



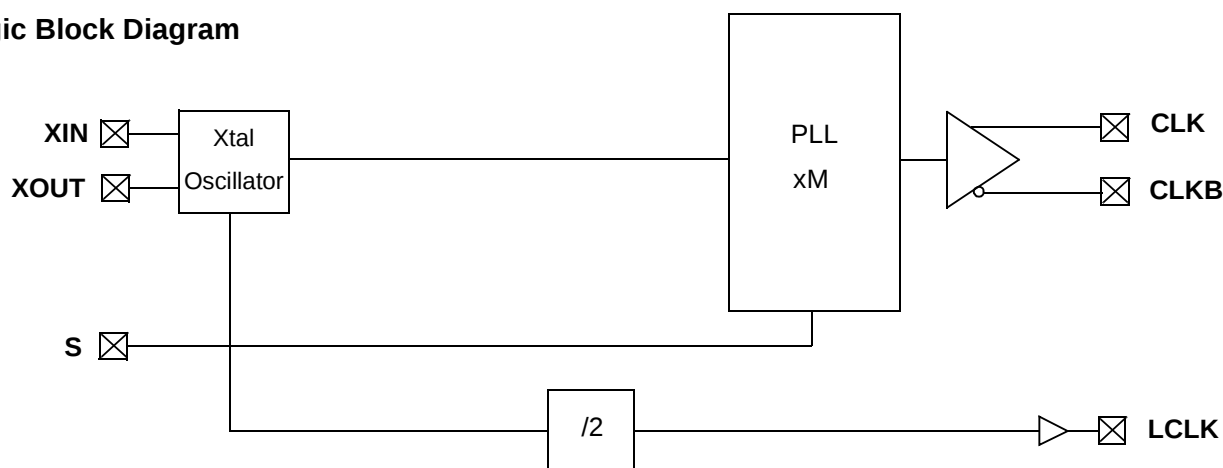
CYPRESS

CY2212

# Direct Rambus™ Clock Generator (Lite)

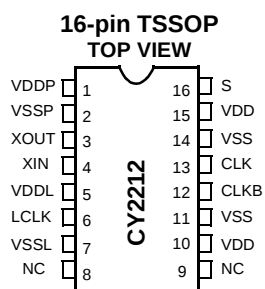
| Features                            | Benefits                                             |
|-------------------------------------|------------------------------------------------------|
| • Direct Rambus™ Clock Support      | One pair of differential output drivers              |
| • High-speed Clock Support          | 400-MHz maximum, 300-MHz minimum output frequency    |
| • Input Select Option               | PLL multiplier select                                |
| • Crystal Oscillator Divider Output | LCLK = XTAL/2, not driven by phase-locked loop (PLL) |
| • Output edge-rate control          | Minimize EMI                                         |
| • 16-pin TSSOP                      | Space-saving, low-cost package                       |

## Logic Block Diagram



Xtal Value = 18.75 MHz

## Pin Configuration



## Frequency Select Table

| S | M (PLL Multiplier) | CLK,CLKB | LCLK      |
|---|--------------------|----------|-----------|
| 0 | 16                 | 300 MHz  | 9.375 MHz |
| 1 | 64/3               | 400 MHz  | 9.375 MHz |

## Pin Description

| Name | Pin | Description                                            |
|------|-----|--------------------------------------------------------|
| VDDP | 1   | 3.3V Power Supply for PLL                              |
| VSSP | 2   | Ground for PLL                                         |
| XOUT | 3   | Reference Crystal Feedback                             |
| XIN  | 4   | Reference Crystal Input                                |
| VDDL | 5   | 1.8V Power Supply for LCLK                             |
| LCLK | 6   | LVC MOS Output, x1/2 Crystal Frequency                 |
| VSSL | 7   | Ground for LCLK                                        |
| NC   | 8   | No Connect (Reserved for Test Mode)                    |
| NC   | 9   | No Connect (Reserved for Test Mode)                    |
| VDD  | 10  | 3.3V Power Supply                                      |
| VSS  | 11  | Ground                                                 |
| CLKB | 12  | Output Clock (complement), Connect to Rambus Channel   |
| CLK  | 13  | Output Clock, Connect to Rambus Channel                |
| VSS  | 14  | Ground                                                 |
| VDD  | 15  | 3.3V Power Supply                                      |
| S    | 16  | PLL Multiplier Select Input, Pull-up Resistor Internal |

