**Semiconductor Optoelectronics**
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**Lecture - 39**
**Practical Laser Diodes and Handling**

Today, we will discuss about practical laser diodes that is practical device. How the device looks like? What kind of packages and what kind of specifications? If you see typical data sheet or a specification sheet, do you understand what the parameter standard for? We will also discuss about handling issues, there are some safety related issues safety to the device as well as safety to the user and these issues we will discuss.

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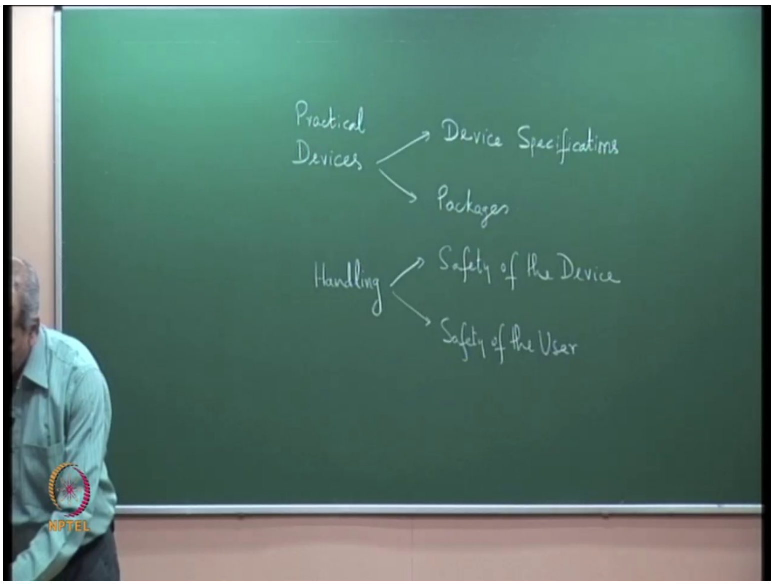


So, practical devices, so devices so in devices I would like to discuss about device specifications, so practical devices. Practical device specification and device packages, what kind of package are used? In handling, there are two issues which is safety from the device and safety of the user, which is safety from the device and safety of the user. Let us start first with the device specification. So, let me keep a typical laser device specification.

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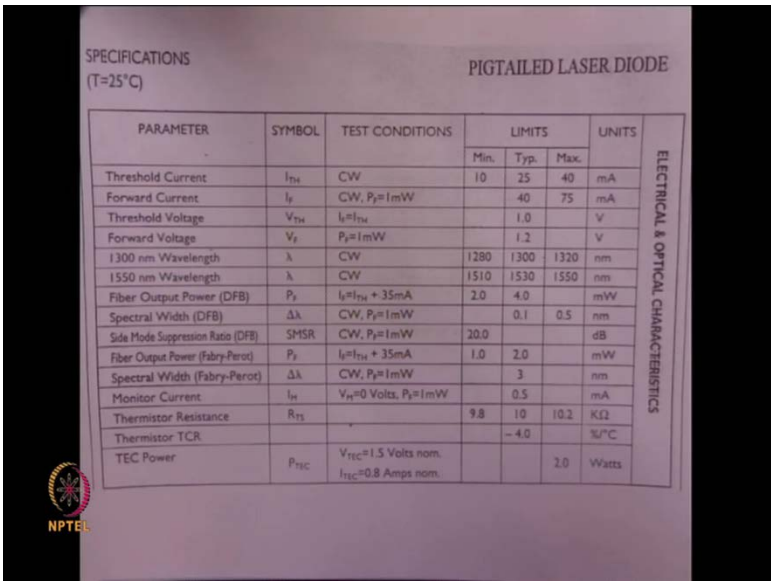

SPECIFICATIONS
(T=25°C)

PIGTAILED LASER DIODE

ELECTRICAL & OPTICAL CHARACTERISTICS

| PARAMETER | SYMBOL | TEST CONDITIONS | LIMITS | | | UNITS |
|---|---|---|---|---|---|---|
| | | | Min. | Typ. | Max. | |
| Threshold Current | $I_{TH}$ | CW | 10 | 25 | 40 | mA |
| Forward Current | $I_F$ | CW, $P_F$=1mW | | 40 | 75 | mA |
| Threshold Voltage | $V_{TH}$ | $I_F=I_{TH}$ | | 1.0 | | V |
| Forward Voltage | $V_F$ | $P_F$=1mW | | 1.2 | | V |
| 1300 nm Wavelength | $\lambda$ | CW | 1280 | 1300 | 1320 | nm |
| 1550 nm Wavelength | $\lambda$ | CW | 1510 | 1530 | 1550 | nm |
| Fiber Output Power (DFB) | $P_F$ | $I_F=I_{TH}$ + 35mA | 2.0 | 4.0 | | mW |
| Spectral Width (DFB) | $\Delta\lambda$ | CW, $P_F$=1mW | | 0.1 | 0.5 | nm |
| Side Mode Suppression Ratio (DFB) | SMSR | CW, $P_F$=1mW | 20.0 | | | dB |
| Fiber Output Power (Fabry-Perot) | $P_F$ | $I_F=I_{TH}$ + 35mA | 1.0 | 2.0 | | mW |
| Spectral Width (Fabry-Perot) | $\Delta\lambda$ | CW, $P_F$=1mW | | 3 | | nm |
| Monitor Current | $I_M$ | $V_M$=0 Volts, $P_F$=1mW | | 0.5 | | mA |
| Thermistor Resistance | $R_{TS}$ | | 9.8 | 10 | 10.2 | KΩ |
| Thermistor TCR | | | | – 4.0 | | %/°C |
| TEC Power | $P_{TEC}$ | $V_{TEC}$=1.5 Volts nom. $I_{TEC}$=0.8 Amps nom. | | | 2.0 | Watts |

It is a big slide there, but I hope you can see that. Let us first see the specifications one by one is these specifications at T equal to 25 degree C. It is a pigtailed laser diode, fiber pigtailed laser diode. What it means, I will show you in a minute, fiber pigtailed laser diode. So, the first parameter which is in written is a threshold current here. I threshold, test condition C W, C W is standing for continuous wave mode of operation.

