Electronics Enclosures Thermal Issues
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Lecture - 32
4X Peltier Cooler

Let me start with the video again, this continuation of this lecture is all about the design of thermoelectric cooling system. Generally whenever we talk about a thermo electric, we concentrate on only the Pelteir. It is real Peltier working with the Peltier is real there is no what you call two things about design of a Pelteir.

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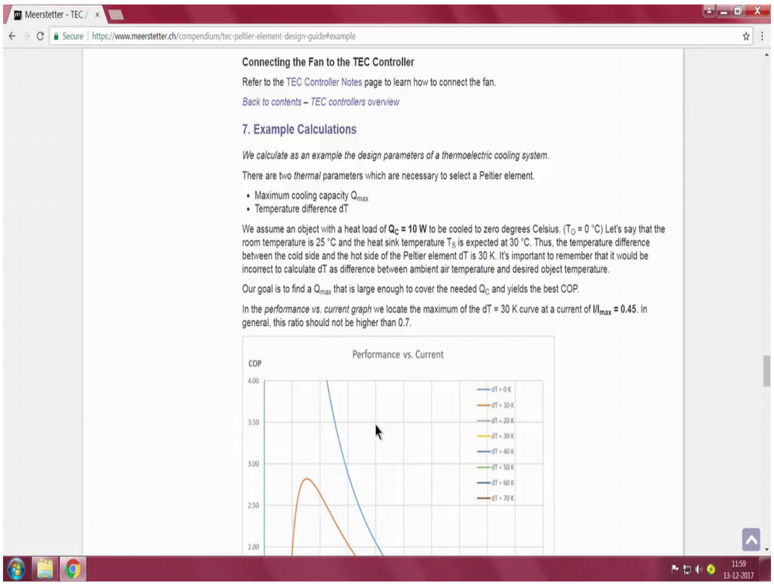

Now if you see the this other monitor, which is mentioned here, this is taken directly from mid straighter side probably it is from Swiss looking by the symbol now we do not know where exactly they what you call use all these things one of the first thing is saying it is a big system.

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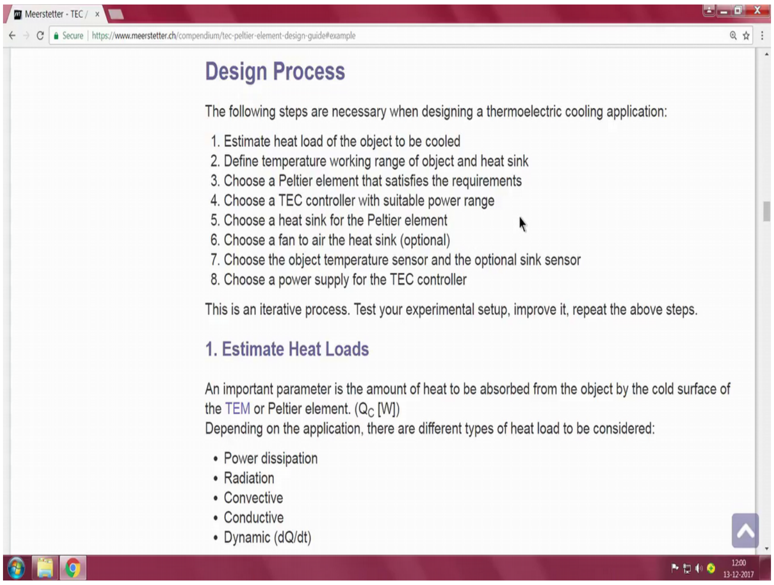

First of all the most important point here is to estimate a load without the load estimation. First of all estimate the heat load of the object to be cooled then define temperature working range of object and heat sink.

So, if we can see my face again, the issue being they were very very interesting think we have a heat sink, which is supposed to take heat from the object that is to be cooled. So, heat sink looks like you know there is something about the infinite. So, by definition it has only a finite capacity of absorbing the heat after that it starts tends to rise and then it will transfer it to the ambient or next cooling medium. The cooling medium can be normally simple air occasionally liquid. So, the temperature of the heat sink seems to be very very critical what you call parameter, which you need to decide approximately.

If the heat sink is cold it is not doing any purpose at all because a cold heat sink cannot transfer any heat to the ambient, let us say the ambient is around designed ambient is around 40 degree centigrade, if the heat sink is already at 40 it can transfer any heat to that. So, we have this peculiar thing being the heat sink final temperature has to be higher than the ambient only then it can transfer heat.

But then if the device that profile is hot it cannot pick up heat from the object to be cooled. So, somewhere you need to fix the two parameters. So, generally a good starting point is start an average. Take the average outside 25 degrees interval are very very standard. But generally you know things are made to such that they are expected to work at a more reasonably good ambient which is there the topics where we come from around 40 seems to be a reasonable thing.

So, I generally start with an ambient or 40 degree centigrade and now any heat sink which needs to transfer heat to 40; obviously, has to be higher than the object that has to be cooled which is probably at 70.

So, if you take an average between 70 and 40, it will come to around 55 degrees. So, if you can make a heat sink which is typically it can reach around 50 degree centigrade, considering its total marks considering the convection heat transferred which it can go we have partly started on our business.

Now if you look at the what you call the monitor what they have given, one of the thing is estimate the heat loads important is the amount of heat to be absorbed from the object by the cold surface of the.

Thermoelectric multi or Peltier element in watts depending on the application, there are two heats power dissipation and convective and conductive thing and dynamic.

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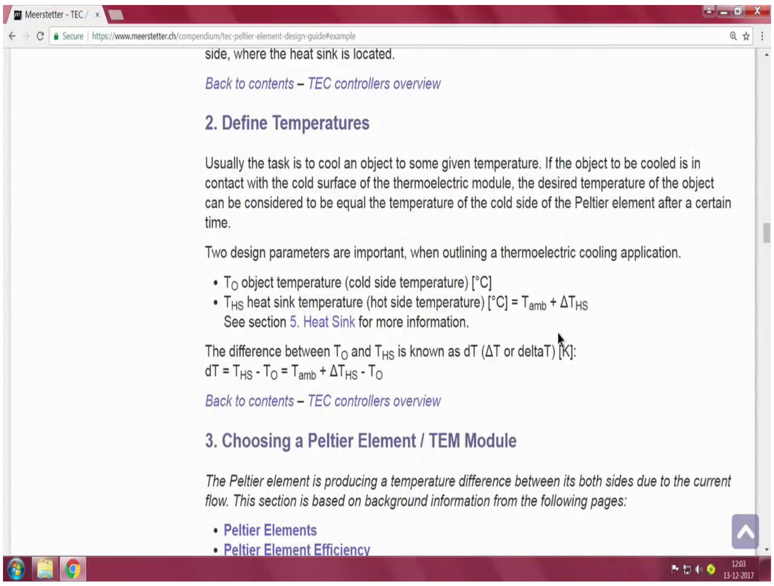

So, do we need to define a temperature saying to object to design parameters are important when outlining a thermoelectric cooling application ok. Object temperature cooled side temperature heat sink temperature hot side temperatures. So, we need to think about it the difference between T o and this is known as the delta T and see suddenly we are in you know we end up with this also ambient temperature delta T minus d object temperature.

