LMV2011

Precision Method for Laser Diode Emission Control

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Technology Edge

Precision Method for Laser Diode Emission Control

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In many applications where light is used to control a process, it is very important to maintain a constant light level. In some systems, a simple LED or laser diode is used to create a light source to provide illumination, however, even with initial calibration the light source will degrade with time. As the LED ages, its current-to-light emission ratio degrades and the level will decrease. If it is desirable to maintain the factory-set emission level over time, then a control circuit is required to monitor the emission, and control the current being supplied to the light emitter to keep the output constant. Uses of such a configuration would be in photometric applications for accurate light levels, control applications for accurate optical positioning of servo mechanisms, and test equipment for optical references. **Figure 1** shows a block diagram of such a system.

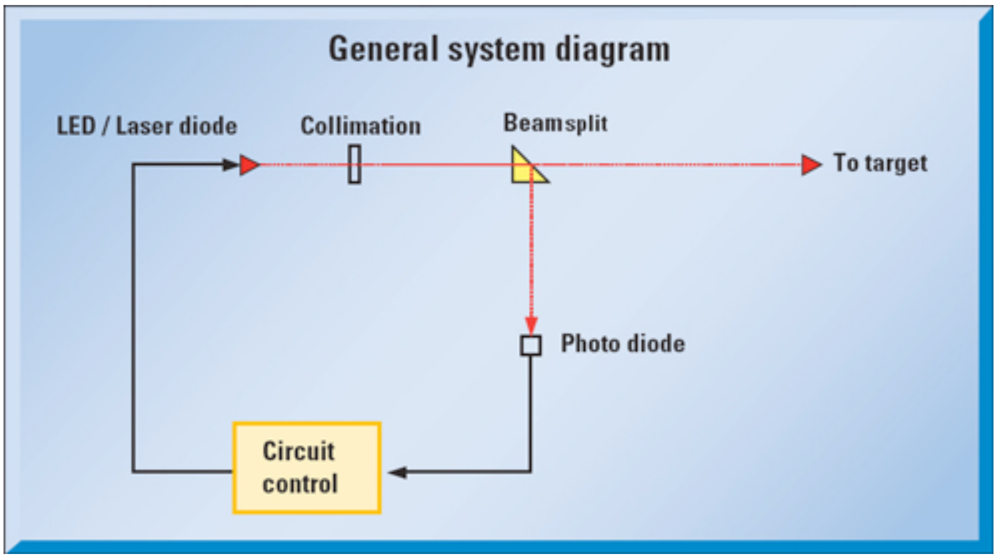

Figure 1

Photodiodes 101

A silicon photodiode is constructed in a similar way to PN junction diodes except that the P layer is very thin. The thickness of the P layer is adjusted for the wavelength of light to be detected. A photodiode also has capacitance, as does its non-photo cousin, which is directly proportional to the reverse bias voltage placed across it. A typical value ranges from 2-20 pF. Photodiodes have two terminals–a cathode and an anode. The diode can be used in either the forward mode (current flowing from the anode to the cathode) or in reverse mode (current flowing from the cathode to the anode). When using a photodiode in reverse mode (anode negative), it is extremely linear with respect to illumination of a given frequency, which is a good thing. It makes building a control circuit much easier when things are linear.

