



## GENERAL DESCRIPTION

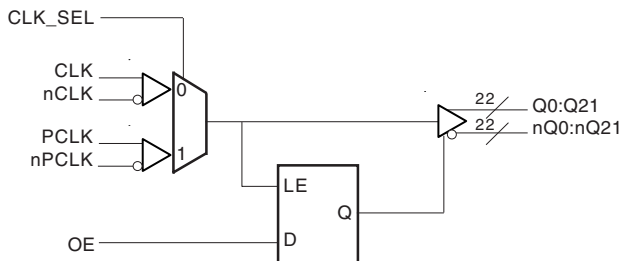


The ICS8524 is a low skew, 1-to-22 Differential-to-HSTL Fanout Buffer and a member of the HiPerClockS™ Family of High Performance Clock Solutions from ICS. The ICS8524 has two selectable clock inputs. The CLK, nCLK pair can accept most standard differential input levels. The PCLK, nPCLK pair can accept LVPECL, CML, or SSTL input levels. The device is internally synchronized to eliminate runt pulses on the outputs during asynchronous assertion/deassertion of the OE pin. The ICS8524's low output and part-to-part skew characteristics make it ideal for workstation, server, and other high performance clock distribution applications.

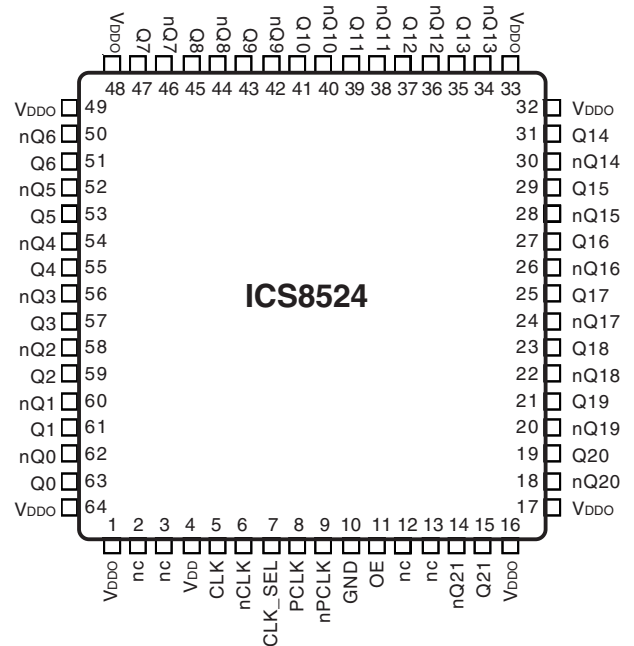
## FEATURES

- 22 differential HSTL outputs each with the ability to drive 50Ω to ground
- Selectable differential CLK, nCLK or LVPECL clock inputs
- CLK, nCLK pair can accept the following differential input levels: LVPECL, LVDS, HSTL, SSTL, HCSL
- PCLK, nPCLK supports the following input types: LVPECL, CML, SSTL
- Maximum output frequency: 500MHz
- Translates any single-ended input signal (LVCMOS, LVTTTL, GTL) to HSTL levels with resistor bias on nCLK input
- Output skew: 80ps (maximum)
- Part-to-part skew: 700ps (maximum)
- Jitter, RMS: 0.04ps (typical)
- LVPECL and HSTL mode operating voltage supply range:  $V_{DD} = 3.3V \pm 5\%$ ,  $V_{DDO} = 1.6V$  to  $2V$ ,  $GND = 0V$
- 0°C to 85°C ambient operating temperature
- Pin compatible with the SY89824L and NB100EP223

## BLOCK DIAGRAM



## PIN ASSIGNMENT



**64-Lead TQFP E-Pad**  
10mm x 10mm x 1.0mm package body  
**Y package**  
Top View



**TABLE 1. PIN DESCRIPTIONS**

Number	Name	Type		Description
1, 16, 17, 32, 33, 48, 49, 64	V <sub>DDO</sub>	Power		Output supply pins.
2, 3, 12, 13	nc	Unused		No connect.
4	V <sub>DD</sub>	Power		Core supply pin.
5	CLK	Input	Pulldown	Non-inverting differential clock input pair.
6	nCLK	Input	Pullup/ Pulldown	Inverting differential clock input pair. Biased to $\frac{2}{3} V_{CC}$ .
7	CLK_SEL	Input	Pullup	Clock select input. When HIGH, selects PCLK, nPCLK inputs. When LOW, selects CLK, nCLK inputs. LVCMOS / LVTTTL interface levels.
8	PCLK	Input	Pulldown	Non-inverting differential LVPECL clock input pair.
9	nPCLK	Input	Pullup/ Pulldown	Inverting differential LVPECL clock input pair. Biased to $\frac{2}{3} V_{CC}$ .
10	GND	Power		Power supply ground.
11	OE	Input	Pullup	Output enable. Controls enabling and disabling of outputs Q0:Q21, nQ0:nQ21. LVCMOS / LVTTTL interface levels.
14, 15	nQ21, Q21	Output		Differential clock outputs. HSTL interface levels.
18, 19	nQ20, Q20	Output		Differential clock outputs. HSTL interface levels.
20, 21	nQ19, Q19	Output		Differential clock outputs. HSTL interface levels.
22, 23	nQ18, Q18	Output		Differential clock outputs. HSTL interface levels.
24, 25	nQ17, Q17	Output		Differential clock outputs. HSTL interface levels.
26, 27	nQ16, Q16	Output		Differential clock outputs. HSTL interface levels.
28, 29	nQ15, Q15	Output		Differential clock outputs. HSTL interface levels.
30, 31	nQ14, Q14	Output		Differential clock outputs. HSTL interface levels.
34, 35	nQ13, Q13	Output		Differential clock outputs. HSTL interface levels.
36, 37	nQ12, Q12	Output		Differential clock outputs. HSTL interface levels.
38, 39	nQ11, Q11	Output		Differential clock outputs. HSTL interface levels.
40, 41	nQ10, Q10	Output		Differential clock outputs. HSTL interface levels.
42, 43	nQ9, Q9	Output		Differential clock outputs. HSTL interface levels.
44, 45	nQ8, Q8	Output		Differential clock outputs. HSTL interface levels.
46, 47	nQ7, Q7	Output		Differential clock outputs. HSTL interface levels.
50, 51	nQ6, Q6	Output		Differential clock outputs. HSTL interface levels.
52, 53	nQ5, Q5	Output		Differential clock outputs. HSTL interface levels.
54, 55	nQ4, Q4	Output		Differential clock outputs. HSTL interface levels.
56, 57	nQ3, Q3	Output		Differential clock outputs. HSTL interface levels.
58, 59	nQ2, Q2	Output		Differential clock outputs. HSTL interface levels.
60, 61	nQ1, Q1	Output		Differential clock outputs. HSTL interface levels.
62, 63	nQ0, Q0	Output		Differential clock outputs. HSTL interface levels.

