

FEMTOCLOCK™ CRYSTAL-TO-LVDS CLOCK GENERATOR

ICS844251-14

General Description



The ICS844251-14 is an Ethernet Clock Generator and a member of the HiPerClocks™ family of high performance devices from IDT. The ICS844251-14 uses an 18pF parallel resonant crystal over the range of 23.2MHz – 30MHz. For Ethernet applications, a 25MHz crystal is used. The device has excellent <1ps phase jitter performance, over the 1.875MHz – 20MHz integration range. The ICS844251-14 is packaged in a small 8-pin TSSOP, making it ideal for use in systems with limited board space.

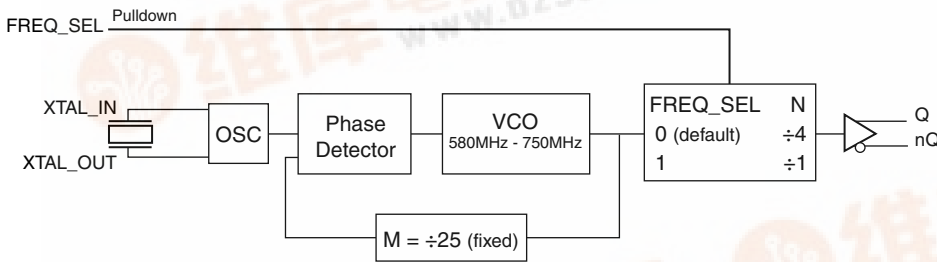
Features

- One differential LVDS output pair
- Crystal oscillator interface designed for 18pF, parallel resonant crystal (23.2MHz – 30MHz)
- Output frequency ranges: 145MHz – 187.5MHz and 580MHz – 750MHz
- VCO range: 580MHz – 750MHz
- RMS phase jitter at 156.25MHz, using a 25MHz crystal (1.875MHz – 20MHz): 0.53ps (typical)
- Full 3.3V or 2.5V output supply modes
- 0°C to 70°C ambient operating temperature
- Available in lead-free (RoHS 6) package

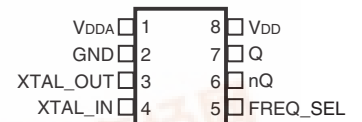
Common Configuration Table

| Inputs | | | | | Output Frequency Range (MHz) |
|-------------------------|----------|----|---|--------------------------|------------------------------|
| Crystal Frequency (MHz) | FREQ_SEL | M | N | Multiplication Value M/N | |
| 25 | 1 | 25 | 1 | 25 | 625 |
| 26.67 | 1 | 25 | 1 | 25 | 666.67 |
| 25 (default) | 0 | 25 | 4 | 6.25 | 156.25 |

Block Diagram



Pin Assignment



ICS844251-14
8 Lead TSSOP
4.40mm x 3.0mm x 0.925mm
package body
G Package
Top View

Table 1. Pin Descriptions

| Number | Name | Type | | Description |
|---------|---------------------|--------|----------|---|
| 1 | V _{DDA} | Output | | Analog supply pin. |
| 2 | GND | Power | | Power supply ground. |
| 3, 4 | XTAL_OUT XTAL_IN | Input | | Crystal oscillator interface. XTAL_IN is the input, XTAL_OUT is the output. |
| 5 | FREQ_SEL | Input | Pulldown | Frequency select pin. LVCMOS/LVTTL interface levels. |
| 6, 7 | nQ, Q | Output | | Differential output pair. LVDS interface levels. |
| 8 | V _{DD} | Power | | Core supply pin. |

NOTE: *Pullup* refers 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 _{PULLdown} | Input Pulldown Resistor | | | 51 | | kΩ |

Absolute Maximum Ratings

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

| Item | Rating |
|---|--------------------------|
| Supply Voltage, V_{DD} | 4.6V |
| Inputs, V_I | -0.5V to $V_{DD} + 0.5V$ |
| Outputs, I_O Continuous Current Surge Current | 10mA 15mA |
| Package Thermal Impedance, θ_{JA} | 129.5°C/W (0 mps) |
| Storage Temperature, T_{STG} | -65°C to 150°C |

DC Electrical Characteristics

Table 3A. 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} | Core Supply Voltage | | 3.135 | 3.3 | 3.465 | V |
| V_{DDA} | Analog Supply Voltage | | $V_{DD} - 0.10$ | 3.3 | V_{DD} | V |
| I_{DD} | Power Supply Current | | | | 100 | mA |
| I_{DDA} | Analog Supply Current | | | | 10 | mA |

Table 3B. Power Supply DC Characteristics, $V_{DD} = 2.5V \pm 5\%$, $T_A = 0^\circ C$ to $70^\circ C$

| 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 | | $V_{DD} - 0.10$ | 2.5 | V_{DD} | V |
| I_{DD} | Power Supply Current | | | | 95 | mA |
| I_{DDA} | Analog Supply Current | | | | 10 | mA |

