

## General Description

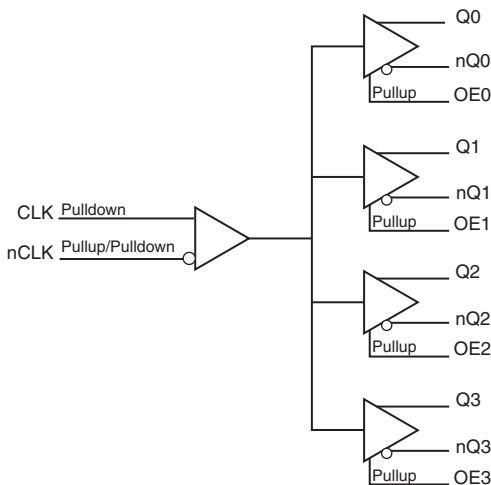
The ICS854104 is a low skew, high performance 1-to-4 Differential-to-LVDS Clock Fanout Buffer. Utilizing Low Voltage Differential Signaling (LVDS), the ICS854104 provides a low power, low noise, solution for distributing clock signals over controlled impedances of 100Ω. The ICS854104 accepts a differential input level and translates it to LVDS output levels.

Guaranteed output and part-to-part skew characteristics make the ICS854104 ideal for those applications demanding well defined performance and repeatability.

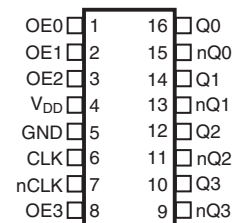
## Features

- Four differential LVDS output pairs
- One differential clock input pair
- CLK/nCLK can accept the following differential input levels: LVPECL, LVDS, LVHSTL, HCSL, SSTL
- Each output has an individual OE control
- Maximum output frequency: 700MHz
- Translates differential input signals to LVDS levels
- Additive phase jitter, RMS: 0.232ps (typical)
- Output skew: 50ps (maximum)
- Part-to-part skew: 350ps (maximum)
- Propagation delay: 1.3ns (maximum)
- 3.3V operating supply
- 0°C to 70°C ambient operating temperature
- Lead-free (RoHS 6) packaging

## Block Diagram



## Pin Assignment



**ICS854104**  
**16-Lead TSSOP**  
**4.4mm x 5.0mm x 0.925mm package body**  
**G Package**  
**Top View**

## Pin Descriptions and Characteristics

**Table 1. Pin Descriptions**

| Number | Name            | Type   |                 | Description  |
|--------|-----------------|--------|-----------------|--|
| 1      | OE0             | Input  | Pullup          | Output enable pin for Q0, nQ0 outputs. See Table 3. LVCMOS/LVTTL interface levels. |
| 2      | OE1             | Input  | Pullup          | Output enable pin for Q1, nQ1 outputs. See Table 3. LVCMOS/LVTTL interface levels. |
| 3      | OE2             | Input  | Pullup          | Output enable pin for Q2, nQ2 outputs. See Table 3. LVCMOS/LVTTL interface levels. |
| 4      | V <sub>DD</sub> | Power  |                 | Positive supply pin.   |
| 5      | GND             | Power  |                 | Power supply ground.   |
| 6      | CLK             | Input  | Pulldown        | Non-inverting differential clock input.  |
| 7      | nCLK            | Input  | Pullup/Pulldown | Inverting differential clock input. V <sub>DD</sub> /2 default when left floating. |
| 8      | OE3             | Input  | Pullup          | Output enable pin for Q3, nQ3 outputs. See Table 3. LVCMOS/LVTTL interface levels. |
| 9, 10  | nQ3, Q3         | Output |                 | Differential output pair. LVDS interface levels.                                   |
| 11, 12 | nQ2, Q2         | Output |                 | Differential output pair. LVDS interface levels.                                   |
| 13, 14 | nQ1, Q1         | Output |                 | Differential output pair. LVDS interface levels.                                   |
| 15, 16 | nQ0, Q0         | 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    |

## Function Table

**Table 3. Output Enable Function Table**

| Inputs  | Outputs          |
|---------|------------------|
| OE[3:0] | Q[0:3], nQ[0:3]  |
| 0       | High-Impedance   |
| 1       | Active (default) |

## 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 the 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, $I_O$ (LVDS)<br>Continuous Current<br>Surge Current | 10mA<br>15mA             |
| Package Thermal Impedance, $\theta_{JA}$                     | 100.3°C/W (0 mps)        |
| Storage Temperature, $T_{STG}$                               | -65°C to 150°C           |

## DC Electrical Characteristics

**Table 4A. LVDS Power Supply 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 |
|----------|-------------------------|-----------------|---------|---------|---------|-------|
| $V_{DD}$ | Positive Supply Voltage |                 | 3.135   | 3.3     | 3.465   | V     |
| $I_{DD}$ | Power Supply Current    |                 |         |         | 75      | mA    |

