



# Low-Power, Compact 2.5Gbps/2.7Gbps Clock-Recovery and Data-Retiming IC

MAX3873

## General Description

The MAX3873 is a compact, low-power 2.488Gbps/2.67Gbps clock-recovery and data-retiming IC for SDH/SONET applications. The phase-locked loop (PLL) recovers a synchronous clock signal from the serial NRZ data input. The input data is then retimed by this recovered clock, providing a clean data output. The MAX3873 meets all SDH/SONET jitter specifications, does not require an external reference clock to aid in frequency acquisition, and provides excellent tolerance to both deterministic and sinusoidal jitter. The MAX3873 provides a PLL loss-of-lock (LOL) output to indicate whether the CDR is in lock. The recovered data and clock outputs are CML with on-chip 50Ω back terminations on each line. The clock output can be powered down if not used.

The MAX3873 is implemented in Maxim's second-generation SiGe process and consumes only 260mW at 3.3V supply (output clock disabled, low output swing). The device is available in a 4mm x 4mm 20-pin QFN exposed-pad package and operates from -40°C to +85°C.

## Applications

Switch Matrix Backplanes  
SDH/SONET Receivers and Regenerators  
Add/Drop Multiplexers  
Digital Cross-Connects  
SDH/SONET Test Equipment  
DWDM Transmission Systems

*Typical Application Circuit appears at end of data sheet.*

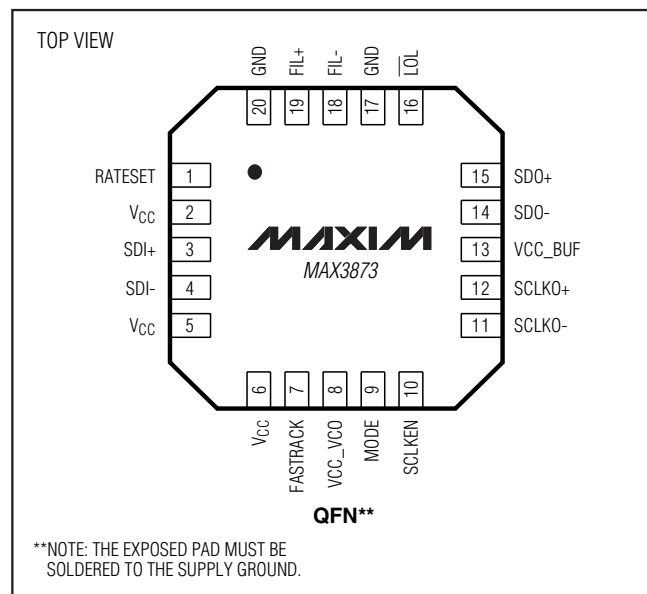
## Features

- ◆ Fully Integrated Clock Recovery and Data Retiming
- ◆ Power Dissipation: 260mW with +3.3V Supply
- ◆ Clock Jitter Generation: 5mUI<sub>RMS</sub>
- ◆ Exceeds ANSI, ITU, and Bellcore SDH/SONET Jitter Specifications
- ◆ Differential Input Range: 50mV<sub>p-p</sub> to 1.6V<sub>p-p</sub>
- ◆ Single +3.3V Power Supply
- ◆ PLL Fast Track (FASTRACK) Mode Available
- ◆ Clock Output Can Be Disabled
- ◆ Input Data Rate: 2.488Gbps or 2.67Gbps
- ◆ Selectable Output Amplitude
- ◆ Tolerates 2000 Consecutive Identical Digits
- ◆ Loss-of-Lock Indicator
- ◆ Differential CML Data and Clock Outputs
- ◆ Operating Temperature Range: -40°C to +85°C

## Ordering Information

| PART       | TEMP RANGE     | PIN-PACKAGE           | PKG. CODE |
|------------|----------------|-----------------------|-----------|
| MAX3873EGP | -40°C to +85°C | 20 QFN<br>(4mm x 4mm) | G2044-3   |

## Pin Configuration



# Low-Power, Compact 2.5Gbps or 2.7Gbps Clock-Recovery and Data-Retiming IC

## ABSOLUTE MAXIMUM RATINGS

Supply Voltage,  $V_{CC}$ .....-0.5V to +5.0V  
 Voltage at  $SDI_{\pm}$  ..... ( $V_{CC} - 1.0V$ ) to ( $V_{CC} + 0.5V$ )  
 CML Output Current at  $SDO_{\pm}$ ,  $SCLKO_{\pm}$  .....22mA  
 Voltage at  $\overline{LOL}$ , FASTRACK,  $FIL_{\pm}$ ,  $SCLKEN$   
 MODE, RATESET.....-0.5V to ( $V_{CC} + 0.5V$ )  
 Continuous Power Dissipation ( $T_A = +85^{\circ}C$ )  
 20-Pin QFN (derate 20.0mW/ $^{\circ}C$  above +85 $^{\circ}C$ ) .....1300mW

Operating Temperature Range .....-40 $^{\circ}C$  to +85 $^{\circ}C$   
 Storage Temperature Range .....-50 $^{\circ}C$  to +150 $^{\circ}C$   
 Processing Temperature.....+400 $^{\circ}C$   
 Lead Temperature (soldering, 10s) .....+300 $^{\circ}C$

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

## DC ELECTRICAL CHARACTERISTICS

( $V_{CC} = 3.0V$  to  $3.6V$ ,  $T_A = -40^{\circ}C$  to  $+85^{\circ}C$ . Typical values are at 2.488Gbps,  $V_{CC} = 3.3V$ ,  $T_A = +25^{\circ}C$ , unless otherwise noted.) (Note 1)

