$ Inputs within Common Mode Range (V_{CMR})
RSECL, PECL, NECL	Standard ECL Termination Techniques
LVTTL, LVCMOS	An External Voltage (V_{THR}) should be applied to the unused complementary differential input. Nominal V_{THR} is 1.5 V for LVTTL and $V_{CC}/2$ for LVCMOS inputs. This voltage must be within the V_{THR} specification.

Application Information

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All NB4L16M inputs can accept LVPECL, CML, LVTTTL, LVCMOS and LVDS signal levels. The limitations for differential input signal (LVDS, PECL, or CML) are minimum input swing of 75 mV and the maximum input swing of 2500 mV. Within these conditions, the input voltage can range from V_{CC} to 1.2 V. Examples interfaces are illustrated below in a 50 Ω environment ($Z = 50 \Omega$).

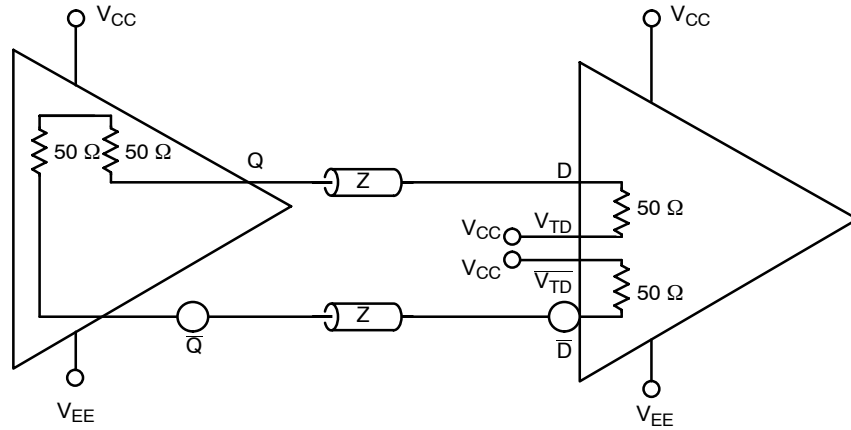


Figure 20. CML to CML Interface

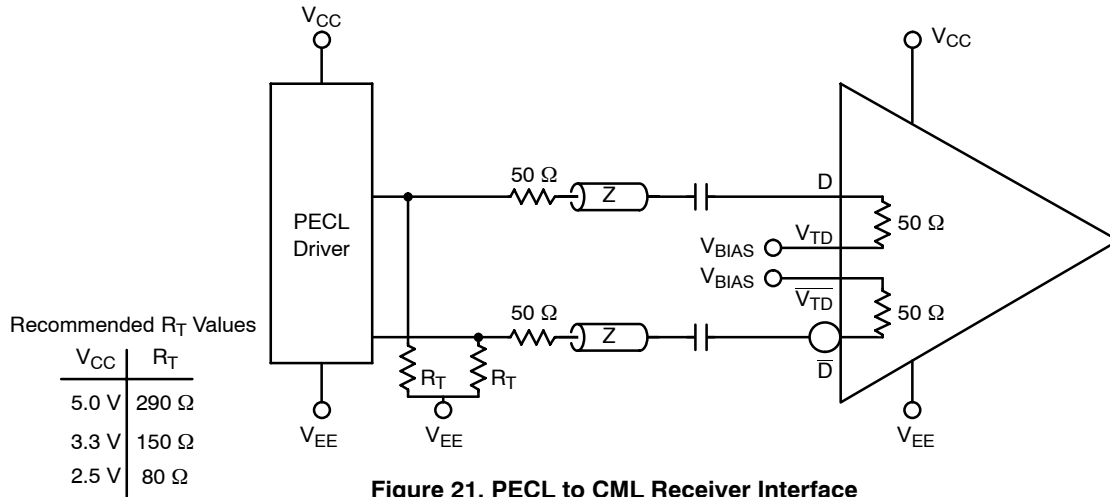


Figure 21. PECL to CML Receiver Interface

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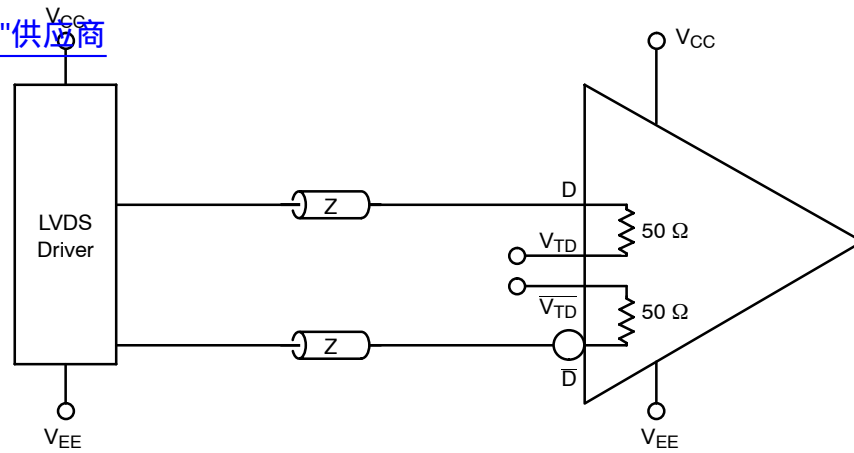


