

Electronics Enclosures Thermal Issues
Prof. N. V. Chalapathi Rao
Department of Electronic Systems Engineering
Indian Institute of Science Bangalore

Lecture - 27
Real Packages

Let me continue where I had left off last time and if you remember I started with small equipment that is we had a PCB and top of the PCB there were small devices and then I have shown you how a small heat sink can be attached to that and then continuation from a previous course and exercise is saying the small heat sinks and all that it is very not very critical, it is more to improve the margin of safety.

So, if you take a small aluminium blower and find out it is theta that is thermal resistance, usually thermal resistances for them will be very high or the order of 20 degree centigrade 10 degree centigrade per watt. But however, since you are dissipating much less than a word it really does not matter practical heat sinks.

However come to the range of around 102 degree centigrade per watt, but as you go higher and higher we are expected to keep thermal resistance to the order of 0 something 0.01 and all or something which is easily achievable by using a large heat sink and making various types of things including fast cooling.

So, next round I took you to the next level show you few heat sinks then I showed you a fan, then also I showed you a very now conventional, but not commonly used pettier cooling. In the end of the lecture I will try to show you a practical what you call ice box.

Which uses a pettier it is not very effective, but still it is use then I have taken you to the; a solar power plant, where huge amount of no megawatts of power is being generated, whatever way power is being generated there will be power loss.

So, imagine a 1 megawatt power station when things are not optimally running it may have 1 megawatt loss. So, 10 percent is normal 1, 10 megawatt plant has a 1 megawatt loss. So, 1 megawatt plant may have a 100 kilo watt loss do not get stuck on the figures the issue being that power loss is real.

So, then I showed you the large racks which had first cooling from outside. So, we had those what you call radial fans and those fans also are a little like a combination of what you will find in a air curtain, plus there actually air is sucked from both the sides and then it is sent off it is like 2 radial blowers kept you know, what we call close to each other.

But, once you start them or once you put them in series we need to take a little more care about, what air comes in and what air goes out for that purpose ducting is used just like you would say ducting in a an air conditioning system, it is there I have shown you that and I have also introduced a little to non conventional heat pipes. Then I went through in detail through 1 of the manufacturers catalogue, the that catalogue which I have shown is a typical of everything I am not endorsing that product.

But such things are a good place to start and those suppliers have become experts in the materials including the weak structure, including the type of working fluid that they want.

So, if you specify the rate at which they you want the heat flux to be taken off saying I have a 10 watts of power being generated and these are the conditions and I need some time with their kept, it is possible to make a heat pipe and there are reversible will heat pipes also, but I will not talk about it right now. Then I have also shown you an example of a practical biomedical pettier thing, saying you can keep pettier in what you call series or in parallel and then.

How you achieve things and all intentionally I have avoided giving you numbers because, numbers you need to do directly from the published literature to which the manufacturer gives with understanding the literature now.

(Refer Slide Time: 04:43)



Let me go forth and show you a few of the things which we have done here, 1 you see here is a high speed drive you can see here know, thing is written here saying it is a it is not clear here it is a high speed drive. What do you notice 1 of the first things you notice is this being a lap set up, it is more of a demonstration prototype.

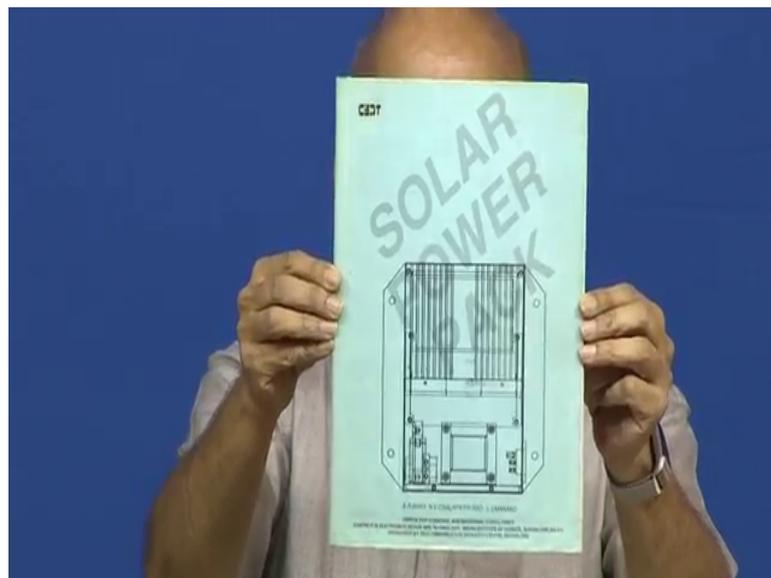
But the critical things what you see is we do have a power supply here switching power supply is not the yet, when this was made this is probably around 20 years old, how but not that much reliable yet. So, it belongs to the old school then the usual things here you see here this part you know is a little over the design of it.

You have a knob and then you rotate it and then we can always see what is the setting we have put. So, the sum of the time their simple voltage types, some of the times it is voltage and current now in case of it is ac, we can have a variable frequency drive also.

So, you can have devices here which shows which is determine speed with which it is running and so on, but this lecture is a little to do with this heat sinks. Now you see with the heat sink and added to that if you see the packaging the fact that it is on the top and it seems horizontal it is what practical that it is mounted in a vertical thing that is the devices are mounted like this, because it is a lab demo they have kept the this what you call so called front panel or control panel at the bottom. So, have an option of changing all of it to here, so that it can be in the vertical direction.

It can be all in the; what they call in a way you can control. So, the way you do the product design where would you like to keep items, where you would like to have the control part of it every machine know as a human or the some other control that control can be removed including something which recognizes, what say you know makes her attention or it can be local. So, typically this is typical of it this being an engineering model it was there.

(Refer Slide Time: 07:09)

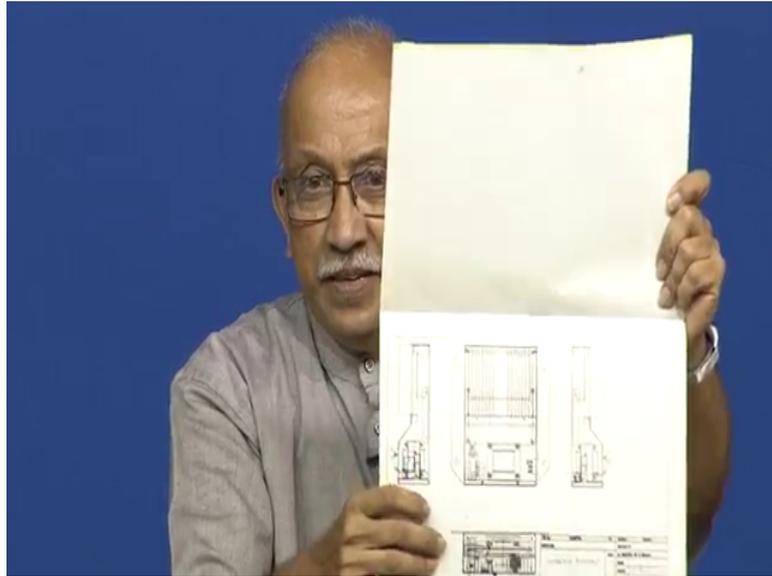


Now, if sir you can see this is a solar power pack we had, once upon a time done for the 1 of the government departments.

This particular thing is an inverter for a small what you call telephone set up, the feature of it is you have very conventional what that treat you have a heat sink with a small modifications.

Then the beauty it is I later on I will show you again once more, of course these have all the necessary pictures and all the idle, this finally shows you the implemented prototype can you see here.

(Refer Slide Time: 07:54)



This is the conventional way we have the front view, then we have 1 of the side views then the other side view.

What you notice here is what you can notice here is you see this is the projection of the fins of the heat sink.

You see here and then you see a small slope has been given here to make sure that any what you call air that enters, might enters here and it goes up at all and other features are there is a small hinge in one case you want a near pair you can open these; what you call 2 screws on the top hinge it out meaning vertical thing know, this vertical thing what you see here hinges out it comes out this way and then you can plug it out and continue with your work.

