19-0323; Rev 2; 8/95

Single +5V, Fully Integrated, 1.2Gbps Laser Diode Driver

General Description

The MAX3261 is a complete, easy-to-program, single +5V-powered, 1.2Gbps laser diode driver with complementary enable inputs and Automatic Power Control (APC). The MAX3261 accepts differential PECL inputs and provides complementary output currents. A temperature-stabilized reference voltage is provided to simplify laser current programming. This allows modulation current to be programmed from 5mA to 25mA and bias current to be programmed from 5mA to 60mA with two external resistors.

Complementary enable inputs allow the MAX3261 to interface with open-fiber-control architecture—a feature not found in other 1.2Gbps laser diode drivers.

An APC circuit is provided to maintain constant laser power in transmitters that use a monitor photodiode. Only one external resistor is required to implement the APC function.

The MAX3261's fully integrated feature set includes a TTL-compatible laser failure indicator and a programmable slow-start circuit to prevent laser damage. The slow-start is preset to 50ns and can be extended by adding an external capacitor.

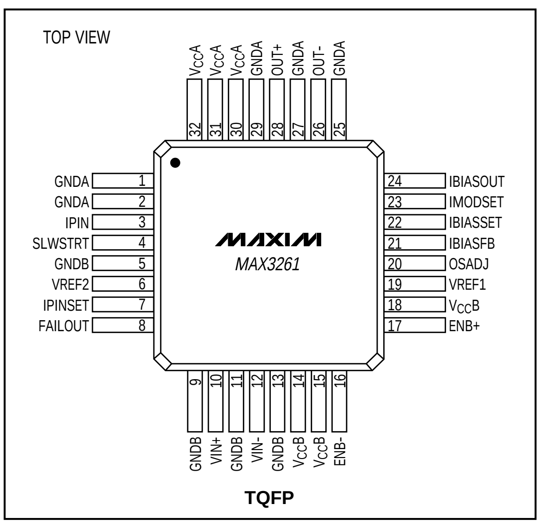
Applications

Laser Diode Transmitters

531Mbps and 1062Mbps Fibre Channel

622Mbps SDH/SONET

Pin Configuration



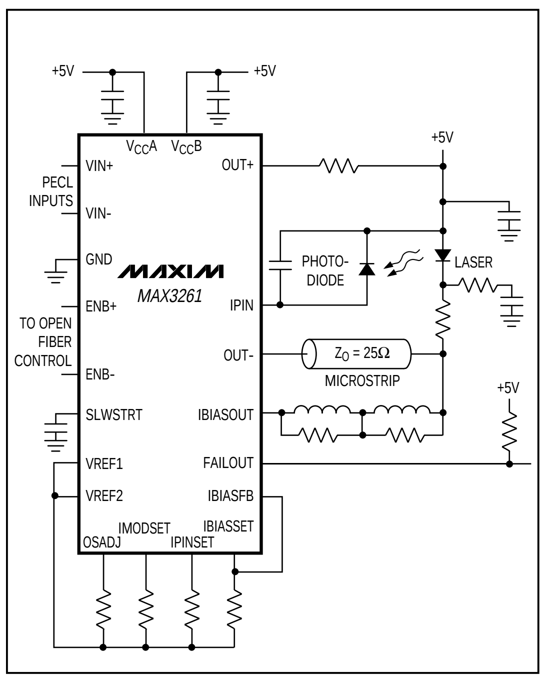
Features

- ♦ **Rise Times Less than 250ps**
- ♦ **Differential PECL Inputs**
- ♦ **Single +5V Supply**
- ♦ **Automatic Power Control**
- ♦ **Temperature-Compensated Reference Voltage**
- ♦ **Complementary Enable Inputs**

Ordering Information

PART	TEMP. RANGE	PIN-PACKAGE
MAX3261CCJ	0°C to +70°C (T_A)	32 TQFP
MAX3261C/D	0°C to +100°C (T_J)	Dice

Typical Operating Circuit



Single +5V, Fully Integrated, 1.2Gbps Laser Diode Driver

ABSOLUTE MAXIMUM RATINGS

(V_{CC} = 5.0V, T_A = +25°C, unless otherwise noted.)

Supply Voltages
$V_{CC}A$, $V_{CC}B$ to GND ....-0.3V, +6V
IPIN, IPINSET, IMODSET, IBIASET, OSADJ, IBIASFB 5mA
OUT+, OUT-, VREF1, VREF2 ....+6V
ENB+, ENB- ....0V, (V_{CC} - 0.3V)
FAILOUT ....0V, V_{CC}
SLWSTRT ....+6V
IBIASOUT 90mA
Input Voltage Levels, VIN-, VIN+ ....0V, +6V
Operating Junction Temperature Range ....-55°C to +175°C
Storage Temperature Range ....-55°C to +175°C
Processing Temperature (Die) ....+400°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} = 5.0V, T_A = 0°C to +70°C, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Range of Programmable Laser Bias Current	I_{BIAS}				60	mA
Reference Voltage	V_{REF}	T_A = +25°C	3.15	3.3	3.45	V
Available Reference Current	I_{REF}			12		mA
Supply Current	I_{VCC}	Failout loaded with 1kΩ to V_{CC}, I_{BIAS} = 0mA, I_{MOD} = 0mA			60	mA
PECL Input High		Minimum swing is 550mV, T_A = +25°C	V_{CC} - 1.165			V
PECL Input Low		Minimum swing is 550mV, T_A = +25°C			V_{CC} - 1.475	V
TTL Low (Inputs/Outputs)					0.8	V
TTL High (Inputs/Outputs)			2.0			V