## Absolute Maximum Conditions

| Parameter    | Description                                                              | Min. | Max.            | Unit |
|--------------|--------------------------------------------------------------------------|------|-----------------|------|
| $V_{DD,ABS}$ | Max. voltage on $V_{DD}$ , $V_{DDP}$ or $V_{DDL}$ with respect to ground | -0.5 | 4.0             | V    |
| $V_{I,ABS}$  | Max. voltage on any pin with respect to ground                           | -0.5 | $V_{DD} + 0.5$  | V    |
| $V_{IL,ABS}$ | Max. voltage on LCLK with respect to ground                              | -0.5 | $V_{DDL} + 0.5$ | V    |

## Crystal Requirements

These are the requirements for the recommended crystal to be used with the CY2212 DRCG Lite clock source. The crystal type is parallel resonant. The mode is fundamental. Internal capacitors will not be implemented in the crystal oscillator circuit. External capacitors will be needed.

| Parameter   | Description                               | Min.    | Max.  | Unit       |
|-------------|-------------------------------------------|---------|-------|------------|
| $X_F$       | Frequency                                 | 14.0625 | 18.75 | MHz        |
| $X_{FTOL}$  | Frequency Tolerance <sup>[1]</sup>        | -15     | 15    | ppm        |
| $X_{EQRES}$ | Equivalent Resistance <sup>[2]</sup>      |         | 100   | $\Omega$   |
| $X_{TEMP}$  | Temperature Drift <sup>[3]</sup>          |         | 10    | ppm        |
| $X_{DRIVE}$ | Drive Level                               | 0.01    | 1500  | $\mu W$    |
| $X_{MI}$    | Motional Inductance                       | 20.7    | 25.3  | mH         |
| $X_{IR}$    | Insulation Resistance                     | 500     |       | M $\Omega$ |
| $X_{SAR}$   | Spurious Attenuation Ratio <sup>[4]</sup> | 3       |       | dB         |
| $X_{OS}$    | Overtone Spurious                         | 8       |       | dB         |

### Notes:

1. At 25°C  $\pm$  3°C.
2. CL = 10 pF.
3. -10°C to 75°C.
4. At  $X_F \pm$  500 kHz.

## DC Electrical Specifications

| Parameter | Description                        | Min. | Max. | Unit       |
|-----------|------------------------------------|------|------|------------|
| $V_{DD}$  | Supply voltage                     | 3.04 | 3.56 | V          |
| $V_{DDL}$ | LCLK supply voltage                | 1.7  | 2.1  | V          |
| $T_A$     | Ambient operating temperature      | 0    | 70   | °C         |
| $V_{IL}$  | Input signal low voltage at pin S  |      | 0.35 | $V_{DD}$   |
| $V_{IH}$  | Input signal high voltage at pin S | 0.65 |      | $V_{DD}$   |
| $R_{PUP}$ | Internal pull-up resistance        | 10   | 100  | k $\Omega$ |

## AC Electrical Specifications

| Parameter     | Description                                     | Min.    | Max.  | Unit |
|---------------|-------------------------------------------------|---------|-------|------|
| $f_{XTAL,IN}$ | Input frequency at crystal input <sup>[5]</sup> | 14.0625 | 18.75 | MHz  |
| $C_{IN,CMOS}$ | Input capacitance at S pin <sup>[6]</sup>       |         | 10    | pF   |

## DC Device Specifications

| Parameter | Description                                            | Min.              | Max.      | Unit     |
|-----------|--------------------------------------------------------|-------------------|-----------|----------|
| $V_{CM}$  | Differential output common-mode voltage                | 1.35              | 1.75      | V        |
| $V_X$     | Differential output crossing-point voltage             | 1.25              | 1.85      | V        |
| $V_{COS}$ | Output voltage swing (p-p single-ended) <sup>[7]</sup> | 0.4               | 0.7       | V        |
| $V_{COH}$ | Output high voltage                                    |                   | 2.1       | V        |
| $V_{COL}$ | Output low voltage                                     | 1.0               |           | V        |
| $r_{OUT}$ | Output dynamic resistance (at pins) <sup>[8]</sup>     | 12                | 50        | $\Omega$ |
| $V_{LOH}$ | LCLK Output high voltage at $I_{OH} = -10$ mA          | $V_{DDL} - 0.45V$ | $V_{DDL}$ | V        |
| $V_{LOL}$ | LCLK Output low voltage at $I_{OL} = 10$ mA            | 0                 | 0.45      | V        |

## State Transition Characteristics

Specifies the maximum settling time of the CLK, CLKB, and LCLK outputs from device power-up. For  $V_{DD}$ ,  $V_{DDP}$ , and  $V_{DDL}$  any sequences are allowed to power-up and power-down the CY2212 DRCG-Lite.

| From                        | To                   | Transition Latency | Description                                                                                |
|-----------------------------|----------------------|--------------------|--------------------------------------------------------------------------------------------|
| $V_{DD}/V_{DDL}/V_{DDP}$ On | CLK/CLKB/LCLK Normal | 3 ms               | Time from $V_{DD}/V_{DDL}/V_{DDP}$ is applied and settled to CLK/CLKB/LCLK outputs settled |

