

# NB3L8504S

## 2.5 V / 3.3 V 1:4 Differential Input to LVDS Fanout Buffer / Translator

### Description

The NB3L8504S is a differential 1:4 LVDS fanout buffer/translator with OE control for each differential output. The differential inputs which can be driven by either a differential or single-ended input, can accept various logic level standards such as LVPECL, LVDS, HSTL, HCSL and SSTL. These signals are then translated to four identical LVDS copies of the input up to 700 MHz. As such, the NB3L8504S is ideal for Clock distribution applications that require low skew.

The NB3L8504S is offered in the TSSOP-16 package.

### Features

- Four Differential LVDS Outputs
- Each Differential Output has OE Control
- 700 MHz Maximum Output Frequency
- 660 ps Max Output Rise and Fall Times, LVCMOS
- Translates Differential Input to LVDS Levels
- Additive Phase Jitter RMS: < 100 fs Typical
- 50 ps Maximum Output Skew
- 350 ps Maximum Part-to-part Skew
- 1.3 ns Maximum Propagation Delay
- Operating Range:  $V_{CC} = 2.5\text{ V} \pm 5\%$  or  $3.3\text{ V} \pm 10\%$
- $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$  Ambient Operating Temperature
- 16-Pin TSSOP, 4.4 mm x 5.0 mm x 0.925 mm
- These are Pb-Free Devices

### Applications

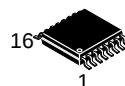
- Telecom
- Ethernet
- Networking
- SONET



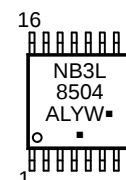
ON Semiconductor®

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### MARKING DIAGRAM\*



TSSOP-16  
DT SUFFIX  
CASE 948F



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.

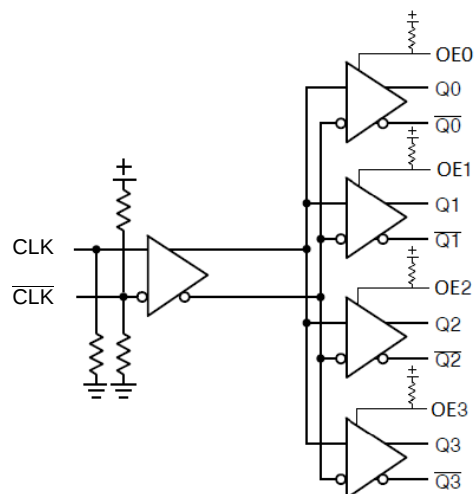


Figure 1. Logic Diagram

### ORDERING INFORMATION

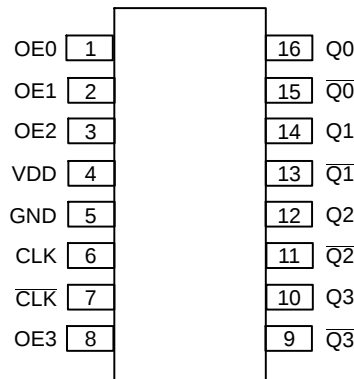
See detailed ordering and shipping information on page 9 of this data sheet.

# NB3L8504S

**Table 1. PIN DESCRIPTIONS AND CHARACTERISTICS**

| Pin | Name                    | I/O                | Description                                                                                                     |
|-----|-------------------------|--------------------|-----------------------------------------------------------------------------------------------------------------|
| 1   | OE0                     | LVTTL/LVCMOS Input | Output Enable pin for Q0, $\overline{Q0}$ outputs. Defaults High when left open; internal pull-up resistor.     |
| 2   | OE1                     | LVTTL/LVCMOS Input | Output Enable pin for Q1, $\overline{Q1}$ outputs. Defaults High when left open; internal pull-up resistor.     |
| 3   | OE2                     | LVTTL/LVCMOS Input | Output Enable pin for Q2, $\overline{Q2}$ outputs. Defaults High when left open; internal pull-up resistor.     |
| 4   | VDD                     | Power              | 3.3 V / 2.5 V Positive Supply Voltage.                                                                          |
| 5   | GND                     | Power              | 3.3 V / 2.5 V Negative Supply Voltage.                                                                          |
| 6   | CLK                     | Multi-Level Input  | Non-inverting differential Clock input. Defaults Low when left open; internal pull-down resistor.               |
| 7   | $\overline{\text{CLK}}$ | Multi-Level Input  | Inverting differential Clock input. Defaults to VDD/2 when left open; internal pull-up and pull-down resistors. |
| 8   | OE3                     | LVTTL/LVCMOS Input | Output Enable pin for Q3, $\overline{Q3}$ outputs. Defaults High when left open; internal pull-up resistor.     |
| 9   | $\overline{Q3}$         | LVDS Output        | Inverting differential Clock output.                                                                            |
| 10  | Q3                      | LVDS Output        | Non-inverting differential Clock output.                                                                        |
| 11  | $\overline{Q2}$         | LVDS Output        | Inverting differential Clock output.                                                                            |
| 12  | Q2                      | LVDS Output        | Non-inverting differential Clock output.                                                                        |
| 13  | $\overline{Q1}$         | LVDS Output        | Inverting differential Clock output.                                                                            |
| 14  | Q1                      | LVDS Output        | Non-inverting differential Clock output.                                                                        |
| 15  | $\overline{Q0}$         | LVDS Output        | Inverting differential Clock output.                                                                            |
| 16  | Q0                      | LVDS Output        | Non-inverting differential Clock output.                                                                        |

