

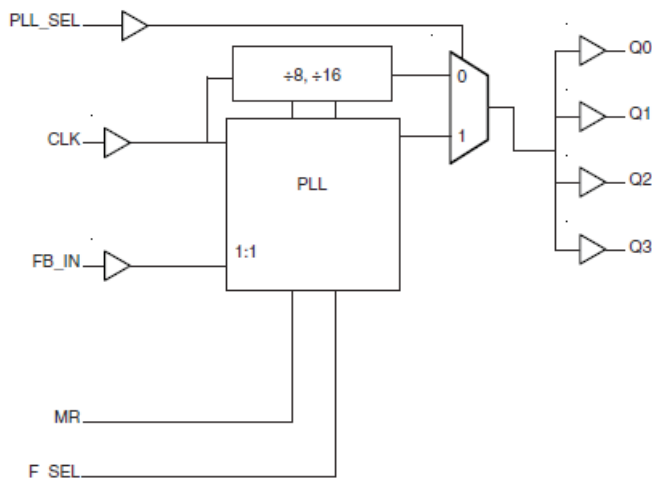
## GENERAL DESCRIPTION

The 86004 is a high performance 1:4 LVCMOS/LVTTL Clock Buffer. The 86004 has a fully integrated PLL and can be configured as zero delay buffer and has an input and output frequency range of 15.625MHz to 62.5MHz. 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 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 divider.

## FEATURES

- Four LVCMOS/LVTTL outputs, 7Ω typical output impedance
- Single LVCMOS/LVTTL clock input
- CLK accepts the following input levels: LVCMOS or LVTTL
- Output frequency range: 15.625MHz to 62.5MHz
- Input frequency range: 15.625MHz to 62.5MHz
- VCO range: 250MHz to 500MHz
- External feedback for “zero delay” clock regeneration with configurable frequencies
- Fully integrated PLL
- Cycle-to-cycle jitter: 65ps (maximum)
- Output skew: 65ps (maximum)
- Full 3.3V or 2.5V, or 3.3V core/2.5V output operating supply
- 0°C to 70° ambient operating temperature
- Available in lead-free RoHS compliant package

## BLOCK DIAGRAM



## PIN ASSIGNMENT

|       |   |    |         |
|-------|---|----|---------|
| Q1    | 1 | 16 | VDDO    |
| GND   | 2 | 15 | Q2      |
| Q0    | 3 | 14 | GND     |
| F_SEL | 4 | 13 | Q3      |
| VDD   | 5 | 12 | VDDO    |
| CLK   | 6 | 11 | MR      |
| GND   | 7 | 10 | FB_IN   |
| VDDA  | 8 | 9  | PLL_SEL |

**86004**

**16-Lead TSSOP**

4.4mm x 5.0mm x 0.925mm package body

**G Package**

Top View

TABLE 1. PIN DESCRIPTIONS

| Number       | Name             | Type   |          | Description                                                                                                                                                                                                 |
|--------------|------------------|--------|----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1, 3, 13, 15 | Q1, Q0, Q3, Q2   | Output |          | Clock outputs. 7 typical output impedance. LVCMOS/LVTTL interface levels.                                                                                                                                   |
| 2, 7, 14     | GND              | Power  |          | Power supply ground.                                                                                                                                                                                        |
| 4            | F_SEL            | Input  | Pulldown | Frequency range select input. See Table 3A and 3B. LVCMOS/LVTTL interface levels.                                                                                                                           |
| 5            | V <sub>DD</sub>  | Power  |          | Core supply pin.                                                                                                                                                                                            |
| 6            | CLK              | Input  | Pulldown | LVCMOS/LVTTL clock input.                                                                                                                                                                                   |
| 8            | V <sub>DDA</sub> | Power  |          | Analog supply pin.                                                                                                                                                                                          |
| 9            | PLL_SEL          | Input  | Pullup   | Selects between the PLL and reference clock as input to the dividers. When LOW, selects the reference clock (PLL Bypass). When HIGH, selects PLL (PLL Enabled). LVCMOS/LVTTL interface levels.              |
| 10           | FB_IN            | Input  | Pulldown | Feedback input to phase detector for regenerating clocks with “zero delay”. Connect to one of the outputs. LVCMOS/LVTTL interface levels.                                                                   |
| 11           | MR               | Input  | Pulldown | Active HIGH Master Reset. When logic HIGH, the internal dividers are reset causing the outputs to go low. When logic LOW, the internal dividers and the outputs are enabled. LVCMOS/LVTTL interface levels. |
| 12, 16       | V <sub>DDO</sub> | Power  |          | Output supply pins.                                                                                                                                                                                         |