**Table 4B. LVCMOS/LVTTL 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   |
|----------|--------------------|--------------------------------|---------|---------|----------------|---------|
| $V_{IH}$ | Input High Voltage |                                | 2       |         | $V_{DD} + 0.3$ | V       |
| $V_{IL}$ | Input Low Voltage  |                                | -0.3    |         | 0.8            | V       |
| $I_{IH}$ | Input High Current | $V_{DD} = V_{IN} = 3.465V$     |         |         | 5              | $\mu A$ |
| $I_{IL}$ | Input Low Current  | $V_{DD} = 3.465V, V_{IN} = 0V$ | -150    |         |                | $\mu A$ |

**Table 4C. Differential 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   |
|-----------|---|---|-----------|---------|-----------------|---------|
| $I_{IH}$  | Input High Current                      | CLK, nCLK<br>$V_{DD} = V_{IN} = 3.465V$ |           |         | 150             | $\mu A$ |
| $I_{IL}$  | Input Low Current                       | CLK<br>$V_{DD} = 3.465V, V_{IN} = 0V$   | -5        |         |                 | $\mu A$ |
|           |   | nCLK<br>$V_{DD} = 3.465V, V_{IN} = 0V$  | -150      |         |                 | $\mu A$ |
| $V_{PP}$  | Peak-to-Peak Voltage;<br>NOTE 1         |   | 0.15      |         | 1.3             | V       |
| $V_{CMR}$ | Common Mode Input Voltage;<br>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  $V_{IH}$ .

**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 |                 | 250     | 350     | 450     | mV    |
| $\Delta V_{OD}$ | $V_{OD}$ Magnitude Change   |                 |         |         | 50      | mV    |
| $V_{OS}$        | Offset Voltage              |                 | 1.2     | 1.3     | 1.45    | V     |
| $\Delta V_{OS}$ | $V_{OS}$ Magnitude Change   |                 |         |         | 50      | mV    |

**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   |  | 0.9     |         | 1.3     | ns    |
| $f_{jit}$   | Buffer Additive Phase Jitter, RMS; refer to Additive Phase Jitter Section | 155.52MHz, Integration Range: 12kHz – 20MHz) |         | 0.232   |         | ps    |
| $tsk(o)$    | Output Skew; NOTE 2, 4  |  |         |         | 50      | ps    |
| $tsk(pp)$   | Part-to-Part Skew; NOTE 3, 4  |  |         |         | 350     | ps    |
| $t_R / t_F$ | Output Rise/Fall Time   | 20% to 80%                                   | 180     |         | 660     | ps    |
| odc         | Output Duty Cycle   |  | 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  $f_{MAX}$  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 voltage and with equal load conditions. Measured at the differential crossing point of the input to the differential output crossing point.