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

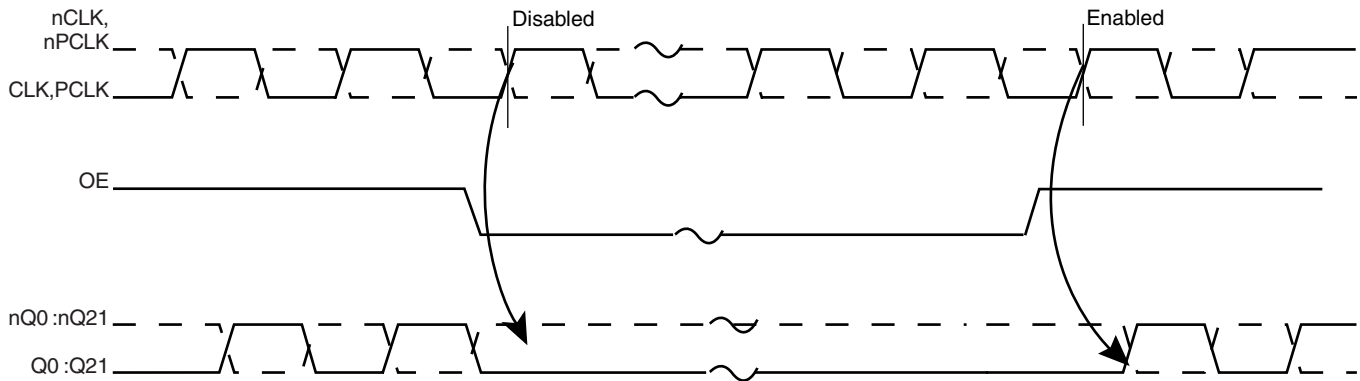


**TABLE 2. PIN CHARACTERISTICS**

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$C_{IN}$	Input Capacitance			4		pF
$R_{PULLUP}$	Input Pullup Resistor			37		$K\Omega$
$R_{PULLDOWN}$	Input Pulldown Resistor			75		$K\Omega$

**TABLE 3A. CONTROL INPUT FUNCTION TABLE**

Inputs		Outputs	
OE	CLK_SEL	Q0:Q21	nQ0:nQ21
0	0	LOW	HIGH
0	1	LOW	HIGH
1	0	CLK	nCLK
1	1	PCLK	nPCLK



**FIGURE 1. OE TIMING DIAGRAM**



**ABSOLUTE MAXIMUM RATINGS**

Supply Voltage, $V_{DD}$	4.6V
Inputs, $V_I$	-0.5V to $V_{DD} + 0.5V$
Outputs, $I_O$	
Continuous Current	50mA
Surge Current	100mA
Package Thermal Impedance, $\theta_{JA}$	22.3°C/W (0 lfpm)
Storage Temperature, $T_{STG}$	-65°C to 150°C

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.

**TABLE 4A. POWER SUPPLY DC CHARACTERISTICS,  $V_{DD} = 3.3V \pm 5\%$ ,  $V_{DDO} = 1.8V \pm 0.2V$ ,  $T_A = 0^\circ C$  TO  $85^\circ C$**

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$V_{DD}$	Core Supply Voltage		3.135	3.3	3.465	V
$V_{DDO}$	Ouput Power Supply Voltage		1.6	1.8	2.0	V
$I_{DD}$	Positive Supply Current				220	mA
$I_{DDO}$	Output Supply Current	No Load		1		mA

**TABLE 4B. LVCMOS / LVTTTL DC CHARACTERISTICS,  $V_{DD} = 3.3V \pm 5\%$ ,  $V_{DDO} = 1.8V \pm 0.2V$ ,  $T_A = 0^\circ C$  TO  $85^\circ C$**

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$V_{IH}$	Input High Voltage		2		$V_{DD} + 0.3$	V
$V_{IL}$	Input Low Voltage		-0.3		0.8	V
$I_{IH}$	Input High Current	OE, CLK_SEL			5	$\mu A$
$I_{IL}$	Input Low Current	OE, CLK_SEL	-150			$\mu A$

**TABLE 4C. DIFFERENTIAL DC CHARACTERISTICS,  $V_{DD} = 3.3V \pm 5\%$ ,  $V_{DDO} = 1.8V \pm 0.2V$ ,  $T_A = 0^\circ C$  TO  $85^\circ C$**

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$I_{IH}$	Input High Current	CLK, nCLK $V_{DD} = V_{IN} = 3.465V$			150	$\mu A$
$I_{IL}$	Input Low Current	CLK, nCLK $V_{DD} = 3.465V, V_{IN} = 0V$	-150			$\mu A$
$V_{PP}$	Peak-to-Peak Input Voltage		0.15		1.3	V
$V_{CMR}$	Common Mode Input Voltage; NOTE 1, 2		GND + 0.5		$V_{DD} - 0.85$	V

NOTE 1: Common mode voltage is defined as  $V_{IH}$ .

NOTE 2: For single ended applications, the maximum input voltage for CLK and nCLK is  $V_{DD} + 0.3V$ .



**TABLE 4D. LVPECL DC CHARACTERISTICS,  $V_{DD} = 3.3V \pm 5\%$ ,  $V_{DDO} = 1.8V \pm 0.2V$ ,  $T_A = 0^\circ C$  TO  $85^\circ C$**

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$I_{IH}$	Input High Current	PCLK, nPCLK $V_{DD} = V_{IN} = 3.465V$			150	$\mu A$
$I_{IL}$	Input Low Current	PCLK, nPCLK $V_{DD} = 3.465V, V_{IN} = 0V$	-150			$\mu A$
$V_{PP}$	Peak-to-Peak Input Voltage		0.3		1	V
$V_{CMR}$	Common Mode Input Voltage; NOTE 1, 2		GND + 1.5		$V_{DD}$	V

NOTE 1: Common mode voltage is defined as  $V_{IH}$ .

