

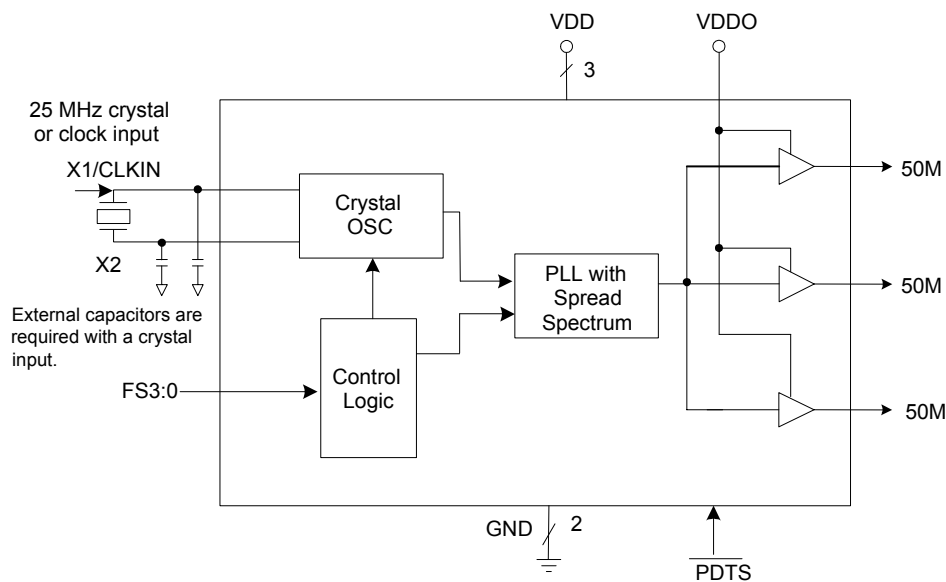
## Description

The ICS650-44 is a spread spectrum clock synthesizer intended for video projector and digital TV applications. It generates three copies of an EMI optimized 50 MHz clock signal (EMI peak reduction of 7 to 14 dB on 3rd through 19th harmonics) through the use of Spread Spectrum techniques from a 25 MHz crystal or clock input. The modulation rate is 50 kHz.

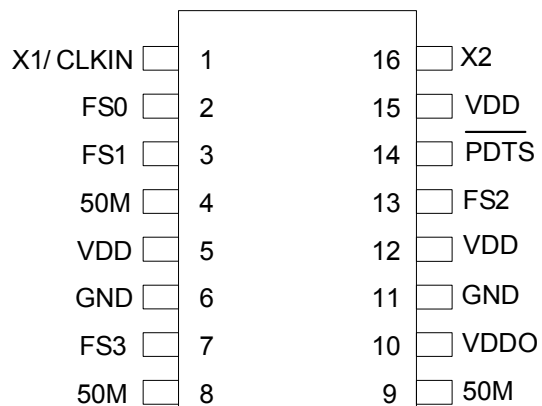
## Features

- Packaged in 16-pin TSSOP (173 mil)
- Supply voltages: VDD = 3.3 V, VDDO = 2.5 V
- Peak-to-peak jitter:  $\pm 125$  ps typ
- Output duty cycle 45/55% (worst case)
- 25 MHz crystal or reference clock input
- Zero (0) ppm frequency error on all output clocks
- Advanced, low-power CMOS process
- Industrial temperature range (-40 to +85°C)
- Pb (lead) free package

## Block Diagram



## Pin Assignment



16-pin (173 mil) TSSOP

## Spread Spectrum and Output Configuration Table

| FS3 | FS2 | FS1 | FS0 | Spread Type | SS Out |
|-----|-----|-----|-----|-------------|--------|
| 0   | 0   | 0   | 0   | Center      | ±0.25  |
| 0   | 0   | 0   | 1   | Center      | ±0.50  |
| 0   | 0   | 1   | 0   | Center      | ±0.75  |
| 0   | 0   | 1   | 1   | Center      | ±1.00  |
| 0   | 1   | 0   | 0   | Center      | ±1.25  |
| 0   | 1   | 0   | 1   | Center      | ±1.50  |
| 0   | 1   | 1   | 0   | Center      | ±1.75  |
| 0   | 1   | 1   | 1   | Center      | ±2.00  |
| 1   | 0   | 0   | 0   | Down        | -0.5   |
| 1   | 0   | 0   | 1   | Down        | -0.75  |
| 1   | 0   | 1   | 0   | Down        | -1.0   |
| 1   | 0   | 1   | 1   | Down        | -1.25  |
| 1   | 1   | 0   | 0   | Down        | -1.5   |
| 1   | 1   | 0   | 1   | Down        | -1.75  |
| 1   | 1   | 1   | 0   | Down        | -2.0   |
| 1   | 1   | 1   | 1   | Off         | Off    |