| PARAMETER  | SYMBOL   | CONDITIONS                            | MIN                 | TYP             | MAX            | UNITS             |
|--|----------|---------------------------------------|---------------------|-----------------|----------------|-------------------|
| Supply Current   | $I_{CC}$ | MODE = GND, $SCLKEN =$ Low (Note 2)   |                     | 79              | 99             | mA                |
|  |          | MODE = OPEN, $SCLKEN =$ High (Note 2) |                     | 105             |                |                   |
| <b>CML INPUT SPECIFICATIONS</b> ( $SDI_{+}$ , $SDI_{-}$ )                                      |          |                                       |                     |                 |                |                   |
| Differential Input Voltage   | $V_{ID}$ | (Figure 1)                            | 50                  |                 | 1600           | mV <sub>P-P</sub> |
| Single-Ended Input Voltage   | $V_{IS}$ | (Figure 1)                            | $V_{CC} - 0.8$      |                 | $V_{CC} + 0.4$ | V                 |
| Input Common-Mode Voltage  |          | DC-coupled (Figure 1)                 | $V_{CC} - V_{ID}/4$ |                 |                | V                 |
| Input Termination to $V_{CC}$  | $R_{IN}$ |                                       | 40                  | 50              | 60             | $\Omega$          |
| <b>CML OUTPUT SPECIFICATIONS</b> ( $SDO_{+}$ , $SDO_{-}$ , $SCLKO_{+}$ , $SCLKO_{-}$ )         |          |                                       |                     |                 |                |                   |
| Differential Output Swing  |          | MODE = Open (Note 3)                  | 600                 | 660             | 1000           | mV <sub>P-P</sub> |
|  |          | MODE = $V_{CC}$ (Note 3)              | 400                 | 500             | 800            |                   |
|  |          | MODE = GND (Note 3)                   | 200                 | 330             | 600            |                   |
| Differential Output Resistance   | $R_O$    |                                       | 80                  | 100             | 120            | $\Omega$          |
| Output Common-Mode Voltage   |          | MODE = Open (Note 3)                  |                     | $V_{CC} - 0.17$ |                | V                 |
|  |          | MODE = $V_{CC}$ (Note 3)              |                     | $V_{CC} - 0.13$ |                |                   |
|  |          | MODE = GND (Note 3)                   |                     | $V_{CC} - 0.08$ |                |                   |
| <b>TTL INPUT/OUTPUT SPECIFICATIONS</b> (FASTRACK, $\overline{LOL}$ , $SCLKEN$ , MODE, RATESET) |          |                                       |                     |                 |                |                   |
| Input High Voltage   | $V_{IH}$ |                                       | 2.0                 |                 |                | V                 |
| Input Low Voltage  | $V_{IL}$ |                                       |                     |                 | 0.8            | V                 |
| Input Current  |          |                                       | -30                 |                 | +30            | $\mu A$           |
| Output High Voltage  | $V_{OH}$ | $I_{OH} =$ sourcing 40 $\mu A$        | 2.4                 |                 |                | V                 |
| Output Low Voltage   | $V_{OL}$ | $I_{OL} =$ sinking 2mA                |                     |                 | 0.4            | V                 |

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MAX3873

## AC ELECTRICAL CHARACTERISTICS

(V<sub>CC</sub> = 3.0V to 3.6V, C<sub>F</sub> = 0.01μF, T<sub>A</sub> = -40°C to +85°C. Typical values are at V<sub>CC</sub> = 3.3V, 2.488Gbps, T<sub>A</sub> = +25°C, unless otherwise noted.) (Note 4)

| PARAMETER   | SYMBOL             | CONDITIONS   | MIN  | TYP   | MAX | UNITS              |
|---|--------------------|--|------|-------|-----|--------------------|
| Serial Input Data Rate  |                    | RATESET = Low  |      | 2.488 |     | Gbps               |
|   |                    | RATESET = High                                       |      | 2.67  |     |                    |
| Clock-to-Q Delay  | t <sub>CLK-Q</sub> | (Figure 2) (Note 5)                                  | -70  |       | +70 | ps                 |
| Jitter Peaking  | J <sub>P</sub>     | f ≤ 2MHz   |      |       | 0.1 | dB                 |
| Jitter Transfer Bandwidth                                       | J <sub>BW</sub>    | RATESET = Low  |      |       | 2.0 | MHz                |
| Sinusoidal Jitter Tolerance (Note 6)                            |                    | f = 70kHz, 0.4UI deterministic jitter on input data  |      | 6.9   |     | UI <sub>P-P</sub>  |
|   |                    | f = 100kHz, 0.4UI deterministic jitter on input data | 2.12 | 4.5   |     |                    |
|   |                    | f = 1MHz, 0.4UI deterministic jitter on input data   | 0.33 | 0.6   |     |                    |
|   |                    | f = 10MHz, 0.4UI deterministic jitter on input data  | 0.15 | 0.3   |     |                    |
| Jitter Generation   | J <sub>GEN</sub>   | (Note 7)   |      | 5.0   | 6.8 | mUI <sub>RMS</sub> |
|   |                    |  |      | 45    | 62  | mUI <sub>P-P</sub> |
| Clock Output Edge Speed   |                    | (20% to 80%)   |      | 60    | 110 | ps                 |
| Data Output Edge Speed  |                    | (20% to 80%)   |      | 60    | 110 | ps                 |
| Tolerated Consecutive Identical Digits                          |                    |  |      | 2000  |     | bits               |
| SDI <sub>±</sub> Input Return Loss (-20log( S <sub>11</sub>  )) |                    | 100kHz to 2.5GHz                                     |      | 17    |     | dB                 |
|   |                    | 2.5GHz to 4.0GHz                                     |      | 14    |     |                    |
| Frequency Acquisition Time                                      |                    | (Figure 4)   |      | 1.0   |     | ms                 |
| L <sub>OL</sub> Assert Time                                     |                    | (Figure 4)   |      | 1.6   |     | μs                 |

