Laser diode controller

Objectives

1. Build a laser diode controller module using PSoC.
   a. A stability of +/- 0.05 dB @ 0dBm (1 mW) optical power output
   b. Provide a facility to modulate the laser

Advantages in using the PsoC

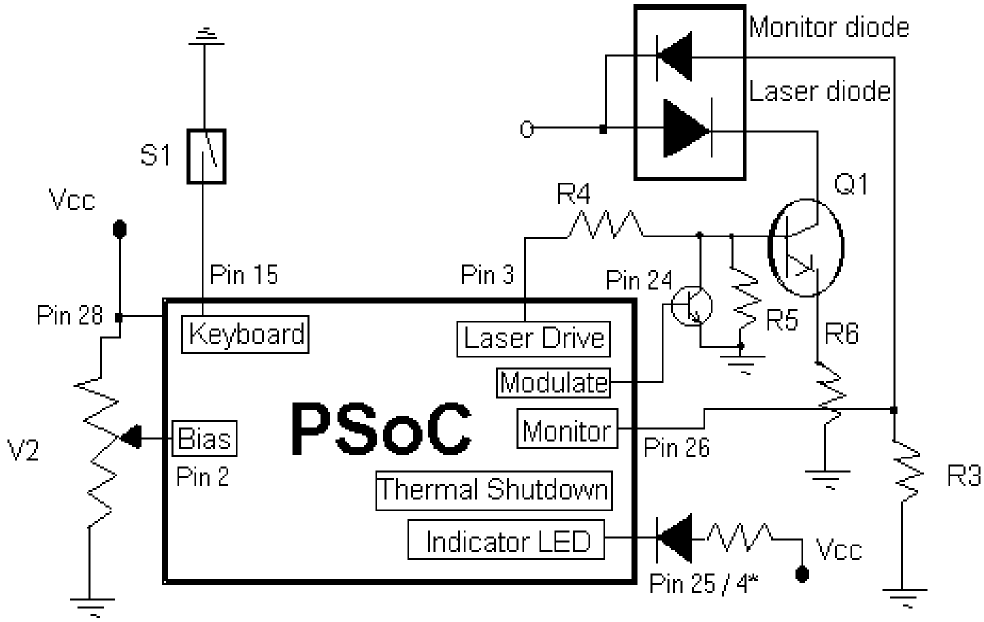
1. A higher level of integration,contains all the building blocks needed. Consequently you fiddle with only a few components. Also results in smaller PCB real estate requirement.

2. Knocks off about 20 - 30 dollars from a typical handheld laser source, eliminating things like digital potentiometers, which in turn need a microcontroller to use, temperature controller, some analog devices and a few TTL IC's.

3. A complete laser controller can be built using just the analog functions of a PsoC controller. The additional functions for a handheld laser source like ,modulation etc may be done in software.

4. Additional options like over current protection and thermal protection may be added using the comparator and FlashTemp user modules respectively. Thermal shutdown may be added if the unit need operation in conditions other than normal operating temperatures.

