Temperature Stabilized Infrared Laser

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Abstract:

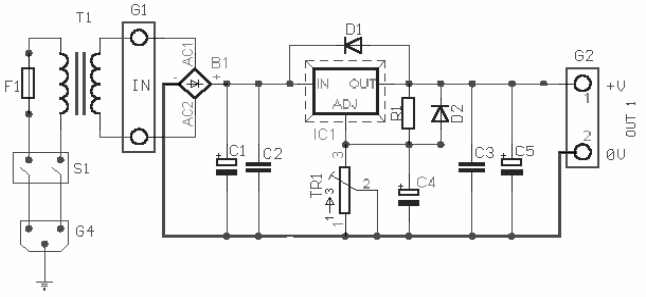
This paper describes the design and construction of a semiconductor laser diode, driving (400) mW to (1000) mW with fixed wavelength of (808) nm. The electronic circuit is delivering up to (1400)mA to a laser diode and capable of keeping the temperature of the laser diode fixed at (25) ^{0}c.To protect the laser diode from failure this circuit includes ,a voltage protection circuit which keeps the voltage of the laser diode around (2.1) V and temperature protection not to exceed (30)^{o}C. This circuit can keeps the temperature of the laser diode at 25 ^{0}c yet the ambient temperature between (–05 - + 50) ^{0}C.

الخلاصة

في هذا البحث يتم تناول تصميم وبناء لبزر أشباه الموصلات ليعمل بقدره متغيرة ما بين (٤٠٠-١٠٠٠) ملي واط مع ثبات الطول ألموجي عند (٨٠٨) نانوميتر للشعاع الليزري المنبعث المتولد منه، عند درجة حرارة ثابتة هي ٢٥ درجه مؤويه،وعليه تم تغذيته من دائرة كهربائية توفر اظافه إلى التيار الذي قيمته (١٤٠٠) ملي أمبير ، حماتيه من الجهد الذي يزيد عن (٢.١) فولت ،كما جهز بدائرة تبريد للحفاظ على درجه حرارته عند ٢٥درجه مؤويه على الرغم من تغير درجة حرارة المحيط مابين (٥٠+ – ٥-)درجه مؤويه.كما جهز بدائرة حماية من ارتفاع درجه حرارة ليزر أشباه الموصلات بحيث لأتزيد عن (٣٠) درجه مؤويه.

System Overview:

An SLD323V laser diode provides a coherent continuous wave output with a typical wavelength of 808 nm and a maximum power of (1) W, at an operating temperature of 25° C [Thompson 1997]. The typical threshold current is 300 mA and the operation current should not exceed 1400 mA at any instant [Goldwasser 2006]. Electrically a diode laser behaves as a diode with turn –on greater than 1 volt. When the laser is biased with a sufficient current so that lasing occurs, a further increase injected current results in a proportional increase optical output[Sony company 2004]. Figure (1) shows the DC power supply for diode laser, it consists of
(Transformer, Full wave bridge rectifier and Voltage regulator) [Neamen 2001].



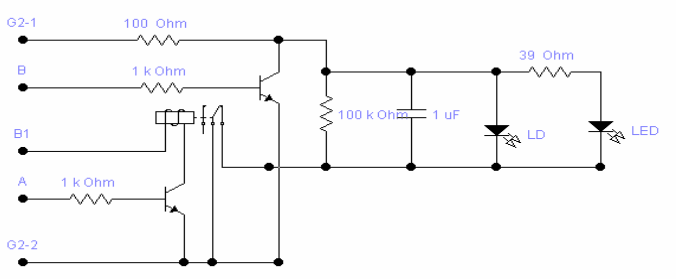


Figure (1) D C power supply circuit

The voltage and current for the power supply we can found from equations(1)&(2)[Brophy 1990].

$$V_{dc} = \frac{2V_m}{\pi} \text{----------(1)}$$

$$I_{dc} = \frac{2I_m}{\pi} = \frac{2V_m}{\pi R_l} \text{----------(2)}$$

Where:

V_m is the maximum value of the secondary voltage.

The simplest filter circuit consist of a capacitor connected in parallel with the load resistance , the capacitor is charged to the peak value of the rectifier voltage V_p and begins to discharged through R_L after rectifier voltage decreased from the peak value. The decreased in a capacitor voltage between charging pulses depends upon the relative values of the R_LC time constant and the period of the input voltage. as shown in figure (2). So that the ripple factor of the capacitor filter is as in equation(3).