AC ELECTRICAL CHARACTERISTICS

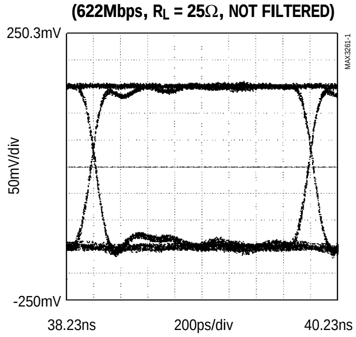
(V_{CC} = +5.0V, R_{LOAD} = 25Ω to +5V, AC parameters are not tested, T_A = +25°C, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Range of Programmable Modulation Current	I_{MOD}	Minimum input swing is 550mV			25	mA
Modulation-Current Rise and Fall Time	t_r, t_f	I_{BIAS} = 25mA, I_{MOD} = 12mA, 8ns period, 10% to 90%			250	ps
Aberrations, Rising and Falling Edge	OS	I_{MOD} = 12mA, MAX3261C/D		±10		%
		I_{MOD} = 12mA, MAX3261CCJ		±15		
Modulation-Current Pulse-Width Distortion	PWD	I_{BIAS} = 25mA, I_{MOD} = 12mA, 8ns period			80	ps

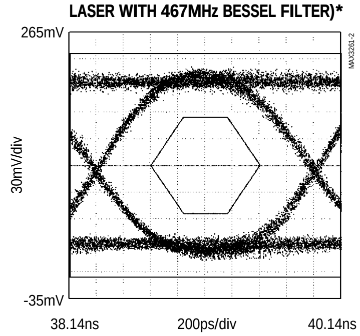
Typical Operating Characteristics

(MAX3261C/D, R_L = 25Ω, T_A = +25°C, unless otherwise noted.)

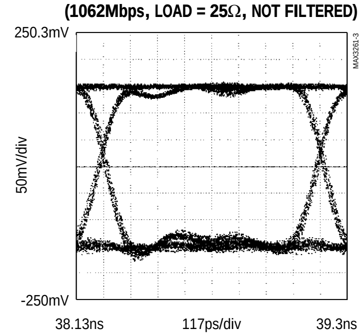
EYE DIAGRAM (622Mbps, R_L = 25Ω, NOT FILTERED)



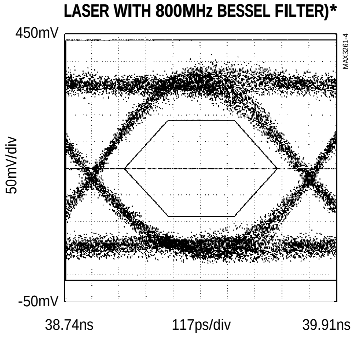
EYE DIAGRAM (622Mbps, LOAD = 1300nm LASER WITH 467MHz BESSEL FILTER)*



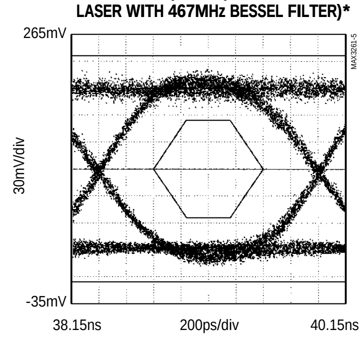
EYE DIAGRAM (1062Mbps, LOAD = 25Ω, NOT FILTERED)



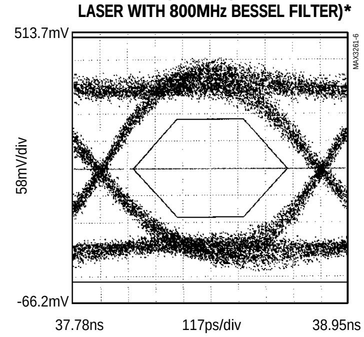
EYE DIAGRAM (1062Mbps, LOAD = 1300nm LASER WITH 800MHz BESSEL FILTER)*



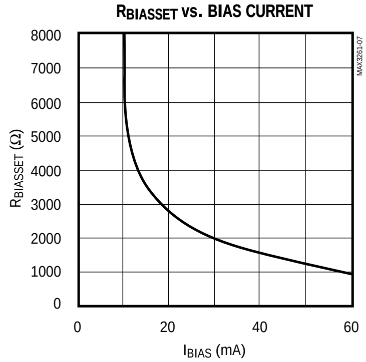
MAX3261CCJ EYE DIAGRAM (622Mbps, LOAD = 1300nm LASER WITH 467MHz BESSEL FILTER)*



