

# NB7VQ58M

## 1.8V / 2.5V / 3.3V Differential 2:1 Clock/Data Multiplexer / Translator with CML Outputs

w/ Selectable Input Equalizer

Multi-Level Inputs w/ Internal Termination

### Description

The NB7VQ58M is a high performance differential 2-to-1 Clock or Data multiplexer with a selectable Equalizer receiver. When placed in series with a Clock /Data path operating up to 7 GHz or 10.7 Gb/s, respectively, the NB7VQ58M inputs will compensate the degraded signal transmitted across an FR4 PCB backplane or cable interconnect. 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  $IN_n/\overline{IN}_n$  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  $IN_n / \overline{IN}_n$  inputs bypass the Equalizer. When EQEN is set High, the  $IN_n / \overline{IN}_n$  inputs flow through the Equalizer. The default state at startup is LOW. As such, the NB7VQ58M 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 NB7VQ58M to accept various logic level standards, such as LVPECL, CML or LVDS.

The NB7VQ58M produces minimal Clock or Data jitter operating up to 7 GHz or 10.7 Gb/s, respectively.

The 16 mA differential CML outputs provide matching internal 50  $\Omega$  terminations and 400 mV output swings when externally terminated with a 50  $\Omega$  resistor to  $V_{CC}$ .

The NB7VQ58M is offered in a low profile 3mm x 3 mm 16-pin QFN package and is a member of the GigaComm™ family of high performance Clock / Data products. Application notes, models, and support documentation are available at [www.onsemi.com](http://www.onsemi.com).

### Features

- Maximum Input Data Rate > 10.7 Gb/s
- Data Dependent Jitter < 15 ps
- Maximum Input Clock Frequency > 7 GHz
- Random Clock Jitter < 0.8 ps RMS
- Selectable Input Equalization
- 180 ps Typical Propagation Delay
- 35 ps Typical Rise and Fall Times
- Differential CML Outputs, 400 mV Peak-to-Peak, Typical
- Operating Range:  $V_{CC} = 1.71 \text{ V to } 3.6 \text{ V}$  with  $GND = 0 \text{ V}$
- Internal 50  $\Omega$  Input Termination Resistors
- This is a Pb-Free Device



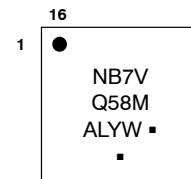
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### MARKING DIAGRAM\*



QFN-16  
MN SUFFIX  
CASE 485G

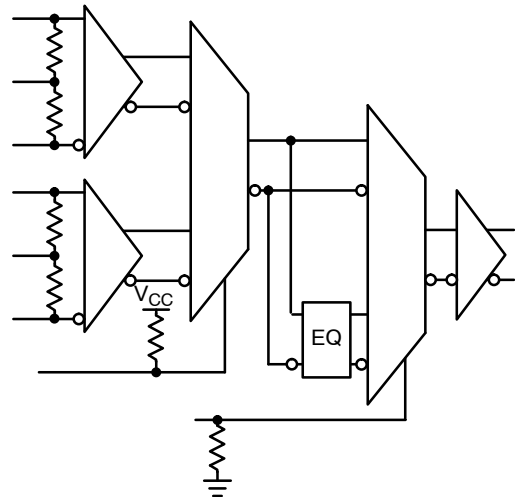


- A = Assembly Location
- L = Wafer Lot
- Y = Year
- W = Work Week
- = Pb-Free Package

(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 8 of this data sheet.

# NB7VQ58M

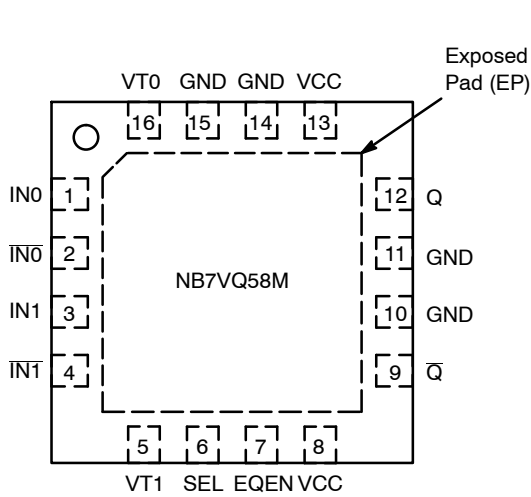


Figure 1. Pin Configuration (Top View)