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



**Figure 2. NB3L8504S Pinout, 16-pin TSSOP (Top View)**

**Table 2. OUTPUT ENABLE FUNCTION TABLE**

| OE[3:0]        | Outputs – Q[0:3], $\overline{Q}$ [0:3] |
|----------------|----------------------------------------|
| LOW            | High Impedance                         |
| HIGH (Default) | Active                                 |

Table 3. ATTRIBUTES

| Characteristics                                                                        | Value                |
|----------------------------------------------------------------------------------------|----------------------|
| ESD Protection Human Body Model<br>Machine Model                                       | > 2 kV<br>> 200 V    |
| R <sub>PU</sub> – Input Pull-up Resistor<br>R <sub>PD</sub> – Input Pull-down Resistor | 50 kΩ<br>50 kΩ       |
| C <sub>IN</sub> – Input Capacitance                                                    | 4 pF                 |
| R <sub>IN</sub> – Input Impedance                                                      | 10 kΩ                |
| Moisture Sensitivity (Note 2) TSSOP–16                                                 | Level 1              |
| Flammability Rating Oxygen Index: 28 to 34                                             | UL 94 V–0 @ 0.125 in |
| Transistor Count                                                                       | 371                  |
| Meets or exceeds JEDEC Spec EIA/JESD78 IC Latchup Test                                 |                      |

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

Table 4. MAXIMUM RATINGS

| Symbol           | Parameter                                                                                             | Condition                               |                          | Rating                       | Unit         |
|------------------|-------------------------------------------------------------------------------------------------------|-----------------------------------------|--------------------------|------------------------------|--------------|
| V <sub>DD</sub>  |                                                                                                       | GND = 0 V                               |                          | 4.6                          | V            |
| V <sub>IN</sub>  |                                                                                                       | GND = 0 V                               |                          | –0.5 to V <sub>DD</sub> +0.5 | V            |
| I <sub>out</sub> | Continuous Current<br>Surge Current                                                                   | LVDS Outputs                            |                          | 10<br>15                     | mA<br>mA     |
| I <sub>OSC</sub> | Output Short Circuit Current<br>Line-to-Line (Q to $\bar{Q}$ )<br>Line-to-GND (Q or $\bar{Q}$ to GND) | Q or $\bar{Q}$<br>Q to $\bar{Q}$ to GND | Continuous<br>Continuous | 12<br>24                     | mA<br>mA     |
| T <sub>A</sub>   | Operating Temperature Range                                                                           | TSSOP–16                                |                          | –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 3)                                                     | 0 lfpm<br>500 lfpm                      | TSSOP–16<br>TSSOP–16     | 138<br>108                   | °C/W<br>°C/W |
| θ <sub>JC</sub>  | Thermal Resistance (Junction-to-Case)                                                                 | (Note 3)                                | TSSOP–16                 | 33 – 36                      | °C/W         |
| T <sub>sol</sub> | 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.

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

# NB3L8504S

**Table 5. DC CHARACTERISTICS**  $V_{DD} = 2.5 \text{ V} \pm 5\%$  or  $3.3 \text{ V} \pm 10\%$ ;  $GND = 0 \text{ V}$ ;  $T_A = -40^\circ\text{C}$  to  $85^\circ\text{C}$

| Symbol | Characteristic | Min | Typ | Max | Unit |
|--------|----------------|-----|-----|-----|------|
|--------|----------------|-----|-----|-----|------|

## POWER SUPPLY / CURRENT (Note 4)

|          |                                   |                                                      |               |            |               |    |
|----------|-----------------------------------|------------------------------------------------------|---------------|------------|---------------|----|
| $V_{DD}$ | Power Supply Voltage              | $V_{DD} = 3.3 \text{ V}$<br>$V_{DD} = 2.5 \text{ V}$ | 2.97<br>2.375 | 3.3<br>2.5 | 3.63<br>2.625 | V  |
| $I_{DD}$ | Power Supply Current for $V_{DD}$ |                                                      |               | 41         | 50            | mA |

