ICS8523I

Low Skew, 1-to-4 Differential-to-HSTL Fanout Buffer

Integrated Circuit Systems, Inc.

General Description

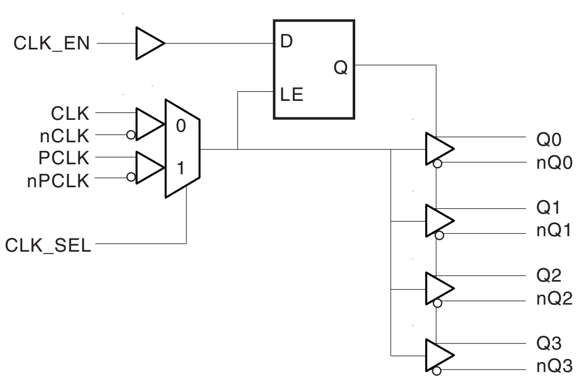
The ICS8523I is a low skew, high performance 1-to-4 Differential-to-HSTL fanout buffer and a member of the HiPerClockS™family of High Performance Clock Solutions from ICS. The ICS8523I has two selectable clock inputs. The CLK, nCLK pair can accept most standard differential input levels. The PCLK, nPCLK pair can accept LVPECL, CML, or SSTL input levels. The clock enable is internally synchronized to eliminate runt pulses on the outputs during asynchronous assertion/deassertion of the clock enable pin.

Guaranteed output and part-to-part skew characteristics make the ICS8523I ideal for those applications demanding well defined performance and repeatability.

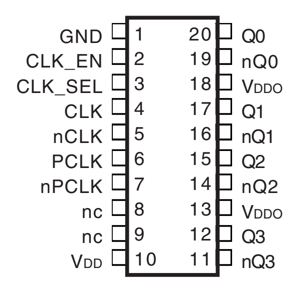
Features

- 4 differential HSTL compatible outputs
- Selectable diffferential CLK, nCLK or LVPECL clock inputs
- CLK, nCLK pair can accept the following differential input levels: LVDS, LVPECL, HSTL, SSTL, HCSL
- PCLK, nPCLK supports the following input types: LVPECL, CML, SSTL
- Maximum output frequency: 650MHz
- Translates any single-ended input signal to HSTL levels with resistor bias on nCLK input
- Output skew: 50ps (maximum)
- Part-to-part skew: 250ps (maximum)
- Propagation delay: 1.6ns (maximum)
- 3.3V core, 1.8V output operating supply
- Lead-Free package available
- -40°C to 85°C ambient operating temperature

Block Diagram



Pin Assignment



ICS8523I

20-Lead TSSOP

6.5mm x 4.4mm x 0.92mm body package

G Package

Top View

TABLE 1. PIN DESCRIPTIONS

Number	Name	Type		Description
1	GND	Power		Power supply ground.
2	CLK_EN	Input	Pullup	Synchronizing clock enable. When HIGH, clock outputs follow clock input. When LOW, Q outputs are forced low, nQ outputs are forced high. LVCMOS / LVTTL interface levels.
3	CLK_SEL	Input	Pulldown	Clock select input. When HIGH, selects differential PCLK, nPCLK inputs. When LOW, selects CLK, nCLK inputs. LVCMOS / LVTTL interface levels.
4	CLK	Input	Pulldown	Non-inverting differential clock input.
5	nCLK	Input	Pullup	Inverting differential clock input.
6	PCLK	Input	Pulldown	Non-inverting differential LVPECL clock input.
7	nPCLK	Input	Pullup	Inverting differential LVPECL clock input.
8, 9	nc	Unused		No connect.
10	V_{DD}	Power		Core supply pin.
11, 12	nQ3, Q3	Output		Differential output pair. HSTL interface levels.
13, 18	V_{DDO}	Power		Output supply pins.
14, 15	nQ2, Q2	Output		Differential output pair. HSTL interface levels.
16, 17	nQ1, Q1	Output		Differential output pair. HSTL interface levels.
19, 20	nQ0, Q0	Output		Differential output pair. 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			51		KΩ
$R_{PULLDOWN}$	Input Pulldown Resistor			51		KΩ

TABLE 3A. CONTROL INPUT FUNCTION TABLE

Inputs			Outputs	
CLK_EN	**CLK_SEL**	**Selected Source**	**Q0:Q3**	**nQ0:nQ3**
0	0	CLK, nCLK	Disabled; LOW	Disabled; HIGH
0	1	PCLK, nPCLK	Disabled; LOW	Disabled; HIGH
1	0	CLK, nCLK	Enabled	Enabled
1	1	PCLK, nPCLK	Enabled	Enabled

After CLK_EN switches, the clock outputs are disabled or enabled following a rising and falling input clock edge as shown in Figure 1.
In the active mode, the state of the outputs are a function of the CLK , nCLK and PCLK, nPCLK inputs as described in Table 3B.

