



## GENERAL DESCRIPTION



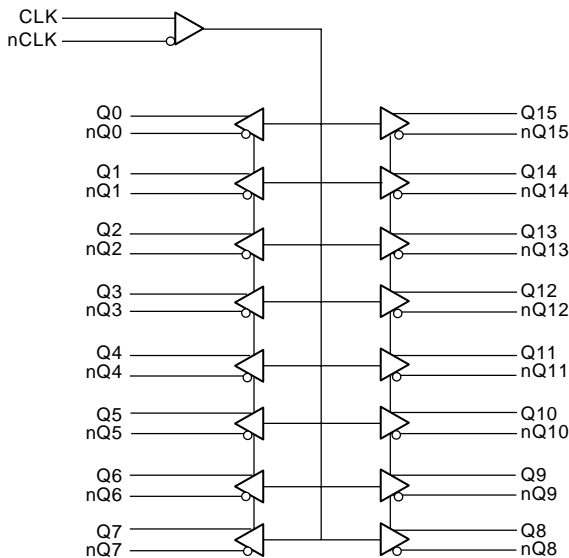
The ICS8520 is a low skew, high performance 1-to-16 Differential-to-LVHSTL Fanout Buffer and a member of the HiPerClockS™ family of High Performance Clock Solutions from ICS. The ICS8520 has 1 clock input pair. The CLK, nCLK pair can accept most standard differential input levels.

Guaranteed output skew, part-to-part skew and crossover voltage characteristics make the ICS8520 ideal for interfacing to today's most advanced microprocessor and static RAMs.

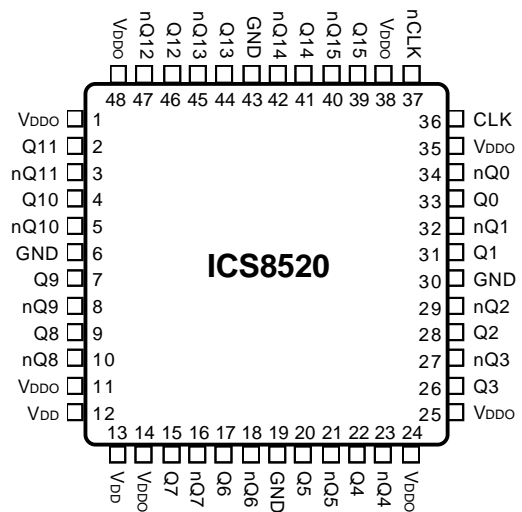
## FEATURES

- 16 differential LVHSTL compatible outputs each with the ability to drive 50Ω to ground
- 1 differential CLK, nCLK input pair
- CLK, nCLK pair can accept the following differential input levels: LVDS, LVPECL, LVHSTL, SSTL, HCSL
- Maximum output frequency: 500MHz
- Translates single ended input levels to LVHSTL levels with resistor bias nCLK input
- Output skew: 110ps (maximum)
- Part-to-part skew: 450ps (maximum)
- Propagation delay: 1.6ns (maximum)
- $V_{OH}$ : 1.3V (maximum)
- 40% of  $V_{OH} \leq V_{crossover} \leq 60\%$  of  $V_{OH}$
- 3.3V core, 1.8V output operating supply voltages
- 0°C to 70°C ambient operating temperature