## LVDS OUTPUTS (Note 5)

|                 |                                                         |      |      |      |    |
|-----------------|---------------------------------------------------------|------|------|------|----|
| $V_{OD}$        | Differential Output Voltage (Figure 12) (Notes 6 and 7) | 250  | 350  | 450  | mV |
| $\Delta V_{OD}$ | $V_{OD}$ Magnitude Change (Figure 12) (Notes 6 and 7)   |      |      | 50   | mV |
| $V_{OS}$        | Offset Voltage (Figure 13) (Notes 6 and 7)              | 1075 | 1250 | 1375 | mV |
| $\Delta V_{OS}$ | $V_{OS}$ Magnitude Change (Figure 13) (Notes 6 and 7)   |      |      | 50   | mV |
| $V_{OH}$        | Output HIGH Voltage                                     |      | 1425 | 1600 | mV |
| $V_{OL}$        | Output LOW Voltage                                      | 900  | 1075 |      | mV |

## DIFFERENTIAL INPUTS DRIVEN DIFFERENTIALLY (see Figure 5 & 6) (Note 11)

|             |                                                                                   |             |            |                 |               |
|-------------|-----------------------------------------------------------------------------------|-------------|------------|-----------------|---------------|
| $V_{IHD}$   | Differential Input HIGH Voltage                                                   | 500         |            | $V_{DD} - 850$  | mV            |
| $V_{ILD}$   | Differential Input LOW Voltage                                                    | -300        |            | $V_{IHD} - 150$ | mV            |
| $V_{ID}$    | Differential Input Voltage ( $V_{IHD} - V_{ILD}$ )                                | 150         |            | 1300            | mV            |
| $V_{IHCMR}$ | Input Common Mode Voltage Range (Differential Configuration) (Note 10) (Figure 7) | $GND + 0.5$ |            | $V_{DD} - 850$  | mV            |
| $I_{IH}$    | Input HIGH Current, $V_{DD} = V_{IN} = 3.63 \text{ V}$                            | CLK, CLK    |            | 150             | $\mu\text{A}$ |
| $I_{IL}$    | Input LOW Current, $V_{DD} = 3.63 \text{ V}$ , $V_{IN} = 0 \text{ V}$             | CLK<br>CLK  | -5<br>-150 |                 | $\mu\text{A}$ |

## LVC MOS – OE Control Inputs

|          |                                                                       |      |  |                |               |
|----------|-----------------------------------------------------------------------|------|--|----------------|---------------|
| $V_{IH}$ | Input HIGH Voltage                                                    | 2.0  |  | $V_{DD} + 0.3$ | V             |
| $V_{IL}$ | Input LOW Voltage                                                     | -0.3 |  | 0.8            | V             |
| $I_{IH}$ | Input HIGH Current, $V_{DD} = V_{IN} = 3.63 \text{ V}$                |      |  | 5              | $\mu\text{A}$ |
| $I_{IL}$ | Input LOW Current, $V_{DD} = 3.63 \text{ V}$ , $V_{IN} = 0 \text{ V}$ | -150 |  |                | $\mu\text{A}$ |

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

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 pins open and output pins loaded with  $R_L = 100 \Omega$  across differential.
- LVDS outputs require  $100 \Omega$  receiver termination resistor between diff. pair. See Figure 14.
- $V_{OS} \text{ max} + \frac{1}{2} V_{OD} \text{ max}$ . Also see Figures 12 and 13.
- $V_{OS} \text{ min} - \frac{1}{2} V_{OD} \text{ max}$ . Also see Figures 12 and 13.
- $V_{IH}$ ,  $V_{IL}$ ,  $V_{th}$ , and  $V_{ISE}$  parameters must be complied with simultaneously.
- $V_{th}$  is applied to the complementary input when operating in single-ended mode.
- $V_{IHCMR} \text{ max}$  varies 1:1 with  $V_{DD}$ ,  $V_{IHCMR} \text{ min}$  varies 1:1 with  $GND$ .
- $V_{IHD}$ ,  $V_{ILD}$ ,  $V_{ID}$  and  $V_{IHCMR}$  parameters must be complied with simultaneously.

**Table 6. AC CHARACTERISTICS**  $V_{DD} = 2.5\text{ V} \pm 5\%$  or  $3.3\text{ V} \pm 10\%$ ;  $GND = 0\text{ V}$ ;  $T_A = -40^\circ\text{C}$  to  $85^\circ\text{C}$  (Note 12) (Figure 10)

