19-4769; Rev 0a; 9/98

EVALUATION KIT AVAILABLE

+3.3V, 2.5Gbps SDH/SONET Laser Driver with Automatic Power Control

MAX3867

General Description

The MAX3867 is a complete, single +3.3V laser driver for SDH/SONET applications up to 2.5Gbps. The device accepts differential PECL data and clock inputs and provides bias and modulation currents for driving a laser. The synchronizing input latch can be bypassed if a clock signal is not available.

An automatic power control (APC) feedback loop is incorporated to maintain a constant average optical power over temperature and lifetime. The wide modulation current range of 5mA to 60mA and bias current of 1mA to 100mA are easy to program, making this product ideal for use in various SDH/SONET applications.

The MAX3867 also provides enable control, a programmable slow-start circuit to set the laser turn-on delay, and a failure-monitor output to indicate when the APC loop is unable to maintain the average optical power. The MAX3867 is available in a small 48-pin TQFP package as well as dice.

Applications

SONET/SDH Transmission Systems

Add/Drop Multiplexers

Digital Cross-Connects

Section Regenerators

2.5Gbps Optical Transmitters

Features

- **Single +3.3V or +5V Power Supply**
- **62mA Supply Current at +3.3V**
- **Programmable Modulation Current from 5mA to 60mA**
- **Programmable Bias Current from 1mA to 100mA**
- **Rise/Fall Time < 90ps**
- **Automatic Average Power Control with Failure Monitor**
- **Complies with ANSI, ITU, and Bellcore SDH/SONET Specifications**
- **Enable Control**

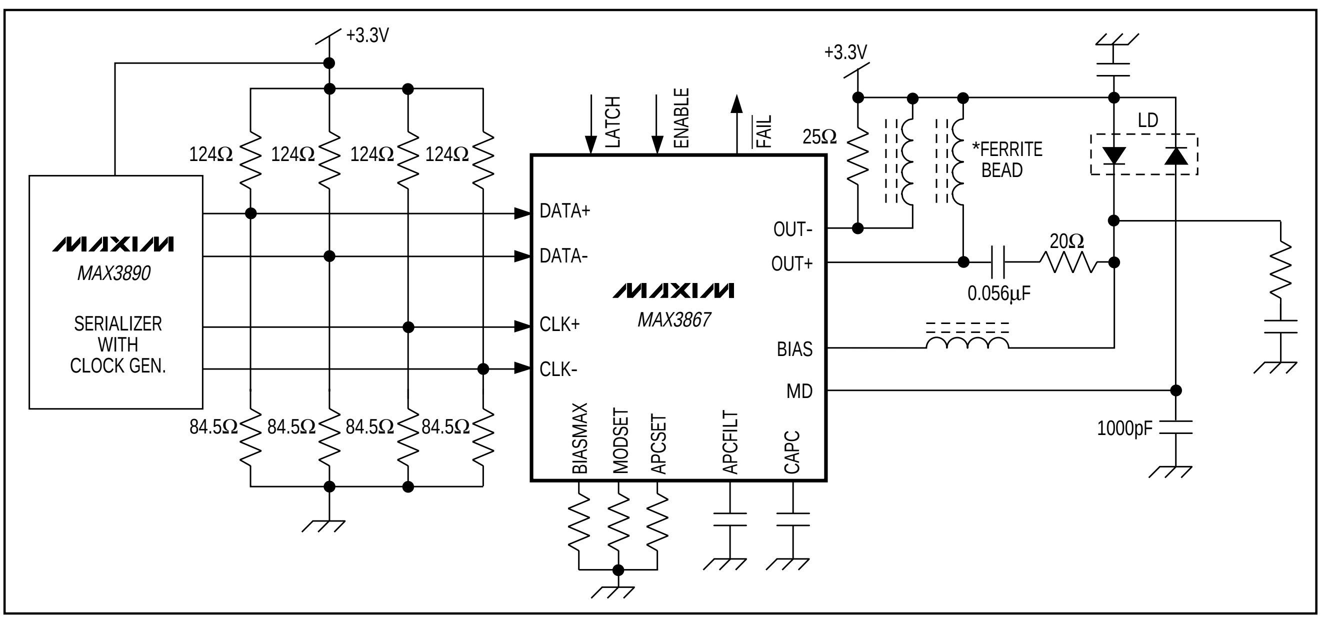
Ordering Information

PART	TEMP. RANGE	PIN-PACKAGE
MAX3867ECM	-40°C to +85°C	48 TQFP
MAX3867E/D	-40°C to +85°C	Dice*

**Dice are designed to operate over this range, but are tested and guaranteed at T_A = +25°C only. Contact factory for availability.*

Pin Configuration appears at end of data sheet.

