



### GENERAL DESCRIPTION



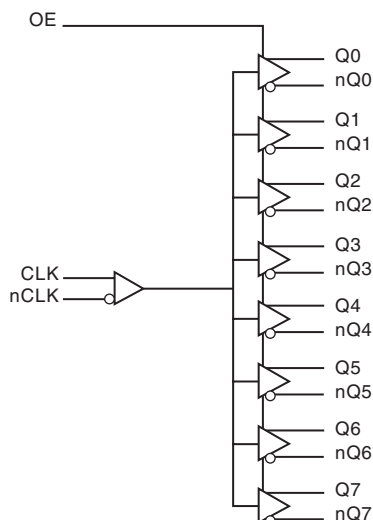
The ICS85408 is a low skew, high performance 1-to-8 Differential-to-LVDS Clock Distribution Chip and a member of the HiPerClockS™ family of High Performance Clock Solutions from ICS. The ICS85408 CLK, nCLK pair can accept most differential input levels and translates them to 3.3V LVDS output levels. Utilizing Low Voltage Differential Signaling (LVDS), the ICS85408 provides a low power, low noise, low skew, point-to-point solution for distributing LVDS clock signals.

Guaranteed output and part-to-part skew specifications make the ICS85408 ideal for those applications demanding well defined performance and repeatability.

### FEATURES

- 8 Differential LVDS outputs
- CLK, nCLK pair can accept the following differential input levels: LVPECL, LVDS, LVHSTL, SSTL, HCSL
- Maximum output frequency: 700MHz
- Translates any differential input signal (LVPECL, LVHSTL, SSTL, HCSL) to LVDS levels without external bias networks
- Translates any single-ended input signal to LVDS with resistor bias on nCLK input
- Multiple output enable inputs for disabling unused outputs in reduced fanout applications
- Output skew: 50ps (maximum)
- Part-to-part skew: 550ps (maximum)
- Propagation delay: 2.4ns (maximum)
- 3.3V operating supply
- 0°C to 70°C ambient operating temperature
- Lead-Free package RoHS compliant

### BLOCK DIAGRAM



### PIN ASSIGNMENT

|     |    |    |      |
|-----|----|----|------|
| nQ6 | 1  | 24 | Q7   |
| Q6  | 2  | 23 | nQ7  |
| nQ5 | 3  | 22 | OE   |
| Q5  | 4  | 21 | GND  |
| nQ4 | 5  | 20 | VDD  |
| Q4  | 6  | 19 | VDD  |
| nQ3 | 7  | 18 | GND  |
| Q3  | 8  | 17 | VDD  |
| nQ2 | 9  | 16 | CLK  |
| Q2  | 10 | 15 | nCLK |
| nQ1 | 11 | 14 | Q0   |
| Q1  | 12 | 13 | nQ0  |