| Symbol          | Characteristic                                                                                                                            | Min | Typ          | Max           | Unit |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------|-----|--------------|---------------|------|
| $f_{MAX}$       | Input Clock Frequency $V_{OUTPP} \geq 250\text{ mV}$ @ $V_{INPPmax}$                                                                      |     |              | 700           | MHz  |
| $V_{OUTPP}$     | Output Voltage Amplitude (@ $V_{INPPmin}$ ) $f_{in} \leq 700\text{ MHz}$<br>(See Figure 3)                                                | 250 | 350          |               | mV   |
| $t_{pd}$        | Differential Input to Differential Output Propagation Delay at $f_{MAX}$<br>@ $V_{DD} = 3.3\text{ V}$                                     | 0.9 |              | 1.3           | ns   |
| $t_{jit}(\phi)$ | Additive Phase Jitter RMS (Figure 4)<br>Integration Range: 12 kHz – 20 MHz<br>$f_{out} = 156.25\text{ MHz}$<br>$f_{out} = 100\text{ MHz}$ |     | 0.07<br>0.10 | 0.08<br>0.105 | ps   |
| $t_{SKEW(o-o)}$ | Output-to-output Skew (Note 14) (Figure 8)                                                                                                |     |              | 50            | ps   |
| $T_{SKEW(pp)}$  | Part-to-part Skew (Note 14)                                                                                                               |     |              | 350           | ps   |
| $t_r / t_f$     | Output Rise/Fall Times @ 50 MHz, 20% – 80%                                                                                                | 180 | 350          | 660           | ps   |
| $t_{DC}$        | Output Clock Duty Cycle (Input Duty Cycle = 50%)                                                                                          | 45  | 50           | 55            | %    |
| $V_{INPP}$      | Input Voltage Swing<br>(Differential Configuration) (Note 13)                                                                             | 150 |              | 1300          | mV   |

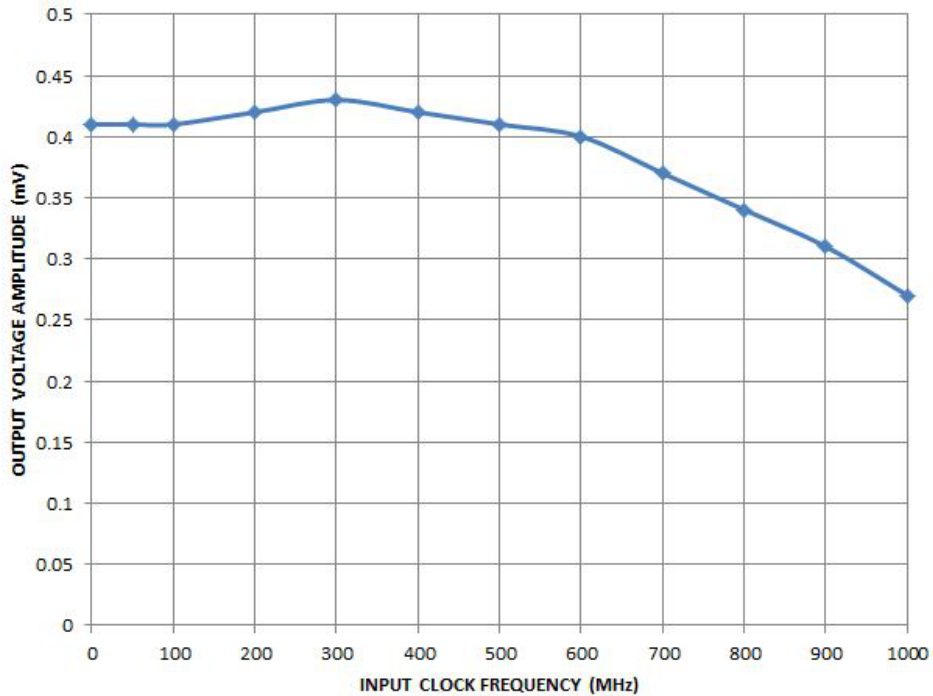
Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

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.

12. Measured by forcing a 50% duty cycle clock source. All LVDS output loading with an external  $R_L = 100\ \Omega$  across  $Q$  &  $\bar{Q}$ .

13.  $V_{INPP(max)}$  cannot exceed  $V_{DD}$ . Input voltage swing is a single-ended measurement operating in differential mode.

14. Skew is measured between outputs under identical transition at 50 MHz.



**Figure 3. Output Voltage Amplitude ( $V_{OUTPP}$ ) vs. Input Clock Frequency ( $f_{in}$ ) and Temperature (@  $V_{DD} = 2.5\text{ V}$ )**

