Using the ispPAC30 in a DWDM Laser Power Control Loop

October 2001 Application Note AN6028

Overview

Semiconductor laser diodes have revolutionized the communications marketplace by providing a significant increase in transmission bandwidth. Laser diodes are used in both long haul and local area communication systems. For long-haul communications systems, a technique known as Dense Wave Division Multiplexing (DWDM) can provide bandwidths up to terabits/second over a single optical fiber. To implement a DWDM system, original equipment manufacturers (OEMs) can purchase completely integrated laser modules where the supplier provides all interface and support electronics inside the laser module. Alternatively, discrete laser diodes modules are also available, providing the laser and various support transducer components (Electro-optical modulator, thermoelectric cooler, optical and thermal sensors) without any support electronics.

The ispPAC®30 is a general-purpose analog signal conditioning component that can be used to provide many of the support and control functions needed to operate a DWDM laser. Examples of such functions include laser bias and power control, as well as current and optical power monitoring.

Application Description

In normal operation, semiconductor laser diodes used in DWDM optical communication must provide optical output at a constant wavelength (λ) and a controlled (often constant) power output level. To achieve these goals usually requires the use of three distinct control loops.

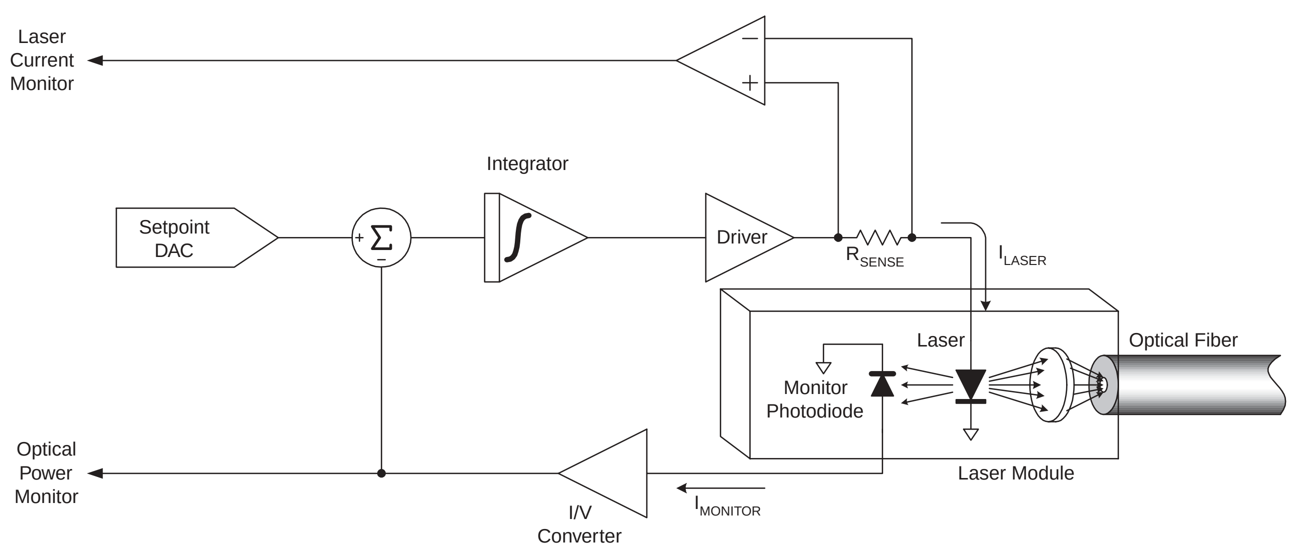
1. Optical Power Control
2. Temperature Control
3. Wavelength Control

This application note will focus on how the ispPAC30 can be used to implement an optical power feedback control system for a DWDM laser.

The Optical Control Loop

Although there are many ways in which an optical power control loop can be implemented, the block diagram of Figure 1 shows the essential functions and features.

Figure 1. Optical Power Control Loop



Other than the laser module itself, the key electronic components of the optical power control loop are:

- Setpoint DAC
- Laser Driver
- I/V Converter
- Summer
- Integrator
- Laser Diode Current Monitor

The **Setpoint DAC** determines the desired level of optical power output. A digital value written into this device produces analog output voltage which is used as the setpoint for the control loop. In the ispPAC30, the setpoint DAC can be either read from E^2 memory at power-up or written to on-the-fly through the SPI port.

The **Laser Driver** takes a voltage signal as an input, and uses it to provide a proportional and large current output (100-500mA) to drive the semiconductor laser. Current limiting functions are also needed in the driver circuit to prevent damage to the laser from turn-on transients.

The **I/V Converter** takes the output current from the monitor photodiode and provides a voltage signal which is then subtracted from the setpoint value by the summer. The resulting error signal is then fed into an integrator.

The **Integrator** both amplifies and filters the error signal to provide stable control of the laser driver. Using an integrator for this function results in a near-zero error signal and highly accurate control.

Additionally, some systems may need to monitor the current being drawn by the laser for diagnostic purposes. For this reason a laser diode current monitor is also frequently implemented.

