

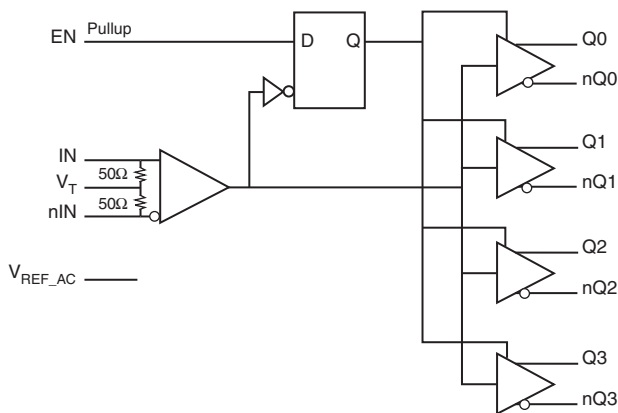
## General Description

The 8S89831I is a high speed 1-to-4 Differential- to-LVPECL/ECL Fanout Buffer. The 8S89831I 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 input and VREF\_AC pin allow other differential signal families such as LVDS, LVHSTL and CML to be easily interfaced to the input with minimal use of external components. The device also has an output enable pin which may be useful for system test and debug purposes. The 8S89831I is packaged in a small 3mm x 3mm 16-pin VFQFN package which makes it ideal for use in space-constrained applications.

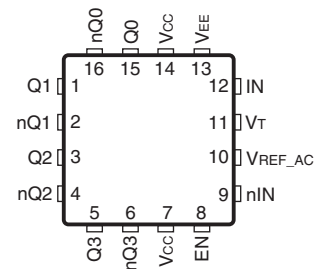
## Features

- Four LVPECL/ECL outputs
- IN, nIN input can accept the following differential input levels: LVPECL, LVDS, CML, SSTL
- 50Ω internal input termination to V<sub>T</sub>
- Output frequency: >2.1GHz
- Output skew: 30ps (maximum)
- Part-to-part skew: 185ps (maximum)
- Additive phase jitter, RMS: 0.31ps (typical)
- Propagation Delay: 570ps (maximum)
- LVPECL mode operating voltage supply range:  
V<sub>CC</sub> = 2.5V±5%, 3.3V±5%, V<sub>EE</sub> = 0V
- ECL mode operating voltage supply range:  
V<sub>CC</sub> = 0V, V<sub>EE</sub> = -3.3V±5%, -2.5V±5%
- -40°C to 85°C ambient operating temperature
- Available in lead-free (RoHS 6) package

## Block Diagram



## Pin Assignment



**8S89831I**

**16-Lead VFQFN**

**3mm x 3mm x 0.925mm package body**

**K Package**

**Top View**

**Table 1. Pin Descriptions**

Number	Name	Type		Description
1, 2	Q1, nQ1	Output		Differential output pair. LVPECL/ECL interface levels.
3, 4	Q2, nQ2	Output		Differential output pair. LVPECL/ECL interface levels.
5, 6	Q3, nQ3	Output		Differential output pair. LVPECL/ECL interface levels.
7, 14	$V_{CC}$	Power		Power supply pins.
8	EN	Input	Pullup	Synchronizing clock enable. When LOW, Qx outputs will go LOW and nQx outputs will go HIGH on the next LOW transition at IN input. Input threshold is $V_{CC}/2$ . Includes a 37k $\Omega$ pull-up resistor. Default state is HIGH when left floating. The internal latch is clocked on the falling edge of the input signal IN. LVTTTL / LVCMOS interface levels.
9	nIN	Input		Inverting differential LVPECL clock input. RT = 50 $\Omega$ termination to $V_T$ .
10	$V_{REF\_AC}$	Output		Reference voltage for AC-coupled applications.
11	$V_T$	Input		Termination input. $I_{REF\_AC} (max.) < \pm 2mA$ .
12	IN	Input		Non-inverting LVPECL differential clock input. RT = 50 $\Omega$ termination to $V_T$ .
13	$V_{EE}$	Power		Negative supply pin.
15, 16	Q0, nQ0	Output		Differential output pair. LVPECL/ECL interface levels.

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

**Table 2. Pin Characteristics**

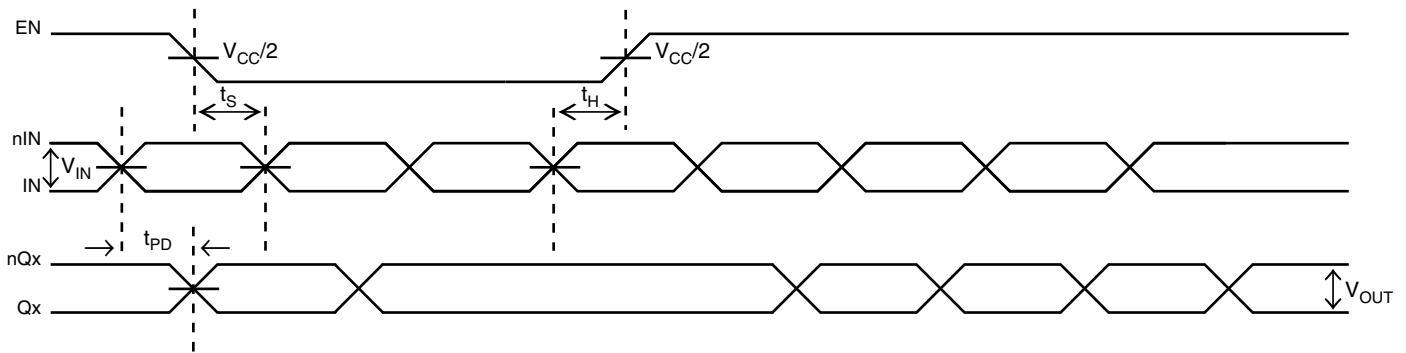
Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$R_{PULLUP}$	Input Pullup Resistor			37		k $\Omega$

## Function Tables

**Table 3A. Control Input Function Table**

Input	Outputs	
EN	Q0:Q3	nQ0:nQ3
0	Disabled; LOW	Disabled; HIGH
1	Enabled	Enabled

NOTE: After EN switches, the clock outputs are disabled or enabled following a falling input clock edge as shown in *Figure 1*.


**Figure 1. EN Timing Diagram**
**Table 3B. Truth Table**

Inputs			Outputs	
IN	nIN	EN	Q0:Q3	nQ0:nQ3
0	1	1	0	1
1	0	1	1	0
X	X	0	0 (NOTE 1)	1 (NOTE 1)

NOTE 1: On the next negative transition of the input signal (IN).

