

### INTRODUCTION

A review of the different electrical interfaces between Digitally Controlled Pots/Resistors and Laser Drivers is presented in the context of open loop and closed loop operation. The end objective of such fiber optic systems is to have a means of varying the amplitude of the light that is digitally modulated between 2 levels of optical power  $P_0$  and  $P_1$ . Those levels are achieved by means of two circuits in the driver: the bias and modulation circuits.

### OPEN-LOOP TOPOLOGIES

For the bias control topology shown in Figure 1(a), the variable resistor sets a current  $I_1$ , which is amplified and sourced into a common cathode (or sunk from a common anode) laser diode. The most common voltage across the resistor is 1.2V, derived from a Band Gap internal to the Laser Driver IC.  $I_1$  ranges in the microamps up to a few milliamps;  $I_2$  ranges in the tens of milliamps to a hundred. In some applications the resistor is used to source current and is no longer tied to ground but to a fixed reference or to the supply.

Figure 1(b) shows a low-side control (to ground) where the input voltage  $V_1$  sets an internal current  $I_1$ , which then is amplified into  $I_2$  to drive the laser diode by sourcing (or sinking) current. A potentiometer is used here whereas a resistor was used in the (a) configuration. The high input impedance seen by  $V_1$  makes a potentiometer ideal.

Figure 1(c) shows a high side control where the control voltage is  $V_1$ . The lower  $V_1$  goes, the higher  $I_1$  and  $I_2$  go to drive the laser diode.

To cause an increase in average optical power out of the laser, the resistance has to decrease in Figure 1(a),  $V_1$  has to increase in Figure 1(b), and  $V_1$  has to decrease in Figure 1(c).

Figure 1(a)

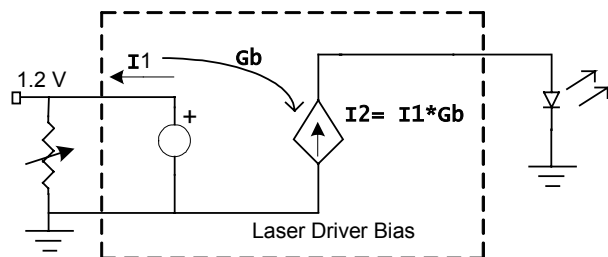


Figure 1(b)

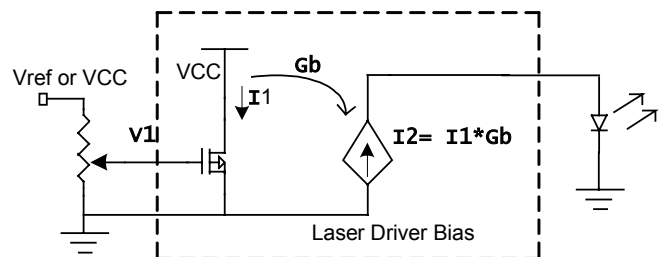
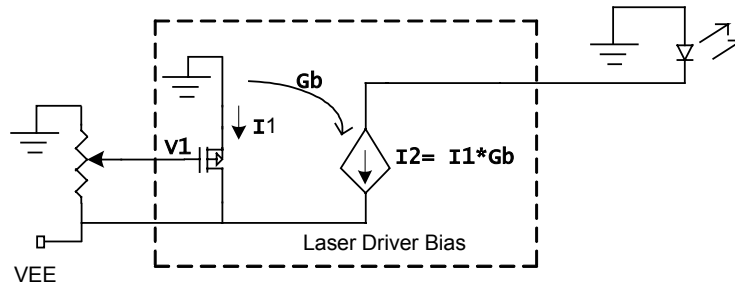


Figure 1(c)



Similar configurations are shown in Figure 2 for the modulation part of the circuit. The setting is generated for the modulation level in the same manner as it is for the bias circuit and serves to modulate the amplitude of the data carrier, resulting in a switched current. In Figure 2(a) as the resistance decreases the peak to peak amplitude of the emitted light increases. In Figure 2(b) this occurs as V3 increases. Also shown here is the injection of both the bias and modulation current into the laser.