So, on 1 side there is a socket to take out power and then there is all these protection devices and all that know is the 1 style of making drawings and finally the whole thing is mounted onto a panel with this mounting wholes and this mounting holes and all that know follow certain what you call conventions, I would not call it as standard certain convention. So, that they can sit on a panel and this particular thing has been made such that you can work from 100 to maybe around 2 kilowatts depending on the various type of construction inside.

(Refer Slide Time: 09:29)



Now, if you look at my pictures here.

(Refer Slide Time: 09:43)



This is few of the other things which are in shape yet this is 1 and then afterwards you know I would like to show you this is a unity power factor front end unit is generally being almost, what you call something which is a black box to another instantly just happens to be white colour.

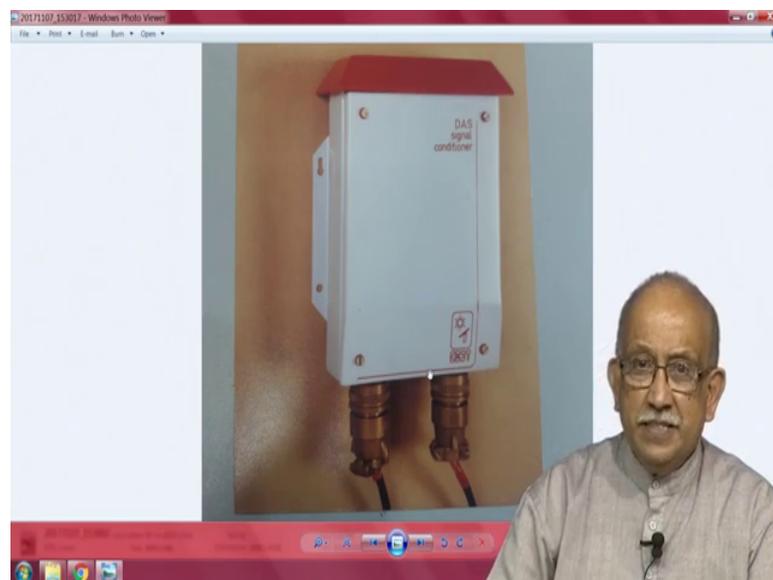
But in general it is a black box nobody needs to see it; however, you see their air also you know we still have a fan which is running their most likely inside know, there is

probably a heat sink inside and then it takes air probably from here it is ducted or outside it takes from here and sends it outside and one thing that is common is you have seen this mounting plate seen here and the mounting plate and top now seems to have something like a keyhole.

I just like to what you call make these remarks you know, contrary to what with thing the hole should be upside down is it not, but that is how it is you put the screw there and then you let it hang bottom need not be a keyhole; generally this will be around also you can put it down and then afterwards you know you can remove it. So, you see here in this case there is a fan there which is trying to take out heat and sometimes this that may not be even a necessity of a heat sink.

we just have to have a fan only as an emergency device, so you have perforations at the bottom then probably have perforations is in the top and perforations at the back and it may be mounted slightly away from the wall where the panel, so the cooling can take place.

(Refer Slide Time: 11:21)

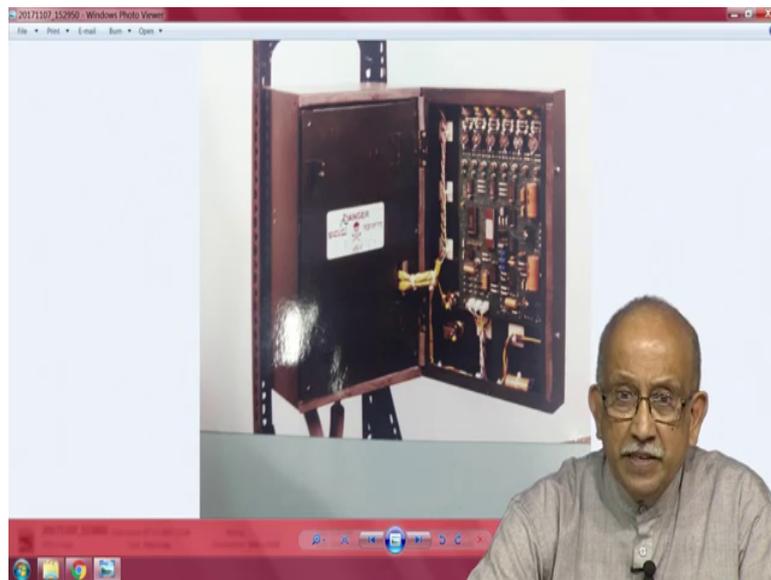


This one is something a little like that this is a data equation system, external module meant for solar applications; not all of it is gimmicky if you remember that keyhole again know you see here this is a keyhole here this is how it is and then you see you may just notice that there is a small gap at the back you understand no small gap is there at the back.

The heat sink power it is turned towards the wall and on top there is a small hood, this hood ensures that directly water does not come and what you call affect the equipment; in spite of it being typically an IP 55 or IP 56 enclosure main for external things.

The beauty of it is what to notice first of all it is sealed, still it has a heat sink at the back which is projecting outside and you open the door inside you can find all the electronics which you can service whenever you require it.

(Refer Slide Time: 12:22)



This is again something which is a little like what you are likely to find inside the equipment, do you will see here the power electronics stuff is all hidden inside here and to simulate how it sits on a panel, a slotted angled rack has been used this is typical of most power electronic equipment. I do not know it may be what you call slow start or soft start starter device maybe for 10 kilowatts.

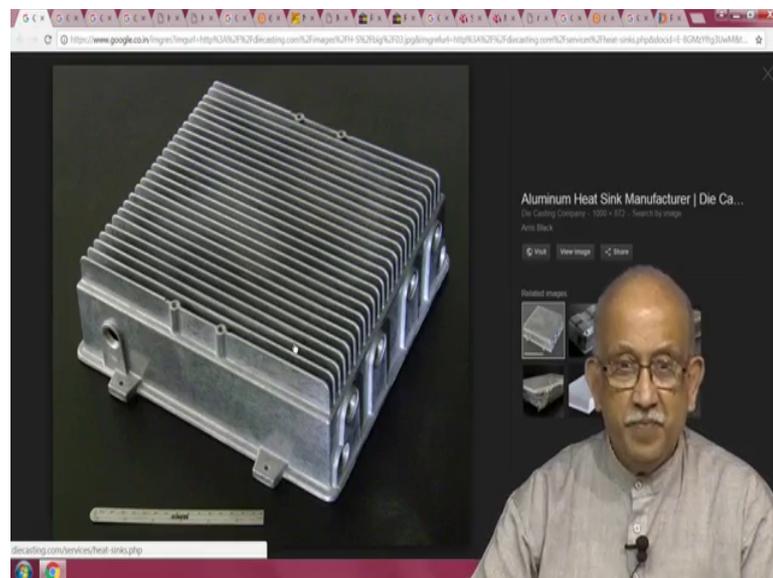
So, depending on your various requirements and all that we have a very neat control of running of a motor, saying the current that it draws has to be used only as a torque and not in heating it up inside or trying to heat up the inertial element of it, the notable feature of it is that in the front you do not find any of the heat generating components or anything and then plus all the high voltage because, it directly works off the 3 phase what you call 400 volt system.

We have this for 15 is a what you call nominal voltage which under which motors and all classified, you see here 1 more thing I have here another such device, again to be mounted vertically in the final mounting know probably it will be like this here.

So, what you see here is it is in the air it is a it is an electronic ballast meant for external high pressure mercury vapour lamps. So, what it does is you feed the necessary power in and all that connected to a large number of what you call lambs and it does whatever it does I have no clue what it does except the words velocity and all that what they think what we need to notice is that, they have this heat sink which is directly mounted on the front of the equipment.

