Electronics Enclosures Thermal Issues
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Lecture – 02
Practical Examples 1

Hello, allow me to continue where I left off yesterday which was essentially introductory remarks. You will notice that equipment continue to dissipate heat and I have also told you about saying, there is always what to you call a loss for the intended function the simplest thing we can talk about is probably a power supply is the input is 230 volts and then the output is typically if you take a computer it is around 18, 19, 16 and half and all that.

So, for a nice rounded thing now let me take the output is 20 volts and input is 230 volts. And then there is an input current and if you multiply the input current and the input voltage and then because of the nature of the switching regulator a power factor, we get a voltage which is typically the heating value of the thing.

Even if you have seen good old RMS power calculations; RMS is still mathematical. The actual thing that is accepted is what you call the heating value. So, if ever assistants or if you have anything you know very well irrespective of the what you call the voltage and current waveforms and the phase difference between them what finally, matters is the heating which is the power actual power conversion.

Now, all electronic circuits they try to be as efficient as possible, but the reality is there is a range of load conditions in which it is optimum; design is optimum anything less load it does not work anything a higher load it becomes inefficient. So, inefficiency of electronic circuits invariably and suppress heat loss and heat loss is real. So, you would have seen it in the case of anything which you come across in at home and the magic is the idea is how to predict the heatless.

So, it is not as if you know I am the only genius here who has come and you know think see if you go to the internet.

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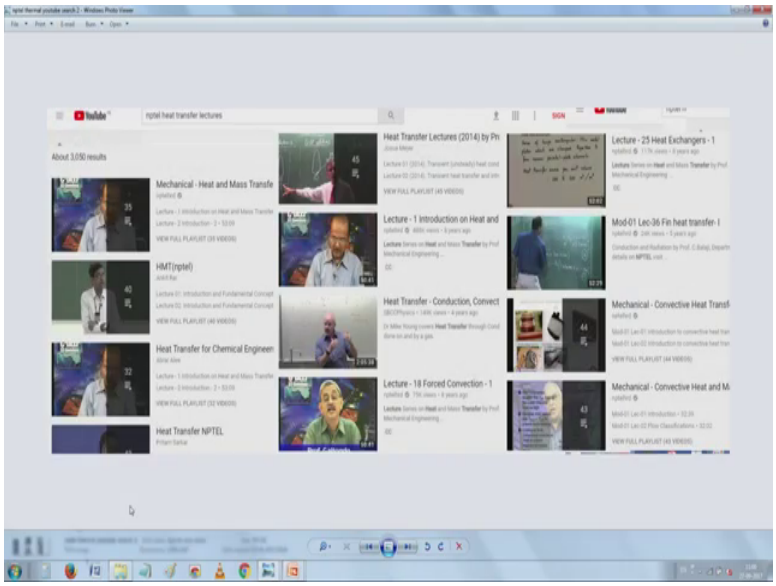

And just give a casual such on convection or heat and mass transfer or heat sink calculations you have multiple heats. And in fact, at the top you know yesterday I was telling you its lot of heats seen this 3000 results on YouTube and all related to only heat and how to deal with what you call, how to manage the heat and; secondly, a lot of them are public lectures.

Now, again they are also as I said no allow me to point out we clearly have two types one is where the teacher wants children to not children I say knowledge seekers you know to understand. So, if you see here we have a lecture on heat transfer by I suggest you do it. And then similarly you know heat exchangers, heat transfer and then convective heat transfer and so on and so on.

So, one part of it is by lecturers and teachers who want all the knowledge seekers know to understand how the final formula has been derived. It is possible for us to use it in conditions if the main problem has been broken up into smaller recall things and then when you have a complicated.

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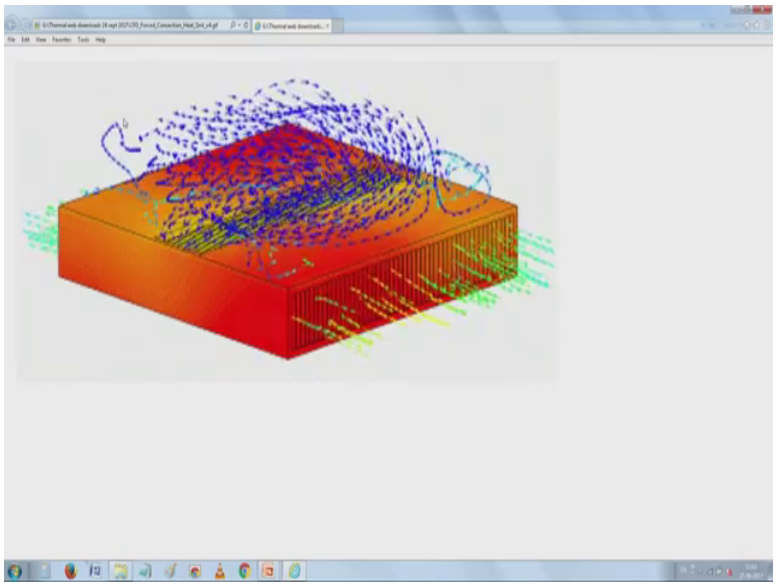

You have seen this; all of that fundamental analysis has eventually ended up in software or I will say I will use the word code. Somebody has you know coded all this and have presented a very beautiful what you call animated image. I am not sure whether this is really simple, straightforward animation or it is an analysis from what you call a package which uses both FA and CFD and then gives you these nice pleasant results.