## Pin Descriptions

| Pin Number | Pin Name | Pin Type | Pin Description  |
|------------|----------|----------|--|
| 1          | X1/CLKIN | Input    | Crystal input. Connect this pin to a 25 MHz crystal or external input clock.                 |
| 2          | FS0      | Input    | Select pin 0. Internal pull-up resistor. See table on page 2.                                |
| 3          | FS1      | Input    | Select pin 1. Internal pull-up resistor. See table on page 2.                                |
| 4          | 50M      | Output   | Spread Spectrum output. Weak internal pull-down when tri-stated.                             |
| 5          | VDD      | Power    | Connect to +3.3 V.   |
| 6          | GND      | Power    | Connect to ground.   |
| 7          | FS3      | Input    | Select pin 3. Internal pull-up resistor. See table on page 2.                                |
| 8          | 50M      | Output   | Spread Spectrum output. Weak internal pull-down when tri-stated.                             |
| 9          | 50M      | Output   | Spread Spectrum output. Weak internal pull-down when tri-stated.                             |
| 10         | VDDO     | Power    | Connect to +2.5 V.   |
| 11         | GND      | Power    | Connect to ground.   |
| 12         | VDD      | Power    | Connect to +3.3 V.   |
| 13         | FS2      | Input    | Select pin 2. Internal pull-up resistor. See table on page 2.                                |
| 14         | PDTS     | Input    | Powers down entire chip. Tri-states CLK outputs when low. Internal pull-up.                  |
| 15         | VDD      | Power    | Connect to +3.3 V.   |
| 16         | X2       | Output   | Crystal Output. Connect this pin to a 25 MHz crystal. Do not connect if clock input is used. |

## External Components

### Decoupling Capacitor

As with any high-performance mixed-signal IC, the ICS650-44 must be isolated from system power supply noise to perform optimally.

A decoupling capacitor of 0.01 $\mu$ F must be connected between each VDD and the PCB ground plane.

### Series Termination Resistor

Clock output traces over one inch should use series termination. To series terminate a 50 $\Omega$  trace (a commonly used trace impedance), place a 33 $\Omega$  resistor in series with the clock line, as close to the clock output pin as possible. The nominal impedance of the clock output is 20 $\Omega$ .

### Crystal Load Capacitors

The device crystal connections should include pads for

small capacitors from X1 to ground and from X2 to ground. These capacitors are used to adjust the stray capacitance of the board to match the nominally required crystal load capacitance. Because load capacitance can only be increased in this trimming process, it is important to keep stray capacitance to a minimum by using very short PCB traces (and no vias) between the crystal and device. Crystal capacitors must be connected from each of the pins X1 and X2 to ground.

The value (in pF) of these crystal caps should equal  $(C_L - 6 \text{ pF})^2$ . In this equation,  $C_L$  = crystal load capacitance in pF. Example: For a crystal with a 16 pF load capacitance, each crystal capacitor would be 20 pF  $[(16-6) \times 2] = 20$ .

### PCB Layout Recommendations

For optimum device performance and lowest output phase noise, the following guidelines should be observed.

1) The 0.01 $\mu$ F decoupling capacitors should be mounted on the component side of the board as close to the VDD pin as possible. No vias should be used between the decoupling capacitors and VDD pins. The PCB trace to VDD pins should be kept as short as possible, as should the PCB trace to the ground via.

2) The external crystal should be mounted just next to the device with short traces. The X1 and X2 traces should not be routed next to each other with minimum spaces, instead they should be separated and away from other traces.

3) To minimize EMI, the 33 $\Omega$  series termination resistor should be placed close to the clock output.

4) An optimum layout is one with all components on the same side of the board, minimizing vias through other signal layers. Other signal traces should be routed away from the ICS650-44. This includes signal traces just underneath the device, or on layers adjacent to the ground plane layer used by the device.

