

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

NB4L16M

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 μF 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.

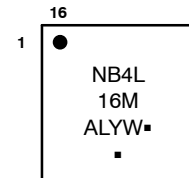
Features

- 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
- These Devices are Pb-Free, Halogen Free and are RoHS Compliant



QFN-16
 MN SUFFIX
 CASE 485G-01

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](http://www.onsemi.com).

ORDERING INFORMATION

| Device | Package | Shipping [†] |
|--------------|------------------|-----------------------|
| NB4L16MMNG | QFN-16 (Pb-Free) | 123 Units/Tube |
| 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](http://www.onsemi.com).

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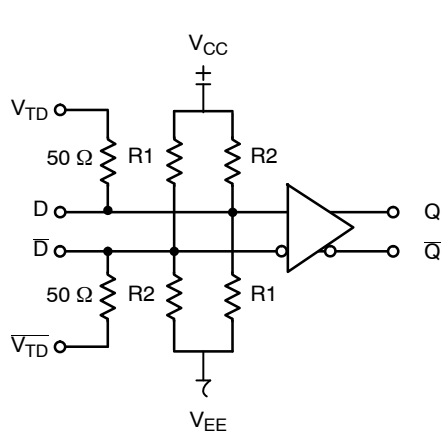


Figure 1. Functional Block Diagram

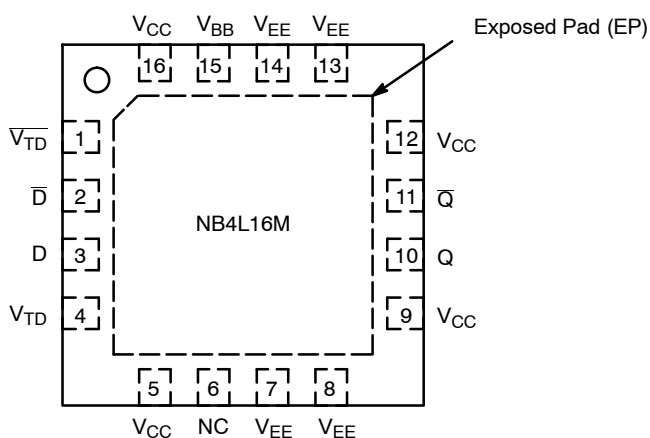


Figure 2. Pin Configuration (Top View)

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 | Non-inverted 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 | Non-inverted 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 1) | Pb-Free Pkg |
| QFN-16 | 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 | |

1. 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 V | | 6 | V |
| V _{EE} | Negative Power Supply | V _{CC} = 0 V | | -6 | V |
| V _I | Positive Input Negative Input | V _{EE} = 0 V V _{CC} = 0 V | V _I = V _{CC} V _I = V _{EE} | 6 -6 | V |
| V _{INPP} | Differential Input Voltage | D - D̄ | | V _{CC} - V _{EE} | V |
| I _{IN} | Input Current Through R _T (50 Ω Resistor) | Static Surge | | 45 80 | mA |
| I _{OUT} | Output Current | Continuous Surge | | 25 50 | mA |
| I _{BB} | V _{BB} Sink/Source | | | ± 0.5 | mA |
| T _A | Operating Temperature Range | | | -40 to +85 | °C |
| T _{stg} | Storage Temperature Range | | | -65 to +150 | °C |
| θ _{JA} | Thermal Resistance (Junction-to-Ambient) (Note 1) | 0 lfpm 500 lfpm | QFN-16 | 42 35 | °C/W |
| θ _{JC} | Thermal Resistance (Junction-to-Case) | 1S2P (Note 1) | QFN-16 | 4 | °C/W |
| T _{sol} | Wave Solder (Pb-Free) | | | 265 | °C |

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

1. 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 1) | $V_{CC} - 40$ | $V_{CC} - 10$ | V_{CC} | mV |
| V_{OL} | Output LOW Voltage (Note 1) | $V_{CC} - 500$ | $V_{CC} - 400$ | $V_{CC} - 300$ | mV |

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

| | | | | | |
|----------|--|-----------------|-----------------|-----------------|----|
| V_{TH} | Input Threshold Reference Voltage Range (Note 3) | 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) | 950 | | $V_{CC} - 75$ | mV |
| V_{ID} | Differential Input Voltage ($V_{IHD} - V_{ILD}$) | 150 | | $V_{CC} - V_{EE}$ | mV |
| I_{IH} | Input HIGH Current (VTD/ $\overline{\text{VTD}}$ Open) | 0 | 100 | 150 | μA |
| | | 0 | 50 | 100 | |
| I_{IL} | Input LOW Current (VTD/ $\overline{\text{VTD}}$ Open) | -100 | -50 | 0 | μA |
| | | -150 | -100 | 0 | |
| 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.

