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Feedback to the student

☐ See also comments in the text

		Very good	Good	Needs improvmt
C O N T E N T	Completeness, quantity of content: Has the report covered all aspects of the lab? Has the analysis been carried out thoroughly?			
	Correctness, quality of content Is the data correct? Is the analysis of the data correct? Are the conclusions correct?			
	Depth of understanding, quality of discussion Does the report show a good technical understanding? Have all the relevant conclusions been drawn?			
	Comments:			
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Raw report mark	/ 5
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The weighting of comments is not intended to be equal, and the relative importance of criteria may vary between modules. A good report should attract 4 marks.

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1 Introduction

This lab activity investigates laser characteristics, including light-current characteristics and output spectrum. The goal is to understand the behavior of lasers under different conditions and analyze their performance based on the measured data.

2 Part I: Measurement of Light-Current Characteristics

The apparatus used for this measurement includes a laser diode, a driver circuit, a photodiode for measuring output power, and a transimpedance amplifier to quantify output power by voltage output. The raw data collected from the experiment will be analyzed to determine some key parameters of the laser, and the circuits used in the experiment. The raw data will be available in appendix.

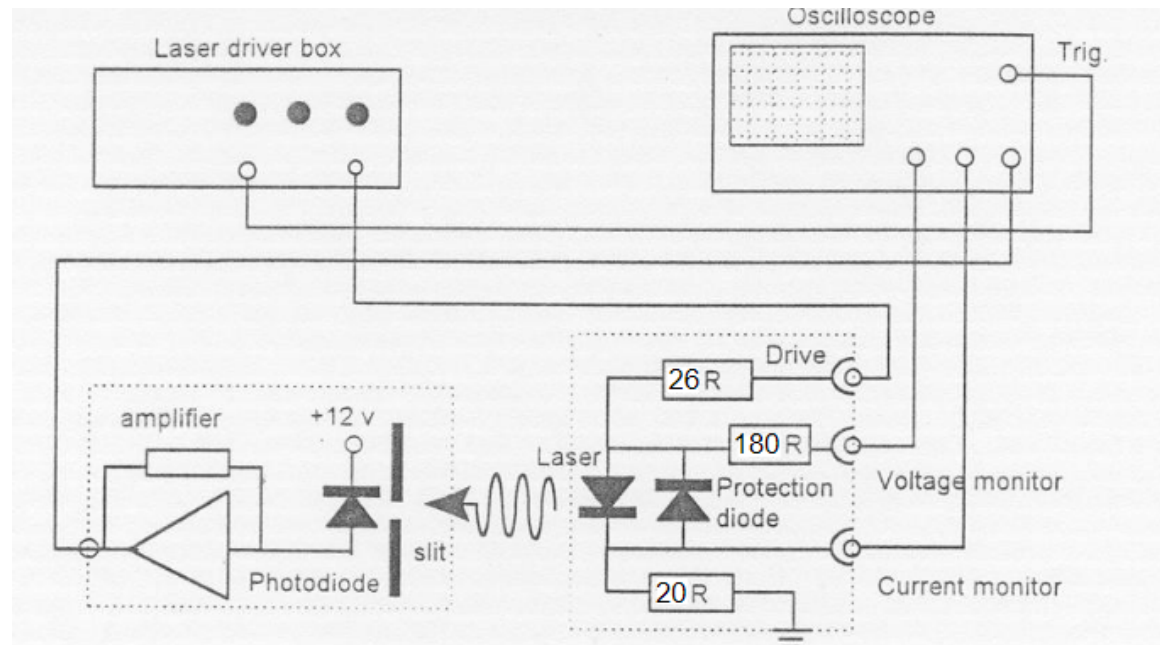


Figure 1: Circuit Diagram

2.1 Laser Theory

According to laser theory, photon emission becomes stimulated when the gain exceeds the losses in the laser cavity. This could be observed in the light-current (L-I) characteristics of a laser, where the output power increases significantly once the threshold current is reached. The expectation of the L-I curve is that it will show a linear increase in output power after the threshold current, with a steep slope indicating efficient lasing action.

As given in the lab handout, this threshold current is between 40 and 55 mA, while the actual threshold current observed from the raw data is around 75 mA. This could be reasonable, because the

operation of laser diode is very temperature sensitive. The threshold current can increase significantly with temperature.

