

# NB7VPQ7021M

## Product Preview

# 1.8 V USB 3.1 Dual Channel Linear Redriver

### Description

The NB7VPQ7021M is a 1.8 V dual channel linear redriver for USB 3.1 Gen 1 and Gen 2 applications that supports both 5 Gbps and 10 Gbps data rates. Signal integrity degrades from PCB traces, transmission cables, and inter-symbol interference (ISI). The NB7VPQ7021M compensates for these losses by engaging varying levels of equalization at the input receiver, and flat gain amplification on the output transmitter.

After power up, the NB7VPQ7021M periodically checks both of the TX output pairs for a receiver connection. When the receiver is detected on both channels the RX termination becomes enabled and the NB7VPQ7021M is set to perform the redriver function.

The NB7VPQ7021M comes in a small 3 x 3 mm UQFN16 package and is specified to operate across the entire industrial temperature range, -40°C to 85°C.

### Features

- 1.8 V ± 0.1 V Power Supply
- Device Supports USB 3.1 Gen 1 and USB 3.1 Gen 2 Data Rates
- Automatic Receiver Termination Detection
- Integrated Input and Output Termination
- Selectable Equalization and FlatGain
- Hot-Plug Capable
- ESD Protection ±4 kV HBM
- Operating Temperature Range: -40°C to 85°C
- Small 3 x 3 x 0.5 mm UQFN16 Package
- This is a Pb-Free Device

### Typical Applications

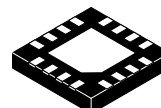
- USB3.1 Type-C Signal Routing
- Mobile Phone and Tablet
- Computer and Laptop
- Docking Station and Dongle
- Active Cable, Back Planes
- Gaming Console, Smart T.V.

This document contains information on a product under development. ON Semiconductor reserves the right to change or discontinue this product without notice.



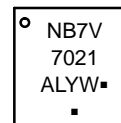
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UQFN16  
CASE 523AF

### MARKING DIAGRAM



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

(Note: Microdot may be in either location)

### ORDERING INFORMATION

| Device           | Package             | Shipping†             |
|------------------|---------------------|-----------------------|
| NB7VPQ7021MMUTXG | UQFN16<br>(Pb-Free) | 3000 /<br>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.