Laser Driver Considerations

To get a semiconductor laser to emit coherent optical radiation, a minimum threshold current needs to be passed through the device. Beyond this threshold current, optical output power increases monotonically with bias current up to some maximum point. From an electrical standpoint, a laser appears as a diode, with an exponential I-V characteristic curve. Because small changes in bias voltage can result in large changes in bias current, accurately controlling optical output power requires that the device be driven with a current source, as opposed to with a voltage source. Because the loop controller will often provide its output in the form of a voltage, the laser driver circuit must be a V-I converter or transconductance amplifier. For contemporary DWDM semiconductor lasers, appropriate operating bias currents range from about 100mA to 500mA, dependent on the particular laser and its optical output ratings.

In addition to providing normal operating current, the laser drive circuit must also limit its maximum output current to a level within the laser's ratings. This is necessary because transients occurring at turn-on could otherwise damage the laser. Because laser diodes can be damaged by very short overloads, it may be unwise to depend on the optical power control loop to limit drive current. Highly responsive current limiting functions can be readily designed into the final driver circuit.

An additional requirement of the laser driver is that of providing a sufficient output voltage compliance range to drive current through the laser. Maximum forward operating voltages for semiconductor lasers tend to range from 1.7V to 2.7V. If a 5V supply is used for laser bias, this leaves between 2.3 and 3.3V that can be dropped across the bias circuit.

Noise immunity is also a factor in the design of appropriate drive circuits. If power supply variations or noise couple into the laser drive current, they will have a proportional effect on the laser's optical power output. Well-regulated power supplies and adequate supply bypassing around the laser control circuits are good starting points for increasing noise immunity. Additionally, the laser driver circuit can be designed in such a way as to minimize the dependence of its output current on the power supply voltage. Because negative feedback is employed to maintain constant output power, the loop controller has some ability to compensate for slow changes in supply voltage. Both the finite gain and response time of the control loop, however, will limit its ability to compensate for transients and other rapid voltage transitions. In addition to depending on supply bypassing and feedback for noise immunity, it is also possible to design driver circuits which provide an output current which is minimally affected by supply voltage.

The terminal connection scheme used in a laser module can also have a major effect on the design of an appropriate driver circuit. The cases of laser modules are normally grounded, and in many cases one of the terminals of the laser diode will be bonded to this ground. The three common connection arrangements are:

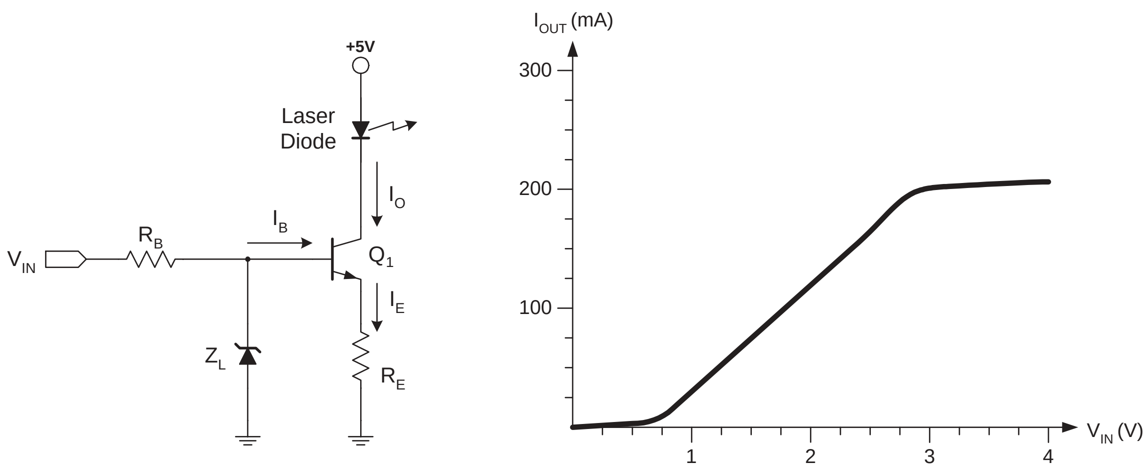
1. Anode and Cathode Floating
2. Grounded Cathode
3. Grounded Anode

Of these connection schemes, 'Anode and Cathode Floating' provides the designer with the most flexibility in implementing a driver circuit. Both the grounded cathode and grounded anode schemes impose constraints which can require somewhat more complex drivers to obtain satisfactory performance. The following section will describe some potentially useful driver circuits, and how they address the requirements presented above.

Laser Driver Circuits

Figure 2a shows a circuit that can be used as a driver for laser diodes which have both terminals floating. A detailed analysis of this circuit's behavior will be used to illustrate many of the design considerations presented in the previous section.

Figure 2. Laser Driver Circuit (a) and DC Transfer Curve (b)



(a) **(b)**

This circuit draws a current into the collector of Q_1 which is proportional to the voltage presented at input V_{IN}. Because the collector current of a bipolar junction transistor (BJT) in its active linear operating region is largely independent of the voltage present at the collector, this circuit provides a good approximation to an ideal current source. Figure 2b shows the I-V response function for this circuit. I_O remains near zero until the value of V_{IN} rises to about 0.6V, at which point the current source turns on. The value of the output current as a function of input voltage (V_{IN} > 0.6V) can be approximated by

$$I_O \approx \frac{V_{IN} - 0.6V}{R_E} \tag{1}$$

As input voltage is increased, Zener diode Z_L will eventually begin to conduct, and will clamp the base voltage of Q_1 at its knee voltage V_{ZK}. This will result in a maximum output current of approximately

$$I_{Omax} \approx \frac{V_{ZK} - 0.6V}{R_E} \tag{2}$$

Although this circuit is conceptually simple, the types and values of each of the components must be carefully selected to ensure proper operation.