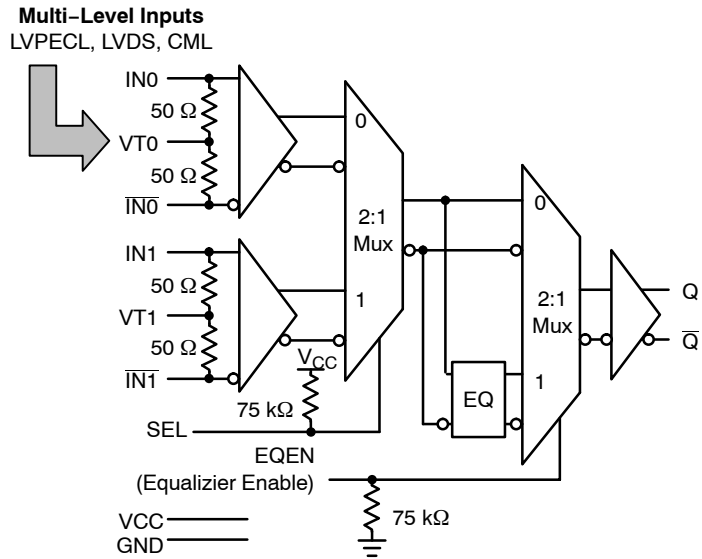


Figure 2. Detailed Block Diagram

Table 1. EQUALIZER ENable FUNCTION

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

Table 2. SElect FUNCTION TRUTH TABLE

SEL	Q	$\overline{Q}$
L	D0	$\overline{D0}$
H	D1	$\overline{D1}$

Table 3. PIN DESCRIPTION

Pin	Name	I/O	Description
1	IN0	LVPECL, CML, LVDS Input	Noninverted Differential Input (Note 1)
2	$\overline{IN0}$	LVPECL, CML, LVDS Input	Inverted Differential Input (Note 1)
3	IN1	LVPECL, CML, LVDS Input	Noninverted Differential Input (Note 1)
4	$\overline{IN1}$	LVPECL, CML, LVDS Input	Inverted Differential Input (Note 1)
5	VT1	-	Internal 50 $\Omega$ Termination Pin for IN1/ $\overline{IN1}$
6	SEL	LVTTL/LVCMOS Input	SEL Input. Low for IN0 inputs, High for IN1 inputs. (Note 1) Pin will default HIGH when left open (has internal pullup resistor)
7	EQEN	LVCMOS Input	Equalizer Enable Input; pin will default LOW when left open (has internal pulldown resistor)
8	VCC	-	Positive Supply Voltage (Note 2)
9	$\overline{Q}$	CML Output	Inverted Differential Output
10	GND	-	Negative Supply Voltage
11	GND	-	Negative Supply Voltage
12	Q	CML Output	Noninverted Differential Output
13	VCC	-	Positive Supply Voltage (Note 2)
14	GND	-	Negative Supply Voltage
15	GND	-	Negative Supply Voltage
16	VT0	-	Internal 50 $\Omega$ Termination Pin for IN0/ $\overline{IN0}$
-	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 pins (VT0, VT1) are connected to a common termination voltage or left open, and if no signal is applied on IN0/ $\overline{IN0}$ , IN1/ $\overline{IN1}$  inputs, then the device will be susceptible to self-oscillation. Q/ $\overline{Q}$  outputs have internal 50  $\Omega$  source termination resistors.

2. All VCC and GND pins must be externally connected to a power supply for proper operation.

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**Table 4. ATTRIBUTES**

Characteristics		Value
ESD Protection	Human Body Model Machine Model	> 2 kV > 200 V
R <sub>PU</sub> – SEL Input Pull-up Resistor		25 kΩ
Moisture Sensitivity (Note 3)	QFN-16	Level 1
Flammability Rating	Oxygen Index: 28 to 34	UL 94 V-0 @ 0.125 in
Transistor Count		312
Meets or exceeds JEDEC Spec EIA/JESD78 IC Latchup Test		