Table 3C. LVCMOS/LVTTL DC Characteristics, $V_{DD} = 3.3V \pm 5\%$ 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 | $V_{DD} = 3.465V$ | 2 | | $V_{DD} + 0.3$ | V |
| | | $V_{DD} = 2.625V$ | 1.7 | | $V_{DD} + 0.3$ | V |
| V_{IL} | Input Low Voltage | $V_{DD} = 3.465V$ | -0.3 | | 0.8 | V |
| | | $V_{DD} = 2.625V$ | -0.3 | | 0.7 | V |
| I_{IH} | Input High Current | $V_{DD} = V_{IN} = 3.465V$ or $2.625V$ | | | 150 | μA |
| I_{IL} | Input Low Current | $V_{DD} = 3.465V$ or $2.625V$, $V_{IN} = 0V$ | -5 | | | μA |

Table 3D. LVDS DC Characteristics, $V_{DD} = 3.3V \pm 5\%$, $T_A = 0^\circ\text{C}$ to 70°C

| Symbol | Parameter | Test Conditions | Minimum | Typical | Maximum | Units |
|-----------------|-----------------------------|-----------------|---------|---------|---------|-------|
| V_{OD} | Differential Output Voltage | | 247 | | 454 | mV |
| ΔV_{OD} | V_{OD} Magnitude Change | | | | 50 | mV |
| V_{OS} | Offset Voltage | | 1.275 | | 1.525 | V |
| ΔV_{OS} | V_{OS} Magnitude Change | | | | 50 | mV |

Table 3E. LVDS DC Characteristics, $V_{DD} = V_{DDA} = 2.5V \pm 5\%$, $T_A = 0^\circ\text{C}$ to 70°C

| Symbol | Parameter | Test Conditions | Minimum | Typical | Maximum | Units |
|-----------------|-----------------------------|-----------------|---------|---------|---------|-------|
| V_{OD} | Differential Output Voltage | | 247 | | 454 | mV |
| ΔV_{OD} | V_{OD} Magnitude Change | | | | 50 | mV |
| V_{OS} | Offset Voltage | | 1.0 | | 1.4 | V |
| ΔV_{OS} | V_{OS} Magnitude Change | | | | 50 | mV |

Table 4. Crystal Characteristics

| Parameter | Test Conditions | Minimum | Typical | Maximum | Units |
|------------------------------------|-----------------|-------------|---------|---------|----------|
| Mode of Oscillation | | Fundamental | | | |
| Frequency | | 23.2 | | 30 | MHz |
| Equivalent Series Resistance (ESR) | | | | 50 | Ω |
| Shunt Capacitance | | | | 7 | pF |

AC Electrical Characteristics

Table 5A. AC Characteristics, $V_{DD} = 3.3V \pm 5\%$, $T_A = 0^\circ C$ to $70^\circ C$

| Parameter | Symbol | Test Conditions | Minimum | Typical | Maximum | Units |
|----------------------|-------------------------------------|---|---------|---------|---------|-------|
| f_{OUT} | Output Frequency | FREQ_SEL = 0 | 145 | | 187.5 | MHz |
| | | FREQ_SEL = 1 | 580 | | 750 | MHz |
| $f_{jit}(\emptyset)$ | RMS Phase Jitter, Random; NOTE 1 | 156.25MHz, Integration Range: 1.875MHz – 20MHz | | 0.53 | | ps |
| | | 625MHz, Integration Range: 1.875MHz – 20MHz | | 0.45 | | ps |
| t_R / t_F | Output Rise/Fall Time | 20% to 80% | 70 | | 550 | ps |
| odc | Output Duty Cycle | FREQ_SEL = 0 | 48 | | 52 | % |
| | | FREQ_SEL = 1 | 46 | | 54 | % |

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 lfpm. The device will meet specifications after thermal equilibrium has been reached under these conditions.

NOTE 1: Please refer to Phase Noise Plots.

