EVALUATION KIT AVAILABLE

MAXIM

622Mbps LAN/WAN Laser Driver with Automatic Power Control and Safety Shutdown

MAX3766

General Description

The MAX3766 is a complete, easy-to-program laser driver for fiber optic LAN transmitters, optimized for operation at 622Mbps. It includes a laser modulator, automatic power control (APC), and a failure indicator with latched shutdown.

Laser modulation current can be programmed up to 60mA at 622Mbps. A programmable modulation temperature coefficient can be used to keep the transmitted extinction ratio nearly constant over a wide temperature range. The modulator operates at data rates up to 1.25Gbps at reduced modulation current. APC circuitry uses feedback from the laser's monitor photodiode to adjust the laser bias current, producing constant output power regardless of laser temperature or age. The MAX3766 supports laser bias currents up to 80mA.

The MAX3766 provides extensive laser safety features, including a failure indicator with latched shutdown and a smooth start-up bias generator. These features help ensure that the transmitter output does not reach hazardous levels. The MAX3766 is available in a compact 20-pin QSOP and dice.

Applications

622Mbps ATM Transmitters

1.25Gbps Fiber Optic LAN Transmitters

1.25Gbps Ethernet Transmitters

Typical Application Circuits appear at end of data sheet.

Features

♦ **60mA Modulation Current**

♦ **80mA Bias Current**

♦ **200ps Edge Speed**

♦ **Modulation-Current Temperature Compensation**

♦ **Automatic Power Control**

♦ **Laser-Fail Indicator with Latched Shutdown**
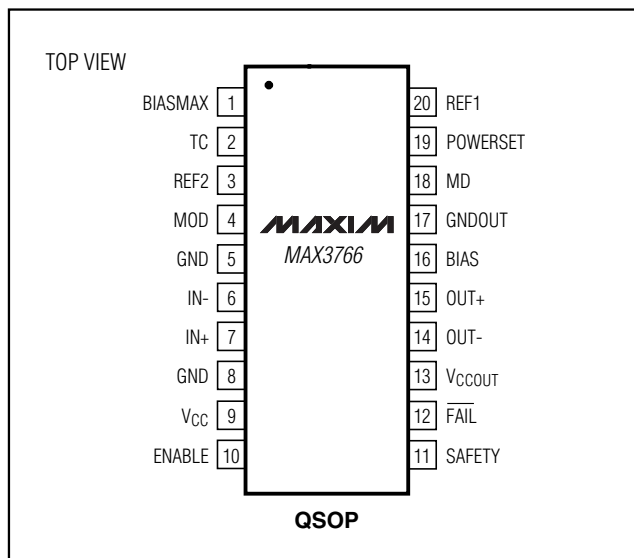
♦ **Smooth Laser Start-Up**

Ordering Information

PART	TEMP RANGE	PIN-PACKAGE
MAX3766EEP	-40°C to +85°C	20 QSOP
MAX3766EEP+	-40°C to +85°C	20 QSOP
MAX3766E/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.

+*Denotes lead-free package.*

Pin Configuration

TOP VIEW

```
           ┌────────┐
BIASMAX  1 │●       │ 20  REF1
    TC   2 │        │ 19  POWERSET
   REF2  3 │        │ 18  MD
   MOD   4 │ MAXIM  │ 17  GNDOUT
   GND   5 │MAX3766 │ 16  BIAS
    IN-  6 │        │ 15  OUT+
    IN+  7 │        │ 14  OUT-
   GND   8 │        │ 13  VCCOUT
   VCC   9 │        │ 12  FAIL
 ENABLE 10 │        │ 11  SAFETY
           └────────┘
              QSOP
```

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For free samples & the latest literature: http://www.maxim-ic.com, or phone 1-800-998-8800.
For small orders, phone 408-737-7600 ext. 3468.

622Mbps LAN/WAN Laser Driver with Automatic Power Control and Safety Shutdown

ABSOLUTE MAXIMUM RATINGS

Supply Voltage, V_{CC}, V_{CCOUT} ....-0.5V to 7.0V
Voltage at IN+, IN-, ENABLE,
  SAFETY, $\overline{FAIL}$ ....-0.5V to (V_{CC} + 0.5V)
Voltage at MOD, BIASMAX, POWERSET, TC ....-0.5V to 4.0V
Current out of REF1, REF2 ....-0.1mA to 10mA
Current into OUT+, OUT- ....-5mA to 100mA
Current into BIAS..-5mA to 130mA
Current into MD ....-5mA to 5mA

Current into $\overline{FAIL}$ ....-5mA to 30mA
Current into SAFETY...-5mA to 10mA
Continuous Power Dissipation (T_A = +85°C)
  QSOP (derate 9.1mW/°C above +85°C)......................590mW
Operating Junction Temperature Range...........-40°C to +150°C
Processing Temperature (dice) ....+400°C
Storage Temperature Range ....-55°C to +150°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.

ELECTRICAL CHARACTERISTICS

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
RECOMMENDED OPERATING CONDITIONS					
Supply Voltage, V_{CC}		4.5	5.0	5.5	V
Ambient Operating Temperature	(Note 1)	-40	25	85	°C
Differential Input Signal Amplitude	V_{IN+} - V_{IN-}, common-mode input = V_{CC} - 1.3V, Figure 1	500	1000	1800	mV
Input Common-Mode Voltage	Referenced to V_{CC}	-1.4	-1.3	-1.19	V
Enable Input High		2.0			V
Enable Input Low				0.8	V
Voltage at OUT+, OUT-		V_{CC} - 2.5			V
Voltage at BIAS		V_{CC} - 2.5			V
$\overline{FAIL}$ Load	All DC testing uses 5.1kΩ load		2.7 to 20		kΩ
Data Rate			DC to 1.25		Gbps
Data Duty Cycle	While using APC		50		%
Laser to PIN Coupling	Not tested		0.001 to 0.1		mA/mA
DC PARAMETERS					
Supply Current	I_{CC} (Note 2)	21	25	32	mA
$\overline{FAIL}$ Output High	$R_{\overline{FAIL}}$ = 5.1kΩ	4.3			V
$\overline{FAIL}$ Output Low	I_{MD} > 15μA, $R_{\overline{FAIL}}$ = 5.1kΩ		0.33	0.44	V
Bias-Current Range	(Note 3)	0.5		80	mA
Bias Current when Driver is Disabled or Shut Down			0.1	10	μA
Modulation-Current Programmable Range	Input data high (Note 3)	2		60	mA
Modulation Current	Input data low (Note 2)		1	200	μA
Modulation Current when Driver is Disabled or Shut Down				10	μA
Minimum Modulation-Current Temperature Compensation	R_{TC} = 0Ω		-50		ppm/°C
Maximum Modulation-Current Temperature Compensation	R_{TC} = open		5600		ppm/°C

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ELECTRICAL CHARACTERISTICS (continued)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Monitor-Diode Current Programmable Range		15		2000	µA
Monitor-Diode Bias Voltage	$V_{CC} - V_{MD}$	1.5	2.1	2.3	V
Upper MD Voltage for Failure	Referenced to V_{CC}	-1.2			V
Lower MD Voltage for Failure	Referenced to V_{CC}			-2.8	V
Range of MD for No Failure	Width of operating window, centered at nominal V_{MD}		300		mV
REF1 Voltage for Failure	Referenced to nominal V_{REF1}	0.5			V
REF1 Reference Voltage	T_A = +25°C, V_{REF1}	2.8	3.1	3.4	V
REF2 Reference Voltage	T_A = +25°C, V_{REF2}	2.1	2.4	2.7	V
AC PARAMETERS (Notes 4, 5, and 6)					
Output Edge Speed (20% to 80%)	I_{MOD} = 60mA		210	400	ps
	I_{MOD} = 30mA		160	300	
	I_{MOD} = 10mA		125	250	
Output Aberrations	I_{MOD} = 30mA		10		%
Pulse-Width Distortion	I_{MOD} = 60mA		5	80	ps
	I_{MOD} = 30mA		20	80	
	I_{MOD} = 10mA		80	120	
Random Jitter	RMS, T_A = +25°C, V_{CC} = +5V, I_{MOD} = 30mA		2	3	ps

Note 1: Dice are tested at room temperature only (T_A = +25°C).