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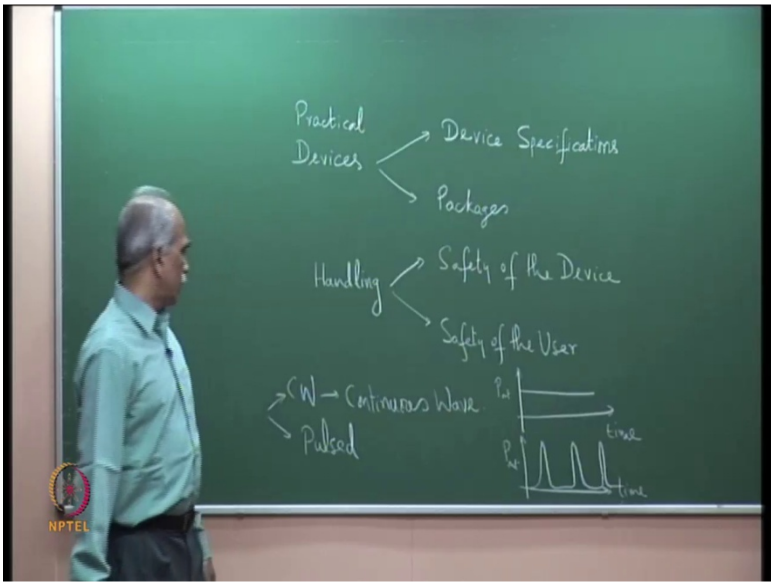


The laser can be operated in C W mode, C W standing for continuous way and pulsed, so two modes of operation for all laser diode C W for continuous wave and pulse. So, C W means if a plot with time times verses power. So, P out if you plot you will have a certain level fixed that is C W continuous wave and if you for pulse laser, if you plot time verses power, P out then you will have power varying and so on. That is a pulsed output, P out verses time.

So, C W and pulsed, so the threshold current typical parameter that you can see the its 25 million here, C W units are given 25 million here. Minimum is 10 maximum is 40 because there could be some variations in device, therefore usually these specify minimum and maximum. Forward current that is the operating current I f for C W to get 1 milliwatt power P out of 1 milliwatt, you pass a current of 40 million ampere. At 40 milliampere, if 25 milliampere is the threshold current that is when power output starts, then at what has been shown there is this.

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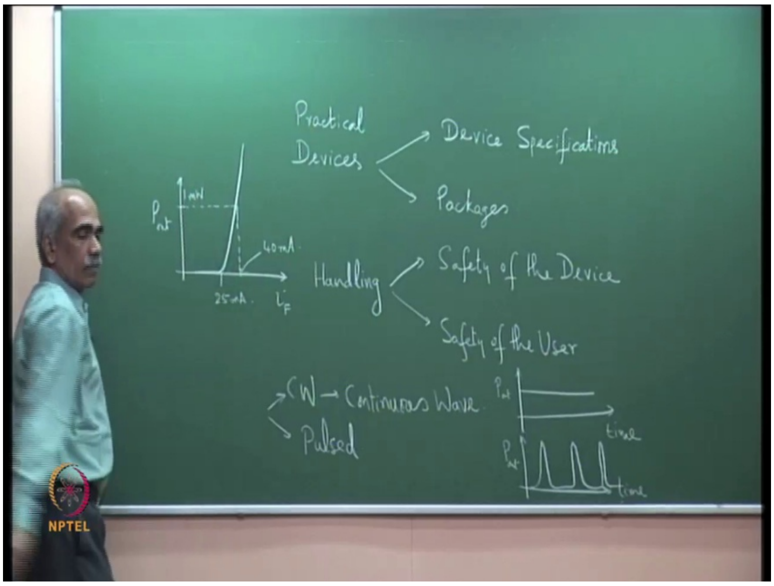


So, we recall the characteristics that we have i F forward current verses P out and we have almost we have almost zero output and then output going like these. So, this is the threshold value so in this particular example 25 m A is here. And when the output is when the current is 40 m A here, 40 m A output is 1 milliwatt. So, we understand these and to get 1 milliwatt you may require some times 75 m A, because that there may be some device degradation, but typically about 40 with the ampere. Forward voltage the voltage because it is a forward diode and it is a diode forward by, its diode for one voltage is 1.2 volt wave length. There are 1,300 nano meter wave length 1,550 nano meter wave lengths.

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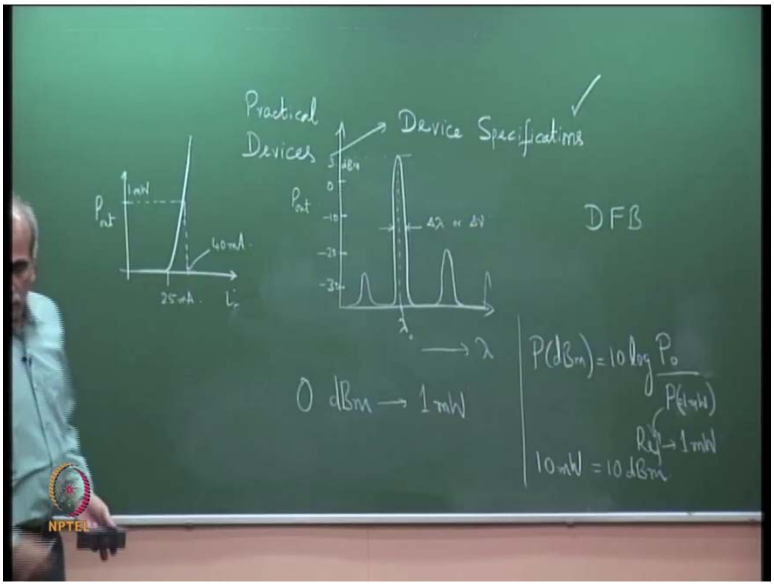


So, 1300 nanometer typical wave length is here maxi minima and maxima that is plus minus 20. It does not mean a particular device will give that the particular device when maintain that a particular temperature and current will give a fixed power output and a fixed wavelength, but in a moth that is in a batch of several devices, some devices may have slightly varying characters. That is what they mean by minimum and maximum. So, fiber output power these 1,615 nanometer C W and this is the typical output and fiber output power for a D F B laser D F B here we have familiar have D F B now distributed feedback. The forward current forward current of I threshold plus 35 milliampere you have an output of 4 milliwatt is the output.

And the spectra width of the D F B so we know now D F B laser distributed feedback. So, I am discussing this, so let me today is the remaining ones. D F B laser, the spectra of width as you can see the spectra of width for the D F B and fabric pair are very different, distributed feedback laser. The output is the output of a distributed feedback laser, if you recall that you have some side lops. So, what have plotted this frequency mu or wave length lambda. Normally in light we discuss in terms of wavelength, so wavelength lambda here, verses the power output. So, P out, this is full width at half maximum. So, whatever is full, so at half maximum is delta long back here.