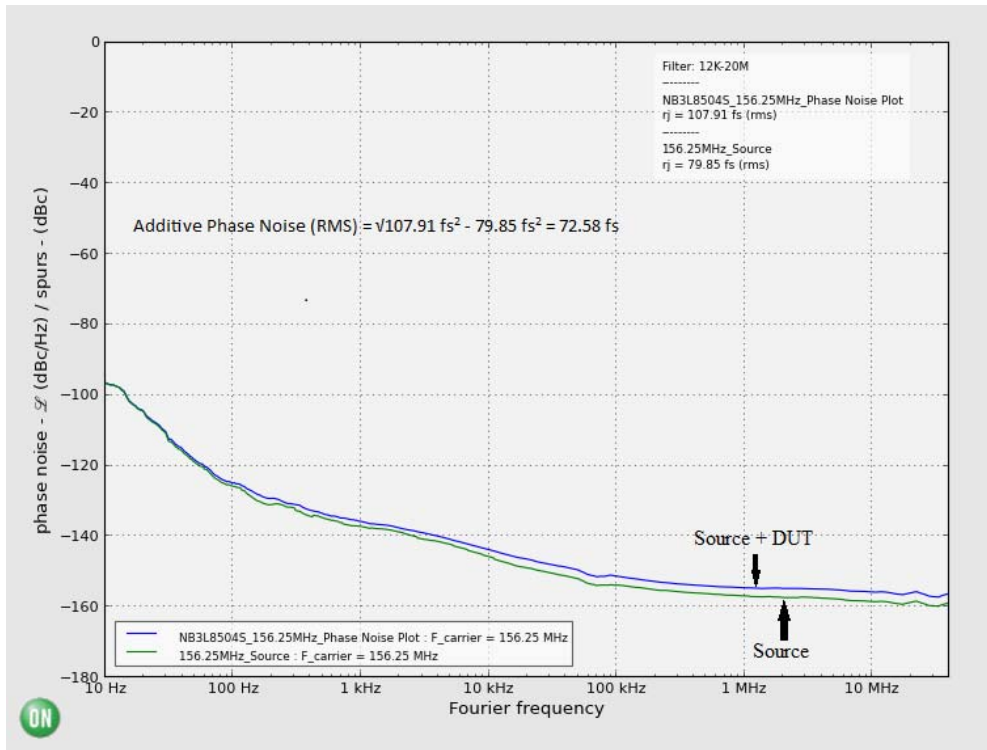


Figure 4. Additive Phase Jitter

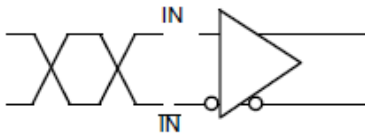


Figure 5. Differential Inputs Driven Differentially

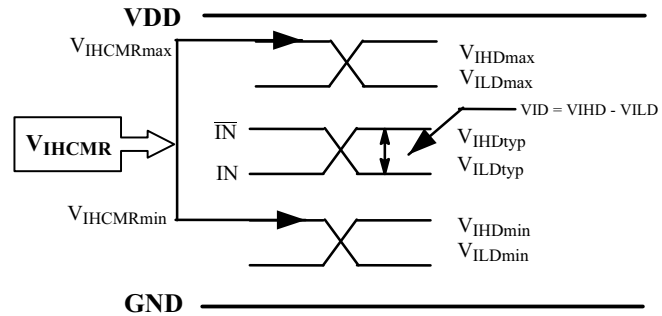


Figure 7. VIHCMR Diagram

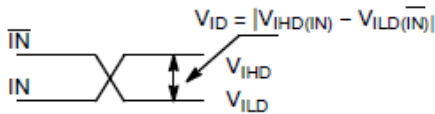


Figure 6. Differential Inputs Driven Differentially

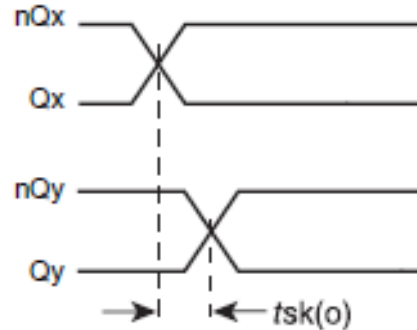


Figure 8. Output-to-Output Skew

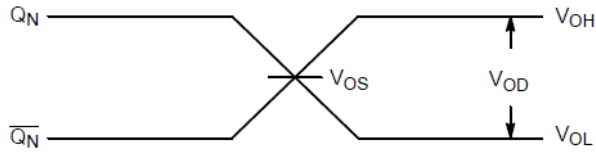


Figure 9. LVDS Output

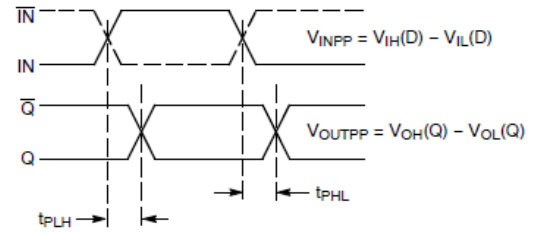


Figure 10. AC Reference Measurements

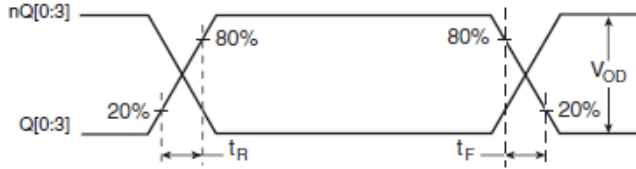