The first consideration in the design of a driver circuit is the selection of an appropriate transistor. The primary criteria for selecting a transistor are its current gain (H_{FE}), its maximum continuous collector current (I_{Cmax}), and its maximum power dissipation (P_D). The current gain needs to be high enough to amplify the base current available from the controller to levels high enough to drive the laser. As an example, assume a laser requires 250mA of operating current. If 10mA is available from the controller to drive the base of the transistor, a transistor with an H_{FE} of 25 (250mA/10mA) will be marginally adequate. In this application, selecting transistors with higher H_{FE}'s will tend to provide more consistent performance and make the design more manufacturable.

While it almost goes without saying that the transistor's maximum allowable collector current (I_{Cmax}) needs to exceed the laser's operating current, this parameter will almost always need to be chosen significantly higher. This is because for most transistors H_{FE} will significantly decrease as the collector current approaches the device's rated maximum. To ensure a sufficiently high H_{FE} at the anticipated operating current levels, it may be desirable to specify a transistor with a I_{Cmax} rating considerably higher than what might appear necessary.

Choosing a transistor with a suitable maximum power dissipation is also important; running a device beyond its maximum power ratings can seriously reduce its reliability. The power dissipation of the transistor will be determined by the product of the voltage drop from the collector to emitter terminals and the collector current (V_{CE} x I_C). In this circuit, maximum power dissipation will be reached when V_{CE} is equal to the voltage drop across R_E. The maximum power dissipation (P_D) can be calculated:

$$P_D = \frac{(V^+ - V_D)^2}{4R_E} \qquad (3)$$

where V^+ is the power supply voltage, and V_D is the forward voltage drop of the laser diode. When specifying the power ratings for a given transistor, one should also consider where the dissipated power is ultimately going; i.e. how the transistor will be heat-sinked. In reality, the maximum allowable power dissipation for a given transistor is as much a function of the associated thermal management system as it is the device itself.

Once a suitable transistor has been selected, the resistors and other components can be specified. The value of R_E determines the I/V gain of this circuit, and needs to be set so that sufficient current is available to drive the laser. Additionally, the value of this component should be chosen in conjunction with Z_L's Zener voltage (V_{ZK}) to set the maximum output current (approximated by Equation 2). Z_L clamps the maximum voltage that can appear at the base of Q1, thus limiting the emitter voltage (V_E), and consequently the output current. As an example, if a 200 mA maximum output current is desired, a Zener diode with a V_{ZK} of 2.7V would limit V_E to ≈2.0V. If a 10Ω resistor was used for R_E, this will provide a maximum output current of approximately 200mA (V_E / R_E). Keep in mind, however, that variations in Z_L's knee voltage (V_{ZK}) and Q_1's base-emitter voltage (V_{BE}) resulting from both manufacturing tolerances and operating temperature drift will cause this limit to have a some variation, both from unit-to-unit and over ambient temperature.

In addition to choosing the combination of Z_L and R_E to limit maximum output current, R_E must be chosen so that there is enough voltage compliance range to operate the laser. In the case above, where R_E is 10Ω, a 150mA output current will raise V_E to 1.5V. Linear-mode operation of Q_1 requires that there be some voltage across the collector and emitter (V_{CE}); depending on the transistor and operating conditions this can range from a fraction of a volt to several volts. At moderate current levels, many transistors can achieve linear operation with V_{CE}'s of ≈1V. If this circuit operates from a +5V supply, there will be a 1.5V drop across R_E and a V_{CE} of 1V, leaving 2.5V to drive the laser. If the voltage available for the laser is insufficient, one can either raise the laser's power supply voltage, decrease the value of R_E, or find a transistor that permits linear operation at a lower V_{CE}.

A final consideration in the selection of R_E is its power rating. Maximum power will be dissipated in R_E when Z_L is turned on and the driver is clamped at maximum output current. The worst-case power dissipation (P) can be estimated by

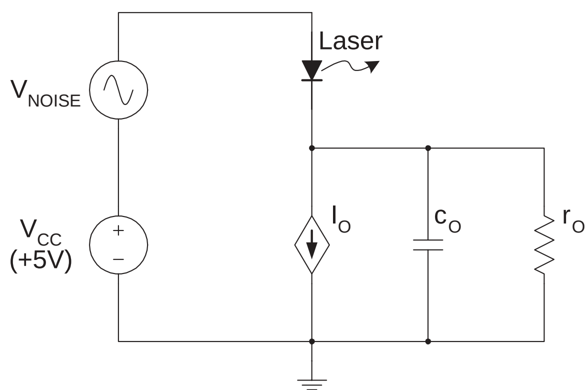
$$P = \frac{(V_{ZK} - 0.6V)^2}{R_E} \qquad (4)$$

In the above example, where V_{ZK} = 2.7V and R_E = 10Ω, R_E's maximum power dissipation is roughly 0.44W.

R_B is included in this circuit for two reasons. The first is to limit the amount of current which can flow through Z_L from the circuit controlling the output driver. The second reason is that a small amount of resistance inserted into the base lead of a BJT is often useful to help keep it from oscillating. R_B needs to be selected so that it is small enough to allow sufficient base current to drive Q_1, but at the same time is large enough to limit current through Z_L to acceptable levels. In this example, setting R_B to a value of 200Ω allows for up to about 10mA of base current to flow from the controller.

