

Features

- Internal DCXO for continuous glitch-free operation
- Zero input-output propagation delay
- 100 ps typical output cycle-to-cycle jitter
- 110 ps typical output-output skew
- 1 MHz to 200 MHz reference input
- Supports industry standard input crystals
- 200 MHz (commercial), 166 MHz (industrial) outputs
- 5 V-tolerant inputs
- Phase-locked loop (PLL) bypass mode
- Dual reference inputs
- 28-pin SSOP
- Split 2.5 V or 3.3 V output power supplies
- 3.3 V core power supply
- Industrial temperature available

Functional Description

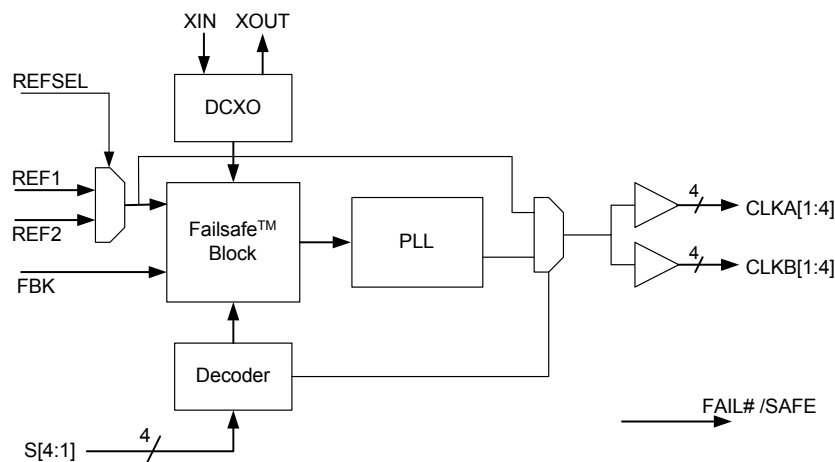
The CY23FS08 is a FailSafe™ Zero Delay Buffer with two reference clock inputs and eight phase-aligned outputs. The device provides an optimum solution for applications where continuous operation is required in the event of a primary clock failure.

Continuous, glitch-free operation is achieved by using a DCXO, which serves as a redundant clock source in the event of a reference clock failure by maintaining the last frequency and phase information of the reference clock.

The unique feature of the CY23FS08 is that the DCXO is in fact the primary clocking source, which is synchronized (phase-aligned) to the external reference clock. When this external clock is restored, the DCXO automatically resynchronizes to the external clock.

The frequency of the crystal connected to the DCXO, must be chosen to be an integer factor of the frequency of the reference clock. This factor is set by four select lines: S[4:1]. see [Table 2](#). The CY23FS08 has three split power supplies; one for core, another for Bank A outputs, and the third for Bank B outputs. Each output power supply, except VDDC can be connected to either 2.5 V or 3.3 V. VDDC is the power supply pin for internal circuits and must be connected to 3.3 V.

Logic Block Diagram



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Pinouts

Figure 1. Pin Configuration

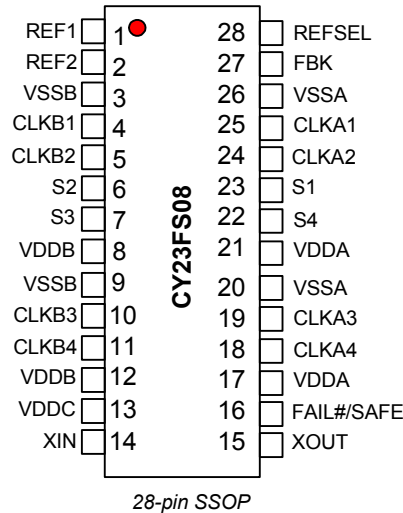


Table 1. Pin Definitions

| Pin Number | Pin Name | Description |
|-------------|------------|--|
| 1,2 | REF1,REF2 | Reference clock inputs. ^[4] 5 V tolerant. |
| 4,5,10,11 | CLKB[1:4] | Bank B clock outputs. ^[1, 2] |
| 25,24,19,18 | CLKA[1:4] | Bank A clock outputs. ^[1, 2] |
| 27 | FBK | Feedback input to the PLL. ^[1] |
| 23,6,7,22 | S[1:4] | Frequency select pins/PLL and DCXO bypass. ^[3] |
| 14 | XIN | Reference crystal input. |
| 15 | XOUT | Reference crystal output. |
| 16 | FAIL#/SAFE | Valid reference indicator. A high level indicates a valid reference input. |
| 13 | VDDC | 3.3 V power supply for the internal circuitry. |
| 8,12 | VDDDB | 2.5 V or 3.3 V power supply for Bank B outputs. |
| 3,9 | VSSB | Ground. |
| 17,21 | VDDA | 2.5 V or 3.3 V power supply for Bank A outputs. |
| 20,26 | VSSA | Ground. |
| 28 | REFSEL | Reference select. Selects the active reference clock from either REF1 or REF2. When REFSEL = 1, REF1 is selected. When REFSEL = 0, REF2 is selected. |

Table 2. Configuration Table

| S[4:1] | XTAL (MHz) | | REF(MHz) | | OUT(MHz) | | REF:OUT Ratio | REF:XTAL Ratio | Out:XTAL Ratio |
|--------|------------|-----|--------------------------|--------|----------|-------|---------------|----------------|----------------|
| | Min | Max | Min | Max | Min | Max | | | |
| 0000 | | | PLL and DCXO Bypass mode | | | | | | |
| 1000 | 8.33 | 30 | 16.67 | 60.00 | 8.33 | 30.00 | ÷2 | 2 | 1 |
| 1110 | 9.50 | 30 | 57.00 | 180.00 | 28.50 | 90.00 | ÷2 | 6 | 3 |

Notes

1. For normal operation, connect either one of the eight clock outputs to the FBK input.
2. Weak pull downs on all CLK outputs.
3. Weak pull ups on these inputs.
4. Weak pull downs on these inputs.