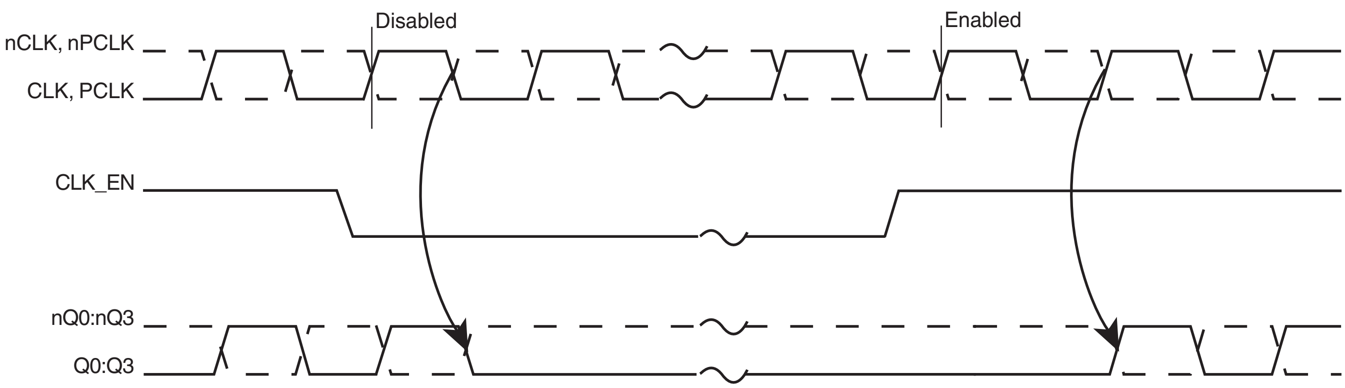


FIGURE 1. CLK_EN TIMING DIAGRAM

TABLE 3B. CLOCK INPUT FUNCTION TABLE

Inputs		Outputs		Input to Output Mode	Polarity
CLK or PCLK	**nCLK or nPCLK**	**Q0:Q3**	**nQ0:nQ3**		
0	0	LOW	HIGH	Differential to Differential	Non Inverting
1	1	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, I_O	
Continuous Current	50mA
Surge Current	100mA
Package Thermal Impedance, θ_{JA}	73.2°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±5%, V_{DDO} = 1.8V±0.2V, TA = 0°C TO 70°C

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
V_{DD}	Core Power Supply Voltage		3.135	3.3	3.465	V
V_{DDO}	Output Power Supply Voltage		1.6	1.8	2.0	V
I_{DD}	Power Supply Current				55	mA

TABLE 4B. LVCMOS / LVTTL DC CHARACTERISTICS, V_{DD} = 3.3V±5%, V_{DDO} = 1.8V±0.2V, TA = 0°C TO 70°C

Symbol	Parameter		Test Conditions	Minimum	Typical	Maximum	Units
V_{IH}	Input High Voltage	CLK_EN, CLK_SEL		2		V_{DD} + 0.3	V
V_{IL}	Input Low Voltage	CLK_EN, CLK_SEL		-0.3		0.8	V
I_{IH}	Input High Current	CLK_EN	$V_{DD} = V_{IN}$ = 3.465V			5	µA
		CLK_SEL	$V_{DD} = V_{IN}$ = 3.465V			150	µA
I_{IL}	Input Low Current	CLK_EN	V_{DD} = 3.465V, V_{IN} = 0V	-150			µA
		CLK_SEL	V_{DD} = 3.465V, V_{IN} = 0V	-5			µA

TABLE 4C. DIFFERENTIAL DC CHARACTERISTICS, V_{DD} = 3.3V±5%, V_{DDO} = 1.8V±0.2V, TA = 0°C TO 70°C

Symbol	Parameter		Test Conditions	Minimum	Typical	Maximum	Units
I_{IH}	Input High Current	nCLK	$V_{DD} = V_{IN}$ = 3.465V			5	µA
		CLK	$V_{DD} = V_{IN}$ = 3.465V			150	µA
I_{IL}	Input Low Current	nCLK	V_{DD} = 3.465V, V_{IN} = 0V	-150			µA
		CLK	V_{DD} = 3.465V, V_{IN} = 0V	-5			µA
V_{PP}	Peak-to-Peak Input Voltage			0.15		1.3	V
V_{CMR}	Common Mode Input Voltage; NOTE 1, 2			0.5		V_{DD} - 0.85	V

NOTE 1: For single ended applications the maximum input voltage for CLK and nCLK is V_{DD} + 0.3V.
NOTE 2: Common mode voltage is defined as V_{IH}.