## 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 (LVPECL mode, $V_{EE} = 0V$ )
Negative Supply Voltage, $V_{EE}$	-4.6V (ECL mode, $V_{CC} = 0V$ )
Inputs, $V_I$ (LVPECL mode)	-0.5V to $V_{CC} + 0.5V$
Inputs, $V_I$ (ECL mode)	0.5V to $V_{EE} - 0.5V$
Outputs, $I_O$ Continuous Current Surge Current	50mA 100mA
Input Current, $I_N$ , nIN	$\pm 50mA$
$V_T$ Current, $I_{VT}$	$\pm 100mA$
$V_{REF\_AC}$ Input Sink/Source Current, $I_{REF\_AC}$	$\pm 2mA$
Operating Temperature Range, $T_A$	-40°C to +85°C
Package Thermal Impedance, $\theta_{JA}$ , (Junction-to-Ambient)	74.7°C/W (0 mps)
Storage Temperature, $T_{STG}$	-65°C to 150°C

## DC Electrical Characteristics

**Table 4A. Power Supply DC Characteristics,  $V_{CC} = 2.5V \pm 5\%$ ,  $3.3V \pm 5\%$ ,  $T_A = -40^\circ C$  to  $85^\circ C$**

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$V_{CC}$	Positive Supply Voltage		2.375	3.3	3.465	V
$I_{EE}$	Power Supply Current				45	mA

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

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$V_{IH}$	Input High Voltage		2.2		$V_{CC} + 0.3$	V
$V_{IL}$	Input Low Voltage		0		0.8	V
$I_{IH}$	Input High Current	$V_{CC} = V_{IN} = 3.465V$			10	$\mu A$
$I_{IL}$	Input Low Current	$V_{CC} = 3.465V, V_{IN} = 0V$	-150			$\mu A$

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

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$R_{IN}$	Differential Input Resistance (IN, nIN)	IN to VT, nIN to VT	40	50	60	$\Omega$
$V_{IH}$	Input High Voltage (IN, nIN)		1.2		$V_{CC}$	V
$V_{IL}$	Input Low Voltage (IN, nIN)		0		$V_{IH} - 0.15$	V
$V_{IN}$	Input Voltage Swing		0.15		1.2	V
$V_{DIFF\_IN}$	Differential Input Voltage Swing		0.3			V
$I_{IN}$	Input Current; NOTE 1 (IN, nIN)				35	mA
$V_{REF\_AC}$	Bias Voltage		$V_{CC} - 1.45$	$V_{CC} - 1.37$	$V_{CC} - 1.32$	V

NOTE 1: Guaranteed by design.

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

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$V_{OH}$	Output High Voltage; NOTE 1		$V_{CC} - 1.175$		$V_{CC} - 0.85$	V
$V_{OL}$	Output Low Voltage; NOTE 1		$V_{CC} - 2.0$		$V_{CC} - 1.575$	V
$V_{OUT}$	Output Voltage Swing		0.6		1.0	V
$V_{DIFF\_OUT}$	Differential Output Voltage Swing		1.2		2.0	V

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

## AC Electrical Characteristics

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

Symbol	Parameter		Test Conditions	Minimum	Typical	Maximum	Units
$f_{MAX}$	Output Frequency		Output Swing $\geq 450mV$	2.1			GHz
$t_{PD}$	Propagation Delay; (Differential); NOTE 1		Input Swing: 150mV	300		570	ps
			Input Swing: 800mV	255		510	ps
$t_{sk(o)}$	Output Skew; NOTE 2, 4					30	ps
$t_{sk(pp)}$	Part-to-Part Skew; NOTE 3, 4					185	ps
$f_{jit}$	Buffer Additive Jitter; RMS; refer to Additive Phase Jitter Section		155.52MHz, Integration Range: 12kHz – 20MHz		0.31		ps
$t_S$	Clock Enable Setup Time	EN to IN/nIN		300			ps
$t_H$	Clock Enable Hold Time	EN to IN/nIN		300			ps
$t_R / t_F$	Output Rise/Fall Time		20% to 80%	100		250	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 lfm. The device will meet specifications after thermal equilibrium has been reached under these conditions.

NOTE: All parameters characterized at  $\leq 1GHz$  unless otherwise noted.

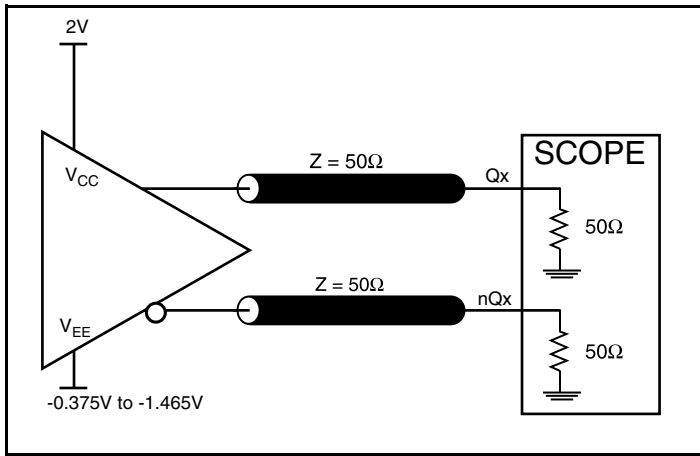
NOTE 1: Measured from the differential input crossing point to the differential output crossing point.

NOTE 2: Defined as skew between outputs at the same supply voltage and with equal load conditions. Measured at the output differential cross points.

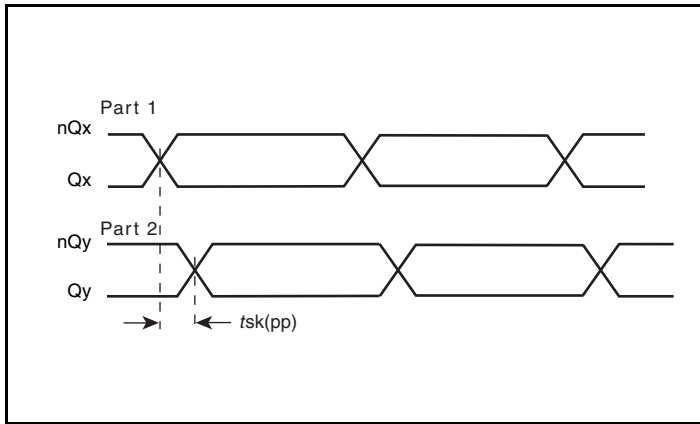
NOTE 3: Defined as skew between outputs on different devices operating at the same supply voltage and with equal load conditions. Using the same type of inputs on each device, the outputs are measured at the differential cross points.

