University of Technology
Laser and Optoelectronics Engineering Department
Laser Eng. Branch

Experiment No. (8)
Argon Ion Laser spectrum

Aim of experiment:

Explain how various wavelengths are selected for single-line operation in an argon laser.

Apparatus:

Argon ion laser, power meter and spectrometer.

Theory:

Figure 1 is an energy-level diagram showing the most important energy levels and transitions involved in operation of an argon ion laser. Energy levels in this diagram are identified by spectrographic notation, and principal lasing transitions are labeled with their wavelengths in microns. Energy is given in electron volts relative to the ionic ground state, which is 16 eV above the neutral atom ground state. (That is, 16 eV is required to remove one of the electrons from the argon atom.) A great many other energy states and transitions are possible for argon ions. Only those of importance in the lasing process are shown. Another ionic laser is krypton ion laser which has a similar energy-level diagram, and the processes described below also apply to krypton laser.

Lasing Action in Ion Lasers

The gain for any one of the possible laser lines in an ion laser depends upon the population inversion between the upper and lower lasing levels for that line. Lines with the greatest population inversions have the greatest gain and, therefore, the highest output power. A dispersing or tuning prism can be used inside the laser cavity to allow only one wavelength to lase at a time. Many lines may lase in a typical argon laser in the visible and UV range. Table 1 lists the strongest lasing lines for argon.

If the tuning prism is removed and laser mirrors are aligned to allow lasing at any wavelength in the overall gain region, several laser lines will produce laser output at once. In argon lasers, the strongest lines usually will lase at once, although in lower-power models one or two of these may be missing.

The other lines will not lase as they are in competition with stronger lines. Two types of line competition are illustrated in Figure 1.

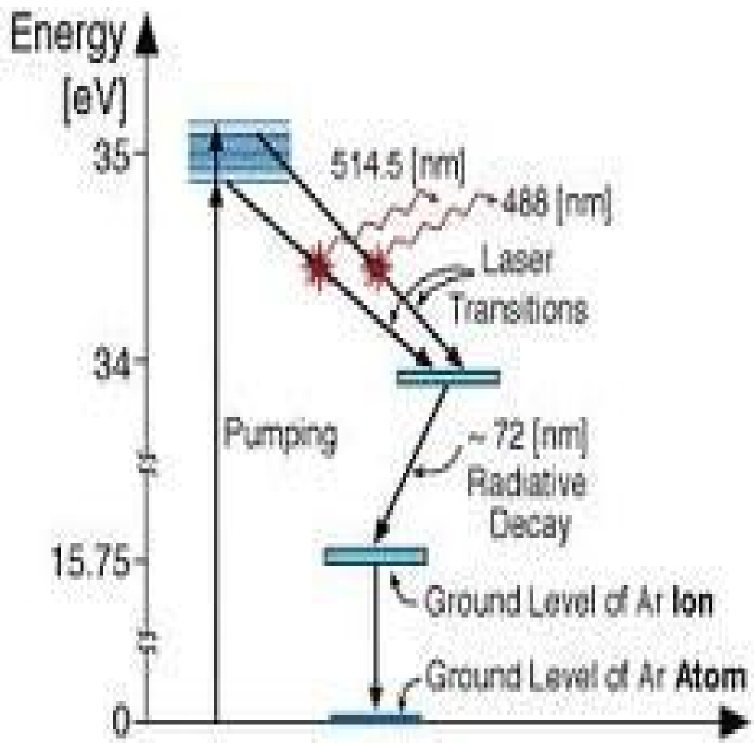

Fig. 1
Energy-level diagram of a singly-ionized argon ion relevant to operation of the argon ion laser.

The greatest population inversion and output power occur for the 488-nm and 514.5-nm lines. These lines share the same lower lasing level. When either or both of these lines produce laser output, they place ions in the lower lasing level, thus increasing its population significantly. Because other lines with this same lower level always have lower populations in their upper levels than the stronger lines, the increase in the lower-level population destroys their population inversions and they will not lase. These weaker lines produce laser output only if the stronger lines are suppressed. The 488-nm and 514.5-nm lines have this same competition, resulting in greater power for either if the other is suppressed.

Wavelength (nm)	*Relative power for specific wavelength to total power%*
514.5 501.7 496.5 488 476.5 472.7 465.8 457.9	35 5 7.5 32.5 12.5 2.5 1.25 3.75

Table 1. Representative Outputs of Ion Lasers.

Procedure:

1- Turn on the argon ion laser and align it with the spectrometer and power meter.
2- Measure output power of all lines by power meter.
3- Operate the laser multiline and use a prism by spectrometer to separate wavelengths outside the laser cavity.
4- Measure the power of each line by power meter.

Discussion:

1- Find the percentage error of each line spectrum power to the total power.
2- Explain the processes by which an argon atom in the ground state is excited to the upper laser level, and how it reaches the ionic ground state after stimulated emission.
3- What are the strongest wavelengths for argon ion laser?

Experiment No. (10)
Construction Pulsed Solid-State Laser

Aim of experiment:

Construction of a pulsed Solid-State laser system in the laboratory, and observe its pulse energy.

Theory:

Pulsed solid-state lasers use a rod of solid-state laser material as the active medium. This rod usually is composed of ruby, Nd: YAG or Nd: glass, although other materials can be used. The rod is optically pumped by a flash lamp, with the light focused into the rod by a pumping cavity. The flash lamp is powered by a pulsed power supply that contains an LC circuit for shaping the input electrical pulse. The optical cavity is usually composed of two plane mirrors mounted external to the rod. Figure 1 is a simplified diagram of such a laser.

