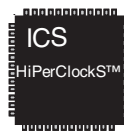


### General Description



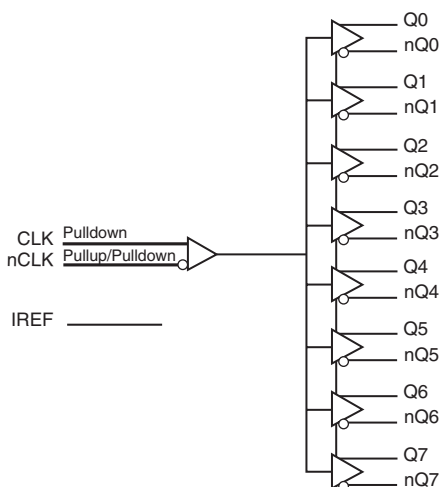
The ICS85108I is a low skew, high performance 1-to-8 Differential-to-0.7V HCSL Clock Distribution Chip and a member of the HiPerClockS™ family of High Performance Clock Solutions from IDT. The ICS85108I CLK, nCLK pair can accept most differential input levels and translates them to 3.3V HCSL output levels. The ICS85108I provides a low power, low noise, low skew, point-to-point solution for distributing HCSL clock signals.

Guaranteed output and part-to-part skew specifications make the ICS85108I ideal for those applications demanding well defined performance and repeatability.

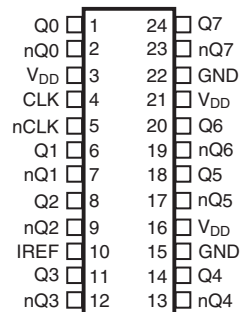
### Features

- Eight 0.7V differential HCSL clock output pairs
- CLK/nCLK input pair can accept the following differential input levels: LVPECL, LVDS, LVHSTL, SSTL, HCSL
- Maximum output frequency: 500MHz
- Additive phase jitter, RMS: 0.09ps (typical)
- Output skew: 80ps (maximum)
- Part-to-part skew: 400ps (maximum)
- Propagation delay: 3ns (maximum)
- Full 3.3V operating supply
- -40°C to 85°C ambient operating temperature
- Available in both standard (RoHS 5) and lead-free (RoHS 6) packages

### Block Diagram



### Pin Assignment



### ICS85108I

**24-Lead TSSOP, 173-MIL**  
**4.4mm x 7.8mm 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. HCSL interface levels.   |
| 3, 16, 21 | V <sub>DD</sub> | Power  |                     | Power supply pins.   |
| 4         | CLK             | Input  | Pulldown            | Non-inverting differential clock input.  |
| 5         | nCLK            | Input  | Pullup/<br>Pulldown | Inverting differential clock input.  |
| 6, 7      | Q1, nQ1         | Output |                     | Differential output pair. HCSL interface levels.   |
| 8, 9      | Q2, nQ2         | Output |                     | Differential output pair. HCSL interface levels.   |
| 10        | IREF            |        |                     | External fixed precision resistor (475Ω) from this pin to ground provides a reference current used for differential current-mode Qx/nQx clock outputs. |
| 11, 12    | Q3, nQ3         | Output |                     | Differential output pair. HCSL interface levels.   |
| 13, 14    | nQ4, Q4         | Output |                     | Differential output pair. HCSL interface levels.   |
| 15, 22    | GND             | Power  |                     | Power supply ground.   |
| 17, 18    | nQ5, Q5         | Output |                     | Differential output pair. HCSL interface levels.   |
| 19, 20    | nQ6, Q6         | Output |                     | Differential output pair. HCSL interface levels.   |
| 23, 24    | nQ7, Q7         | Output |                     | Differential output pair. HCSL 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 Resistors   |                 |         | 51      |         | kΩ    |
| R <sub>PULLDOWN</sub> | Input Pulldown Resistors |                 |         | 51      |         | kΩ    |

## Function Tables

**Table 3. Clock Input Function Table**

| Inputs         |                | Outputs |        | Input to Output Mode         | Polarity      |
|----------------|----------------|---------|--------|------------------------------|---------------|
| CLK            | nCLK           | Q[0:7]  | n[0:7] |                              |               |
| 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, $V_{DD}$                 | 4.6V                     |
| Inputs, $V_I$                            | -0.5V to $V_{DD} + 0.5V$ |
| Outputs, $V_O$                           | -0.5V to $V_{DD} + 0.5V$ |
| Package Thermal Impedance, $\theta_{JA}$ | 87.8°C/W (0 mps)         |
| Storage Temperature, $T_{STG}$           | -65°C to 150°C           |

## DC Electrical Characteristics

**Table 4A. Power Supply DC Characteristics,  $V_{DD} = 3.3V \pm 10\%$ ,  $T_A = -40^\circ C$  to  $85^\circ C$**

| Symbol   | Parameter            | Test Conditions | Minimum | Typical | Maximum | Units |
|----------|----------------------|-----------------|---------|---------|---------|-------|
| $V_{DD}$ | Power Supply Voltage |                 | 2.97    | 3.3     | 3.63    | V     |
| $I_{DD}$ | Power Supply Current |                 |         |         | 27      | mA    |

**Table 4B. Differential DC Characteristics,  $V_{DD} = 3.3V \pm 10\%$ ,  $T_A = -40^\circ C$  to  $85^\circ C$**

| Symbol    | Parameter                            | Test Conditions                        | Minimum   | Typical | Maximum         | Units   |
|-----------|--------------------------------------|--|-----------|---------|-----------------|---------|
| $I_{IH}$  | Input High Current                   | CLK, nCLK<br>$V_{DD} = V_{IN} = 3.63V$ |           |         | 150             | $\mu A$ |
| $I_{IL}$  | Input Low Current                    | CLK<br>$V_{DD} = 3.63V, V_{IN} = 0V$   | -5        |         |                 | $\mu A$ |
|           |                                      | nCLK<br>$V_{DD} = 3.635V, V_{IN} = 0V$ | -150      |         |                 | $\mu A$ |
| $V_{PP}$  | Peak-to-Peak Voltage; NOTE 1         |  | 0.15      |         | 1.3             | V       |
| $V_{CMR}$ | Common Mode Input Voltage; NOTE 1, 2 |  | GND + 0.5 |         | $V_{DD} - 0.85$ | V       |

NOTE 1:  $V_{IL}$  should not be less than -0.3V.