## BLOCK DIAGRAM



## PIN ASSIGNMENT



**48-Lead LQFP**  
7mm x 7mm x 1.4mm body package  
**Y Package**  
Top View



**TABLE 1. PIN DESCRIPTIONS**

Number	Name	Type		Description
1, 11, 14, 24, 25, 35, 38, 48	V <sub>DDO</sub>	Power		Output supply pins.
2, 3	Q11, nQ11	Output		Differential output pair. LVHSTL interface levels.
4, 5	Q10, nQ10	Output		Differential output pair. LVHSTL interface levels.
6, 19, 30, 43	GND	Power		Power supply ground.
7, 8	Q9, nQ9	Output		Differential output pair. LVHSTL interface levels.
9, 10	Q8, nQ8	Output		Differential output pair. LVHSTL interface levels.
12, 13	V <sub>DD</sub>	Power		Core supply pins.
15, 16	Q7, nQ7	Output		Differential output pair. LVHSTL interface levels.
17, 18	Q6, nQ6	Output		Differential output pair. LVHSTL interface levels.
20, 21	Q5, nQ5	Output		Differential output pair. LVHSTL interface levels.
22, 23	Q4, nQ4	Output		Differential output pair. LVHSTL interface levels.
26, 27	Q3, nQ3	Output		Differential output pair. LVHSTL interface levels.
28, 29	Q2, nQ2	Output		Differential output pair. LVHSTL interface levels.
31, 32	Q1, nQ1	Output		Differential output pair. LVHSTL interface level
33, 34	Q0, nQ0	Output		Differential output pair. LVHSTL interface level
36	CLK	Input	Pulldown	Non inverting differential clock input.
37	nCLK	Input	Pullup	Inverting differential clock input.
39, 40	Q15, nQ15	Output		Differential output pair. LVHSTL interface levels.
41, 42	Q14, nQ14	Output		Differential output pair. LVHSTL interface levels.
44, 45	Q13, nQ13	Output		Differential output pair. LVHSTL interface levels.
46, 47	Q12, nQ12	Output		Differential output pair. LVHSTL 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 <sub>IN</sub>	Input Capacitance				4	pF
R <sub>PULLUP</sub>	Input Pullup Resistor			51		KΩ
R <sub>PULLDOWN</sub>	Input Pulldown Resistor			51		KΩ

**TABLE 3. FUNCTION TABLE**

Inputs		Outputs		Input to Output Mode	Polarity
CLK	nCLK	Q0:Q15	nQ0:nQ15		
0	1	LOW	HIGH	Differential to Differential	Non Inverting
1	0	HIGH	LOW	Differential to Differential	Non Inverting
0	Biased; NOTE 1	LOW	HIGH	Single Ended to Differential	Non Inverting
1	Biased; NOTE 1	HIGH	LOW	Single Ended to Differential	Non Inverting
Biased; NOTE 1	0	HIGH	LOW	Single Ended to Differential	Inverting
Biased; NOTE 1	1	LOW	HIGH	Single Ended to Differential	Inverting

NOTE 1: Please refer to the Application Information Section, "Wiring the Differential input to accept single ended levels".



**ABSOLUTE MAXIMUM RATINGS**

Supply Voltage, $V_{DD}$	4.6V
Inputs, $V_i$	-0.5V to $V_{DD} + 0.5V$
Outputs, $V_o$	-0.5V to $V_{DDO} + 0.5V$
Package Thermal Impedance, $\theta_{JA}$	47.9°C/W (0 lfm)
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  $70^\circ C$**

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$V_{DD}$	Positive Supply Voltage		3.135	3.3	3.465	V
$V_{DDO}$	Output Supply Voltage		1.6	1.8	2.0	V
$I_{DD}$	Power Supply Current				190	mA
$I_{DDO}$	Output Supply Current				10	$\mu A$

**TABLE 4B. DIFFERENTIAL DC CHARACTERISTICS,  $V_{DD} = 3.3V \pm 5\%$ ,  $V_{DDO} = 1.8V \pm 0.2V$ ,  $T_A = 0^\circ C$  TO  $70^\circ C$**

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$I_{IH}$	Input High Current	CLK	$V_{IN} = V_{DD} = 3.465V$		150	$\mu A$
		nCLK	$V_{IN} = V_{DD} = 3.465V$		1	$\mu A$
$I_{IL}$	Input Low Current	CLK	$V_{IN} = 0V, V_{DD} = 3.465V$	-1		$\mu A$
		nCLK	$V_{IN} = 0V, V_{DD} = 3.465V$	-150		$\mu A$
$V_{PP}$	Peak-to-Peak Input Voltage		0.15		1.3	V
$V_{CMR}$	Common Mode Voltage Range; 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, nCLK is  $V_{DD} + 0.3V$ .

**TABLE 4C. LVHSTL DC CHARACTERISTICS,  $V_{DD} = 3.3V \pm 5\%$ ,  $V_{DDO} = 1.8V \pm 0.2V$ ,  $T_A = 0^\circ C$  TO  $70^\circ C$**

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$V_{OH}$	Output High Voltage; NOTE 1		0.9		1.3	V
$V_{OL}$	Output Low Voltage; NOTE 1		0		0.4	V
$V_{OX}$	Output Crossover Voltage		$40\% \times (V_{OH} - V_{OL}) + V_{OL}$		$60\% \times (V_{OH} - V_{OL}) + V_{OL}$	V

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



**TABLE 5. AC CHARACTERISTICS,**  $V_{DD} = 3.3V \pm 5\%$ ,  $V_{DDO} = 1.8V \pm 0.2V$ ,  $T_A = 0^\circ C$  TO  $70^\circ C$