## Absolute Maximum Ratings

Stresses above the ratings listed below can cause permanent damage to the ICS650-44. These ratings, which are standard values for IDT commercially rated parts, are stress ratings only. Functional operation of the device at these or any other conditions above those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods can affect product reliability. Electrical parameters are guaranteed only over the recommended operating temperature range.

| Item                                       | Rating              |
|--|---------------------|
| Supply Voltage, VDD                        | 5 V                 |
| All Inputs and Outputs                     | -0.5 V to VDD+0.5 V |
| Ambient Operating Temperature              | -40 to +85° C       |
| Storage Temperature                        | -65 to +150° C      |
| Junction Temperature                       | 125° C              |
| Soldering Temperature (max. of 10 seconds) | 260° C              |

## Recommended Operation Conditions

| Parameter                                       | Min.   | Typ. | Max.   | Units |
|---|--------|------|--------|-------|
| Ambient Operating Temperature                   | -40    | –    | +85    | °C    |
| Power Supply Voltage (VDD, with respect to GND) | +3.135 | +3.3 | +3.465 | V     |
| Power Supply Voltage (VDDO)                     | +2.375 | +2.5 | +2.625 | V     |
| Power Supply Ramp Time, Figure 4                |        |      | 4      | ms    |

## DC Electrical Characteristics

Unless stated otherwise,  $V_{DD} = 3.3\text{ V} \pm 5\%$ ,  $V_{DDO} = 2.5\text{ V} \pm 5\%$ , Ambient Temperature  $-40$  to  $+85^\circ\text{C}$

| Parameter                   | Symbol   | Conditions                                   | Min.                | Typ.     | Max.                | Units      |
|-----------------------------|----------|--|---------------------|----------|---------------------|------------|
| Operating Supply Current    | IDD      | no load                                      |                     | 27       |                     | mA         |
|                             |          | $\overline{PDTS} = 0$ , no load              |                     | 40       |                     | uA         |
|                             | IDDO     | no load                                      |                     | 4        |                     | mA         |
|                             |          | $\overline{PDTS} = 0$ , no load              |                     | 1        |                     | uA         |
| Input High Voltage          | $V_{IH}$ | FS3:0, $\overline{PDTS}$                     | 2                   |          |                     | V          |
| Input Low Voltage           | $V_{IL}$ | FS3:0, $\overline{PDTS}$                     |                     |          | 0.8                 | V          |
| Input High Voltage          | $V_{IH}$ | X1/CLKIN                                     | $0.7 \times V_{DD}$ |          |                     | V          |
| Input Low Voltage           | $V_{IL}$ | X1/CLKIN                                     |                     |          | $0.3 \times V_{DD}$ | V          |
| Output High Voltage         | $V_{OH}$ | $I_{OH} = -4\text{ mA}$                      | 1.8                 |          |                     | V          |
| Output Low Voltage          | $V_{OL}$ | $I_{OL} = 4\text{ mA}$                       |                     |          | 0.6                 | V          |
| Short Circuit Current       | $I_{OS}$ |  |                     | $\pm 50$ |                     | mA         |
| Nominal Output Impedance    | $Z_O$    |  |                     | 20       |                     | $\Omega$   |
| Internal Pull-up Resistor   | $R_{PU}$ | FS3:0, $\overline{PDTS}$                     |                     | 360      |                     | k $\Omega$ |
| Input Leakage Current       | $I_I$    | FS3:0, $\overline{PDTS}$ , $V_{IN} = V_{DD}$ |                     | 1        |                     | uA         |
| Internal Pull-down Resistor | $R_{PD}$ | CLK outputs                                  |                     | 900      |                     | k $\Omega$ |
| Input Capacitance           | $C_{IN}$ | Inputs                                       |                     | 4        |                     | pF         |

## AC Electrical Characteristics

Unless stated otherwise,  $V_{DD} = 3.3\text{ V} \pm 5\%$ ,  $V_{DDO} = 2.5\text{ V} \pm 5\%$ , Ambient Temperature  $-40$  to  $+85^\circ\text{ C}$

