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# 2.488Gbps/2.667Gbps Clock and Data Recovery with Limiting Amplifier

MAX3874

## General Description

The MAX3874 is a compact, dual-rate clock and data recovery with limiting amplifier for OC-48 and OC-48 with FEC SONET/SDH applications. Without using an external reference clock, the fully integrated 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. An additional serial input (SLBI±) is available for system-loopback diagnostic testing. Alternatively, this input can be connected to a reference clock to maintain a valid clock output in the absence of data transitions. The device also includes a loss-of-lock (LOL) output.

The MAX3874 contains a vertical threshold control to compensate for optical noise due to EDFAs in DWDM transmission systems. The recovered data and clock outputs are CML with on-chip 50Ω back termination on each line. Its jitter performance exceeds all SONET/SDH specifications. The MAX3874A is the MAX3874 with a voltage-controlled oscillator (VCO) centered at 2.0212GHz.

The MAX3874 operates from a single +3.3V supply and typically consumes 580mW. It is available in a 5mm × 5mm 32-pin QFN with exposed pad package and operates over the -40°C to +85°C temperature range.

## Applications

SONET/SDH Receivers and Regenerators  
Add/Drop Multiplexers  
Digital Cross-Connects  
SONET/SDH Test Equipment  
DWDM Transmission Systems  
Access Networks

## Features

- ◆ 2.488Gbps and 2.667Gbps Input Data Rates
- ◆ Reference Clock Not Required for Data Acquisition
- ◆ Exceeds ANSI, ITU, and Bellcore SONET/SDH Jitter Specifications
- ◆ 2.7mUI<sub>RMS</sub> Clock Jitter Generation
- ◆ 10mV<sub>p-p</sub> Input Sensitivity Without Threshold Adjust
- ◆ 0.65UI<sub>p-p</sub> High-Frequency Jitter Tolerance
- ◆ ±170mV Wide Input Threshold Adjust Range
- ◆ Clock Holdover Capability Using Frequency-Selectable Reference Clock
- ◆ Serial Loopback Input Available for System Diagnostic Testing
- ◆ Loss-of-Lock (LOL) Indicator
- ◆ Small 5mm × 5mm 32-Pin QFN Package

## Ordering Information

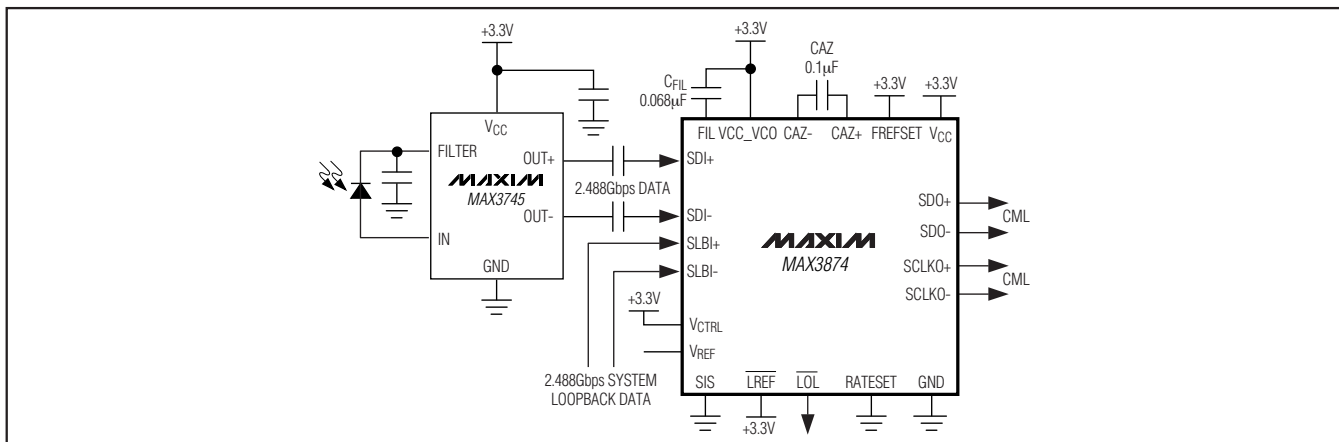
PART	TEMP RANGE	PIN-PACKAGE	PKG CODE
MAX3874EGJ	-40°C to +85°C	32 QFN	G3255-1
MAX3874AEGJ**	-40°C to +85°C	32 QFN	G3255-1
MAX3874AETJ+**	-40°C to +85°C	32 TQFN	T3255-3

\*\*Contains a VCO centered at 2.0212GHz.

+Denotes lead-free package.

Pin Configuration appears at end of data sheet.

## Typical Application Circuit



# 2.488Gbps/2.667Gbps Clock and Data Recovery with Limiting Amplifier

## ABSOLUTE MAXIMUM RATINGS

Supply Voltage,  $V_{CC}$ .....-0.5V to +5.0V  
 Input Voltage Levels (SDI+, SDI-, SLBI+, SLBI-).....( $V_{CC} - 1.0V$ ) to ( $V_{CC} + 0.5V$ )  
 Input Current Levels (SDI+, SDI-, SLBI+, SLBI-)..... $\pm 20mA$   
 CML Output Current (SDO+, SDO-, SCLKO+, SCLKO-) ... $\pm 22mA$   
 Voltage at  $\overline{LOL}$ ,  $\overline{LREF}$ , SIS, FIL, RATESET, FREFSET,  $V_{CTRL}$ ,  $V_{REF}$ , CAZ+, CAZ-.....-0.5V to ( $V_{CC} + 0.5V$ )

Continuous Power Dissipation ( $T_A = +85^\circ C$ )  
 32-Pin QFN (derate 21.3mW/ $^\circ C$  above +85 $^\circ C$ ) .....1384mW  
 Operating Junction Temperature Range.....-55 $^\circ C$  to +150 $^\circ C$   
 Storage Temperature Range.....-55 $^\circ C$  to +150 $^\circ C$   
 Processing Temperature (die).....+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 at  $V_{CC} = +3.3V$ ,  $T_A = +25^\circ C$ , unless otherwise noted.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Supply Current	$I_{CC}$	(Note 2)		175	215	mA
<b>INPUT SPECIFICATION (SDI<math>\pm</math>, SLBI<math>\pm</math>)</b>						
Single-Ended Input Voltage Range	$V_{IS}$	Figure 1	$V_{CC} - 0.8$		$V_{CC} + 0.4$	V
Input Common-Mode Voltage		Figure 1	$V_{CC} - 0.4$		$V_{CC}$	V
Input Termination to $V_{CC}$	$R_{IN}$		42.5	50	57.5	$\Omega$
<b>THRESHOLD-SETTING SPECIFICATION (SDI<math>\pm</math>)</b>						
Differential Input Voltage Range (SDI $\pm$ )		Threshold adjust enabled	50		600	mV <sub>P-P</sub>
Threshold Adjustment Range	$V_{TH}$	Figure 2	-170		+170	mV
Threshold Control Voltage	$V_{CTRL}$	Figure 2 (Note 3)	0.3		2.1	V
Threshold Control Linearity				$\pm 5$		%
Threshold Setting Accuracy		Figure 2	-18		+18	mV
Threshold Setting Stability		$15mV \leq  V_{TH}  \leq 80mV$	-6		+6	mV
		$80mV <  V_{TH}  \leq 170mV$	-12		+12	
Maximum Input Current	$I_{CTRL}$		-10		+10	$\mu A$
Reference Voltage Output	$V_{REF}$		2.14	2.2	2.24	V
<b>CML OUTPUT SPECIFICATION (SDO<math>\pm</math>, SCLKO<math>\pm</math>)</b>						
CML Differential Output Impedance	$R_O$		85	100	115	$\Omega$
CML Output Common-Mode Voltage		(Note 4)		$V_{CC} - 0.2$		V

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## DC ELECTRICAL CHARACTERISTICS (continued)

(V<sub>CC</sub> = +3.0V to +3.6V, T<sub>A</sub> = -40°C to +85°C. Typical values at V<sub>CC</sub> = +3.3V, T<sub>A</sub> = +25°C, unless otherwise noted.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
<b>LVTTTL INPUT/OUTPUT SPECIFICATION (LOL, LREF, RATESET, FREFSET)</b>						
LVTTTL Input High Voltage	V <sub>IH</sub>		2.0			V
LVTTTL Input Low Voltage	V <sub>IL</sub>				0.8	V
LVTTTL Input Current			-10		+10	μA
LVTTTL Output High Voltage	V <sub>OH</sub>	I <sub>OH</sub> = +20μA	2.4			V
LVTTTL Output Low Voltage	V <sub>OL</sub>	I <sub>OL</sub> = -1mA			0.4	V

**Note 1:** At -40°C, DC characteristics are guaranteed by design and characterization.

**Note 2:** CML outputs open.

**Note 3:** Voltage applied to V<sub>CTRL</sub> pin is from 0.3V to 2.1V when input threshold is adjusted from +170mV to -170mV.

