

## General Description

The SY88982L is a single 3.3V supply, low power consumption, small form factor driver for telecom/datacom applications using FP/DFB lasers at data rates up to 2.7Gbps. The driver can deliver modulation current up to 90mA, and the high compliance voltage it offers, makes the part suitable for high-current operation (with the laser AC- or DC-coupled to it). This device is intended to be used with Micrel's MIC3003 Optical Transceiver Management IC, which allows for both modulation and bias current control and monitoring, automatic power control, and temperature compensation.

All support documentation can be found on Micrel's web site at: [www.micrel.com](http://www.micrel.com).

## Features

- 2.4V minimum laser compliance voltage for high-current DC-coupled applications
- 48mA power supply current typical
- Operation up to 2.7Gbps
- Modulation current up to 90mA
- Designed for use with the MIC3003
- Laser may be DC- or AC-coupled
- Small form factor 16-pin (3mm x 3mm) QFN package

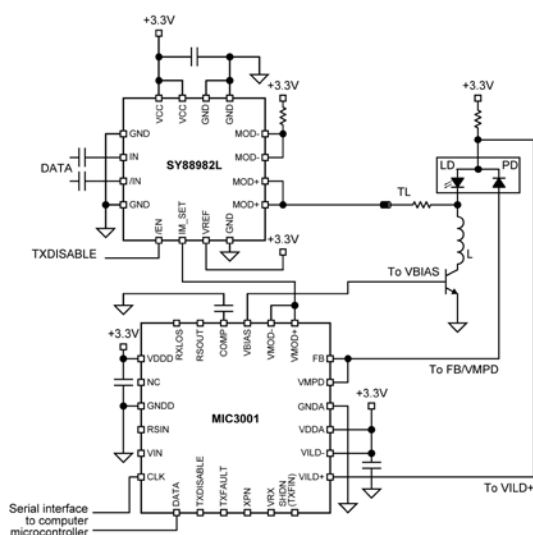
## Applications

- Multi-rate LAN, MAN applications up to 2.7Gbps:  
FC, GbE, SONET OC3/12/24/48 and SDH STM1/4/8/16
- SFF, SFP modules

