Description

The 8S89296 is a high performance LVDS programmable delay line. The delay can vary from 2.2ns to 12.5ns in 10ps steps. The 8S89296 is characterized to operate from a 2.5V power supply and is guaranteed over industrial temperature range.

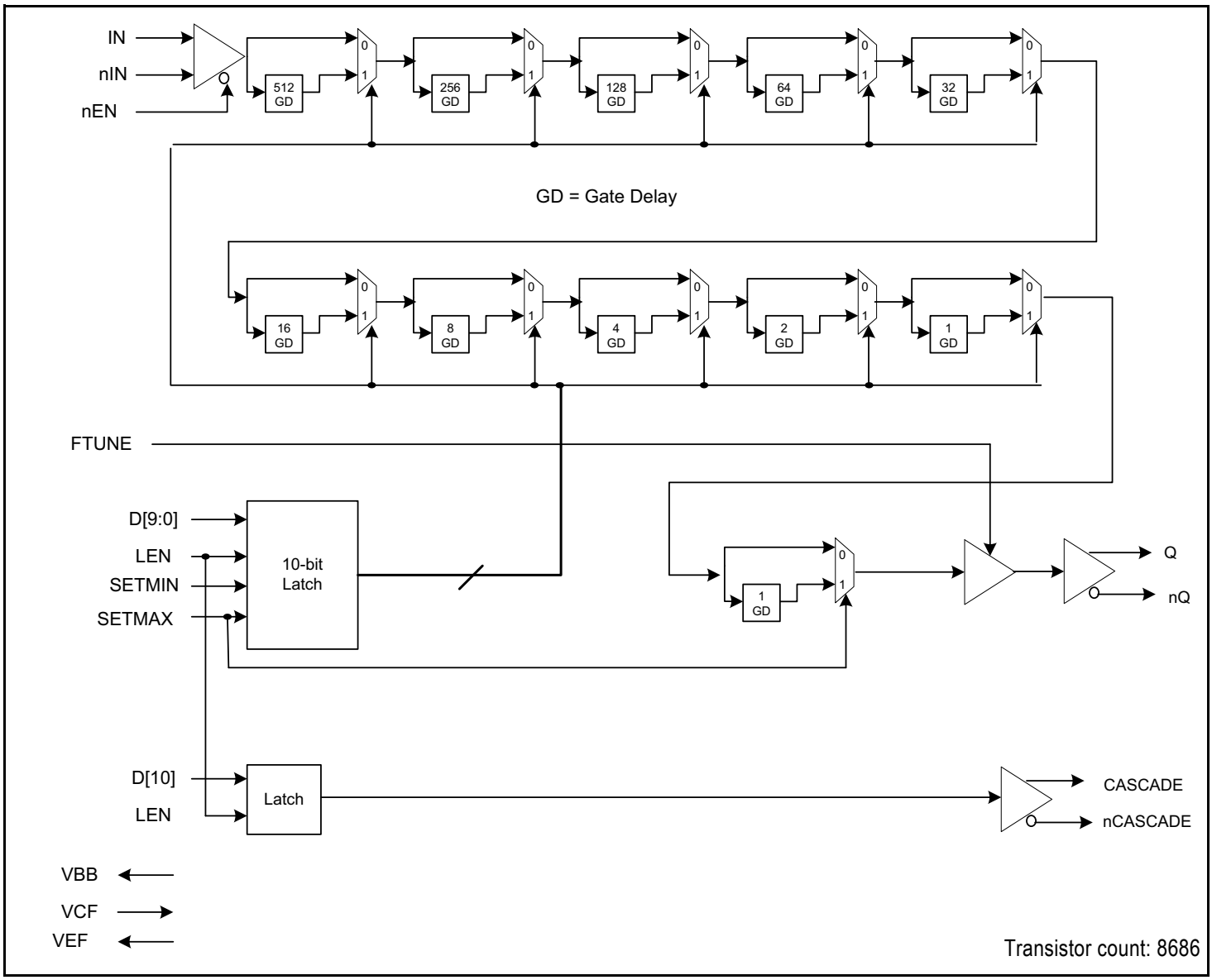
The delay of the device varies in discrete steps based on a control word. A 10-bit long control word sets the delay in 10ps increments. Also, the input pins IN and nIN default to an equivalent low state when left floating. The control register can accept CMOS or TTL level signals.

Features

- One LVDS level output
- One differential clock input pair
- Differential input clock (IN, nIN) can accept the following signaling levels: LVPECL, LVDS, CML
- Maximum frequency: 800MHz
- Programmable Delay Range: 2.2ns to 12.5ns in 10ps steps
- D[10:0] can accept LVPECL, LVCMOS or LVTTL levels
- Full 2.5V supply voltages
- -40°C to 85°C ambient operating temperature
- Available in lead-free (RoHS 6) package