**ICS85408**  
**24-Lead, 173-MIL TSSOP**  
4.4mm x 7.8mm x 0.92mm body package  
**G Package**  
Top View



**TABLE 1. PIN DESCRIPTIONS**

| Number     | Name            | Type   |          | Description                                                                                                                                                                    |
|------------|-----------------|--------|----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1, 2       | nQ6, Q6         | Output |          | Differential output pair. LVDS interface levels.                                                                                                                               |
| 3, 4       | nQ5, Q5         | Output |          | Differential output pair. LVDS interface levels.                                                                                                                               |
| 5, 6       | nQ4, Q4         | Output |          | Differential output pair. LVDS interface levels.                                                                                                                               |
| 7, 8       | nQ3, Q3         | Output |          | Differential output pair. LVDS interface levels.                                                                                                                               |
| 9, 10      | nQ2, Q2         | Output |          | Differential output pair. LVDS interface levels.                                                                                                                               |
| 11, 12     | nQ1, Q1         | Output |          | Differential output pair. LVDS interface levels.                                                                                                                               |
| 13, 14     | nQ0, Q0         | Output |          | Differential output pair. LVDS interface levels.                                                                                                                               |
| 15         | nCLK            | Input  | Pullup   | Inverting differential clock input.                                                                                                                                            |
| 16         | CLK             | Input  | Pulldown | Non-inverting differential clock input.                                                                                                                                        |
| 17, 19, 20 | V <sub>DD</sub> | Power  |          | Positive supply pins.                                                                                                                                                          |
| 18, 21     | GND             | Power  |          | Power supply ground.                                                                                                                                                           |
| 22         | OE              | Input  | Pullup   | Output enable. Controls the enabling and disabling of outputs Qx, nQx. When HIGH, the outputs are enabled. When LOW, the outputs are in HiZ. LVCMOS / LVTTTL interface levels. |
| 23, 24     | nQ7, Q7         | Output |          | Differential output pair. LVDS 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    |
| C <sub>PD</sub>       | Power Dissipation Capacitance (per output) |                 |         | 4       |         | pF    |

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

| Inputs | Outputs |         |
|--------|---------|---------|
| OE     | Q0:Q7   | nQ0:nQ7 |
| 0      | HiZ     | HiZ     |
| 1      | ACTIVE  | ACTIVE  |

**TABLE 3B. CLOCK INPUT FUNCTION TABLE**

| Inputs         |                | Outputs |         | Input to Output Mode         | Polarity      |
|----------------|----------------|---------|---------|------------------------------|---------------|
| CLK            | nCLK           | Q0:Q7   | nQ0:nQ7 |                              |               |
| 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 $V_{DD} + 0.5$ V |
| Outputs, $I_O$                           |                           |
| Continuous Current                       | 10mA                      |
| Surge Current                            | 15mA                      |
| Package Thermal Impedance, $\theta_{JA}$ | 70°C/W (0 mps)            |
| 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,  $V_{DD} = 3.3V \pm 5\%$ ,  $T_A = 0^\circ\text{C}$  TO  $70^\circ\text{C}$**

| Symbol   | Parameter               | Test Conditions | Minimum | Typical | Maximum | Units |
|----------|-------------------------|-----------------|---------|---------|---------|-------|
| $V_{DD}$ | Positive Supply Voltage |                 | 3.135   | 3.3     | 3.465   | V     |
| $I_{DD}$ | Power Supply Current    |                 |         |         | 90      | mA    |

**TABLE 4B. LVCMOS/LVTTL DC CHARACTERISTICS,  $V_{DD} = 3.3V \pm 5\%$ ,  $T_A = 0^\circ\text{C}$  TO  $70^\circ\text{C}$**

| Symbol   | Parameter          | Test Conditions                   | Minimum | Typical | Maximum        | Units         |
|----------|--------------------|-----------------------------------|---------|---------|----------------|---------------|
| $V_{IH}$ | Input High Voltage | OE                                | 2       |         | $V_{DD} + 0.3$ | V             |
| $V_{IL}$ | Input Low Voltage  | OE                                | -0.3    |         | 0.8            | V             |
| $I_{IH}$ | Input High Current | OE $V_{DD} = V_{IN} = 3.465V$     |         |         | 5              | $\mu\text{A}$ |
| $I_{IL}$ | Input Low Current  | OE $V_{DD} = 3.465V, V_{IN} = 0V$ | -150    |         |                | $\mu\text{A}$ |

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

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

NOTE 1: For single ended applications, the maximum input voltage for CLK, nCLK is  $V_{DD} + 0.3V$ .

NOTE 2: Common mode voltage is defined as  $V_{IH}$ .