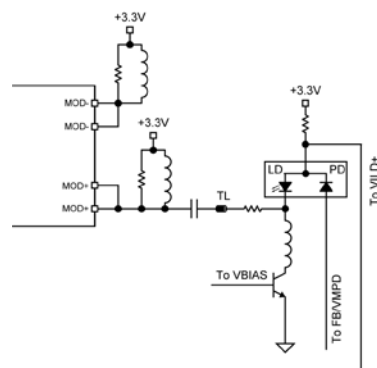
## Markets

- Telecom, Datacom

## Typical Application

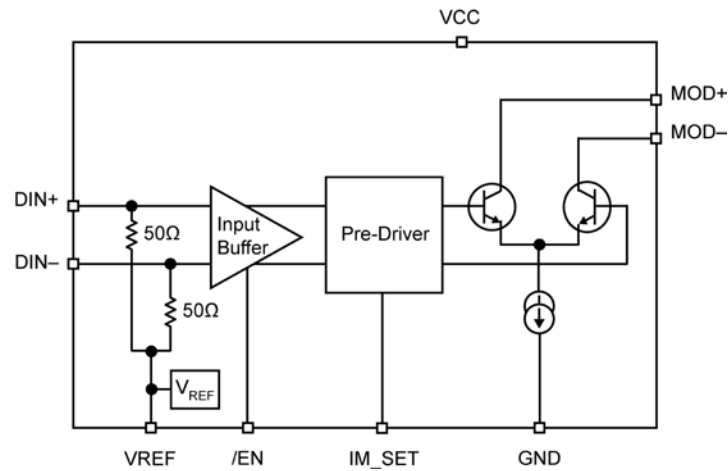


## Laser DC-Coupled to the Driver



### Laser AC-Coupled to the Driver

Functional Block Diagram



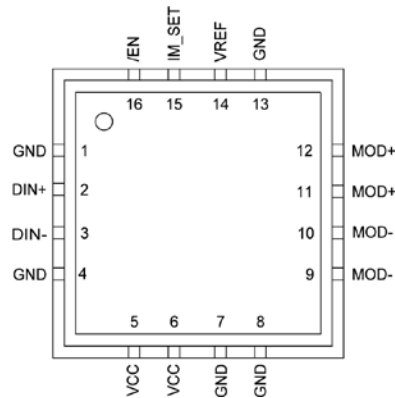
Ordering Information<sup>(1)</sup>

Part Number	Package Type	Operating Range	Package Marking	Lead Finish
SY88982LMG	QFN-16	Industrial	982L with Pb-Free bar-line indicator	NiPdAu Pb-Free
SY88982LMGTR <sup>(2)</sup>	QFN-16	Industrial	982L with Pb-Free bar-line indicator	NiPdAu Pb-Free

Notes:

- 1. Contact factory for die availability. Dice are guaranteed at T<sub>A</sub> = +25°C, DC Electricals only.
- 2. Tape and Reel.

Pin Configuration



16-Pin QFN

## Pin Description

Pin Number	Pin Name	Pin Function
1, 4, 7, 8, 13	GND	Ground. Ground and exposed pad must be connected to the plane of the most negative potential.
2	DIN+	Non-Inverting Input Data. Internally terminated with 50Ω to a reference voltage.
3	DIN-	Inverting Input Data. Internally terminated with 50Ω to a reference voltage.
5, 6	VCC	Supply Voltage. Bypass with a 0.1μF//0.01μF low ESR capacitor as close to VCC pin as possible.
9, 10	MOD-	Inverted Modulation Current Output. Provides modulation current when input data is negative.
11, 12	MOD+	Non-Inverted Modulation Current Output. Provides modulation current when input data is positive.
14	VREF	Reference Voltage. Install a 0.1μF capacitor between VREF and VCC.
15	IM_SET	Modulation current setting and control. The voltage applied to this pin will set the modulation current. To be connected to the MIC3003 pin 24 (VMOD+). Input impedance 25kΩ.
16	/EN	A high level signal applied to this pin will disable the output stage of the driver. Internally pulled down with 25kΩ resistor.

## Truth Table

DIN+	DIN-	/EN	MOD+ <sup>(1)</sup>	MOD-	Laser Output <sup>(2)</sup>
L	H	L	H	L	L
H	L	L	L	H	H
X	X	H	H	H	L

Notes:

1.  $I_{MOD} = 0$  when MOD+ = H.
2. Assuming that the laser is tied to MOD+.

## Absolute Maximum Ratings<sup>(1)</sup>

Supply Voltage ( $V_{IN}$ ) ..... -0.5V to +4.0V  
 CML Input Voltage ( $V_{IN}$ ) .....  $V_{CC}-1.2V$  to  $V_{CC}+0.5V$   
 TTL Control Input Voltage ( $V_{IN}$ ) ..... 0V to  $V_{CC}$   
 Lead Temperature (soldering, 20sec.) ..... +260°C  
 Storage Temperature ( $T_s$ ) ..... -65°C to +150°C

## Operating Ratings<sup>(2)</sup>

Supply Voltage ( $V_{CC}$ ) ..... +3.0V to +3.6V  
 Ambient Temperature ( $T_A$ ) ..... -40°C to +85°C  
 Package Thermal Resistance<sup>(3)</sup>  
 QFN  
 ( $\theta_{JA}$ ) Still-air ..... 60°C/W  
 ( $\psi_{JB}$ ) ..... 33°C/W

## DC Electrical Characteristics

$T_A$  = -40°C to 85°C and  $V_{CC}$  = +3.0V to +3.6V, unless otherwise noted. Typical values are  $V_{CC}$  = +3.3V,  $T_A$  = 25°C,  $I_{MOD}$  = 60mA.

