

## General Description

The 8S89202 is a high speed 1-to-8 Differential-to-LVPECL Clock Divider and is part of the high performance clock solutions from IDT. The 8S89202 is optimized for high speed and very low output skew, making it suitable for use in demanding applications such as SONET, 1 Gigabit and 10 Gigabit Ethernet, and Fibre Channel. The internally terminated differential inputs and  $V_{REF\_AC}$  pins allow other differential signal families such as LVPECL, LVDS and CML to be easily interfaced to the input with minimal use of external components.

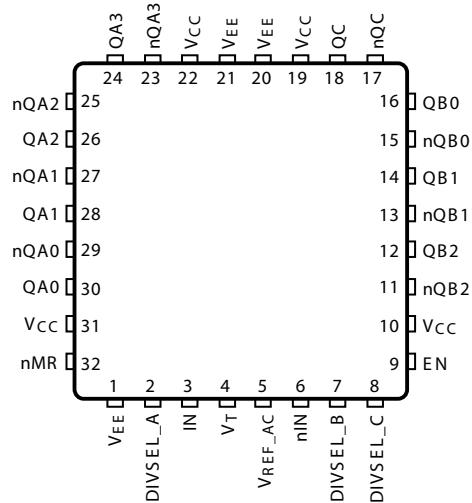
The device also has a selectable  $\div 1$ ,  $\div 2$ ,  $\div 4$  output divider, which can allow the part to support multiple output frequencies from the same reference clock.

The 8S89202 is packaged in a small 5mm x 5mm 32-pin VFQFN package which makes it ideal for use in space-constrained applications.

## Features

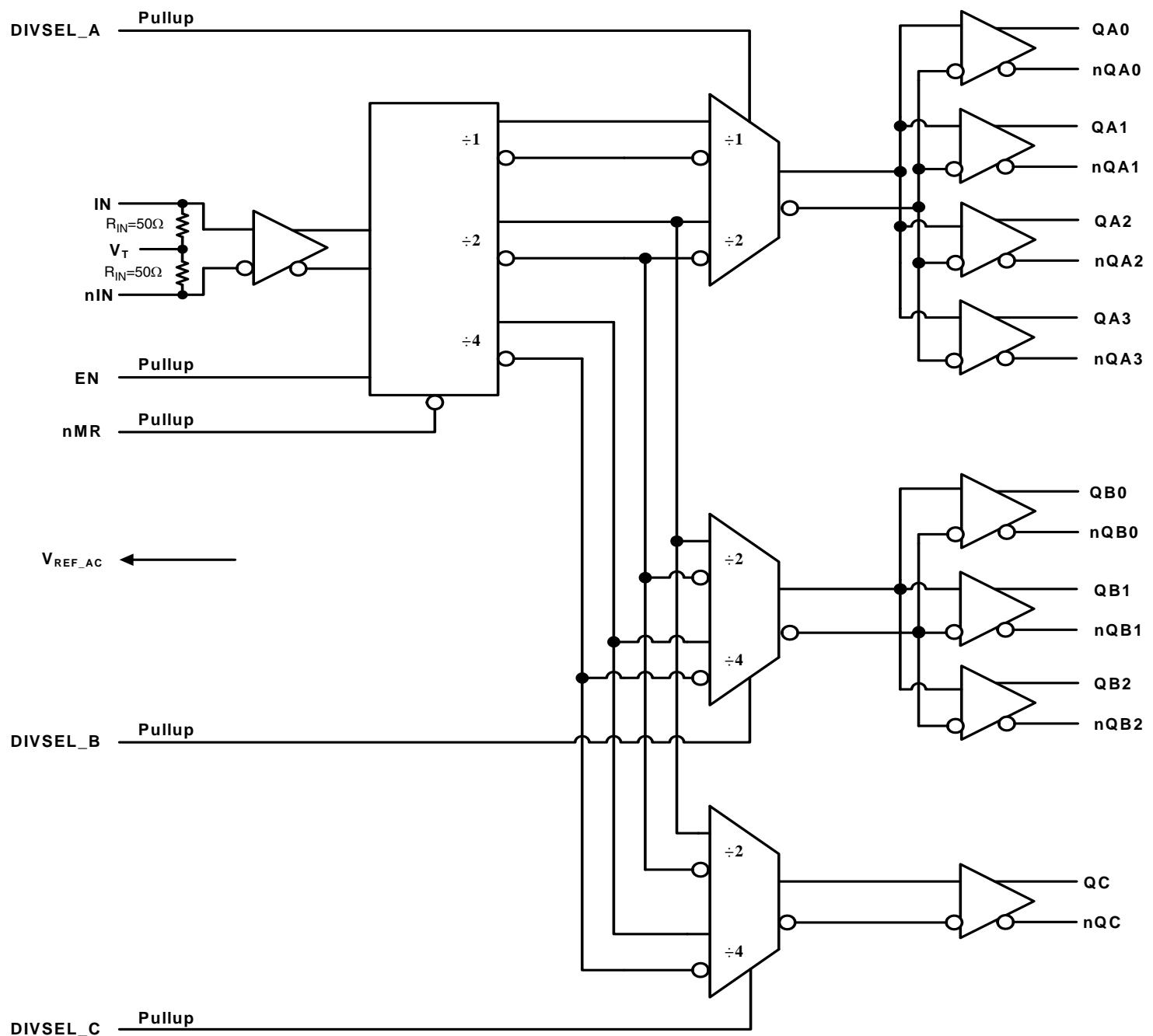
- Three output banks, consisting of eight LVPECL output pairs total
- IN<sub>x</sub>, nIN<sub>x</sub> inputs can accept the following differential input levels: LVPECL, LVDS, CML
- Selectable output divider values of  $\div 1$ ,  $\div 2$  and  $\div 4$
- Maximum output frequency: 1.5GHz
- Maximum input frequency: 3GHz
- Bank skew: 6ps (typical)
- Part-to-part skew: 250ps (maximum)
- Additive phase jitter, RMS: 0.166ps (typical)
- Propagation delay: 854ps (typical)
- Output rise time: 156ps (typical)
- Full 2.5V $\pm$ 5% and 3.3V $\pm$ 10% operating supply voltage
- -40°C to 85°C ambient operating temperature
- Available in lead-free (RoHS 6) package

## Pin Assignment



**8S89202**  
**32-Lead VFQFN**  
**5mm x 5mm x 0.925mm package body**  
**K Package**  
**Top View**

## Block Diagram



**Table 1. Pin Descriptions**

| Number         | Name          | Type   |        | Description  |
|----------------|---------------|--------|--------|--|
| 1, 20, 21      | $V_{EE}$      | Power  |        | Negative supply pins.  |
| 2              | DIVSEL_A      | Input  | Pullup | Output divider select pin. Controls output divider settings for Bank A. See Table 3 for additional information. LVCMOS/LVTTL interface levels. |
| 3              | IN            | Input  |        | Non-inverting differential LVPECL clock input. $R_{IN} = 50\Omega$ termination to $V_T$ .  |
| 4              | $V_T$         | Input  |        | Termination center-tap input.  |
| 5              | $V_{REF\_AC}$ | Output |        | Reference voltage for AC-coupled applications.   |
| 6              | nIN           | Input  |        | Inverting differential LVPECL clock input. $R_{IN} = 50\Omega$ termination to $V_T$ .  |
| 7              | DIVSEL_B      | Input  | Pullup | Output divider select pin. Controls output divider settings for Bank B. See Table 3 for additional information. LVCMOS/LVTTL interface levels. |
| 8              | DIVSEL_C      | Input  | Pullup | Output divider select pin. Controls output divider settings for Bank C. See Table 3 for additional information. LVCMOS/LVTTL interface levels. |
| 9              | EN            | Input  | Pullup | Output enable pin. See Table 3 for additional information. LVCMOS/LVTTL interface levels.  |
| 10, 19, 22, 31 | $V_{CC}$      | Power  |        | Positive supply pins.  |
| 11, 12         | nQB2, QB2     | Output |        | Differential output pair. LVPECL interface levels.   |
| 13, 14         | nQB1, QB1     | Output |        | Differential output pair. LVPECL interface levels.   |
| 15, 16         | nQB0, QB0     | Output |        | Differential output pair. LVPECL interface levels.   |
| 17, 18         | nQC, QC       | Output |        | Differential output pair. LVPECL interface levels.   |
| 23, 24         | nQA3, QA3     | Output |        | Differential output pair. LVPECL interface levels.   |
| 25, 26         | nQA2, QA2     | Output |        | Differential output pair. LVPECL interface levels.   |
| 27, 28         | nQA1, QA1     | Output |        | Differential output pair. LVPECL interface levels.   |
| 29, 30         | nQA0, QA0     | Output |        | Differential output pair. LVPECL interface levels.   |
| 32             | nMR           | Input  | Pullup | Master Reset. See additional 3 for additional information. LVCMOS/LVTTL interface levels.  |

NOTE: *Pullup* refers to internal input resistor. See Table 2, *Pin Characteristics*, for typical values.

