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# NB7VQ14M

## 1.8V/2.5V/3.3V 8GHz / 14Gbps Differential 1:4 Clock / Data CML Fanout Buffer w/ Selectable Input Equalizer

### Multi-Level Inputs w/ Internal Termination

#### Description

The NB7VQ14M is a high performance differential 1:4 CML fanout buffer with a selectable Equalizer receiver. When placed in series with a Clock /Data path operating up to 8 GHz or 14 Gb/s, respectively, the NB7VQ14M inputs will compensate the degraded signal transmitted across a FR4 PCB backplane or cable interconnect and output four identical CML copies of the input signal with a 1.8 V, 2.5 V or 3.3 V power supply. Therefore, the serial data rate is increased by reducing Inter-Symbol Interference (ISI) caused by losses in copper interconnect or long cables. The Equalizer ENable pin (EQEN) allows the IN/ $\overline{IN}$  inputs to either flow through or bypass the Equalizer section. Control of the Equalizer function is realized by setting EQEN; When EQEN is set Low, the IN/ $\overline{IN}$  inputs bypass the Equalizer. When EQEN is set High, the IN/ $\overline{IN}$  inputs flow through the Equalizer. The default state at start-up is LOW. As such, NB7VQ14M is ideal for SONET, GigE, Fiber Channel, Backplane and other Clock/Data distribution applications.

The differential inputs incorporate internal 50  $\Omega$  termination resistors that are accessed through the VT pin. This feature allows the NB7VQ14M to accept various logic level standards, such as LVPECL, CML or LVDS. The 1:4 fanout design was optimized for low output skew applications.

The NB7VQ14M is a member of the GigaComm™ family of high performance clock products.

#### Features

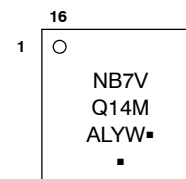
- Input Data Rate > 14 Gb/s, Typical
- Input Clock Frequency > 8 GHz, Typical
- 165 ps Typical Propagation Delay
- 30 ps Typical Rise and Fall Times
- < 15 ps Maximum Output Skew
- < 0.8 ps Maximum RMS Clock Jitter
- < 10 ps pp of Data Dependent Jitter
- Differential CML Outputs, 400 mV Peak-to-Peak, Typical
- Selectable Input Equalization
- Operating Range:  $V_{CC} = 1.71$  V to 3.6 V with GND = 0 V
- Internal Input Termination Resistors, 50  $\Omega$
- -40°C to +85°C Ambient Operating Temperature
- These are Pb-Free Devices



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#### MARKING DIAGRAM\*

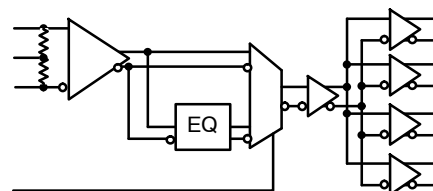


A	= Assembly Location
L	= Wafer Lot
Y	= Year
W	= Work Week
▪	= Pb-Free Package

(Note: Microdot may be in either location)