## AC Device Specifications

| Parameter    | Description                                            | Min. | Max. | Unit        |
|--------------|--------------------------------------------------------|------|------|-------------|
| $t_{CYCLE}$  | Clock cycle time                                       | 2.5  | 3.33 | ns          |
| $t_j$        | Jitter over 1–6 clock cycles at 400 MHz <sup>[9]</sup> |      | 100  | ps          |
|              | Jitter over 1–6 clock cycles at 300 MHz <sup>[9]</sup> |      | 140  | ps          |
| $t_{JL}$     | Long-term jitter at 400 MHz                            |      | 300  | ps          |
|              | Long-term jitter at 300 MHz                            |      | 400  | ps          |
| DC           | Long-term average output duty cycle                    | 45%  | 55%  | $t_{CYCLE}$ |
| $t_{DC,ERR}$ | Cycle-cycle duty cycle error at 400 MHz                |      | 50   | ps          |
|              | Cycle-cycle duty cycle error at 300 MHz                |      | 70   | ps          |

### Notes:

- Nominal condition with 18.75-MHz crystal.
- Capacitance measured at Freq = 1 MHz, DC Bias = 0.9 V, and VAC < 100 mV.
- $V_{COS} = V_{OH} - V_{OL}$ .
- $r_{OUT} = \Delta V_O / \Delta I_O$ . This is defined at the output pins, not at the measurement point of Figure 3.
- Output short-term jitter specification is peak-peak and defined in Figure 10.

**AC Device Specifications** (continued)

| Parameter        | Description                                                                                | Min.              | Max.              | Unit          |
|------------------|--------------------------------------------------------------------------------------------|-------------------|-------------------|---------------|
| $t_{CR}, t_{CF}$ | Output rise and fall times (measured at 20%–80% of output voltage)                         | 250               | 500               | ps            |
| $t_{CR, CF}$     | Difference between output rise and fall times on the same pin of a single device (20%–80%) |                   | 100               | ps            |
| $BW_{LOOP}$      | PLL loop bandwidth                                                                         | 50 kHz<br>(–3 dB) | 8 MHz<br>(–20 dB) |               |
| $t_{CYCLE,L}$    | LCLK clock cycle time                                                                      | 106.6             | 142.2             | ns            |
| $t_{LR}, t_{LF}$ | LCLK output rise and fall time                                                             |                   | 1                 | ns            |
| $t_{JC,L}$       | LCLK cycle jitter <sup>[10]</sup>                                                          | –0.8              | 0.8               | ns            |
| $t_{J10,L}$      | LCLK 10-cycle jitter <sup>[10,11]</sup>                                                    | $-1.1 * t_{JC,L}$ | $1.1 * t_{JC,L}$  | ns            |
| $DC_L$           | LCLK output duty cycle                                                                     | 40%               | 60%               | $t_{CYCLE,L}$ |

**Functional Specifications**

This section gives the detailed functional specifications of the device physical layer. These specifications refer to the logical and physical interfaces.

**Crystal Input**

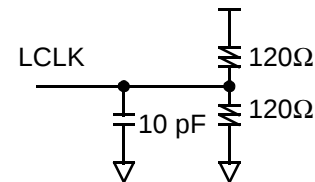
The CY2212 receives its reference from an external crystal. Pin XIN is the reference crystal input, and pin XOUT is the reference crystal feedback. The parameters for the crystal are given on page 3 of this data sheet.

**Select Input**

There is only one select input, pin S. This pin selects the frequency multiplier in the PLL, and is a standard LVCMOS input. The S pin has an internal pull-up resistor. The multiplier selection is given on page 1 of this data sheet.

**LCLK Output Driver**

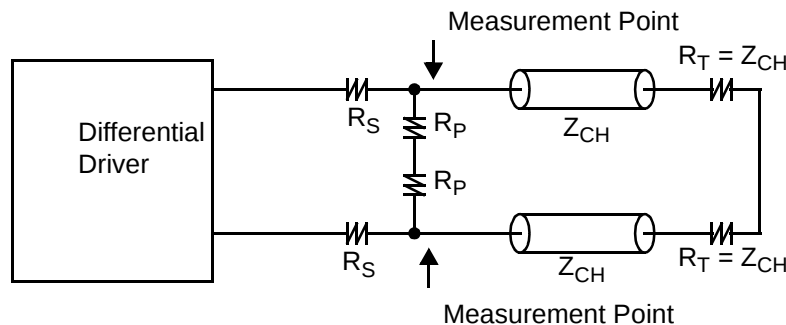
In addition to the Rambus clock driver outputs, there is another clock output driver. The LCLK driver is a standard LVCMOS output driver. *Figure 1* below shows the LCLK output driver load circuit.