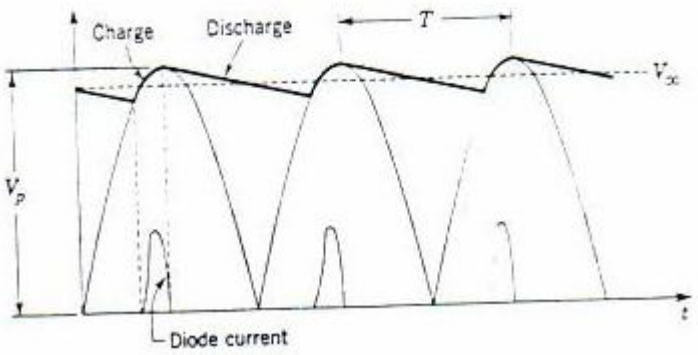


Figure (2)output voltage of a capacitor filter[Tsukada & shima 1975].

$$r = \frac{1}{2\sqrt{3} f R_L C} \text{----------(3)}$$

The actual dc output voltage from the capacitor filter is equal to the peak capacitor voltage less the average ripple component, as in equation (4) .

$$V_{dc} = V_p - \frac{I_{dc}}{2fc} \text{----------(4)}$$

The output voltage from the capacitor filter (12 V Dc) can reduce to (2.1 V Dc) by using three terminals positive regulator type [LM 338], by this type of regulator can

adjustable the input voltage between 1.2 V to 32 V by applying equation(5)[Thomas & Mistry 1974].

$$V_{outT} = 1.25\left(1+\left(\frac{R_2}{R_1}\right)\right) + R_2 * I_{ADJ} \quad \text{----------} \quad (5)$$

Where:

I_{ADJ} = 50 µA for this type

In general, the best type of capacitors to use are solid tantalum.

R1 = 240 Ω
TR 1 = variable resistance (0-5 K Ω)
D1 and D2 IN 4001

Voltage protection :

The laser diode my be damaged when the voltage applied on it exceeds 2.1 volt[Thomas & Mistry 1974], hence the operation of the laser diode needs protection, this keeps voltage applied on the laser diode always around 2.1 volt or less .This can be shown in figure (3) . the comparator compares between this voltage and the reference voltage, if the voltage equals or less than 2.1 volt the laser diode can operate normally, but if the voltage exceeds 2.1 volt, the comparator will send a signal to the base transistor which connects the voltage applied to the anode of laser diode to the ground, so the voltage applied now on the laser diode equals to zero.

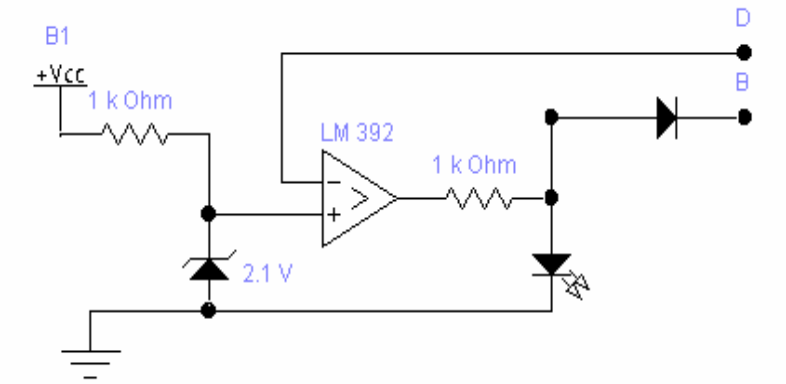


Figure (3) Laser diode Voltage protection circuit

Temperature protection :

The laser diode will be damaged if the temperature generated is high, in This work the temperature of the laser diode is kept less than 30 C^o [Koechner 2003], when the temperature generated in laser diode exceeds 30 C^o, the voltage sensed from the Thermistor equals about (9.1) mV, this voltage is sent to the comparator, if the voltage is less than 9.1 mV the laser diode operated normally, but if the voltage exceeds this voltage, the comparator connect the voltage applied to the laser diode to the ground directly ,this can be shown in figure (4).

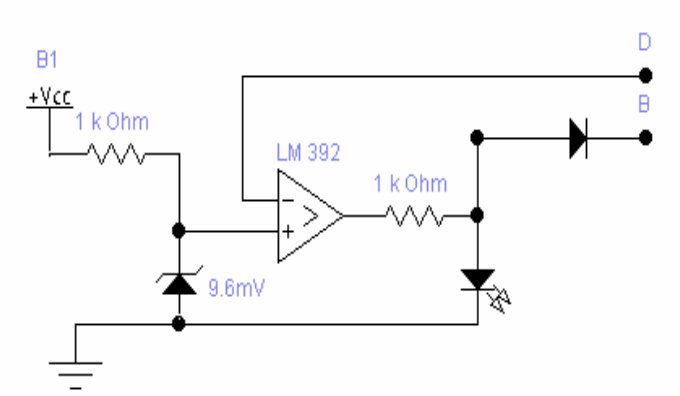


Figure (4) Laser diode temperature protection circuit,

Hence a cooling system is needed .The main task of a cooling system in this work is to control the temperature of the diode laser about (+25)°C. And dissipated the heat generated in the active medium . The cooling system in this work comprises of a Thermoelectric cooler [TEC], thermistor ,heat sink and a fan[LEMT company 2001] .