**Note 4:** R<sub>L</sub> = 50Ω to V<sub>CC</sub>.

## AC ELECTRICAL CHARACTERISTICS

(V<sub>CC</sub> = +3.0V to +3.6V, T<sub>A</sub> = -40°C to +85°C. Typical values at V<sub>CC</sub> = +3.3V, T<sub>A</sub> = +25°C, unless otherwise noted.) (Note 5)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Serial Input Data Rate		MAX3874 (RATESET = GND)		2.488		Gbps
		MAX3874 (RATESET = VCC)		2.667		
		MAX3874A		2.0212		
Differential Input Voltage (SDI±)	V <sub>ID</sub>	Threshold adjust disabled, Figure 1 (Note 6)	10		1600	mV <sub>P-P</sub>
Differential Input Voltage (SLBI±)		BER ≤ 10 <sup>-10</sup>	50		800	mV <sub>P-P</sub>
Jitter Transfer Bandwidth	J <sub>BW</sub>	MAX3874		1.5	2.0	MHz
		MAX3874A		0.7		
Jitter Peaking	J <sub>P</sub>	f ≤ J <sub>BW</sub>			0.1	dB
Sinusoidal Jitter Tolerance (MAX3874)		f = 100kHz	3.1	8.0		UI <sub>P-P</sub>
		f = 1MHz	0.62	0.93		
		f = 10MHz	0.44	0.65		
Sinusoidal Jitter Tolerance (MAX3874A)		f = 1MHz (Note 7)		>0.5		UI <sub>P-P</sub>
		f = 10MHz (Note 7)		>0.3		
Sinusoidal Jitter Tolerance with Threshold Adjust Enabled (Note 8)		f = 100kHz		7.1		UI <sub>P-P</sub>
		f = 1MHz		0.82		
		f = 10MHz		0.54		
Jitter Generation	J <sub>GEN</sub>	(Note 9)		2.7	4.0	mUI <sub>RMS</sub>
Differential Input Return Loss (SDI±, SLBI±)	-20log  S <sub>11</sub>	100kHz to 2.5GHz		16		dB
		2.5GHz to 4GHz		15		
<b>CML OUTPUT SPECIFICATION (SDO±, SCLKO±)</b>						
Output Edge Speed	t <sub>r</sub> , t <sub>f</sub>	20% to 80%			110	ps
CML Output Differential Swing		R <sub>L</sub> = 100Ω differential	600	800	1000	mV <sub>P-P</sub>
Clock-to-Q Delay	t <sub>CLK-Q</sub>	(Note 10)	-40		+40	ps

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## AC ELECTRICAL CHARACTERISTICS (continued)

( $V_{CC} = +3.0V$  to  $+3.6V$ ,  $T_A = -40^{\circ}C$  to  $+85^{\circ}C$ . Typical values at  $V_{CC} = +3.3V$ ,  $T_A = +25^{\circ}C$ , unless otherwise noted.) (Note 5)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
<b>PLL ACQUISITION/LOCK SPECIFICATION</b>						
Tolerated Consecutive Identical Digits		$BER \leq 10^{-10}$		2000		Bits
Acquisition Time		Figure 4 (Note 11)			1.0	ms
$\overline{LOL}$ Assert Time		Figure 4	2.3		10.0	$\mu s$
Low-Frequency Cutoff for DC-Offset Cancellation Loop		$CAZ = 0.1\mu F$		4		kHz
<b>CLOCK HOLDOVER SPECIFICATION</b>						
Reference Clock Frequency				Table 4		
Maximum VCO Frequency Drift		(Note 12)			400	ppm

- Note 5:** Minimum and maximum AC characteristics are guaranteed by design and characterization using the MAX3874. Specifications apply to the MAX3874A only when noted.
- Note 6:** Jitter tolerance is guaranteed ( $BER \leq 10^{-10}$ ) within this input voltage range. Input threshold adjust is disabled with  $V_{CTRL}$  connected to  $V_{CC}$ .
- Note 7:** Measurements limited by equipment capability.
- Note 8:** Measured using a 100mV<sub>P-P</sub> differential swing with a 20mVDC offset and an edge speed of 145ps (4th-order Bessel filter with  $f_{3dB} = 1.8GHz$ ).
- Note 9:** Measured with 10mV<sub>P-P</sub> differential input,  $2^{23} - 1$  PRBS pattern at OC-48 with bandwidth from 12kHz to 20MHz.
- Note 10:** Relative to the falling edge of the SCLKO+ (Figure 3).
- Note 11:** Measured at OC-48 data rate using a 0.068 $\mu F$  loop filter capacitor initialized to +3.6V.
- Note 12:** Measured at OC-48 data rate under  $\overline{LOL}$  condition with the CDR clock output set by the external reference clock.

## Timing Diagrams

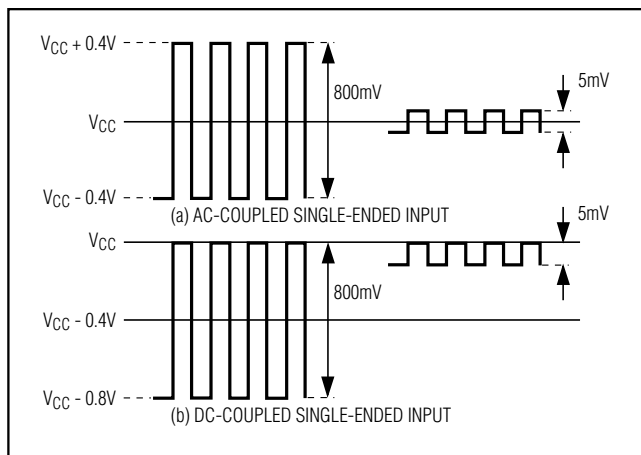


Figure 1. Definition of Input Voltage Swing

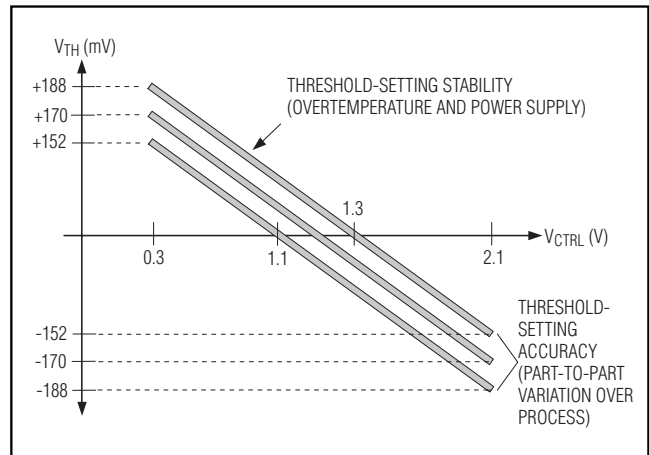


Figure 2. Relationship Between Control Voltage and Threshold Voltage

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## Timing Diagrams (continued)