The analysis to this point has focussed on the circuit's DC, or steady-state, performance. Susceptibility to power-supply noise is also important, as any variations in laser drive current (as a result of power supply variation) will appear as variations in optical power output. The sensitivity of the driver circuit's output current to supply variation (noise) can be analyzed by considering the simplified circuit of Figure 3.

Figure 3. Simplified Model for Analyzing Power-Supply Sensitivity



In this circuit, the collector of the transistor is modeled as the parallel connection of an ideal current source, an output resistance (r_o) and an output capacitance (c_o). The power supply 'noise' can be modeled as a voltage source (V_{NOISE}) in series with the DC supply voltage (V_{CC}).

Because the laser can be roughly considered to have a constant voltage drop across it, being a diode, any variations in its anode voltage will be passed through to its cathode. Changing the voltage at this point will cause the current flowing through r_o to change. For a bipolar transistor, r_o is inversely proportional to collector current, and can range from a few hundred ohms to hundreds of kilo-ohms, depending on the specific device and its operating conditions. The laser bias current's (I_L) sensitivity with respect to supply voltage from r_o will be

$$\frac{\delta I_L}{\delta V_{CC}} = \frac{1}{r_o} \tag{5}$$

Another factor contributing to power supply sensitivity is the output capacitance of the transistor (co), which can range from a few pF to a few hundred pF, again dependent on the specific device and its operating conditions. While this capacitance does not affect the performance at DC, it can affect the circuit's sensitivity to high-frequency power supply noise. The AC sensitivity of the laser current (i_L) as a function of frequency can be estimated by

$$\frac{i_L}{V_{NOISE}} = \frac{1}{2\pi fC} \tag{6}$$

To get some idea of the magnitude of this effect, an output capacitance of 100pF will contribute as much power supply noise sensitivity at 1MHz as a 1.6kΩ output resistance does at DC.

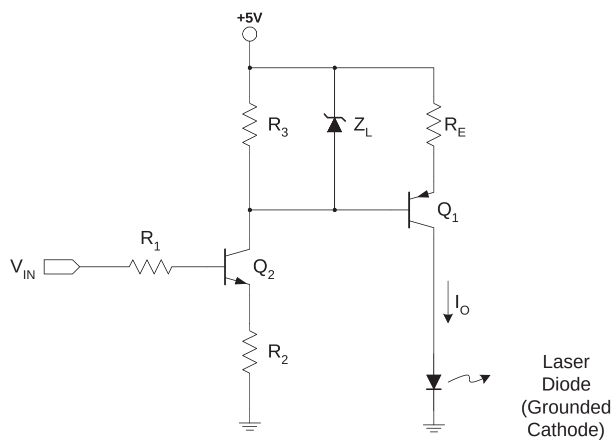
One important point to note is that because the driver circuit is part of a feedback loop whose objective is to maintain constant current, the effective output resistance of the driver will be amplified by the total control loop gain. Because the control loop gain drops with increasing frequency, the driver circuit's intrinsic immunity to power supply variation begins to become important at fairly low frequencies (a few kHz). This means that although the laser power control loop can maintain constant optical power output despite low-frequency power supply variation, immunity to higher frequency supply noise requires supply-insensitive drive circuits.

Drivers for Grounded Anode and Grounded Cathode Lasers

While many lasers have both anode and cathode terminals floating, it is also common to see one or the other of these terminals bonded to case ground. Although it is necessary to use different driver circuits to accommodate these alternate grounding schemes, the design considerations discussed above are still relevant.

Figure 4 shows a schematic for a circuit which can drive a laser with a grounded cathode. The operation of this circuit is as follows: Q_2 and R_2 form a voltage controlled current source which provides a collector current $I_{CQ2} \approx (V_{IN} - 0.6)/R_2$. This current is fed into the base of Q_1, where it is amplified to ultimately provide I_O.

Figure 4. Driver for Grounded Cathode Laser

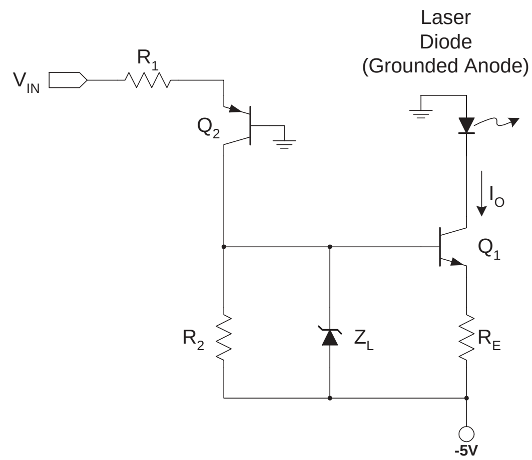


In this circuit, output current is clamped by the combination of Z_L and R_E, in a manner similar to that of the circuit in Figure 3. R_3 is present to set a maximum gain between the current output current of Q_2 and the output current of Q_1; in the absence of this resistor, the current gain will be controlled exclusively by Q_1's H_{FE}, which can vary significantly.

The reason for converting V_{IN} into a current, instead of just driving Q_1 directly (as done in the circuit of Figure 3), is to reduce the circuit's dependence on supply voltage. The collector of Q_2 draws appears as a constant current source to the rest of the circuit, with its output current only minimally influenced by the positive supply voltage. If V_{IN} were coupled into the base of Q_1 through a resistor, changes in the positive supply would significantly affect the value of I_O.