**Figure 1. LCLK Test Load Circuit**

**RSL Clock Output Driver**

*Figure 2* shows the clock driver equivalent circuit.



**Figure 2. Equivalent Circuit**

The differential driver has a low output impedance in the range of about 20 ohms. The driver also produces a specified voltage swing on the channel. The nominal value of the channel impedance,  $Z_{CH}$ , is 28 ohms. Series resistor  $R_S$  and parallel resistor  $R_P$  are used to set the voltage swing on the channel. The driver output characteristics are defined together with the external components, and the output clock is specified at the measurement point indicated in *Figure 2*. The complete set of external components for the output driver, including edge-rate filter capacitors required for system operation, are shown in *Figure 3*. The values for the external components are given in *Table 1*.

**Notes:**

10. LCLK cycle jitter and 10-cycle jitter are defined as the difference between the measured period and the nominal period as defined on page 8.

11. LCLK 10-cycle jitter specification is based on the measured value of LCLK cycle jitter as defined on page 8.

The output clocks drive transmission lines, potentially long lines. Since circuit board traces will act as lossy, imperfectly terminated transmission lines with some discontinuities, there will be reflections generated which will travel back to the DRCG-Lite output driver. If the output impedance does not match  $Z_{CH}$ , secondary reflections will be generated that will add to position-dependent timing uncertainty. Therefore, the CY2212 not only provides proper output voltage swings, but also provides a well-matched output impedance. The driver impedance,  $R_{OUT}$ , is in series with  $R_S$ , and the combination is in parallel with  $R_P$ .

The clock driver is specified as a black-box at the packaged pins. The output characteristics are measured after the series resistance,  $R_S$ . The outputs are terminated differentially, with no applied termination voltage.

Figure 3 below shows the clock driver implemented as a push-pull driver. When stimulating the output driver, the transmission lines shown in Figure 3 can be replaced by a direct connection to the termination resistors,  $R_T$ . The values for the external components are given in Table 1.

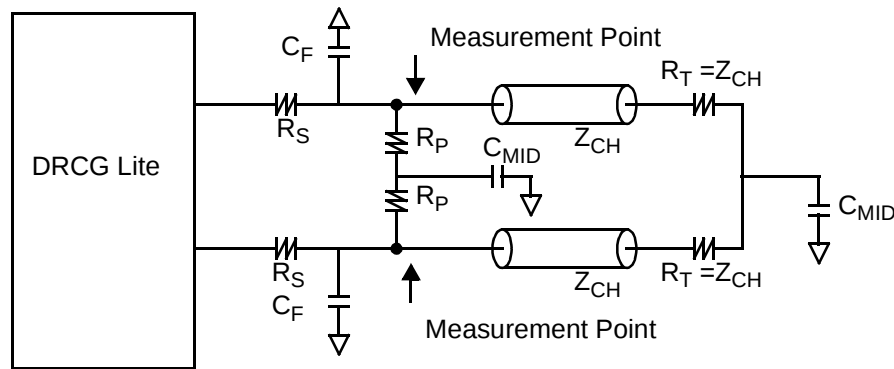
As mentioned previously, the clock driver's output impedance matches the channel impedance. To accomplish this, each of the output driver devices are sized to have an  $R_{OUT}$  of about 20 ohms when fully turned on.  $R_{OUT}$  is the dynamic output resistance, and is defined in the DC Device Characteristics Table on page 3 of this data sheet. Since  $R_{OUT}$  is in series with  $R_S$ , and that combination is in parallel with  $R_P$ , the effective output impedance is given by:

$$R_P(R_S + R_{OUT}) / (R_P + R_S + R_{OUT}).$$

This calculation results in a effective output impedance of about 27 ohms for the values listed in Table 1. Since the total impedance is dominated by the external resistors, a large possible range of  $R_{OUT}$  is allowed. When the output is transitioning, the impedance of the CMOS devices increases dramatically. The purpose of  $R_P$  is to limit the maximum output impedance during output transitions.

In order to control signal attenuation and EMI, clock signal rise/fall times must be tightly controlled. Therefore, external filter capacitors  $C_F$  are used to control the output slew rate. In addition, the capacitor  $C_{MID}$  is used to provide AC ground at the mid-point of the  $R_P$  resistors.