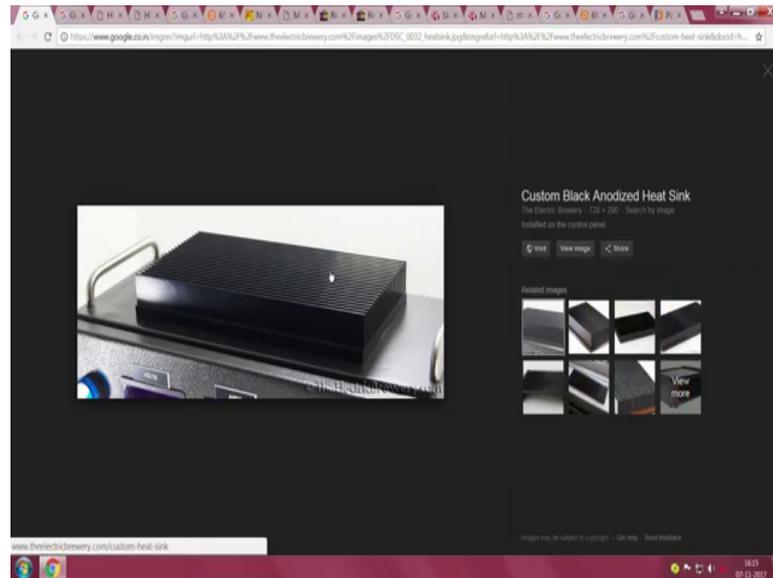
So, now, as they come now you will notice that equipment can now heat sink in the front, you can have it at the back, similarly you can have them on the sides also. There one on the sides I did not get eventually I will get it and show you ok. This probably completes what I wanted to show from our collection of things.

(Refer Slide Time: 14:44)



Now, let me take you onto the; my funny habit of showing you something from the internet because, you are not in this place of you know being able to make everything here. You have seen this here typically it is a full fledged, a full device I have no clue whether it is a heat sink with water cooling or anything, what you see here whole thing is a die cast. So, you have all the necessary advantages of a die cast device.

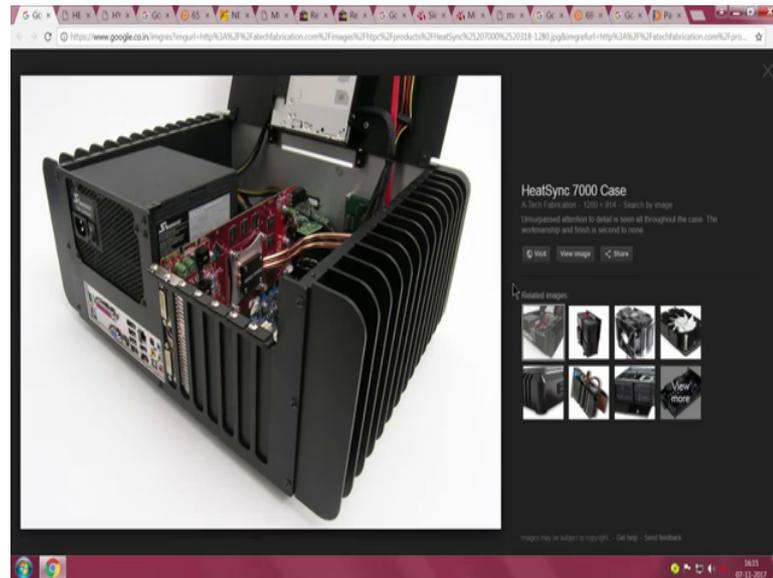
(Refer Slide Time: 15:18)



You have seen this that is the heat sink here, which is mounted on top of the equipment in a horizontal position, these are all generally only demonstrative and not the optimum way of doing it is unlikely anybody will use one equipment like this, but with the available this things and all that it is sufficient for you is it not.

I would prefer that whole top panel know would have been problem made with a thicker gauge aluminium sheet, the whole thing can be made out of a single bit of aluminium and the cooling is likely to be much better than what you have; see here he call I mean they call it you know what you call custom anodizing anodized heat sinks and all that.

(Refer Slide Time: 16:05)



I will take you to some other heat sink case, you see here whether we have a beautiful heat sink case went for I do not know what it is, but we have made such equipment earlier. Obviously, have a power supply here this could be anything as I said by a continue to tell you see the sides you know in kept in a horizontal condition.

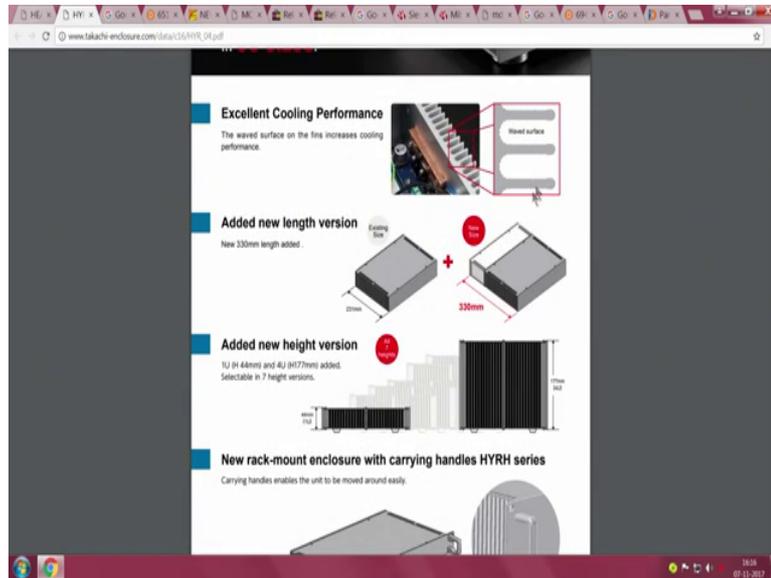
We have this sides which are part of the cooling medium. So, these things are occasionally used as free standalone devices, which you can use and goead with your things here you will see here as a beautiful case here.

(Refer Slide Time: 16:53)



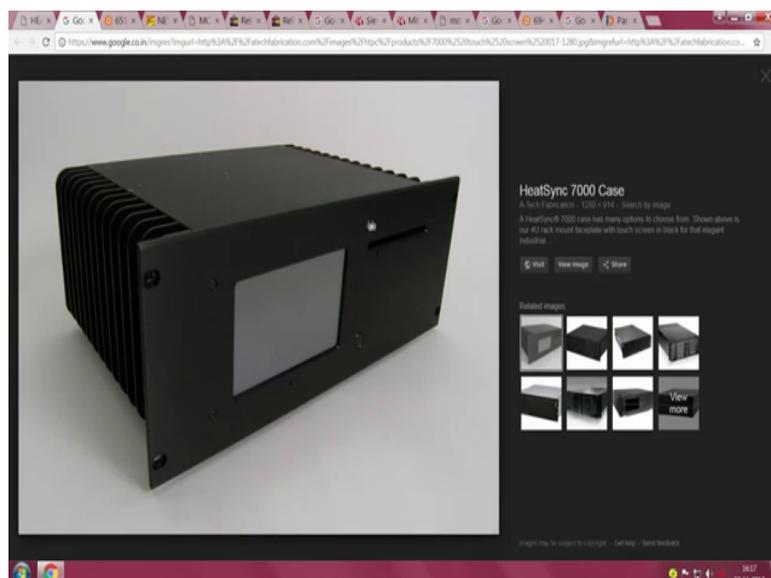
Now if you go down here can you see we have catalogues which show there are computers here without here vicotas fan blowing air in and out? So, some you know extra care has been taken to make cases.

(Refer Slide Time: 17:14)



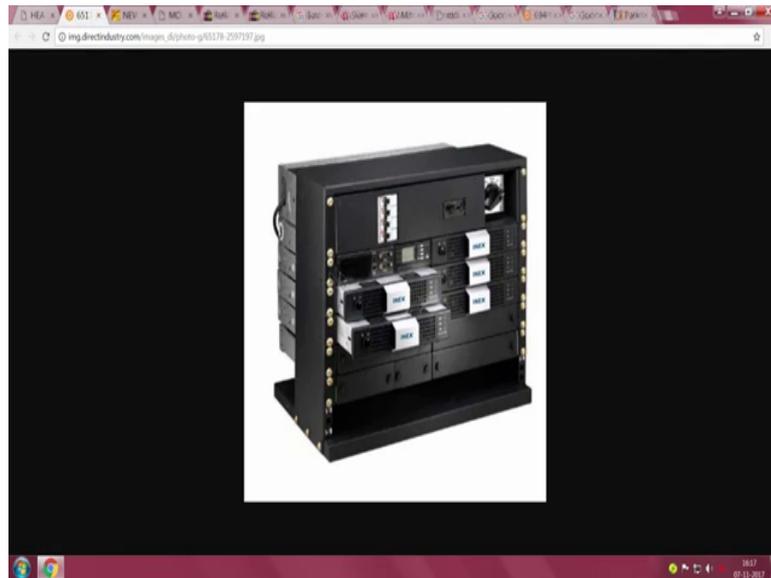
So, there are all these devices you know which can be used directly in here.