TABLE 4D. LVPECL DC CHARACTERISTICS, V_{DD} = 3.3V±5%, V_{DDO} = 1.8V±0.2V, TA = 0°C TO 70°C

Symbol	Parameter		Test Conditions	Minimum	Typical	Maximum	Units
I_{IH}	Input High Current	PCLK	$V_{DD} = V_{IN}$ = 3.465V			150	µA
		nPCLK	$V_{DD} = V_{IN}$ = 3.465V			5	µA
I_{IL}	Input Low Current	PCLK	V_{DD} = 3.465V, V_{IN} = 0V	-5			µA
		nPCLK	V_{DD} = 3.465V, V_{IN} = 0V	-150			µA
V_{PP}	Peak-to-Peak Input Voltage			0.3		1	V
V_{CMR}	Common Mode Input Voltage; NOTE 1, 2			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 4D. HSTL DC CHARACTERISTICS, V_{DD} = 3.3V±5%, V_{DDO} = 1.8V±0.2V, TA = 0°C TO 70°C

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
V_{OH}	Output High Voltage; NOTE 1		0.9		1.4	V
V_{OL}	Output Low Voltage; NOTE 1		0		0.4	V
V_{OX}	Output Crossover Voltage		40% x (V_{OH} - V_{OL}) + V_{OL}		60% x (V_{OH} - V_{OL}) + V_{OL}	V
V_{SWING}	Peak-to-Peak Output Voltage Swing		0.6		1.3	V

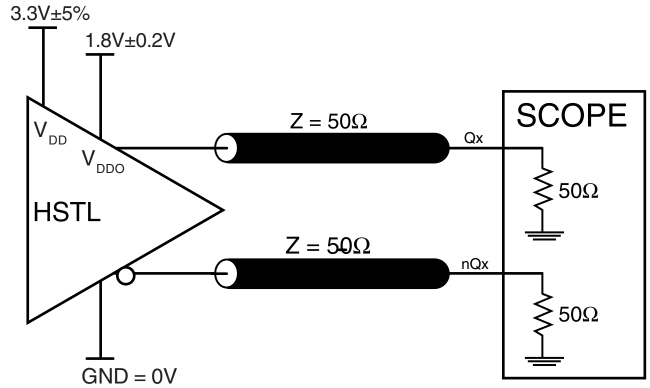
NOTE 1: Outputs terminated with 50Ω to ground.

TABLE 5. AC CHARACTERISTICS, V_{DD} = 3.3V±5%, V_{DDO} = 1.8V±0.2V, TA = 0°C TO 70°C

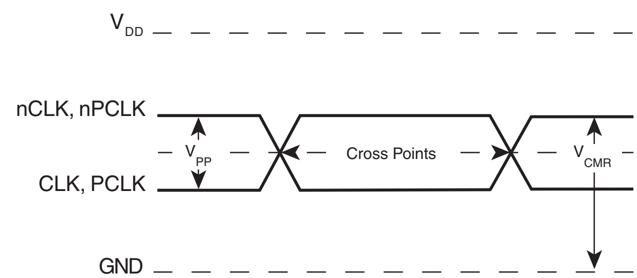
Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
f_{MAX}	Output Frequency				650	MHz
t_{PD}	Propagation Delay; NOTE 1	$f \leq$ 650MHz	1.0		1.6	ns
*t*sk(o)	Output Skew; NOTE 2, 4				50	ps
*t*sk(pp)	Part-to-Part Skew; NOTE 3, 4				250	ps
t_R	Output Rise Time	20% to 80% @ 50MHz	300		700	ps
t_F	Output Fall Time	20% to 80% @ 50MHz	300		700	ps
odc	Output Duty Cycle		45		55	%

All parameters measured at 500MHz unless noted otherwise.
The cycle to cycle jitter on the input will equal the jitter on the output. The part does not add jitter.
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 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.