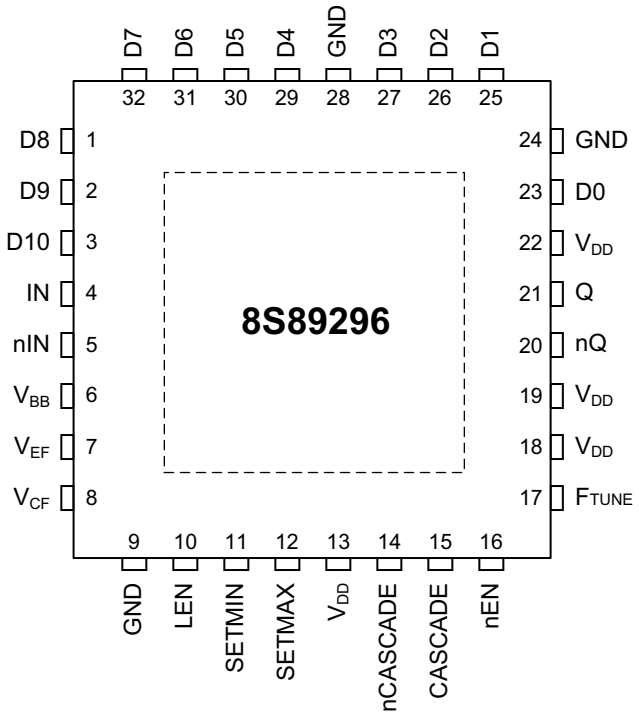
Block Diagram

Figure 1: Block Diagram



Pin Assignments

Figure 2: Pin Assignments for 5mm x 5mm 32-Lead Package



Pin Description and Pin Characteristic Tables

Table 1: Pin Descriptions

Number	Name	Type[a]	Description
1	D8	Input (PD)	Parallel data input D8. Single-ended LVCMOS, LVTTL, LVPECL interface levels.
2	D9	Input (PD)	Parallel data input D9. Single-ended LVCMOS, LVTTL, LVPECL interface levels.
3	D10	Input (PD)	Parallel data input D10. Single-ended LVCMOS, LVTTL, LVPECL interface levels.
4	IN	Input (PD)	Non-inverting differential input.
5	nIN	Input (PU/ PD)	Inverting differential input.
6	V_{BB}	Output	Reference voltage output. This pin can be used to re-bias AC-coupled inputs to IN and nIN. When used, de-couple to V_{DD} using a 0.01µF capacitor. If not used, leave floating.
7	V_{EF}	Output	Reference voltage output. See Table 4.
8	V_{CF}	Input	Reference voltage input. The voltage driven on V_{CF} sets the logic transition threshold for D[10:0].
9	GND	Power	Power supply ground.
10	LEN	Input (PD)	D inputs LOAD and HOLD control input. When HIGH, latches the D[10:0] bits. When LOW, the D[10:0] latches are transparent. Single-ended LVPECL interface levels. See Table 3.

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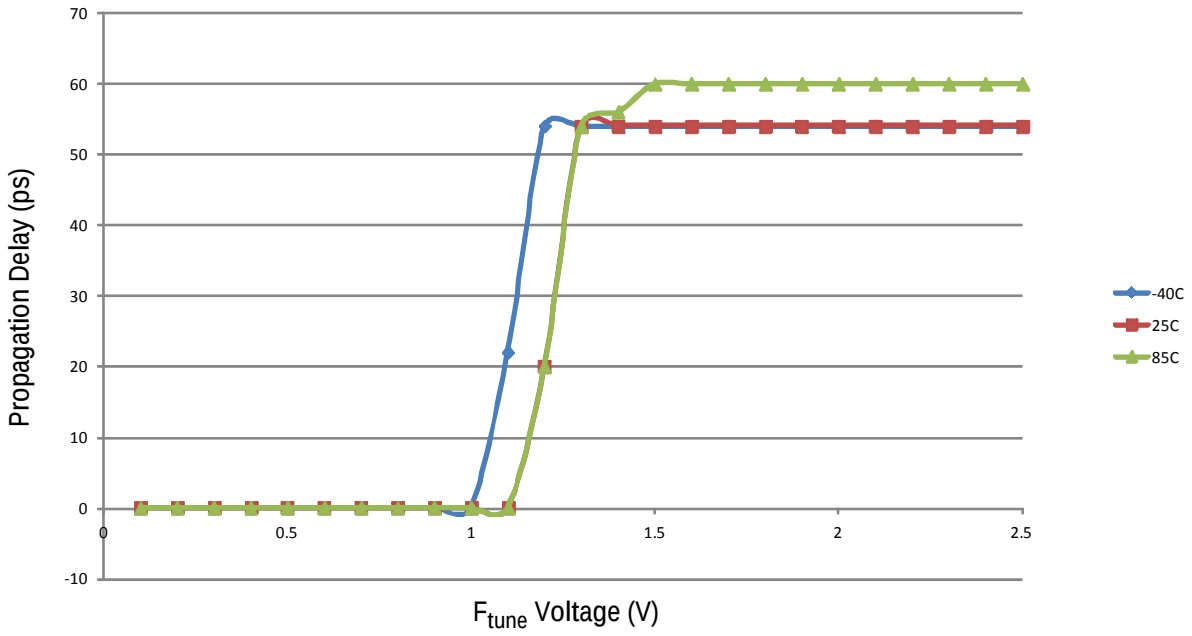
Table 1: Pin Descriptions