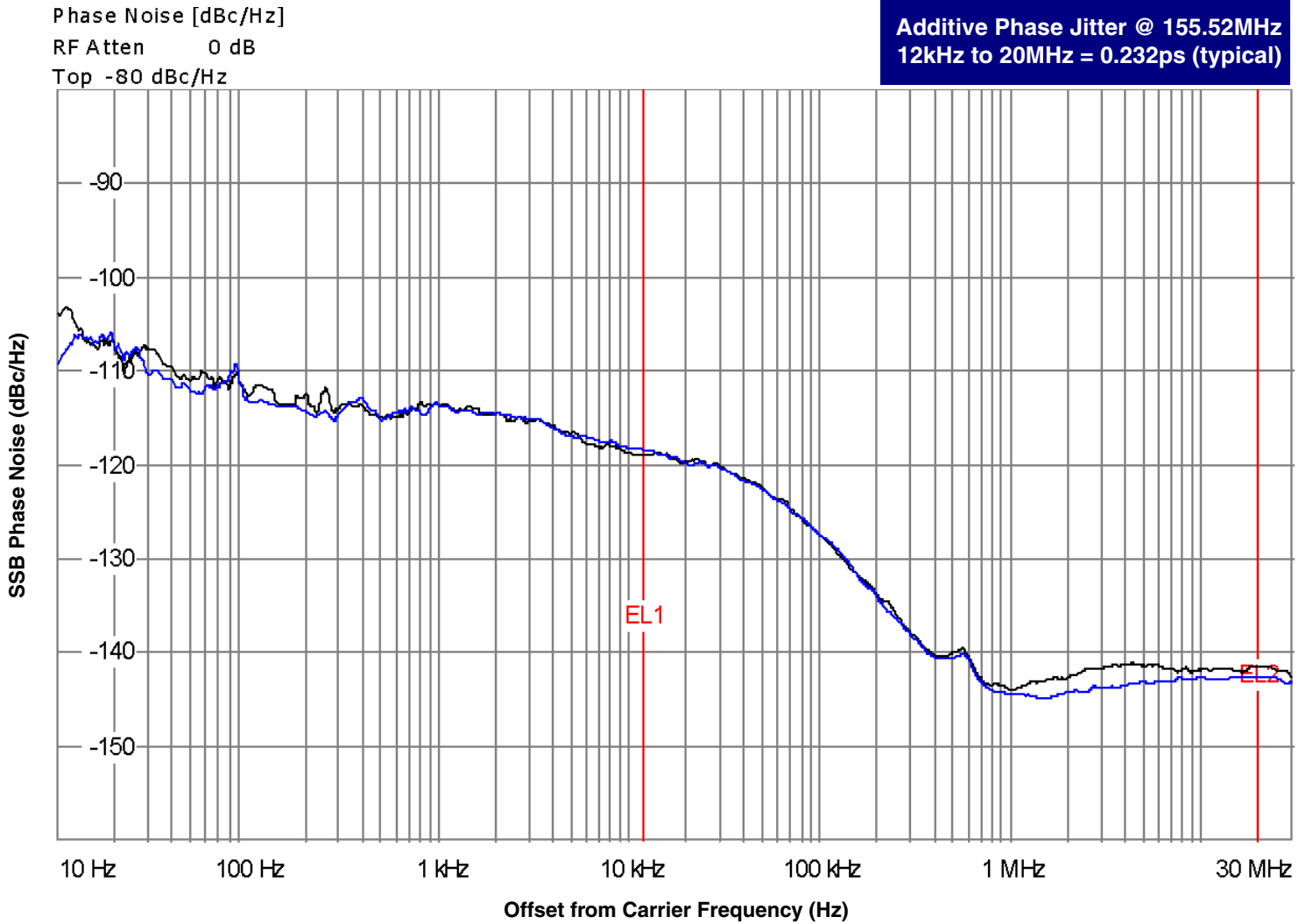
NOTE 3: Defined as skew between outputs on different devices operating at the same supply voltages and with equal load conditions. Using the same type of inputs on each device, the outputs are measured at the differential cross points.

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

## 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

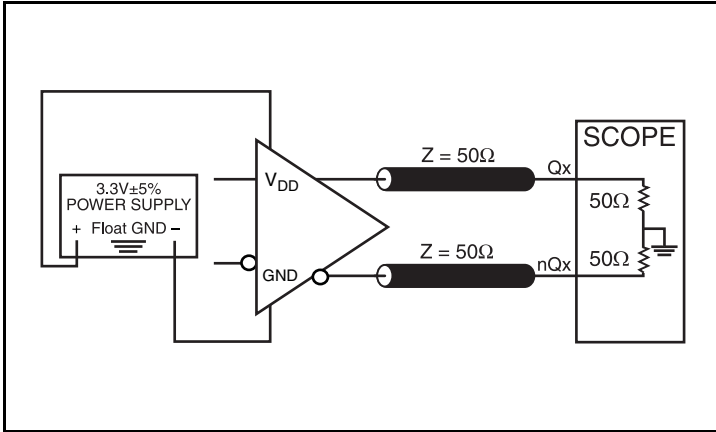
of the power in the 1Hz band to the power in the fundamental. When the required offset is specified, the phase noise is called a ***dBc*** value, which simply means dBm at a specified offset from the fundamental. By investigating jitter in the frequency domain, we get a better understanding of its effects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



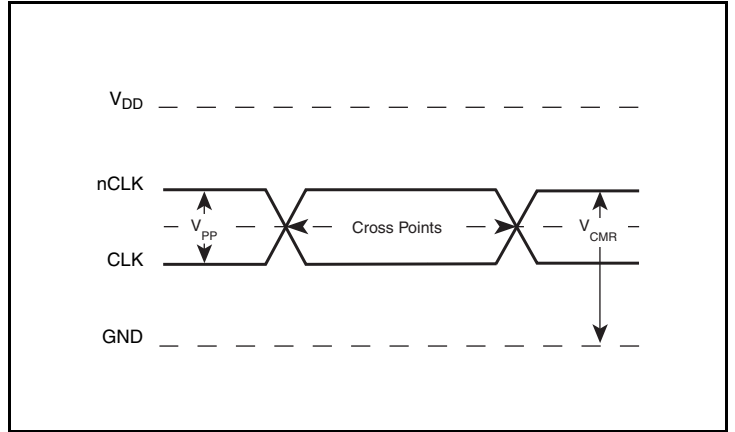
As with most timing specifications, phase noise measurements has issues relating to the limitations of the equipment. Often the noise floor of the equipment is higher than the noise floor of the device. This

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.