**Note 1:** At T<sub>A</sub> = -40°C, DC characteristics are guaranteed by design and characterization.

**Note 2:** CML outputs open.

**Note 3:** R<sub>L</sub> = 50Ω to V<sub>CC</sub>.

**Note 4:** AC characteristics are guaranteed by design and characterization.

**Note 5:** Relative to the falling edge of SCLKO+. See Figure 2.

**Note 6:** Measured with 2<sup>23</sup> - 1 PRBS.

**Note 7:** Jitter BW = 12kHz to 20MHz.

# Low-Power, Compact 2.5Gbps or 2.7Gbps Clock-Recovery and Data-Retiming IC

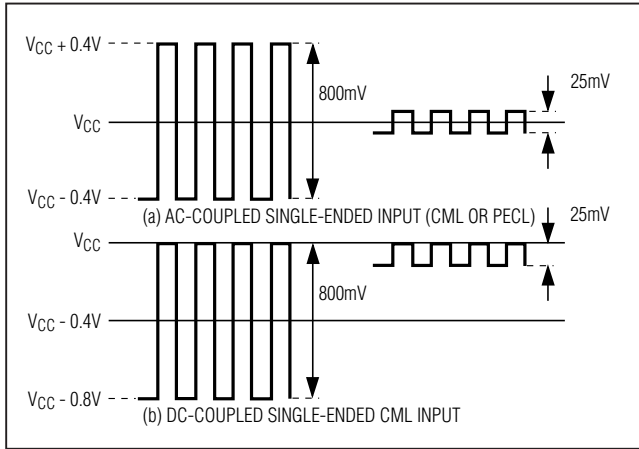


Figure 1. Definition of Input Voltage Swing

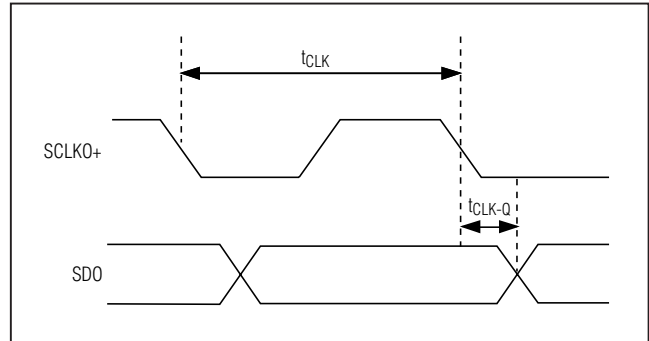


Figure 2. Definition of Clock-to-Q Delay

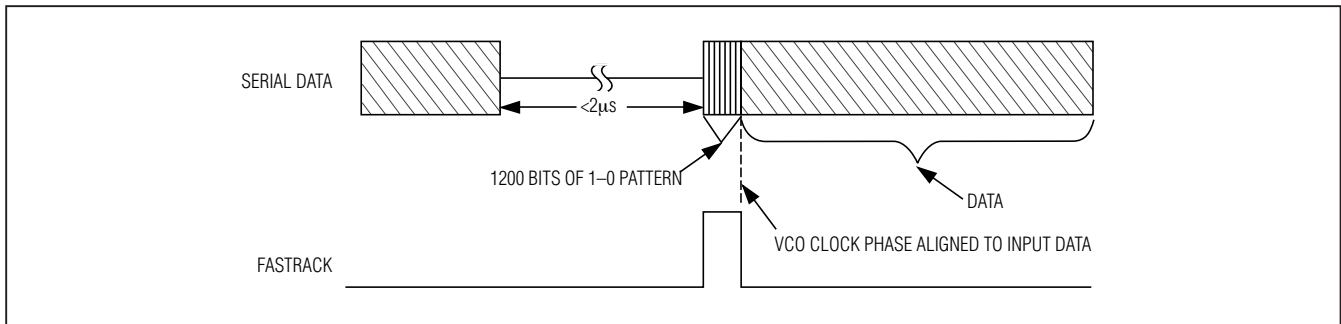


Figure 3. Definition of Phase Acquisition Time

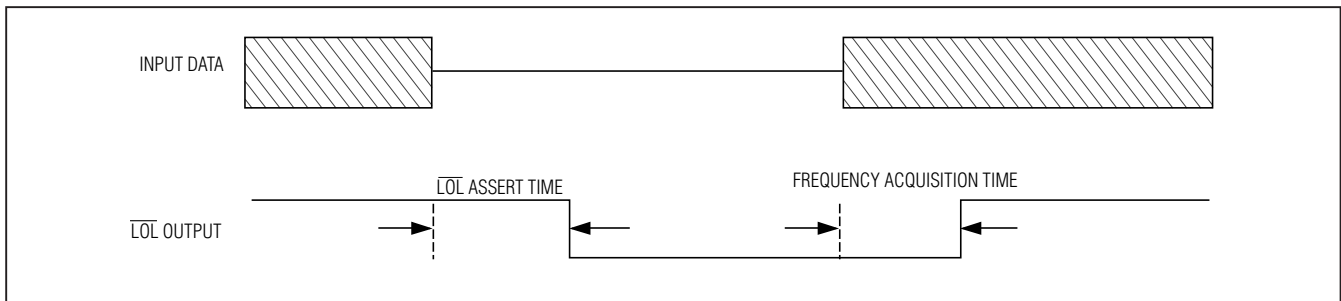


Figure 4. Definition of  $\overline{L0L}$  Assert Time and Frequency Acquisition Time

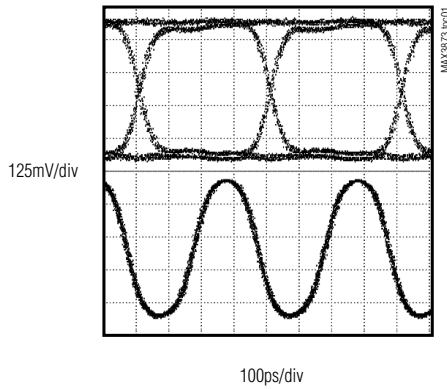
# Low-Power, Compact 2.5Gbps or 2.7Gbps Clock-Recovery and Data-Retiming IC

**MAX3873**

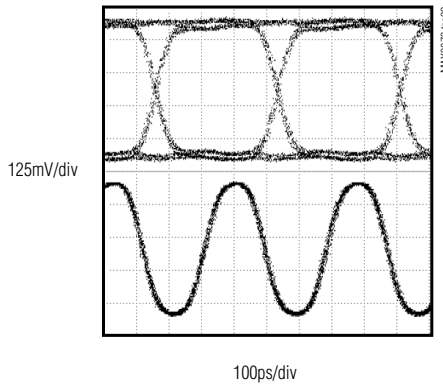
## Typical Operating Characteristics

( $T_A = +25^\circ\text{C}$ , unless otherwise noted.)

