MAXIM

Single +5V, Fully Integrated, 155Mbps Laser Diode Driver

MAX3263

_____General Description

The MAX3263 is a complete, easy-to-program, single +5V-powered, 155Mbps laser diode driver with complementary enable inputs and Automatic Power Control (APC). It 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.

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 MAX3263'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.

_____Features

♦ **Rise Times Less than 1ns**

♦ **Differential PECL Inputs**

♦ **Single +5V Supply**

♦ **Automatic Power Control**

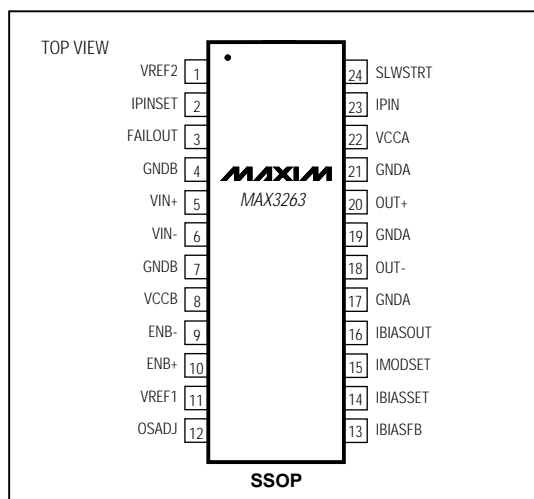♦ **Temperature-Compensated Reference Voltage**

♦ **Complementary Enable Inputs**

_____Ordering Information

PART	TEMP. RANGE	PIN-PACKAGE
MAX3263CAG	0°C to +70°C	24 SSOP

_____Applications

Laser Diode Transmitters

155Mbps SDH/SONET

155Mbps ATM

_____Pin Configuration

TOP VIEW

SSOP

Pin	Name		Pin	Name
1	VREF2		24	SLWSTRT
2	IPINSET		23	IPIN
3	FAILOUT		22	VCCA
4	GNDB		21	GNDA
5	VIN+		20	OUT+
6	VIN-		19	GNDA
7	GNDB		18	OUT-
8	VCCB		17	GNDA
9	ENB-		16	IBIASOUT
10	ENB+		15	IMODSET
11	VREF1		14	IBIASSET
12	OSADJ		13	IBIASFB

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_____Typical Operating Circuit
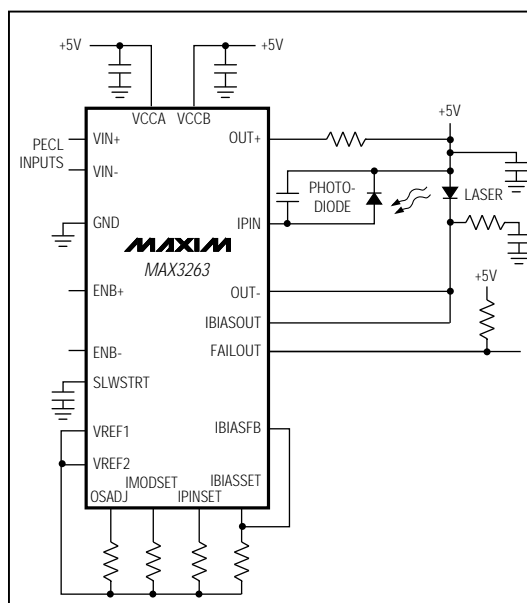
Call toll free 1-800-998-8800 for free samples or literature.

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ABSOLUTE MAXIMUM RATINGS

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

Supply Voltages
VCCA, VCCB 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
Continuous Power Dissipation (T_A = +70°C)
SSOP 640mW
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} = 5.0V ±5%, 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}			15		mA
Supply Current (I_{VCCA} + I_{VCCB})	I_{VCC}	Failout loaded with 1kΩ to V_{CC}			65	mA
PECL Input High		Minimum signal is 550mV, T_A = +25°C	V_{CC} - 1.165			V
PECL Input Low		Minimum signal 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.)