Symbol	Parameter	Condition	Min	Typ	Max	Units
$I_{CC}$	Power Supply Current	Modulation current excluded		48	65 <sup>(4)</sup>	mA
$V_{MOD\_MIN}$	Minimum Voltage Required at the Driver Output (headroom) for Proper Operation		0.6			V
$R_{IN(DATA)}$	Input Resistance (DIN+, DIN-)		45	50	55	$\Omega$
$V_{ID}$	Differential Input Voltage Swing		200		2400	mV <sub>PP</sub>
/EN Low					0.8	V
/EN High			2			V
$R_{IN(I_{MOD\_SET})}$	$I_{M\_SET}$ Input Resistance			25		k $\Omega$
$V_{IM\_SET}$	Voltage Range on $I_{M\_SET}$ Pin	$I_{MOD}$ range 10mA – 90mA			1.2	V

## AC Electrical Characteristics

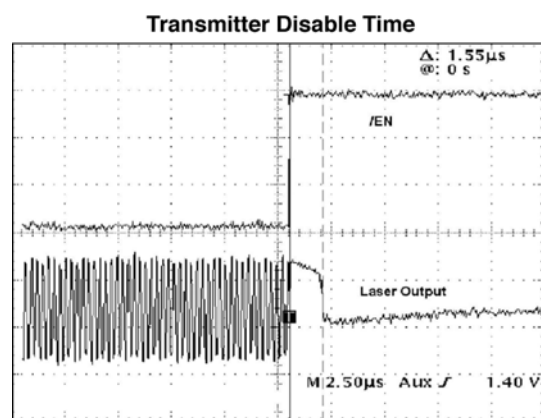
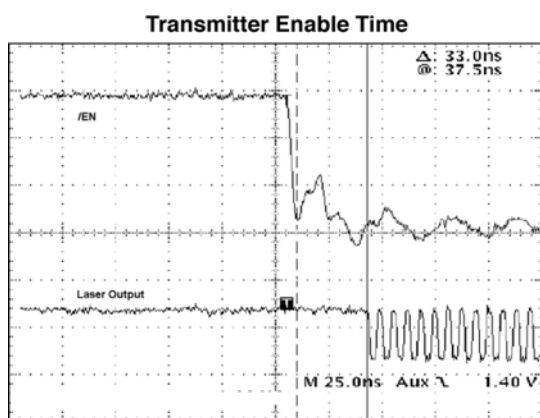
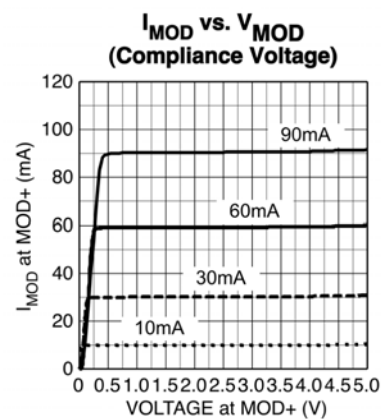
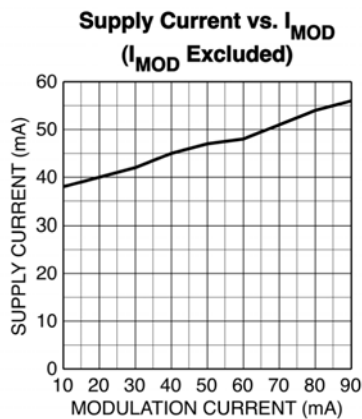
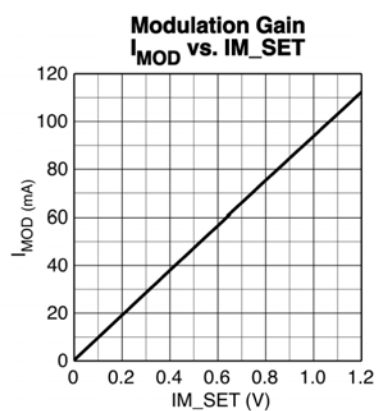
$T_A$  = -40°C to 85°C and  $V_{CC}$  = +3.0V to +3.6V, unless otherwise noted. Typical values are  $V_{CC}$  = +3.3V,  $T_A$  = 25°C,  $I_{MOD}$  = 60mA.