Table 2. Configuration Table (continued)

| S[4:1] | XTAL (MHz) | | REF(MHz) | | OUT(MHz) | | REF:OUT Ratio | REF:XTAL Ratio | Out:XTAL Ratio |
|--------|------------|-----|----------|--------|----------|--------|---------------|----------------|----------------|
| | Min | Max | Min | Max | Min | Max | | | |
| 0101 | 8.50 | 30 | 6.80 | 24.00 | 1.70 | 6.00 | ÷4 | 4/5 | 1/5 |
| 1011 | 8.33 | 30 | 25.00 | 90.00 | 6.25 | 22.50 | ÷4 | 3 | 3/4 |
| 0011 | 8.33 | 30 | 2.78 | 10.00 | 2.78 | 10.00 | ×1 | 1/3 | 1/3 |
| 1001 | 8.33 | 30 | 8.33 | 30.00 | 8.33 | 30.00 | ×1 | 1 | 1 |
| 1111 | 8.00 | 25 | 32.00 | 100.00 | 32.00 | 100.00 | ×1 | 4 | 4 |
| 1100 | 8.00 | 25 | 64.00 | 200.00 | 64.00 | 200.00 | ×1 | 8 | 8 |
| 0001 | 8.33 | 30 | 1.04 | 3.75 | 2.08 | 7.50 | ×2 | 1/8 | 1/4 |
| 0110 | 8.33 | 30 | 4.17 | 15.00 | 8.33 | 30.00 | ×2 | 1/2 | 1 |
| 1101 | 8.33 | 30 | 16.67 | 60.00 | 33.33 | 120.00 | ×2 | 2 | 4 |
| 0100 | 8.33 | 30 | 4.17 | 15.00 | 16.67 | 60.00 | ×4 | 1/2 | 2 |
| 1010 | 8.33 | 30 | 12.50 | 45.00 | 50.00 | 180.00 | ×4 | 3/2 | 6 |
| 0010 | 8.33 | 30 | 1.39 | 5.00 | 11.11 | 40.00 | ×8 | 1/6 | 4/3 |
| 0111 | 8.33 | 30 | 6.25 | 22.50 | 50.00 | 180.00 | ×8 | 3/4 | 6 |

FailSafe Function

The CY23FS08 is targeted at clock distribution applications that requires or may require continued operation if the main reference clock fails. Existing approaches to this requirement have used multiple reference clocks with either internal or external methods to switch between references. The problem with this technique is that it leads to interruptions (or glitches) when transitioning from one reference to another, often requiring complex external circuitry or software to maintain system stability. The technique implemented in this design completely eliminates any switching of references to the PLL, greatly simplifying system design.

The CY23FS08 PLL is driven by the crystal oscillator, which is phase-aligned to an external reference clock so that the output of the device is effectively phase-aligned to reference via the external feedback loop. This is accomplished by using a digitally

controlled capacitor array to pull the crystal frequency over an approximate range of ±300 ppm from its nominal frequency.

In this mode, if the reference frequency fails (that is, stops or disappears), the DCXO maintains its last setting and a flag signal (FAIL#/SAFE) is set to indicate failure of the reference clock.

The CY23FS08 provides four select bits, S1 through S4 to control the reference to crystal frequency ratio. The DCXO is internally tuned to the phase and frequency of the external reference only when the reference frequency divided by this ratio is within the DCXO capture range. If the frequency is out of range, a flag is set on the FAIL#/SAFE pin notifying the system that the selected reference is not valid. If the reference moves in range, then the flag is cleared, indicating to the system that the selected reference is valid.

Figure 2. Fail#/Safe Timing for Input Reference Failing Catastrophically

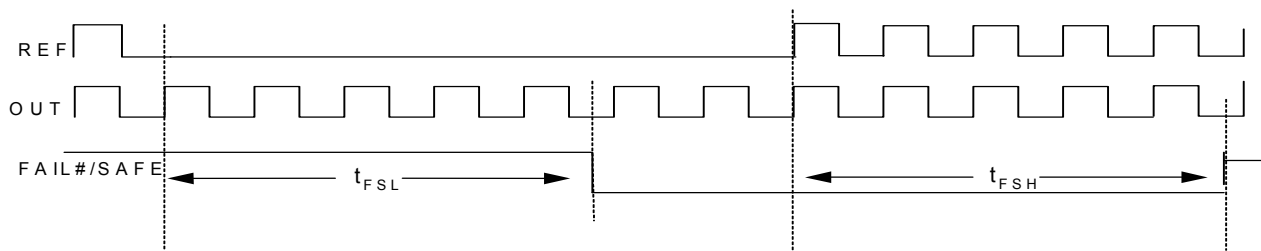


Figure 3. Fail#/Safe Timing Formula

$$t_{FSL(max)} = 2 (t_{REF} \times n) + 25 ns$$

$$n = \frac{F_{REF}}{F_{XTAL}} = 4 \text{ (in above example)}$$

$$t_{FSH(min)} = 12 (t_{REF} \times n) + 25 ns$$

Table 3. Failsafe Timing Table

| Parameter | Description | Conditions | Min | Max | Unit |
|------------------|---------------------------|--------------------------------------|--------------|--------------|------|
| t _{FSL} | Fail#/Safe Assert Delay | Measured at 80% to 20%, Load = 15 pF | | See Figure 3 | ns |
| t _{FSH} | Fail#/Safe Deassert Delay | Measured at 80% to 20%, Load = 15 pF | See Figure 3 | | ns |