So delta lambda or delta mu and this is the central wave length, lambda c or lambda 0, the central wave length of the D F B these are power in. So, typical power if you see here that this may be 3 d B 0 d B m, so 3 d B m, so 3 d B m this is 0, this is minus 10, minus 20, minus 30, d B m d B m and I hope you know the definition of d B m. 1 d B m is 0 d B m here refers to implies 1 milliwatt, the power in d B those of you are not familiar power in d B m is define as 10 log of P here in milliwatts, so in watts here divided by with respect…

So, P 1 by P 2 whatever is P 1 by P 2. So, here 10 log P 1 by P 2 here. P 2 is reference and therefore, so P 2 is reference to 1milliwatt. This is the extra output power output. So, P 1 by these is the definition in general but definition of d B m is P out actual power with respect to P 2 here that is equal to 1milliwatt. What it means is if the output power is 10 miiliwatt, those of you are not familiar, if the output power is 10 milliwatt, then if in the denominator is 1 milliwatt, these ratio is 10, so log 10 is 1. So, multiplied by 10, so this is 10 d B m equal to 10 d B m.

So, 10 milliwatt power is equal to 10 d B m. If the output power is 1 milliwatt, so if you substitute 1 here this is 1, log 1 is 0, so 0 d B m. So, 0 d B m is 1 milliwatt and so on. Please, those of you are not familiar puts on numbers and be familiar with it. So, the fiber output here is in these case it is given milliwatt. So, 4 milliwatt the spectra of width delta lambda is given here for C W at 1 milliwatt power is 0.1 nanometer, delta lambda is 0.1 nanometer. If you look at fabric parolises, normal fabric parolises it is about 2 to 3 nanometers this been a D F B laser the spectra line width is very narrow. Then you see the side modes of spectra ratio I have discussed about these for D F B S M S R at C W output of 1 milliwatt that is S M S R is 20 d B, 20 d B is the ratio of these power to these power.

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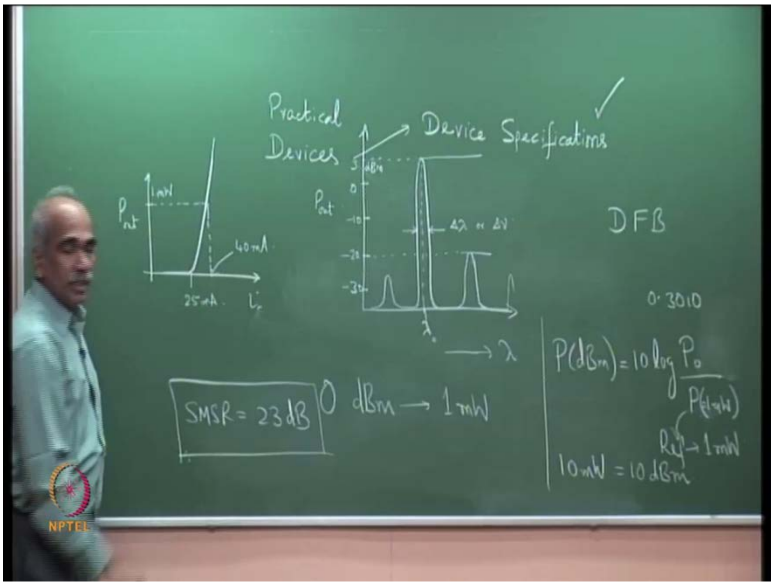


In my diagram for example, this is 3 d B m and this is minus 20. Therefore, what is the S M S R, so S M S R is equal to 23 d B. In my diagram it is 23 d B output is 3 d B m 3 d B m those who are not familiar is 2 miiliwatt 2 milliwatt is 3 d B m you put here log of 2 milliwatt by 1 milliwatt, log 2. Log 2 if you know the number these 0.3010 multiplied by 10 is 3.01. It is 3 d B m, all right? So, 3 d B m is 2 milliwatt here and the power in the side lop is minus 20 d B. So, the difference is 23 d B, these is the ratio. So, please see these d B is not d B m S M S R is the ratio so it is in d B.

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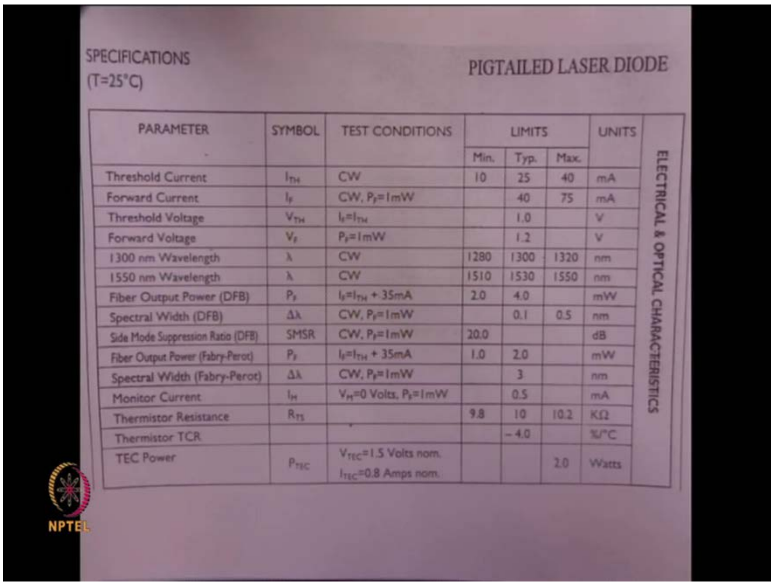

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| Thermistor TCR | | | | -4.0 | | %/°C |
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So, if you go for the the spectral width for a fabri pero is given here 3 nanometer. Just now I mention for a fabric peroliser the spectral width is delta lambda equal to 3 nanometer. So, typically 2 to 3 nanometer is for a fabric pero and 0.1 or less if the current D F B lasers have given much less than 0.1 nanometer has the line width. The next one is monitor current. You see is as a parameter return monitor current at V m equal to 0 volt that is monitor voltage is equal to 0 output power equal to 1 milliwatt, the monitor current is 0.5 milliampere.

I will discuss these in a minute. So, let me finish their remaining parameters here, thermistor resistance, there is a thermistor here and the resistance of the thermistor is given 1 kilo ohm typical and thermistor temperature coefficient of resistance. These two are required to maintain the temperature of the device. I will discuss in a minute, but you can see thermistor temperature coefficient of resistance is minus 4 percent per degree centigrade, which means as temperature increases thermistor resistance decreases. If its minus 4 percent of the resistance, if originally if it was 100 ohms of the thermistor, then one degree increasing is minus 4 percent.

That is it will come down to 96 ohms. So, the temperature is changing at the resistance is changing with temperature that is the temperature coefficient of resistance. And this is the T E C power that thermo electric cooler power, all laser diodes are operated with a temperature controller. It is a T E C that is thermo electric cooler, the power taken by the cooler is typically about 2 watts. So, this is a sheet of specifications. So, we now and we look at the specification, the only thing I have not discuss so far is the monitor photo diode and the thermistor.