NOTE 4: This parameter is defined in accordance with JEDEC Standard 65.

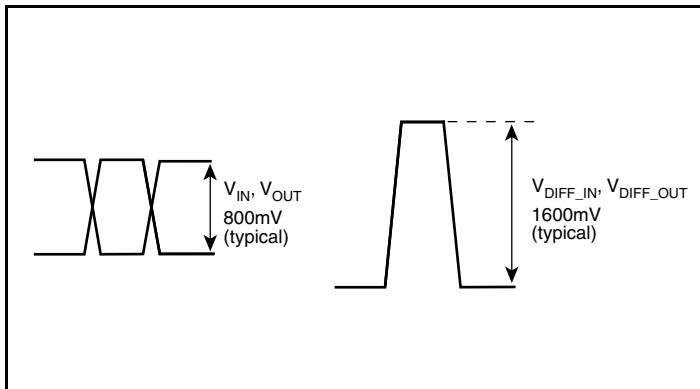
### Parameter Measurement Information



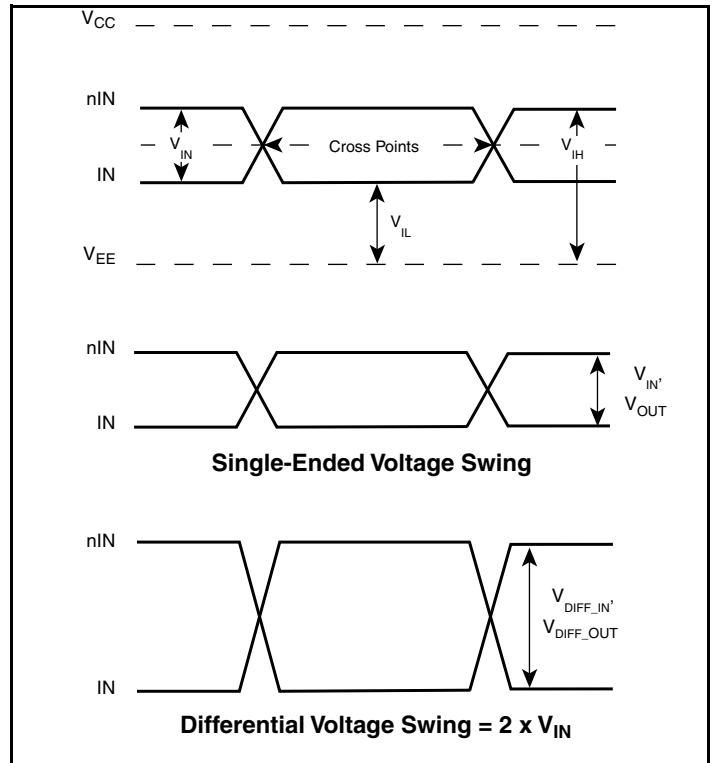
Output Load AC Test Circuit



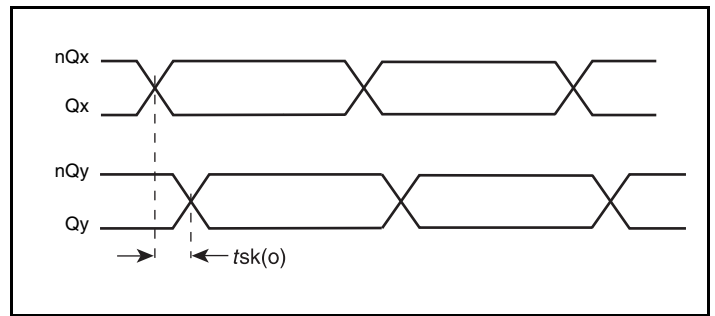
Part-to-Part Skew



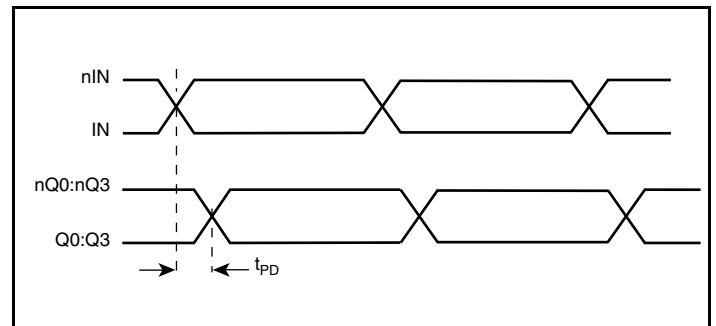
Single-ended & Differential Input Voltage Swing



