



Integrated  
Circuit  
Systems, Inc.

**PRELIMINARY**

# ICS8602

## ZERO DELAY, DIFFERENTIAL-TO-LVCMOS/LVTTL CLOCK GENERATOR

### GENERAL DESCRIPTION

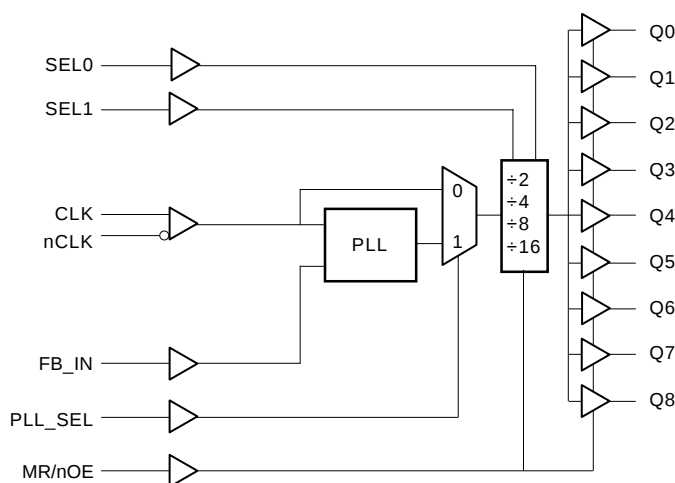


The ICS8602 is a high performance, low skew, 1-to-9 Differential-to-LVCMOS/LVTTL Zero Delay Buffer and a member of the HiPerClockS™ family of High Performance Clocks Solutions from ICS. The CLK, nCLK pair can accept most standard differential input levels. The VCO operates at a frequency range of 250MHz to 500MHz. The external feedback allows the device to achieve “zero delay” between the input clock and the output clocks. The device is designed only for 1:1 input/output frequency ratios. The output divider allows a wide input/output frequency range with the 250MHz to 500MHz VCO. The PLL\_SEL pin can be used to bypass the PLL for system test and debug purposes. In bypass mode, the reference clock is routed around the PLL and into the internal output dividers. The low impedance LVCMOS/LVTTL outputs are designed to drive 50Ω series or parallel terminated transmission lines. The effective fanout can be doubled by utilizing the ability of the outputs to drive two series terminated lines. The differential reference clock input will accept any differential signal levels.

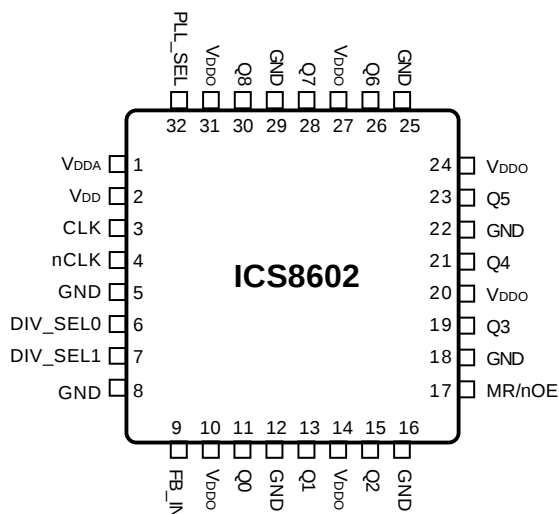
### FEATURES

- Fully integrated PLL
- 9 LVCMOS/LVTTL outputs, 7Ω typical output impedance
- CLK, nCLK pair can accept the following differential input levels: LVPECL, LVDS, LVHSTL, SSTL, HCSL
- Output frequency range: 15.625MHz to 250MHz
- Input frequency range: 15.625MHz to 250MHz
- VCO range: 250MHz to 500MHz
- External feedback for “zero delay” clock regeneration with configurable frequencies
- Cycle-to-cycle jitter: 36ps (typical)
- Output skew: 125ps (maximum)
- Static Phase Offset: TBD±100ps (typical)
- 3.3V supply voltage
- 0°C to 70°C ambient operating temperature

### BLOCK DIAGRAM



### PIN ASSIGNMENT



#### 32-Lead LQFP

7mm x 7mm x 1.4mm package body

#### Y Package

Top View

The Preliminary Information presented herein represents a product in prototyping or pre-production. The noted characteristics are based on initial product characterization. Integrated Circuit Systems, Incorporated (ICS) reserves the right to change any circuitry or specifications without notice.