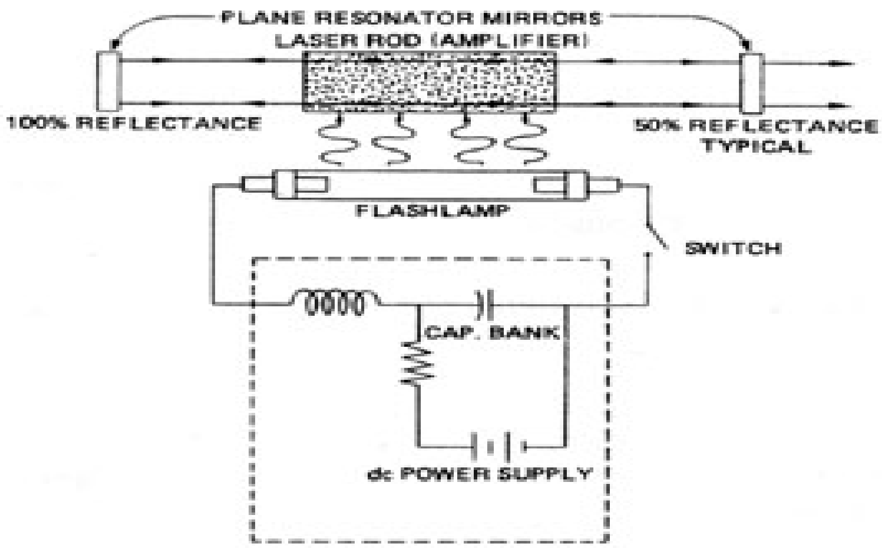

Fig. 1 Simplified schematic of a pulsed solid-state laser.

The laser rod is a cylinder of solid-state laser material with a relatively smooth ground outer surface and optically polished ends. The ends of plane-parallel laser rods are usually coated with antireflection coatings for the laser wavelength, although this is not always done. The ends are usually plane parallel

A reasonably efficient pumping geometry is an elliptical cylinder reflector with the lamp and rod mounted on the focii of the ellipse (shown in Figure 2). It can be shown that, in a plane perpendicular to the cylinder axis, a ray emanating from one focus of an ellipse and reflecting off the wall will cross through the other focus. Greater pumping efficiency is achieved with the rod and lamp as near one another as possible with an ellipse of low eccentricity.

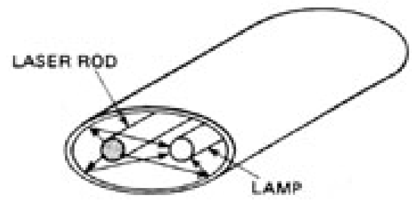

Fig. 2
Pumping geometry, elliptical reflector.

Simpler, but less efficient reflector geometry is a round cylinder with the rod and lamp as close as possible to each other in the center (shown in Figure 3).

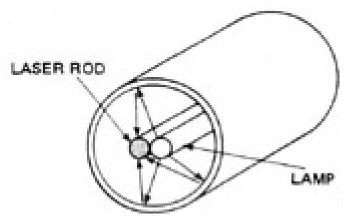

Fig. 3
Pumping geometry, cylindrical reflector.

<u>Procedure:</u>

1. Construct the laser as shown in fig.1.
2. Connect the flash lamp to power supply.
3. Align the components in the optical axis.
4. Turn on power supply and observe the output power.

<u>Discussion:</u>

1. Draw Pumping Geometries for two and three flash lamps?
2. What happens to output energy of the laser when the optical system is
   not aligned?
3. If we replace the coupler mirror with other high transmission, low transmission, what are happens for the output energy in two states?
4. Why the optical cavity of a pulsed solid state laser is usually composed of two plane mirrors?
5. What is the reason of coating the ends of plane-parallel laser rods with antireflection coatings for the laser wavelength?

Experiment No.(4)

Electrical Characteristics of Gas Discharges

Aim of experiment:

Study Electrical discharges in gases are characterized by current/voltage characteristics , operation region discharge for each laser

Theory:

Most gas lasers are pumped by an electrical discharge that flows through the gas mixture between electrodes in the gas. Collisions between electrons in the electric discharge and the molecules in the gas transfer energy from the electrons to the energy levels of the molecule. In this process, the upper levels of the laser transition become populated. To describe the requirements of the power supplies needed to drive the gas discharges, we begin with a discussion of the nature of the discharge and its initiation.

Electrical discharges in gases are characterized by current/voltage characteristics shown in Figure 1. The exact characteristics, of course, depend on the nature of the gas, its pressure, and the length and diameter of the discharge. At low values of voltage applied to the gas, there is no current flow.

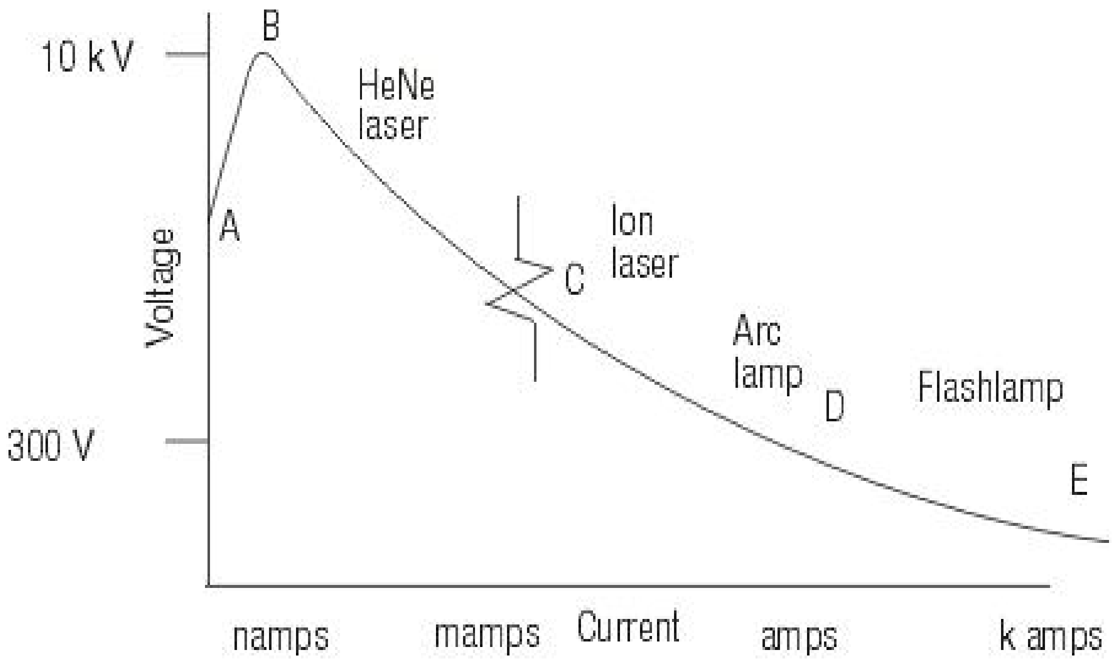

Fig. 1 Current/voltage curve for a gas discharge curve

As the voltage is increased, the current remains essentially zero until some relatively high voltage is reached. This is denoted point A in the figure. At this point a very small current begins to flow because of a small amount of ionization that is always present. This small amount of ionization is provided by the presence of natural radioactivity and cosmic rays. The small current is referred to as the pre-breakdown current. The value of the current in this region may be a few nanoamperes.