Number	Name	Type[a]	Description
11	SETMIN	Input (PD)	Minimum delay set logic input. When HIGH, D[10:0] registers are reset. When LOW, the delay is set by SETMAX or D[10:0]. Default is LOW when left floating. Single-ended LVPECL interface levels. See Table 5.
12	SETMAX	Input (PD)	Maximum delay set logic input. When SETMAX is set HIGH and SETMIN is set LOW, D[10:0] = 1111111111. When SETMAX is LOW, the delay is set by SETMIN or D[10:0]. Default is LOW when left floating. Single-ended LVPECL interface levels. See Table 5.
13	V_{DD}	Power	Positive supply pin.
14	nCASCADE	Output	LVDS inverted output.
15	CASCADE	Output	LVDS non-inverted output.
16	nEN	Input (PD)	Single-ended control enable pin. When LOW, Q is delayed from IN. When HIGH, Q is a differential LOW. Default is LOW when left floating. Single-ended LVPECL interface levels. See Table 2.
17	F_{TUNE}	Analog Input	Fine tune delay control input. By varying the input voltage, it provides an additional delay.
18	V_{DD}	Power	Positive supply pin.
19	V_{DD}	Power	Positive supply pin.
20	nQ	Output	Differential output pair. LVDS interface levels.
21	Q	Output	Differential output pair. LVDS interface levels.
22	V_{DD}	Power	Positive supply pin.
23	D0	Input (PD)	Parallel data input D0. Single-ended LVCMOS, LVTTL, LVPECL interface levels.
24	GND	Power	Power supply ground.
25	D1	Input (PD)	Parallel data input D1. Single-ended LVCMOS, LVTTL, LVPECL interface levels.
26	D2	Input (PD)	Parallel data input D2. Single-ended LVCMOS, LVTTL, LVPECL interface levels.
27	D3	Input (PD)	Parallel data input D3. Single-ended LVCMOS, LVTTL, LVPECL interface levels.
28	GND	Power	Power supply ground.
29	D4	Input (PD)	Parallel data input D4. Single-ended LVCMOS, LVTTL, LVPECL interface levels.
30	D5	Input (PD)	Parallel data input D5. Single-ended LVCMOS, LVTTL, LVPECL interface levels.
31	D6	Input (PD)	Parallel data input D6. Single-ended LVCMOS, LVTTL, LVPECL interface levels.
32	D7	Input (PD)	Parallel data input D7. Single-ended LVCMOS, LVTTL, LVPECL interface levels.

a. Pull-up (PU) and pull-down (PD) resistors are indicated in parentheses. *Pullup and Pulldown* refer to internal input resistors. See Table 7, *Pin Characteristics,* for typical values.

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Figure 3: Propagation Delay vs. F_{TUNE} Voltage Graph



Function Tables

Table 2: Delay Enable

nEN	Q, nQ
0 (default)	IN, nIN delayed
1	Q = LOW, nQ = HIGH

Table 3: Digital Control Latch

LEN	Latch Action
0 (default)	Pass through D[10:0]
1	Latched D[10:0]

Table 4: V_{CF} Connection for D[10:0] Logic Interface

Input	V_{CF} Connection	D[10:0] Logic Interface
V_{CF}	V_{EF}[a]	LVPECL
V_{CF}	No Connect	LVCMOS
V_{CF}	1.5V source	LVTTL

a. Connect V_{CF} (pin 8) to V_{EF} (pin 7).

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Table 5: Theoretical Delta Delay Values[a]

D[9:0] Value	SETMIN	SETMAX	Programmable Delay[b] (ps)
XXXXXXXXXX	H	L	0
0000000000	L	L	0 (default)
0000000001	L	L	10
0000000010	L	L	20
0000000011	L	L	30
0000000100	L	L	40
0000000101	L	L	50
0000000110	L	L	60
0000000111	L	L	70
0000001000	L	L	80
0000010000	L	L	160
0000100000	L	L	320
0001000000	L	L	640
0010000000	L	L	1280
0100000000	L	L	2560
1000000000	L	L	5120
1111111111	L	L	10230
XXXXXXXXXX	L	H	10240

a. Refer to Table 13, *AC Characteristics*, for typical step delay values.

b. Inherent propagation delay not included.
Propagation delay = inherent propagation delay + programmable delay.
Inherent Propagation delay equals the propagation delay with the programmable delay = 0ps.

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Absolute Maximum Ratings

The absolute maximum ratings are stress ratings only. Stresses greater than those listed below can cause permanent damage to the device. Functional operation of the 8S89296 at absolute maximum ratings is not implied. Exposure to absolute maximum rating conditions may affect device reliability.

Table 6: Absolute Maximum Ratings Table

Item	Rating
Supply voltage, V_{DD}	4.6V
Inputs, V_I	-0.5V to V_{DD} + 0.5V
Outputs, I_O (LVDS) Continuous current Surge current	 10mA 15mA
Junction temperature, T_J	125°C
Storage temperature, T_{STG}	-65°C to 150°C

DC Electrical Characteristics

Table 7: DC Input Characteristics

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
C_{IN}	Input capacitance			2		pF
R_{PULLUP}	Input pull-up resistor			50		kΩ
$R_{PULLDOWN}$	Input pull-down resistor			50		kΩ

Table 8: Power Supply DC Characteristics, V_{DD} = 2.5V ± 5%, T_A = -40°C to 85°C

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
V_{DD}	Positive supply voltage		2.375	2.5	2.625	V
I_{DD}	Power supply current	No load, maximum V_{DD}			158	mA

Table 9: LVCMOS/LVTTL DC Characteristics, V_{DD} = 2.5V ± 5%, T_A = -40°C to 85°C

Symbol	Parameter		Test Conditions	Minimum	Typical	Maximum	Units
V_{IH}	Input high voltage			1.7		V_{DD} + 0.3	V
V_{IL}	Input low voltage			-0.3		0.7	V
I_{IH}	Input high current	D[10:0]	V_{DD} = V_{IN} = 2.625V			150	µA
I_{IL}	Input low current	D[10:0]	V_{DD} = 2.625V, V_{IN} = 0V	-10			µA

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Table 10: LVPECL Differential DC Characteristics, V_{DD} = 2.5V ± 5%, GND = 0V, T_A = -40°C to 85°C

Symbol	Parameter		Test Conditions	Minimum	Typical	Maximum	Units
I_{IH}	Input high current	IN, nIN	V_{DD} = V_{IN} = 2.625V			150	µA
I_{IL}	Input low current	IN	V_{DD} = 2.625V, V_{IN} = 0V	-10			µA
		nIN	V_{DD} = 2.625V, V_{IN} = 0V	-150			µA
V_{PP}	Peak-to-peak voltage			0.15		1.3	V
V_{CMR}	Common mode range[a]			GND + 0.95		V_{DD}	V
V_{BB}	Output voltage reference		I_{BB} = +150µA	V_{DD} – 1.55	V_{DD} – 1.35	V_{DD} – 1.15	V
V_{EF}	Mode connection		I_{EF} = +150µA	V_{DD} – 1.55	V_{DD} – 1.35	V_{DD} – 1.15	V

a. Common mode input voltage is defined as V_{IH}.