NOTE 2: For single ended applications, the maximum input voltage for PCLK and nPCLK is  $V_{DD} + 0.3V$ .

**TABLE 4E. HSTL DC CHARACTERISTICS,  $V_{DD} = 3.3V \pm 5\%$ ,  $V_{DDO} = 1.8V \pm 0.2V$ ,  $T_A = 0^\circ C$  TO  $85^\circ C$**

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$V_{OH}$	Output High Voltage; NOTE 1		1.0		1.4	V
$V_{OL}$	Output Low Voltage; NOTE 1		0		0.4	V
$V_{OX}$	Output Crossover Voltage; NOTE 2		40		60	%
$V_{SWING}$	Peak-to-Peak Output Voltage Swing		0.6		1.1	V

NOTE 1: Outputs terminated with  $50\Omega$  to ground.

NOTE 2: Defined with respect to output voltage swing at a given condition.

**TABLE 5. AC CHARACTERISTICS,  $V_{DD} = 3.3V \pm 5\%$ ,  $V_{DDO} = 1.8V \pm 0.2V$ ,  $T_A = 0^\circ C$  TO  $85^\circ C$**

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$f_{MAX}$	Output Frequency				500	MHz
$t_{PD}$	Propagation Delay; NOTE 1		1.7		2.7	ns
$t_{sk(o)}$	Output Skew; NOTE 2, 4				80	ps
$t_{sk(pp)}$	Part-to-Part Skew; NOTE 3, 4				700	ps
$f_{jit}$	Buffer Additive Phase Jitter, RMS; refer to Additive Phase Jitter section			0.04		ps
$t_R / t_F$	Output Rise/Fall Time	20% to 80%	300		700	ps
$t_S$	Setup Time		1.0			ns
$t_H$	Hold Time		0.5			ns
odc	Output Duty Cycle	$f \leq 133MHz$	49		51	%
		$133 < f \leq 266MHz$	48		52	%

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 voltages and with equal load conditions at the same temperature. Using the same type of inputs on each device, the outputs are measured at the differential cross points.

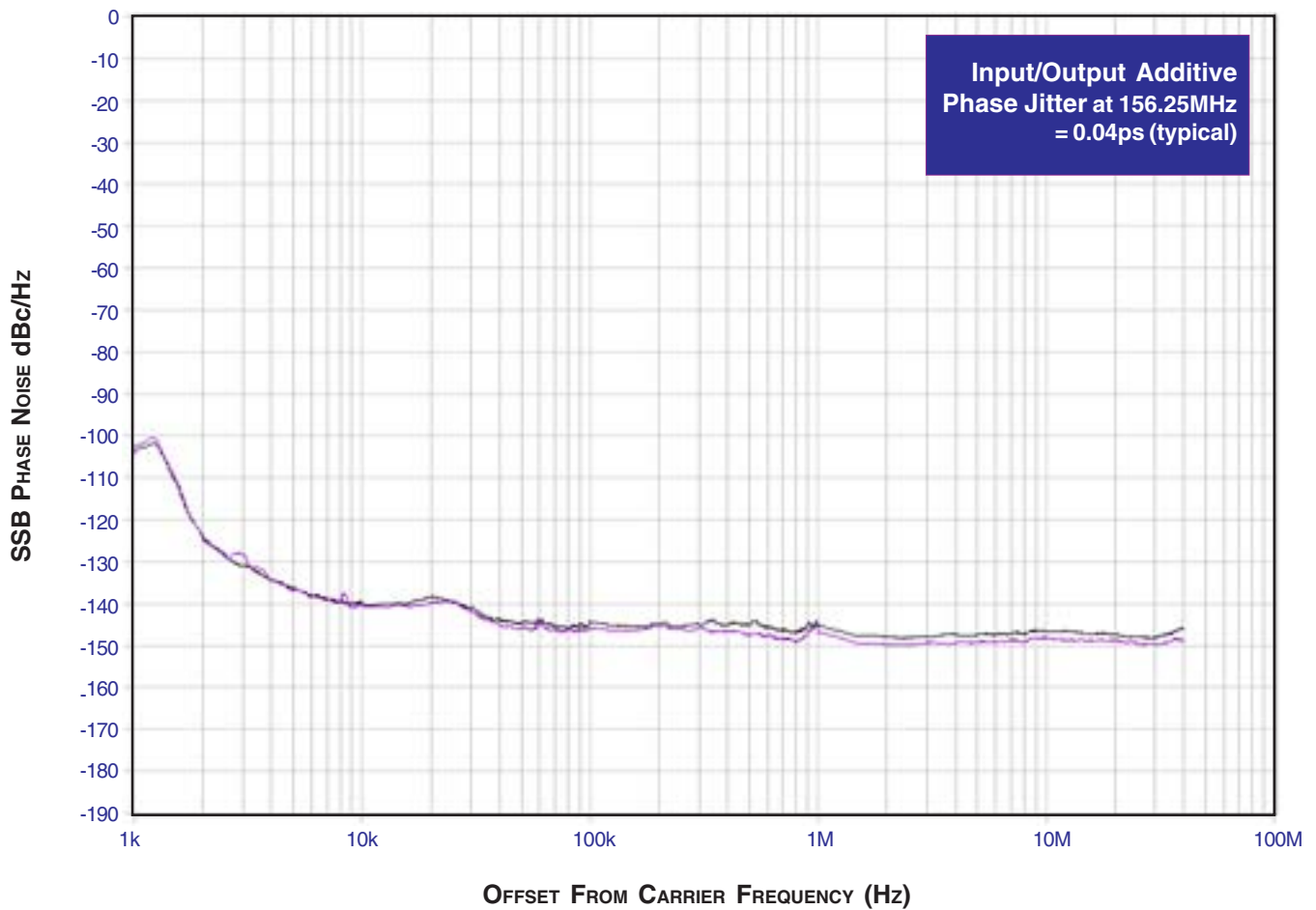
NOTE 4: This parameter is defined in accordance with JEDEC Standard 65.