1. CML outputs require $50\ \Omega$ receiver termination resistors to V_{CC} for proper operation. See Figure 14.
2. Input and output parameters vary 1:1 with V_{CC} .
3. V_{th} is applied to the complementary input when operating in single-ended mode.
4. $V_{CMR\ min}$ varies 1:1 with V_{EE} , $V_{CMR\ max}$ 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 1))

| Symbol | Characteristic | -40°C | | | 25°C | | | 85°C | | | Unit |
|--------------------------|---|------------|--------------------------|-----------------------|------------|--------------------------|-----------------------|------------|--------------------------|-----------------------|------|
| | | Min | Typ | Max | Min | Typ | Max | Min | Typ | Max | |
| V_{OUTPP} | Output Voltage Amplitude (@ $V_{INPPmin}$) (Figures 3 and 4) $f_{in} \leq 3.5\text{ GHz}$ $f_{in} \leq 4.5\text{ GHz}$ | 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 2) Device-to-Device Skew (Note 6) | | 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 4) $f_{in} \leq 4.5\text{ GHz}$ Peak-to-Peak Data Dependent Jitter (Note 5) $f_{DATA} = 2.5\text{ Gb/s}$ $f_{DATA} = 3.5\text{ Gb/s}$ $f_{DATA} = 5.0\text{ Gb/s}$ | | 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 3) | 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.

1. 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.
2. Duty cycle skew is measured between differential outputs using the deviations of the sum of T_{pw-} and T_{pw+} @ 0.5 GHz.
3. $V_{INPP(MAX)}$ cannot exceed $V_{CC} - V_{EE}$. Input voltage swing is a single-ended measurement operating in differential mode. See Figure 11.
4. Additive RMS jitter with 50% duty cycle input clock signal.
5. 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.
6. Device-to-device skew is measured between outputs under identical transition @ 0.5 GHz.

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TYPICAL OPERATING CHARACTERISTICS

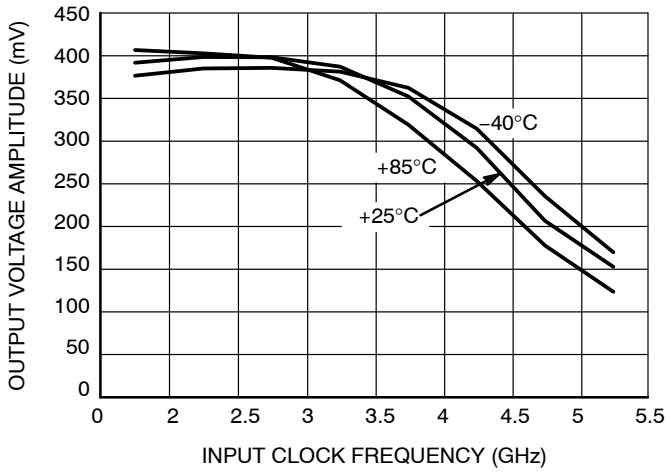


Figure 3. Output Voltage Amplitude (V_{OUTPP}) vs. Input Clock Frequency (f_{in}) and Temperature at 3.3 V Power Supply