The other interconnection scenario is when the anode of the laser diode is bonded to case ground. This complicates the drive circuit even more because a negative voltage is now required to bias the laser. For a controller based around the ispPAC30, this requires level shifting to translate the 0-5V output signal of the ispPAC30 into a negative signal that can drive the laser. This can be accomplished by the circuit of Figure 5.

Figure 5. Driver for Grounded Anode Laser



Again, this circuit uses a limited current source, realized by Q_1, R_E, Z_L, and R_2. This sub-circuit is again controlled by a current output from the collector of Q_2. In this circuit, however, Q_2 is configured as a common-base amplifier. The current developed through R_1 in response to V_{IN} flows into Q_2's emitter, and out through the base and collector leads. The impedance which Q_2's collector presents to the rest of the circuit, however, is sufficiently high so that it will appear to be a near-ideal current source. As in the previous example, the value of this control current will be largely insensitive to variations in the negative supply rail.

Use of BJTs vs. MOSFETs in Driver Circuits

In many cases, the BJT-based circuits presented in the last section, can also be adapted for use with Darlington transistors or power MOSFETs. Table 1 lists some of the advantages and disadvantages of each technology.

Table 1. Comparison of Various Transistor Technologies

Technology	Advantages	Disadvantages
BJT	Low cost	Requires large base current
	Consistent performance with simple circuits	Requires large (>50) H_{FE} at operating conditions
Darlington	Requires small base current	Requires large V_{CE} (>1.2V) for linear operation
		Less consistent key parameters (V_{BE} variation)
MOSFET	Zero base drive current	Less consistent key parameters (V_T)
		Higher cost

Note that one issue which doesn't appear in this table is that of efficiency. Because MOSFETs can be turned on and off quickly and easily and have very low on-state resistance, they are commonly used to build highly efficient switched-mode power circuits. To drive a laser diode, however, requires that the power transistor, whether it is a BJT or MOSFET, be operated in linear mode, and the resulting power efficiencies will be similar. In this particular application, the choice of BJTs vs. MOSFETs will be driven by a combination of the specific requirements of a given design, the availability of suitable parts, and the preference of the circuit designer.

Monitoring Optical Power

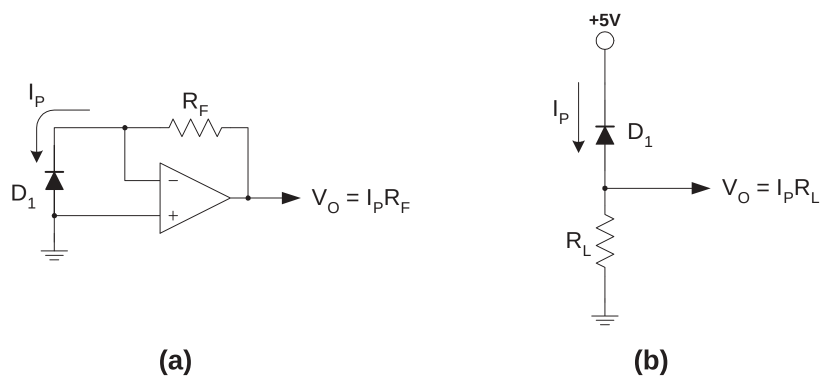
To maintain constant optical output power requires a means of monitoring the intensity of light emitted by the laser diode. Most contemporary laser diode modules incorporate one or more photodiodes to monitor both output power and wavelength. These diodes are typically placed near the rear facet of the laser so as not to require splitting the high-power output beam.

Photodiodes are normally operated with either a zero or reverse bias voltage, and convert light into an output current, which is proportional to the intensity of incident light. Both bias modes offer distinct advantages for different applications.

Operation with zero bias voltage minimizes leakage current, and is typically used for applications in which the photodiode must detect very low light levels. A common op-amp circuit for operating a photodiode in this mode is shown in Figure 6a. In this circuit, the op-amp's feedback maintains zero voltage across the photodiode. Current flowing through the photodiode (I_P) and out of the op-amp's summing junction is balanced by an equal current flowing into the summing junction through R_F. This results in an output voltage $V_O = I_P R_F$. With a suitable photodiode, this circuit can provide linear response over six or more decades of incident illumination.

It is also possible to use the circuit of Figure 6a to operate the photodiode in reverse-biased mode, by tying the photodiode's anode to a negative voltage source instead of ground. While reverse biasing the photodiode will increase its leakage current, it will also reduce its junction capacitance, and consequently reduces its response time.

Figure 6. Classic Photodiode Amplifier (a), Resistive Photocurrent Detector (b)

