

**General Description**



The ICS85304-01 is a low skew, high performance 1-to-5 Differential-to-3.3V LVPECL fanout buffer and a member of the HiPerClockS™ family of High Performance Clock Solutions from IDT. The ICS85304-01 has two selectable clock inputs. The

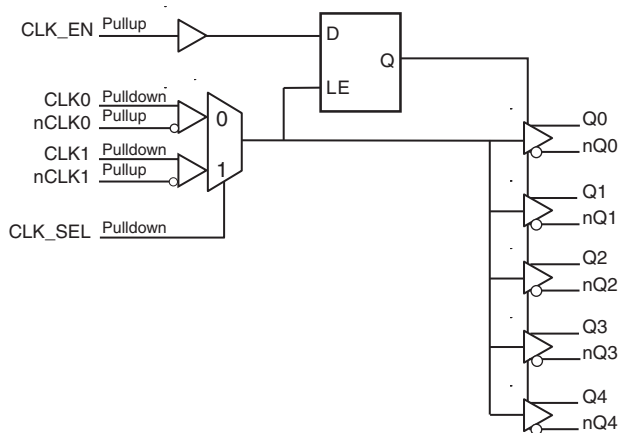
CLKx, nCLKx pairs can accept most standard differential input levels. The clock enable is internally synchronized to eliminate runt clock pulses on the outputs during asynchronous assertion/deassertion of the clock enable pin.

Guaranteed output and part-to-part skew characteristics make the ICS85304-01 ideal for those applications demanding well defined performance and repeatability.

**Features**

- Five 3.3V differential LVPECL output pairs
- Selectable differential CLKx/nCLKx input pairs
- CLKx/nCLKx input pairs can accept the following differential levels: LVDS, LVPECL, LVHSTL, SSTL and HCSL levels
- Maximum output frequency: 650MHz
- Translates any single-ended input signal to 3.3V LVPECL levels with resistor bias on nCLKx inputs
- Output skew: 35ps (maximum)
- Part-to-part skew: 150ps (maximum)
- Propagation delay: 2.1ns (maximum)
- Full 3.3V supply mode
- 0°C to 70°C ambient operating temperature
- Available in both standard (RoHS 5) and lead-free (RoHS 6) packages

**Block Diagram**



**Pin Assignment**

Q0	1	20	Vcc
nQ0	2	19	CLK_EN
Q1	3	18	Vcc
nQ1	4	17	nCLK1
Q2	5	16	CLK1
nQ2	6	15	VEE
Q3	7	14	nCLK0
nQ3	8	13	CLK0
Q4	9	12	CLK_SEL
nQ4	10	11	Vcc

**ICS85304-01**  
**20-Lead TSSOP**  
**6.5mm x 4.4mm x 0.925mm**  
**package body**  
**G Package**  
**Top View**

**Table 1. Pin Descriptions**

Number	Name	Type		Description
1, 2	Q0, nQ0	Output		Differential output pair. LVPECL interface levels.
3, 4	Q1, nQ1	Output		Differential output pair. LVPECL interface levels.
5, 6	Q2, nQ2	Output		Differential output pair. LVPECL interface levels.
7, 8	Q3, nQ3	Output		Differential output pair. LVPECL interface levels.
9, 10	Q4, nQ4	Output		Differential output pair. LVPECL interface levels.
11, 18, 20	V <sub>CC</sub>	Power		Positive supply pins.
12	CLK_SEL	Input	Pulldown	Clock select input. When HIGH, selects CLK1, nCLK1 inputs. When LOW, selects CLK0, nCLK0 inputs. LVTTTL/LVCMOS interface levels.
13	CLK0	Input	Pulldown	Non-inverting differential clock input.
14	nCLK0	Input	Pullup	Inverting differential clock input.
15	V <sub>EE</sub>	Power		Negative supply pin.
16	CLK1	Input	Pulldown	Non-inverting differential clock input.
17	nCLK1	Input	Pullup	Inverting differential clock input.
19	CLK_EN	Input	Pullup	Synchronizing clock enable. When HIGH, clock outputs follow clock input. When LOW, Qx outputs are forced LOW, nQx outputs are forced HIGH. LVTTTL/LVCMOS 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>PULLDOWN</sub>	Input Pulldown Resistor			51		kΩ
R <sub>PULLUP</sub>	Input Pullup Resistor			51		kΩ

## Function Tables

Table 3A. Control Input Function Table

Inputs			Outputs	
CLK_EN	CLK_SEL	Selected Source	Q0:Q4	nQ0:nQ4
0	0	CLK0, nCLK0	Disabled; LOW	Disabled; HIGH
0	1	CLK1, nCLK1	Disabled; LOW	Disabled; HIGH
1	0	CLK0, nCLK0	Enabled	Enabled
1	1	CLK1, nCLK1	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 CLKx/nCLKx inputs as described in Table 3B.