So, you see here then after that which comes to I suggest to go to the what you call this site and try to read about this whole thing from the top to the bottom, how do you choose a controller and how do you choose a element.

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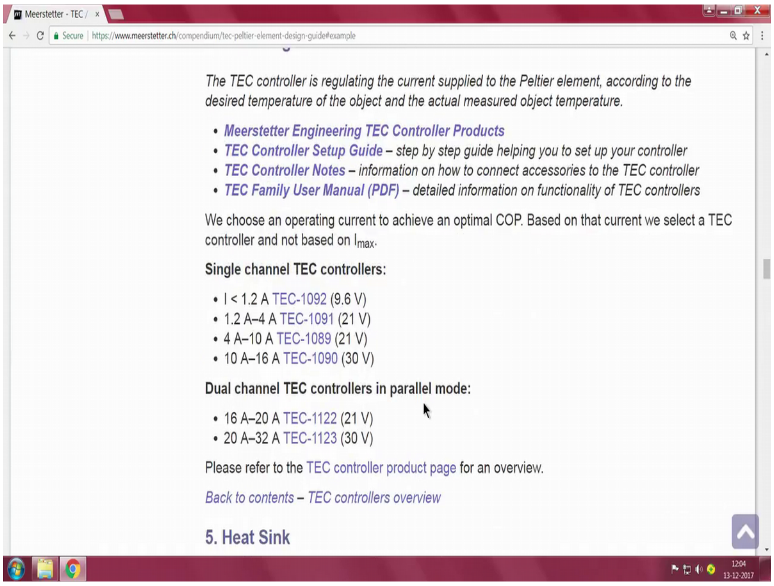

A controller is about regulating the current applied to the Peltier element, according to the desired temperature of the object. But since where electronic engineers chances are you would want to build your controller is nothing, but a constant current source.

They also sell controllers, but because of various what you call operational or your packaging issues, it is possible for you to probably build your own constant current source otherwise buy the whole thing from them. So, if you go down here we have things which are listed which works with 9.6 all these you know 21 30 dual channel is there. So, controller product pages there.

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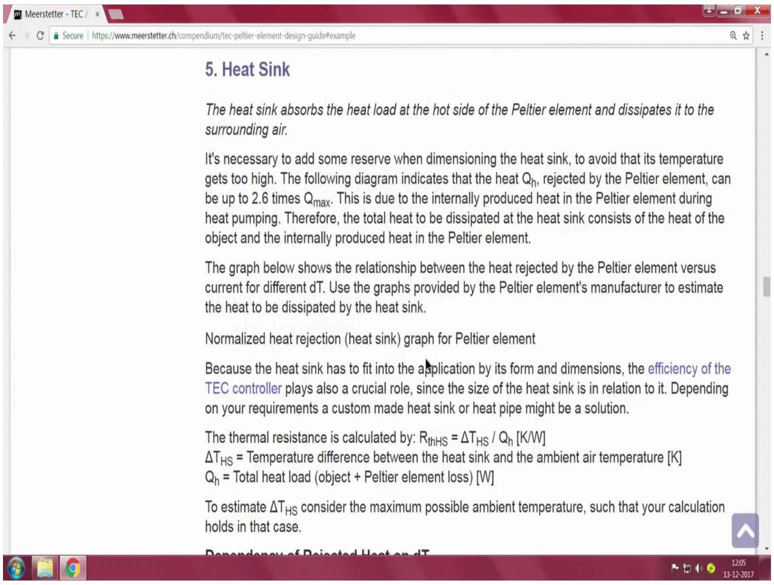

Now, it is necessary to add some reserve and dimension in the heat sink to avoid that its temperature goes to high, following diagram indicates and so on.

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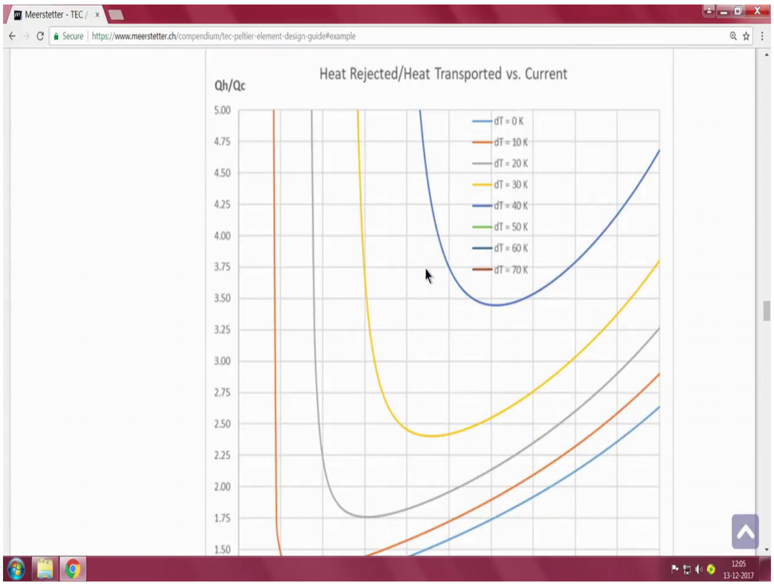

If you go down you know heat rejected heat transported versus we have a several types of curves here. You are seen here first of all when there is no temperature difference across the sites that is, you are able to elevate to hide uniformly to the temperature difference which is at the max; so the curves are plotted here seen here you now you see all the way to these things.

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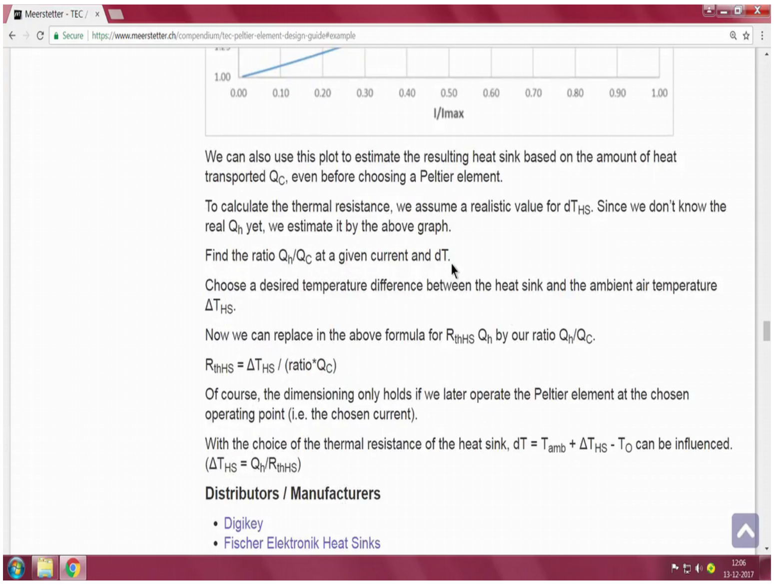

We can use this plot to estimate resulting heat sink based on the amount of heat transported even before choosing a Peltier element. To calculate thermal resistance we assume a realistic value of delta T at the heat sink. Since we do not know the real Qh at to be estimate by the above graph find the ratio choose a desired temperature difference and so on and then finally, we come to this fan thing.