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

**Table 5. MAXIMUM RATINGS**

Symbol	Parameter	Condition 1	Condition 2	Rating	Unit
V <sub>CC</sub>	Positive Power Supply	GND = 0 V		4.0	V
V <sub>IN</sub>	Positive Input Voltage	GND = 0 V		-0.5 to V <sub>CC</sub> +0.5	V
V <sub>INPP</sub>	Differential Input Voltage  I <sub>Nn</sub> – I <sub>Nn̄</sub>			1.89	V
I <sub>OUT</sub>	Output Current	Continuous Surge		34 40	mA
I <sub>IN</sub>	Input Current Through R <sub>T</sub> (50 Ω Resistor)			± 40	mA
T <sub>A</sub>	Operating Temperature Range			-40 to +85	°C
T <sub>stg</sub>	Storage Temperature Range			-65 to +150	°C
θ <sub>JA</sub>	Thermal Resistance (Junction-to-Ambient) (Note 4)	0 LFPM 500 LFPM	QFN-16 QFN-16	42 35	°C/W
θ <sub>JC</sub>	Thermal Resistance (Junction-to-Case) (Note 4)		QFN-16	4	°C/W
T <sub>sol</sub>	Wave Solder Pb-Free			265	°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 6. DC CHARACTERISTICS POSITIVE CML OUTPUT** ( $V_{CC} = 1.71\text{ V to }3.6\text{ V}$ ;  $GND = 0\text{ V}$ ;  $T_A = -40^\circ\text{C to }85^\circ\text{C}$ ) (Note 5)

Symbol	Characteristic	Min	Typ	Max	Unit
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## POWER SUPPLY CURRENT

$I_{CC}$	Power Supply Current (Inputs and Outputs Open)		100	150	mA
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## 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	$V_{CC} = 3.3\text{ V}$	$V_{CC} - 500$	$V_{CC} - 400$	$V_{CC} - 300$	mV
		$V_{CC} = 2.5\text{ V}$	2800	2900	3000	
		$V_{CC} = 1.8\text{ V}$	2000	2100	2200	
			1770	1795	1800	
			1300	1400	1500	

## DIFFERENTIAL INPUTS DRIVEN SINGLE-ENDED (Note 7) (Figures 6 & 8)

$V_{th}$	Input Threshold Reference Voltage Range (Note 8)	1050		$V_{CC} - 100$	mV
$V_{IH}$	Single-ended Input HIGH Voltage	$V_{th} + 100$		$V_{CC}$	mV
$V_{IL}$	Single-ended Input LOW Voltage	GND		$V_{th} - 100$	mV
$V_{ISE}$	Single-ended Input Voltage ( $V_{IH} - V_{IL}$ )	200		1200	mV

## DIFFERENTIAL IN0/IN0, IN1/IN1, INPUTS DRIVEN DIFFERENTIALLY (Figures 7 & 9) (Note 9)

$V_{IHD}$	Differential Input HIGH Voltage	1100		$V_{CC}$	mV
$V_{ILD}$	Differential Input LOW Voltage	GND		$V_{CC} - 100$	mV
$V_{ID}$	Differential Input Voltage ( $V_{IHD} - V_{ILD}$ )	100		1200	mV
$V_{CMR}$	Input Common Mode Range (Differential Configuration, Note 10) (Figure 10)	1050		$V_{CC} - 50$	mV
$I_{IH}$	Input HIGH Current (VTn Open)	-150		150	$\mu\text{A}$
$I_{IL}$	Input LOW Current (VTn Open)	-150		150	$\mu\text{A}$

## CONTROL INPUT (SEL, EQEN)

$V_{IH}$	Input HIGH Voltage	$V_{CC} \times 0.65$		$V_{CC}$	mV
$V_{IL}$	Input LOW Voltage	GND		$V_{CC} \times 0.35$	mV
$I_{IH}$	Input HIGH Current	-150		+150	$\mu\text{A}$
$I_{IL}$	Input LOW Current	-200		+200	$\mu\text{A}$

## 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.

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

6. CML outputs loaded with  $50\ \Omega$  to  $V_{CC}$  for proper operation.

7.  $V_{th}$ ,  $V_{IH}$ ,  $V_{IL}$  and  $V_{ISE}$  parameters must be complied with simultaneously.