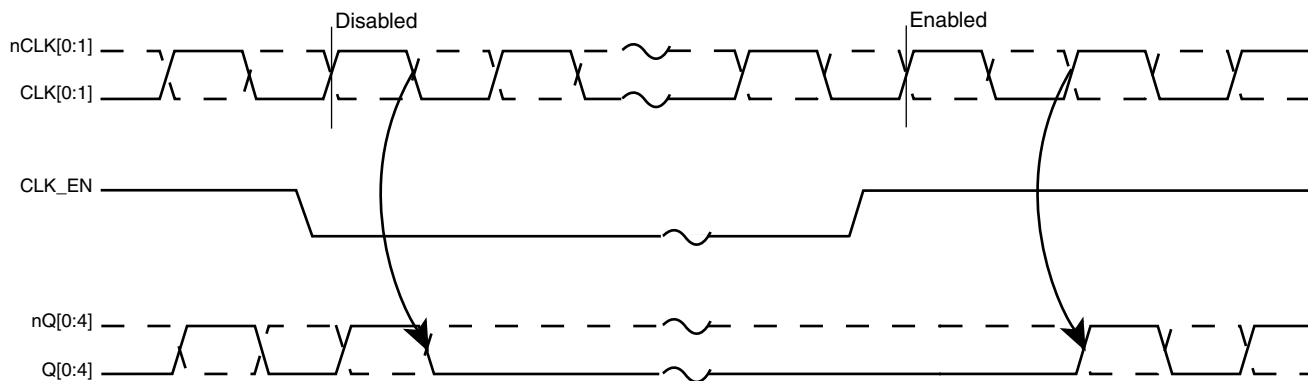


Figure 1. CLK\_EN Timing Diagram

Table 3B. Clock Input Function Table

Inputs		Outputs		Input to Output Mode	Polarity
CLK0 or CLK1	nCLK0 or nCLK1	Q[0:4]	nQ[0:4]		
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

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
Inputs, $V_I$	-0.5V to $V_{CC} + 0.5V$
Outputs, $I_O$ Continuous Current Surge Current	50mA 100mA
Package Thermal Impedance, $\theta_{JA}$	73.2°C/W (0 lfpm)
Storage Temperature, $T_{STG}$	-65°C to 150°C

## DC Electrical Characteristics

**Table 4A. Power Supply DC Characteristics,  $V_{CC} = 3.3V \pm 5\%$ ,  $V_{EE} = 0V$ ,  $T_A = -40^\circ C$  to  $85^\circ C$**

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$V_{CC}$	Core Supply Voltage		3.135	3.3	3.465	V
$I_{EE}$	Power Supply Current				55	mA

**Table 4B. LVCMOS/LVTTL DC Characteristics,  $V_{CC} = 3.3V \pm 5\%$ ,  $V_{EE} = 0V$ ,  $T_A = -40^\circ C$  to  $85^\circ C$**

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$V_{IH}$	Input High Voltage		2		3.765	V
$V_{IL}$	Input Low Voltage		-0.3		0.8	V
$I_{IH}$	Input High Current	CLK_EN	$V_{CC} = V_{IN} = 3.465V$		5	$\mu A$
		CLK_SEL	$V_{CC} = V_{IN} = 3.465V$		150	$\mu A$
$I_{IL}$	Input Low Current	CLK_EN	$V_{CC} = 3.465V, V_{IN} = 0V$	-150		$\mu A$
		CLK_SEL	$V_{CC} = 3.465V, V_{IN} = 0V$	-5		$\mu A$

**Table 4C. Differential DC Characteristics,  $V_{CC} = 3.3V \pm 5\%$ ,  $V_{EE} = 0V$ ,  $T_A = -40^\circ C$  to  $85^\circ C$** 

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$I_{IH}$	Input High Current	nCLK0, nCLK1	$V_{CC} = V_{IN} = 3.465V$		5	$\mu A$
		CLK0, CLK1	$V_{CC} = V_{IN} = 3.465V$		150	$\mu A$
$I_{IL}$	Input Low Current	nCLK0, nCLK1	$V_{CC} = 3.465V, V_{IN} = 0V$	-150		$\mu A$
		CLK0, CLK1	$V_{CC} = 3.465V, V_{IN} = 0V$	-5		$\mu A$
$V_{PP}$	Peak-to-Peak Voltage; NOTE 1		0.15		1.3	V
$V_{CMR}$	Common Mode Input Voltage; NOTE 1, 2		$V_{EE} + 0.5$		$V_{CC} - 0.85$	V

NOTE 1:  $V_{IL}$  should not be less than -0.3VNOTE 2: Common mode input voltage is defined as  $V_{IH}$ .**Table 4D. LVPECL DC Characteristics,  $V_{CC} = 3.3V \pm 5\%$ ,  $V_{EE} = 0V$ ,  $T_A = -40^\circ C$  to  $85^\circ C$** 