Figure 11. LVDS Output

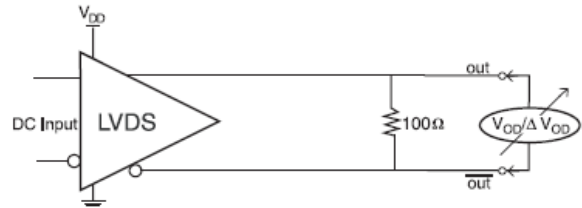


Figure 12.  $V_{OD}$  and  $\Delta V_{OD}$

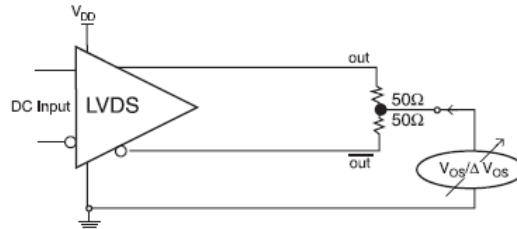


Figure 13.  $V_{OS}$  and  $\Delta V_{OS}$

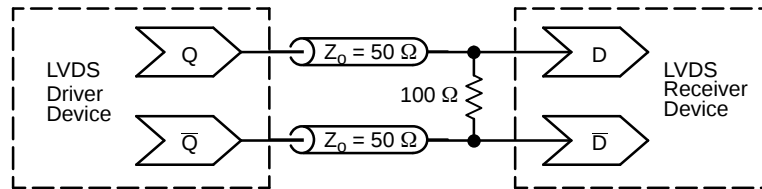


Figure 14. Typical LVDS Termination for Output Driver and Device Evaluation

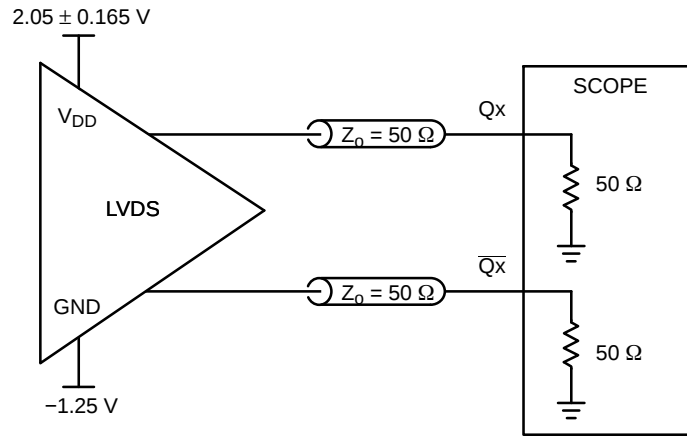


Figure 15. Typical Test Setup and Termination for Evaluation. The  $V_{DD} = 2.05 \text{ V} \pm 0.165 \text{ V}$  and GND of  $-1.25 \text{ V}$  Split Supply Allows a Direct Connection to an Oscilloscope  $50 \text{ } \Omega$  Input Module