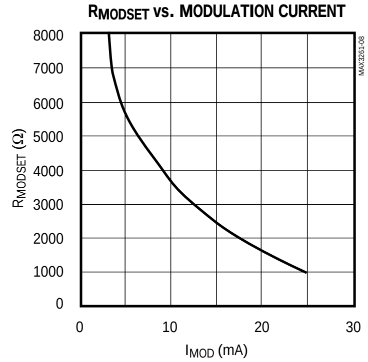
MAX3261CCJ EYE DIAGRAM (1062Mbps, LOAD = 1300nm LASER WITH 800MHz BESSEL FILTER)*



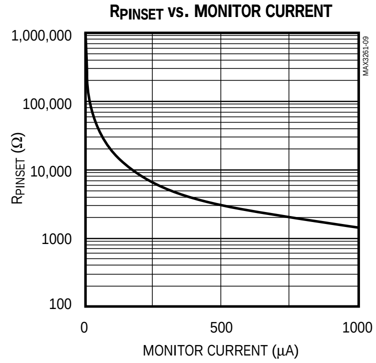
$R_{BIASSET}$ vs. BIAS CURRENT



R_{MODSET} vs. MODULATION CURRENT



R_{PINSET} vs. MONITOR CURRENT



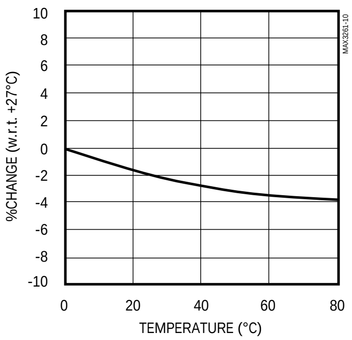
* EPITAXX EDL 1300RFC TO-STYLE HEADER

Single +5V, Fully Integrated, 1.2Gbps Laser Diode Driver

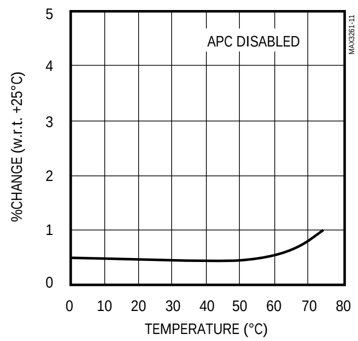
Typical Operating Characteristics (continued)

(MAX3216C/D, R_L = 25Ω, T_A = +25°C, unless otherwise noted.)

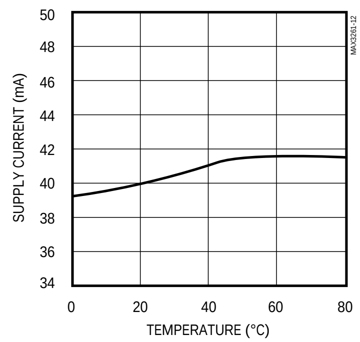
MAX3261C/D PERCENT CHANGE IN MODULATION CURRENT vs. TEMPERATURE



BIAS CURRENT STABILITY vs. TEMPERATURE



SUPPLY CURRENT vs. TEMPERATURE



Pin Description

PIN	NAME	FUNCTION
1, 2, 25, 27, 29	GNDA	Ground for Output and Bias Driver
3	IPIN	Current Source from Monitor Photodiode
4	SLWSTRT	Capacitor Port for Slow Start-Up. Turn-on time = 25.4k ($C_{SLWSTRT}$ + 2pF).
5, 9, 11, 13	GNDB	Grounds for VREF and APC
6	VREF2	Temperature-Compensated Reference, 3.25V typical
7	IPINSET	Current Input for APC. Proportional to monitor-diode current.
8	FAILOUT	Active-Low Open-Collector TTL Output. Asserts when IPIN voltage drops below 2.6V.
10	VIN+	Positive PECL Inputs
12	VIN-	Negative PECL Inputs
14, 15, 18	$V_{CC}B$	Positive Supplies for VREF and APC, +5V, ±0.25V
16, 17	ENB-, ENB+	Complementary TTL Input to Enable Output Currents
19	VREF1	Temperature-Compensated Reference, 3.25V typical
20	OSADJ	Overshoot Adjust, sets current for input stage. Connect to VREF with resistor.
21	IBIASFB	Output from APC Circuit, used to set laser bias current. Connect to IBIASSET terminal for APC operation.
22	IBIASSET	Sets Laser Bias Current. IBIASOUT = 40 x (IBIASSET + IBIASFB).
23	IMODSET	Sets Laser Modulation Current. Modulation Current = 20 x IMODSET.
24	IBIASOUT	Laser Bias Output Current
26	OUT-	Primary Laser Modulation Outputs
28	OUT+	Secondary Laser Modulation Outputs
30, 31, 32	$V_{CC}A$	Positive Supplies for Output and Bias Driver

Detailed Description

The MAX3261 laser driver has three main sections: a reference generator with temperature compensation, a laser bias block with automatic power control, and a high-speed modulation driver.

The reference generator provides temperature-compensated biasing and a voltage-reference output. The voltage reference is used to program the current levels of the high-speed modulation driver, laser diode, and PIN (p+, intrinsic, n-) monitor diode.

