

# NB7L86M

## 2.5V/3.3V 12 Gb/s Differential Clock/Data SmartGate with CML Output and Internal Termination

The NB7L86M is a multi-function differential Logic Gate, which can be configured as an AND/NAND, OR/NOR, XOR/XNOR, or 2:1 MUX. This device is part of the GigaComm family of high performance Silicon Germanium products. The NB7L86M is an ultra-low jitter multi-logic gate with a maximum data rate of 12 Gb/s and input clock frequency of 8 GHz suitable for Data Communication Systems, Telecom Systems, Fiber Channel, and GigE applications.

Differential inputs incorporate internal 50 Ω termination resistors and accept LVNECL (Negative ECL), LVPECL (Positive ECL), LVCMOS, LVTTTL, CML, or LVDS. The differential 16 mA CML output provides matching internal 50 Ω termination, and 400 mV output swing when externally terminated 50 Ω to V<sub>CC</sub>.

The device is housed in a low profile 3x3 mm 16-pin QFN package.

Application notes, models, and support documentation are available on [www.onsemi.com](http://www.onsemi.com).

### Features

- Maximum Input Clock Frequency up to 8 GHz
- Maximum Input Data Rate up to 12 Gb/s Typical
- < 0.5 ps of RMS Clock Jitter
- < 10 ps of Data Dependent Jitter
- 30 ps Typical Rise and Fall Times
- 90 ps Typical Propagation Delay
- 2 ps Typical Within Device Skew
- Operating Range: V<sub>CC</sub> = 2.375 V to 3.465 V with V<sub>EE</sub> = 0 V
- CML Output Level (400 mV Peak-to-Peak Output) Differential Output
- 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 are Pb-Free Devices

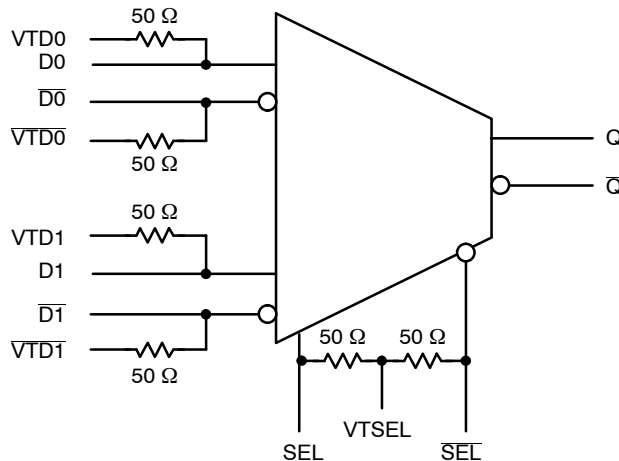


Figure 1. Simplified Logic Diagram



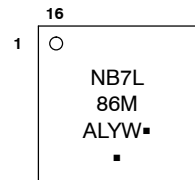
ON Semiconductor®

<http://onsemi.com>



QFN16  
MN SUFFIX  
CASE 485G

### MARKING DIAGRAM\*



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

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

### ORDERING INFORMATION

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

## NB7L86M

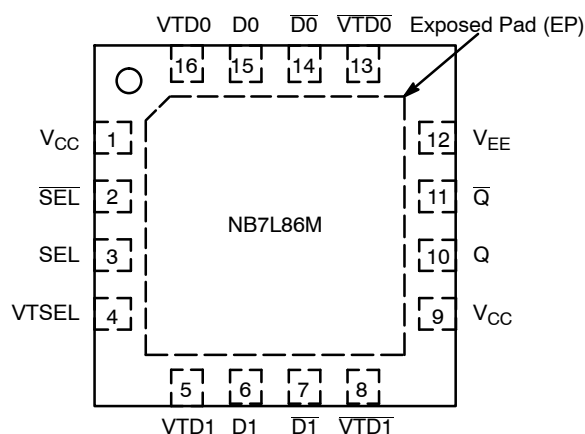


Figure 2. Pin Configuration (Top View)

Table 1. PIN DESCRIPTION

Pin	Name	I/O	Description
1, 9	$V_{CC}$	Power Supply	Positive supply voltage. All $V_{CC}$ pins must be externally connected to power supply to guarantee proper operation.
2	$\overline{SEL}$	LVPECL, CML, LVCMOS, LVTTTL, LVDS Input	Inverted differential select logic input.
3	SEL	LVPECL, CML, LVCMOS, LVTTTL, LVDS Input	Non-inverted differential select logic Input.
4	$V_{TSEL}$	-	Common internal 50 $\Omega$ termination pin for SEL/ $\overline{SEL}$ . See Table 6. (Note 1)
5	$V_{TD1}$	-	Internal 50 $\Omega$ termination pin for D1. See Table 6. (Note 1)
6	D1	LVPECL, CML, LVCMOS, LVTTTL, LVDS Input	Non-inverted differential clock/data input D1. (Note 1)
7	$\overline{D1}$	LVPECL, CML, LVCMOS, LVTTTL, LVDS Input	Inverted differential clock/data input $\overline{D1}$ . (Note 1)
8	$\overline{V_{TD1}}$	-	Internal 50 $\Omega$ termination pin for $\overline{D1}$ . See Table 6. (Note 1)
10	Q	CML Output	Non-inverted output with internal 50 $\Omega$ source termination resistor. (Note 2)
11	$\overline{Q}$	CML Output	Inverted output with internal 50 $\Omega$ source termination resistor. (Note 2)
12	$V_{EE}$	Power Supply	Negative supply voltage. All $V_{EE}$ pins must be externally connected to power supply to guarantee proper operation.
13	$\overline{V_{TD0}}$	-	Internal 50 $\Omega$ termination pin for D0. (Note 1)
14	$\overline{D0}$	LVPECL, CML, LVCMOS, LVTTTL, LVDS Input	Non-inverted differential clock/data input $\overline{D0}$ . (Note 1)
15	D0	LVPECL, CML, LVCMOS, LVTTTL, LVDS Input	Non-inverted differential clock/data input D0. (Note 1)
16	$V_{TD0}$	-	Internal 50 $\Omega$ termination pin for $\overline{D0}$ . (Note 1)
-	EP	-	Exposed Pad. Thermal pad on the package bottom must be attached to a heatsinking conduit to improve heat transfer. It is recommended to connect the EP to the lower potential ( $V_{EE}$ ).