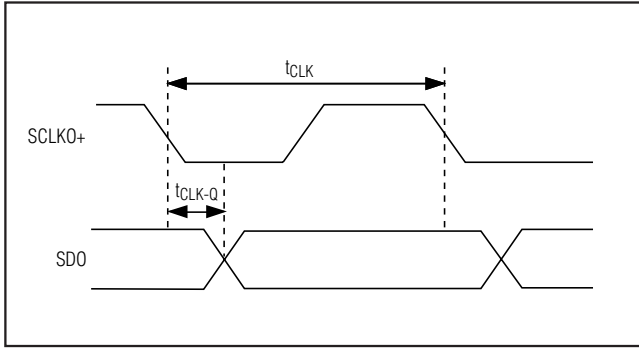


Figure 3. Definition of Clock-to-Q Delay

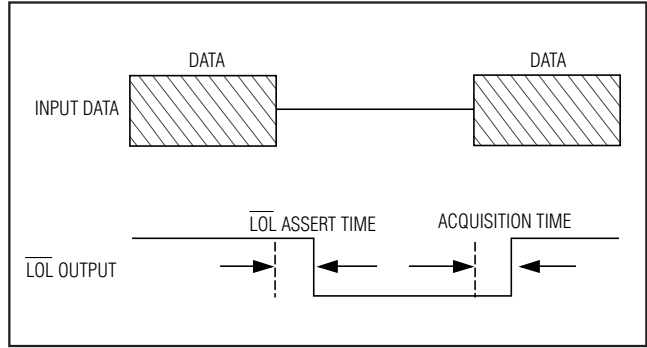
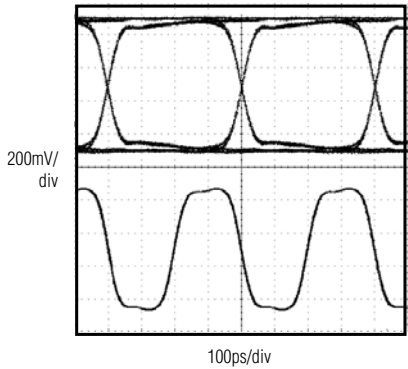


Figure 4.  $\overline{LOL}$  Assert Time and PLL Acquisition Time Measurement

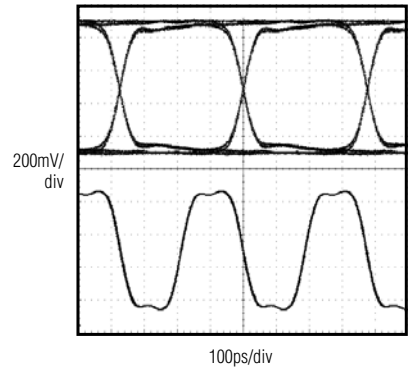
## Typical Operating Characteristics

( $V_{CC} = +3.3V$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)

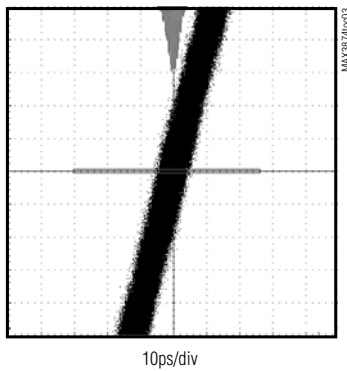
**RECOVERED CLOCK AND DATA**  
(2.488Gbps, 2<sup>23</sup>-1 PATTERN,  $V_{IN} = 10mV_{p-p}$ )



**RECOVERED CLOCK AND DATA**  
(2.67Gbps, 2<sup>23</sup>-1 PATTERN,  $V_{IN} = 10mV_{p-p}$ )

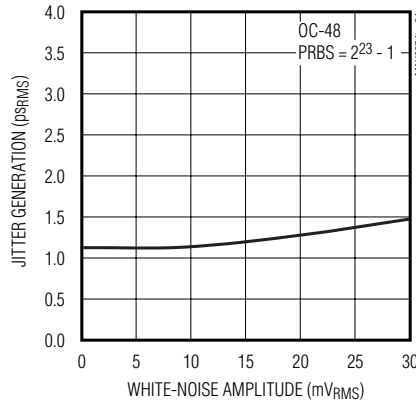


**RECOVERED CLOCK JITTER**  
(2.488Gbps)

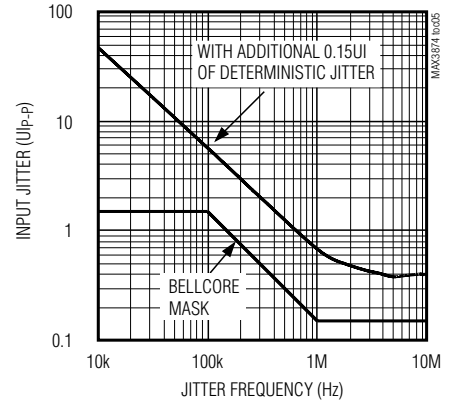


TOTAL WIDEBAND RMS JITTER = 1.60ps  
PEAK-TO-PEAK JITTER = 12.20ps

**JITTER GENERATION**  
vs. POWER-SUPPLY WHITE NOISE



**JITTER TOLERANCE**  
(2.488Gbps, 2<sup>23</sup>-1 PATTERN,  $V_{IN} = 10mV_{p-p}$ )

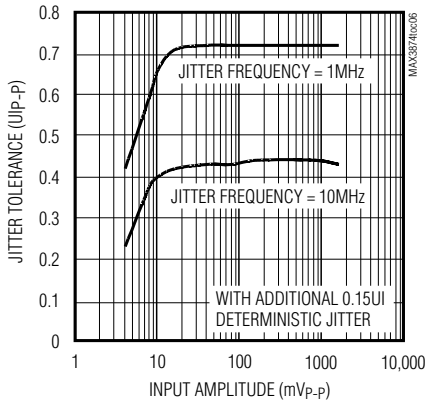


# 2.488Gbps/2.667Gbps Clock and Data Recovery with Limiting Amplifier

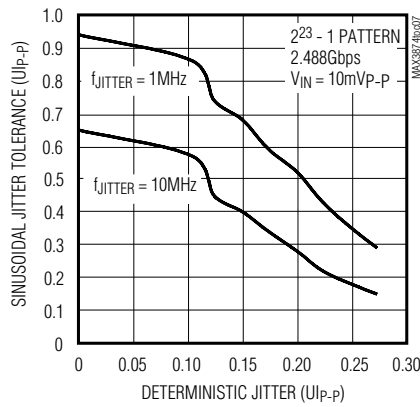
## Typical Operating Characteristics (continued)

(V<sub>CC</sub> = +3.3V, T<sub>A</sub> = +25°C, unless otherwise noted.)

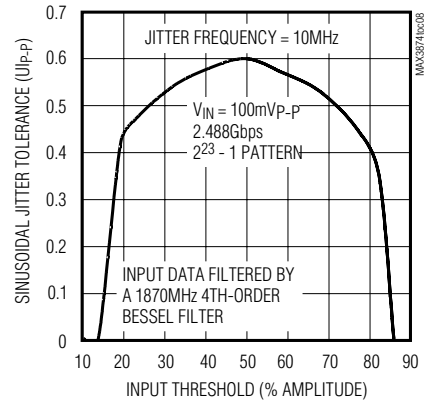
**JITTER TOLERANCE vs. INPUT AMPLITUDE (2.488Gbps, 2<sup>23</sup>-1 PATTERN)**



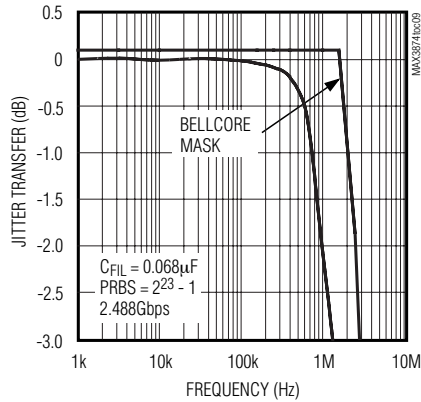
**JITTER TOLERANCE vs. INPUT DETERMINISTIC JITTER**



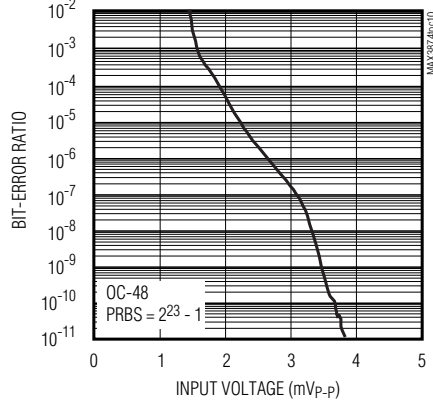
**JITTER TOLERANCE vs. THRESHOLD ADJUST**