One thing would have noticed a is in a generic case its very very useful; in a very generic case meaning you know this fin spacing you know the profile of the fins and then you know various things about fin effectiveness and then the heat transfer coefficients. But in your individual case these things may or may not what you call really make any sense as I said if you remember I try to show you this phone.

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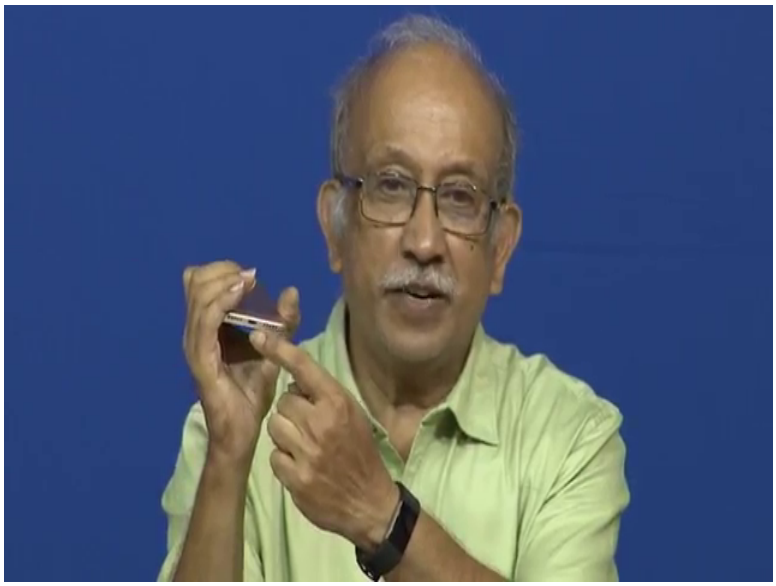

This has 5 to 6 radios some of them are on simultaneously; some are not and then you also have a charger, a power charger usually because of the layout it is kept you know close to the 5 volts input.

So, somewhere here there is a power charger then their thing and lot of them are being built these days with wireless charging. So, you also have a wireless receiver and all of them are unique every instance is unique to the; it is not easy for us not to say.

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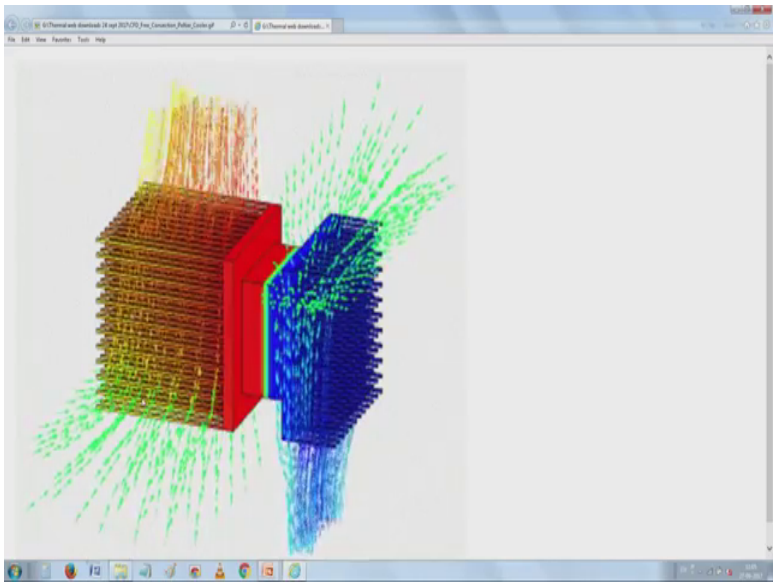

Seen again one more thing; now one very interesting thing notice here is this is typical of the Peltier module I had shown yesterday do you remember that.

So, it is conventional and maybe a little to do with our definition of what you call red then blue and all that you know. Left side is a pin fin heat sink which is trying to what you call extract heat from the I think the one surface of the Peltier whatever module and then you see it is kept red saying it is hot.

On the other side the blue shows that same thing you know again heat is being exchanged to another medium blue is typically called something to do with infrared being hot and then; however, you know the other end of the spectrum not being contributing to that. So, its conventional that it is, but it is not as a blue light automatically cools or infrared heats are anything infrared heating is real the other part you know you have to see in due course.

