Indian Institute of Science

Design of Photovoltaic Systems

Prof. L. Umanand
Department of Electronic Systems Engineering
Indian Institute of Science, Bangalore

NPTEL Online Certification Course

This topic of peltier junction of peltier element that it is called is very popular topic in recent times, the peltier element is also a semi-conductor material junction, the PV cell is also semi-conductor material interfacing these two to produce the action that the peltier is generally used for, the peltier is used as a heat pump where it transfers heat from a cold body to a hot body, from a lower temperature to a higher temperature.

So this mechanism of heat pump by providing an electrical energy at its terminals has a lot of important applications, and refrigeration and cooling and cooling devices which are generating heat which we will discuss. But it is a hard topic especially for electrical engineers in the sense that there is this aspect of electrical circuits interfacing to the electrical port of the peltier element.

But there is also this topic of tamil domain, because all the applications where the peltier element is used is for cooling, refrigeration where thermal aspects play a very, very important role. Therefore, understanding thermal aspects and then designing the cooling product, peltier cooling product together integrated with the electrical and electronic circuits is a very hard concept.

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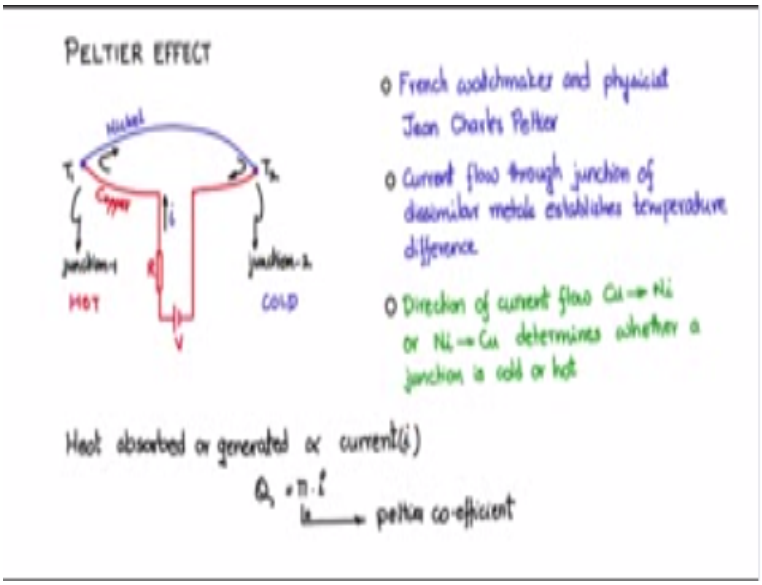

Consider two dissimilar metals, let us say one of the metal is nickel like this, it could be iron constant and nickel copper, copper aluminum. So there are many metal pairs that can be used. So let us say nickel and copper we use, this red line is the copper wire, blue line is the nickel wire. And let me connect it to a resistor and a potential source a battery like this.

So there can be a current flow in this fashion depending upon the polarity of the voltage potential of line so let us say that is copper and is the resistance R and the voltage V let us close the circuit when you switch it on you will see the current flow like that has shown so current I so when a current I flows through this copper nickel, nickel to copper and back there is a temperature difference between copper to nickel current flow and nickel to copper current flow junctions.

So you will say this is one junction this is another junction so one junction will be temperature t1 another temperature t2 so junction 1 and junction 2 depending up on the direction of the current flow one of the junctions will be hot and the other junction will be cold, so this peltier effect was discovered by a watch maker physicist Jean Charles Peltier so he found that by passing a current through a junction or dissimilar metals there was a temperature difference between the junctions.

Now the current flow through the v of dissimilar metals establishes a temperature difference but note that current flow from copper to nickel and current flow from nickel to copper is different let us say copper to nickel there is heat that is generated this becomes hot nickel to copper there is heat that is observed in therefore this becomes cold so one of the junctions will be hot the

other will be clod if you reverse the direction of the current flow if current flows in this direction here it is copper to nickel here it is nickel to copper and therefore the hot and cold also reverses.

The direction of current flow is important so that is one conclusion determines whether a junction is hot or cold heat absorbed or generated heat generated heat absorbed is proportional to the current flow I this current so you can say heat absorbed or generated let us call that as Q is equal to some proportionality factor into I so this proportionality factor by is called the LT here coefficient.