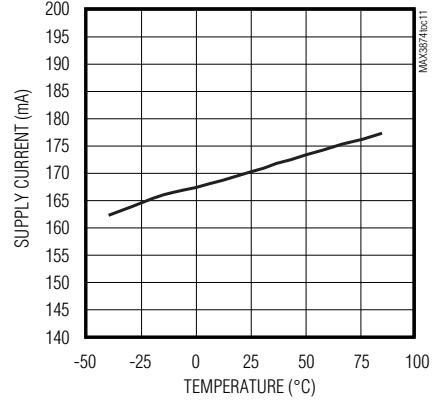
**JITTER TRANSFER**



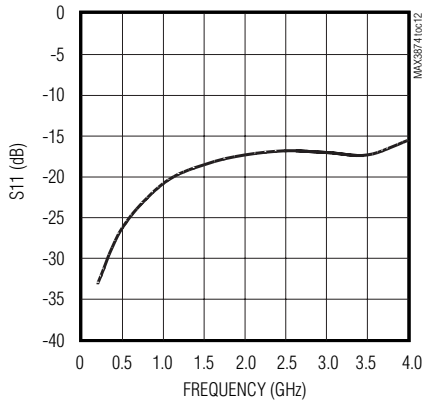
**BIT-ERROR RATIO vs. INPUT AMPLITUDE**



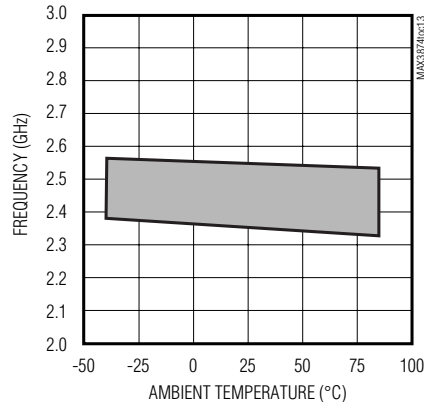
**SUPPLY CURRENT vs. TEMPERATURE**



**DIFFERENTIAL S11 vs. FREQUENCY**



**PULLIN RANGE (RATESET = 0)**



# 2.488Gbps/2.667Gbps Clock and Data Recovery with Limiting Amplifier

## Pin Description

**MAX3874**

PIN	NAME	FUNCTION
1, 4, 27	VCC	+3.3V Supply Voltage
2	SDI+	Positive Serial Data Input, CML
3	SDI-	Negative Serial Data Input, CML
5	SLBI+	Positive System Loopback Input or Reference Clock Input, CML
6	SLBI-	Negative System Loopback Input or Reference Clock Input, CML
7	SIS	Signal Selection Input, LVTTTL. Set low for normal operation, set high for system loopback.
8	$\overline{\text{LREF}}$	Lock-to-Reference Clock Input, LVTTTL. Set high for PLL lock to serial data, set low for PLL lock to reference clock.
9	$\overline{\text{LOL}}$	Loss-of-Lock Output, LVTTTL. Active low.
10, 11, 16, 25, 32	GND	Supply Ground
12	FIL	PLL Loop-Filter Capacitor Input. Connect a 0.068 $\mu$ F capacitor between FIL and VCC_VCO.
13, 18	VCC_VCO	+3.3V Supply Voltage for the VCO
14, 15	N.C.	Not Connected
17	RATESET	VCO Frequency Select Input, LVTTTL (Tables 2, 3, and 4)
19	SCLKO-	Negative Serial Clock Output, CML
20	SCLKO+	Positive Serial Clock Output, CML
21, 24	VCC_OUT	Supply Voltage for the CML Outputs
22	SDO-	Negative Serial Data Output, CML
23	SDO+	Positive Serial Data Output, CML
26	FREFSET	Reference Clock Frequency Select Input, LVTTTL (Tables 2, 3, and 4)
28	CAZ+	Positive Capacitor Input for DC-Offset Cancellation Loop. Connect a 0.1 $\mu$ F capacitor between CAZ+ and CAZ-.
29	CAZ-	Negative Capacitor Input for DC-Offset Cancellation Loop. Connect a 0.1 $\mu$ F capacitor between CAZ+ and CAZ-.
30	VREF	+2.2V Bandgap Reference Voltage Output. Optionally used for threshold adjustment.
31	VCTRL	Analog Control Input for Threshold Adjustment. Connect to VCC to disable threshold adjust.
EP	Exposed Pad	Ground. The exposed pad must be soldered to the circuit board ground for proper thermal and electrical performance.

# 2.488Gbps/2.667Gbps Clock and Data Recovery with Limiting Amplifier

## Detailed Description

The MAX3874 consists of a fully integrated PLL limiting amplifier with threshold adjust, DC-offset cancellation loop, data retiming block, and CML output buffers (Figure 5). The PLL consists of a phase/frequency detector, a loop filter, and a 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.

### SDI Input Amplifier

The SDI inputs of the MAX3874 accept serial NRZ data with a differential input amplitude from 10mV<sub>P-P</sub> to 1600mV<sub>P-P</sub>. The input sensitivity is 10mV<sub>P-P</sub>, at which the jitter tolerance is met for a BER of 10<sup>-10</sup> with threshold adjust disabled. The input sensitivity can be as low as 4mV<sub>P-P</sub> and still maintain a BER of 10<sup>-10</sup>. The MAX3874 inputs are designed to directly interface with a transimpedance amplifier such as the MAX3745.

For applications in which vertical threshold adjustment is needed, the MAX3874 can be connected to the output of an AGC amplifier such as the MAX3861. When using the threshold adjust, the input voltage range is 50mV<sub>P-P</sub> to 600mV<sub>P-P</sub> (see the *Design Procedure* section).

### SLBI Input Amplifier

The SLBI input amplifier accepts either NRZ loopback data or a reference clock signal. This amplifier can accept a differential input amplitude from 50mV<sub>P-P</sub> to 800mV<sub>P-P</sub>.

### Phase Detector

The phase detector incorporated in the MAX3874 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) acquires frequency lock without the use of an external reference clock. The frequency difference between the received data and the VCO clock is derived by sampling the in-phase and quadrature VCO outputs on both edges of the data-input signal. Depending on the polarity of the frequency difference, 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. False locking is eliminated by this digital frequency detector.

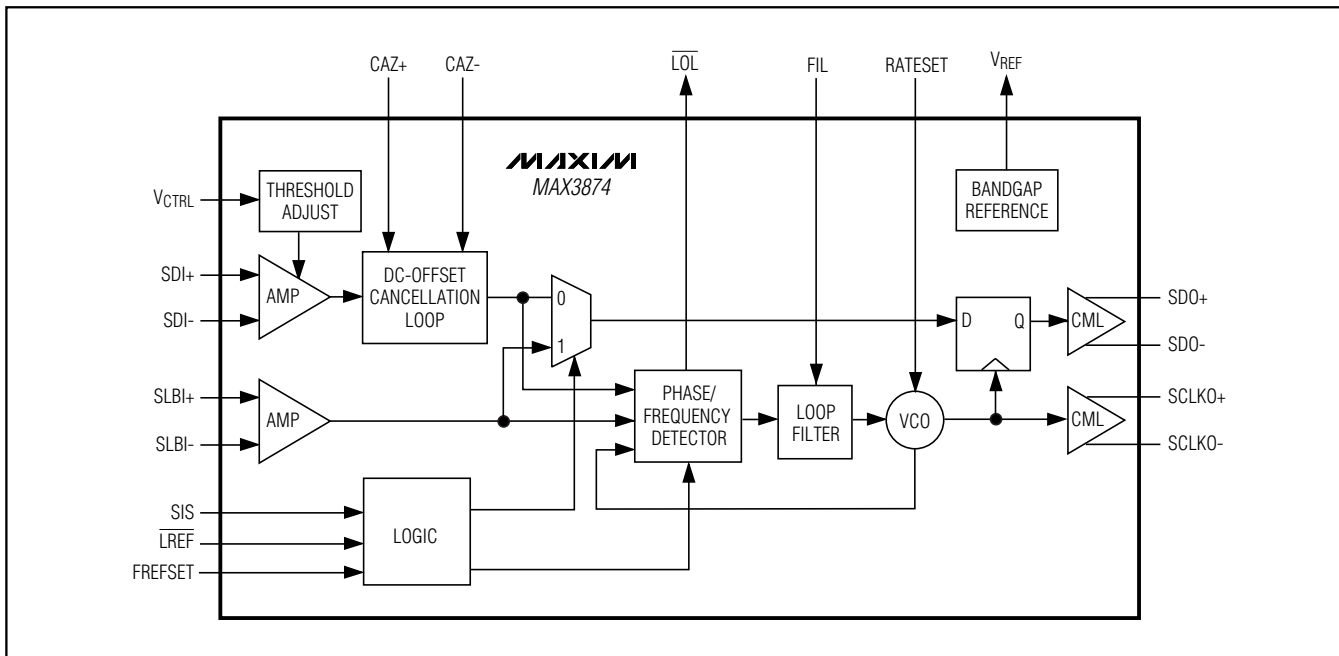


Figure 5. Functional Diagram



## 2.488Gbps/2.667Gbps Clock and Data Recovery with Limiting Amplifier

### Loop Filter and VCO

The phase detector and frequency detector outputs are summed into the loop filter. An external capacitor ( $C_{FIL}$ ) connected from FIL to VCC\_VCO is required to set the PLL damping ratio. Note that the PLL jitter bandwidth does not change as the external capacitor changes, but the jitter peaking, acquisition time, and loop stability are affected. See the *Design Procedure* section for guidelines on selecting this capacitor.