The pre-breakdown current increases slowly until a point called the breakdown voltage (perhaps around 10kv) is reached (point B in the figure). This is the value at which a large number of gas molecules becomes ionized. The conductivity of the gas is increased and the electrons are accelerated to velocities at which they can transfer enough energy to ionize more molecules through collisions. Thus as the current increases, the resistance of the gas decreases and the voltage required to sustain the discharge actually decreases with increasing current (region C in the figure). This is a condition called negative resistance. It is the behavior that would be predicted by Ohm’s law with a value of resistance less than zero.

The current would continue to increase, through region D (amperes) to thousands of amperes (region E), with less and less voltage required to sustain it. Eventually some catastrophic event would occur. Thus, the current must be limited by inserting a positive resistance in the circuit. This positive resistance, called a ballast resistor, has the effect of limiting the current and keeping it within acceptable bounds.

<u>Procedure:</u>

1-Connect the circuit as shown in Fig.(3) and connect tube gases.

2-Inecrease applied voltage to reach breakdown voltage.

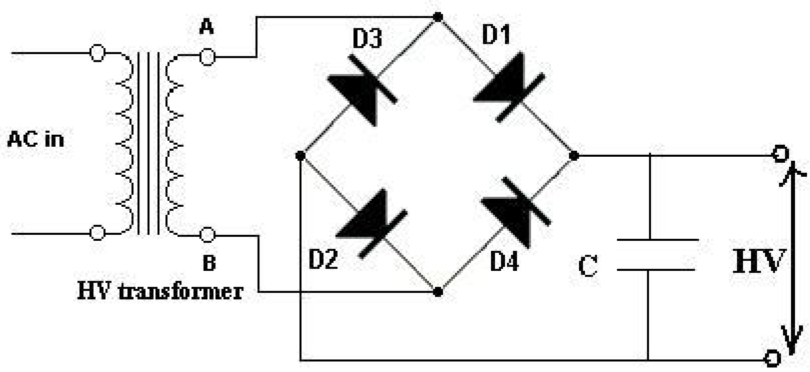

Figure 3 schematic power supply

Calculation:

1. Complete the following table:

Gas types	**Breakdown voltage (VB), V**	**Current (I) mA**	**Discharge length (d) cm**
O_2, Ar^+, N_2, H_2, Ne, He			

2. Find E/p for each gas.

Which E=VB/d

Pressure= 450 torr

Discussion:

1- Discuss E/P for each gas?

Experiment No.(3)

Flash lamp Impedance Parameter

Aim of experiment:

Study flash lamp power supply which consists of a high-voltage DC charging supply, an energy-storage capacitor bank, a trigger circuit. describe flash lamp construction.

Theory:

All electrical discharges in gaseous media, including flash lamps and arc lamps, have common characteristics, which were described in connection**.** At low values of voltage applied to the gas, there is no current flow. As the voltage is increased, the current remains essentially zero until some relatively high voltage is reached, at which point a very small current begins to flow because of a small amount of ionization that is always present. This current increases slowly until a point called the breakdown voltage is reached. This is the value at which a large number of gas molecules becomes ionized. The conductivity of the gas is increased and the electrons are accelerated to velocities at which they can ionize more molecules through collisions. Thus, as the current increases, the resistance of the gas decreases and the voltage required to sustain the discharge actually decreases with increasing current. This is a condition called negative resistance.

The power supply for a pulsed flash lamp performs a number of functions:

1- Charges a capacitor that stores electrical charge until the flash lamp is ready to fire.

2- Provides a trigger pulse that initiates the pulse.

3- Controls the flow of current during the pulse to control the pulse shape.

A prototypical circuit that performs all these functions is shown in Figure 1. The charging power supply charges a capacitor C, which holds the charge until the pulse is desired. Then the trigger circuit delivers a high-voltage pulse that breaks down the flash lamp and initiates the current flow. The capacitor discharges through the flash lamp, with the pulse characteristics controlled by the values of C, inductance L, and resistance of the flash lamp, to provide the desired pulse shape. We will discuss all these functions in turn. We will conclude the discussion of power supplies with a description of a variant method of operation called simmer or pseudo simmer.

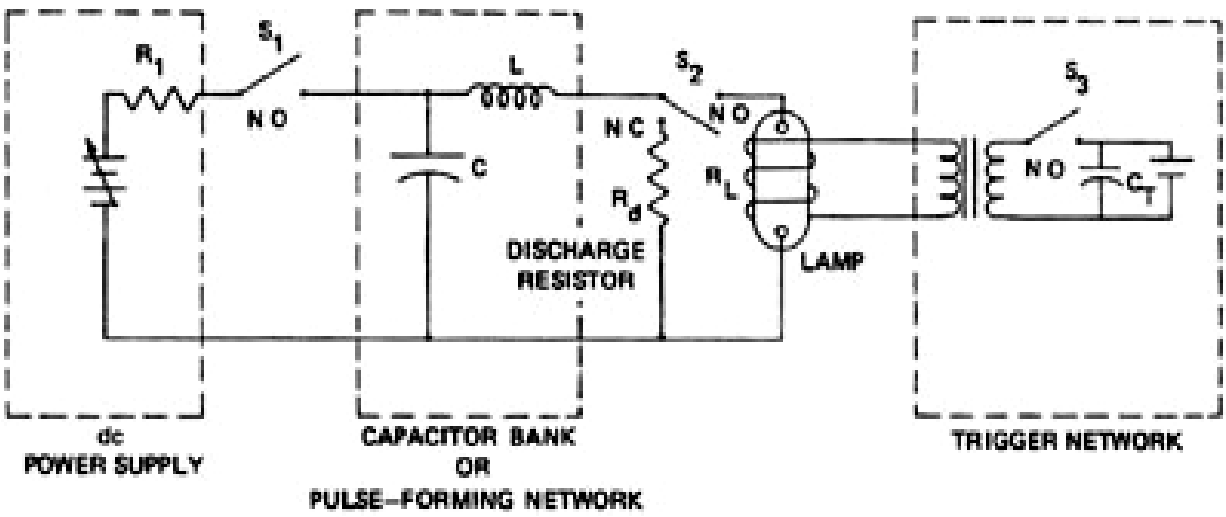

Fig.1 Prototype circuit for flash lamp operation.