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

#### SIMPLIFIED BLOCK DIAGRAM



#### ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 9 of this data sheet.

# NB7VQ14M

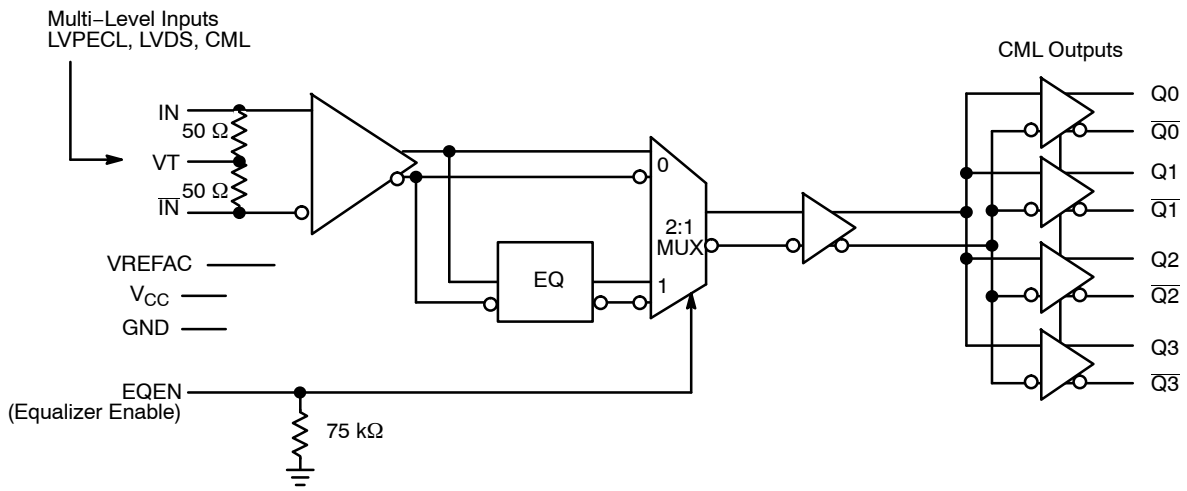


Figure 1. Detailed Block Diagram of NB7VQ14M

# NB7VQ14M

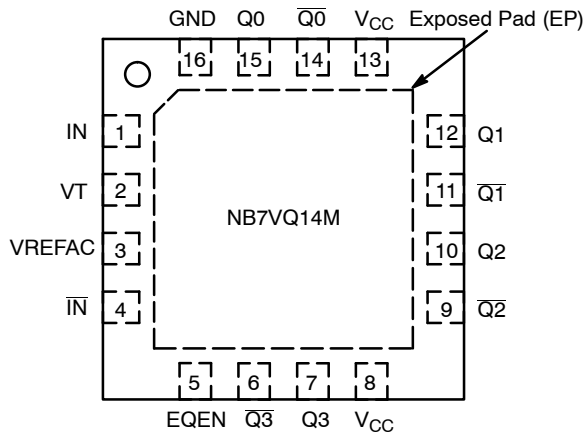


Figure 2. QFN-16 Pinout (Top View)

Table 1. EQUALIZER ENABLE FUNCTION

EQEN	Function
0	IN / $\overline{\text{IN}}$ Inputs By-pass the Equalizer section
1	Inputs flow through the Equalizer

Table 2. PIN DESCRIPTION

Pin	Name	I/O	Description
1	IN	LVPECL, CML, LVDS Input	Non-inverted Differential Input. Note 1.
2	VT		Internal 100 $\Omega$ Center-tapped Termination Pin for IN / $\overline{\text{IN}}$
3	VREFAC		Output Voltage Reference for Capacitor-Coupled Inputs, only
4	$\overline{\text{IN}}$	LVPECL, CML, LVDS Input	Inverted Differential Input. Note 1.
5	EQEN	LVC MOS Input	Equalizer Enable Input; pin will default LOW when left open (has internal pull-down resistor)
6	$\overline{\text{Q3}}$	CML Output	Inverted Differential Output. Typically Terminated with 50 $\Omega$ Resistor to $V_{\text{CC}}$ .
7	Q3	CML Output	Non-inverted Differential Output. Typically Terminated with 50 $\Omega$ Resistor to $V_{\text{CC}}$ .
8	VCC	-	Positive Supply Voltage
9	$\overline{\text{Q2}}$	CML Output	Inverted Differential Output. Typically Terminated with 50 $\Omega$ Resistor to $V_{\text{CC}}$ .
10	Q2	CML Output	Non-inverted Differential Output. Typically Terminated with 50 $\Omega$ Resistor to $V_{\text{CC}}$ .
11	$\overline{\text{Q1}}$	CML Output	Inverted Differential Output. Typically Terminated with 50 $\Omega$ Resistor to $V_{\text{CC}}$ .
12	Q1	CML Output	Non-inverted Differential Output. Typically Terminated with 50 $\Omega$ Resistor to $V_{\text{CC}}$ .
13	VCC	-	Positive Supply Voltage
14	$\overline{\text{Q0}}$	CML Output	Inverted Differential Output. Typically Terminated with 50 $\Omega$ Resistor to $V_{\text{CC}}$ .
15	Q0	CML Output	Non-inverted Differential Output. Typically Terminated with 50 $\Omega$ Resistor to $V_{\text{CC}}$ .
16	GND	-	Negative Supply Voltage
-	EP	-	The Exposed Pad (EP) on the QFN-16 package bottom is thermally connected to the die for improved heat transfer out of package. The exposed pad must be attached to a heat-sinking conduit. The pad is electrically connected to the die, and must be electrically and thermally connected to GND on the PC board.

1. In the differential configuration when the input termination pin (VT) is connected to a common termination voltage or left open, and if no signal is applied on IN /  $\overline{\text{IN}}$  input, then, the device will be susceptible to self-oscillation.
2. All VCC and GND pins must be externally connected to a power supply for proper operation.