The loop filter output controls the two on-chip VCOs. The VCOs provide low phase noise and are trimmed to the 2.488GHz and 2.667GHz frequencies. (The MAX3874A uses a single VCO trimmed to 2.0212GHz.) The RATESET pin is used to select the appropriate VCO. See Tables 2, 3, and 4 for the proper settings.

### Loss-of-Lock Monitor

The  $\overline{LOL}$  output indicates a PLL lock failure due to excessive jitter present at the data input or due to loss of input data. The LOL output is asserted low when the PLL loses lock.

### DC-Offset Cancellation Loop

A DC-offset cancellation loop is implemented to remove the DC offset of the limiting amplifier. To minimize the low-frequency pattern-dependent jitter associated with this DC-cancellation loop, the low-frequency cutoff is 10kHz (typ) with  $CAZ = 0.1\mu\text{F}$ , connected from CAZ+ to CAZ-. The DC-offset cancellation loop operates only when threshold adjust is disabled.

## Design Procedure

### Decision Threshold Adjust

In applications in which the noise density is not balanced between logical zeros and ones (i.e., optical amplification using EDFA amplifiers), lower bit-error ratios (BERs) can be achieved by adjusting the input threshold. Varying the voltage at  $V_{CTRL}$  from +0.3V to +2.1V achieves a vertical decision threshold adjustment of +170mV to -170mV, respectively (Figure 2). Use the provided bandgap reference voltage output ( $V_{REF}$ ) with a voltage-divider circuit or the output of a DAC to set the voltage at  $V_{CTRL}$ . See Figure 10 when using  $V_{REF}$  to generate the voltage for  $V_{CTRL}$ .  $V_{REF}$  can be used to generate the voltage for  $V_{CTRL}$  (Figure 10). If threshold adjust is not required, disable it by connecting  $V_{CTRL}$  directly to VCC and leave  $V_{REF}$  floating.

### Modes of Operation

The MAX3874 has three operational modes controlled by the  $\overline{LREF}$  and SIS inputs: normal, system loopback, and clock holdover. Normal operation mode requires a serial data stream at the SDI $\pm$  inputs, system loopback mode requires a serial data stream at the SLBI $\pm$  inputs, and clock holdover mode requires a reference clock signal at the SLBI $\pm$  inputs. See Table 1 for the required  $\overline{LREF}$  and SIS settings. Once an operational mode is chosen, the remaining logic inputs (RATESET, FREFSET) program the input data rate or reference clock frequency.

### Normal and System Loopback Settings

The RATESET pin is available for setting the SDI $\pm$  and SLBI $\pm$  inputs to receive the appropriate data rate. The FREFSET pin can be set to a zero or 1 while in normal or system-loopback mode (Tables 2 and 3).

### Clock Frequencies in Holdover Mode

Set the incoming reference-clock frequency and outgoing serial-clock frequency by setting RATESET and FREFSET appropriately (Table 3).

**Table 1. Operational Modes**

MODE	$\overline{LREF}$	SIS
Normal	1	0
System loopback	1	1
Clock holdover	0	1 or 0

**Table 2. Data-Rate Settings (MAX3874)**

INPUT DATA RATE (Gbps)	RATESET	FREFSET
2.667	1	1 or 0
2.488	0	1 or 0

**Table 3. Data-Rate Settings (MAX3874A)**

INPUT DATA RATE (Gbps)	RATESET	FREFSET
2.0212	0	1 or 0

## 2.488Gbps/2.667Gbps Clock and Data Recovery with Limiting Amplifier

Table 4. Holdover Frequency Settings

REFERENCE CLOCK FREQUENCY (MHz)	SCLKO FREQUENCY (GHz)	RATESET	FREFSET
666.51	2.667	1	0
622.08	2.488	0	0
166.63	2.667	1	1
155.52	2.488	0	1

### Setting the Loop Filter

The MAX3874 is designed for both regenerator and receiver applications. Its fully integrated PLL is a classic 2nd-order feedback system, with a jitter transfer bandwidth ( $J_{BW}$ ) below 2MHz. The external capacitor ( $C_{FIL}$ ) connected from FIL to VCC\_VCO sets the PLL damping. Note that the PLL jitter transfer bandwidth does not change as  $C_{FIL}$  changes, but the jitter peaking, acquisition time, and loop stability are affected. 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  $C_{FIL}$ , and can be approximated according to:

$$f_z = \frac{1}{2\pi(650\Omega)C_{FIL}}$$

For an overdamped system ( $f_z / J_{BW} < 0.25$ ), the jitter peaking ( $J_P$ ) of a 2nd-order system can be approximated by:

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

where  $J_{BW}$  is the jitter transfer bandwidth for a given data rate.

The recommended value of  $C_{FIL} = 0.068\mu\text{F}$  is to guarantee a maximum jitter peaking of less than 0.1dB. Decreasing  $C_{FIL}$  from the recommended value decreases acquisition time, with the trade-off of increased peaking. Excessive reduction of  $C_{FIL}$  can cause PLL instability.  $C_{FIL}$  must be a low-TC, high-quality capacitor of type X7R or better.

### Input Terminations

The  $SDI_{\pm}$  and  $SLBI_{\pm}$  inputs of the MAX3874 are current-mode-logic (CML) compatible. The inputs all provide internal  $50\Omega$  termination to reduce the required number of external components. AC-coupling is recom-

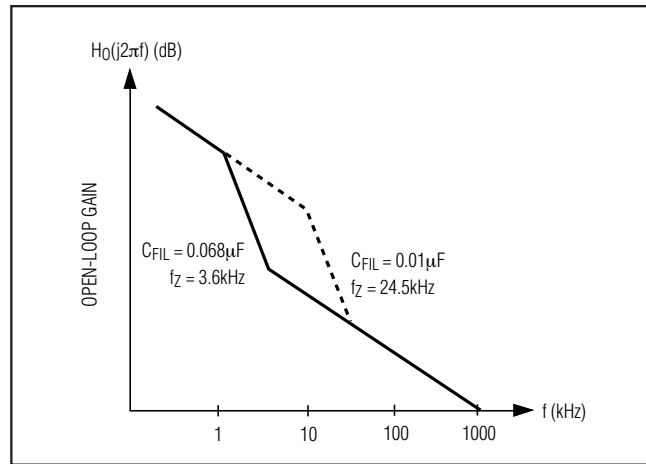


Figure 6. Open-Loop Transfer Function

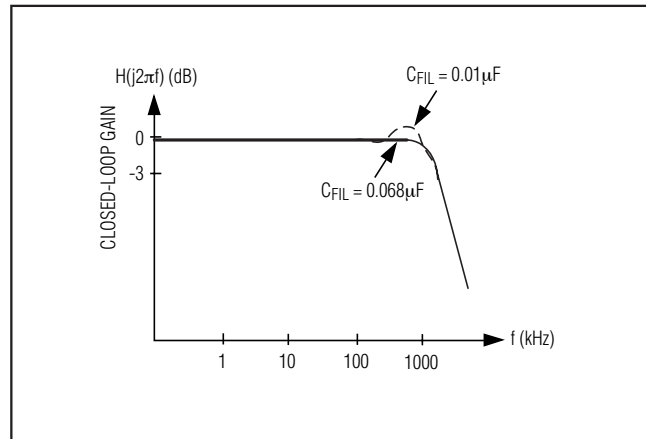


Figure 7. Closed-Loop Transfer Function

mended. See Figure 8 for the input structure. For additional information about logic interfacing, refer to Maxim Application Note HFAN 1.0: *Introduction to LVDS, PECL, and CML*.