Procedure:

1- Connect the power supply as shown in Fig.(1).

2-With the output of the current probe going to the oscilloscope to measurements of current-pulse duration. Charge the capacitor bank and fire the laser. Start at a relatively low voltage and increase it in steps until you reach the voltage V_o. For each step, photograph the waveform of the current pulse using the oscilloscope.. Measure the pulse duration for the current pulse from the photographs of the waveform. Record the value of the pulse duration at each step. Also for each step, record the energy input to the flash lamp.

Calculation :

1-Measure the impedance constant for flash lamp by blow equation:

$$\text{Impedance constant } (K_O) = 1.28 \ \frac{Arc\ length}{Bore} \ \left(\frac{Fill\ pressure\ in\ Torr}{Constant}\right)^{0.2}$$

(i) constant =450 for (xenon)

(ii) constant =850 for (krypton)

2-measure the electrical pulse energy as it is shown in the equation:

$$E = \frac{1}{2} C V^2$$

Discussion :

1- Describe basic flash lamp operation.
2- Describe four basic types of flash lamp trigger circuits.
3- What are the parameters which to be destroyed the flash lamp operation.

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Experiment No.(2)

Laser Diode End Pumped Nd :YVO_4 Laser

Aim of experiment:

A. Study how the reflectivity of the output coupler will affect on the cavity loss.

B. Understand how the cavity length effect on the cavity loss by change cavity loss with fixed coupling loss.

Apparatus:

1-Laser current driver, 2-aiming on optical plate 3-several output coupler mirror, 4-HR coating or 1064nm, 5-IR sensor card, 6-power meter device.

Theory:

Nd^{3+}doped yttrium orthovanadate (YVO_4) has shown a relatively low threshold at pulsed operation, early studies of this crystal were hampered by severe crystal growth problems, and as a result YVO_4 was discarded as a host. With the emergence of diode pumping, Nd :YVO_4 has become an important solid-state.

A diode-end pumped solid-state laser (DPSSL) especially single-end-pump solid-state laser with high efficiency, high output power, a good spatial beam profile, and good stability is highly desired for use in material processing and other scientific applications such as pumping other laser crystals.

Laser diode pumping has numerous advantage compared to lamp pumping including:

- Matching the laser diode emission with the absorption bands of gain medium .
- Easy to match laser diode beam profile to the fundamental laser resonator mode volume in the gain medium.
- Laser diode has high efficiency more than 30% for high power and 85% for low power .
- Lifetimes are quit high more than 5,000 hours
- Cooling system is very easy heat sink only .
- Low cost, weight , and other advantage .

The Nd :YVO_4 crystal was identified as a promising gain medium because of its many advantages such as a high absorption over a wide pump-wavelength bandwidth, a large efficient stimulated emission crosssection, a high allowed doping level and a polarized output, it has been used in high-power DPSSL more and more.

Compared with Nd:YAG and Nd:YLF for diode laser pumping, Nd:YVO4 lasers possess the advantages of lower dependency on pump wavelength and temperature control of a diode laser, wide absorption band, higher slope efficiency, lower lasing threshold, linearly polarized emission and single-mode output.

Procedure:

- Relation between reflectivity of o/p coupler and laser o/p

1. Insert the o/p coupler to short cavity position.
2. Switch on the laser aiming kit, find out the red spot of the output coupler.
3. Adjust the angle of the coupler to align the red spot to the light source of the aiming kit.
4. Switch on the power supply to (1000 mA), use the IR card to check whether the laser o/p is ready.
5. Then fine tune the o/p coupler to achieve TEM00 mode or max power o/p.
6. Use the power meter device to measure the laser power o/p.
7. Decrease the current, use the IR card sensor to measure the electric current where the laser is just emitted, that figure will be the threshold current I_{th}.
8. Record the IR laser o/p under different electric & plots the I-P graph.
9. Alter the reflectivity of the o/p coupler, then repeat above step.

Calculation:

1. Complete the following tables:

R1= 95%

I (A)	P_o (mW)	Ith (A)

Table (1)

R2 =90%

I (A)	P_o (mW)	Ith

Table (2)

R3 =80%

I (A)	P_o (mW)	Ith (A)

Table (3)

R4 =70%

I (A)	P_o (mW)	Ith (A)

Table (4)

Discussion:

1. Discuss the I-P graph and Ith graph?
2. Compare the end pumped with the side pumped ?
3. Give characteristics of mirrors (rear &coupler) for DPSSL.

Experiment No. (6)
Laser diode characteristics

Aim of experiment:

Measuring operating characteristics for a diode laser, including threshold current, output power versus current, and slope efficiency.

Theory:

Diode lasers have been called "wonderful little devices." They are small and efficient. The laser operation occurs at a p-n junction that is the boundary region between p-type and n-type materials. Such a junction can serve as a rectifying diode for electrical circuits, but it is also the critical region for laser operation. In the neighborhood of the junction, the energy bands undergo a shift. An energy barrier restricts electrons in the conduction band from flowing to the right or holes in the valence band from flowing to the left. Thus the junction has electrical rectification properties. Figure 1 shows the output characteristics of a laser diode as a function of input current. At low values of the input, the device acts as a light-emitting diode (LED), producing a relatively small amount of incoherent light. At a threshold value, where the population inversion is large enough so that gain by stimulated emission can overcome the losses, the coherent light is emitted. As current increases above the threshold value, the light output increases much more rapidly than in the LED region. Ideally, the light output should increase linearly with current, as shown in figure (1).