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$V_{OH}$	Output High Current; NOTE 1		$V_{CC} - 1.4$		$V_{CC} - 1.0$	$\mu A$
$V_{OL}$	Output Low Current; NOTE 1		$V_{CC} - 2.0$		$V_{CC} - 1.7$	$\mu A$
$V_{SWING}$	Peak-to-Peak Output Voltage Swing		0.6		0.85	V

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

## AC Electrical Characteristics

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

Parameter	Symbol	Test Conditions	Minimum	Typical	Maximum	Units
$f_{MAX}$	Maximum Output Frequency				650	MHz
$t_{PD}$	Propagation Delay; NOTE 1	$f \leq 650MHz$	1.0		2.1	ns
$t_{sk(o)}$	Output Skew; NOTE 2, 3				35	ps
$t_{sk(pp)}$	Part-to-Part Skew; NOTE 3, 4				150	ps
$t_R / t_F$	Output Rise/Fall Time	20% to 80% @ 50MHz	300		700	ps
odc	Output Duty Cycle		48	50	52	%

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.

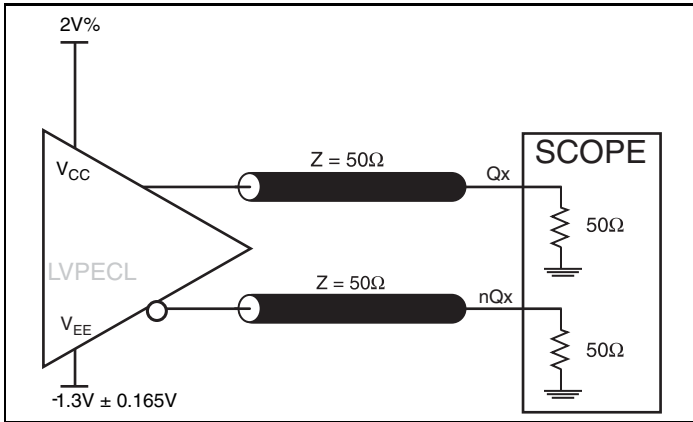
NOTE 2: Defined as skew between outputs at the same supply voltage and with equal load conditions. Measured at the output differential cross points.

NOTE 3: This parameter is defined in accordance with JEDEC Standard 65.

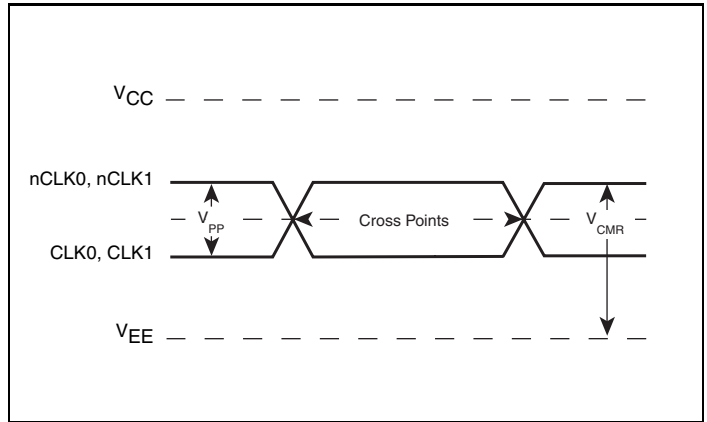
NOTE 4: Defined as skew between outputs on different devices operating at the same supply voltages and with equal load conditions.

Using the same type of inputs on each device, the outputs are measured at the differential cross points.