# NB7VQ14M

**Table 3. ATTRIBUTES**

Characteristics		Value
ESD Protection	Human Body Model Machine Model	> 2 kV > 200V
$R_{PD}$ – EQEN Input Pulldown Resistor		75 k $\Omega$
Moisture Sensitivity (Note 3)	16–QFN	Level 1
Flammability Rating	Oxygen Index: 28 to 34	UL 94 V–0 @ 0.125 in
Transistor Count		210
Meets or exceeds JEDEC Spec EIA/JESD78 IC Latchup Test		

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

**Table 4. MAXIMUM RATINGS**

Symbol	Parameter	Condition 1	Condition 2	Rating	Unit
$V_{CC}$	Positive Power Supply – Core	GND = 0 V		4.0	V
$V_{IO}$	Positive Input/Output Voltage	GND = 0 V		–0.5 to $V_{CC} + 0.5$	V
$V_{INPP}$	Differential Input Voltage $ I_N - \bar{I}_N $			1.89	V
$I_{IN}$	Input Current Through $R_T$ (50 $\Omega$ Resistor)			$\pm 40$	mA
$I_{OUT}$	Output Current Through $R_T$ (50 $\Omega$ Resistor)			$\pm 40$	mA
$I_{VFREFAC}$	VREFAC Sink/Source Current			$\pm 1.5$	mA
$T_A$	Operating Temperature Range	16 QFN		–40 to +85	$^{\circ}C$
$T_{stg}$	Storage Temperature Range			–65 to +150	$^{\circ}C$
$\theta_{JA}$	Thermal Resistance (Junction–to–Ambient) (Note 4)	0 lfpm 500 lfpm	16 QFN 16 QFN	42 35	$^{\circ}C/W$ $^{\circ}C/W$
$\theta_{JC}$	Thermal Resistance (Junction–to–Case) (Note 4)		16 QFN	4	$^{\circ}C/W$
$T_{sol}$	Wave Solder Pb–Free			265	$^{\circ}C$

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.

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

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**Table 5. DC CHARACTERISTICS, MULTI-LEVEL INPUTS**  $V_{CC} = 1.71\text{ V to }3.6\text{ V}$ ;  $GND = 0\text{ V}$ ;

$T_A = -40^\circ\text{C to }85^\circ\text{C}$  (Note 5)

Symbol	Characteristic	Min	Typ	Max	Unit
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## POWER SUPPLY CURRENT

$V_{CC}$	Power Supply Voltage	$V_{CC} = 3.3\text{ V}$	3.135	3.3	3.6	V
		$V_{CC} = 2.5\text{ V}$	2.375	2.5	2.625	
		$V_{CC} = 1.8\text{ V}$	1.71	1.8	1.89	
$I_{CC}$	Power Supply Current (Inputs and Outputs Open)			170	210	mA

## CML OUTPUTS (Note 6)

$V_{OH}$	Output HIGH Voltage	$V_{CC} = 3.3\text{ V}$	$V_{CC} - 30$	$V_{CC} - 5$	$V_{CC}$	mV
		$V_{CC} = 2.5\text{ V}$	3270	3295	3300	
		$V_{CC} = 1.8\text{ V}$	2470	2495	2500	
$V_{OL}$	Output LOW Voltage	$V_{CC} = 3.3\text{ V}$	$V_{CC} - 525$	$V_{CC} - 425$	$V_{CC} - 325$	mV
		$V_{CC} = 2.5\text{ V}$	2775	2875	2975	
		$V_{CC} = 1.8\text{ V}$	1975	2075	2175	
		$V_{CC} = 1.8\text{ V}$	1275	1375	1475	

## DIFFERENTIAL INPUT DRIVEN SINGLE-ENDED (see Figures 5 and 7) (Note 7)

$V_{IH}$	Single-ended Input HIGH Voltage	$V_{th} + 100$		$V_{CC}$	mV
$V_{IL}$	Single-ended Input LOW Voltage	GND		$V_{th} - 100$	mV
$V_{th}$	Input Threshold Reference Voltage Range (Note 8)	1050		$V_{CC} - 100$	mV
$V_{ISE}$	Single-ended Input Voltage Amplitude ( $V_{IH} - V_{IL}$ )	200		2800	mV

## VREFAC

$V_{REFAC}$	Output Reference Voltage @ 100 $\mu\text{A}$ for capacitor – coupled inputs, only (Note 9)	$V_{CC} = 3.3\text{ V}$	$V_{CC} - 650$	$V_{CC} - 500$	$V_{CC} - 350$	mV
		$V_{CC} = 2.5\text{ V}$	2650	2800	2950	
		$V_{CC} = 2.5\text{ V}$	1850	2000	2150	
		$V_{CC} = 1.8\text{ V}$	1150	1300	1450	