We will come to this in a minute all right? Let me show, let me discuss the packages and then I will come to these monitor photo diode. All right, maybe I will first monitor photo diode because when we go to packages also you will see that there are leads which are connected to thermistors and monitor photodiode. So, it is better to discuss the monitor photodiode are written. So, if we see the typical data sheet and if we understand all the parameters technical parameters of a device, it means that we have reasonably understood that device and its operation. Otherwise, if thinking means we know only the theory. We know only the theory, we have no idea about what is it in practice.

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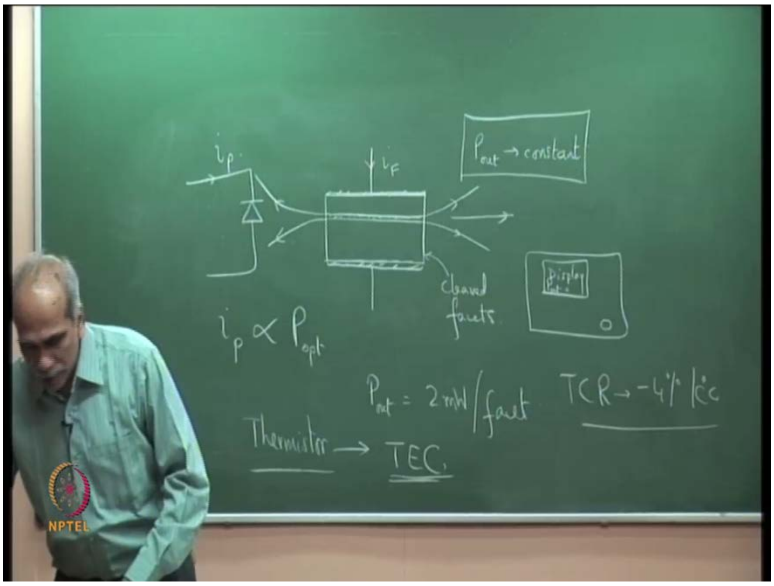


So, let me take device package, the thermistor. You see here the monitor photodiode. What is this monitor photodiode? A typical fabric peroliser or DMP laser, so you have, I have shown only the active region and other layers are understood. So, I am not showing it again. This is our active region and the current is flowing here and output is coming, output is coming from here. Please see, these are cleaved facets 32 percent reflection both the sides.

So, obviously output will come from both directions. Output comes from both the directions in a laser diode. In fact the early laser diodes in the specification it used to be today, it does not say it is simply says output power. In the early laser diodes it was always specified pout equal to 2 milliwatt per facet. In the 1970’s and 80’s the power was facet, means surface which means, 2 milliwatts, the watts come from here and 2 milliwatts come from here, two directions. But, in any application we need light coming from one direction. You do not imagine a torch light or light is coming from in front and behind.

So, you want light to come from one direction normally and therefore but in a normal device light will come from both the directions unless you code. These, code this is with a mirror, which is a difficult proposition expensive proposition. Therefore, what is in turn is this output is incident on a photo detector. I am showing this photo detector as a diode here, which is actually integrated with the chief. But I am showing it as separate. The output is incident on a photo rejector. The photo rejector will generate a reverse current i p. What is the advantage by measuring these current i p?

These i p is proportional to incident power, the i p, the photo current reverse photo current is proportional P optical power incident on it. Therefore, by measuring these i p, we can find out what is the power which is coming, we can calibrate it. Then we know simply by measuring the current we know what is the output power. What is the advantage? The output power coming from the other side is the same as the output power which is coming here. So, if you know this you know the output without disturbing the output when the laser is on, you know what is the output power?

So, today’s laser drivers we have an output here, and there is a display here. We displayed in, the display there are several parameters which comes, but it also tells you what is the P out? How will it say, what is the P out because output is coming from here, without measuring these P out. How does it says it is P out? It is saying these P out by measuring the power coming from the other end. So, monitor photo diode and the monitor current is very important measure for the device.

Why, if you want to maintain power constant, many applications require that the output power P out should remain constant. If you monitor the photo current here, you can find out what is the power which is coming. If the monitor current starts dropping, it tells you that the output is dropping. Even without measuring separately what is the output coming from here. So, the output power is constant is if the monitor current is constant. So, this monitor current is independent of the output which is coming from the device.

So, by monitoring this current, you can find out what is the output is not just finding out the output. If the power starts falling down the current starts dropping here, then there is a feedback which is given. So, that this current I is increased. So, that the output again is jacked up, when the power start dropping, the monitor current drops. That is why it is called monitor photo diode and monitor can these monitoring continuously, as the current drops. For whatever reason if the output goes down, you can increase the power current or the bias current to the diode and raise it back. So, that the output power remains a constant.

This is very important in the case of constant output power devices. The monitor current is the one which gives you the different signal. So, that by bringing maintaining that the different signal constant you can maintain that the output power constant. So, that is the the monitor photo diode. So, these photo diode is integrated with the laser shift and. There are terminals provided for the monitor photo diode separate terminals. When I talk about the device package, I will show you that there are terminals provided for the photo diode. So, that you can also take out the current for some other external circuit which will maintain that current, it will maintain the power out constant by measuring the different signal or the change in the monitor current.

This is the monitor photodiode. The second thing that we encountered is thermistor. The thermistor is a temperature dependent resister. Thermistor is nothing but temperature dependent resister with a temperature coefficient of resistance. It is a temperature dependent resistant resistance which means, if you change the temperature the resistance changes and this thermistor is also integrated along with the laser chip in the same chip. So, that if the temperature of the chip changes that means, if the temperature of the laser diode changes, their will a change in this resister.

The change in resister is can be used as a different signal again to far to that thermo electric cooler TEC thermo electric cooler. The change in resistance of the thermistor can be used to power thermo electric cooler. What is that thermo electric cooler? The Pelteir cooler, were by passing a current you can change the change the temperature between two junctions a two junctions sitting at two different temperatures will give raise to a voltage signal and by changing the current you can change the voltage or by changing the voltage you can change the temperature.

So, these TEC is a thermo electric cooler based on the junctions and the current to this TEC. The TEC the was consuming about 1 watt power. The current to this TEC can be controlled by this resister, temperature dependent resister. So, that if the temperature of the chip changes the resistance changes and therefore that the temperature (( )) there was a parameter TCR, which was minus 4 percent per degree centigrade, which means, if the temperature changes to 1 degree the resistor changes by minus 4 percent that is it decreases. All these thermistors are basically photo conductors. If you increase the temperature, the resistance drops because more number of carriers are generated, thermal generated carriers, and therefore resistance drops. That is why you see here, minus there is a minus 4 percent.