Figure 4. FailSafe Timing Diagram: Input Reference Slowly Drifting Out of FailSafe Capture Range

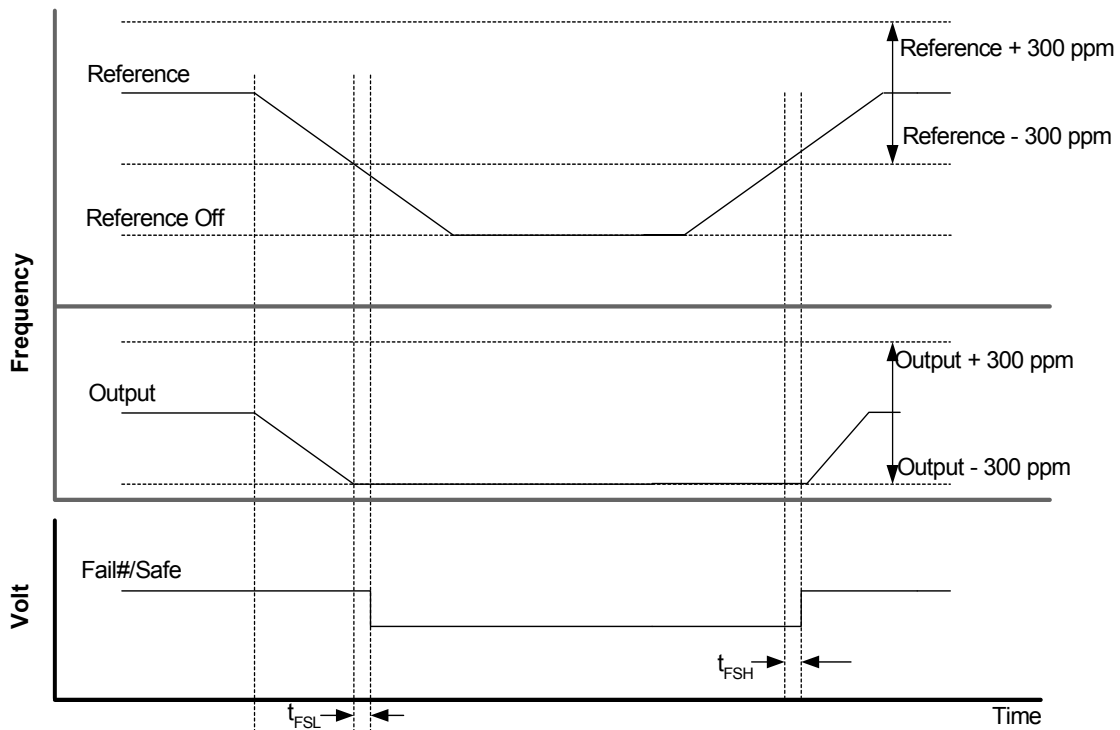
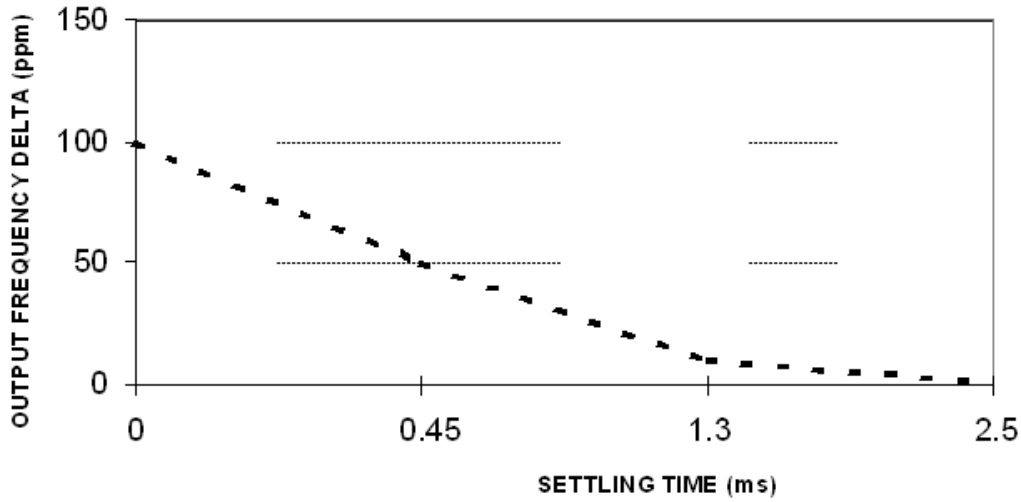


Figure 5. FailSafe Reference Switching Behavior

Failsafe typical frequency settling time

Initial valid Ref1 = 20 MHz +100 ppm,
then switching to REF2 = 20 MHz



Because of the DCXO architecture, the CY23FS08 has a much lower bandwidth than a typical PLL-based clock generator. This is shown in Figure 6. This low bandwidth makes the CY23FS08 also useful as a jitter attenuator. The loop bandwidth curve is also known as the jitter transfer curve.