**TABLE 1. PIN DESCRIPTIONS**

| Number                                | Name                                  | Type   |          | Description                                                                                                                                                                                                                                    |
|---------------------------------------|---------------------------------------|--------|----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1                                     | $V_{DDA}$                             | Power  |          | Analog supply pin.                                                                                                                                                                                                                             |
| 2                                     | $V_{DD}$                              | Power  |          | Core supply pin.                                                                                                                                                                                                                               |
| 3                                     | CLK                                   | Input  | Pulldown | Non-inverting differential clock input.                                                                                                                                                                                                        |
| 4                                     | nCLK                                  | Input  | Pullup   | Inverting differential clock input.                                                                                                                                                                                                            |
| 5, 8, 12 16,<br>18, 22, 25, 29        | GND                                   | Power  |          | Power supply ground.                                                                                                                                                                                                                           |
| 6, 7                                  | DIV_SEL0, DIV_SEL1                    | Input  | Pulldown | Determines output divider valued in Table 3. LVCMOS / LVTTL interface levels.                                                                                                                                                                  |
| 9                                     | FB_IN                                 | Input  | Pulldown | Feedback input to phase detector for regenerating clocks with "zero delay". LVCMOS / LVTTL interface levels.                                                                                                                                   |
| 10, 14, 20,<br>24, 27, 31             | $V_{DDO}$                             | Power  |          | Output supply pins.                                                                                                                                                                                                                            |
| 11, 13, 15, 19, 21,<br>23, 26, 28, 30 | Q0, Q1, Q2, Q3, Q4,<br>Q5, Q6, Q7, Q8 | Output |          | Clock outputs. 7 $\Omega$ typical output impedance. LVCMOS / LVTTL interface levels.                                                                                                                                                           |
| 17                                    | MR/nOE                                | Input  | Pulldown | Active HIGH Master Reset. Active LOW output enable. When logic HIGH, the internal dividers are reset and the outputs are tri-stated (HiZ). When logic LOW, the internal dividers and the outputs are enabled. LVCMOS / LVTTL interface levels. |
| 32                                    | PLL_SEL                               | Input  | Pullup   | Selects between the PLL and the reference clock as the input to the dividers. When HIGH, selects PLL. When LOW, selects reference clock. LVCMOS / LVTTL interface levels.                                                                      |

NOTE: *Pullup* and *Pulldown* refer to internal input resistors. See Table 2, Pin Characteristics, for typical values.

**TABLE 2. PIN CHARACTERISTICS**

| Symbol         | Parameter                                  | Test Conditions                    | Minimum | Typical | Maximum | Units      |
|----------------|--------------------------------------------|------------------------------------|---------|---------|---------|------------|
| $C_{IN}$       | Input Capacitance                          |                                    |         |         | 4       | pF         |
| $R_{PULLUP}$   | Input Pullup Resistor                      |                                    |         | 51      |         | K $\Omega$ |
| $R_{PULLDOWN}$ | Input Pulldown Resistor                    |                                    |         | 51      |         | K $\Omega$ |
| $C_{PD}$       | Power Dissipation Capacitance (per output) | $V_{DD}, V_{DDA}, V_{DDO} = 3.47V$ |         | TBD     |         | pF         |
| $R_{OUT}$      | Output Impedance                           |                                    |         | 7       |         | $\Omega$   |

**TABLE 3A. CONTROL INPUT FUNCTION TABLE, PLL\_SEL = 1**

| DIV_SEL1 | DIV_SEL0 | f <sub>OUT</sub> = f <sub>IN</sub><br>Frequency Range (MHz) |         |
|----------|----------|-------------------------------------------------------------|---------|
|          |          | Minimum                                                     | Maximum |
| 0        | 0        | 125                                                         | 250     |
| 0        | 1        | 62.5                                                        | 125     |
| 1        | 0        | 31.25                                                       | 62.5    |
| 1        | 1        | 15.625                                                      | 31.25   |