2.2 Data Analysis

As shown in Figure 2, the plot of the raw data of L-I curve shows a clear threshold behavior. Below the threshold current, the light output is negligible. This is because the gain is not sufficient to overcome the losses in the cavity. the laser is not lasing, and only spontaneous emission occurs. Above the threshold current, the output power increases rapidly, indicating that the laser is lasing and the gain exceeds the losses. The large slope of the L-I curve above the threshold can provide insights into the efficiency of the laser, with a steeper slope indicating higher efficiency in converting electrons to photons.

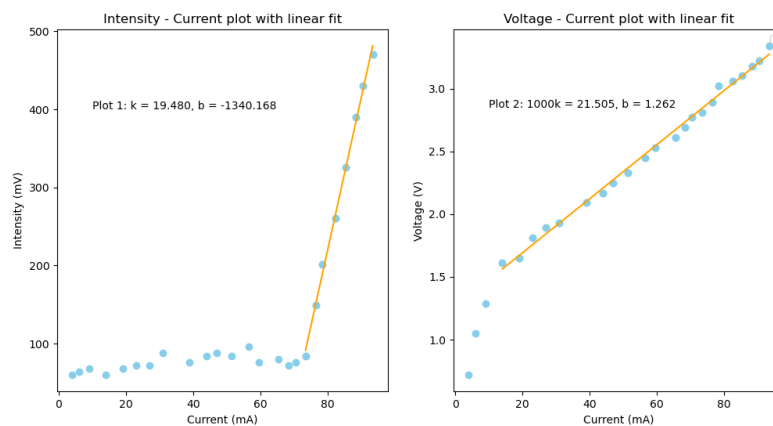


Figure 2: Plot and linear fit of raw data

While the other plot shows relation of voltage across the laser diode and the current through the laser diode. The V-I relation can be derived from the equivalent circuit of the laser diode, as shown in Figure 3.

There is a non-negligible stray series resistance in the laser diode, which contributes to the increase in voltage across the laser diode as the current increases.

The relation could be expressed as:

$$V = V_{th} + I \cdot R_s$$

Where V and I are the voltage across the laser diode and the current through the laser diode, respectively. V_{th} is the threshold voltage, and R_s is the stray series resistance.

By the linear fit of the V-I curve, we can determine the threshold voltage and the stray series

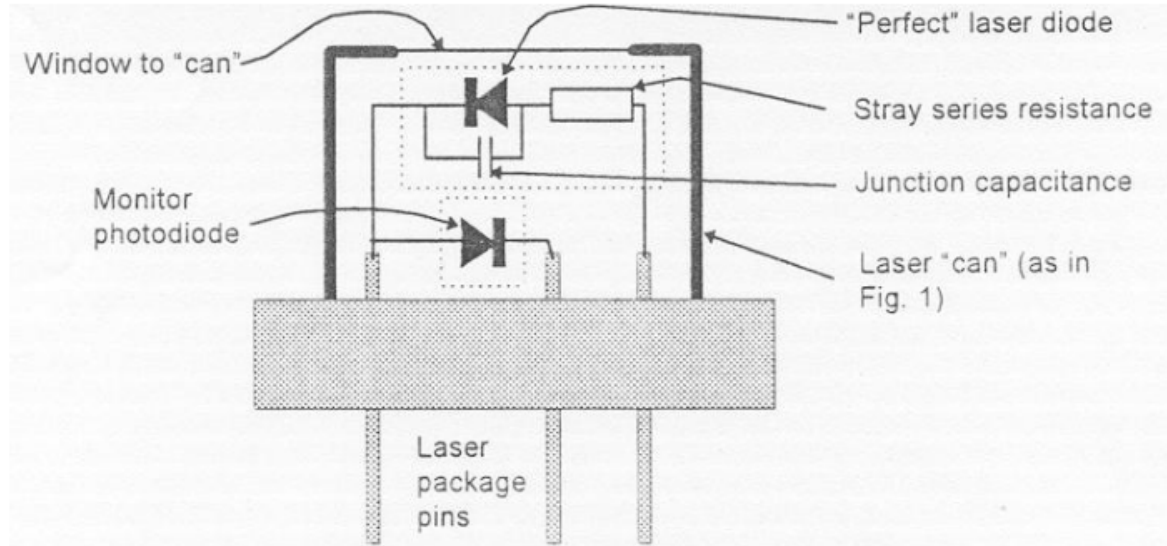


Figure 3: Equivalent Circuit of Laser Diode

resistance. $V_{th} \approx 1.262V$, and $R_s \approx 21.505\Omega$.