## DIFFERENTIAL INPUTS DRIVEN DIFFERENTIALLY (see Figures 6 and 8) (Note 9)

$V_{IHD}$	Differential Input HIGH Voltage	1200		$V_{CC}$	mV
$V_{ILD}$	Differential Input LOW Voltage	0		$V_{IHD} - 100$	mV
$V_{ID}$	Differential Input Voltage ( $V_{IHD} - V_{ILD}$ )	100		1200	mV
$V_{CMR}$	Input Common Mode Range (Differential Configuration) (Note 10) (Figure 9)	1050		$V_{CC} - 50$	mV
$I_{IH}$	Input HIGH Current $I_N / \bar{I}_N$ , (VT Open)	-150		150	$\mu\text{A}$
$I_{IL}$	Input LOW Current $I_N / \bar{I}_N$ , (VT Open)	-150		150	$\mu\text{A}$

## CONTROL INPUTS (EQEN)

$V_{IH}$	Input HIGH Voltage for Control Pins	$V_{CC} \times 0.65$		$V_{CC}$	V
$V_{IL}$	Input LOW Voltage for Control Pins	GND		$V_{CC} \times 0.35$	V
$I_{IH}$	Input HIGH Current	-150		150	$\mu\text{A}$
$I_{IL}$	Input LOW Current	-150		150	$\mu\text{A}$

## TERMINATION RESISTORS

$R_{TIN}$	Internal Input Termination Resistor	45	50	55	$\Omega$
$R_{TOUT}$	Internal Output Termination Resistor	45	50	55	$\Omega$

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.

- Input and output parameters vary 1:1 with  $V_{CC}$ .
- CML outputs loaded with 50  $\Omega$  to  $V_{CC}$  for proper operation.
- $V_{th}$ ,  $V_{IH}$ ,  $V_{IL}$ , and  $V_{ISE}$  parameters must be complied with simultaneously.
- $V_{th}$  is applied to the complementary input when operating in single-ended mode.
- $V_{IHD}$ ,  $V_{ILD}$ ,  $V_{ID}$  and  $V_{CMR}$  parameters must be complied with simultaneously.
- $V_{CMR}$  min varies 1:1 with GND,  $V_{CMR}$  max varies 1:1 with  $V_{CC}$ . The  $V_{CMR}$  range is referenced to the crosspoint side of the differential input signal.

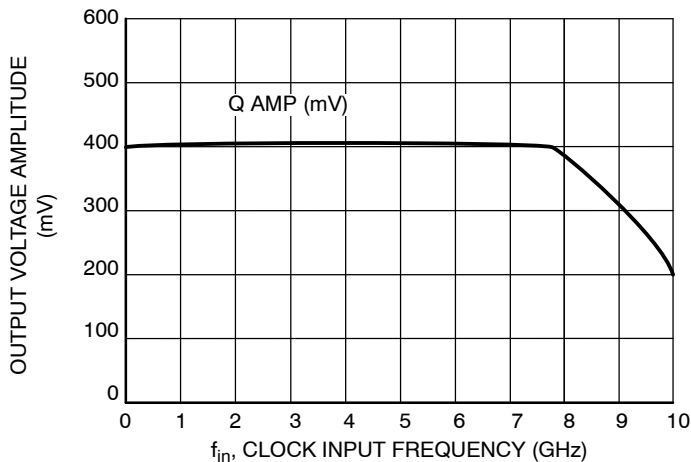
# NB7VQ14M

**Table 6. AC CHARACTERISTICS**  $V_{CC} = 1.71\text{ V to }3.6\text{ V}$ ;  $GND = 0\text{ V}$ ;  $T_A = -40^\circ\text{C to }85^\circ\text{C}$  (Note 11)