Table 11: LVPECL Single-Ended DC Characteristics, V_{DD} = 2.5V ± 5%, GND = 0V, T_A = -40°C to 85°C

Symbol	Parameter		Test Conditions	Minimum	Typical	Maximum	Units
V_{IH}	Input high voltage[a]	D[10:0], LEN, nEN, SETMIN, SETMAX		V_{DD} – 1.2		V_{DD} – 0.940	V
V_{IL}	Input low voltage[a]	D[10:0], LEN, nEN, SETMIN, SETMAX		V_{DD} – 1.870		V_{DD} – 1.45	V
I_{IH}	Input high current	D[10:0], LEN, nEN, SETMIN, SETMAX	V_{DD} = V_{IN} = 2.625V			150	µA
I_{IL}	Input low current	D[10:0], LEN, nEN, SETMIN, SETMAX	V_{DD} = 2.625V, V_{IN} = 0V	-10			µA

a. To enable LVPECL interface levels on pins D[10:0], pin 7 must be connected to pin 8. See Table 4.

Table 12: LVDS DC Characteristics, V_{DD} = 2.5V ± 5%, T_A = -40°C to 85°C

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
V_{OD}	Differential output voltage		350		650	mV
ΔV_{OD}	V_{OD} magnitude change				50	mV
V_{OS}	Offset voltage		1.10		1.30	V
ΔV_{OS}	V_{OS} magnitude change				50	mV

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AC Electrical Characteristics

Table 13: AC Characteristics, V_{DD} = 2.5V ± 5%, T_A = -40°C to 85°C[a], [b]

Symbol	Parameter		Test Conditions	Minimum	Typical	Maximum	Units
f_{OUT}	Output frequency	Q, nQ output				800	MHz
t_{PD}	Propagation delay	IN to Q, nQ	Dx = 0	1700	2200	2700	ps
		IN to Q, nQ	Dx = 1023	9500	12500	15000	ps
		nEN to Q, nQ	Dx = 0	1700	2400	3200	ps
t_{PD_RANGE}	Programmable propagation range		$t_{PD_MAX} - t_{PD_MIN}$	8000			ps
Δt	Step Delay		D0 = HIGH		15		ps
			D1 = HIGH		25		ps
			D2 = HIGH		45		ps
			D3 = HIGH		85		ps
			D4 = HIGH		165		ps
			D5 = HIGH		330		ps
			D6 = HIGH		645		ps
			D7 = HIGH		1270		ps
			D8 = HIGH		2540		ps
			D9 = HIGH		5075		ps
			D[9:0] = HIGH		10135		ps
INL	Integral non-linearity[c]				±10		ps
t_S	Setup time	D to LEN			-20		ps
		D to IN, nIN			-80		ps
		nEN to IN, IN			-35		ps
t_H	Hold time	LEN to D			-175		ps
		IN, nIN to nEN			-575		ps
t_R	Release time	nEN to IN, nIN			250		ps
		SETMAX to LEN			225		ps
		SETMIN to LEN			240		ps
t_R / t_F	Output rise/fall time	Q, nQ	20% to 80% at 100MHz	70		300	ps
odc	Output duty cycle			40		60	%

a. Characterized up to f_{OUT} = 800MHz unless noted otherwise.

b. 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 500lfpm. The device will meet specifications after thermal equilibrium has been reached under these conditions.

c. Deviation from a linear delay (actual Min. to Max.) in the 1024 programmable steps.

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Applications Information

Recommendations for Unused Input Pins

Inputs:

