

## 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 MIC3000/1 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 MIC3000/1
- Small form factor 16-Pin (3mm x 3mm) MLF™ package
- Laser may be DC- or AC-coupled

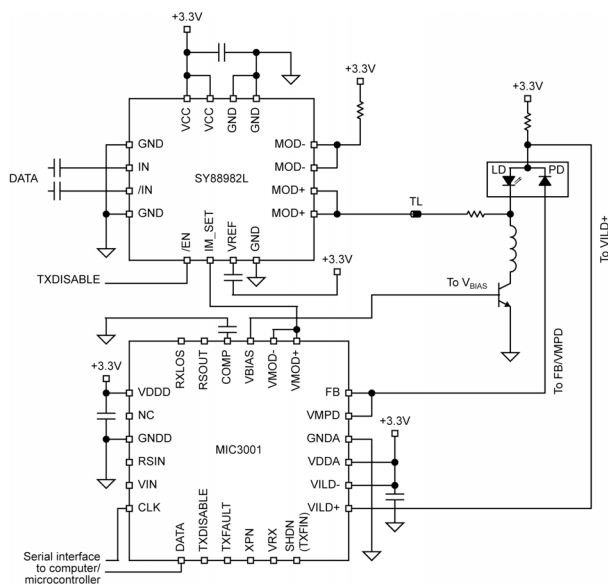
## Applications

- 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

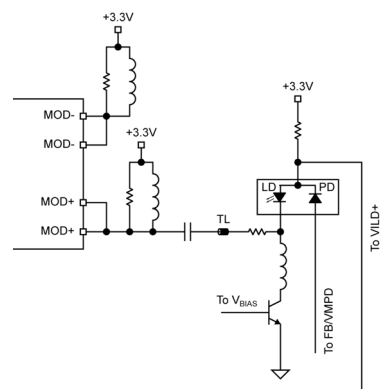
## Markets

- Telecom, Datacom

## Typical Application

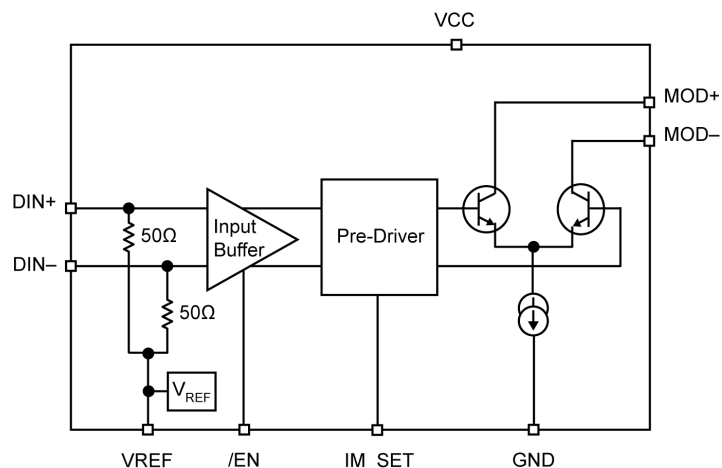


## Laser DC-Coupled to the Driver



### Laser AC-Coupled to the Driver

## Functional Block Diagram



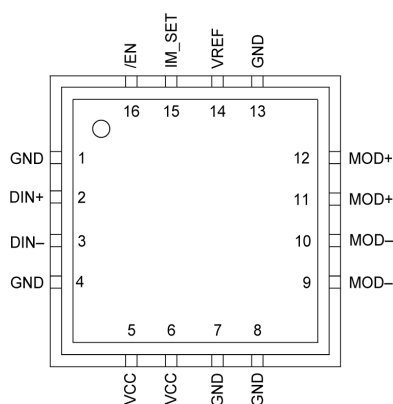
## Ordering Information<sup>(1)</sup>

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

### Notes:

1. Contact factory for die availability. Dice are guaranteed at  $T_A = +25^\circ\text{C}$ , DC Electricals only.
2. Tape and Reel.