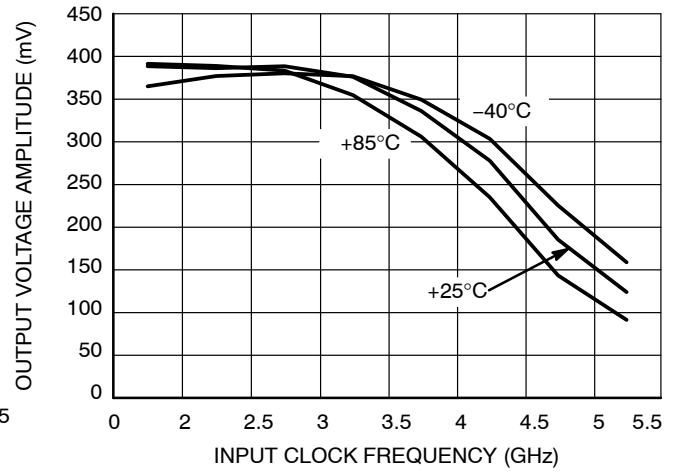


Figure 4. Output Voltage Amplitude (V_{OUTPP}) vs. Input Clock Frequency (f_{in}) and Temperature at 2.5 V Power Supply

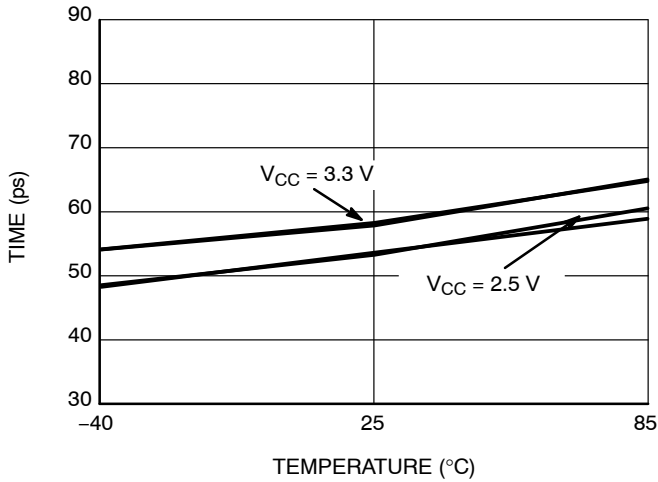


Figure 5. Rise/Fall Time vs. Temperature and Power Supply

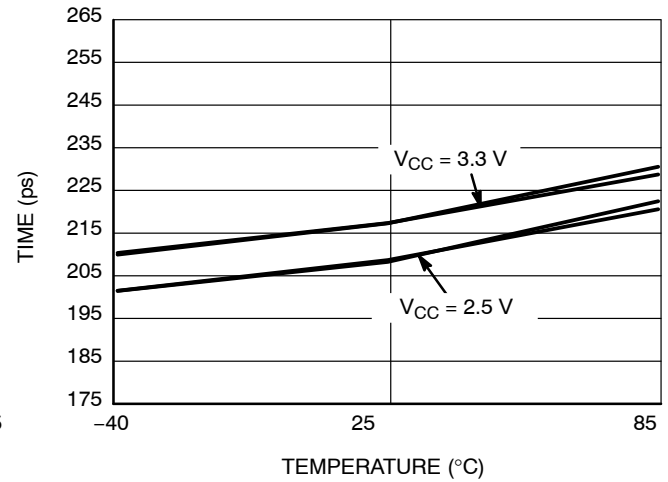


Figure 6. Propagation Delay vs. Temperature and Power Supply

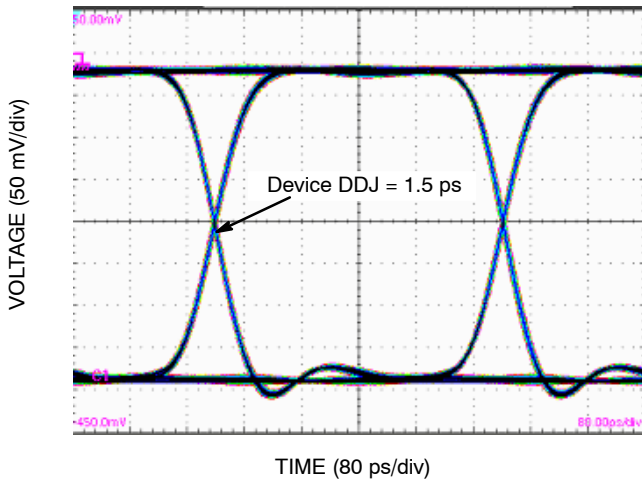


Figure 7. Typical Output Waveform at 2.488 Gb/s with PRBS $2^{23}-1$ ($V_{INPP} = 75$ mV; Input Signal DDJ = 12 ps)