Differential Input Level

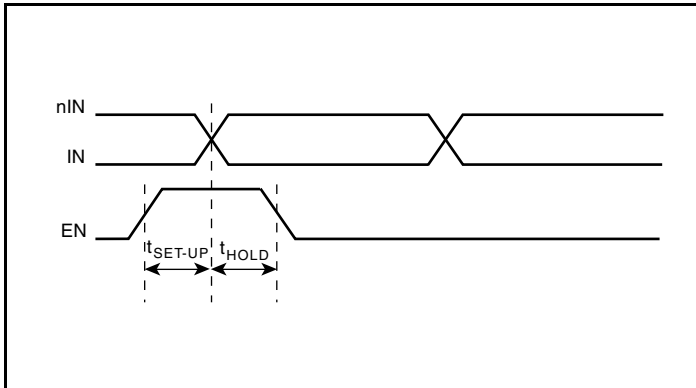


Output Skew

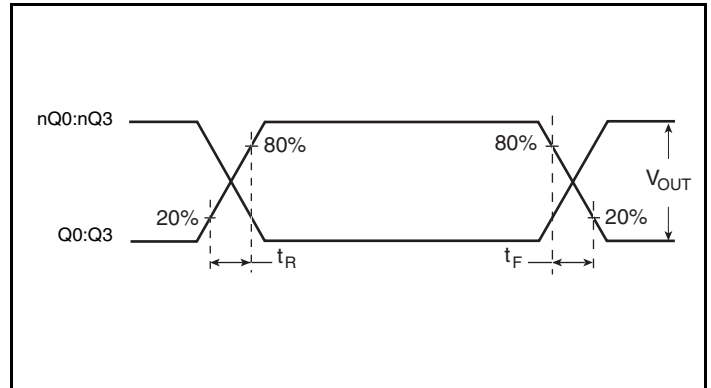


Propagation Delay

## Parameter Measurement Information, continued



**Setup & Hold Time**



**Output Rise/Fall Time**

## Application Information

### Recommendations for Unused Output Pins

#### Outputs:

##### LVPECL Outputs

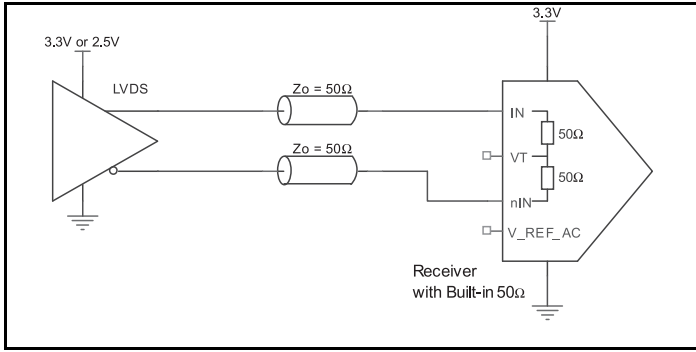
All unused LVPECL outputs can be left floating. We recommend that there is no trace attached. Both sides of the differential output pair should either be left floating or terminated.



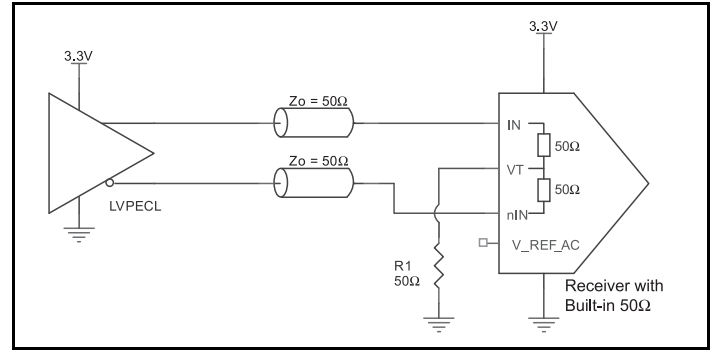
### 3.3V Differential Input with Built-In 50Ω Termination Interface

The IN/nIN with built-in 50Ω terminations accept LVDS, LVPECL, LVHSTL, CML, SSTL and other differential signals. Both signals must meet the  $V_{IN}$  and  $V_{IH}$  input requirements. *Figures 2A to 2D* show interface examples for the IN/nIN input with built-in 50Ω terminations driven by the most common driver types. The input interfaces

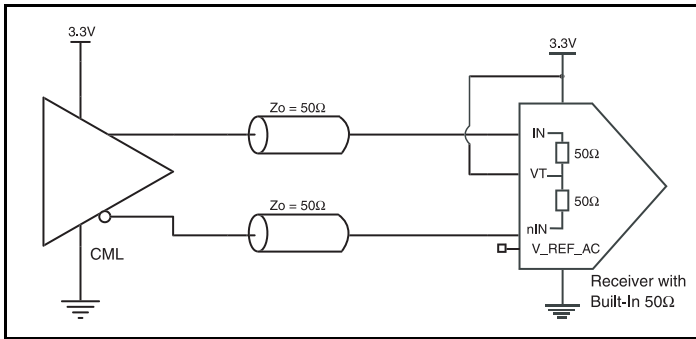
suggested here are examples only. If the driver is from another vendor, use their termination recommendation. Please consult with the vendor of the driver component to confirm the driver termination requirements.



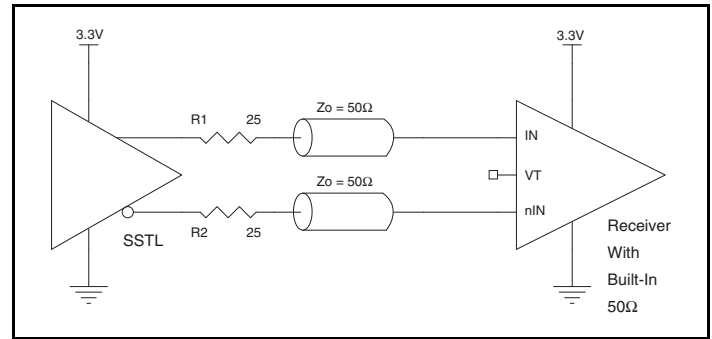
**Figure 2A. IN/nIN Input with Built-In 50Ω Driven by an LVDS Driver**



**Figure 2B. IN/nIN Input with Built-In 50Ω Driven by an LVPECL Driver**



**Figure 2C. IN/nIN Input with Built-In 50Ω Driven by a CML Driver with Open Collector**

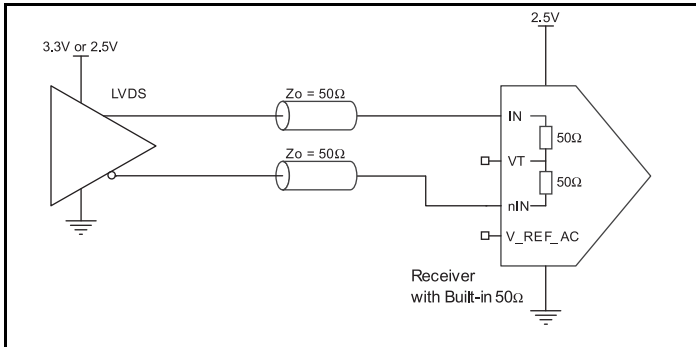


**Figure 2D. IN/nIN Input with Built-In 50Ω Driven by an SSTL Driver**

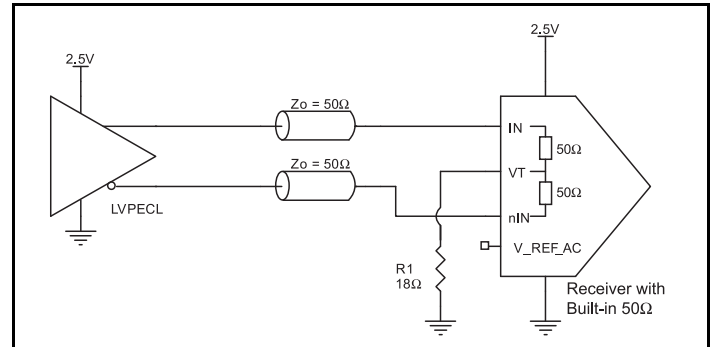
## 2.5V LVPECL Input with Built-In 50Ω Termination Interface