Typical Operating Circuit



+3.3V, 2.5Gbps SDH/SONET Laser Driver with Automatic Power Control

ABSOLUTE MAXIMUM RATINGS

Supply Voltage, V_{CC} .... -0.5V to +7.0V
Current into BIAS ....-20mA to +150mA
Current into OUT+, OUT- ....-20mA to +100mA
Current into MD..-5mA to +5mA
Voltage at DATA+, DATA-, CLK+, CLK-,
ENABLE, LATCH, $\overline{FAIL}$, SLWSTRT.........-0.5V to (V_{CC} + 0.5V)
Voltage at APCFILT, CAPC, MODSET,
BIASMAX, APCSET ....-0.5V to +3.0V
Voltage at OUT+, OUT-............................+1.5V to (V_{CC} + 1.5V)
Voltage at BIAS ....+1.0V to (V_{CC} + 0.5V)
Current into $\overline{FAIL}$ ....-10mA to +30mA
Continuous Power Dissipation (T_A = +85°C)
TQFP (derate 20.8mW/°C above +85°C)..................1354mW
Storage Temperature Range ....-65°C to +165°C
Operating Junction Temperature Range...........-55°C to +150°C
Processing Temperature (die) ....+400°C
Lead Temperature (soldering, 10sec) ....+300°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} = +3.14V to +5.5V, T_A = -40°C to +85°C. Typical values are at V_{CC} = +3.3V, I_{MOD} = 30mA, I_{BIAS} = 60mA, and T_A = +25°C, unless otherwise noted.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Supply Current	I_{CC}	(Note 2)			62	105	mA
Bias Current Range	I_{BIAS}	(Note 3)		1		100	mA
Bias Off Current	$I_{BIAS-OFF}$	ENABLE = low (Note 4)				100	µA
Bias-Current Stability		APC open loop, I_{BIAS} = 100mA			230		ppm/°C
		APC open loop, I_{BIAS} = 1mA			900		
Bias-Current Absolute Accuracy	(Note 5)	APC open loop		-15		15	%
Differential Input Voltage	V_{ID}	Figure 1		200		1600	mVp-p
Common-Mode Input Voltage	V_{ICM}	PECL compatible		V_{CC} - 1.49	V_{CC} - 1.32	V_{CC} - V_{ID}/4	V
Clock and Data Input Current	I_{IN}			-1		10	µA
TTL Input High Voltage (ENABLE, LATCH)				2.0			V
TTL Input Low Voltage (ENABLE, LATCH)						0.8	V
TTL Output High Voltage $\overline{FAIL}$		Sourcing 50µA		2.4	V_{CC} - 0.3	V_{CC}	V
TTL Output Low Voltage $\overline{FAIL}$		Sinking 100µA		0.1		0.44	V
Monitor-Diode Reverse Bias Voltage				1.5			V
Monitor-Diode DC Current Range	I_{MD}			18		1000	µA
Monitor-Diode Bias Setpoint Stability		(Note 6)	I_{MD} = 1mA	-480	50	480	ppm/°C
			I_{MD} = 18µA		90		
Monitor-Diode Bias Absolute Accuracy		(Note 5)		-15		15	%

Note 1: Characteristics at -40°C guaranteed by design and characterization. Dice are tested at T_A = +25°C only.
Note 2: Tested at R_{MODSET} = 2.49kΩ, $R_{BIASMAX}$ = 1.69kΩ, excluding I_{BIAS} and I_{MOD}.
Note 3: Voltage on BIAS pin is (V_{CC} - 1.6V).
Note 4: Both the bias and modulation currents will be switched off if any of the current set pins are grounded.
Note 5: Accuracy refers to part-to-part variation.
Note 6: Assuming that the laser to monitor-diode transfer function does not change with temperature.

AC ELECTRICAL CHARACTERISTICS

(V_{CC} = +3.14V to +5.5V, load as shown in Figure 2, T_A = -40°C to +85°C. Typical values are at V_{CC} = +3.3V, I_{MOD} = 30mA, and T_A = +25°C.) (Note 7)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Input Latch Setup Time	t_{SU}	LATCH = high, Figure 3		100			ps
Input Latch Hold Time	t_H	LATCH = high, Figure 3		100			ps
Modulation-Current Range	I_{MOD}			5		60	mA
Modulation-Off Current	$I_{MOD-OFF}$	ENABLE = low (Note 4)				200	µA
Modulation-Current Stability		I_{MOD} = 60mA		-480	-50	480	ppm/°C
		I_{MOD} = 5mA			250		
Modulation-Current Absolute Accuracy		(Note 6)		-15		15	%
Output Rise Time	t_R	20% to 80% (Note 8)	MAX3867ECM		79		ps
			MAX3867C/D		69		
Output Fall Time	t_F	20% to 80% (Note 8)	MAX3867ECM		88	(Note 10)	ps
			MAX3867C/D		79		
Output Aberrations		(Note 8)			±15		%
Enable/Start-Up Delay					250		ns
Maximum Consecutive Identical Digits				80			bits
Pulse-Width Distortion	PWD	(Notes 8, 9)			9	50	ps
Jitter Generation		Jitter BW = 12kHz to 20MHz, 0-1 pattern			7	20	ps_{p-p}

Note 7: AC characteristics are guaranteed by design and characterization.
Note 8: Measured with 622Mbps 0-1 pattern, LATCH = high.
Note 9: PWD = (wider pulse - narrower pulse) / 2.
Note 10: See *Typical Operating Characteristics* for worst-case distribution.