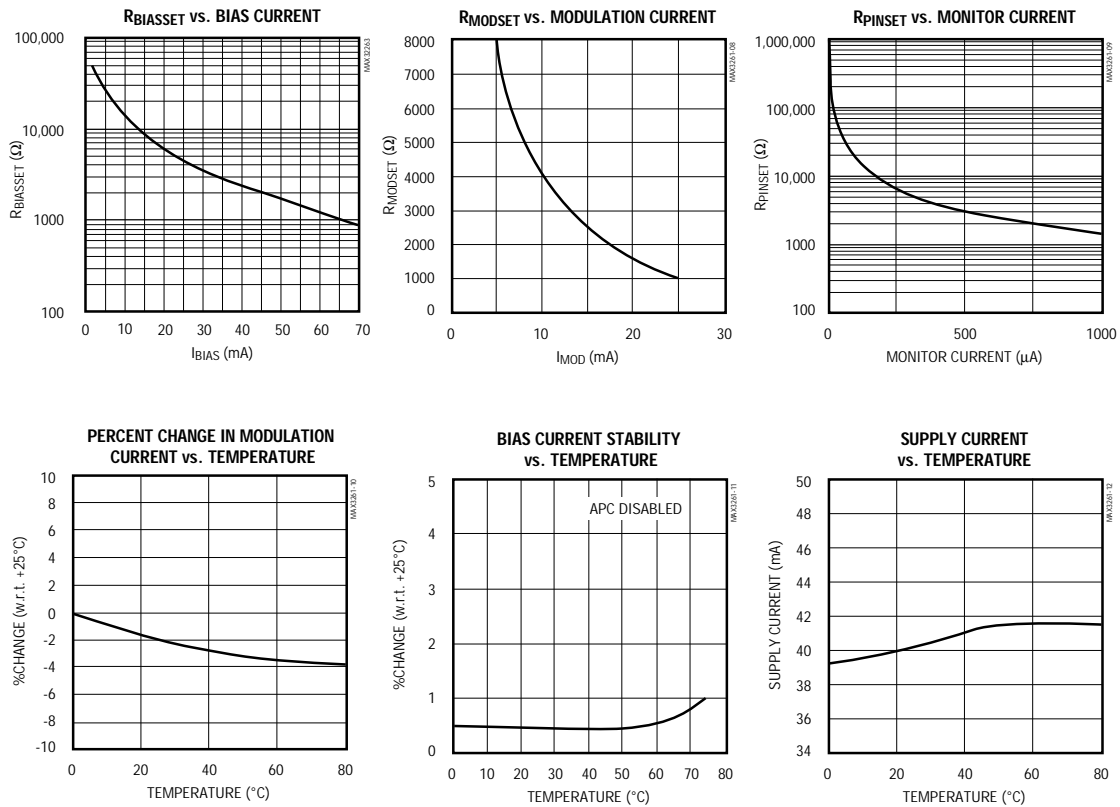| PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Range of Programmable Modulation Current	I_{MOD}	Minimum input signal is 550mV			25	mA
Modulation-Current Rise and Fall Time	t_r, t_f	I_{BIAS} = 25mA, I_{MOD} = 12mA, 8ns period, 10% to 90%			1	ns
Aberrations, Rising and Falling Edge	OS	I_{MOD} = 12mA		±15		%
Modulation-Current Pulse-Width Distortion	PWD	I_{BIAS} = 25mA, I_{MOD} = 12mA, 8ns period			100	ps

/V/IXI/VI

Single +5V, Fully Integrated, 155Mbps Laser Diode Driver

_____**Typical Operating Characteristics**

(T$_A$ = +25°C, unless otherwise noted.)