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

## AC Electrical Characteristics

**Table 5. HCSL AC Characteristics,  $V_{DD} = V_{DDO} = 3.3V \pm 10\%$ ,  $T_A = -40^\circ\text{C}$  to  $85^\circ\text{C}$**

| Symbol             | Parameter   | Test Conditions                             | Minimum | Typical | Maximum | Units |
|--------------------|---|---|---------|---------|---------|-------|
| $f_{MAX}$          | Output Frequency  |   |         |         | 500     | MHz   |
| $t_{PD}$           | Propagation Delay; NOTE 1   |   | 1.5     |         | 3       | ns    |
| $tsk(o)$           | Output Skew; NOTE 2, 3  |   |         |         | 80      | ps    |
| $tsk(pp)$          | Part-to-Part Skew; NOTE 3, 4  |   |         |         | 400     | ps    |
| $f_{jit}$          | Buffer Additive Phase Jitter, RMS; refer to Additive Phase Jitter Section | 250MHz, Integration Range:<br>12kHz – 20MHz |         | 0.09    |         | ps    |
| $V_{RB}$           | Ring-back Voltage Margin; NOTE 5, 6                                       |   | -100    |         | 100     | mV    |
| $t_{STABLE}$       | Time before $V_{RB}$ is allowed; NOTE 5, 6                                |   | 500     |         |         | ps    |
| $V_{MAX}$          | Absolute Maximum Output Voltage; NOTE 7, 8                                |   |         |         | 1150    | mV    |
| $V_{MIN}$          | Absolute Minimum Output Voltage; NOTE 7, 9                                |   | -300    |         |         | mV    |
| $V_{CROSS}$        | Absolute Crossing Voltage; NOTE 7, 10, 11                                 |   | 250     |         | 550     | mV    |
| $\Delta V_{CROSS}$ | Total Variation of $V_{CROSS}$ over all edges; NOTE 7, 10, 12             |   |         |         | 140     | mV    |
|                    | Rise/Fall Edge Rate; NOTE 5, 13   | Measured between -150mV to +150mV           | 0.6     |         | 5.5     | V/ns  |
| odc                | Output Duty Cycle; NOTE 14  |   | 45      |         | 55      | %     |

NOTE: Electrical parameters are guaranteed over the specified ambient operating temperature range, which is established when the device is mounted in a test socket with maintained transverse airflow greater than 500 lpm. The device will meet specifications after thermal equilibrium has been reached under these conditions.

NOTE: All parameters measured at  $f \leq 250\text{MHz}$  unless noted otherwise.

NOTE 1: Measured from the differential input 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 voltage, same temperature and with equal load conditions. Using the same type of inputs on each device, the outputs are measured at the differential cross points.

NOTE 5: Measurement taken from differential waveform.

NOTE 6:  $T_{STABLE}$  is the time the differential clock must maintain a minimum  $\pm 150\text{mV}$  differential voltage after rising/falling edges before it is allowed to drop back into the  $V_{RB} \pm 100\text{mV}$  differential range. See Parameter Measurement Information Section.

NOTE 7: Measurement taken from single-ended waveform.

NOTE 8: Defined as the maximum instantaneous voltage including overshoot. See Parameter Measurement Information Section.

NOTE 9: Defined as the minimum instantaneous voltage including undershoot. See Parameter Measurement Information Section.

NOTE 10: Measured at crossing point where the instantaneous voltage value of the rising edge of Qx equals the falling edge of nQx.

See Parameter Measurement Information Section.

NOTE 11: Refers to the total variation from the lowest crossing point to the highest, regardless of which edge is crossing. Refers to all crossing points for this measurement. See Parameter Measurement Information Section.

NOTE 12: Defined as the total variation of all crossing voltage of rising Qx and falling nQx. This is the maximum allowed variance in the  $V_{CROSS}$  for any particular system. See Parameter Measurement Information Section.