Construction of the laser system:

The fabricated laser driver with its controls and display panel is shown in Figures (5).The cooling system is shown in figures (6).

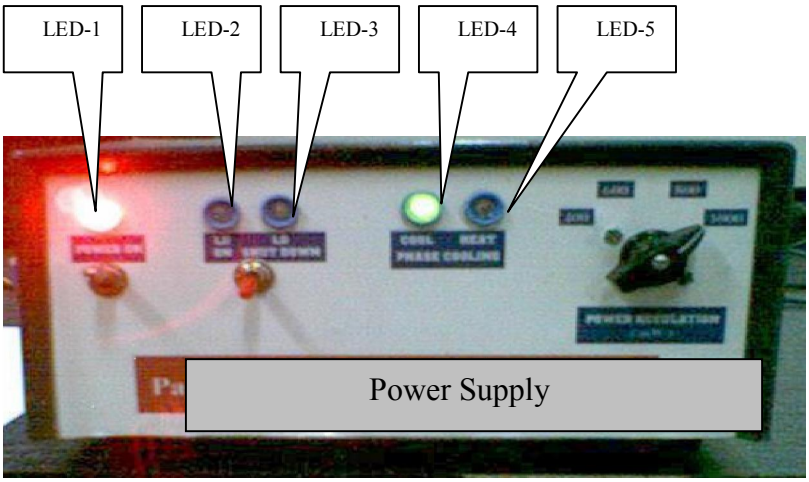


Figure (5) System Front view

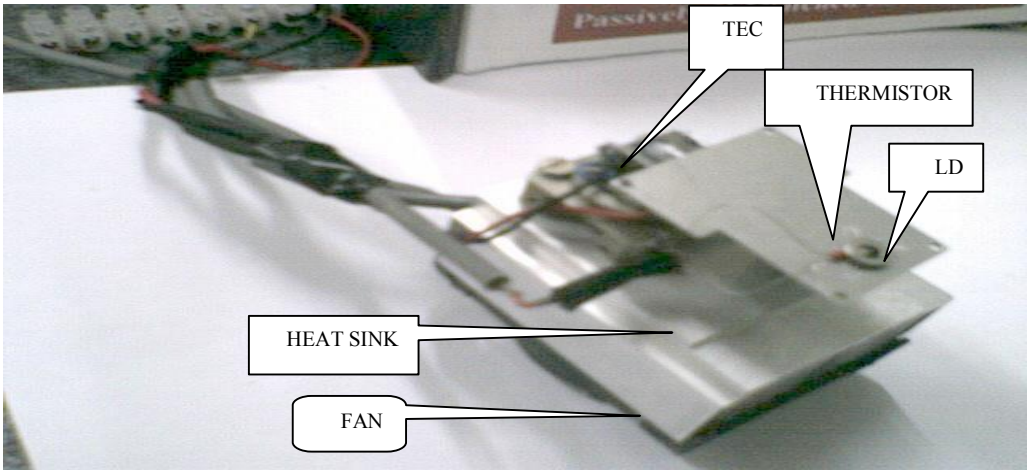


Figure (6) cooling components view with laser diode

Results:

We measured the wavelength (λ), band width ($\Delta\lambda$) and temperature (T) of the laser diode by using a Monochrometer type (optronic laboratories Inc, model 746), power meter type (Metrologic Radiometer) and thermometer Type (ASWAR , M-890G), as shown in figure (7).

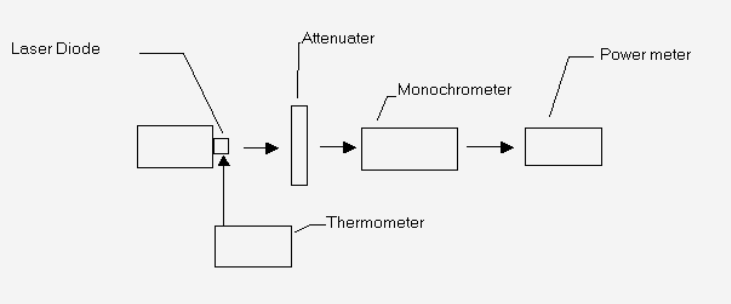


Figure (7) the setup of measuring the wavelength (λ), bandwidth ($\Delta\lambda$) and temperature (T) of the laser diode.

Found the wavelength of the laser diode λ = 810 nm, and bandwidth $\Delta\lambda$ = 4nm at temperature 25 ^{0}c from the above set up.

Applications:

1- Optical Pump source (Koechner 2003). A CW diode is pumping Nd:YAG and Nd:YVO4 in two different pumping geometries at relatively high average pumping power levels.

2- Medical application (LEMT company 2001) .It provides treatment of eye- ground nd ciliary body pathalogies.

Conclusions:

This circuit demonstrates a successful application of a driver for high power laser diode (1000 mW) with constant wavelength at 808 nm, and Temperature Stabilized around 25 ^{0}C.

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