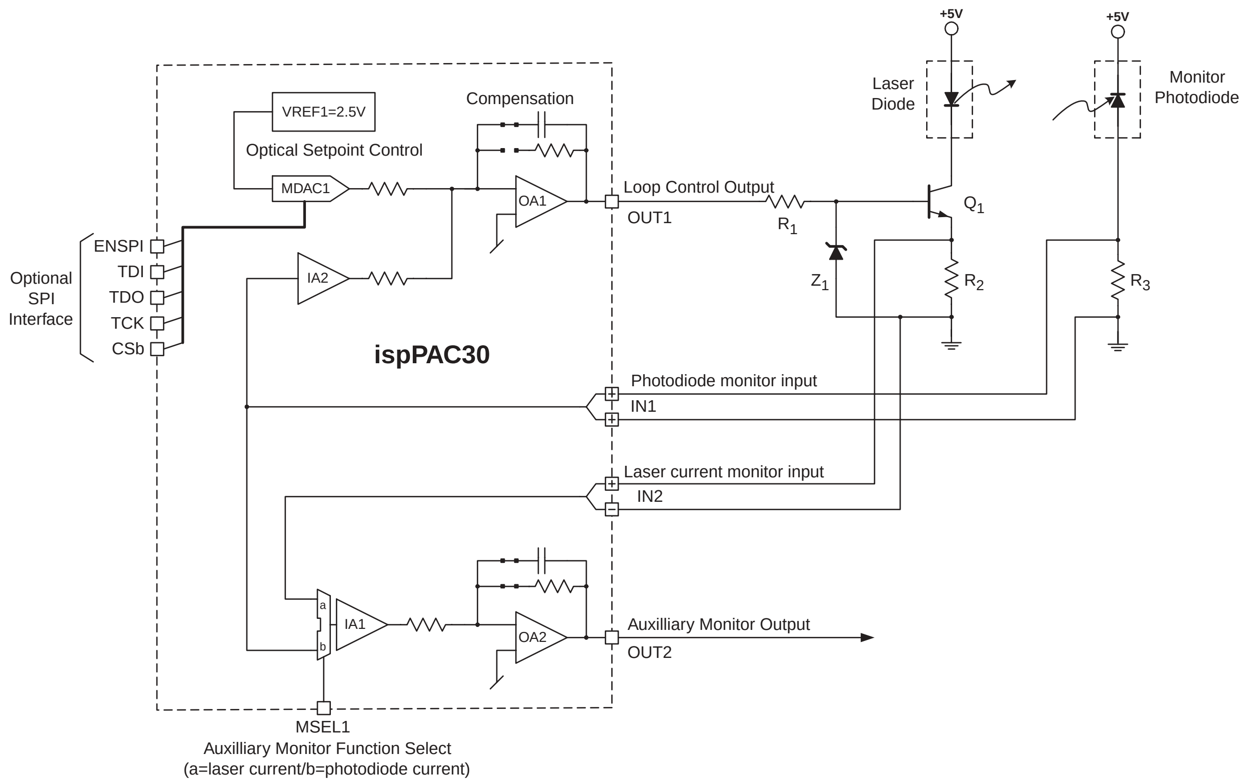


Because the photodiodes used in laser power controls are strongly illuminated in normal operation, they provide a significant amount of output current, typically in the range of 10-500μA. For output currents of these magnitudes, a resistor will often make an adequate current-to-voltage converter, when used as shown in Figure 6b. The value of this resistor should be chosen as small as possible consistent with obtaining an adequate output signal voltage. While higher values of resistors will produce more output voltage for a given amount of light, they will result in a slower response time, which can adversely affect the stability of the control loop. Large excursions in the voltage across the photodiode can also detrimentally affect the linearity of its response.

ispPAC30 Implementation

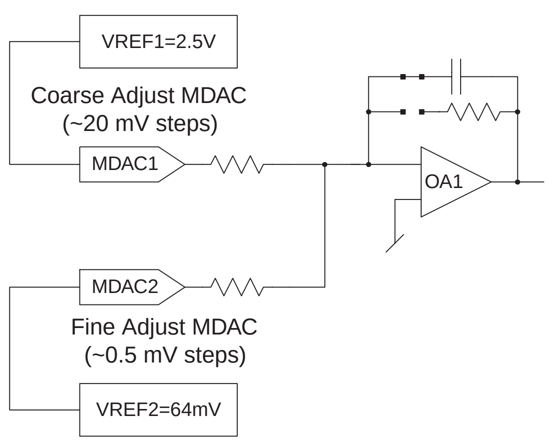
Having described circuits for interfacing to the laser and monitor photodiode, we can now describe how the ispPAC30 can be used in a laser power control loop. Figure 7 shows a complete optical power controller based on the ispPAC30.

Figure 7. Laser Optical Power Control with ispPAC30



Setpoint control is provided by the combination of voltage reference VREF1 and multiplying DAC MDAC1, which form a programmable voltage source. Although MDAC1 offers 8 bits of resolution, VREF1 can be programmed to several values (64mV, 128mV, 256mV, 512mV, 1024mV, 2048mV, 2500mV), so their combination provides nearly 13 bits of dynamic range. Alternatively, because the ispPAC30 has a second voltage reference and MDAC, the two references and MDACs can be combined to provide a coarse-fine setpoint adjustment, as shown in Figure 8

Figure 8. Combining both VREFs and MDACs for Coarse/Fine Adjustment



In this circuit, VREF1 and MDAC1 provide a coarse adjustment over a range of 2.5V, with a resolution of ~20mV. VREF2 and MDAC2 provide a fine adjustment over a range of 64mV, with a resolution of 0.5mV. Summing the outputs of the two MDACs provides a total adjustment range of 2.564V, with 0.5mV of resolution, which is comparable to the range and resolution available from a 13-bit DAC.

Regardless of whether one or both VREF/MDAC pairs are used, setpoints can be established in several ways. The first is by programming them into the ispPAC30's non-volatile E^2 memory. When this is done, the setpoint will be automatically loaded into the references and the MDACs when the ispPAC30 is initialized on power-up. For laser systems in which optical power levels are either adjusted once at time-of-manufacture or are infrequently calibrated, this is the simplest way to establish a setpoint. Because this E^2 memory can be written to under computer control, it becomes possible to automate this part of the manufacturing process. Additionally, since the E^2 memory can be written to in excess of 10,000 times, iterative programming algorithms can be used to adjust the setpoint to meet a desired set of operating requirements.