Symbol	Characteristic	Min	Typ	Max	Unit
$f_{MAX}$	Maximum Input Clock Frequency; $V_{OUT} \geq 200\text{ mV}$	7	8.5		GHz
$f_{DATAMAX}$	Maximum Operating Data Rate NRZ, (PRBS23)	10	14		Gbps
$V_{OUTPP}$	Output Voltage Amplitude, EQEN = 0 or 1 (Note 15) (See Figure 10) $f_{in} \leq 7\text{ GHz}$	200	400		mV
$t_{PLH}$ , $t_{PHL}$	Propagation Delay IN to $Q_x$	125	175	225	ps
$t_{SKEW}$	Duty Cycle Skew (Note 12) Output – Output Within Device Skew Device to Device Skew		3	15 15 50	ps
$t_{DC}$	Output Clock Duty Cycle (Reference Duty Cycle = 50%) $f_{in} \leq 7\text{ GHz}$	40	50	60	%
$\Phi_N$	Phase Noise, $f_{in} = 1\text{ GHz}$ 10 kHz 100 kHz 1 MHz 10 MHz 20 MHz 40 MHz		-134 -136 -150 -151 -151 -151		dBc
$t_{J\Phi N}$	Integrated Phase Jitter $f_{in} = 1\text{ GHz}$ , 12 kHz – 20 MHz Offset (RMS)		35		fs
$t_{JITTER}$	RMS Random Clock Jitter (Note 13) $f_{in} \leq 7\text{ GHz}$ Peak-to-Peak Data Dependent Jitter (Note 14) $f_{IN} \leq 14\text{ Gbps EQEN} = 0$ ( $\leq 3''\text{ FR4}$ ) $f_{IN} \leq 10\text{ Gbps EQEN} = 1$ ( $12''\text{ FR4}$ )		0.2	0.8 10 10	ps rms ps pk-pk ps pk-pk
$V_{INPP}$	Input Voltage Swing/Sensitivity (Differential Configuration) (Note 15)	100		1200	mV
$t_r$ $t_f$	Output Rise/Fall Times @ 1.0 GHz (20% – 80%) $Q_x, \bar{Q}_x$	15	30	45	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.

11. Measured by forcing  $V_{INPP}$  400mV 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%).
12. Skew is measured between outputs under identical transitions and conditions @ 0.5 GHz. Duty cycle skew is measured between differential outputs using the deviations of the sum of  $T_{pw-}$  and  $T_{pw+}$  @ 0.5 GHz.
13. Additive RMS jitter with 50% duty cycle clock signal.
14. Additive peak-to-peak data dependent jitter with input NRZ data at PRBS23.
15. Input and output voltage swings are single-ended measurements operating in a differential mode.



**Figure 3. CLOCK Output Voltage Amplitude ( $V_{OUTPP}$ ) vs. Input Frequency ( $f_{in}$ ) at Ambient Temperature (Typical)**