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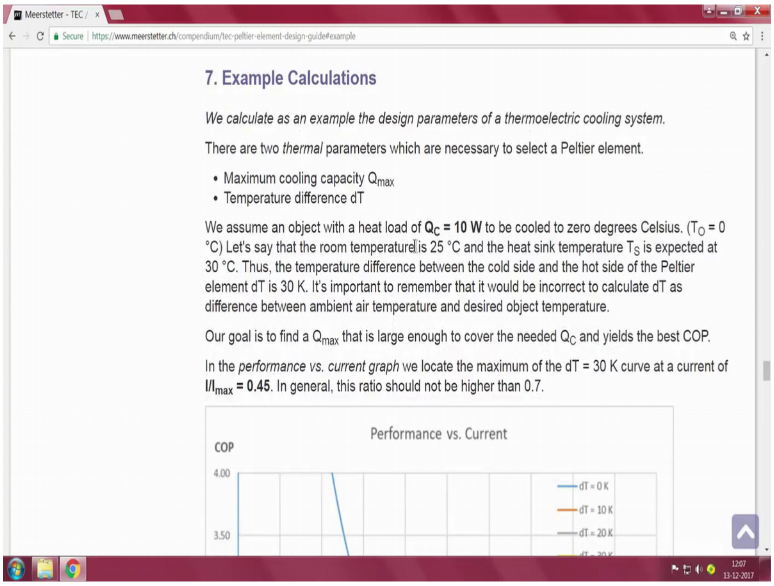

This I suggest you know I just to write it I will try to read it along with you, but its peculiarly claim unless you have gone through it yourself it would not make sense. Not very different from learning cycle balancing or swimming you have to get yourself wet, and unless you do that you know a no simple way of learning either of them here they are given here if you see clearly we have just as a working example, there is a maximum cooling capacity we require is about 10 watts to be cool to zero degrees Celsius zero.

And the room temperature is 25. By 25 is taken else this is the standard condition in which most testing takes place and then as I said in your practical example you can probably go up to 40 degrees. 40 degrees is a reasonable thing and generally wherever we use our equipment probably the ambience are controlled and just around the electronic equipment it is relatively easy to maintain 25 maximum it go at to 30 the room itself can be a little higher. The temperature difference between the old and the hot side of the Peltier is 30 degrees it is important remember that would be incorrect.

To calculate delta T as difference would in ambient air and the desired object temperature you have seen that know. So, our goal is to find the Q max that is large enough to cover the needed, Q c and yields the best coefficient of performance. In the performance versus current graph we locate the maximum of the delta 30 K curve at a current of 0.45 they should not be more than 0.7.

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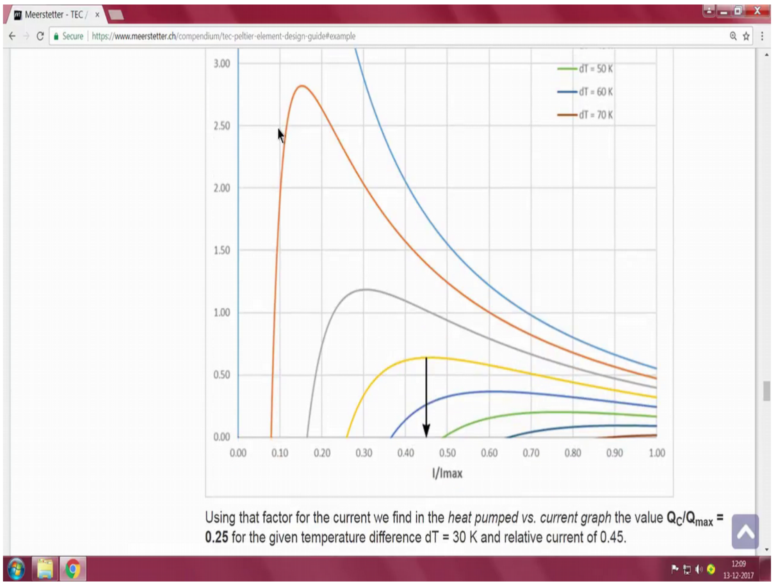

You see here this is where the current should be if you exceeded this side we have a little problem about it, and there is an inherent the heating inside. So, the actual current what we need to draw should be way below this somewhere know, more like I would prefer this in the end of the example he will tell you how to come back here.

And now here you see here if you go using the factor for the current, we find the heat pumped versus current graph if you see by Q max is equal to 0.25 seen this here 0.45 you go to 0.25.

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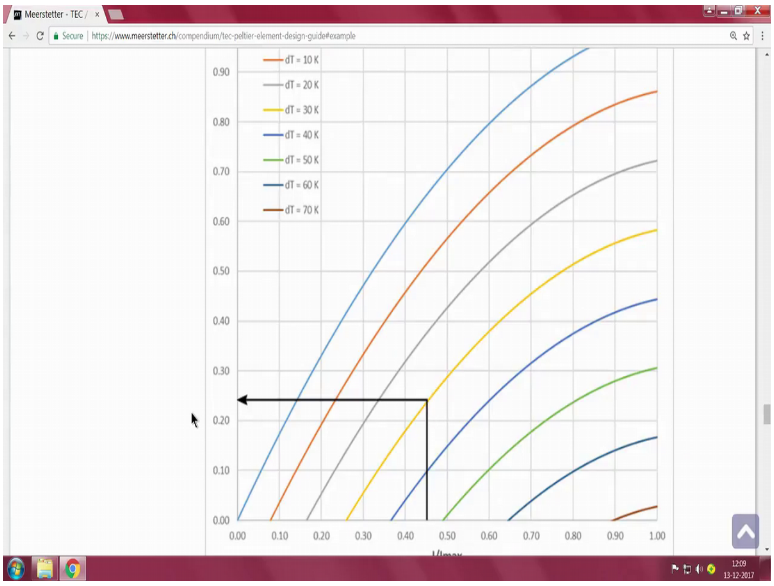

Heat pumped versus current. So, you see now Q c by Q max you know is typically around 0.25.