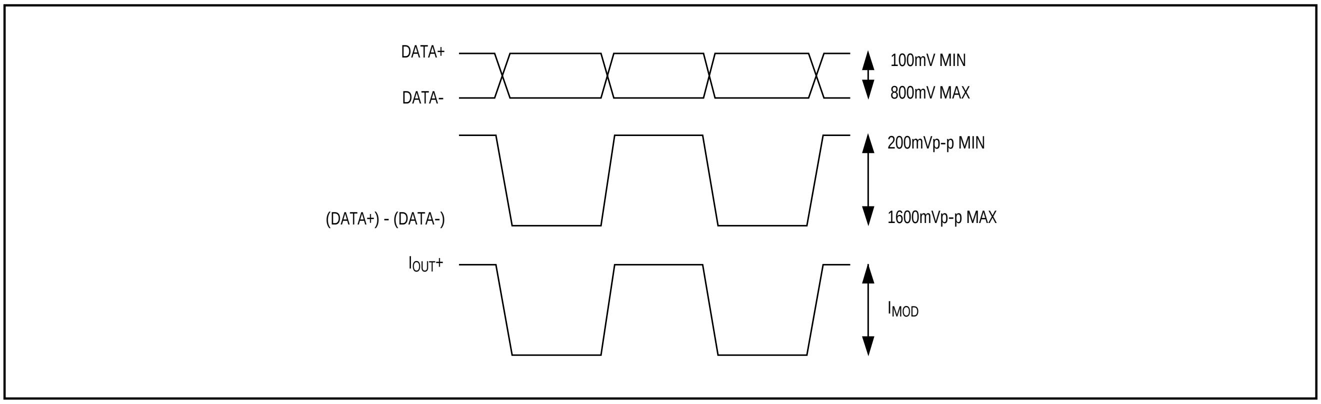


Figure 1. Required Input Signal and Output Polarity

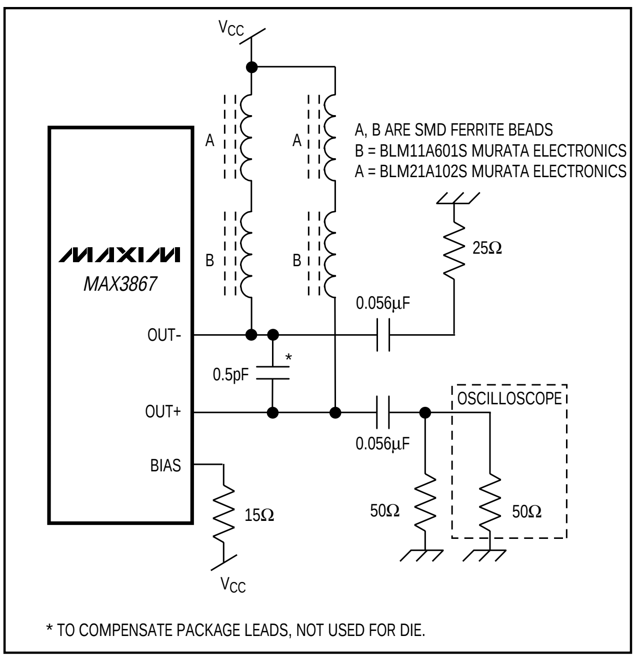


Figure 2. Output Termination for Characterization

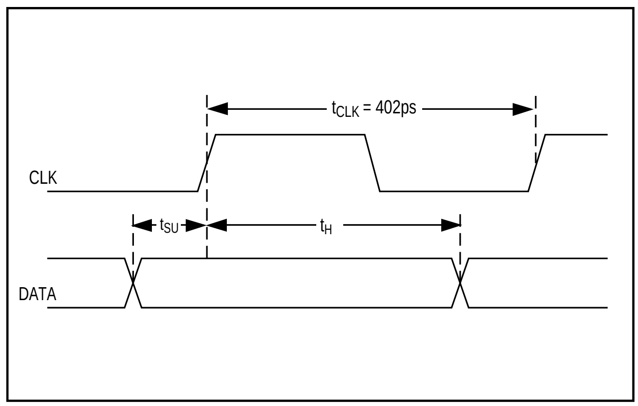
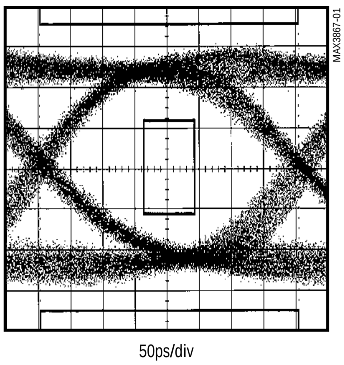


Figure 3. Setup/Hold Time Definition

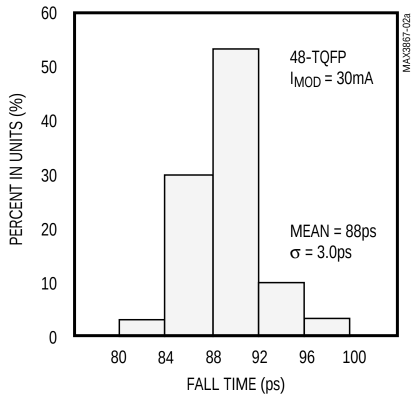
Typical Operating Characteristics

(V_{CC} = +3.3V, load as shown in Figure 2, T_A = +25°C, unless otherwise noted.)

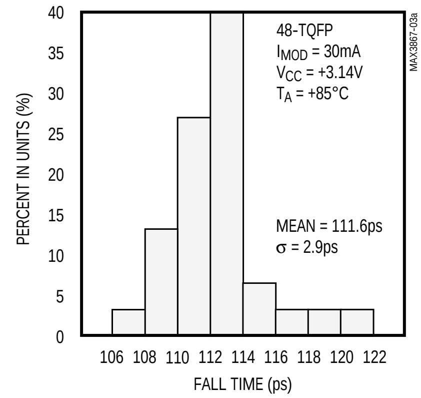
EYE DIAGRAM (2.488Gbps, 1300nm FP LASER, 1.87GHz FILTER, 48-TQFP)



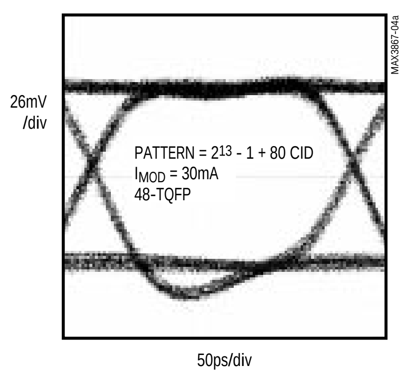
TYPICAL DISTRIBUTION OF FALL TIME



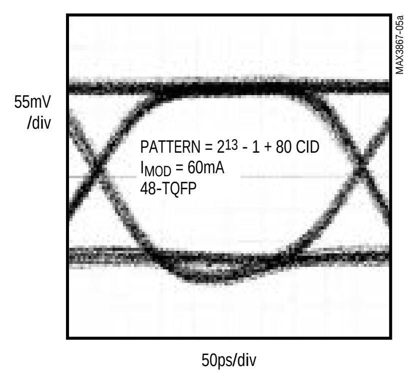
DISTRIBUTION OF FALL TIME (WORST-CASE CONDITIONS)