From the circuit diagram given, the stray series resistance is 26Ω , which is close to the value obtained from the linear fit, with an error of 17.3%. This error could be attributed to the measurement errors, and the non-ideal behavior of the laser diode.

With the threshold value of perfect diode, we could estimate the lasing wavelength of the laser diode λ_0 by the following equation:

$$\lambda_0 = \frac{hc}{eV_{th}}$$

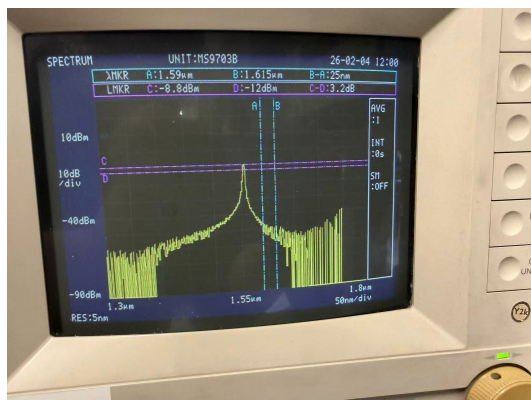
The value of wavelength is 983.12nm, which is within infrared range. This calculation agrees to the observation during the lab, there was no visible light emitted from the laser diode.

2.3 Error Analysis

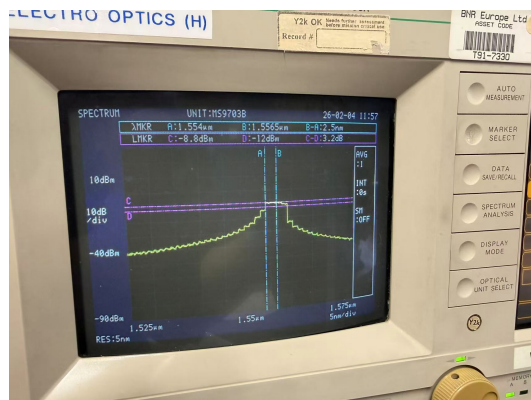
3 Part II: Measurement of laser output spectrum

4 Conclusion

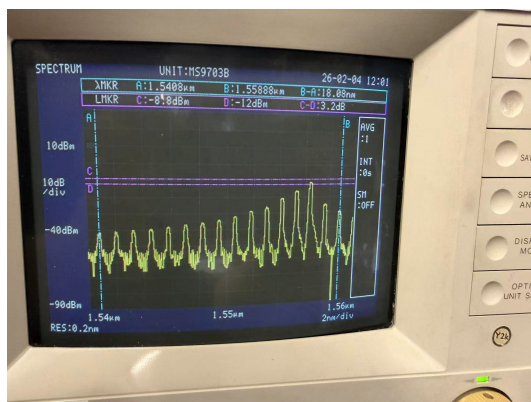
5 Appendix



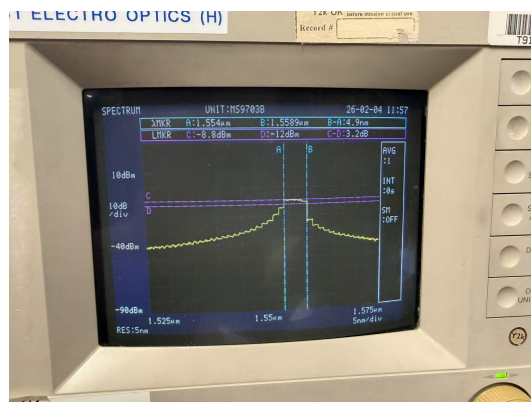
(a)



(b)