# 2.488Gbps/2.667Gbps Clock and Data Recovery with Limiting Amplifier

MAX3874

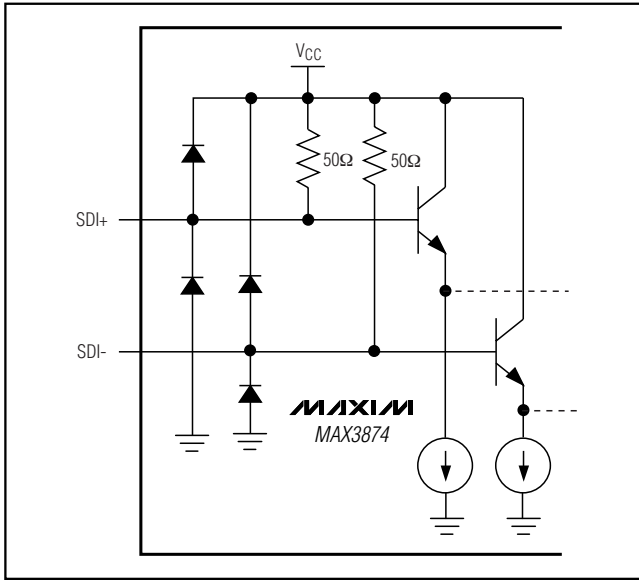


Figure 8. CML Input Model

### Output Terminations

The MAX3874 uses CML for its high-speed digital outputs (SDO± and SCLKO±). The configuration of the output circuit includes internal 50Ω back terminations to VCC. See Figure 9 for the output structure. CML outputs can be terminated by 50Ω to VCC, or by 100Ω differential impedance. For additional information on logic interfacing, refer to Maxim Application Note HFAN 1.0: *Introduction to LVDS, PECL, and CML*.

### Applications Information

#### Clock Holdover Capability

Clock holdover is required in some applications in which a valid clock must be provided to the upstream device in the absence of data transitions. To provide this function, an external reference clock signal must be applied to the SLBI± inputs and the proper control signals set (see the *Modes of Operation* section). To enter holdover mode automatically when there are no transitions applied to the SDI+ inputs, LOL or the system LOS can be directly connected to LREF.

#### System Loopback

The MAX3874 is designed to allow system-loopback testing. When the device is set for system-loopback mode, the serial output data of a transmitter can be directly connected to the SLBI inputs to run system diagnostics. See Table 1 for selecting system loopback operation mode. While in system loopback mode, LREF should not be connected to LOL.

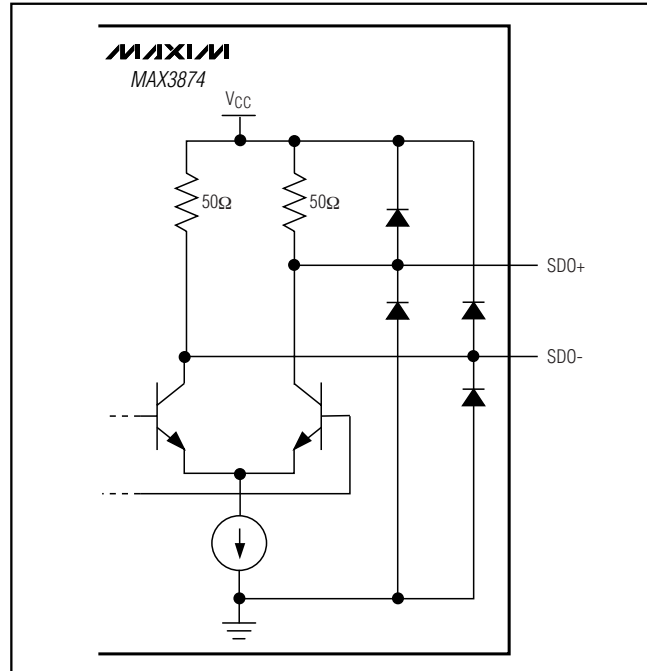


Figure 9. CML Output Model

### Consecutive Identical Digits (CIDs)

The MAX3874 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 better than 10<sup>-10</sup>. The CID tolerance is tested using a 2<sup>13</sup> - 1 PRBS with long runs of ones and zeros inserted in the pattern. A CID tolerance of 2000 bits is typical.

### Exposed Pad (EP) Package

The EP, 32-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 MAX3874 and should be soldered to the circuit board for proper thermal and electrical performance.

### Layout Considerations

For best performance, use good high-frequency layout techniques. Filter voltage supplies, keep ground connections short, and use multiple vias where possible. Use controlled-impedance transmission lines to interface with the MAX3874 high-speed inputs and outputs. Place power-supply decoupling as close to VCC as possible. To reduce feedthrough, isolate the input signals from the output signals. If a bare die is used, mount the back of die to ground (GND) potential.

Figure 10 shows interfacing with the MAX3861 AGC using threshold adjust.

# 2.488Gbps/2.667Gbps Clock and Data Recovery with Limiting Amplifier

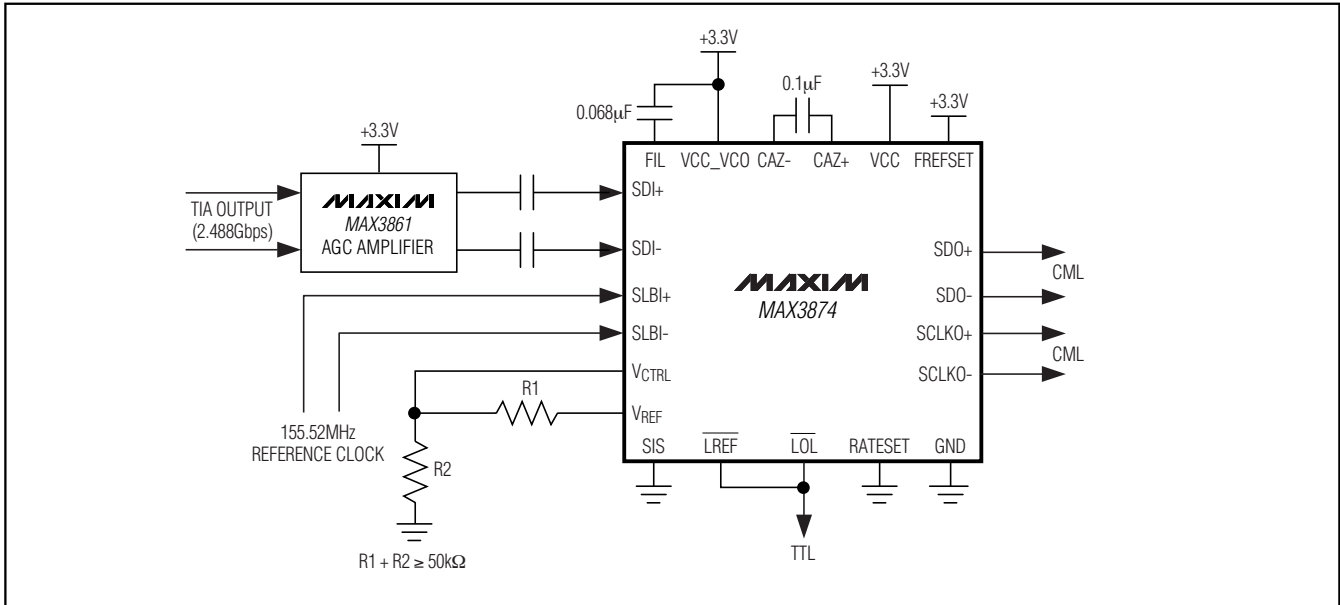
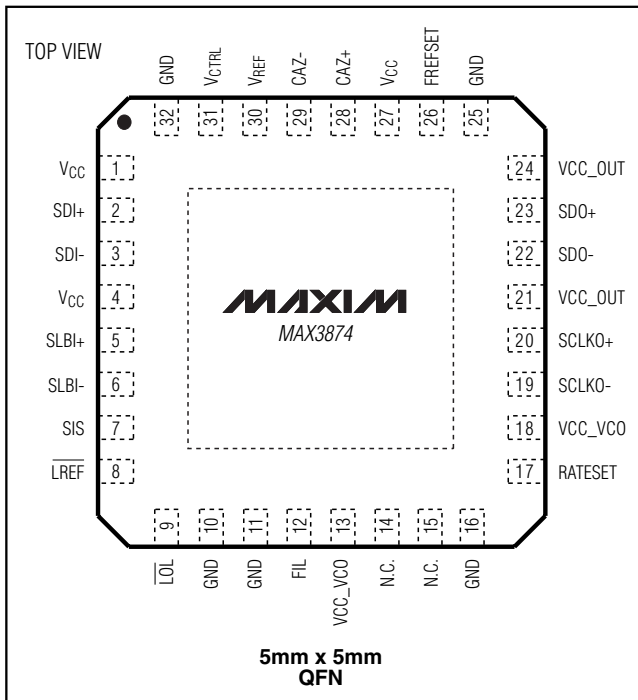