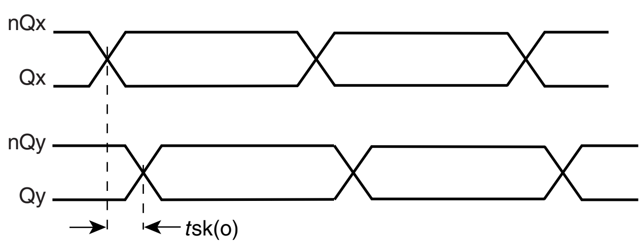
PARAMETER MEASUREMENT INFORMATION



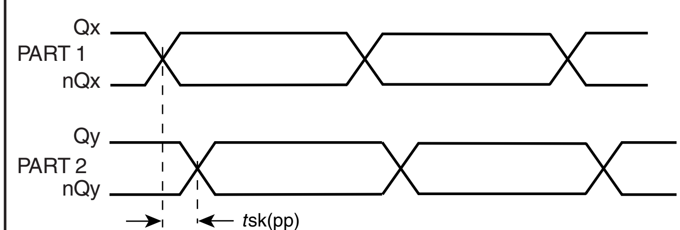
3.3V/1.8V OUTPUT LOAD AC TEST CIRCUIT



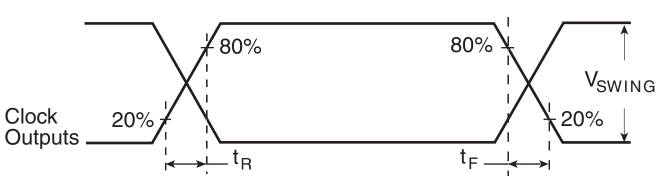
DIFFERENTIAL INPUT LEVEL



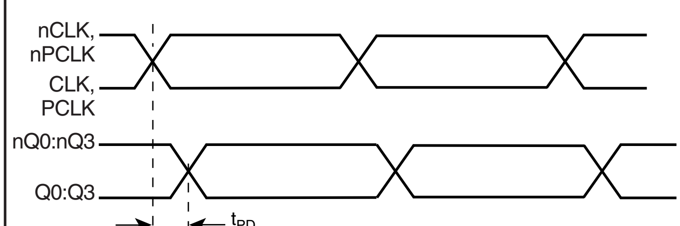
OUTPUT SKEW



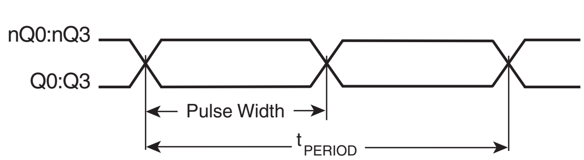
PART-TO-PART SKEW



OUTPUT RISE/FALL TIME



PROPAGATION DELAY



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

odc & t_{PERIOD}

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.

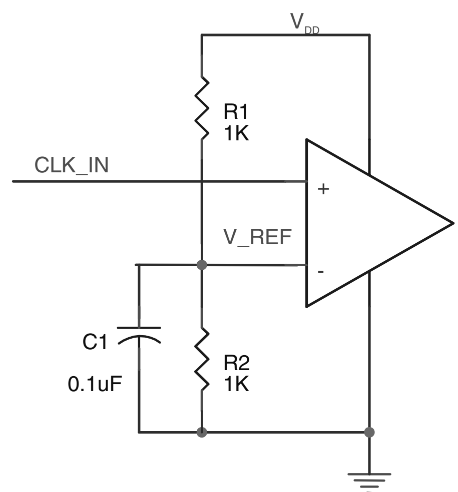


FIGURE 2. SINGLE ENDED SIGNAL DRIVING DIFFERENTIAL INPUT

DIFFERENTIAL CLOCK INPUT INTERFACE

The CLK /nCLK accepts LVDS, LVPECL, HSTL, SSTL, HCSL 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 3A,* the input termination applies for ICS HiPerClockS HSTL drivers. If you are using an HSTL driver from another vendor, use their termination recommendation.