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

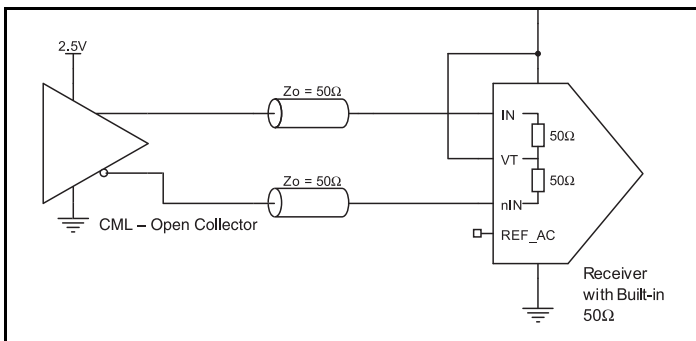
the most common driver types. The input interfaces suggested here are examples only. If the driver is from another vendor, use their termination recommendation. Please consult with the vendor of the driver component to confirm the driver termination requirements.



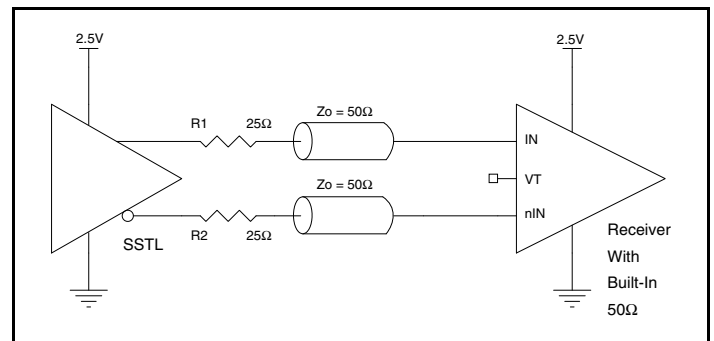
**Figure 3A. IN/nIN Input with Built-In 50Ω Driven by an LVDS Driver**



**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 an SSTL Driver**

### 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 outputs are low impedance follower outputs 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 50Ω

transmission lines. Matched impedance techniques should be used to maximize operating frequency and minimize signal distortion.

Figures 4A and 4B 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.

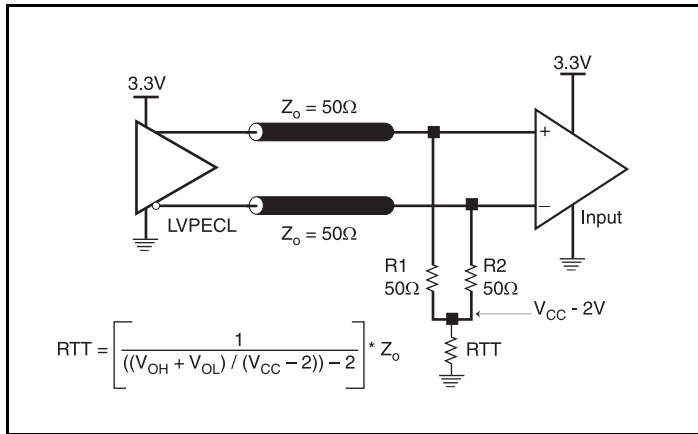


Figure 4A. 3.3V LVPECL Output Termination

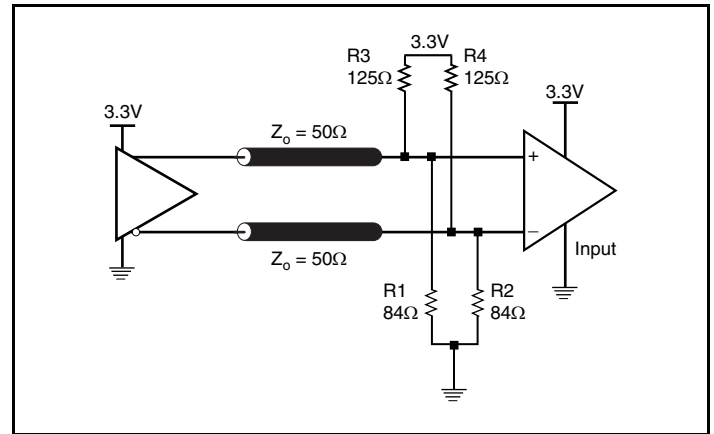


Figure 4B. 3.3V LVPECL Output Termination

### Termination for 2.5V LVPECL Outputs

Figure 5A and Figure 5B 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 5B can be eliminated and the termination is shown in Figure 5C.