**TABLE 3B. CONTROL INPUT FUNCTION TABLE, PLL\_SEL = 0  
PLL BYPASS MODE**

| DIV_SEL1 | DIV_SEL0 | Frequency Divider |                     |
|----------|----------|-------------------|---------------------|
|          |          | f <sub>IN</sub>   | f <sub>OUT</sub>    |
| 0        | 0        | f <sub>IN</sub>   | f <sub>IN</sub> /2  |
| 0        | 1        | f <sub>IN</sub>   | f <sub>IN</sub> /4  |
| 1        | 0        | f <sub>IN</sub>   | f <sub>IN</sub> /8  |
| 1        | 1        | f <sub>IN</sub>   | f <sub>IN</sub> /16 |



# ABSOLUTE MAXIMUM RATINGS

|                                          |                           |
|------------------------------------------|---------------------------|
| Supply Voltage, $V_{DD}$                 | 4.6V                      |
| Inputs, $V_I$                            | -0.5V to $V_{DD} + 0.5V$  |
| Outputs, $V_O$                           | -0.5V to $V_{DDO} + 0.5V$ |
| Package Thermal Impedance, $\theta_{JA}$ | 42.1°C/W (0 lfpm)         |
| Storage Temperature, $T_{STG}$           | -65°C to 150°C            |

NOTE: Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. These ratings are stress specifications only. Functional operation of product at these conditions or any conditions beyond those listed in the *DC Characteristics* or *AC Characteristics* is not implied. Exposure to absolute maximum rating conditions for extended periods may affect product reliability.

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

| Symbol    | Parameter             | Test Conditions | Minimum | Typical | Maximum | Units |
|-----------|-----------------------|-----------------|---------|---------|---------|-------|
| $V_{DD}$  | Core Supply Voltage   |                 | 3.135   | 3.3     | 3.465   | V     |
| $V_{DDA}$ | Analog Supply Voltage |                 | 3.135   | 3.3     | 3.465   | V     |
| $V_{DDO}$ | Output Supply Voltage |                 | 3.135   | 3.3     | 3.465   | V     |
| $I_{DD}$  | Power Supply Current  |                 |         | 40      |         | mA    |
| $I_{DDA}$ | Analog Supply Current |                 |         | 10      |         | mA    |
| $I_{DDO}$ | Output Supply Current |                 |         | 160     |         | mA    |

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

| Symbol   | Parameter                   | Test Conditions                   | Minimum                        | Typical | Maximum        | Units         |
|----------|-----------------------------|-----------------------------------|--------------------------------|---------|----------------|---------------|
| $V_{IH}$ | Input High Voltage          |                                   | 2                              |         | $V_{DD} + 0.3$ | V             |
| $V_{IL}$ | Input Low Voltage           |                                   | -0.3                           |         | 0.8            | V             |
| $I_{IH}$ | Input High Current          | DIV_SEL0, DIV_SEL1, FB_IN, MR/nOE | $V_{DD} = V_{IN} = 3.465V$     |         | 150            | $\mu\text{A}$ |
|          |                             | PLL_SEL                           | $V_{DD} = V_{IN} = 3.465V$     |         | 5              | $\mu\text{A}$ |
| $I_{IL}$ | Input Low Current           | DIV_SEL0, DIV_SEL1, FB_IN, MR/nOE | $V_{DD} = 3.465V, V_{IN} = 0V$ | -5      |                | $\mu\text{A}$ |
|          |                             | PLL_SEL                           | $V_{DD} = 3.465V, V_{IN} = 0V$ | -150    |                | $\mu\text{A}$ |
| $V_{OH}$ | Output High Voltage; NOTE 1 |                                   | 2.6                            |         |                | V             |
| $V_{OL}$ | Output Low Voltage; NOTE 1  |                                   |                                |         | 0.5            | V             |

NOTE 1: Outputs terminated with  $50\Omega$  to  $V_{DDO}/2$ . See Parameter Measurement Information, *3.3V Output Load Test Circuit*.