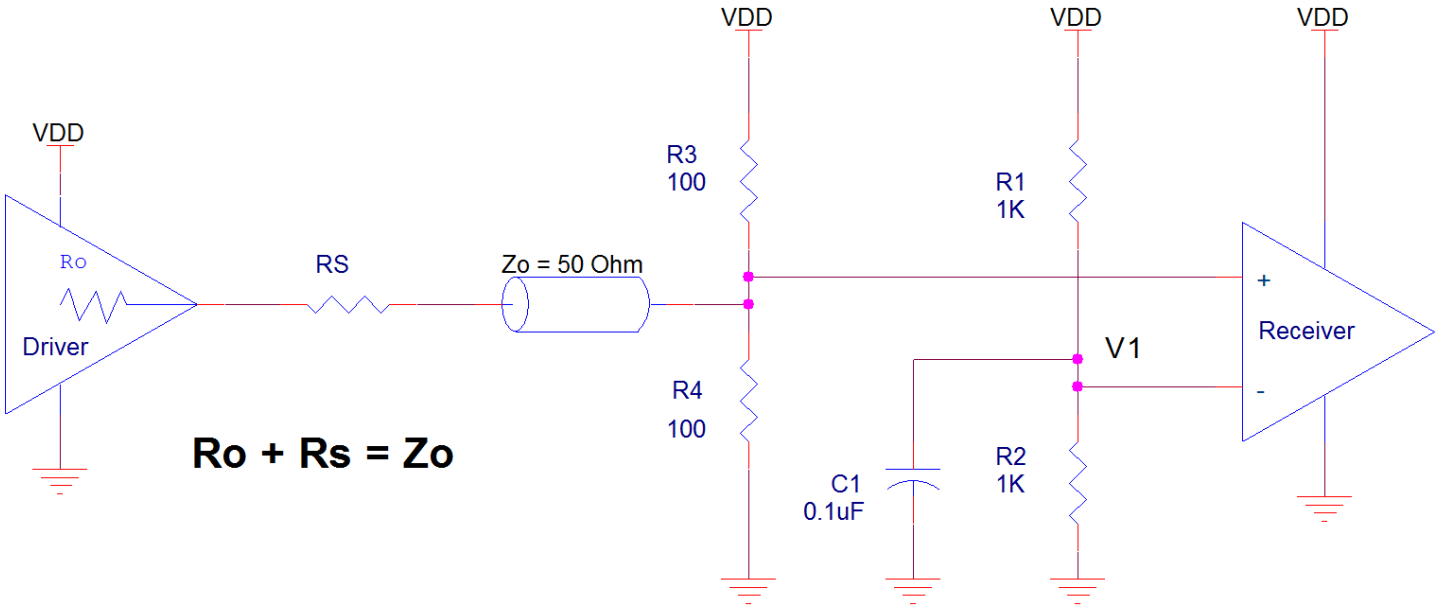
LVCMOS Control Pins

All control pins have internal pulldown resistors; additional resistance is not required but can be added for additional protection. A 1kΩ resistor can be used.

Wiring the Differential Input to Accept Single-Ended Levels

Figure 4 shows how a differential input can be wired to accept single ended levels. The reference voltage $V_{REF} = V_{DD}/2$ is generated by the bias resistors R1 and R2. The bypass capacitor (C1) is used to help filter noise on the DC bias. This bias circuit should be located as close to the input pin as possible. The ratio of R1 and R2 might need to be adjusted to position the V_{REF} in the center of the input voltage swing. For example, if the input clock swing is 2.5V and V_{DD} = 3.3V, R1 and R2 value should be adjusted to set V_{REF} at 1.25V. The values below are for when both the single ended swing and V_{DD} are at the same voltage. This configuration requires that the sum of the output impedance of the driver (Ro) and the series resistance (Rs) equals the transmission line impedance. In addition, matched termination at the input will attenuate the signal in half. This can be done in one of two ways. First, R3 and R4 in parallel should equal the transmission line impedance. For most 50Ω applications, R3 and R4 can be 100Ω. The values of the resistors can be increased to reduce the loading for slower and weaker LVCMOS driver. When using single-ended signaling, the noise rejection benefits of differential signaling are reduced. Even though the differential input can handle full rail LVCMOS signaling, it is recommended that the amplitude be reduced. The datasheet specifies a lower differential amplitude, however this only applies to differential signals. For single-ended applications, the swing can be larger, however V_{IL} cannot be less than -0.3V and V_{IH} cannot be more than V_{DD} +0.3V. Suggest edge rate faster than 1V/ns. Though some of the recommended components might not be used, the pads should be placed in the layout. They can be utilized for debugging purposes. The datasheet specifications are characterized and guaranteed by using a differential signal.

Figure 4: Recommended Schematic for Wiring a Differential Input to Accept Single-ended Levels



2.5V LVPECL Clock Input Interface

The IN/nIN accepts LVPECL, LVDS, CML and other differential signals. Both differential signals must meet the V_{PP} and V_{CMR} input requirements. *Figure 5 to Figure 9* show interface examples for the IN/nIN 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 5. IN/nIN Input Driven by a CML Driver

