

One-PLL General-Purpose Flash-Programmable and I²C Programmable Clock Generator

Features

- Integrated phase-locked loop (PLL)
- Commercial and industrial operation
- Flash programmable
- Field programmable
- Two-wire I²C interface
- Low skew, low jitter, high accuracy outputs
- 3.3 V operation with 2.5 V output option
- 16-pin TSSOP

Benefits

- Internal PLL to generate six outputs up to 200 MHz. Able to generate custom frequencies from an external crystal or a driven source.
- Performance guaranteed for applications that require an extended temperature range.
- Nonvolatile reprogrammable technology allows easy customization, quick turnaround on design changes and product performance enhancements, and better inventory

control. Parts can be reprogrammed up to 100 times, reducing inventory of custom parts and providing an easy method for upgrading existing designs.

- The CY22150 can be programmed at the package level. In-house programming of samples and prototype quantities is available using the CY3672 Development Kit. Production quantities are available through Cypress's value added distribution partners or by using third party programmers from BP Microsystems™, HiLo Systems™, and others.
- The CY22150 provides an industry standard interface for volatile, system level customization of unique frequencies and options. Serial programming and reprogramming allows quick design changes and product enhancements, eliminates inventory of old design parts, and simplifies manufacturing.
- High performance suited for commercial, industrial, networking, telecom, and other general purpose applications.
- Application compatibility in standard and low power systems.
- Industry standard packaging saves on board space.

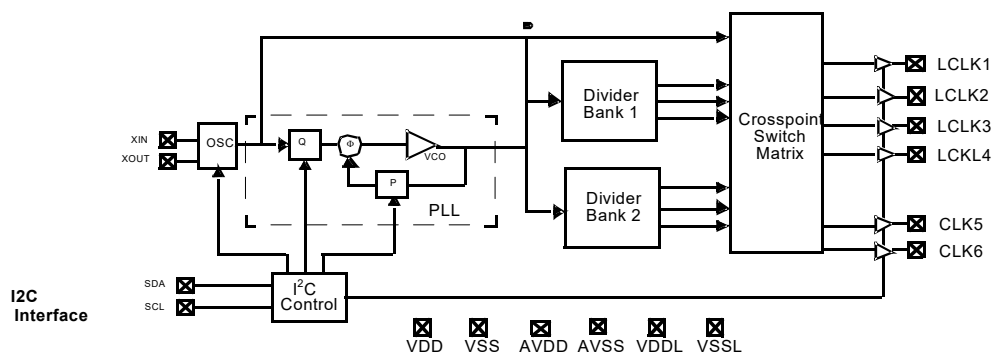
Functional Description

For a complete list of related documentation, click [here](#).

Selection Guide

| Part Number | Outputs | Input Frequency Range | Output Frequency Range | Specifications |
|--------------|---------|---|--|---|
| CY22150KFZXC | 6 | 8 MHz to 30 MHz (external crystal) 1 MHz to 133 MHz (driven clock) | 80 kHz to 200 MHz (3.3 V) 80 kHz to 166.6 MHz (2.5 V) | Field programmable Serially programmable Commercial temperature |
| CY22150KFZXI | 6 | 8 MHz to 30 MHz (external crystal) 1 MHz to 133 MHz (driven clock) | 80 kHz to 166.6 MHz (3.3 V) 80 kHz to 150 MHz (2.5 V) | Field programmable Serially programmable Industrial temperature |

Logic Block Diagram

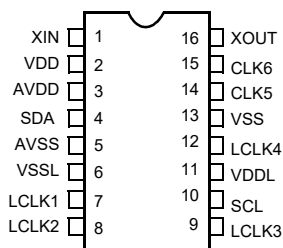


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Pin Configuration

Figure 1. 16-pin TSSOP pinout



Pin Definitions

| Pin Name | Pin Number | Description |
|---------------------|------------|--|
| XIN | 1 | Reference Input. Driven by a crystal (8 MHz to 30 MHz) or external clock (1 MHz to 133 MHz). Programmable input load capacitors allow for maximum flexibility in selecting a crystal, regardless of manufacturer, process, performance, or quality |
| VDD | 2 | 3.3 V Voltage Supply |
| AVDD | 3 | 3.3 V Analog Voltage Supply |
| SDA | 4 | I ² C Serial Data Input/Output |
| AVSS | 5 | Analog Ground |
| VSSL | 6 | LCLK Ground |
| LCLK1 | 7 | Configurable Clock Output 1 at V _{DDL} level (3.3 V or 2.5 V) |
| LCLK2 | 8 | Configurable Clock Output 2 at V _{DDL} level (3.3 V or 2.5 V) |
| LCLK3 | 9 | Configurable Clock Output 3 at V _{DDL} level (3.3 V or 2.5 V) |
| SCL | 10 | I ² C Serial Clock Input |
| VDDL | 11 | LCLK Voltage Supply (2.5 V or 3.3 V) |
| LCLK4 | 12 | Configurable Clock Output 4 at V _{DDL} level (3.3 V or 2.5 V) |
| VSS | 13 | Ground |
| CLK5 | 14 | Configurable Clock Output 5 (3.3 V) |
| CLK6 | 15 | Configurable Clock Output 6 (3.3 V) |
| XOUT ^[1] | 16 | Reference Output |

Note

1. Float XOUT if XIN is driven by an external clock source.

Functional Overview

Frequency Calculation and Register Definitions

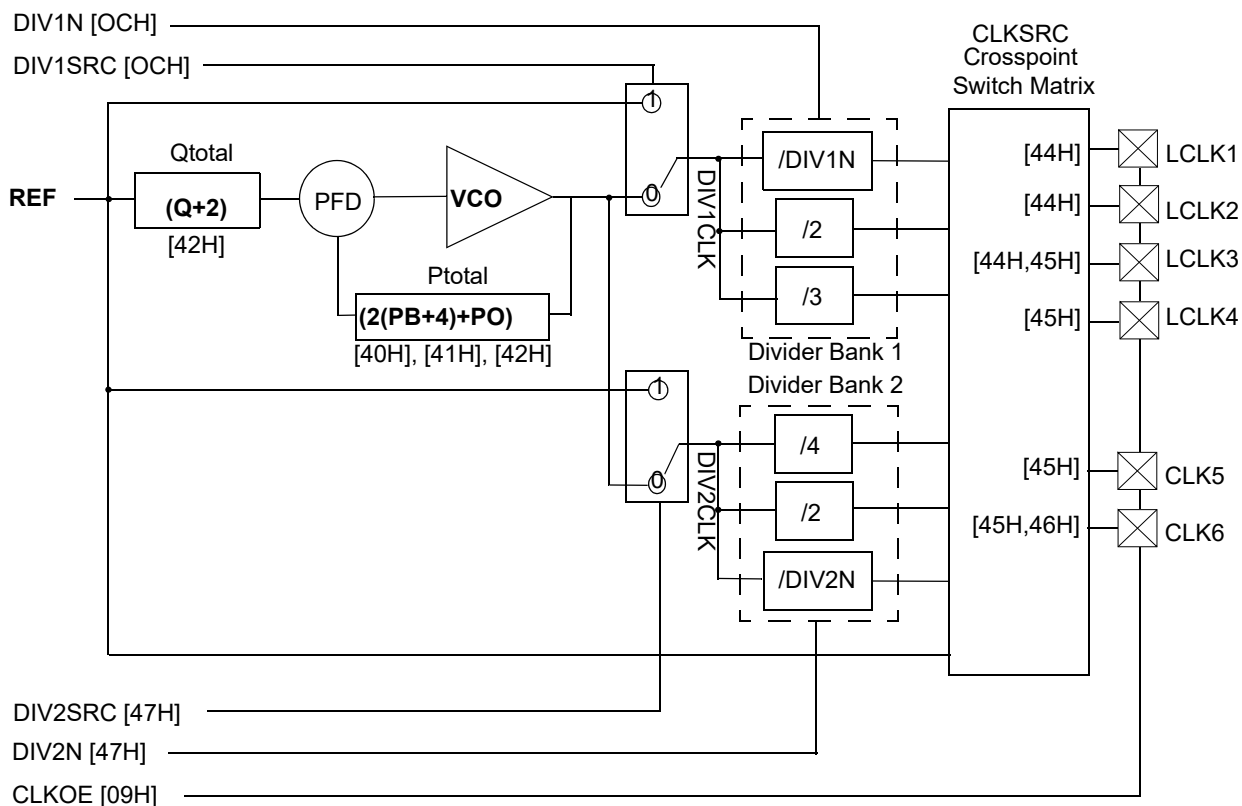
The CY22150 is an extremely flexible clock generator with four basic variables that are used to determine the final output frequency. They are the input reference frequency (REF), the internally calculated P and Q dividers, and the post divider, which can be a fixed or calculated value. There are three formulas to determine the final output frequency of a CY22150 based design:

- $CLK = ((REF * P)/Q)/\text{Post Divider}$
- $CLK = REF/\text{Post Divider}$
- $CLK = REF$.

The basic PLL block diagram is shown in [Figure 2](#). Each of the six clock outputs on the CY22150 has a total of seven output options available to it. There are six post divider options available: /2 (two of these), /3, /4, /DIV1N and /DIV2N. DIV1N and DIV2N are independently calculated and are applied to individual output groups. The post divider options can be applied to the calculated VCO frequency $((REF * P)/Q)$ or to the REF directly.

In addition to the six post divider output options, the seventh option bypasses the PLL and passes the REF directly to the crosspoint switch matrix.

Figure 2. Basic Block Diagram of CY22150 PLL



Default Startup Condition for the CY22150

The default (programmed) condition of the device is generally set by the distributor who programs the device using a customer specific JEDEC file produced by CyClocksRT™. Parts shipped from the factory are blank and unprogrammed. In this condition, all bits are set as default settings, all outputs are three-stated, and the crystal oscillator circuit is active.

While you can develop your own subroutine to program any or all of the individual registers described in the following pages, it may be easier to use CyClocksRT to produce the required register setting file.

The serial interface address of the CY22150 is 69H. If there is a conflict with any other devices in your system, then this can also be changed using CyClocksRT.

Frequency Calculations and Register Definitions using the I²C Interface

The CY22150 provides an industry standard serial interface for volatile, in-system programming of unique frequencies and options. Serial programming and re-programming allows for quick design changes and product enhancements, eliminates inventory of old design parts, and simplifies manufacturing.

The I²C Interface provides volatile programming. This means when the target system is powered down, the CY22150 reverts to its pre-I²C state, as defined above (programmed or unprogrammed). When the system is powered back up again, the I²C registers must be reconfigured again.

All programmable registers in the CY22150 are addressed with eight bits and contain eight bits of data. The CY22150 is a slave device with an address of 1101001 (69H).

[Table 1](#) lists the I²C registers and their definitions. Specific register definitions and their allowable values are listed below.

Table 1. Summary Table – CY22150 Programmable Registers

| Register | Description | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|----------|--|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|
| 09H | CLKOE control | 0 | 0 | CLK6 | CLK5 | LCLK4 | LCLK3 | LCLK2 | LCLK1 |
| OCH | DIV1SRC mux and DIV1N divider | DIV1SRC | DIV1N(6) | DIV1N(5) | DIV1N(4) | DIV1N(3) | DIV1N(2) | DIV1N(1) | DIV1N(0) |
| 12H | Input crystal oscillator drive control | 0 | 0 | 1 | XDRV(1) | XDRV(0) | 0 | 0 | 0 |
| 13H | Input load capacitor control | CapLoad (7) | CapLoad (6) | CapLoad (5) | CapLoad (4) | CapLoad (3) | CapLoad (2) | CapLoad (1) | CapLoad (0) |
| 40H | Charge pump and PB counter | 1 | 1 | 0 | Pump(2) | Pump(1) | Pump(0) | PB(9) | PB(8) |
| 41H | | PB(7) | PB(6) | PB(5) | PB(4) | PB(3) | PB(2) | PB(1) | PB(0) |
| 42H | PO counter, Q counter | PO | Q(6) | Q(5) | Q(4) | Q(3) | Q(2) | Q(1) | Q(0) |
| 44H | Crosspoint switch matrix control | CLKSRC2 for LCLK1 | CLKSRC1 for LCLK1 | CLKSRC0 for LCLK1 | CLKSRC2 for LCLK2 | CLKSRC1 for LCLK2 | CLKSRC0 for LCLK2 | CLKSRC2 for LCLK3 | CLKSRC1 for LCLK3 |
| 45H | | CLKSRC0 for LCLK3 | CLKSRC2 for LCLK4 | CLKSRC1 for LCLK4 | CLKSRC0 for LCLK4 | CLKSRC2 for CLK5 | CLKSRC1 for CLK5 | CLKSRC0 for CLK5 | CLKSRC2 for CLK6 |
| 46H | | CLKSRC1 for CLK6 | CLKSRC0 for CLK6 | 1 | 1 | 1 | 1 | 1 | 1 |
| 47H | DIV2SRC mux and DIV2N divider | DIV2SRC | DIV2N(6) | DIV2N(5) | DIV2N(4) | DIV2N(3) | DIV2N(2) | DIV2N(1) | DIV2N(0) |

Reference Frequency

The REF can be a crystal or a driven frequency. For crystals, the frequency range must be between 8 MHz and 30 MHz. For a driven frequency, the frequency range must be between 1 MHz and 133 MHz.

Using a Crystal as the Reference Input:

The input crystal oscillator of the CY22150 is an important feature because of the flexibility it allows the user in selecting a crystal as a REF source. The input oscillator has programmable gain, allowing maximum compatibility with a reference crystal, regardless of manufacturer, process, performance, and quality.

Programmable Crystal Input Oscillator Gain Settings:

The Input crystal oscillator gain (XDRV) is controlled by two bits in register 12H and are set according to [Table 2 on page 6](#). The

parameters controlling the gain are the crystal frequency, the internal crystal parasitic resistance (ESR, available from the manufacturer), and the CapLoad setting during crystal startup.

Bits 3 and 4 of register 12H control the input crystal oscillator gain setting. Bit 4 is the MSB of the setting, and bit 3 is the LSB. The setting is programmed according to [Table 2 on page 6](#). All other bits in the register are reserved and should be programmed as shown in [Table 3 on page 6](#).

Using an External Clock as the Reference Input:

The CY22150 also accepts an external clock as reference, with speeds up to 133 MHz. With an external clock, the XDRV (register 12H) bits must be set according to [Table 4 on page 6](#).