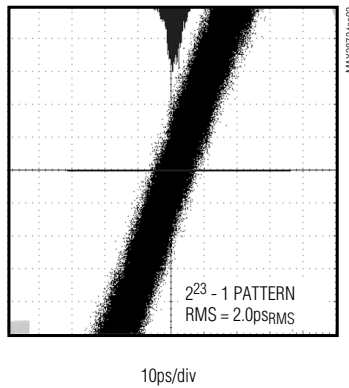
**RECOVERED CLOCK AND DATA  
(2.488Gbps,  $2^{23} - 1$  PATTERN,  
 $V_{IN} = 50\text{mVp-p}$ )**



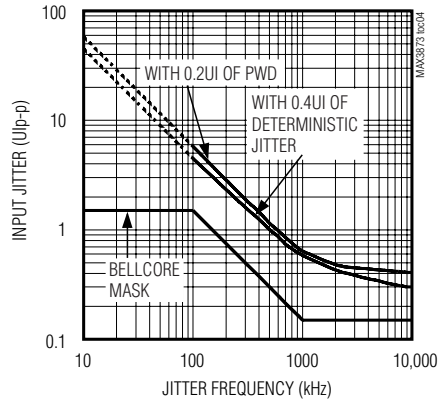
**RECOVERED CLOCK AND DATA  
(2.67Gbps,  $2^{23} - 1$  PATTERN,  
 $V_{IN} = 50\text{mVp-p}$ )**



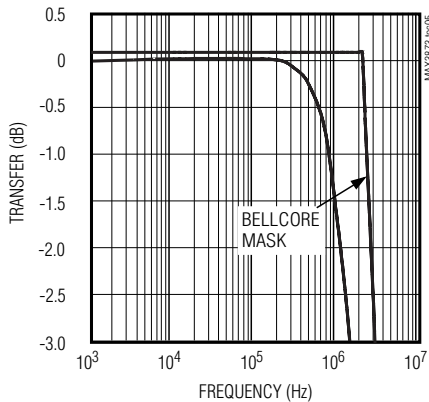
**RECOVERED CLOCK JITTER  
(2.488Gbps)**



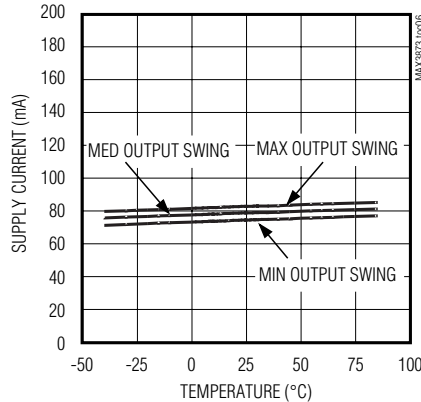
**JITTER TOLERANCE  
(2.488Gbps,  $2^{23} - 1$  PATTERN,  
 $V_{IN} = 50\text{mVp-p}$ )**



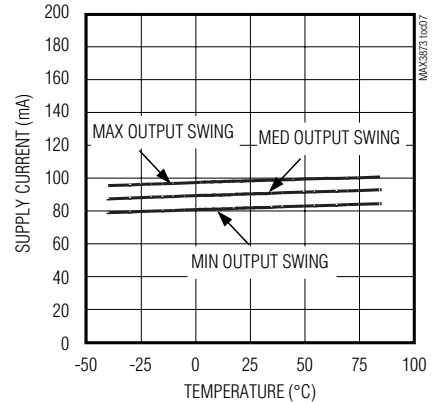
**JITTER TRANSFER**



**SUPPLY CURRENT vs. TEMPERATURE  
(SCLKO DISABLED)**



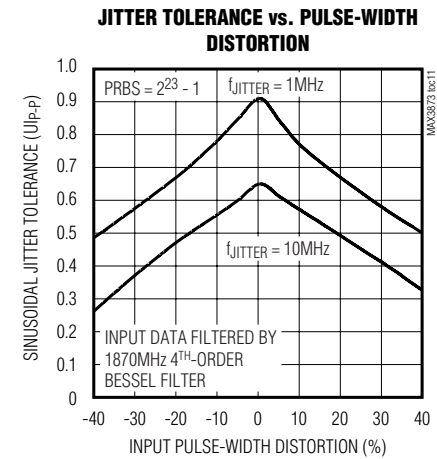
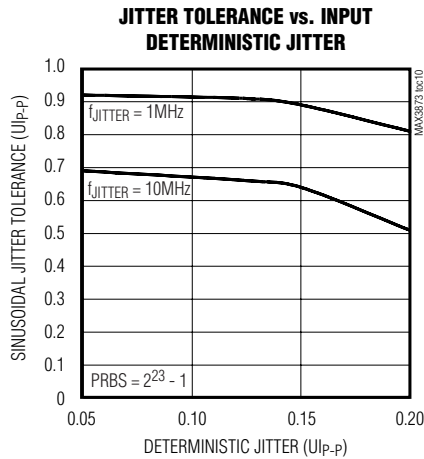
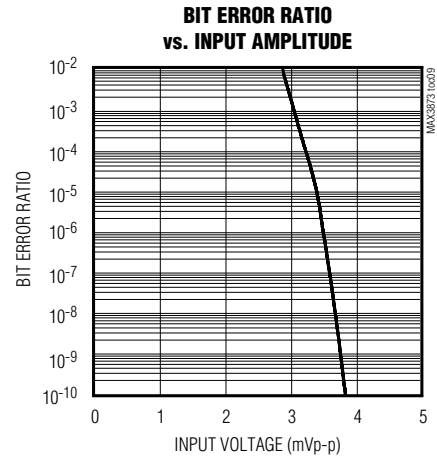
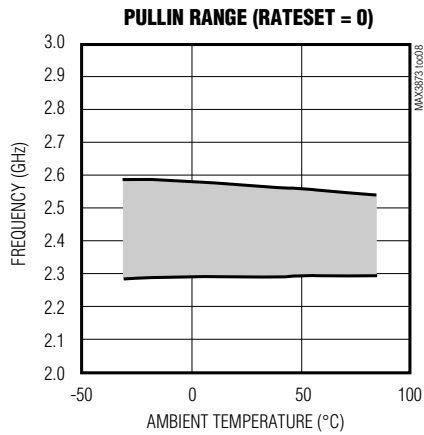
**SUPPLY CURRENT vs. TEMPERATURE  
(SCLKO ENABLED)**



# Low-Power, Compact 2.5Gbps or 2.7Gbps Clock-Recovery and Data-Retiming IC

## Typical Operating Characteristics (continued)

( $T_A = +25^\circ\text{C}$ , unless otherwise noted.)