Figure 6. FailSafe Effective Loop Bandwidth (min)

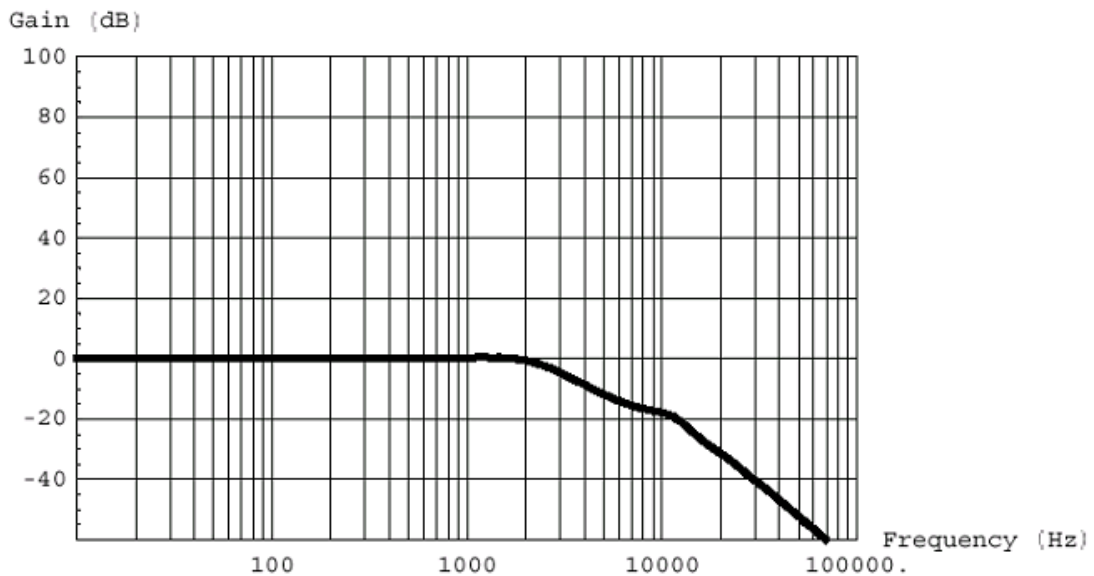


Figure 7. Duty Cycle

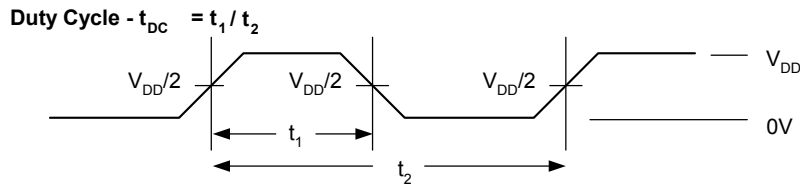


Figure 8. Input Slew Rate

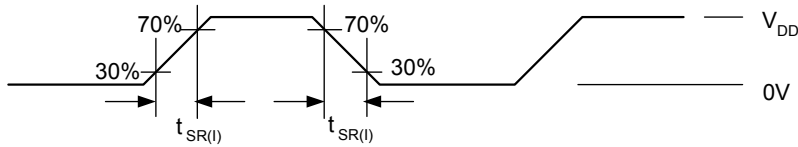


Figure 9. Output Slew Rate

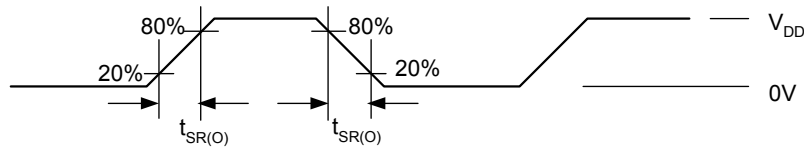


Figure 10. Output to Output Skew and Intrabank Skew

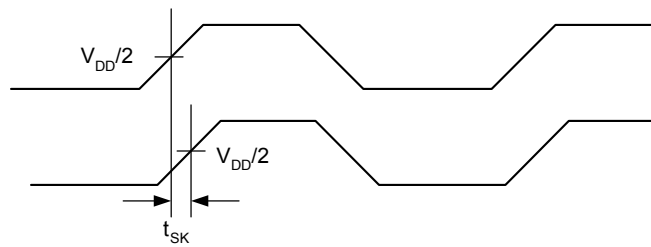


Figure 11. Part to Part Skew

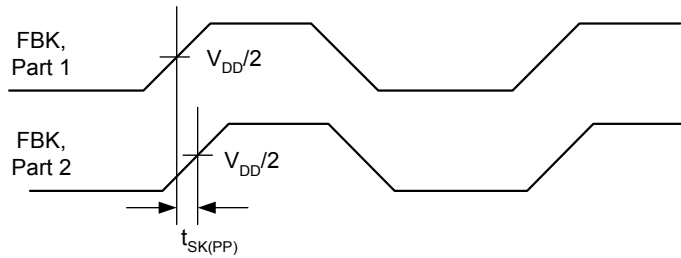
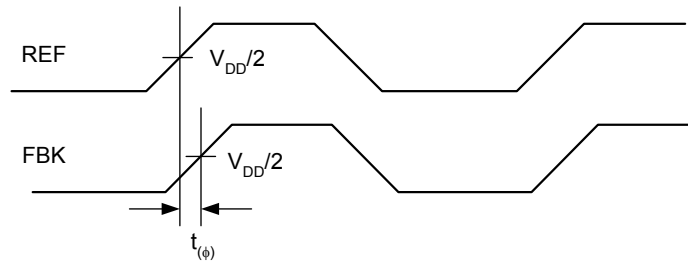