# NB7VPQ7021M

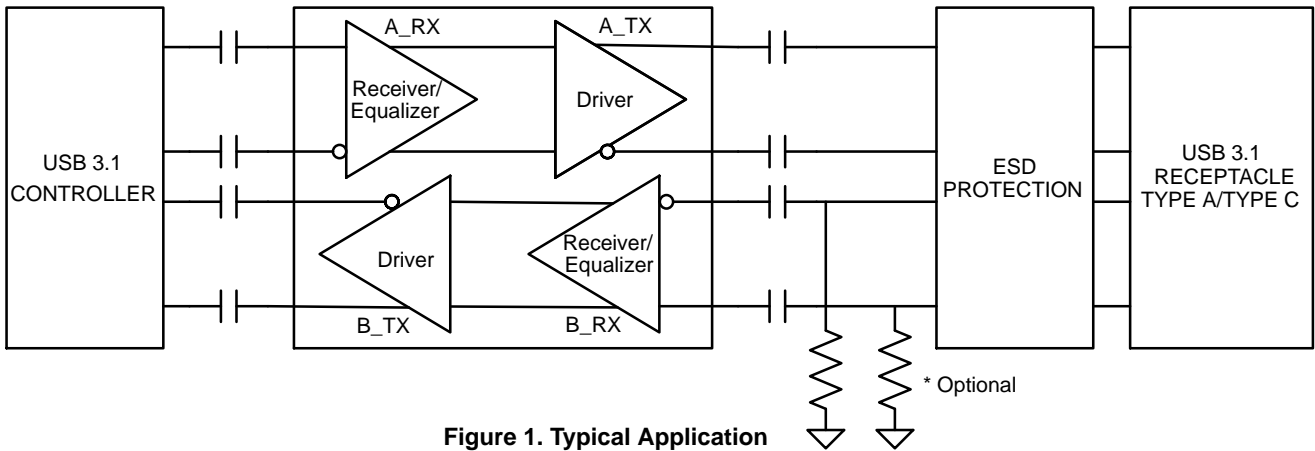


Figure 1. Typical Application

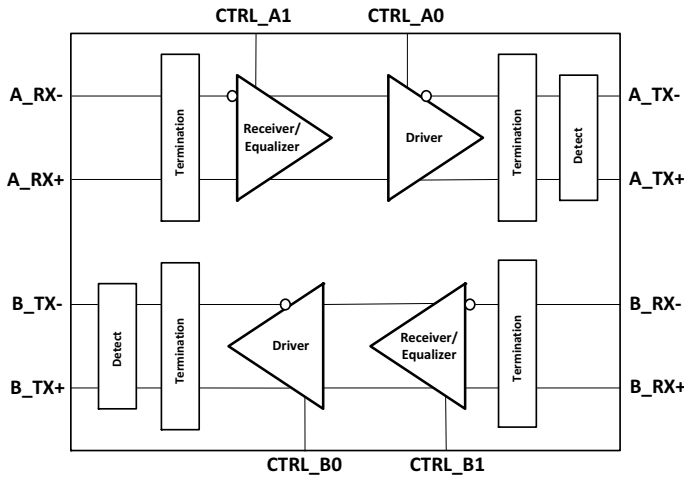


Figure 2. Logic Diagram of NB7VPQ7021M

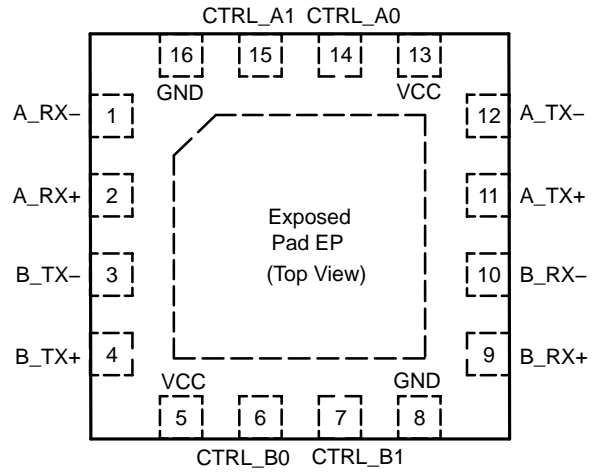


Figure 3. UQFN Package Pin out

Table 1. PIN DESCRIPTION

| Pin Number | Pin Name | Type      | Description  |
|------------|----------|-----------|--|
| 1          | A_RX-    | DIFF IN   | Channel A Differential input pair for 5 / 10 Gbps USB signals. Must be externally AC-coupled.  |
| 2          | A_RX+    |           |  |
| 3          | B_TX-    | DIFF OUT  | Channel B Differential output for 5 / 10 Gbps USB signals. Must be externally AC-coupled.  |
| 4          | B_TX+    |           |  |
| 5, 13      | VCC      | Power     | 1.8 V power supply. VCC pins must be externally connected to power supply to guarantee proper operation.   |
| 6          | CTRL_B0  | LVCMOS IN | Control pin "B0 and B1" for equalization and flat gain on Channel B. 4-state input with integrated pull-up and pull-down resistors.  |
| 7          | CTRL_B1  |           |  |
| 8, 16      | GND      | GND       | Reference Ground. GND pins must be externally connected to power supply to guarantee proper operation.   |
| 9          | B_RX+    | DIFF IN   | Channel B Differential input pair for 5 / 10 Gbps USB signals. Must be externally AC-coupled.  |
| 10         | B_RX-    |           |  |
| 11         | A_TX+    | DIFF OUT  | Channel A Differential output for 5 / 10 Gbps USB signals. Must be externally AC-coupled.  |
| 12         | A_TX-    |           |  |
| 14         | CTRL_A0  | LVCMOS IN | Control pin "A0 and A1" for equalization and flat gain on Channel A. 4-state input with integrated pull-up and pull-down resistors.  |
| 15         | CTRL_A1  |           |  |
| EP         | GND      | GND       | 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 electrically connected to the GND. It is recommended to be soldered to GND on the PC Board. |