Alternatively, the setpoint can be controlled dynamically through the ispPAC30's SPI port. This feature allows an external microprocessor to set the amount of optical output power to meet changes in operating requirements. When using the SPI interface, it is possible to write parameters directly to the ispPAC30's SRAM registers without performing an E^2 write cycle, allowing an unlimited number of updates. Note that the SPI control features are available *in addition* to the E^2 memory feature. The combination of E^2 memory and SPI control provides perhaps the most useful operating mode, where the chip configuration and an initial 'safe' operating point are programmed into E^2 memory, and when the system is properly initialized, an external microprocessor can take over control of the ispPAC30 through the SPI port.

In Figure 7, the control loop's error signal is developed by summing the output of the setpoint MDAC with the output of IA2. Input IN1 and input amplifier IA2 measure the voltage across R_2, and the output of IA2 is consequently proportional to the laser's output power. Because the gain of IA2 is negative, this signal is subtracted from the setpoint value to form an error signal, which is then fed into OA1.

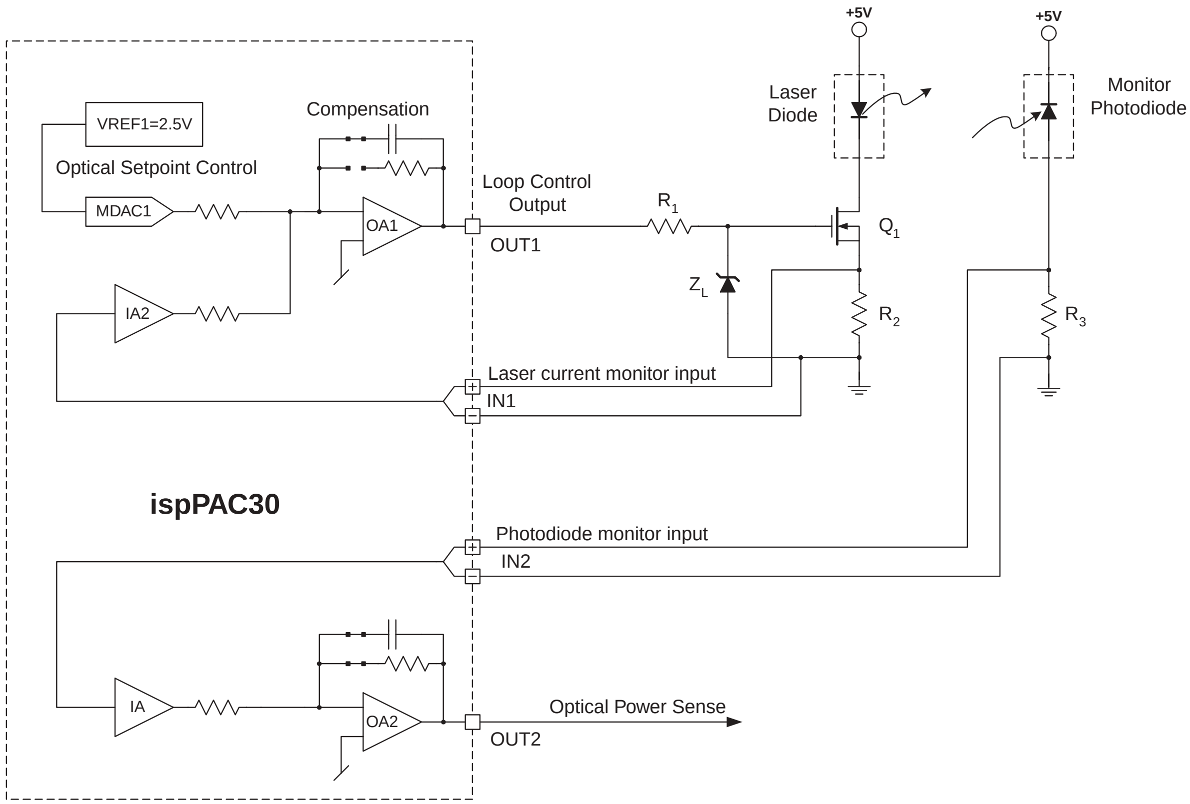
OA1 is configured as an integrator for two reasons. The first is that the integrator circuit provides a high (80dB) DC gain, which is necessary for minimizing the difference between the setpoint power and the measured power. The second reason for using an integrator is that the feedback capacitor provides compensation dynamics that are useful in stabilizing the feedback loop against both oscillation and the effects of spurious noise. The output of OA1 can swing from ground to +5V, and is capable of providing up to 30mA to control the laser driver circuit.

In addition to using the output of the monitor photodiode as control feedback, it is often desirable to be able to externally monitor optical output power to determine if the laser is functioning properly. Similarly, the laser bias current is also frequently monitored. When the laser approaches its end-of-life, the operating current required to achieve a given level of optical output begins to increase. Providing these signals to an outside system can be accomplished in an ispPAC30 by using output amplifier OA2 and the IA1 multiplexor. The choice of which monitor signal is presented at OUT2 is selected by the digital state input to the MSEL1 pin.