Say you see things like this or possible and if you have the Peltier junction in between and then we can always extract heat from one surface and then you can transfer it to the other surface. Again by convention here I expect that one of them is a hot surface and then I will avoid the judgment saying which side is hot and which side is cooled I think you should figure it out yourself.

Now, I will come to the more thing these are all taken from there not mine.

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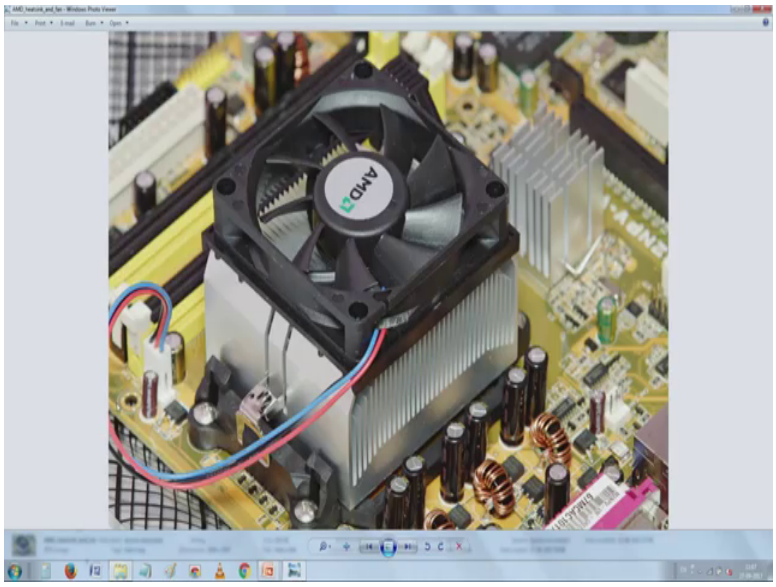

We come to the second type of how do I say data which is available on the internet. The second type of data relates to manufacturers who have actually attempt to fabricate devices which are useful for us that is in this case that is a cooler; loosely the word pentium cooler is used, but I expected is any cooler which is built into most of the you call our common ubiquitous personal computers.

You see at the base of it we have a; at the base somewhere mounted on the circuit board is probably the what you call the source of heat in this case it could be any chip. And then you see here very elaborate arrangement has been made to hold the chip and then you have a heat sink here and then on top of it you have this small fan which sends what you call air onto that.

If you remember what I was trying to tell you yesterday you will notice that the profile has been made somewhat carefully this so, called heat sink profile. You see at the base it is thicker in the middle and it slowly tapers off into the corner. This is where a little by what you call actually making and finding out and a lot more these days by analysis they have found out how to maintain the fin effectiveness.

In this case again coming back to the old this thing; the vertical fins are spaced evenly and they are thin. So, it we you know appearing to slightly violate what I have told you earlier; in the case of forced convection we expect the fin tip to be thin and then all along the fin the temperature is you know they try to maintain it high by making it little you know thicker at the base, but then it will interfere again with the flow of heat; smooth flow of it somewhere they are made a compromise. Probably they have taken you know the same raw material and then they have probably cut fins, actually mounted it with different fans found out one particular combination it seems to work well. So, this optimization keeps doing well.

These industry standards people also know they keep trying it and all sorts of thing; the very fact that heat sink catalogs are big thick and there are. So, many of them shows that they are still under development for every unique case, you need a different heat sink. A reasonable example I can tell you is we have come to these LED lighting and commonly you know we think LED lighting is all about replacing a bulb so the word LED bulb size used.

Now, the most of them are a chip LED and at the back they get hot. So, how does one now cool these devices how do you do it? So, you have a chance for a new heat sink; I hope you got my point. My point is that any time a new application is found typically the. So, called led bulb there is always a chance of having to make a new heat sink. So, multiple attempts are made one way the attempt has made such that the heat is minimized.

And in that case the load is practically constant, it was somewhere you regulate the input voltage and then if you maintain the current we can make a proper switching device which will keep the heat low. And then LED's are being improved such that no a LED typically which gives about 25300 millivolts does not need a separate heat sink. If you can just put it directly on the copper; the copper lead itself can be made to carry certain amount of heat. So, somebody is working on these things all along you need to just.