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$f_{MAX}$	Output Frequency				500	MHz
$t_{PD}$	Propagation Delay, Low-to-High; NOTE 1		1.1	1.3	1.6	ns
$t_{sk(o)}$	Output Skew; NOTE 2, 4				110	ps
$t_{sk(pp)}$	Part-to-Part Skew; NOTE 3, 4	$f \leq 400MHz$			450	ps
$t_R/t_F$	Output Rise/Fall Time	$f \leq 300MHz$	200		900	ps
		$f > 300MHz$	200		600	ps
odc	Output Duty Cycle	$f \leq 133MHz$	48		52	%
		$133MHz < f \leq 300MHz$	46		54	%
		$f > 300MHz$	42		58	%

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.

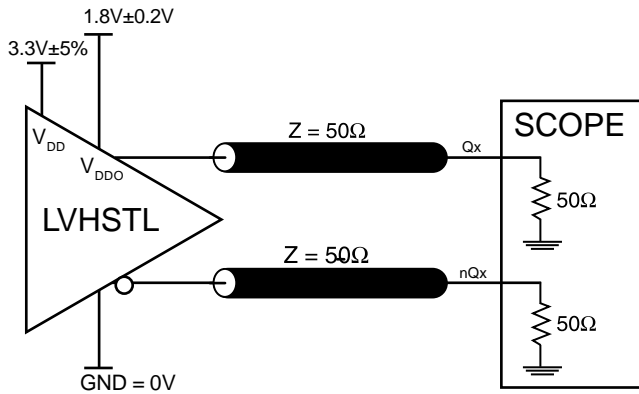
Measured at the output differential cross points.

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

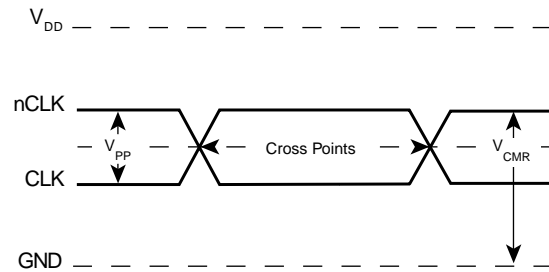
NOTE 4: This parameter is defined in accordance with JEDEC Standard 65.



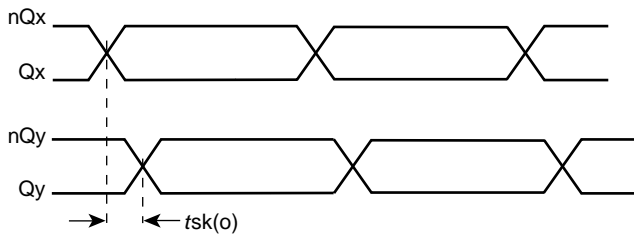
## PARAMETER MEASUREMENT INFORMATION



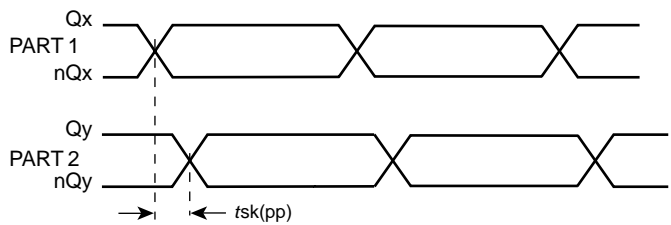
**3.3V/1.8V OUTPUT LOAD AC TEST CIRCUIT**