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

| Symbol    | Parameter                            | Test Conditions | Minimum                        | Typical | Maximum         | Units         |
|-----------|--------------------------------------|-----------------|--------------------------------|---------|-----------------|---------------|
| $I_{IH}$  | Input High Current                   | CLK             | $V_{DD} = V_{IN} = 3.465V$     |         | 150             | $\mu\text{A}$ |
|           |                                      | nCLK            | $V_{DD} = V_{IN} = 3.465V$     |         | 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 Input Voltage           |                 | 0.15                           |         | 1.3             | V             |
| $V_{CMR}$ | Common Mode Input Voltage; NOTE 1, 2 |                 | GND + 0.5                      |         | $V_{DD} - 0.85$ | V             |

NOTE 1: Common mode voltage is defined as  $V_{IH}$ .

NOTE 2: For single ended applications, the maximum voltage for CLK, nCLK is  $V_{DD} + 0.3V$ .



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

| Symbol         | Parameter                                 | Test Conditions                                            | Minimum | Typical       | Maximum | Units |
|----------------|-------------------------------------------|------------------------------------------------------------|---------|---------------|---------|-------|
| $f_{MAX}$      | Output Frequency                          |                                                            | 15.625  |               | 250     | MHz   |
| $tp_{LH}$      | Propagation Delay,<br>Low-to-High; NOTE 1 | PLL_SEL=0V, $0MHz \leq f \leq 250MHz$                      | TBD     |               | TBD     | ns    |
| $t(\emptyset)$ | Static Phase Offset; NOTE 2               | PLL_SEL = 3.3V, $f_{REF} = 133MHz$ ,<br>$f_{VCO} = 266MHz$ |         | TBD $\pm 100$ |         | ps    |
|                |                                           | PLL_SEL = 3.3V, $f_{REF} = 50MHz$ ,<br>$f_{VCO} = 100MHz$  |         | TBD $\pm 100$ |         | ps    |
| $tsk(o)$       | Output Skew; NOTE 3, 4                    | Measured on rising edge at $V_{DDO}/2$                     |         |               | 125     | ps    |
| $f_{jit(cc)}$  | Cycle-to-Cycle Jitter; NOTE 4             | Measured on rising edge at $V_{DDO}/2$                     |         | 36            |         | ps    |
| $t_L$          | PLL Lock Time                             |                                                            |         |               | 1       | ms    |
| $t_R$          | Output Rise Time                          | 20% to 80% @ 50MHz                                         | 400     |               | 950     | ps    |
| $t_F$          | Output Fall Time                          | 20% to 80% @ 50MHz                                         | 400     |               | 950     | ps    |
| odc            | Output Duty Cycle                         | $f = 250MHz$                                               |         | 50            |         | %     |

All parameters measured at  $f_{MAX}$  unless noted otherwise.

NOTE 1: Measured from the differential input crossing point to the output at  $V_{DDO}/2$ .

NOTE 2: Defined as the time difference between the input reference clock and the average feedback input signal when the PLL is locked and the input reference frequency is stable.

NOTE 3: Defined as skew between outputs at the same supply voltage and with equal load conditions.

Measured at  $V_{DDO}/2$ .