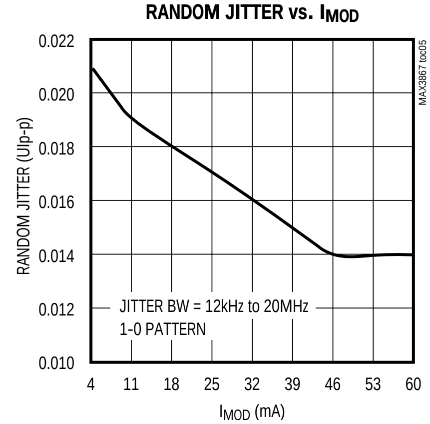
ELECTRICAL EYE DIAGRAM



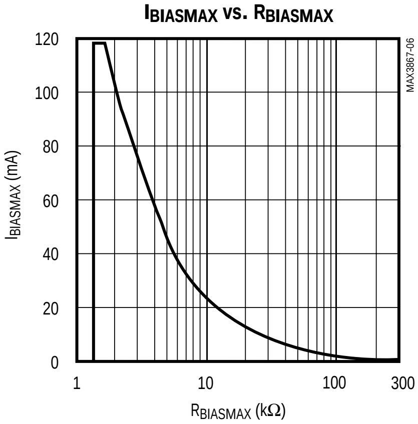
ELECTRICAL EYE DIAGRAM



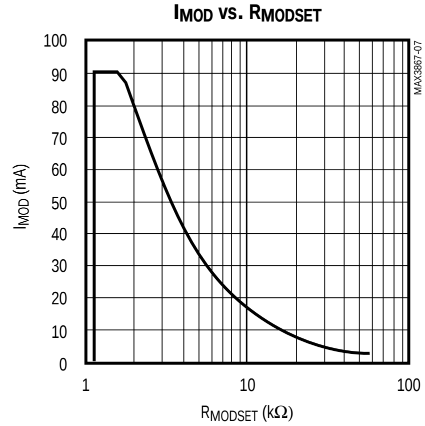
RANDOM JITTER vs. I_{MOD}



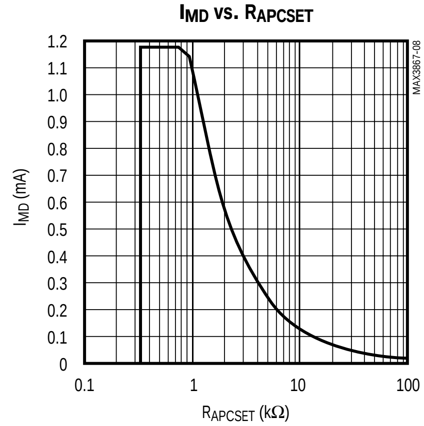
$I_{BIASMAX}$ vs. $R_{BIASMAX}$



I_{MOD} vs. R_{MODSET}



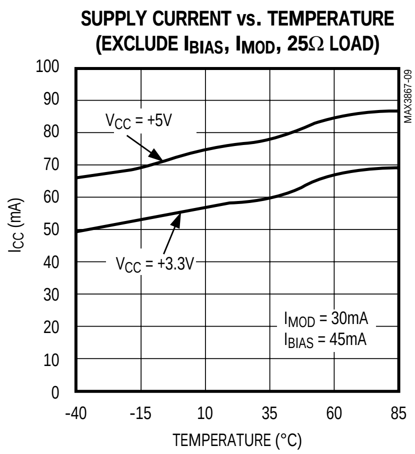
I_{MD} vs. R_{APCSET}

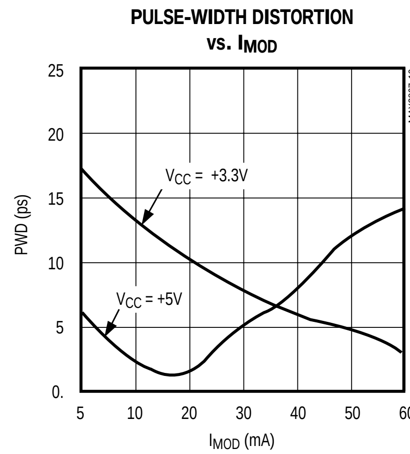


+3.3V, 2.5Gbps SDH/SONET Laser Driver with Automatic Power Control

Typical Operating Characteristics (continued)

(V_{CC} = +3.3V, load as shown in Figure 2, T_A = +25°C, unless otherwise noted.)





Pin Description

PIN	NAME	FUNCTION
1, 42, 45	GND2	Ground for internal reference
2, 7, 12, 15, 16,	GND1	Ground for digital circuits
3, 6, 8, 11, 18	$V_{CC}1$	Power supply for digital circuits
4	DATA+	Positive PECL Data Input
5	DATA-	Negative PECL Data Input
9	CLK+	Positive PECL Clock Input. Connect to V_{CC} if latch function is not used.
10	CLK-	Negative PECL Clock Input. Leave unconnected if latch function is not used.
13	LATCH	TTL/CMOS Latch Input. High for latched data, low for direct data.
14	ENABLE	TTL/CMOS Enable Input. High for normal operation, low to disable laser bias and modulation currents.
17	SLWSTRT	A capacitor from this pad to ground delays the turn-on time of laser bias and modulation currents.
19	$\overline{FAIL}$	TTL/CMOS output. Indicates APC failure when low.
21, 26, 28, 31, 39, 41, 43	N.C.	No Connection. Leave unconnected.
22	APCFILT	Connect a capacitor ($C_{APCFILT}$ = 0.1µF) from this pad to ground to filter the APC noise.
20, 23, 33	GND4	Ground for output circuitry
24, 27, 32	$V_{CC}4$	Power Supply for output circuitry

Pin Description (continued)

PIN	NAME	FUNCTION
25	BIAS	Laser Bias Current Output
29	OUT+	Positive Modulation-Current Output. I_{MOD} flows through this pad when input data is high.
30	OUT-	Negative Modulation-Current Output. I_{MOD} flows through this pad when input data is low.
35	MD	Monitor Diode Input. Connect this pad to a monitor photodiode anode. A capacitor to ground is required to filter high-speed AC monitor photocurrent.
34, 36, 40	GND3	Ground for APC
37	$V_{CC}3$	Power Supply for APC
38	CAPC	A capacitor connected from this pad to ground controls the dominant pole of the APC feedback loop. (C_{APC} = 0.1µF)
44	APCSET	A resistor connected from this pad to ground sets the desired average optical power. Connect 100kΩ from this pad to ground if APC is not used.
46	MODSET	A resistor connected from this pad to ground sets the desired modulation current.
47	BIASMAX	A resistor connected from this pad to ground sets the maximum bias current. The APC function can subtract from this maximum value, but can not add to it.
48	$V_{CC}2$	Power Supply for internal reference