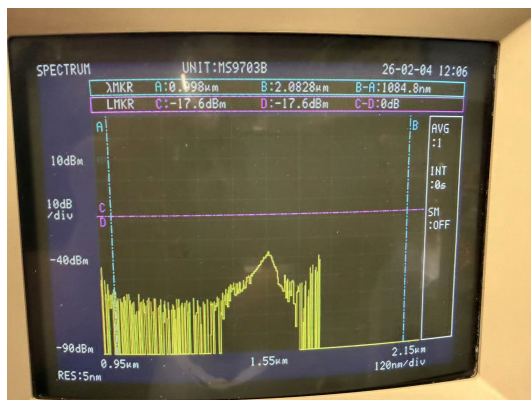


(c)

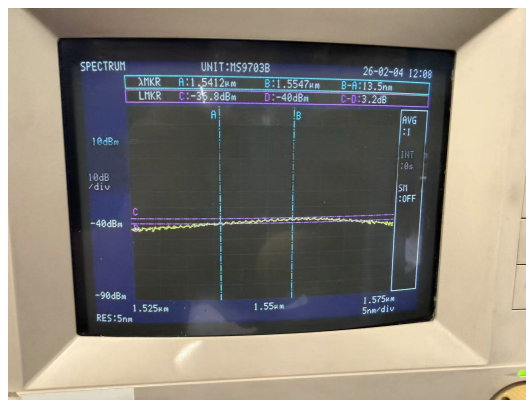


(d)

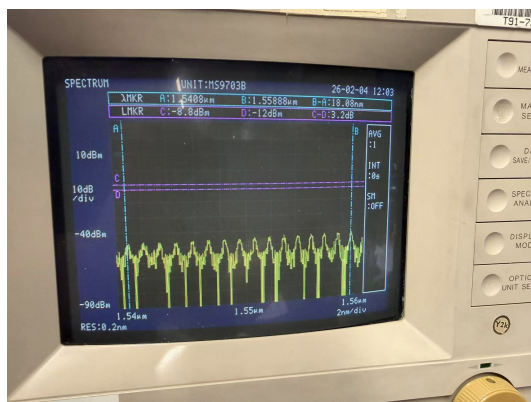
Figure 4



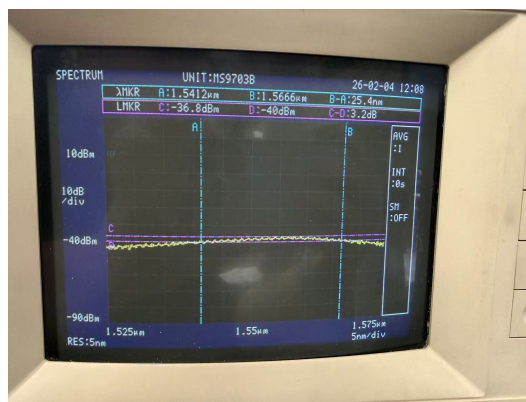
(a)



(b)



(c)



(d)

Figure 5

Voltage Probe Reading (V)	Current Probe Reading (V)	Actual Current (mA)	Photodiode Probe Reading (mV)
3.34	1.87	93.5	470
3.22	1.81	90.5	430
3.18	1.77	88.5	390
3.1	1.71	85.5	326
3.06	1.65	82.5	261
3.02	1.57	78.5	201
2.89	1.53	76.5	149
2.81	1.47	73.5	84
2.77	1.41	70.5	76
2.69	1.37	68.5	72
2.61	1.31	65.5	80
2.53	1.19	59.5	76
2.45	1.13	56.5	96
2.33	1.03	51.5	84
2.25	0.94	47	88
2.17	0.88	44	84
2.09	0.78	39	76
1.93	0.62	31	88
1.89	0.54	27	72
1.81	0.46	23	72
1.65	0.38	19	68
1.61	0.28	14	60
1.29	0.18	9	68
1.05	0.12	6	64
0.72	0.08	4	60

Imax (mA)	93.5	Imax (V)	1.87
TIR resistor (ohm)	20		

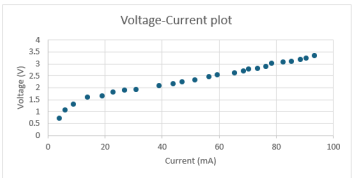
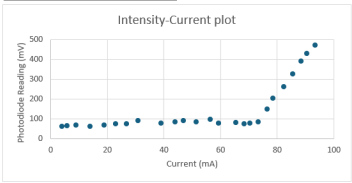


Figure 6: Raw Data