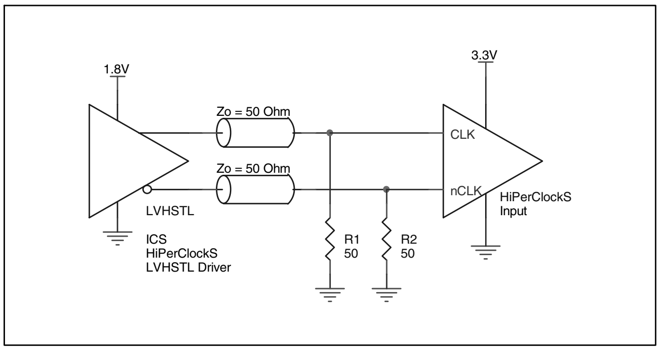


FIGURE 3A. HIPERCLOCKS CLK/nCLK INPUT DRIVEN BY ICS HIPERCLOCKS HSTL DRIVER

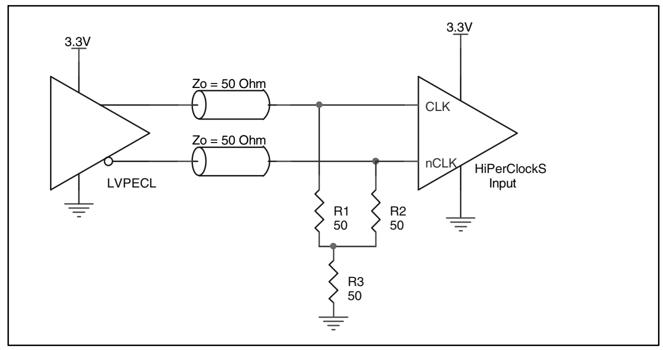


FIGURE 3B. HIPERCLOCKS CLK/nCLK INPUT DRIVEN BY 3.3V LVPECL DRIVER

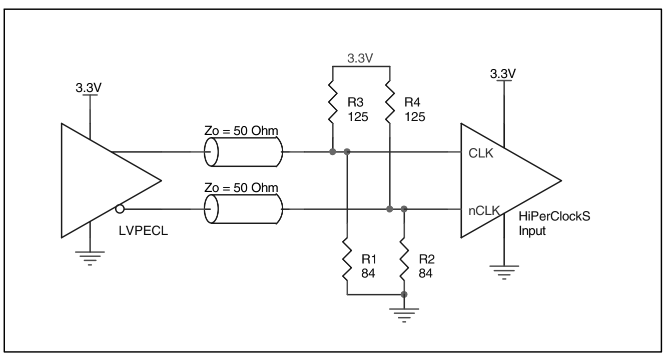


FIGURE 3C. HIPERCLOCKS CLK/nCLK INPUT DRIVEN BY 3.3V LVPECL DRIVER

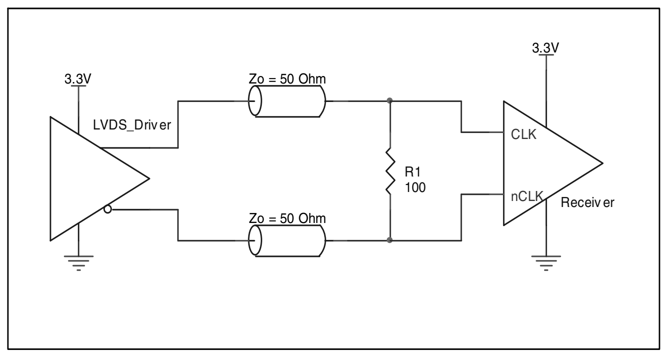


FIGURE 3D. HIPERCLOCKS CLK/nCLK INPUT DRIVEN BY 3.3V LVDS DRIVER

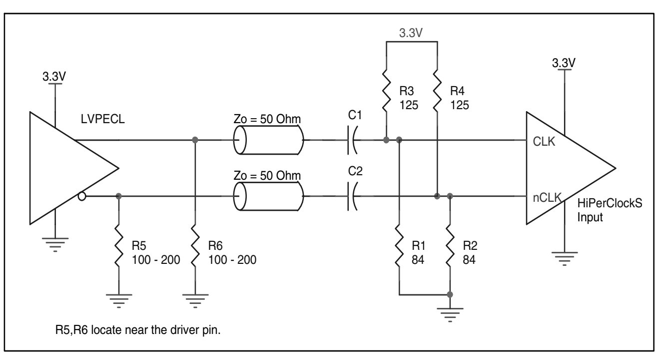


FIGURE 3E. HIPERCLOCKS CLK/nCLK INPUT DRIVEN BY 3.3V LVPECL DRIVER WITH AC COUPLE

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 4F* show interface examples for the HiPerClockS PCLK/nPCLK 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.