## Pin Description

| PIN     | NAME     | FUNCTION  |
|---------|----------|---|
| 1       | RATESET  | Input Rate Select. Connect to TTL low for 2.488Gbps data and to TTL high for 2.67Gbps data.   |
| 2, 5, 6 | VCC      | 3.3V Supply Voltage   |
| 3       | SDI+     | Positive Serial Data Input  |
| 4       | SDI-     | Negative Serial Data Input  |
| 7       | FASTRACK | PLL Fast Track Control, TTL Input. When FASTRACK is TTL high, the PLL is switched to a fast-track mode for fast phase acquisition. When FASTRACK is TTL low, the PLL operates normally. |
| 8       | VCC_VCO  | 3.3V VCO Supply Voltage   |
| 9       | MODE     | Output Amplitude Mode Select. MODE = OPEN sets the CML output amplitude to high; MODE = high sets the output amplitude to medium; MODE = low sets the output amplitude to low.          |

# Low-Power, Compact 2.5Gbps or 2.7Gbps Clock-Recovery and Data-Retiming IC

## Pin Description (continued)

| PIN    | NAME                    | FUNCTION  |
|--------|-------------------------|---|
| 10     | SCLKEN                  | Clock Output Enable, TTL Input. When SCLKEN = OPEN or SCLKEN = High, the clock outputs (SCLKO±) are enabled. When SCLKEN = Low, the clock outputs are disabled and SCLKO± = V <sub>CC</sub> . |
| 11     | SCLKO-                  | Negative Clock Output, CML. This output can be disabled by setting SCLKEN to Low.   |
| 12     | SCLKO+                  | Positive Clock Output, CML. This output can be disabled by setting SCLKEN to Low.   |
| 13     | VCC_BUF                 | 3.3V CML Output Buffer Supply Voltage   |
| 14     | SDO-                    | Negative Data Output, CML   |
| 15     | SDO+                    | Positive Data Output, CML   |
| 16     | $\overline{\text{LOL}}$ | Loss-of-Lock Output, TTL (Active-Low). The $\overline{\text{LOL}}$ output indicates a PLL lock failure.   |
| 17, 20 | GND                     | Supply Ground   |
| 18     | FIL-                    | Negative PLL Loop Filter Connection. Connect a 0.01 $\mu$ F capacitor between FIL+ and FIL-.  |
| 19     | FIL+                    | Positive PLL Loop Filter Connection. Connect a 0.01 $\mu$ F capacitor between FIL+ and FIL-.  |
| EP     | Exposed Pad             | Ground. The exposed pad must be soldered to the circuit board ground for proper electrical and thermal operation.   |

## Detailed Description

The MAX3873 consists of a fully integrated phase-locked loop (PLL), input amplifier, and CML output buffers (Figure 5). The PLL consists of a phase/frequency detector, a loop filter, and a voltage-controlled oscillator (VCO).

This device is designed to deliver the best combination of jitter performance and power dissipation by using a fully-differential signal architecture and low-noise design techniques.

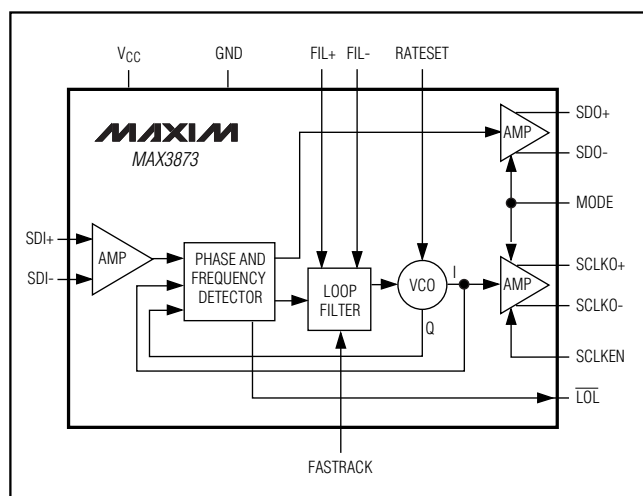


Figure 5. Functional Diagram

### Input Amplifier

The input amplifier provides internal 50 $\Omega$  line terminations and can accept a differential input amplitude from 50mV<sub>P-P</sub> to 1600mV<sub>P-P</sub>. The structure of the input amplifier is shown in Figure 9.

### Phase Detector

The phase detector incorporated in the MAX3873 produces a voltage proportional to the phase difference between the incoming data and the internal clock. Because of its feedback nature, the PLL drives the error voltage to zero, aligning the recovered clock to the center of the incoming data eye for retiming.

### Frequency Detector

The digital frequency detector (FD) aids frequency acquisition during startup conditions. The frequency difference between the received data and the VCO clock is derived by sampling the VCO outputs on each edge of the data input signal. The FD drives the VCO until the frequency difference is reduced to zero. Once frequency acquisition is complete, the FD returns to a neutral state.

### Loop Filter and VCO

The phase detector and frequency detector outputs are summed into the loop filter. An external capacitor, C<sub>F</sub>, is required to set the PLL damping ratio. See the *Design Procedure* section for guidelines on selecting this capacitor.

# Low-Power, Compact 2.5Gbps or 2.7Gbps Clock-Recovery and Data-Retiming IC

The loop filter output controls the on-chip LC VCO running at either 2.488GHz or 2.67GHz. The VCO provides low phase noise and is trimmed to the correct frequency. Clock jitter generation is typically 2psRMS within a jitter band of 12kHz to 20MHz.

## Loss-of-Lock Monitor

A loss-of-lock ( $\overline{\text{LOL}}$ ) monitor is incorporated in the MAX3873 to indicate either a loss of frequency lock or the absence of incoming data. Under loss of lock conditions,  $\overline{\text{LOL}}$  may momentarily assert high due to noise.