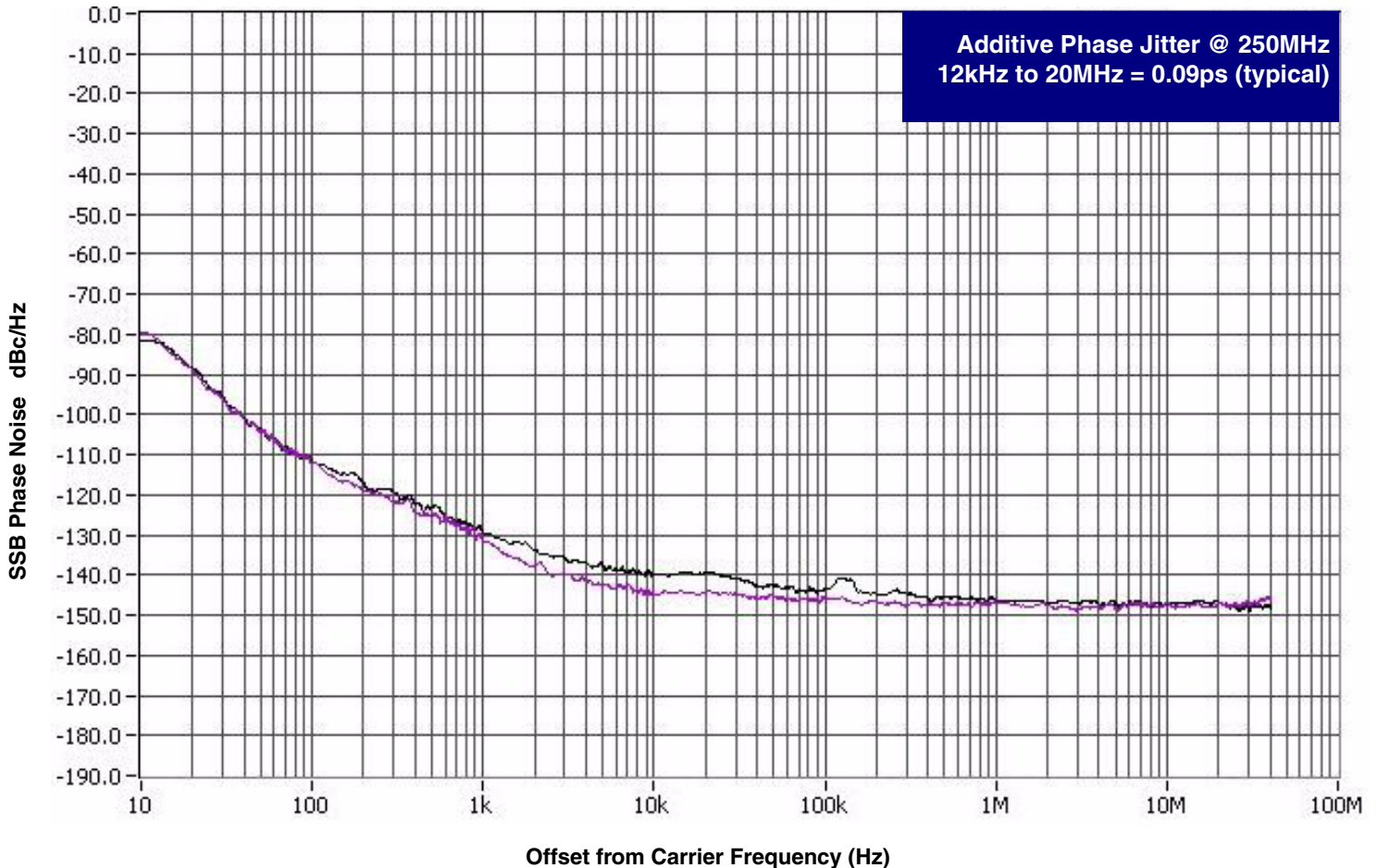
NOTE 13: Measured from -150mV to +150mV on the differential waveform (derived from Qx minus nQx). The signal must be monotonic through the measurement region for rise and fall time. The 300mV measurement window is centered on the differential zero crossing.

NOTE 14: Input duty cycle must be 50%.

## 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

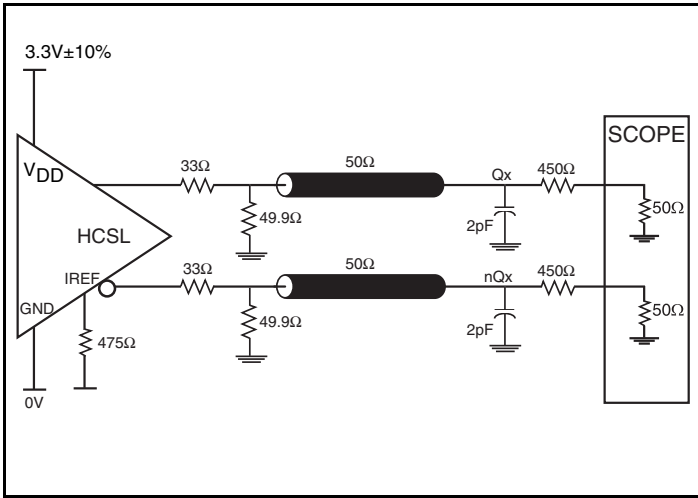
of the power in the 1Hz band to the power in the fundamental. When the required offset is specified, the phase noise is called a **dBc** value, which simply means dBm at a specified offset from the fundamental. By investigating jitter in the frequency domain, we get a better understanding of its effects 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.



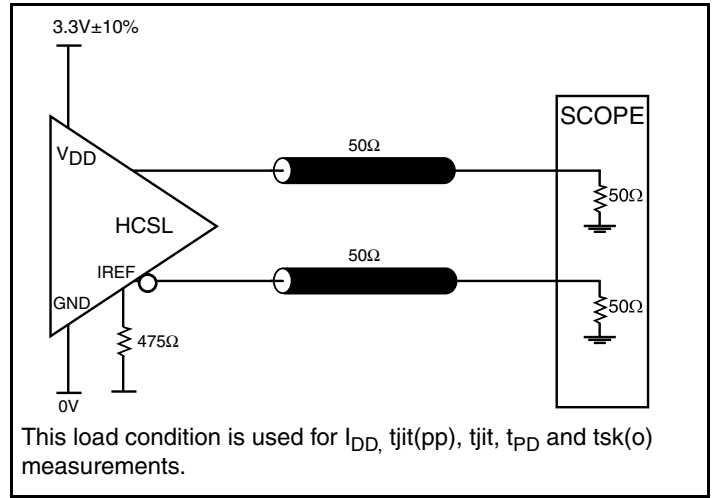
As with most timing specifications, phase noise measurements have issues relating to the limitations of the equipment. Often the noise floor of the equipment is higher than the noise floor of the device. This

is illustrated above. The device meets the noise floor of what is shown, but can actually be lower. The phase noise is dependent on the input source and measurement equipment.