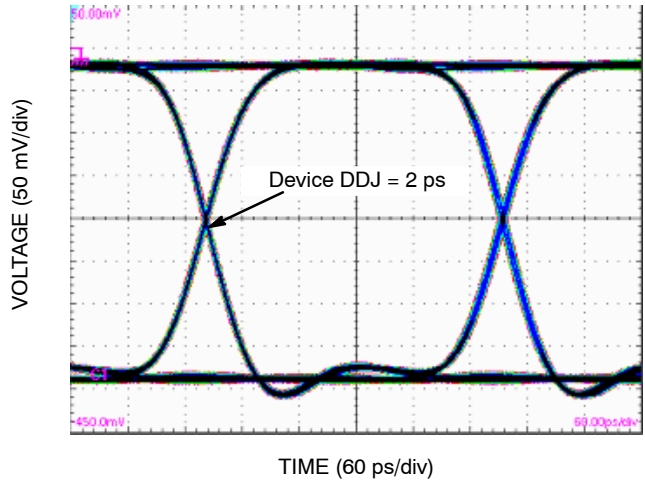


Figure 8. Typical Output Waveform at 3.2 Gb/s with PRBS $2^{23}-1$ ($V_{INPP} = 75$ mV; Input Signal DDJ = 12 ps)

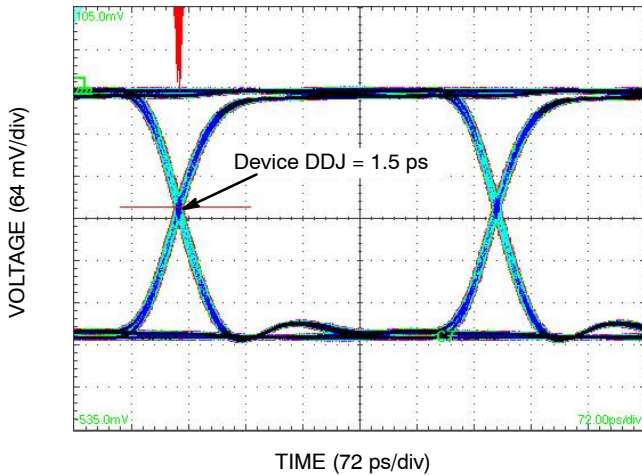


Figure 9. Typical Output Waveform at 2.488 Gb/s with PRBS $2^{23}-1$ ($V_{INPP} = 400$ mV; Input Signal DDJ = 12 ps)

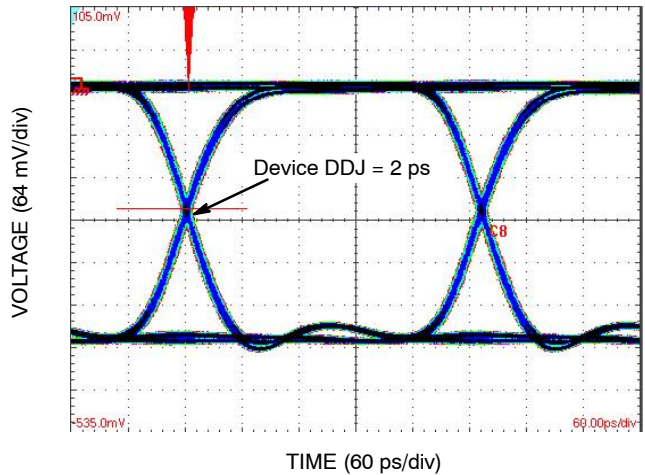


Figure 10. Typical Output Waveform at 3.2 Gb/s with PRBS $2^{23}-1$ ($V_{INPP} = 400$ mV; Input Signal DDJ = 12 ps)

