Operation and Planning of Power Distribution Systems
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Lecture - 05
Load Characteristics and Load management

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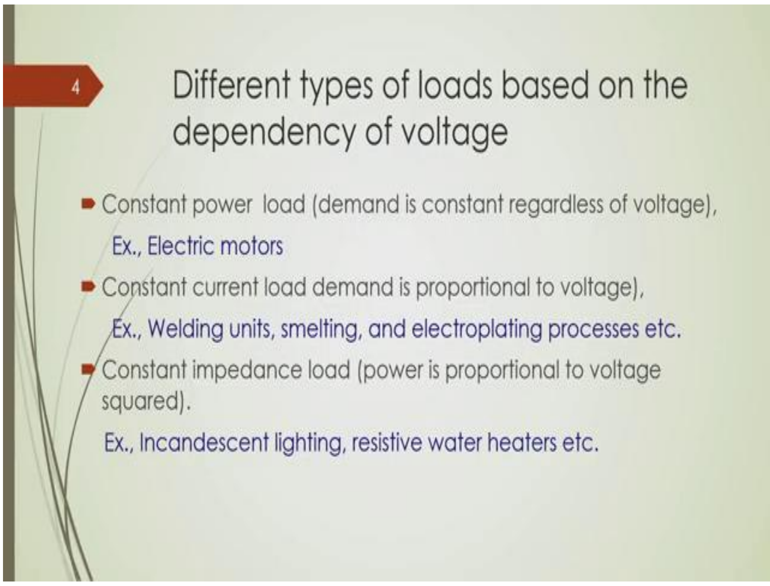

In the last 2 lectures we are discussing Load Characteristics and Load management ok and also a load modeling. So, in last two lectures, I discuss several indices to quantify this load demand in view of a electrical power distribution engineer.

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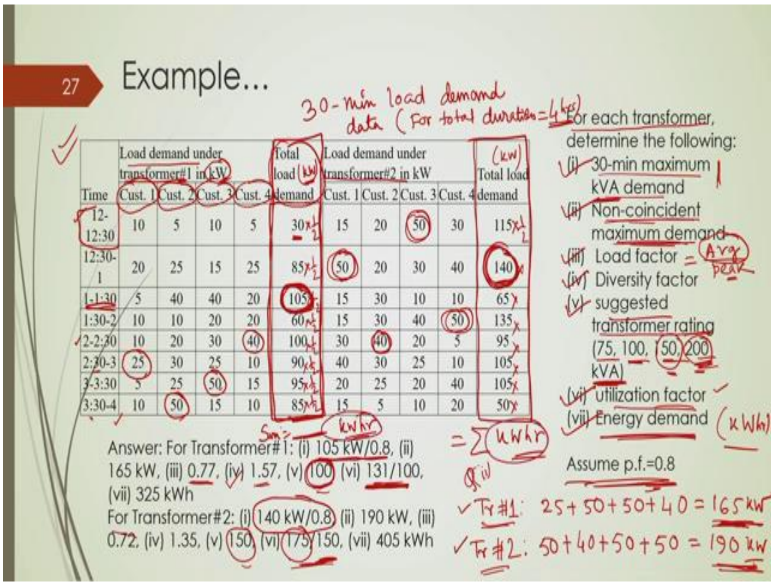

So, today I will start with a numerical example with a numerical problem. So, look at this numerical problem. So, here we have load demand under two transformer; one is transformer 1 another is transformer 2 ok and both the transformers are connected and at a substation and they are connected in parallel ok.