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

| Symbol           | Parameter                                 | Test Conditions   | Minimum | Typical | Maximum | Units   |
|------------------|-------------------------------------------|-------------------|---------|---------|---------|---------|
| $V_{OD}$         | Differential Output Voltage               | $R_L = 100\Omega$ | 250     | 400     | 600     | mV      |
| $\Delta V_{OD}$  | $V_{OD}$ Magnitude Change                 |                   |         |         | 50      | mV      |
| $V_{OS}$         | Offset Voltage                            | $R_L = 100\Omega$ | 1.125   | 1.4     | 1.6     | V       |
| $\Delta V_{OS}$  | $V_{OS}$ Magnitude Change                 |                   |         |         | 50      | mV      |
| $I_{OZ}$         | High Impedance Leakage Current            |                   | -10     |         | +10     | $\mu A$ |
| $I_{OFF}$        | Power Off Leakage                         |                   | -1      |         | +1      | $\mu A$ |
| $I_{OSD}$        | Differential Output Short Circuit Current |                   |         |         | -5.5    | mA      |
| $I_{OS}/I_{OSB}$ | Output Short Circuit Current              |                   |         |         | -12     | mA      |

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

| Symbol             | Parameter                    | Test Conditions | Minimum | Typical | Maximum | Units |
|--------------------|------------------------------|-----------------|---------|---------|---------|-------|
| $f_{MAX}$          | Output Frequency             |                 |         |         | 700     | MHz   |
| $t_{PD}$           | Propagation Delay; NOTE 1    |                 | 1.6     |         | 2.4     | ns    |
| $t_{sk(o)}$        | Output Skew; NOTE 2, 4       |                 |         |         | 50      | ps    |
| $t_{sk(pp)}$       | Part-to-Part Skew; NOTE 3, 4 |                 |         |         | 550     | ps    |
| $t_R / t_F$        | Output Rise/Fall Time        | 20% to 80%      | 50      |         | 600     | ps    |
| odc                | Output Duty Cycle            |                 | 45      |         | 55      | %     |
| $t_{PZL}, t_{PZH}$ | Output Enable Time; NOTE 5   |                 |         |         | 5       | ns    |
| $t_{PLZ}, t_{PHZ}$ | Output Disable Time; NOTE 5  |                 |         |         | 5       | ns    |

All parameters measured at  $f \leq 622\text{MHz}$  unless noted otherwise.

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 voltages and with equal load conditions. Measured at the output differential cross points.

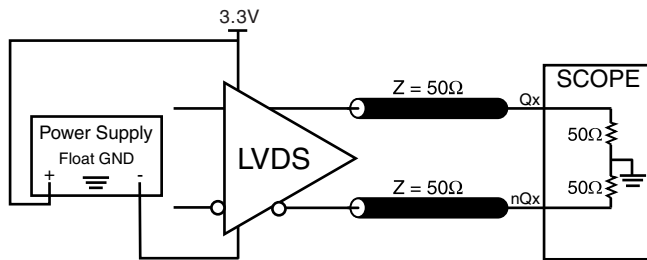
NOTE 3: Defined as skew between outputs on different devices operating at the same supply voltages and with equal load conditions. Using the same type of inputs on each device, the outputs are measured at the differential cross points.

NOTE 4: This paragraph is defined according with JEDEC Standard 65.

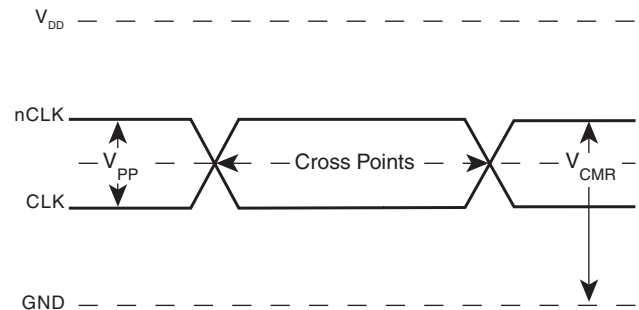
NOTE 5: These parameters are guaranteed by characterization. Not tested in production 5.