Symbol	Parameter	Condition	Min	Typ	Max	Units
	Data Rate	NRZ	0.155		2.7	Gbps
$I_{MOD}$	Modulation Current <sup>(5)</sup>	AC-coupled	10		90	mA
		DC-coupled	10		70 <sup>(6)</sup>	mA
$I_{MOD\_OFF}$	Modulation OFF Current	Current at MOD+ when the device is disabled.			750	$\mu$ A
$t_r$	Output Current Rise Time	20% to 80%, $I_{MOD}$ = 60mA, 15 $\Omega$ load		55	80	ps
$t_f$	Output Current Fall Time	20% to 80%, $I_{MOD}$ = 60mA, 15 $\Omega$ load		55	80	ps
	Total Jitter	@2.5Gbps data rate			20	ps <sub>PP</sub>
	Pulse-Width Distortion	$I_{MOD}$ range 10mA – 90mA			20	ps

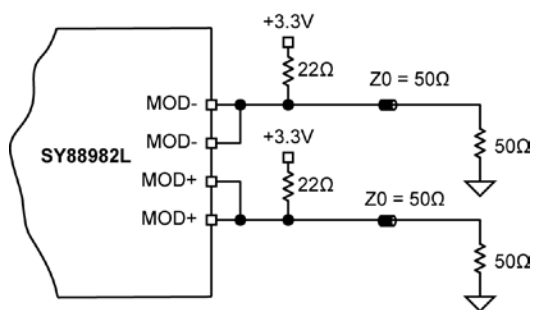
### Notes:

- Permanent device damage may occur if absolute maximum ratings are exceeded. This is a stress rating only and functional operation is not implied at conditions other than those detailed in the operational sections of this data sheet. Exposure to absolute maximum ratings conditions for extended periods may affect device reliability.
- The data sheet limits are not guaranteed if the device is operated beyond the operating ratings.
- Package Thermal Resistance assumes exposed pad is soldered (or equivalent) to the devices most negative potential on the PCB.  $\psi_{JB}$  uses a 4-layer and  $\theta_{JA}$  in still air unless otherwise stated.
- $I_{CC}$  = 48mA for worst-case conditions with  $I_{MOD}$  = 90mA,  $T_A$  = +85°C,  $V_{CC}$  = 3.6.
- Load = 15 $\Omega$ .
- Assuming  $V_{CC}$  = 3.0V, Laser bandgap voltage = 1V, laser package inductance = 1nH, laser equivalent series resistor = 5 $\Omega$ , and damping resistor = 10 $\Omega$ .

## Typical Operating Characteristics

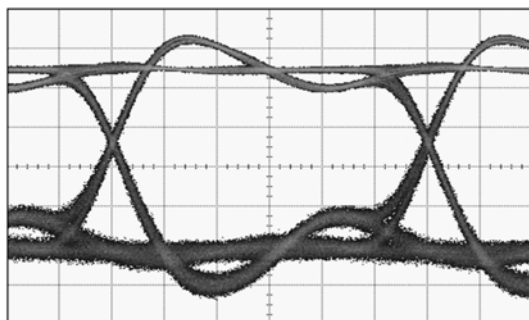


## Test Circuit



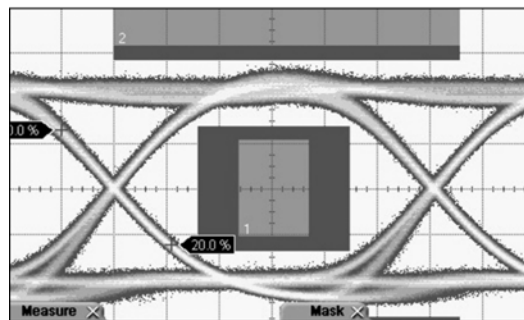
## Functional Characteristics

**Electrical Eye Diagram**  
2.5Gbps, PRBS 2<sup>23</sup>-1, 15Ω Load, 60mA Modulation



TIME (66ps/div.)