Note 2: V_{CC} = +5.5V, $R_{BIASMAX}$ = 887Ω, R_{MOD} = 887Ω, $R_{POWERSET}$ = 287Ω, R_{TC} = 0Ω, V_{BIAS} = V_{OUT+} = V_{OUT-} = 3.0V. Supply current excludes I_{BIAS}, I_{OUT+}, I_{OUT-}, and $I_{\overline{FAIL}}$.

Note 3: Total output current must be reduced at high temperatures with packaged product to maintain maximum junction temperature of T_j = +150°C. See the *Design Procedure* section.

Note 4: All AC parameters are measured with a 25Ω load. I_{MOD} is the AC current amplitude at either OUT pin. The AC voltage at OUT is greater than V_{CC} - 2.5V.

Note 5: Pulse-width distortion is measured at the 50% crossing point. Data input is a 155MHz square wave, with $t_R \approx$ 300ps.
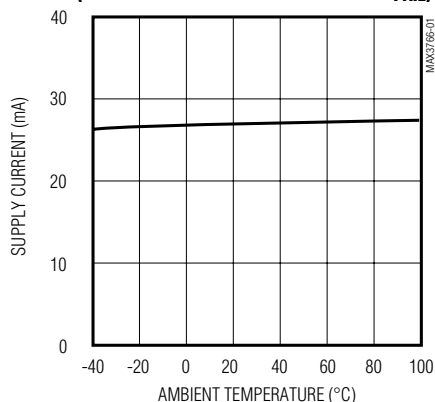
Note 6: AC specifications are guaranteed by design and characterization.

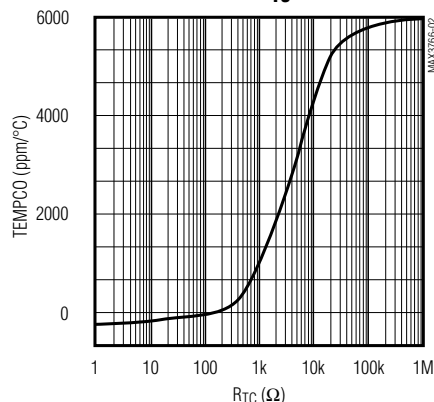# 622Mbps LAN/WAN Laser Driver with Automatic Power Control and Safety Shutdown

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Typical Operating Characteristics

(Typical Operating Characteristics are measured on the MAX3766 evaluation kit, V_{CC} = +5.0V, T_A = +25°C, unless otherwise noted.)
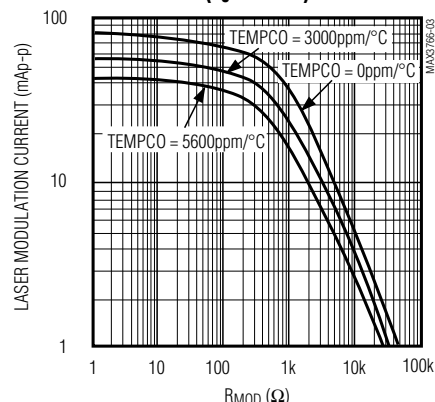

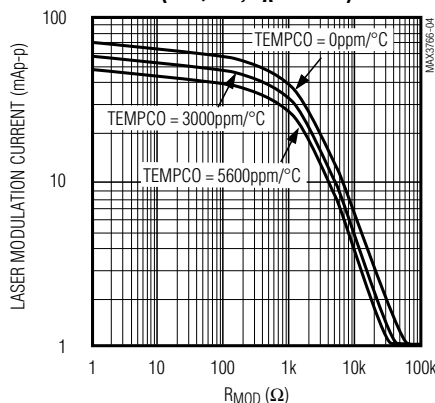SUPPLY CURRENT vs. TEMPERATURE
(EXCLUDES OUTPUT CURRENTS AND I_{FAIL})

MODULATION CURRENT TEMPCO
vs. R_{TC}

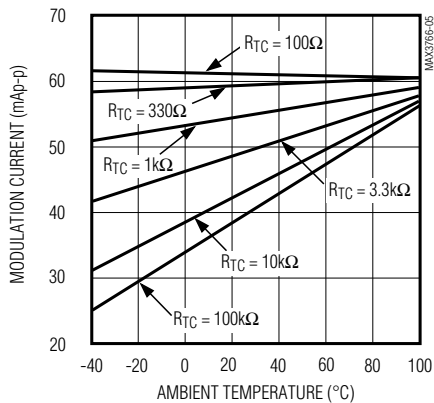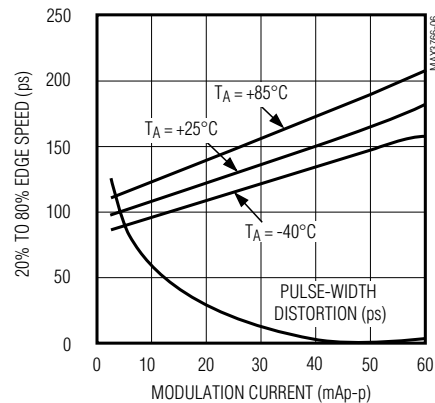DIE MODULATION CURRENT vs. R_{MOD}
(T_J = +25°C)

MODULATION CURRENT vs. R_{MOD}
(20 QSOP, T_A = +25°C)

MODULATION CURRENT
vs. TEMPERATURE

MODULATION EDGE SPEED AND
PWD vs. AMPLITUDE

EYE DIAGRAM
(622Mbps, 1300nm LASER, 470MHz FILTER)
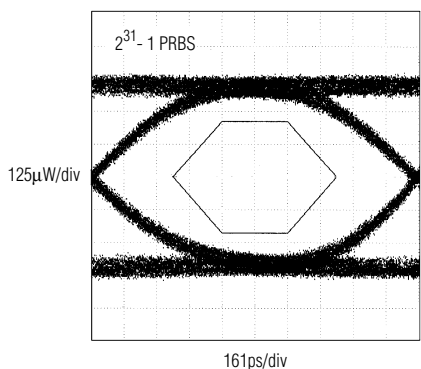
EYE DIAGRAM
(1.244Gbps, 25Ω LOAD, I_{MOD} = 60mA)
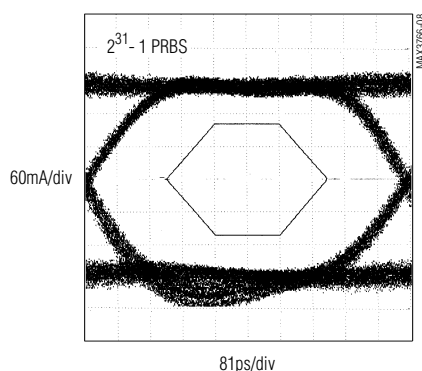
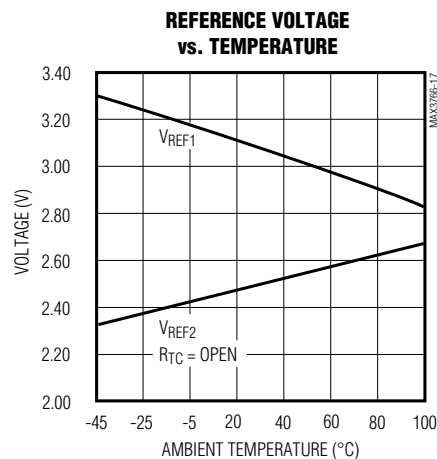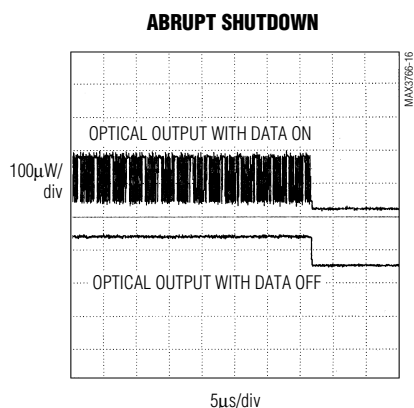MONITOR CURRENT vs. $R_{POWERSET}$
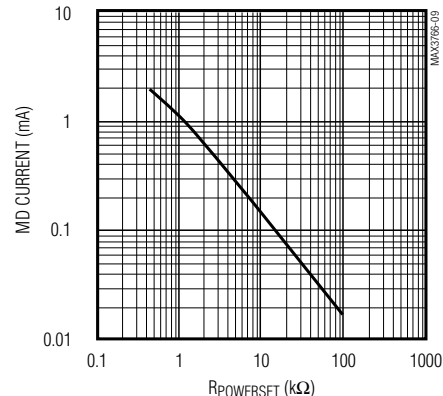
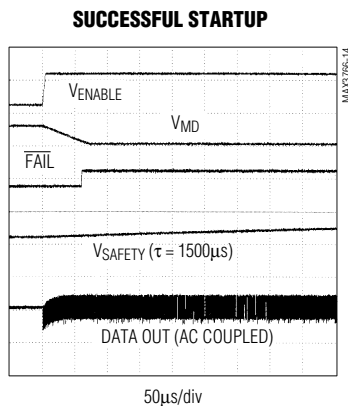4

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MAX3766

Typical Operating Characteristics (continued)

(Typical Operating Characteristics are measured on the MAX3766 evaluation kit, V_{CC} = +5.0V, T_A = +25°C, unless otherwise noted.)