(Refer Slide Time: 17:19)



Maybe the next picture has a better picture of it, I say one more heat sink with case from the earlier example.

(Refer Slide Time: 17:24)



This is typical of most industrial equipment, you have some you know devices here and then you have all the necessary power electronic stuff which is all hiding behind.

(Refer Slide Time: 17:39)

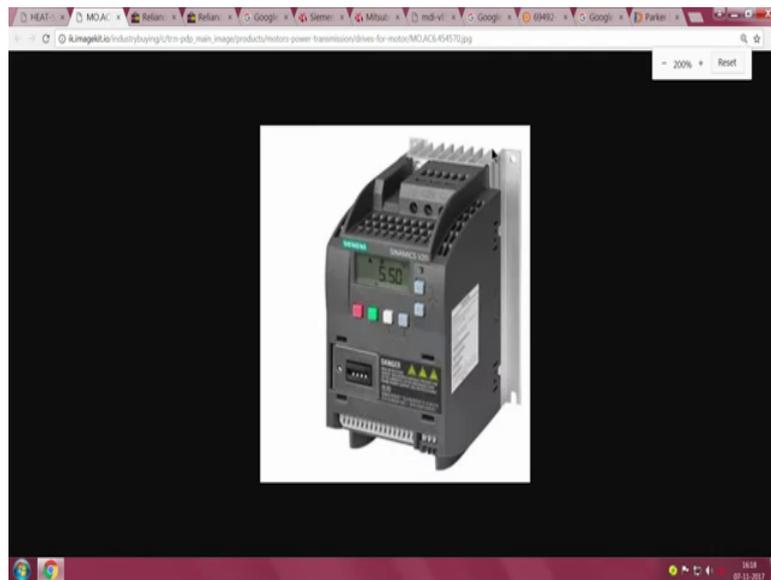


See here neat is not it, you see at the back maybe can you see a small openings are at there the back end.

If you still what you call if you see clearly, mounts are there for mounting it and then you have screws here probably if you remove the screws you can remove front panel and you have access of the equipment, similar to what I have shown you earlier.

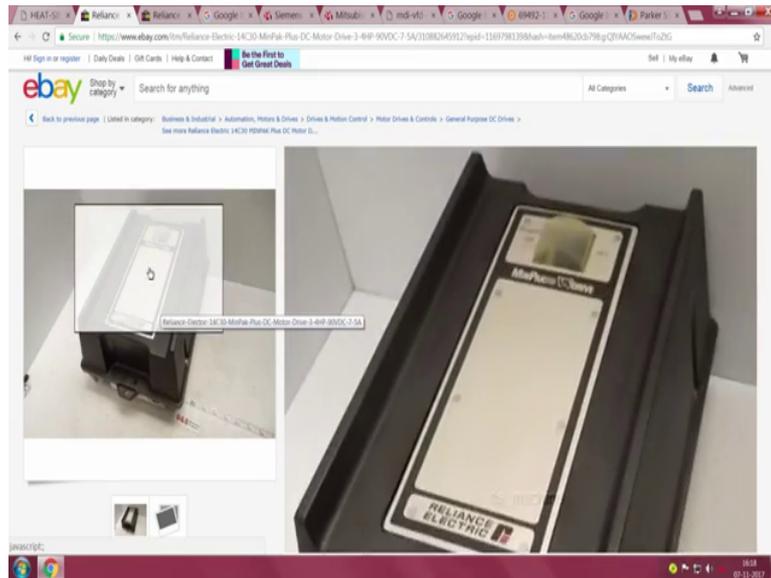
So, these are all typically what you call equipment which are likely to find often, this is probably you know something seen that nicely and then here slowly you will notice something very clear heat sinks.

(Refer Slide Time: 18:41)



I am not black anymore, long ago we use to think they are required to be black ; obviously, any aluminium especially the one which is in convection, the anodized sink layer anodic layer you know has something do with more with protection and electrical installation and soon. So, in this case the mounting holes and this whole thing you now has been integrated into that end, this whole shell goes directly sits and top of it.

(Refer Slide Time: 19:15)



Seen here we have cute little what you call various types of variable frequency drives, all of them directly go on panels and once they are inside a panel it is possible for you to work with them. You see here at the bottom in the front, you can see the [music] various inputs and things there at the front you have some.

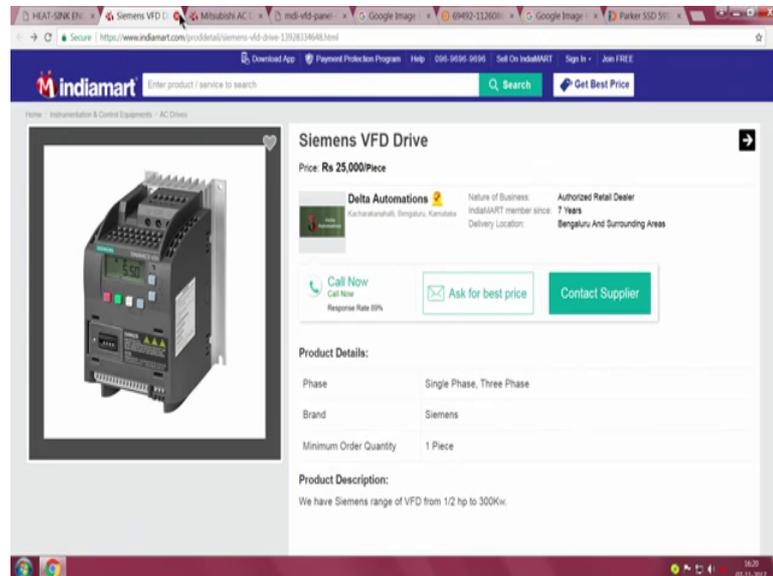
(Refer Slide Time: 19:49)



Inputs and all at the bottom in the front I will close it here I will see if the next 1 know; now slowly we are getting into other drives. Seen this beautiful top back, heat sinks

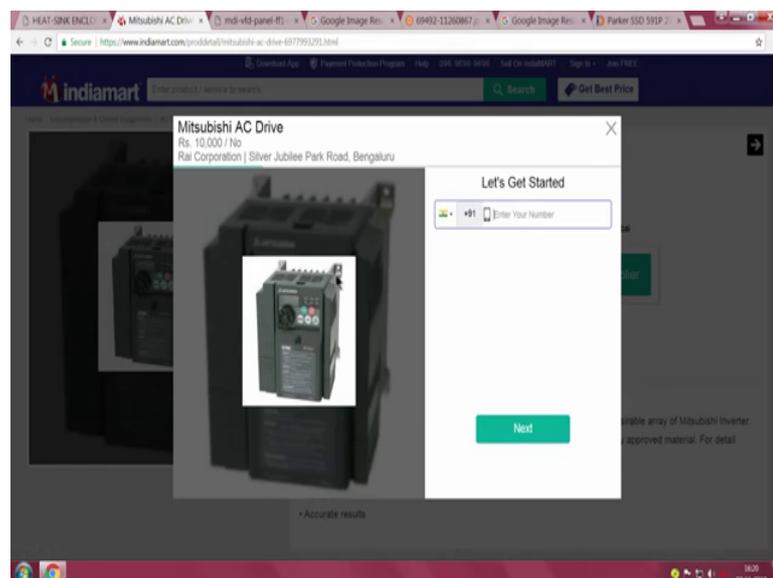
hidden away the thing the intention is not to hide them as much as have a safe and secure thing such that you are not you know affected by those things.