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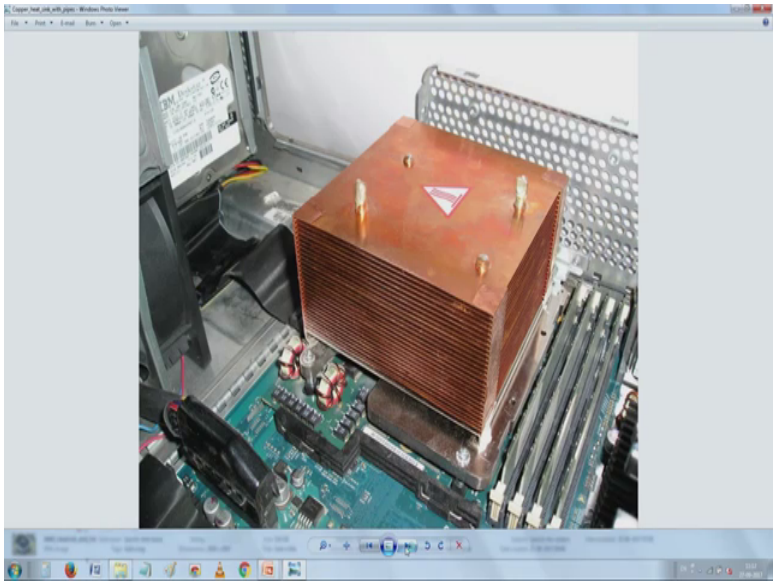

See the next picture again it is taken from the internet I am not sure whether its experimental, it is real or what is it, but you will notice here no its again somebody is trying something. They have tried to stack copper plates, I am not very clear where is experimental or what is it. And what you call there are overclocking enthusiasts, they seem to play with water cooling and so on and so on. You see here there is a stacked plate of some something something underneath; I am not very sure. So, these things seem to be going working all the time.

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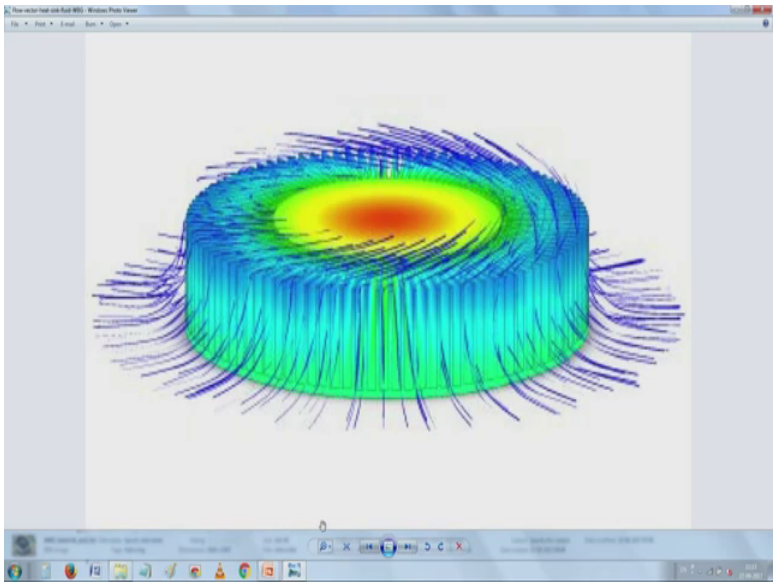

So, I have a circular what you call heat sink with radial fins that was not just radial that are strictly not radial if you see know, they were all been made sort of halfway between tangential and radial. Because when the air from the fans fins it seems to also take it into a particular thing. So, it maybe it makes sense to make things like that and you see at the core of it simulation has yielded a beautiful red color. So; obviously, that red color is where you know it continues to still get hot and the tip is cold; relatively it is cold. So, this is where the heat sink manufacturers try to make something.

Next time when you get a chance when you have; so, many of yours you are what you call e waste. So, if you have an earlier series of computer there are two ways of it one of is the outside box you can remove and then use it as a footrest and the inside lot of hardware is there. One of them typically is the cooler which is that next time I suggest you open the cooler have a look at it a heat sink turn it upside down, you will notice is that the core well the outside is an aluminum the core is made with FRHC copper; Fire Refined High Conductivity special copper.

And then they make a copper slug and the copper slug is attached to that; that is the only known material and probably they have modified it with the proper appropriate metallurgy, to have the lowest conduction you understood know? I am sorry highest conduction and the lowest what you call thermal resistance in conduction.

Now, when it comes here this you know it makes things easier, see here while that thing is swirling this thing seems to be directly being taken out radially because this is a pin fin heat sink same circular pin fin heat sink.

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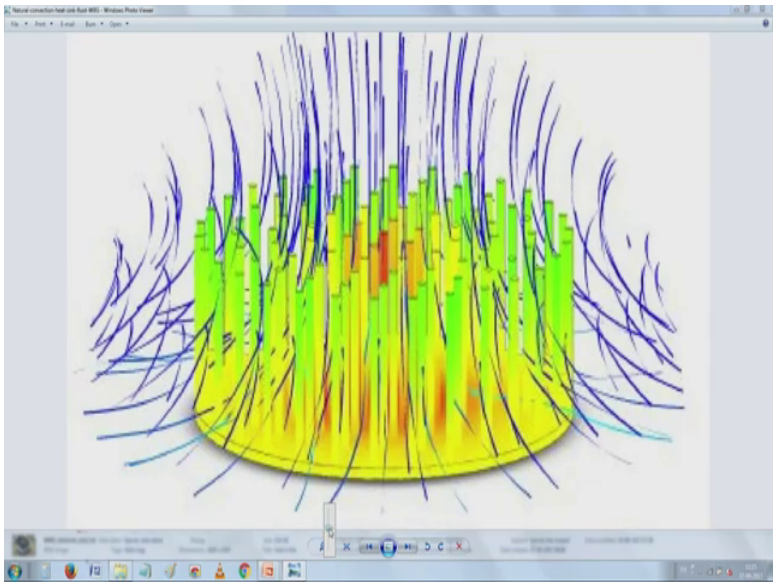