BIAS CURRENT vs. R$_{BIASMAX}$
(NO APC, OPEN-LOOP CONFIGURATION)

MONITOR CURRENT vs. TEMPERATURE

DATA-DEPENDENT JITTER
vs. TEMPERATURE (CMD = 0.1µF)

UNSUCCESSFUL STARTUP

SUCCESSFUL STARTUP

SMOOTH STARTUP

ABRUPT SHUTDOWN

REFERENCE VOLTAGE
vs. TEMPERATURE

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| PIN	NAME	FUNCTION
1	BIASMAX	The current into BIASMAX sets the maximum laser bias current. Connecting BIASMAX directly to REF1 allows the largest possible bias current.
2	TC	The resistance (R_{TC}) between TC and REF1 programs the temperature coefficient of REF2. Connecting TC directly to REF1 produces the minimum tempco. Leaving TC unconnected produces the maximum tempco.
3	REF2	REF2 is the reference voltage used to program the modulation current. The tempco of REF2 is programmed by R_{TC}.
4	MOD	The current into MOD programs the laser modulation current. Connect MOD to REF2 with a resistor or potentiometer.
5, 8	GND	Ground. All grounds must be connected.
6	IN-	Inverting Data Input
7	IN+	Noninverting Data Input
9	V_{CC}	Positive Supply Voltage. All V_{CC} pins must be connected.
10	ENABLE	ENABLE is a TTL-compatible input. When low or open, this pin disables the output modulation and bias current.
11	SAFETY	A capacitor to ground at SAFETY determines the turn-on delay for the safety circuits. If SAFETY is grounded or TTL low, internal safety shutdown features are disabled. A TTL high at SAFETY enables the internal safety shutdown features.
12	$\overline{FAIL}$	The $\overline{FAIL}$ output asserts low if the voltage at MD is above or below nominal. $\overline{FAIL}$ also asserts if REF1 is inadvertently tied to the positive supply. $\overline{FAIL}$ has TTL-compatible output voltage levels.
13	V_{CCOUT}	Supply Voltage for the Output Current Drivers
14	OUT-	Inverting Modulation-Current Output
15	OUT+	Noninverting Modulation-Current Output
16	BIAS	Connection for the DC Laser Bias Current
17	GNDOUT	Ground for the Output Current Drivers
18	MD	Input for the laser monitor photodiode current.
19	POWERSET	The current into POWERSET programs the average optical output power when automatic power control is used.
20	REF1	REF1 is a voltage reference used to program laser bias current and average power.

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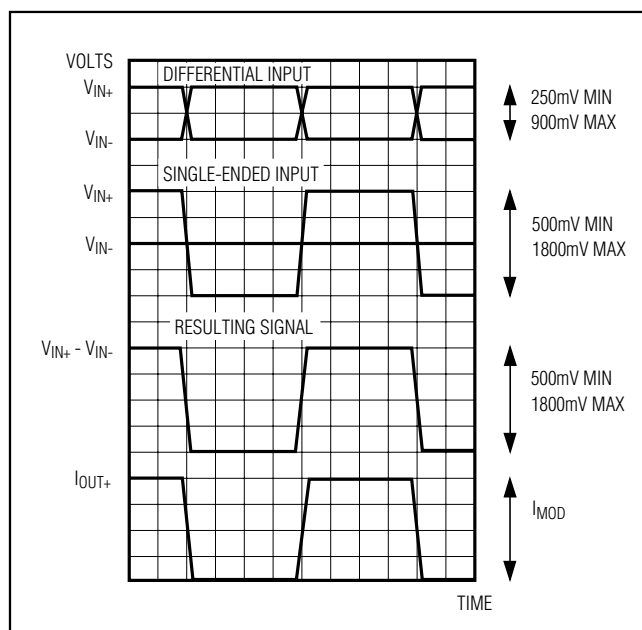
Figure 1. Required Input Signal and Output Polarity

Detailed Description

Figure 2 is a functional block diagram of the MAX3766 laser driver. The major functional blocks are the reference generator, PECL input buffer, laser-bias circuit, modulation-current driver, automatic power control (APC), failure detection, and safety circuit.

Reference Generator

The MAX3766 provides adjustments for maximum laser-bias current, laser modulation current, and average laser power. To program these adjustments, simply use the currents obtained by inserting a resistor in series with integrated voltage references REF1 and REF2. The temperature coefficient (tempco) of REF1 compensates for the tempco of the bias, modulation, and APC current mirrors. Therefore, a programming current derived from REF1 is constant with temperature. REF2 provides a positive tempco, which can be applied to the modulation current. A positive modulation-current tempco will compensate for the thermal characteristics of typical laser diodes. The modulation-current tempco is programmed by an external resistor (R_{TC}), which is connected from REF1 to TC. R_{TC} and an internal 2kΩ resistor form a weighted sum of the temperature-compensated reference (REF1) and the temperature-increasing reference, which is buffered and output at REF2. REF1 and REF2 are stable with no bypass capacitance. Bypass filtering REF1 or REF2 is not required.

PECL Input Buffer

The differential PECL input signals are connected to the high-speed PECL input buffer at IN+ and IN-. The input impedance at IN+ and IN- is greater than 100kΩ, and the input bias current is less than 10µA. The MAX3766's data inputs are not self-biasing. The common-mode input should be set by the external PECL termination circuitry. To obtain good AC performance, inputs should always be greater than 2.2V and less than V_{CC}.

Laser Modulation-Current Driver

The laser modulation-current driver consists of a current mirror and an emitter coupled pair. The mirror has a gain of +30mA/mA. Modulation-current amplitude is programmed with external resistor R_{MOD} connected from REF2 to MOD. R_{MOD} can be estimated as follows:

$$R_{MOD} = \frac{1.55V(30)}{I_{MOD}} - 520\Omega$$

with $R_{TC} = 0\Omega$.

The MAX3766 AC output drives up to 60mA of laser current. Pulse-width distortion and overshoot are lowest between 30mA and 60mA. However, output edge speed increases at lower currents. When the output current is between 2mA and 60mA, the edge speed is suitable for communications up to 622Mbps. Edge speeds below 30mA are suitable for communications up to 1.25Gbps (see Typical Operating Characteristics).

The modulation-current tempco can be programmed with an external resistor R_{TC}, as described in the Reference Generator section. An internal 520Ω resistor is included to limit the maximum modulation current if MOD is connected directly to REF2.

If the MAX3766 is shut down or disabled, the modulation programming current is shunted to ground. Any remaining modulation current is switched to OUT-.

For optimum performance, the voltage at OUT+ and OUT- must always exceed V_{CC} - 2.5V.