Detailed Description

The MAX3867 laser driver consists of two main parts: a high-speed modulation driver and a laser-biasing block with Automatic Power Control (APC). The circuit design is optimized for both high-speed and low-voltage (+3.3V) operation. To minimize the pattern-dependent jitter of the input signal at speeds as high as 2.5Gbps, the device accepts a differential PECL clock signal for data retiming. When LATCH is high, the input data is synchronized by the clock signal. When LATCH is low, the input data is directly applied to the output stage.

The output stage is composed of a high-speed differential pair and a programmable modulation current source. Since the modulation output drives a maximum current of 60mA into the laser with an edge speed of 100ps, large transient voltage spikes can be generated due to the parasitic inductance. These transients and the laser forward voltage leave insufficient headroom for the proper operation of the laser driver if the modulation output is DC-coupled to the laser diode. To solve this problem, the MAX3867's modulation output is designed to be AC-coupled to the cathode of a laser diode. An external pull-up inductor is necessary to DC-bias the modulation output at V_{CC}. Such a configuration isolates laser forward voltage from the output circuitry and allows the output at OUT+ to swing above and below the supply voltage V_{CC}. A simplified functional diagram is shown in Figure 4.

The MAX3867 modulation output is optimized for driving a 25Ω load; the minimum required voltage at OUT+ is 2.0V. Modulation current swings of 80mA are possible, but due to minimum power supply and jitter requirements at 2.5Gbps, the specified maximum modulation current is limited to 60mA. To interface with the laser diode, a damping resistor (R_D) is required for impedance matching. An RC shunt network is also necessary to compensate for the laser-diode parasitic inductance, thereby improving the optical output aberrations and duty-cycle distortion.

At the data rate of 2.5Gbps, any capacitive load at the cathode of a laser diode will degrade the optical output performance. Since the BIAS output is directly connected to the laser cathode, minimize the parasitic capacitance associated with this pin by using an inductor to isolate the BIAS pin from the laser cathode.

Automatic Power Control

To maintain constant average optical power, the MAX3867 incorporates an APC loop to compensate for the changes in laser threshold current over temperature and lifetime. A back-facet photodiode mounted in the