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) | V <sub>DD</sub> , V <sub>DDA</sub> , V <sub>DDO</sub> = 3.465V |         |         | 23      | pF    |
|                       |                                            | V <sub>DD</sub> , V <sub>DDA</sub> , V <sub>DDO</sub> = 2.625V |         |         | 17      | pF    |
| R <sub>OUT</sub>      | Output Impedance                           | 3.3V ± 5%                                                      | 5       | 7       | 12      | Ω     |

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

| Input<br>F_SEL | Input/Output<br>Frequency Range (MHz) |         |
|----------------|---------------------------------------|---------|
|                | Minimum                               | Maximum |
| 0              | 31.25                                 | 62.5    |
| 1              | 15.625                                | 31.25   |

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

| Input<br>F_SEL | Output   |
|----------------|----------|
| 0              | Ref ÷ 8  |
| 1              | Ref ÷ 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, $\theta_{JA}$ | 89°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     | $V_{DD}$ | V     |
| $V_{DDO}$ | Output Supply Voltage |                 | 3.135   | 3.3     | 3.465    | V     |
| $I_{DD}$  | Power Supply Current  |                 |         |         | 98       | mA    |
| $I_{DDA}$ | Analog Supply Current |                 |         |         | 17       | mA    |
| $I_{DDO}$ | Output Supply Current |                 |         |         | 8        | mA    |

**TABLE 4B. POWER SUPPLY DC CHARACTERISTICS,  $V_{DD} = V_{DDA} = 3.3V \pm 5\%$ ,  $V_{DDO} = 2.5V \pm 5\%$ ,  $T_A = 0^\circ\text{C}$  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     | $V_{DD}$ | V     |
| $V_{DDO}$ | Output Supply Voltage |                 | 2.375   | 2.5     | 2.625    | V     |
| $I_{DD}$  | Power Supply Current  |                 |         |         | 98       | mA    |
| $I_{DDA}$ | Analog Supply Current |                 |         |         | 17       | mA    |
| $I_{DDO}$ | Output Supply Current |                 |         |         | 8        | mA    |

**TABLE 4C. POWER SUPPLY DC CHARACTERISTICS,  $V_{DD} = V_{DDA} = V_{DDO} = 2.5V \pm 5\%$ ,  $T_A = 0^\circ\text{C}$  TO  $70^\circ\text{C}$**

| Symbol    | Parameter             | Test Conditions | Minimum | Typical | Maximum  | Units |
|-----------|-----------------------|-----------------|---------|---------|----------|-------|
| $V_{DD}$  | Core Supply Voltage   |                 | 2.375   | 2.5     | 2.625    | V     |
| $V_{DDA}$ | Analog Supply Voltage |                 | 2.375   | 2.5     | $V_{DD}$ | V     |
| $V_{DDO}$ | Output Supply Voltage |                 | 2.375   | 2.5     | 2.625    | V     |
| $I_{DD}$  | Power Supply Current  |                 |         |         | 88       | mA    |
| $I_{DDA}$ | Analog Supply Current |                 |         |         | 14       | mA    |
| $I_{DDO}$ | Output Supply Current |                 |         |         | 6        | mA    |