### Parameter Measurement Information

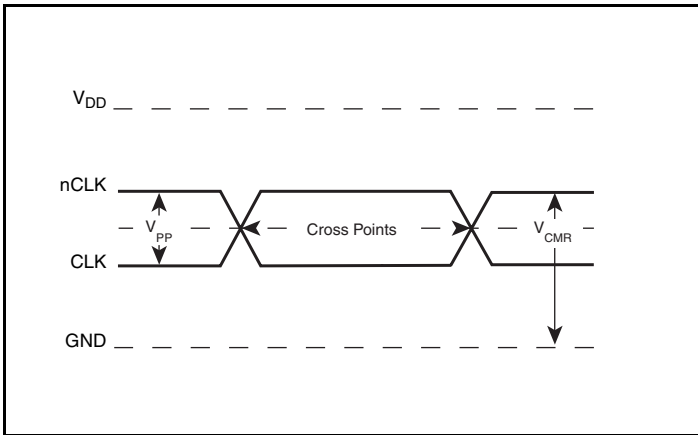


Output Load AC Test Circuit

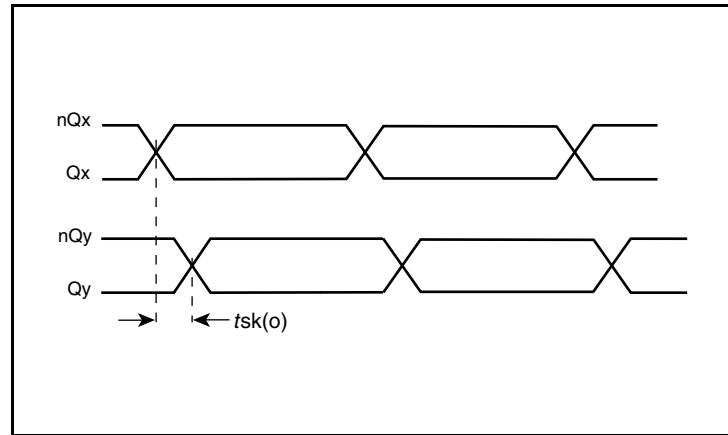


This load condition is used for  $I_{DD}$ ,  $t_{jit}(pp)$ ,  $t_{jit}$ ,  $t_{PD}$  and  $t_{sk}(o)$  measurements.