### 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.

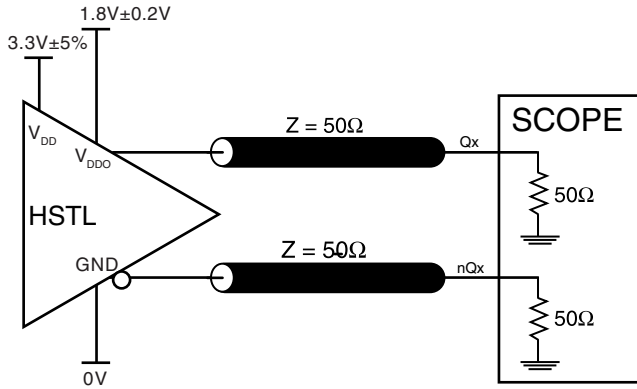


As with most timing specifications, phase noise measurements have issues. The primary issue relates to the limitations of the equipment. Often the noise floor of the equipment is higher than the noise floor of the device. This is illustrated above. The de-

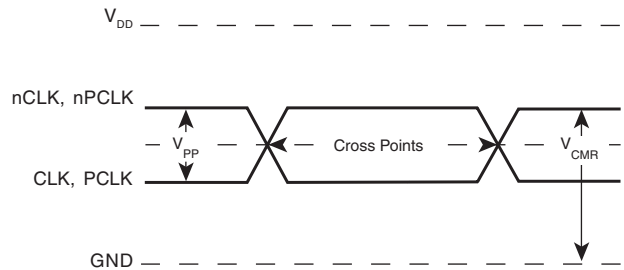
vice meets the noise floor of what is shown, but can actually be lower. The phase noise is dependant on the input source and measurement equipment.



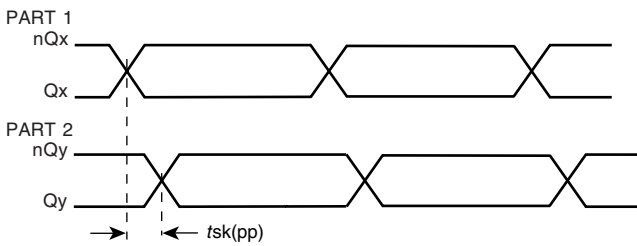
## PARAMETER MEASUREMENT INFORMATION



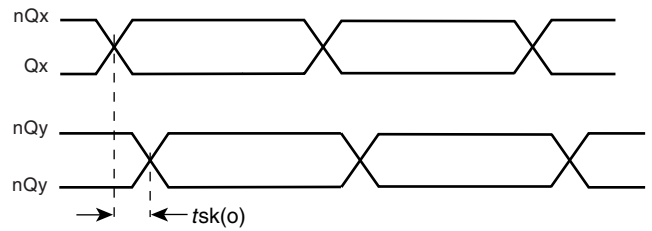
**3.3V CORE/1.8V OUTPUT LOAD AC TEST CIRCUIT**



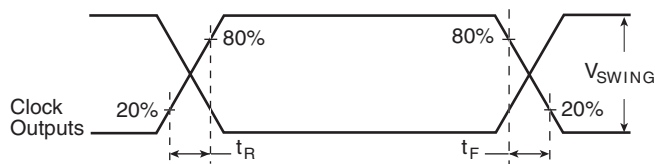
**DIFFERENTIAL INPUT LEVEL**



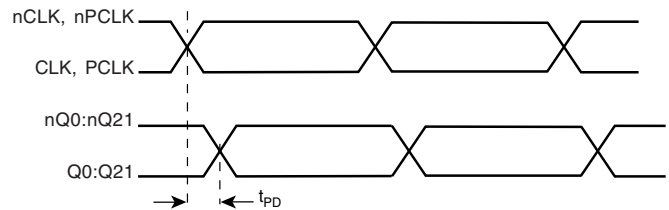
**PART-TO-PART SKEW**



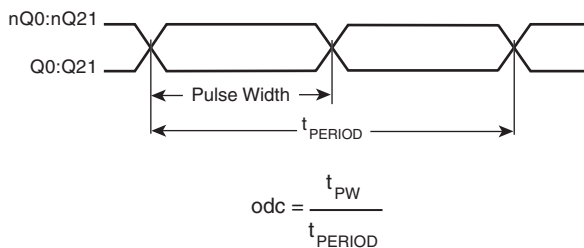
**OUTPUT SKEW**



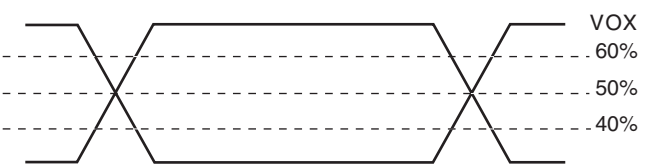
**OUTPUT RISE/FALL TIME**



**PROPAGATION DELAY**



**OUTPUT DUTY CYCLE/PULSE WIDTH/PERIOD**



**OUTPUT CROSSOVER VOLTAGE**



## APPLICATION INFORMATION

### WIRING THE DIFFERENTIAL INPUT TO ACCEPT SINGLE ENDED LEVELS

Figure 2 shows how the 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, R2 and C1. This bias circuit should be located as close as possible to the input pin. 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 only 2.5V and  $V_{DD} = 3.3V$ ,  $V_{REF}$  should be 1.25V and  $R2/R1 = 0.609$ .