In the case of a pin fin, all the things are going up now this is where what you call our creativity comes. One is try to use strictly a trial and error heat and miss method another is try to use a little bit of your analytical tools and then try to design.

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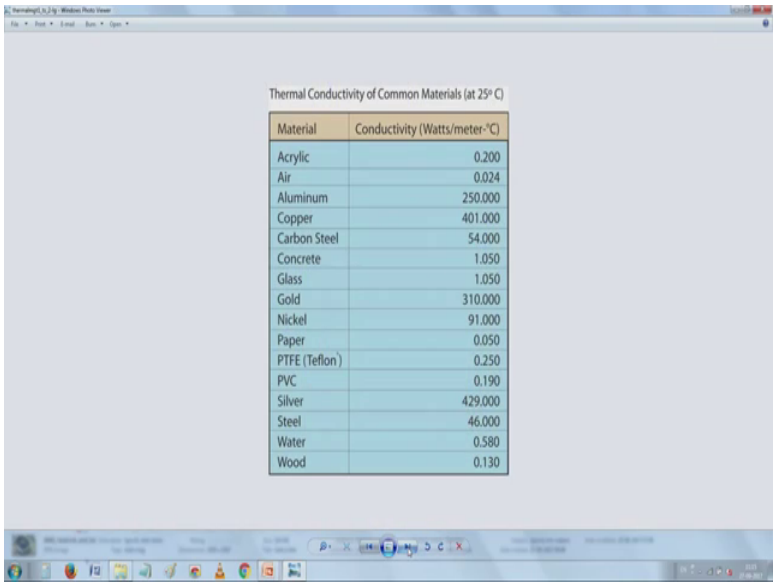

So, they what you call manufacturers all the time seem to be making these things; I do not know if its visible, but maybe if you enlarge it you can definitely see it and then depending only your; you have seen something very very interesting about here. The material conductivity; obviously, sliver is the best conductor; so, it is pure and other than making what you call small black coating on it when exposed to the atmosphere it; thermal conductivity what is per meter per degree centigrade it is all the highest is thing.

Next as we all know right from what you call our old physics, I do not know whether you study it when you are in 10 year about 11 years old about 15 years old, you would have been told that gold is not such a good conductor of heat, we do not know how it has happened. Next best is copper, but we see in that if you go for copper; first of all copper has certain disadvantages. One of them being it is not that easily available and we have unless it is a very critical application they do not use it.

So, next to based; obviously, is aluminum; so, right now a combination of copper and aluminum well you have a core which is made of copper and then you have aluminum which is used in the fins and all that, which can be worked upon seems to be the choice which people use. However, if you remember my last what you call lecture, I have shown you most equipment the enclosure material is probably still usually we called sheet metal.

So, coming back to my; this thing here and then that has a small element of usually carbon which makes it what you call mild compared to hard steel. So, you see carbon steel are the usual mild steel, still compared to aluminum and copper it is very very low. And then insulation is real; follow insulation that is whenever you want to be have any active device and especially if it is one of the connections is attached to the case as in the case of a power transistor or a switching transistor. And things like the old TO 3 and now we have this T 20, we need to mounting device usually it is the collector or the emitter.

So, depending on PNP; NPN know one of them that small aluminum thing is needs to be insulated. The first insulation we can think of it is probably you will see here the simplest insulation we think about is PVC; PTFE or paper, but all of them now seem to be not; so, great thermal conductivity is not good.

So, work is going on about trying to make silicone pads that is again proprietary item by which they have a matrix; a fibrous material which has, which is impregnated with

silicone materials and the whole thing is cured and then it is available to end sheets. Those things have very good electrical insulation properties and very what you call good thermal conductivity problems; which is slightly different in nature.