Table 2. Programmable Crystal Input Oscillator Gain Settings

| | Cap Register Settings | 00H–80H | | 80H–C0H | | C0H–FFH | |
|-------------------------|--------------------------------------|---------------|------|----------------|------|----------------|------|
| | Effective Load Capacitance (CapLoad) | 6 pF to 12 pF | | 12 pF to 18 pF | | 18 pF to 30 pF | |
| | Crystal ESR | 30 Ω | 60 Ω | 30 Ω | 60 Ω | 30 Ω | 60 Ω |
| Crystal Input Frequency | 8 to 15 MHz | 00 | 01 | 01 | 10 | 01 | 10 |
| | 15 to 20 MHz | 01 | 10 | 01 | 10 | 10 | 10 |
| | 20 to 25 MHz | 01 | 10 | 10 | 10 | 10 | 11 |
| | 25 to 30 MHz | 10 | 10 | 10 | 11 | 11 | N/A |

Table 3. Crystal Oscillator Gain Bit Locations and Values

| Address | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|---------|----|----|----|---------|---------|----|----|----|
| 12H | 0 | 0 | 1 | XDRV(1) | XDRV(0) | 0 | 0 | 0 |

Table 4. Programmable External Reference Input Oscillator Drive Settings

| Reference Frequency | 1 to 25 MHz | 25 to 50 MHz | 50 to 90 MHz | 90 to 133 MHz |
|---------------------|-------------|--------------|--------------|---------------|
| Drive Setting | 00 | 01 | 10 | 11 |

Input Load Capacitors:

Input load capacitors allow the user to set the load capacitance of the CY22150 to match the input load capacitance from a crystal. The value of the input load capacitors is determined by 8 bits in a programmable register [13H]. Total load capacitance is determined by the formula:

$$\text{CapLoad} = (C_L - C_{\text{BRD}} - C_{\text{CHIP}}) / 0.09375 \text{ pF}$$

where:

- C_L = specified load capacitance of your crystal.
- C_{BRD} = the total board capacitance, due to external capacitors and board trace capacitance. In CyClocksRT, this value defaults to 2 pF.
- C_{CHIP} = 6 pF.
- 0.09375 pF = the step resolution available due to the 8-bit register.

In CyClocksRT, only the crystal capacitance (C_L) is specified. C_{CHIP} is set to 6 pF and C_{BRD} defaults to 2 pF. If your board capacitance is higher or lower than 2 pF, the formula given earlier is used to calculate a new CapLoad value and programmed into register 13H.

In CyClocksRT, enter the crystal capacitance (C_L). The value of CapLoad is determined automatically and programmed into the CY22150. Through the SDA and SCL pins, the value can be adjusted up or down if your board capacitance is greater or less than 2 pF. For an external clock source, CapLoad defaults to 0. See Table 5 for CapLoad bit locations and values.

The input load capacitors are placed on the CY22150 die to reduce external component cost. These capacitors are true parallel-plate capacitors, designed to reduce the frequency shift that occurs when nonlinear load capacitance is affected by load, bias, supply, and temperature changes.

Table 5. Input Load Capacitor Register Bit Settings

| Address | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|---------|------------|------------|------------|------------|------------|------------|------------|------------|
| 13H | CapLoad(7) | CapLoad(6) | CapLoad(5) | CapLoad(4) | CapLoad(3) | CapLoad(2) | CapLoad(1) | CapLoad(0) |

PLL Frequency, Q Counter [42H(6..0)]

The first counter is known as the Q counter. The Q counter divides REF by its calculated value. Q is a 7 bit divider with a maximum value of 127 and minimum value of 0. The primary value of Q is determined by 7 bits in register 42H (6..0), but 2 is added to this register value to achieve the total Q, or Q_{total} . Q_{total} is defined by the formula:

$$Q_{total} = Q + 2$$

The minimum value of Q_{total} is 2. The maximum value of Q_{total} is 129. Register 42H is defined in the table.

Stable operation of the CY22150 cannot be guaranteed if REF/Q_{total} falls below 250 kHz. Q_{total} bit locations and values are defined in [Table 6](#).

Table 6. P Counter and Q Counter Register Definition

| Address | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|---------|-------|-------|-------|---------|---------|---------|-------|-------|
| 40H | 1 | 1 | 0 | Pump(2) | Pump(1) | Pump(0) | PB(9) | PB(8) |
| 41H | PB(7) | PB(6) | PB(5) | PB(4) | PB(3) | PB(2) | PB(1) | PB(0) |
| 42H | PO | Q(6) | Q(5) | Q(4) | Q(3) | Q(2) | Q(1) | Q(0) |

PLL Frequency, P Counter [40H(1..0)], [41H(7..0)], [42H(7)]

The next counter definition is the P (product) counter. The P counter is multiplied with the (REF/Q_{total}) value to achieve the VCO frequency. The product counter, defined as P_{total} , is made up of two internal variables, PB and PO. The formula for calculating P_{total} is:

$$P_{total} = (2(PB + 4) + PO)$$

PB is a 10-bit variable, defined by registers 40H(1:0) and 41H(7:0). The 2 LSBs of register 40H are the two MSBs of variable PB. Bits 4..2 of register 40H are used to determine the charge pump settings. The 3 MSBs of register 40H are preset and reserved and cannot be changed. PO is a single bit variable, defined in register 42H(7). This allows for odd numbers in P_{total} .

The remaining seven bits of 42H are used to define the Q counter, as shown in [Table 6](#).

The minimum value of P_{total} is 8. The maximum value of P_{total} is 2055. To achieve the minimum value of P_{total} , PB and PO should both be programmed to 0. To achieve the maximum value of P_{total} , PB should be programmed to 1023, and PO should be programmed to 1.

Stable operation of the CY22150 cannot be guaranteed if the value of $(P_{total} * (REF/Q_{total}))$ is above 400 MHz or below 100 MHz.

PLL Post Divider Options [0CH(7..0)], [47H(7..0)]

The output of the VCO is routed through two independent muxes, then to two divider banks to determine the final clock output frequency. The mux determines if the clock signal feeding into the divider banks is the calculated VCO frequency or REF. There are two select muxes (DIV1SRC and DIV2SRC) and two divider banks (Divider Bank 1 and Divider Bank 2) used to determine this clock signal. The clock signal passing through DIV1SRC and DIV2SRC is referred to as DIV1CLK and DIV2CLK, respectively.

The divider banks have four unique divider options available: /2, /3, /4, and /DIVxN. DIVxN is a variable that can be independently programmed (DIV1N and DIV2N) for each of the two divider banks. The minimum value of DIVxN is 4. The maximum value of DIVxN is 127. A value of DIVxN below 4 is not guaranteed to work properly.

DIV1SRC is a single bit variable, controlled by register 0CH. The remaining seven bits of register 0CH determine the value of post divider DIV1N.

DIV2SRC is a single bit variable, controlled by register 47H. The remaining seven bits of register 47H determine the value of post divider DIV2N.

Register 0CH and 47H are defined in [Table 7](#).

Table 7. PLL Post Divider Options

| Address | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|---------|---------|----------|----------|----------|----------|----------|----------|----------|
| 0CH | DIV1SRC | DIV1N(6) | DIV1N(5) | DIV1N(4) | DIV1N(3) | DIV1N(2) | DIV1N(1) | DIV1N(0) |
| 47H | DIV2SRC | DIV2N(6) | DIV2N(5) | DIV2N(4) | DIV2N(3) | DIV2N(2) | DIV2N(1) | DIV2N(0) |

Charge Pump Settings [40H(2..0)]

The correct pump setting is important for PLL stability. Charge pump settings are controlled by bits (4..2) of register 40H, and are dependent on internal variable PB (see “PLL Frequency, P

Counter[40H(1..0)], [41H(7..0)], [42H(7)]”). Table 8 summarizes the proper charge pump settings, based on P_{total}.

See Table 9 for register 40H bit locations and values.

Table 8. Charge Pump Settings

| Charge Pump Setting – Pump(2..0) | Calculated P _{total} |
|----------------------------------|--------------------------------------|
| 000 | 16–44 |
| 001 | 45–479 |
| 010 | 480–639 |
| 011 | 640–799 |
| 100 | 800–1023 |
| 101, 110, 111 | Do not use – device will be unstable |

Table 9. Register 40H Change Pump Bit Settings

| Address | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|---------|----|----|----|---------|---------|---------|-------|-------|
| 40H | 1 | 1 | 0 | Pump(2) | Pump(1) | Pump(0) | PB(9) | PB(8) |

Although using the above table guarantees stability, it is recommended to use the Print Preview function in CyClocksRT to determine the correct charge pump settings for optimal jitter performance.

PLL stability cannot be guaranteed for values below 16 and above 1023. If values above 1023 are needed, use CyClocksRT to determine the best charge pump setting.