(Refer Slide Time: 20:17)



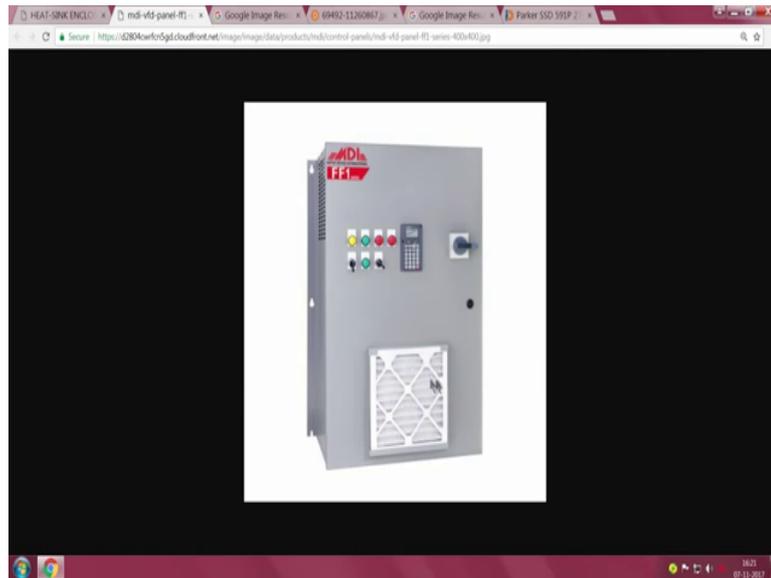
So, you have you see here in this particular device, we also have fans on top you see here small there is a Mitsubishi fan here.

(Refer Slide Time: 20:45)



And easier for us to ac drive easier for us to understand what we have.

(Refer Slide Time: 20:48)



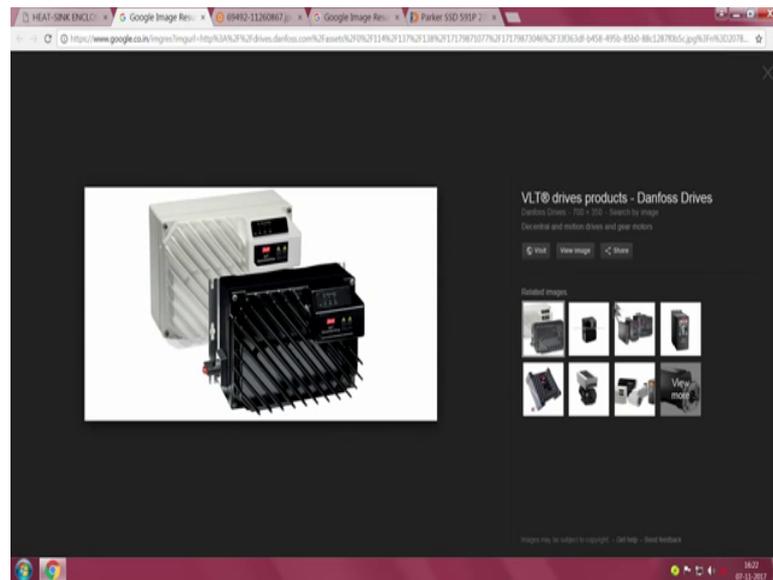
Now, here now I would like to show you something which is little more quite common, as well as I do not know how to say whether rare or common or anything notice here there is a air inlet directly with a filter, which in one of the what you call earliest things I have shown you.

This air filter is a must otherwise air will get air will carry away all the dust, anytime you have air being circle inside also does to get stuck inside and so you need to have a filter the moment you have a filter plugged filters have to be maintained.

So, generally they have a routine what they do is, this is probably you have to just lift and remove the clips lift and remove it and then clean it and put it back inside, there is a reality of it and then. If you see carefully here on the top, can you see here we have outlets for the air here have seen this?

These outlets will what you call take away have the fact that we have a filter here, shows that this is probably the inlet; I just wanted to show you typically the construction that is used to the industry.

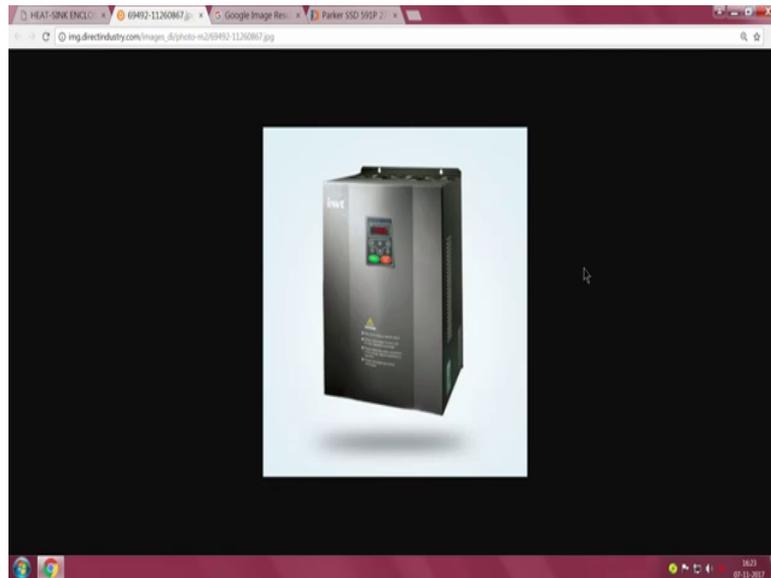
(Refer Slide Time: 22:20)



So, we have I think some of you must have heard of done first which make all these compressors and all for large what you call industrial equipment. So, typically if you see know it is their own drives which have been made. So, the fact that these films are made at a; an angle, may give you a small hint that you can mount it either in the horizontal of the vertical position is unlikely.

But, still you see here we have mounting one mounting bracket here, I do not know whether the this is directly this may be an attachment on this, many advantage is air instead of coming out this part of the thing also is used for calling they are. So, these are all I will fill it now I we would not call them jimmies, but what you call a little bit of you know trailer ender methods to arrive at a reasonably complicated drive.

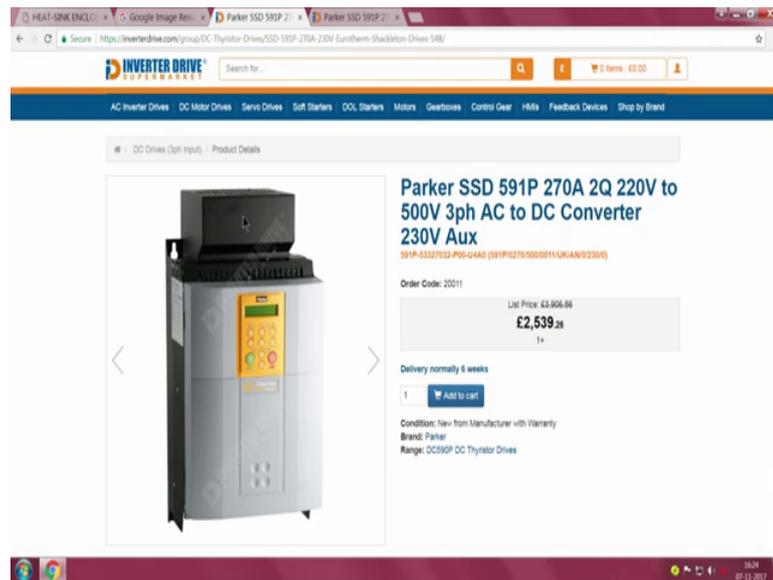
(Refer Slide Time: 23:28)



So, the next picture you know again is the same, this is what I have been showing you in our power electronics; this is typically what we make in our own per electronic equipment. So, in general all of them have probably a front panel, which you need to have there are mounting holes, mounting else can be on top or in the side and heat sink can be directly closest to the panel and these sides are all covered.

Since these involve only an occasional setting they do not need that elaborate graphical interface anymore and these are only sort of you know safety devices are during installation you do this later on, your equipment you know takes care of the remaining things.