Figure 10. Interfacing with the MAX3861 AGC Using Threshold Adjust

## Pin Configuration



## Chip Information

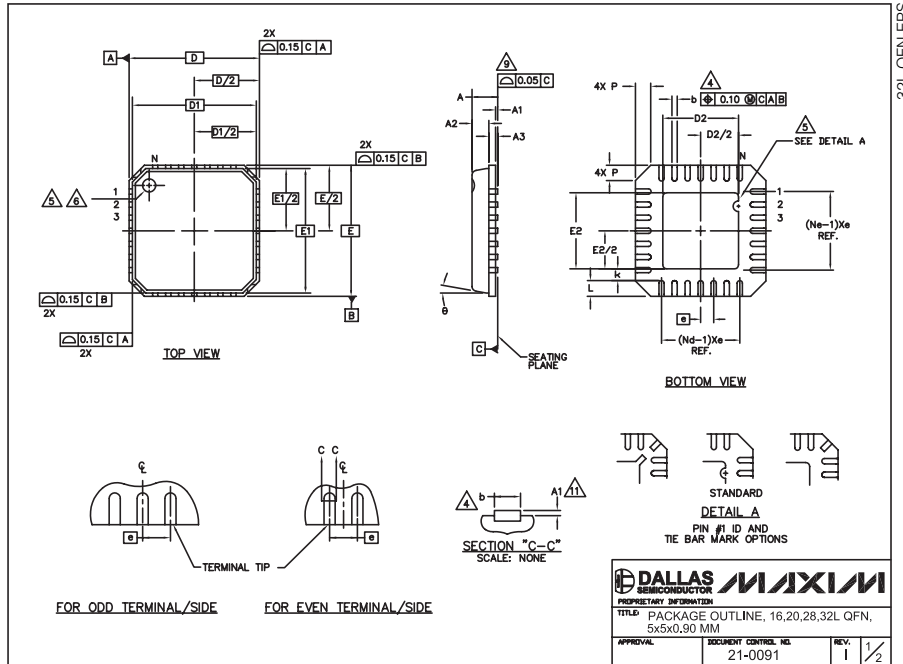
TRANSISTOR COUNT: 5142  
 PROCESS: SiGe BiPolar  
 SUBSTRATE: SOI

# 2.488Gbps/2.667Gbps Clock and Data Recovery with Limiting Amplifier

## Package Information

(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).)

MAX3874



COMMON DIMENSIONS												
PKG	16L 5x5			20L 5x5			28L 5x5			32L 5x5		
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	0.80	0.90	1.00	0.80	0.90	1.00	0.80	0.90	1.00	0.80	0.90	1.00
A1	0.00	0.01	0.05	0.00	0.01	0.05	0.00	0.01	0.05	0.00	0.01	0.05
A2	0.00	0.65	1.00	0.00	0.65	1.00	0.00	0.65	1.00	0.00	0.65	1.00
A3	0.20 REF			0.20 REF			0.20 REF			0.20 REF		
b	0.28	0.33	0.40	0.23	0.28	0.35	0.18	0.23	0.30	0.18	0.23	0.30
D	4.90	5.00	5.10	4.90	5.00	5.10	4.90	5.00	5.10	4.90	5.00	5.10
D1	4.75 BSC			4.75 BSC			4.75 BSC			4.75 BSC		
E	4.90	5.00	5.10	4.90	5.00	5.10	4.90	5.00	5.10	4.90	5.00	5.10
E1	4.75 BSC			4.75 BSC			4.75 BSC			4.75 BSC		
e	0.80 BSC			0.65 BSC			0.50 BSC			0.50 BSC		
k	0.25	-	-	0.25	-	-	0.25	-	-	0.25	-	-
L	0.35	0.55	0.75	0.35	0.55	0.75	0.35	0.55	0.75	0.30	0.40	0.50
N	16			20			28			32		
ND	4			5			7			8		
NE	4			5			7			8		
P	0.00	0.42	0.60	0.00	0.42	0.60	0.00	0.42	0.60	0.00	0.42	0.60
ø	0"			12"			0"			12"		

EXPOSED PAD VARIATIONS									
PKG CODES	D2			E2					
	MIN.	NDM.	MAX.	MIN.	NDM.	MAX.	MIN.	NDM.	MAX.
G1655-3	2.95	3.10	3.25	2.95	3.10	3.25			
G2055-1	2.55	2.70	2.85	2.55	2.70	2.85			
G2055-2	2.95	3.10	3.25	2.95	3.10	3.25			
G2855-1	2.55	2.70	2.85	2.55	2.70	2.85			
G2855-2	2.95	3.10	3.25	2.95	3.10	3.25			
G3255-1	2.95	3.10	3.25	2.95	3.10	3.25			