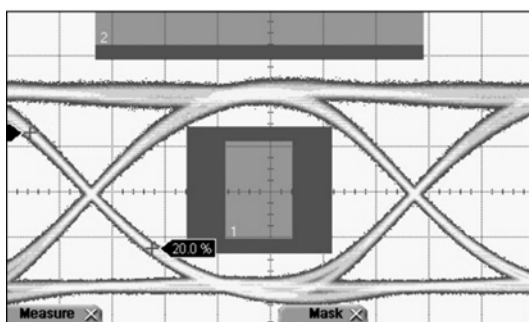
**Optical Eye Diagram**  
2.7Gbps, PRBS 2<sup>23</sup>-1, Laser AC-Coupled



TIME (66ps/div.)

ER = 10dB, 30% Mask Margin

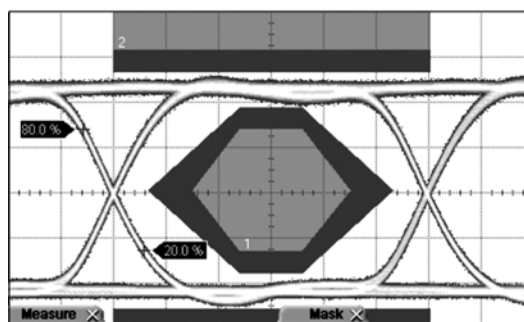
**Optical Eye Diagram**  
2.5Gbps, PRBS 2<sup>23</sup>-1, Laser DC-Coupled



TIME (65ps/div.)

ER = 11dB, 30% Mask Margin

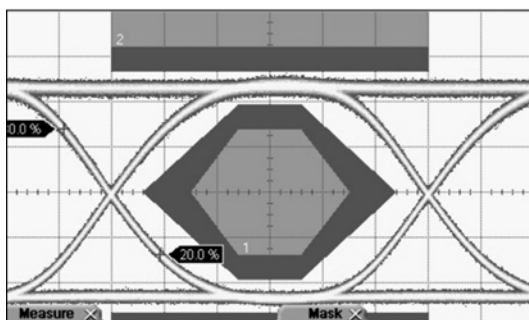
**Optical Eye Diagram with OC-48 Filter**  
1.25Gbps, PRBS 2<sup>23</sup>-1, Laser DC-Coupled



TIME (133ps/div.)

ER = 11dB, 55% Mask Margin

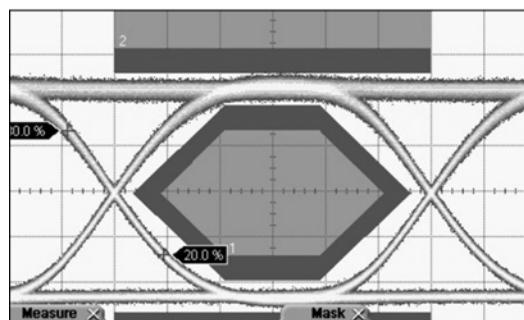
**Optical Eye Diagram**  
622Mbps, PRBS 2<sup>23</sup>-1, Laser DC-Coupled



TIME (267ps/div.)

ER = 11.3dB, 60% Mask Margin

**Optical Eye Diagram**  
155Mbps, PRBS 2<sup>23</sup>-1, Laser DC-Coupled



TIME (1075ps/div.)