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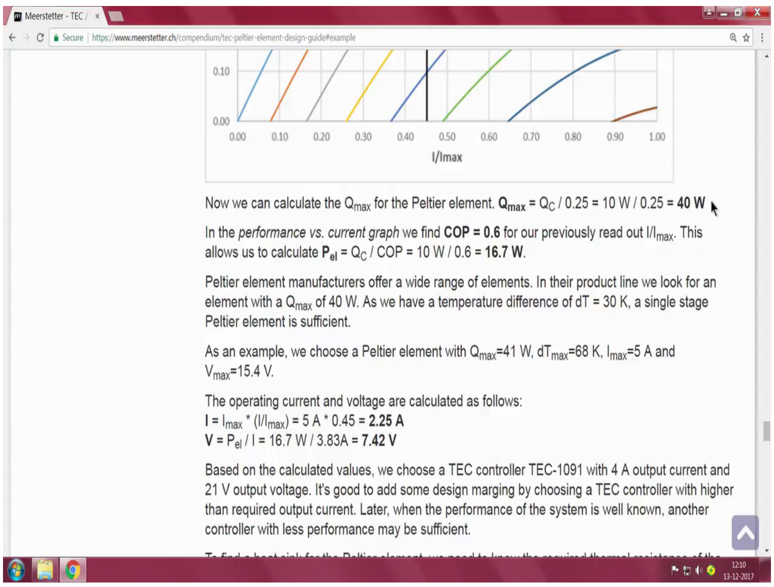

We can calculate the Q max for the Peltier element by calculating the saying, this is the first critical step taking an element which is higher is a very prudent way of working anything higher then this will be much much better.

Even if it is a 50 or 60 or 70 watts its way better than just taking something which say little lower, because in the end you may end up with wrongly sized components and then we end up with you know more and more thing having to come back here and work with it.

So, typically I will strict to this 0.25 and I will strict to this 40 watts the performance which current graph we find cop is 0.6 sort of (Refer Time: 12:42) clear about this thing, this allows to calculate Q c by COP is typically is 16.07 watts. Peltier element manufacturers offer a wide range of elements in their product line we look for an element or Q c max of 40.

As we have a temperature difference of 30 K a single stage Peltier element is sufficient which is a peliteir element the max what even watts is intentional because its 40 know has taken 41 watts delta T can be anything I max 5 ms, and we makes us 15.4 volts. The operating current and voltage are calculated. So, we come to 7.4 volts, in which you know the Peltier element has to be operated upon and typically I will be around 2.25 hams. Based on the calculated values are which say the second part know we need not worry too much about it.

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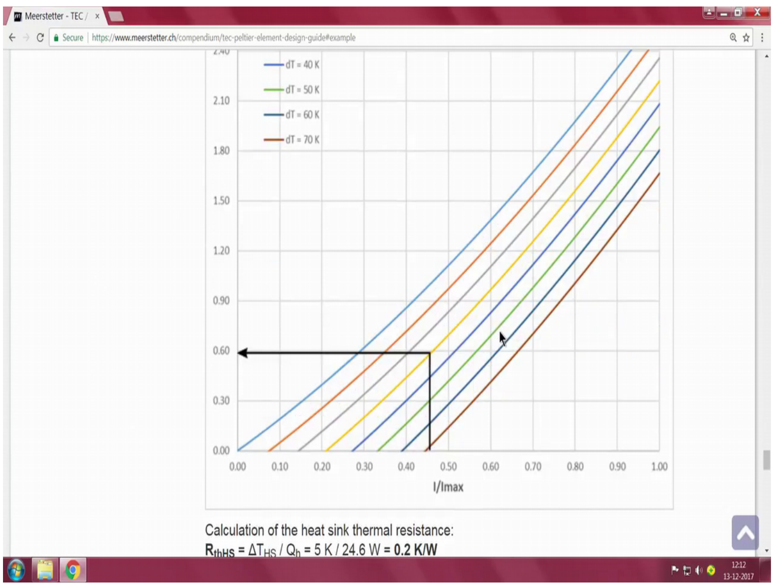

And you see here usually you know heat rejected versus current again verses know saying heat sink thermal resistance should be approximately 0.2 degree K per watt. W e need a heat sink the thermal resistance smaller than 0.2 degrees K per watt it is stuff its not easy. Normally we come to things which are 1 a 2 degree centigrade per watt. So, hence will be forced to real system and iterating through their design steps is necessary determine the optimal system parameters seen this no important thing is earlier starting point.

In the starting point we have come up cross where you read these things again, you got to the more website and you will be able to see all this thing saying.

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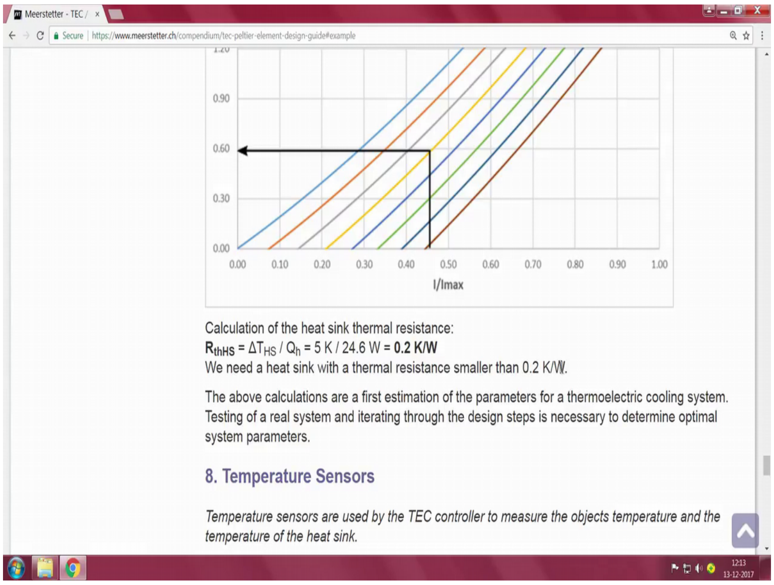

Critical thing is 0.2 degrees Kelvin per watt tough extremely tough and we come to the test.

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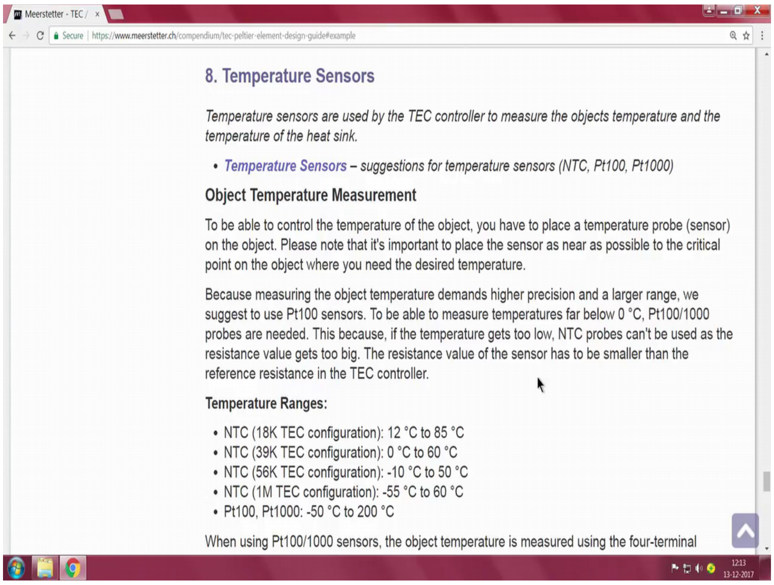

I suggest you just read it through when you are looking when you are looking for heat sinks with that typically very small what you call thermal resistance one of the other important thing is how do you measure the temperature. Obviously, we need to have this different type of you have seen this here we have a several types of machining object temperature demands higher precision in the larger range we suggest use the Pt 100.