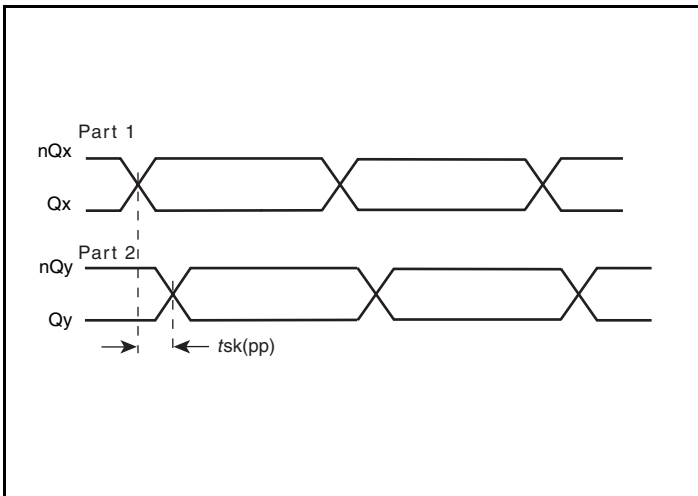
Output Load AC Test Circuit



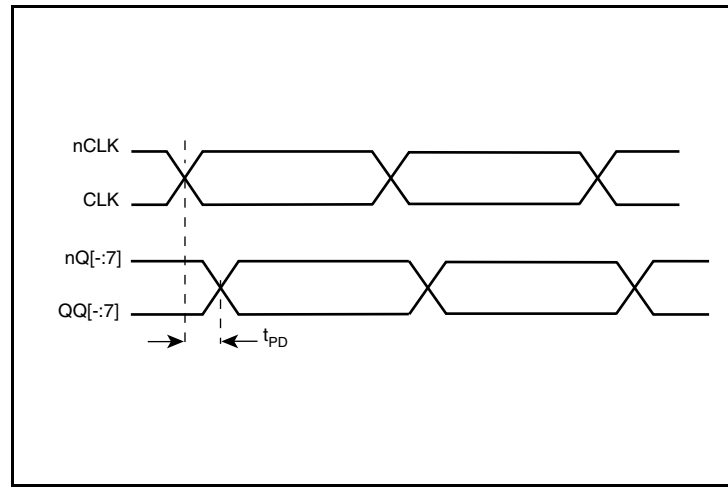
Differential Input Level



Output Skew

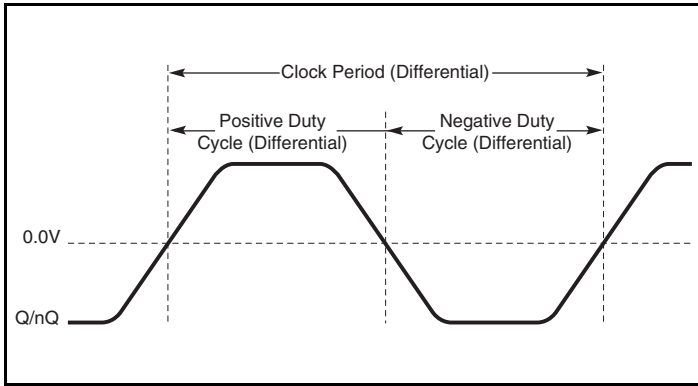


Part-to-Part Skew

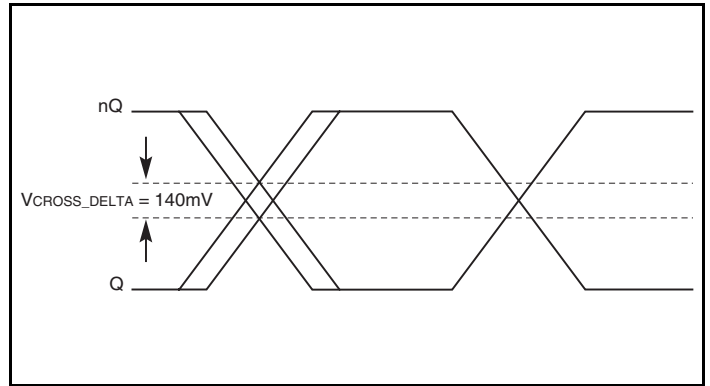


Propagation Delay

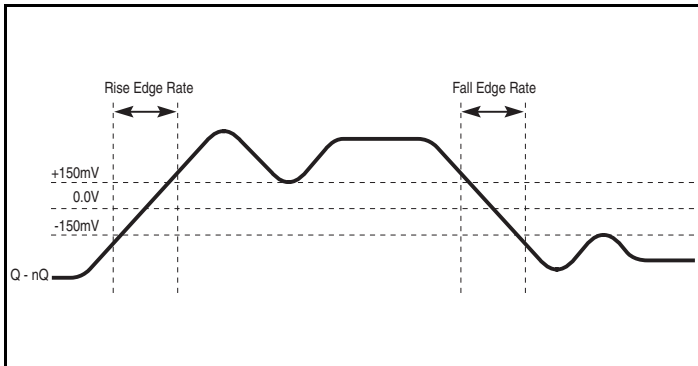
### Parameter Measurement Information, continued



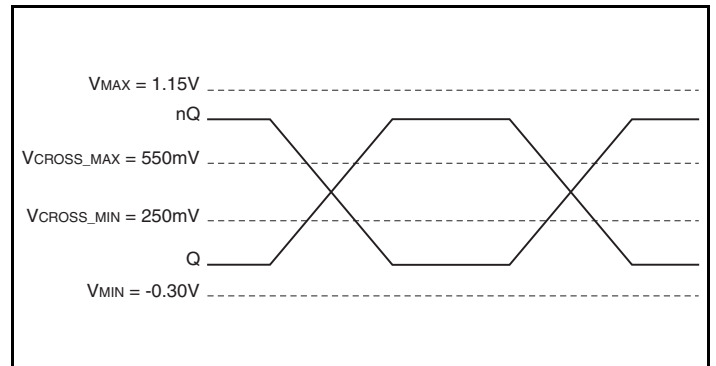
Differential Measurement Points for Duty Cycle/Period



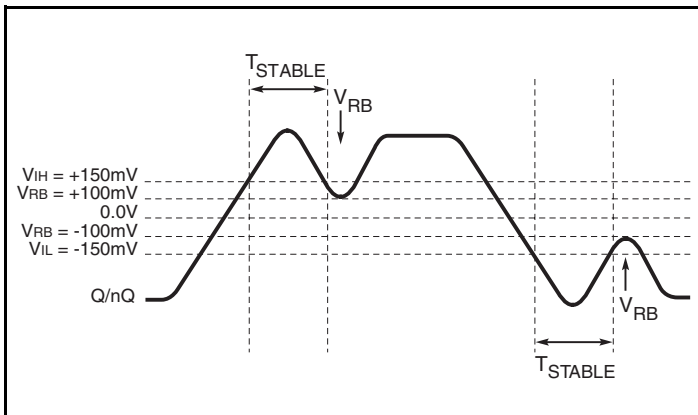
Single-ended Measurement Points for Delta Cross Point



Differential Measurement Points for Rise/Fall Edge Rate



Single-ended Measurement Points for Absolute Cross Point/Swing



Differential Measurement Points for Ringback

## 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  $R2/R1 = 0.609$ .

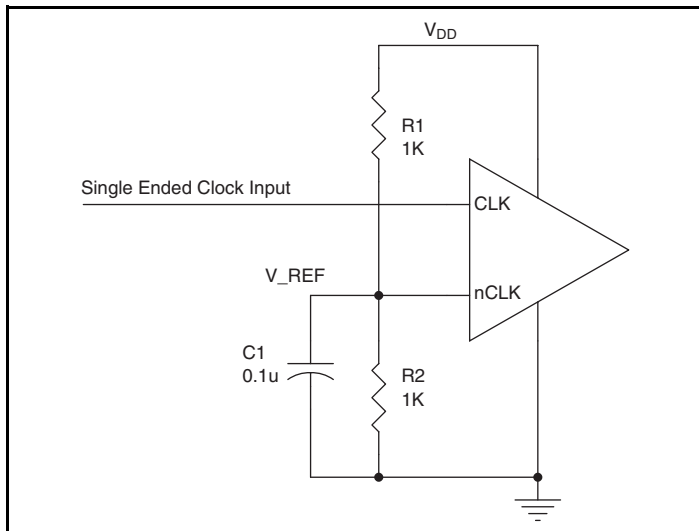


Figure 1. Single-Ended Signal Driving Differential Input

## Recommendations for Unused Output Pins

### Outputs:

#### Differential Outputs

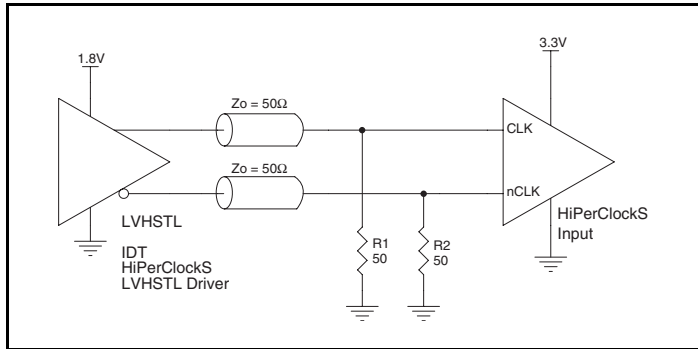
All unused differential outputs can be left floating. We recommend that there is no trace attached. Both sides of the differential output pair should either be left floating or terminated.