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

9.  $V_{IHD}$ ,  $V_{ILD}$ ,  $V_{ID}$  and  $V_{CMR}$  parameters must be complied with simultaneously.

10.  $V_{CMR}$  min varies 1:1 with GND,  $V_{CMR}$  max varies 1:1 with  $V_{CC}$ . The  $V_{CMR}$  range is referenced to the most positive side of the differential input signal.

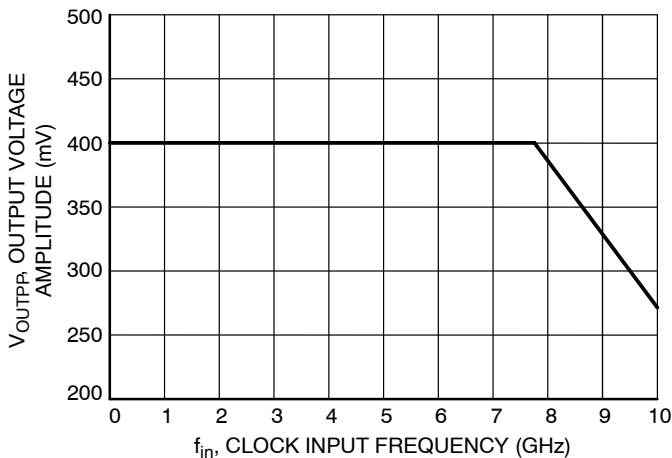
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**Table 7. AC CHARACTERISTICS** ( $V_{CC} = 1.71\text{ V to }3.6\text{ V}$ ;  $GND = 0\text{ V}$ ;  $T_A = -40^\circ\text{C to }85^\circ\text{C}$ ) (Note 11)

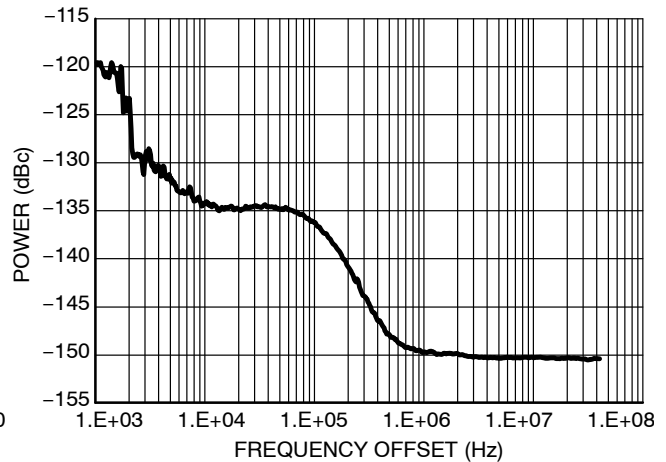
Symbol	Characteristic	Min	Typ	Max	Unit	
$f_{MAX}$	Maximum Input Clock Frequency $V_{OUTPP} \geq 200\text{ mV}$	7	8		GHz	
$f_{DATAMAX}$	Maximum Operating Data Rate (PRBS23)	10.7	12		Gbps	
$f_{SEL}$	Maximum Toggle Frequency, SEL	25	50		MHz	
$V_{OUTPP}$	Output Voltage Amplitude EQEN = 0 or 1 (Note 12) (Figures 3 and 11)	$f_{in} \leq 7\text{ GHz}$	200	400		mV
$t_{PLH}$ , $t_{PHL}$	Propagation Delay to Differential Outputs, @ 1 GHz, measured at differential cross-point EQEN = 0 or 1	$I_{Nn}/I_{N\bar{n}}$ to Q, $\bar{Q}$ SEL to Q, $\bar{Q}$	120 5	180 13	240 22	ps ns
$t_{PLH\ TC}$	Propagation Delay Temperature Coefficient		50		$\Delta\text{fs}/^\circ\text{C}$	
$t_{skew}$	Device – Device skew (tpdmax – tpdmin)			50	ps	
$t_{DC}$	Output Clock Duty Cycle (Reference Duty Cycle = 50%)	$f_{in} \leq 5.0\text{ GHz}$ $f_{in} \leq 7.0\text{ GHz}$	45 40	50 50	55 60	%
$t_{JITTER}$	RMS Random Clock Jitter (Note 13) Peak-to-Peak Data Dependent Jitter (Note 14)	$f_{in} \leq 7.0\text{ GHz}$  $f_{in} \leq 10.7\text{ Gbps}$ EQEN = 0 ( $\leq 3''\text{ FR4}$ ) EQEN = 1 ( $12''\text{ FR4}$ )		0.2	0.8	ps rms ps pk-pk
$\Phi_N$	Phase Noise, $f_c = 1\text{ GHz}$	10 kHz 100 kHz 1 MHz 10 MHz 20 MHz 40 MHz		-135 -136 -150 -151 -151 -151		dBc
$t_{\int\Phi_N}$	Integrated Phase Jitter (Figure 4) $f_c = 1\text{ GHz}$ , 12 kHz – 20 MHz Offset (RMS)		35			fs
	Crosstalk Induced Jitter (Adjacent Channel) (Note 15)			0.7		ps RMS
$V_{INPP}$	Input Voltage Swing (Differential Configuration) (Figure 11) (Note 12)		100		1200	mV
$t_r$ , $t_f$	Output Rise/Fall Times @ 1 GHz (20% – 80%)	Q, $\bar{Q}$	15	35	50	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 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.