Clock Output Settings: CLKSRC – Clock Output Crosspoint Switch Matrix [44H(7..0)], [45H(7..0)], [46H(7..6)]

Every clock output can be defined to come from one of seven unique frequency sources. The CLKSRC(2..0) crosspoint switch matrix defines which source is attached to each individual clock output. CLKSRC(2..0) is set in Registers 44H, 45H, and 46H. The remainder of register 46H(5:0) must be written with the values stated in the register table when writing register values 46H(7:6).

When DIV1N is divisible by four, then CLKSRC(0,1,0) is guaranteed to be rising edge phase-aligned with CLKSRC(0,0,1). When DIV1N is six, then CLKSRC(0,1,1) is guaranteed to be rising edge phase-aligned with CLKSRC(0,0,1).

When DIV2N is divisible by four, then CLKSRC(1,0,1) is guaranteed to be rising edge phase-aligned with CLKSRC(1,0,0). When DIV2N is divisible by eight, then CLKSRC(1,1,0) is guaranteed to be rising edge phase-aligned with CLKSRC(1,0,0).

Table 10. Clock Output Setting

| CLKSRC2 | CLKSRC1 | CLKSRC0 | Definition and Notes |
|---------|---------|---------|--|
| 0 | 0 | 0 | Reference input. |
| 0 | 0 | 1 | DIV1CLK/DIV1N. DIV1N is defined by register [OCH]. Allowable values for DIV1N are 4 to 127. If Divider Bank 1 is not being used, set DIV1N to 8. |
| 0 | 1 | 0 | DIV1CLK/2. Fixed /2 divider option. If this option is used, DIV1N must be divisible by 4. |
| 0 | 1 | 1 | DIV1CLK/3. Fixed /3 divider option. If this option is used, set DIV1N to 6. |
| 1 | 0 | 0 | DIV2CLK/DIV2N. DIV2N is defined by Register [47H]. Allowable values for DIV2N are 4 to 127. If Divider Bank 2 is not being used, set DIV2N to 8. |
| 1 | 0 | 1 | DIV2CLK/2. Fixed /2 divider option. If this option is used, DIV2N must be divisible by 4. |
| 1 | 1 | 0 | DIV2CLK/4. Fixed /4 divider option. If this option is used, DIV2N must be divisible by 8. |
| 1 | 1 | 1 | Reserved – do not use. |

CLKOE – Clock Output Enable Control [09H(5..0)]

Each clock output has its own output enable, controlled by register 09H(5..0). To enable an output, set the corresponding CLKOE bit to 1. CLKOE settings are in [Table 11](#).

The output swing of LCLK1 through LCLK4 is set by V_{DDL} . The output swing of CLK5 and CLK6 is set by V_{DD} .

Table 11. CLKOE Bit Setting

| Address | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|---------|----|----|------|------|-------|-------|-------|-------|
| 09H | 0 | 0 | CLK6 | CLK5 | LCLK4 | LCLK3 | LCLK2 | LCLK1 |

Test, Reserved, and Blank Registers

Writing to any of the following registers causes the part to exhibit abnormal behavior, as follows.

[00H to 08H] – Reserved
 [0AH to 0BH] – Reserved

[0DH to 11H] – Reserved
 [14H to 3FH] – Reserved
 [43H] – Reserved
 [48H to FFH] – Reserved.

Table 12. Clock Output Register Setting

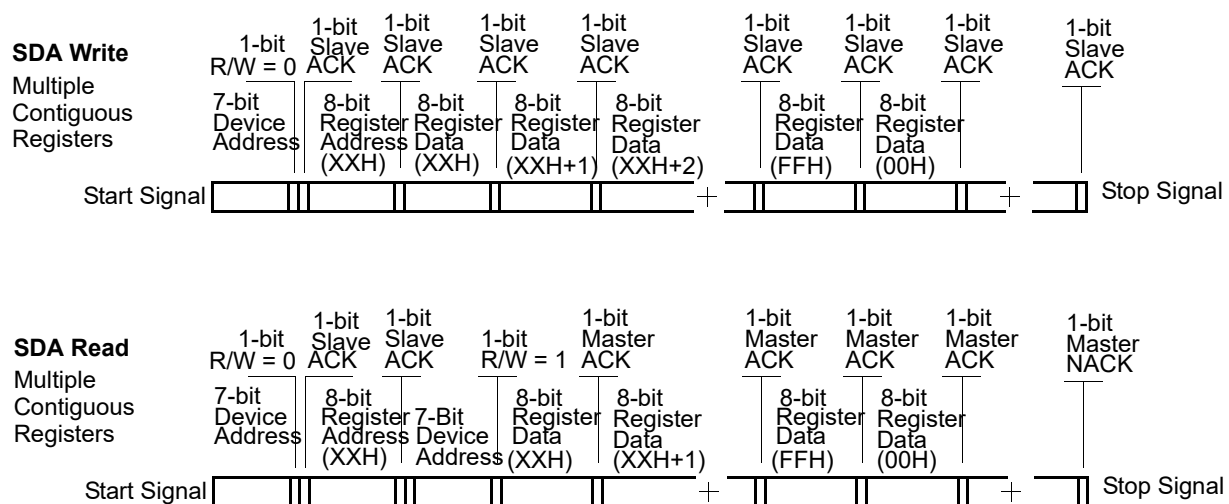
| Address | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|---------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|
| 44H | CLKSRC2 for LCLK1 | CLKSRC1 for LCLK1 | CLKSRC0 for LCLK1 | CLKSRC2 for LCLK2 | CLKSRC1 for LCLK2 | CLKSRC0 for LCLK2 | CLKSRC2 for LCLK3 | CLKSRC1 for LCLK3 |
| 45H | CLKSRC0 for LCLK3 | CLKSRC2 for LCLK4 | CLKSRC1 for LCLK4 | CLKSRC0 for LCLK4 | CLKSRC2 for CLK5 | CLKSRC1 for CLK5 | CLKSRC0 for CLK5 | CLKSRC2 for CLK6 |
| 46H | CLKSRC1 for CLK6 | CLKSRC0 for CLK6 | 1 | 1 | 1 | 1 | 1 | 1 |

I²C Interface Timing

The CY22150 uses a two-wire I²C-interface that operates up to 400 kbits/second in Read or Write mode. The basic Write serial format is as follows.

Start Bit; seven-bit Device Address (DA); R/W Bit; Slave Clock Acknowledge (ACK); eight-bit Memory Address (MA); ACK; eight-bit data; ACK; eight-bit data in MA + 1 if desired; ACK; eight-bit data in MA+2; ACK; and so on until STOP bit. The basic serial format is illustrated in [Figure 3](#).

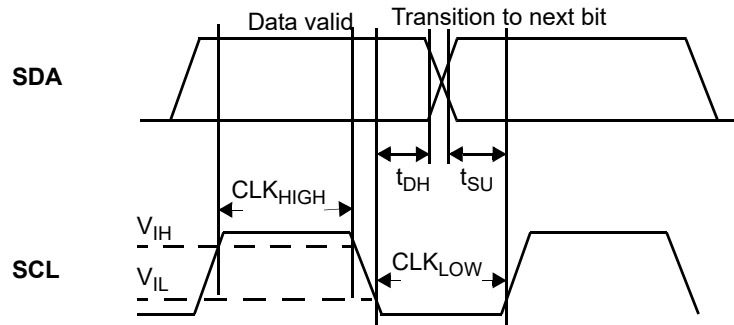
Figure 3. Data Frame Architecture



Data Valid

Data is valid when the Clock is HIGH, and may only be transitioned when the clock is LOW, as illustrated in Figure 4.

Figure 4. Data Valid and Data Transition Periods



Data Frame

Every new data frame is indicated by a start and stop sequence, as illustrated in Figure 5 on page 10.