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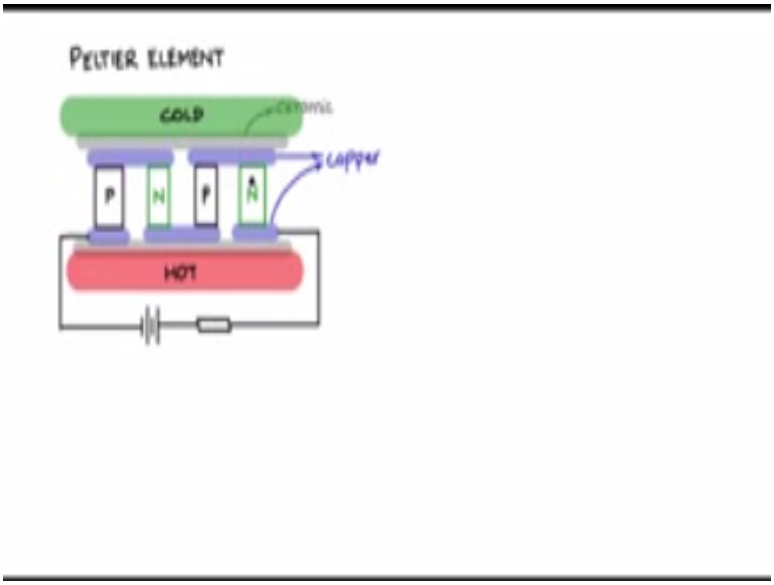

When the pass apply switched on V by this resistance plus the overall resistance between the terminal of the element will dictate the current flow and the current in this fashion it will take the path through this copper n block through this copper b block then n block b block so on.

The PELTIER element now a days is not made up of discrete dissimilar metals that which as discussed while discussing the principle of the PLETIER effect today now a days the PELTIER element is a solid state device it is made up of semi conductor material and it is having P typo and n type materials so let us see how a PELTIER element looks like, so if you look at this I have placed some strips here imagine them as strips the tope side and the bottom side in this fashion.

Now let them be copper strips now these two copper strips sets of copper strips will be inter connected with blocks of semi conductor material, now let us say I inter connect this strip and

the strip using a P block I will interconnect here with and N block and like that alternatively I will interconnect the top and the bottom copper strip with EN, N block as shown here and then let me put as ceramic substrate casing like this and encapsulated in this fashion.

So this is how a PELTIER element is the alternate PN, N block and there is a kind of connectivity here the current can flow in this fashion so this is ceramic substrate and this is copper, copper strips now let us bring out two wires one from this side and one from this side and interconnect them externally, so let me take a wire and use a battery or a DC source or a photovoltaic source in series with the resistance and connected like this.

So you have a complete circuit you see the current can flow in this fashion it can flow in through this into this copper strip up, then block copper strip down, the P block copper strip up then block copper strip down the P block, copper strip copper and then back again.

So there is a junction formed here on this side of the surface the junction form this side of the surface there is a junction form this side of the surface so and so there are multiple junctions that are formed is one set of junctions which are absorbing, heat absorbing other set of junction which are heat generating, so you will have a cold and the hot side, so let us say this side is the hot side the other side will be the cold side, so this will be hot and that will be cold.

So this is how today's new advanced semi conductor based solid state peltier element will operate, will behave and then how it is internal block look like. Let us now see how our real peltier element looks like.

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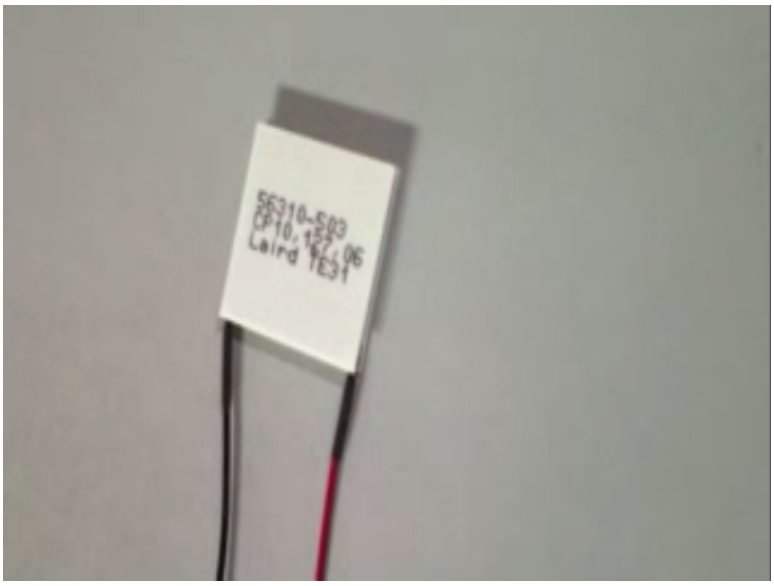

Here you see a real peltier element, it is laird at made TE31, 56310-503 so this is the number that you will have to keen into Google and download the data sheet if you are interested and looking at this characteristic, see it has two wires the red wire is connected to the positive of the battery or the DC source, the black wire is connected to the negative and if there is a current flow through this element and back through the black wire one side of it becomes hot and the other side becomes cold.