# NB7VQ14M

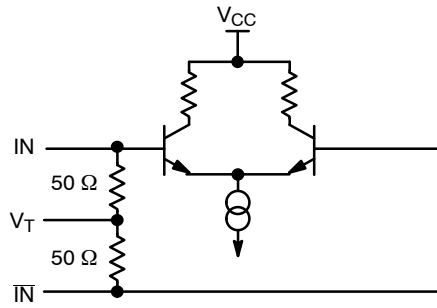


Figure 4. Input Structure

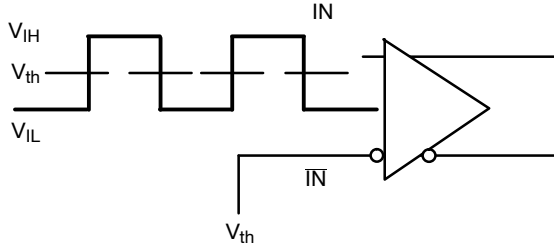


Figure 5. Differential Input Driven Single-Ended

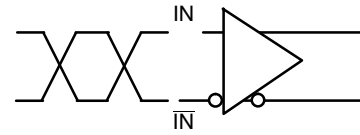


Figure 6. Differential Inputs Driven Differentially

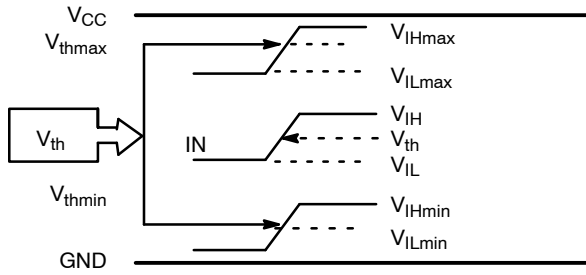


Figure 7.  $V_{th}$  Diagram

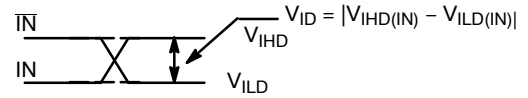


Figure 8. Differential Inputs Driven Differentially

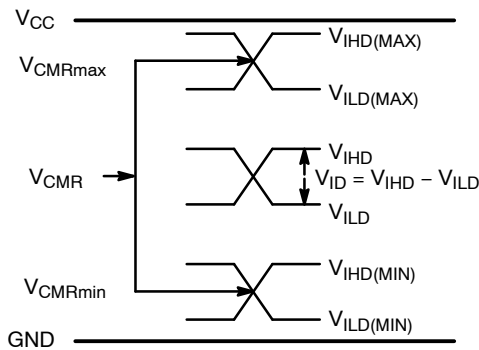


Figure 9.  $V_{CMR}$  Diagram

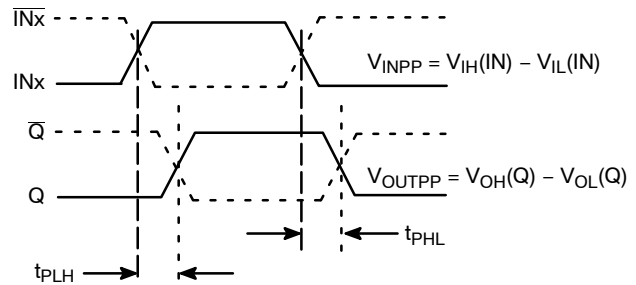


Figure 10. AC Reference Measurement



# NB7VQ14M

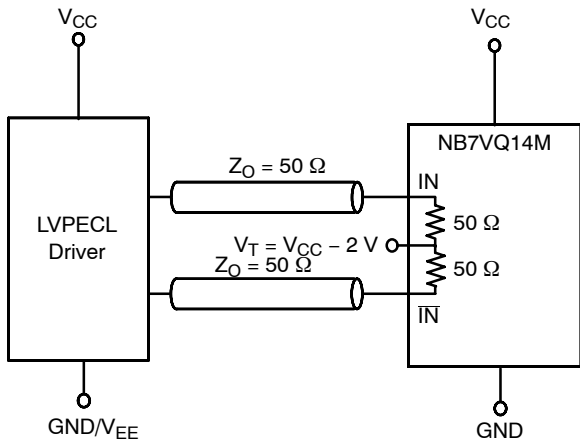


Figure 11. LVPECL Interface

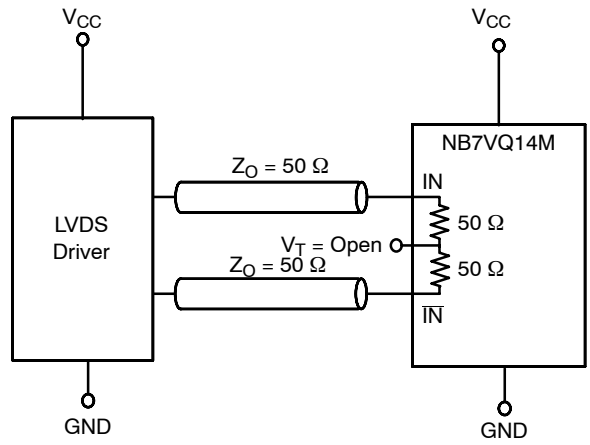


Figure 12. LVDS Interface

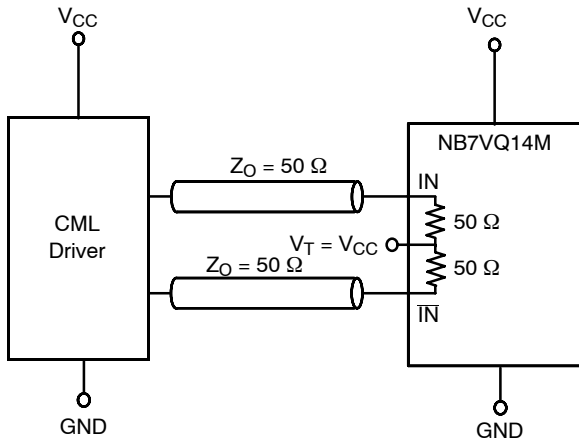


Figure 13. Standard 50 Ω Load CML Interface

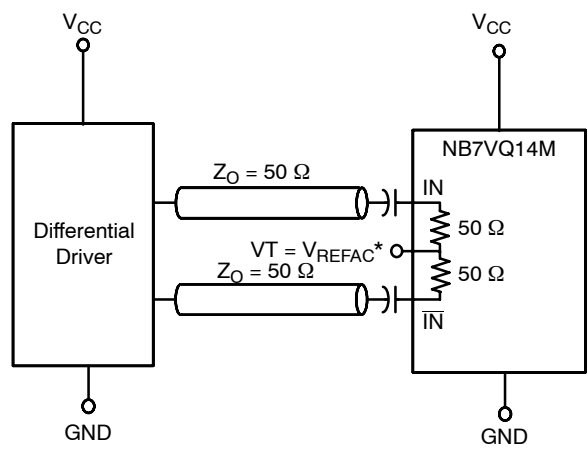


Figure 14. Capacitor-Coupled  
Differential Interface  
( $V_T$  Connected to  $V_{REFAC}$ )