ER = 11.3dB, 60% Mask Margin

## Input and Output Stages

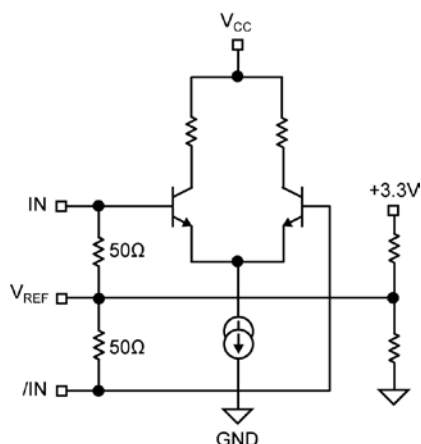


Figure 1a. Simplified Input Stage

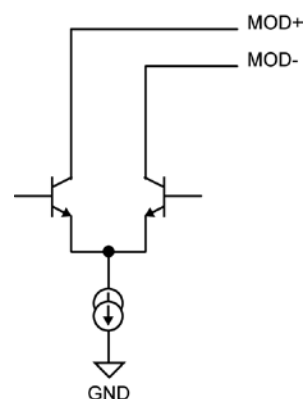


Figure 1b. Simplified Output Stage

## Interfacing the Input to Different Logic Drivers

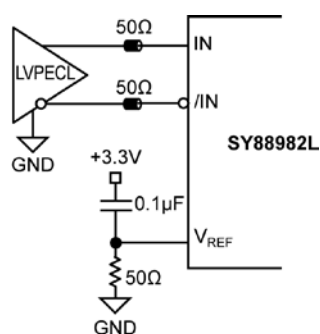


Figure 2a. DC-Coupling to LVPECL Driver

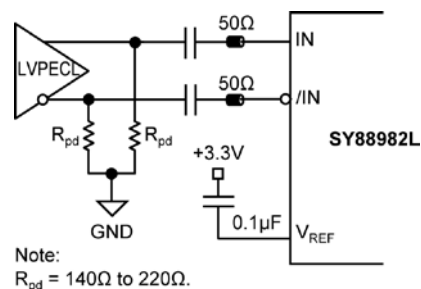


Figure 2b. AC-Coupling to LVPECL Driver

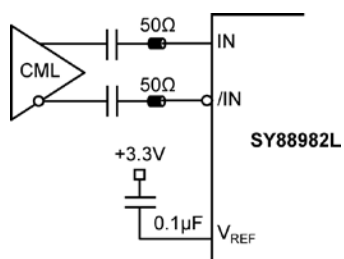


Figure 2c. AC-Coupling to CML Driver

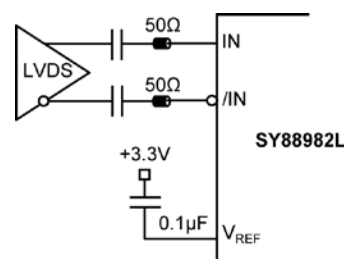


Figure 2d. AC-Coupling to LVDS Driver



## Application Information

The typical applications diagram on the first page shows how to connect the driver to the laser, single ended. To improve transition time and laser response, the laser can be driven differentially as shown in Figures 3 and 4. Driving the laser differentially will also minimize the crosstalk with the rest of the circuitry on the board, especially the receiver.

### DC-Coupling

In addition to the low power consumption and high modulation current, the SY88982L offers a high compliance voltage. As can be seen in the "Typical Operating Characteristics" section ( $I_{MOD}$  vs.  $V_{MOD}$  curves), the minimum voltage needed at the output of the driver for proper operation is less than 600mV, leaving a large headroom,  $V_{CC}$ -600mV, to the laser with the damping resistor. To show the importance of this high compliance voltage, consider the voltage drops along the path from  $V_{CC}$  to ground through the laser, damping resistor, and driver:

$$V_{CC} = \text{Driver Headroom} + V_{Rd} + V_{laser}$$

$$V_{Rd} = R_d \times I_{MOD}$$

$$V_{laser} = V_{band-gap} + R_{laser} \times I_{MOD} + L di/dt$$

$$V_{band-gap} + R_{laser} \times I_{MOD} = 1.6V \text{ at maximum for a Fabry Perrot or a DFB laser.}$$