1. In the differential configuration when the input termination pins ( $V_{TDx}$ ,  $\overline{V_{TDx}}$ ,  $V_{TSEL}$ ) are connected to a common termination voltage or left open, and if no signal is applied on  $Dx$ ,  $\overline{Dx}$ , SEL and  $\overline{SEL}$  then the device will be susceptible to self-oscillation.
2. CML output require 50  $\Omega$  receiver termination resistor to  $V_{CC}$  for proper operation.

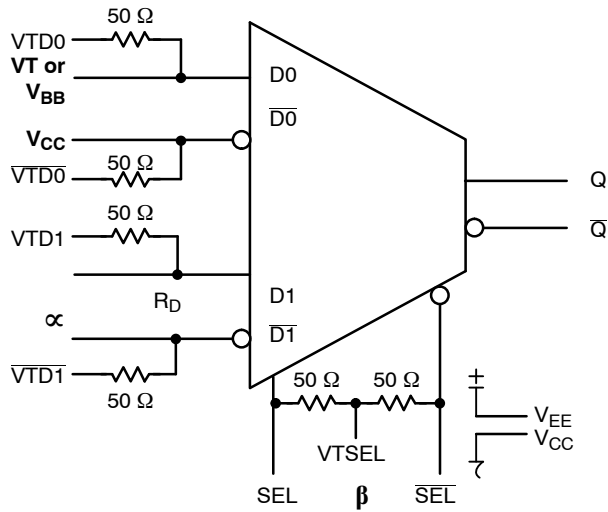


Figure 3. Configuration for AND/NAND Function

Table 2. AND/NAND TRUTH TABLE (Note 3)

	$\infty$	b	$\infty$ AND b
D0	D1	SEL	Q
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1

3.  $\overline{D0}$ ,  $\overline{D1}$ ,  $\overline{SEL}$  are complementary of D0, D1, SEL unless specified otherwise.

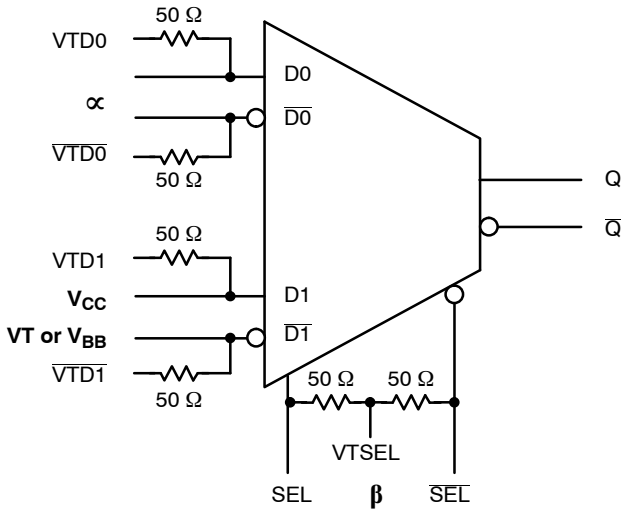


Figure 4. Configuration for OR/NOR Function

Table 3. OR/NOR TRUTH TABLE (Note 4)

$\infty$		$\beta$	$\infty$ or $\beta$
D0	D1	SEL	Q
0	1	0	0
0	1	1	1
1	1	0	1
1	1	1	1

4.  $\overline{D0}$ ,  $\overline{D1}$ ,  $\overline{SEL}$  are complementary of D0, D1, SEL unless specified otherwise.