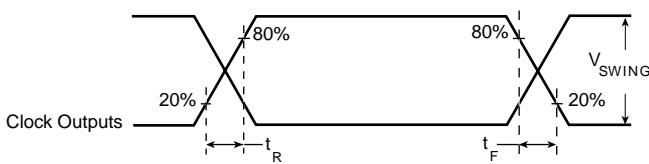
**DIFFERENTIAL INPUT LEVEL**



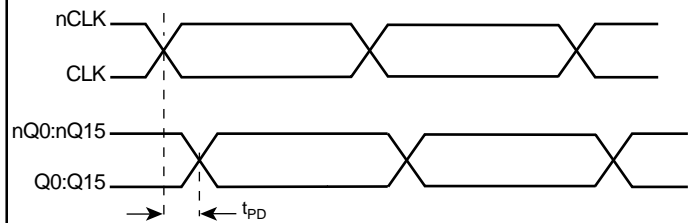
**OUTPUT SKEW**



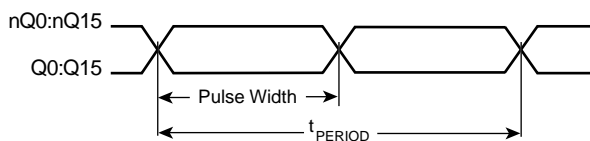
**PART-TO-PART SKEW**



**OUTPUT RISE/FALL TIME**



**PROPAGATION DELAY**



$$odc = \frac{t_{PW}}{t_{PERIOD}}$$

**odc & t<sub>PERIOD</sub>**



## POWER CONSIDERATIONS

This section provides information on power dissipation and junction temperature for the ICS8520. Equations and example calculations are also provided.

### 1. Power Dissipation.

The total power dissipation for the ICS8520 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> =  $V_{DD\_MAX} * I_{DD\_MAX} = 3.465V * 190mA = 658.4mW$
- Power (outputs)<sub>MAX</sub> = **32.6mW/Loaded Output pair**  
If all outputs are loaded, the total power is  $16 * 32.6mW = 521.6mW$

**Total Power**<sub>MAX</sub> (3.465V, with all outputs switching) =  $658.4mW + 521.6mW = 1180mW$

### 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 a moderate air flow of 200 linear feet per minute and a multi-layer board, the appropriate value is 42.1°C/W per Table 6 below.

Therefore,  $T_j$  for an ambient temperature of 70°C with all outputs switching is:

$70^\circ C + 1.18W * 42.1^\circ C/W = 119.7^\circ C$ . 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 (single layer or multi-layer).

**TABLE 6. THERMAL RESISTANCE  $\theta_{JA}$  FOR 48-PIN LQFP, FORCED CONVECTION**

$\theta_{JA}$ by Velocity (Linear Feet per Minute)			
	0	200	500
Single-Layer PCB, JEDEC Standard Test Boards	67.8°C/W	55.9°C/W	50.1°C/W
Multi-Layer PCB, JEDEC Standard Test Boards	47.9°C/W	42.1°C/W	39.4°C/W

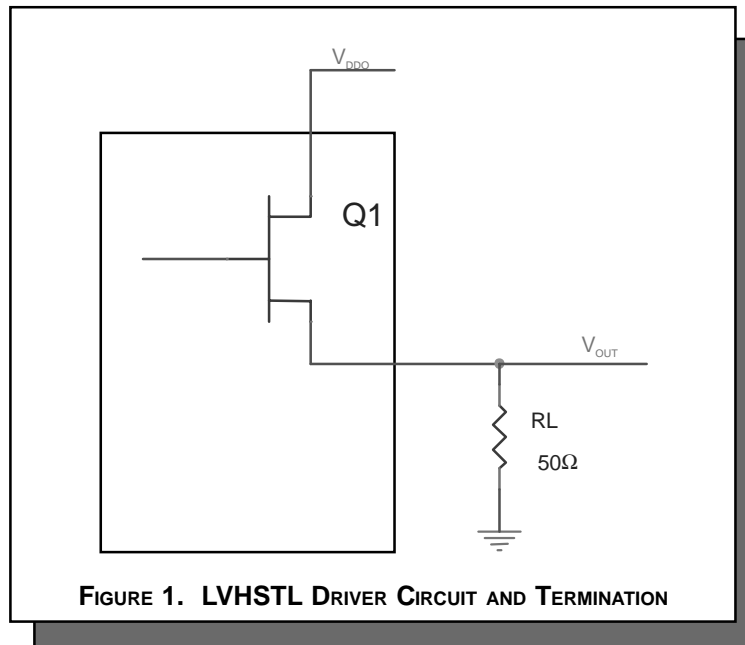
**NOTE:** Most modern PCB designs use multi-layered boards. The data in the second row pertains to most designs.



### 3. Calculations and Equations.

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

LVHSTL output driver circuit and termination are shown in *Figure 1*.



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.