**Table 2. Pin Characteristics**

| Symbol       | Parameter             | Test Conditions | Minimum | Typical | Maximum | Units      |
|--------------|-----------------------|-----------------|---------|---------|---------|------------|
| $C_{IN}$     | Input Capacitance     |                 |         | 2       |         | pF         |
| $R_{PULLUP}$ | Input Pullup Resistor |                 |         | 25      |         | k $\Omega$ |

## Function Tables

Table 3. SEL Function Table

| nMR | EN  | DIVSEL_A | DIVSEL_B | DIVSEL_C | Output Bank A | Output Bank B | Output Bank C |
|-----|-----|----------|----------|----------|---------------|---------------|---------------|
| 0   | n/a | n/a      | n/a      | n/a      | 0             | 0             | 0             |
| 1   | 0   | n/a      | n/a      | n/a      | 0             | 0             | 0             |
| 1   | 1   | 0        | 0        | 0        | $\div 1$      | $\div 2$      | $\div 2$      |
| 1   | 1   | 1        | 1        | 1        | $\div 2$      | $\div 4$      | $\div 4$      |

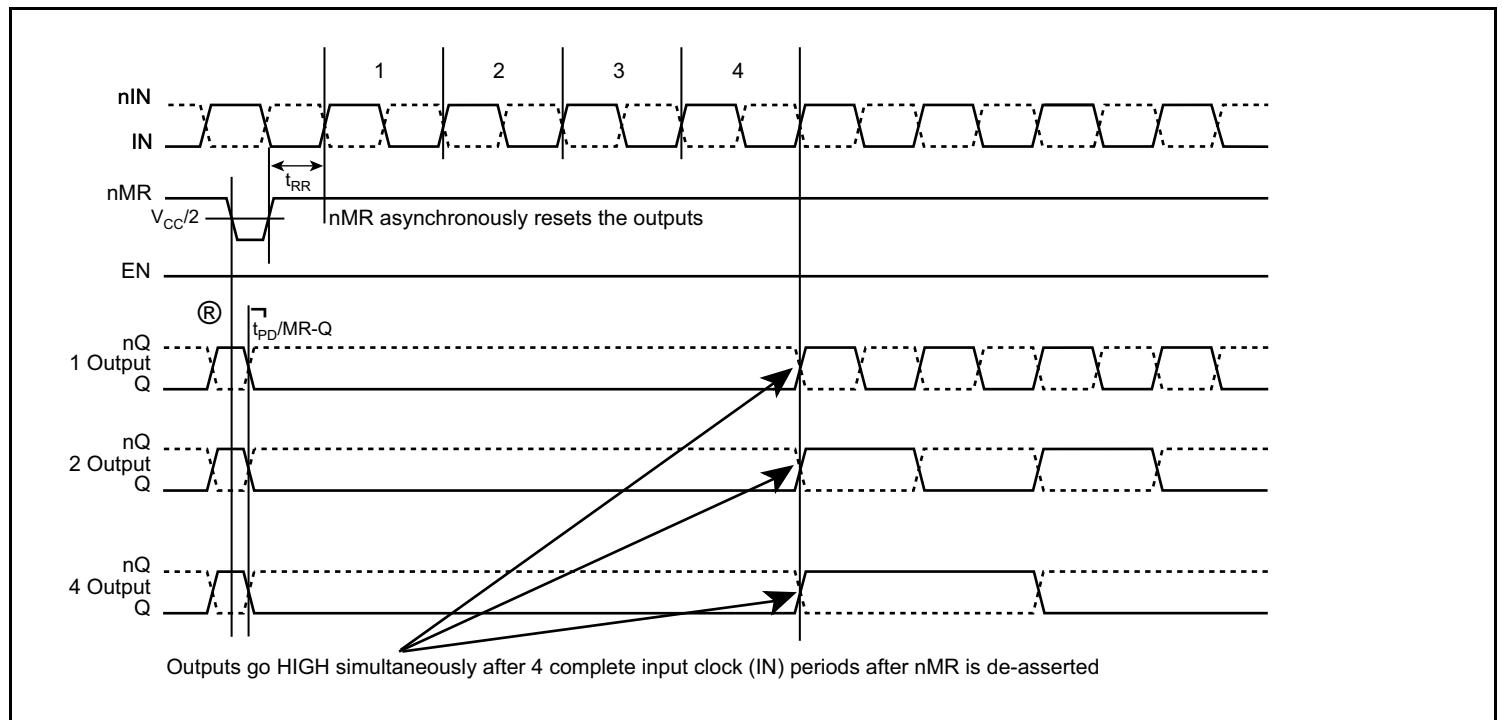


Figure 1A. Reset with Output Enabled

Figure 1B. Enabled Timing

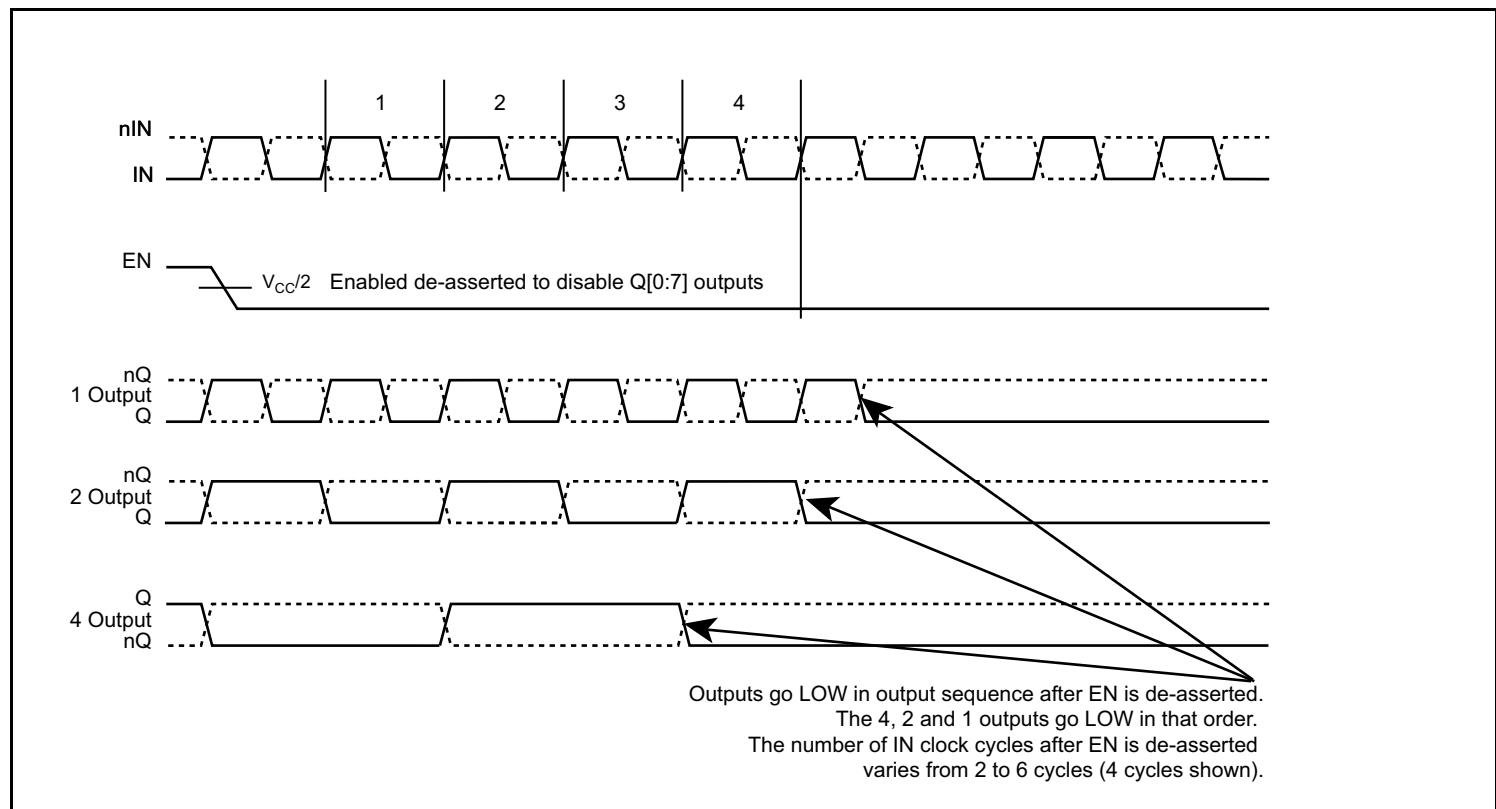
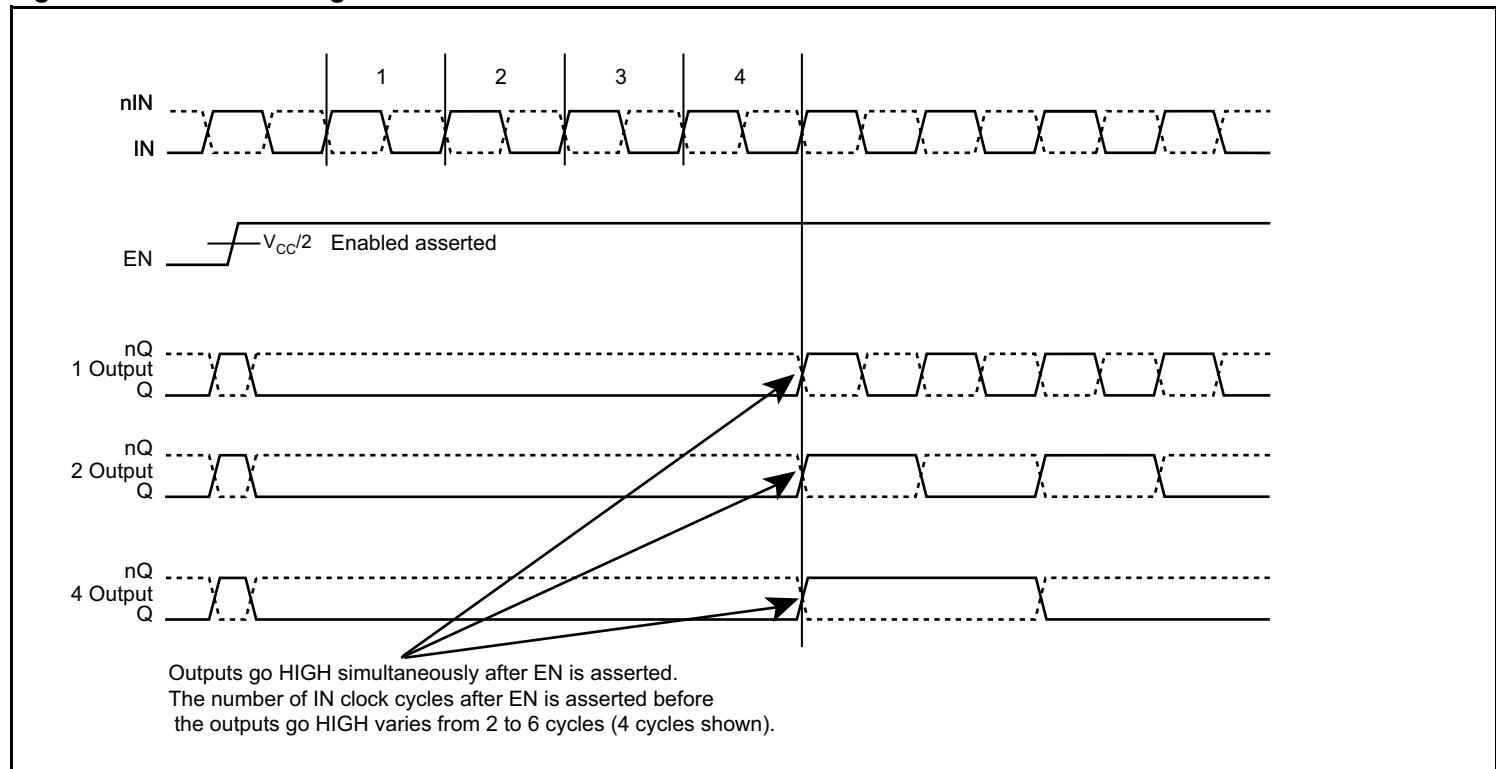