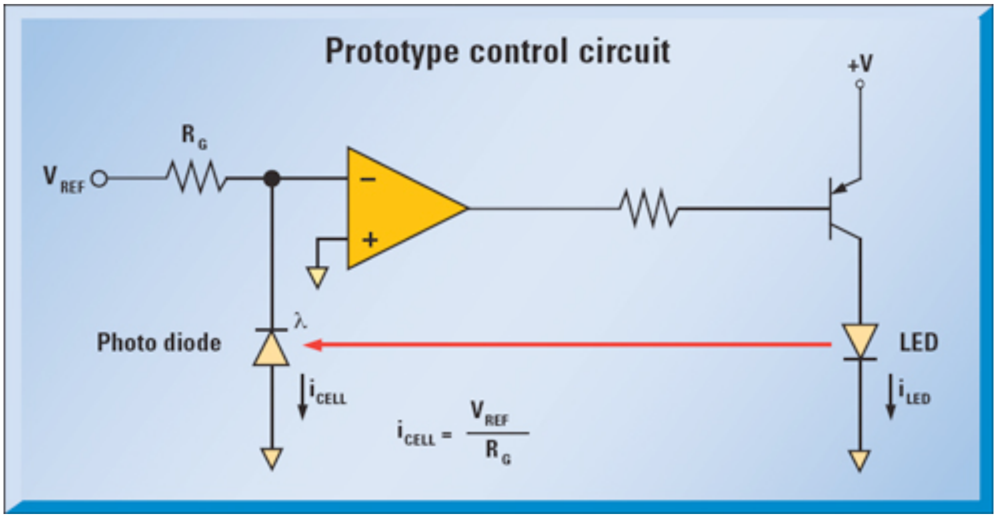

Figure 2

Prototype Design

In **Figure 2**, a prototype circuit is used for analysis of a control loop using an operation amplifier. The circuit drives a PNP transistor, which supplies current to an LED to generate light emission. A portion of this emission falls on the photodiode, which converts it to a very small current – typically 10 µA or so. In this case, the diode is used in reverse mode so when no light is present, there is nothing but leakage current (also known as the “dark current”) in the photodiode and the amplifier is in overload. This condition pulls current limited by a resistor from the base of the transistor initially placing it in saturation. Once current starts to flow through the transistor, the LED or laser diode will begin to emit light. The photodiode will convert a portion of this light to a current, which flows through R_G. As the current increases, so will the voltage drop developing across R_G. As that voltage approaches V_{BIAS} (which is ground in **Figure 2**), the loop will close and maintain the correct drive to the transistor to maintain the current in the LED to keep a constant light level (or current in the photodiode). This forms the basis for the DC- analysis of the circuit. **Figure 3** shows a practical implementation of the circuit using a National Semiconductor LMV2011 precision operation amplifier. The reference voltage is generated using a National Semiconductor LM4041-1.2 shunt reference, which provides a fixed 1.225V reference voltage. The current in the reference is set at approximately 10 mA, which is the middle of its operating range. V_{BIAS} is generated by two 1% precision resistors, which set the value to approximately 1V. To calculate the photodiode current at which the control loop is closed, the difference between V_{REF} and V_{BIAS} is divided by R_G. Note that V_{BIAS} must be less then V_{REF} for this circuit to work. For a photodiode current of 10 µA, R_G is 0.2 x 10E-6 or 20.0 KW. The PN200A PNP transistor's base current is limited by a 4.7 KW resistor, which sets the limit at around 1 mA. The transistor has a beta of around 100, so the maximum current the transistor can supply is around 100 mA, which would exceed the thermal dissipation of the tiny SOT-23 package. To prevent thermal runaway in the transistor, the collector current is limited by a resistor in series with the LED or laser diode to the operating maximum of the diode. If more current is required, a transistor with a larger collector current should be used along with a larger package such as a SOT-223. To limit the bandwidth of the circuit to maintain stability, the amplifier is rolled off at around 250 KHz by a 15 pF capacitor in parallel with the photodiode capacitance (which is also around 15 pF with the 1.2 V_{BIAS})

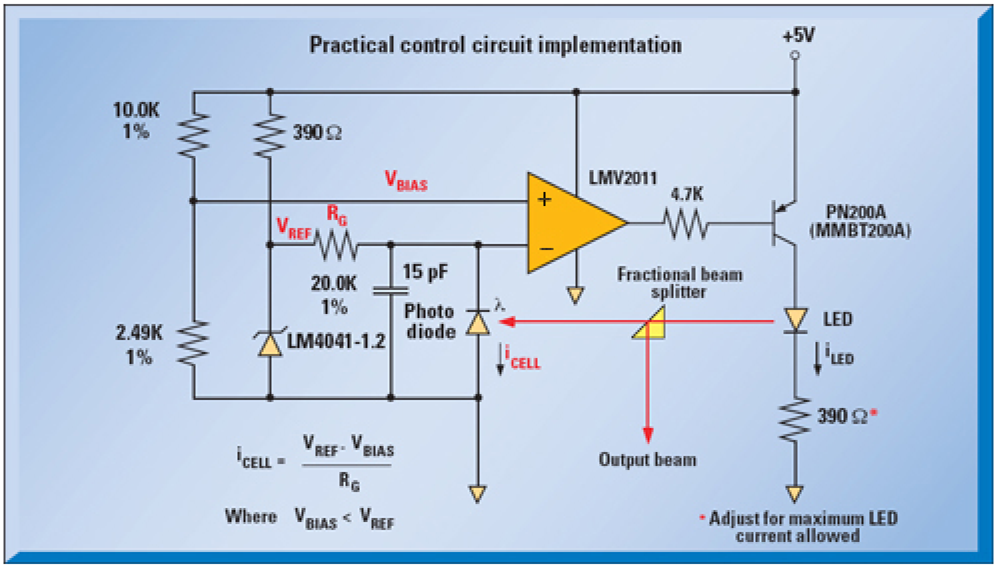

Figure 3

Conclusions

With a simple operational amplifier circuit as shown above, it is quite easy to create an accurate light level for many different applications. As shown above, even as the light emitter ages, the control loop will maintain a constant level by adjusting the current flowing in the LED.

For more information on National's amplifier family, and live WEBENCH® simulations of the LMV2011, visit: amplifiers.national.com

Sources

A Primer on Photodiode Technology - Centrovision www.centrovision.com/tech2.htm

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