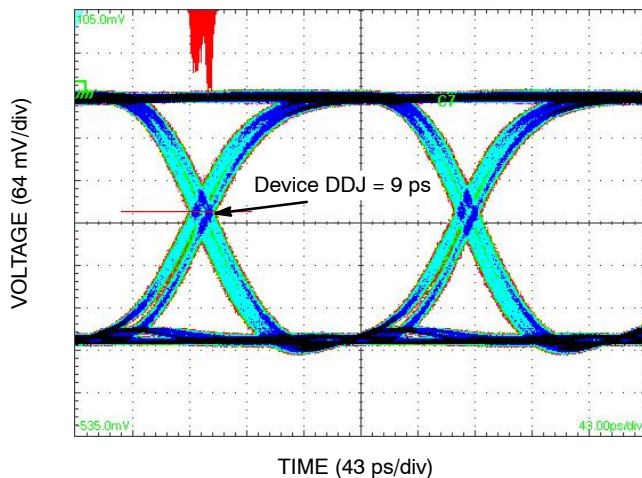


Figure 11. Typical Output Waveform at 5 Gb/s with PRBS $2^{23}-1$ ($V_{INPP} = 400$ mV; Input Signal DDJ = 13 ps)

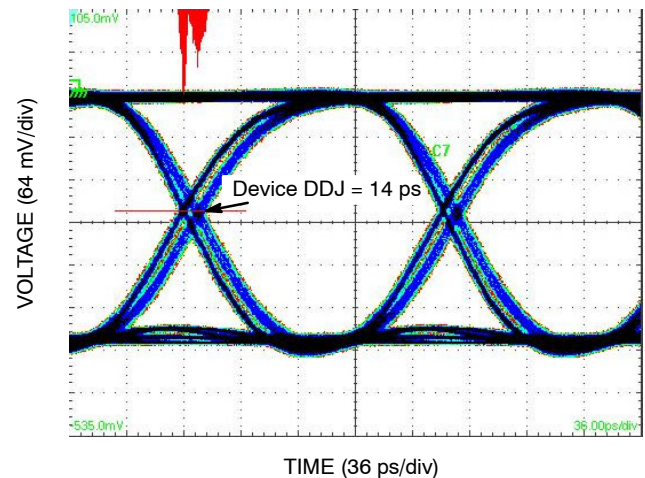


Figure 12. Typical Output Waveform at 6.125 Gb/s with PRBS $2^{23}-1$ ($V_{INPP} = 400$ mV; Input Signal DDJ = 15 ps)

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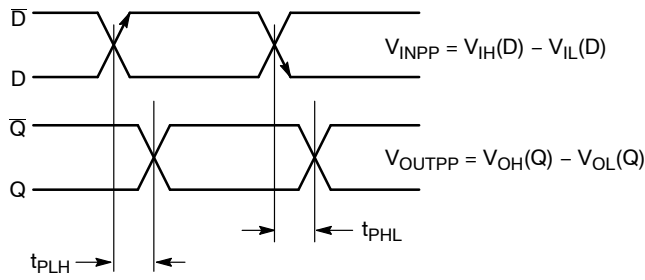