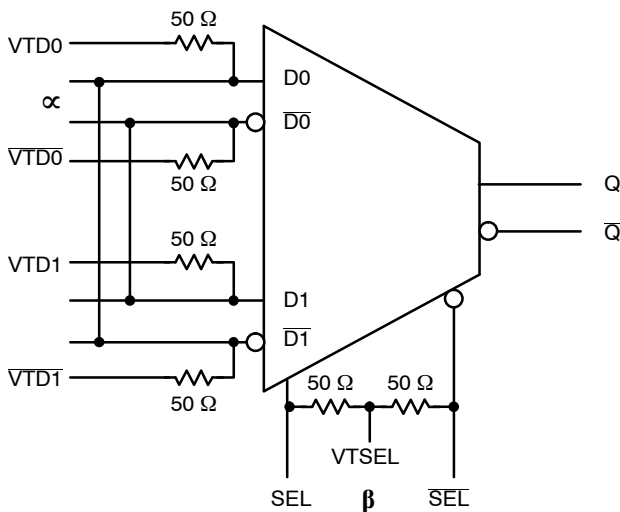


Figure 5. Configuration for XOR/XNOR Function

Table 4. XOR/XNOR TRUTH TABLE (Note 5)

$\infty$		$\beta$	$\infty$ XOR $\beta$
D0	D1	SEL	Q
0	1	0	0
0	1	1	1
1	0	0	1
1	0	1	0

5.  $\overline{D0}$ ,  $\overline{D1}$ ,  $\overline{SEL}$  are complementary of D0, D1, SEL unless specified otherwise.

# NB7L86M

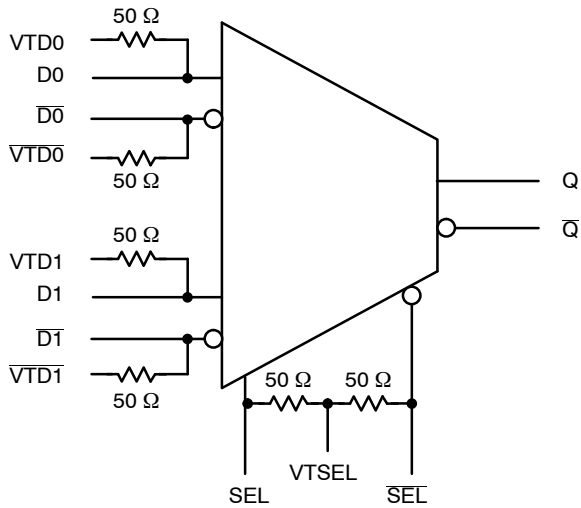


Figure 6. Configuration for 2:1 MUX Function

Table 5. 2:1 MUX TRUTH TABLE (Note 6)

SEL	Q
1	D1
0	D0

6.  $\overline{D0}$ ,  $\overline{D1}$ ,  $\overline{SEL}$  are complementary of D0, D1, SEL unless specified otherwise.

Table 6. ATTRIBUTES

Characteristics		Value	
ESD Protection	Human Body Model	> 1500 V	
	Machine Model	> 50 V	
	Charged Device Model	> 500 V	
Moisture Sensitivity (Note 7)		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		400	
Meets or exceeds JEDEC Spec EIA/JESD78 IC Latchup Test			

7. For additional Moisture Sensitivity information, refer to Application Note AND8003/D.

Table 7. MAXIMUM RATINGS

Symbol	Parameter	Condition 1	Condition 2	Rating	Units
$V_{CC}$	Positive Power Supply	$V_{EE} = 0\text{ V}$		3.6	V
$V_I$	Input Voltage	$V_{EE} = 0\text{ V}$	$V_{EE} \leq V_I \leq V_{CC}$	3.6	V
$V_{INPP}$	Differential Input Voltage $[D - \overline{D}]$	$V_{CC} - V_{EE} \geq 2.8\text{ V}$ $V_{CC} - V_{EE} < 2.8\text{ V}$		2.8 $ V_{CC} - V_{EE} $	V V
$I_{IN}$	Input Current Through $R_T$ (50 $\Omega$ Resistor)	Continuous Surge		25 50	mA mA
$I_{out}$	Output Current	Continuous Surge		25 50	mA mA
$T_A$	Operating Temperature Range	QFN-16		-40 to +85	$^{\circ}\text{C}$
$T_{stg}$	Storage Temperature Range			-65 to +150	$^{\circ}\text{C}$
$\theta_{JA}$	Thermal Resistance (Junction-to-Ambient) (Note 8)	0 lfpm 500 lfpm	QFN-16 QFN-16	42 36	$^{\circ}\text{C}/\text{W}$ $^{\circ}\text{C}/\text{W}$
$\theta_{JC}$	Thermal Resistance (Junction-to-Case)	2S2P (Note 8)	QFN-16	3 to 4	$^{\circ}\text{C}/\text{W}$
$T_{sol}$	Wave Solder	Pb Pb-Free		265 265	$^{\circ}\text{C}$

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

8. JEDEC standard multilayer board – 2S2P (2 signal, 2 power).

# NB7L86M

**Table 8. DC CHARACTERISTICS** ( $V_{CC} = 2.375 \text{ V to } 3.465 \text{ V}$ ,  $V_{EE} = 0 \text{ V}$ ,  $T_A = -40^\circ\text{C to } +85^\circ\text{C}$ )

Symbol	Characteristic	Min	Typ	Max	Unit
$I_{CC}$	Power Supply Current (Inputs and Outputs Open)		38	50	mA
$V_{OH}$	Output HIGH Voltage (Notes 9 and 10)	$V_{CC} - 60$	$V_{CC} - 30$	$V_{CC}$	mV
$V_{OL}$	Output LOW Voltage (Notes 9 and 10)	$V_{CC} - 460$	$V_{CC} - 400$	$V_{CC} - 310$	mV