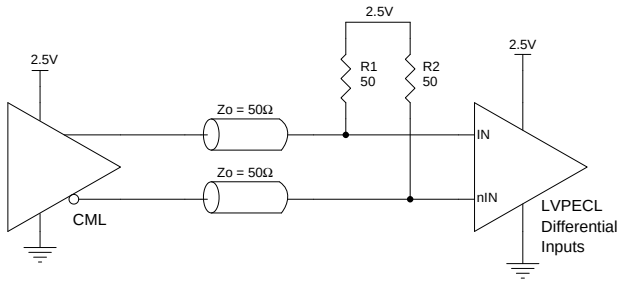


Figure 6. ON/nIN Input Driven by a 2.5V LVPECL Driver

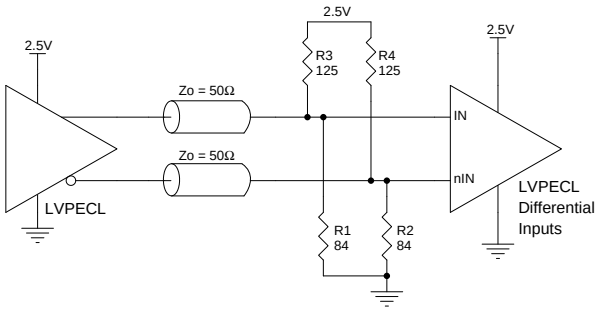


Figure 7. IN/nIN Input Driven by a 2.5V LVDS Driver

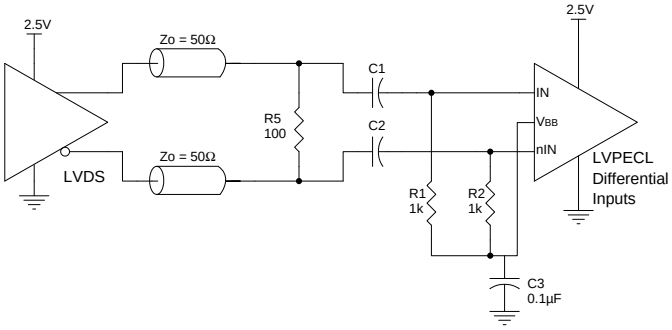


Figure 8. IN/nIN Input Driven by a Built-In Pullup CML Driver

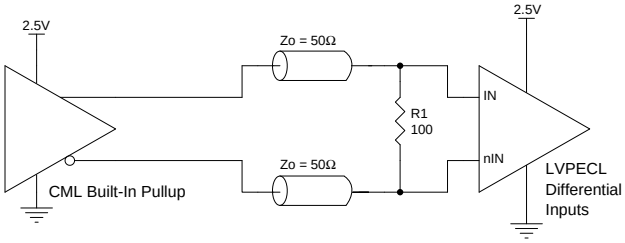
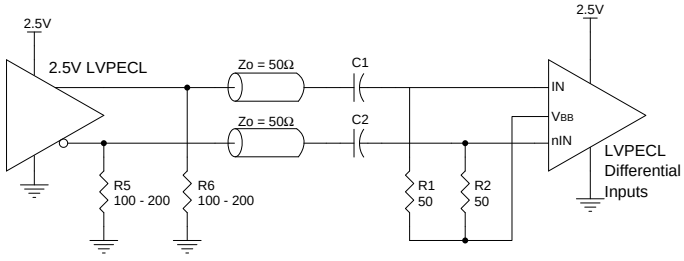


Figure 9. IN/nIN Input Driven by a 2.5V LVPECL Driver with AC Couple

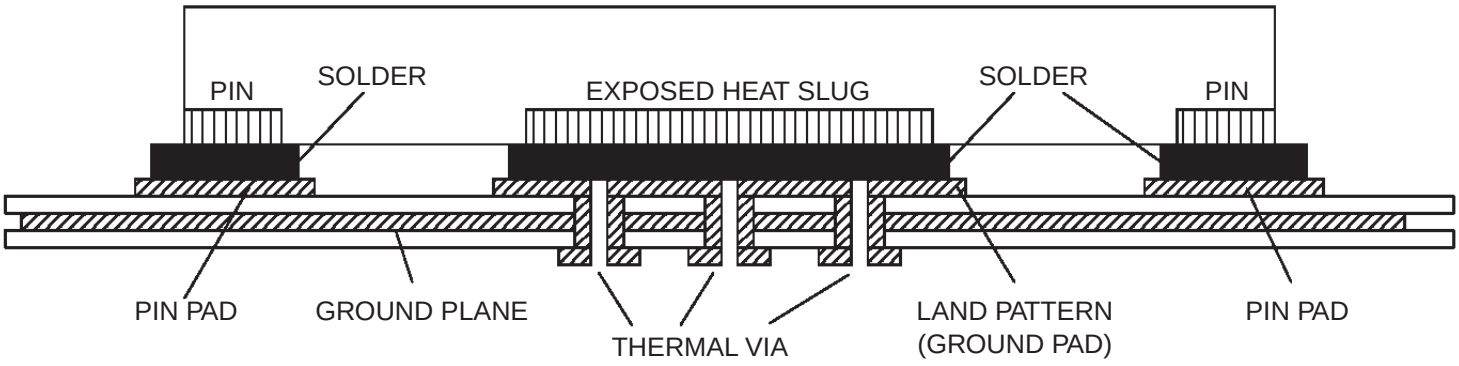


VFQFN EPAD Thermal Release Path

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 10*. 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 Lead-frame Base Package, Amkor Technology.

Figure 10: P.C. Assembly for Exposed Pad Thermal Release Path – Side View (drawing not to scale)



LVDS Driver Termination

For a general LVDS interface, the recommended value for the termination impedance (Z_T) is between 90Ω and 132Ω. The actual value should be selected to match the differential impedance (Z_0) of your transmission line. A typical point-to-point LVDS design uses a 100Ω parallel resistor at the receiver and a 100Ω differential transmission-line environment. In order to avoid any transmission-line reflection issues, the components should be surface mounted and must be placed as close to the receiver as possible. IDT offers a full line of LVDS compliant devices with two types of output structures: current source and voltage source. The standard termination schematic as shown in *Figure 11* can be used with either type of output structure. *Figure 12*, which can also be used with both output types, is an optional termination with center tap capacitance to help filter common mode noise. The capacitor value should be approximately 50pF. If using a non-standard termination, it is recommended to contact IDT and confirm if the output structure is current source or voltage source type. In addition, since these outputs are LVDS compatible, the input receiver's amplitude and common-mode input range should be verified for compatibility with the output.

Figure 11: Standard LVDS Termination

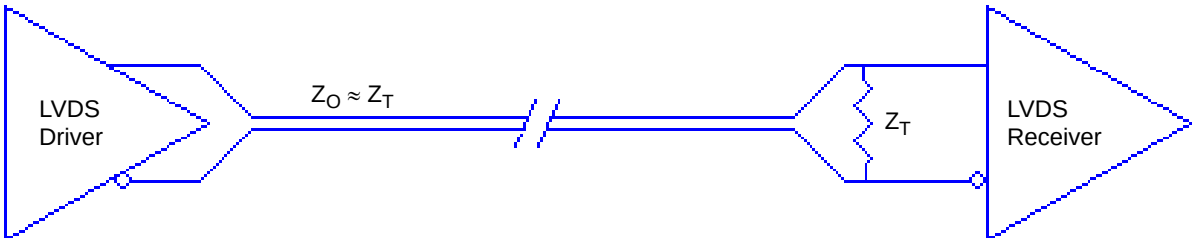
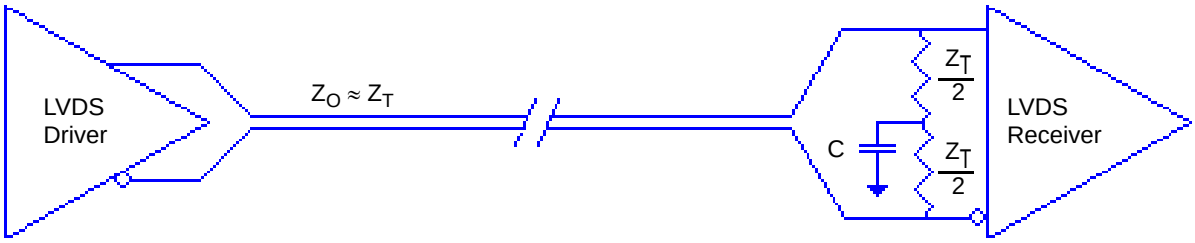


Figure 12: Optional LVDS Termination



Power Considerations

This section provides information on power dissipation and junction temperature for the 8S89296.
Equations and example calculations are also provided.