R$_{BIASSET}$ vs. BIAS CURRENT

R$_{MODSET}$ vs. MODULATION CURRENT

R$_{PINSET}$ vs. MONITOR CURRENT

PERCENT CHANGE IN MODULATION CURRENT vs. TEMPERATURE

BIAS CURRENT STABILITY vs. TEMPERATURE

SUPPLY CURRENT vs. TEMPERATURE

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Pin Description

PIN	NAME	FUNCTION
1, 11	VREF2, VREF1	Temperature-Compensated References
2	IPINSET	Current Input for APC, proportional to monitor diode current.
3	FAILOUT	Open-Collector TTL Output. Asserts low when monitor diode current is less than I_{PINSET}.
4, 7	GNDB	Ground for VREF and APC
5	VIN+	Positive PECL Input
6	VIN-	Negative PECL Input
8	VCCB	Positive supply for VREF and APC
9, 10	ENB-, ENB+	TTL Inputs to Enable Output Currents
12	OSADJ	Sets current for laser driver input stage.
13	IBIASFB	Output from APC Circuit, used to set laser bias current.
14	IBIASSET	Sets laser bias current.
15	IMODSET	Sets laser modulation current.
16	IBIASOUT	Sets laser bias output current.
17, 19, 21	GNDA	Negative Supplies for Output and Bias Driver
18	OUT-	Primary Laser Modulation Output
20	OUT+	Secondary Laser Modulation Output
22	VCCA	Positive Supply for Output and Bias Driver
23	IPIN	Connects to monitor photodiode
24	SLWSTRT	Capacitor Port for Slow Start-Up

Detailed Description

The MAX3263 laser driver has three main sections: a reference generator with temperature compensation, a laser bias block with automatic power control, and a 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 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 MAX3263's input range. Keep the output voltage of the bias stage above 2.6V to prevent saturation.

The modulation driver consists of an 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.

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 require 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.

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.

Table 1. Optimum R_{OSADJ}

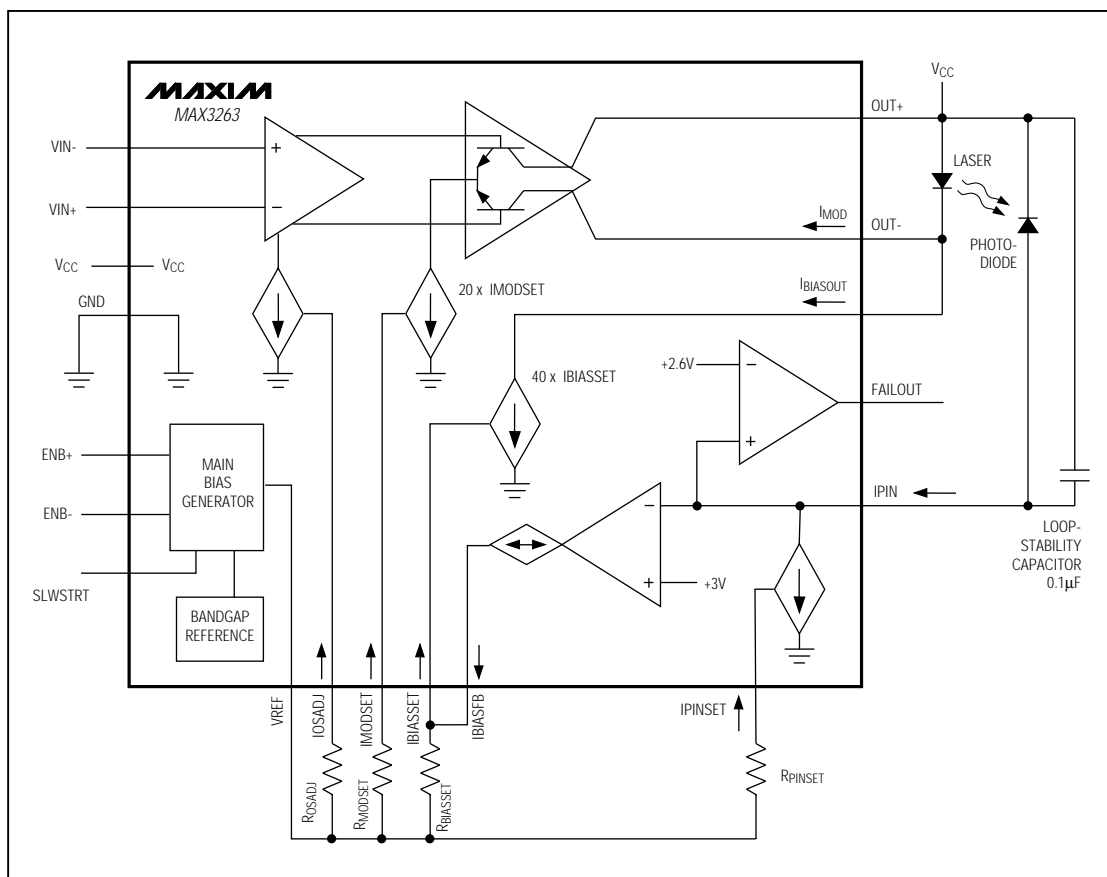| I_{MOD} (mA)	Max R_{OSADJ} (kΩ)
10	7.50
15	6.00
20	5.25
25	4.25
30	3.70