Laser Bias Circuit

The laser bias circuit is a current mirror with a gain of +40mA/mA. Redundant controls disable the bias current during a shutdown or disable event: the programming current is switched off, and any remaining bias output current is switched away from the laser. Ensure that the voltage at BIAS always remains above V_{CC} - 2.5V. If the bias circuit is not used, connect BIAS to V_{CC}.
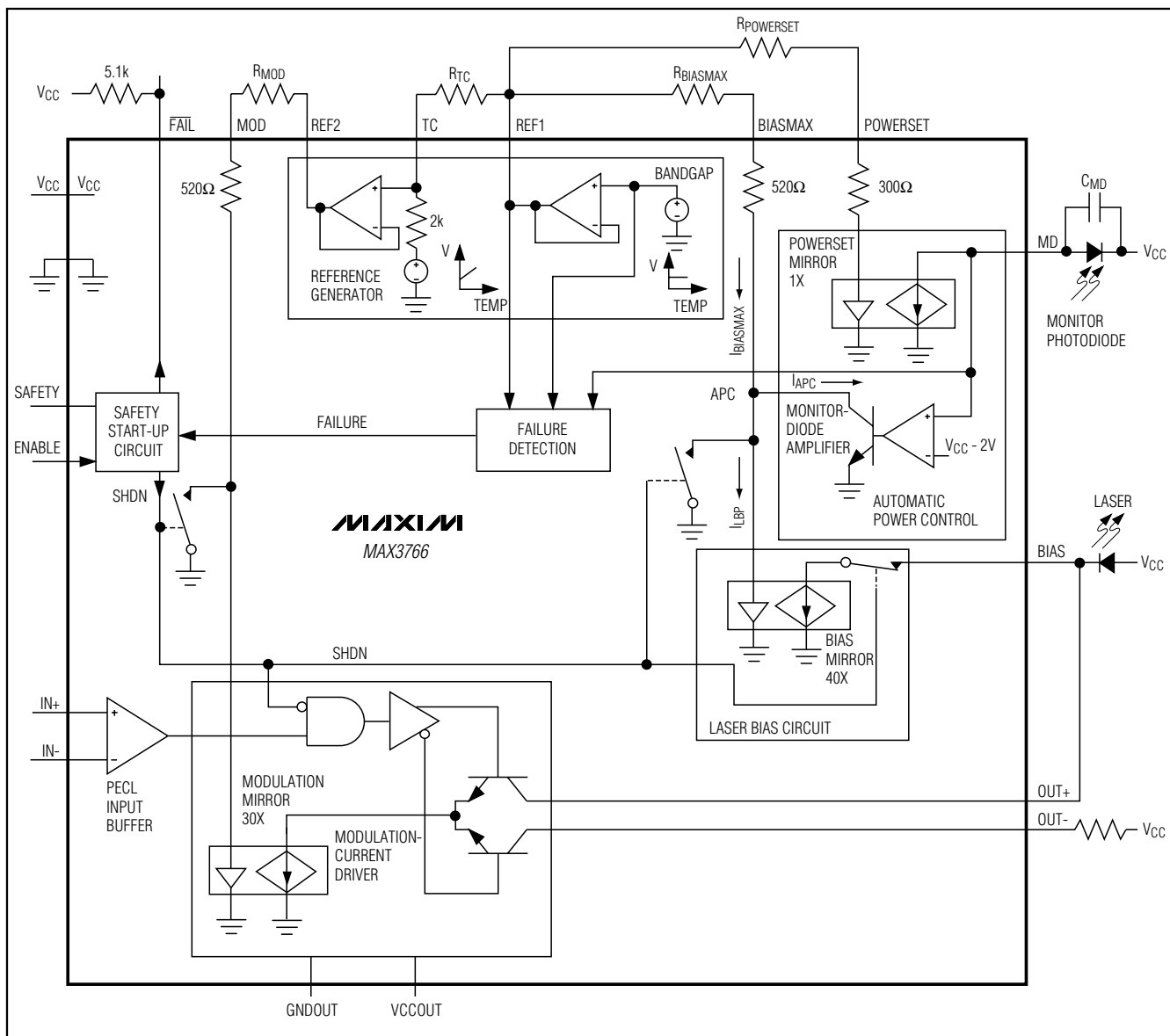
MAX3766

Figure 2. Functional Diagram

The available laser bias current is programmed by connecting external resistor $R_{BIASMAX}$ from REF1 to BIASMAX. The BIASMAX programming current is adjusted by the APC circuit and amplified by the laser bias circuit.

An internal 520Ω resistor between BIASMAX and the mirror input at internal node APC limits the maximum laser bias current when BIASMAX is connected directly to REF1. BIASMAX can be directly connected to REF1 in space-constrained designs, causing the maximum

programming current (about 2.5mA) to flow into BIASMAX. Selecting a BIASMAX resistor saves power and limits the transmitter's maximum light output. $R_{BIASMAX}$ can be estimated as follows:

$$R_{BIASMAX} = \frac{1.55V\left(40\right)}{I_{BIASMAX}} - 520\Omega$$

This equation applies to maximum bias currents above 10mA.

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Automatic Power Control

Transmitters employing a laser with monitor photodiode can use the APC circuit to maintain constant power, regardless of laser threshold changes due to temperature and aging. The APC circuit consists of the POWERSET current mirror and the monitor diode amplifier.

The POWERSET current mirror provides an accurate method of programming the back facet monitor photodiode current, which is assumed to be proportional to laser output power. An external resistor from REF1 to POWERSET programs the current in the unity-gain current mirror. $R_{POWERSET}$ can be estimated as follows:

$$R_{POWERSET} = \frac{1.55V}{I_{MOD}} - 300\Omega$$

The monitor-diode amplifier senses the current from the monitor photodiode at MD, provides gain, and adjusts the laser bias programming current (I_{LBP}). The monitor-diode amplifier forces the monitor-diode current to equal the current programmed at POWERSET. The monitor-diode amplifier can reduce the laser bias programming current, but cannot increase it. Therefore, the APC circuit can adjust laser bias current between 0 and the setting determined by $R_{BIASMAX}$.

When the APC feedback loop is closed, the voltage at MD is approximately 2V below V_{CC}. If the loop cannot close due to excess or insufficient photocurrent, a failure is detected by the failure-detection circuit. Internal circuitry prevents the voltage at MD from dropping below V_{CC} - 3.2V.

The stability and time constant of the APC feedback loop is determined by an external compensation capacitor (C_{MD}) of at least 0.1µF. Connect the compensation capacitor from V_{CC} to MD, as shown in *Typical Application Circuits*, to ensure a smooth start-up at power-on or transmitter enable.

If a monitor diode is not available, the APC feature can be disabled by connecting $R_{POWERSET}$ to GND and leaving MD unconnected.

Failure Detection

Figure 3 shows a simplified schematic of the failure-detection circuit. The failure-detection circuit senses two conditions. First, if the APC control loop cannot control the monitor current due to laser undercurrent, overcurrent, or a fault condition, a window comparator detects that V_{MD} is above or below V_{CC} - 2V and asserts the failure signal. Second, if REF1 is shorted to the positive supply (or any another voltage above the normal operating level), a comparator detects this condition and asserts the failure signal. If left undetected,

the reference voltage would rise, the current at POWER-SET would increase, and the APC loop would attempt to add laser current beyond the intended value.

Either failure condition causes the $\overline{FAIL}$ output to assert TTL low. The $\overline{FAIL}$ output buffer is an open-collector output and is designed to operate with a 5.1kΩ external pull-up resistor.

Safety/Start-Up Circuit

The safety circuit includes the digital logic needed to provide a latched internal shutdown signal (SHDN) for disabling the laser if a failure condition exists. The MAX3766 produces less than 20µA of total laser current when disabled by safety features or by the ENABLE input. Figure 4 is a simplified schematic of the safety circuit.

If ENABLE is low or open, the laser bias and modulation outputs are disabled by SHDN, regardless of the state of the safety logic. The TTL-compatible ENABLE input is internally pulled low with a 100kΩ resistor.

There are two useful safety configurations: failure indication and latched shutdown.