A relatively simple circuit suitable for driving a continuous unmodulated laser diode is shown in Figure 2.

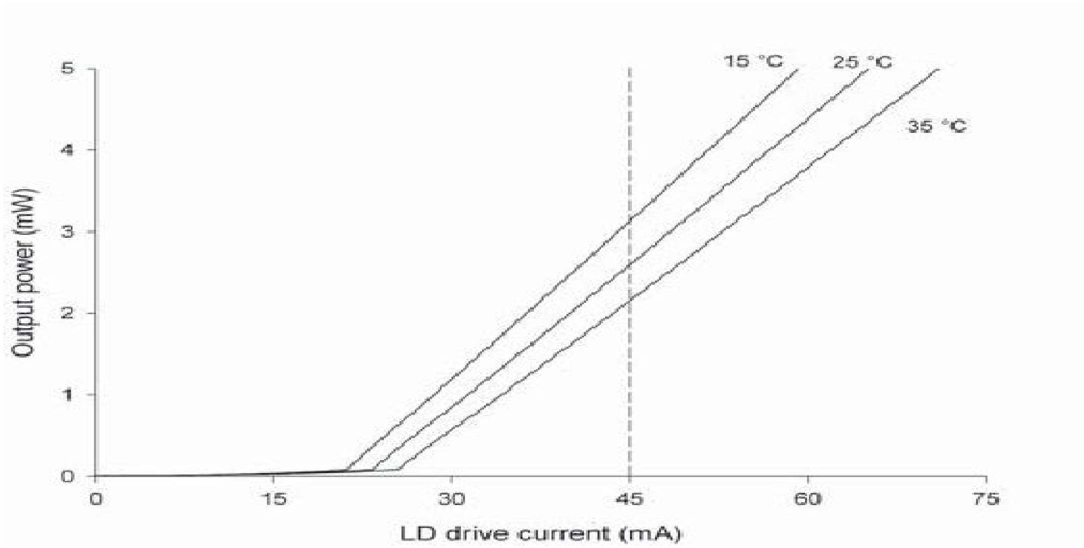

Fig.1 Schematic sketch of the output of a laser diode as a function of drive current.

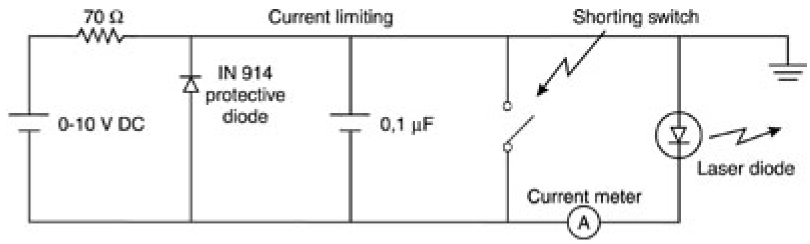

Fig. 2 Basic form of drive circuit for continuous diode laser

<u>Procedure:</u>

1- Set up the drive circuit for continuous diode laser.

2- Turn on the power supply. Then open the switch and adjust the potentiometer slowly to increase the current. Be sure to stay below the maximum value of current specified by the manufacturer. When turning off the laser, reverse the procedure. At first adjust the temperature at 15^0C

3- Direct the beam from the laser into the power meter. The distance between the laser and the power meter should be short to ensure that all laser light enters the meter. Gradually increase the current in steps from below the threshold for laser operation to well above the threshold. At each step, record the output power, the current through the diode and the voltage equal to 12V.

4- Tabulate your results in table (1).

	T= 15^0	***T= 20^0***	***T= 25^0***
I mA	***P_o***	***P_o***	***P_o***

Table(1)

5-Repeat the above steps with T= 15^0C ,20^0C and 25^0C.

Calculations:

1- Plot the output power as a function of the current through the diode for each temperature. From the plot, identify the threshold current for laser operation.
2- Identify two points on the curve above the laser threshold and in a region where the curve is linear. Calculate the slope efficiency from the equation:

$$\text{Slope Efficiency} = [(P_1 - P_2)/ (I_1 V_1 - I_2 V_2)] * 100\%$$

Where point 1 is considered to be the point with higher output; P_1, I_1, and V_1 are the output power, current, and voltage at point 1; and P_2, I_2, and V_2 are the output power, current, and voltage at point 2.

Discussion:

1- Describe proper procedures for turning on and off a continuous laser diode, so as to minimize current transients.
2- List laser diode failure?
3- How the temperature affects the laser diode operation?
4- What is the difference between laser diode and LED?
5- Is it true that laser diodes don't have a resonator?

Experiment No .(5)
Measuring the efficiency of a sealed CO_2 laser

Aim of experiment:

Study Electrical discharges in gases are characterized by current/voltage characteristics , efficiency of CO_2 laser.

Apparatus:

voltage probe , current probe , power meter co2 laser , oscilloscope.

Theory:

Lasing has been observed in a large number of molecular gases. Of particular importance is the carbon dioxide (CO2) molecular gas laser, which has lasing transitions at several wavelengths in the infrared, principally around 9.6 μ m and 10.6 μ m.

Development of the CO2 laser has proceeded at a fast pace. CO2 lasers are capable of continuous, repetitively-pulsed, Q-switched, and mode-locked operation with high energy outputs and large working efficiencies (10%-30%). Furthermore, they emit light at a frequency exhibiting little atmospheric absorption.

An important area of industrial application for CO2 lasers has been in materials processing, including hole drilling in various substances, paper cutting and perforation, cloth cutting, scribing of semiconductor wafers, and welding. In addition, carbon dioxide lasers are being used in laser-induced fusion studies, experimental optical communications and tracking systems, and in environmental testing and monitoring.