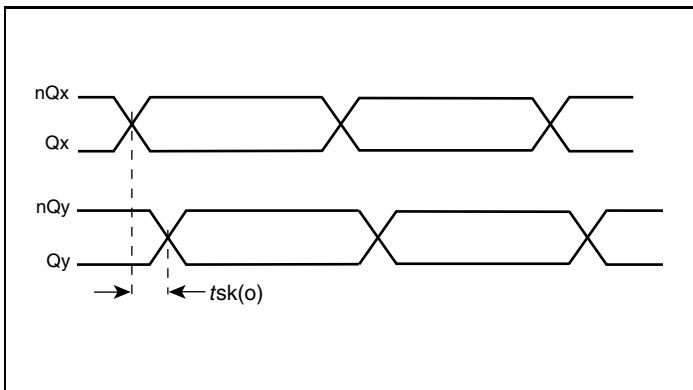
### Parameter Measurement Information



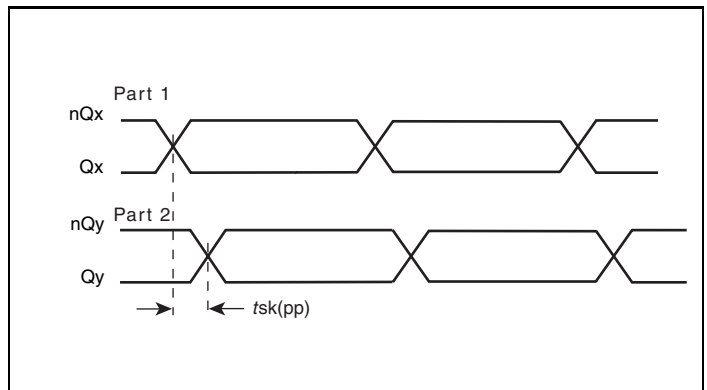
3.3V Output Load AC Test Circuit



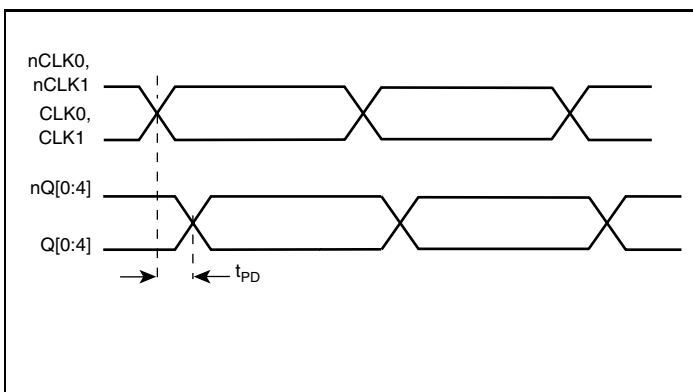
Differential Input Level



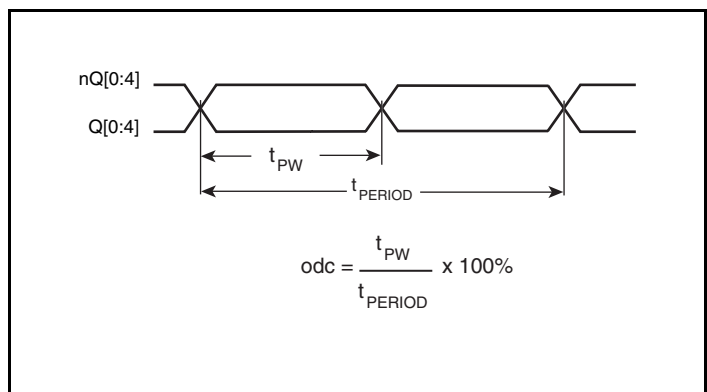
Output Skew



Part-to-Part Skew

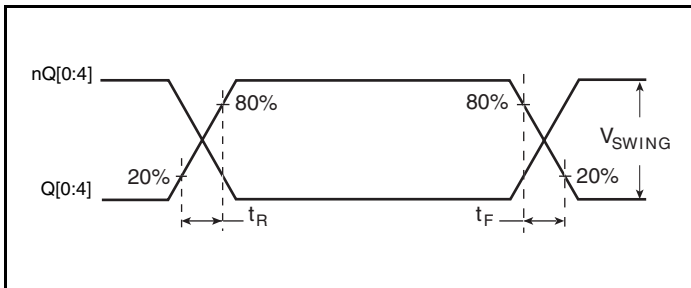


Output Duty Cycle/Pulse Width/Period



Output Duty Cycle/Pulse Width/Period

## Parameter Measurement Information, continued



Output Rise/Fall Time

## Application Information

### Wiring the Differential Input to Accept Single-Ended Levels

Figure 1 shows how the differential input can be wired to accept single-ended levels. The reference voltage  $V_{REF} = V_{CC}/2$  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  $V_{CC} = 3.3V$ ,  $V_{REF}$  should be 1.25V and  $R2/R1 = 0.609$ .

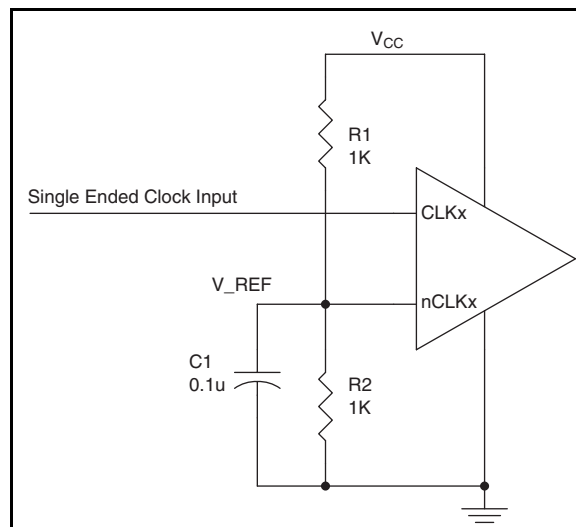
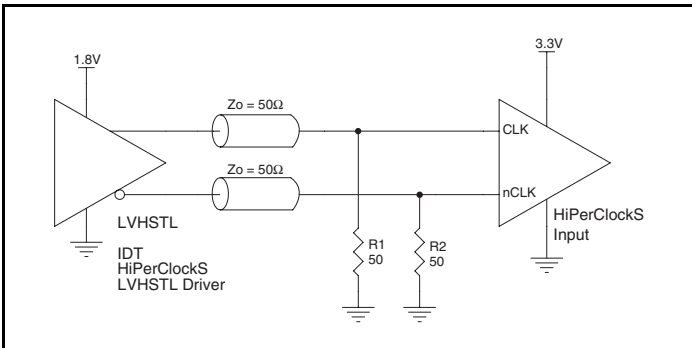