So, that controls the current, which goes to the TEC and TEC can again pass more current and make it cooler. So, that the temperature is maintaining. So, both the thermistor and monitor photo diode are to maintain constant temperature and constant power of output of the device. So, we have seen now, all the specifications here. So, let me remove this and we go to the device packages. So, we understand now, all the specification which are there. There are some more specifications in data sheets of certain manufacturers. I would not go into those details these are the basic things, which are there in general in almost of all lasers in all lasers diodes. There may be specific parameters relevant to specific devices in edition.

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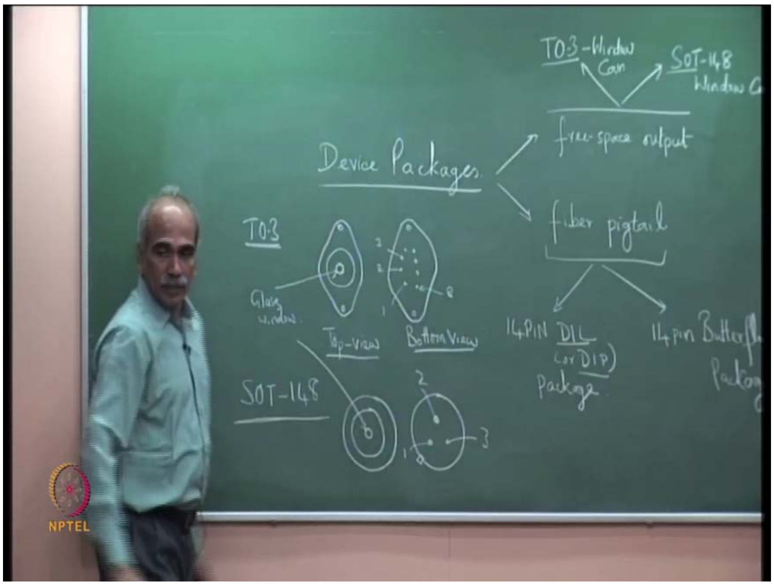


So, let us look at device packages and then will go to handling. All the packages either they free space output. So, free space output packages which gives free space output or packages which have fiber pigtail. Almost all the laser diodes used in communication or fiber pigtailed laser diodes, because we can directly splies it to the fiber, which is on the line. Fiber pigtail or free space output. Fiber pigtail output there are two specific packages here; one is called the 14 pin DIL dual in line or sometimes DIP 14 pin DIL package.

Usually for low power applications and for high power applications it is variable 14 pin, 14 pin butterfly package. I will show you, this I have brought a butterfly package the DIL. I will show you, this is just like an I C typical I C. The free space output here, there are two common packages, which are used one is called TO3 window can package and the other one is SOT 148 window can. The four types of packages which you see in common, so first let me show the TO3 window package.

So, TO3 find out what are the, it may be interesting to find out what are the abbreviations standing for, you find out what are these TO3 and SOT 148? So, the TO3 package look like typical power and power transistor those of you, were seen power transistor it looks almost the same shape. I hope you have seen the power transistor in a top view. There are two holes here to mount the power transistor. These are slots to mount these is the top elevated, this one and the bottom looks like this.

Typically 8 pin, these are 8 pin these are 8 pin devices. This is the bottom view, so top view and bottom view. The pin start from one from here. One, two of course, these are all provided in the data field and 8 comes here. It is usually in clockwise direction when you looks from the bottom 1, 2, 3, 4, and 8. That is top and at the top there is always a window. So, this is a glass window. So, here this is glass window that will need a glass window to the light to come out.

So, light comes out from here in this direction. So, this is the light comes out perpendicular to the board. There is a glass window otherwise, it look keep the glass window was not there it just like power transistor. So, there is the glass window from which light comes out like this. I will show you the next one, SOT 148 because I also have those SOT 148 packages. So, I will you will this is SOT 148 this looks like this, the top it is circular. The top view is this with a window if we place these.

Transistors electronic transistors diodes and auto electronic components like laser diodes. There is no difference except, that there will always be a glass window on top. Because light has to come out from the source and for a photo detector light has to be incident. Otherwise they look like just can of a transistor, that familiar device. So, I will show you in a minute. So, these is the top and from the bottom. There are different four pin devices three pin devices. So, usually there is a cut provided, which will tell you that this starts with 1, 2 and 3 also. But others will not have a opportunity to see this. So, it is more important for the others.

But never well as DOP people also can come, come at 12 o clock, if you are free? After 12, it is just after 11 to 12 class, you come okay? All right, let us continue, so these is the top view and these is the glass window as before. So, here is the glass window and these are the bottom view here. So, I will show the packages, we can see the packages here. We are not suppose to touch those but there are one out two things, what I have kept along with this is a normal LED here. An LED which is 2 pin diode light emitting diode and this is this is a point one. So, I can touch that, but it is important that you see that that there are three terminals there. There are three terminals and this are the same three terminals here. 1, 2, 3 and that is the bottom view and the top view. As you can see there is a glass window in each one of the devices. This is a laser diode used in c d writing device. And from these is an output power of about 20 million watts.

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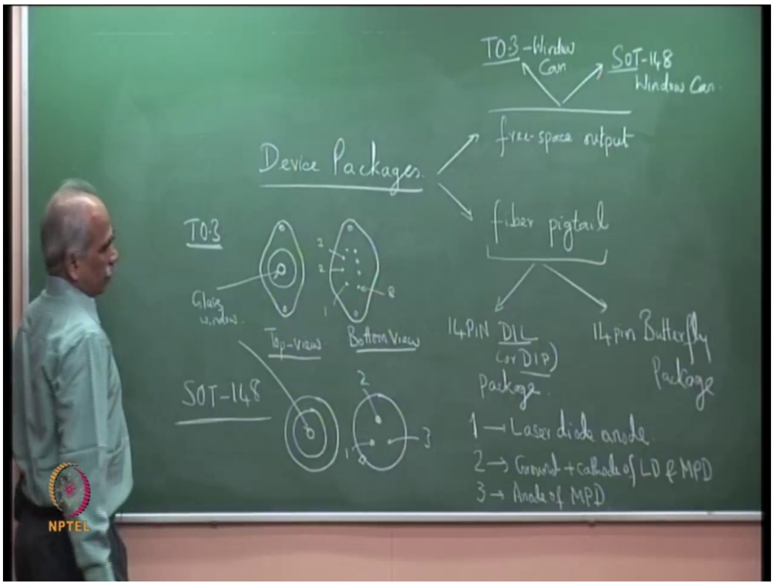


These small device give about power of 20 milliwatts. There are 3 3 terminals, there are like this the first one is 1, let me write 1. Laser diode anode, laser diode anode 2 is common ground. Ground that is case ground ground plus cathode of cathode of laser diode and monitor photo diode. M P D, I am writing MPD monitor photo diode. Cathodes of LD and MPD and 3 is the anode of anode of monitor photo diode. I will show a schematic, how it looks like? Where can I show all right? Because, next we will discuss the so it looks like this, is a three terminal device.