The laser bias block sets the bias current in the laser diode and maintains it above the threshold point. A current-controlled current source (current mirror) programs the bias, with IBIASSET as the input. The mirror's gain is approximately 40 over the MAX3261's input range. Keep the output voltage of the bias stage above 2.6V to prevent saturation.

The modulation driver consists of a high-speed input buffer and a common-emitter differential output stage. The modulation current mirror sets the laser modulation current in the output stage. This current is switched between the OUT+ and OUT- ports of the laser driver. The modulation current mirror has a gain of approximately 20.

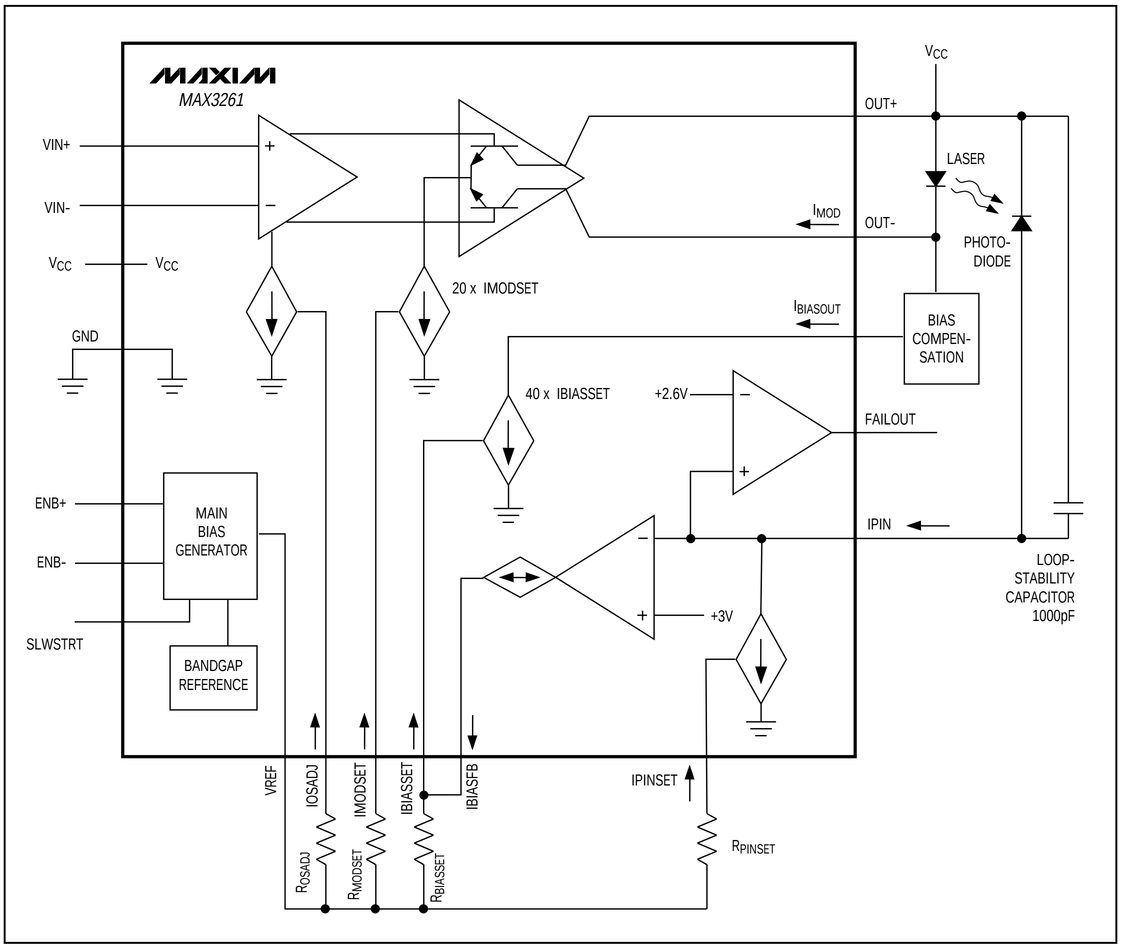


Figure 1. Block Diagram

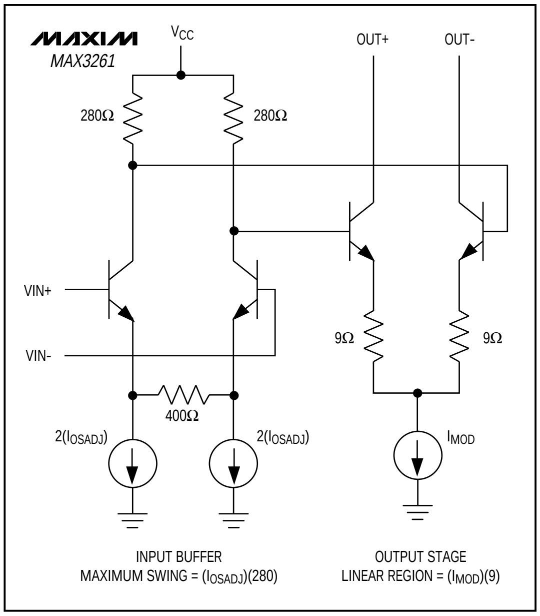


Figure 2. MAX3261 Modulation Driver (Simplified)