Figure 1. Single-Ended Signal Driving Differential Input

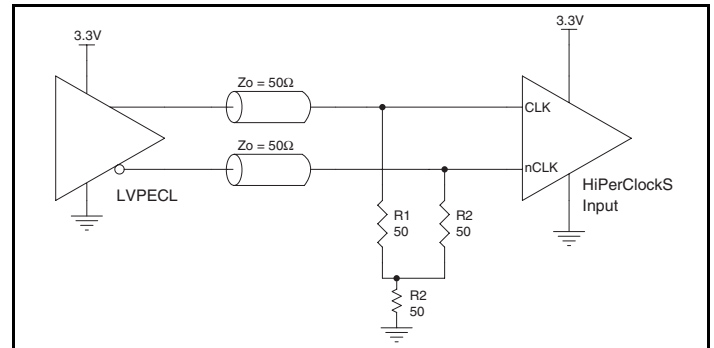
### Differential Clock Input Interface

The CLK /nCLK accepts LVDS, LVPECL, LVHSTL, SSTL, HCSL and other differential signals. Both  $V_{SWING}$  and  $V_{OH}$  must meet the  $V_{PP}$  and  $V_{CMR}$  input requirements. Figures 2A to 2F 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

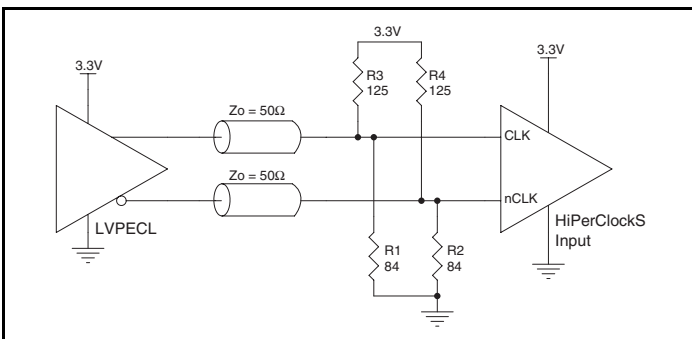
component to confirm the driver termination requirements. For example, in Figure 2A, the input termination applies for IDT HiPerClockS open emitter LVHSTL drivers. If you are using an LVHSTL driver from another vendor, use their termination recommendation.



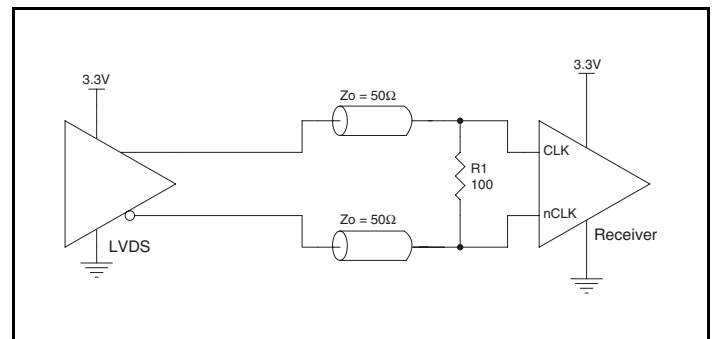
**Figure 2A. HiPerClockS CLK/nCLK Input Driven by an IDT Open Emitter HiPerClockS LVHSTL Driver**



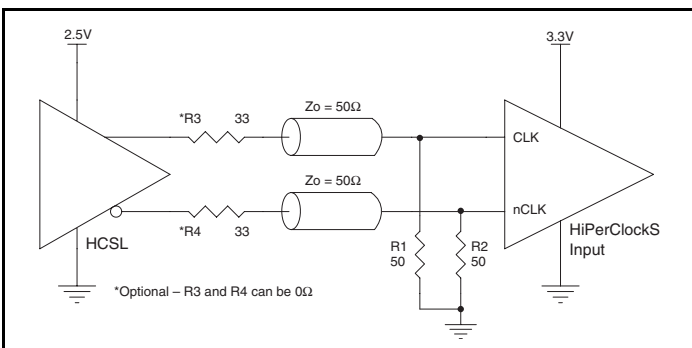
**Figure 2B. HiPerClockS CLK/nCLK Input Driven by a 3.3V LVPECL Driver**



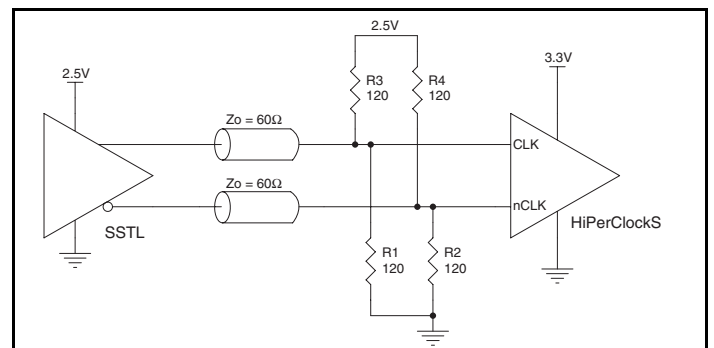
**Figure 2C. HiPerClockS CLK/nCLK Input Driven by a 3.3V LVPECL Driver**