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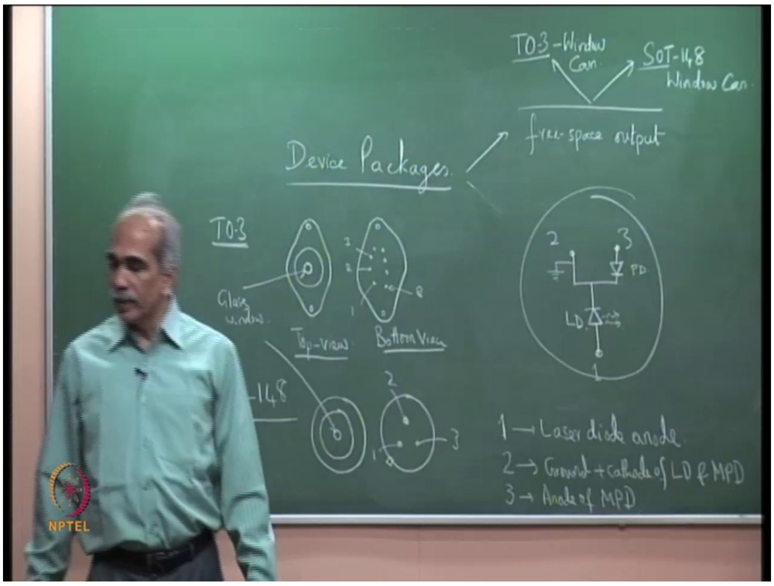


So, this is one the laser diode terminal 1, this is terminal 2, which is actually grounded to case ground. This is case ground and here at terminal 3 we have the monitor photo diode. So, anode of this is 1, 2, 3, this 1, 2, 3. Now, I have showed is 1, 2, 1, 2, 3. 2 is so we said common cathode here. This is the monitor photo diode, so this is the photo detector MPD and this is the laser diode. So, the three terminals that you see on the device here, the three terminals or I hope you can see all the three terminals and that this is a used one its defective one.

So, you can see that, that is now not really is a is a good view, because you will not see the lead if I completely keep it. It is sitting in that slot. Now I keep in but do not touch the device, why you should not touch? I will discuss in a minute. So, this is the SOT 148 package, typical laser diode. If we give you there is a small another small laser diode here, it is a low power 1 and let me take it out and you can see, just it is just like a transistor. There are three terminals is like a transistor except that at the top there is a glass window. In a transistor you simply have a cane metal cane there is no window. Here in every opto electronic device there will be a window at the top.

Let let me go next to the other two packages. We have to wined it up and very important of the DIL and the butterfly package. Again I have brought a butterfly package to show you. It is also a used one the defective one, otherwise cannot touch these. Let me take this out and show you, the butterfly package and you will know why it is called a butterfly package?

It is a fiber pigtailed device. This is a fiber pigtailed butterfly package. I hope you can see, so what you have is a 14 pin device, you can see seven pins seven pins on other side and fiber is coming out. So, this is already pigtailed to a fiber and this is the connectorized output of the fiber, because in all fiber opto electronic instrumentation, you need connectorized output. And therefore fiber end is connectorized. And here is the butterfly device. It is called butterfly because when butterfly opens its wings it looks like so it is looks like wings of the butterfly.

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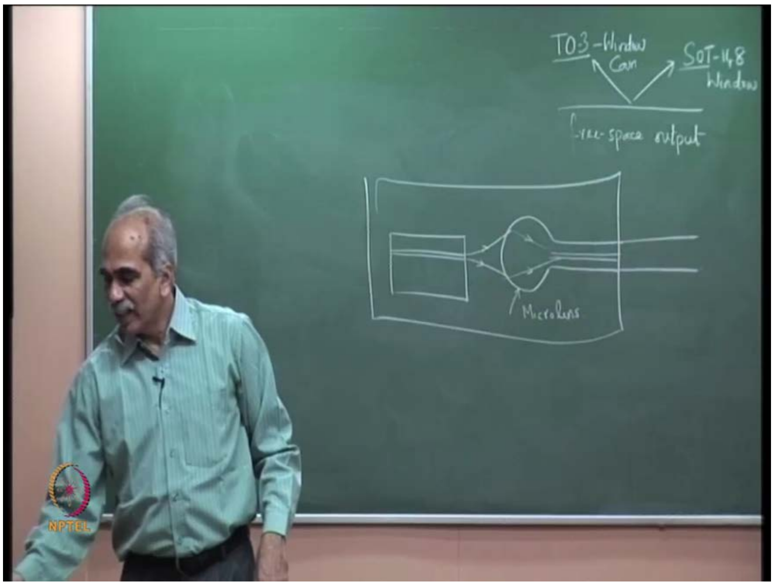


Hence, the name butterfly and fiber pigtail fiber is already pigtailed here. Pigtailed means, if you had a device which is coming out here, there is a device coming out the light which is coming out here. Then the fiber, there may be micro lengths usually there are different techniques of coupling light in to the fiber. The fiber end is the micro lengths made at end of the fiber. This is the optical fiber micro lens is of micro lens the fiber end is made in the shape of micro lens. So, that the light is which is coming out of the diode is immediately couple into the fiber cote.

So, and the whole thing is sealed. So, that there is no relative this placement it is already completely ready and the fiber is coming out from here. So, this is called fiber pigtail. Fiber pigtail it is a diode its device where the fiber is already aligned, pre aligned and formatically sealed its pre aligned and sealed in the package. So, this has 14 pins, I will show you another diagram. This is a very nice device because you can see its bottom. It can be mounted with 4 screws on a heat sink and and it has a very good contact with the heat sink.

The bottom is belly this is its belly. The bottom is good contact with heat sink that helps in maintaining the temperature. So, you can mount it with four screws here, at the four corners and gives very good contact with the heat sink. I will show a diagram of the 14 pin DIL package or DIP. So, here is the it looks like an I C at back there is a connector for connecting plate, which is again for providing heat sink.