11. Measured using a  $V_{INPPmin}$  source, 50% duty cycle clock source. All output loading with external  $50\ \Omega$  to  $V_{CC}$ . Input edge rates 40 ps (20% – 80%).
12. Input and output voltage swings are single-ended measurements operating in differential mode.
13. Additive RMS jitter with 50% duty cycle clock signal.
14. Additive Peak-to-Peak data dependent jitter with input NRZ data at PRBS23 at 3 Gbps.
15. Crosstalk is measured at the output while applying two similar clock frequencies that are asynchronous with respect to each other at the inputs.



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



**Figure 4. Typical Phase Noise ( $V_{CC} = 1.8\text{ V}$ ,  $T = 25^\circ\text{C}$ ,  $f_c = 1\text{ GHz}$ )**

# NB7VQ58M

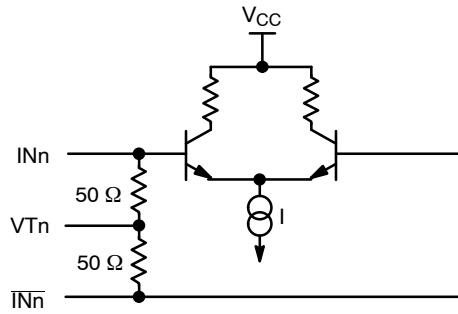