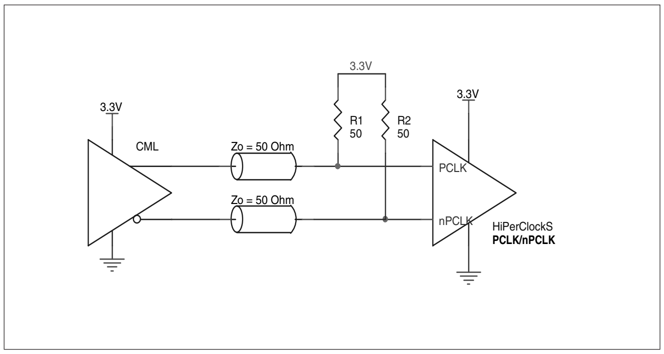


FIGURE 4A. HIPERCLOCKS PCLK/nPCLK INPUT DRIVEN BY AN OPEN COLLECTOR CML DRIVER

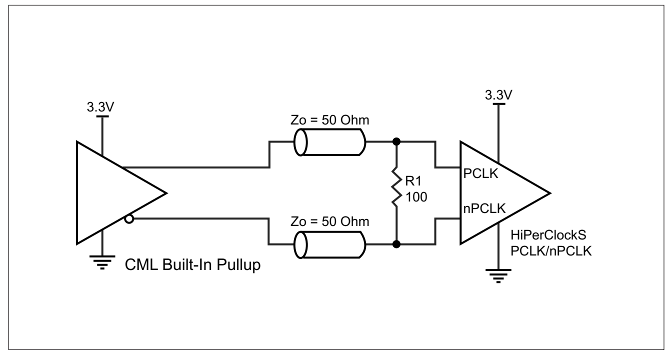


FIGURE 4B. HIPERCLOCKS PCLK/nPCLK INPUT DRIVEN BY A BUILT-IN PULLUP CML DRIVER

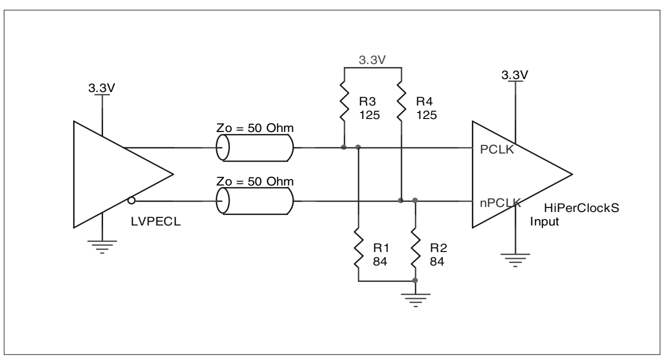


FIGURE 4C. HIPERCLOCKS PCLK/nPCLK INPUT DRIVEN BY A 3.3V LVPECL DRIVER

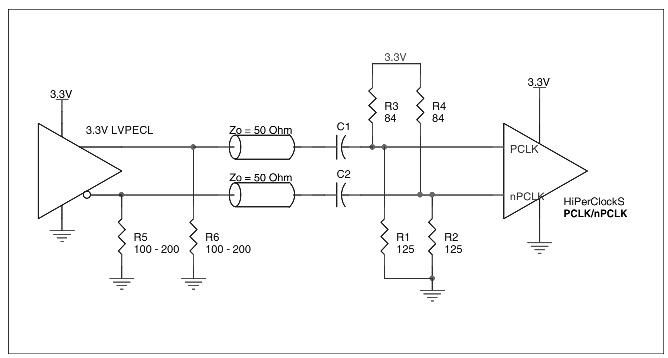


FIGURE 4D. HIPERCLOCKS PCLK/nPCLK INPUT DRIVEN BY A 3.3V LVPECL DRIVER WITH AC COUPLE

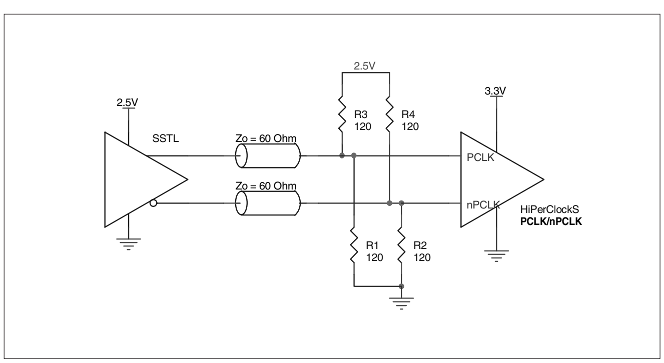


FIGURE 4E. HIPERCLOCKS PCLK/nPCLK INPUT DRIVEN BY AN SSTL DRIVER

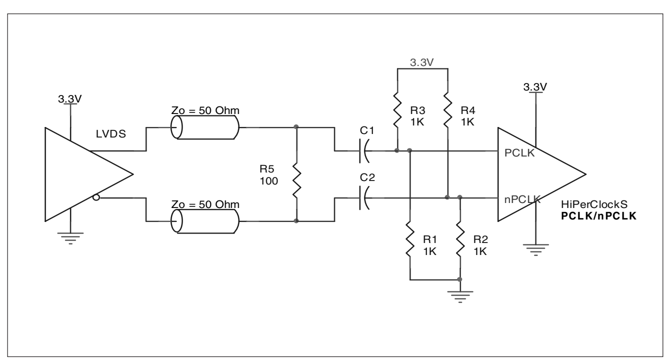


FIGURE 4F. HIPERCLOCKS PCLK/nPCLK INPUT DRIVEN BY A 3.3V LVDS DRIVER

SCHEMATIC EXAMPLE

Figure 5 shows a schematic example of the ICS8523I. 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 ICS8523I, the unused clock outputs can be left floating.