Failure-Indication Configuration

Select the failure-indication configuration by connecting SAFETY to ground. In this configuration, a failure condition is reported at $\overline{FAIL}$, but does not cause a latched shutdown. This configuration requires no additional circuitry for start-up.
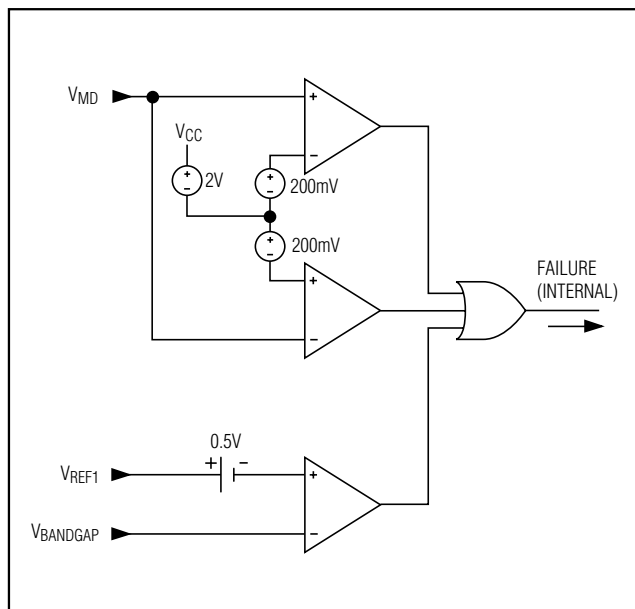

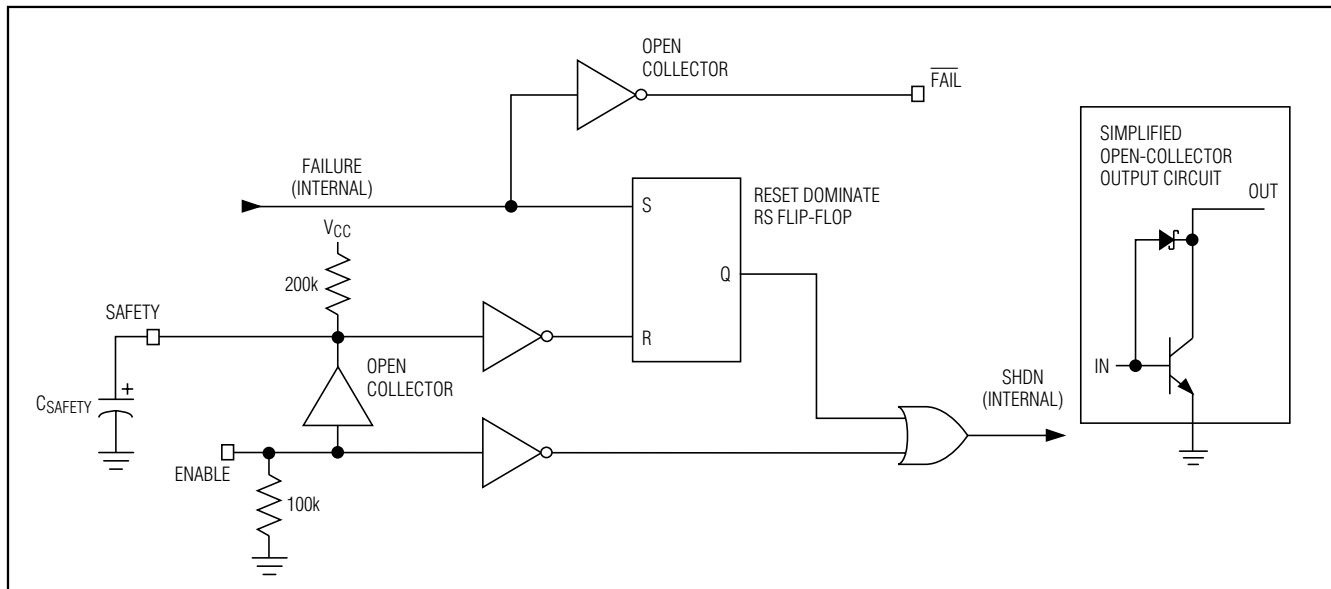*Figure 3. Failure-Detection Circuit (Simplified)*

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Figure 4. Simplified Safety Circuit Schematic

Latched Shutdown Configuration

This configuration is shown in the *Typical Application Circuits* (configured for best performance), and can be selected by connecting a capacitor (C_{SAFETY}) to ground at SAFETY. In this configuration, the transmitter is shut down when a failure is detected. It can be restarted only by a power-on cycle or a toggle of the ENABLE input.

During start-up, $\overline{FAIL}$ is asserted until laser power reaches the programmed level. The safety circuit must be disabled at power-on or at transmitter enable, providing enough time for the APC circuit to reach the programmed laser power level.

In space-constrained designs, C_{SAFETY} can be selected to provide a shutdown delay. When power is initially applied, or when the ENABLE signal is toggled from a logic 0 to a logic 1, the voltage at SAFETY is low, and rises with a time constant set by C_{SAFETY} and an internal 200kΩ pull-up resistor. The SAFETY signal is inverted and resets the input of a reset-dominant RS flip-flop. The internal signal FAILURE from the failure-detection circuit is connected to the set input of the flip-flop. After SAFETY has gone high (allowing time for the APC feedback loop to settle) and if internal signal FAILURE is low, the flip-flop output is low, and the bias and modulation outputs are allowed to remain on. Refer to Figure 5 for a timing diagram of start-up in the latched shutdown configuration.
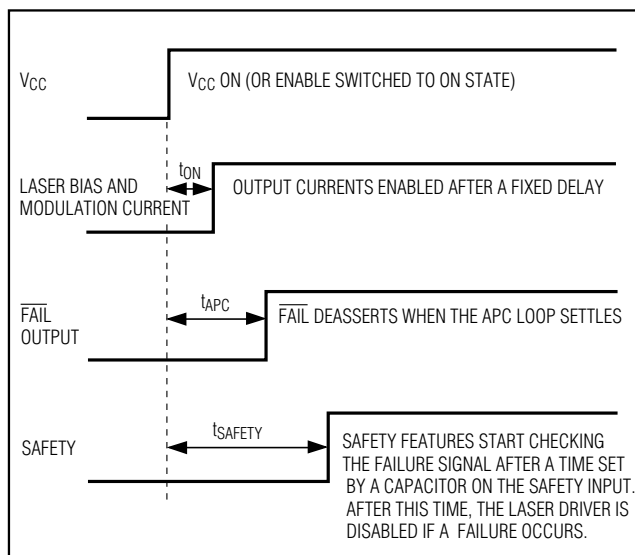

Figure 5. Start-Up Sequence Timing

The duration of t_{SAFETY} must be about 10 times t_{APC} for a successful start-up. After start-up, the transmitter operates normally until a failure is detected, causing the output currents to be shut down. The laser-current outputs remain off until the failure condition is eliminated and the ENABLE input is toggled, or until the power is cycled. A potential problem with this transmitter-enable method is that a slow-rising power supply may not enable the transmitter.

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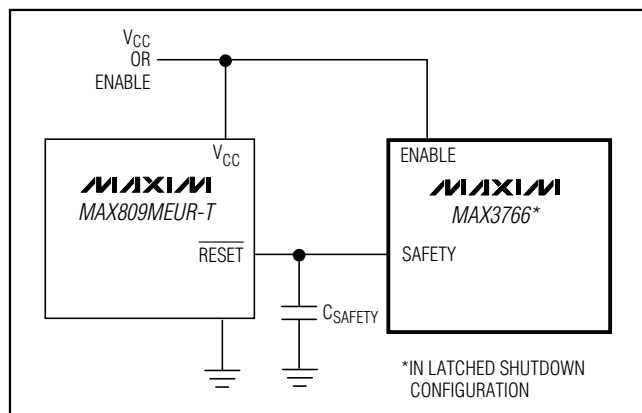# 622Mbps LAN/WAN Laser Driver with Automatic Power Control and Safety Shutdown

Figure 6. Reset Pulse Generator

If PC board space is not a constraint, Maxim recommends enabling the transmitter with a reset-pulse generator, such as the MAX809, which generates a reset signal after V$_{CC}$ reaches 4.5V (Figure 6). This method ensures that the transmitter starts correctly, even if the supply ramps very slowly.

_____*Design Procedure*

Select Laser

Select a communications-grade laser with a rise time of 0.5ns or better for 622Mbps applications. The voltage swing at the OUT+ pin affects the output waveform, and is largely determined by the laser resistance, inductance, and modulation current. To obtain the MAX3766's AC specifications, the output voltage at OUT+ must remain above V$_{CC}$ - 2.5V at all times.

An approximation for the minimum voltage at OUT+ is given by the following equation (Table 1):

$$V_{OUT(MIN)} = V_{CC(MIN)} - V_{LASER} - \left(I_{MOD}\right)\left(R_L + R_D + \frac{L}{t_r}\right)$$

Select a laser that meets the output voltage criteria. A high-efficiency laser requires low modulation current and generates low voltage swing at OUT+. Laser package inductance can be reduced by trimming leads. Typical package leads have inductance of 25nH per inch (1nH/mm). A compensation filter network can also be used to reduce ringing, edge speed, and voltage swing.