# NB7VPQ7021M

## DEVICE CONFIGURATION

**Table 2. CONTROL PIN EFFECTS** (Typical Values)

| Settings | CHANNEL A |         | EQ    | FG      | CHANNEL B |         |
|----------|-----------|---------|-------|---------|-----------|---------|
|          | CTRL_A0   | CTRL_A1 |       |         | CTRL_B1   | CTRL_B0 |
| 1        | L         | L       | 3 dB  | -1.5 dB | L         | L       |
| 2        |           | R       | 6 dB  | -1.5 dB | R         |         |
| 3        |           | F       | 9 dB  | -1.5 dB | F         |         |
| 4        |           | H       | 12 dB | -1.5 dB | H         |         |
| 5        | R         | L       | 15 dB | -1.5 dB | L         | R       |
| 6        |           | R       | 6 dB  | 0 dB    | R         |         |
| 7        |           | F       | 9 dB  | 0 dB    | F         |         |
| 8        |           | H       | 12 dB | 0 dB    | H         |         |
| 9        | F         | L       | 15 dB | 0 dB    | L         | F       |
| 10       |           | R       | 18 dB | 0 dB    | R         |         |
| 11       |           | F       | 3 dB  | 0 dB    | F         |         |
| 12       |           | H       | 3 dB  | +1.5 dB | H         |         |
| 13       | H         | L       | 6 dB  | +1.5 dB | L         | H       |
| 14       |           | R       | 9 dB  | +1.5 dB | R         |         |
| 15       |           | F       | 12 dB | +1.5 dB | F         |         |
| 16       |           | H       | 15 dB | +1.5 dB | H         |         |

NOTE: L = Low, R = Ext Resistor, F = Float, H = High. Default – All Control Pins Float

**Table 3. ATTRIBUTES**

| Parameter  |                        |  |
|--|------------------------|--|
| ESD Protection   | Human Body Model       | Human Body Model<br>Charged Device Model |
|  |                        | > 4 kV<br>> 1.5 kV                       |
| Moisture Sensitivity, Indefinite Time Out of Dry pack (Note 1) |                        | Level 1                                  |
| Flammability Rating  | Oxygen Index: 28 to 34 | UL 94 V-O @ 0.125 in                     |
| Meets or exceeds JEDEC Spec EIA/JESD78 IC Latchup Test         |                        |  |

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

**Table 4. ABSOLUTE MAXIMUM RATINGS** Over operating free-air temperature range (unless otherwise noted)

| Parameter  | Description      | Min  | Max                   | Unit |
|--|------------------|------|-----------------------|------|
| Supply Voltage (Note 2)  | V <sub>CC</sub>  | -0.5 | +2.5                  | V    |
| Voltage range at any input or output terminal                              | Differential I/O | -0.5 | 1.89                  | V    |
|  | LVC MOS inputs   | -0.3 | V <sub>CC</sub> + 0.3 | V    |
| Storage Temperature Range, T <sub>SG</sub>                                 |                  | -65  | 150                   | °C   |
| Maximum Junction Temperature, T <sub>J</sub>                               |                  |      | 125                   | °C   |
| Operating Ambient Temperature Range, T <sub>A</sub>                        |                  | -40  | 85                    | °C   |
| Junction-to-Ambient Thermal Resistance @ 500 lfm, 8J <sub>A</sub> (Note 3) |                  |      | 34                    | °C/W |
| Wave Solder, Pb-Free, T <sub>SOL</sub>                                     |                  |      | 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.

2. All voltage values are with respect to the GND terminals.

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

# NB7VPQ7021M

**Table 5. RECOMMENDED OPERATING CONDITIONS** Over operating free-air temperature range (unless otherwise noted)

| Parameter       | Description                    | Min  | Nom  | Max  | Unit |
|-----------------|--------------------------------|------|------|------|------|
| V <sub>CC</sub> | Main power supply              | 1.70 | 1.80 | 1.90 | V    |
| T <sub>A</sub>  | Operating free-air temperature | -40  |      | +85  | °C   |
| C <sub>AC</sub> | External AC Coupling Capacitor | 75   | 100  | 265  | nF   |

Functional operation above the stresses listed in the Recommended Operating Ranges is not implied. Extended exposure to stresses beyond the Recommended Operating Ranges limits may affect device reliability.

**Table 6. POWER SUPPLY CHARACTERISTICS**

| Parameter       | Test Conditions   | Min  | Typ (Note 4) | Max | Unit |
|-----------------|-------------------|--|--------------|-----|------|
| I <sub>CC</sub> | Active            | Link in U0 with Super Speed Plus data transmission | 140          |     | mA   |
|                 | U2/U3             | Link in U2 or U3 power saving state                | 2.5          |     | mA   |
|                 | No USB Connection | No connection state, termination disabled          |              | 500 | μA   |