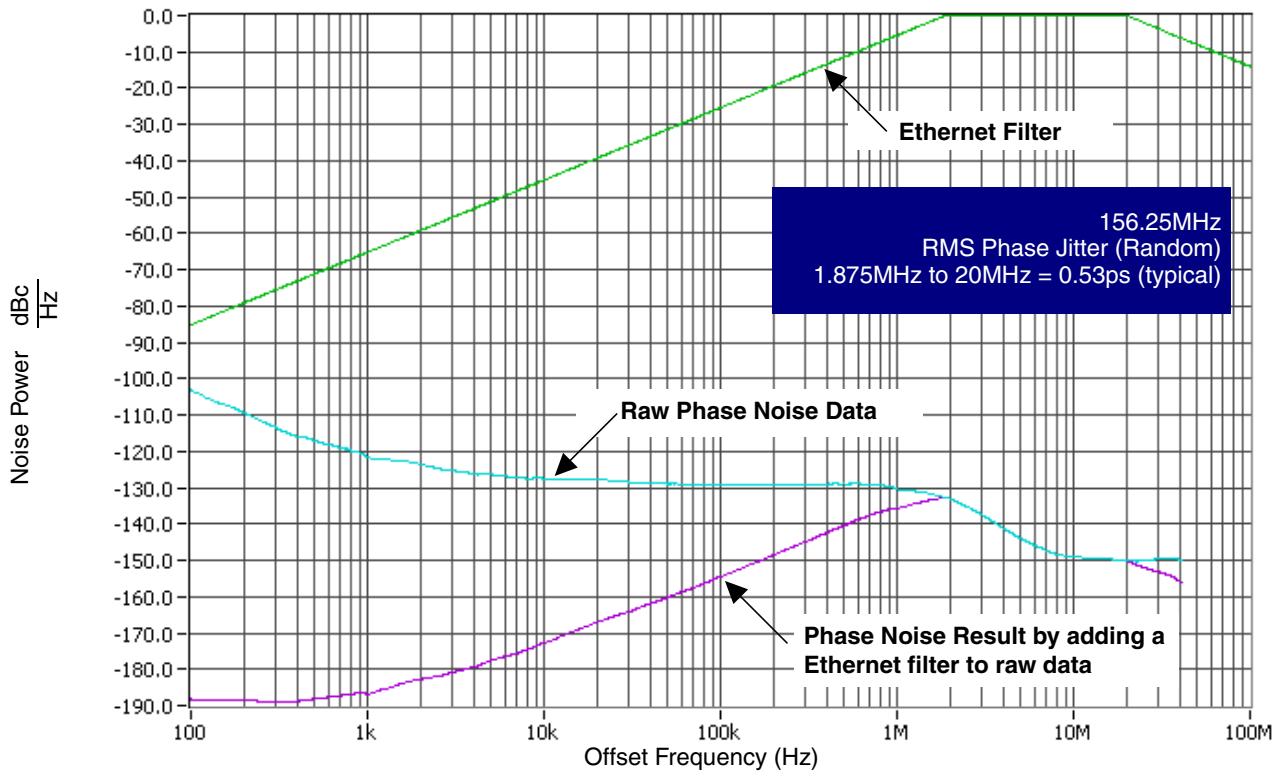
Table 5B. AC Characteristics, $V_{DD} = 2.5V \pm 5\%$, $T_A = 0^\circ C$ to $70^\circ C$

| Parameter | Symbol | Test Conditions | Minimum | Typical | Maximum | Units |
|----------------------|-------------------------------------|---|---------|---------|---------|-------|
| f_{OUT} | Output Frequency | FREQ_SEL = 0 | 145 | | 187.5 | MHz |
| | | FREQ_SEL = 1 | 580 | | 750 | MHz |
| $f_{jit}(\emptyset)$ | RMS Phase Jitter, Random; NOTE 1 | 156.25MHz, Integration Range: 1.875MHz – 20MHz | | 0.54 | | ps |
| | | 625MHz, Integration Range: 1.875MHz – 20MHz | | 0.45 | | ps |
| t_R / t_F | Output Rise/Fall Time | 20% to 80% | 70 | | 550 | ps |
| odc | Output Duty Cycle | FREQ_SEL = 0 | 48 | | 52 | % |
| | | FREQ_SEL = 1 | 46 | | 54 | % |

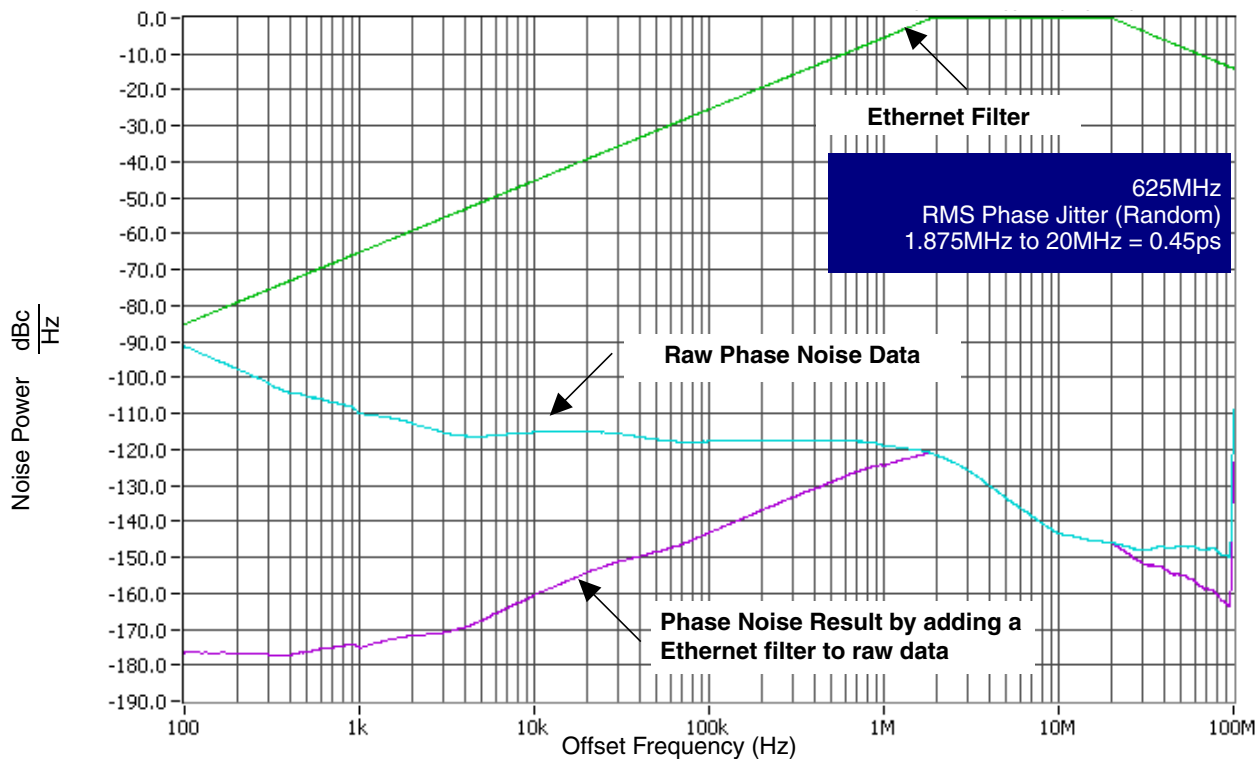
NOTE: Electrical parameters are guaranteed over the specified ambient operating temperature range, which is established when the device is mounted in a test socket with maintained transverse airflow greater than 500 lfpm. The device will meet specifications after thermal equilibrium has been reached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