1. Power Dissipation.

The total power dissipation for the 8S89296 is the sum of the core power plus the power dissipated in the load(s).
The following is the power dissipation for V_{DD} = 2.5V + 0.125V = 2.625V, which gives worst case results.

The maximum current at -40°C is as follows:
I_{DD_MAX} = 158mA

- $Power_{_MAX} = V_{DD_MAX} * I_{DD_MAX}$ = 2.625V * 158mA = 415mW

The maximum current at 85°C is as follows:
I_{DD_MAX} = 150mA
$Power_{_MAX} = V_{DD_MAX} * I_{DD_MAX}$ = 2.625V * 150mA = 394mW

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, Tj, to 125°C ensures that the bond wire and bond pad temperature remains below 125°C.

The equation for T_J is as follows: $Tj = \theta_{JA} * Pd_total + T_A$

T_J = Junction Temperature

θ_{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 θ_{JA} must be used. Assuming no air flow and a multi-layer board, the appropriate value is 39.5°C/W per Table 14 below.

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

85°C + 0.394W * 39.5°C/W = 100.6°C. This is below the limit of 125°C.

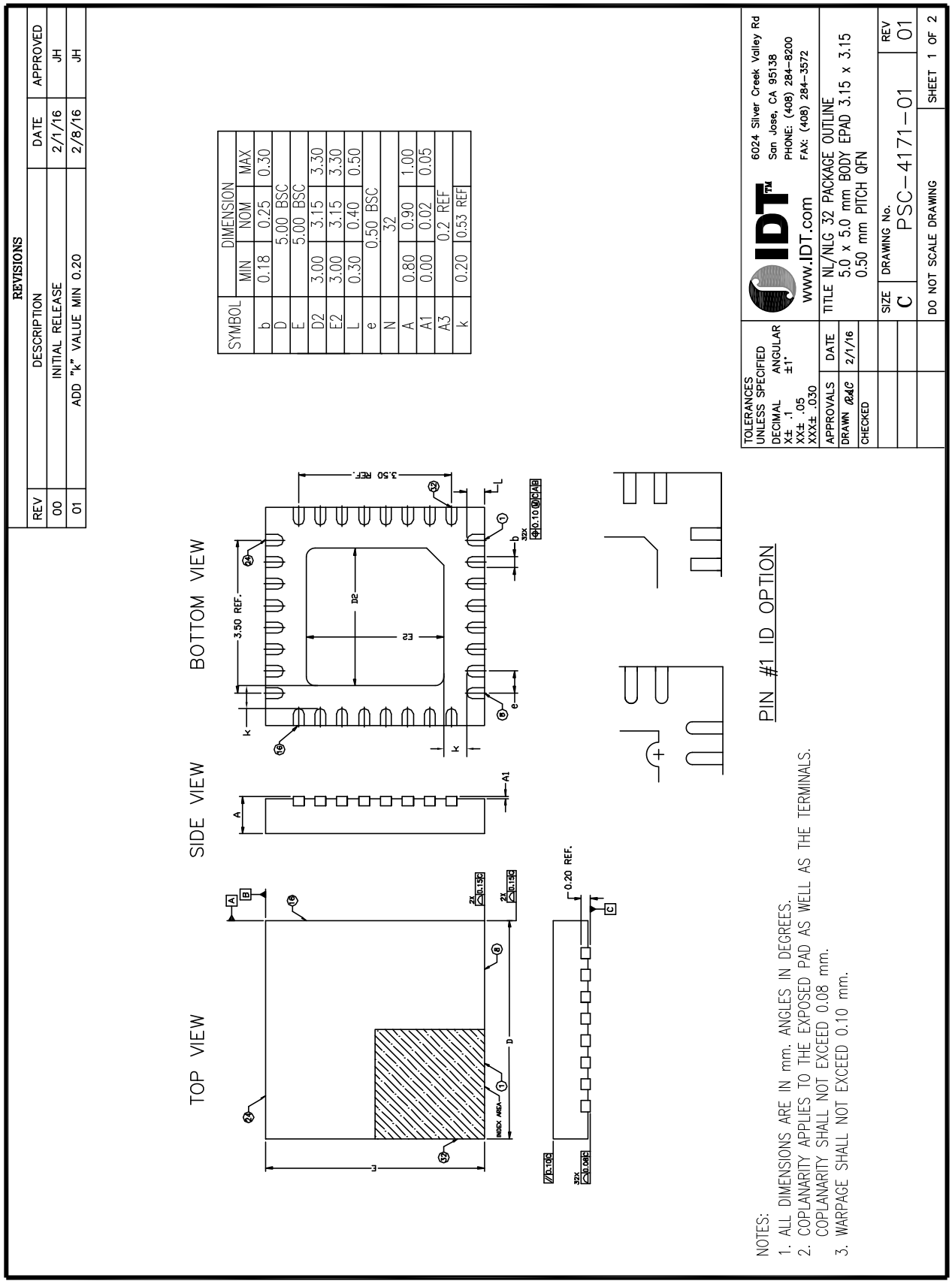
This calculation is only an example. T_J will obviously vary depending on the number of loaded outputs, supply voltage, air flow and the type of board (multi-layer).