**Differential Input Driven Single-Ended (see Figures 16 & 18)**

$V_{th}$	Input Threshold Reference Voltage Range (Note 11)	1125		$V_{CC} - 75$	mV
$V_{IH}$	Single-ended Input HIGH Voltage (Note 12)	$V_{th} + 75$		$V_{CC}$	mV
$V_{IL}$	Single-ended Input LOW Voltage (Note 12)	$V_{EE}$		$V_{CC} - 150$	mV

**Differential Inputs Driven Differentially (see Figures 17 & 19)**

$V_{IHD}$	Differential Input HIGH Voltage	1200		$V_{CC}$	mV	
$V_{ILD}$	Differential Input LOW Voltage	$V_{EE}$		$V_{CC} - 75$	mV	
$V_{CMR}$	Input Common Mode Range (Differential Configuration)	1163		$V_{CC} - 38$	mV	
$V_{ID}$	Differential Input Voltage ( $V_{IHD} - V_{ILD}$ )	75		2500	mV	
$I_{IH}$	Input HIGH Current	D0/D0̄/D1/D1̄	0	50	150	μA
		SEL/SEL	0	20	150	
$I_{IL}$	Input LOW Current	D0/D0̄/D1/D1̄	-50	50	100	μA
		SEL/SEL	-50	20	100	
$R_{TIN}$	Internal Input Termination Resistor	45	50	55	Ω	
$R_{TOUT}$	Internal Output Termination Resistor	45	50	55	Ω	
$R_{Temp\ Coef}$	Internal I/O Termination Resistor Temperature Coefficient		6.38		mΩ/°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 airflow greater than 500 lfpm. 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.

9. CML outputs require 50 Ω receiver termination resistors to  $V_{CC}$  for proper operation.

10. Input and output parameters vary 1:1 with  $V_{CC}$ .

11.  $V_{th}$  is applied to the complementary input when operating in single-ended mode.

12.  $V_{CMR}$  min varies 1:1 with  $V_{EE}$ ,  $V_{CMR}$  max varies 1:1 with  $V_{CC}$ .

# NB7L86M

**Table 9. AC CHARACTERISTICS** ( $V_{CC} = 2.375\text{ V}$  to  $3.465\text{ V}$ ,  $V_{EE} = 0\text{ V}$ ; Note 13)

Symbol	Characteristic	-40° C			25° C			85° C			Unit
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
$V_{OUTPP}$	Output Voltage Amplitude (@ $V_{INPPmin}$ ) $f_{in} \leq 4\text{ GHz}$ (See Figure 7) $f_{in} \leq 8\text{ GHz}$	240 125	350 230		240 125	350 230		240 125	350 230		mV
$f_{data}$	Maximum Operating Data Rate	10.7	12		10.7	12		10.7	12		Gb/s
$t_{PLH}$ , $t_{PHL}$	Propagation Delay to $Dx/\overline{Dx}$ to $Q/\overline{Q}$ Output Differential @ 1 GHz (See Figure 7) $SEL/\overline{SEL}$ to $Q/\overline{Q}$	70 110	90 135	120 180	70 110	90 135	120 180	70 110	90 135	120 180	ps
$t_{SKEW}$	Duty Cycle Skew (Note 14) Device-to-Device Skew (Note 15)		2.0 5.0	10 20		2.0 5.0	10 20		2.0 5.0	10 20	ps
$t_S$	Set-Up Time (Dx to SEL)	100			100			100			ps
$t_H$	Hold-Up Time (Dx to SEL)	-15			-15			-15			ps
$t_{JITTER}$	RMS Random Clock Jitter (Note 16) $f_{in} = 4\text{ GHz}$ $f_{in} = 8\text{ GHz}$ Peak/Peak Data Dependent Jitter $f_{data} = 5\text{ Gb/s}$ (Note 17) $f_{data} = 10\text{ Gb/s}$		0.2 0.2	0.5 0.5		0.2 0.2	0.5 0.5		0.2 0.2	0.5 0.5	ps
$V_{INPP}$	Input Voltage Swing/Sensitivity (Differential Configuration) (Note 18)	75	400	2500	75	400	2500	75	400	2500	mV
$t_r$ , $t_f$	Output Rise/Fall Times @ 1 GHz (20% - 80%) $Q, \overline{Q}$		35	60		35	60		35	60	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 airflow greater than 500 lpm. 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.

13. Measured by forcing  $V_{INPP}$  (TYP) 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%).

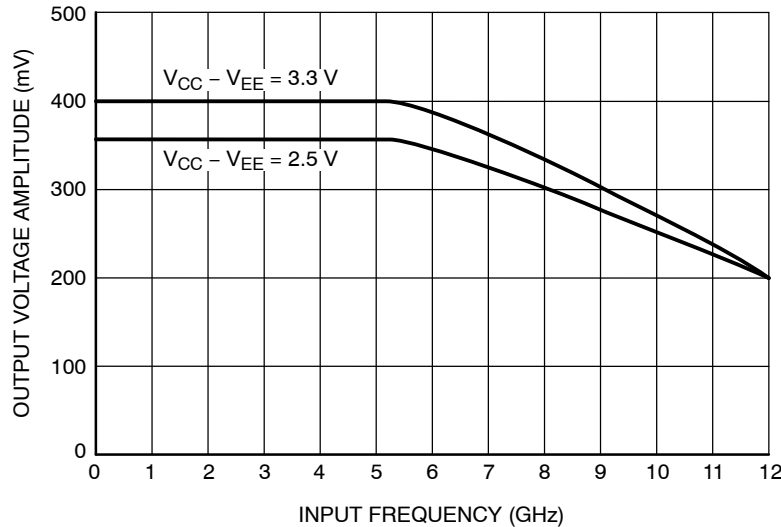
14. Duty cycle skew is measured between differential outputs using the deviations of the sum of  $T_{pw-}$  and  $T_{pw+}$  @ 1 GHz.