| Parameter                            | Symbol    | Conditions  | Min. | Typ.      | Max. | Units |
|--------------------------------------|-----------|---|------|-----------|------|-------|
| Input Frequency                      | $F_{IN}$  | Crystal or clock input  |      | 25        |      | MHz   |
| Spread Spectrum Modulation Frequency |           |   |      | 50        |      | kHz   |
| Duty Cycle                           | $t_2/t_1$ | At $V_{DD}/2$ , Note 1 and Figures 1 and 2  | 45   | 50        | 55   | %     |
| Output Fall Time                     | $t_3$     | 80% to 20%, Note 1 and Figures 1 & 3  |      | 1.5       |      | ns    |
| Output Rise Time                     | $t_4$     | 20% to 80%, Note 1 and Figures 1 & 3  |      | 1.5       |      | ns    |
| One Sigma Clock Period Jitter        |           | Note 1  |      | 30        |      | ps    |
| Absolute Jitter, Peak-to-Peak        | $t_{ja}$  | Deviation from mean, Note 1 & Figures 1 and 6   |      | $\pm 125$ |      | ps    |
| Output Enable Time                   | $t_{EN}$  | $\overline{PDT\overline{S}}$ high to PLL locked to within 1% of final value, Figure 5 |      | 2.5       | 5    | ms    |
| Output Disable Time                  | $t_{DIS}$ | $\overline{PDT\overline{S}}$ low to tri-state, Figure 5                               |      | 20        |      | ns    |
| Output-to-Output Skew                |           |   |      | $\pm 180$ |      | ps    |
| Power-up Time                        | $t_P$     | PLL lock-time from power-up to 1% of final value, Figure 4                            |      | 6         | 10   | ms    |

Note 1: Measured with 5 pF load.