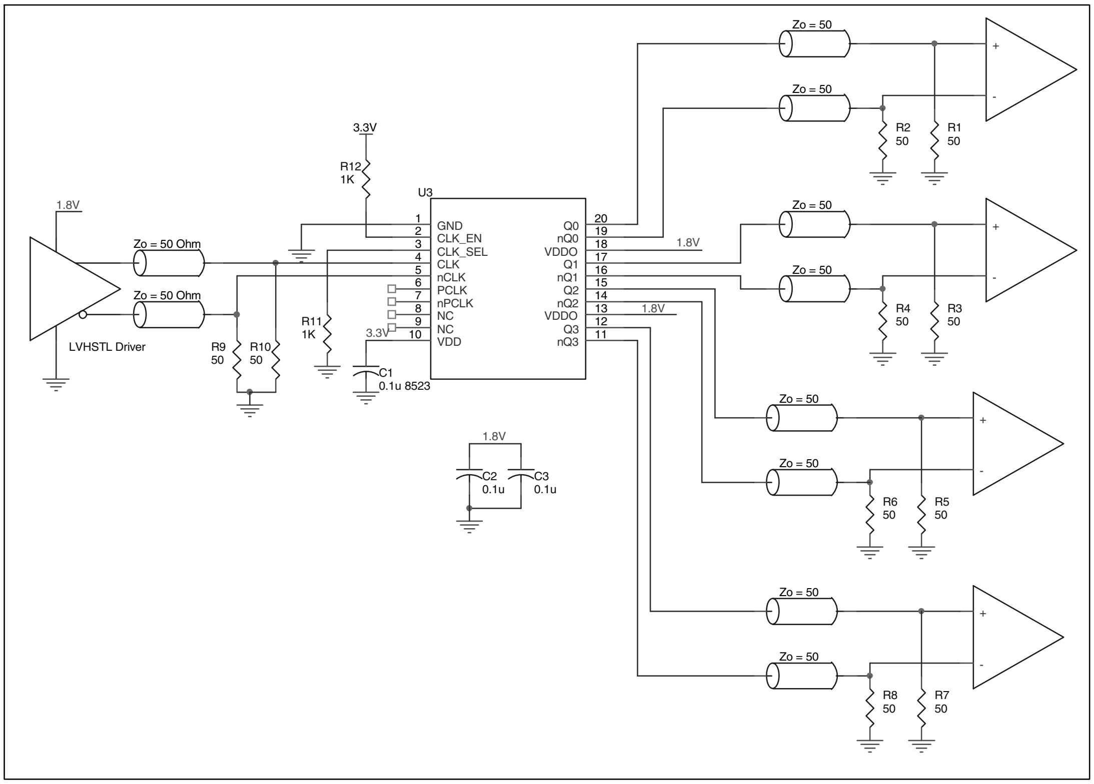


FIGURE 5. ICS8523I HSTL BUFFER SCHEMATIC EXAMPLE

POWER CONSIDERATIONS

This section provides information on power dissipation and junction temperature for the ICS8523I.
Equations and example calculations are also provided.

1. Power Dissipation.
The total power dissipation for the ICS8523I 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)$_{MAX}$ = V_{DD_MAX} * I_{DD_MAX} = 3.465V * 55mA = **190.6mW**
- Power (outputs)$_{MAX}$ = **32.6mW/Loaded Output pair**
  If all outputs are loaded, the total power is 4 * 32.6mW = **130.4mW**

Total Power$_{\_MAX}$ (3.465V, with all outputs switching) = 190.6mW + 130.4mW = **321mW**

2. Junction Temperature.
Junction temperature, Tj, 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 Tj is as follows: Tj = θ_{JA} * Pd_total + T_A

Tj = 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 a moderate air flow of 200 linear feet per minute and a multi-layer board, the appropriate value is 66.6°C/W per Table 6 below.
Therefore, Tj for an ambient temperature of 85°C with all outputs switching is:

85°C + 0.321W * 66.6°C/W = 106.4°C. This is well below the limit of 125°C.

This calculation is only an example. Tj 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 θ_{JA} FOR 20-PIN TSSOP, FORCED CONVECTION

θ_{JA} by Velocity (Linear Feet per Minute)

	0	**200**	**500**
Single-Layer PCB, JEDEC Standard Test Boards	114.5°C/W	98.0°C/W	88.0°C/W
Multi-Layer PCB, JEDEC Standard Test Boards	73.2°C/W	66.6°C/W	63.5°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.

HSTL output driver circuit and termination are shown in *Figure 6.*

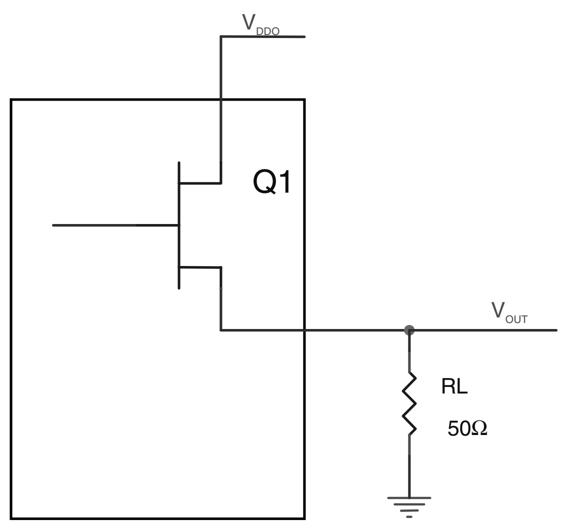


FIGURE 6. HSTL DRIVER CIRCUIT AND TERMINATION

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/50Ω) * (2V -0.9V) = **19.8mW**
Pd_L = (0.4V/50Ω) * (2V - 0.4V) = **12.8mW**