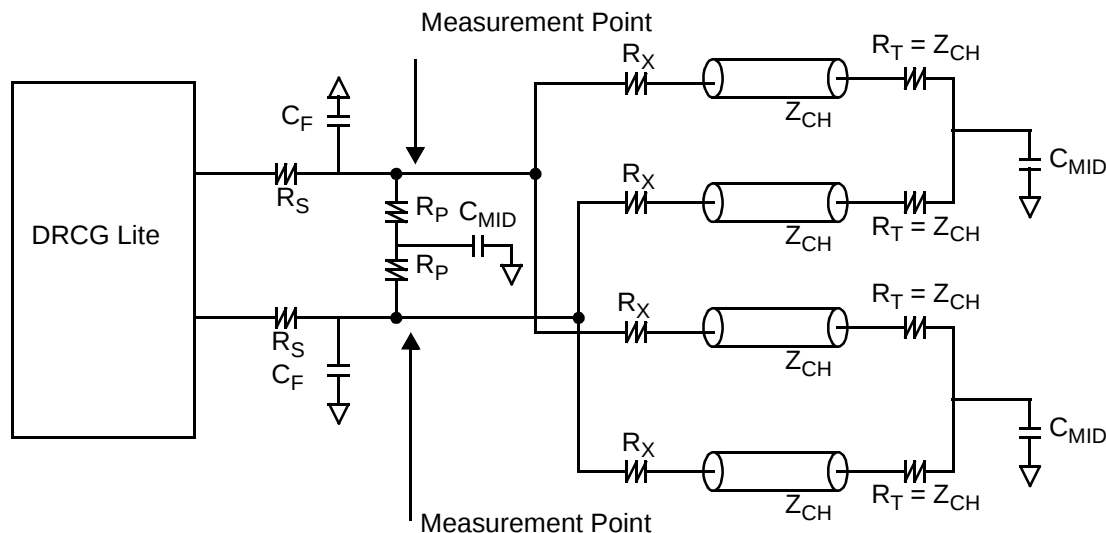
Table 1 gives the nominal values of the external components and their maximum acceptable tolerance, assuming  $Z_{CH} = 28$  ohms.



**Figure 3. Output Driver**

**Table 1. Output External Component Values**

| Parameter | Description                | Value | Tolerance | Unit |
|-----------|----------------------------|-------|-----------|------|
| $R_S$     | Series Resistor            | 68    | ±5%       | ohm  |
| $R_P$     | Parallel Resistor          | 39    | ±5%       | ohm  |
| $C_F$     | Edge-rate Filter Capacitor | 15    | ±10%      | pF   |
| $C_{MID}$ | AC Ground Capacitor        | 0.01  | ±20%      | μF   |



**Figure 4. Output Driving Two Channels**

## Dual-Channel Output Driver

Figure 4 shows the clock driver driving two high-impedance channels. The purpose of the series resistors  $R_X$  is to decouple the two-channels, and prevent noise from one channel from coupling onto the second channel. With  $Z_{CH} = 40$  ohms and the series resistor set to  $R_X = 16$  ohms, the channel becomes an effective 56-ohm channel. The two channels in parallel can be treated as a single 28-ohm channel, and all of the external component values listed in Table 1 can be used.

## Signal Waveforms

A physical signal which appears at the pins of the device is deemed valid or invalid depending on its voltage and timing relations with other signals. This section defines the voltage and timing waveforms for the input and output pins of the CY2212. The Device Characteristics tables list the specifications for the device parameters that are defined here.

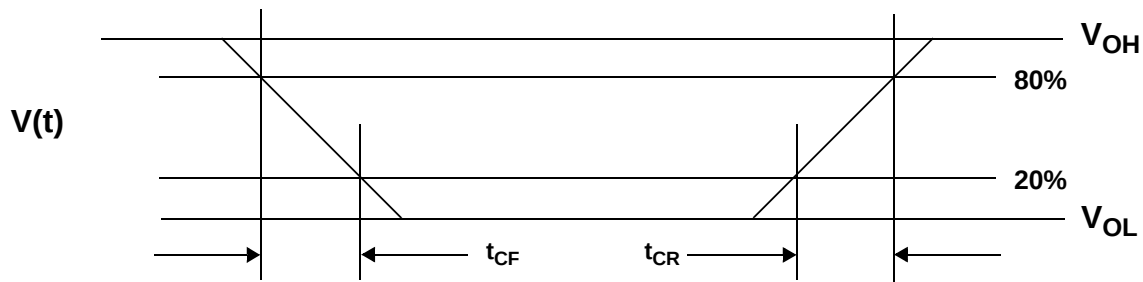
Input and Output voltage waveforms are defined as shown in Figure 5. Both rise and fall times are defined between the 20%

and 80% points of the voltage swing, with the swing defined as  $V_H - V_L$ . For example, the output voltage swing  $V_{COS} = V_{OH} - V_{OL}$ .