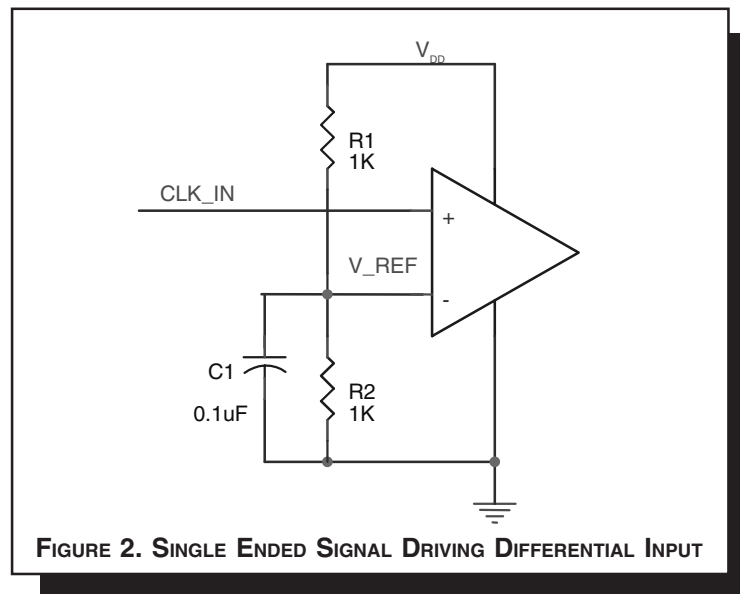


FIGURE 2. SINGLE ENDED SIGNAL DRIVING DIFFERENTIAL INPUT

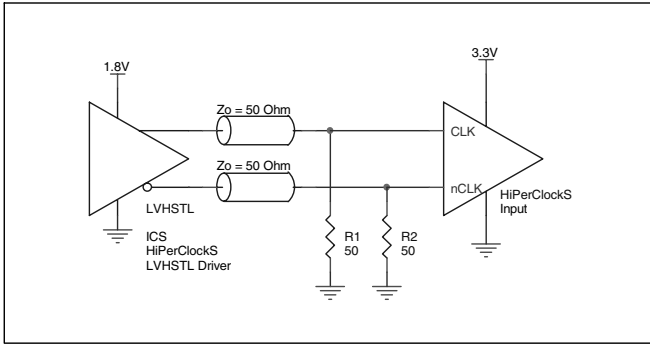




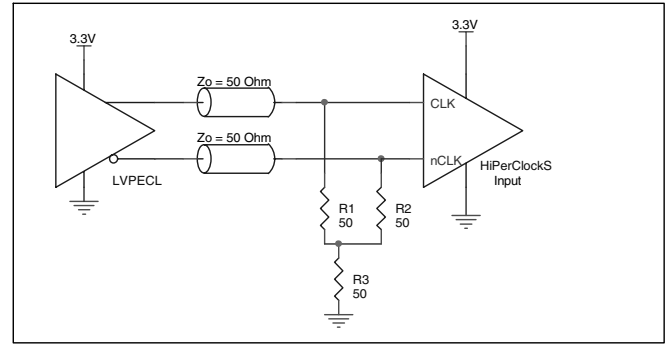
**DIFFERENTIAL CLOCK INPUT INTERFACE**

The CLK /nCLK accepts LVDS, LVPECL, HSTL, SSTL, HCSSL and other differential signals. Both  $V_{SWING}$  and  $V_{OH}$  must meet the  $V_{PP}$  and  $V_{CMR}$  input requirements. Figures 3A to 3E show interface examples for the HiPerClockS CLK/nCLK input driven by the most common driver types. The input interfaces suggested

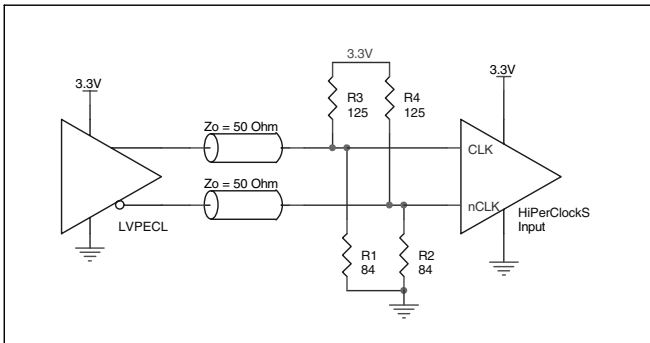
here are examples only. Please consult with the vendor of the driver component to confirm the driver termination requirements. For example in *Figure 4A*, the input termination applies for ICS HiPerClockS HSTL drivers. If you are using an LVHSTL driver from another vendor, use their termination recommendation.



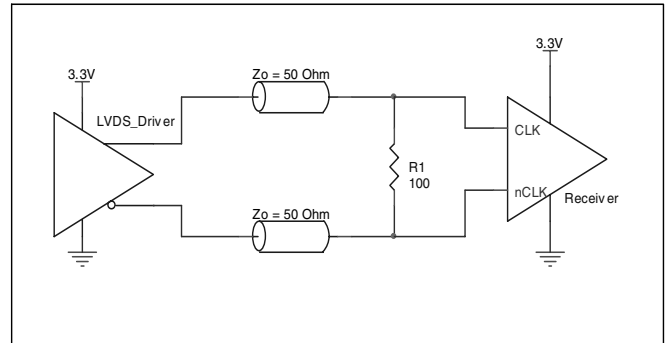
**FIGURE 3A. HiPerClockS CLK/nCLK INPUT DRIVEN BY ICS HiPerClockS HSTL DRIVER**



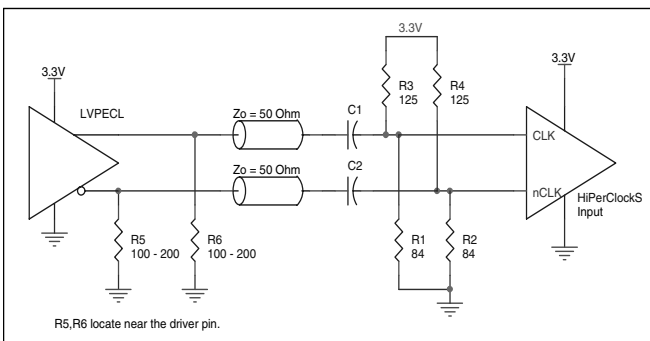
**FIGURE 3B. HiPerClockS CLK/nCLK INPUT DRIVEN BY 3.3V LVPECL DRIVER**



**FIGURE 3C. HiPerClockS CLK/nCLK INPUT DRIVEN BY 3.3V LVPECL DRIVER**



**FIGURE 3D. HiPerClockS CLK/nCLK INPUT DRIVEN BY 3.3V LVDS DRIVER**



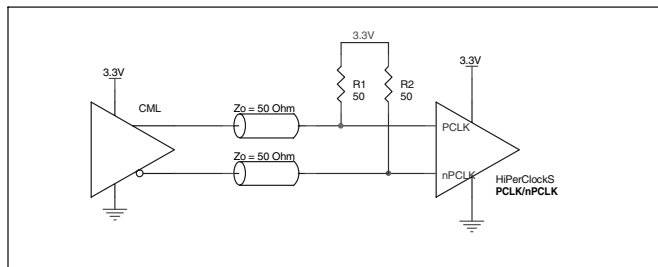
**FIGURE 3E. HiPerClockS CLK/nCLK INPUT DRIVEN BY 3.3V LVPECL DRIVER WITH AC COUPLE**