Figure 13. AC Reference Measurement

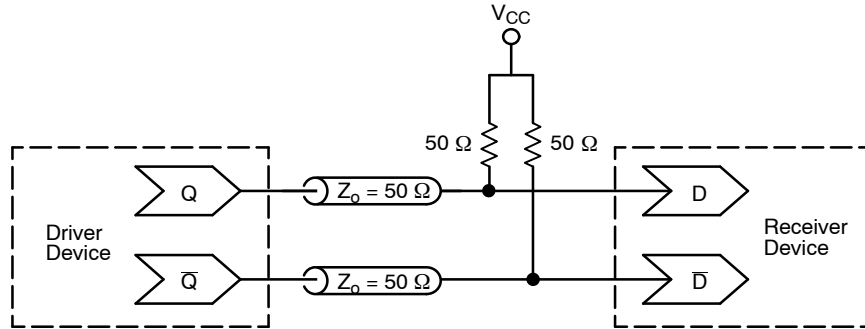


Figure 14. Typical Termination for Output Driver and Device Evaluation

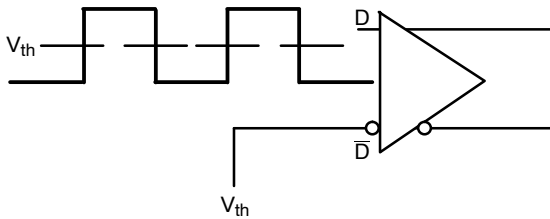


Figure 15. Differential Input Driven Single-Ended

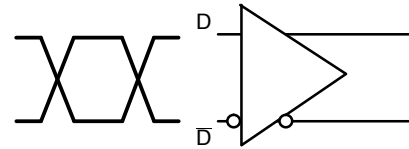


Figure 16. Differential Inputs Driven Differentially

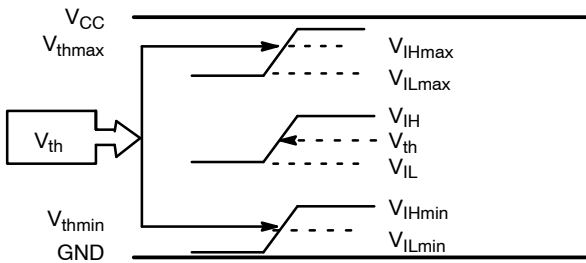


Figure 17. V_{th} Diagram

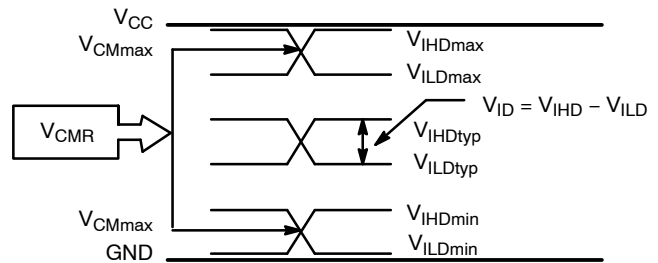


Figure 18. V_{CMR} Diagram

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

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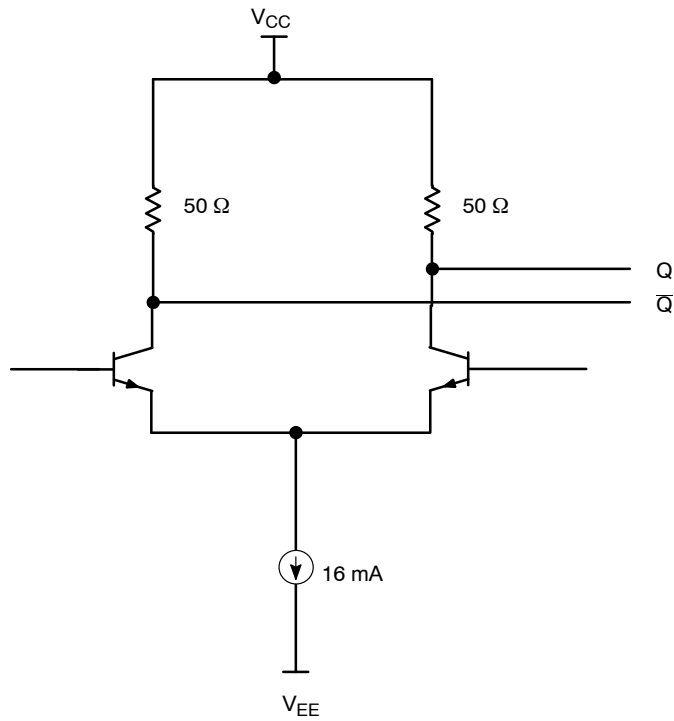


Figure 19. CML Output Structure

Table 6. INTERFACING OPTIONS

| INTERFACING OPTIONS | CONNECTIONS |
|---------------------|---|
| CML | Connect V_{TD} and \bar{V}_{TD} to V_{CC} |
| LVDS | Connect V_{TD} and \bar{V}_{TD} Together |
| AC-COUPLED | Bias V_{TD} and \bar{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. |

NB4L16M

APPLICATION INFORMATION

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 ($Z = 50 \Omega$).