The overshoot mirror sets the bias in the input buffer stage. Reducing this current slows the input stage and reduces overshoot in the modulation signal. At the same time, the peak-to-peak output swing of the input buffer stage is reduced. Careful design must be used to ensure that the buffer stage can switch the output stage completely into the nonlinear region (Figure 3). For the output stage, the width of the linear region is a function of the desired modulation current. Increasing the modulation current increases the linear region. Therefore, increases in the modulation current requires larger output levels from the first stage. Table 1 shows the maximum allowable R_{OSADJ} (to ensure complete switching) versus the laser modulation-current level.

Table 1. Optimum R_{OSADJ}

I_{MOD} (mA)	Max R_{OSADJ} (kΩ)
10	7.50
15	6.00
20	5.25
25	4.25
30	3.70

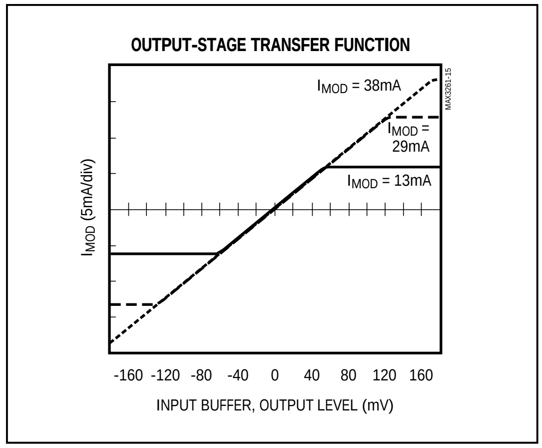


Figure 3. Output-Stage Transfer Function

Failure to ensure that the output stage switches completely results in a loss of modulation current (and extinction ratio). In addition, if the modulation port does not switch completely off, the modulation current will contribute to the bias current, and may complicate module assembly.

Automatic Power Control

The automatic power control (APC) feature allows an optical transmitter to maintain constant power, despite changes in laser efficiency with temperature or age. The APC requires the use of a monitor photodiode.

The APC circuit incorporates the laser diode, the monitor photodiode, the PIN set current mirror, a transconductance amplifier, the bias set current mirror, and the laser fail comparator (Figure 1). Light produced by the laser diode generates an average current in the monitor photodiode. This current flows into the MAX3261's IPIN input. The PIN set current mirror draws current away from the IPIN node. When the current into the IPIN node equals the current drawn away by IPINSET, the node voltage is set by the 3V reference of the transconductance amplifier. When the monitor current exceeds IPINSET, the IPIN node voltage will be forced higher. If the monitor current decreases, the IPIN node voltage is decreased. In either case, the voltage change is amplified by the transconductance amplifier, and results in a feedback current at the IBIASFB node. Under normal APC operation, IBIASFB is summed with IBIASSET, and the laser bias level is adjusted to maintain constant output power. This feedback process continues until the monitor-diode current equals IPINSET.

If the monitor-diode current is sufficiently less than IPINSET (i.e., the laser stops functioning), the voltage on the IPIN node will drop below 2.6V. This will trigger the failout comparator, which provides a TTL signal indicating laser failure. The FAILOUT output asserts only if the monitor-diode current is low, not in the reverse situation where the monitor current exceeds IPINSET.

The transconductance amplifier can output currents up to approximately 1mA. Since the laser bias generator has a gain of approximately 40, the APC function has a limit of approximately 40mA (up or down) from the initial set point. To take full advantage of this adjustment range, it may be prudent to program the laser bias current slightly higher than required for normal operation.

To maintain APC loop stability, a 1000pF bypass capacitor may be required across the photodiode. If the APC function is not used, disconnect the IBIASFB pad.

Enable Inputs

The MAX3261 provides complementary enable inputs (ENB+, ENB-) for interfacing with open-fiber-control architecture. Laser control is achieved by reducing the reference voltage outputs (VREF1, VREF2). Only one logic state will enable laser operation (Table 2).

Table 2. MAX3261 Truth Table

ENB-	ENB+	VREF
0	0	Off
0	1	On
1	0	Off
1	1	Off

The APC circuit requires a 1000pF capacitor between the IPIN input and ground for stability. With a 1000pF stability capacitor, the MAX3261 modulation and bias can be enabled and disabled within 5µs. This timing satisfies the requirements of the Open Fiber Control system used in Fibre Channel networks.

Temperature Considerations

The MAX3261 output currents are programmed by current mirrors. These mirrors each have a $2V_{BE}$ temperature coefficient. The reference voltage (VREF) is adjusted $2V_{BE}$ so these changes largely cancel, resulting in output currents that are very stable with respect to temperature (see *Typical Operating Characteristics*).