**TABLE 4D. LVCMOS / LVTTTL DC CHARACTERISTICS,  $V_{DD} = V_{DDA} = V_{DDO} = 3.3V \pm 5\%$  OR  $2.5V \pm 5\%$ ,  $T_A = 0^\circ C$  TO  $70^\circ C$** 

| Symbol   | Parameter                   | Test Conditions                                         | Minimum | Typical | Maximum        | Units   |
|----------|-----------------------------|---------------------------------------------------------|---------|---------|----------------|---------|
| $V_{IH}$ | Input High Voltage          | $V_{DD} = 3.3V$                                         | 2       |         | $V_{DD} + 0.3$ | V       |
|          |                             | $V_{DD} = 2.5V$                                         | 1.7     |         | $V_{DD} + 0.3$ | V       |
| $V_{IL}$ | Input Low Voltage           | $V_{DD} = 3.3V$                                         | -0.3    |         | 0.8            | V       |
|          |                             | $V_{DD} = 2.5V$                                         | -0.3    |         | 0.7            | V       |
| $I_{IH}$ | Input High Current          | CLK, MR, FB_IN, F_SEL<br>$V_{DD} = V_{IN} = 3.465V$     |         |         | 150            | $\mu A$ |
|          |                             | PLL_SEL<br>$V_{DD} = V_{IN} = 3.465V$                   |         |         | 5              | $\mu A$ |
| $I_{IL}$ | Input Low Current           | CLK, MR, FB_IN, F_SEL<br>$V_{DD} = 3.465V, V_{IN} = 0V$ | -5      |         |                | $\mu A$ |
|          |                             | PLL_SEL<br>$V_{DD} = 3.465V, V_{IN} = 0V$               | -150    |         |                | $\mu A$ |
| $V_{OH}$ | Output High Voltage; NOTE 1 | $V_{DDO} = 3.465V$                                      | 2.6     |         |                | V       |
|          |                             | $V_{DDO} = 2.625V$                                      | 1.8     |         |                | V       |
| $V_{OL}$ | Output Low Voltage; NOTE 1  | $V_{DDO} = 3.465V$ or $2.625V$                          |         |         | 0.5            | V       |

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

**TABLE 5A. 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                       | F_SEL = 0                 | 31.25   |         | 62.5    | MHz   |
|                |                                        | F_SEL = 1                 | 15.625  |         | 31.25   | MHz   |
| $t_{p_{LH}}$   | Propagation Delay, Low-to-High; NOTE 1 | PLL_SEL = 0V, Bypass Mode | 4.1     |         | 6.1     | ns    |
| $t(\emptyset)$ | Static Phase Offset; NOTE 2, 4         | PLL_SEL = 3.3V            | -500    |         | 500     | ps    |
| $tsk(o)$       | Output Skew; NOTE 3, 4                 | PLL_SEL = 0V              |         |         | 65      | ps    |
| $t_{jit(cc)}$  | Cycle-to-Cycle Jitter; NOTE 4          |                           |         | 50      | 65      | ps    |
| $t_L$          | PLL Lock Time                          |                           |         |         | 1       | mS    |
| $t_R / t_F$    | Output Rise/Fall Time                  |                           | 0.4     |         | 1       | ns    |
| odc            | Output Duty Cycle                      |                           | 49      |         | 51      | %     |

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 voltages and with equal load conditions.

Measured at  $V_{DDO}/2$ .

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

**TABLE 5B. AC CHARACTERISTICS,  $V_{DD} = V_{DDA} = 3.3V \pm 5\%$ ,  $V_{DDO} = 2.5V \pm 5\%$ ,  $T_A = 0^\circ\text{C}$  TO  $70^\circ\text{C}$** 