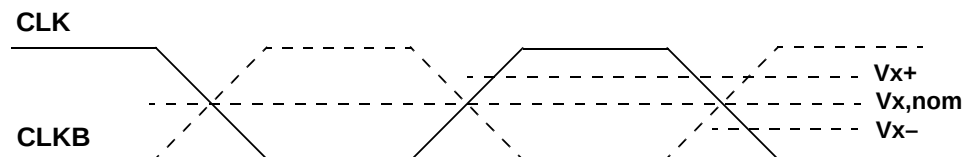
The device parameters defined according to Figure 5 are as follows.

**Table 2. Definition of Device Parameters**

| Parameter        | Definition                                                      |
|------------------|-----------------------------------------------------------------|
| $V_{OH}, V_{OL}$ | Clock output high and low voltages                              |
| $V_{COS}$        | Clock output swing $V_{COS} = V_{OH} - V_{OL}$                  |
| $V_{CM}$         | Common-mode voltage $V_{CM} = (V_{OH} - V_{OL})/2$              |
| $V_{IH}, V_{IL}$ | Vdd LVCMOS input high and low voltages                          |
| $t_{CR}, t_{CF}$ | Clock output rise and fall times                                |
| $t_{CR}, C_F$    | Clock output rise/fall time delta $t_{CR,CF} = t_{CR} - t_{CF}$ |



**Figure 5. Voltage Waveforms**



**Figure 6. Crossing-point Voltage**

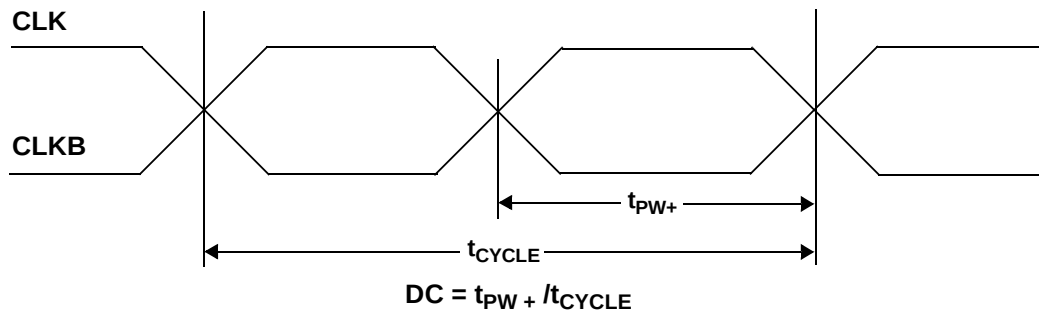
Figure 6 shows the definition of output crossing point. The nominal crossing point between the complementary outputs is defined to be at the 50% point of the DC voltage levels. There are two crossing points defined,  $V_{x+}$  at the rising edge of CLK and  $V_{x-}$  at the falling edge of CLK. For some clock waveforms, both  $V_{x+}$  and  $V_{x-}$  might be below  $V_{x, nom}$  (for example, if  $t_{CR}$  is larger than  $t_{CF}$ ).  $V_x$  is defined as the differential output crossing point voltage.

Figure 7 shows the definition of long-term duty cycle, which is simply the waveform high-time divided by the cycle time (defined at the crossing point). Long-term duty cycle is the average over many (>10,000) cycles. Short-term duty cycle is

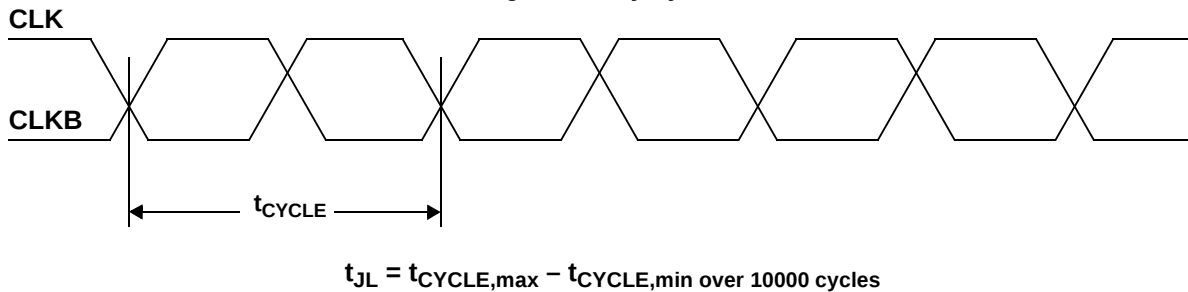
defined in the next section. DC is defined as the output clock long-term duty cycle.