Table 1. Output Voltage Approximation

VARIABLE	DESCRIPTION	TYPICAL VALUE
V$_{OUT(MIN)}$	Approximation for the lowest voltage at the OUT+ pin	2.2V
V$_{CC(MIN)}$	Minimum power supply	4.5V
V$_{LASER}$	Laser forward voltage at operating power	1.3V
R$_L$	Laser dynamic resistance	3Ω
I$_{OUT}$	Laser modulation current	30mA
R$_D$	Any damping resistance or line termination in series with the laser (but not in series with BIAS)	10Ω
L	Total series inductance of laser, laser package, and board traces to the MAX3766	6nH
t$_r$	20% to 80% rise time of the laser modulation current, filtered by a compensation network	300ps (20% to 80%)

Set Modulation-Current Tempco

Compute the required modulation tempco from the slope efficiency of the laser at T_A = +25°C and at a hot temperature. Then select the value of R_{TC} from the *Typical Operating Characteristics*.

For example, suppose a laser has a slope efficiency (SE) of 0.021mW/mA at +25°C, which reduces to 0.018mW/mA at +85°C. The temperature coefficient is given by the following:

$$\text{Laser tempco} = \frac{\left(SE_{85} - SE_{25}\right)}{SE_{25} \cdot \left(85 - 25\right)} \cdot 10^6$$
$$= -2380\text{ppm}/°C$$

From the *Typical Operating Characteristics*, the value for R_{TC}, which offsets the tempco of the laser, is 3kΩ. If modulation temperature compensation is not desired, connect TC directly to REF1.

Set Modulation Current

The modulation-current amplitude can be programmed with a fixed resistor or adjusted with a potentiometer. A small internal resistance is provided to prevent damage if the potentiometer is adjusted to the end of its range. The value of R_{MOD} can be selected from the *Typical Operating Characteristics*.

Example: A transmitter requires average power of -8dBm (160µW), with an extinction ratio of 15. The optical signal output is 280µW (see *Optical Power Relations*). If the slope efficiency is 0.021mW/mA at +25°C, then the required modulation current is 0.280mW / 0.021mW/mA = 13.3mA. From the *Typical Operating Characteristics*, the value of R_{MOD} is selected to be 3kΩ.

Set Average Laser Power and Maximum Bias Current

When APC is used, the average power control is programmed by $R_{POWERSET}$, which is typically a potentiometer. The value of $R_{POWERSET}$ can be estimated from the *Typical Operating Characteristics*.

Example: Suppose a transmitter's output power will be adjusted to -8dBm (160µW) average power during manufacturing. The coupling efficiency from laser to monitor photodiode varies from 0.4A/W to 0.8A/W for the selected laser, causing monitor current to vary between 64µA and 128µA. From the *Typical Operating Characteristics*, $R_{POWERSET}$ should be adjustable between 12kΩ and 24kΩ.

Select $R_{BIASMAX}$ to provide sufficient current for a hot laser at its end of life. For example, if the expected laser threshold at +85°C and end of life is 40mA, then from the *Typical Operating Characteristics*, $R_{BIASMAX}$ should be 1kΩ or less.

If APC is not used, the laser bias current is programmed by $R_{BIASMAX}$. Select $R_{BIASMAX}$ from the *Typical Operating Characteristics*.

Set APC Time Constant

Capacitor C_{MD} determines the APC time constant, and must be large enough not to cause data-dependent jitter. For 622Mbps SONET/ATM applications, Maxim recommends selecting $C_{MD} \geq 0.1\mu F$.

Select C_{SAFETY}

When using the latched shutdown configuration, determine the minimum value of C_{SAFETY} from the *Typical Operating Characteristics*. Calculate C_{SAFETY} as follows:

$$C_{SAFETY} = \frac{C_{MD}}{20k\Omega \cdot I_{MD}}$$

For example: If C_{MD} is 0.1µF and typical monitor current (I_{MD}) is 100µA, then the value of C_{SAFETY} should be 50nF or larger. This ensures that t_{SAFETY} is at least 10 times the t_{APC}.

Design Bias Filter

To reduce data-dependent jitter, add a filter at BIAS (see *Typical Operating Circuit*). Maxim recommends a 1µH inductor or ferrite bead with a self-resonance frequency of 200MHz or more.

Design Laser-Compensation Filter Network

Laser package lead inductance causes the laser impedance to increase at high frequencies, which leads to ringing, overshoot, and degradation of the output eye. A laser-compensation filter network can be used to reduce the output load seen by the MAX3766 at high frequencies, thereby reducing output ringing and overshoot.

The compensation components (R_{COMP} and C_{COMP}) are most easily determined by experimentation. Begin with a no-compensation network, and observe the ring frequency (f_n) of the laser and laser driver (Figure 7). Begin with R_{COMP} = 25Ω and C_{COMP} = 1/(2πf_n R_{COMP}). Increase C_{COMP} until the desired transmitter eye is obtained.
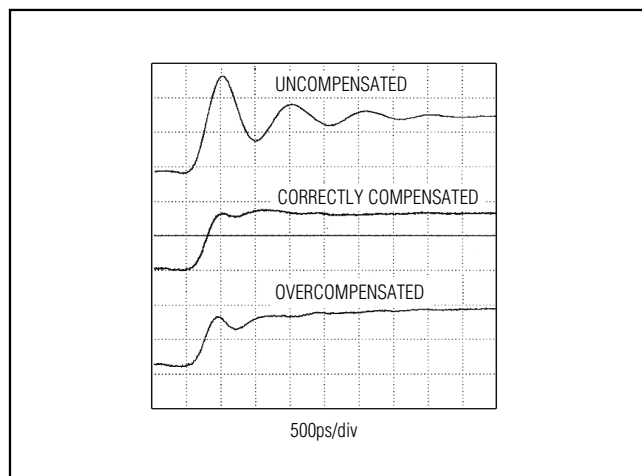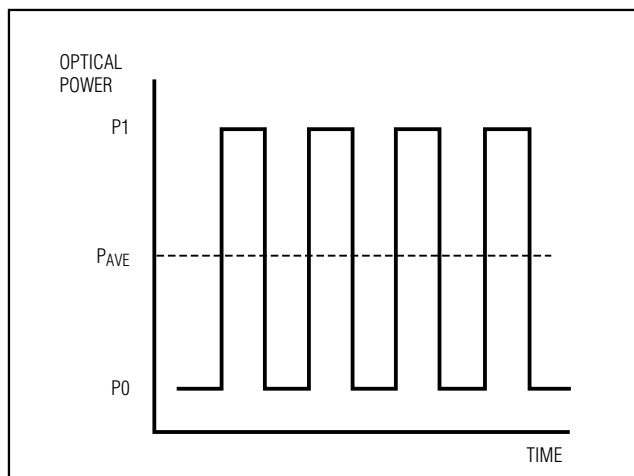
Figure 7. Example Laser Compensation

Figure 8. Optical Power Relations

Calculate Power Consumption

The MAX3766's junction temperature must be kept below +150°C at all times. Calculate total power dissipated on the MAX3766 by laser power as follows:

$$Power = V_{CC}(I_{CC} + I_{BIAS} + I_{MOD})$$
$$- (I_{MOD}/2 + I_{BIAS})V_{LASER}.$$

where I_{BIAS} is the maximum bias current allowed by $R_{BIASMAX}$, I_{MOD} is the AC modulation current, V_{LASER} is the typical laser forward voltage.

Junction temperature = power (Watts) • 110 (°C/W).

Applications Information

Optical Power Relations

Many MAX3766 specifications relate to output current amplitude. When working with fiber optic transmitters, the output is normally expressed in terms of average optical power and extinction ratio (Figure 8). Table 2 lists relations that are helpful in converting optical power to output signal amplitude when designing with the MAX3766. The relations are true if the average duty cycle of the input data is 50%.

Input Terminations

The MAX3766's data inputs must be biased externally. Refer to Figure 9 for common input terminations.

Laser Safety and IEC 825

The International Electrotechnical Commission (IEC) determines standards for hazardous light emissions from fiber optic transmitters. Specification IEC 825 defines the maximum light output for various hazard levels. The MAX3766 provides features that aid compliance with IEC 825.