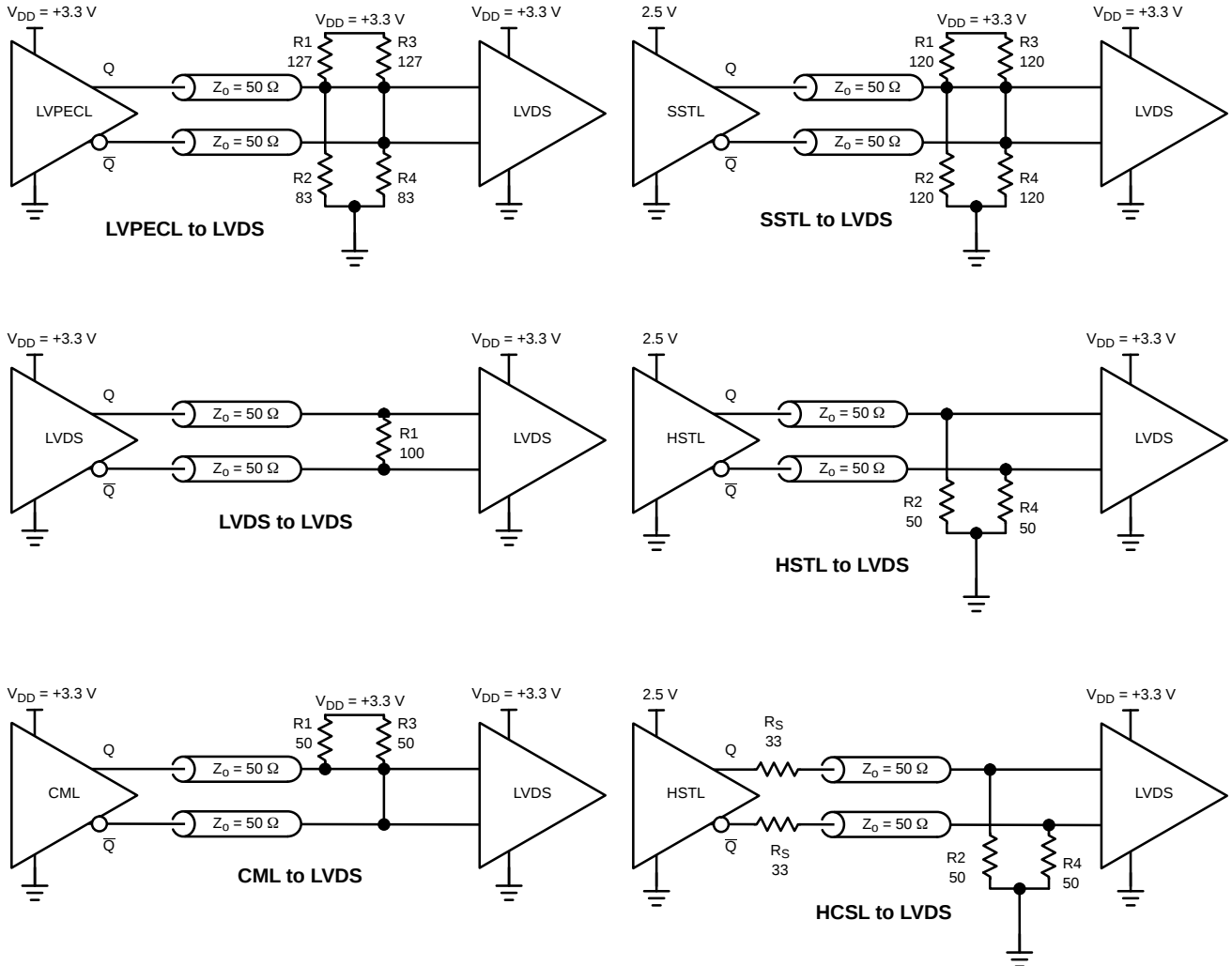
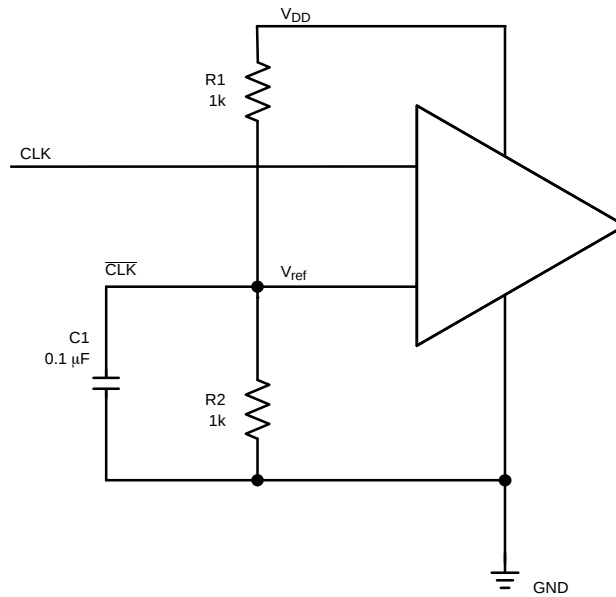


Figure 16. Differential Input Interface from LVPECL, CML, LVDS, HSTL, SSTL or HCSL

## NB3L8504S



**Figure 17. Differential Input Driven Single-ended**

### Differential Clock Input to Accept Single-ended Input

Figure 17 shows how the CLK input can be driven by a single-ended Clock signal. C1 is connected to the  $V_{ref}$  node

as a bypass capacitor. Locate these components close the device pins. R1 and R2 must be adjusted to position  $V_{ref}$  to the center of the input swing on CLK.

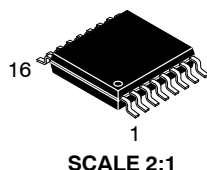
**Table 7. ORDERING INFORMATION**

| Device         | Package               | Shipping           |
|----------------|-----------------------|--------------------|
| NB3L8504SDTG   | TSSOP-16<br>(Pb-Free) | 96 Units / Tube    |
| NB3L8504SDTR2G | TSSOP-16<br>(Pb-Free) | 2500 / 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.