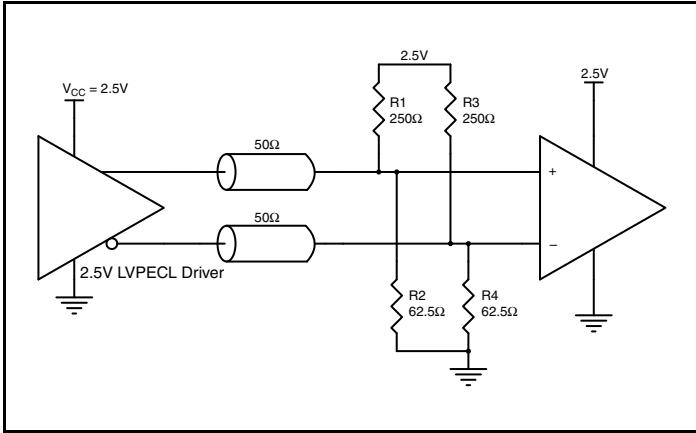


Figure 5A. 2.5V LVPECL Driver Termination Example

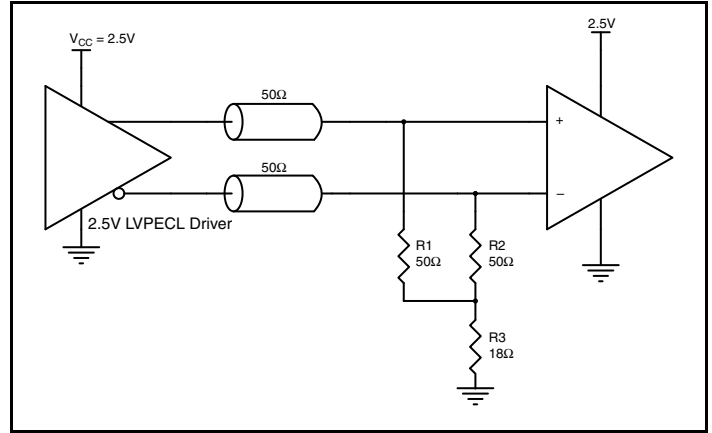


Figure 5B. 2.5V LVPECL Driver Termination Example

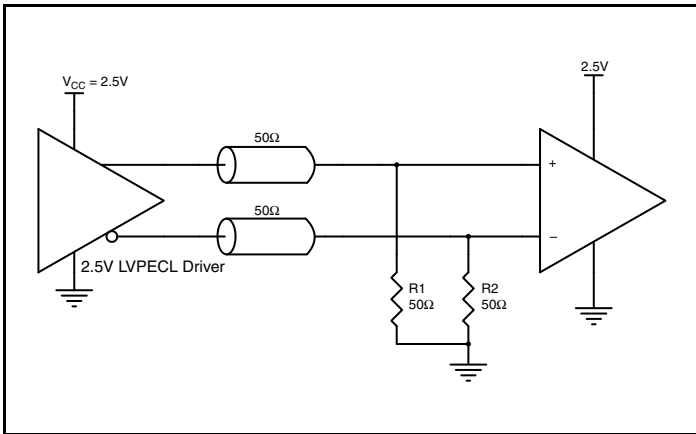


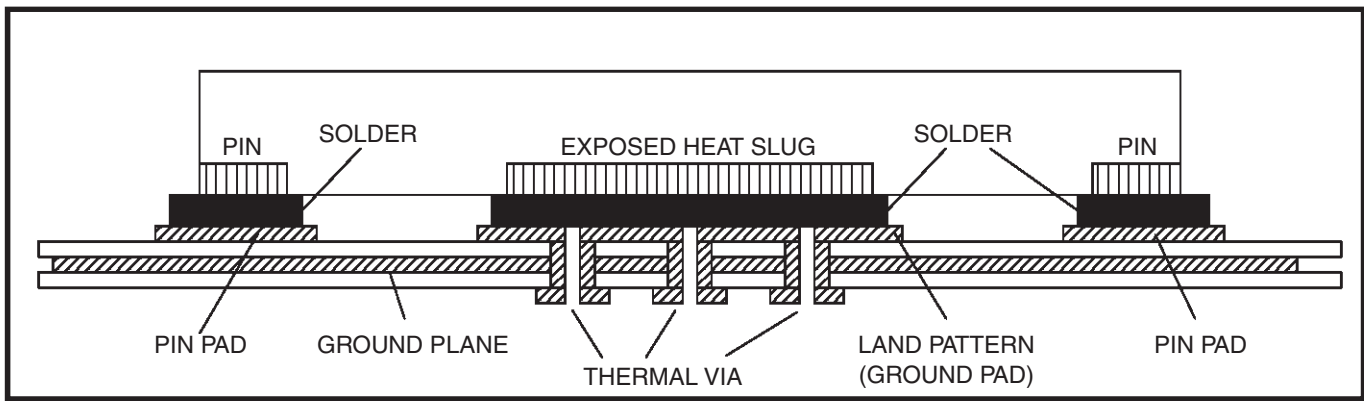
Figure 5C. 2.5V LVPECL Driver Termination Example

### 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)**

### Schematic Example

Figure 7 shows a schematic example of the 8S89831I. This schematic provides examples of input and output handling. The 8S89831I input has built-in 50Ω termination resistors. The input can directly accept various types of differential signal without AC couple. For AC couple termination, the 8S89831I also provides the VREF\_AC pin for proper offset level after the AC couple. This example shows the 8S89831I input driven by a 2.5V LVPECL driver

with AC couple. The 8S89831I outputs are LVPECL driver. In this example, we assume the traces are long transmission line and the receiver is high input impedance without built-in matched load. An example of 3.3V LVPECL termination is shown in this schematic. Additional termination approaches are shown in the LVPECL Termination Application Note.