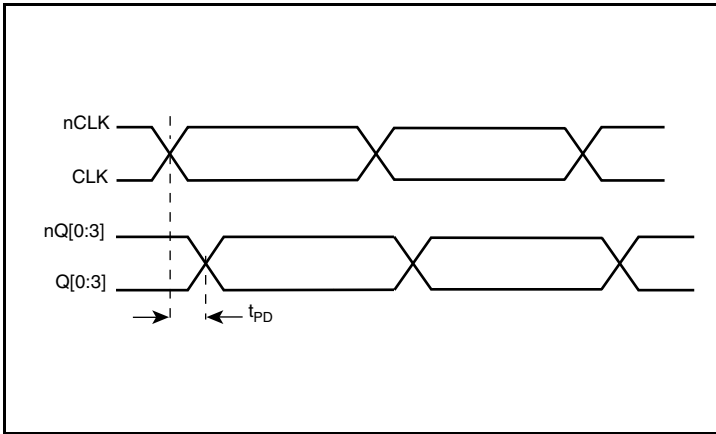
## Parameter Measurement Information



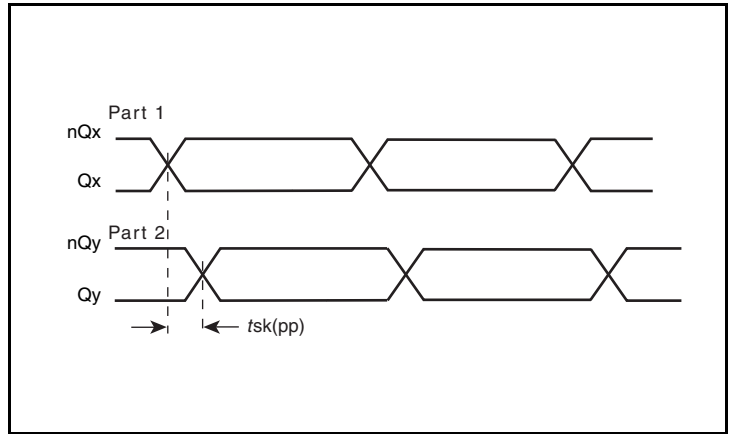
3.3V LVDS Output Load AC Test Circuit



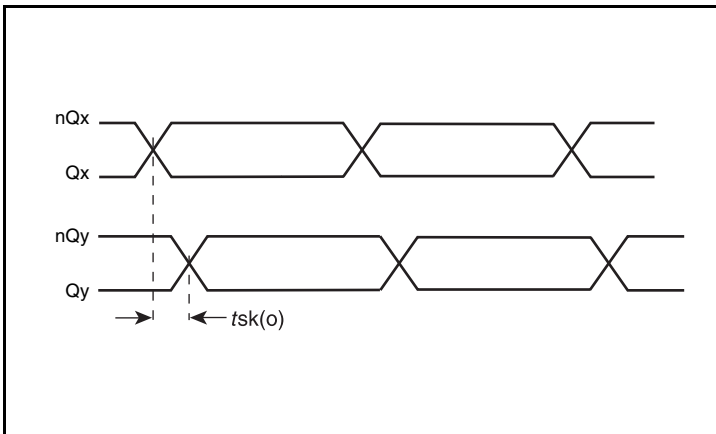
Differential Input Level



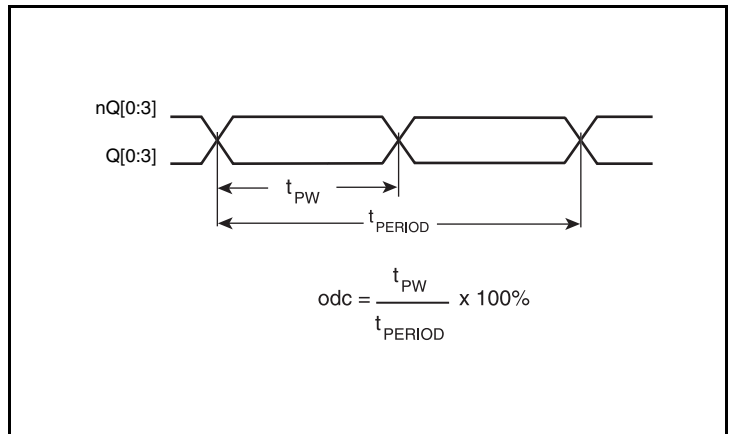
Propagation Delay



Part-to-Part Skew

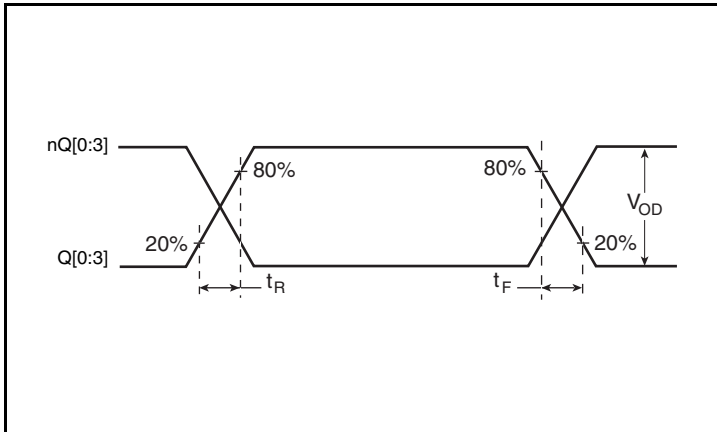


Output Skew

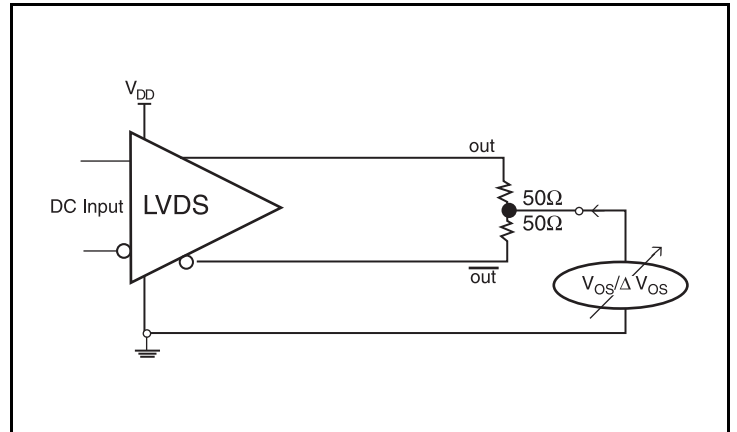


Output Duty Cycle/Pulse Width/Period

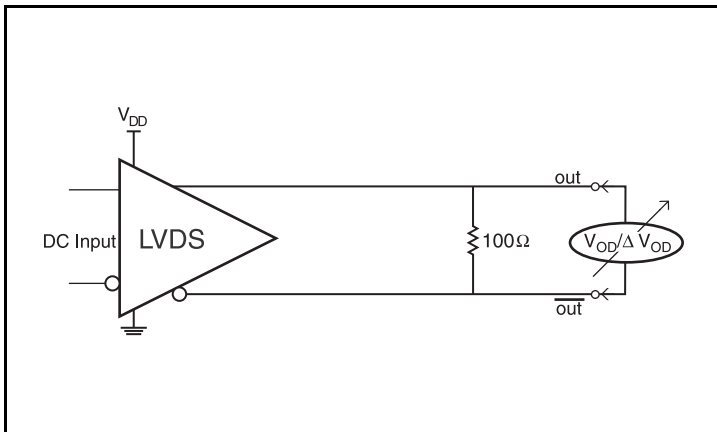
Parameter Measurement Information, continued



Output Rise/Fall Time



Offset Voltage Setup