NOTE 1: Please refer to Phase Noise Plots.

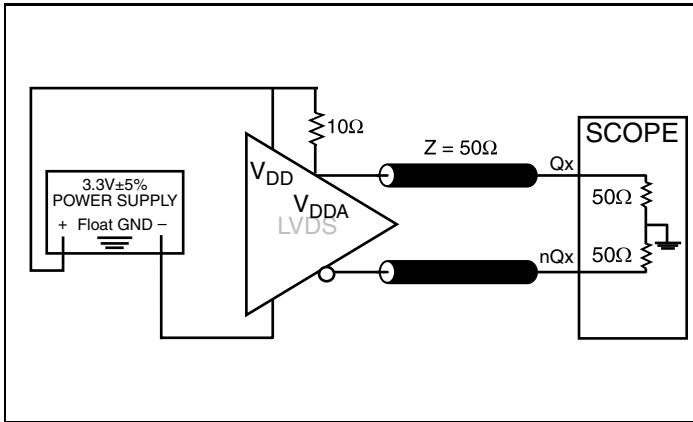
Typical Phase Noise at 156.25MHz (3.3V)



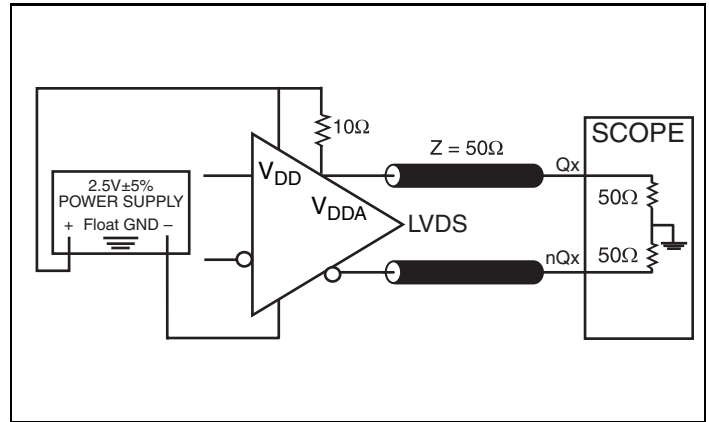
Typical Phase Noise at 625MHz (3.3V)