| Symbol         | Parameter                              | Test Conditions              | Minimum | Typical | Maximum | Units |
|----------------|----------------------------------------|------------------------------|---------|---------|---------|-------|
| $f_{MAX}$      | Output Frequency                       | F_SEL = 0                    | 31.25   |         | 62.5    | MHz   |
|                |                                        | F_SEL = 1                    | 15.625  |         | 31.25   | MHz   |
| $t_{p_{LH}}$   | Propagation Delay, Low-to-High; NOTE 1 | PLL_SEL = 0V,<br>Bypass Mode | 4.25    |         | 6.25    | ns    |
| $t(\emptyset)$ | Static Phase Offset; NOTE 2, 4         | PLL_SEL = 2.5V               | -500    |         | 500     | ps    |
| $tsk(o)$       | Output Skew; NOTE 3, 4                 | PLL_SEL = 0V                 |         |         | 65      | ps    |
| $t_{jit(cc)}$  | Cycle-to-Cycle Jitter; NOTE 4          |                              |         |         | 65      | ps    |
| $t_L$          | PLL Lock Time                          |                              |         |         | 1       | mS    |
| $t_R / t_F$    | Output Rise/Fall Time                  |                              | 0.4     |         | 1       | ns    |
| odc            | Output Duty Cycle                      |                              | 48      |         | 52      | %     |

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 voltages and with equal load conditions.

Measured at  $V_{DDO}/2$ .

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

**TABLE 5C. AC CHARACTERISTICS,  $V_{DD} = V_{DDA} = V_{DDO} = 2.5V \pm 5\%$ ,  $T_A = 0^\circ\text{C}$  TO  $70^\circ\text{C}$** 

| Symbol         | Parameter                              | Test Conditions              | Minimum | Typical | Maximum | Units |
|----------------|----------------------------------------|------------------------------|---------|---------|---------|-------|
| $f_{MAX}$      | Output Frequency                       | F_SEL = 0                    | 31.25   |         | 62.5    | MHz   |
|                |                                        | F_SEL = 1                    | 15.625  |         | 31.25   | MHz   |
| $t_{p_{LH}}$   | Propagation Delay, Low-to-High; NOTE 1 | PLL_SEL = 0V,<br>Bypass Mode | 4.5     |         | 6.5     | ns    |
| $t(\emptyset)$ | Static Phase Offset; NOTE 2, 4         | PLL_SEL = 2.5V               | -500    |         | 500     | ps    |
| $tsk(o)$       | Output Skew; NOTE 3, 4                 | PLL_SEL = 0V                 |         |         | 65      | ps    |
| $t_{jit(cc)}$  | Cycle-to-Cycle Jitter; NOTE 4          |                              |         |         | 70      | ps    |
| $t_L$          | PLL Lock Time                          |                              |         |         | 1       | mS    |
| $t_R / t_F$    | Output Rise/Fall Time                  |                              | 0.4     |         | 1       | ns    |
| odc            | Output Duty Cycle                      |                              | 48      |         | 52      | %     |

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

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

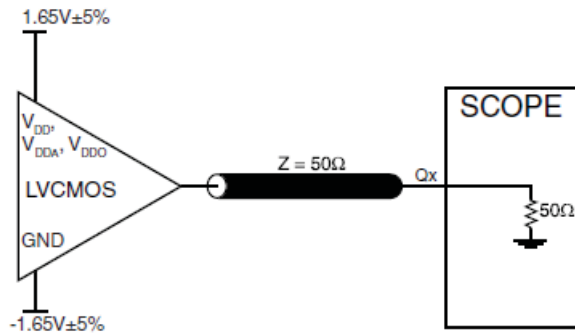
NOTE 2: Defined as the time difference between the input reference clock and the average feedback input signal when the PLL is locked and the input reference frequency is stable.

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

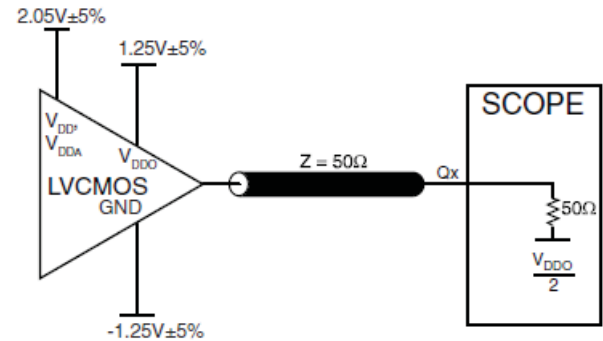
Measured at  $V_{DDO}/2$ .