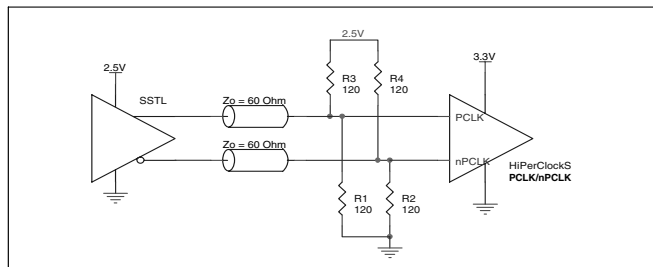
### LVPECL CLOCK INPUT INTERFACE

The PCLK /nPCLK accepts LVPECL, CML, SSTL and other differential signals. Both  $V_{SWING}$  and  $V_{OH}$  must meet the  $V_{PP}$  and  $V_{CMR}$  input requirements. *Figures 4A to 4E* show interface examples for the HiPerClockS PCLK/nPCLK input driven by the most common driver types. The input interfaces sug-

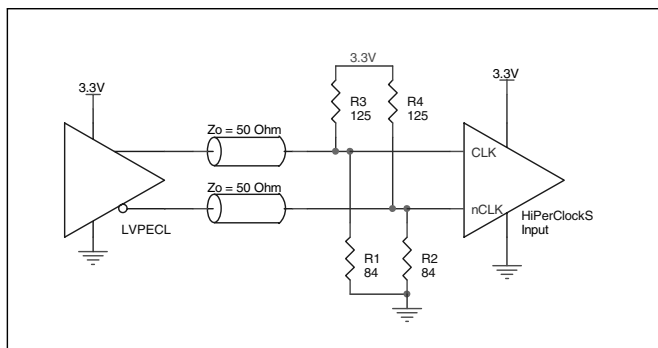
gested here are examples only. If the driver is from another vendor, use their termination recommendation. Please consult with the vendor of the driver component to confirm the driver termination requirements.



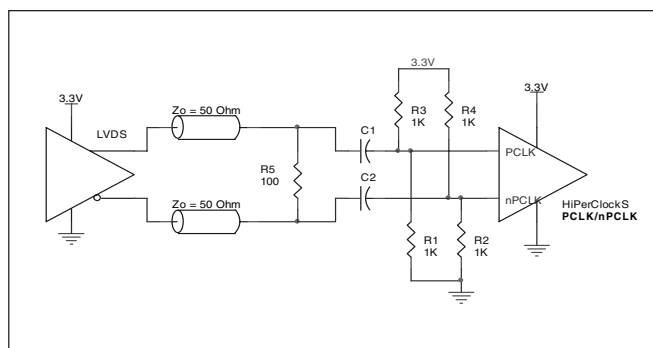
**FIGURE 4A. HiPerClockS PCLK/nPCLK INPUT DRIVEN BY A CML DRIVER**



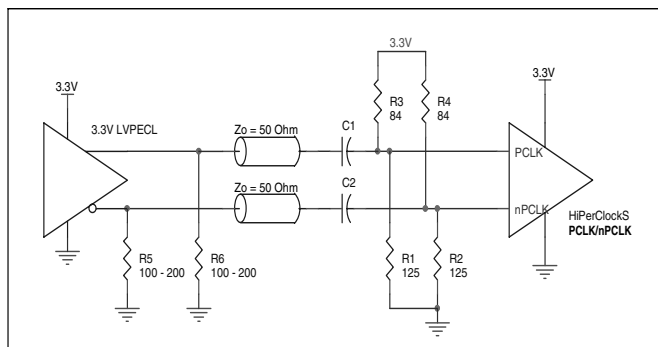
**FIGURE 4B. HiPerClockS PCLK/nPCLK INPUT DRIVEN BY AN SSTL DRIVER**



**FIGURE 4C. HiPerClockS PCLK/nPCLK INPUT DRIVEN BY A 3.3V LVPECL DRIVER**



**FIGURE 4D. HiPerClockS PCLK/nPCLK INPUT DRIVEN BY A 3.3V LVDS DRIVER**



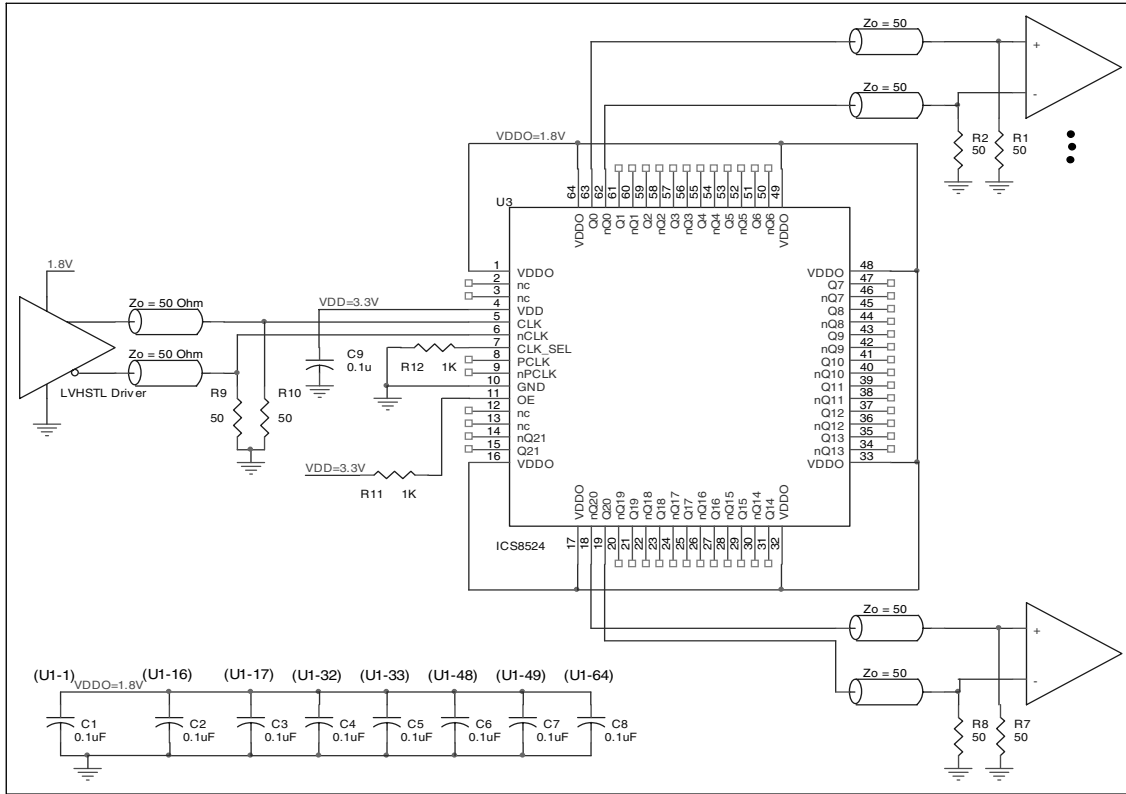
**FIGURE 4E. HiPerClockS PCLK/nPCLK INPUT DRIVEN BY A 3.3V LVPECL DRIVER WITH AC COUPLE**