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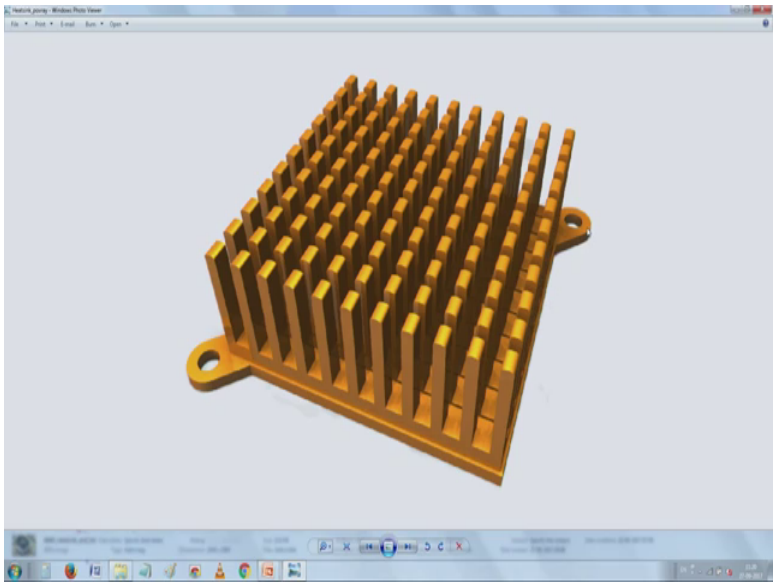

So, we will come to this sort of lot of figures; you see here this is a pin fin heat sink and then you notice something which is we will slowly getting it saying. Other than the basic thermal aspects, we also end up with this sort of mounting you have two mounting tabs that are given here. So, it occupies space is there a better way of doing it and then do you just need to put force or underneath that do you put a some thermal, what you call paste and limited that or use the paste itself as a bonding material; can you make a thermally conductive setting at adhesive.

So, you have these epoxies which are also thermally conducting plus this set. So, the forces are a little low and then you can avoid the tabs which are present there; I think this if you remember.

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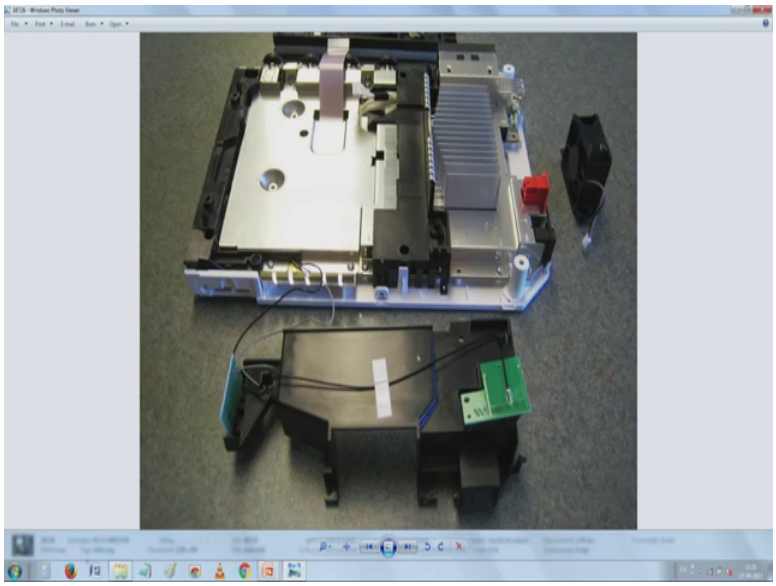

I was trying to show you this yesterday, this is taken from some game console. So, you have seen this there is a hood on top of it and then that hood has been removed and then at this back you know, actually it is turned around there is a fan here and then the fan seems to blow the heat inside.

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The next pictures we will show you a little more about this; notice something as is before sorry for repeating it. They are thin fins and then they also appear to be tapered from the bottom to the top and they are a little tapered and then that place here for you know the

fan is not directly attached to this. And what you call there is a cowling which was attached in the previous picture I showed you the cowling and the air is blowing that side.

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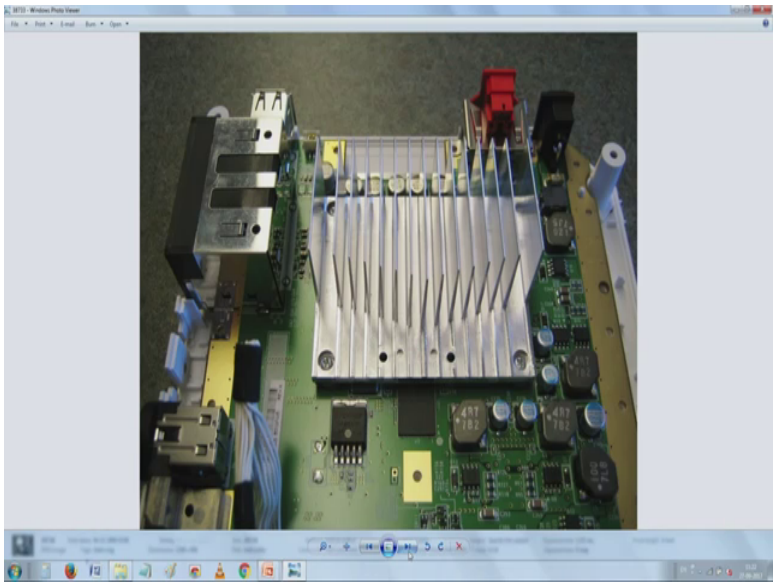

This is the same view from the other side; why did not they make that all that what you call why did they go to great lengths to. If you see this profile have you seen? It seems to be a normal extruded heat sink and then after the extrusion is done and everything else is done, they have gone about making machining such that this screw sit here and then there are I am not very sure why these openings are there, but one thing you notice is it has been machined in a peculiarly what you call geometric ordered way, this is the reality of products and design for products.