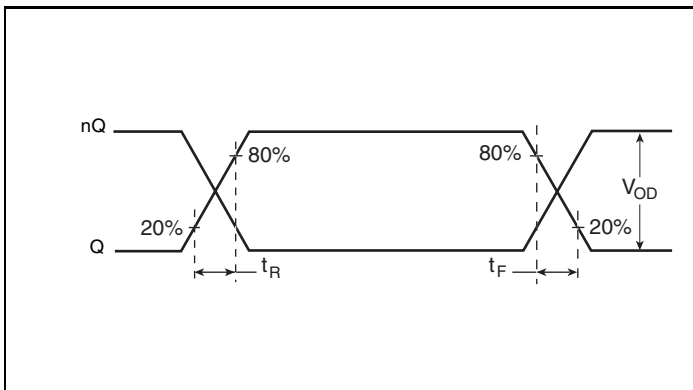
Parameter Measurement Information



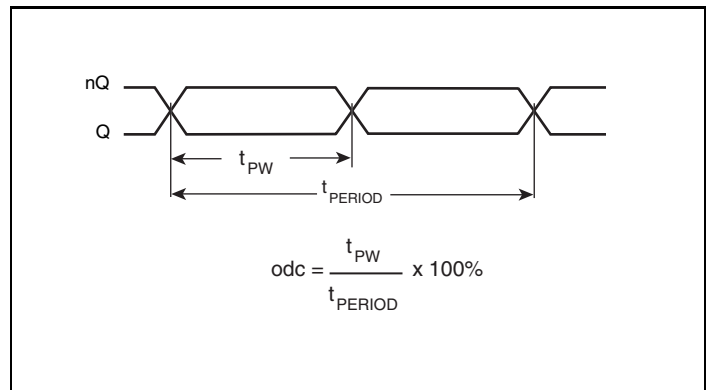
3.3V LVDS Output Load AC Test Circuit



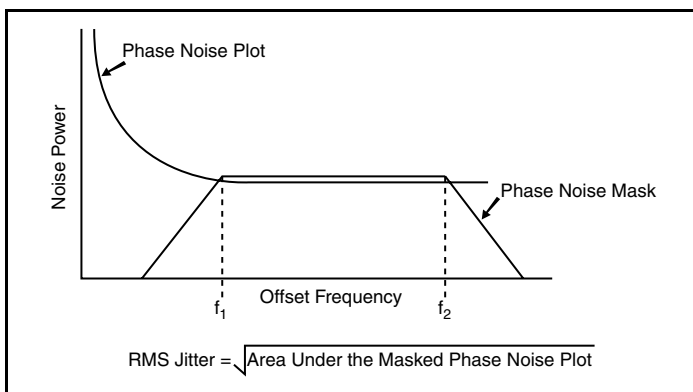
2.5V LVDS Output Load AC Test Circuit



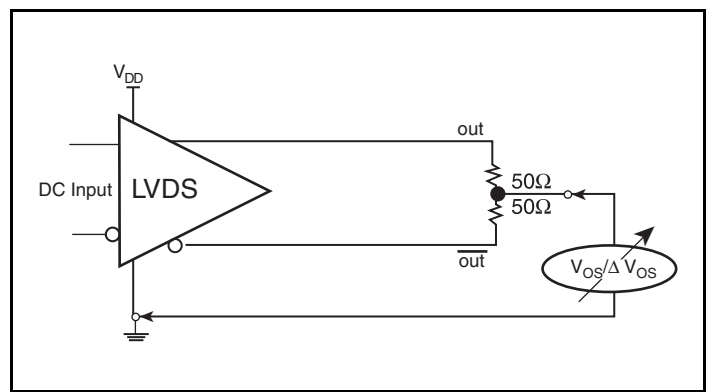
Output Rise/Fall Time



Output Duty Cycle/Pulse Width/Period

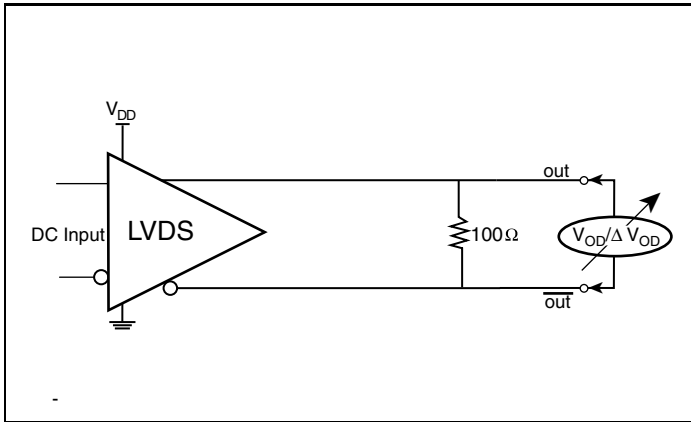


RMS Phase Jitter



OFFSET VOLTAGE SETUP

Parameter Measurement Information, continued



DIFFERENTIAL OUTPUT VOLTAGE SETUP

Application Information

Power Supply Filtering Technique

As in any high speed analog circuitry, the power supply pins are vulnerable to random noise. To achieve optimum jitter performance, power supply isolation is required. The ICS844251-14 provides separate power supplies to isolate any high switching noise from the outputs to the internal PLL. V_{DD} and V_{DDA} should be individually connected to the power supply plane through vias, and $0.01\mu\text{F}$ bypass capacitors should be used for each pin. *Figure 1* illustrates this for a generic V_{DD} pin and also shows that V_{DDA} requires that an additional 10Ω resistor along with a $10\mu\text{F}$ bypass capacitor be connected to the V_{DDA} pin.

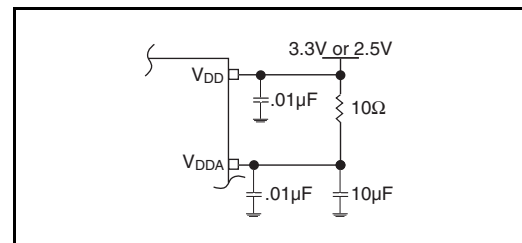


Figure 1. Power Supply Filtering

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Crystal Input Interface

The ICS844251-14 has been characterized with 18pF parallel resonant crystals. The capacitor values, C1 and C2, shown in *Figure 2* below were determined using a 25MHz, 18pF parallel

resonant crystal and were chosen to minimize the ppm error. The optimum C1 and C2 values can be slightly adjusted for different board layouts.