\* $V_{REFAC}$  bypassed to ground with a 0.01  $\mu$ F capacitor

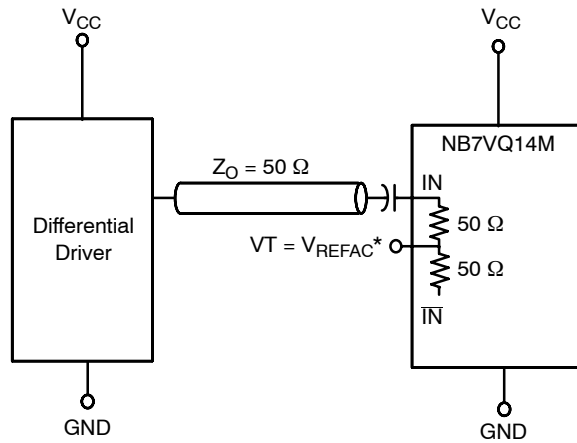
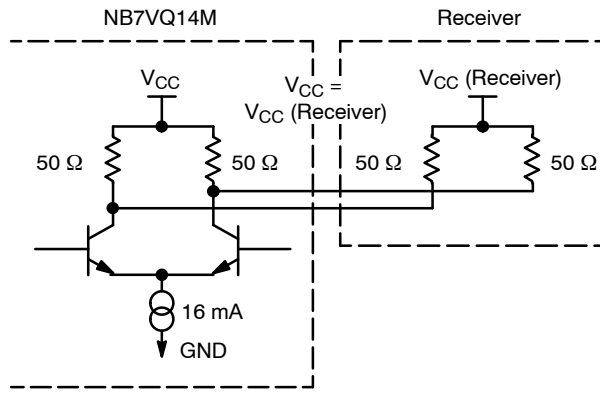
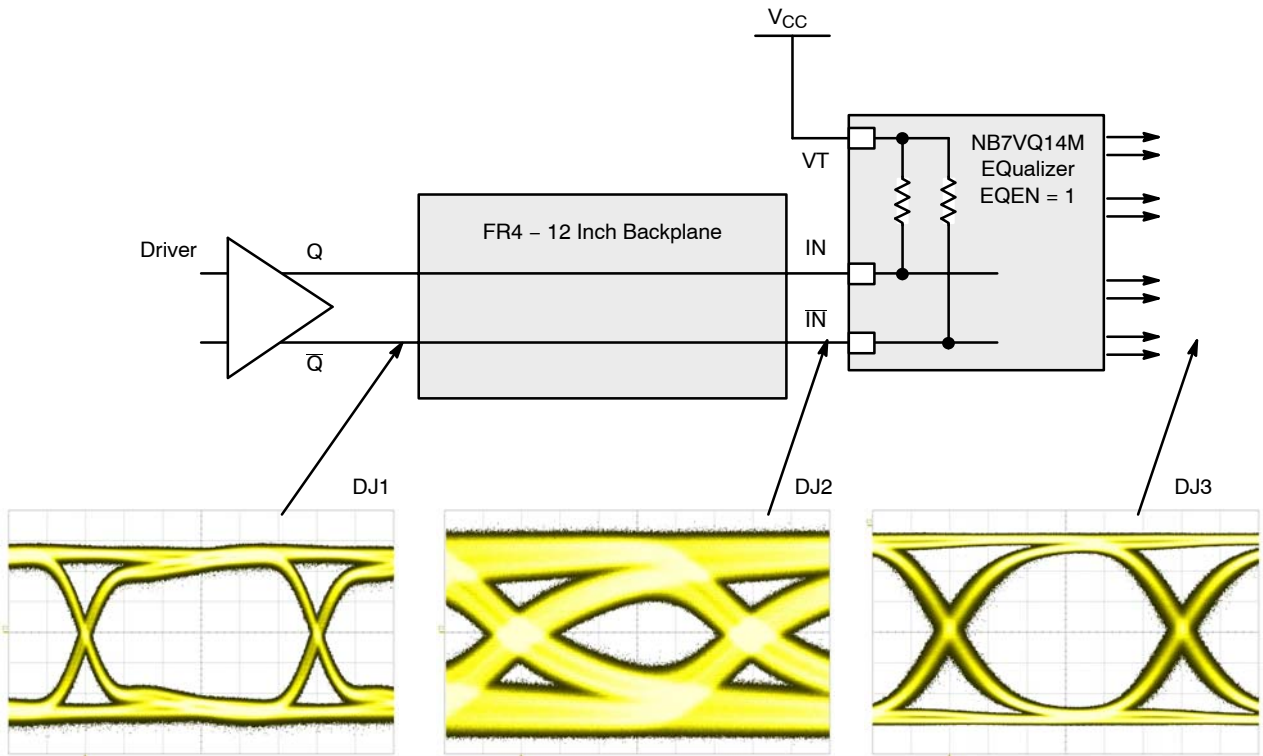