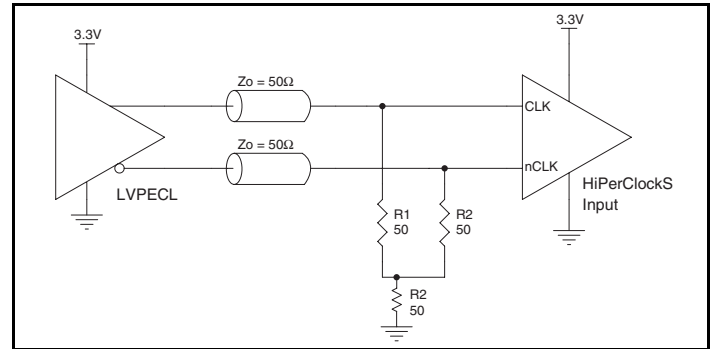
### Differential Clock Input Interface

The CLK /nCLK accepts LVDS, LVPECL, LVHSTL, SSTL, HCSL and other differential signals. The differential signals 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

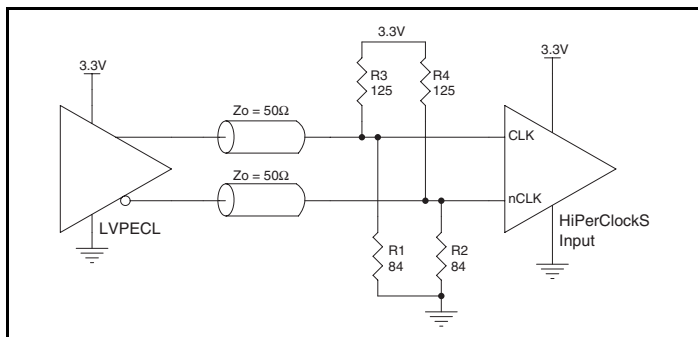
component to confirm the driver termination requirements. For example, in Figure 2A, the input termination applies for IDT HiPerClockS open emitter LVHSTL drivers. If you are using an LVHSTL driver from another vendor, use their termination recommendation.



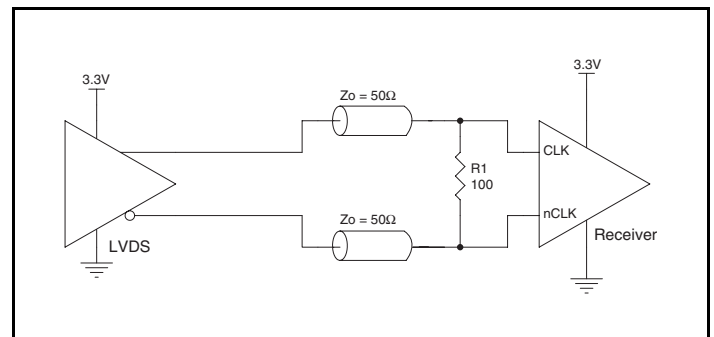
**Figure 2A. HiPerClockS CLK/nCLK Input Driven by an IDT Open Emitter HiPerClockS LVHSTL Driver**



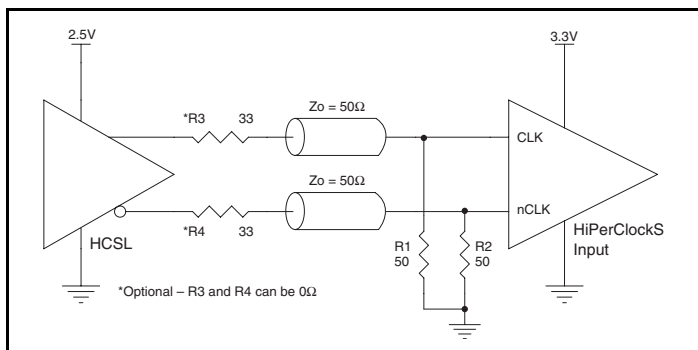
**Figure 2B. HiPerClockS CLK/nCLK Input Driven by a 3.3V LVPECL Driver**



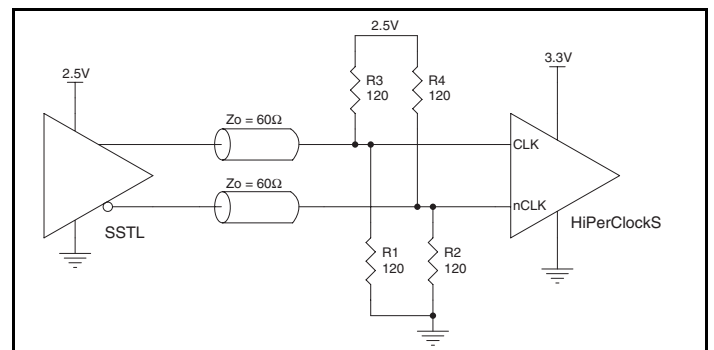
**Figure 2C. HiPerClockS CLK/nCLK Input Driven by a 3.3V LVPECL Driver**



**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**

## Recommended Termination

Figure 3A is the recommended termination for applications which require the receiver and driver to be on a separate PCB. All traces should be  $50\Omega$  impedance.