Table 2. Optical Power Definitions

PARAMETER	SYMBOL	RELATION
Average Power	P_{AVE}	$P_{AVE} = (P0 + P1)/2$
Extinction Ratio	r_e	$r_e = P1/P0$
Optical Power of a "1"	P1	$P1 = 2P_{AVE}\dfrac{r_e}{r_e + 1}$
Optical Power of a "0"	P0	$P0 = 2P_{AVE}/(r_e + 1)$
Signal Amplitude	P_{INPUT}	$P_{INPUT} = P1 - P0 = 2P_{AVE}\dfrac{r_e - 1}{r_e + 1}$

A common safety requirement is single-point fault tolerance, whereby one unplanned short, open, or resistive connection does not cause excess light output. When the MAX3766 is used in the latched shutdown configuration, as shown in *Typical Application Circuits*, the circuit responds as shown in Table 3.

Using the MAX3766 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.

MAX3766

Table 3. MAX3766 Fault Response in Latched Shutdown Configuration

PIN	CIRCUIT RESPONSE TO OVERVOLTAGE OR SHORT TO V_{CC}	CIRCUIT RESPONSE TO UNDERVOLTAGE OR SHORT TO GROUND
BIASMAX	Depending upon the setting of $R_{POWERSET}$, there is either no effect, or a latched shutdown.	Bias current reduction causes a low laser output, resulting in a latched shutdown.
REF1	High voltage on REF1 causes a failure and latched shutdown.	Modulation and bias currents are reduced or off; no hazard exists.
REF2, TC, MOD	Modulation current is increased. Either the APC circuit will reduce power levels, or an overcurrent will be detected at MD, causing a failure signal and latched shutdown.	Modulation current is reduced; no hazard exists.
ENABLE	Normal condition for circuit operation.	Modulation and bias currents are shut down.
IN+, IN-	Forces output to either constant 1 or 0. APC maintains the power level at the programmed level.	Forces output to either constant 1 or 0. APC maintains the power level at the programmed level.
SAFETY	Normal condition for circuit operation.	Safety shutdown features are disabled, but a hazard is not created.
$\overline{FAIL}$	No effect on circuit.	No effect on circuit.
OUT+, BIAS	Voltage increase at these pins will turn off the laser.	High laser output asserts $\overline{FAIL}$. A complete short will destroy the laser, eliminating the hazard. A resistive short may cause a hazard. External circuitry combined with the $\overline{FAIL}$ signal may be used to protect against a resistive short (Figure 10).
OUT-	Normal condition for circuit operation.	Forces output to be logic 1. APC maintains the power level at the programmed level.
MD	Voltage increase at MD causes a failure and output current shutdown.	Voltage decrease at MD causes a failure and output current shutdown.
POWERSET	Laser output increases, but is limited by the setting of $R_{BIASMAX}$.	Laser output decreases.

MAXIM
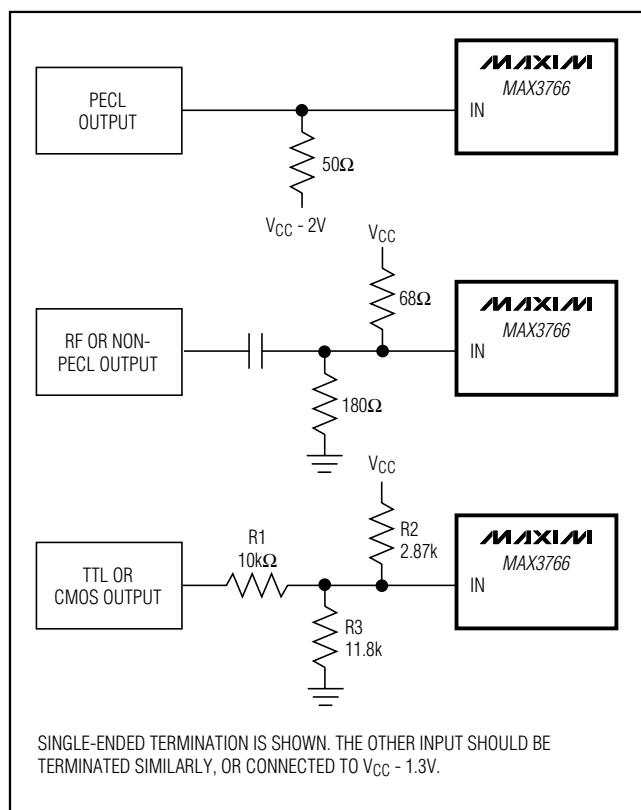
MAX3766

Figure 9. Input Terminations

Figure 10. External Laser Shutdown Circuit

2) **Low-frequency oscillation on the bias-current output.**

Ensure $C_{MD} \geq 0.1\mu F$.

3) **Modulation driver is not needed.**

If only the bias-current driver and safety circuits are needed, connect IN+ to V_{CC}, and leave IN- unconnected. Connect OUT+ and OUT- to the supply. Leave MOD, TC, and REF2 unconnected.

4) **APC is not needed.**

If only the high-speed modulation driver is used, connect BIAS to V_{CC}, and leave POWERSET, MD, $\overline{FAIL}$, and BIASMAX unconnected. Connect SAFETY to ground.

5) **Laser edge switching speed is low.**

Refer to the *Design Bias Filter* section. It may be necessary to select L_{BIAS} with a higher self-resonating frequency.

Wire Bonding Die

The MAX3766 uses bondpads with gold metalization. Make connections to the die with gold wire only, using ball bonding techniques. Wedge bonding is not recommended. Pad size is 4 mils (0.1mm) square. Die thickness is typically 15 mils (0.38mm).

Interface Models

Figure 11 shows typical models for the inputs and outputs of the MAX3766, including package parasitics. If dice are used, replace the package parasitic elements with bondwire parasitic elements.

Layout Considerations

The MAX3766 is a high-frequency product. The performance of the circuit is largely dependent upon the layout of the circuit board.

Use a multilayer circuit board with a dedicated ground plane. Use short laser package leads placed close to OUT+ and OUT- to keep output inductance low. Power supplies should be capacitively bypassed to the ground plane with surface-mount capacitors placed near the power-supply pins.

Solutions to Common Problems

1) **Laser output is ringing and contains overshoot.**

This is often caused by inductive laser packaging. Try reducing the lead length of the laser pins. Modify the compensation network to reduce the driver's output edge speed (see *Design Procedure*). This problem can also occur if the voltage at OUT+, OUT-, or BIAS is below V_{CC} - 2.5V. Test this by increasing the supply voltage, or reducing the modulation current.
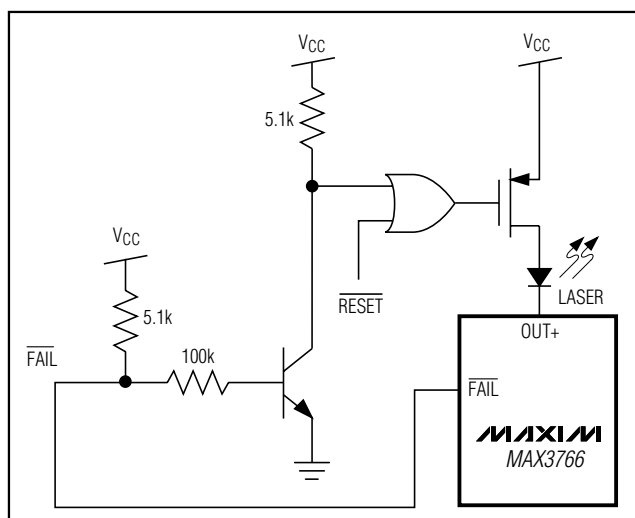
622Mbps LAN/WAN Laser Driver with Automatic Power Control and Safety Shutdown
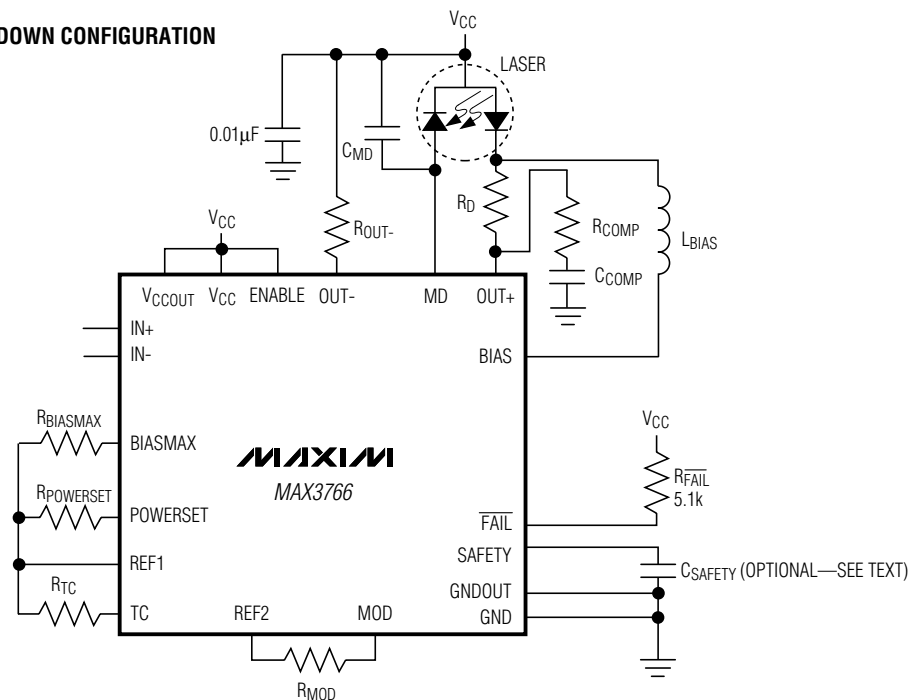