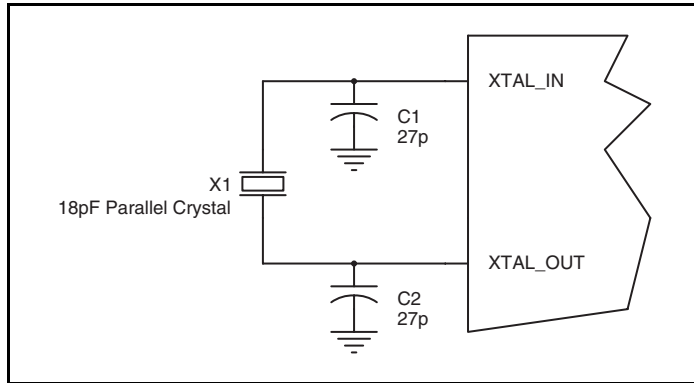


Figure 2. Crystal Input Interface

LVC MOS to XTAL Interface

The XTAL_IN input can accept a single-ended LVC MOS signal through an AC coupling capacitor. A general interface diagram is shown in *Figure 3*. The XTAL_OUT pin can be left floating. The input edge rate can be as slow as 10ns. For LVC MOS inputs, it is recommended that the amplitude be reduced from full swing to half swing in order to prevent signal interference with the power rail and to reduce noise. This configuration requires that the output

impedance of the driver (R_o) plus the series resistance (R_s) equals the transmission line impedance. In addition, matched termination at the crystal input will attenuate the signal in half. This can be done in one of two ways. First, R_1 and R_2 in parallel should equal the transmission line impedance. For most 50Ω applications, R_1 and R_2 can be 100Ω. This can also be accomplished by removing R_1 and making R_2 50Ω.

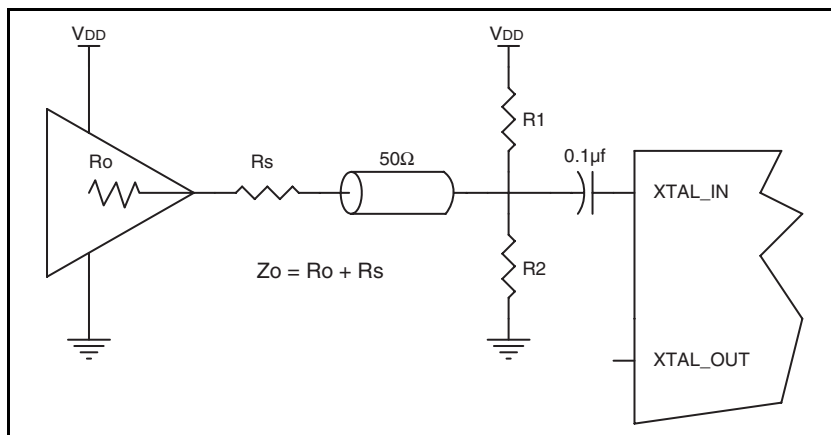


Figure 3. General Diagram for LVC MOS Driver to XTAL Input Interface

3.3V, 2.5V LVDS Driver Termination

A general LVDS interface is shown in *Figure 4*. In a 100Ω differential transmission line environment, LVDS drivers require a

matched load termination of 100Ω across near the receiver input.

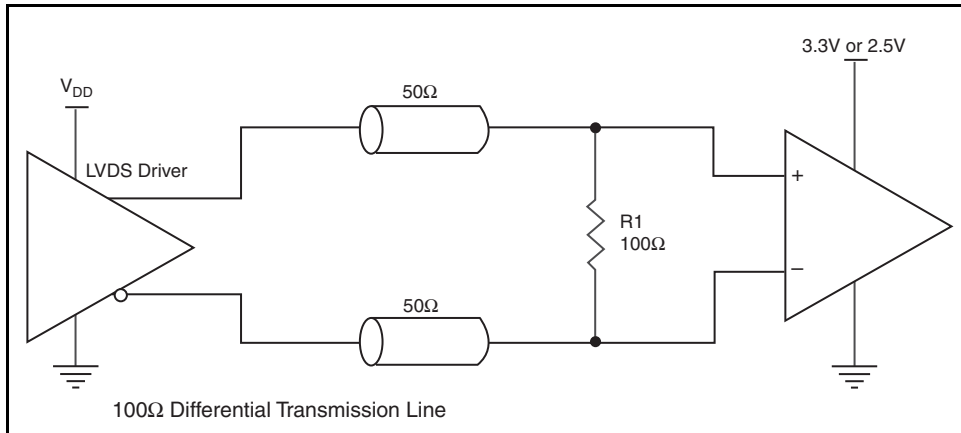


Figure 4. Typical LVDS Driver Termination

Schematic Example

Figure 5 shows an example of ICS844251-14 application schematic. In this example, the device is operated at $V_{DD} = 3.3V$. The decoupling capacitor should be located as close as possible to the power pin. The 18pF parallel resonant 25MHz crystal is used. The $C1 = 27pF$ and $C2 = 27pF$ are recommended for

frequency accuracy. For different board layouts, the $C1$ and $C2$ may be slightly adjusted for optimizing frequency accuracy. For the LVDS output drivers, place a 100Ω resistor as close to the receiver as possible.