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

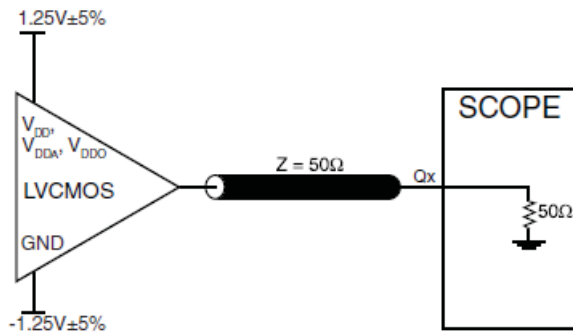
## PARAMETER MEASUREMENT INFORMATION



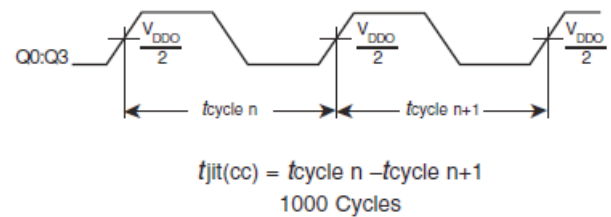
3.3V CORE/3.3V OUTPUT LOAD AC TEST CIRCUIT



3.3V CORE/2.5V OUTPUT LOAD AC TEST CIRCUIT



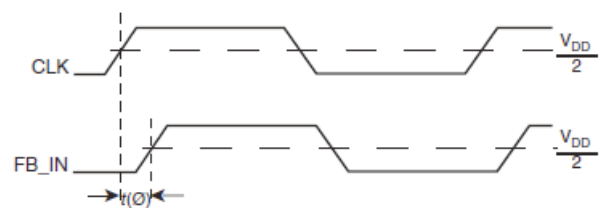
2.5V CORE/ 2.5V OUTPUT LOAD AC TEST CIRCUIT



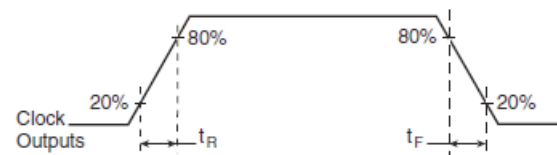
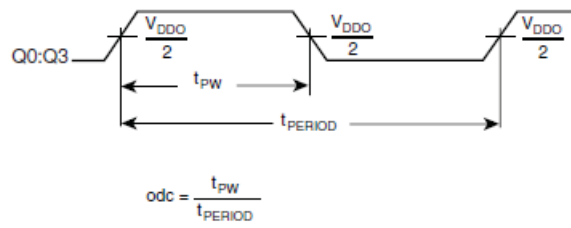
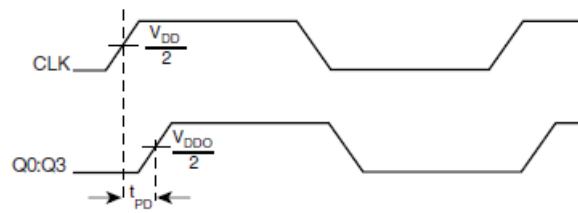
CYCLE-TO-CYCLE JITTER



OUTPUT SKEW



STATIC PHASE OFFSET


**OUTPUT DUTY CYCLE/PULSE WIDTH/PERIOD**
**OUTPUT RISE/FALL TIME**

**PROPAGATION DELAY**

## APPLICATION INFORMATION

### POWER SUPPLY FILTERING TECHNIQUES

As in any high speed analog circuitry, the power supply pins are vulnerable to random noise. The 86004 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 1* illustrates how a  $10\Omega$  resistor along with a  $10\mu F$  and a  $.01\mu F$  bypass capacitor should be connected to each  $V_{DDA}$ .