## Timing Diagrams

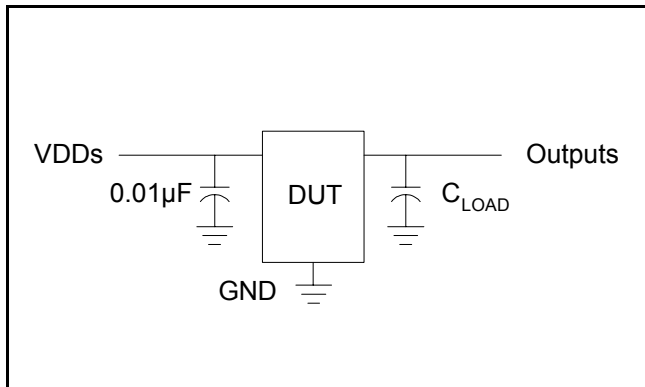


Figure 1: Test and Measurement Setup

Figure 5:  $\overline{\text{PDTs}}$  to Stable Clock Output Timing

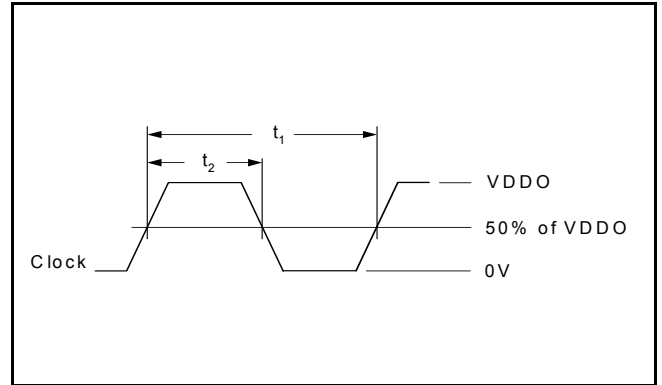


Figure 2: Duty Cycle Definitions

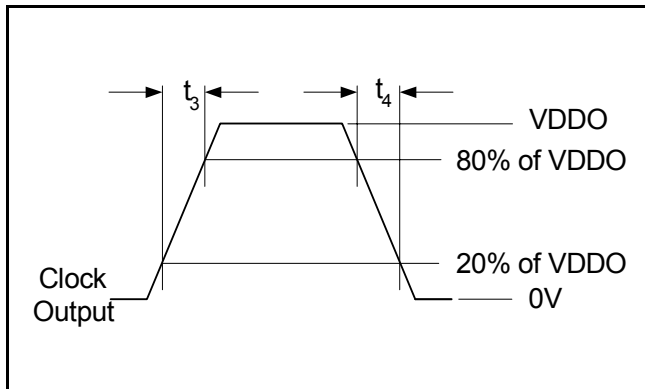


Figure 3: Rise and Fall Time Definitions

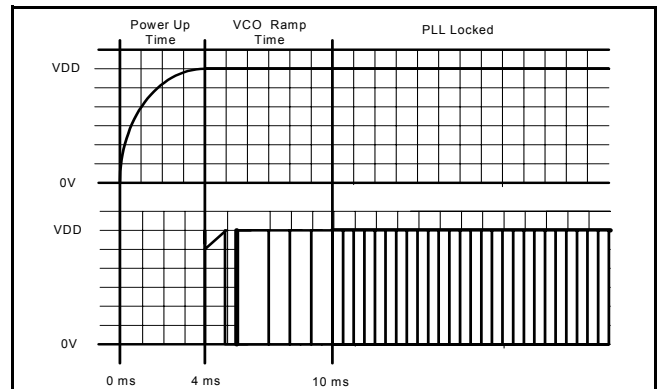


Figure 4: Power Up and PLL Lock Timing

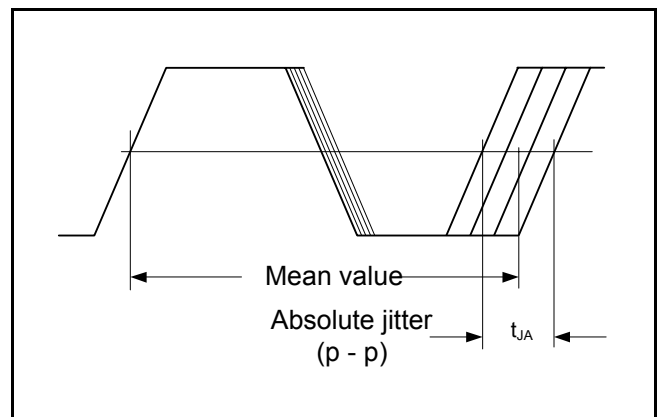
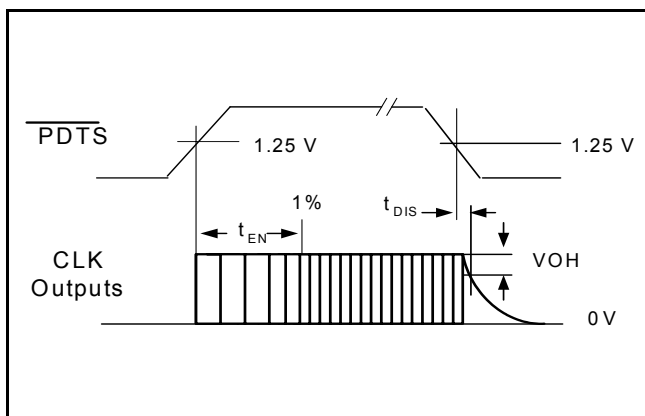
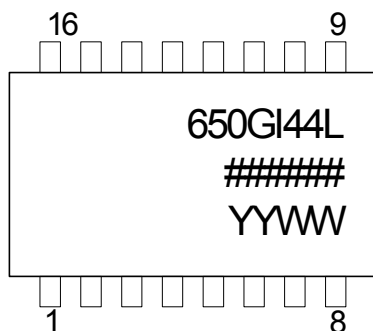


Figure 6: Short Term Jitter Definition

## Thermal Characteristics

| Parameter                              | Symbol        | Conditions     | Min. | Typ. | Max. | Units |
|--|---------------|----------------|------|------|------|-------|
| Thermal Resistance Junction to Ambient | $\theta_{JA}$ | Still air      |      | 78   |      | °C/W  |
|  | $\theta_{JA}$ | 1 m/s air flow |      | 70   |      | °C/W  |
|  | $\theta_{JA}$ | 3 m/s air flow |      | 68   |      | °C/W  |
| Thermal Resistance Junction to Case    | $\theta_{JC}$ |                |      | 37   |      | °C/W  |