$L di/dt$  is the voltage drop due to the laser parasitic inductance during  $I_{MOD}$  transitions. Assuming  $L = 1nH$ ,  $t_f = t_r = 80ps$  (measured between 20% and 80% of  $I_{MOD}$ ), and  $I_{MOD} = 70mA$  (42mA from 20% to 80%), then  $L di/dt$  will be equal to 525mV. This number can be minimized by making the laser leads as short as possible and using an RC compensation network between the cathode of the laser and ground or across the laser driver outputs as shown in Figure 3.

To be able to drive the laser DC-coupled with a high current, it is necessary to keep the damping resistor as small as possible. For example, if the drop due to parasitic inductance of the laser is neglected (compensated for) and the maximum drop across the laser (1.6V) considered while keeping a minimum of 600mV headroom for the driver, then the maximum damping resistor that allows a 70mA modulation current into the laser is:

$$R_{dmax} = (V_{CC} - 0.6V - 1.6V) / 0.07A$$

The worst case will be with  $V_{CC} = 3.0V$ , leading to  $R_{dmax} = 11.4\Omega$

On the other hand, the smaller is the value of  $R_d$ , the higher is the overshoot/undershoot on the optical signal from the laser. In the circuit shown in Figure 3, the RC compensation network across the driver

outputs (MOD+ and MOD-) allows the user  $R_d = 10\Omega$ . The optical eye diagrams at data rates of 155Mbps/622Mbps/1.25Gbps/2.5Gbps, shown in "Functional Characteristics" section, are all obtained with the same circuit using  $R_d = 10\Omega$ ,  $R_{Comp} = 100\Omega$ , and  $C_{Comp} = 3pF$ . The compensation network may change from one board to another and from one type of laser to another. An additional compensation network (RC) can be added at the laser cathode for further compensation and eye smoothing.

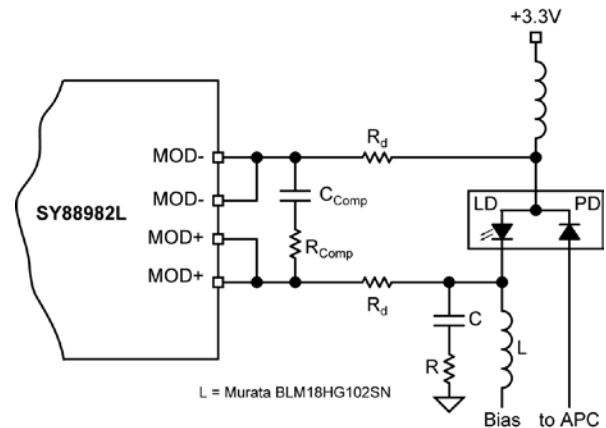


Figure 3. Laser DC-Coupled

### AC-Coupling

When trying to AC couple the laser to the driver, the headroom of the driver is no longer a problem since it is DC isolated from the laser with the coupling capacitor. At the output, the headroom of the driver is determined by the pull-up network. In Figure 4, the modulation current out of the driver is split between the pull-up network and the laser. If, for example, the total pull-up resistor is twice the sum of the damping resistor and laser equivalent series resistance, only two thirds (2/3) of the modulation current will be used by the laser. So, to keep most of the modulation current going through the laser, the total pull-up resistor must be kept as high as possible. One solution consists in using an inductor alone as pull-up, presenting a high impedance path for the modulation current and zero ohm ( $\Omega$ ) path for the DC current offering a headroom of the driver equal to  $V_{CC}$  and almost all the modulation current goes into the laser. The inductor alone will cause signal distortion, and, to improve that, a combination of resistors and inductors can be used (as shown on Figure 4). In this case, the headroom of the driver is  $V_{CC} - R_1 \times \alpha I_{MOD}$ , where  $\alpha I_{MOD}$  is the portion of the modulation current that goes through the pull-up network.