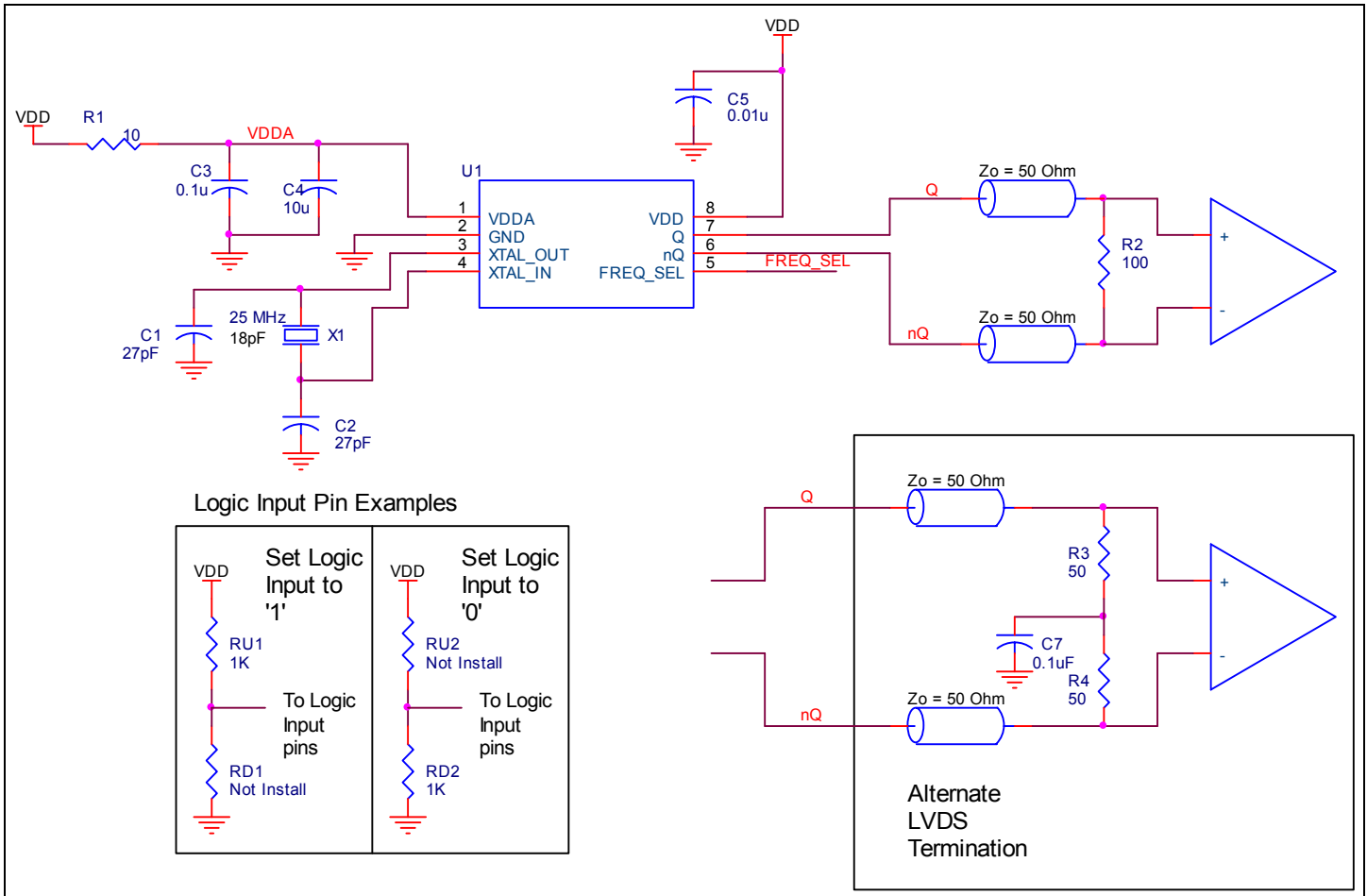


Figure 5. ICS844251-14 Schematic Example

Power Considerations

This section provides information on power dissipation and junction temperature for the ICS844251-14. Equations and example calculations are also provided.

1. Power Dissipation.

The total power dissipation for the ICS844251-14 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.

NOTE: Please refer to Section 3 for details on calculating power dissipated in the load.

- Power (core)_{MAX} = $V_{DD_MAX} * (I_{DD_MAX} + I_{DDA_MAX}) = 3.465V * (100mA + 10mA) = 381.15mW$

2. Junction Temperature.

Junction temperature, T_j , is the temperature at the junction of the bond wire and bond pad and directly affects the reliability of the device. The maximum recommended junction temperature for HiPerClockS devices is 125°C.