## Design Procedure

### Setting the Loop Filter

The MAX3873 is designed for both regenerator and receiver applications. Its fully integrated PLL is a classic second-order feedback system, with a loop bandwidth ( $J_{\text{BW}}$ ) below 2.0MHz. The external capacitor,  $C_F$ , can be adjusted to set the loop damping. Figures 6 and 7 show the open-loop and closed-loop transfer functions. The PLL zero frequency,  $f_z$ , is a function of external capacitor  $C_F$ , and can be approximated according to:

$$f_z = \frac{1}{2\pi (3000\Omega) C_F}$$

with  $C_F$  expressed in F.

For an overdamped system, the jitter peaking ( $J_P$ ) of a second-order system can be approximated by:

$$J_P = 20 \log \left( 1 + \frac{f_z}{J_{\text{BW}}} \right)$$

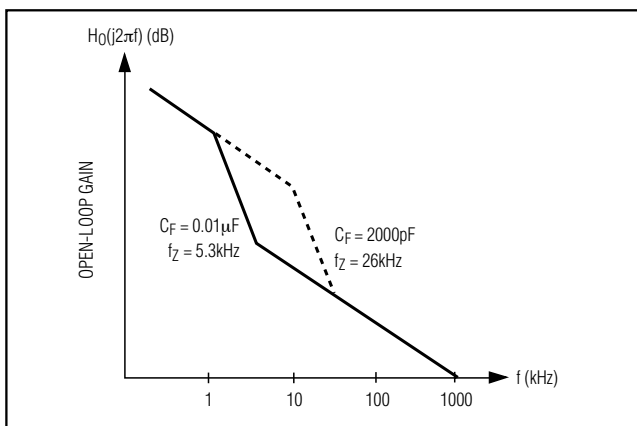


Figure 6. Open-Loop Transfer Function

For example, using  $C_F = 2000\text{pF}$  results in jitter peaking of 0.2dB. Reducing  $C_F$  below 500pF might result in PLL instability. The recommended value is  $C_F = 0.01\mu\text{F}$  to guarantee a maximum jitter peaking of less than 0.1dB.  $C_F$  must be a low TC, high-quality capacitor of type X7R or better.

## FASTRACK Mode

The MAX3873 has a PLL fast-track (FASTRACK) mode to decrease locking time in switched data applications. In applications where the input data is switched from one source to another, there is a brief period where there is no valid data input to the MAX3873. In the absence of input data, the PLL phase will slowly drift from the ideal position. By enabling FASTRACK during reacquisition, the time required to regain phase alignment is reduced. This is accomplished by increasing the loop bandwidth by approximately 50%.

The bandwidth of the MAX3873 is also linearly dependent upon the transition density of the input data. By using a preamble of 1200 bits of a 1-0 pattern during switching, the loop bandwidth is increased by a factor of approximately 2 (see Figure 3). Thus by using a 1-0 pattern preamble and enabling FASTRACK, the PLL bandwidth is increased by a factor of approximately 3, resulting in the fastest possible reacquisition of phase lock.

FASTRACK increases the rate at which the MAX3873 acquires the proper phase, assuming that the VCO is already running at the proper frequency. On startup conditions, however, the VCO frequency is significantly different from the input data, and the time required to lock to the incoming data is increased to approximately 1.0ms.

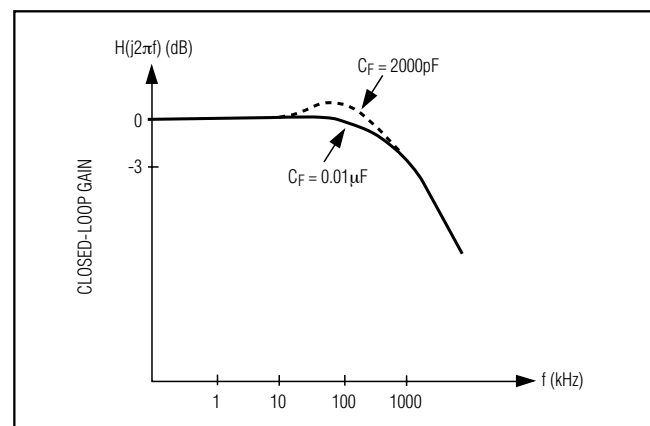


Figure 7. Closed-Loop Transfer Function



# Low-Power, Compact 2.5Gbps or 2.7Gbps Clock-Recovery and Data-Retiming IC

## Sinusoidal Jitter Tolerance and Input Deterministic Jitter Trade-Offs

The MAX3873 has excellent jitter tolerance. Adding DJ to the input will close the eye opening and result in reduced sinusoidal jitter tolerance. It typically can tolerate more than  $0.3UI_{p-p}$  of 10MHz jitter when measured with a  $2^{23} - 1$  PRBS data stream with  $0.4UI$  of deterministic jitter (DJ). This gives a total high-frequency jitter tolerance of  $0.7UI$ . Refer to the Jitter Tolerance vs. Pulse-Width Distortion and Jitter Tolerance vs. Deterministic Jitter graphs in the *Typical Operating Characteristics* section.

## Input and Output Terminations

The MAX3873's digital CML outputs (SDO+, SDO-, SCLKO+, SCLKO-) have selectable output amplitude controlled by the MODE input. If the SCLKO outputs are not used, they can be disabled (see the Supply Current vs. Temperature graph in the *Typical Operating Characteristics* section).

The structure of the high-speed digital outputs is shown in Figure 8. The MODE input sets the current in the current source, thereby controlling the output swing. The SCLKEN input sets the current in the SCLKO current source to 0mA, disabling the output.

The structure of the CML inputs (SDI±) is shown in Figure 9. Unless the CML input is DC-coupled to a CML output, use AC-coupling with the CML inputs to avoid upsetting the common-mode voltage.