Figure 1C. Disabled Timing

## Absolute Maximum Ratings

NOTE: Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These ratings are stress specifications only. Functional operation of product at these conditions or any conditions beyond those listed in the *DC Characteristics* or *AC Characteristics* is not implied. Exposure to absolute maximum rating conditions for extended periods may affect product reliability.

| Item  | Rating                   |
|---|--------------------------|
| Supply Voltage, $V_{CC}$                              | 4.6V                     |
| Inputs, $V_I$   | -0.5V to $V_{CC} + 0.5V$ |
| Outputs, $I_O$<br>Continuous Current<br>Surge Current | 50mA<br>100mA            |
| Input Current, $I_{IN}$ , $nIN$                       | $\pm 50mA$               |
| $V_T$ Current, $I_{VT}$                               | $\pm 100mA$              |
| Input Sink/Source, $I_{REF\_AC}$                      | $\pm 2mA$                |
| Package Thermal Impedance, $\theta_{JA}$              | 42.7°C/W (0 mps)         |
| Storage Temperature, $T_{STG}$                        | -65°C to 150°C           |

## DC Electrical Characteristics

**Table 4A. Power Supply DC Characteristics,  $V_{CC} = 2.5V \pm 5\%$ ,  $V_{EE} = 0V$ ,  $T_A = -40^\circ C$  to  $85^\circ C$**

| Symbol   | Parameter               | Test Conditions | Minimum | Typical | Maximum | Units |
|----------|-------------------------|-----------------|---------|---------|---------|-------|
| $V_{CC}$ | Positive Supply Voltage |                 | 2.375   | 2.5     | 2.625   | V     |
| $I_{EE}$ | Power Supply Current    |                 |         | 117     | 131     | mA    |

**Table 4B. Power Supply DC Characteristics,  $V_{CC} = 3.3V \pm 10\%$ ,  $V_{EE} = 0V$ ,  $T_A = -40^\circ C$  to  $85^\circ C$**

| Symbol   | Parameter               | Test Conditions | Minimum | Typical | Maximum | Units |
|----------|-------------------------|-----------------|---------|---------|---------|-------|
| $V_{CC}$ | Positive Supply Voltage |                 | 2.97    | 3.3     | 3.63    | V     |
| $I_{EE}$ | Power Supply Current    |                 |         | 125     | 139     | mA    |

**Table 4C. LVCMOS/LVTTL DC Characteristics,  $V_{CC} = 3.3V \pm 10\%$  or  $2.5V \pm 5\%$ ,  $V_{EE} = 0V$ ,  $T_A = -40^\circ C$  to  $85^\circ C$**

| Symbol   | Parameter          | Test Conditions                              | Minimum | Typical | Maximum        | Units   |
|----------|--------------------|--|---------|---------|----------------|---------|
| $V_{IH}$ | Input High Voltage | $V_{CC} = 3.3V$                              | 2.2     |         | $V_{CC} + 0.3$ | V       |
|          |                    | $V_{CC} = 2.5V$                              | 1.7     |         | $V_{CC} + 0.3$ | V       |
| $V_{IL}$ | Input Low Voltage  | $V_{CC} = 3.3V$                              | -0.3    |         | 0.8            | V       |
|          |                    | $V_{CC} = 2.5V$                              | -0.3    |         | 0.7            | V       |
| $I_{IH}$ | Input High Current | $V_{CC} = V_{IN} = 3.63V$ or $2.625V$        | -125    |         | 20             | $\mu A$ |
| $I_{IL}$ | Input Low Current  | $V_{CC} = 3.63V$ or $2.625V$ , $V_{IN} = 0V$ |         |         | -300           | $\mu A$ |

**Table 4D. Differential DC Characteristics,  $V_{CC} = 3.3V \pm 10\%$  or  $2.5V \pm 5\%$ ,  $V_{EE} = 0V$ ,  $T_A = -40^\circ C$  to  $85^\circ C$** 

| Symbol         | Parameter                        | Test Conditions | Minimum             | Typical        | Maximum        | Units           |
|----------------|----------------------------------|-----------------|---------------------|----------------|----------------|-----------------|
| $R_{IN}$       | Input Resistance                 | IN, nIN         | IN to VT, nIN to VT |                | 50             | $\Omega$        |
| $V_{IH}$       | Input High Voltage               | IN, nIN         |                     | 0.15           |                | $V_{CC} + 0.3$  |
| $V_{IL}$       | Input Low Voltage                | IN, nIN         |                     | 0              |                | $V_{CC} - 0.15$ |
| $V_{IN}$       | Input Voltage Swing              |                 |                     | 0.15           |                | $V_{CC}$        |
| $V_{DIFF\_IN}$ | Differential Input Voltage Swing |                 |                     | 0.3            |                | $V$             |
| $V_{REF\_AC}$  | Bias Voltage                     |                 |                     | $V_{CC} - 1.7$ | $V_{CC} - 1.3$ | $V_{CC} - 0.9$  |

**Table 4E. LVPECL DC Characteristics,  $V_{CC} = 3.3V \pm 10\%$ ,  $V_{EE} = 0V$ ,  $T_A = -40^\circ C$  to  $85^\circ C$** 

| Symbol          | Parameter                         | Test Conditions | Minimum         | Typical        | Maximum        | Units |
|-----------------|-----------------------------------|-----------------|-----------------|----------------|----------------|-------|
| $V_{OH}$        | Output High Voltage; NOTE 1       |                 | $V_{CC} - 1.65$ | $V_{CC} - 1.0$ | $V_{CC} - 0.5$ | $V$   |
| $V_{OL}$        | Output Low Voltage; NOTE 1        |                 | $V_{CC} - 2.25$ | $V_{CC} - 1.8$ | $V_{CC} - 1.6$ | $V$   |
| $V_{OUT}$       | Output Voltage Swing              |                 | 0.7             | 0.8            | 1.1            | $V$   |
| $V_{DIFF\_OUT}$ | Differential Output Voltage Swing |                 | 1.4             | 1.6            | 2.2            | $V$   |

NOTE 1: Outputs terminated with  $50\Omega$  to  $V_{CC} - 2V$ .

**Table 4F. LVPECL DC Characteristics,  $V_{CC} = 2.5V \pm 5\%$ ,  $V_{EE} = 0V$ ,  $T_A = -40^\circ C$  to  $85^\circ C$** 

| Symbol          | Parameter                         | Test Conditions | Minimum         | Typical         | Maximum         | Units |
|-----------------|-----------------------------------|-----------------|-----------------|-----------------|-----------------|-------|
| $V_{OH}$        | Output High Voltage; NOTE 1       |                 | $V_{CC} - 1.35$ | $V_{CC} - 1.0$  | $V_{CC} - 0.70$ | $V$   |
| $V_{OL}$        | Output Low Voltage; NOTE 1        |                 | $V_{CC} - 2.00$ | $V_{CC} - 1.75$ | $V_{CC} - 1.50$ | $V$   |
| $V_{OUT}$       | Output Voltage Swing              |                 | 0.6             | 0.8             | 1.0             | $V$   |
| $V_{DIFF\_OUT}$ | Differential Output Voltage Swing |                 | 1.2             | 1.6             | 2.0             | $V$   |

NOTE 1: Outputs terminated with  $50\Omega$  to  $V_{CC} - 2V$ .