Figure 5. Input Structure

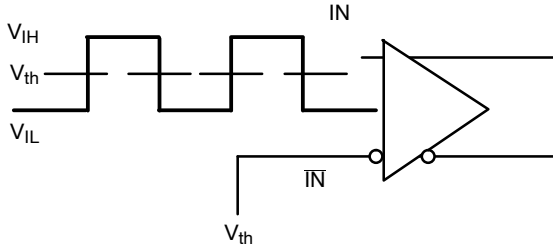


Figure 6. Differential Input Driven Single-Ended

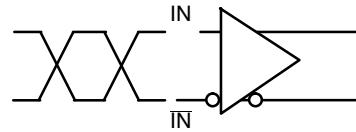


Figure 7. Differential Inputs Driven Differentially

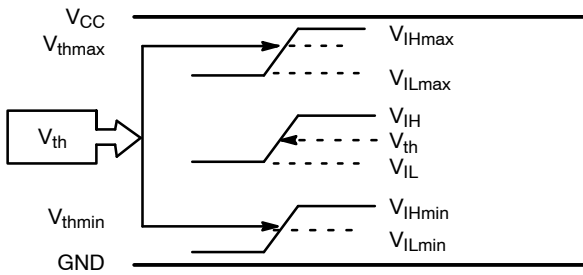


Figure 8.  $V_{th}$  Diagram

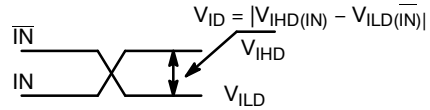


Figure 9.  $V_{ID}$  - Differential Inputs Driven Differentially

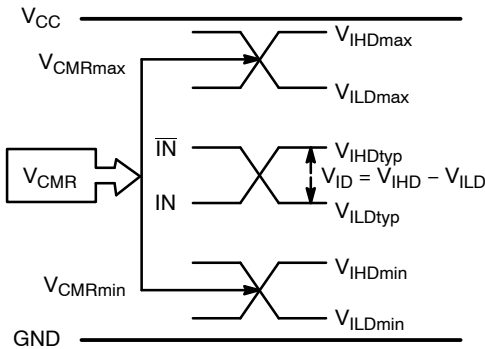


Figure 10.  $V_{CMR}$  Diagram

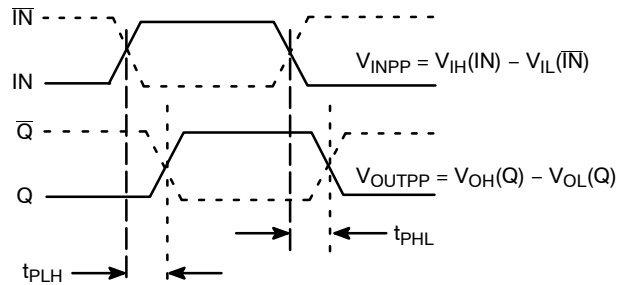


Figure 11. AC Reference Measurement

# NB7VQ58M

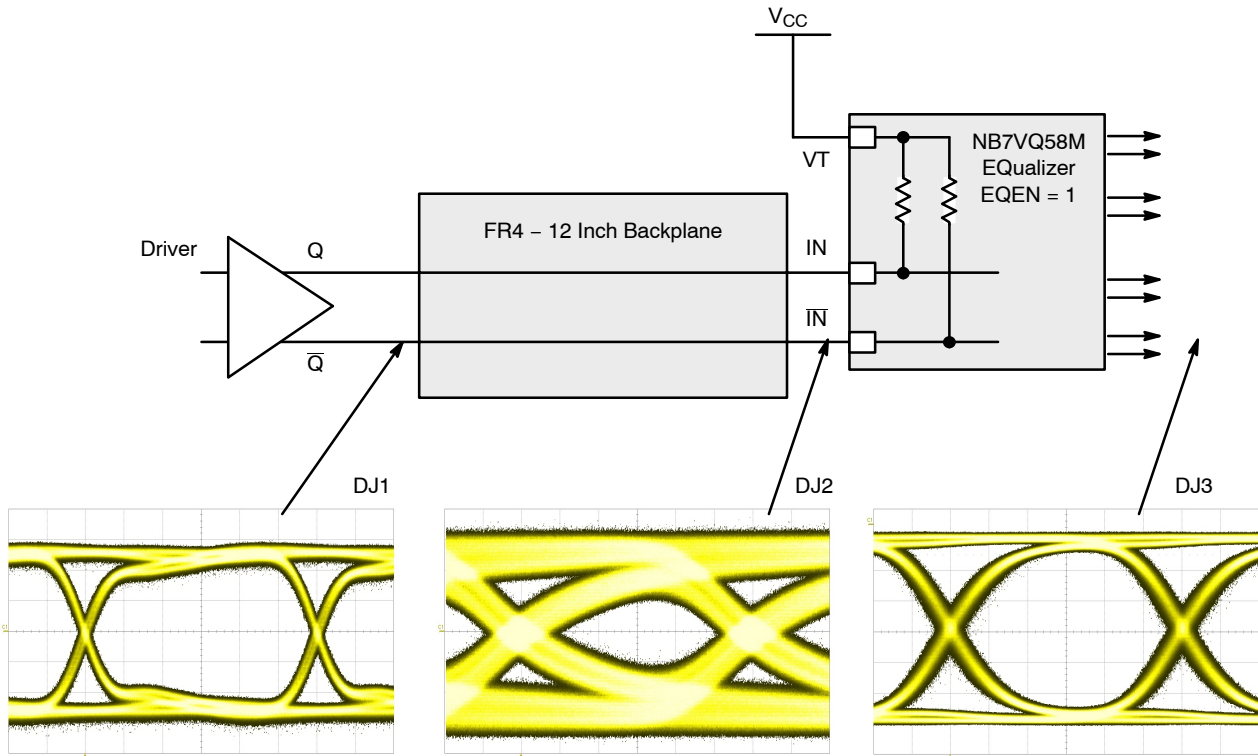


Figure 12. Typical NB7VQ58M Equalizer Application and Interconnect with PRBS23 pattern at 6.5 Gbps, EQEN = 1