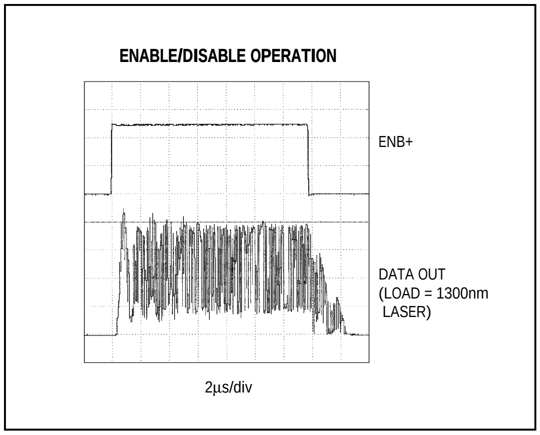


Figure 4. Enable/Disable Operation

Wire Bonding Die

For reliable operation, the MAX3261 has gold metallization. Make connections to the die with gold wire only, using ball bonding techniques. Wedge bonding is not recommended. Pad size is 4mils.

Design Procedure

Interfacing Suggestions

Use high-frequency design techniques for the board layout of the MAX3261 laser driver. High-speed interfaces often require fixed-impedance transmission lines (Figure 6). Adding some damping resistance in series with the laser raises the load impedance, making the

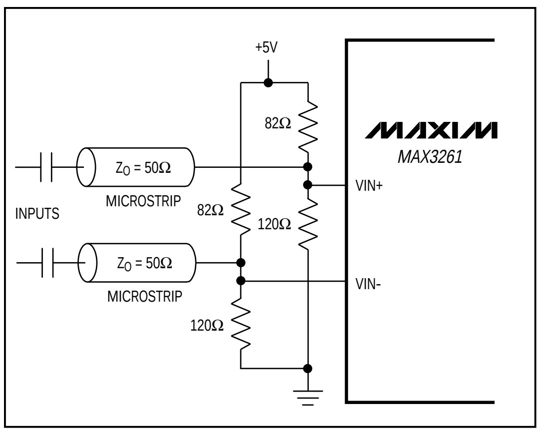


Figure 5. Typical Thevenin Equivalent Circuit, 50Ω to 3V

transmission line more realizable, and it also helps reduce power consumption (see the section *Reducing Power Consumption*). Minimize any series inductance to the laser, and place a bypass capacitor as close to the laser's anode as possible.

Power connections labeled $V_{CC}A$ are used to supply the laser modulation and laser bias circuits. $V_{CC}B$ connections supply the bias-generator and automatic-power control circuits. For optimum operation, isolate these supplies from each other by independent bypass filtering.

$V_{CC}A$, $V_{CC}B$, and GND all have multiple connections provided. Even though only one connection is required for each of these supplies, proper use of the additional connections improves the MAX3261's high-frequency performance. Ground connections between signal lines (VIN+, VIN-, OUT+, OUT-) improve the quality of the signal path by reducing the impedance of the interconnect. Multiple connections, in general, reduce inductance in the signal path and improve the high-speed signal quality. GND pins should be tied to the ground plane with short runs and multiple vias. Avoid ground loops, since they are a source of high-frequency noise.

The MAX3261 inputs interface to PECL signal levels. If the incoming data stream has a 50% duty cycle (NRZ), the inputs can be AC coupled and connected to other differential logic levels. If logic levels other then PECL are used, it is important to bias the modulation inputs (VIN+, VIN-) with a circuit that provides a Thevenin equivalent of 50Ω to 3V (Figure 5).

Bias Network Compensation

When driving the laser diode with transmission lines, it is important to maintain a constant load impedance in order to minimize aberrations due to reflections. The inductive nature of laser packages will cause the laser impedance to increase with frequency, and the parasitic capacitance of the laser driver bias output (IBIASOUT) has some loading effects at high frequency. Of these two effects, the loading due to the laser lead inductance dominates. Impedance variation must be compensated for high-frequency operation. One possible approach is to use a shunt R-C network in parallel with the laser diode (Figure 6). Adding a two-stage R-L circuit in series with the bias output results in even better performance.

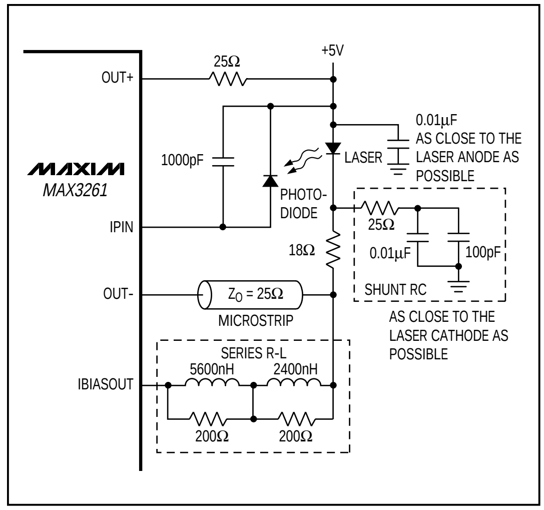


Figure 6. Typical Laser Interface with Bias Compensation

Reducing Power Consumption

The laser driver typically consumes 40mA of current for internal functions. Typical load currents, such as 12mA of modulation current and 20mA of bias current, bring the total current requirement to 72mA. If this were dissipated entirely in the laser driver, it would generate 360mW of heat. Fortunately, a substantial portion of this power is dissipated across the laser diode. A typical laser diode will drop approximately 1.6V when forward biased. This leaves 3.4V at the MAX3261's OUT- terminal. It is safe to reduce the output terminal voltage even further with a series damping resistor. Terminal voltage levels down to 2.2V can be used without degrading the laser driver's high-frequency performance. Power dissipation can be further reduced by adding a series resistor on the laser driver's OUT+ side. Select the series resistor so the OUT+ terminal voltage does not drop below 2.2V with the maximum modulation current.