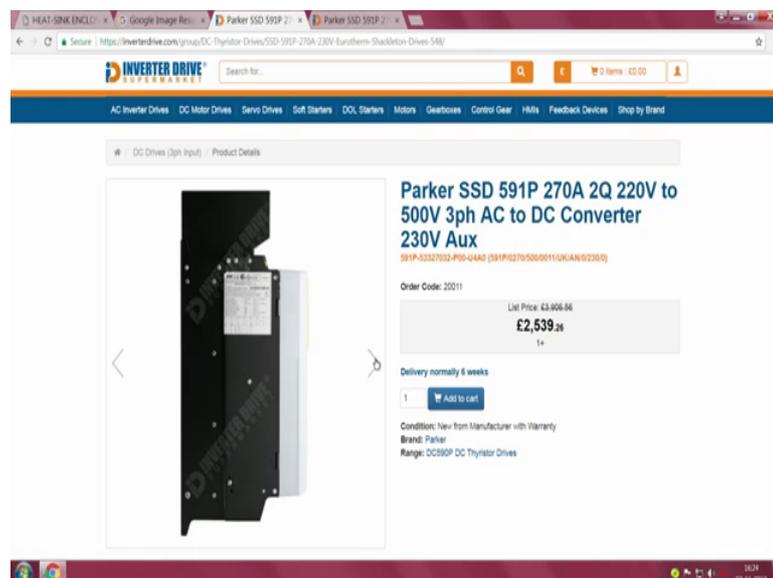
(Refer Slide Time: 24:20)



We have here it is I am not able to get the picture properly yeoh sorry correct, you see here we have things which you know all sorts of you know very large equipment this may be only just a representative picture of how it drive will loop you see here and then we have an equipped you know something sitting and top of it.

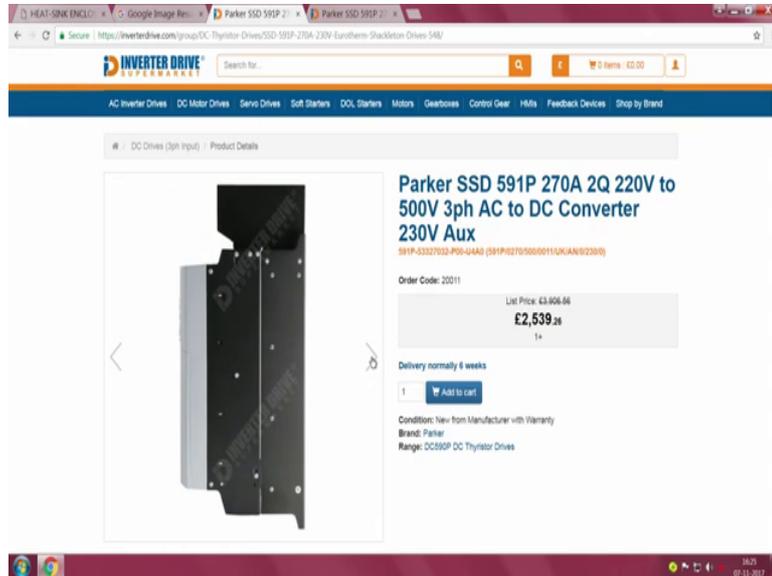
Lot of power 500 volt 3 phase dc 230 volts and so on know. So, you see here these things are little generates, but this height like structure know is the one that gives it the special advantage and then you have a gap also here.

(Refer Slide Time: 25:15)



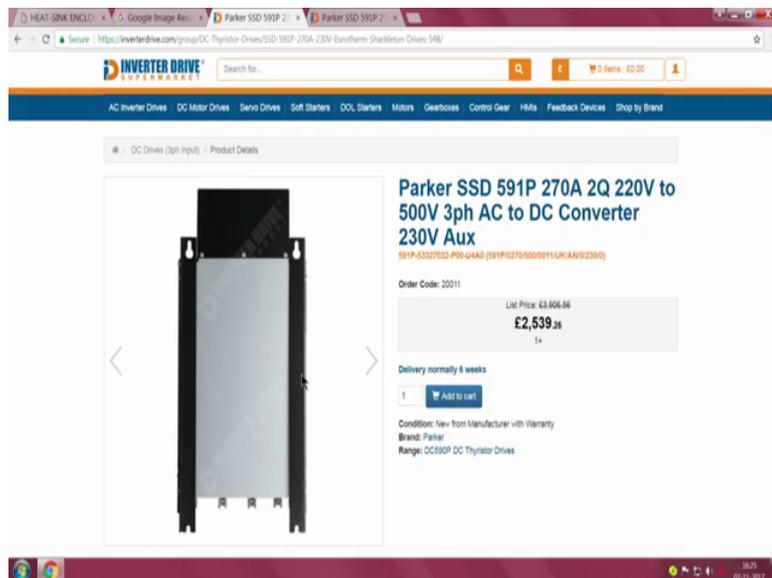
I have still do not know fully what it is, but maybe taking a look here will give a little more thing about it saying, it is for you know to decide what is it that you can do for it.

(Refer Slide Time: 25:24)



These are the pictures similar to what I have shown you earlier.

(Refer Slide Time: 25:28)

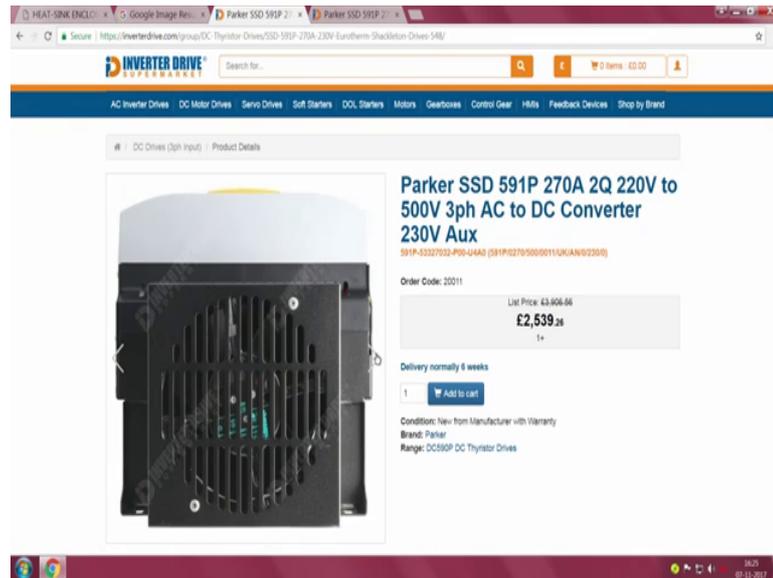


Now, you will see at the back of the drive and then you see the nice 3 connections here, probably this represent the UV w r RY by connections and probably somewhere there is a what you call some this 500 volt bus means sorry, 400 volt bus and this 6 on it and then

you see here we have this very nice mounting holes after you insert and push them down, they have given a u type thing here.

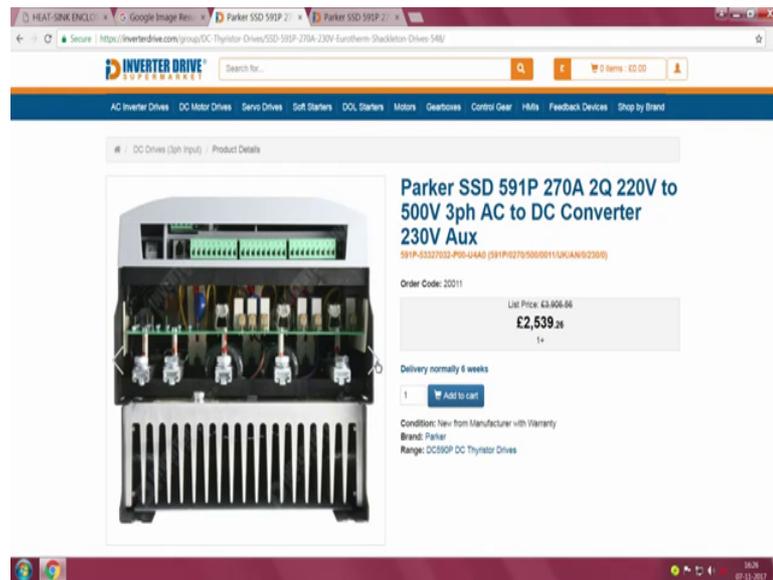
So, when you want to unscrew it you just probably need to loosen these 2 things and loosen 2 screws here lift it and take it off and our equipment now has to fit all this.