Figure 15. Capacitor-Coupled  
Single-Ended Interface  
( $V_T$  Connected to  $V_{REFAC}$ )

# NB7VQ14M



**Figure 16. Typical CML Output Structure and Termination**



**Figure 17. Typical NB7VQ14M Equalizer Application and Interconnect with PRBS23 pattern at 6.5 Gbps, EQEN = 1**

## ORDERING INFORMATION

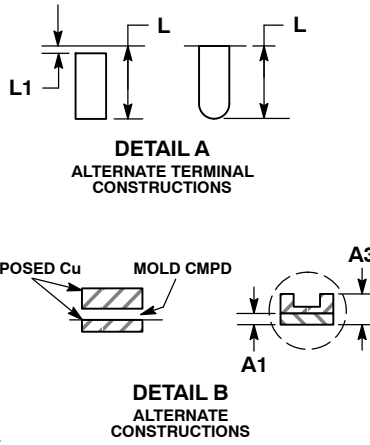
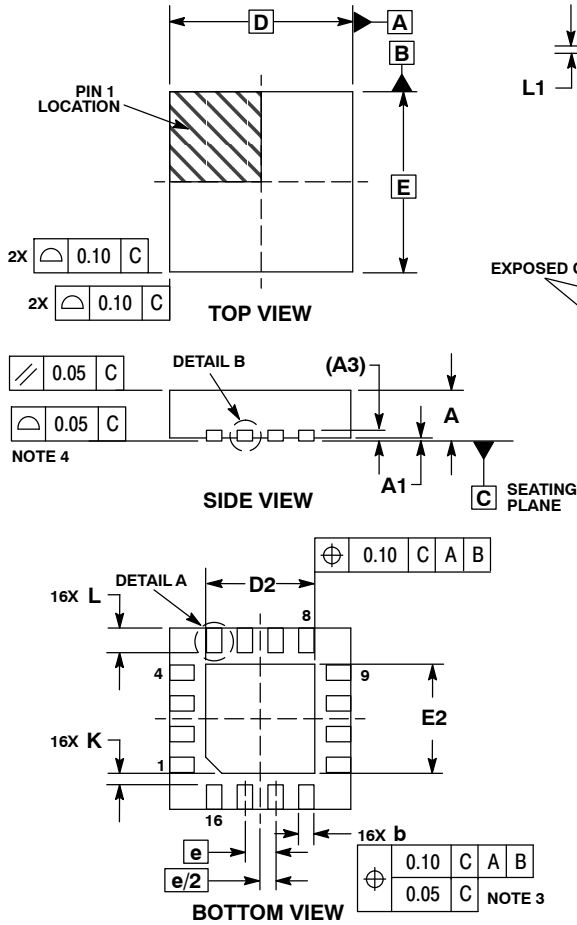
Device	Package	Shipping†
NB7VQ14MMNG	QFN-16 (Pb-Free)	123 Units / Rail
NB7VQ14MMNHTBG	QFN-16 (Pb-Free)	100 / Tape & Reel
NB7VQ14MMNTXG	QFN-16 (Pb-Free)	3000 / Tape & Reel

†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.

# NB7VQ14M

## PACKAGE DIMENSIONS

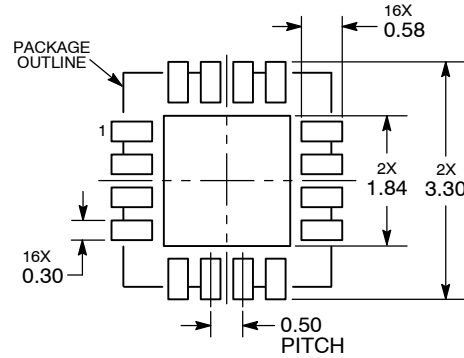
QFN16 3x3, 0.5P  
CASE 485G-01  
ISSUE E



- 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	1.65	1.85
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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