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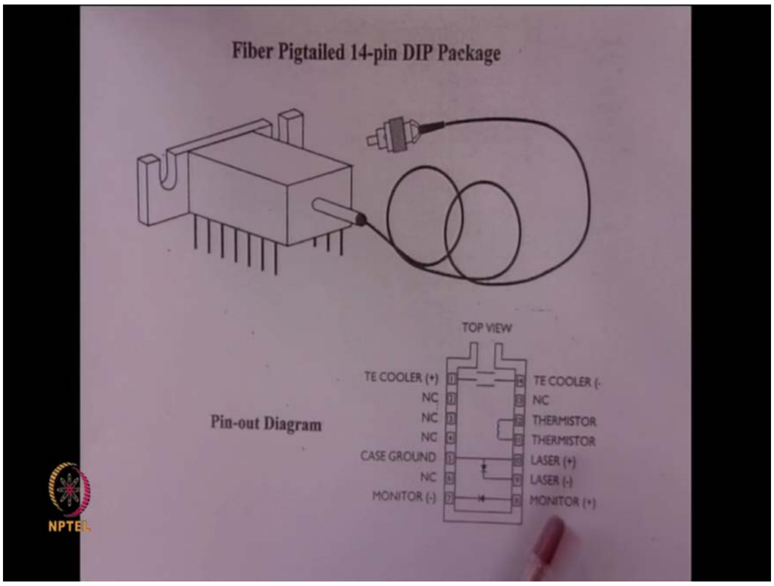


So, this is for heat sink here, I hope the diagram is clear? The systematic and you can see fiber connector and fiber pigtail and here also the pin diagrams are shown. You can again see what the pin stands for? Monitor photo negative, monitor photo diode positive, here is the monitor photo diode. The laser diode positive anode and cathode the thermistor, there is a thermistor shown here. Thermistor NC standing for not connected.

Although there are 14 pins all pins are not connected. So, NC standing for not connected and the top 2 electrodes are for 30. This is the pin diagram and if you see this, if you understand what is there in a practical device? I hope you know how the device looks like. So, this is a 14 pin DIP package. Let me very quickly come to the laser handling, safety to the device and safety to the user.

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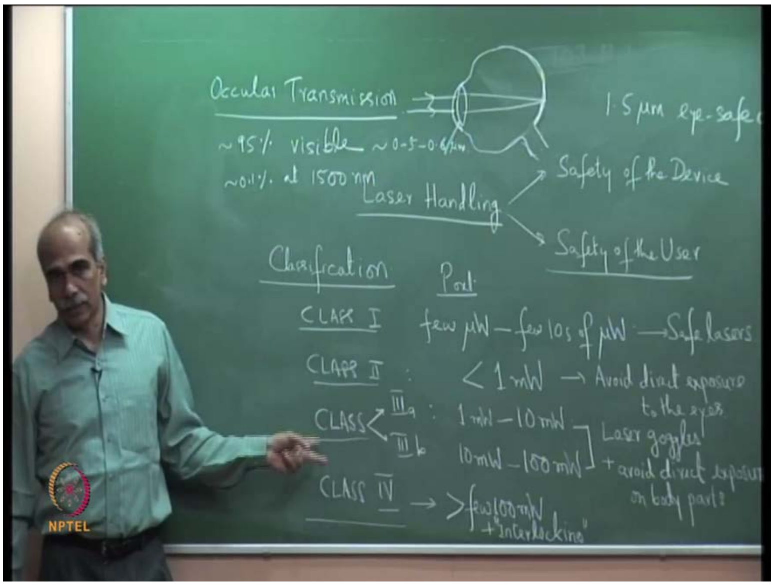


A very briefly safety is a very big topic, so laser handling safety of the safety of the device and safety of user. Every user is supposed to be aware of the safety laser safety aspects. In fact these are mandatory by law that those who use laser diodes or lasers in general must know the safety aspects. So, let me first discuss the safety of the user. The safety of the user is of course, because of the power output of the laser. The damage that laser output can cause, the damage is primarily because it is a highly mono chromatic coherent radiation, can be focused to very small part sizes.

And therefore, intensity at the focused spot can be very large and can cause burns and if it is incident on the eyes. Then eyes can get damaged and therefore lasers are classified based on the output power. Classification classification classification of lasers based on output power, these are called class 1, class 2, class 3. Class 3 has usually 2 sub classes, class 3 a, class 3 b. This is two for all laser not just semiconductor lasers and class 4 lasers, class 4 actual classification will also depend on what is the wavelength of a mission.

But typical approximate range of powers; class 1, the power is typically few micro watts P output. So, this P output few micro watts to few 10 of micro watts. Few micro watts to few 10 of micro watts, these are safe places. Most of these are used at the research level and there are material, which give very small amount of power and few class one laser. Class 2 here stands for powers less than anywhere, but less than 1 milliwatt. P out less than 1 milliwatt. Reasonably safe, but avoid direct exposure avoid direct exposure to the eyes. Exposure to the eyes means, in the laser beam goes directly into the eyes, it could damage the eye.

So, avoid otherwise the reasonable precautions, you can handle these lasers without going to special special safety measures, but care to note take care to avoid direct exposure to eye or metallic reflections from metals, which are as good as high reflection entering your eye. Class three a here stands for typically 1 milliwatt to 10 milliwatt. Class a and class 3 b is typically 10 milliwatt to 100 milliwatt. Please let me make it clear, that the numbers are very width the wave length and the damage that a particular laser can pass but these are the approximate power range.

Most of the lasers which we handle in applications other than non-linear optics experiments or in industrial applications, we handle class 3 a and class 3 b lasers. In most of our laboratories communication applications the power is hold on here, class 3 a and class 3 b. So, class 3 a and 3 b here. I where there is a must laser goggles, so laser goggles were laser goggles or laser safety wear. So, laser goggles plus avoid direct exposure exposure on body parts. Avoid direct exposure on your hands body parts. It could be harm full to the skin. But, laser goggles is must, you must use laser goggles when you are handling class three lasers, because they are definitely harmful to the eyes.

The scattering the amount of scattering that could come or reflections, which could enter your eye could be large enough to damage your retina. Again as I said it will depend on the ocular transmission. The something called ocular transmission. Ocular transmission is the fraction of energy transmitted from the eye lens to the retina. The energy transmitted from the lens of the eye, if you… All right? Let me this is your eye, all right or my eye. So, the retina is here, the back and this is the lens, eye lens, so the fraction of the energy transmitted, so light is incident from here.

This is the cornea and the eye lens, the dimensional are not alright just to the light, which is incident on retina here. So, retina is at back the fraction of light which is incident is for ocular transmission. So, the ocular transmission is the very high for visible almost 95% in the visible region. In the visible region that is approximately 0.6, so around 0.6 to 0.5 micrometers 0.5 to 0.6 micrometer, whereas this is about 0.1 percent at 1550 nanometer or 1500 nanometer fortunately for optical communication people.