4. TYP values use V<sub>CC</sub> = 1.8 V, T<sub>A</sub> = 25°C.

**Table 7. LVCMOS CONTROL PIN CHARACTERISTICS** 4-State LVCMOS Inputs (CTRL\_A0, CTRL\_A1, CTRL\_B0, CTRL\_B1)

| Parameter        | Test Conditions                         | Min  | Typ                  | Max | Unit |
|------------------|---|--|----------------------|-----|------|
| V <sub>IL</sub>  | DC Input Setting "L"                    | Input pin connected to GND                               | GND                  |     | V    |
| V <sub>IR</sub>  | DC Input Setting "R"                    | A specified resistor must be applied between pin and GND | 0.33*V <sub>CC</sub> |     | V    |
| V <sub>IF</sub>  | DC Input Setting "F"                    | Input pin is left floating                               | 0.66*V <sub>CC</sub> |     | V    |
| V <sub>IH</sub>  | DC Input Setting "H"                    | Input pin connected to V <sub>CC</sub>                   | V <sub>CC</sub>      |     | V    |
| R <sub>PU</sub>  | Internal pull-up resistance             |  | 100                  |     | KΩ   |
| R <sub>PD</sub>  | Internal pull-down resistance           |  | 200                  |     | KΩ   |
| I <sub>IH</sub>  | High-level input current                | V <sub>IN</sub> = 1.9 V                                  |                      | +20 | μA   |
| I <sub>IL</sub>  | Low-level input current                 | V <sub>IN</sub> = GND, V <sub>CC</sub> = 1.9 V           | -20                  |     | μA   |
| R <sub>ext</sub> | External Resistor for input setting "R" |  | 68                   |     | KΩ   |

5. Floating refers to a pin left in an open state, with no external connections

**Table 8. RECEIVER AC/DC CHARACTERISTICS** Over operating free-air temperature range (unless otherwise noted)

| Parameter                | Test Conditions  | Min   | Typ             | Max  | Unit             |                  |
|--------------------------|--|---|-----------------|------|------------------|------------------|
| V <sub>RX-DIFF-pp</sub>  | Input differential voltage swing                           | AC-coupled, peak-to-peak  | 100             | 1200 | mV <sub>PP</sub> |                  |
| V <sub>RX-CM</sub>       | Common-mode voltage bias in the receiver (DC)              |   | V <sub>CC</sub> |      | V                |                  |
| Z <sub>RX-DIFF</sub>     | Differential input impedance (DC)                          | Present after an USB device is detected on TX+/TX-                  | 80              | 100  | 120              | Ω                |
| Z <sub>RX-CM</sub>       | Common-mode input impedance (DC)                           | Present after an USB device is detected on TX+/TX-                  | 20              | 25   | 30               | Ω                |
| Z <sub>RX-HIGH-IMP</sub> | Common-mode input impedance with termination disabled (DC) | Present when no USB device is detected on TX+                       | 25              | 190  |                  | kΩ               |
| V <sub>TH-LFPS-pp</sub>  | Low Frequency Periodic Signaling (LFPS) Detect Threshold   | Output voltage is considered squelched below this threshold voltage | 100             | 200  | 300              | mV <sub>PP</sub> |

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.