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

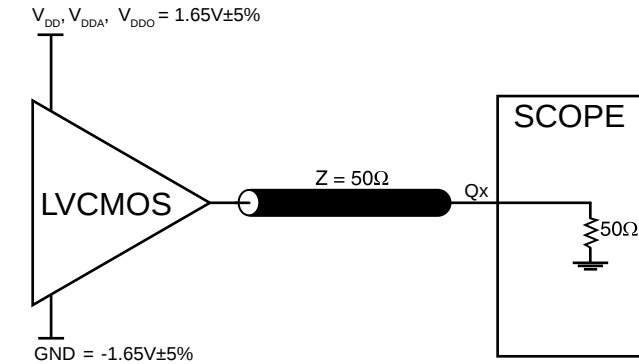


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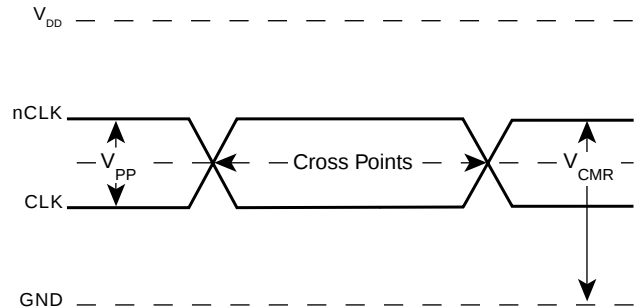
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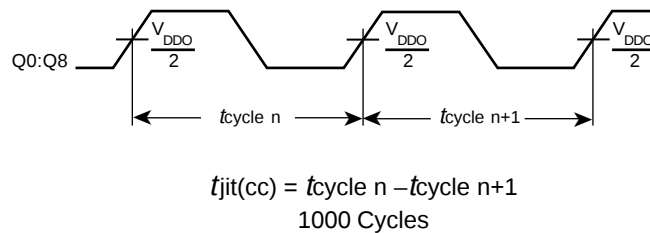
## PARAMETER MEASUREMENT INFORMATION



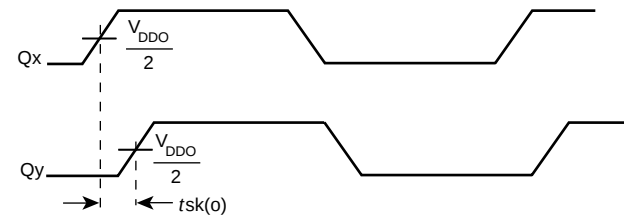
**3.3V OUTPUT LOAD AC TEST CIRCUIT**



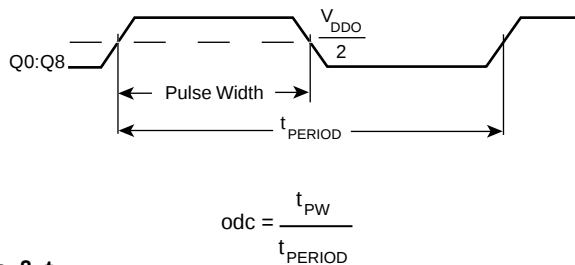
**DIFFERENTIAL INPUT LEVEL**



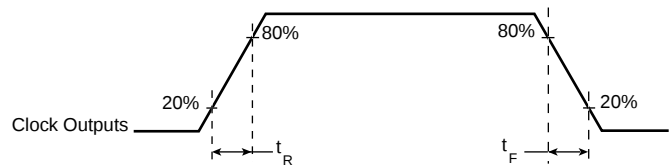
**CYCLE-TO-CYCLE JITTER**



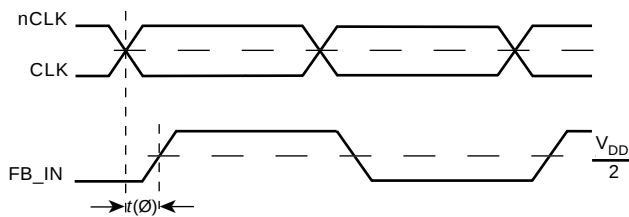
**OUTPUT SKEW**



**odc &  $t_{PERIOD}$**



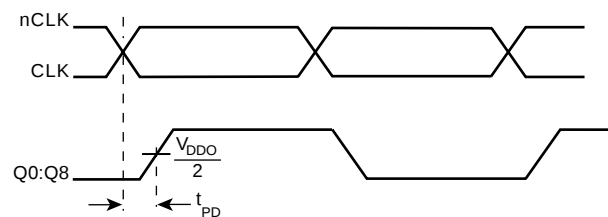
**OUTPUT RISE/FALL TIME**



$t(\emptyset)_{mean}$  = Static Phase Offset

(where  $t(\emptyset)$  is any random sample, and  $t(\emptyset)_{mean}$  is the average of the sampled cycles measured on controlled edges)