## AC Electrical Characteristics

**Table 5. AC Characteristics,  $V_{CC} = 3.3V \pm 10\%$  or  $2.5V \pm 5\%$ ,  $V_{EE} = 0V$ ,  $T_A = -40^\circ C$  to  $85^\circ C$**

| Symbol      | Parameter   | Test Conditions                              | Minimum | Typical | Maximum | Units |
|-------------|---|--|---------|---------|---------|-------|
| $f_{OUT}$   | Output Frequency  |  |         |         | 1.5     | GHz   |
| $f_{IN}$    | Input Frequency   |  |         |         | 3       | GHz   |
| $t_{PD}$    | Propagation Delay; NOTE 1   | IN to Qx                                     | 660     | 845     | 1020    | ps    |
|             |   | nMR to Qx                                    | 600     | 772     | 905     | ps    |
| $tsk(b)$    | Bank to Bank Skew; NOTE 2, 3  | Same divide setting                          |         | 6       | 26      | ps    |
| $tsk(w)$    | Bank to Bank Skew; NOTE 2, 3  | Different divide setting                     |         | 27      | 103     | ps    |
| $tsk(o)$    | Within-Bank Skew; NOTE 2, 4   | Within same fanout bank                      |         | 3       | 13      | ps    |
| $tsk(pp)$   | Part-to-Part Skew; NOTE 2, 5  |  |         |         | 250     | ps    |
| $j_{fit}$   | Buffer Additive Phase Jitter, RMS; refer to Additive Phase Jitter section | 156.25MHz, Integration Range: 12kHz to 20MHz |         | 0.166   | 0.193   | ps    |
| $t_R / t_F$ | Output Rise/Fall Time   | 20% to 80%                                   | 73      | 156     | 218     | ps    |

NOTE: Electrical parameters are guaranteed over the specified ambient operating temperature range, which is established when the device is mounted in a test socket with maintained transverse airflow greater than 500 lfpm. The device will meet specifications after thermal equilibrium has been reached under these conditions.

NOTE 1: Measured from the differential input crossing point to the differential output crossing point.

NOTE 2: This parameter is defined in accordance with JEDEC Standard 65.

NOTE 3: Defined as skew between outputs at the same supply voltage and with equal load conditions. Measured at the output differential cross points.

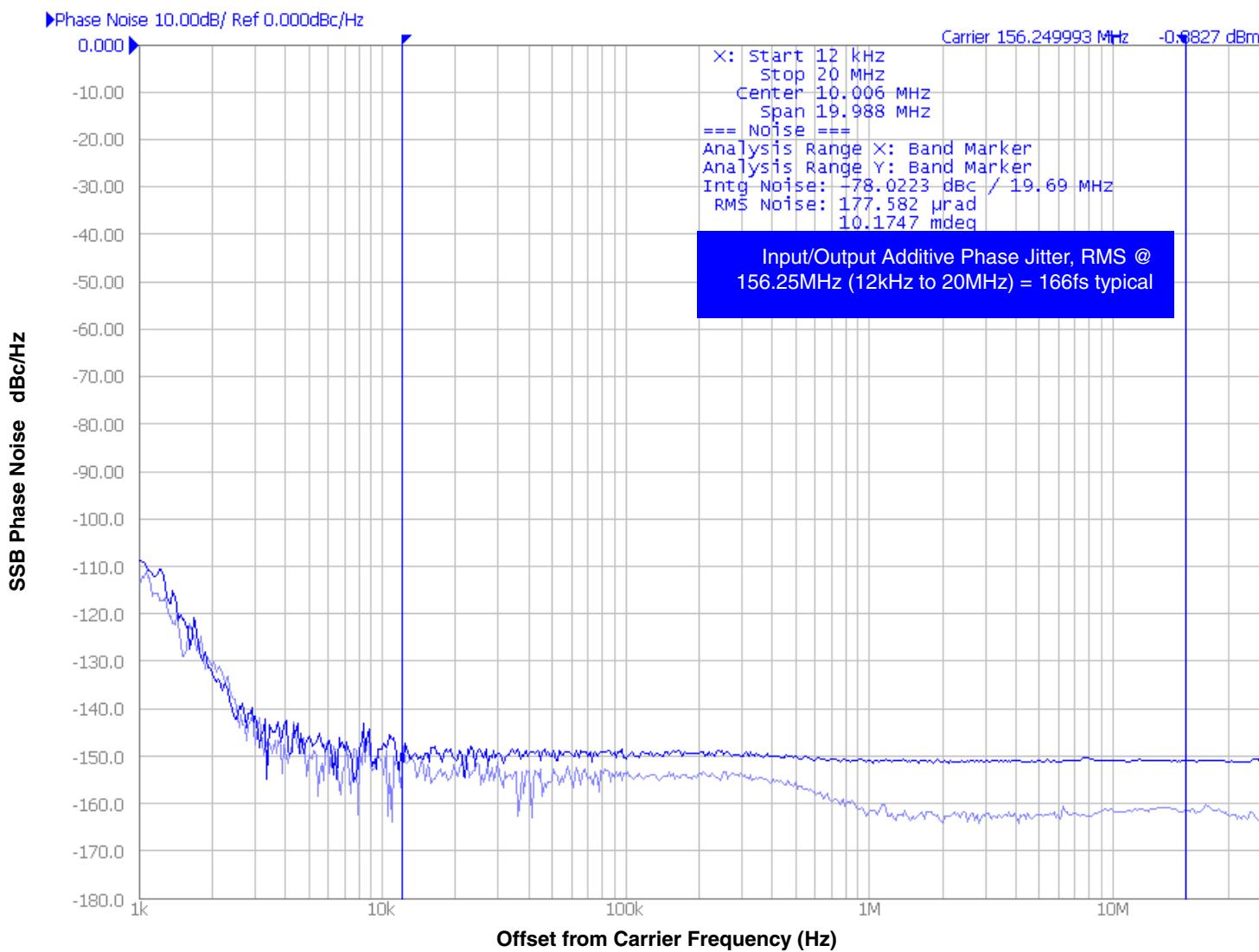
NOTE 4: Defined as skew within a bank of outputs at the same voltage and with equal load conditions.

NOTE 5: Defined as skew between outputs on different devices operating at the same supply voltage, same temperature, same frequency and with equal load conditions. Using the same type of inputs on each device, the outputs are measured at the differential cross points.

## Additive Phase Jitter

The spectral purity in a band at a specific offset from the fundamental compared to the power of the fundamental is called the **dBc Phase Noise**. This value is normally expressed using a Phase noise plot and is most often the specified plot in many applications. Phase noise is defined as the ratio of the noise power present in a 1Hz band at a specified offset from the fundamental frequency to the power value of the fundamental. This ratio is expressed in decibels (dBm) or a ratio

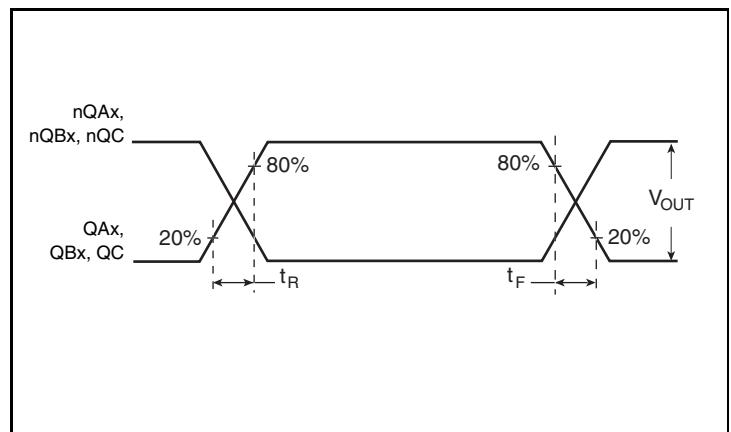
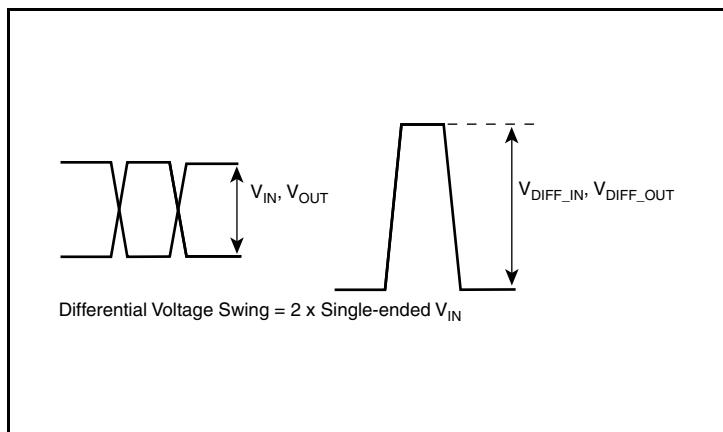
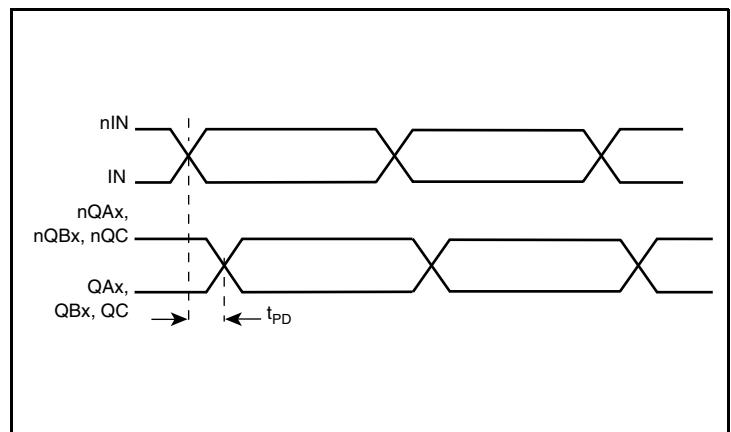
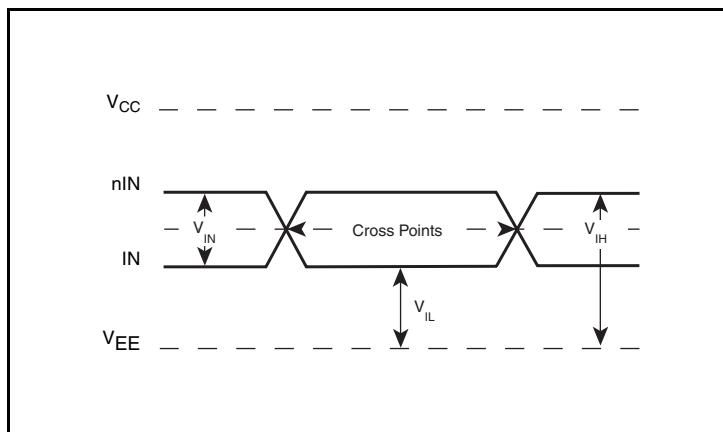
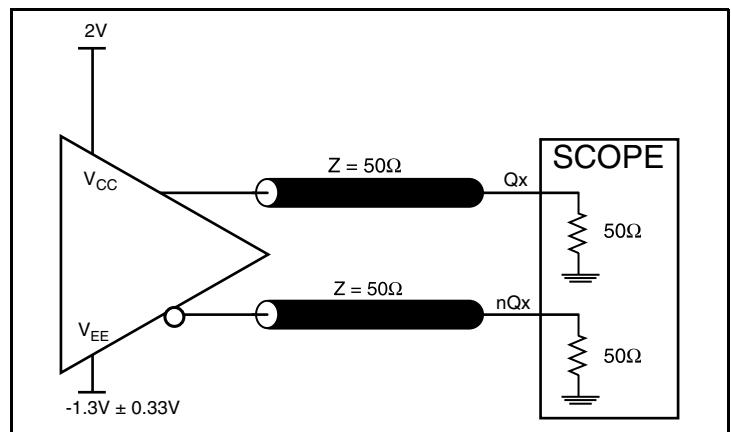
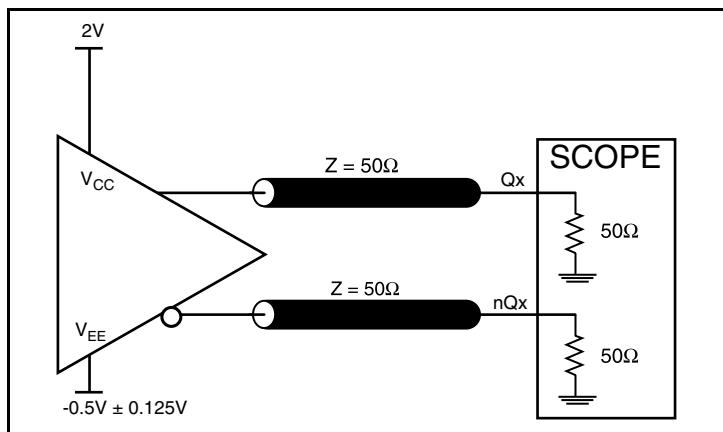
of the power in the 1Hz band to the power in the fundamental. When the required offset is specified, the phase noise is called a **dBc** value, which simply means dBm at a specified offset from the fundamental. By investigating jitter in the frequency domain, we get a better understanding of its effects on the desired application over the entire time record of the signal. It is mathematically possible to calculate an expected bit error rate given a phase noise plot.