The equation for T_j is as follows: $T_j = \theta_{JA} * Pd_total + T_A$

T_j = Junction Temperature

θ_{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 θ_{JA} must be used. Assuming no air flow and a multi-layer board, the appropriate value is 129.5°C/W per Table 6 below.

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

$$70^\circ\text{C} + 0.381\text{W} * 129.5^\circ\text{C/W} = 119.3^\circ\text{C}. \text{ This is below the limit of } 125^\circ\text{C}.$$

This calculation is only an example. T_j will obviously vary depending on the number of loaded outputs, supply voltage, air flow and the type of board (single layer or multi-layer).

Table 6. Thermal Resistance θ_{JA} for 8 Lead TSSOP, Forced Convection

| Meters per Second | θ_{JA} by Velocity | | |
|---|---------------------------|-----------|-----------|
| | 0 | 1 | 2.5 |
| Multi-Layer PCB, JEDEC Standard Test Boards | 129.5°C/W | 125.5°C/W | 123.5°C/W |

Reliability Information

Table 7. θ_{JA} vs. Air Flow Table for a 8 Lead TSSOP

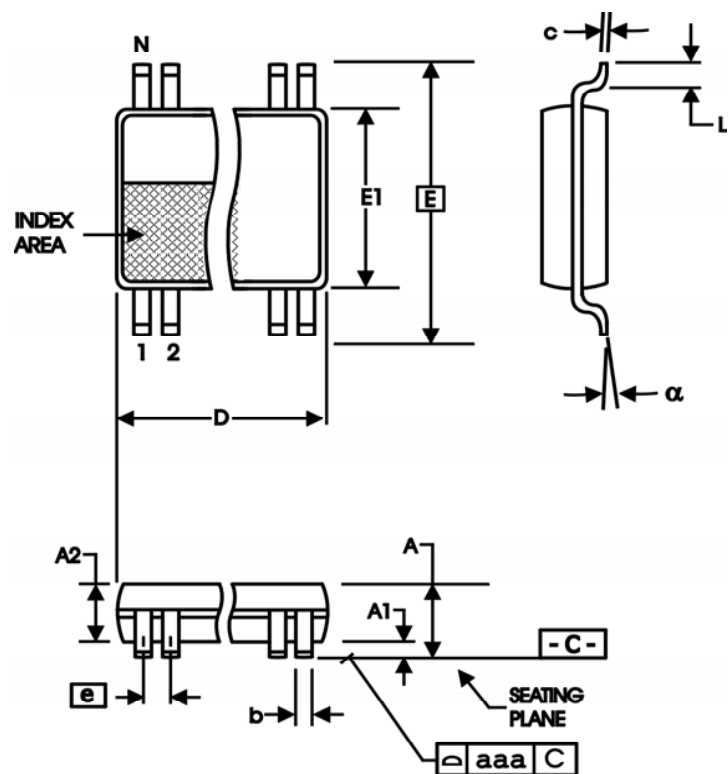
| θ_{JA} vs. Air Flow | | | |
|---|-----------|-----------|-----------|
| Meters per Second | 0 | 1 | 2.5 |
| Multi-Layer PCB, JEDEC Standard Test Boards | 129.5°C/W | 125.5°C/W | 123.5°C/W |

Transistor Count

The transistor count for ICS844251-14 is: 2401

Package Outline and Package Dimensions

Table 8. Package Dimensions



Package Outline - G Suffix for 8 Lead TSSOP

| All Dimensions in Millimeters | | |
|-------------------------------|------------|---------|
| Symbol | Minimum | Maximum |
| N | 8 | |
| A | | 1.20 |
| A1 | 0.5 | 0.15 |
| A2 | 0.80 | 1.05 |
| b | 0.19 | 0.30 |
| c | 0.09 | 0.20 |
| D | 2.90 | 3.10 |
| E | 6.40 Basic | |
| E1 | 4.30 | 4.50 |
| e | 0.65 Basic | |
| L | 0.45 | 0.75 |
| α | 0° | 8° |
| aaa | | 0.10 |

Reference Document: JEDEC Publication 95, MO-153

Ordering Information

Table 9. Ordering Information

| Part/Order Number | Marking | Package | Shipping Packaging | Temperature |
|-------------------|---------|--------------------------|--------------------|-------------|
| 844251BG-14 | 51B14 | 8 Lead TSSOP | Tube | 0°C to 70°C |
| 844251BG-14T | 51B14 | 8 Lead TSSOP | 2500 Tape & Reel | 0°C to 70°C |
| 844251BG-14LF | 1B14L | "Lead-Free" 8 Lead TSSOP | Tube | 0°C to 70°C |
| 844251BG-14LFT | 1B14L | "Lead-Free" 8 Lead TSSOP | 2500 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.

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Revision History Sheet

| Rev | Table | Page | Description of Change | Date |
|-----|-------|------|-------------------------|--------|
| A | | 11 | Added schematic layout. | 5/1/09 |
| | | | | |

ICS844251-14

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