We were able to measure the between I mean below this thing, we may require a Pt 100ah the probes are required the temperature gets too low NTC probes can be used as the resistance value gets too big.

So, here one more thing is often know we have directly small chips which are taken from any of the standard websites, which you can continue to use it, but by definition invariably we are expected to use 4 wire sensing because we are dealing with thermal parameters and then all wires you know also have a temperature coefficient and we are talking about small changes 0.1 0.2 millivolts change.

This is sufficient the disturbing all the reading. So, invariably they have the 4 volt I mean 4 wires are sensing this thing. So, you go to current carrying and voltage sensing electrodes are used more information about 4 wire terminals and singles given there if I click on it know it will now I will see whether I can open it in a new tab and let it keep opening at the back.

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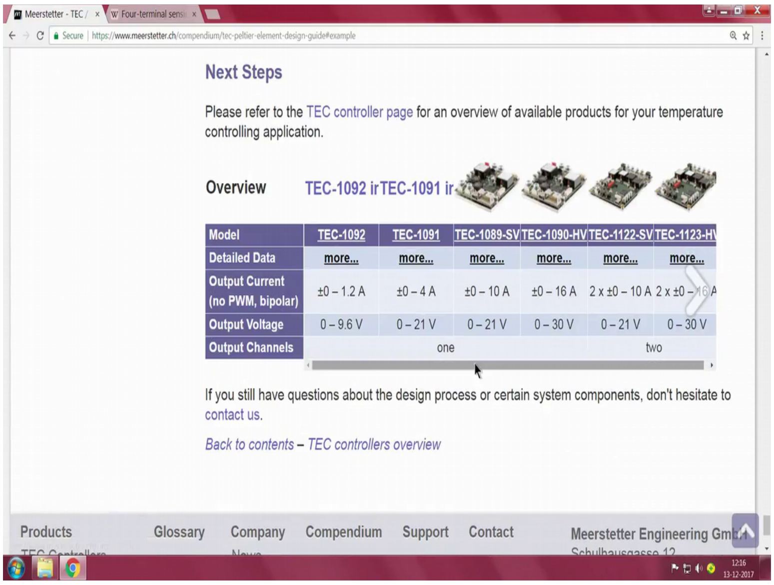

Then we have power supply, and then you see we have all these things here. At this point let me see if you see here a little about the.

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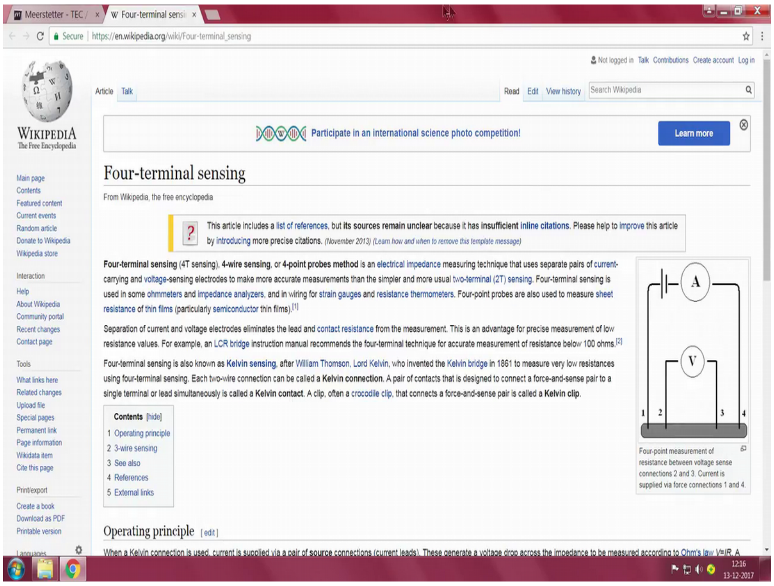

Four wire sensing is used meaning what is the actual current and what is the voltage a current. I suggest since your electronic engineers you know you need to probably read it up yourself. So, far there is only a simple worked example, which is taken from here to here.

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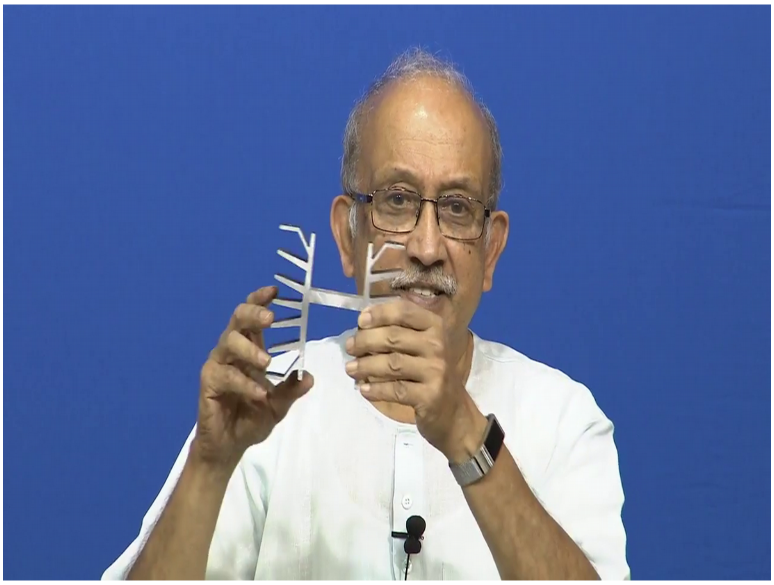

If you are looking for things like that 0.2 degrees centigrade per watt we end up with this powerful heat sinks, which is not easy with to manage with this. And now how do you use this heat sink and attach it to your device to be cooled. So obviously, whichever way you look at it if I put the Peltier here and if I put the device here I still have a lot of these hot things are there, and one Peltier I can do can I use any way of me to put a perltier on both directions. So, I will give you an example of.

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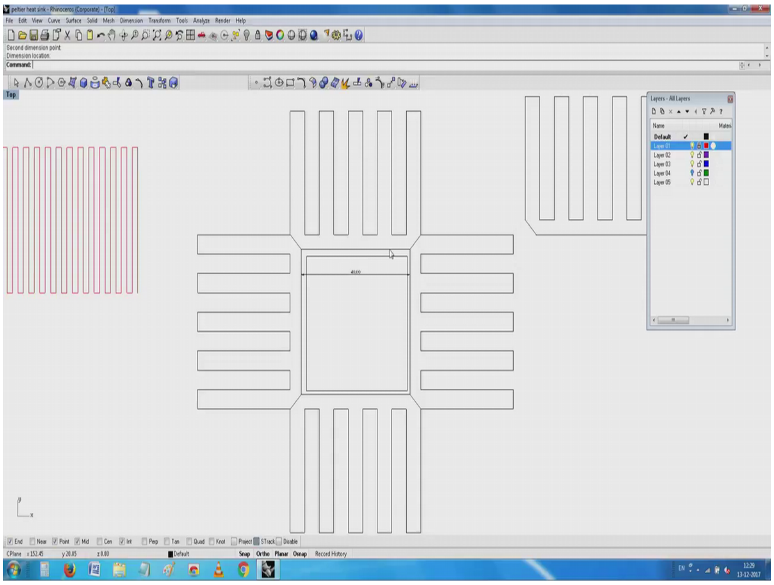

See what in attempt we are trying to make here is, I am trying to design see there. I have taken a 40 mm by 40 mm Peltier module, which by all other calculations and typically that is what is occasionally used in it and saying now is there a way of for me for attaching 4 of them.