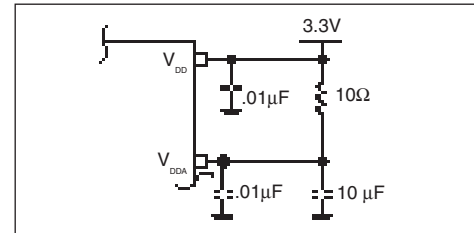


FIGURE 1. POWER SUPPLY FILTERING

### RECOMMENDATIONS FOR UNUSED INPUT AND OUTPUT PINS

#### INPUTS:

##### LVCNOS CONTROL PINS:

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

#### OUTPUTS:

##### LVCNOS OUTPUT:

All unused LVCNOS output can be left floating. We recommend that there is no trace attached.

### SCHEMATIC EXAMPLE

*Figure 2* shows a schematic example of using an 86004. It is recommended to have one decouple capacitor per power pin. Each decoupling capacitor should be located as close as possible to the

power pin. The low pass filter R7, C11 and C16 for clean analog supply should also be located as close to the  $V_{DDA}$  pin as possible.

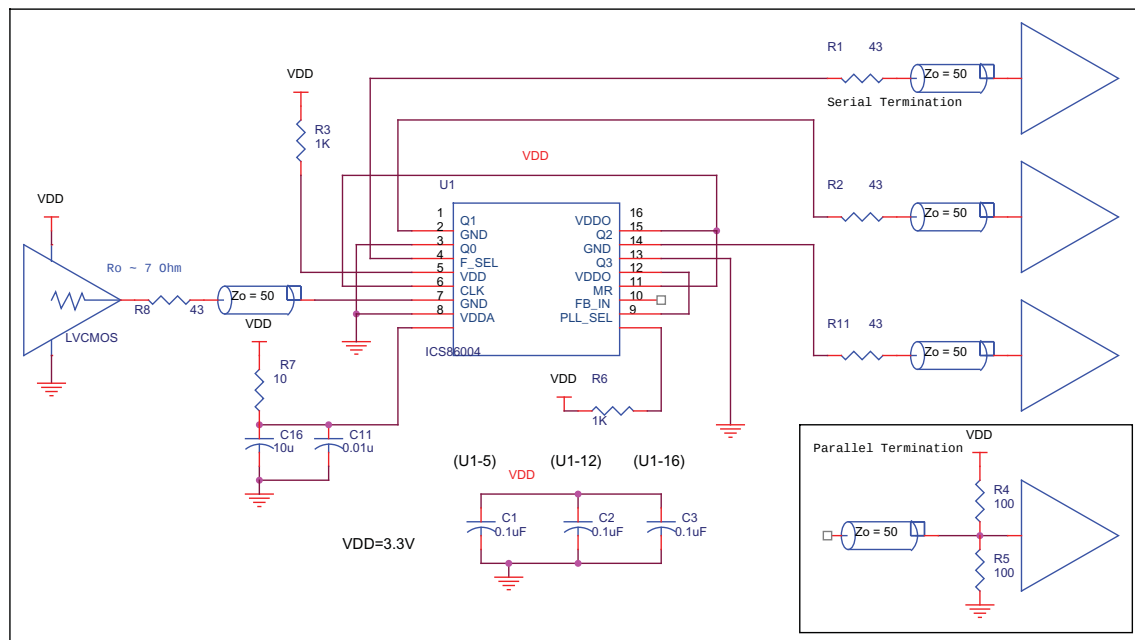


FIGURE 2. 86004 SCHEMATIC EXAMPLE

## RELIABILITY INFORMATION

**TABLE 5.  $\theta_{JA}$  VS. AIR FLOW TABLE FOR 16 LEAD TSSOP**

| $\theta_{JA}$ by Velocity (Linear Feet per Minute)                                                                  |           |           |           |
|---------------------------------------------------------------------------------------------------------------------|-----------|-----------|-----------|
|                                                                                                                     | 0         | 200       | 500       |
| Single-Layer PCB, JEDEC Standard Test Boards                                                                        | 137.1°C/W | 118.2°C/W | 106.8°C/W |
| Multi-Layer PCB, JEDEC Standard Test Boards                                                                         | 89.0°C/W  | 81.8°C/W  | 78.1°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 86004 is: 2496