## Pin Configuration



16-Pin MLF™ (MLF-16)

## Pin Description

| Pin Name       | Pin Number | 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 data input. Internally terminated with 50Ω to a reference voltage.                                                                                                |
| 3              | DIN-       | Inverting data input. 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. Outputs modulation current when input data is negative.                                                                                     |
| 11, 12         | MOD+       | Non-inverted modulation current output. Outputs 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 MIC3000/1 pin 24 (VMOD+). Input impedance 25KΩ. |
| 16             | /EN        | A low level signal on this pin will enable the output stage of the driver. Internally pulled down with 75KΩ.                                                                    |

## 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                   | L    | 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>  
 MLF™  
 ( $\theta_{JA}$ ) Still-air ..... 60°C/W  
 ( $\psi_{JB}$ ) ..... 33°C/W

## DC Electrical Characteristics

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

| Symbol                 | Parameter                                                                     | Condition                    | Min | Typ | Max               | Units            |
|------------------------|-------------------------------------------------------------------------------|------------------------------|-----|-----|-------------------|------------------|
| $I_{CC}$               | Power Supply Current                                                          | Modulation currents 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                |
| $R_{IN}(I_{MOD\_SET})$ | $I_{MOD\_SET}$ Input Resistance                                               |                              |     | 25  |                   | k $\Omega$       |
| $V_{IM\_SET}$          | Voltage Range on $I_{MOD\_SET}$ Pin                                           | $I_{MOD}$ range 10mA to 90mA |     |     | 1.2               | V                |

## AC Electrical Characteristics

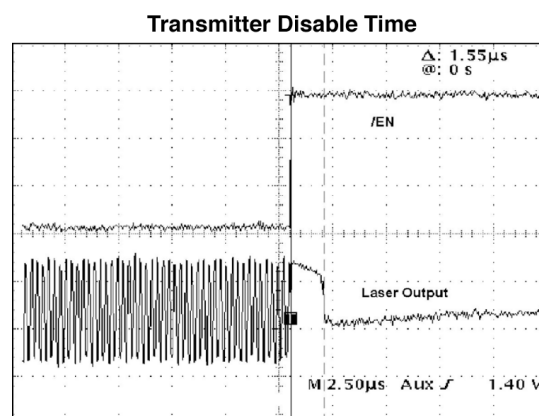
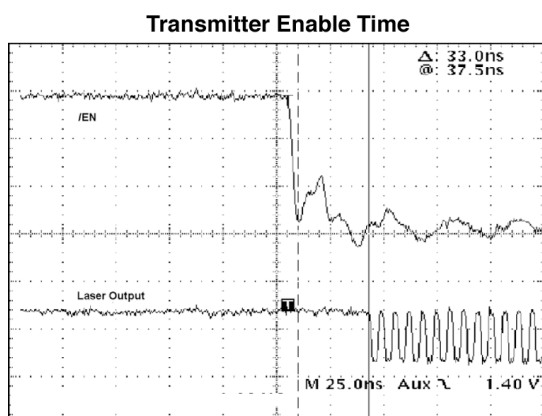
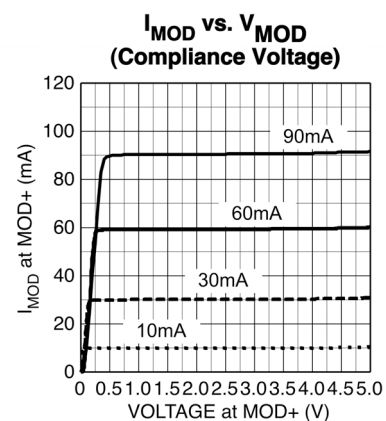
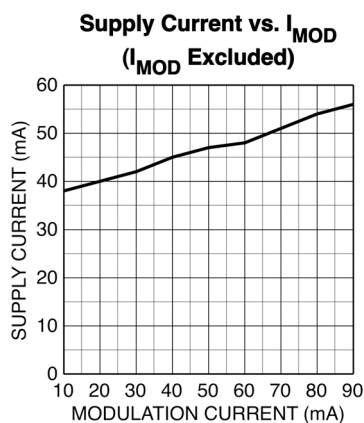
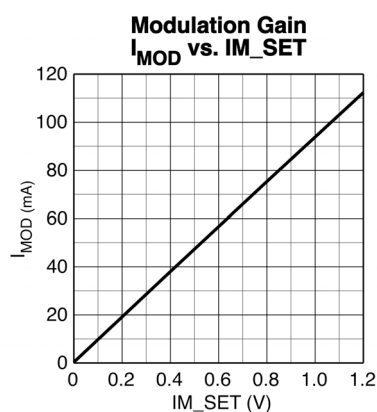
$T_A = -40^\circ\text{C}$  to  $+85^\circ\text{C}$  and  $V_{CC} = +3.0V$  to  $+3.6V$ , unless otherwise noted. Typical values are  $V_{CC} = +3.3V$ ,  $T_A = 25^\circ\text{C}$ ,  $I_{MOD} = 60\text{mA}$ .