# NB7VQ58M

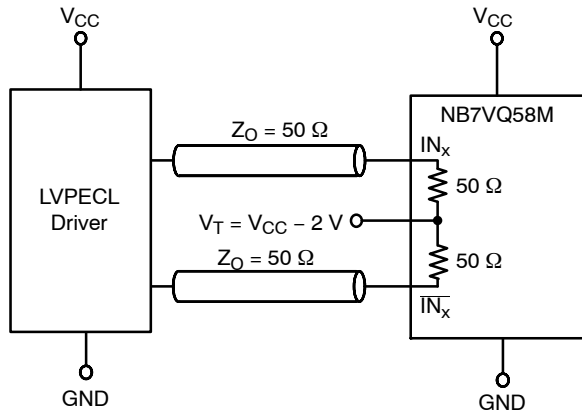


Figure 13. LVPECL Interface

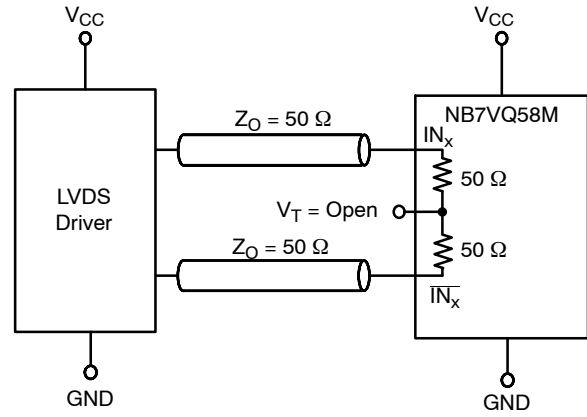


Figure 14. LVDS Interface

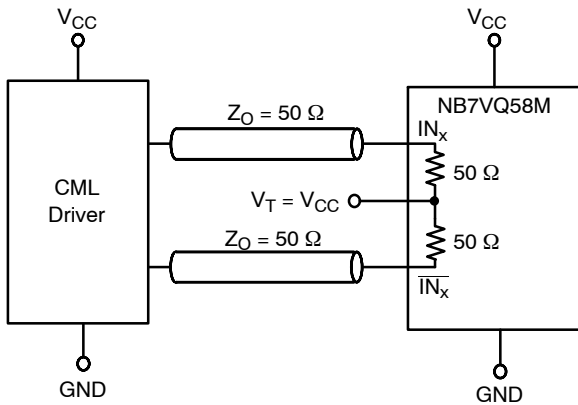


Figure 15. Standard 50  $\Omega$  Load CML Interface

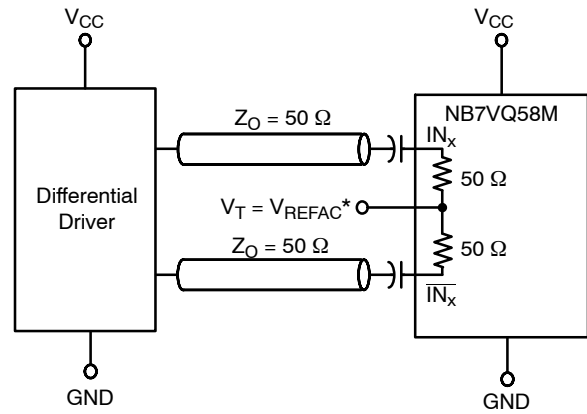


Figure 16. Capacitor-Coupled Differential Interface  
( $V_T$  Connected to External  $V_{REFAC}$ )