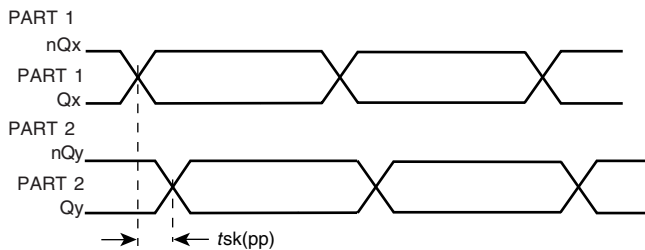
## PARAMETER MEASUREMENT INFORMATION



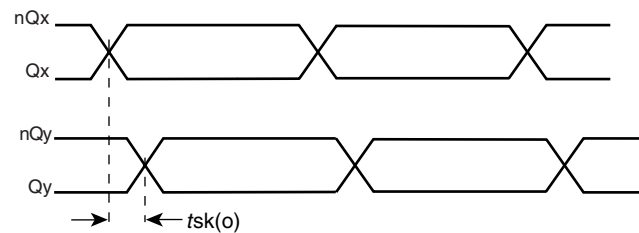
**3.3V OUTPUT LOAD AC TEST CIRCUIT**



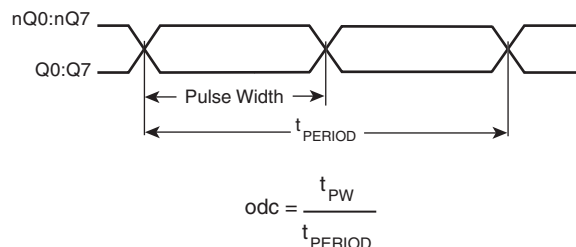
**DIFFERENTIAL INPUT LEVEL**



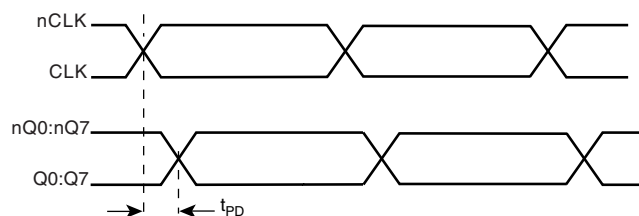
**PART-TO-PART SKEW**



**OUTPUT SKEW**



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



**PROPAGATION DELAY**

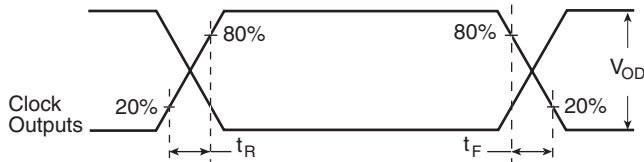


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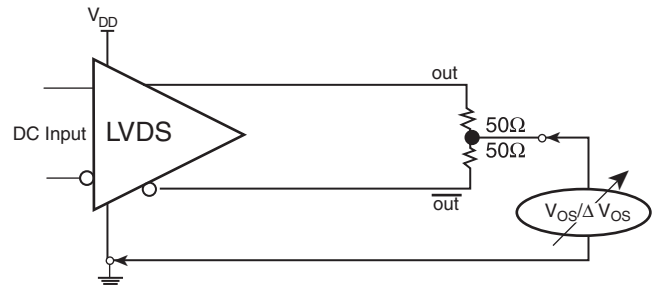
# ICS85408