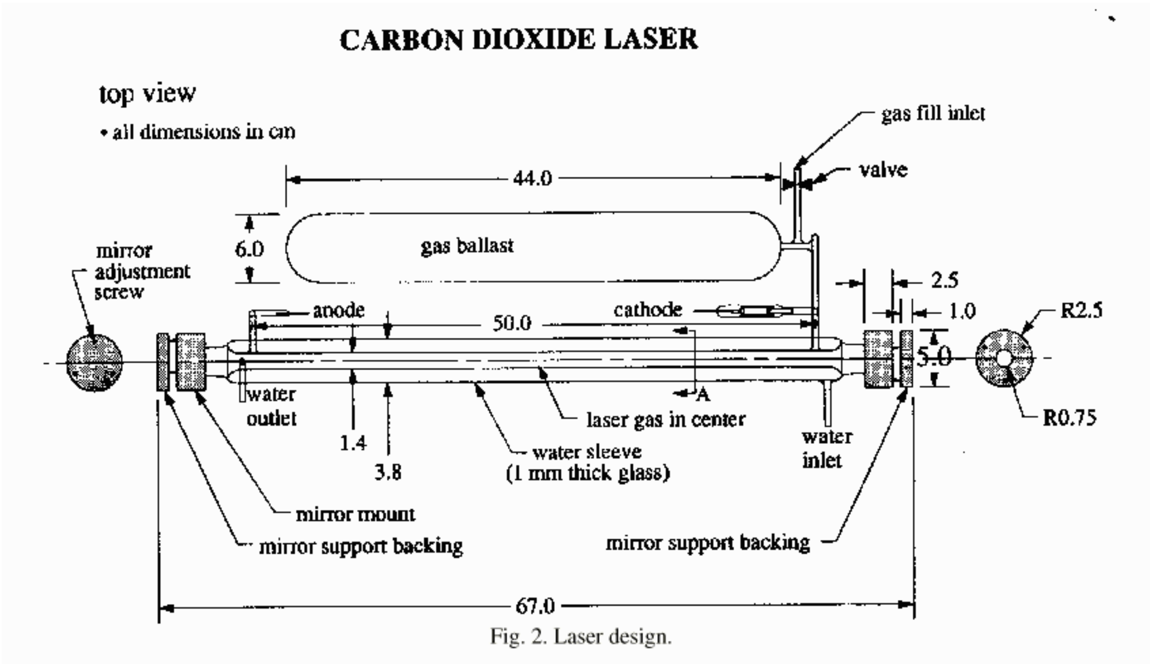

Fig.(1) Schematic of a sealed CO2 laser

Procedure:

1- Switch on power supply of the laser CO_2 .
2- Switch on the cooling system of the laser .
3- Increase the current to 10mA by step 1mA and record the power by power meter .
4- Measure the voltage by using voltage probe .

I_{in} (mA)	V_{in} (V)	P_{in} (W)	P_{out} (W)

Calculation:

1- Calculate the input power by product P_{in}=I*V .
2- Plot P_{out} vs P_{in} the slope represent efficiency of the laser CO_2.

Discussion:

1- What meaning of laser sealed and what different with other type ?
2- What importance of the He atom in the laser design ?
3- What the losses of output power in laser sealed ?
4- Explain how the output power of CO2 laser depend on water flow rate?

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Experiment No.(1)

Power Supply Characteristics of He-Ne Laser

Aim of experiment:

In this exp. , the student measure voltage operation for **He-Ne** tube.

Theory:

The excitation of the neon atoms to the upper laser level is derived from an electrical discharge. In steady operation, the discharge passes a few milliamperes of current through the gas at a voltage in the range 1-2 kilovolts. Electrons in the discharge collide with the helium and neon atoms and raise them to excited energy levels. Most of the excitation is received by the more abundant helium atoms, which easily can transfer their excitation energy to neon atoms. This produces in the neon a condition of population inversion

The basic blocks of the power supply for a typical small helium-neon laser are shown in Figure 1. The input voltage first is increased by a transformer. The high-voltage exciter circuit supplies a voltage pulse that breaks down the gas and initiates the electrical discharge through it

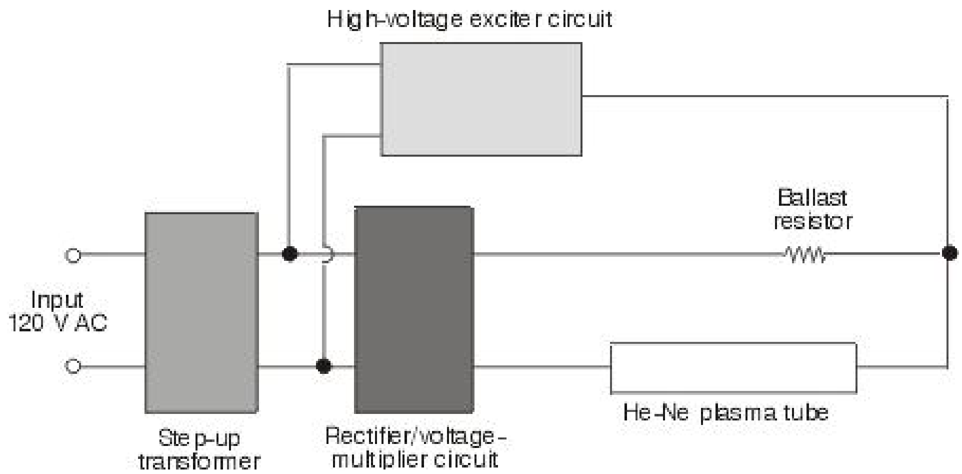

Figure .1 block diagram of power supply for helium-neon laser

Fig.(2) shows a schematic diagram of a He-Ne laser power supply. A detailed description of the operation of this supply is beyond the scope of this module. The following simplified description illustrates the three functional components of the power supply.