Figure 11. Interface Models

Typical Application Circuits

FAILURE-INDICATION CONFIGURATION
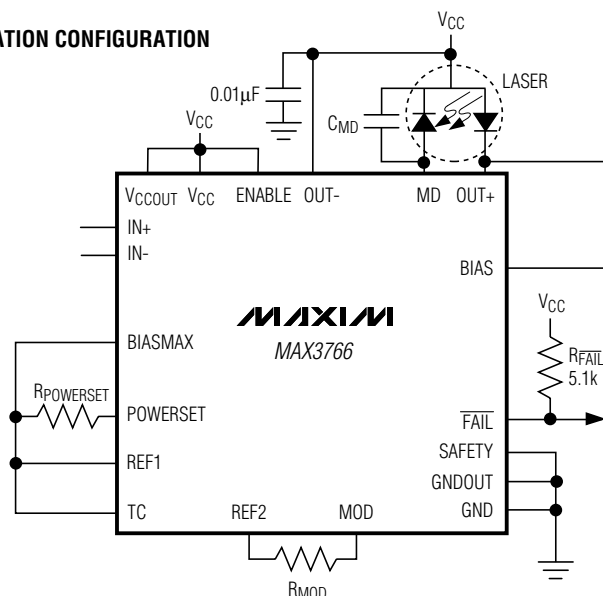
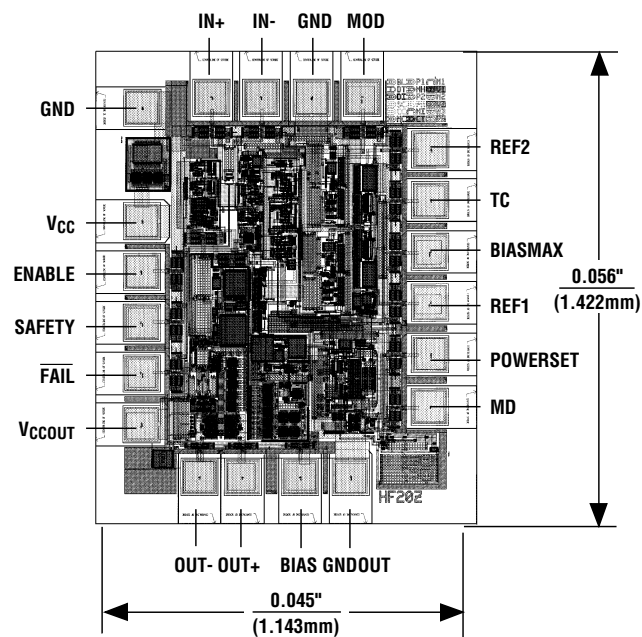CONFIGURED FOR MINIMUM COMPONENT COUNT.

LATCHED SHUTDOWN CONFIGURATION

CONFIGURED FOR BEST PERFORMANCE.
R_{TC} SETS THE TEMPERATURE COEFFICIENT OF THE MODULATION CURRENT.

622Mbps LAN/WAN Laser Driver with
Automatic Power Control and Safety Shutdown
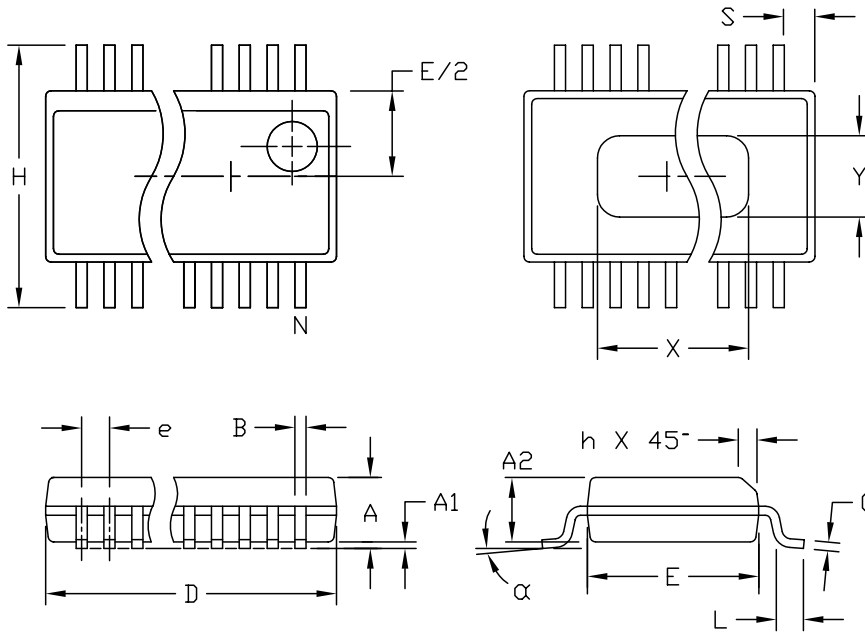
MAX3766

_____*Chip Topography*

TRANSISTOR COUNT: 725

SUBSTRATE CONNECTED TO GND AND GNDOUT.

Package Information

MAX3766

QSOP.EPS

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	.061	.068	1.55	1.73
A1	.004	.0098	0.102	0.249
A2	.055	.061	1.40	1.55
B	.008	.012	0.20	0.31
C	.0075	.0098	0.191	0.249
D	SEE VARIATIONS			
E	.150	.157	3.81	3.99
e	.025 BSC		0.635 BSC	
H	.230	.244	5.84	6.20
h	.010	.016	0.25	0.41
L	.016	.035	0.41	0.89
N	SEE VARIATIONS			
X	SEE VARIATIONS			
Y	.071	.087	1.803	2.209
α	0°	8°	0°	8°

VARIATIONS:

	INCHES		MILLIMETERS			
	MIN.	MAX.	MIN.	MAX.	N	
D	.189	.196	4.80	4.98	16	AA
S	.0020	.0070	0.05	0.18		
X	.107	.123	2.72	3.12		
D	.337	.344	8.56	8.74	20	AB
S	.0500	.0550	1.270	1.397		
D	.337	.344	8.56	8.74	24	AC
S	.0250	.0300	0.635	0.762		
D	.386	.393	9.80	9.98	28	AD
S	.0250	.0300	0.635	0.762		
X	.271	.287	6.88	7.29		

NOTES:
1. D & E DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.
2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED .006" PER SIDE.
3. HEAT SLUG DIMENSIONS X AND Y APPLY ONLY TO 16 AND 28 LEAD POWER-QSOP PACKAGES.
4. CONTROLLING DIMENSIONS: INCHES.
5. MEETS JEDEC MO137.

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PROPRIETARY INFORMATION

TITLE:
PACKAGE OUTLINE, QSOP, .150", .025" LEAD PITCH

APPROVAL	DOCUMENT CONTROL NO.	REV	
	21-0055	C	1/1

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MAX3766

NOTES

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- Подбор аналогов;
- Консультации по применению компонента;
- Поставка образцов и прототипов;
- Техническая поддержка проекта;
- Защита от снятия компонента с производства.

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