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Figure 1. Block Diagram

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 IPINSET 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 MAX3263's IPIN input. The IPINSET 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 drops below 2.6V. This triggers the failout

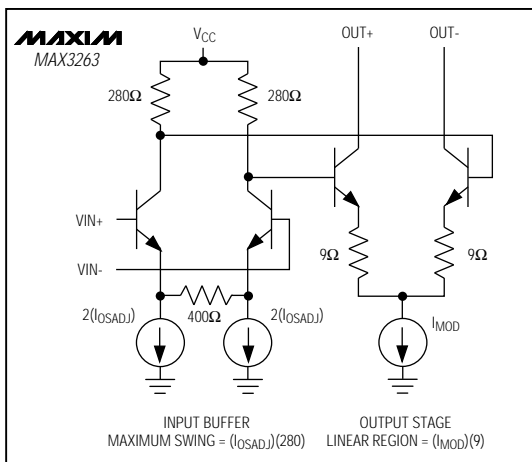# Single +5V, Fully Integrated, 155Mbps Laser Diode Driver

Figure 2. MAX3263 Modulation Driver (Simplified)

Figure 3. Output-Stage Transfer Function

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 through the IBIASFB pin. 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 0.1µF bypass capacitor may be required across the photodiode. If the APC function is not used, disconnect the IBIASFB pin.

The time constant of the APC is set by the loop-stability capacitor. The IPIN input impedance is 80Ω.

Enable Inputs
The MAX3263 provides complementary enable inputs (ENB+, ENB-). Laser control is achieved by reducing the reference voltage outputs (VREF1, VREF2). Only one logic state enables laser operation (Table 2).
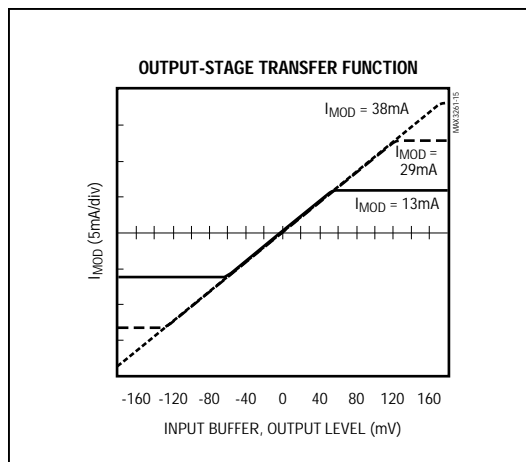
Table 2. MAX3263 Truth Table

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

Temperature Considerations
The MAX3263 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*).

Design Procedure

Interfacing Suggestions
Use high-frequency design techniques for the board layout of the MAX3263 laser driver. Minimize any series inductance to the laser, and place a bypass capacitor as close to the laser's anode as possible.

Power connections labeled VCCA are used to supply the laser modulation and laser bias circuits. VCCB connections supply the bias-generator and automatic-power control circuits. For optimum operation, isolate these supplies from each other by independent bypass filtering.