Figure 12. Phase Offset



XTAL Selection Criteria and Application Example

Selecting the appropriate XTAL ensures the FailSafe device is able to span an appropriate frequency of operation. Also, the XTAL parameters determine the holdover frequency stability. Critical parameters are given here. Cypress recommends that you choose:

- Low C0/C1 ratio (240 or less) so that the XTAL has enough range of pullability.
- Low temperature frequency variation
- Low manufacturing frequency tolerance
- Low aging

Example:

$$C_{LOADMIN} = (12 \text{ pF IC input cap} + 0 \text{ pF pulling cap} + 6 \text{ pF trace cap on board}) / 2 = 9 \text{ pF}$$

$$C_{LOADMAX} = (12 \text{ pF IC input cap} + 48 \text{ pF pulling cap} + 6 \text{ pF trace cap on board}) / 2 = 33 \text{ pF}$$

$$\text{Pull Range} = (f_{C_{LOADMIN}} - f_{C_{LOADMAX}}) / f_{C_{LOADMIN}} = (C1 / 2) * [(1 / (C0 + C_{LOADMIN})) - (1 / (C0 + C_{LOADMAX}))]$$

$$\text{Pull Range in ppm} = (C1 / 2) * [(1 / (C0 + C_{LOADMIN})) - (1 / (C0 + C_{LOADMAX}))] * 10^6$$

C0 is the XTAL shunt capacitance (3 pF to 7 pF typ).

C1 is the XTAL motional capacitance (10 fF to 30 fF typ).

The capacitive load as “seen” by the XTAL is across its terminals. It is named C_{LOADMIN} (for minimum value), and C_{LOADMAX} (for maximum value). These are used for calculating the pull range.

Note that the C_{LOAD} range “center” is approximately 20 pF, but we may not want a XTAL calibrated to that load. This is because the pullability is not linear, as represented in the equation below. Plotting the pullability of the XTAL shows this expected behavior as shown in Figure 13. In this example, specifying a XTAL calibrated to 14 pF load provides a balanced ppm pullability range around the nominal frequency.

Figure 13. Frequency vs. C_{LOAD} Behavior for Example XTAL

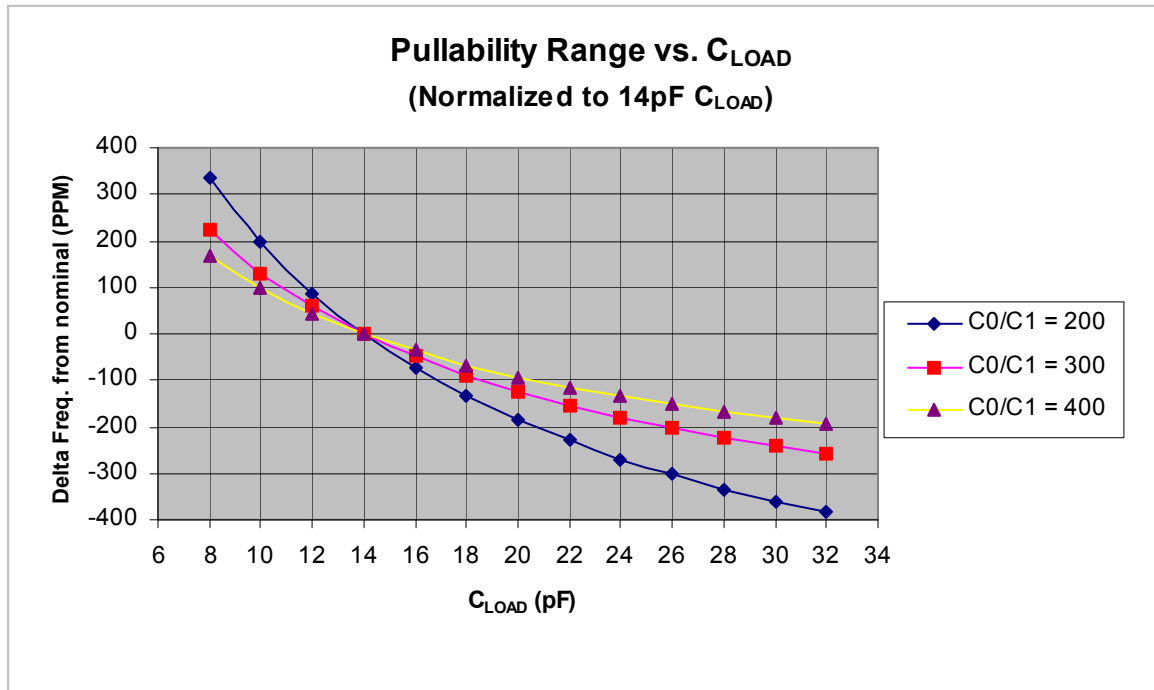


Table 4. Pullability Range from XTAL with Different C0/C1 Ratio

| C0/C1 Ratio | C _{LOADMIN} | C _{LOADMAX} | Pullability Range | |
|-------------|----------------------|----------------------|-------------------|-----|
| 200 | 8 | 32 | -385 | 333 |
| 300 | 8 | 32 | -256 | 222 |
| 400 | 8 | 32 | -192 | 166 |

Calculated value of the pullability range for the XTAL with C0/C1 ratio of 200, 300, and 400 are shown in Table 4. For this calculation C_{LOADMIN} = 8 pF and C_{LOADMAX} = 32 pF is used. Using a XTAL that has a nominal frequency specified at load capacitance of 14 pF, almost symmetrical pullability range is obtained.