Start Sequence – Start frame is indicated by SDA going LOW when SCL is HIGH. Every time a Start signal is given, the next eight-bit data must be the device address (seven bits) and a R/W

bit, followed by register address (eight bits) and register data (eight bits).

Stop Sequence – Stop frame is indicated by SDA going HIGH when SCL is HIGH. A Stop frame frees the bus for writing to another part on the same bus or writing to another random register address.

Figure 5. Start and Stop Frame

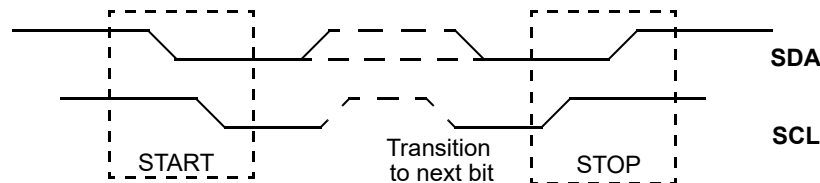
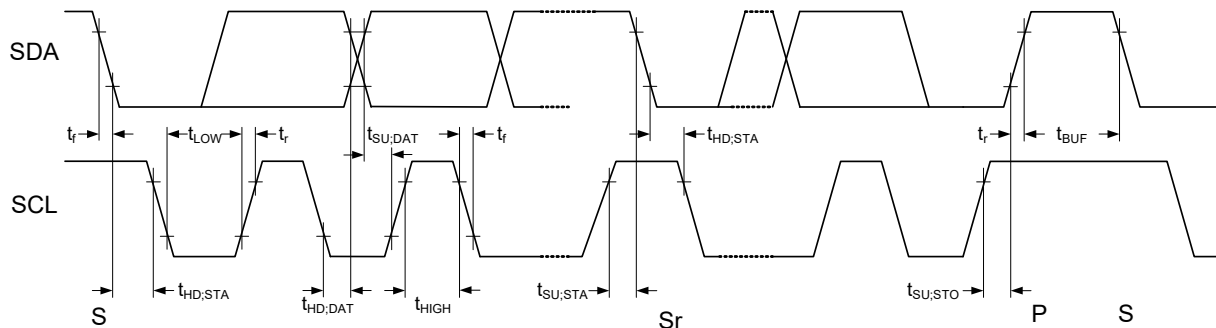


Figure 6. Definition for Timing on the Serial BUS

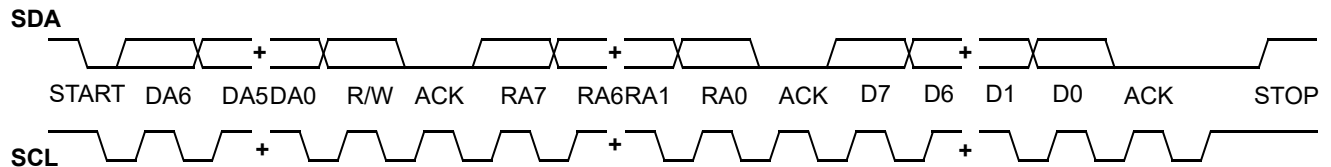


Acknowledge Pulse

During Write mode, the CY22150 responds with an ACK pulse after every eight bits. This is accomplished by pulling the SDA line LOW during the N*9th clock cycle, as illustrated in [Figure 7](#)

on [page 11](#). (N = the number of eight-bit segments transmitted.) During Read mode, the ACK pulse after the data packet is sent is generated by the master.

Figure 7. Frame Format (Device Address, R/W, Register Address, Register Data)



Serial Bus specifications

| Parameter | Description | Min | Max | Unit |
|---------------------|---|-----|-----|------|
| f _{SCL} | Frequency of SCL | – | 400 | kHz |
| t _{HD:STA} | Hold time START condition | 0.6 | – | μs |
| t _{LOW} | Low period of the SCK clock | 1.3 | – | μs |
| t _{HIGH} | High period of the SCK clock | 0.6 | – | μs |
| t _{SU:STA} | Setup time for a repeated START condition | 0.6 | – | μs |
| t _{DH} | Data hold (SCL LOW to data transition) | 100 | – | ns |
| t _{HD:DAT} | Data hold time | 100 | – | ns |
| t _{SU:DAT} | Data setup time | 100 | – | ns |
| t _R | Rise time | – | 300 | ns |
| t _F | Fall time | – | 300 | ns |
| t _{SU:STO} | Setup time for STOP condition | 0.6 | – | μs |
| t _{BUF} | Bus-free time between STOP and START conditions | 1.3 | – | μs |

Applications

Controlling Jitter

Jitter is defined in many ways including: phase noise, long term jitter, cycle to cycle jitter, period jitter, absolute jitter, and deterministic. These jitter terms are usually given in terms of rms, peak to peak, or in the case of phase noise dBC/Hz with respect to the fundamental frequency.

Power supply noise and clock output loading are two major system sources of clock jitter. Power supply noise is mitigated by proper power supply decoupling (0.1 μ F ceramic cap 0.25") of the clock and ensuring a low impedance ground to the chip. Reducing capacitive clock output loading to a minimum lowers current spikes on the clock edges and thus reduces jitter.

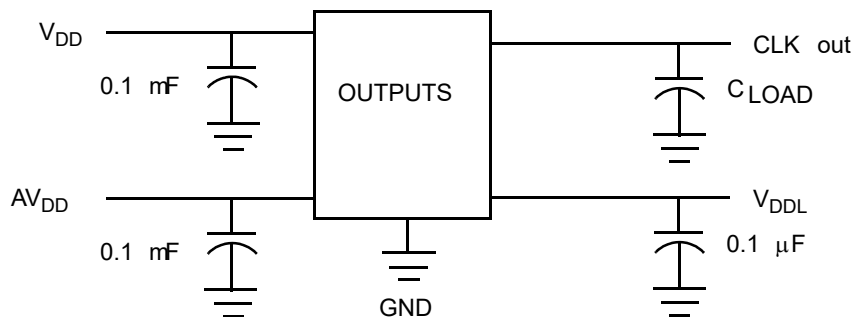
Reducing the total number of active outputs also reduce jitter in a linear fashion. However, it is better to use two outputs to drive two loads than one output to drive two loads.

The rate and magnitude that the PLL corrects the VCO frequency is directly related to jitter performance. If the rate is too slow, then long term jitter and phase noise is poor. Therefore, to improve long term jitter and phase noise, reducing Q to a minimum is advisable. This technique increases the speed of the Phase Frequency Detector which in turn drive the input voltage of the VCO. In a similar manner increasing P till the VCO is near its maximum rated speed also decreases long term jitter and phase noise. For example: Input Reference of 12 MHz; desired output frequency of 33.3 MHz. The following solution is possible: Set Q = 3, P = 25, Post Div = 3. However, the best jitter results is Q = 2, P = 50, Post Div = 9.

For more information, contact your local Cypress field applications engineer.