**Figure 2D. HiPerClockS CLK/nCLK Input Driven by a 3.3V LVDS Driver**



**Figure 2E. HiPerClockS CLK/nCLK Input Driven by a 3.3V HCSL Driver**



**Figure 2F. HiPerClockS CLK/nCLK Input Driven by a 2.5V SSTL Driver**



## Recommendations for Unused Input and Output Pins

### Inputs:

#### LVC MOS Control Pins

All control pins have internal pull-ups or pull-downs; additional resistance is not required but can be added for additional protection. A 1k $\Omega$  resistor can be used.

#### CLK/nCLK Inputs

For applications not requiring the use of the differential input, both CLK and nCLK can be left floating. Though not required, but for additional protection, a 1k $\Omega$  resistor can be tied from CLK to ground.

### 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.

## 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.

FOUT and nFOUT 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 50 $\Omega$

transmission lines. Matched impedance techniques should be used to maximize operating frequency and minimize signal distortion. *Figures 3A and 3B* 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.

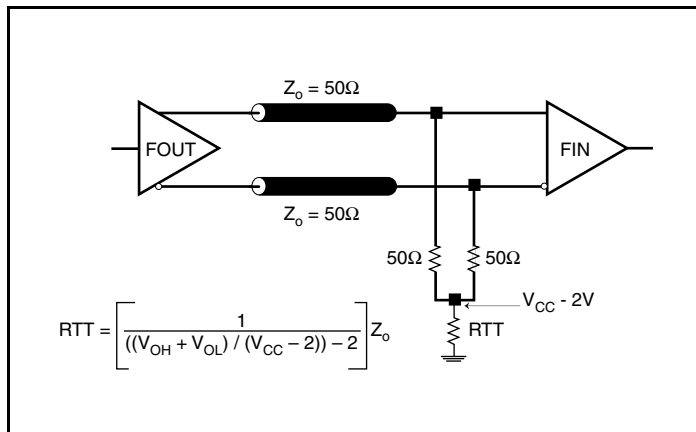


Figure 3A. 3.3V LVPECL Output Termination

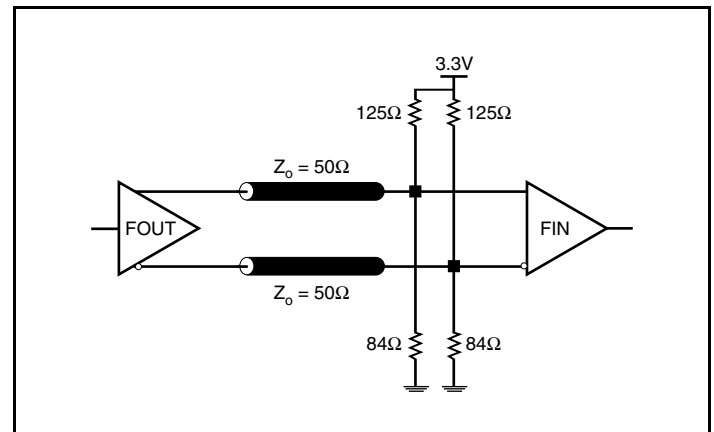


Figure 3B. 3.3V LVPECL Output Termination

## Power Considerations

This section provides information on power dissipation and junction temperature for the ICS85304-01. Equations and example calculations are also provided.

### 1. Power Dissipation.

The total power dissipation for the ICS85304-01 is the sum of the core power plus the power dissipated 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 dissipated in the load.

- Power (core)<sub>MAX</sub> =  $V_{CC\_MAX} * I_{EE\_MAX} = 3.465V * 55mA = 190.57mW$
- Power (outputs)<sub>MAX</sub> = **30.2mW/Loaded Output pair**  
If all outputs are loaded, the total power is  $5 * 30.2mW = 151mW$

**Total Power**<sub>MAX</sub> (3.465V, with all outputs switching) =  $190.57mW + 151mW = 341.57mW$

### 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 no air flow and a multi-layer board, the appropriate value is 73.2°C/W per Table 6 below.