## LOW SKEW, 1-TO-8

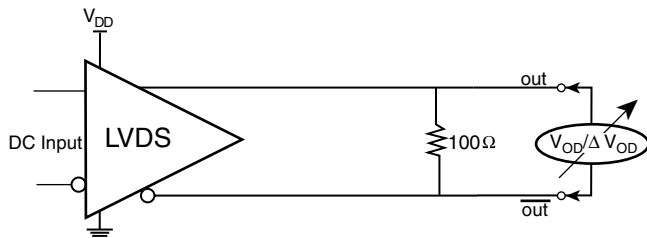
### DIFFERENTIAL-TO-LVDS CLOCK DISTRIBUTION CHIP



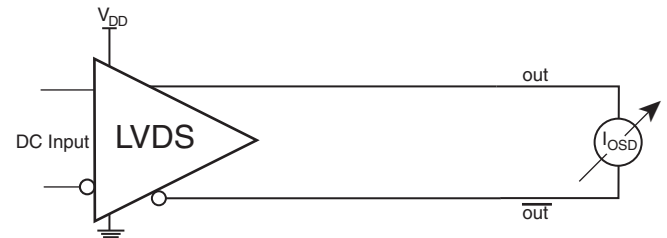
OUTPUT RISE/FALL TIME



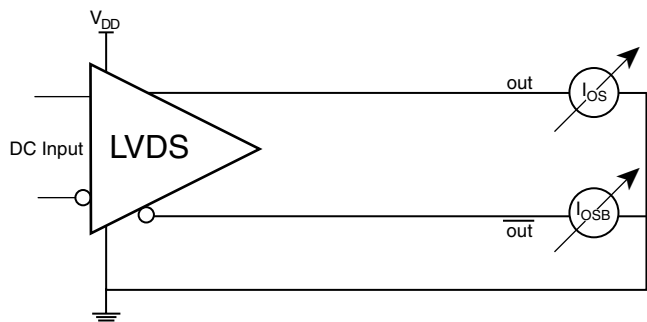
$V_{OS}$  SETUP



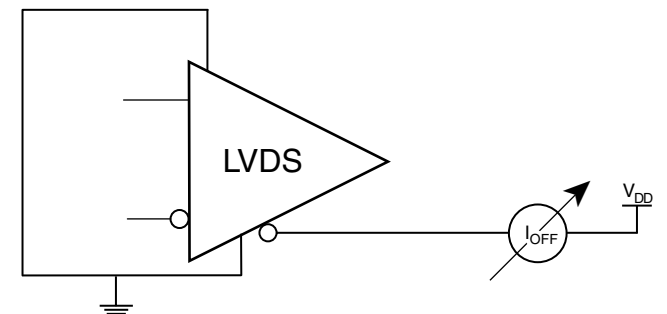
$V_{OD}$  SETUP



$I_{OD}$  SETUP



$I_{OS}$  SETUP



$I_{OFF}$  SETUP

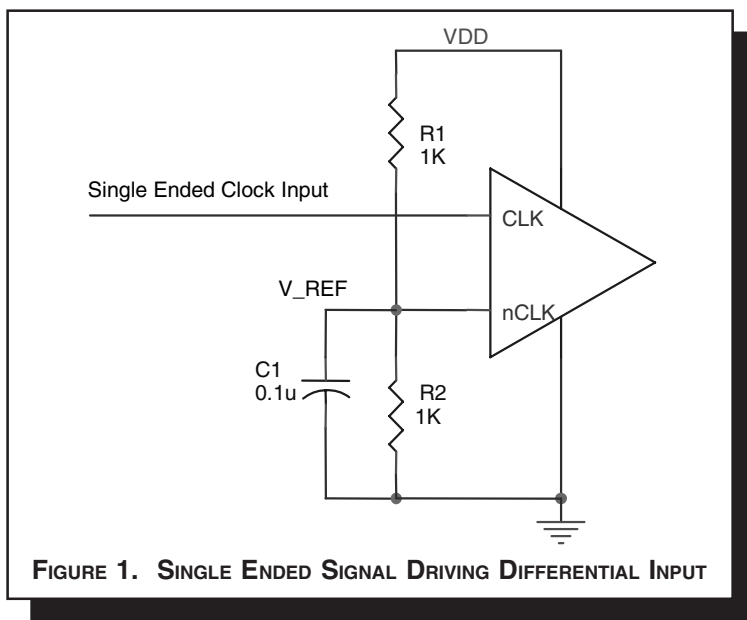


## APPLICATION INFORMATION

### 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  $V_{REF} = V_{DD}/2$  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