Differential Output Voltage 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  $R2/R1 = 0.609$ .

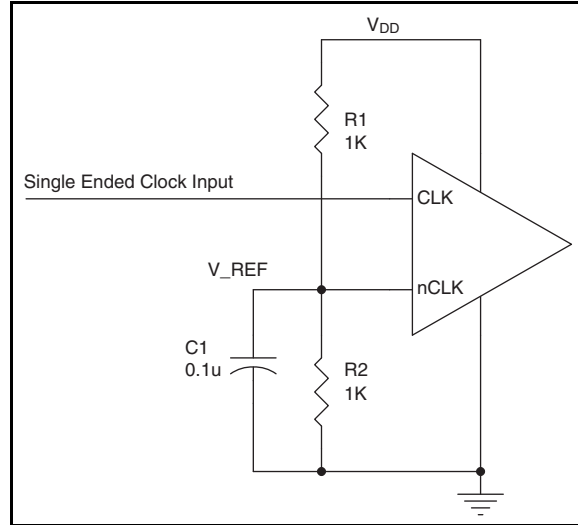


Figure 1. Single-Ended Signal Driving Differential Input

### Recommendations for Unused Input and Output Pins

#### Inputs:

##### LVC MOS Control Pins

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

#### Outputs:

##### LVDS Outputs

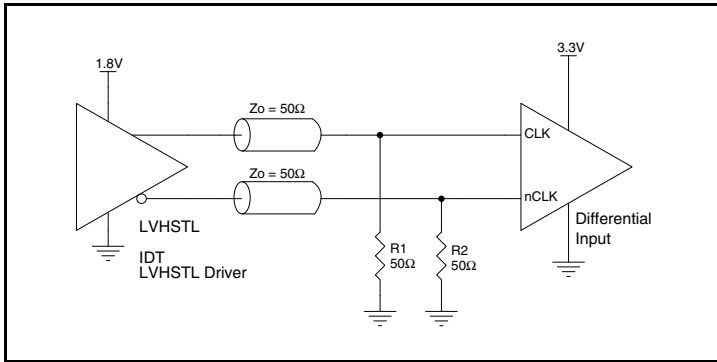
All unused LVDS output pairs can be either left floating or terminated with 100 $\Omega$  across. If they are left floating, there should be no trace attached.