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

$$70^\circ\text{C} + 0.342W * 73.2^\circ\text{C/W} = 95^\circ\text{C}. \text{ This is well below the limit of } 125^\circ\text{C}.$$

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 20 Lead TSSOP, Forced Convection**

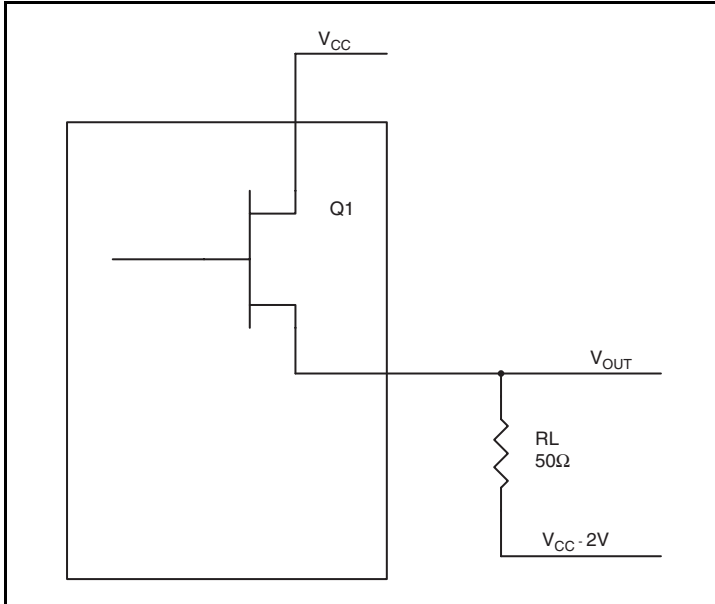
Linear Feet per Minute	$\theta_{JA}$ by Velocity		
	0	200	500
Single-Layer PCB, JEDEC Standard Test Boards	114.5°C/W	98.0°C/W	88.0°C/W
Multi-Layer PCB, JEDEC Standard Test Boards	73.2°C/W	66.6°C/W	63.5°C/W

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.

LVPECL output driver circuit and termination are shown in *Figure 4*.



**Figure 4. 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,  $V_{OUT} = V_{OH\_MAX} = V_{CC\_MAX} - 1.0V$   
( $V_{CC\_MAX} - V_{OH\_MAX}$ ) = **1.0V**
- For logic low,  $V_{OUT} = V_{OL\_MAX} = V_{CC\_MAX} - 1.7V$   
( $V_{CC\_MAX} - V_{OL\_MAX}$ ) = **1.7V**

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

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

$$Pd\_H = [(V_{OH\_MAX} - (V_{CC\_MAX} - 2V))/R_L] * (V_{CC\_MAX} - V_{OH\_MAX}) = [(2V - (V_{CC\_MAX} - V_{OH\_MAX}))/R_L] * (V_{CC\_MAX} - V_{OH\_MAX}) = [(2V - 1.0V)/50\Omega] * 1.0V = \mathbf{20mW}$$

$$Pd\_L = [(V_{OL\_MAX} - (V_{CC\_MAX} - 2V))/R_L] * (V_{CC\_MAX} - V_{OL\_MAX}) = [(2V - (V_{CC\_MAX} - V_{OL\_MAX}))/R_L] * (V_{CC\_MAX} - V_{OL\_MAX}) = [(2V - 1.7V)/50\Omega] * 1.7V = \mathbf{10.2mW}$$

$$\text{Total Power Dissipation per output pair} = Pd\_H + Pd\_L = \mathbf{30.2mW}$$

## Reliability Information

Table 7.  $\theta_{JA}$  vs. Air Flow Table for a 20 Lead TSSOP

Linear Feet per Minute	$\theta_{JA}$ by Velocity		
	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 ICS85304-01 is: 489

## Package Outline and Package Dimensions

Package Outline - G Suffix for 20 Lead TSSOP

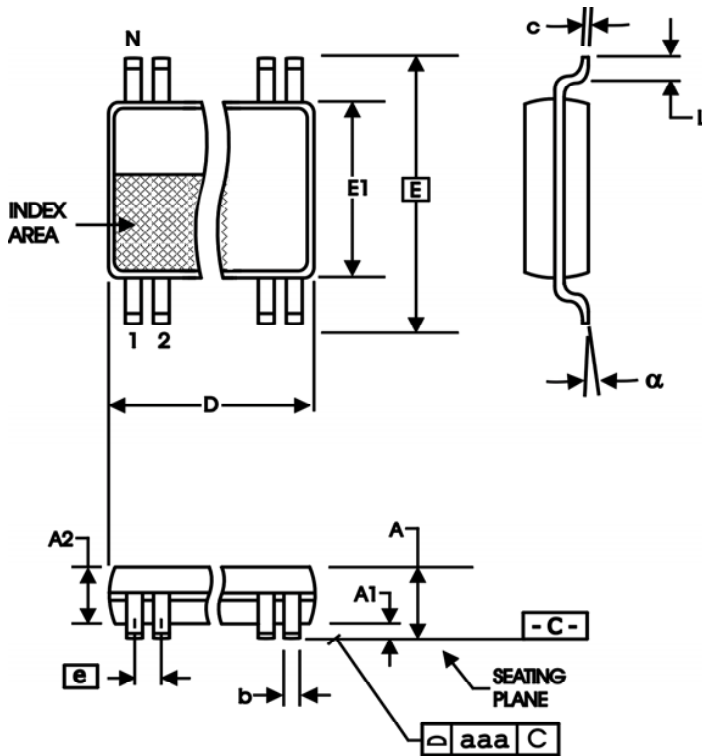


Table 8. Package Dimensions

All Dimensions in Millimeters		
Symbol	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, MO-153