Test Circuit

Figure 8. Test Circuit



Absolute Maximum Conditions

| Parameter | Description | Min | Max | Unit |
|-----------|--|-----------------|-----------------|------|
| V_{DD} | Supply Voltage | -0.5 | 7.0 | V |
| V_{DDL} | I/O Supply Voltage | -0.5 | 7.0 | V |
| T_S | Storage Temperature ^[2] | -65 | 125 | °C |
| T_J | Junction Temperature | – | 125 | °C |
| | Package Power Dissipation – Commercial Temperature | – | 450 | mW |
| | Package Power Dissipation – Industrial Temperature | – | 380 | mW |
| | Digital Inputs | $AV_{SS} - 0.3$ | $AV_{DD} + 0.3$ | V |
| | Digital Outputs Referred to V_{DD} | $V_{SS} - 0.3$ | $V_{DD} + 0.3$ | V |
| | Digital Outputs Referred to V_{DDL} | $V_{SS} - 0.3$ | $V_{DDL} + 0.3$ | V |
| ESD | Static Discharge Voltage per MIL-STD-883C, Method 3015 | – | 2000 | V |

Recommended Operating Conditions

| Parameter | Description | Min | Typ | Max | Unit |
|---------------------|---|-------|-----|-------|------|
| V_{DD} | Operating Voltage | 3.135 | 3.3 | 3.465 | V |
| $V_{DDL_HI}^{[3]}$ | Operating Voltage | 3.135 | 3.3 | 3.465 | V |
| $V_{DDL_LO}^{[3]}$ | Operating Voltage | 2.375 | 2.5 | 2.625 | V |
| T_{AC} | Ambient Commercial Temp | 0 | – | 70 | °C |
| T_{AI} | Ambient Industrial Temp | -40 | – | 85 | °C |
| C_{LOAD} | Max. Load Capacitance, $V_{DD}/V_{DDL} = 3.3$ V | – | – | 15 | pF |
| C_{LOAD} | Max. Load Capacitance, $V_{DDL} = 2.5$ V | – | – | 15 | pF |
| f_{REFD} | Driven REF | 1 | – | 133 | MHz |
| f_{REFC} | Crystal REF | 8 | – | 30 | MHz |
| t_{PU} | Power up time for all VDDs to reach minimum specified voltage (power ramps must be monotonic) | 0.05 | – | 500 | ms |

Notes

- Rated for 10 years.
- V_{DDL} is only specified and characterized at $3.3 \text{ V} \pm 5\%$ and $2.5 \text{ V} \pm 5\%$. V_{DDL} may be powered at any value between 3.465 V and 2.375 V.

DC Electrical Characteristics

| Parameter ^[4] | Description | Conditions | Min | Typ | Max | Unit |
|--------------------------|--|--|------|-----|-----|---------------|
| $I_{OH3.3}$ | Output High Current | $V_{OH} = V_{DD} - 0.5\text{ V}$, $V_{DD}/V_{DDL} = 3.3\text{ V}$ (sink) | 12 | 24 | – | mA |
| $I_{OL3.3}$ | Output Low Current | $V_{OL} = 0.5\text{ V}$, $V_{DD}/V_{DDL} = 3.3\text{ V}$ (source) | 12 | 24 | – | mA |
| $I_{OH2.5}$ | Output High Current | $V_{OH} = V_{DDL} - 0.5\text{ V}$, $V_{DDL} = 2.5\text{ V}$ (source) | 8 | 16 | – | mA |
| $I_{OL2.5}$ | Output Low Current | $V_{OL} = 0.5\text{ V}$, $V_{DDL} = 2.5\text{ V}$ (sink) | 8 | 16 | – | mA |
| V_{IH} | Input High Voltage | CMOS levels, 70% of V_{DD} | 0.7 | – | – | V_{DD} |
| V_{IL} | Input Low Voltage | CMOS levels, 30% of V_{DD} | – | – | 0.3 | V_{DD} |
| C_{IN} | Input Capacitance | SCL and SDA Pins | – | – | 7 | pF |
| I_{IZ} | Input Leakage Current | SCL and SDA Pins | – | 5 | – | μA |
| V_{HYS} | Hysteresis of Schmitt triggered inputs | SCL and SDA Pins | 0.05 | – | – | V_{DD} |
| $I_{VDD}^{[5, 6]}$ | Supply Current | AV_{DD}/V_{DD} Current | – | 45 | – | mA |
| $I_{VDDL3.3}^{[5, 6]}$ | Supply Current | V_{DDL} Current ($V_{DDL} = 3.465\text{ V}$) | – | 25 | – | mA |
| $I_{VDDL2.5}^{[5, 6]}$ | Supply Current | V_{DDL} Current ($V_{DDL} = 2.625\text{ V}$) | – | 17 | – | mA |

Device Characteristics

| Parameter | Description | Value | Unit |
|---------------|------------------|--------|----------------------|
| θ_{JA} | Theta JA | 115 | $^{\circ}\text{C/W}$ |
| Complexity | Transistor Count | 74,600 | Transistors |

Notes

4. Not 100% tested.
5. I_{VDD} currents specified for two CLK outputs running at 125 MHz, two LCLK outputs running at 80 MHz, and two LCLK outputs running at 66.6 MHz.
6. Use CyClocksRT to calculate actual I_{VDD} and I_{VDDL} for specific output frequency configurations.

AC Electrical Characteristics

| Parameter ^[7] | Description | Conditions | Min | Typ | Max | Unit |
|--------------------------|--|--|---------------|------|-------|------|
| t1 | Output Frequency, Commercial Temperature | Clock output limit, 3.3 V | 0.08 (80 kHz) | – | 200 | MHz |
| | | Clock output limit, 2.5 V | 0.08 (80 kHz) | – | 166.6 | MHz |
| | Output Frequency, Industrial Temperature | Clock output limit, 3.3 V | 0.08 (80 kHz) | – | 166.6 | MHz |
| | | Clock output limit, 2.5 V | 0.08 (80 kHz) | – | 150 | MHz |
| t2 _{LO} | Output Duty Cycle | Duty cycle is defined in Figure 9 on page 16 ; t1/t2, f _{OUT} < 166 MHz, 50% of V _{DD} | 45 | 50 | 55 | % |
| t2 _{HI} | Output Duty Cycle | Duty cycle is defined in Figure 9 ; t1/t2, f _{OUT} > 166 MHz, 50% of V _{DD} | 40 | 50 | 60 | % |
| t3 _{LO} | Rising Edge Slew Rate (V _{DDL} = 2.5 V) | Output clock rise time, 20% to 80% of V _{DDL} . Defined in Figure 10 | 0.6 | 1.2 | – | V/ns |
| t4 _{LO} | Falling Edge Slew Rate (V _{DDL} = 2.5 V) | Output clock fall time, 80% to 20% of V _{DDL} . Defined in Figure 10 | 0.6 | 1.2 | – | V/ns |
| t3 _{HI} | Rising Edge Slew Rate (V _{DDL} = 3.3 V) | Output clock rise time, 20% to 80% of V _{DD} /V _{DDL} . Defined in Figure 10 | 0.8 | 1.4 | – | V/ns |
| t4 _{HI} | Falling Edge Slew Rate (V _{DDL} = 3.3 V) | Output clock fall time, 80% to 20% of V _{DD} /V _{DDL} . Defined in Figure 10 | 0.8 | 1.4 | – | V/ns |
| t5 ^[8] | Skew | Output-output skew between related outputs | – | – | 250 | ps |
| t6 ^[9] | Clock Jitter | Peak-to-peak period jitter | – | 250 | – | ps |
| t10 | PLL Lock Time | | – | 0.30 | 3 | ms |

Notes

7. Not 100% tested, guaranteed by design.

8. Skew value guaranteed when outputs are generated from the same divider bank. See [Logic Block Diagram on page 1](#) for more information.

9. Jitter measurements vary. Actual jitter is dependent on XIN jitter and edge rate, number of active outputs, output frequencies, V_{DDL}, (2.5 V or 3.3 V jitter).