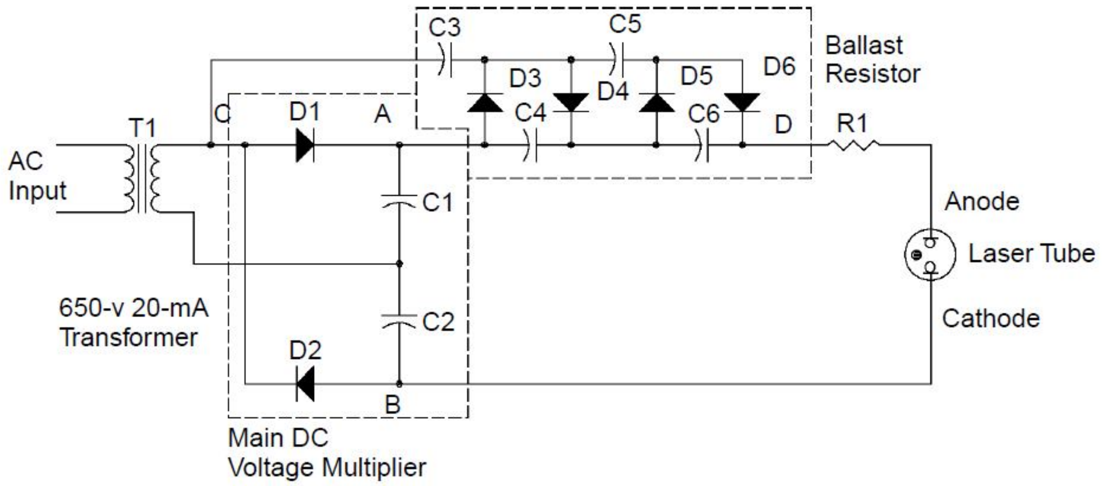

Fig.2 Helium–Neon Laser Power Supply

When the power switch is closed, current flows through the step-up transformer and it produce an ac output voltage of approximately 750V. remainder of the running supply consists of a voltage doubler-rectifier circuit that converts this ac voltage to dc voltage of approximately 1750V. This voltage is not of sufficient value to ionize the tube, but it will sustain current flow once it has begun.The starter circuit consists of a voltage multiplier circuit capable of delivering several kilovolts but no current. Once the **breakdown voltage** is reached, the tube ionizes, and the diodes in this circuit conduct the current. The voltage difference across the starter circuit becomes nearly zero, and the voltage of the running supply is delivered to the tube and ballast resistor.The value of the **ballast resistor** depends upon the degree to which the current is to be limited. If this circuit is used with the tube whose **negative resistance region**, the ballast resistance value is 300kΩ, which limits tube current to 4.5mA, resulting in a voltage drop of 800 V across the ballast resistor and a drop of 1750V across the laser tube.

<u>Procedure & Calculation</u>:

1. Set up experiment as illustrated in Fig (2). The negative terminal of the ammeter is connected to the negative terminal of the power supply. The positive terminal of the ammeter is connected to the tube cathode.
2. Refer to Fig(2). Connect the positive lead of the Volt meter to point A and the negative lead to point B.
3. With the power supply switch off and the variable transformer set to zero volts.
4. Turn on the power supply.

5. Rotate the voltage control of the variable transformer slowly until the tube ionizes and stays on. Set the voltage control for the lowest current that produces a constant discharge.
6. Measure and record in the Data Table (1) the tube current, the power supply voltage, and the laser output power.
7. Determine and record total ballast resistance (the total of the internal ballast resistance of the power supply and the added external resistors).
8. Increase the tube current in steps of 1mA, taking readings at each setting, until a current of 5mA is reached.
9. Remove the external ballast resistors from the circuit, and continue to take data at 1mA intervals until a tube current of 10mA is reached. This process may require the shorting of one or more of the internal ballast resistors of the power supply. Do not allow the tube to run more than a few seconds at currents above 8mA, as the power supply or tube may be damaged.
10. Calculate the voltage drop across the ballast resistor by multiplication of resistance times current.
11. Calculate the voltage drop across the tube by subtraction of ballast resistor voltage from power supply voltage.
12. Complete the data table.
13. Draw graph Tube voltage as functions of tube current.

Current mA	Voltage tube V	Voltage cross ballast resistor V	R ballast KΩ

Table (1)

Discussion:

1- Saturation region or negative resistance region in I-V curve of the He-Ne tube.
2- The cathode of the tube is quite large and is contained inside a large gas ballast volume.
3- List at least four transition wavelengths in He-Ne laser.
4- What is role of He atoms in He-Ne laser.

Experiment (9)

Second harmonic generation

Aim of experiment:

In this experiment a 532nm (green) light will be produced by frequency doubling of a 1064nm (Infrared) diode-pumped YAG laser, using a KTP crystal as the nonlinear medium.

Apparatus:

1. Diode laser 808nm, 500mw.
2. Collimator.
3. Focusing unit.
4. Nd: YAG rod.
5. KTP crystal.
6. Power meter.

Theory:

Second harmonic generation SHG; also called frequency doubling is a nonlinear optical process, in which the photons that interacting with a nonlinear material are effectively "combined" to form new photons with twice the energy, and therefore twice the frequency and half the wavelength of the initial photons. It is a special case of sum frequency generation.

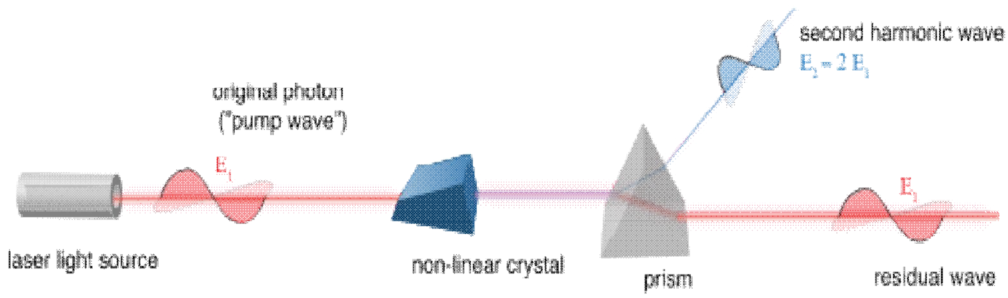

Figure 1: A typical configuration for frequency doubling.

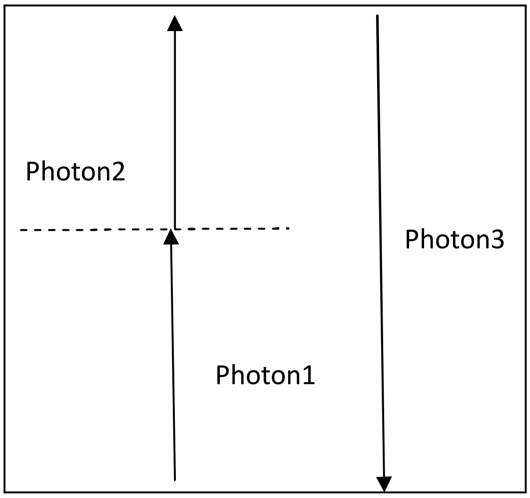

Fig.2 Formation of photon 3 from photon 1 and photon 2.