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

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

$$Pd_H = (0.9V/50\Omega) * (2V - 0.9V) = \mathbf{19.8mW}$$

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

$$\text{Total Power Dissipation per output pair} = Pd_H + Pd_L = \mathbf{32.6mW}$$



## RELIABILITY INFORMATION

TABLE 7.  $\theta_{JA}$  VS. AIR FLOW TABLE

$\theta_{JA}$ by Velocity (Linear Feet per Minute)			
	0	200	500
Single-Layer PCB, JEDEC Standard Test Boards	67.8°C/W	55.9°C/W	50.1°C/W
Multi-Layer PCB, JEDEC Standard Test Boards	47.9°C/W	42.1°C/W	39.4°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 ICS8520 is: 1563





PACKAGE OUTLINE - Y SUFFIX

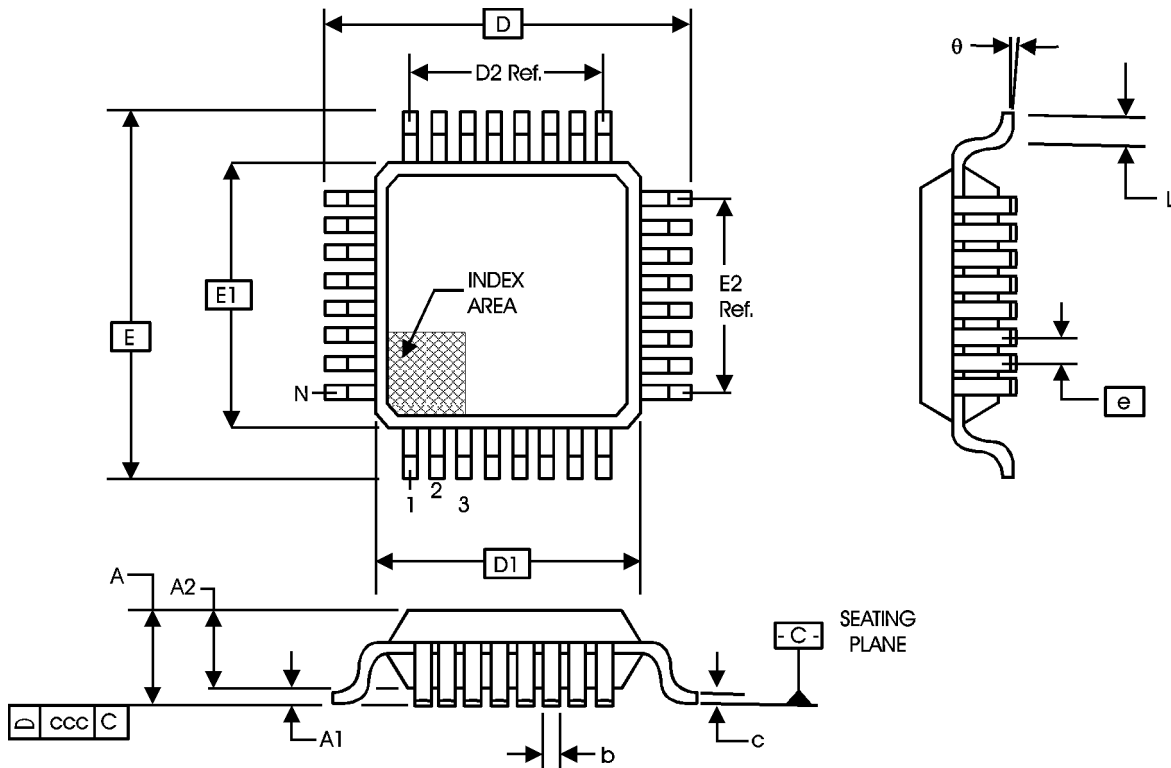


TABLE 8. PACKAGE DIMENSIONS

JEDEC VARIATION ALL DIMENSIONS IN MILLIMETERS			
SYMBOL	BBC		
	MINIMUM	NOMINAL	MAXIMUM
N	48		
A	--	--	1.60
A1	0.05	--	0.15
A2	1.35	1.40	1.45
b	0.17	0.22	0.27
c	0.09	--	0.20
D	9.00 BASIC		
D1	7.00 BASIC		
D2	5.50 Ref.		
E	9.00 BASIC		
E1	7.00 BASIC		
E2	5.50 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  
Circuit  
Systems, Inc.

**ICS8520**  
LOW SKEW, 1-TO-16  
DIFFERENTIAL-TO-LVHSTL FANOUT BUFFER

**TABLE 9. ORDERING INFORMATION**

<b>Part/Order Number</b>	<b>Marking</b>	<b>Package</b>	<b>Count</b>	<b>Temperature</b>
ICS8520DY	ICS8520DY	48 Lead LQFP	250 per tray	0°C to 70°C
ICS8520DYT	ICS8520DY	48 Lead LQFP on Tape and Reel	1000	0°C to 70°C

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