**STATIC PHASE OFFSET**



**PROPAGATION DELAY**

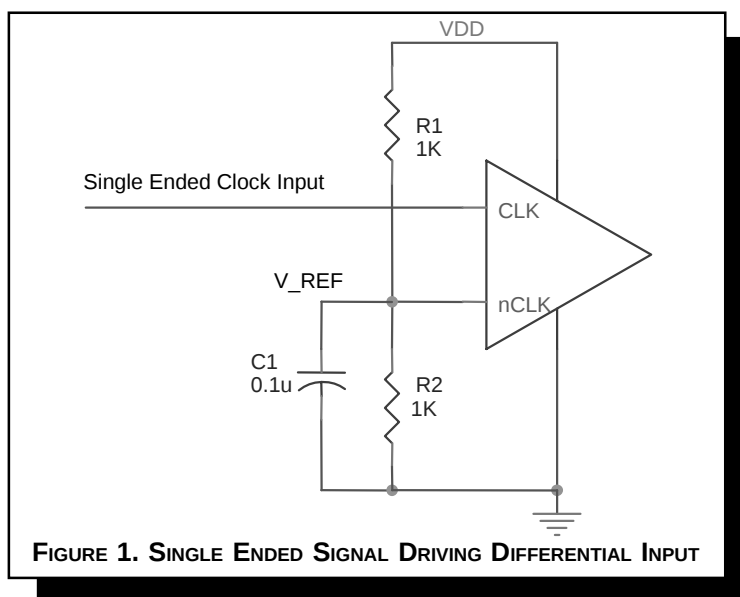


## APPLICATION INFORMATION

### WIRING THE DIFFERENTIAL INPUT TO ACCEPT SINGLE ENDED LEVELS

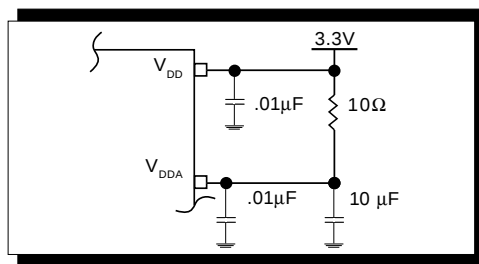
Figure 1 shows how the differential input can be wired to accept single ended levels. The reference voltage  $V_{REF} = V_{DD}/2$  is generated by the bias resistors R1, R2 and C1. This bias circuit should be located as close as possible to the input pin. The ratio

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  $R2/R1 = 0.609$ .



### POWER SUPPLY FILTERING TECHNIQUES

As in any high speed analog circuitry, the power supply pins are vulnerable to random noise. The ICS8602 provides separate power supplies to isolate any high switching noise from the outputs to the internal PLL.  $V_{DD}$ ,  $V_{DDA}$ , and  $V_{DDO}$  should be individually connected to the power supply plane through vias, and bypass capacitors should be used for each pin. To achieve optimum jitter performance, power supply isolation is required. Figure 2 illustrates how a 10Ω resistor along with a 10μF and a .01μF bypass capacitor should be connected to each  $V_{DDA}$  pin.