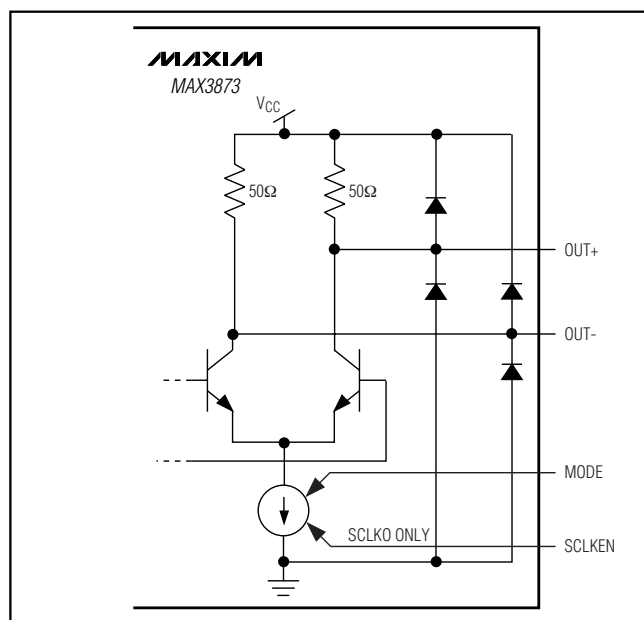


Figure 8. CML Output Model

## Applications Information

### Consecutive Identical Digits (CID)

The MAX3873 has a low phase and frequency drift in the absence of data transitions. As a result, long runs of consecutive zeros and ones can be tolerated while maintaining a BER of less than  $10^{-10}$ . The CID tolerance is tested using a  $2^{13} - 1$  PRBS, substituting a long run of zeros to simulate the worst case. A CID tolerance of 2000 bits is typical.

### Exposed-Pad Package

The exposed-pad (EP), 20-pin QFN incorporates features that provide a very low thermal-resistance path for heat removal from the IC. The pad is electrical ground on the MAX3873 and must be soldered to the circuit board for proper thermal and electrical performance.

### Layout

Circuit board layout and design can significantly affect the MAX3873's performance. Use good high-frequency design techniques, including minimizing ground inductance and using controlled-impedance transmission lines on the data and clock signals. Power-supply decoupling should be placed as close to the VCC pins as possible. Isolate the input from the output signals to reduce feedthrough.

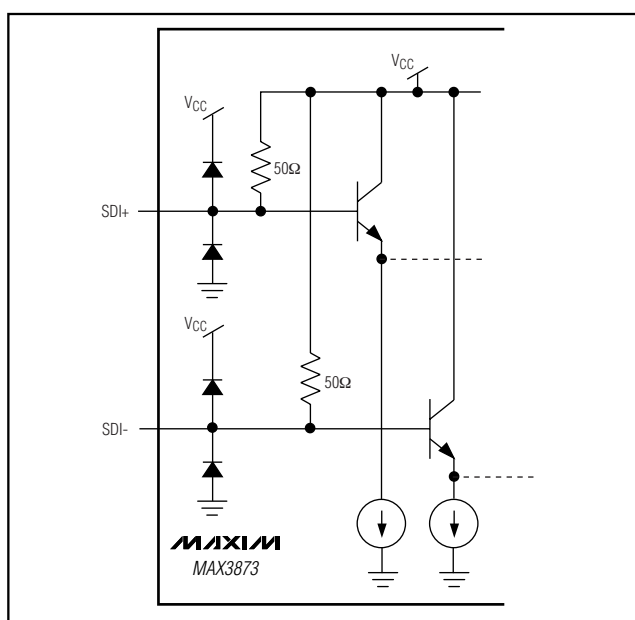
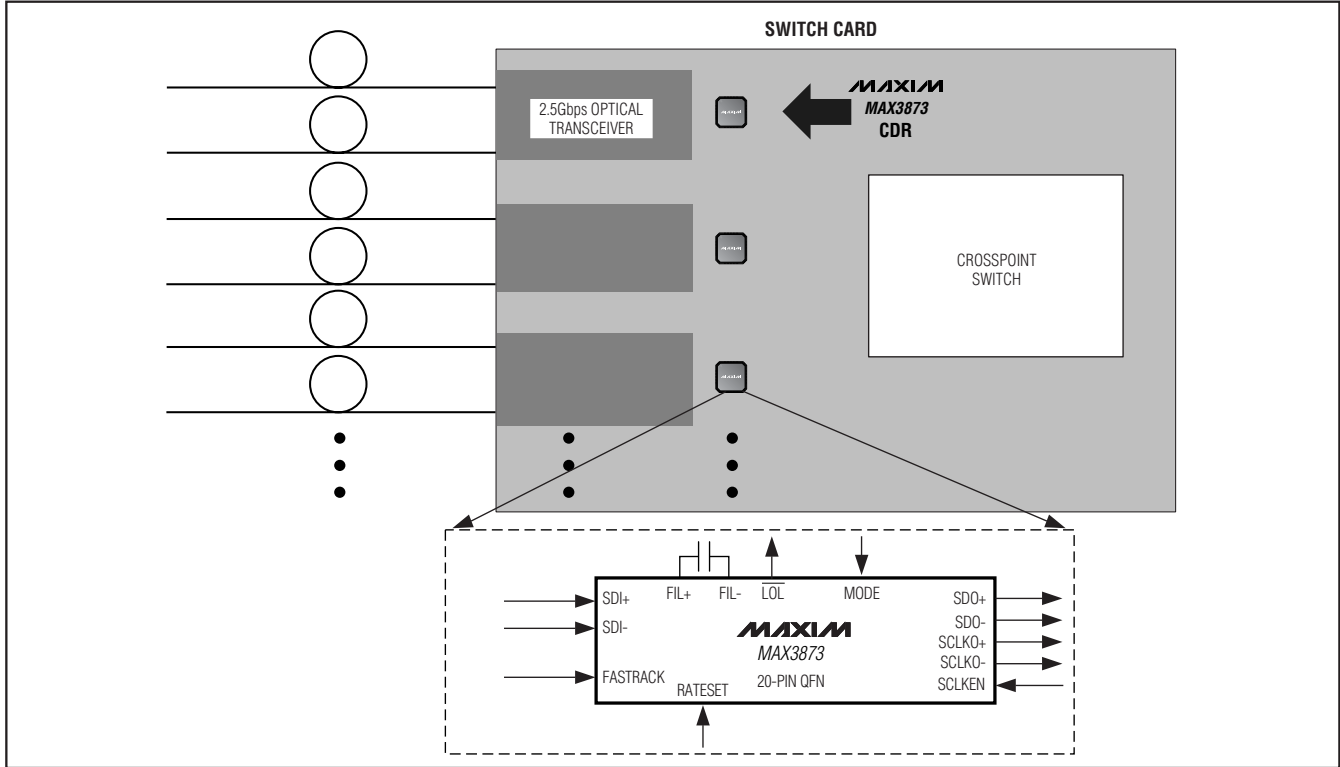


Figure 9. CML Input Model

# Low-Power, Compact 2.5Gbps or 2.7Gbps Clock-Recovery and Data-Retiming IC

## Typical Application Circuit



## Chip Information

TRANSISTOR COUNT: 2028

PROCESS: SiGe BiCMOS



# Low-Power, Compact 2.5Gbps or 2.7Gbps Clock-Recovery and Data-Retiming IC

## Package Information (continued)

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information, go to [www.maxim-ic.com/packages](http://www.maxim-ic.com/packages).)