# NB7VPQ7021M

**Table 9. TRANSMITTER AC/DC CHARACTERISTICS** Over operating free-air temperature range (unless otherwise noted)

| Parameter                     |  | Test Conditions   | Min | Typ              | Max      | Unit              |
|-------------------------------|--|---|-----|------------------|----------|-------------------|
| $V_{sw\_100M}$                | -1 dB compression point Output swing at 100 MHz          |   |     | 1200             |          | mV <sub>PPd</sub> |
| $V_{sw\_5G}$                  | -1 dB compression point Output swing at 5 GHz            |   |     | 900              |          | mV <sub>PPd</sub> |
| $C_{TX}$                      | TX input capacitance to GND                              | At 2.5 GHz  |     | 1.25             |          | pF                |
| $Z_{TX-DIFF}$                 | Differential output impedance (DC)                       | Present after an USB device is detected on TX+/TX-                    | 80  | 100              | 120      | $\Omega$          |
| $Z_{TX-CM}$                   | Common-mode output impedance (DC)                        | Present after an USB device is detected on TX+/TX-                    | 20  |                  | 30       | $\Omega$          |
| $I_{TX-SC}$                   | TX short circuit current                                 | TX+ or TX- shorted to GND   |     | 60               |          | mA                |
| $V_{TX-CM}$                   | Common-mode voltage bias in the transmitter (DC)         |   |     | $V_{CC} - 0.675$ | $V_{CC}$ | V                 |
| $V_{TX-CM-ACpp}$              | AC common-mode peak-to-peak voltage swing in active mode | Within U0 and within LFPS   |     |                  | 100      | mV <sub>PP</sub>  |
| $V_{TX-IDLE-DIFF-ACpp}$       | Differential voltage swing during electrical idle        | Tested with a high-pass filter  | 0   |                  | 10       | mV <sub>PP</sub>  |
| $V_{TX-RXDET}$                | Voltage change to allow receiver detect                  | Positive voltage to sense receiver termination                        |     |                  | 600      | mV                |
| $t_R, t_F$                    | Output rise, fall time                                   | 20% – 80% of differential voltage measured 1 inch from the output pin |     | 40               |          | ps                |
| $t_{RF-MM}$                   | Output rise, Fall time mismatch                          | 20% – 80% of differential voltage measured 1 inch from the output pin |     |                  | 5        | ps                |
| $t_{diff-LH}, t_{diff-HL}$    | Differential propagation delay                           | Propagation delay between 50% level at input and output               |     | 150              |          | ps                |
| $t_{idleEntry}, t_{idleExit}$ | Idle entry and exit times                                |   |     | 10               |          | ns                |

**Table 10. TIMING AND JITTER CHARACTERISTICS**

| Parameter |  | Test Conditions | Min | Typ | Max | Unit |
|-----------|--|-----------------|-----|-----|-----|------|
|-----------|--|-----------------|-----|-----|-----|------|

**TIMING**

|             |   |   |  |     |  |    |
|-------------|---|---|--|-----|--|----|
| $t_{READY}$ | Time from power applied until RX termination is enabled | Apply 0 V to $V_{CC}$ , connect USB termination to TX+, apply 1.8 V to $V_{CC}$ , and measure when $Z_{RX-DIFF}$ is enabled |  | 110 |  | ms |
|-------------|---|---|--|-----|--|----|

**JITTER FOR 5 Gbps**

|               |                               |                     |  |      |  |             |
|---------------|-------------------------------|---------------------|--|------|--|-------------|
| $T_{JTX-EYE}$ | Total jitter (Notes 6, 7)     | CTRL Pins are float |  | 0.5  |  | UI (Note 8) |
| $D_{JTX}$     | Deterministic jitter (Note 7) |                     |  | 0.25 |  | UI          |
| $R_{JTX}$     | Random jitter (Note 7)        |                     |  | 0.1  |  | UI          |

**JITTER FOR 10 Gbps**

|               |                               |                     |  |      |  |             |
|---------------|-------------------------------|---------------------|--|------|--|-------------|
| $T_{JTX-EYE}$ | Total jitter (Notes 6, 7)     | CTRL Pins are float |  | 0.5  |  | UI (Note 8) |
| $D_{JTX}$     | Deterministic jitter (Note 7) |                     |  | 0.25 |  | UI          |
| $R_{JTX}$     | Random jitter (Note 7)        |                     |  | 0.1  |  | UI          |