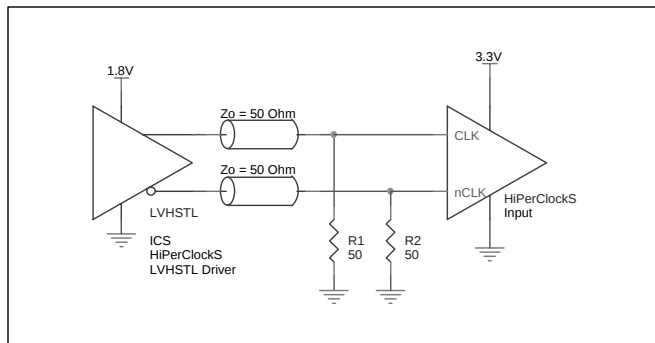




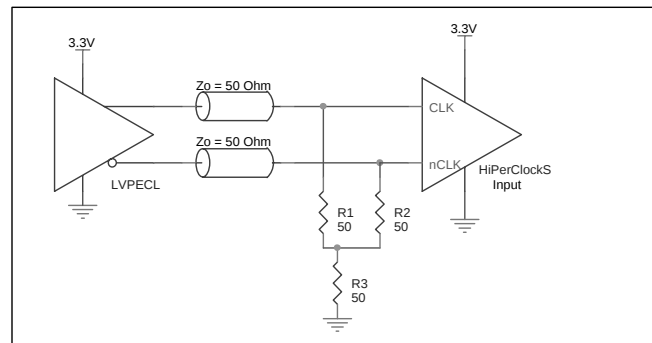
### DIFFERENTIAL CLOCK INPUT INTERFACE

The CLK /nCLK accepts LVDS, LVPECL, LVHSTL, SSTL, HCSL and other differential signals. Both  $V_{\text{SWING}}$  and  $V_{\text{OH}}$  must meet the  $V_{\text{PP}}$  and  $V_{\text{CMR}}$  input requirements. Figures 3A to 3D show interface examples for the HiPerClockS CLK/nCLK input driven by the most common driver types. The input interfaces suggested

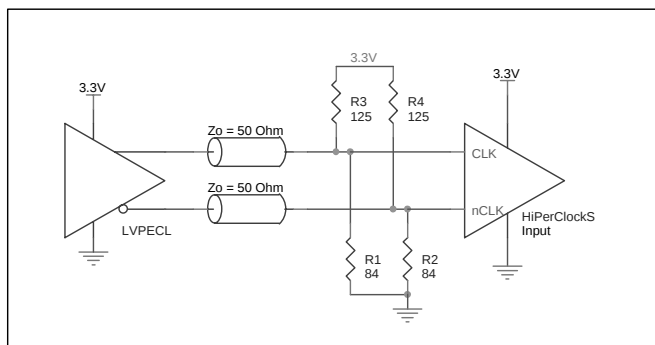
here are examples only. Please consult with the vendor of the driver component to confirm the driver termination requirements. For example in Figure 3A, the input termination applies for ICS HiPerClockS LVHSTL drivers. If you are using an LVHSTL driver from another vendor, use their termination recommendation.



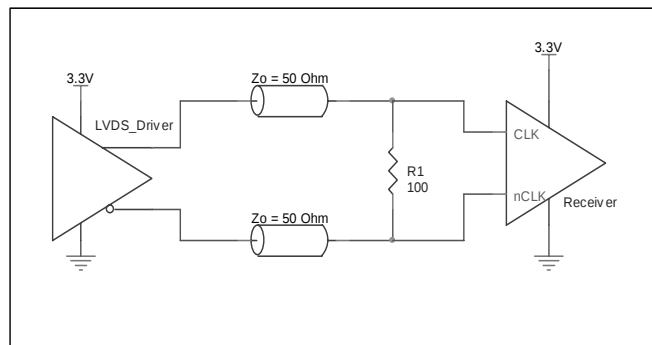
**FIGURE 3A. HiPerClockS CLK/nCLK INPUT DRIVEN BY ICS HiPerClockS LVHSTL DRIVER**



**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**



## RELIABILITY INFORMATION

TABLE 6.  $\theta_{JA}$  VS. AIR FLOW TABLE

| $\theta_{JA}$ by Velocity (Linear Feet per Minute)                                                                  |          |          |          |
|---------------------------------------------------------------------------------------------------------------------|----------|----------|----------|
|                                                                                                                     | 0        | 200      | 500      |
| Single-Layer PCB, JEDEC Standard Test Boards                                                                        | 67.8°C/W | 55.9°C/W | 50.1°C/W |
| Multi-Layer PCB, JEDEC Standard Test Boards                                                                         | 47.9°C/W | 42.1°C/W | 39.4°C/W |
| <b>NOTE:</b> Most modern PCB designs use multi-layered boards. The data in the second row pertains to most designs. |          |          |          |

### TRANSISTOR COUNT

The transistor count for ICS8602 is: 1828



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#### PACKAGE OUTLINE - Y SUFFIX