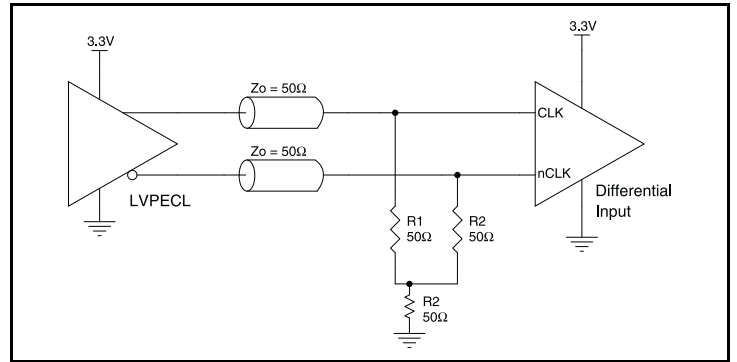
## Differential Clock Input Interface

The CLK /nCLK accepts LVDS, LVPECL, LVHSTL, SSTL, HCSL and other differential signals. Both signals must meet the  $V_{PP}$  and  $V_{CMR}$  input requirements. *Figures 2A to 2F* show interface examples for the CLK/nCLK input driven by the most common driver types. The input interfaces suggested here are examples only. Please consult with the

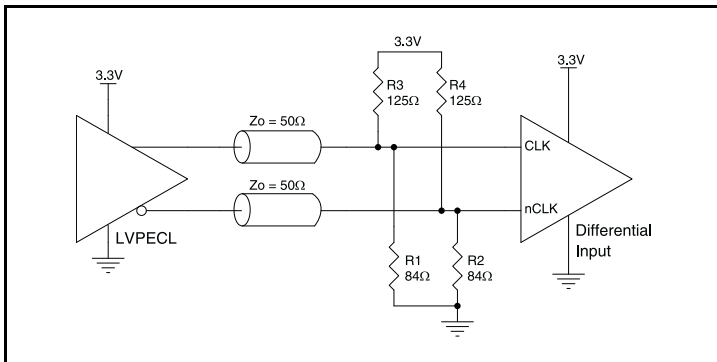
vendor of the driver component to confirm the driver termination requirements. For example, in Figure 2A, the input termination applies for IDT open emitter LVHSTL drivers. If you are using an LVHSTL driver from another vendor, use their termination recommendation.



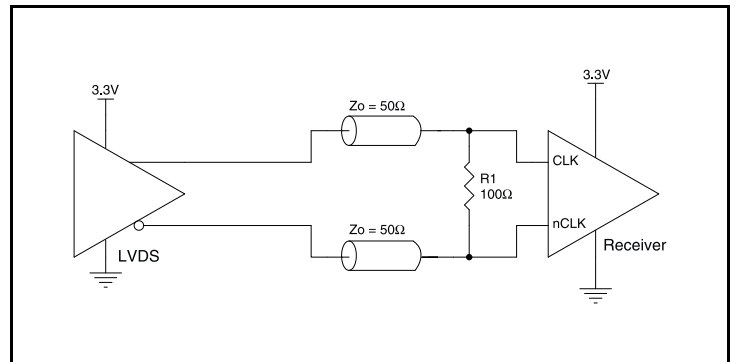
**Figure 2A. CLK/nCLK Input Driven by an IDT Open Emitter LVHSTL Driver**



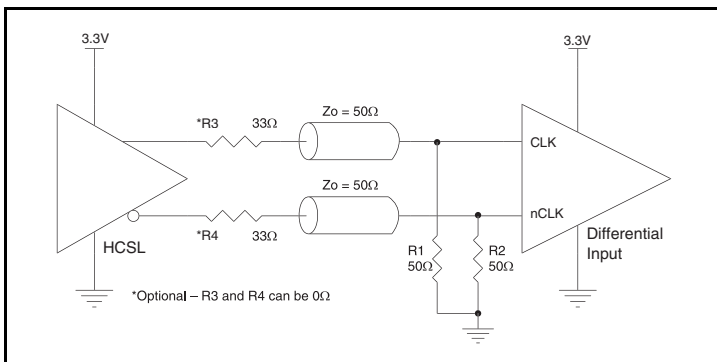
**Figure 2B. CLK/nCLK Input Driven by a 3.3V LVPECL Driver**