| 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               | $\mu\text{A}$    |
| $t_r$          | Output Current Rise Time          | 20% to 80%, $I_{MOD} = 60\text{mA}$ , 15 $\Omega$ load |       | 55  | 80                | ps               |
| $t_f$          | Output Current Fall Time          | 20% to 80%, $I_{MOD} = 60\text{mA}$ , 15 $\Omega$ load |       | 55  | 80                | ps               |
|                | Total Jitter                      | @2.5Gbps data rate                                     |       |     | 20                | ps <sub>pp</sub> |
|                | Pulse-Width Distortion            |                                                        |       |     | 20                | ps               |

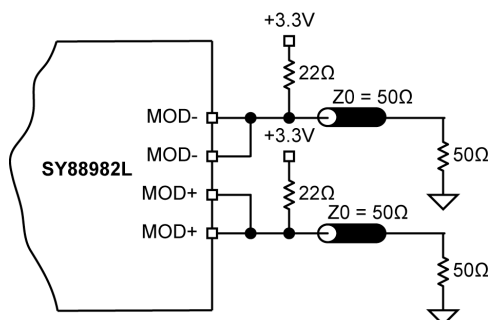
### Notes:

- 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  $q_{JA}$  in still air unless otherwise stated.
- $I_{CC} = 65\text{mA}$  for worst-case conditions with  $I_{MOD} = 90\text{mA}$ ,  $T_A = +85^\circ\text{C}$ ,  $V_{CC} = 3.6V$ .
- 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

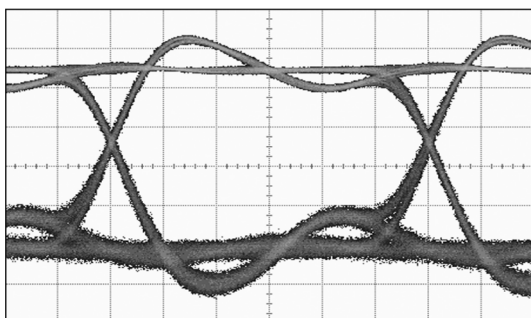


## Test Circuit



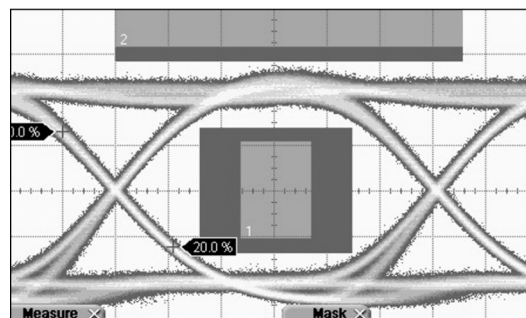
## Functional Characteristics

**Electrical Eye Diagram**  
2.5Gbps, PRBS  $2^{23}-1$ , 15Ω Load, 60mA Modulation



TIME (66ps/div.)