PACKAGE OUTLINE - G SUFFIX 16 LEAD TSSOP

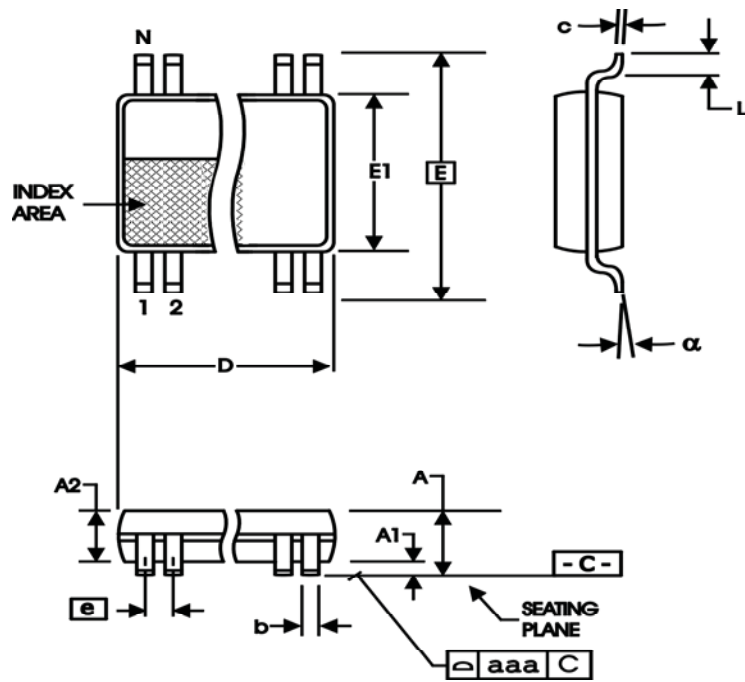


TABLE 6. PACKAGE DIMENSIONS

| SYMBOL   | Millimeters |         |
|----------|-------------|---------|
|          | 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

**TABLE 7. ORDERING INFORMATION**

| Part/Order Number | Marking  | Package                   | Shipping Packaging | Temperature |
|-------------------|----------|---------------------------|--------------------|-------------|
| 86004BGLF         | 86004BGL | 16 Lead "Lead-Free" TSSOP | Tube               | 0°C to 70°C |
| 86004BGLFT        | 86004BGL | 16 Lead "Lead-Free" TSSOP | 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.

# REVISION HISTORY SHEET

| Rev | Table | Page    | Description of Change                                                                                                                                                                                                | Date    |
|-----|-------|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|
| A   | T7    | 1<br>12 | Pin Assignment - corrected package body dimensions from 4.4mm x 3.0 mm x 0.92mm to 4.4mm x5.0 mm x 0.925mm.<br>Ordering Information Table - corrected marking from 86004BG from 86004BG.<br>Added lead-free marking. | 3/31/06 |
| B   | 4A    | 3       | 3.3V Power Supply Table - changed $V_{DDA}$ max from 3.465V to $V_{DD}$ , changed $I_{DDO}$ from 79mA max. to 8mA max.                                                                                               | 6/21/06 |
|     | 4B    | 3       | 3.3V/2.5V Power Supply Table - changed $V_{DDA}$ max from 3.465V to $V_{DD}$ , changed $I_{DDO}$ from 79mA max. to 8mA max.                                                                                          |         |
|     | 4C    | 3       | 2.5V Power Supply Table - changed $V_{DDA}$ max from 3.465V to $V_{DD}$ , changed $I_{DDO}$ from 79mA max. to 6mA max.                                                                                               |         |
| B   | T7    | 11      | Ordering Information - removed leaded devices.<br>Updated data sheet format.                                                                                                                                         | 7/10/15 |

**Corporate Headquarters**

6024 Silver Creek Valley Road  
San Jose, California 95138

**Sales**

800-345-7015 or +408-284-8200  
Fax: 408-284-2775  
www.IDT.com

**Technical Support**

**email:** [clocks@idt.com](mailto:clocks@idt.com)

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