Schematic

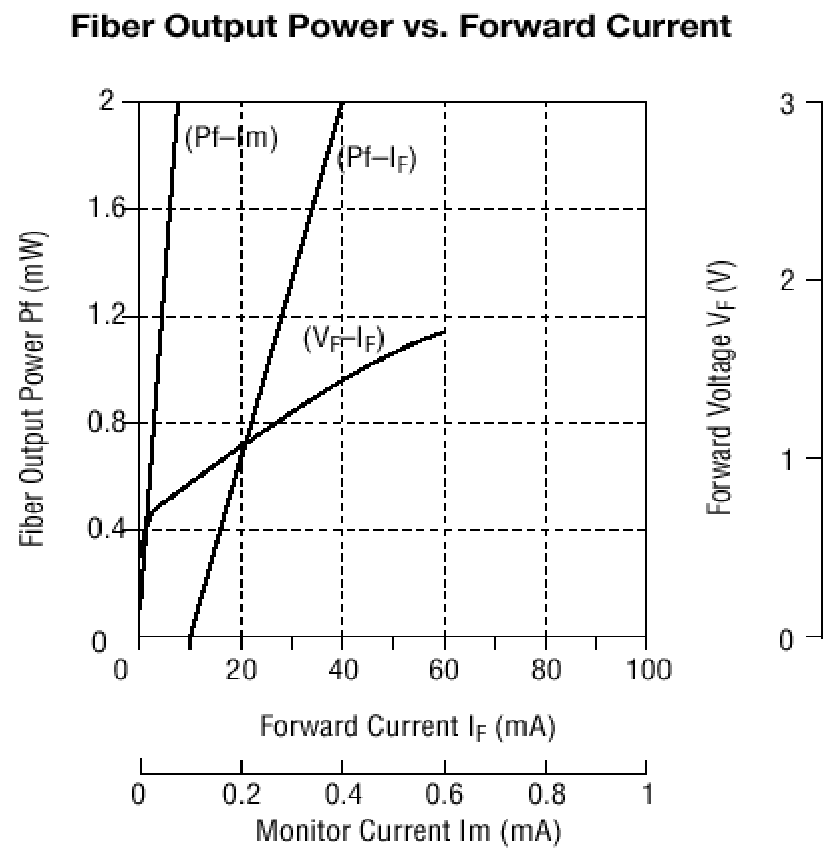


* the pin used in the other configuration with over light(current) shutdown

The schematic above shows a handheld laser source.

Operation

The laser diode package used should have a monitor photodiode for APC(automatic power control)Shown below is a typical characteristics for a laser diode and its monitor diode. The basic APC idea is to adjust the forward current inversely proportional to the monitor diode current.



The schematic used in the project is shown above. The equivalent circuit used for simulations can be found in "**Project Number 247 – Simulations.pdf".** The component vales shown are by no means optimal or desirable. It just serves the purpose of this simulation.

The laser is properly biased using the potentiometer V2 within the safe operating region for the device. The monitor current provides feedback to the circuit. Any change in the device characteristics due to a change in temperature for example will result in the laser putting out more / less optical power causing the monitor current to change proportionally. This will cause the drive circuit putting out more/less current to compensate for the change and essentially balances itself.

The instrumentation amplifier user module and R4 & R5 are used to provide the required gain for the feedback control. Please refer to "Project Number 247 – Simulations.pdf" for details on the amplifier configuration.Q1 and R6 form the current source for the laser diode. The monitor current generates a voltage on R3 used for monitor current sensing for the instrumentation amplifier.

A power on indicator is used to indicate laser on condition. Holding down the switch S1 causes the laser output to be modulated at 1KHz for the first press and then to continuous wave mode on the second key press. The cycle will repeat. The circuit will try to compensate for the loss of 3dB power due to 50% duty cycle modulation and will drive the Laser at maximum possible current in the 'on' period. This is OK (depends on the laser diode) as the current is limited and the average current will still remain the same. In some cases the drive circuit may not be able to compensate fully under modulation condition and there will be a optical power drop under modulation condition.

The modulation is achieved using a counter module dividing the available clocks. Another counter divides the modulation clock further to provide a visual indication of modulation condition.

PsoC implementation

The design in the schematic was implemented using the following PsoC blocks. The details are discussed below.

1) Instrumentation Amplifier - INSAMP_1
The input to the Amplifier is given through multiplexers. The non-inverting input is given through pin2(Bias i/p in schematic) and the inverting input through pin 26(Monitor i/p). The gain of the amplifier is set to 2.000 and the reference to AGND. The output of the amplifier will appear on pin3.

2) Counter8_2
This counter provides the 1KHz signal. The clock used for the counter is 24V2.This is obtained by diving the 24V1(24Mhz/16)/15. For getting a 1KHZ signal , this clock is further divided by the value set in the period register of the counter. The period value set for the counter is 100 (24V2/100=1000). The 1KHz output is connected to pin 24(Modulate o/p).

3) Counter8_1
This counter provides 10Hz output. The clock for this counter is obtained from digital block DBA03 (1kHz). For obtaining a 10HZ output this clock is divided by the period value of the counter. The period value is set to 100 (1000/100). This 10Hz (Indicator LED o/p) is available on Pin 25 (Pin4 in implementation with OCP).

4) CMPREG_1(used only in the implementation with OCP)
The inverting input of instrumentation amplifier is also connected to input of comparator through multiplexer. For obtaining a threshold voltage of 2.185, the ref. value is set to 0.437 and low limit to Vss. The output of the comparator is connected to pin25 through analog output bus. The output may be used to cut-off the laser current through Q1 or switch off the power supply (in case Q1 breaks down)Rather than monitoring the laser monitor current ,we may also directly monitor the laser drive current through R6.In that case a separate input pin for OCP is required.