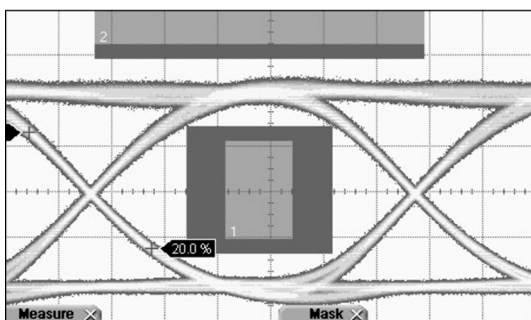
**Optical Eye Diagram**  
2.7Gbps, PRBS  $2^{23}-1$ , Laser AC-Coupled



TIME (66ps/div.)

ER = 10dB, 30% Mask Margin

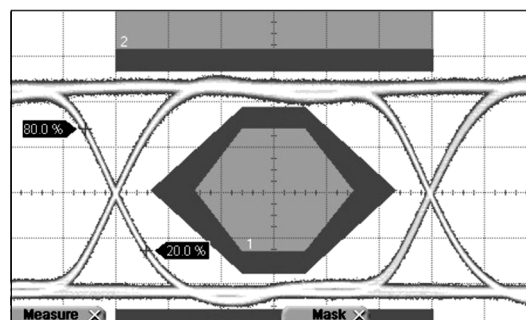
**Optical Eye Diagram**  
2.5Gbps, PRBS  $2^{23}-1$ , Laser DC-Coupled



TIME (65ps/div.)

ER = 11dB, 30% Mask Margin

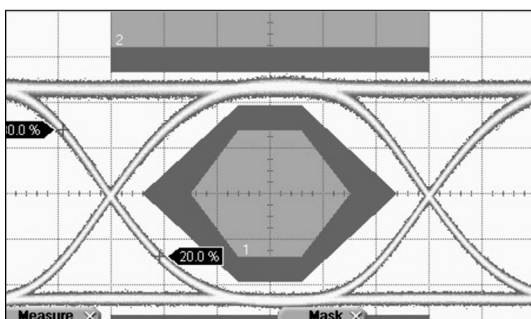
**Optical Eye Diagram with OC-48 Filter**  
1.25Gbps, PRBS  $2^{23}-1$ , Laser DC-Coupled



TIME (133ps/div.)

ER = 11dB, 55% Mask Margin

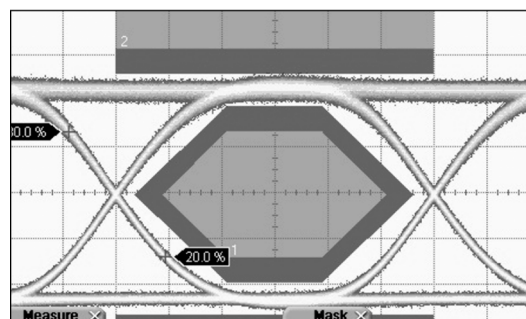
**Optical Eye Diagram**  
622Mbps, PRBS  $2^{23}-1$ , Laser DC-Coupled



TIME (267ps/div.)

ER = 11.3dB, 60% Mask Margin

**Optical Eye Diagram**  
155Mbps, PRBS  $2^{23}-1$ , Laser DC-Coupled



TIME (1075ps/div.)