Well in case of analytical things, we take an aluminum block because it is easier for us to test and then especially if you have multiple choice questions tick one of them. There we talked about saying take an aluminum blocker and then imagine there are rows of what you call slits in it and we analyze it. But in reality if you see none of the that length of where the total area is available for you to do the convective heat transfer is not constant, it seems to vary in this case luckily; it is a geometry it slightly easier to model, but an actual reason why they have why they are forced to make it.

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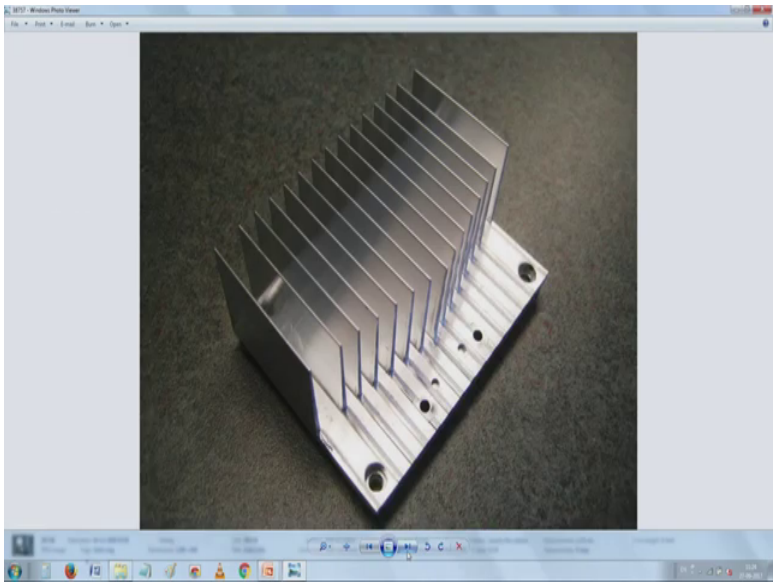

And make a very complicated heat sink like this is dependent on the actual packaging issues.

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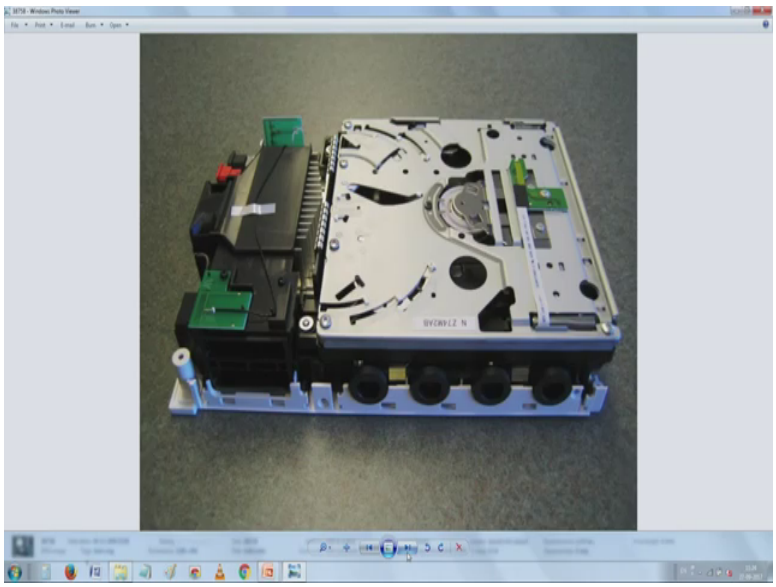

So, you cannot treat anything in isolation; if you see here now can you see? You have a fan there and then you have a cowling and it comes here and then it blows here. This clearance is required for the air to be drawn in understand know all the accumulate; air accumulates and then comes through thus spaces in between in comes out.

So, based on physical layout based on other considerations; these nonelectrical items including what you call the mounting screws, including various things are there and then I have told you about I think in another picture now I have told you how various antennas and all are made maybe that is one of the antennas. So, you have this tremendous amount of influence of physical layout of the equipment on design of the other thing. So, you need to pack them where all you can you have seen this is what I was trying to tell you.