Figure 9. Duty Cycle Definition; $DC = t_2/t_1$

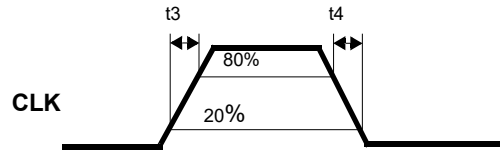


Figure 10. Rise and Fall Time Definitions

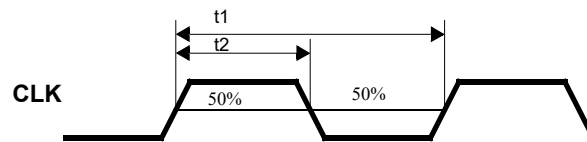
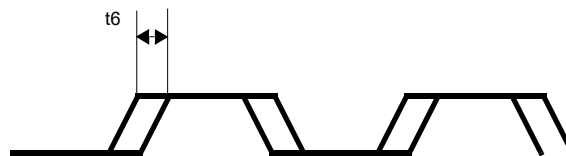


Figure 11. Peak-to-Peak Jitter



Ordering Information

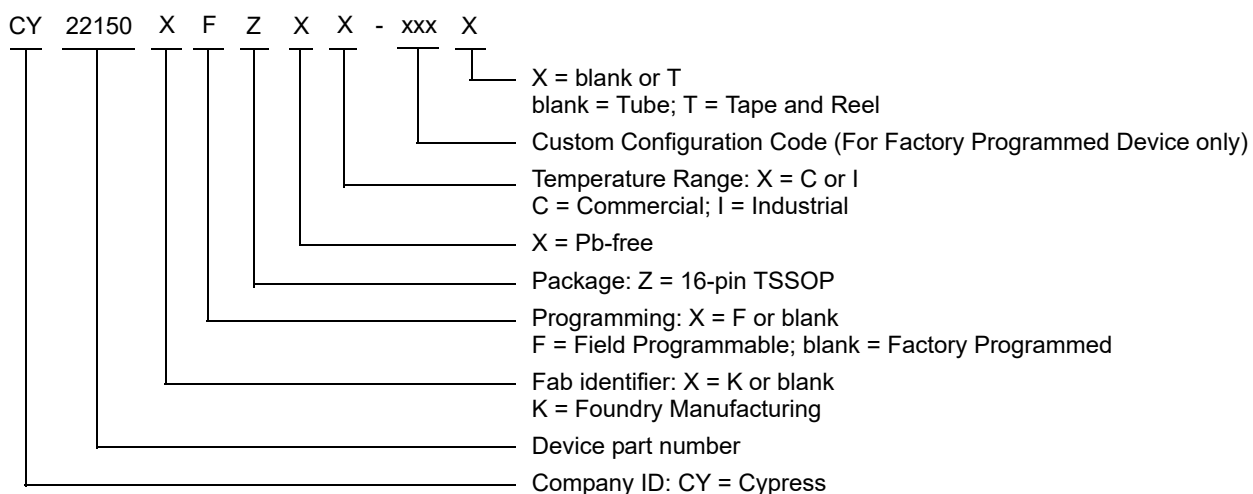
| Ordering Code | Package Type | Operating Range | Operating Voltage |
|-------------------|---------------------------------------|------------------------------|-------------------|
| Pb-free | | | |
| CY22150KFZXC | 16-pin TSSOP | Commercial (0 °C to 70 °C) | 3.3 V |
| CY22150KFZXCT | 16-pin TSSOP – Tape and Reel | Commercial (0 °C to 70 °C) | 3.3 V |
| CY22150FZXC | 16-pin TSSOP | Commercial (0 °C to 70 °C) | 3.3 V |
| CY22150FZXCT | 16-pin TSSOP – Tape and Reel | Commercial (0 °C to 70 °C) | 3.3 V |
| CY22150FZXI | 16-pin TSSOP | Industrial (–40 °C to 85 °C) | 3.3 V |
| CY22150FZXIT | 16-pin TSSOP – Tape and Reel | Industrial (–40 °C to 85 °C) | 3.3 V |
| Programmer | | | |
| CY3672-USB | Programmer with USB interface | | |
| CY3695 | CY22150 Adapter Socket for CY3672-USB | | |

Some product offerings are factory programmed customer specific devices with customized part numbers. The Possible Configurations table shows the available device types, but not complete part numbers. Contact your local Cypress FAE or Sales Representative for more information.

Possible Configurations

| Ordering Code | Package Type | Operating Range | Operating Voltage |
|---------------------------------|------------------------------|------------------------------|-------------------|
| CY22150ZXC-xxx ^[10] | 16-pin TSSOP | Commercial (0 °C to 70 °C) | 3.3 V |
| CY22150ZXC-xxxT ^[10] | 16-pin TSSOP – Tape and Reel | Commercial (0 °C to 70 °C) | 3.3 V |
| CY22150ZXI-xxx ^[10] | 16-pin TSSOP | Industrial (–40 °C to 85 °C) | 3.3 V |
| CY22150ZXI-xxxT ^[10] | 16-pin TSSOP – Tape and Reel | Industrial (–40 °C to 85 °C) | 3.3 V |

Ordering Code Definitions

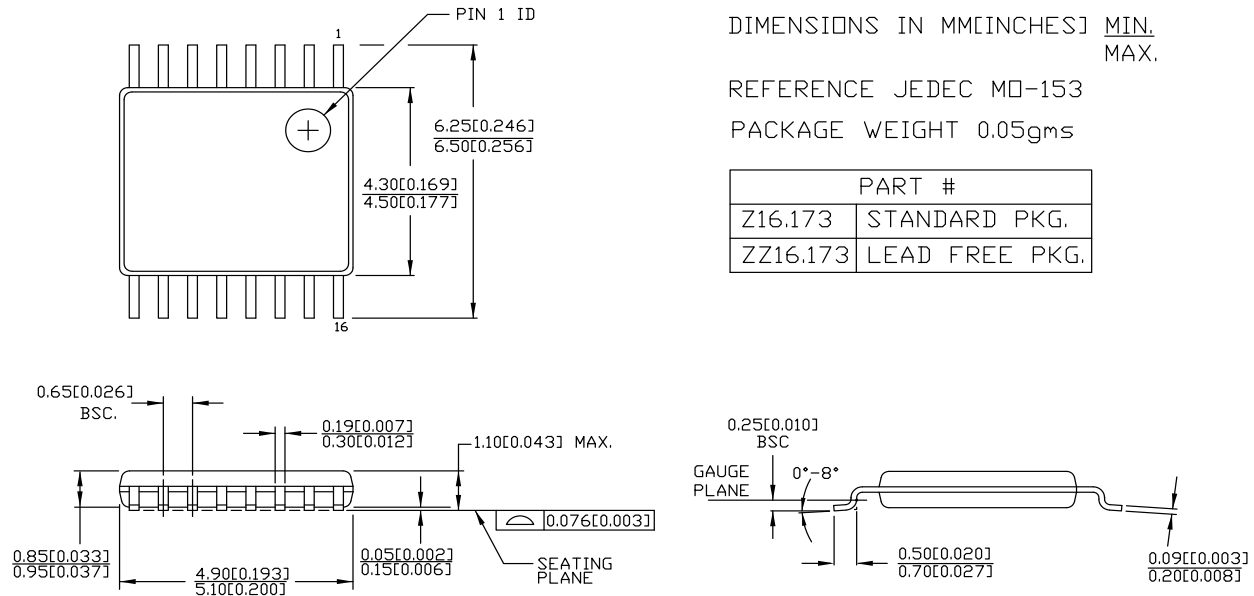


Notes

10. The CY22150ZC-xxx and CY22150ZI-xxx are factory programmed configurations. Factory programming is available for high volume design opportunities of 100 Ku/year or more in production. For more details, contact your local Cypress FAE or Cypress Sales Representative.