ER = 11.3dB, 60% Mask Margin

## Input and Output Stages

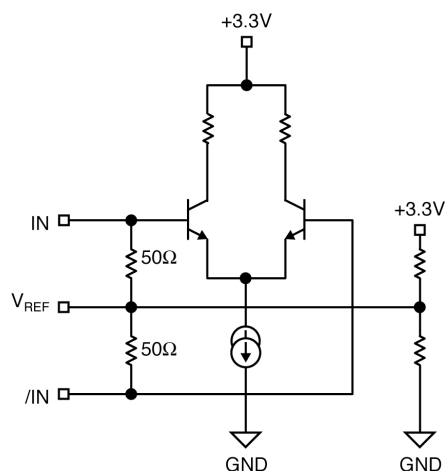


Figure 1a. Simplified Input Stage

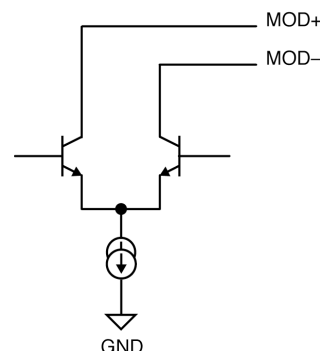


Figure 1b. Simplified Output Stage

## Interfacing the Input to Different Logic Drivers

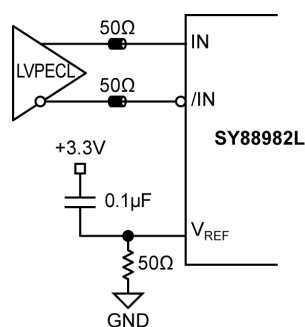


Figure 2a. DC-Coupling to LVPECL Driver

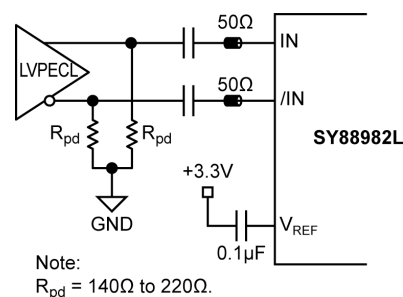


Figure 2b. AC-Coupling to LVPECL Driver

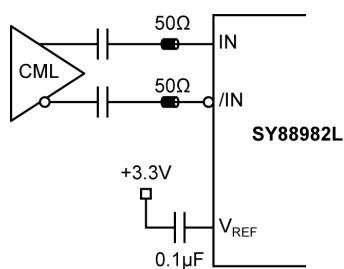


Figure 2c. AC-Coupling to CML Driver

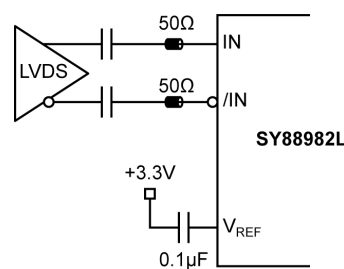


Figure 2d. AC-Coupling to LVDS Driver

## 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 cross talk 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 VCC to ground through the laser, damping resistor, and driver:

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

$$V_{Rd} = R_d * I_{mod}$$

$$V_{laser} = V_{band-gap} + R_{laser} * I_{mod} + L di/dt$$

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

$L di/dt$  is the voltage drop due to the laser parasitic inductance during  $I_{mod}$  transitions. Assuming  $L = 1nH$ ,  $t_r = t_f = 80ps$  (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 small 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.

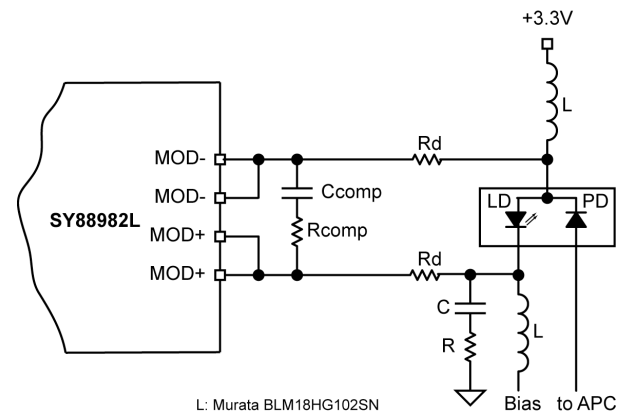


Figure 3. Laser DC-Coupled

### 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. The headroom of the driver is determined by the pull-up network at the output. 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 resistors 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 ( $0\Omega$ ) path for the DC current offering a headroom of the driver equal to VCC 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  $VCC - R1 \times \alpha I_{mod}$ , 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 charge 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-dependant 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.