Figure 22. LVDS to CML Receiver Interface

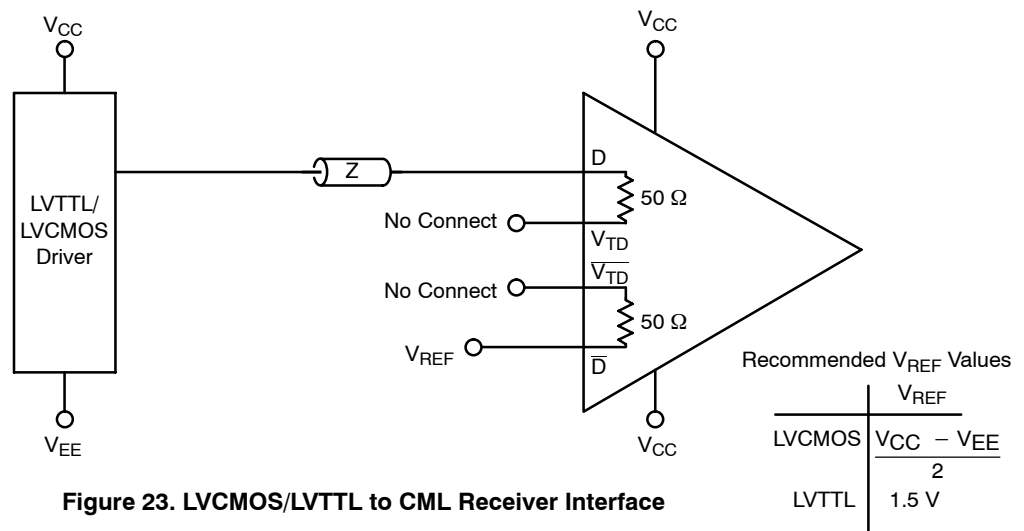


Figure 23. LVCMOS/LVTTL to CML Receiver Interface

ORDERING INFORMATION

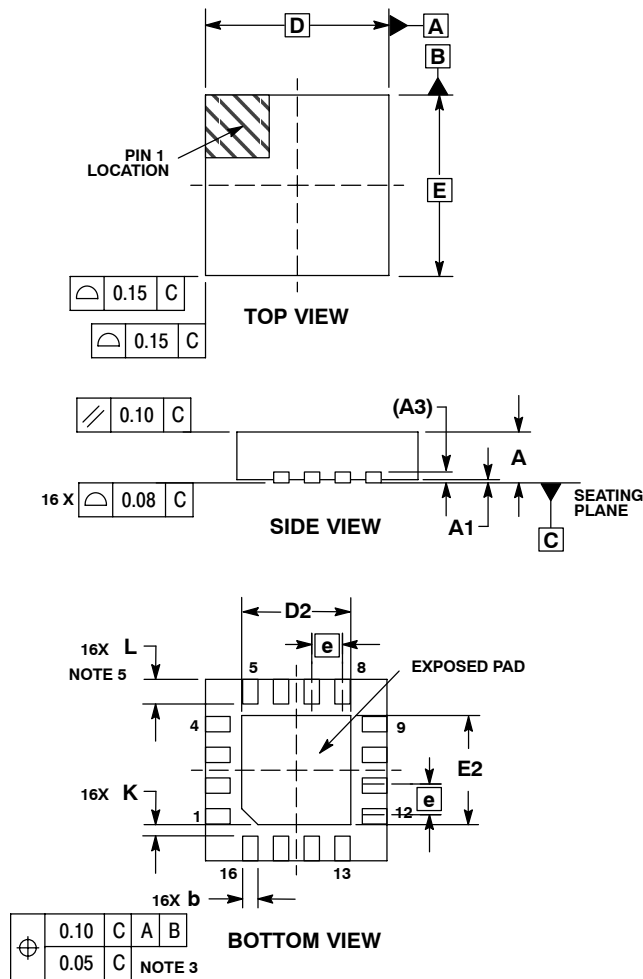
Device	Package	Shipping [†]
NB4L16MMN	QFN-16	123 Units / Rail
NB4L16MMNG	QFN-16 (Pb-Free)	123 Units / Rail
NB4L16MMNR2	QFN-16	3000 / Tape & Reel
NB4L16MMNR2G	QFN-16 (Pb-Free)	3000 / Tape & Reel

[†]For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

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PACKAGE DIMENSIONS

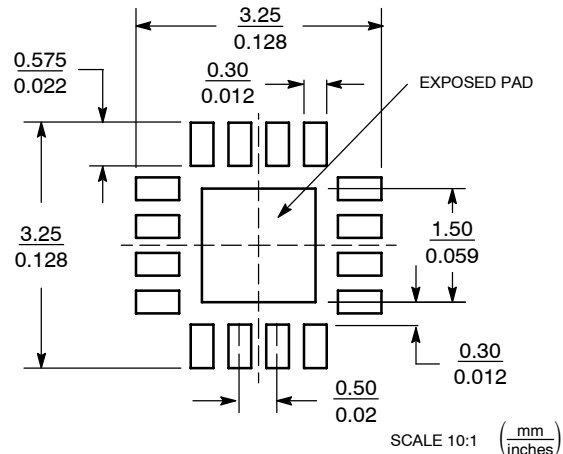
16 PIN QFN
CASE 485G-01
ISSUE B



- NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
 2. CONTROLLING DIMENSION: MILLIMETERS.
 3. DIMENSION b APPLIES TO PLATED TERMINAL AND IS MEASURED BETWEEN 0.25 AND 0.30 MM FROM TERMINAL.
 4. COPLANARITY APPLIES TO THE EXPOSED PAD AS WELL AS THE TERMINALS.
 5. L_{max} CONDITION CAN NOT VIOLATE 0.2 MM MINIMUM SPACING BETWEEN LEAD TIP AND FLAG

DIM	MILLIMETERS	
	MIN	MAX
A	0.80	1.00
A1	0.00	0.05
A3	0.20 REF	
b	0.18	0.30
D	3.00 BSC	
D2	1.65	1.85
E	3.00 BSC	
E2	1.65	1.85
e	0.50 BSC	
K	0.20	---
L	0.30	0.50

SOLDERING FOOTPRINT*



*For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

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