Package Diagram

Figure 12. 16-pin TSSOP (4.40 mm Body) Package Outline, 51-85091



51-85091 *E

Acronyms

Table 13. Acronyms Used in this Document

| Acronym | Description | Acronym | Description |
|---------|---|---------|-----------------------------------|
| ACK | Acknowledge | LSB | Least Significant Bit |
| BSC | Basic Spacing between Centers | MA | Memory Address |
| CLKOE | Clock Output Enable | MSB | Most Significant Bit |
| CMOS | Complementary Metal Oxide Semiconductor | PFD | Phase Frequency Detector |
| DA | Device Address | PLL | Phase Locked Loop |
| ESD | Electrostatic Discharge | SCL | Serial interface Clock |
| ESR | Equivalent Series Resistance | SDA | Serial interface Data |
| FAE | Field Applications Engineer | TSSOP | Thin Shrunk Small Outline Package |
| I/O | Input / Output | USB | Universal Serial Bus |
| I2C | Inter Integrated Circuit | VCO | Voltage-Controlled Oscillator |
| JEDEC | Joint Electron Device Engineering Council | | |

Document Conventions

Units of Measure

Table 14. Units of Measure

| Symbol | Unit of Measure | Symbol | Unit of Measure |
|--------|--|--------|-------------------------------|
| °C | degree Celsius | μVrms | microvolts root-mean-square |
| dB | decibel | μW | microwatt |
| dBc/Hz | decibels relative to the carrier per Hertz | mA | milliampere |
| fC | femtocoulomb | mm | millimeter |
| fF | femtofarad | ms | millisecond |
| Hz | hertz | mV | millivolt |
| KB | 1024 bytes | nA | nanoampere |
| Kbit | 1024 bits | ns | nanosecond |
| kHz | kilohertz | nV | nano volt |
| kΩ | kilohm | Ω | ohm |
| MHz | megahertz | pA | picoampere |
| MΩ | megaohm | pF | picofarad |
| μA | microampere | pp | peak-to-peak |
| μF | microfarad | ppm | parts per million |
| μH | microhenry | ps | picosecond |
| μs | microsecond | sps | samples per second |
| μV | microvolt | σ | sigma: one standard deviation |

Document History Page

| Document Title: CY22150, One-PLL General-Purpose Flash-Programmable and I ² C Programmable Clock Generator Document Number: 38-07104 | | | | |
|--|---------|-----------------|-----------------|--|
| Revision | ECN | Orig. of Change | Submission Date | Description of Change |
| ** | 107498 | CKN | 08/08/2001 | New data sheet. |
| *A | 110043 | CKN | 02/06/2002 | Changed status from Preliminary to Final. Added Package Diagram . |
| *B | 113514 | CKN | 05/01/2002 | Updated Functional Overview : Updated I2C Interface Timing : Updated Acknowledge Pulse : Updated Figure 7 (Removed overline in "Register Address, Register Data" in caption). Updated Serial Bus specifications : Changed unit of CLK _{HIGH} parameter from ns to μ s. Updated DC Electrical Characteristics : Updated details in "Description" column (Added (sink) at the end for I _{OH3.3} and I _{OL2.5} parameters, added (source) at the end for I _{OL3.3} and I _{OH2.5} parameters). |
| *C | 121868 | RBI | 12/14/2002 | Updated Absolute Maximum Conditions : Added t _{PU} parameter and its details. |
| *D | 125453 | CKN | 05/19/2003 | Updated Functional Overview : Updated Frequency Calculations and Register Definitions using the I2C Interface : Updated Table 1 : Replaced 0 with 1 corresponding to D5 of 12H register. Updated Reference Frequency : Updated description (Reworded and reformatted Programmable Crystal Input Oscillator Gain Settings text). Updated Table 3 : Replaced 0 with 1 corresponding to D5 of 12H register. |
| *E | 242808 | RGL | 07/15/2004 | Minor Change: Fixed the broken line in the block diagram |
| *F | 252352 | RGL | 08/11/2004 | Updated Functional Overview : Updated Frequency Calculations and Register Definitions using the I2C Interface : Updated Reference Frequency : Updated Table 2 . Updated Package Diagram : spec 51-85091 – Changed revision from ** to *A. |
| *G | 296084 | RGL | 12/06/2004 | Updated Ordering Information : Updated part numbers (Added Pb-free devices). |
| *H | 2440846 | AESA | 04/25/2008 | Updated Ordering Information : Added Note "Not recommended for new designs." Updated part numbers (Added part numbers CY22150KFC, CY22150KFCT, CY22150KFI, CY22150KFZXC, CY22150KFZXCT, CY22150KFZXI, CY22150KFZXIT, CY22150KZXI-xxxT, and CY22150KZI-xxxT). Replaced Lead Free with Pb-free. Updated to new template. |
| *I | 2649578 | KVM / PYRS | 01/29/2009 | Updated Ordering Information : Removed reference of Note "Not recommended for new designs" for the following parts: CY22150KFC, CY22150KFCT, CY22150KFI. Updated part numbers (Added CY22150KZI-xxx and removed CY22150ZC-xxx, CY22150ZC-xxxT and CY22150ZI-xxx). Replaced CY3672 with CY3672-USB, and moved to the bottom of the table. |

Document History Page (continued)

| Document Title: CY22150, One-PLL General-Purpose Flash-Programmable and I ² C Programmable Clock Generator Document Number: 38-07104 | | | | |
|--|---------|-----------------|-----------------|--|
| Revision | ECN | Orig. of Change | Submission Date | Description of Change |
| *J | 2900690 | KVM | 03/29/2010 | Changed title from "One-PLL General-Purpose Flash-Programmable and 2-Wire Serially Programmable Clock Generator" to "One-PLL General-Purpose Flash-Programmable and I ² C Programmable Clock Generator". Updated Features : Replaced "Serial Programming Interface (SPI)" with "I ² C Interface". Updated Selection Guide . Updated Logic Block Diagram : Replaced "Serial Programming Interface (SPI)" with "I ² C Interface". Updated Ordering Information : Updated part numbers (Removed inactive parts). Added Possible Configurations . Updated Package Diagram : spec 51-85091 – Changed revision from *A to *B. |
| *K | 3210225 | CXQ | 03/30/2011 | Updated Functional Overview : Updated I²C Interface Timing : Updated Acknowledge Pulse : Updated Figure 7 . Updated Serial Bus specifications : Changed minimum value of t _{DH} parameter from 0 ns to 100 ns. Updated Ordering Information : No change in part numbers. Added Ordering Code Definitions . Updated Package Diagram : spec 51-85091 – Changed revision from *B to *C. Added Acronyms and Units of Measure . Completing Sunset Review. |
| *L | 3402048 | AJU | 10/11/2011 | Updated Ordering Information : Updated part numbers. Updated Package Diagram : spec 51-85091 – Changed revision from *C to *D. |
| *M | 3846671 | PURU | 12/19/2012 | Updated Ordering Information : Updated Possible Configurations : Updated part numbers (Removed all Non-K Devices and added K Devices). |
| *N | 4379249 | AJU | 05/14/2014 | Updated to new template. Completing Sunset Review. |
| *O | 4575273 | AJU | 11/20/2014 | Updated Functional Description : Added "For a complete list of related documentation, click here ." at the end. Updated Package Diagram : spec 51-85091 – Changed revision from *D to *E. |
| *P | 5240950 | TAVA | 05/04/2016 | Updated Functional Overview : Updated I²C Interface Timing : Updated Figure 3 . Updated Data Frame : Added Figure 6 . Updated Serial Bus specifications : Updated entire table. Updated Ordering Information : Updated Possible Configurations : Updated part numbers (Updated details in "Ordering Code" column). Updated to new template. Completing Sunset Review. |

Document History Page (continued)

| Document Title: CY22150, One-PLL General-Purpose Flash-Programmable and I ² C Programmable Clock Generator Document Number: 38-07104 | | | | |
|--|---------|-----------------|-----------------|--|
| Revision | ECN | Orig. of Change | Submission Date | Description of Change |
| *Q | 5747984 | TAVA / PSR | 05/25/2017 | Replaced "SDAT" with "SDA" in all instances across the document. Replaced "SCLK" with "SCL" in all instances across the document. Updated Pin Definitions : Replaced "Input" with "Input/Output" in description column corresponding to "SDA" pin. Updated Functional Overview : Updated Default Startup Condition for the CY22150 : Updated description. Updated Ordering Information : Updated part numbers. Updated to new template. |
| *R | 6213085 | XHT | 06/20/2018 | Updated to new template. Completing Sunset Review. |

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