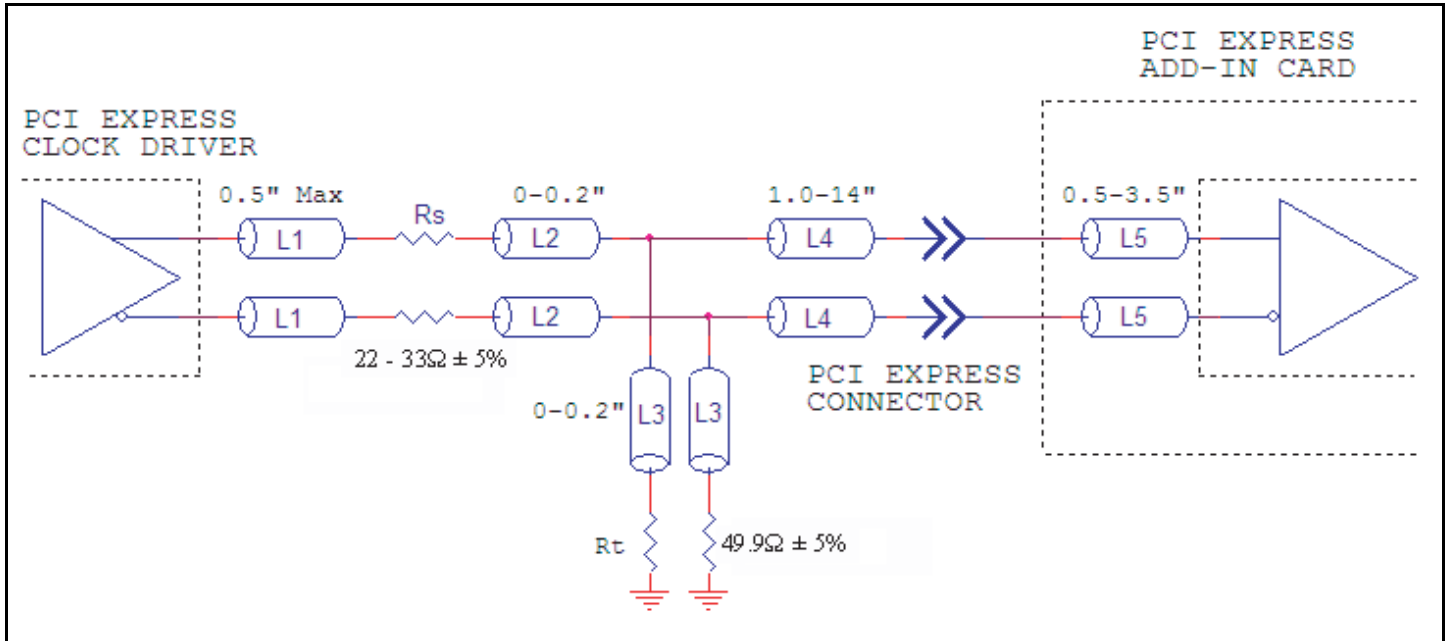


Figure 3A. Recommended Termination

Figure 3B is the recommended termination for applications which require a point to point connection and contain the driver and receiver

on the same PCB. All traces should all be  $50\Omega$  impedance.

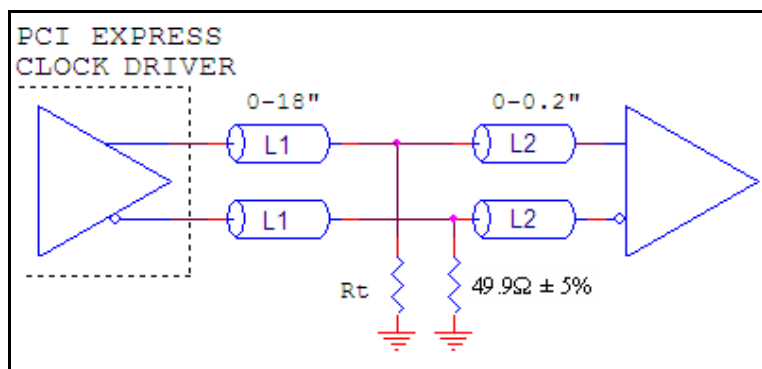


Figure 3B. Recommended Termination

## Power Considerations

This section provides information on power dissipation and junction temperature for the ICS85108I. Equations and example calculations are also provided.

### 1. Power Dissipation.

The total power dissipation for the ICS85108I is the sum of the core power plus the analog power plus the power dissipated in the load(s). The following is the power dissipation for  $V_{DD} = 3.3V + 10\% = 3.63V$ , 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> =  $V_{DD\_MAX} * I_{DD\_MAX} = 3.63V * 27mA = \mathbf{98.01mW}$
- Power (outputs)<sub>MAX</sub> = **47.3mW/Loaded Output Pair**  
If all outputs are loaded, the total power is  $8 * 47.3mW = \mathbf{378.4mW}$

**Total Power<sub>MAX</sub>** = (3.465V, with all outputs switching) =  $98.01mW + 378.4mW = \mathbf{476.41mW}$

### 2. Junction Temperature.

Junction temperature,  $T_j$ , is the temperature at the junction of the bond wire and bond pad directly affects the reliability of the device. The maximum recommended junction temperature for HiPerClockS devices is 125°C. Limiting the internal transistor junction temperature,  $T_j$ , to 125°C ensures that the bond wire and bond pad temperature remains below 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 1 meter per second and a multi-layer board, the appropriate value is 83.5°C/W per Table 6 below.

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

$$85^\circ\text{C} + 0.476\text{W} * 83.5^\circ\text{C/W} = 124.7^\circ\text{C}. \text{ This is below the limit of } 125^\circ\text{C}.$$

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 (multi-layer).