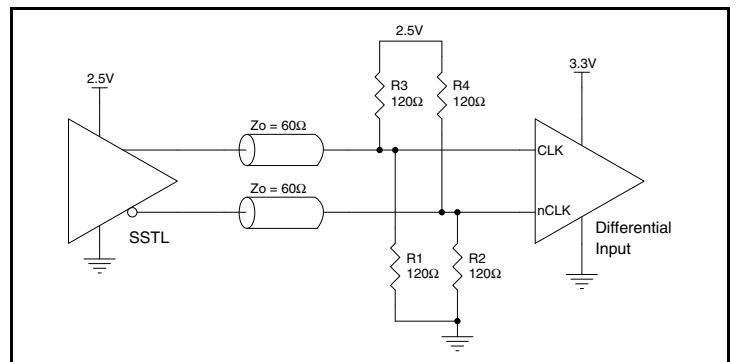
**Figure 3C. CLK/nCLK Input Driven by a 3.3V LVPECL Driver**



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



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

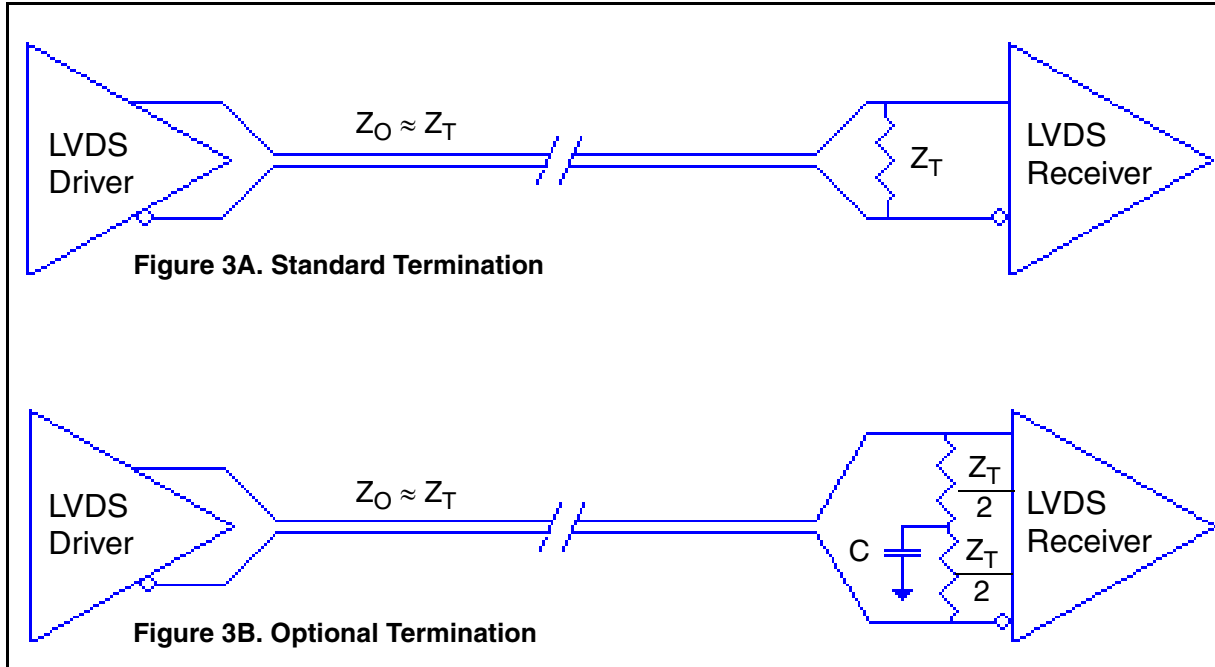


**Figure 2F. CLK/nCLK Input Driven by a 2.5V SSTL Driver**

## LVDS Driver Termination

For a general LVDS interface, the recommended value for the termination impedance ( $Z_T$ ) is between  $90\Omega$  and  $132\Omega$ . The actual value should be selected to match the differential impedance ( $Z_0$ ) of your transmission line. A typical point-to-point LVDS design uses a  $100\Omega$  parallel resistor at the receiver and a  $100\Omega$  differential transmission-line environment. In order to avoid any transmission-line reflection issues, the components should be surface mounted and must be placed as close to the receiver as possible. IDT offers a full line of LVDS compliant devices with two types of output structures: current source and voltage source type. The

standard termination schematic as shown in *Figure 3A* can be used with either type of output structure. *Figure 3B*, which can also be used with both output types, is an optional termination with center tap capacitance to help filter common mode noise. The capacitor value should be approximately  $50\text{pF}$ . If using a non-standard termination, it is recommended to contact IDT and confirm if the output structure is current source or voltage source type. In addition, since these outputs are LVDS compatible, the input receiver's amplitude and common-mode input range should be verified for compatibility with the output.



### LVDS Termination

## Power Considerations

This section provides information on power dissipation and junction temperature for the ICS854104. Equations and example calculations are also provided.

### 1. Power Dissipation.

The total power dissipation for the ICS854104 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  $V_{DD} = 3.3V + 5\% = 3.465V$ , which gives worst case results.