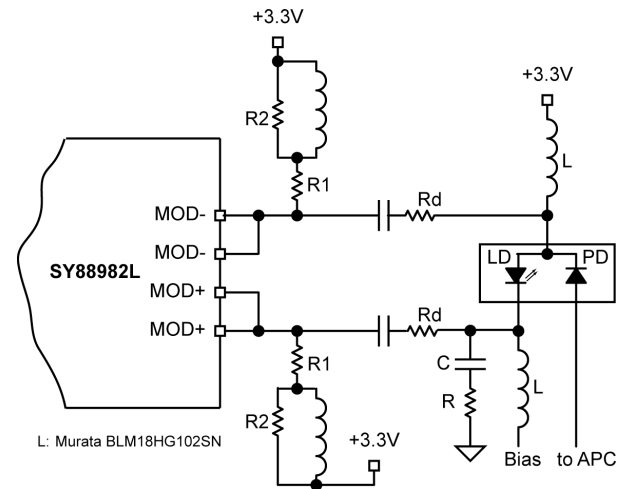
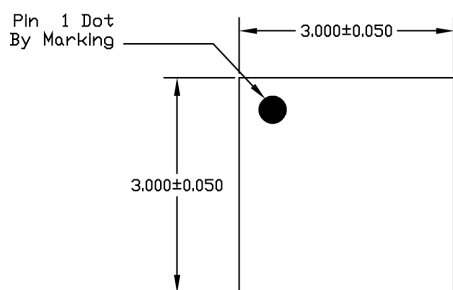
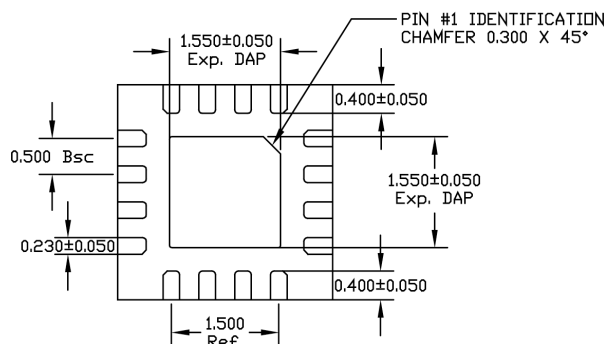


Figure 4. Laser AC-Coupled

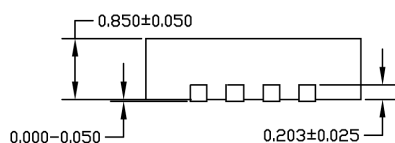
## Package Information



TOP VIEW



BOTTOM VIEW



SIDE VIEW

NOTE:

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) MLF™ (MLF-16)

**MICREL, INC. 2180 FORTUNE DRIVE SAN JOSE, CA 95131 USA**  
 TEL +1 (408) 944-0800 FAX +1 (408) 474-1000 WEB <http://www.micrel.com>

The information furnished by Micrel in this data sheet is believed to be accurate and reliable. However, no responsibility is assumed by Micrel for its use. Micrel reserves the right to change circuitry and specifications at any time without notification to the customer.

Micrel Products are not designed or authorized for use as components in life support appliances, devices or systems where malfunction of a product can reasonably be expected to result in personal injury. Life support devices or systems are devices or systems that (a) are intended for surgical implant into the body or (b) support or sustain life, and whose failure to perform can be reasonably expected to result in a significant injury to the user. A Purchaser's use or sale of Micrel Products for use in life support appliances, devices or systems is a Purchaser's own risk and Purchaser agrees to fully indemnify Micrel for any damages resulting from such use or sale.

© 2005 Micrel, Incorporated.