Table 14: Thermal Resistance θ_{JA} for 32 Lead VFQFN, Forced Convection

θ_{JA} by Velocity			
Meters per Second	0	1	2.5
Multi-Layer PCB, JEDEC Standard Test Boards	39.5°C/W	34.5°C/W	31.0°C/W

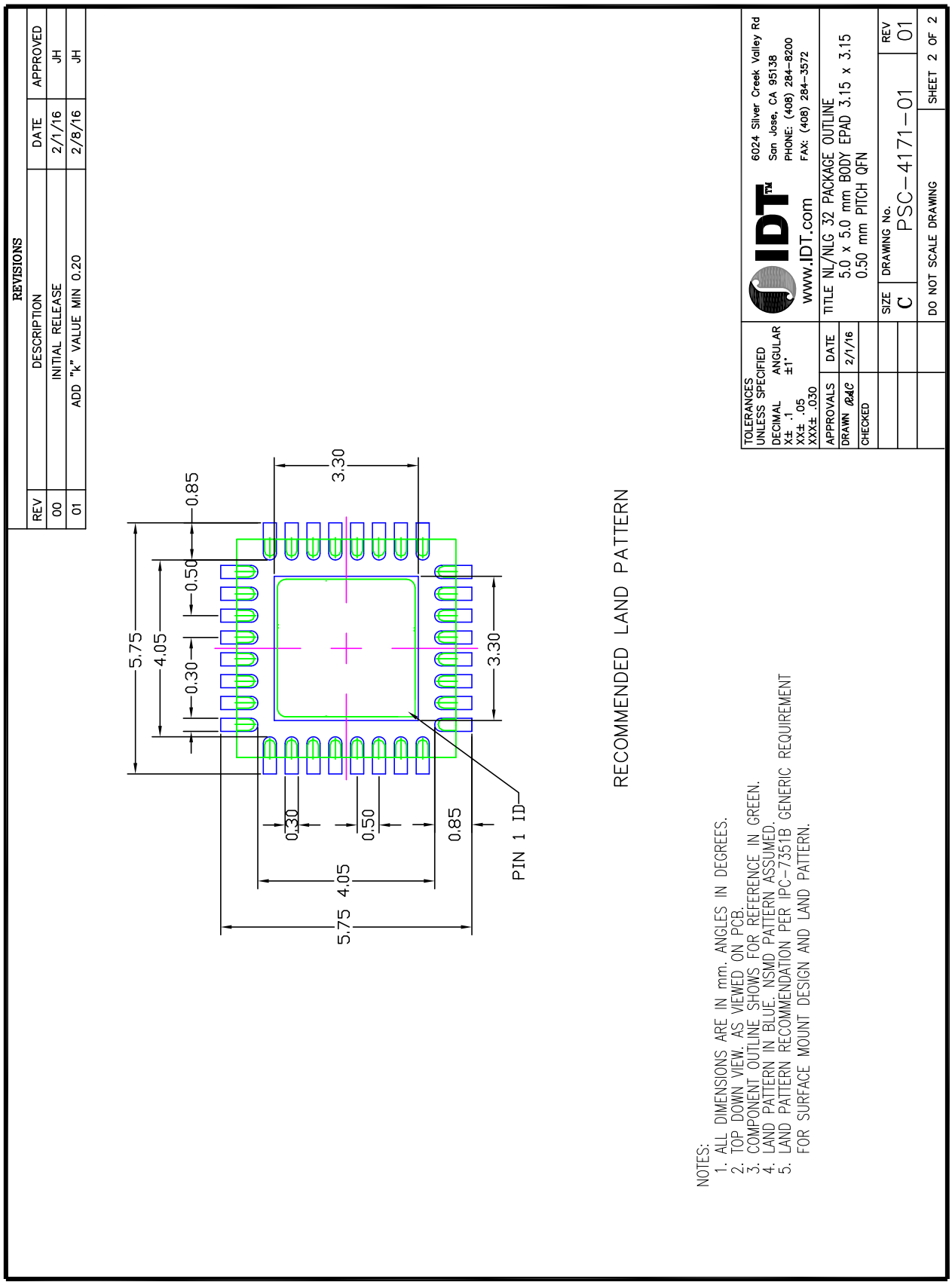
Package Outline and Package Dimensions

Figure 13: 32-Lead VFQFN Package

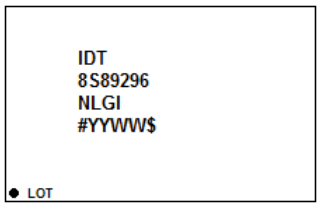


Package Outline and Package Dimensions, continued

Figure 14: 32-Lead VFQFN Package



Marking Diagram



1. Line 1 IDT is the part number prefix.
2. Line 2 is the part number.
3. Line 3 is the package code.
4. Line 4:
   # denotes stepping.
   “YWW” is the last digit of the year and week that the part was assembled.
   “$” denotes mark code.

Ordering Information

Part/Order Number	Marking	Package	Shipping Packaging	Temperature
8S89296NLGI	IDT8S89296NLGI	32 Lead VFQFN, lead-free	Tray	-40°C to +85°C
8S89296NLGI8	IDT8S89296NLGI	32 Lead VFQFN, lead-free	Tape & Reel	-40°C to +85°C

Revision History

Revision Date	Description of Change
February 14, 2017	Initial datasheet.

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Corporate Headquarters

TOYOSU FORESIA, 3-2-24 Toyosu,
Koto-ku, Tokyo 135-0061, Japan
www.renesas.com

Contact Information

For further information on a product, technology, the most up-to-date version of a document, or your nearest sales office, please visit:
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