\* $V_{REFAC}$  Bypassed to Ground with 0.01  $\mu\text{F}$  Capacitor

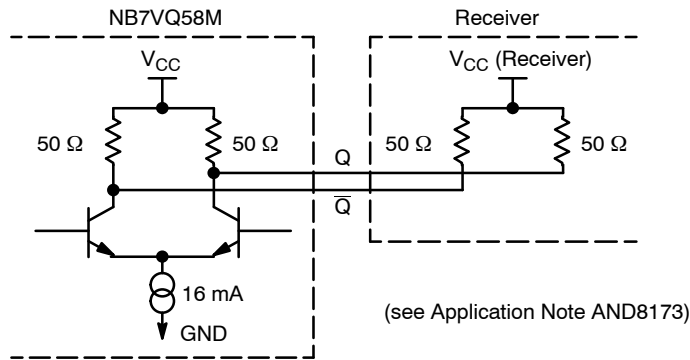


Figure 17. Typical CML Output Structure and Termination

## ORDERING INFORMATION

Device	Package	Shipping <sup>†</sup>
NB7VQ58MMNG	QFN-16 (Pb-Free)	123 Units / Rail
NB7VQ58MMNHTBG	QFN-16 (Pb-Free)	100 / Tape & Reel
NB7VQ58MMNTXG	QFN-16 (Pb-Free)	3000 / Tape & Reel

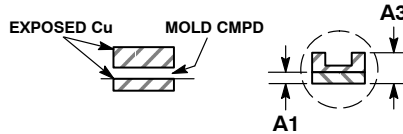
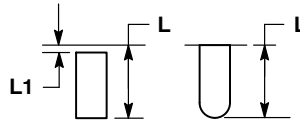
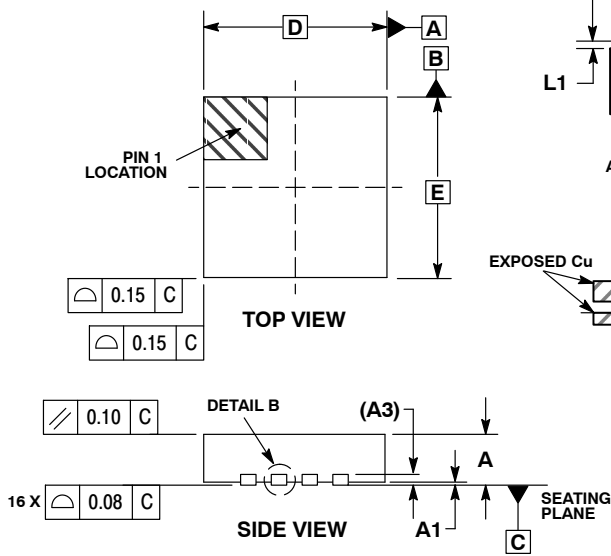
<sup>†</sup>For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.



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## PACKAGE DIMENSIONS

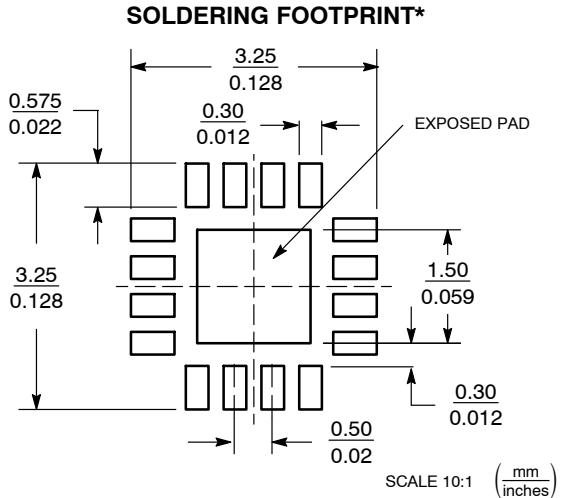
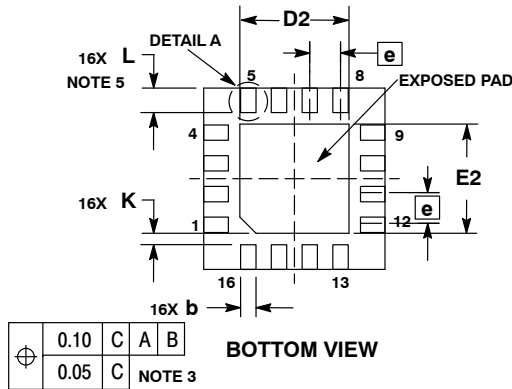
16 PIN QFN  
CASE 485G-01  
ISSUE D



**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<sub>max</sub> 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	0.18 TYP	
L	0.30	0.50
L1	0.00	0.15



\*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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