Referring to figure (2), photons 1 and 2 are identical to the frequency doubling in this case, photon 3 possesses the energy

$$E_3 = E_{2v} = E_1 + E_2 = 2h\nu \qquad \text{......... (1)}$$

$$E_1 = E_2 = h\nu \qquad \text{......... (2)}$$

Efficient frequency doubling at moderate powers (e.g. in continuous-wave operation) is often accomplished with intracavity frequency doubling, i.e., by placing the frequency doubler crystal inside a laser resonator, thus exploiting the high intracavity intensity. Frequency doubling is a phase-sensitive process which usually requires phase matching. For low pump intensities; the second-harmonic conversion efficiency is small and grows with increasing pump intensity, so that the intensity of the second-harmonic (frequency-doubled) wave grows with the square of the pump intensity:

$$\eta_{SHG} = P_2 / P_1 = C.\, L^2 .\, P_1 / A \qquad \text{.......... (3)}$$

Where:

P_1 is the power of the fundamental wave.

P_2 is the power of the second harmonic wave.

η_{SHG} is the conversion efficiency.

P_1 is the power of the fundamental wave.

L is the length of the crystal.

C is a non linear constant.

A is the area of laser spot.

The second harmonic Nd: YAG laser has many advantages over the fundamental Nd: YAG laser:

(1) Smaller focused spot size.

(2) Better absorption coefficient.

(3) Higher power density.

Procedure:

(1) Adjust a parallel beam by means of the collimator.
(2) Insert the focusing unit.
(3) Insert the YAG- rod.
(4) Insert the KTP crystal which is mounted on a holder which is inserting on a 5-axis adjustment unit.
(5) Arrange the light to go through the KTP crystal.
(6) Measure the output power of the green light.
(7) Plot the output power versus input power for the optimum angle of incidence.

Discussion:

1. Define non linear optics? What is the advantage of using such a technique?
2. What are the parameters that must be satisfied to ensure second harmonic generation?
3. What are the critical parameters affecting the conversion efficiency of SHG? Discuss their effects.
4. What is the KTP crystal and are their another types of non linear crystals or media?
5. Is the generation of a green light from Nd: YAG laser using a KTP crystal the same as obtaining a red light from a white light using a piece of glass?
6. How could you get a double red laser? Is this wavelength achieved by intracavity frequency doubling?
7. An Nd: YAG laser pulse of (2.5 Mw) peak power and (20ns) width is incident on a nonlinear crystal with a conversion efficiency of 10%. What is the conversion efficiency of this crystal if the width of the pulse is compressed to (10 ns)?

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Experiment No. (7)
Studying the characteristics of Pulsed mode diode laser

Aim of experiment:

In this experiment, the output wave form, pulse duration and amplitude of the drive current signal for the diode laser will be studied, and the maximum value of frequency carried out by the laser diode will be determined.

Apparatus:

1. Pulsed laser diode.
2. Oscilloscope.
3. Current probe.

Theory:

Pulsed laser diodes have their roots in military applications. They are ideally suited to range finding because of their short pulse widths and high output powers. Improvements in technology and cost efficiency have opened up new areas of application in metrology and medicine.

The input power requirements for semiconductor diode lasers are much more modest than for most lasers. Instead of the kilovolt power supplies encountered with gas and solid-state lasers, diode lasers typically are powered by a few-volt battery. The semiconductor laser is a current-controlled device, rather than a voltage-controlled device. The power supply, or driver, as it is commonly called, must simply furnish a well-regulated and controlled supply of current, often in the range of 100 milliamperes or so. Ideally what does one desire for a laser diode driver circuit? Important features include: High stability, Good control, Low noise, Current-limiting to avoid accidental overdriving of the diode, Slow starting and filtering to avoid transient current pulses, Capability for modulation.

A relatively simple circuit for driving a pulsed laser diode is shown in Figure (1).The capacitor is charged while the silicon-controlled rectifier is open-circuited, so that the laser diode is not in the circuit. Then the silicon-controlled rectifier is triggered by a voltage pulse. When the silicon-controlled rectifier closes, the capacitor discharges through the path that includes the laser diode. The resistor in series with the discharge (perhaps 2 ohms) limits the current and helps to reduce ringing. The protective diode also helps to suppress ringing.

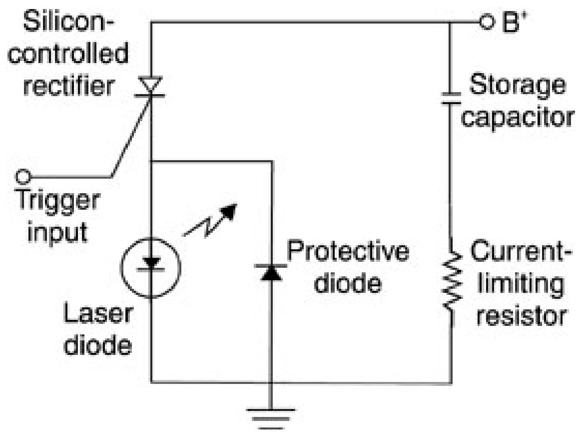

Fig.1 Block diagram of simple circuit for pulsed laser diode operation

Procedure:

1- Connect laser diode to its power supply.
2- Connect the current probe along the path of the derive current.
3- Connect the coaxial cable of the current probe to the scope.
4- Turn on the power supply.
5- Turn on the scope.
6- Select a value of current. Display the current signal related to this current value on the scope and measure the amplitude and pulse duration of it.
7- Repeat step 6 for three different values of current.
8- Select other values of frequency, repeat step 6 and 7.

Discussion:

1- What is role of silicon control rectifier (thyristor) in the power supply?
2- Design oscillator circuit that gives you a 200ns and 1 kHz.
3- List three applications for this laser.
4- What are the main differences between pulsed and CW operation of laser diode?