Observe that this Peltier element is made up of lot of this blocks the P and N blocks semi conductor material and it is having on the top at sheet copper sheet at the bottom also copper sheet it is section where each block is setting on copper section this like as indicated in the crawling so that when the current flows through the red wire in so it kind of loops through each of the tn and n blocks.

And has this multiple junctions coming into the picture and then you have that cumulative effect of heat absorption one side it will be cold junction the heat generation of the other side which will be the hot junction .

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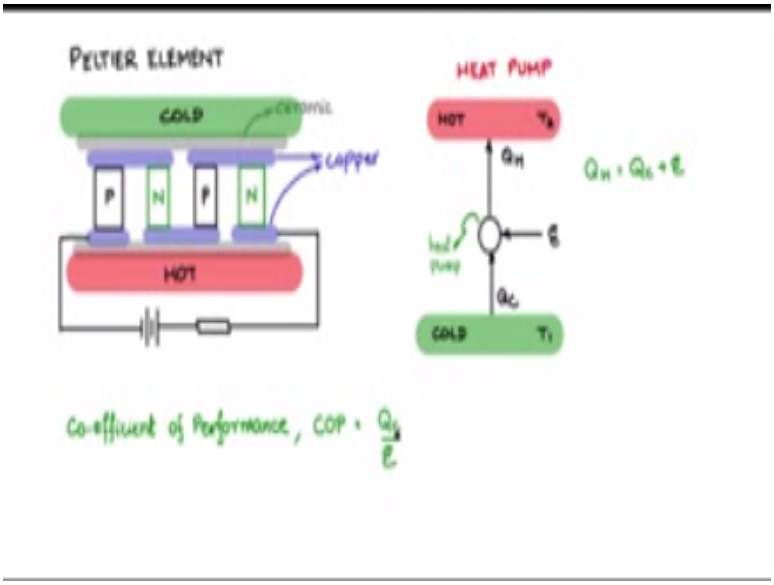

Just like you have a water pump that drips water from lower potential to higher potential we can consider this peltier here element operation of the peltier here element as a heat pump so let us say this peltier the element is a heat pump what it does is you have a hot junction and you have a cold junction it pumps heat from the cold junction the lower potential to a hot junction higher potential.

So it removes heat from this cold junction and pass it through the pump and then puts into the hot junction in this manner but in order to pump from lowered potential to high potential you need external energy and that is very much analog is to a water pump when it wants the when you need to lift the water from a lower level to higher level.

You need to external electrical energy to operate the pump so let us say this is the cold junction the button green and it is temperature T1 and the hot junction is T2 and there is the external energy, electrical energy needed. Let us say Qc amount of energy is removed from the cold junction. You add the external electric energy of E Qc and E are deliver to the hot junction as Qh, so therefore this junction as the heat pump delivers Qh to the hot junction and that is = the amount of the heat removed from the cold junction + the external energy.

Electric energy needed to do the pumping which also goes off as heat, there is the parameter coefficient of performance this is the figure of narrate which we can use for comparing junctions, we will call it COP co efficient of performance COP, so what is that it is the ratio, of the amount

of the heat that you will remove from the cold junction to the amount of heat electrical energy that is needed to perform the heat removal.

So Qc/ E , so what it just basically means is that if the electrical energy needed is 0 than the coefficient of performances is infinite, higher the coefficient of performance it is better, with the least energy one is removing a large quantity of heat that is what it would mean higher the coefficient performs greater the amount of heat energy that can removed from the cold junction with least amount of electrical energy.

So QC is the energy extracted from cold junction and E is the electrical energy needed to do the pumping action the unit of energy is joules and the unit of energy extracted is actually watts it is because you are talking of energy flow or heat flow so let us just look at this in terms of the units because in the data sheets you will generally see that QC is expressed as watts.

So QC is nothing but energy extracted from the cold junction so heat that is removed heat that flows out so it is nothing but heat flow heat as the unit of joules heat flow is basically rate of energy flow which is d/dt watt second or d/dt joules which is nothing but power so unit of power is joules per second which is nothing but watts so without loss of geniality if you say that the heat extracted in the given time the energy given to the penalty junction in a given time.

Then you can use the units of power watts everywhere for QC E and QH so in the data sheet you will see that QC is expressed in terms of watts and automatically E will get expressed in terms of watts all in the same given time and QH also will be in watts and COP will be QC energy extracted in watts divided by energy needed for pumping in watts so we can say it is the heat flow power divided by the power needed to pump all expressed in watts.