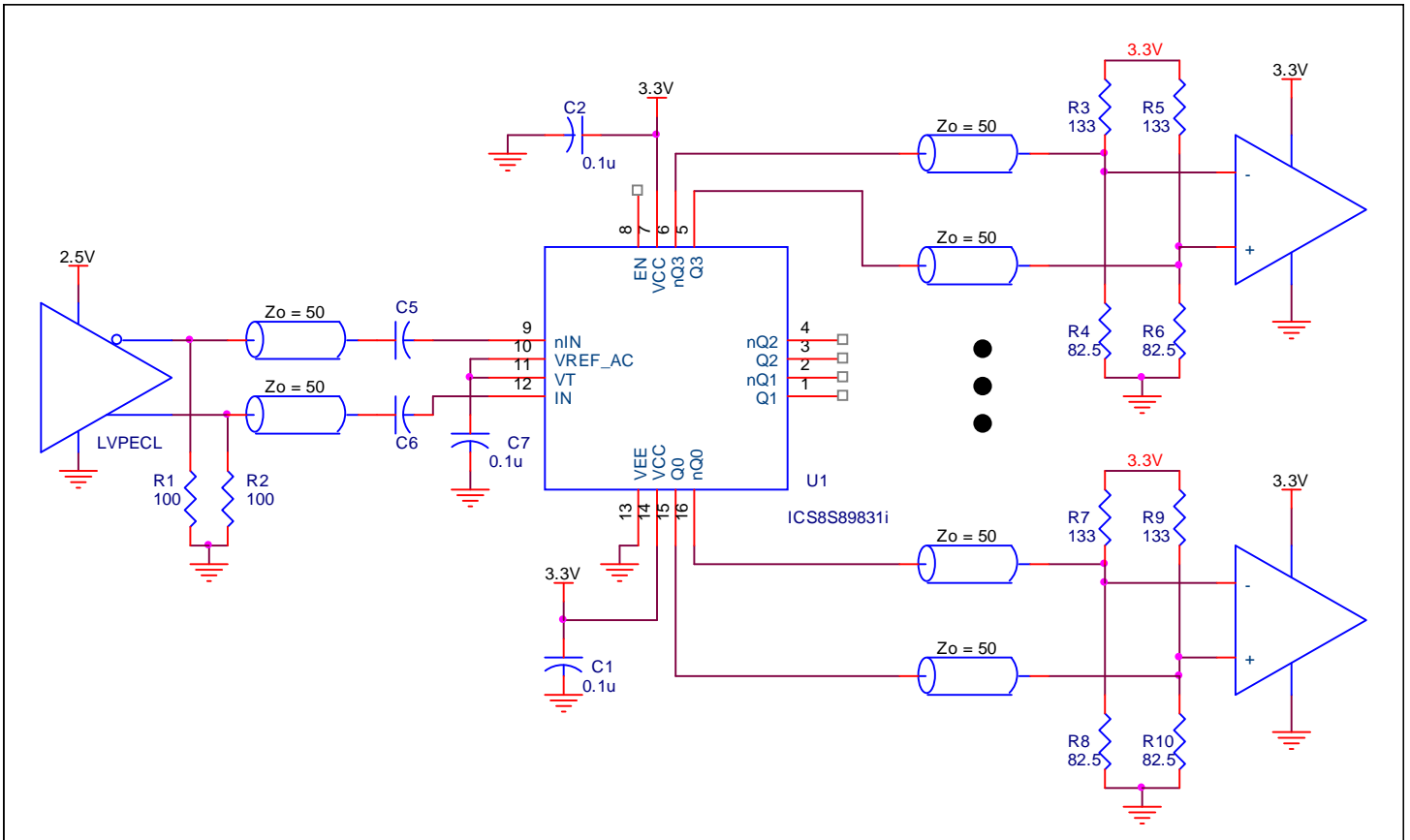


Figure 7. 8S89831I Application Schematic Example

## Power Considerations

This section provides information on power dissipation and junction temperature for the 8S89831I. Equations and example calculations are also provided.

### 1. Power Dissipation.

The total power dissipation for the 8S89831I is the sum of the core power plus the power dissipation in the load(s). The following is the power dissipation for  $V_{CC} = 3.3V + 5\% = 3.465V$ , which gives worst case results.

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

- Power (core)<sub>MAX</sub> =  $V_{CC\_MAX} * I_{EE\_MAX} = 3.465V * 45mA = 155.925mW$
- Power (outputs)<sub>MAX</sub> = **32.94mW/Loaded Output pair**  
If all outputs are loaded, the total power is  $4 * 32.94mW = 131.76mW$
- Power Dissipation for internal termination  $R_T$   
Power ( $R_T$ )<sub>MAX</sub> =  $(V_{IN\_MAX})^2 / R_{T\_MIN} = (1.2V)^2 / 80\Omega = 18mW$

**Total Power**<sub>MAX</sub> (3.3V, with all outputs switching) =  $155.925mW + 131.76mW + 18mW = 305.685mW$

### 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 74.7°C/W per Table 6 below.

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

$85^\circ C + 0.306W * 74.7^\circ C/W = 107.9^\circ C$ . This is well below the limit of 125°C.

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

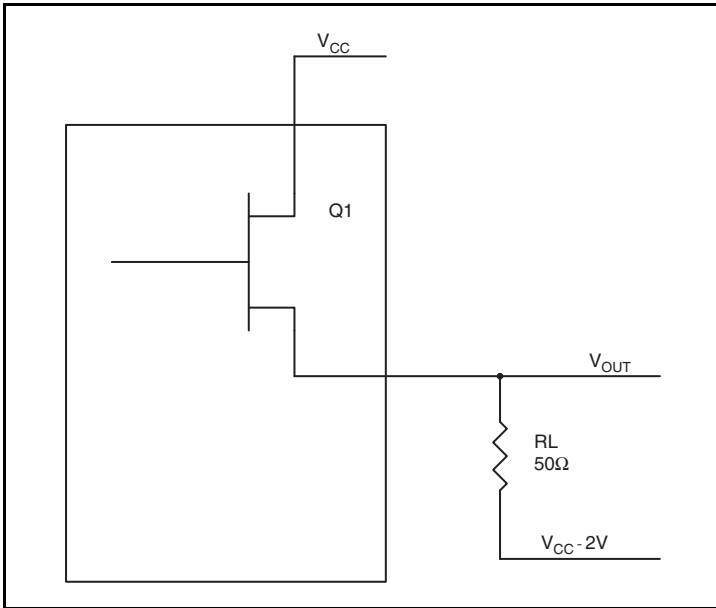
**Table 6. Thermal Resistance  $\theta_{JA}$  for 16 Lead VFQFN, Forced Convection**

Meters per Second	$\theta_{JA}$ by Velocity		
	0	1	2.5
Multi-Layer PCB, JEDEC Standard Test Boards	74.7°C/W	65.3°C/W	58.5°C/W

### 3. Calculations and Equations.

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

The LVPECL output driver circuit and termination are shown in *Figure 8*.



**Figure 8. LVPECL Driver Circuit and Termination**

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

- For logic high,  $V_{OUT} = V_{OH\_MAX} = V_{CC\_MAX} - 0.85V$   
 $(V_{CC\_MAX} - V_{OH\_MAX}) = 0.85V$
- For logic low,  $V_{OUT} = V_{OL\_MAX} = V_{CC\_MAX} - 1.575V$   
 $(V_{CC\_MAX} - V_{OL\_MAX}) = 1.575V$

$Pd\_H$  is power dissipation when the output drives high.

$Pd\_L$  is the power dissipation when the output drives low.

$$Pd\_H = [(V_{OH\_MAX} - (V_{CC\_MAX} - 2V))/R_L] * (V_{CC\_MAX} - V_{OH\_MAX}) = [(2V - (V_{CC\_MAX} - V_{OH\_MAX}))/R_L] * (V_{CC\_MAX} - V_{OH\_MAX}) = [(2V - 0.85V)/50\Omega] * 0.85V = \mathbf{19.55mW}$$

$$Pd\_L = [(V_{OL\_MAX} - (V_{CC\_MAX} - 2V))/R_L] * (V_{CC\_MAX} - V_{OL\_MAX}) = [(2V - (V_{CC\_MAX} - V_{OL\_MAX}))/R_L] * (V_{CC\_MAX} - V_{OL\_MAX}) = [(2V - 1.575V)/50\Omega] * 1.575V = \mathbf{13.39mW}$$

Total Power Dissipation per output pair =  $Pd\_H + Pd\_L = \mathbf{32.94mW}$



## Reliability Information

**Table 7.  $\theta_{JA}$  vs. Air Flow Table for a 16 Lead VFQFN**

$\theta_{JA}$ by Velocity			
Meters per Second	0	1	2.5
Multi-Layer PCB, JEDEC Standard Test Boards	74.7°C/W	65.3°C/W	58.5°C/W