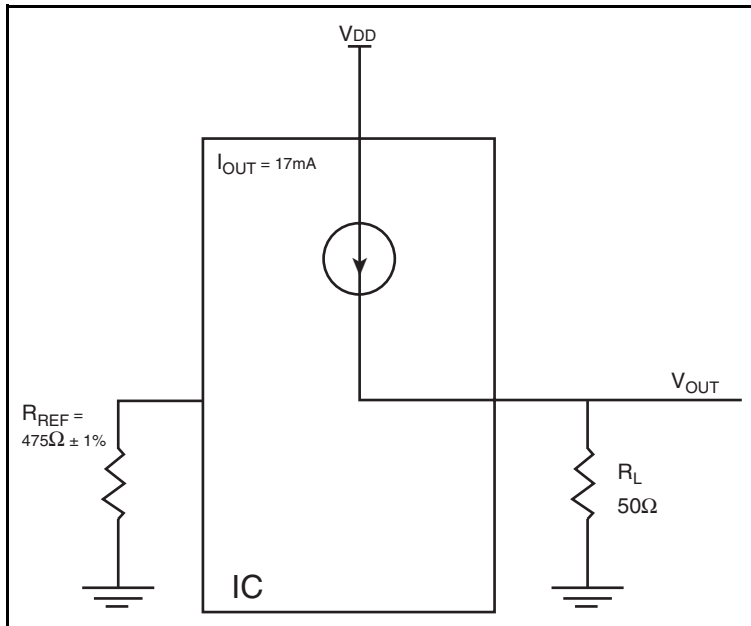
**Table 6. Thermal Resistance  $\theta_{JA}$  for 24 Lead TSSOP, Forced Convection**

| $\theta_{JA}$ Vs. Air Flow                  |          |          |          |
|---|----------|----------|----------|
| Meters per Second                           | 0        | 1        | 2.5      |
| Multi-Layer PCB, JEDEC Standard Test Boards | 87.8°C/W | 83.5°C/W | 81.3°C/W |

### 3. Calculations and Equations.

The purpose of this section is to calculate power dissipation on the IC per HCSL output pair.

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



**Figure 4. HCSL Driver Circuit and Termination**

HCSL is a current steering output which sources a maximum of 17mA of current per output. To calculate worst case on-chip power dissipation, use the following equations which assume a 50Ω load to ground.

The highest power dissipation occurs when  $V_{DD\_MAX}$ .

$$\begin{aligned}
 \text{Power} &= (V_{DD\_MAX} - V_{OUT}) * I_{OUT}, \\
 &\text{since } V_{OUT} = I_{OUT} * R_L \\
 &= (V_{DD\_MAX} - I_{OUT} * R_L) * I_{OUT} \\
 &= (3.63V - 17mA * 50\Omega) * 17mA
 \end{aligned}$$

Total Power Dissipation per output pair = **47.3mW**

## Reliability Information

Table 7.  $\theta_{JA}$  vs. Air Flow Table for a 24 Lead TSSOP

| $\theta_{JA}$ vs. Air Flow                  |          |          |          |
|---|----------|----------|----------|
| Meters per Second                           | 0        | 1        | 2.5      |
| Multi-Layer PCB, JEDEC Standard Test Boards | 87.8°C/W | 83.5°C/W | 81.3°C/W |

## Transistor Count

The transistor count for ICS85108I is: 583

## Package Outline and Package Dimensions

Package Outline - G Suffix for 24 Lead TSSOP

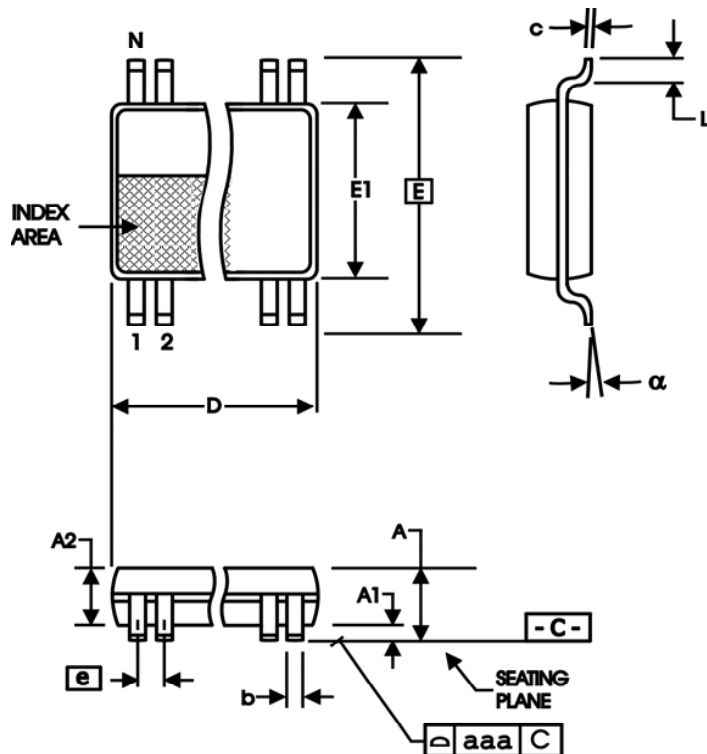


Table 8. Package Dimensions

| All Dimensions in Millimeters |            |         |
|-------------------------------|------------|---------|
| Symbol                        | Minimum    | Maximum |
| N                             | 24         |         |
| A                             |            | 1.20    |
| A1                            | 0.5        | 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    |
| 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   |
|-------------------|---------------|---------------------------|--------------------|---------------|
| 85108AGI          | ICS85108AGI   | 24 Lead TSSOP             | Tray               | -40°C to 85°C |
| 85108AGIT         | ICS85108AGI   | 24 Lead TSSOP             | 2500 Tape & Reel   | -40°C to 85°C |
| 85108AGILF        | ICS85108AGILF | "Lead-Free" 24 Lead TSSOP | Tray               | -40°C to 85°C |
| 85108AGILFT       | ICS85108AGILF | "Lead-Free" 24 Lead TSSOP | 2500 Tape & Reel   | -40°C to 85°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   | T1    | 2    | Pin Description Table - corrected sequence of pin names to correspond to Pin Assignment. Pin 13 should be nQ4 and pin 14 should be Q4.                         | 10/22/09 |
| A   | T1    | 2    | Pin Description Table - corrected sequence of pin names to correspond to Pin Assignment. Pins 17 - 20 and pins 23 - 24 are in reverse order of Pin Assignment. | 10/23/09 |



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