Seen here something has been made here which is exactly I am trying to attach 4 of these on 4 corners like this, the moment I have it and the dimensioning also has been done such that from here to here it is 40 mm is approximately 40 this is 40 and this is 40 total I have 120 mm and miraculously this fan is also 120 mm fan.

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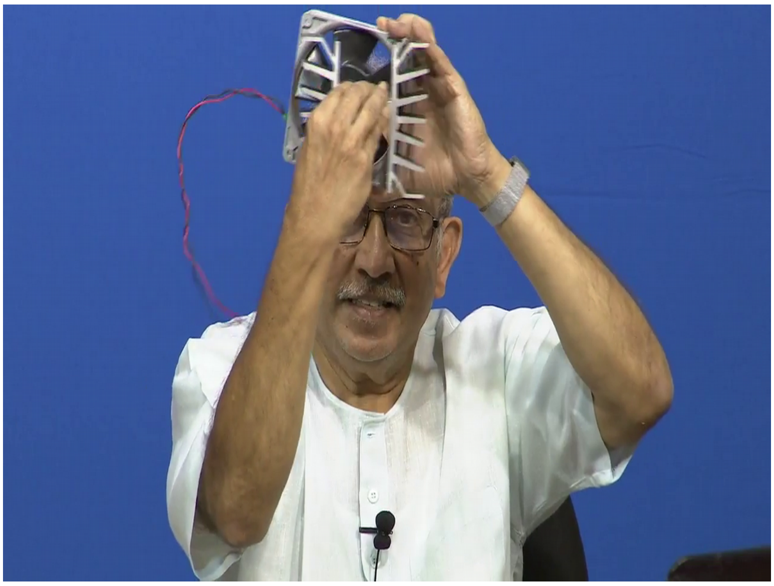

Instead of my directly just putting it here like this and then trying to live with it, I now try to I now try to see whether used this portion with a small square what do you call a cubical or what you call elongated ellipsoid with a cross section, where all the 4 sides of it are packed with thermoelectric coolers.

Advantage of that fur meal now I have a cavity in the middle, which is typically like this understand know you see the little squarish appearance and if I can make the whole thing by directly using the heat sinks, it is possible to make a small cavity inside which has lowest overall mass of it.

What you see here is the outside of you understand what you see here know here to here is the outside, the inside here know come the Peltiers and I have a cavity typically if I.

You see there you see that small square, which I have one inside the thickness represents the thickness of the Peltier element. Now it is for us to decide whether what happens to that corner.

If each of them is this much do you make it overlap here, or you make it overlap here or just leave a gap in the corner. I would prefer you make some arrangement by which you attach one more heat conducting thing, typically an aluminium tube or something and you are all your items alone should be inside that aluminium tube. In the moment you are using a square tube we end up with the corner which has a little gap.

So, fill the corner with some insulating material; typically you can continue to use something like depending on the temperature if it is not likely takes it 70 or 80 degrees, you can maybe packet with poly urethane foam pieces.

You probably require something is around 4 mm by 4 mm. You carefully what you call sculpt their small piece and trying to push it in the corners. So, getting back you have a square, we have a square what you call tube extrusion is this 40 mm by 40 mm 4 corners we have be 40 mm Peltiers stuck with it right now I will say you sticking because there are heat conductive and then the corners you can now put your whatever that thing typically a poly urethane rigid poly urethane foam which is the normal installation we use. Moment you put it now if I suffer my argument I will take that 4 mm is the thickness of the Peltier 40 plus 4 plus a 4 48.

So, typically I can now start looking at it and see how big or how small this heat sink needs to be right. Now it is 40 we can afford to make it a little bigger, maybe 50 mm can be bigger. Now obviously, in a very very simple way of making something is, make all the heat sinks about equal only thing is right now the length has not been yet fixed. And now just to put a fan we have an advantage now in that once you have a fan here, you also will have a need area to start your work.

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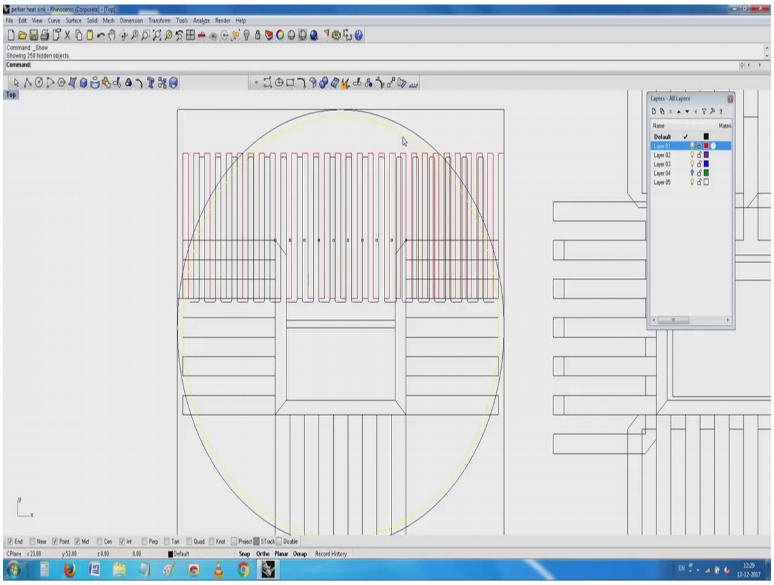

You see here this is typically a fan, fan outline and then this is the actually the force I am sorry where the air is getting blown inside, we need these dimensions for various other thing moment you have it, suddenly I notice a very very important thing. You see I still have a little more place here is it possible for me why let that wind are the cooling air go wasted in that small sector because if you consider all the 4 of it no it is still significant it will contribute to around extra you know ten percent of the total blow that is possible, and the flow can be regulated properly.

Unless we block this area the chances are all the air will escape into this partner, this is wherever product design issues come into picture. So, I now start working and seeing what else can I do about it. So, one estimate has been here made here you see there. So, what we will do for the purposes of this thing here, I now switch over to another drawing which I have already created, and oh sorry you see here.