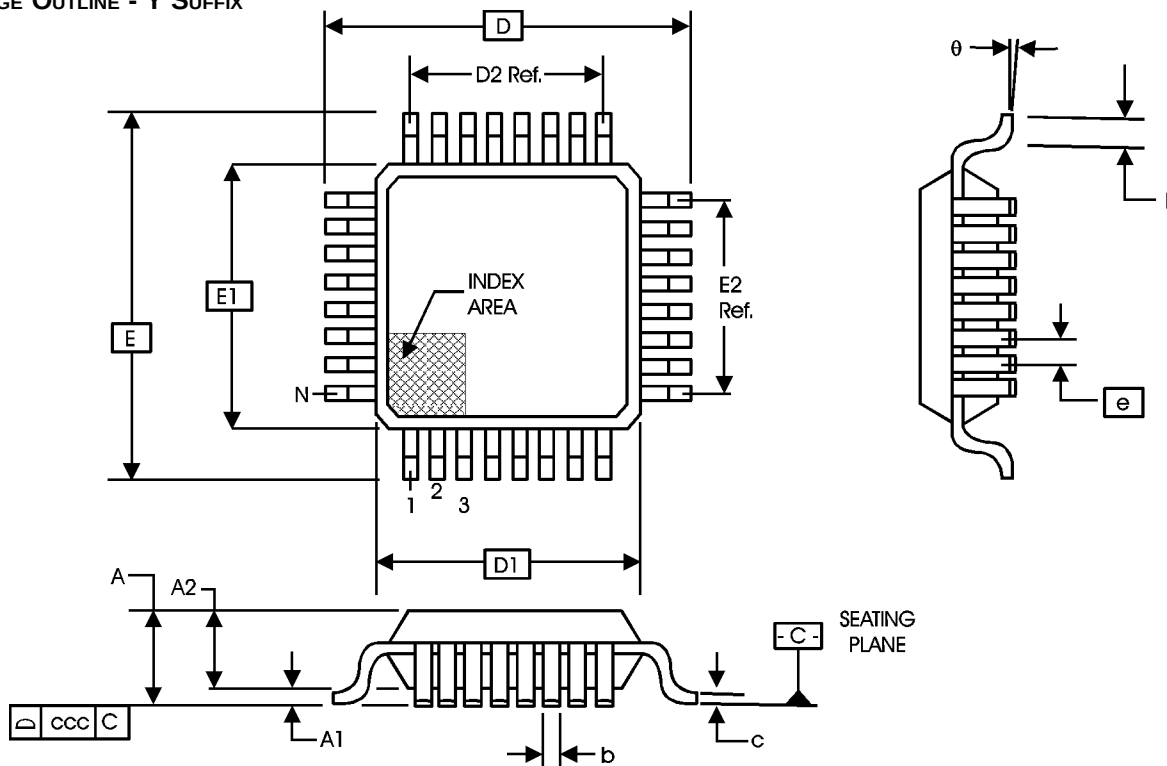


TABLE 7. PACKAGE DIMENSIONS

| JEDEC VARIATION<br>ALL DIMENSIONS IN MILLIMETERS |            |         |         |
|--------------------------------------------------|------------|---------|---------|
| SYMBOL                                           | BBA        |         |         |
|                                                  | MINIMUM    | NOMINAL | MAXIMUM |
| N                                                | 32         |         |         |
| A                                                | --         | --      | 1.60    |
| A1                                               | 0.05       | --      | 0.15    |
| A2                                               | 1.35       | 1.40    | 1.45    |
| b                                                | 0.30       | 0.37    | 0.45    |
| c                                                | 0.09       | --      | 0.20    |
| D                                                | 9.00 BASIC |         |         |
| D1                                               | 7.00 BASIC |         |         |
| D2                                               | 5.60 Ref.  |         |         |
| E                                                | 9.00 BASIC |         |         |
| E1                                               | 7.00 BASIC |         |         |
| E2                                               | 5.60 Ref.  |         |         |
| e                                                | 0.80 BASIC |         |         |
| L                                                | 0.45       | 0.60    | 0.75    |
| theta                                            | 0°         | --      | 7°      |
| ccc                                              | --         | --      | 0.10    |

Reference Document: JEDEC Publication 95, MS-026



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**TABLE 8. ORDERING INFORMATION**

| Part/Order Number | Marking   | Package                       | Count        | Temperature |
|-------------------|-----------|-------------------------------|--------------|-------------|
| ICS8602BY         | ICS8602BY | 32 Lead LQFP                  | 250 per tray | 0°C to 70°C |
| ICS8602BYT        | ICS8602BY | 32 Lead LQFP on Tape and Reel | 1000         | 0°C to 70°C |

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