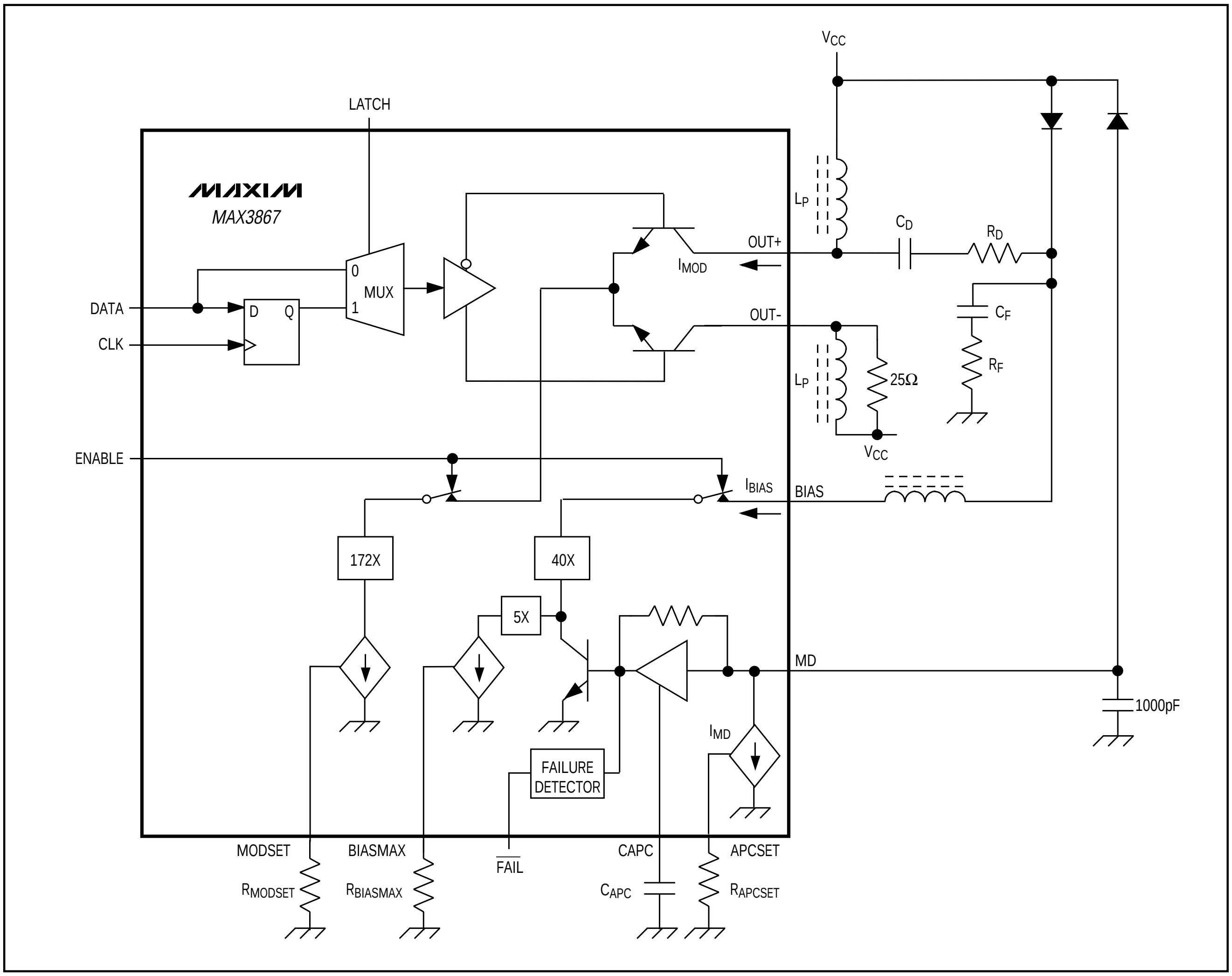


Figure 4. Functional Diagram

laser package is used to convert the optical power into a photocurrent. The APC loop adjusts the laser bias current so that the monitor current is matched to a reference current set by R_{APCSET}. The time constant of the APC loop is determined by an external capacitor (C_{APC}). To eliminate the pattern-dependent jitter associated with the APC loop-time constant, and to guarantee loop stability, the recommended value for C_{APC} is 0.1µF.

When the APC loop is functioning, the maximum allowable bias current is set by an external resistor, $R_{BIASMAX}$. An APC failure flag ($\overline{FAIL}$) is set low when the bias current can no longer be adjusted to achieve the desired average optical power. To filter out the APC loop noise, use an external capacitor at APCFILT with a recommended value of 0.1µF.

APC closed-loop operation requires the user to set three currents with external resistors connected between ground and BIASMAX, MODSET, and APCSET. Detailed guidelines for these resistor settings are described in the *Design Procedure* section.

Open-Loop Operation

If necessary, the MAX3867 is fully operational without APC. In this case, the laser current is directly set by two external resistors connected from ground to BIASMAX and MODSET. See the *Design Procedure* section for more details on open-loop operation.

Optional Data Input Latch

To minimize input data pattern-dependent jitter, the differential clock signal should be connected to the data input latch, which is selected by an external LATCH control. If LATCH is high, the input data is retimed by the rising edge of CLK+. If LATCH is low, the input data is directly connected to the output stage. When this latch function is not used, connect CLK+ to V_{CC} and leave CLK- unconnected.

Enable Control

The MAX3867 incorporates a laser driver enable function. When ENABLE is low, both the bias and modulation currents are off. The typical laser enable time is 250ns and the typical disable time is 25ns.

Slow-Start

For laser safety reasons, the MAX3867 incorporates a slow-start circuit which provides a programmable delay time for enabling a laser diode. An external capacitor ($C_{SLWSTRT}$) connected from this pad to ground programs the delay by the equation:

$$t_{ENABLE} \cong 100k\Omega \cdot (C_{SLWSTRT} + 2.5pF)$$

APC Failure Monitor

The MAX3867 provides an APC failure monitor (TTL/CMOS) to indicate an APC loop tracking failure. $\overline{FAIL}$ is set low when the APC loop can no longer adjust the bias current to maintain the desired monitor current.

Short-Circuit Protection

The MAX3867 provides short-circuit protection for the modulation, bias and monitor current sources. If either BIASMAX, MODSET, or APCSET is shorted to ground, the bias and modulation output will be turned off.

Design Procedure

When designing a laser transmitter, the optical output is usually expressed in terms of average power and extinction ratio. Table 1 gives the relationships that are helpful in converting between the optical average power and the modulation current. These relationships are valid if the average duty cycle of optical waveform is 50%

Programming the Modulation Current

For a given laser power P_{AVE}, slope efficiency η, and extinction ration r_e, the modulation current can be calculated by Table 1. Refer to the I_{MOD} vs. R_{MODSET} graph in the *Typical Operating Characteristics* and select the value of R_{MODSET} that corresponds to the required current at +25°C.

Programming the Bias Current

When using the MAX3867 in open-loop operation, the bias current is determined by the $R_{BIASMAX}$ resistor. To select this resistor, determine the required bias current at +25°C. Refer to the $I_{BIASMAX}$ vs. $R_{BIASMAX}$ graph in the *Typical Operating Characteristics* and select the value of $R_{BIASMAX}$ that corresponds to the required current at +25°C.

When using the MAX3867 in closed-loop operation, the $R_{BIASMAX}$ resistor sets the maximum bias current available to the laser diode over temperature and life. The APC loop can subtract from this maximum value but cannot add to it. Refer to the $I_{BIASMAX}$ vs. $R_{BIASMAX}$ graph in the *Typical Operating Characteristics* and select the value of $R_{BIASMAX}$ that corresponds to the end-of-life bias current at +85°C.

Programming the APC Loop

When the MAX3867's APC feature is used, program the average optical power by adjusting the APCSET resistor. To select this resistor, determine the desired monitor current to be maintained over temperature and life. Refer to the I_{MD} vs. R_{APCSET} graph in the *Typical Operating Characteristics* and select the value of R_{APCSET} that corresponds to the required current.

Interfacing with the Laser Diode

To minimize optical output aberrations due to the laser parasitic inductance, an RC shunt network is required (Figure 4). If R_L represents the laser diode resistance, the recommended total resistance for $R_D + R_L$ is 25Ω. Starting values for coaxial lasers are R_F = 75Ω and C_F = 3.3pF. R_F and C_F should be experimentally adjusted until the optical output waveform is optimized. A bypass capacitor should also be placed as close to the laser anode as possible, for the best performance.

Pattern-Dependent Jitter (PDJ)

When transmitting NRZ data with long strings of consecutive identical digits (CID), LF droop can occur and contribute to pattern-dependent jitter. To minimize this

Table 1. Optical Power Definition

PARAMETER	SYMBOL	RELATION
Average Power	P_{AVE}	$P_{AVE} = (P_0 + P_1) / 2$
Extinction Ratio	r_e	$r_e = P_1 / P_0$
Optical Power High	P_1	$P_1 = 2P_{AVE} \cdot r_e / (r_e + 1)$
Optical Power Low	P_0	$P_0 = 2P_{AVE} / (r_e + 1)$
Optical Amplitude	Pp-p	$P_{p-p} = 2P_{AVE} (r_e - 1) / (r_e + 1)$
Laser Slope Efficiency	η	$\eta = P_{p-p} / I_{MOD}$
Modulation Current	I_{MOD}	$I_{MOD} = P_{p-p} / \eta$

pattern-dependent jitter, three external components must be properly chosen: capacitor C_{APC}, which dominates the APC loop time constant; pull-up inductor L_P; and AC-coupling capacitor C_D.