Next, it is important to calculate the pullability range including error tolerances. This is the **capture range** of the input reference frequency that the FailSafe device and XTAL combination can reliably span.

Calculating the **capture range** involves subtracting error tolerances as follows:

| | |
|---|---------------|
| Parameter | f error (ppm) |
| Manufacturing frequency tolerance | 15 |
| Temperature stability | 30 |
| Aging | 3 |
| Board/trace variation | 5 |
| Total | 53 |

Example: Capture Range for XTAL with C0/C1 Ratio of 200

Negative Capture Range = -385 ppm + 53 ppm = -332 ppm

Positive Capture Range = 333 ppm - 53 ppm = +280 ppm

It is important to note that the XTAL with lower C0/C1 ratio has wider **pullability/capture range** as compared to the higher C0/C1 ratio. This helps to select the appropriate XTAL for use in the FailSafe application.

Absolute Maximum Conditions

Exceeding maximum ratings may shorten the useful life of the device. User guidelines are not tested.

| Parameter | Description | Condition | Min | Max | Unit |
|--------------------|-----------------------------------|-----------------------------|-------|-----------------------|------|
| V _{DD} | Supply Voltage | | -0.5 | 4.6 | V |
| V _{IN} | Input Voltage | Relative to V _{SS} | -0.5 | V _{DD} + 0.5 | VDC |
| T _S | Temperature, Storage | Non Functional | -65 | 150 | °C |
| T _J | Temperature, Junction | Functional | - | 125 | °C |
| ESD _{HBM} | ESD Protection (Human Body Model) | MIL-STD-883, Method 3015 | 2000 | - | V |
| ∅ _{JC} | Dissipation, Junction to Case | Mil-Spec 883E Method 1012.1 | 36.17 | | °C/W |
| ∅ _{JA} | Dissipation, Junction to Ambient | JEDEC (JESD 51) | 100.6 | | °C/W |
| UL-94 | Flammability Rating | At 1/8 in. | V-0 | | |
| MSL | Moisture Sensitivity Level | | 1 | | |

Multiple Supplies: The voltage on any input or I/O pin cannot exceed the power pin during power-up. Power supply sequencing is NOT required.

Recommended Pullable Crystal Specifications^[5]

| Parameter | Name | Comments | Min | Typ | Max | Unit |
|--------------------------------|--|--|------|-----|-------|------|
| F _{NOM} | Nominal crystal frequency | Parallel resonance, fundamental mode, AT cut | 8.00 | - | 30.00 | MHz |
| C _{LNOM} | Nominal load capacitance | | - | 14 | - | pF |
| R ₁ | Equivalent series resistance (ESR) | Fundamental mode | - | - | 25 | Ω |
| R ₃ /R ₁ | Ratio of third overtone mode ESR to fundamental mode ESR | Ratio used because typical R ₁ values are much less than the maximum spec | 3 | - | - | |
| DL | Crystal drive level | No external series resistor assumed | - | 0.5 | 2 | mW |
| F _{3SEPLI} | Third overtone separation from 3*F _{NOM} | High side | 300 | - | - | ppm |
| F _{3SEPLO} | Third overtone separation from 3*F _{NOM} | Low side | - | - | -150 | ppm |
| C ₀ | Crystal shunt capacitance | | - | - | 7 | pF |
| C ₀ /C ₁ | Ratio of shunt to motional capacitance | | 180 | - | 250 | |
| C ₁ | Crystal motional capacitance | | 14.4 | 18 | 21.6 | fF |

Operating Conditions

| Parameter | Description | Min | Max | Unit |
|--|---|-------|-------|------|
| V _{DDC} | 3.3 V Supply Voltage | 3.135 | 3.465 | V |
| V _{DDA} , V _{DDB} | 2.5 V Supply Voltage Range | 2.375 | 2.625 | V |
| | 3.3 V Supply Voltage Range | 3.135 | 3.465 | V |
| T _A | Ambient Operating Temperature, Commercial | 0 | 70 | °C |
| | Ambient Operating Temperature, Industrial | -40 | 85 | °C |
| C _L | Output Load Capacitance (F _{out} ≤ 100 MHz) | - | 30 | pF |
| | Output Load Capacitance (F _{out} > 100 MHz) | - | 15 | pF |
| C _{IN} | Input Capacitance (except XIN) | - | 7 | pF |
| C _{XIN} | Crystal Input Capacitance (all internal caps off) | 10 | 13 | pF |
| t _{PU} | Power up time for all VDDs to reach minimum specified voltage (power ramps must be monotonic) | 0.05 | 500 | ms |

Note

5. Ecliptek crystals ECX-5788-13.500M, ECX-5807-19.440M, ECX-5872-19.53125M, ECX-6362-18.432M, ECX-5808-27.000M, ECX-5884-17.664M, ECX-5883-16.384M, ECX-5882-19.200M, ECX-5880-24.576M meet these specifications.