Constant-Current Mode Operation

In some applications it is assumed that the laser is stable enough so that it can be operated from a constant current source without the use of optical feedback. One of the simplest and most straightforward methods of building a stable current source, however, also uses feedback, measuring the actual output current, and using a control loop to maintain it at a given setpoint. Figure 9 shows one way in which the ispPAC30 can be used to implement a constant-current source for biasing a laser diode.

Figure 9. Constant-Current Controller using ispPAC30



The most significant differences between this circuit and the constant optical power circuit previously described (Figure 1) are the source of the feedback and the use of a MOSFET (Q_1) as the output driver transistor. The feedback is developed from a sense resistor at the source of the driver MOSFET, and will be equal to I_L x R_2. Although one would generally like the feedback signal to be as large as possible to minimize errors by maximizing R_2, the maximum value of this resistor will be limited by the need to leave enough voltage headroom to properly bias the laser and the MOSFET.

The second change in this circuit is the use of a MOSFET instead of a BJT, which is because a MOSFET requires no base drive current. If a BJT were used, the base drive current would add into the emitter current, and create a small ($\approx 1/H_{FE}$) error in the measured laser current. By using a MOSFET one totally avoids this problem.

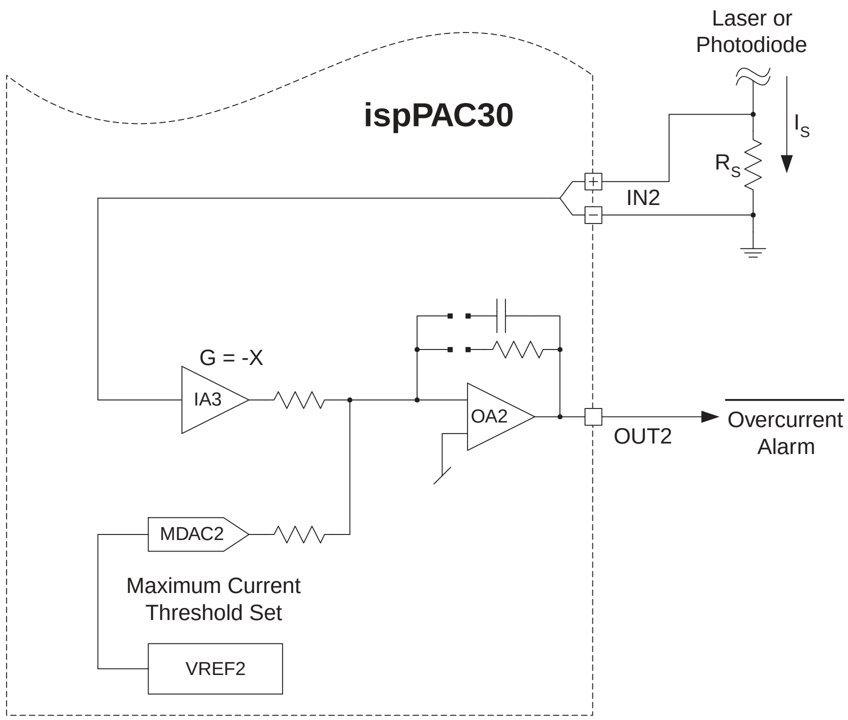
Note that although the feedback loop will attempt to maintain a constant current, a V-I architecture is still used for the driver circuit. The use of this type of circuit provides two advantages. The first is improved loop stability because the V-I circuit provides a fairly stable gain. The second advantage is overcurrent protection for the laser. This feature is particularly important when the feedback loop stabilizes in response to a power-on event.

Laser end-of-life is still an important issue in constant-current laser drivers. Instead of monitoring laser current, however, one needs to monitor the optical power output. Because only about half the resources of the ispPAC30 are needed to implement the current control loop, it is possible to monitor the optical output power with the remaining output amplifier OA2.

Overcurrent Alarms

By monitoring a laser bias current and optical output, it is possible to determine when a laser diode is nearing its end-of-life, as its efficiency will begin to degrade. In many cases, however, one may not wish to actually measure these currents, but merely need to know if a current has gone over or under a given setpoint. Because the ispPAC30 output amplifiers can be used as comparators, it is possible to implement user-programmable threshold detectors. Figure 10 shows an example of how this can be done.

Figure 10. Overcurrent Alarm Function in ispPAC30



In this circuit, OA2 is configured in comparator mode (CP2). The signal to be monitored is amplified to an appropriate level by IA3. The combination of VREF2 and MDAC2 is used to provide a user-programmable threshold. By setting IA3 to a negative gain, one effectively subtracts the monitored signal from the threshold level. When the monitored signal exceeds the threshold, the difference will go negative, driving the output of CP2 low. For a more extensive discussion of how to implement threshold detection circuits with the ispPAC30, please see AN6025, *Voltage Monitoring with the ispPAC30*.

Conclusion

The ispPAC30 is an efficient and flexible means of implementing a power control loop for a DWDM laser. By performing on-chip reconfiguration, the ispPAC30 can provide control based on either optical power or bias current feedback. Additionally, it is possible to monitor either of these variables. The ispPAC30's internal E^2 memory provides both circuit configuration and an initial optical power set-point when power is applied to the system. Finally, JTAG and SPI interfaces allow configuration information to be loaded into the ispPAC30's E^2 memory at end-of-line test, allowing for fully automated adjustment of system operating parameters.

Technical Support Assistance

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