To filter out noise effects and guarantee loop stability, the recommended value for C_{APC} is 0.1µF. This results in an APC loop bandwidth of 10kHz or a time constant of 16µs. As a result, the pattern-dependent jitter associated with an APC loop time constant can be ignored.

The time constant associated with the output pull-up inductor (L_P), and the AC-coupling capacitor (C_D), will also impact the pattern-dependent jitter. For such a second-order network, the PDJ due to the low frequency cutoff will be dominated by L_P. For a data rate of 2.5Gbps, the recommended value for C_D is 0.056µF. During the maximum CID period t, it is recommended to limit the peak voltage droop to less than 12% of the average (6% of the amplitude). The time constant can be estimated by:

$$12\% = 1 - e^{-t/\tau_{LP}}$$

$$\tau_{LP} = 7.8t$$

If $\tau_{LP} = L_P / 25\Omega$, and t = 100UI = 40ns, then L_P = 7.8µH. To reduce the physical size of this element (L_P), use of SMD ferrite beads is recommended (Figure 2).

Input Termination Requirement

The MAX3867 data and clock inputs are PECL-compatible. However, it is not necessary to drive the MAX3867 with a standard PECL signal. As long as the specified common-mode voltage and the differential voltage swings are met, the MAX3867 will operate properly.

Calculate Power Consumption

The junction temperature of the MAX3867 dice must be kept below +150°C at all times. The total power dissipation of the MAX3867 can be estimated by the following:

$$P = V_{CC} \cdot V_{CC} + (V_{CC} - V_f) \cdot I_{BIAS} + I_{MOD} (V_{CC} - 25\Omega \cdot I_{MOD} / 2)$$

where I_{BIAS} is the maximum bias current set by $R_{BIASMAX}$, I_{MOD} is the modulation current, and V_f is the typical laser forward voltage.

$$\text{Junction temperature} = P(W) \cdot 48\ (°C/W)$$

Applications Information

The following is an example of how to set up the MAX3867.

Select Laser

A communication-grade laser should be selected for 2.488Gbps applications. Assume the laser output average power is P_{AVE} = 0dBm, minimum extinction ratio is r_e = 6.6 (8.2dB), the operating temperature is -40°C to +85°C, and the laser diode has the following characteristics:

Wavelength:	λ = 1.3µm
Threshold Current:	I_{TH} = 22mA at +25°C
Threshold Temperature Coefficient:	β_{TH} = 1.3%/°C
Laser to Monitor Transfer:	ρ_{MON} = 0.2A/W
Laser Slope Efficiency:	η = 0.05mW/mA at +25°C

Determine R_{APCSET}

The desired monitor diode current is estimated by $I_{MD} = P_{AVE} \cdot \rho_{MON}$ = 200µA. The I_{MD} vs. R_{APCSET} graph in the *Typical Operating Characteristics* shows that R_{APCSET} should be 6.0kΩ.

Determine R_{MODSET}

To achieve a minimum extinction ratio (r_e) of 6.6dB over temperature and lifetime, calculate the required extinction ratio at 25°C. Assuming r_e = 20, the peak-to-peak optical power P_{p-p} = 1.81mW according to Table 1. The required modulation current is 1.81(mW) / 0.05(mW/mA) = 36.2mA. The I_{MOD} vs. R_{MODSET} graph in the *Typical Operating Characteristics* shows that R_{MODSET} should be 4.8kΩ.

Determine $R_{BIASMAX}$

Calculate the maximum threshold current ($I_{TH(MAX)}$) at T_A = +85°C and end of life. Assuming $I_{TH(MAX)}$ = 50mA, the maximum bias current should be:

$$I_{BIASMAX} = I_{TH(MAX)} + I_{MOD}/2$$

In this example, $I_{BIASMAX}$ = 68.1mA. The $I_{BIASMAX}$ vs. $R_{BIASMAX}$ graph in the *Typical Operating Characteristics* shows that $R_{BIASMAX}$ should be 3.2kΩ.

Modulation Current More than 60mA

At +5V power supply, the headroom voltage for the MAX3867 is significantly improved. In this case, it is possible to achieve a modulation current of more than 60mA with AC-coupling, if the junction temperature is kept below 150°C. The MAX3867 can also be DC-coupled to a laser diode when operating at +5V supply; the voltage at OUT+ should be ≥2.0V for proper operation.

Wire Bonding Die

For high current density and reliable operation, the MAX3867 uses gold metalization. Make connections to the die with gold wire only, using ball-bonding techniques. Wedge bonding is not recommended. Die-pad size is 4 mils (100µm) square, and die thickness is 12 mils (300µm) mils.