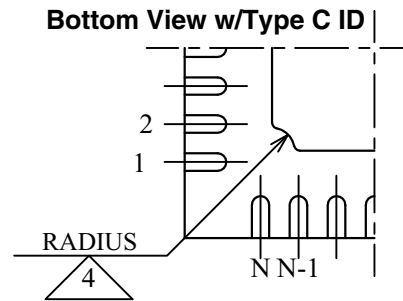
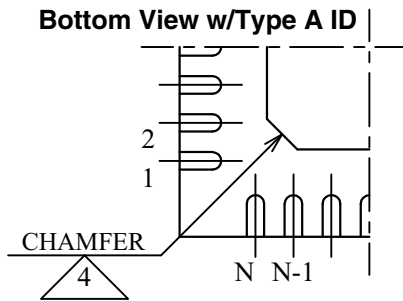
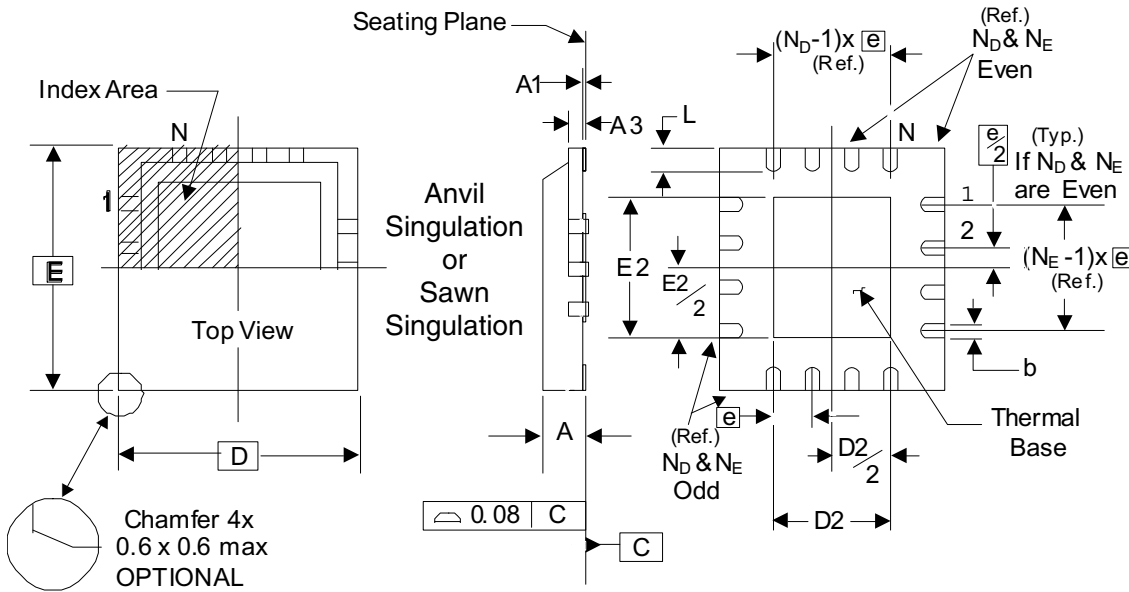
## Transistor Count

The transistor count for 8S89831I is: 328

This device is pin and function compatible and a suggested replacement for 889831.

# Package Outline and Package Dimensions

## Package Outline - K Suffix for 16 Lead VFQFN



- 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 8. Package Dimensions**

JEDEC Variation: VEED-2/-4 All Dimensions in Millimeters		
Symbol	Minimum	Maximum
N	16	
A	0.80	1.00
A1	0	0.05
A3	0.25 Ref.	
b	0.18	0.30
N <sub>D</sub> & N <sub>E</sub>	4	
D & E	3.00 Basic	
D2 & E2	1.00	1.80
e	0.50 Basic	
L	0.30	0.50

Reference Document: JEDEC Publication 95, MO-220

## Ordering Information

Table 9. Ordering Information

Part/Order Number	Marking	Package	Shipping Packaging	Temperature
8S89831AKILF	831A	"Lead-Free" 16 Lead VFQFN	Tube	-40°C to 85°C
8S89831AKILFT	831A	"Lead-Free" 16 Lead VFQFN	Tape & Reel	-40°C to 85°C

## Revision History Sheet

Rev	Table	Page	Description of Change	Date
A		11	Deleted <i>Differential Input with Built-in 50Ω Termination Unused Input Handling</i> application section. This section does not apply when there is only one input.	4/22/10
		15	Power Considerations - in Power Dissipation section, corrected Power (RT) calculation. Calculation = 18mW from 98mW. Total Power and Junction Temperature calculations have also been updated.	
A	T9	1 19	Removed ICS from part numbers where needed. General Description - Deleted ICS chip. Ordering Information - Deleted quantity in tape in reel. Deleted LF note below table. Updated header and footer.	1/27/16



Corporate Headquarters  
6024 Silver Creek Valley Road  
San Jose, CA 95138 USA  
[www.IDT.com](http://www.IDT.com)

Sales  
1-800-345-7015 or 408-284-8200  
Fax: 408-284-2775  
[www.IDT.com/go/sales](http://www.IDT.com/go/sales)

Tech Support  
[www.idt.com/go/support](http://www.idt.com/go/support)

DISCLAIMER Integrated Device Technology, Inc. (IDT) reserves the right to modify the products and/or specifications described herein at any time, without notice, at IDT's sole discretion. Performance specifications and operating parameters of the described products are determined in an independent state and are not guaranteed to perform the same way when installed in customer products. The information contained herein is provided without representation or warranty of any kind, whether express or implied, including, but not limited to, the suitability of IDT's products for any particular purpose, an implied warranty of merchantability, or non-infringement of the intellectual property rights of others. This document is presented only as a guide and does not convey any license under intellectual property rights of IDT or any third parties.

IDT's products are not intended for use in applications involving extreme environmental conditions or in life support systems or similar devices where the failure or malfunction of an IDT product can be reasonably expected to significantly affect the health or safety of users. Anyone using an IDT product in such a manner does so at their own risk, absent an express, written agreement by IDT.

Integrated Device Technology, IDT and the IDT logo are trademarks or registered trademarks of IDT and its subsidiaries in the United States and other countries. Other trademarks used herein are the property of IDT or their respective third party owners.

For datasheet type definitions and a glossary of common terms, visit [www.idt.com/go/glossary](http://www.idt.com/go/glossary).

Copyright ©2016 Integrated Device Technology, Inc. All rights reserved.