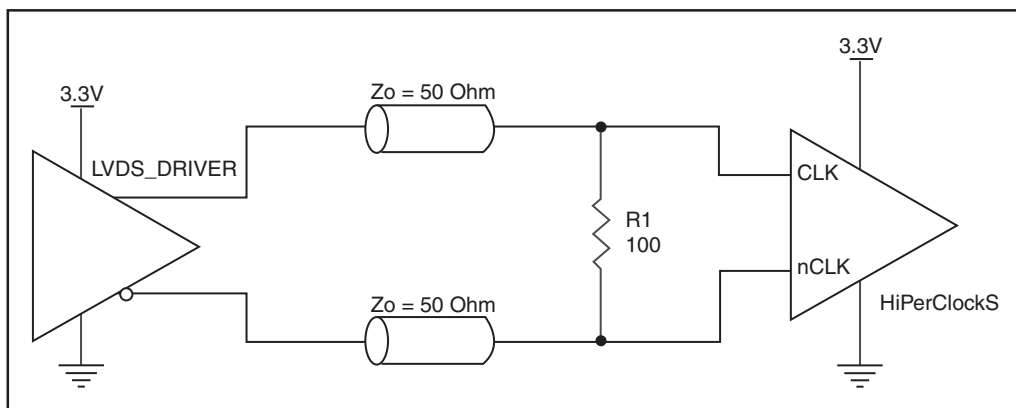
of R1 and R2 might need to be adjusted to position the  $V_{REF}$  in the center of the input voltage swing. For example, if the input clock swing is only 2.5V and  $V_{DD} = 3.3V$ ,  $V_{REF}$  should be 1.25V and  $R2/R1 = 0.609$ .



### LVDS DRIVER TERMINATION

A general LVDS interface is shown in Figure 2. In a 100Ω differential transmission line environment, LVDS drivers require a matched load termination of 100Ω across near the receiver in-

put. For a multiple LVDS outputs buffer, if only partial outputs are used, it is recommended to terminate the un-used outputs.

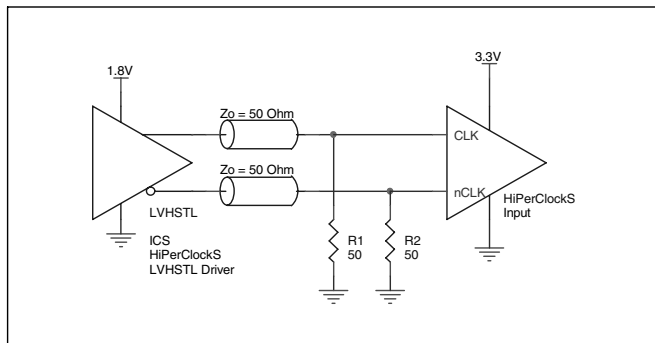




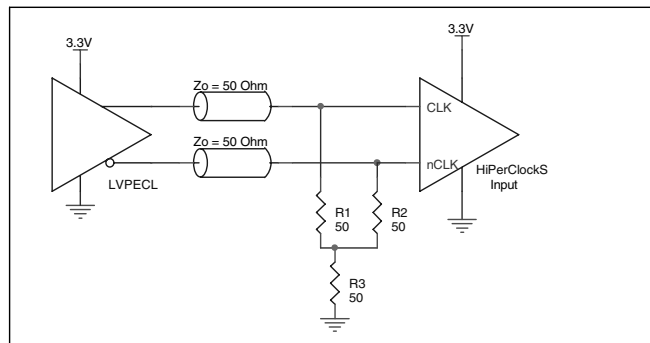
#### DIFFERENTIAL CLOCK INPUT INTERFACE

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 3A to 3E show interface examples for the HiPerClockS CLK/nCLK input driven by the most common driver types. The input interfaces suggested