15. Device to device skew is measured between outputs under identical transition @ 1 GHz.

16. Additive RMS jitter with 50% duty cycle clock signal.

17. Additive peak-to-peak data dependent jitter with input NRZ data (PRBS  $2^{23}-1$ ).

18.  $V_{INPP}$  (MAX) cannot exceed  $V_{CC} - V_{EE}$ . Input voltage swing is a single-ended measurement operating in differential mode.



**Figure 7. Output Voltage Amplitude ( $V_{OUTPP}$ ) versus Input Clock Frequency ( $f_{in}$ ) at Ambient Temperature (Typical)**

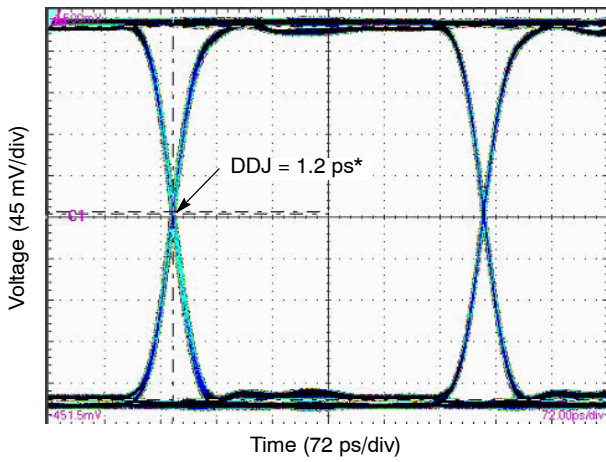


Figure 8. Typical Output Waveform at 2.488 Gb/s with PRBS  $2^{23}-1$  ( $V_{inpp} = 75$  mV)

\*Input signal DDJ = 10 ps

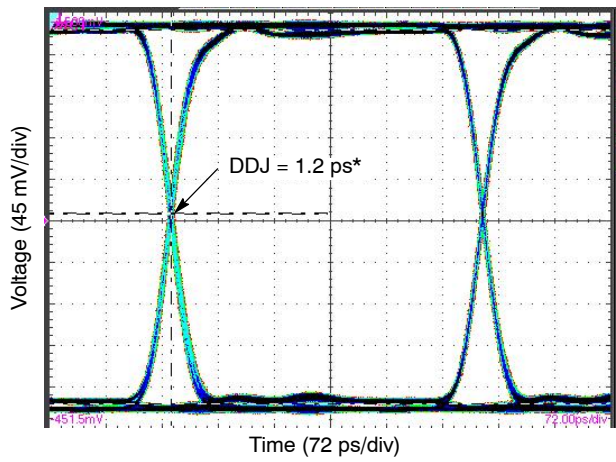


Figure 9. Typical Output Waveform at 2.488 Gb/s with PRBS  $2^{23}-1$  ( $V_{inpp} = 400$  mV)

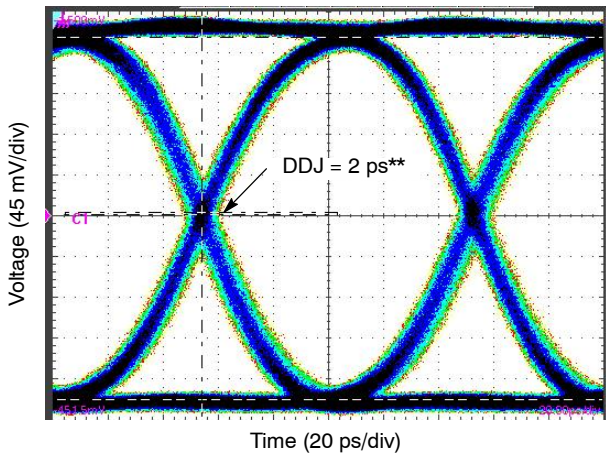


Figure 10. Typical Output Waveform at 10 Gb/s with PRBS  $2^{23}-1$  ( $V_{inpp} = 75$  mV)

\*\*Input signal DDJ = 12 ps

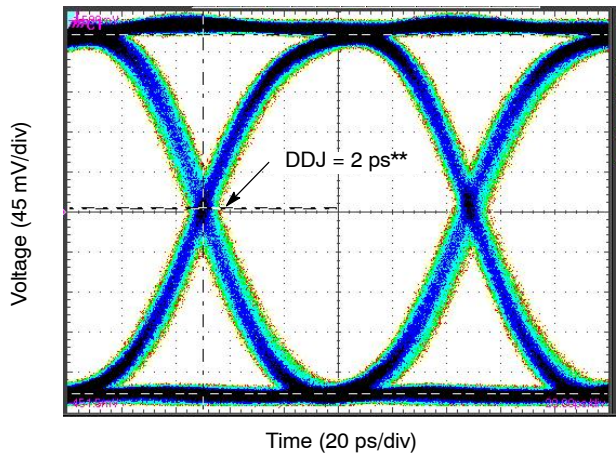


Figure 11. Typical Output Waveform at 10 Gb/s with PRBS  $2^{23}-1$  ( $V_{inpp} = 400$  mV)