## Jitter

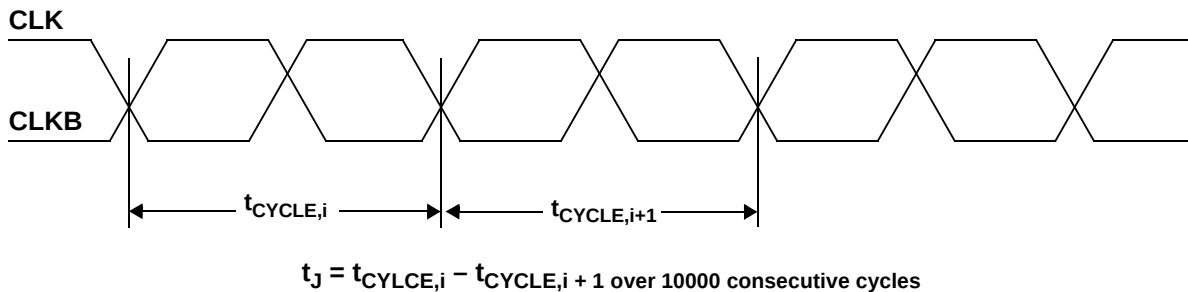
This section defines the specifications that relate to timing uncertainty (or jitter) of the input and output waveforms. Figure 8 shows the definition of long-term jitter with respect to the falling edge of the CLK signal. Long-term jitter is the difference between the minimum and maximum cycle times. Equal requirements apply for rising edges of the CLK signal.  $t_{jL}$  is defined as the output long-term jitter.



**Figure 7. Duty Cycle**



**Figure 8. Long-term Jitter**



**Figure 9. Cycle-to-cycle Jitter**

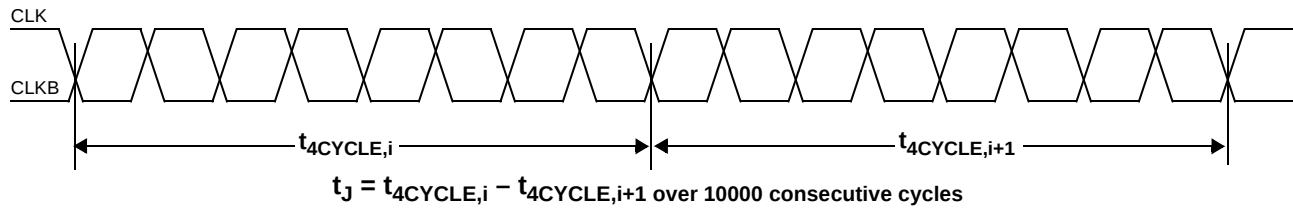
Figure 9 shows the definition of cycle-to-cycle jitter with respect to the falling edge of the CLK signal. Cycle-to-cycle jitter is the difference between cycle times of adjacent cycles. Equal requirements apply for rising edges of the CLK signal.  $t_J$  is defined as the clock output cycle-to-cycle jitter.

Figure 10 shows the definition of four-cycle short-term jitter. Short-term jitter is defined with respect to the falling edge of the CLK. Four-cycle short-term jitter is the difference between the cumulative cycle times of adjacent four cycles. Equal requirements apply for rising edges of the CLK signal. Equal requirements also apply for two-cycle short-term jitter and three-cycle short-term jitter, and for five-cycle short-term jitter and six-cycle short-term jitter.  $t_J$  is defined as the clock output short-term jitter over 2, 3, 4, 5, or 6 cycles.

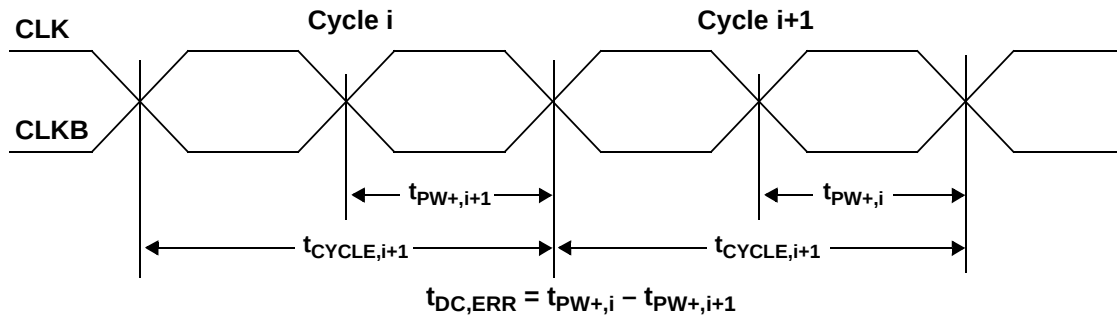
The purpose of this definition of short-term jitter is to define errors in the measured time (for example,  $t_{4CYCLE,i}$ ) vs. the expected time. The purpose for measuring the adjacent time