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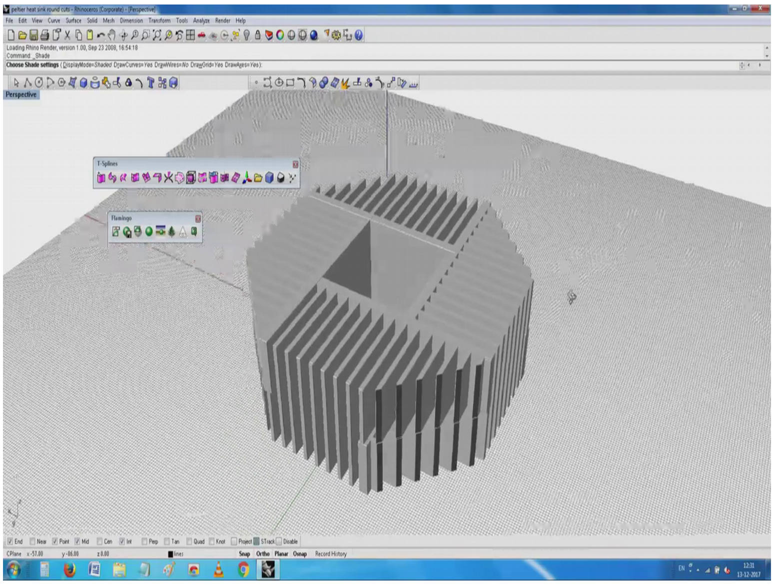

See what has been done here is, our little bit of work see what I have try to do. I feel this is the slightly innovative part of any of our product design hence I feel compelled that I know I should share with you.

So, what has been done is in the normal course I will just keep only one of them on and see how things go.

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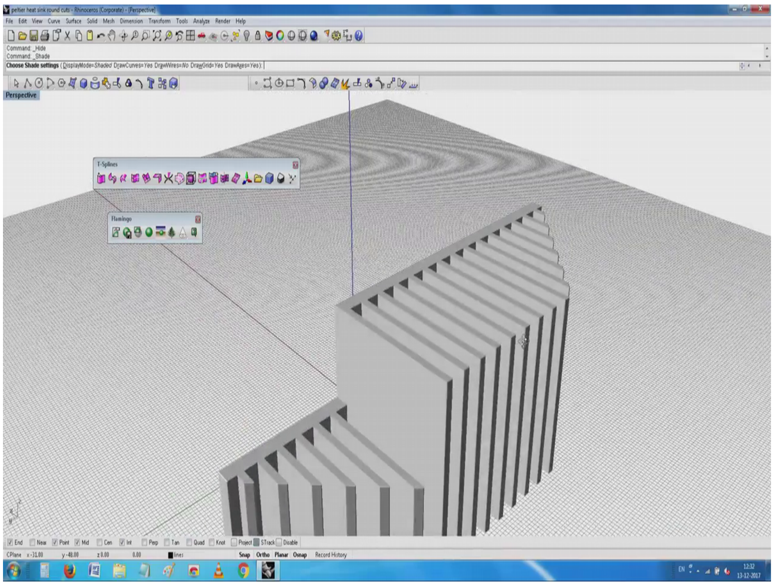

See what has been done? If I go to the plan view looks fine we have the corners and you know it looks and so on like that.

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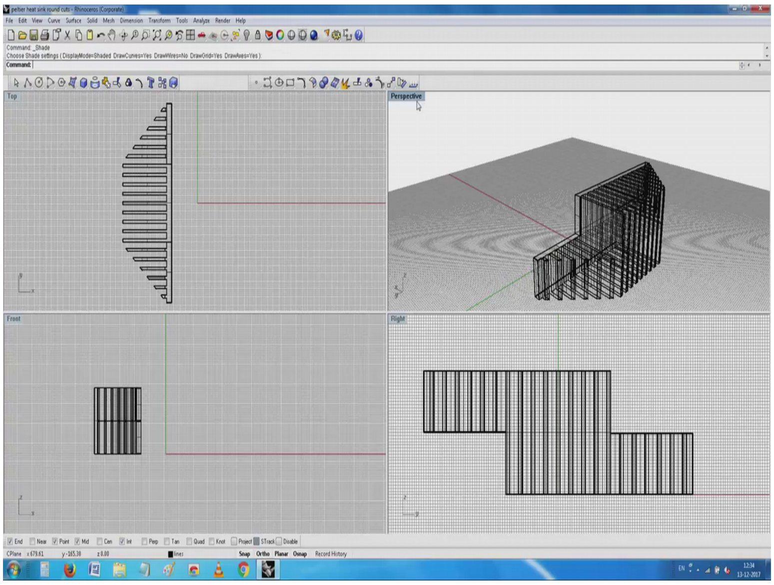

Now we come to the much more are equally critical way of dealing with this whole situation. Coming back to the heat sink design if you remember I told you why these all these heat things has been made this way, you have a little what you call little factor thing and then after that we have this limb which is slowly getting tapered here all along and then we have each of them fins is the tapered fin.

How it has been done is total they have try to calculate what is the cross sectional area of the heat to be going out, and with the temperature which is actually at that point and all the way in reality the heat sink at the tip should be about the same temperature as at the base when it is being cooled, that is what is equal into what is called the fin effectiveness.

See it now the fin will not be effective unless the whole thing is at the same temperature and how do you make it at the same temperature; when you have a blower cooling it all the time. So, the rate of heat conduction heat conduction should be balanced to the rate of heat convection to the ambient, and now have try to put another you know what you call unwanted thing here, we have a corner here, you have seen here you have this corner now.

When we have two of these devices how do I now what do I do? If I put one more device here like this on this corner, that will not have enough of a base to conduct away heat to the tip of the fin. So, what I have done is, which I feel I mean it just a matter of I am trying to get it fabricated, now whether ah. This thing is really universal or not will come to it later, see what has been done? Each of these heat sinks one half has been milled out. Why this is a is on the corresponding side one more half is there. So, now, if I go back to the back of this heat sink, it is just I mean at one point you know you may call it a jimmig and at one point I feel this is how we try to build a bit of ip content into that.

So, a lot of these commercial heat sinks are, maybe people try like this. So, we have here this part of it is fully understood there is no problem, now part of this flow in this corners can be used by putting a heat sink here and to make them symmetrical one half I have attached a base to this here and other side I have the other half in which the other half is offset and kept here.

Advantage being now when I give one hour top of the other I have a gut feeling or an intuitive feeling, that all of them will probably form a nice cute feature like this.

Now you see here when I put all of them together, I have the advantage of this centre portion top portion is covered by this part of the heat sink and bottom portion is covered by this part of the heat sink the with it being now I have this corner thing, yes I am happy that you have noticed.

That saying sir where what is this doing here in this corner and then if I see in this plan we have lot of this thing is a waste is not yes. Most likely you know a lot of it its probably an overdue overkill and too much of effort to go into this. If I had control on the profile extrusion, probably I will also ensure that at this point the spacing is a little larger you understand know this spacing is a little larger, to the extent now when we look down on this area here when we look down on this on this area here, you will have less of any interference from adjoining heat sinks and then I have what looks like a neat Rangoli.