- Power (core)<sub>MAX</sub> =  $V_{DD\_MAX} * I_{DD\_MAX} = 3.465V * 75mA = 259.875mW$

### 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 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 no air flow and a multi-layer board, the appropriate value is 100.3°C/W per Table 6 below.

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

$$70^\circ\text{C} + 0.260\text{W} * 100.3^\circ\text{C/W} = 96.1^\circ\text{C}. \text{ This is well below the limit of } 125^\circ\text{C}.$$

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 (multi-layer).

**Table 6. Thermal Resistance  $\theta_{JA}$  for 16-Lead TSSOP, Forced Convection**

| $\theta_{JA}$ by Velocity                   |           |          |          |
|---|-----------|----------|----------|
| Meters per Second                           | 0         | 1        | 2.5      |
| Multi-Layer PCB, JEDEC Standard Test Boards | 100.3°C/W | 96.0°C/W | 93.9°C/W |

## Reliability Information

Table 7.  $\theta_{JA}$  vs. Air Flow Table for a 16-Lead TSSOP

| $\theta_{JA}$ by Velocity                   |           |          |          |
|---|-----------|----------|----------|
| Meters per Second                           | 0         | 1        | 2.5      |
| Multi-Layer PCB, JEDEC Standard Test Boards | 100.3°C/W | 96.0°C/W | 93.9°C/W |

## Transistor Count

The transistor count for ICS854104 is: 286

Pin compatible with SN65LVDS104

## Package Outline and Package Dimensions

Package Outline - G Suffix for 16-Lead TSSOP

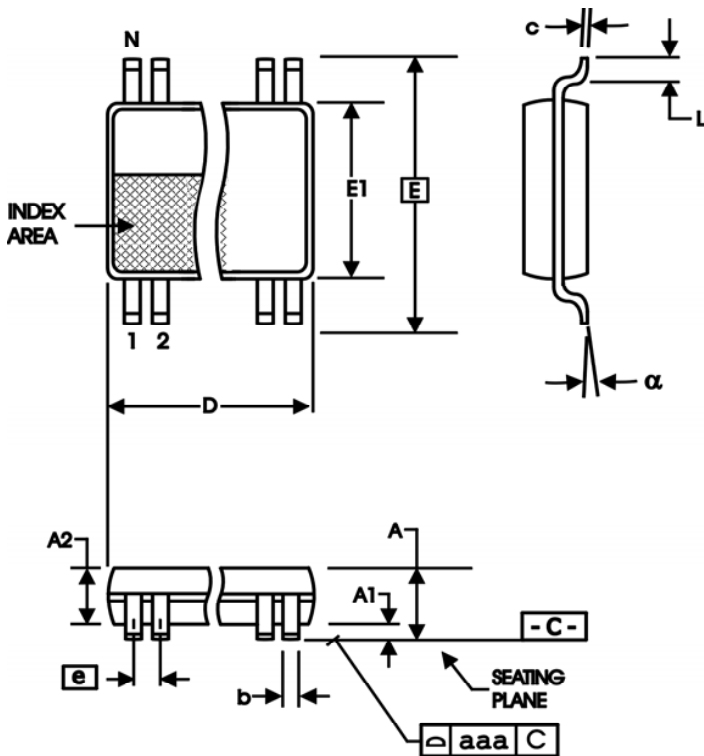


Table 8. Package Dimensions

| All Dimensions in Millimeters |            |         |
|-------------------------------|------------|---------|
| Symbol                        | Minimum    | Maximum |
| N                             | 16         |         |
| A                             |            | 1.20    |
| A1                            | 0.05       | 0.15    |
| A2                            | 0.80       | 1.05    |
| b                             | 0.19       | 0.30    |
| c                             | 0.09       | 0.20    |
| D                             | 4.90       | 5.10    |
| 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, MO-153

## Ordering Information

Table 9. Ordering Information

| Part/Order Number | Marking  | Package                   | Shipping Packaging | Temperature |
|-------------------|----------|---------------------------|--------------------|-------------|
| 854104AGLF        | 854104AL | "Lead-Free" 16-Lead TSSOP | Tube               | 0°C to 70°C |
| 854104AGLFT       | 854104AL | "Lead-Free" 16-Lead TSSOP | Tape & Reel        | 0°C to 70°C |

## Revision History Sheet

| Rev | Table     | Page    | Description of Change   | Date    |
|-----|-----------|---------|---|---------|
| A   | T5        | 4       | AC Characteristics - deleted "Bank A" test conditions from part-to-part skew row.   | 8/13/09 |
| A   | T4B<br>T9 | 3<br>13 | Corrected typo error; $I_{IH} = 5\mu A$ Max, $I_{IL} = -150\mu A$ Min.<br>Deleted Leaded ordering option, deleted quantity from Tape & Reel | 1/30/14 |
|     |           |         |   |         |



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