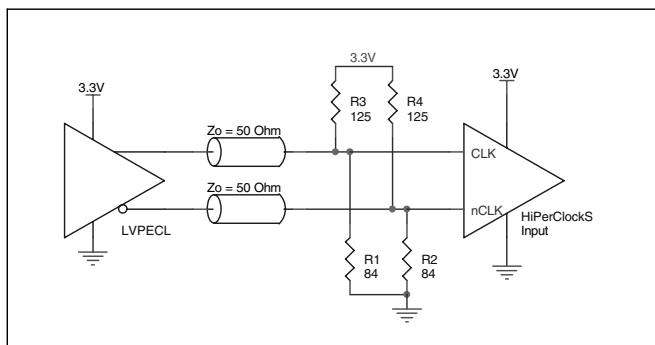
here are examples only. Please consult with the vendor of the driver component to confirm the driver termination requirements. For example in *Figure 3A*, the input termination applies for ICS HiPerClockS LVHSTL drivers. If you are using an LVHSTL driver from another vendor, use their termination recommendation.



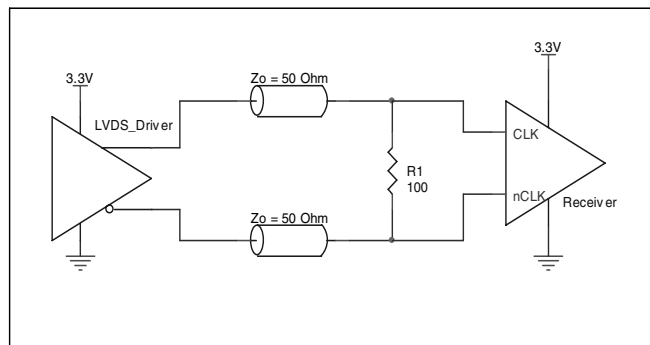
**FIGURE 3A. HiPerClockS CLK/nCLK INPUT DRIVEN BY ICS HiPerClockS LVHSTL DRIVER**



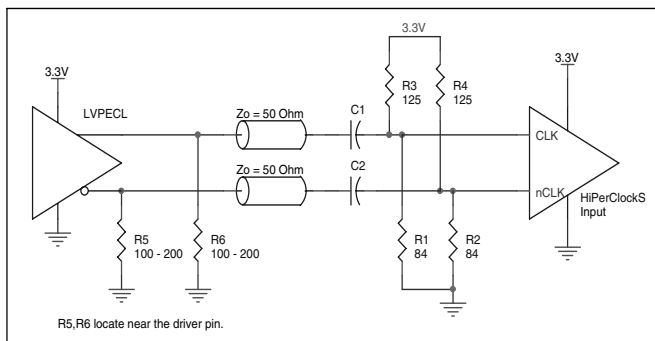
**FIGURE 3B. HiPerClockS CLK/nCLK INPUT DRIVEN BY 3.3V LVPECL DRIVER**



**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**





## RELIABILITY INFORMATION

TABLE 6.  $\theta_{JA}$  VS. AIR FLOW TABLE FOR 24 LEAD TSSOP

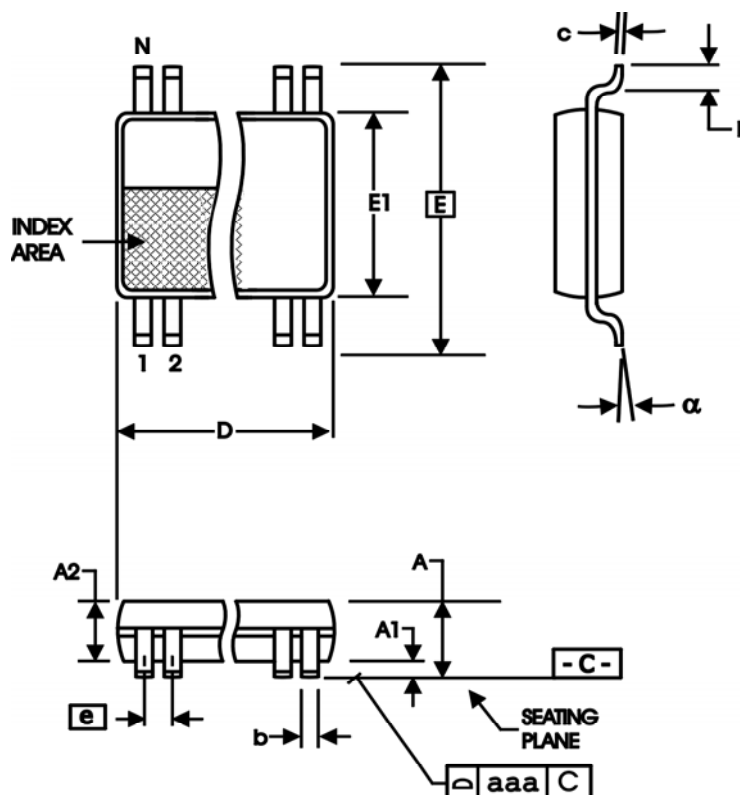
| $\theta_{JA}$ by Velocity (Meters per Second) |        |        |        |
|-----------------------------------------------|--------|--------|--------|
|                                               | 0      | 1      | 2.5    |
| Multi-Layer PCB, JEDEC Standard Test Boards   | 70°C/W | 65°C/W | 62°C/W |