### NOTES:

1. DIE THICKNESS ALLOWABLE IS 0.305mm MAXIMUM (.012 INCHES MAXIMUM).
2. DIMENSIONING & TOLERANCES CONFORM MUST TO ASME Y14.5M. – 1994.
3. N IS THE NUMBER OF TERMINALS.  
Nd IS THE NUMBER OF TERMINALS IN X-DIRECTION &  
Ne IS THE NUMBER OF TERMINALS IN Y-DIRECTION.
4. DIMENSION b APPLIES TO PLATED TERMINAL AND IS MEASURED BETWEEN 0.20 AND 0.25mm FROM TERMINAL TIP.
5. THE PIN #1 IDENTIFIER MUST BE EXISTED ON THE TOP SURFACE OF THE PACKAGE BY USING INDENTATION MARK OR INK/LASER MARKED. DETAILS OF PIN #1 IDENTIFIER IS OPTIONAL, BUT MUST BE LOCATED WITHIN ZONE INDICATED.
6. EXACT SHAPE AND SIZE OF THIS FEATURE IS OPTIONAL.
7. ALL DIMENSIONS ARE IN MILLIMETERS.
8. PACKAGE WARPAGE MAX 0.05mm.
9. APPLIED FOR EXPOSED PAD AND TERMINALS.  
EXCLUDE EMBEDDING PART OF EXPOSED PAD FROM MEASURING.
10. MEETS JEDEC MO220; EXCEPT DIMENSION "b".
11. THIS PACKAGE OUTLINE APPLIES TO PUNCHED QFN (STEPPED SIDES).

| SYMBOL | COMMON DIMENSIONS |      |      | NOTE |
|--------|-------------------|------|------|------|
|        | MIN.              | NOM. | MAX. |      |
| A      | 0.80              | 0.90 | 1.00 |      |
| A1     | 0.00              | 0.01 | 0.05 |      |
| A2     | 0.00              | 0.65 | 0.80 |      |
| A3     | 0.20 REF.         |      |      |      |
| D      | 4.00 BSC          |      |      |      |
| D1     | 3.75 BSC          |      |      |      |
| E      | 4.00 BSC          |      |      |      |
| E1     | 3.75 BSC          |      |      |      |
| Ø      | 0*                | –    | 12*  |      |
| P      | 0.24              | 0.42 | 0.60 |      |

| SYMBOL | PITCH VARIATION A |      |      | SYMBOL | PITCH VARIATION B |      |      | SYMBOL | PITCH VARIATION C |      |      | SYMBOL | PITCH VARIATION D |      |      | SYMBOL |
|--------|-------------------|------|------|--------|-------------------|------|------|--------|-------------------|------|------|--------|-------------------|------|------|--------|
|        | MIN.              | NOM. | MAX. |        | MIN.              | NOM. | MAX. |        | MIN.              | NOM. | MAX. |        | MIN.              | NOM. | MAX. |        |
| Ø      | 0.80 BSC          |      |      | Ø      | 0.65 BSC          |      |      | Ø      | 0.50 BSC          |      |      | Ø      | 0.50 BSC          |      |      |        |
| N      | 12                |      |      | N      | 16                |      |      | N      | 20                |      |      | N      | 24                |      |      |        |
| Nd     | 3                 |      |      | Nd     | 4                 |      |      | Nd     | 5                 |      |      | Nd     | 6                 |      |      |        |
| Ne     | 3                 |      |      | Ne     | 4                 |      |      | Ne     | 5                 |      |      | Ne     | 6                 |      |      |        |
| L      | 0.50              | 0.60 | 0.75 | L      | 0.50              | 0.60 | 0.75 | L      | 0.50              | 0.60 | 0.75 | L      | 0.30              | 0.40 | 0.50 |        |
| b      | 0.28              | 0.33 | 0.40 | b      | 0.23              | 0.28 | 0.35 | b      | 0.18              | 0.23 | 0.30 | b      | 0.18              | 0.23 | 0.30 |        |

| PKG. CODE | EXPOSED PAD VARIATION |      |      |      |      |      |
|-----------|-----------------------|------|------|------|------|------|
|           | D2                    |      |      | E2   |      |      |
|           | MIN.                  | NOM. | MAX. | MIN. | NOM. | MAX. |
| G1244-2   | 1.95                  | 2.10 | 2.25 | 1.95 | 2.10 | 2.25 |
| G1644-1   | 1.95                  | 2.10 | 2.25 | 1.95 | 2.10 | 2.25 |
| G2044-3   | 1.95                  | 2.10 | 2.25 | 1.95 | 2.10 | 2.25 |
| G2044-4   | 1.55                  | 1.70 | 1.85 | 1.55 | 1.70 | 1.85 |
| G2444-1   | 1.95                  | 2.10 | 2.25 | 1.95 | 2.10 | 2.25 |

|  |                      |              |     |
|--|----------------------|--------------|-----|
| <b>DALLAS SEMICONDUCTOR</b>                            |                      | <b>MAXIM</b> |     |
| PROPRIETARY INFORMATION                                |                      |              |     |
| TITLE PACKAGE OUTLINE<br>12,16,20,24L QFN, 4x4x0.90 MM |                      |              |     |
| APPROVAL   | DOCUMENT CONTROL NO. | REV.         |     |
|  | 21-0106              | E            | 2/2 |

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