DC Electrical Characteristics

| Parameter | Description | Test Conditions | Min | Typ | Max | Unit |
|------------------|---------------------|---|---------------------|-----|---------------------|------|
| V _{IL} | Input Low Voltage | CMOS Levels, 30% of V _{DD} | – | – | 0.3×V _{DD} | V |
| V _{IH} | Input High Voltage | CMOS Levels, 70% of V _{DD} | 0.7×V _{DD} | – | – | V |
| I _{IL} | Input Low Current | V _{IN} = V _{SS} (100k pull up only) | – | – | 50 | μA |
| I _{IH} | Input High Current | V _{IN} = V _{DD} (100k pull down only) | – | – | 50 | μA |
| I _{OL} | Output Low Current | V _{OL} = 0.5 V, V _{DD} = 2.5 V | – | 18 | – | mA |
| | | V _{OL} = 0.5 V, V _{DD} = 3.3 V | – | 20 | – | mA |
| I _{OH} | Output High Current | V _{OH} = V _{DD} – 0.5 V, V _{DD} = 2.5 V | – | 18 | – | mA |
| | | V _{OH} = V _{DD} – 0.5 V, V _{DD} = 3.3 V | – | 20 | – | mA |
| I _{DDQ} | Quiescent Current | All Inputs grounded, PLL and DCXO in bypass mode, Reference Input = 0 | – | – | 250 | μA |

Switching Characteristics

| Parameter ^[7] | Description | Test Conditions | Min | Typ | Max | Unit |
|----------------------------------|-----------------------|--|------|-----|-------|-------------------|
| f _{REF} | Reference Frequency | Commercial Grade | 1.04 | – | 200 | MHz |
| | | Industrial Grade | 1.04 | – | 166.7 | MHz |
| f _{OUT} | Output Frequency | 15 pF Load, Commercial Grade | 1.70 | – | 200 | MHz |
| | | 15 pF Load, Industrial Grade | 1.70 | – | 166.7 | MHz |
| f _{XIN} | DCXO Frequency | | 8.0 | – | 30 | MHz |
| t _{DC} | Duty Cycle | Measured at V _{DD} /2 | 47 | – | 53 | % |
| t _{SR(I)} | Input Slew Rate | Measured on REF1 Input, 30% to 70% of V _{DD} | 0.5 | – | 4.0 | V/ns |
| t _{SR(O)} | Output Slew Rate | Measured from 20% to 80% of V _{DD} = 3.3V, 15 pF Load | 0.8 | – | 4.0 | V/ns |
| | | Measured from 20% to 80% of V _{DD} = 2.5V, 15 pF Load | 0.4 | – | 3.0 | V/ns |
| t _{SK(O)} | Output to Output Skew | All outputs equally loaded, measured at V _{DD} /2 | – | 110 | 200 | ps |
| t _{SK(IB)} | Intrabank Skew | All outputs equally loaded, measured at V _{DD} /2 | – | – | 75 | ps |
| t _{SK(PP)} | Part to Part Skew | Measured at V _{DD} /2 | – | – | 500 | ps |
| t _(φ) ^[6] | Static Phase Offset | Measured at V _{DD} /2 | – | – | 250 | ps |
| t _{D(φ)} ^[6] | Dynamic Phase Offset | Measured at V _{DD} /2 | – | – | 500 | ps |
| t _{J(CC)} | Cycle-to-Cycle Jitter | Load = 15 pF, f _{OUT} ≥ 6.25 MHz | – | 100 | 200 | ps |
| | | | – | 18 | 35 | ps _{RMS} |
| t _{LOCK} | Lock Time | At room temperature with 18.432 MHz Crystal | – | 70 | – | ms |

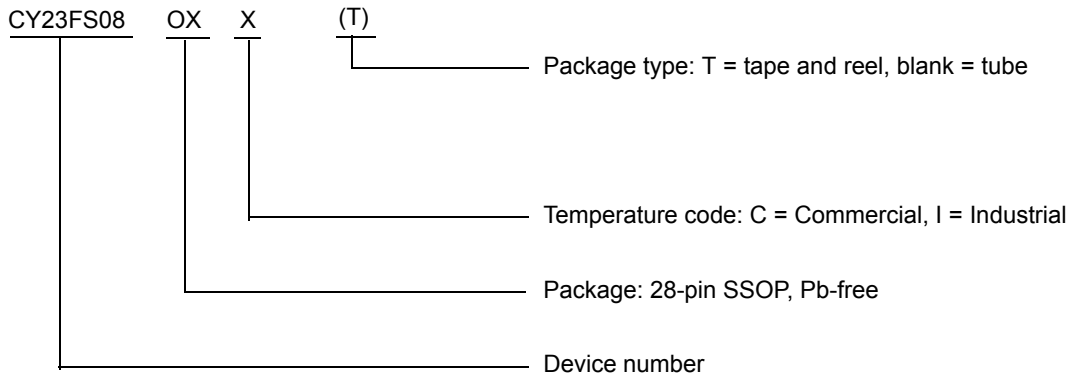
Ordering Information

| Part Number | Package Type | Product Flow |
|----------------|-----------------------------|-----------------------------|
| Pb-free | | |
| CY23FS08OXI | 28-pin SSOP | Industrial, –40 °C to 85 °C |
| CY23FS08OXIT | 28-pin SSOP – Tape and Reel | Industrial, –40 °C to 85 °C |
| CY23FS08OXC | 28-pin SSOP | Commercial, 0 °C to 70 °C |
| CY23FS08OXCT | 28-pin SSOP – Tape and Reel | Commercial, 0 °C to 70 °C |