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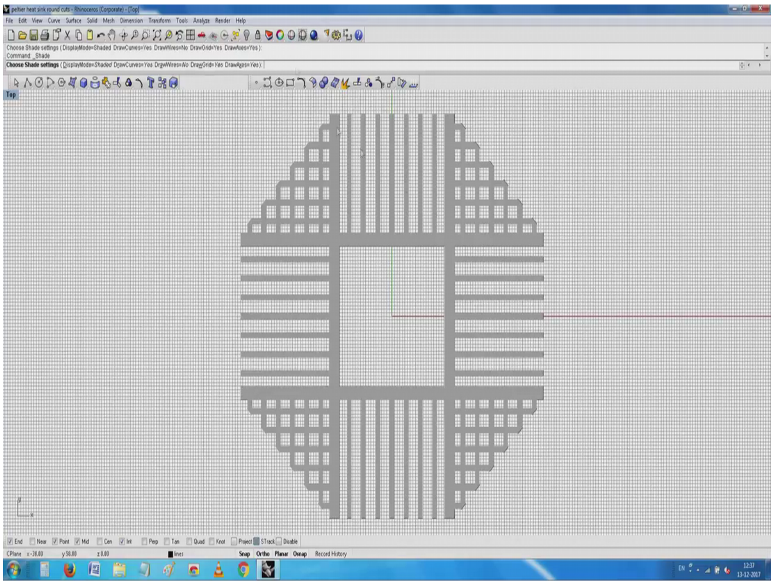

The issue here is not Rangoli the issue is if I now spend what you call enough effort and time and coming up with a heat sink design like this most likely I can have a if we in it others can copied no issue about it, I will know optimize it by putting it through some sort of a simulation.

The simulation is it will take care of each of these devices and then a full fledged qfd probably running on MATLAB or other code has these required to solve these problems. Having done this now I have notice rather I would like you to I like to point out to you this heat sink I will take up.

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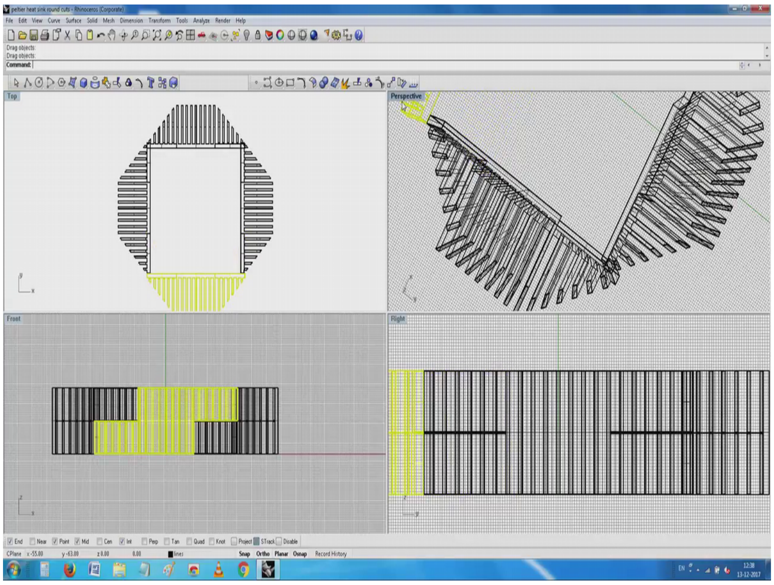

See this.

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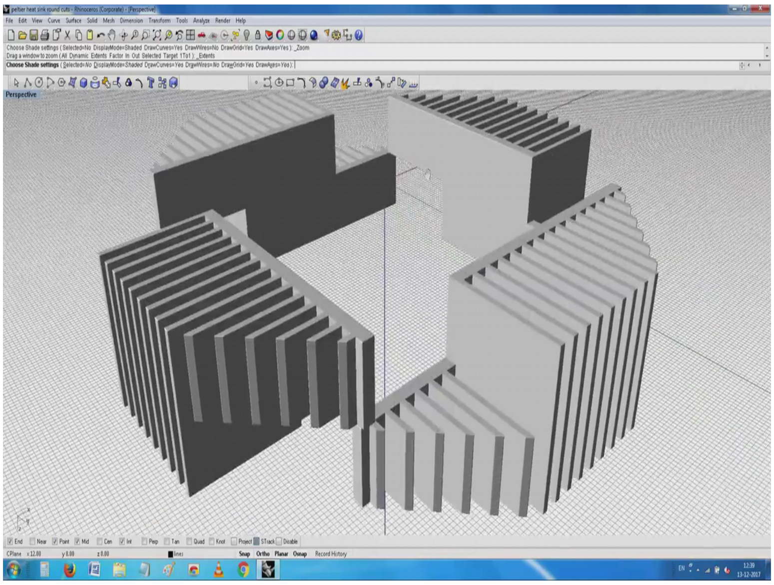

Maybe is a chance for you to I am not bragging saying this is the only way to do. Now you see here and probably a little gap and I will use all these devices in the place here to introduce that small Pt 100 or other type of tiny what you call this thermocouples, which can be probably you can drill a small hole insert it inside on the bottom surface and my indue inside I have Peltiers, and inside those Peltiers I have the aluminium tube.

And if you remember I have the corner still I have a little access to the corners here. And once I have access to the corners here either I can leave a gap between these two heat sink top and bottom. So, that I do not need to drill the heat sink in anyway alternatively I can make a small half circle a semicircular groove here by which it can go inside and directly it can take in one of the corners.

And then when I have that 40 by 40 conductive tube I have access to all the 4 corners, and then I can put my what you call this thermister elements wherever I want. I can keep them one in the corner one in the bottom and all that. So, I way we have now directly measuring the temperature on the full profile which is available for me.

Having done this all I need to do is now I have a fan now I need to take that little this thing is in blowing or something, earlier itself I have told you about it is much much convenient if you put always colder to be sucker by the fan and fans is the cold air in I mean afterwards.

You have our heat sinks and things here only for purposes of illustration, I will show you here imagine we have one device here with a little bit of or the flow to develop, you require at least 10 millimetres, then only flow develops freely. Alternatively it will start making too much of a noise which is in instantly it is the same principle, in which air ride sirens work. Air ride siren works by closely these things here coming close to it and making a terrific racket. If you just leave around 10 millimetre that racket would not be there imagine you have one heat sink here and then something double the height know, one more will be there and as I said know these things will be straight long, but this portion will be coupled to this and so on.

And in principle the top can be left open and you can try your best to see if you can now provide a chute or something, leave a little gap leave it absolutely open. Further if you want in case the flow is not sufficient you know just add and your fan.

Once you do all this in principle the idea should be that the heat sink itself you know should be something which is fresh taken off the shelf, and something we do a little bit of modification only for mounting it together. The very fact that we have so many types of heat sink shows that there is always place for one more design which I feel know is relatively easy here.

So, today I mean for this session allow me to stop here, I will try to continue on this next time when I take then you can read it here. You will again see the same view then I have a fan which is attached to the top fan at the bottom, and then in due course after the milling and all is over probably I will try to show it you. So, I will stop here today

Thank you.