This is the fraction of light which is incident on the retina is much smaller and their fore most of the light is absorbed here in between. That is actually over a wide region and therefore it is not so harm full, but here at the focused spot the amount of light incident is only 0.1 percent at 1550. In fact those who with the defense they call it as eye safe laser 1.5 micrometer is called eye safe laser. So, 1.5, so eye safe laser, there are many places they need to use lasers for aligning or for range finding. So, you would like to lasers, but they should not harm the eye and their fore they tend to use the eye safe laser wave length, to mark target we have to use lasers and usually it is around 1.5 microwatt. Because, they are relatively harm full.

Class 4 laser, let me come to class four; laser it is mandatory to wear laser goggles and definitely you need to, so power t out greater than few 100 milliwatt few 100 milliwatt depends on the laser. As I said you see ocular transmission is different, similarly the transmission to the skin the absorption to the body skin depends on the wave and their fore exactly you cannot specify the numbers, but few 100 milliwatt, several watt the India laser which we use in the lab several watts power. You must wear all the safety goggles, safety wear and it is necessary to use interlocking system for the laser lab. That is interlocking plus interlocking arrangement. What is this interlocking? That I am referring to that is your working in a laser lab.

There has to be a red light blinking, red light. If the laser is on there has to be a red light which is blinking, such class four lasers. These are the requirements by law that there has to be a red light blinking. And which means any user or any one any visitor cannot enter the lab when red light is blinking. By chance by mistake if he opens the door if he or she opens the door, the laser would automatically shutdown. That is an interlock with that you open the door and laser will shut down there automatically.

So, that is called interlock locking arrangement. So, this is also mandatory by lock for some reason the interlocking is not working, sometimes it happens in our lab. Then we bolt the room from inside. So, that no body by mistake enter someone has to knock and wait. There and then you will switch off the laser or put the shutter on and then open the door. So, this is the safety measures depending on the classification of risks, so safety of the user. Last point safety of the device. I hope we have couple of minute’s, safety of the device. I will stop here.

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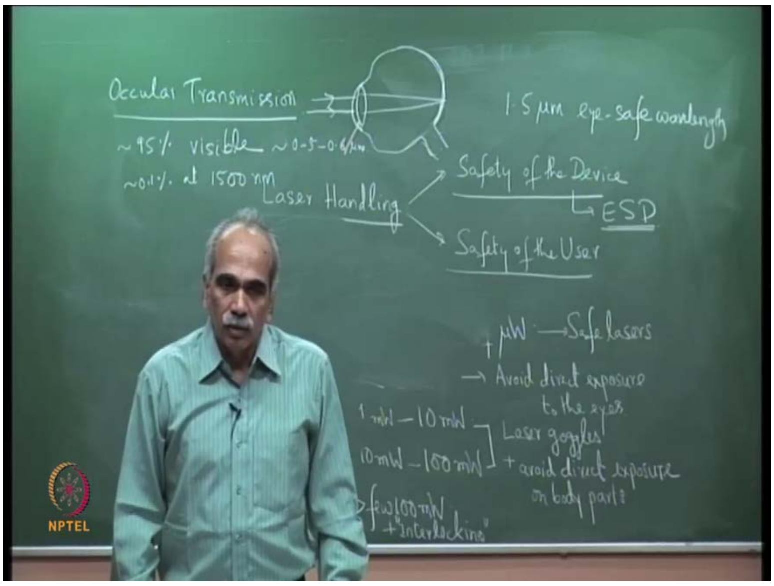


All these high speed devices are sensitive to ESD, electro static discharge, ESD electro static discharge. Maybe we will discuss at some other class because we do not have time, but all high speed devices including SIMOS devices, you may be knowing that they are static sensitive, so the environment has to be static free you have to use grounded mats.

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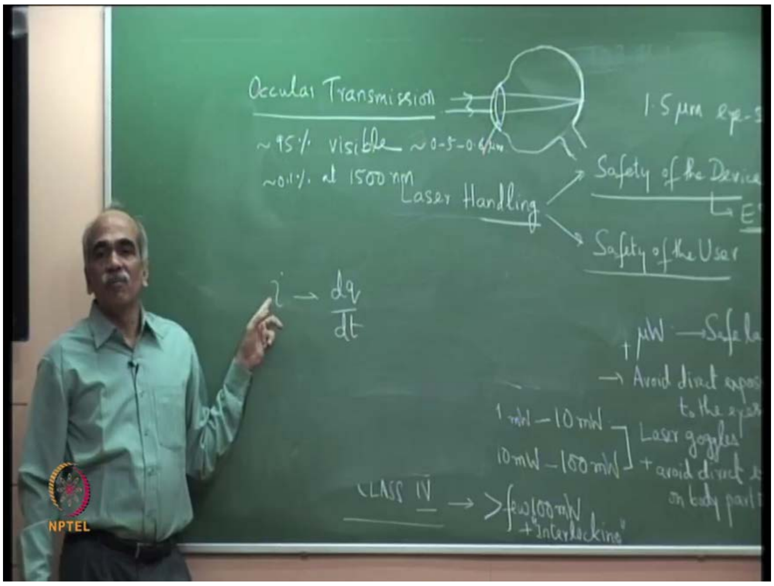


The user has to wear you have to wear grounded straps, straps and the wire has to go to a central node were it is grounded. It is grounded means, you are not directly grounded grounded to a 1 megohm resistance. Please, remember there has to be a 1 megohm resistance, otherwise you will be a ground and by chance if there is a short circuit it will just all the current will go through you and therefore it goes to a 1 megohm resistance. So, this is these are straps which need to be worn and I will show it here, for those of you are not able to see. It is a metallic strap with a pin and that goes to a point where you are grounded.

Grounded means, the grounded path is provided, so that any static charge which is their in environment which is on your body does not pass through your device, you please see the basic idea what is current i, i is the d q by d t, current is d q by d t. If the charge passes through in a very short time, current will be very large that is the whole idea about ESD. There are some chargers which are on your body or on the work table and when you touch the device, the charge will pass through the device because the device is very fast, d t will be small.

It will pass through at a very fast and therefore, if put here narrow second and this charge is charge may be very small, the current will become very large. Therefore, this ESD problem is only with the high speed devices, including electronic devices as SIMOS devices, very high speed devices. These is very, very important for laser diodes otherwise you are bound to damage laser diode. I will stop here more details you can see from the literature; this is basically to give you an idea about the various practical issues practical aspects of the devices.