Notes

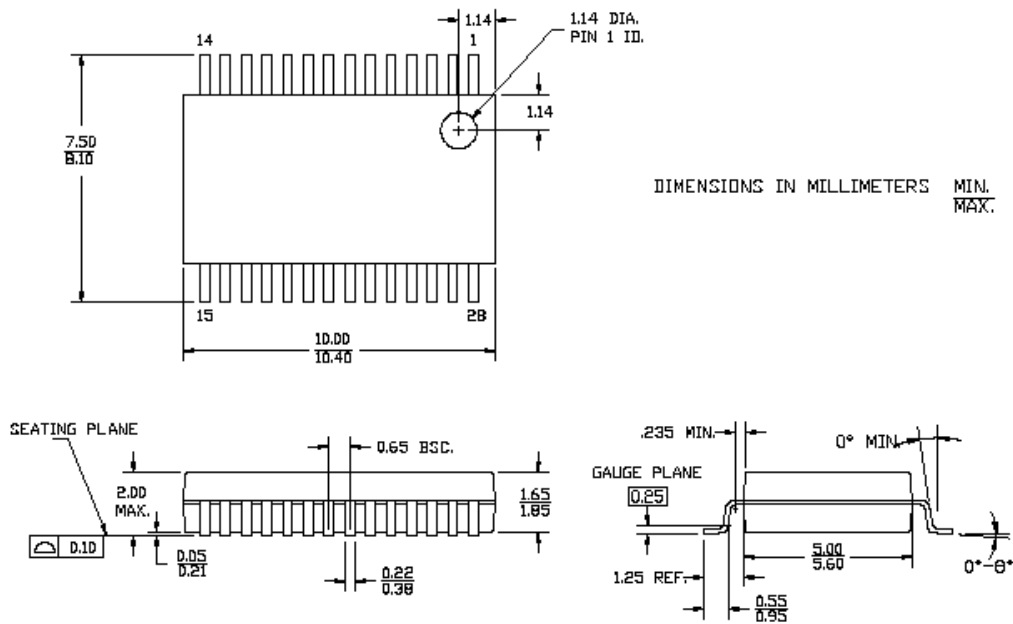
- The t_(φ) reference feedback input delay is guaranteed for a maximum 4:1 input edge ratio between the two signals as long as t_{SR(I)} is maintained.
- Parameters guaranteed by design and characterization, not 100% tested in production.

Ordering Code Definition



Package Diagram

Figure 14. 28-pin (5.3 mm) Shrunken Small Outline Package SP28



Acronyms

| Acronym | Description |
|---------|---|
| DCXO | digitally controlled crystal oscillator |
| ESD | electrostatic discharge |
| PLL | phase locked loop |
| RMS | root mean square |
| SSOP | shrunk small outline package |
| XTAL | crystal |

Document Conventions

Units of Measure

| Symbol | Unit of Measure |
|--------|-------------------|
| °C | degree Celsius |
| μA | micro Amperes |
| mA | milli Amperes |
| ms | milli seconds |
| MHz | Mega Hertz |
| ns | nano seconds |
| pF | pico Farad |
| ps | pico seconds |
| ppm | parts per million |
| W | Watts |
| Ω | ohms |
| V | Volts |

Document History Page

| Document Title: CY23FS08 Failsafe™ 2.5 V/3.3 V Zero Delay Buffer Document Number: 38-07518 | | | | |
|---|---------|-----------------|-----------------|---|
| Rev. | ECN No. | Submission Date | Orig. of Change | Description of Change |
| ** | 123699 | 04/23/03 | RGL | New Data Sheet |
| *A | 224067 | See ECN | RGL/ZJX | Changed the XTAL Specifications table. |
| *B | 276749 | See ECN | RGL | Removed (T _{LOCK}) Lock Time Specification. |
| *C | 417645 | See ECN | RGL | Added Lead-free devices Added typical nos. on jitters |
| *D | 2865396 | 01/25/2010 | KVM | Remove figures showing dynamic response to 180° phase change to REF Add waveforms for input slew rate and intrabank skew Change "CI" to "C _{LOAD} " Absolute Maximum Conditions table: remove duplicate T _A parameter Replace crystal ECX-5806-18.432M with ECX-6362-18.432M Remove obsolete part numbers CY23FS08OI, CY23FS08OIT, CY23FS08OC and CY23FS08OCT Replace "Lead-free" with "Pb-free" Remove unreferenced footnote 9 Change package drawing title from "O28" to "SP28", updated package diagram Added Table of Contents |
| *E | 2925613 | 04/30/10 | KVM | Posting to external web. |
| *F | 3130032 | 01/06/2011 | BASH | Changed t _{D(φ)} max value from 200 to 500 and removed t _{D(φ)} Typical value in Switching Characteristics on page 11. Added Ordering Code Definition . Added Acronyms and Units of Measure on page 13. |

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