There is not much in the way of software in this projects no flowcharts are provides. All the design details are in "Project Number 247 code no OCP.zip" file and another design with (OCP) over current protection is in Project Number 247 code with OCP.zip" as PsoC 3.1 designer files. The prototype pictures are available as "Project 247 pic1.jpg" and "Project 247 pic2.jpg".

Test Plan

Before plugging in the Laser diode we need to test the circuit."Project Number 247 code no OCP.zip" project is downloaded into the 28-pin dip part CY8C26443-24PI.

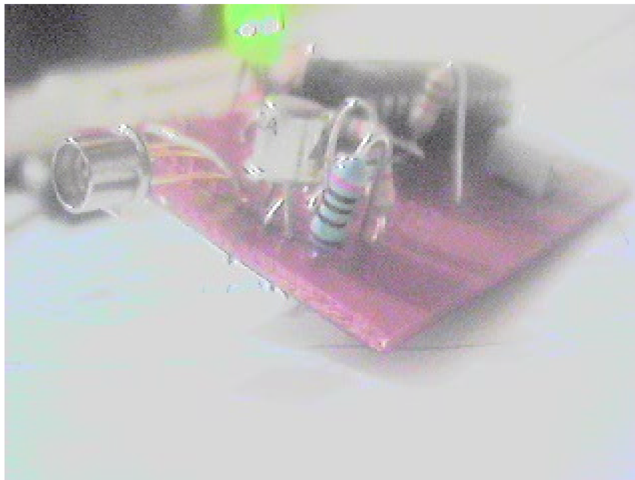
Condition	***Expected result***	***Status***
Indicator LED on pin 25	The led should turn on on power up.	Pass
Modulate on/off key on pin 15	Hold down the key for about a second and release. The LED on Pin 25 should pulse at 10	Pass

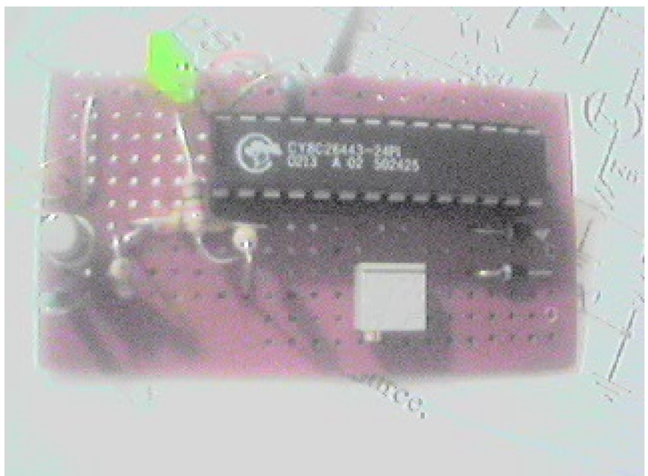
Condition	Expected result	Status
	Hz and the base of Q1 should have a 1KHz modulation. Press and release key a second time and the Modulate pin should turn low again and the LED should remain lit.	
Control loop test. Bias (pin 2) set at 2.52 volts, Monitor(pin 26) connected to a potentiometer and applied with various voltages and plot Laser drive (pin 3) to verify the Instrumentation amp. operation	From the test results calculate the gain from the control loop function. See "Project 247 test result.xls" for the test data in sheet 1	The gain is close to 2 , the expected gain in most of the area except in a small area. The power supply used had bad regulation ,need to retest.

"Project Number 247 code with OCP.zip" project is downloaded into the 18-pin dip part CY8C26443-24PI before this test.

Condition	Expected result	Status
Indicator LED on pin 4	The led should turn on on power up.	Pass
Modulate on/off key on pin 15	Hold down the key for about a second and release. The LED on Pin 4 should pulse at 10 Hz and the base of Q1 should have a 1KHz modulation. Press and release key a second time and the Modulate pin should turn low again and the LED should remain lit.	Pass
Over current(monitor diode current) protection test Bias (pin 2) set at 2.45 volts, Monitor(pin 26) connected to a potentiometer and applied with various voltages and plot Laser drive (pin 3)	The OCP o/p pin 25 should go high when the monitor voltage exceeds 2.185V as per design. See "Project 247 test result.xls" for the test data in sheet 2	The OCP comparator switched high when the monitor voltage got above 2.14V.The switching threshold difference might be related to the lower power supply voltage of 4.89V Vcc instead of 5V However the gain remained close to 2 even though we were multiplexing pin 26 for 2 functions

The unit is now ready for further tests.

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