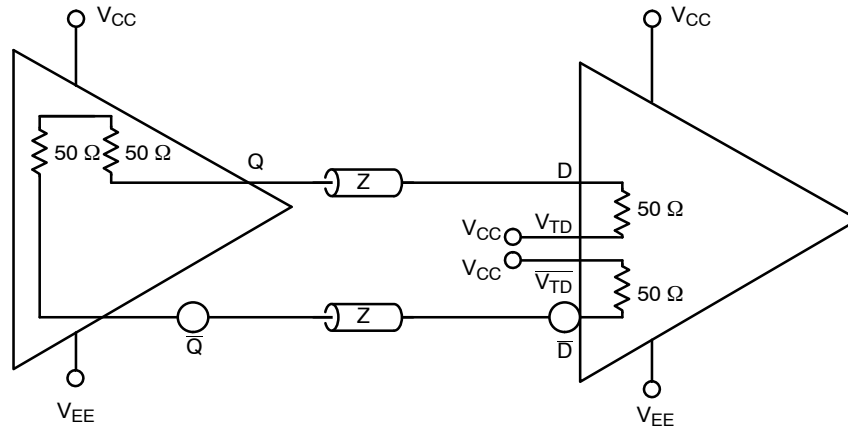


Figure 20. CML to CML Interface

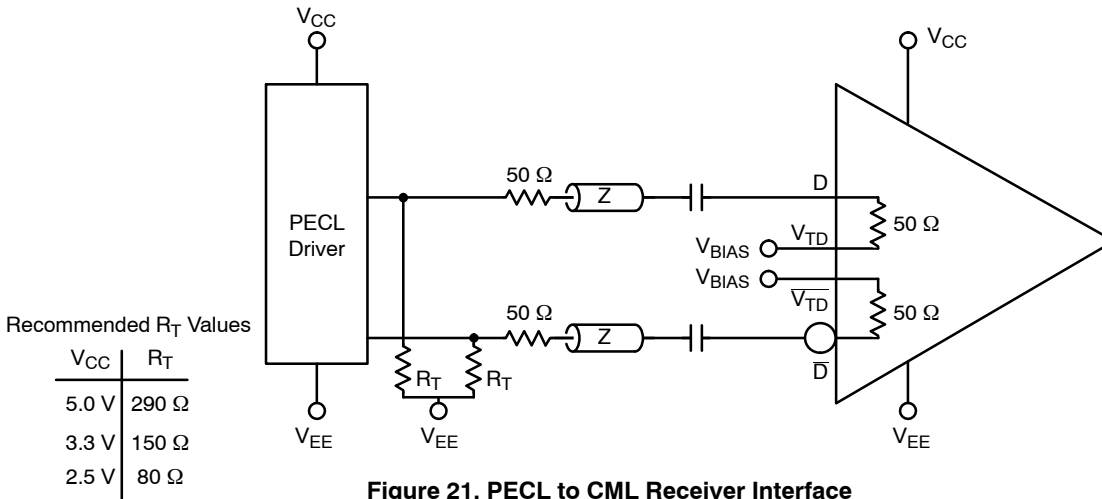


Figure 21. PECL to CML Receiver Interface

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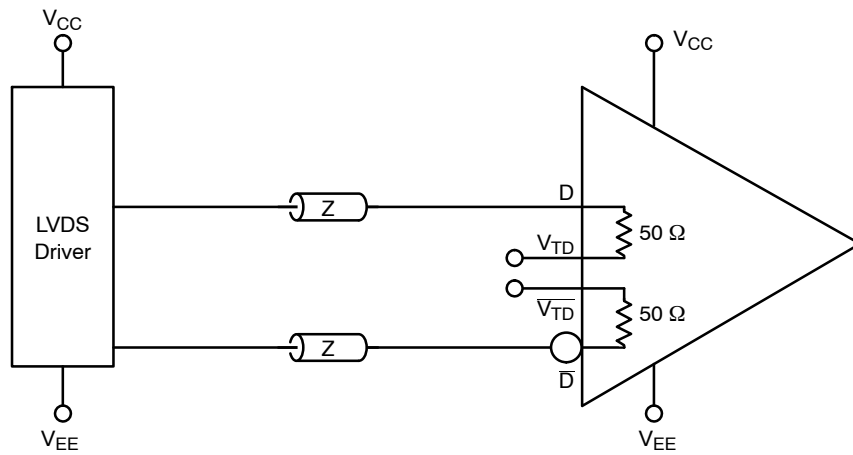