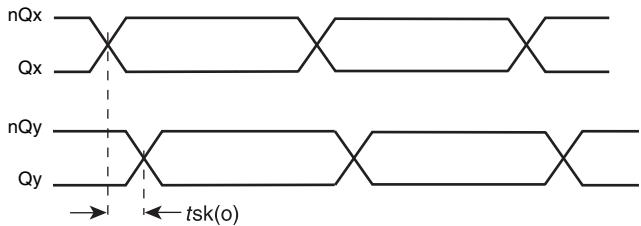
As with most timing specifications, phase noise measurements have issues relating to the limitations of the measurement equipment. The noise floor of the equipment can be higher or lower than the noise floor of the device. Additive phase noise is dependent on both the noise floor of the input source and measurement equipment.

The additive phase jitter for this device was measured using a Rohde & Schwarz SMA100 input source and an Agilent E5052 Phase noise analyzer.

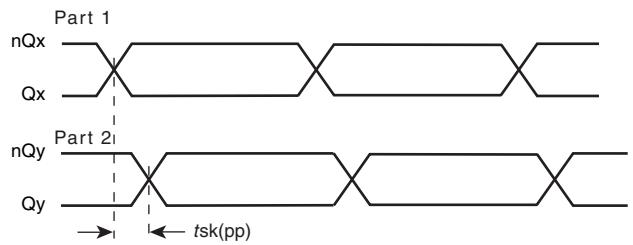
## Parameter Measurement Information



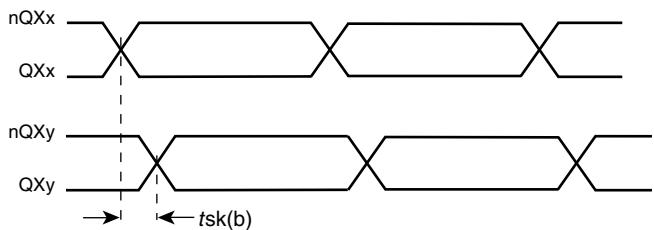
## Parameter Measurement Information, continued



Within Bank Skew

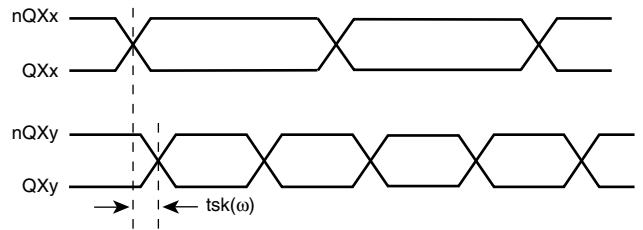


Part-to-Part Skew



Where X = Bank A, Bank B or Bank C

Bank to Bank Skew (same divide setting)



Bank to Bank (different divide settings)

## Applications Information

### Recommendations for Unused Input and Output Pins

#### Inputs:

##### LVCMOS Select Pins

All control pins have internal pullups; additional resistance is not required but can be added for additional protection. A  $1\text{k}\Omega$  resistor can be used.

#### Outputs:

##### LVPECL Outputs

All unused LVPECL outputs can be left floating. We recommend that there is no trace attached. Both sides of the differential output pair should either be left floating or terminated.

### 2.5V LVPECL Input with Built-In $50\Omega$ Termination Interface

The IN /nIN with built-in  $50\Omega$  terminations accept LVDS, LVPECL, CML and other differential signals. Both  $V_{OH}$  and  $V_{OL}$  must meet the  $V_{IN}$  and  $V_{IH}$  input requirements. Figures 2A to 2D show interface examples for the IN/nIN with built-in  $50\Omega$  termination input driven by

the most common driver types. The input interfaces suggested here are examples only. If the driver is from another vendor, use their termination recommendation. Please consult with the vendor of the driver component to confirm the driver termination requirements.