Figure 2(a)

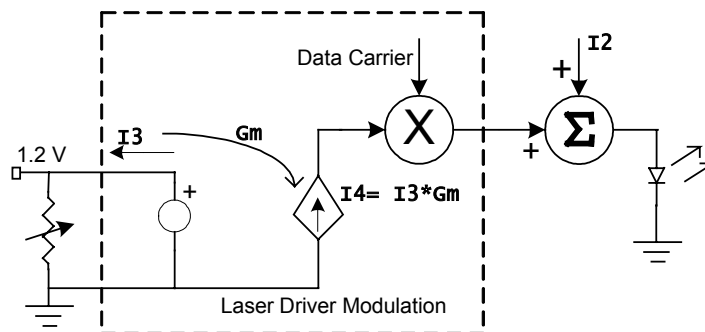
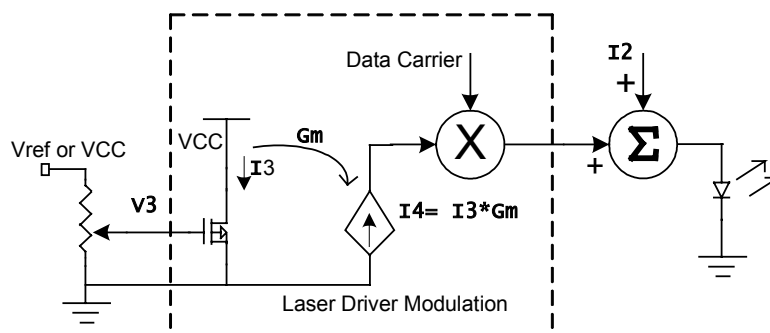


Figure 2(b)



Note that in Figures 1(b) and 2(b) the input of the Laser Driver IC can be a bipolar npn.

## CLOSED LOOP TOPOLOGIES

APC (Average Power Control) circuits have been commonly used to regulate the optical average with closed loop control of the light emitted from the laser into a photodiode monitor placed in the feedback. Less common are the closed loop modulation control circuits. Figures 3(a) and 3(b) show a resistor interface to such laser drivers.

In Figure 3(a) the laser bias current is an amplified version of the error between the current fed back from the photodiode monitor ( $I_{fa}$ ) and a reference current ( $I_1$ ). As the resistance decreases,  $I_1$  increases. Since  $I_{fa}$  tracks  $I_1$ , the average optical power increases.

Figure 3(b) is a simplistic representation of a closed-loop modulation application. A feedback signal ( $I_{fb}$ ) extracted from the photodiode current is compared to a reference current  $I_3$ . The error is amplified and then modulates the data carrier's amplitude, resulting in a switched current. As the resistance decreases, the peak-to-peak optical power increases. In Figure 3(b) the bias current  $I_2$  is added in to complete the picture.

Figure 3(a)

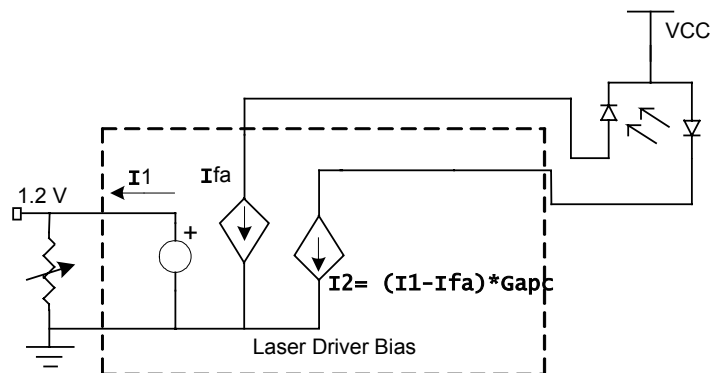
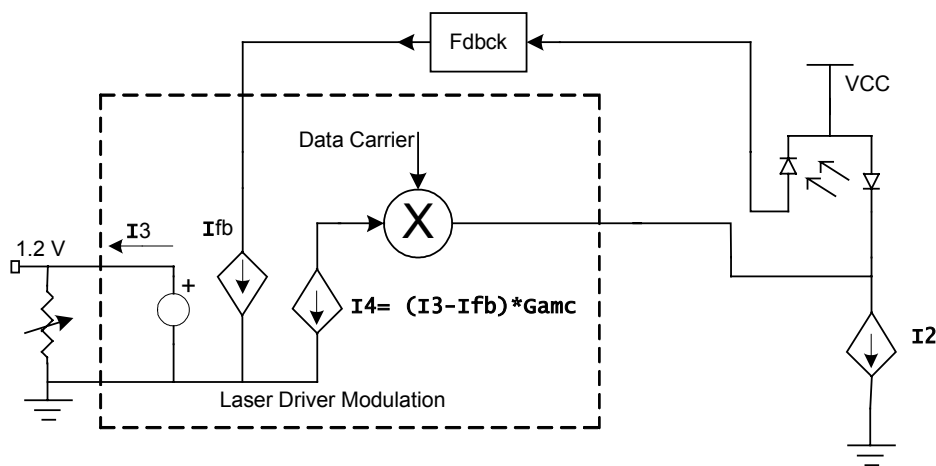