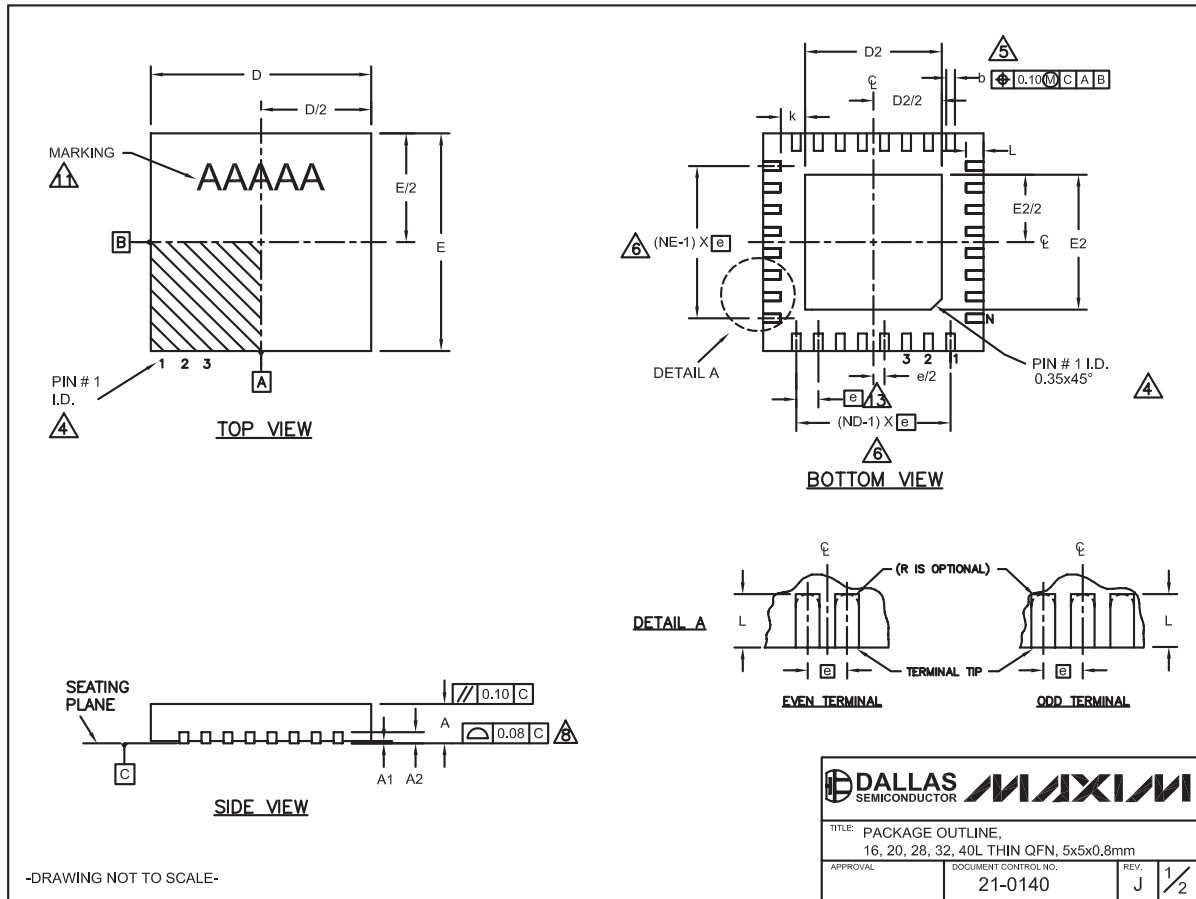
**NOTES:**

- DIE THICKNESS ALLOWABLE IS 0.305mm MAXIMUM (.012 INCHES MAXIMUM)
- DIMENSIONING & TOLERANCES CONFORM TO ASME Y14.5M - 1994.
- N IS THE NUMBER OF TERMINALS.  
Nd IS THE NUMBER OF TERMINALS IN X-DIRECTION & Ne IS THE NUMBER OF TERMINALS IN Y-DIRECTION.
- DIMENSION b APPLIES TO PLATED TERMINAL AND IS MEASURED BETWEEN 0.20 AND 0.25mm FROM TERMINAL TIP.
- 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.
- EXACT SHAPE AND SIZE OF THIS FEATURE IS OPTIONAL.
- ALL DIMENSIONS ARE IN MILLIMETERS.
- PACKAGE WARPAGE MAX 0.05mm.
- APPLIED FOR EXPOSED PAD AND TERMINALS. EXCLUDE EMBEDDED PART OF EXPOSED PAD FROM MEASURING.
- MEETS JEDEC M0220; EXCEPT DIMENSION "b".
- APPLIED FOR EXPOSED PAD AND TERMINALS. EXCLUDE EMBEDDING PART OF EXPOSED PAD FROM MEASURING.
- THIS PACKAGE OUTLINE APPLIES TO ANVIL SINGULATION (STEPPED SIDES).

# 2.488Gbps/2.667Gbps Clock and Data Recovery with Limiting Amplifier

## 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).)



QFN THIN.EPS

TITLE: PACKAGE OUTLINE, 16, 20, 28, 32, 40L THIN QFN, 5x5x0.8mm		
APPROVAL	DOCUMENT CONTROL NO. 21-0140	REV. J 1/2

# 2.488Gbps/2.667Gbps Clock and Data Recovery with Limiting Amplifier

MAX3874

## 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).)

COMMON DIMENSIONS															
PKG.	16L 5x5			20L 5x5			28L 5x5			32L 5x5			40L 5x5		
SYMBOL	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	0.70	0.75	0.80	0.70	0.75	0.80	0.70	0.75	0.80	0.70	0.75	0.80	0.70	0.75	0.80
A1	0	0.02	0.05	0	0.02	0.05	0	0.02	0.05	0	0.02	0.05	0	0.02	0.05
A2	0.20 REF.			0.20 REF.			0.20 REF.			0.20 REF.			0.20 REF.		
b	0.25	0.30	0.35	0.25	0.30	0.35	0.20	0.25	0.30	0.20	0.25	0.30	0.15	0.20	0.25
D	4.90	5.00	5.10	4.90	5.00	5.10	4.90	5.00	5.10	4.90	5.00	5.10	4.90	5.00	5.10
E	4.90	5.00	5.10	4.90	5.00	5.10	4.90	5.00	5.10	4.90	5.00	5.10	4.90	5.00	5.10
e	0.80 BSC.			0.65 BSC.			0.50 BSC.			0.50 BSC.			0.40 BSC.		
k	0.25	-	-	0.25	-	-	0.25	-	-	0.25	-	-	0.25	-	-
L	0.30	0.40	0.50	0.45	0.55	0.65	0.45	0.55	0.65	0.30	0.40	0.50	0.30	0.40	0.50
N	16			20			28			32			40		
ND	4			5			7			8			10		
NE	4			5			7			8			10		
JEDEC	WHHB			WHHC			WHHD-1			WHHD-2			-----		

EXPOSED PAD VARIATIONS								
PKG. CODES	D2			E2				
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.		
T1655-2	3.00	3.10	3.20	3.00	3.10	3.20		
T1655-3	3.00	3.10	3.20	3.00	3.10	3.20		
T1655N-1	3.00	3.10	3.20	3.00	3.10	3.20		
T2055-3	3.00	3.10	3.20	3.00	3.10	3.20		
T2055-4	3.00	3.10	3.20	3.00	3.10	3.20		
T2055-5	3.15	3.25	3.35	3.15	3.25	3.35		
T2855-3	3.15	3.25	3.35	3.15	3.25	3.35		
T2855-4	2.60	2.70	2.80	2.60	2.70	2.80		
T2855-5	2.60	2.70	2.80	2.60	2.70	2.80		
T2855-6	3.15	3.25	3.35	3.15	3.25	3.35		
T2855-7	2.60	2.70	2.80	2.60	2.70	2.80		
T2855-8	3.15	3.25	3.35	3.15	3.25	3.35		
T2855N-1	3.15	3.25	3.35	3.15	3.25	3.35		
T3255-3	3.00	3.10	3.20	3.00	3.10	3.20		
T3255-4	3.00	3.10	3.20	3.00	3.10	3.20		
T3255-5	3.00	3.10	3.20	3.00	3.10	3.20		
T3255N-1	3.00	3.10	3.20	3.00	3.10	3.20		
T4055-1	3.40	3.50	3.60	3.40	3.50	3.60		
T4055-2	3.40	3.50	3.60	3.40	3.50	3.60		

\*\*SEE COMMON DIMENSIONS TABLE

NOTES:

- DIMENSIONING & TOLERANCING CONFORM TO ASME Y14.5M-1994.
- ALL DIMENSIONS ARE IN MILLIMETERS. ANGLES ARE IN DEGREES.
- N IS THE TOTAL NUMBER OF TERMINALS.

⚠ THE TERMINAL #1 IDENTIFIER AND TERMINAL NUMBERING CONVENTION SHALL CONFORM TO JEDEC 95-1 SPP-012. DETAILS OF TERMINAL #1 IDENTIFIER ARE OPTIONAL, BUT MUST BE LOCATED WITHIN THE ZONE INDICATED. THE TERMINAL #1 IDENTIFIER MAY BE EITHER A MOLD OR MARKED FEATURE.

⚠ DIMENSION b APPLIES TO METALLIZED TERMINAL AND IS MEASURED BETWEEN 0.25 mm AND 0.30 mm FROM TERMINAL TIP.

⚠ ND AND NE REFER TO THE NUMBER OF TERMINALS ON EACH D AND E SIDE RESPECTIVELY.

7. DEPOPULATION IS POSSIBLE IN A SYMMETRICAL FASHION.

⚠ COPLANARITY APPLIES TO THE EXPOSED HEAT SINK SLUG AS WELL AS THE TERMINALS.

9. DRAWING CONFORMS TO JEDEC MO220, EXCEPT EXPOSED PAD DIMENSION FOR T2855-3 AND T2855-6.


⚠ WARPAGE SHALL NOT EXCEED 0.10 mm.

11. MARKING IS FOR PACKAGE ORIENTATION REFERENCE ONLY.

12. NUMBER OF LEADS SHOWN ARE FOR REFERENCE ONLY.

⚠ LEAD CENTERLINES TO BE AT TRUE POSITION AS DEFINED BY BASIC DIMENSION "e", ±0.05.

-DRAWING NOT TO SCALE-



TITLE: PACKAGE OUTLINE,  
16, 20, 28, 32, 40L THIN QFN, 5x5x0.8mm

APPROVAL: \_\_\_\_\_ DOCUMENT CONTROL NO. 21-0140 REV. J 2/2

## Revision History

Rev 0; 2/03:	Original data sheet release.
Rev 1; 4/03:	Page 3: Changed Jitter Transfer Bandwidth (MAX3874A) typ from 0.75MHz to 0.7MHz.
Rev 2; 5/03:	Page 1: Deleted -EP from package information.
Rev 3; 1/05:	Page 1: Added lead-free package information.
Rev 4; 7/06:	Page 1: Removed future status from MAX3745 in Typical Application Circuit.

Maxim cannot assume responsibility for use of any circuitry other than circuitry entirely embodied in a Maxim product. No circuit patent licenses are implied. Maxim reserves the right to change the circuitry and specifications without notice at any time.

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