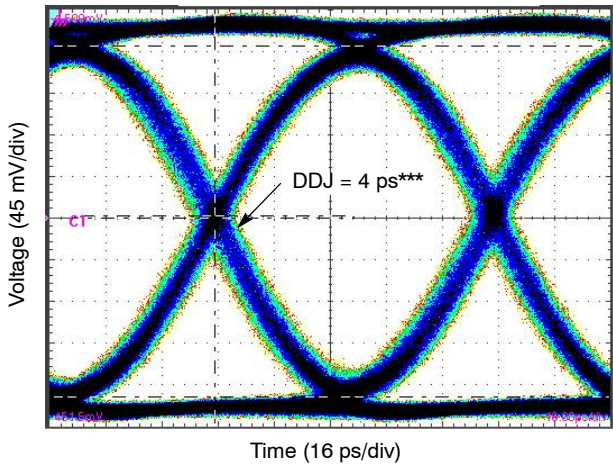


Figure 12. Typical Output Waveform at 12 Gb/s with PRBS  $2^{23}-1$  ( $V_{inpp} = 75$  mV)

\*\*\*Input signal DDJ = 14 ps

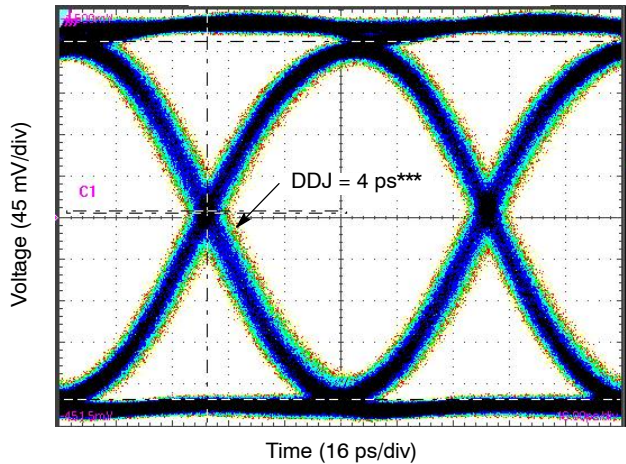


Figure 13. Typical Output Waveform at 12 Gb/s with PRBS  $2^{23}-1$  ( $V_{inpp} = 400$  mV)

# NB7L86M

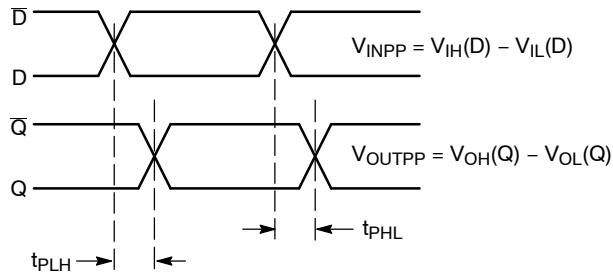


Figure 14. AC Reference Measurement

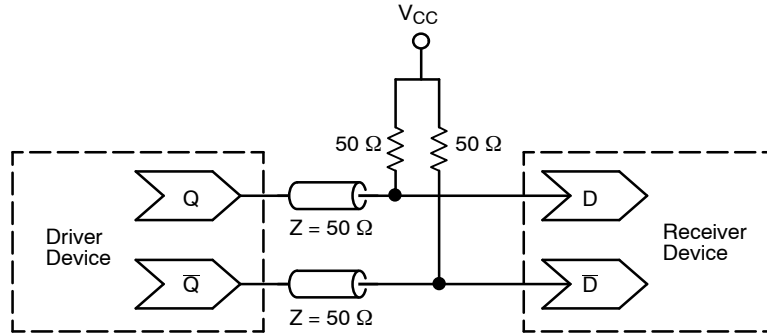


Figure 15. Typical Termination for Output Driver and Device Evaluation (Refer to Application Note AND8173 – Termination and Interface of ON Semiconductor of ECL Logic Devices with CML Output Structure)