## Ordering Information

Table 9. Ordering Information

Part/Order Number	Marking	Package	Shipping Packaging	Temperature
85304AG-01	ICS85304AG01	20 Lead TSSOP	Tube	0°C to 70°C
85304AG-01T	ICS85304AG01	20 Lead TSSOP	2500 Tape & Reel	0°C to 70°C
85304AG-01LF	ICS85304A01L	“Lead-Free” 20 Lead TSSOP	Tube	0°C to 70°C
85304AG-01LFT	ICS85304A01L	“Lead-Free” 20 Lead TSSOP	2500 Tape & Reel	0°C to 70°C

NOTE: Parts that are ordered with an "LF" suffix to the part number are the Pb-Free configuration and are RoHS compliant.

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## Revision History Sheet

Rev	Table	Page	Description of Change	Date
A	T4B	4	V <sub>CMR</sub> values changed from 1.5V min. to 0.5V min.; V <sub>DD</sub> max. to V <sub>CC</sub> - 0.85V max. V <sub>OH</sub> values changed from 1.9μA min. to V <sub>CC</sub> - 1.4μA min.; 2.3μA max. to V <sub>CC</sub> - 1.0μA. V <sub>OL</sub> values changed from 1.2μA min. to V <sub>CC</sub> - 2.0μA; 1.6μA max. to V <sub>CC</sub> - 1.7μA max. Replaced t <sub>pLH</sub> and t <sub>pHL</sub> with t <sub>pD</sub> at the same values. Replaced t <sub>pW</sub> and values of t <sub>CYCLE</sub> /2 - 40 min., t <sub>CYCLE</sub> /2 typ., t <sub>CYCLE</sub> /2 + 40 max. with odc at values of 48% min., 50% typ., 52% max.	5/14/01
	T4D	5		
	T5	5		
B	T4D	5	LVPECL DC Characteristics Table - added I <sub>IH</sub> , I <sub>IL</sub> , V <sub>PP</sub> , and V <sub>CMR</sub> rows. AC Characteristics Table - t <sub>R</sub> and t <sub>F</sub> values changed from 275ps min to 300ps min; 650ps max. to 700ps max.	5/22/01
	T5			
C	T4D	5	Differential DC Characteristics Table - V <sub>CMR</sub> values changed from V <sub>CC</sub> - 0.85V max. to V <sub>CC</sub> .	8/21/01
C		3	Revised Figure 1, CLK_EN Timing Diagram.	10/17/01
C		3	Revised Figure 1, CLK_EN Timing Diagram.	11/2/01
C	T3B	3	Revised Inputs heading from CLK or CLK, nPCLK or nPCLK to CLK or PCLK, nCLK or nPCLK.	12/28/01
C		8	Added <i>Termination for LVEPCL Output</i> section.	5/30/02
C		6	3.3V Output Load Test Circuit Diagram - corrected V <sub>EE</sub> = -1.3V ± 0.135V to V <sub>EE</sub> = -1.3V ± 0.165V. Updated Output Rise/Fall Time Diagram.	8/26/02
		7		
D	T2	1	Added Lead-Free bullet in Features section. Pin Characteristics table - changed C <sub>IN</sub> 4pF max. to 4pF typical. Absolute Maximum Ratings, updated Outputs rating. Updated Parameter Measurement Information. Added <i>Differential Clock Input Interface</i> section. Added <i>LVPECL Clock Input Interface</i> section. Ordering Information table - added Lead Free part number.	6/17/04
		2		
		4		
		6		
	8			
T9	14			
E	T9	8	Per Document Errata, NEN-08-03, corrected name of PCLK/nPCLK to CLK1/nCLK1 and changed CLK/nCLK to CLK0/nCLK0 throughout the datasheet. Updated <i>Differential Clock Input Interface</i> section. Deleted <i>LVPECL Clock Input Interface</i> section. Added <i>Recommendations for Unused Input and Output Pins</i> section. Power Considerations - corrected Junction Temperature calculations. Ordering Information Table - corrected marking. Updated format throughout the datasheet.	6/20/08
		9		
		10		
		13		
E		3	Corrected Figure 1, CLK_EN Timing Diagram.	7/8/08

**Contact Information:**

**www.IDT.com**

**Sales**

800-345-7015 (inside USA)  
+408-284-8200 (outside USA)  
Fax: 408-284-2775  
[www.IDT.com/go/contactIDT](http://www.IDT.com/go/contactIDT)

**Technical Support**

[netcom@idt.com](mailto:netcom@idt.com)  
+480-763-2056

**Corporate Headquarters**

Integrated Device Technology, Inc.  
6024 Silver Creek Valley Road  
San Jose, CA 95138  
United States  
800-345-7015 (inside USA)  
+408-284-8200 (outside USA)