6. Includes RJ at  $10^{-12}$ .

7. Measured at the ends of reference channel with a K28.5 pattern, VID = 1000 mVpp.

8. 5 Gbps, UI = 200 ps for 10 Gbps, UI = 100 ps

PARAMETER MEASUREMENT DIAGRAMS

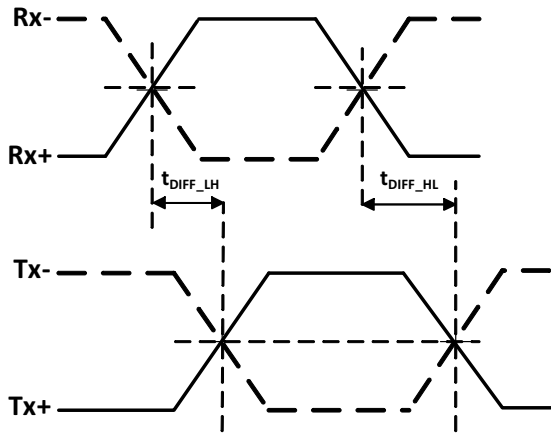


Figure 4. Propagation Delay

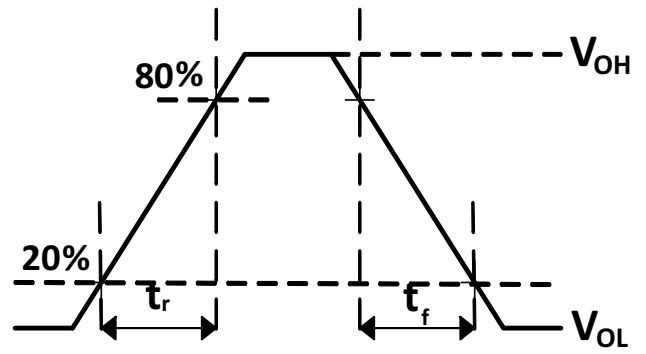
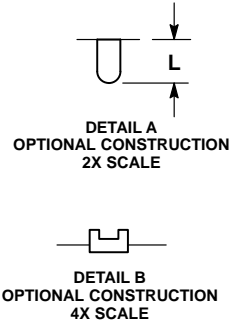
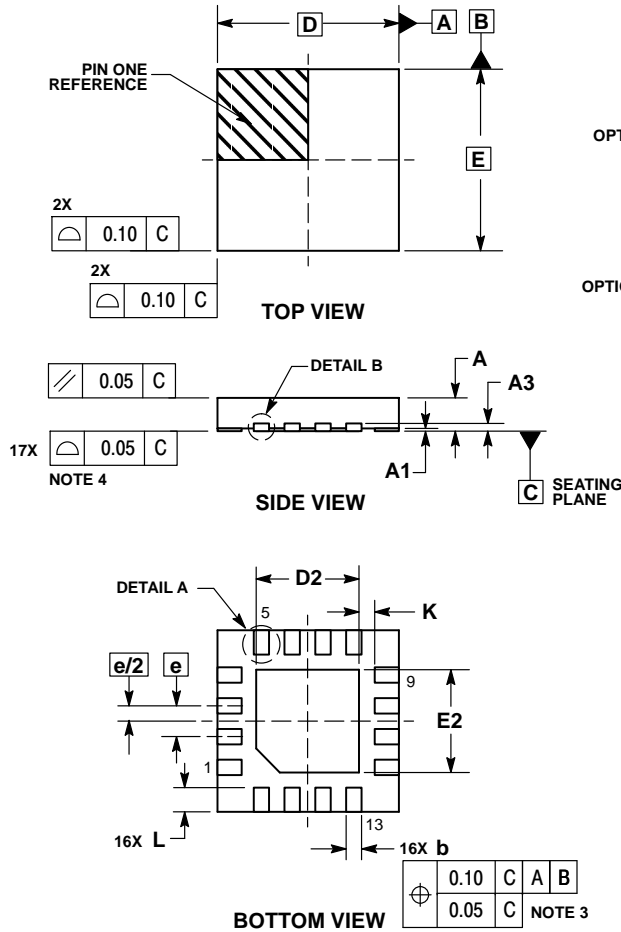


Figure 5. Output Rise and Fall Times

# NB7VPQ7021M

## PACKAGE DIMENSIONS

UQFN16 3x3, 0.5P  
CASE 523AF  
ISSUE B

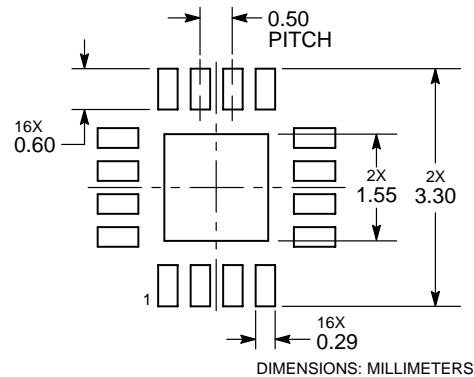


**NOTES:**

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 TERMINAL TIP.
4. COPLANARITY APPLIES TO THE EXPOSED PAD AS WELL AS THE TERMINALS.

| DIM | MILLIMETERS |      |
|-----|-------------|------|
|     | MIN         | MAX  |
| A   | 0.45        | 0.55 |
| A1  | 0.00        | 0.05 |
| A3  | 0.127 REF   |      |
| b   | 0.20        | 0.30 |
| D   | 3.00 BSC    |      |
| D2  | 1.60        | 1.80 |
| E   | 3.00 BSC    |      |
| E2  | 1.60        | 1.80 |
| e   | 0.50 BSC    |      |
| K   | 0.20        | —    |
| L   | 0.30        | 0.50 |

**SOLDERING FOOTPRINT\***



\*For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERM/D.

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