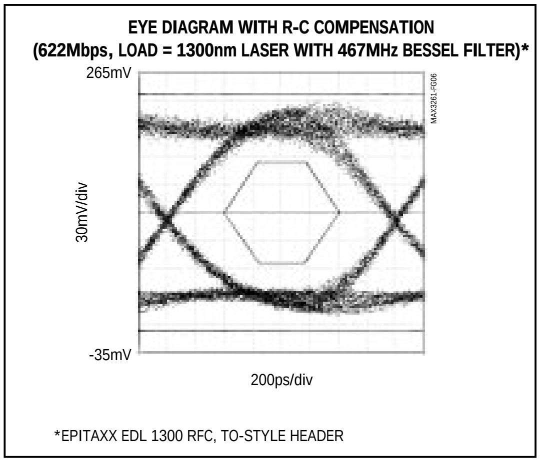


Figure 7. Eye Diagram with R-C Compensation (R_L = 1300nm Laser)

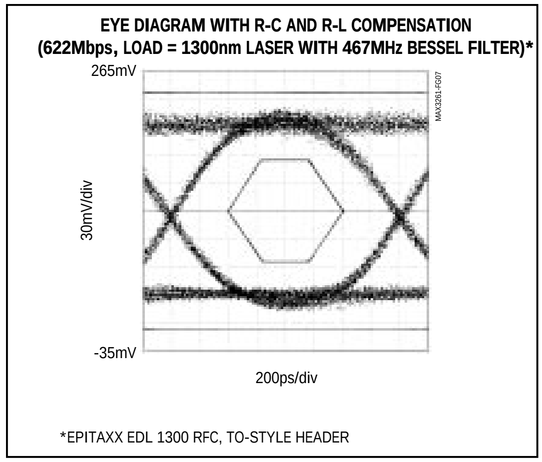


Figure 8. Eye Diagram with R-C and R-L Compensation (R_L = 1300nm Laser)

Applications Information

Programming the MAX3261 Laser Driver

Programming the MAX3261 is best explained by an example. Assume the following laser diode characteristics:

Wavelength	λ	780nm
Threshold Current	I_{TH}	20mA at +25°C (+0.35mA/°C temperature variation)
Monitor Responsivity	ρ_{mon}	0.1A/W (monitor current / average optical power into the fiber)
Modulation Efficiency	η	0.1mW/mA (worst case)

Now assume the communications system has the following requirements:

Average Power	P_{AVE}	0dBm (1mW)
Extinction Ratio	Er	6dB (Er = 4)
Temperature Range	Tr	0°C to +70°C

1) Determine the value of IPINSET:

The desired monitor-diode current is (P_{AVE})(ρ_{mon}) = (1mW)(0.1A/W) = 100µA. The *Typical Operating Characteristics* show that R_{PINSET} should be 18kΩ.

2) Determine R_{MODSET}:

The average power is defined as (P1 + P0) / 2, where P1 is the average amplitude of a transmitted “one” and P0 is the average amplitude of a transmitted “zero.” The extinction ratio is P1/P0. Combining these equations results in P1 = (2 x P_{AVE} x Er) / (Er + 1) and P0 = (2 x P_{AVE}) / (Er + 1). In this example, P1 = 1.6mW and P0 = 0.4mW. The optical modulation is 1.2mW. The modulation current required to produce this output is 1.2mW / η = (1.2mW) / (0.1mA/mW) = 12mA. The *Typical Operating Characteristics* show that R_{MODSET} = 3kΩ yields the desired modulation current.

3) Determine the value of R_{OSADJ}:

Using Table 1, a 6.8kΩ resistor is chosen for 12mA of modulation current. The values given in Table 1 minimize aberrations in the waveform and ensure that the driver stage operates fully limited.

4) Determine the value of $R_{BIASSET}$:

The automatic power control circuit can adjust the bias current 40mA from the initial setpoint. This feature makes the laser driver circuit reasonably insensitive to variations of laser threshold from lot to lot. The bias setting can be determined using one of two methods:

A) Set the bias at the laser threshold.

B) Set the bias at the midpoint of the highest and lowest expected threshold values.

Method A is straightforward. In the second method, it is assumed that the laser threshold will increase with age. The lowest threshold current occurs at 0°C, when the laser is new. The highest threshold current occurs at +70°C, at the end of the product’s life. Assume the laser is near the end of life when its threshold reaches two-times its original value.