**SCHEMATIC EXAMPLE**

Figure 5 shows a schematic example of the ICS8524. In this example, the input is driven by an ICS HiPerClockS HSTL driver. The decoupling capacitors should be physically located near the

power pin. For ICS8524, the unused clock outputs can be left floating.

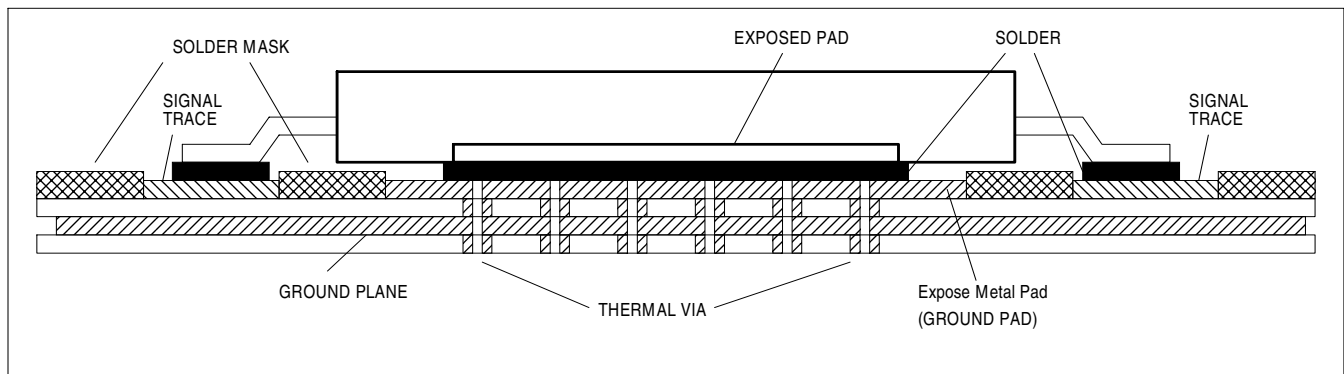


**FIGURE 5. ICS8524 HSTL BUFFER SCHEMATIC EXAMPLE**

**THERMAL RELEASE PATH**

The expose metal pad provides heat transfer from the device to the P.C. board. The expose metal pad is ground pad connected to ground plane through thermal via. The exposed pad on the device to the exposed metal pad on the PCB is contacted through

solder as shown in Figure 6. For further information, please refer to the Application Note on Surface Mount Assembly of Amkor's Thermally /Electrically Enhance Leadframe Base Package, Amkor Technology.



**FIGURE 6. P.C. BOARD FOR EXPOSED PAD THERMAL RELEASE PATH EXAMPLE**



## POWER CONSIDERATIONS

This section provides information on power dissipation and junction temperature for the ICS8524. Equations and example calculations are also provided.

### 1. Power Dissipation.

The total power dissipation for the ICS8524 is the sum of the core power plus the power dissipated in the load(s). The following is the power dissipation for  $V_{DD} = 3.3V + 5\% = 3.465V$ , which gives worst case results.

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

- Power (core)<sub>MAX</sub> =  $V_{DD\_MAX} * I_{DD\_MAX} = 3.465V * 220mA = 762.3mW$
- Power (outputs)<sub>MAX</sub> = **32.8mW/Loaded Output pair**  
If all outputs are loaded, the total power is  $22 * 32.8mW = 721.6mW$

**Total Power**<sub>MAX</sub> (3.465V, with all outputs switching) =  $762.3mW + 721.6mW = 1483.9mW$

### 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 for HiPerClockS™ devices is 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 an air flow of 500 linear feet per minute and a multi-layer board, the appropriate value is 15.1°C/W per Table 6 below.

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

$85^\circ C + 1.484W * 15.1^\circ C/W = 107.4^\circ C$ . 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 (single layer or multi-layer).

**TABLE 6. THERMAL RESISTANCE  $\theta_{JA}$  FOR 64-PIN TQFP, E-PAD FORCED CONVECTION**

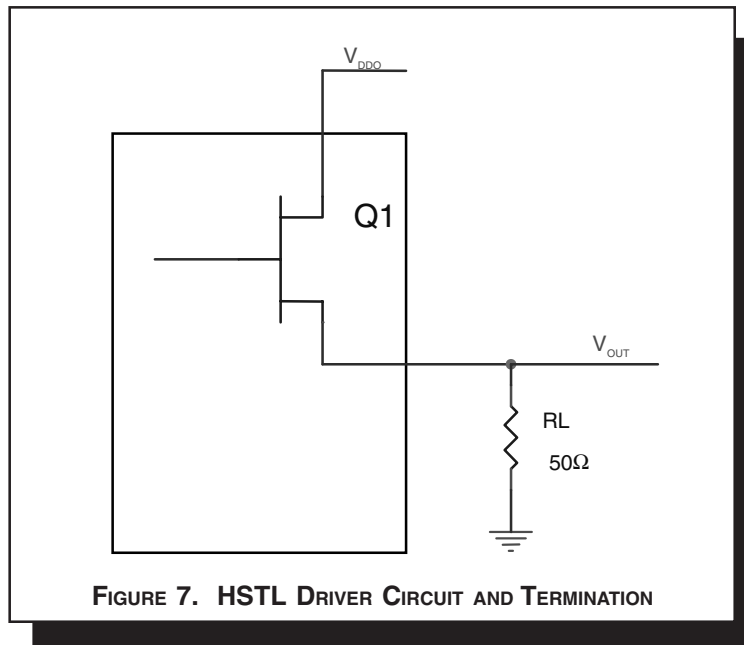
$\theta_{JA}$ by Velocity (Linear Feet per Minute)			
	0	200	500
Multi-Layer PCB, JEDEC Standard Test Boards	22.3°C/W	17.2°C/W	15.1°C/W
<b>NOTE:</b> Most modern PCB designs use multi-layered boards. The data in the second row pertains to most designs.			