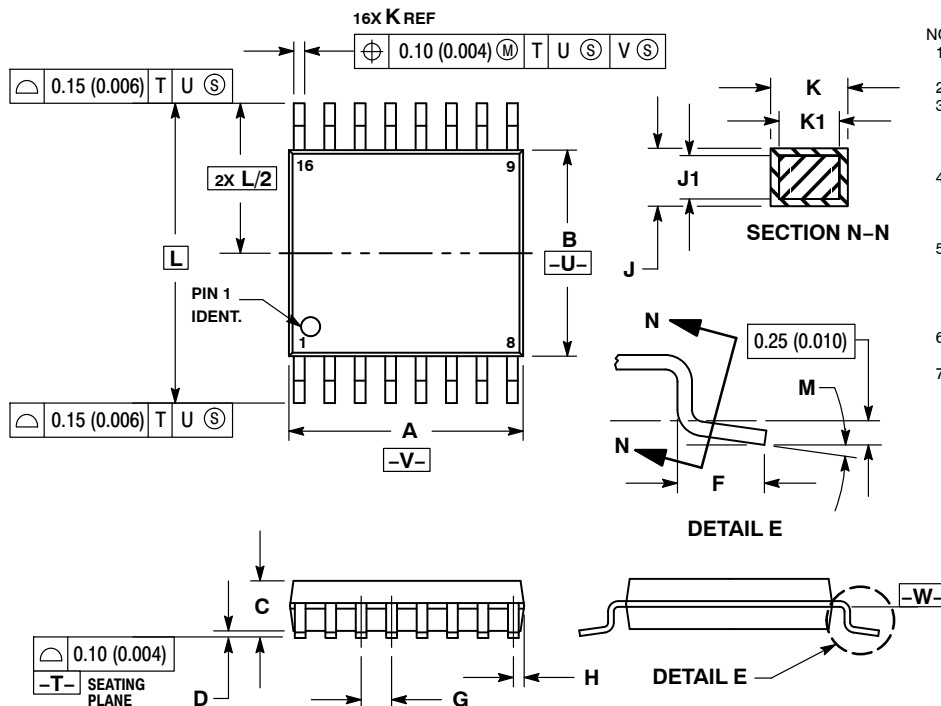
# MECHANICAL CASE OUTLINE PACKAGE DIMENSIONS

ON Semiconductor®



**TSSOP-16**  
CASE 948F-01  
ISSUE B

DATE 19 OCT 2006

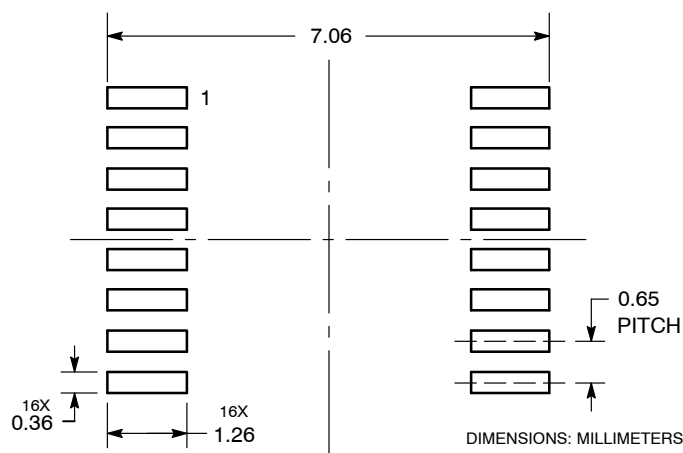


## NOTES:

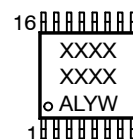
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSION A DOES NOT INCLUDE MOLD FLASH. PROTRUSIONS OR GATE BURRS. MOLD FLASH OR GATE BURRS SHALL NOT EXCEED 0.15 (0.006) PER SIDE.
4. DIMENSION B DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSION. INTERLEAD FLASH OR PROTRUSION SHALL NOT EXCEED 0.25 (0.010) PER SIDE.
5. DIMENSION K DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.08 (0.003) TOTAL IN EXCESS OF THE K DIMENSION AT MAXIMUM MATERIAL CONDITION.
6. TERMINAL NUMBERS ARE SHOWN FOR REFERENCE ONLY.
7. DIMENSION A AND B ARE TO BE DETERMINED AT DATUM PLANE -W-.

| DIM | MILLIMETERS |      | INCHES    |       |
|-----|-------------|------|-----------|-------|
|     | MIN         | MAX  | MIN       | MAX   |
| A   | 4.90        | 5.10 | 0.193     | 0.200 |
| B   | 4.30        | 4.50 | 0.169     | 0.177 |
| C   | ---         | 1.20 | ---       | 0.047 |
| D   | 0.05        | 0.15 | 0.002     | 0.006 |
| F   | 0.50        | 0.75 | 0.020     | 0.030 |
| G   | 0.65 BSC    |      | 0.026 BSC |       |
| H   | 0.18        | 0.28 | 0.007     | 0.011 |
| J   | 0.09        | 0.20 | 0.004     | 0.008 |
| J1  | 0.09        | 0.16 | 0.004     | 0.006 |
| K   | 0.19        | 0.30 | 0.007     | 0.012 |
| K1  | 0.19        | 0.25 | 0.007     | 0.010 |
| L   | 6.40 BSC    |      | 0.252 BSC |       |
| M   | 0°          | 8°   | 0°        | 8°    |

## SOLDERING FOOTPRINT



## GENERIC MARKING DIAGRAM\*



XXXX = Specific Device Code  
A = Assembly Location  
L = Wafer Lot  
Y = Year  
W = Work Week  
G or ■ = Pb-Free Package

\*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.

|                  |             |                                                                                                                                                                                  |
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