When the laser is AC-coupled to the driver, the coupling capacitor creates a low-frequency cutoff in the circuit, and its value must be chosen as large as



possible. If the value of the cap is too high, it will slow down the fast signals edges, and, if its value is too small, it won't be able to hold a constant change between the first bit and the last bit of a long string of identical bits in a low data rate application. This leads to higher pattern-dependent jitter in the transmitter signal. 0.1 $\mu$ F is found to be good for all applications from 155Mbps to 2.7Gbps.

AC-coupling the laser to the driver brings a solution to the driver headroom problem at the expense of extra components, loss of part of the modulation current wasted in the pull-up network, and additional power consumption.

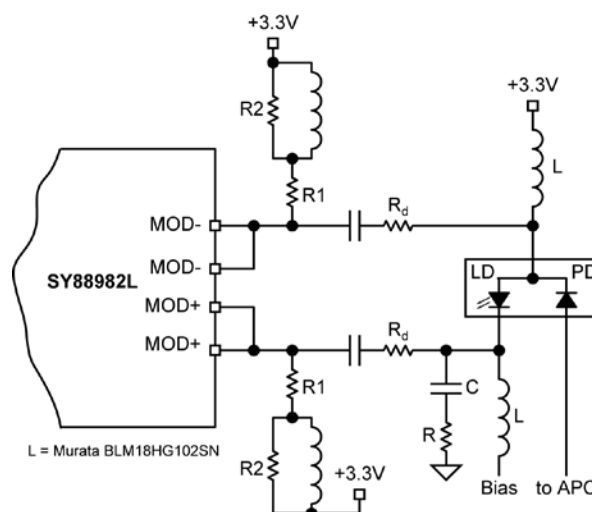
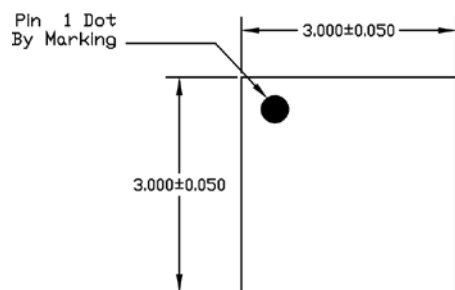
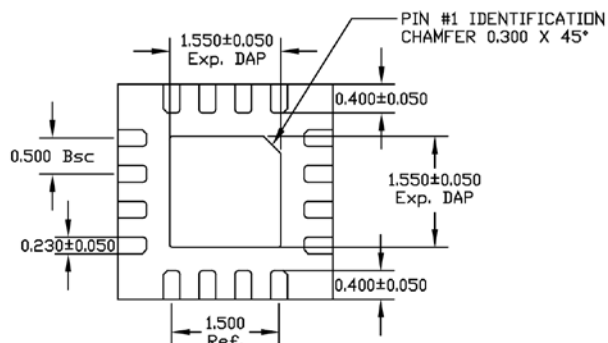


Figure 4. Laser AC-Coupled

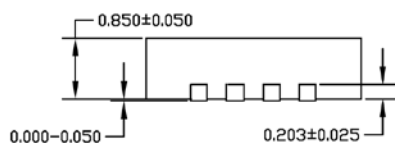
## Package Information



TOP VIEW



BOTTOM VIEW



SIDE VIEW

NOTE:

- NOTE:
1. ALL DIMENSIONS ARE IN MILLIMETERS.
  2. MAX. PACKAGE WARPAGE IS 0.05 mm.
  3. MAXIMUM ALLOWABLE BURRS IS 0.076 mm IN ALL DIRECTIONS.
  4. PIN #1 ID ON TOP WILL BE LASER/INK MARKED.

### 16-Pin (3mm x 3mm) QFN

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