Total Power Dissipation per output pair = Pd_H + Pd_L = **32.6mW**

RELIABILITY INFORMATION

TABLE 7. θ_{JA} VS. AIR FLOW TABLE FOR 20 LEAD TSSOP

θ_{JA} by Velocity (Linear Feet per Minute)	0	200	500
Single-Layer PCB, JEDEC Standard Test Boards	114.5°C/W	98.0°C/W	88.0°C/W
Multi-Layer PCB, JEDEC Standard Test Boards	73.2°C/W	66.6°C/W	63.5°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 ICS8523I is: 472

PACKAGE OUTLINE - G SUFFIX FOR 20 LEADP TSSOP

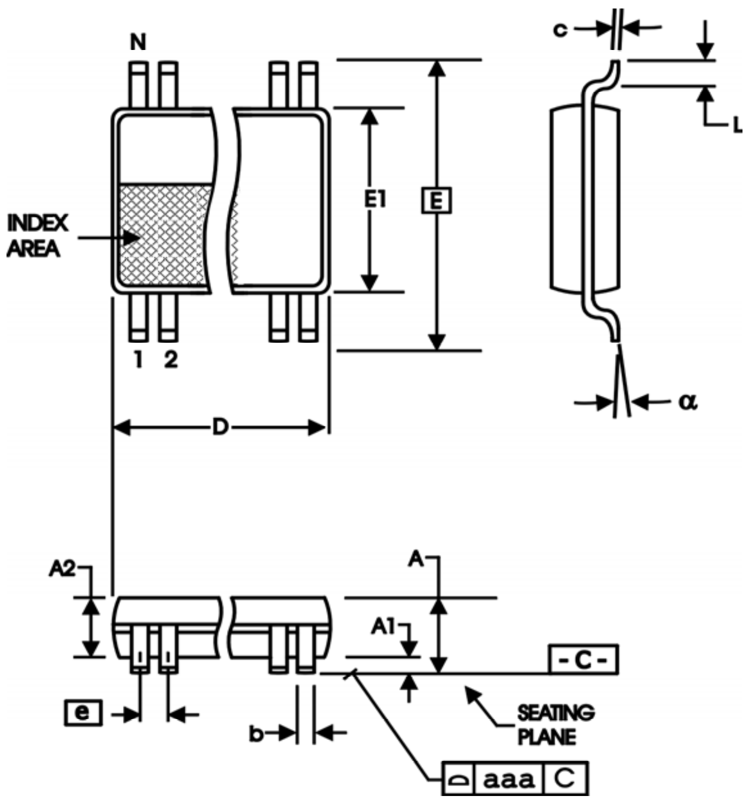


TABLE 8. PACKAGE DIMENSIONS

SYMBOL	Millimeters	
	Minimum	Maximum
N	20	
A	--	1.20
A1	0.05	0.15
A2	0.80	1.05
b	0.19	0.30
c	0.09	0.20
D	6.40	6.60
E	6.40 BASIC	
E1	4.30	4.50
e	0.65 BASIC	
L	0.45	0.75
α	0°	8°
aaa	--	0.10

Reference Document: JEDEC Publication 95, MS-153

TABLE 9. ORDERING INFORMATION

Part/Order Number	Marking	Package	Count	Temperature
ICS8523BGI	ICS8523BGI	20 lead TSSOP	72 per tube	-40°C to 85°C
ICS8523BGIT	ICS8523BGI	20 lead TSSOP on Tape and Reel	2500	-40°C to 85°C
ICS8523BGILF	ICS8523BGILF	20 lead "Lead-Free" TSSOP	72 per tube	-40°C to 85°C
ICS8523BGILFT	ICS8523BGILF	20 lead "Lead-Free" TSSOP on Tape and Reel	2500	-40°C to 85°C

REVISION HISTORY SHEET				
Rev	Table	Page	Description of Change	Date
B	T5	5	AC Characteristics table. t_{PD} row, changed Min. from 1.2ns to 1.0ns.	1/11/02
B		1	Revised Features section, Bullet 1,6 - took out 1.8V	5/6/02
B		8 - 10	In the Application Information section, added Schematic Examples	10/28/02
C	T2 T4D	2 4 5 11 - 12	Pin Characteristics Table - changed C_{IN} 4pF max. to 4pF typical. Absolute Maximum Ratings - changed Output rating. HSTL DC Characteristics Table - changed V_{OH} 1V min. to 0.9V min. Power Considerations - changed Total Power Dissipation to reflect V_{OH} change. Calculations changed due to new Total Power Dissipation. Changed LVHSTL to HSTL throughout data sheet.	6/23/03
C	 T9	1 9 15	Added Lead-Free bullet to Features section. Updated LVPECL Clock Input Interface section. Added Lead-Free Part Number to Ordering Information TAble.	9/16/04