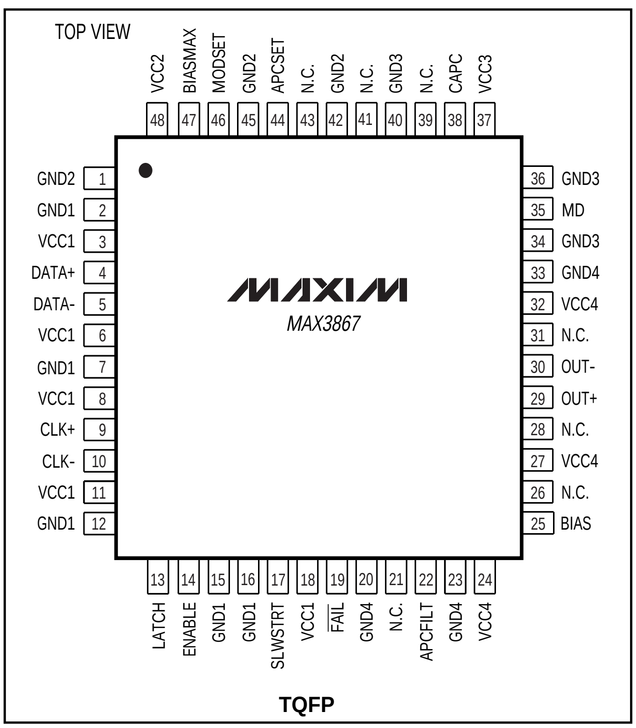
Layout Considerations

To minimize inductance, keep the connections between the MAX3867 output pins and LD as close as possible. Optimize the laser diode performance by placing a bypass capacitor as close as possible to the laser anode. Use good high-frequency layout techniques and multilayer boards with uninterrupted ground planes to minimize EMI and crosstalk.

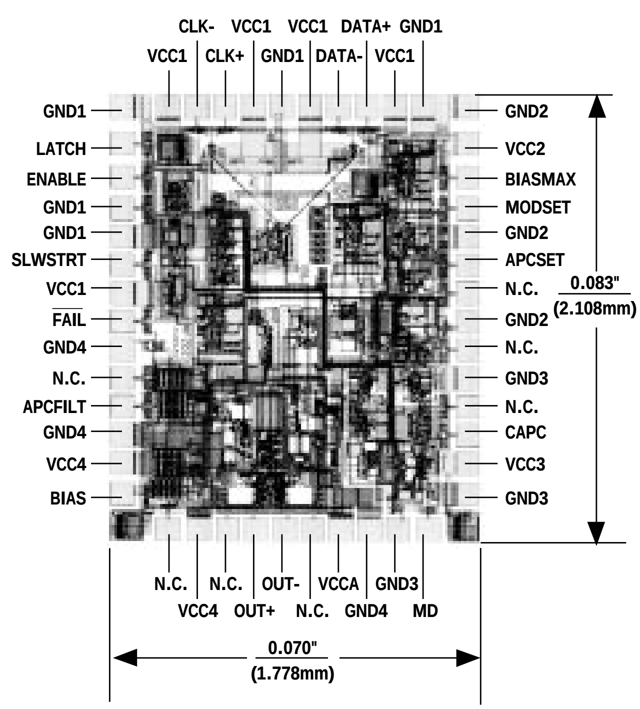
Laser Safety and IEC 825

Using the MAX3867 laser driver alone does not ensure that a transmitter design is compliant with IEC 825. The entire transmitter circuit and component selections must be considered. Each customer must determine the level of fault tolerance required by their application, recognizing that Maxim products are not designed or authorized for use as components in systems intended for surgical implant into the body, for applications intended to support or sustain life, or for any other application where the failure of a Maxim product could create a situation where personal injury or death may occur.

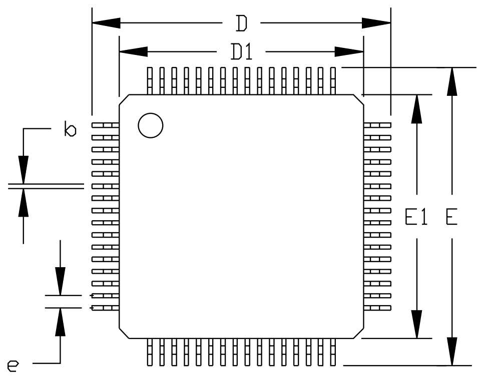
Pin Configuration

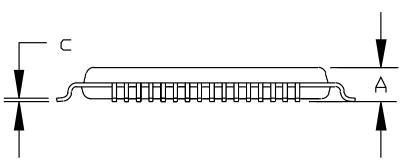


Chip Topography

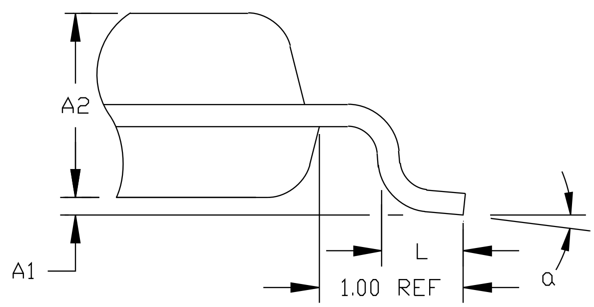


Package Information





JEDEC VARIATION	BC		BE		BJ	
	32 LEAD		48 LEAD		64 LEAD	
	MIN.	MAX.	MIN.	MAX.	MIN.	MAX.
A	---	1.60	---	1.60	---	1.60
A1	0.05	0.15	0.05	0.15	0.05	0.15
A2	1.35	1.45	1.35	1.45	1.35	1.45
D	8.90	9.10	8.90	9.10	12.00	BSC.
D1	7.00	BSC.	7.00	BSC.	10.00	BSC.
E	8.90	9.10	8.90	9.10	12.00	BSC.
E1	7.00	BSC.	7.00	BSC.	10.00	BSC.
e	0.8	BSC.	0.5	BSC.	0.5	BSC.
L	0.45	0.75	0.45	0.75	0.45	0.75
b	0.30	0.45	0.17	0.27	0.17	0.27
c	0.09	0.20	0.09	0.20	0.09	0.20
α	0°	7°	0°	7°	0°	7°



TQFPPO.EPS

NOTES:

1. ALL DIMENSIONING AND TOLERANCING CONFORM TO ANSI Y14.5-1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. THIS OUTLINE CONFORMS TO JEDEC PUBLICATION 95 REGISTRATION MO-136, VARIATIONS BC, BE AND BJ.

MAXIM

PROPRIETARY INFORMATION

TITLE: PACKAGE OUTLINE, TQFP

APPROVAL	DOCUMENT CONTROL NO.	REV	
	21-0054	C	1/1