Lowest Bias Current:

$I_{TH} + \Delta I_{TH}$ = 20mA + (0.35mA/°C)(-25°C) = 11.25mA

Highest Bias Current:

2 x $I_{TH} + \Delta I_{TH}$ = 40mA + (0.35mA/°C)(+45°C) = 55.8mA

In this case, set the initial bias value to 34mA (which is the midpoint of the two extremes). The 40mA adjustment range of the MAX3261 maintains the average laser power at either extreme.

The *Typical Operating Characteristics* show that $R_{BIASSET}$ = 1.8kΩ delivers the required bias current.

End-of-Life Indicator

Some applications require a failout flag (end-of-life indicator) to be set when the laser bias current reaches two-times its original setting. A simple comparator circuit monitoring IBIASFB and IBIASSET can be implemented to provide this type of failout signal (Figure 9).

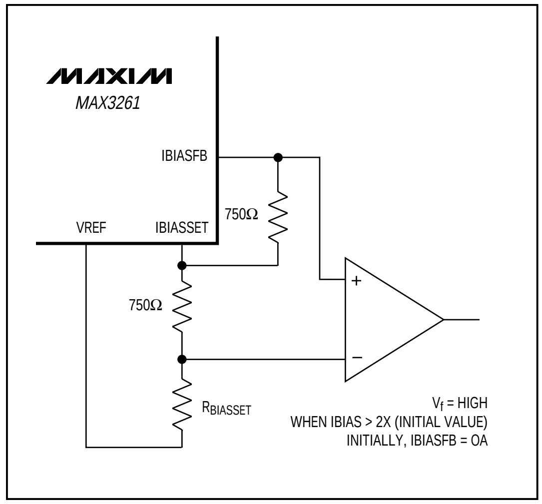
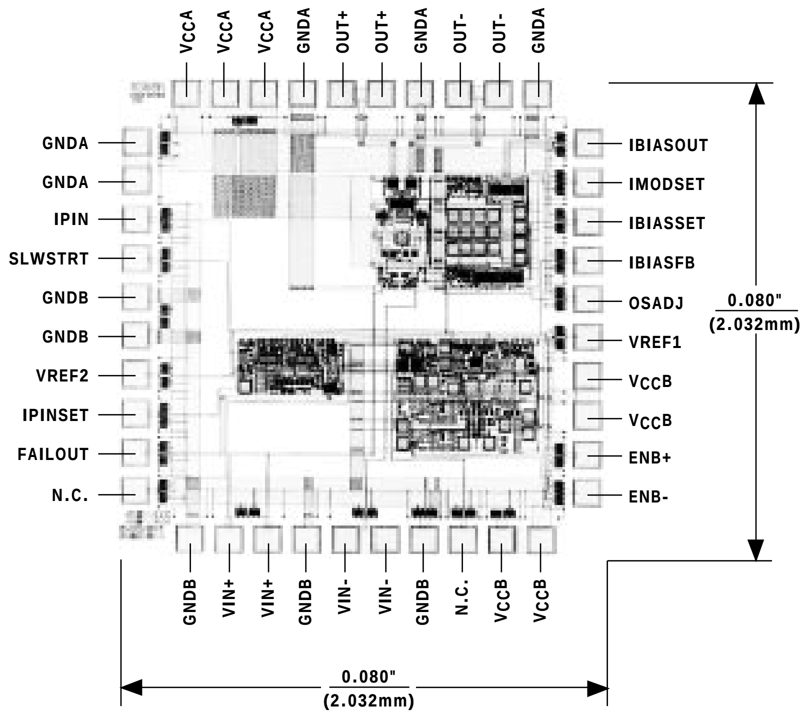


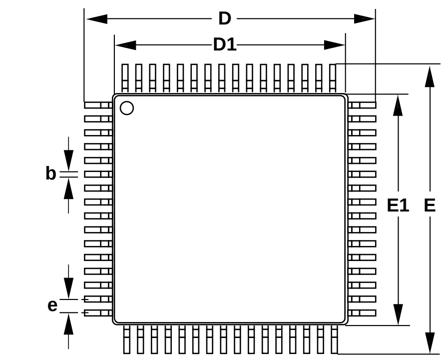
Figure 9. End-of-Life Indicator

Chip Topography



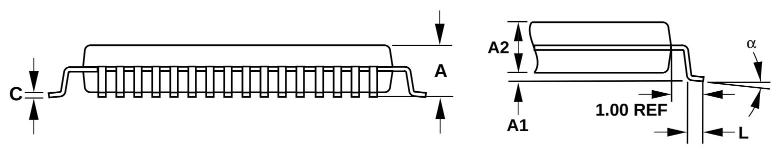
TRANSISTOR COUNT: 204
SUBSTRATE CONNECTED TO GNDA AND GNDB

Package Information



JEDEC VARIATION						
DIM	BC		BE		BF	
	32 PIN		48 PIN		64 PIN	
	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		.05 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°

21-0054B



TQFP THIN QUAD FLAT PACK

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.