(Refer Slide Time: 26:14)



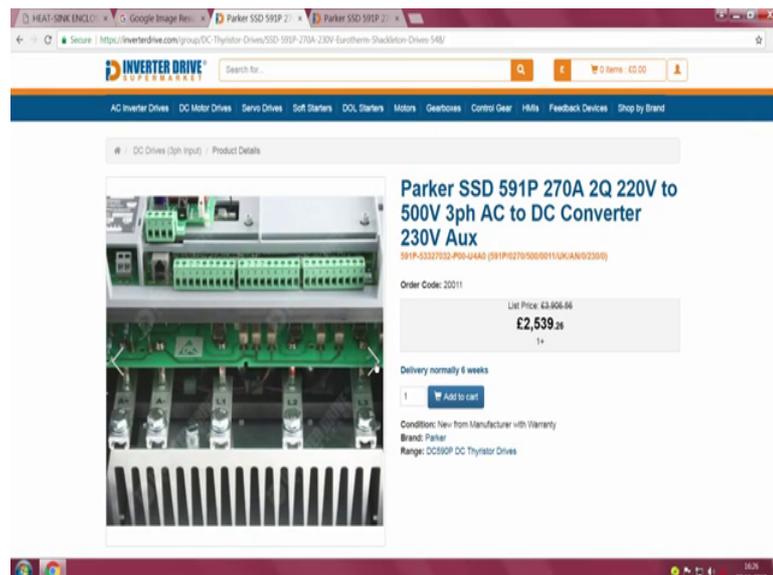
Now you know what is there on top can you see what it is, what they have put is they put a huge fan there, because this is a little probably lower rated you have a single fan the other 1 know is the bigger 1 probably has 2 fans are there and top and this let us out the actual thing here can you see here what we have at the bottom.

(Refer Slide Time: 26:32)



We have the same heat sink and they have we have all the what you call power devices and you see here probably these are all IT bit is that something which as mounted here, then you have getting circuits then we have all the another other cutting connection diagrams and the mounting arrangement what I spoke to you here you said the bought them here. So, this is typical characteristic of any of the power electronics equipment and these can now directly go into a panel.

(Refer Slide Time: 27:12)



You can do whatever you want with it, see here slowly you are able to make out probably line 1, line 2, line 3 is probably what they call I have no idea what the about their designation, but they are this beautiful stack if receive a connectors. You have 1 level 2 level and 3 level which are typically that phoenix has multi level connectors.

So, finally equipment probably looks like this, what is inside know this. Once you cover it up it all comes here in this what I was showing you earlier, see you are all of them are typically generic except that it says I mean a very threatening thing saying it can be obsolete. So, I will now close this and I hope you have read along something with me and gained a little bit of expertise on this.

So, for today I will just take a small break, I just wanted to show 1 of the boxes I have here I will bring it along.

(Refer Slide Time: 28:30)



If you remember earlier I was speaking a little about this to you, this is typically the practical use of a peltier module you see here; we have something going out then we have inlet and outlet and depending on which way you plug.

This in know minus and plus, it is possible for us to either cool it or warm it and when you open it inside all you will find is space can you see, the effectiveness of this whole thing is giving it a good insulation and if you see at the top they have 4 screws here, there was a mechanic you know the thing which will keep things cool.

(Refer Slide Time: 30:56)



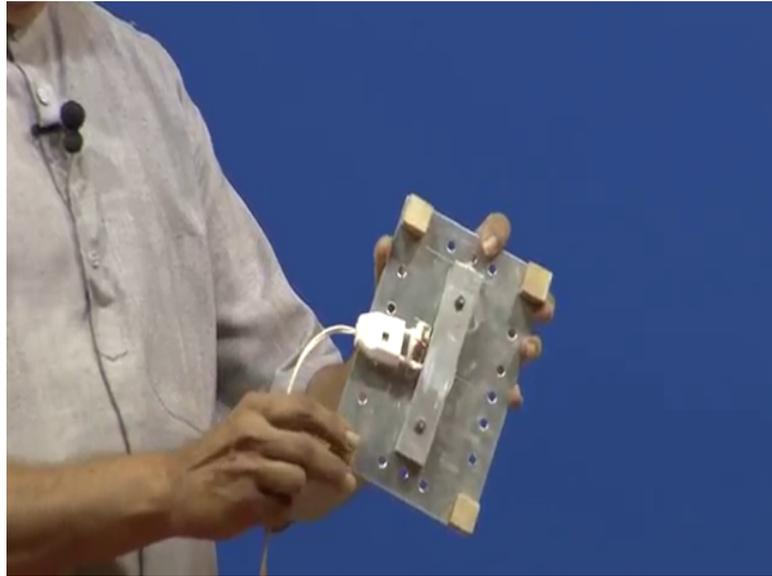
So, you need to heat or cool your lunch or your; what you call beverage, after cooling you to keep it here it maintains around 5 degrees centigrade. So, this were quite popular at 1 time, even though they are sold, but they are not very effective.

Then after I stopped playing with it started smelling and we had to discard it and other the reput is you see this connector, this connector can be plugged and both ways saying you can plug in like this or you can plug in like this; both ways it is not there is no barrier, which you say is only this is the first negative.

If you connect it in the reverse it does not matter, if you are connect plus to plus it cools, if you connect you know minus to plus the other way it warms up some reason. Now in weather conditions know it is going smell and smoke. So, that means, we have learned or lesson in it a warmer box you do not need to have all that what you call control and peltier is not very or there is a practical any heating application.

However, if you want to do both heating and cooling there you want, in this case just to demonstrate I had started with 1 of this thing this 1 is a small 5 watts heating element taken from a mosquito heater.

(Refer Slide Time: 30:56)



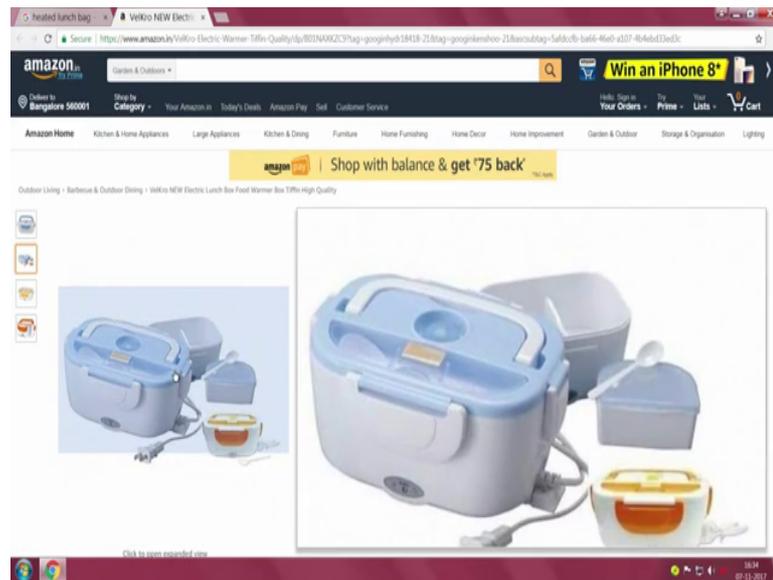
And the whole thing has been clamped with all the necessary things and then I have a since this is a 230 volt device, I have connected this here directly and the whole thing sits neatly in this. In this upside down instant for a practical purposes; we had made something like this; now this 1 heats much better than a peltier junction.

So, maybe I can just show you electrical little high and see here, if this heats much better than a pelteir junction, though it is 5 watts. If you properly insulate it in this face you know after around 30 minutes, the temperature rises all the way up to 50 to 60 degrees centigrade inside, that they use it in some applications.