3. Calculations and Equations.

The purpose of this section is to derive the power dissipated into the load.

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



To calculate worst case power dissipation into the load, use the following equations which assume a 50Ω load.

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

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

$$Pd_H = (V_{OH\_MIN} / R_L) * (V_{DDO\_MAX} - V_{OH\_MIN})$$

$$Pd_L = (V_{OL\_MAX} / R_L) * (V_{DDO\_MAX} - V_{OL\_MAX})$$

$$Pd_H = (1V/50\Omega) * (2V - 1V) = \mathbf{20mW}$$

$$Pd_L = (0.4V/50\Omega) * (2V - 0.4V) = \mathbf{12.8mW}$$

$$\text{Total Power Dissipation per output pair} = Pd_H + Pd_L = \mathbf{32.8mW}$$



## RELIABILITY INFORMATION

TABLE 7.  $\theta_{JA}$  VS. AIR FLOW TABLE FOR 64 LEAD TQFP, E-PAD

$\theta_{JA}$ by Velocity (Linear Feet per Minute)			
	0	200	500
Multi-Layer PCB, JEDEC Standard Test Boards	22.3°C/W	17.2°C/W	15.1°C/W

**NOTE:** Most modern PCB designs use multi-layered boards. The data in the second row pertains to most designs.

### TRANSISTOR COUNT

The transistor count for ICS8524 is: 1474



PACKAGE OUTLINE - Y SUFFIX FOR 64 LEAD TQFP, E-PAD

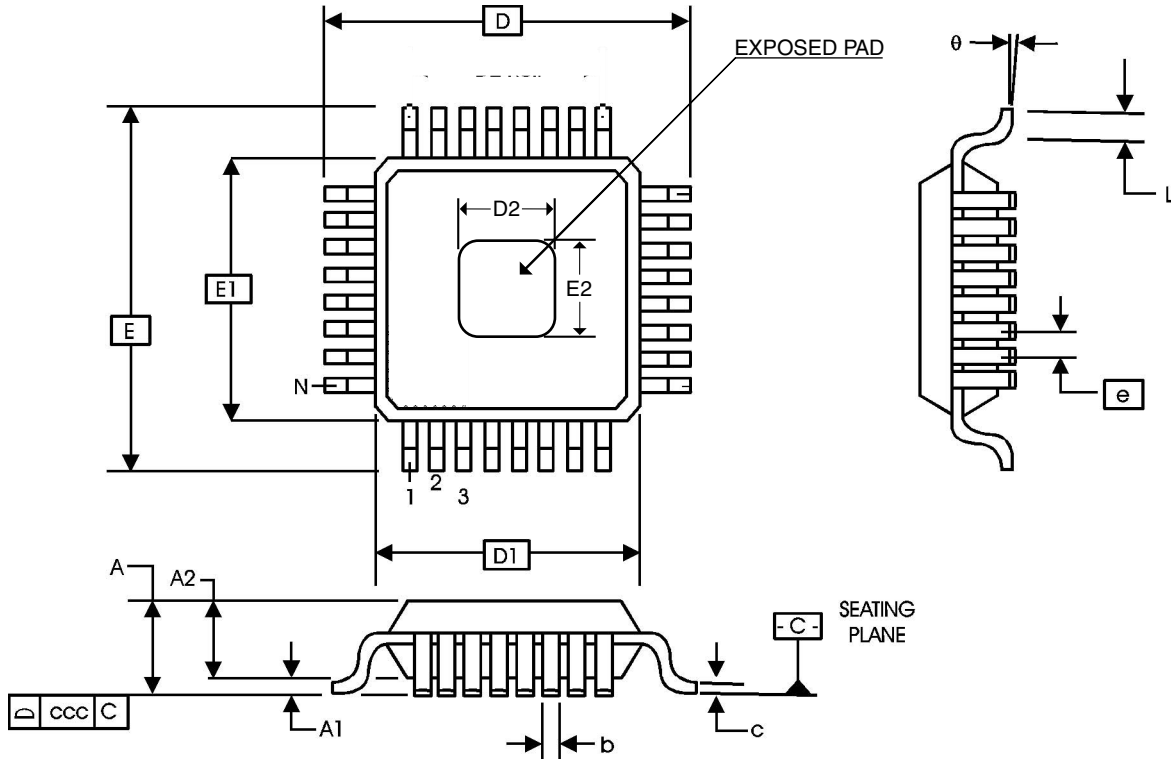


TABLE 8. PACKAGE DIMENSIONS

JEDEC VARIATION ALL DIMENSIONS IN MILLIMETERS			
SYMBOL	BCD		
	MINIMUM	NOMINAL	MAXIMUM
N	64		
A	--	--	1.20
A1	0.05	--	0.15
A2	.95	1.0	1.05
b	0.17	0.22	0.27
c	0.09	--	0.20
D	12.00 BASIC		
D1	10.00 BASIC		
D2	5.00 Ref.		
E	12.00 BASIC		
E1	10.00 BASIC		
E2	5.00 Ref.		
e	0.50 BASIC		
L	0.45	0.60	0.75
theta	0°	--	7°
ccc	--	--	0.08

Reference Document: JEDEC Publication 95, MS-026



Integrated  
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# ICS8524

## LOW SKEW, 1-TO-22 DIFFERENTIAL-TO-HSTL FANOUT BUFFER

**TABLE 9. ORDERING INFORMATION**

Part/Order Number	Marking	Package	Count	Temperature
ICS8524AY	ICS8524AY	64 lead TQFP, E-Pad	160 per tray	0°C to 85°C
ICS8524AYT	ICS8524AY	64 lead TQFP, E-Pad on Tape and Reel	500	0°C to 85°C

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**ICS8524**  
LOW SKEW, 1-TO-22  
DIFFERENTIAL-TO-HSTL FANOUT BUFFER

REVISION HISTORY SHEET				
Rev	Table	Page	Description of Change	Date
B	T5	1	Added Phase Jitter to Features section.	9/18/03
		5	AC Characteristics Table - added Phase Jitter row.	
		6	Added Additive Phase Jitter section.	