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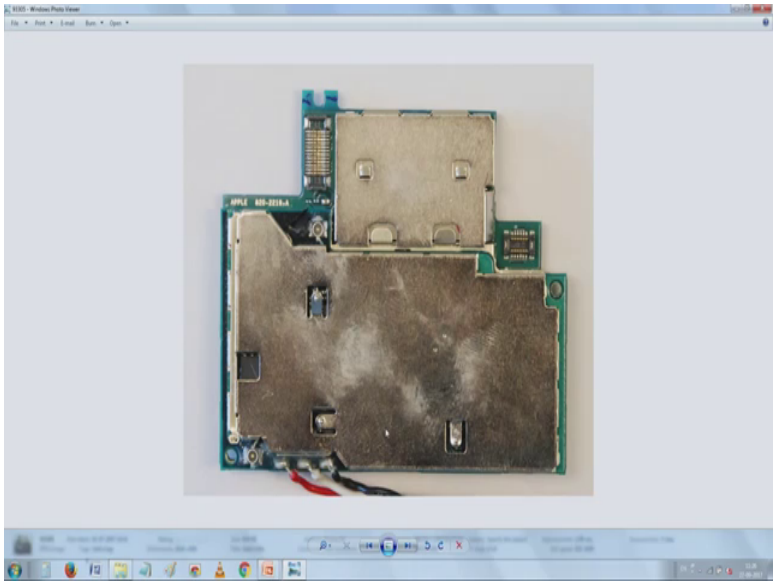

Now, I will try to go up again; I do not even know what it is.

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You will be surprised if you take a device like this; it gets hot. So, if you see the specs on the charger typically the charger spec say 5 volts and about 2 amps, but 2 amps maybe peak it may not be what you call continuous. And then secondly when they talk about an intelligent charger; I do not know how whether the charges sees the load or the load communicates with the charger, some tricks the employ maybe signals are sent via the pwm thing and all then.

Now, you see if I take a thing like a 5 volts, 2 amps for our supply we are pumping 10 watts and I do not know how much of it is actually goes into this battery. Some of them are a single cell 3.7 volts, some of them are a collection they are parallel and as if life was not complicated you know, we also have wireless devices. Some of them have 2, 3, 4, 5, 6 wirelesses in that; we are all familiar with good old GPRS. And then as the new LTE and all have come some of them it look like end up with two antennas one antenna is used for transmitter receiver one antenna is for receive only and then same thing with Wi-Fi.

Sometimes they say Wi-Fi also has two antennas as if our life was not you know bad enough, we have a NFC communication very near field communication. And then we have Bluetooth and then after everything is over suddenly wireless charger has come into place. So, everything you know requires access, everything has some inductive elements,

everything needs access to the surface plus that same surface is required for as for cooling and several of them are probably made of special plastics.

So, you see this is typically in one of the; I mean as you said you know very common thing which I just picked it up from the internet.

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A lot very very tough for us know; now how do you cool a device like this. So, in this case inside the enclosure we have cooling only and somehow all the stuff know is brought to the surface and hence you know occasionally you will find it surface being hot and then electronics has been made such that know it minimizes everything only during charging you try to what you call give; continuous power.

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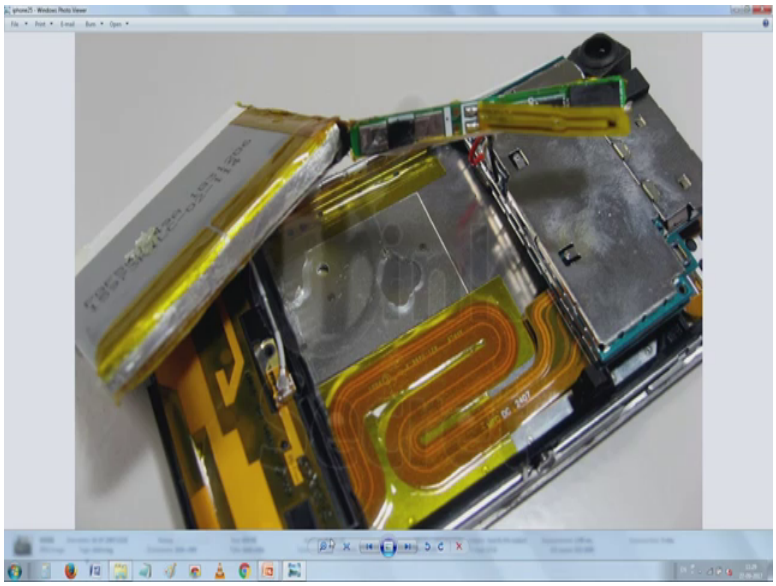

And in the case of use even when the device is communicating with the tower, it will only communicate in short bus which shows that I am here, but with every burst we have energy being radiated. All the energy that is not being radiated ends up as heating of the chip. So, and for the purpose of assembly and disassembly even these connections and all have been made into a zig-zag pattern so that an accordion type of construction is given. So, that it will come out here this is typically; then maybe I should stop here and go back to the starting point. So, even if you see in the case of something which is mounted on.