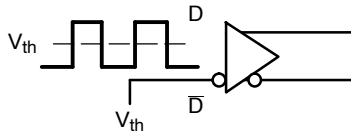


Figure 16. Differential Input Driven Single-Ended

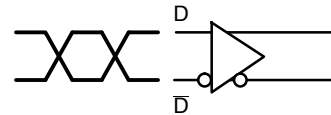


Figure 17. Differential Inputs Driven Differentially

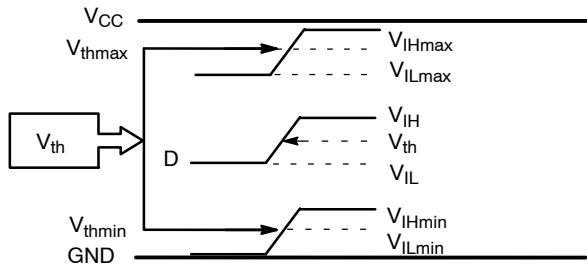


Figure 18.  $V_{th}$  Diagram

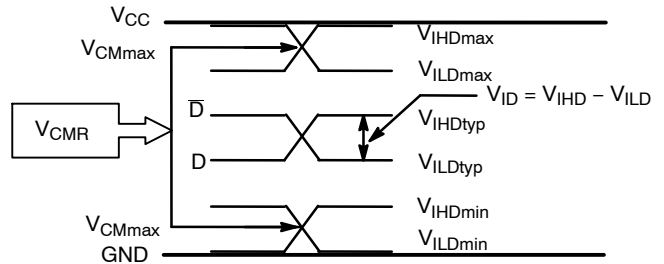


Figure 19.  $V_{CMR}$  Diagram



# NB7L86M

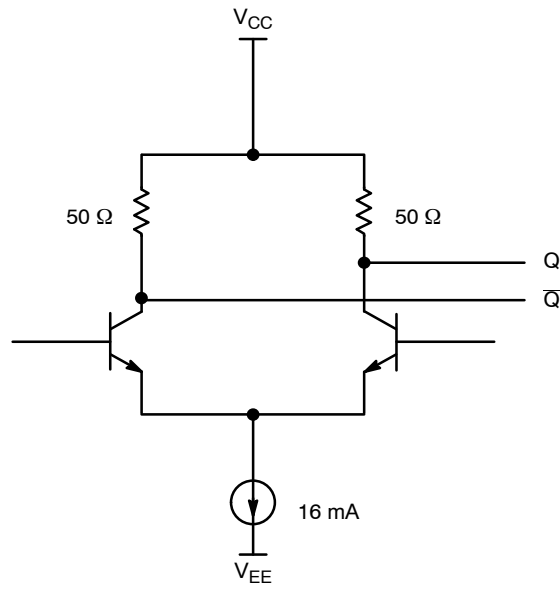


Figure 20. CML Output Structure

Table 10. INTERFACING OPTIONS

INTERFACING OPTIONS	CONNECTIONS
CML	Connect VTD0, $\overline{\text{VTD0}}$ , VTD1, $\overline{\text{VTD1}}$ , VTSEL to $V_{CC}$
LVDS	Connect VTD0, $\overline{\text{VTD0}}$ together for D0 input. Connect VTD1, $\overline{\text{VTD1}}$ together for D0 input. Leave VTSEL open for SEL input.
AC-COUPLED	Bias VTD0, $\overline{\text{VTD0}}$ , VTSEL and VTD1, $\overline{\text{VTD1}}$ Inputs within ( $V_{CMR}$ ) Common Mode Range
RSECL, LVPECL	Standard ECL Termination Techniques. See AND8020/D.
LVTTTL, LVCMOS	An external voltage should be applied to the unused complementary differential input. Nominal voltage 1.5 V for LVTTTL and $V_{CC}/2$ for LVCMOS inputs.

# NB7L86M

## Application Information

All inputs can accept PECL, CML, and LVDS signal levels. The input voltage can range from  $V_{CC}$  to 1.2 V.

Examples interfaces are illustrated below in a  $50\ \Omega$  environment ( $Z = 50\ \Omega$ ).