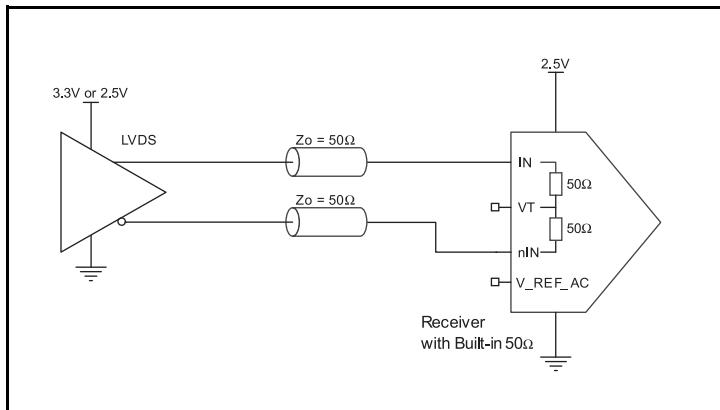


Figure 2A. IN/nIN Input with Built-In  $50\Omega$  Driven by an LVDS Driver

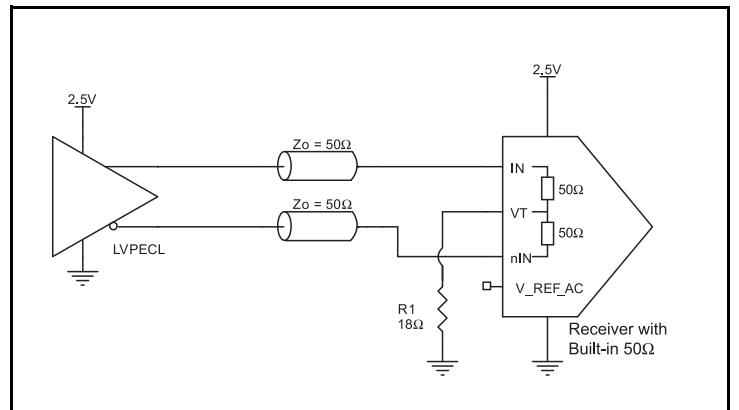


Figure 2B. IN/nIN Input with Built-In  $50\Omega$  Driven by an LVPECL Driver

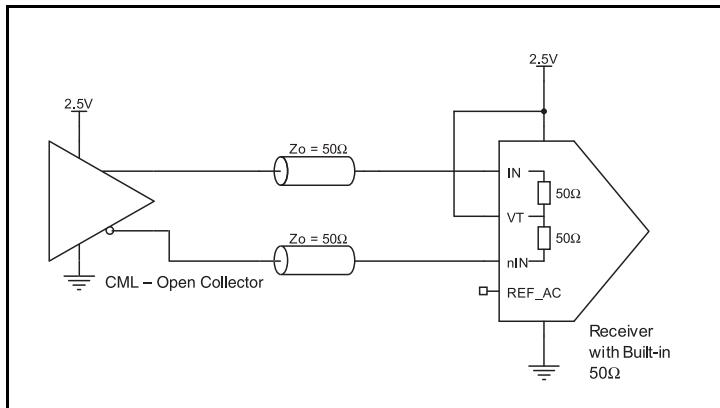


Figure 2C. IN/nIN Input with Built-In  $50\Omega$  Driven by a CML Driver

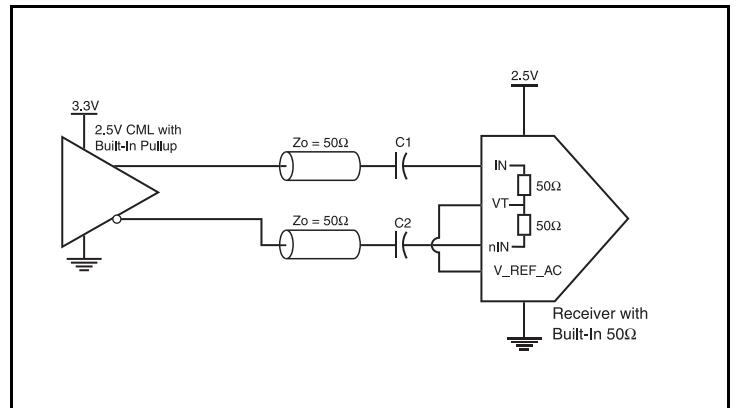
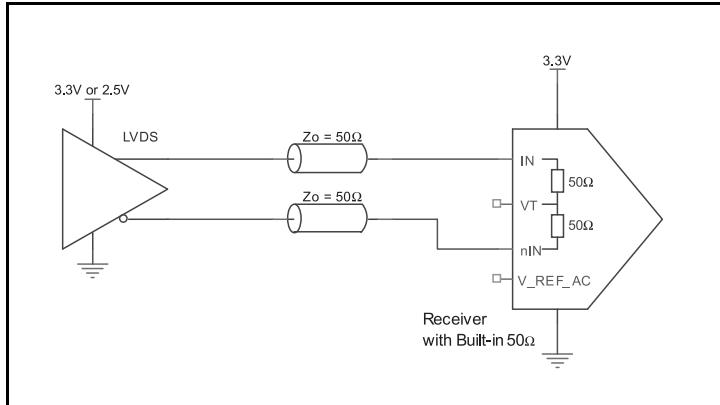


Figure 2D. IN/nIN Input with Built-In  $50\Omega$  Driven by a CML Driver with Built-In  $50\Omega$  Pullup

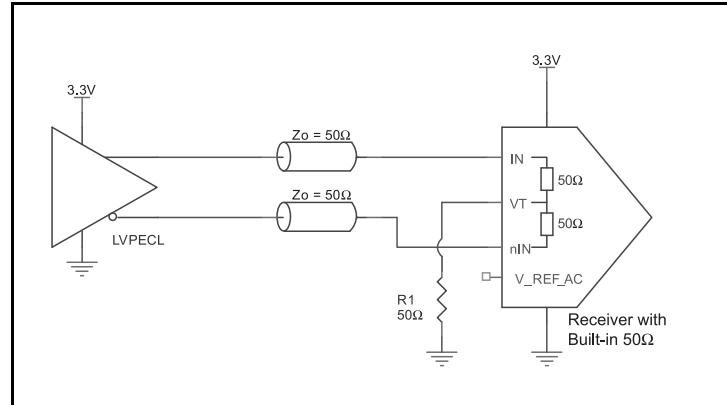
### 3.3V LVPECL Input with Built-In 50Ω Termination Interface

The IN /nIN with built-in 50Ω terminations accept LVDS, LVPECL, CML and other differential signals. Both  $V_{OH}$  and  $V_{OL}$  must meet the  $V_{IN}$  and  $V_{IH}$  input requirements. *Figures 3A to 3D* show interface examples for the IN /nIN input with built-in 50Ω terminations driven by

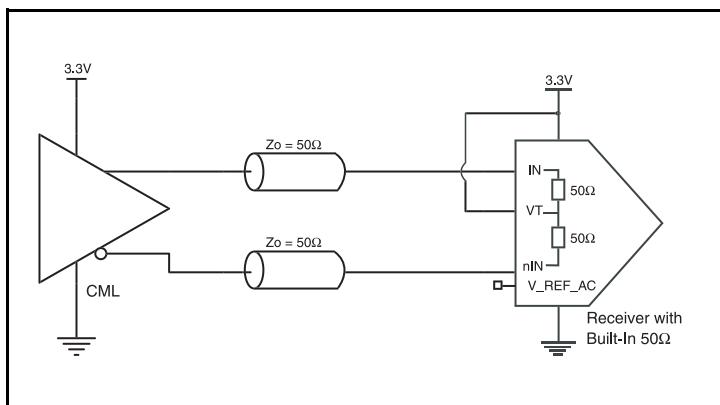
the most common driver types. The input interfaces suggested here are examples only. If the driver is from another vendor, use their termination recommendation. Please consult with the vendor of the driver component to confirm the driver termination requirements.



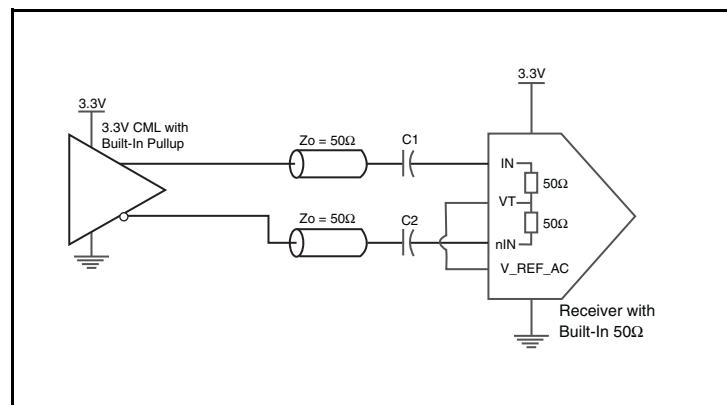
**Figure 3A. IN/nIN Input with Built-In 50Ω Driven by an LVDS Driver**



**Figure 3B. IN/nIN Input with Built-In 50Ω Driven by an LVPECL Driver**



**Figure 3C. IN/nIN Input with Built-In 50Ω Driven by a CML Driver with Open Collector**



**Figure 3D. IN/nIN Input with Built-In 50Ω Driven by a CML Driver with Built-In 50Ω Pullup**

## Termination for 2.5V LVPECL Outputs

Figure 4A and Figure 4B show examples of termination for 2.5V LVPECL driver. These terminations are equivalent to terminating  $50\Omega$  to  $V_{CC} - 2V$ . For  $V_{CC} = 2.5V$ , the  $V_{CC} - 2V$  is very close to ground

level. The  $R3$  in Figure 4B can be eliminated and the termination is shown in Figure 4C.

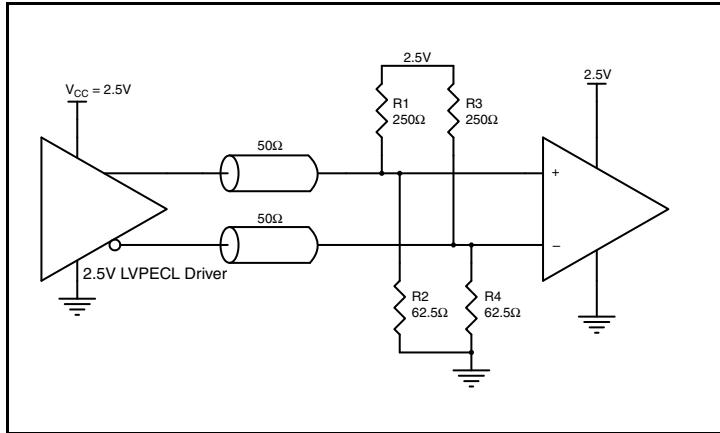


Figure 4A. 2.5V LVPECL Driver Termination Example

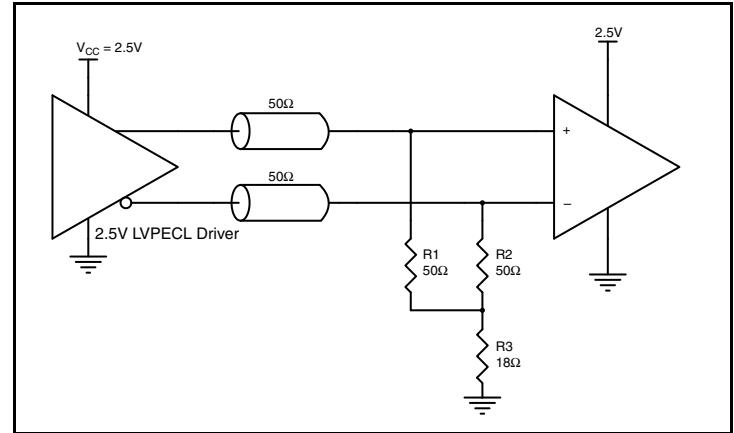


Figure 4B. 2.5V LVPECL Driver Termination Example

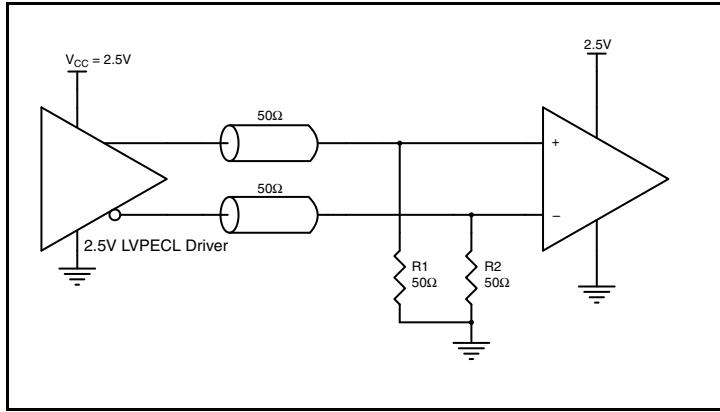


Figure 4C. 2.5V LVPECL Driver Termination Example

## Termination for 3.3V LVPECL Outputs

The clock layout topology shown below is a typical termination for LVPECL outputs. The two different layouts mentioned are recommended only as guidelines.