The MAX3263 inputs interface to PECL (V_{CC}-referenced ECL) 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 than PECL are used, it is important to bias the modulation inputs (VIN+, VIN-) with a circuit that provides a PECL common-mode voltage (Figure 4).

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Bias Network Compensation

For best laser transmitter performance, add a filter to the circuit. Most laser packages (TO-46 or DIL) have a significant amount of package inductance (4nH to 20nH), which limits their usable data rate. The MAX3263 OUT pin has about 1pF of capacitance. These two parasitic components can cause high-frequency ringing and aberrations on the output signal.

If ringing is present on the transmitter output, try adding a shunt RC filter to the laser node. This limits the bandwidth of the transmitter to usable levels, and reduces ringing dramatically.

      L = Laser inductance

      C = Shunt filter capacitance

      R = Shunt filter resistance

A good starting point is $R = 25\Omega$ and $C = L / 4R$. Increase C until aberrations are reduced.

The IBIASOUT pin has about 4pF of parasitic capacitance. When operating at bias levels over 50mA, the impedance of the bias output may be low enough to decrease the rise time of the transmitter. If this occurs, the impedance of the IBIASOUT pin can be increased by adding a large inductor in series with the pin. A 47µH inductor with a self-resonant frequency of 1MHz should work well in any application.

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 drops approximately 1.6V when forward biased. This leaves 3.4V at the MAX3263'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.
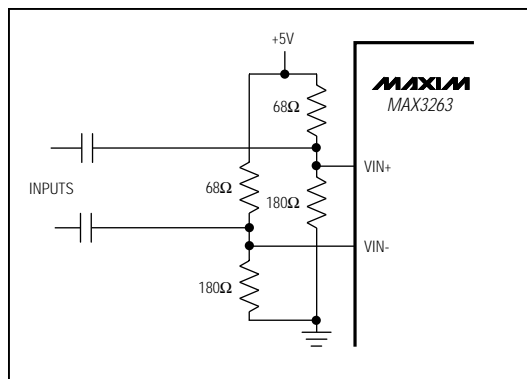

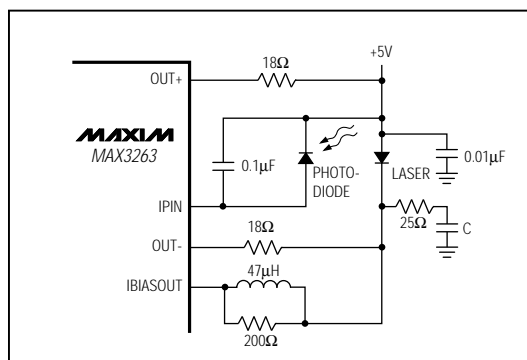Figure 4. Driving the MAX3263 with Non-PECL Levels

Figure 5. Typical Laser Interface with Bias Compensation

Applications Information

Programming the MAX3263 Laser Driver

Programming the MAX3263 is best explained by an example. Assume the following laser diode characteristics:

Wavelength	λ	1300nm
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)

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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 $(P_{AVE})(\rho_{mon})$ = (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.

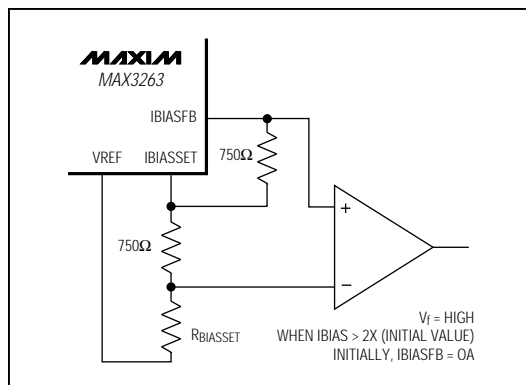Method A is straightforward. In the second method, it is assumed that the laser threshold will increase with age.

Figure 6. End-of-Life Indicator

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 MAX3263 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 6).