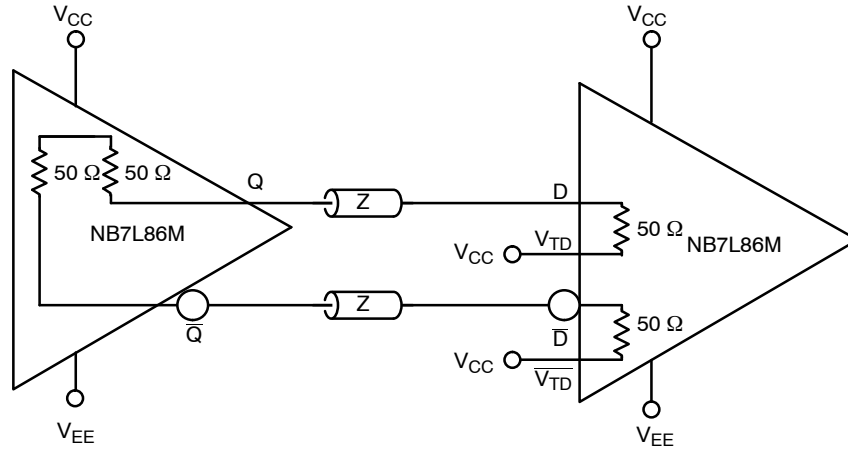


Figure 21. CML to CML Interface

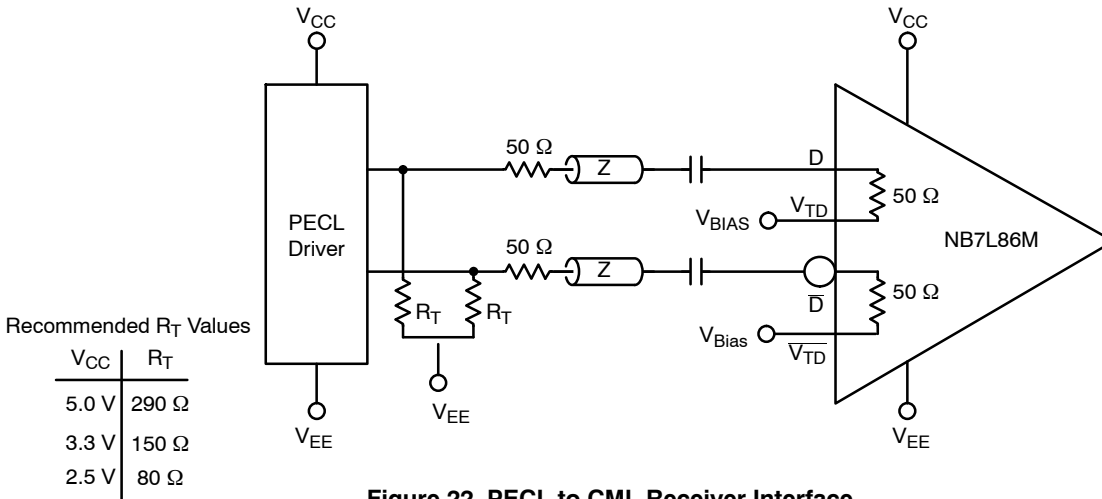


Figure 22. PECL to CML Receiver Interface

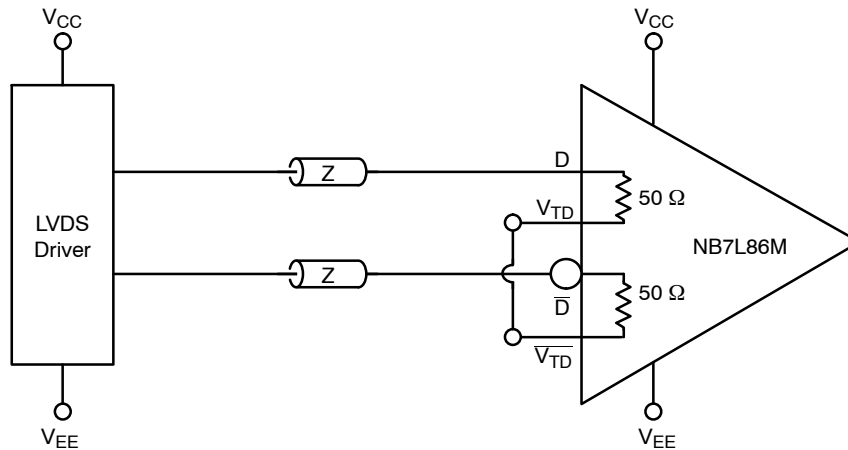


Figure 23. LVDS to CML Receiver Interface

# NB7L86M

## ORDERING INFORMATION

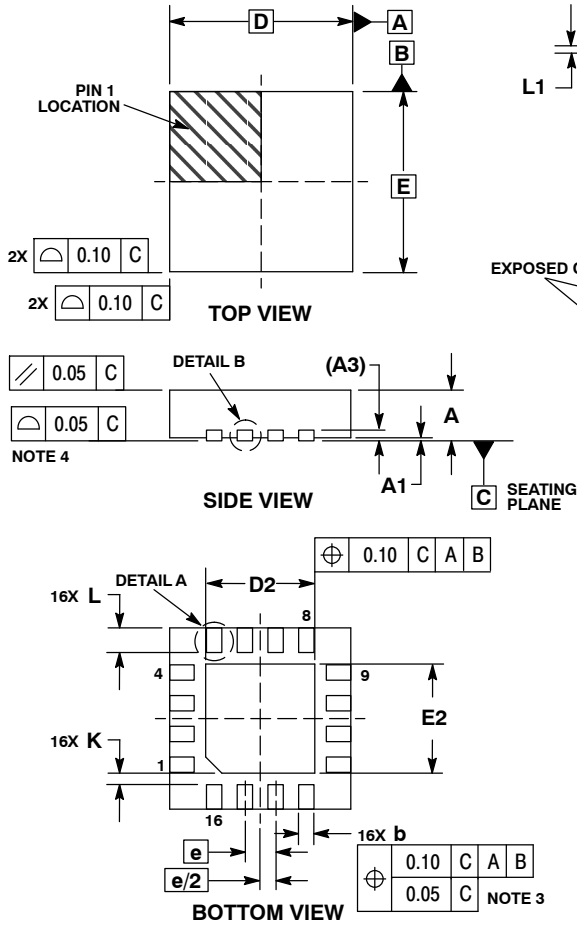
Device	Package	Shipping†
NB7L86MMNG	QFN-16 (Pb-Free)	123 Units/Rail
NB7L86MMNR2G	QFN-16 (Pb-Free)	3000 Tape & Reel

†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.

# NB7L86M

## PACKAGE DIMENSIONS

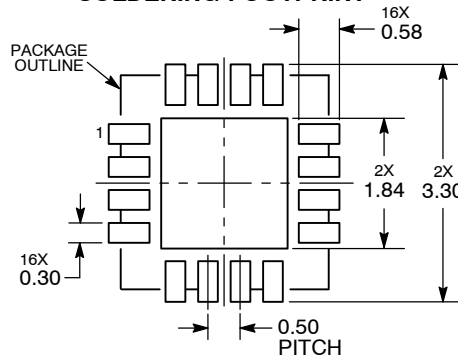
QFN16 3x3, 0.5P  
CASE 485G-01  
ISSUE E



- 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.

MILLIMETERS		
DIM	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	0.18 TYP	
L	0.30	0.50
L1	0.00	0.15

### RECOMMENDED SOLDERING FOOTPRINT\*



DIMENSIONS: MILLIMETERS

\*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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