## Marking Diagram (Pb free)



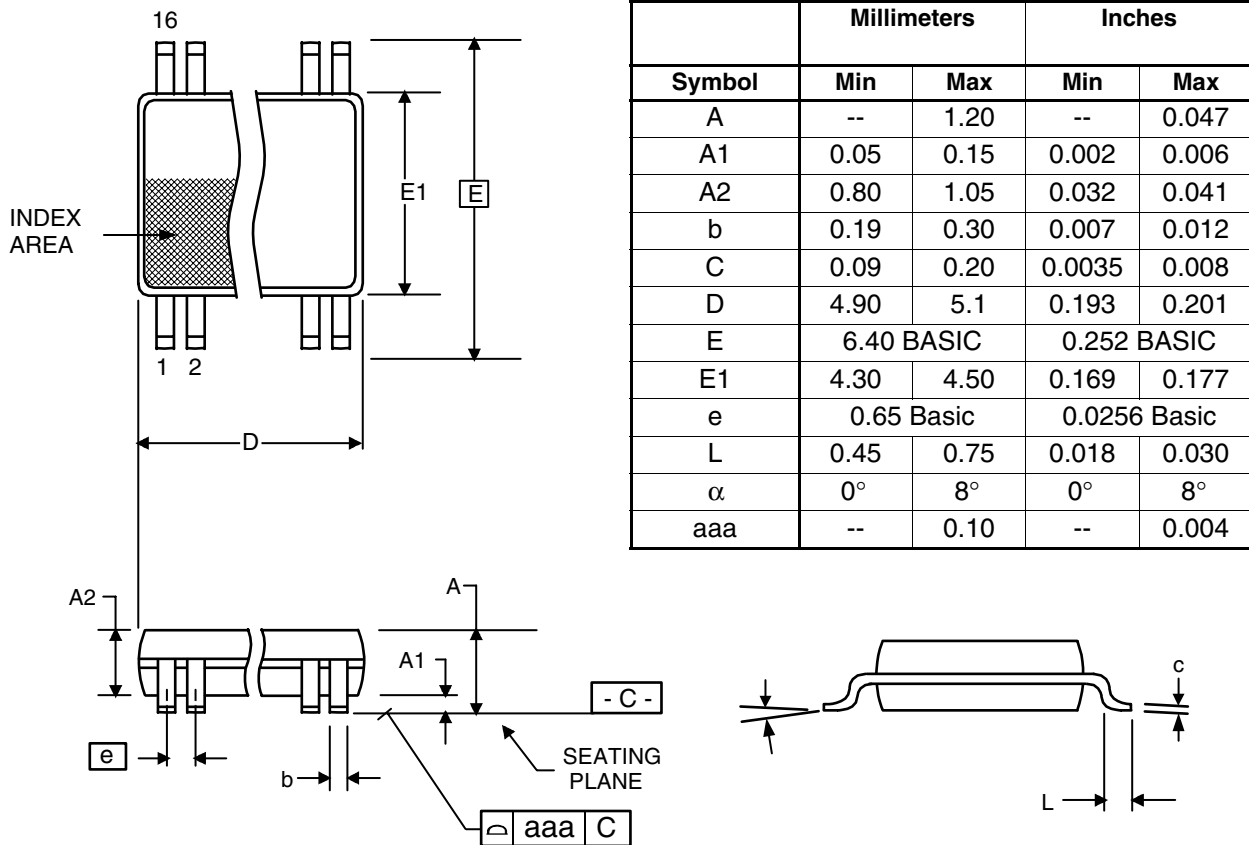
### Notes:

1. ##### is the lot number.
2. YYWW is the last two digits of the year and the week number that the part was assembled.
3. "I" designates industrial temperature range.
4. "L" designates Pb (lead) free package.
5. Bottom marking: (origin)  
Origin = country of origin of not USA.



## Package Outline and Package Dimensions (16-pin TSSOP, 173 Mil. Narrow Body)

Package dimensions are kept current with JEDEC Publication No. 95



## Ordering Information

| Part / Order Number | Marking    | Shipping Packaging | Package      | Temperature   |
|---------------------|------------|--------------------|--------------|---------------|
| 650GI-44LF          | see page 7 | Tubes              | 16-pin TSSOP | -40 to +85° C |
| 650GI-44LFT         |            | Tape and Reel      | 16-pin TSSOP | -40 to +85° C |

Parts that are ordered with a "LF" suffix to the part number are the Pb-Free configuration and are RoHS compliant.

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## Revision History

| Rev. | Originator  | Date     | Description of Change  |
|------|-------------|----------|--|
| -    | P. Griffith | 05/13/05 | New proposal.  |
| A    | P. Griffith | 05/24/05 | Move from Advance (proposal) to Preliminary. Added ICS part number and LF. |
| B    | P. Griffith | 06/14/05 | Added "Output-to-Output skew" psec of $\pm 180$ ps.                        |
| C    | P. Griffith | 08/03/05 | Removed references to SS_EN.   |
| D    |             | 10/27/09 | Added EOL note for non-green parts   |
| E    |             | 05/13/10 | Removed EOL note and non-green parts                                       |



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[84329BYLF](#)