$t_{4CYCLE,i+1}$  is only to help determine the expected time for  $t_{4CYCLE,i}$ . Alternate methods of determining  $t_J$  are possible, including comparing the measured time to an expected time based on a local cycle time,  $t_{CYCLE,LOCAL}$ . This local cycle time could be determined by taking the rolling average of a group of cycles (5–10 cycles) proceeding the measured cycles. However, it is important to differentiate this rolling average from the average cycle time,  $t_{CYCLE,AVG}$ , which is the average cycle time over the 10,000 cycles. Using a long-term average instead of a rolling average would define  $t_J$  as a long-term jitter instead of a short-term jitter, and would normally give overly pessimistic results.

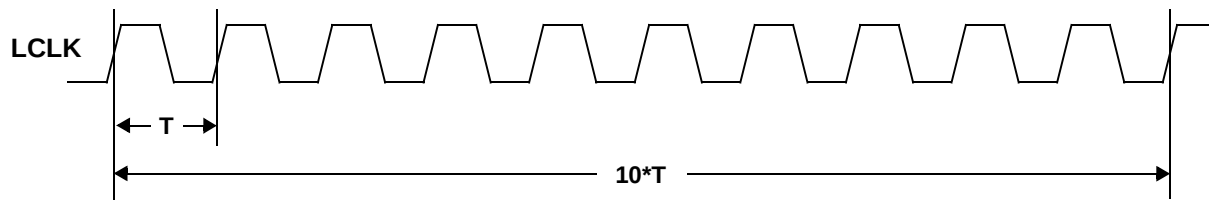
Figure 11 shows the definition of cycle-to-cycle duty cycle error. Cycle-to-cycle duty cycle error is defined as the difference between high-times of adjacent cycles. Equal requirements apply to the low-times.  $t_{DC,ERR}$  is defined as the clock output cycle-to-cycle duty cycle error.



**Figure 10. Short-term Jitter**



**Figure 11. Cycle-to-cycle Duty Cycle Error**



**Figure 12. LCLK Jitter**

Figure 12 shows the definition of LCLK cycle jitter and LCLK 10-cycle jitter. These parameters apply to the LCLK output, and not to the Rambus channel clock outputs.

LCLK cycle jitter is the variation in the clock period,  $T$ , over a continuous set of clock cycles. The difference between the maximum period and the nominal period in the set of clock cycles measured would be compared to the max spec listed in the AC Device Characteristics Table on page 3. LCLK cycle jitter is measured between rising edges at 50% of the output voltage, and is measured continuously over 30,000 cycles.

LCLK 10-cycle jitter is the variation in the time of 10 clock cycles,  $10 \cdot T$ , where  $T$  is the clock period. The difference between the maximum 10-cycle period and the nominal 10-cycle period in the set of clock cycles measured would be compared to the max spec listed in the AC Device Characteristics Table on page 5. Note that the specification for LCLK 10-cycle jitter is defined based on the measured value of LCLK cycle jitter. LCLK 10-cycle jitter is measured between the first rising edge and the tenth rising edge at 50% of the output voltage, and is measured over 30,000 continuous cycles.  $t_{JC,L}$

is defined as the LCLK output cycle jitter, and  $t_{J10,L}$  is defined as the LCLK output jitter over 10 cycles.

### Measurement

The short-term jitter specification (over one to six cycles) for the clock source is given as  $t_J$ , as previously shown. Jitter should be measured using a jitter measurement system that has the flexibility of measuring cycle-to-cycle jitter as a function of cycle count. It is important that the short-term jitter be measured over consecutive cycles in order to prevent long-term drift from causing overly-pessimistic results. When measured over 10,000 consecutive cycles, the short-term jitter measurements generate large amounts of data which can be viewed in a histogram. Figure 13 shows an example histogram of data from a 4-cycle short-term jitter measurement, with results that are within spec lines for  $t_J$ . Note that the jitter is specified as peak-to-peak, so the center of the histogram need not be exactly zero.

Further details of jitter measurement methodologies are given in the Rambus *DRCG-Lite Specification* Appendix A published by Rambus, Inc.



**Document History Page**

| <b>Document Title: CY2212 Direct Rambus™ Clock Generator (Lite)</b><br><b>Document Number: 38-07466</b> |                |                   |                        |                              |
|---------------------------------------------------------------------------------------------------------|----------------|-------------------|------------------------|------------------------------|
| <b>REV.</b>                                                                                             | <b>ECN NO.</b> | <b>Issue Date</b> | <b>Orig. of Change</b> | <b>Description of Change</b> |
| **                                                                                                      | 117801         | 12/10/02          | CKN                    | New Data Sheet               |