The differential output is a low impedance follower output that generate ECL/LVPECL compatible outputs. Therefore, terminating resistors (DC current path to ground) or current sources must be used for functionality. These outputs are designed to drive  $50\Omega$

transmission lines. Matched impedance techniques should be used to maximize operating frequency and minimize signal distortion. *Figures 5A and 5B* show two different layouts which are recommended only as guidelines. Other suitable clock layouts may exist and it would be recommended that the board designers simulate to guarantee compatibility across all printed circuit and clock component process variations.

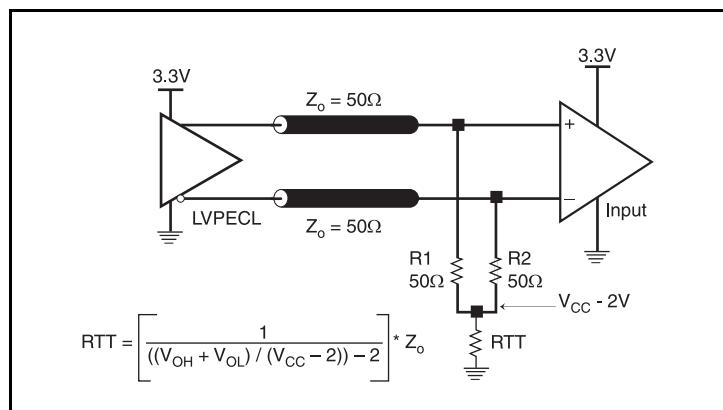


Figure 5A. 3.3V LVPECL Output Termination

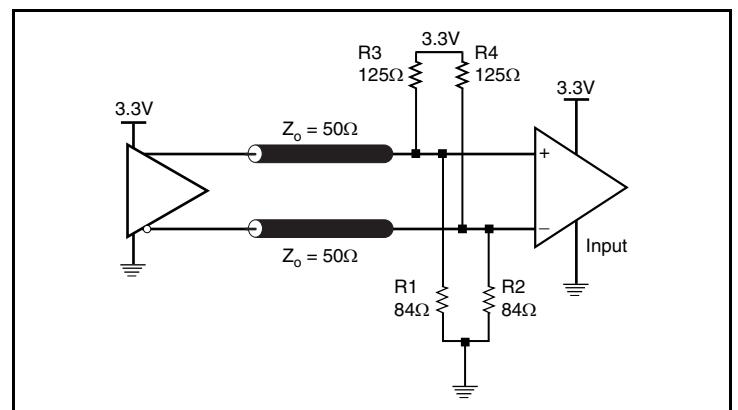


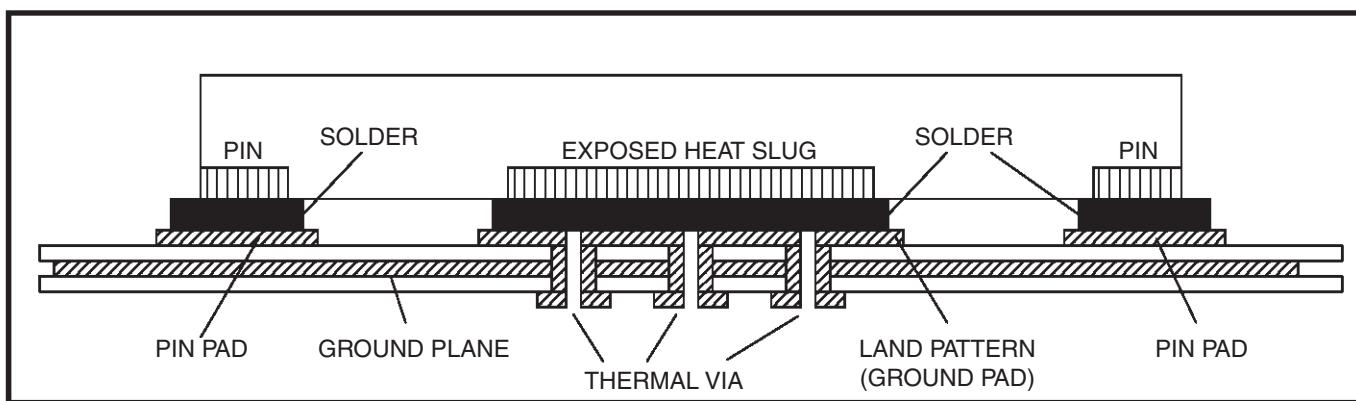
Figure 5B. 3.3V LVPECL Output Termination

## VFQFN EPAD Thermal Release Path

In order to maximize both the removal of heat from the package and the electrical performance, a land pattern must be incorporated on the Printed Circuit Board (PCB) within the footprint of the package corresponding to the exposed metal pad or exposed heat slug on the package, as shown in *Figure 6*. The solderable area on the PCB, as defined by the solder mask, should be at least the same size/shape as the exposed pad/slug area on the package to maximize the thermal/electrical performance. Sufficient clearance should be designed on the PCB between the outer edges of the land pattern and the inner edges of pad pattern for the leads to avoid any shorts.

While the land pattern on the PCB provides a means of heat transfer and electrical grounding from the package to the board through a solder joint, thermal vias are necessary to effectively conduct from the surface of the PCB to the ground plane(s). The land pattern must be connected to ground through these vias. The vias act as "heat pipes". The number of vias (i.e. "heat pipes") are application specific

and dependent upon the package power dissipation as well as electrical conductivity requirements. Thus, thermal and electrical analysis and/or testing are recommended to determine the minimum number needed. Maximum thermal and electrical performance is achieved when an array of vias is incorporated in the land pattern. It is recommended to use as many vias connected to ground as possible. It is also recommended that the via diameter should be 12 to 13mils (0.30 to 0.33mm) with 1oz copper via barrel plating. This is desirable to avoid any solder wicking inside the via during the soldering process which may result in voids in solder between the exposed pad/slug and the thermal land. Precautions should be taken to eliminate any solder voids between the exposed heat slug and the land pattern. Note: These recommendations are to be used as a guideline only. For further information, please refer to the Application Note on the Surface Mount Assembly of Amkor's Thermally/Electrically Enhance Leadframe Base Package, Amkor Technology.



**Figure 6. P.C. Assembly for Exposed Pad Thermal Release Path – Side View (drawing not to scale)**

## Power Considerations

This section provides information on power dissipation and junction temperature for the 8S89202. Equations and example calculations are also provided.

### 1. Power Dissipation.

The total power dissipation for the 8S89202 is the sum of the core power plus the power dissipated in the load(s). The following is the power dissipation for  $V_{CC} = 3.63V$ , which gives worst case results.

NOTE: Please refer to Section 3 for details on calculating power dissipated in the load.

The maximum current at 85°C is as follows:

$$I_{EE\_MAX} = 128mA$$

- Power (core)<sub>MAX</sub> =  $V_{CC\_MAX} * I_{EE\_MAX} = 3.63V * 139mA = 504.57mW$
- Power (outputs)<sub>MAX</sub> = **27.8mW/Loaded Output pair**  
If all outputs are loaded, the total power is  $8 * 27.8mW = 222.4mW$
- Power Dissipation for internal termination  $R_T$   
 $Power (R_T)_{MAX} = (V_{IN\_MAX})^2 / R_{T\_MIN} = (1.1V)^2 / 80\Omega = 15.12mW$

$$\text{Total Power}_{-MAX} = (3.63V, \text{ with all outputs switching}) = 504.57mW + 222.4mW + 15.12mW = \mathbf{742.09mW}$$

### 2. Junction Temperature.

Junction temperature,  $T_j$ , is the temperature at the junction of the bond wire and bond pad, and directly affects the reliability of the device. The maximum recommended junction temperature is 125°C. Limiting the internal transistor junction temperature,  $T_j$ , to 125°C ensures that the bond wire and bond pad temperature remains below 125°C.

The equation for  $T_j$  is as follows:  $T_j = \theta_{JA} * Pd\_total + T_A$

$T_j$  = Junction Temperature

$\theta_{JA}$  = Junction-to-Ambient Thermal Resistance

$Pd\_total$  = Total Device Power Dissipation (example calculation is in section 1 above)

$T_A$  = Ambient Temperature

In order to calculate junction temperature, the appropriate junction-to-ambient thermal resistance  $\theta_{JA}$  must be used. Assuming no air flow and a multi-layer board, the appropriate value is 42.7°C/W per Table 6 below.

Therefore,  $T_j$  for an ambient temperature of 85°C with all outputs switching is:

$$85^{\circ}\text{C} + 0.742W * 42.7^{\circ}\text{C}/\text{W} = 116.7^{\circ}\text{C}. \text{ This is below the limit of } 125^{\circ}\text{C}.$$

This calculation is only an example.  $T_j$  will obviously vary depending on input swing, the number of loaded outputs, supply voltage, air flow and the type of board (multi-layer).

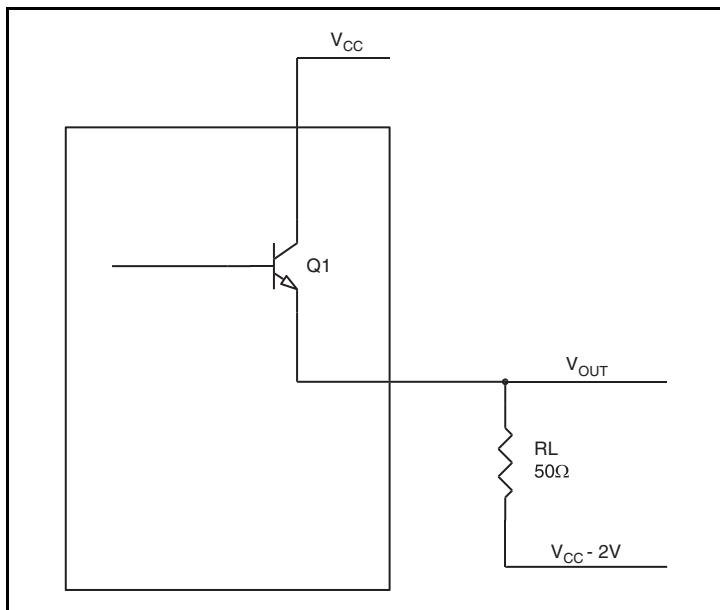
**Table 6. Thermal Resistance  $\theta_{JA}$  for 32 Lead VFQFN, Forced Convection**

| $\theta_{JA}$ vs. Air Flow                  |          |          |          |
|---|----------|----------|----------|
| Meters per Second                           | 0        | 1        | 2.5      |
| Multi-Layer PCB, JEDEC Standard Test Boards | 42.7°C/W | 37.3°C/W | 33.5°C/W |

### 3. Calculations and Equations.

The purpose of this section is to calculate the power dissipation for the LVPECL output pairs.