When you need to this in typical if you want to keep your lunch warm you can use it and in this case it works with 230 volts and it was also possible very much not to replace all this with a simple resistor, this one as a that thermister you know to slope for thermister from a heating coil must of heating coil.

If you replace it with a 12 volt device, you can make your own heater without having to go to the that what you call peltier junction, this is what you will find in if you have take your lunch boxes, several of the lunch boxes have it. So, allow me to 1 more time search on the; what you call internet for a typical device.

(Refer Slide Time: 32:54)



See we have this beautiful you know device here, this is they call it you know heated lunch box contrary to popular mythology.

They do not work with a peltier; peltier is a waste of, what you call waste of effort the amount of control and all is miss has not required ; all it has is usually a small heater typically I will see if he was written many thing yehe says it is a 40 watt heater.

So, actually it is a 40 watt with a little bit of control probably a diet control, after it reaches a certain temperature that mean what you call it thermostat is switches it off or switch it on or gets it into the low power mode.

So, typically something like this is enough, but the beauty of it is about the insulation and about the rate of heating and total mass that is include it in, but if you have to cool something then you end up with the that cooler devices typically; peltier and if something can be brought near ambient, then to a heat pipe.

Now we come to other thing can we have secondary and other conditions, now saying inside you can have a heat pipe an outside now can we have a peltier and then try to cool this is all possible combinations exists in real life. So, thank you until we meet again my suggestion is mean while.

You also go on the; this thing and scrounge around or search around for these devices, these are all easily available and the small things you can do is you can try to make your

own peltier small thing cooler device. So, there are peltier devices no which can keep a small volume cool, I had shown you last time know if you remember one take up warmer.

So, if you put a peltier maybe you can make a cooler also in the same thing and in my case I would rather know keep the warmer thing down, keep the pelteir and then we do not want it know a peltier can be on top as a cup which have other thing you remove that and keep a the single insulated in that case you know.

If you have to take let us say any cool zones are soda or anything, you can maintain it at a drinkable temperature around 10 or 15 degrees centigrade, at that temperature not much of power is involved and we can make it easily.

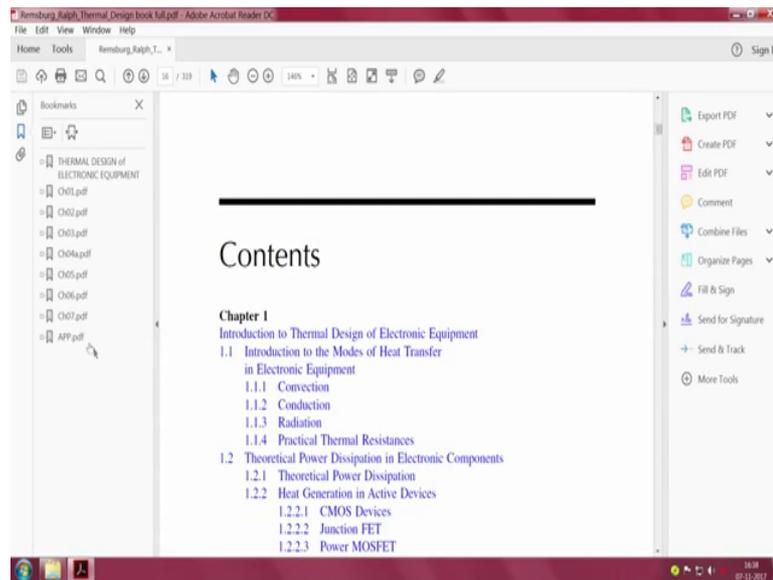
So, I suggest you try the experiment there enough data available on the internet, I suggest you try it and then in case you feel like it posted somewhere. So, that I can see it on the blog similarly heat pipe is something was a little difficult to make and with the unpredictable results, if we can lay on your hands on a hit pipe by contacting the manufacturers, you can try also for all other things.

Only thing we have is fans heat sinks and our own creativity on how do you mount the heat sinks sides, front of the equipment right of. The equipment sometimes on the top then you have to create a duct like thing and if it is spinal mounted you have something or if it is the table mounted you have something else.

So, thank you until we meet in the next session including, what is a vapour chamber and where are you likely to see them and so on which I have given a hint earlier and if you have patience and if you go to Ransburg that thing.

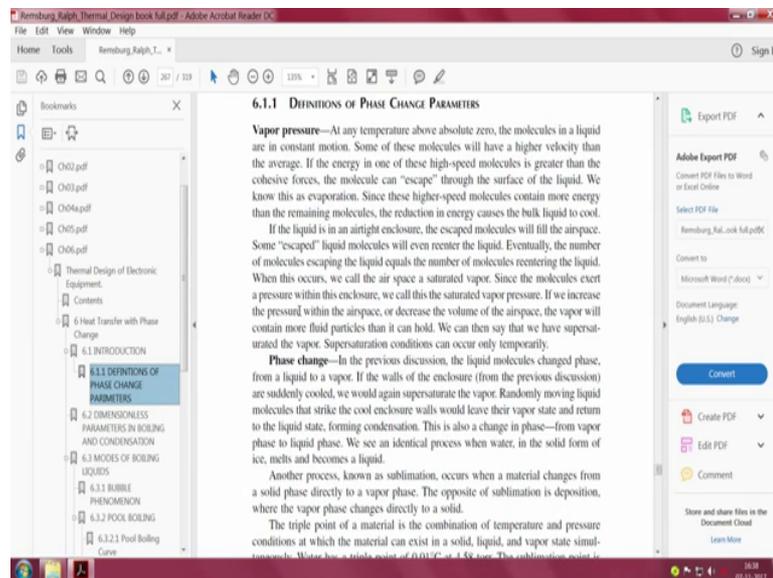
I will just to show you there is an interesting thing which allows me to.

(Refer Slide Time: 37:05)



So, if you go to this Ransburg the later chapters, a lot of stuff about tool boiling and you know how things take place.

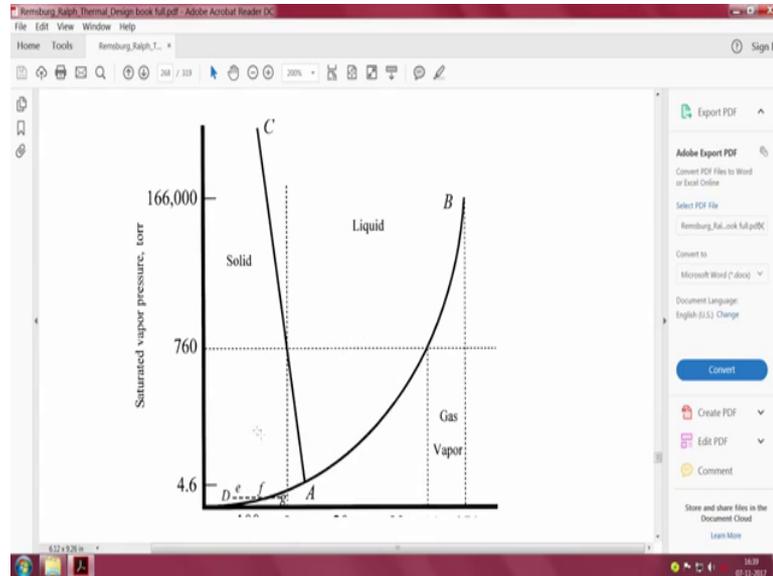
(Refer Slide Time: 37:35)



There is a lot of stuff about what you call phase change cooling, in the case of phase change continuously there is boiling and there will be condensation in other place this is the probably starting point of any other phase change type of cooling, including you can have boiling that vapour chamber and so on.

Know all of them depend on it, so I suggest you download this thing or any other any other equivalent book and I have shown you about you know graphs here and so on.

(Refer Slide Time: 38:24)



Saying where these things you know where these things work and you know whereas, we have a liquid and where do you have a now what if all condensation vapour and all this you read it and I will end the lecture on this note.

So, thank you until I will get back with more topics and maybe a practical demonstration of 1 liquid cooled system, which we had made, I hope the video is there with us.

So, Thank you that will be all for today.