### TRANSISTOR COUNT

The transistor count for ICS85408 is: 1821



**PACKAGE OUTLINE - G SUFFIX FOR 24 LEAD TSSOP**



**TABLE 7. PACKAGE DIMENSIONS**

| SYMBOL   | Millimeters |         |
|----------|-------------|---------|
|          | Minimum     | Maximum |
| N        | 24          |         |
| A        | --          | 1.20    |
| A1       | 0.05        | 0.15    |
| A2       | 0.80        | 1.05    |
| b        | 0.19        | 0.30    |
| c        | 0.09        | 0.20    |
| D        | 7.70        | 7.90    |
| E        | 6.40 BASIC  |         |
| E1       | 4.30        | 4.50    |
| e        | 0.65 BASIC  |         |
| L        | 0.45        | 0.75    |
| $\alpha$ | 0°          | 8°      |
| aaa      | --          | 0.10    |

Reference Document: JEDEC Publication 95, MS-153



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# ICS85408

## LOW SKEW, 1-TO-8 DIFFERENTIAL-TO-LVDS CLOCK DISTRIBUTION CHIP

**TABLE 8. ORDERING INFORMATION**

| Part/Order Number | Marking    | Package                   | Shipping Packaging | Temperature |
|-------------------|------------|---------------------------|--------------------|-------------|
| ICS85408BG        | ICS85408BG | 24 Lead TSSOP             | tube               | 0°C to 70°C |
| ICS85408BGT       | ICS85408BG | 24 Lead TSSOP             | 1000 tape & reel   | 0°C to 70°C |
| ICS85408BGLF      | TBD        | 24 Lead "Lead-Free" TSSOP | tube               | 0°C to 70°C |
| ICS85408BGLFT     | TBD        | 24 Lead "Lead-Free" TSSOP | 1000 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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**ICS85408**  
LOW SKEW, 1-TO-8  
DIFFERENTIAL-TO-LVDS CLOCK DISTRIBUTION CHIP

| REVISION HISTORY SHEET |       |      |                                                                                                |         |
|------------------------|-------|------|------------------------------------------------------------------------------------------------|---------|
| Rev                    | Table | Page | Description of Change                                                                          | Date    |
| A                      | T6    | 9    | Reliability Table - revised air flow from Linear Feet per Minute to Meters per Second.         | 5/6/04  |
|                        | T8    | 11   | Ordering Information Table - corrected typo in Part/Order Number from ICS8540BG to ICS85408BG. |         |
| A                      |       | 1    | Pin Assignment - corrected package information from 300-MIL to 173-MIL                         | 8/25/04 |
| A                      | T8    | 1    | Features Section - added Lead-Free bullet. Corrected Block Diagram.                            | 4/25/05 |
|                        |       | 11   | Ordering Information Table - Added Lead-Free part number.                                      |         |