Figure 22. LVDS to CML Receiver Interface

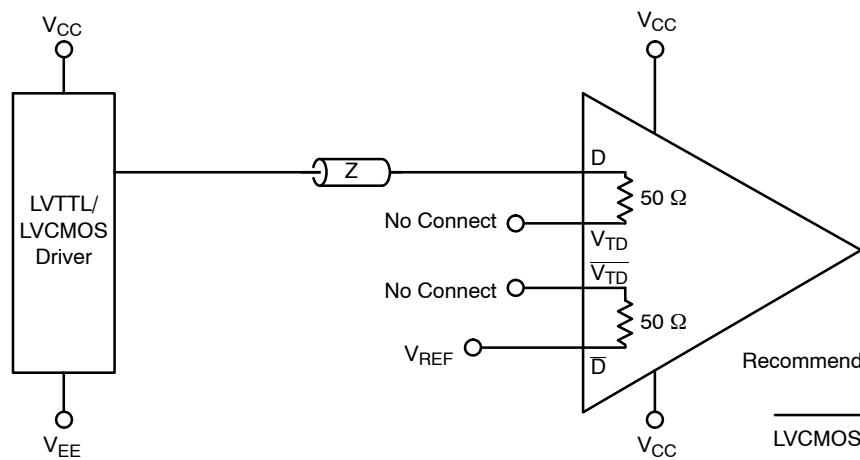


Figure 23. LVCMOS/LVTTL to CML Receiver Interface

Recommended V_{REF} Values

| | V_{REF} |
|--------|-----------------------------|
| LVCMOS | $\frac{V_{CC} - V_{EE}}{2}$ |
| LVTTL | 1.5 V |

MECHANICAL CASE OUTLINE PACKAGE DIMENSIONS



SCALE 2:1

QFN16 3x3, 0.5P
CASE 485G
ISSUE G

DATE 08 OCT 2021

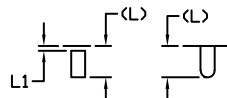


NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS
3. DIMENSION *b* APPLIES TO PLATED TERMINAL AND IS MEASURED BETWEEN 0.15 AND 0.30 MM FROM THE TERMINAL TIP.
4. COPLANARITY APPLIES TO THE EXPOSED PAD AS WELL AS THE TERMINALS.



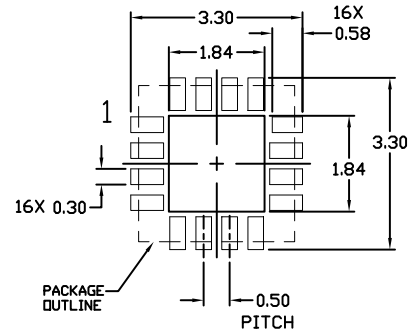
DETAIL B
ALTERNATE
CONSTRUCTIONS



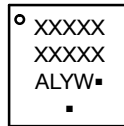
DETAIL A
ALTERNATE TERMINAL
CONSTRUCTIONS

| DIM | MILLIMETERS | | |
|----------|-------------|------|------|
| | MIN. | NDM. | MAX. |
| A | 0.80 | 0.90 | 1.00 |
| A1 | 0.00 | 0.03 | 0.05 |
| A3 | 0.20 REF | | |
| <i>b</i> | 0.18 | 0.24 | 0.30 |
| D | 3.00 BSC | | |
| D2 | 1.65 | 1.75 | 1.85 |
| E | 3.00 BSC | | |
| E2 | 1.65 | 1.75 | 1.85 |
| <i>e</i> | 0.50 BSC | | |
| <i>k</i> | 0.18 TYP | | |
| L | 0.30 | 0.40 | 0.50 |
| L1 | 0.00 | 0.08 | 0.15 |

MOUNTING FOOTPRINT



GENERIC MARKING DIAGRAM*



- XXXXX = Specific Device Code
- A = Assembly Location
- L = Wafer Lot
- Y = Year
- W = Work Week
- = Pb-Free Package

(Note: Microdot may be in either location)

*This information is generic. Please refer to device data sheet for actual part marking. Pb-Free indicator, "G" or microdot "▪", may or may not be present. Some products may not follow the Generic Marking.

| | | |
|-------------------------|------------------------|--|
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| DESCRIPTION: | QFN16 3X3, 0.5P | PAGE 1 OF 1 |

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