LVPECL output driver circuit and termination are shown in *Figure 7*.



**Figure 7. LVPECL Driver Circuit and Termination**

To calculate worst case power dissipation into the load, use the following equations which assume a  $50\Omega$  load, and a termination voltage of  $V_{CC} - 2V$ .

- For logic high,  $V_{OUT} = V_{OH\_MAX} = V_{CC\_MAX} - 0.5V$   
 $(V_{CC\_MAX} - V_{OH\_MAX}) = 0.5V$
- For logic low,  $V_{OUT} = V_{OL\_MAX} = V_{CC\_MAX} - 1.6V$   
 $(V_{CC\_MAX} - V_{OL\_MAX}) = 1.6V$

$Pd_H$  is power dissipation when the output drives high.

$Pd_L$  is the power dissipation when the output drives low.

$$Pd_H = [(V_{OH\_MAX} - (V_{CC\_MAX} - 2V)) / R_L] * (V_{CC\_MAX} - V_{OH\_MAX}) = [(2V - (V_{CC\_MAX} - V_{OH\_MAX})) / R_L] * (V_{CC\_MAX} - V_{OH\_MAX}) = [(2V - 0.5V) / 50\Omega] * 0.5V = 15mW$$

$$Pd_L = [(V_{OL\_MAX} - (V_{CC\_MAX} - 2V)) / R_L] * (V_{CC\_MAX} - V_{OL\_MAX}) = [(2V - (V_{CC\_MAX} - V_{OL\_MAX})) / R_L] * (V_{CC\_MAX} - V_{OL\_MAX}) = [(2V - 1.6V) / 50\Omega] * 1.6V = 12.8mW$$

Total Power Dissipation per output pair =  $Pd_H + Pd_L = 27.8mW$

## Reliability Information

**Table 7.  $\theta_{JA}$  vs. Air Flow Table for a 32 Lead VFQFN**

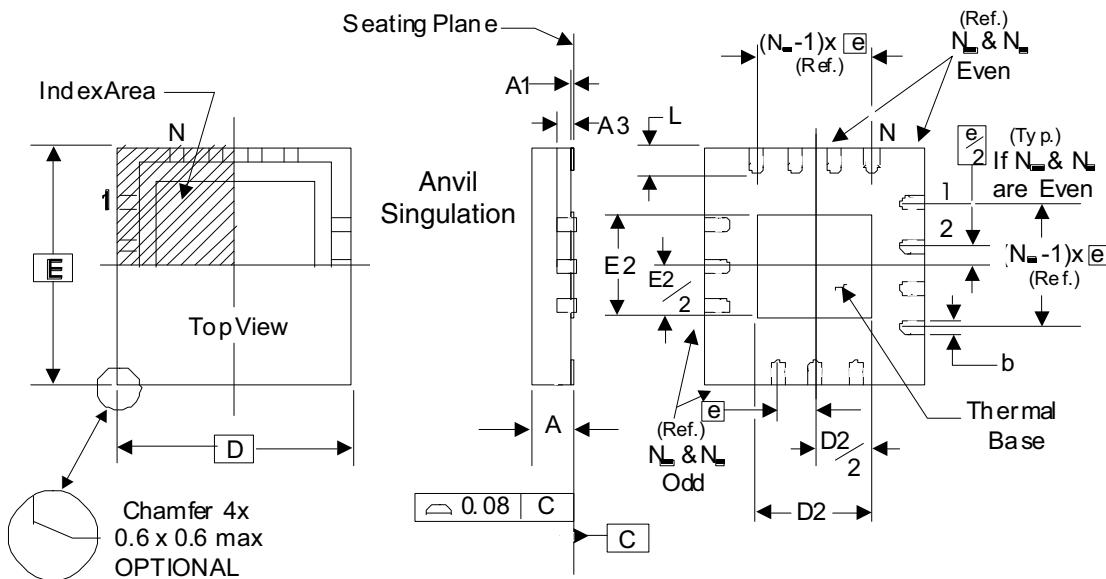
| $\theta_{JA}$ vs. Air Flow                  |          |          |          |
|---|----------|----------|----------|
| Meters per Second                           | 0        | 1        | 2.5      |
| Multi-Layer PCB, JEDEC Standard Test Boards | 42.7°C/W | 37.3°C/W | 33.5°C/W |

## Transistor Count

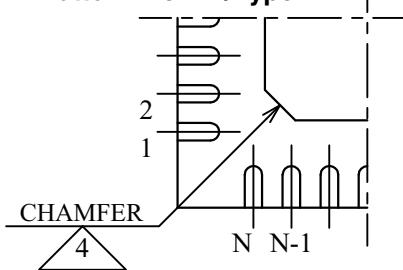
The transistor count for 8S89202: 689

## 32 Lead VFQFN Package Outline and Package Dimensions

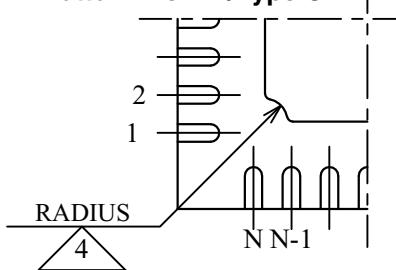
### Package Outline - K Suffix for 32 Lead VFQFN



**Bottom View w/Type A ID**



**Bottom View w/Type C ID**



There are 2 methods of indicating pin 1 corner at the back of the VFQFN package:

1. Type A: Chamfer on the paddle (near pin 1)
2. Type C: Mouse bite on the paddle (near pin 1)

**Table 9. Package Dimensions**

| JEDEC Variation: VHHD-2/4<br>All Dimensions in Millimeters |         |            |         |
|--|---------|------------|---------|
| Symbol   | Minimum | Nominal    | Maximum |
| N  |         | 32         |         |
| A  | 0.80    |            | 1.00    |
| A1   | 0       |            | 0.05    |
| A3   |         | 0.25 Ref.  |         |
| b  | 0.18    | 0.25       | 0.30    |
| $N_D \& N_E$   |         |            | 8       |
| D & E  |         | 5.00 Basic |         |
| D2 & E2  | 3.0     |            | 3.3     |
| e  |         | 0.50 Basic |         |
| L  | 0.30    | 0.40       | 0.50    |

NOTE: The following package mechanical drawing is a generic drawing that applies to any pin count VFQFN package. This drawing is not intended to convey the actual pin count or pin layout of this device. The pin count and pinout are shown on the front page. The package dimensions are in Table 9.

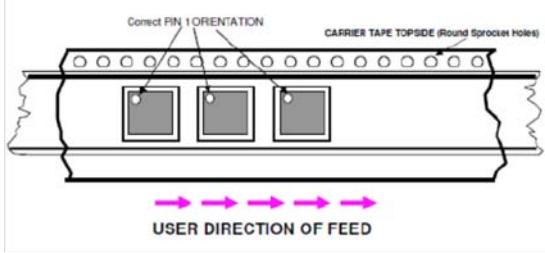
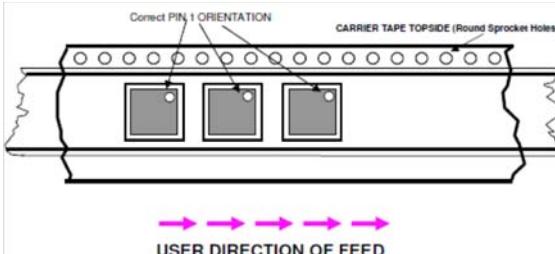
Reference Document: JEDEC Publication 95, MO-220

## Ordering Information

**Table 8. Ordering Information**

| Part/Order Number | Marking     | Package                   | Shipping Packaging                        | Temperature   |
|-------------------|-------------|---------------------------|---|---------------|
| 8S89202BKILF      | ICS89202BIL | "Lead-Free" 32 Lead VFQFN | Tray                                      | -40°C to 85°C |
| 8S89202BKILFT     | ICS89202BIL | "Lead-Free" 32 Lead VFQFN | Tape & Reel, pin 1 orientation: EIA-481-C | -40°C to 85°C |
| 8S89202BKILF/W    | ICS89202BIL | "Lead-Free" 32 Lead VFQFN | Tape & Reel, pin 1 orientation EIA-481-D  | -40°C to 85°C |

**Table 9. Pin 1 Orientation in Tape and Reel Packaging**

| Part Number Suffix | Pin 1 Orientation      | Illustration  |
|--------------------|------------------------|---|
| T                  | Quadrant 1 (EIA-481-C) |   |
| /W                 | Quadrant 2 (EIA-481-D) |  |

## Revision History Sheet

| Rev | Table   | Page     | Description of Change  | Date   |
|-----|---------|----------|--|--------|
| B   | T9<br>8 | 21<br>21 | Added Pin 1 Orientation in Tape and Reel Table.<br>Ordering Information - Added W part number. | 7/1/15 |
|     |         |          |  |        |
|     |         |          |  |        |
|     |         |          |  |        |



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