Figure 3(b)



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**EXAMPLE: THE MAX3273 / DS1847 SET**

In interfacing Laser Driver MAX3273 to the Digitally Controlled Resistor DS1847, first determine what your Average Optical Power ( $P_{avg}$ ) and peak-to-peak Optical Modulation Power ( $P_{mod}$ ) are.

$P_{avg}$  is regulated by an APC loop around the Laser Driver (refer to Figure 3(a)) and is directly dependent on current  $I_1$  as well as the Responsivity (mA/mW) of the photodiode. The DS1847 resistor sets  $I_1$  as equal to  $1.2 / R$ . Next,  $P_{avg} = I_1 / \text{Responsivity} = 1.2 / (\text{Responsivity} * R)$ . Noteworthy is the dependence of  $R$  on the photodiode characteristic in order to achieve the required average power. Therefore, it is recommended that the designer know the statistical distribution as well as the temperature dependence of this parameter in order to achieve reasonable design yields. For instance, using a DFB laser SLT2170-LN @  $P_{avg} = .4\text{mW}$  the photodiode current ranges upward from .15mA, which calls for a resistance that is less than 8K: resistor 1 in the DS1847 should be used for the APC function.

$P_{mod}$  is not regulated within the MAX3273 Laser Driver and essentially runs open loop. It is controlled by a resistor (refer to Figure 2(a)) that sets  $I_3$ .  $I_3$  in turn sets the peak-to-peak modulation current, which is added to the bias current and injected into the laser. Consequently, the laser light output consists of a DC + Pulsed component. The pulsed component ( $P_{mod}$ ) depends on the laser quantum efficiency ( $\eta$ ) which is expressed in mW / mA, the gain  $G_m$  (figure 2 (a)) , and  $I_3 (=1.2 / R_{mod})$ . Essentially,  $P_{mod} = 1.2 * G_m * \eta / R_{mod}$ . Again, noteworthy is the dependence Of  $R_{mod}$  on  $\eta$  for a given  $P_{mod}$ . An understanding of the variation of  $\eta$  is recommended. For instance, using the same laser SLT2170-LN with  $P_{mod} = 0.3 \text{ mW}$ ,  $G_m = 165$ ,  $\eta = 0.06$  the required resistance will be less than 40K. Resistor 0 in the DS1847 should be used for the modulation function.

The DS1847 features look-up tables for temperature compensation (see Application Note *AN167: Considerations for the DS1847/1848 Look-Up Tables*). Such temperature compensation is imperative for both APC and modulation controls. In APC mode the table primarily serves to offset the temperature dependence of photodiode responsivity, which can vary by up to  $\pm 1.5\text{dBm}$  (about 40%), as per the SLT2170-LN data sheet. As for the modulation, the corresponding table primarily serves to offset the temperature dependence of the laser efficiency  $\eta$ , which can vary by up to  $\pm 3\text{dBm}$  (a factor of 2). An added benefit of the look-up tables is that they help compensate for the temperature dependence of other parameters in the application. These can include laser driver gain and resistor value. DS1847 Resistor value is characterized at Dallas's factory at various temperatures. The result is fit into an equation and the coefficients are stored in registers for use during calibration at the customer's site (see Application Note *AN167: Considerations for the DS1847/1848 Look-Up Tables*).