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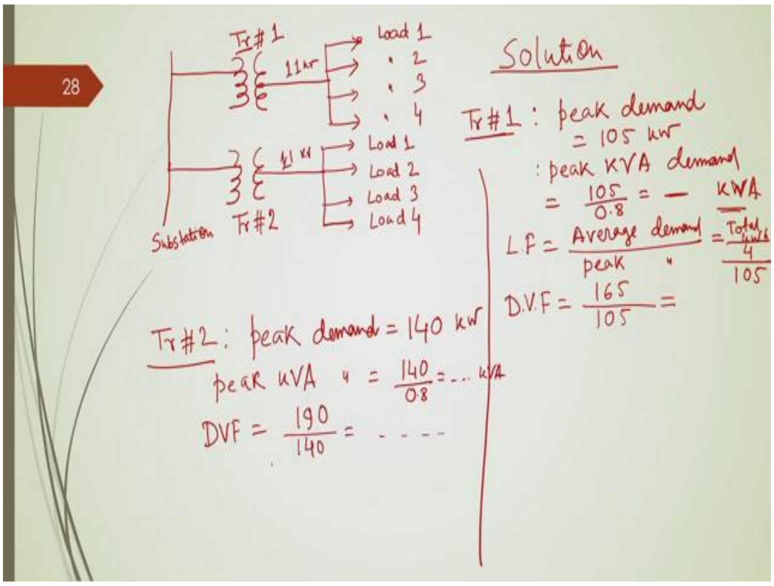

So, if we draw these transformers, it will be something like that. So, this is let us say transformer 1 and this is let us say transformer 2. Now, this transformer is connected to 4 numbers of customers like this is load 1, load 2, load 3 or load 4; similarly this transformer is also connected to another four different sets of load like this, load 1, load 2, load 3 and load 4 ok.

So, this is the substation and this is, suppose, transformer 1. So, I am representing transformer by Tr and this is, suppose transformer 2; I am representing it by Tr 2 ok. Now, look at this table. This table shows 4 hours 30 minutes load demand data; load demand data for total duration of 4 hours ok. So, this duration starts from 12'O clock in the afternoon and it is up to 4:00 PM ok. Now as I said, for all these loads both the transformers are connected with 4 customers.

So, this is customer 1 for transformer 1, this is customer 2, this is customer 3 and this is customer 4 and this column is representing the load demand of individual customers ok. Now, if you look at this individual column you will understand that for customer 1 the peak load is 25 kilowatt. So, all are mentioned in kilowatt ok.

So, the peak load is 25 kilowatt and it occurs at 2:30 to 3:00'O clock the afternoon ok. Now, for customer 2, the peak load demand is 50 kilowatt and it occurs at 3.30 to 4:00'O clock. For customer 3 of this transformer 1, its peak load demand is again 50 kilowatt and it occurs at 3:00 to 3:30; similarly in customer 4, the peak load demand is 40 kilowatt and it occurs at 2:00 to 2:30 ok. So, one thing you can understand from this example is that this all these customers they have different values of peak load demand and they occur at different times.

For customer 1 it is it occurs at 2:30 to 3:00; for customer 2 it is a different time 3:30 to 4; for customer 3 it is 3:00 to 3:30; and for customer 4 it is 2:00 to 2:30 ok. Now, here in this particular column; we have added all these rows and these are basically representing the total load demand under this transformer 1.

So, if you sum up these load demand of individual customers you will get total load demand. For example, one I can show you at 12:00 to 12:30, the load demands are 10 kilowatt, 5 kilowatt, 10 kilowatt, and 5 kilowatt. So, if you sum up this 4 then you will get 30 ok. Now, similarly we have added this all this load demand data and we prepare a total load demand under this transformer 1.

Now, look at this peak load demand of this transformer 1 it is coming out to be 105 kilowatt and it occurs at 1:00 to 1:30. So, one thing you can understand from this point why I kept this example here that individual customers their peak load demand occur at different times. One is 2.30 to 3; one is for 3:00 to 3:30; one is for 3:30 to 4:00; one is for 2:00 to 2:30 that does not mean that the group peak demand should occur out of this 4 time intervals. So, group peak demand occurs at 1:00 to 1:30 when none of the customers are having peak load demand.

So, group demand occurs its magnitude is 105 and it occurs at completely different time as compared to the individual peak demand of the customers ok. Similarly under this transformer 2, we can also find out the peak load demand under this customer 1 is at 50 kilowatt it occurs at 12:30 to 1:00.

For customers 2 it is equal to 40 kilowatt ok and it occurs at 2:00 to 2:30. Similarly, for customer 3 it occurs its peak load demand is 50 kilowatt ok. So, I am circling the peak load demand data for individual customers as well as the group of customers; that means the total load demand under this transformer ok.

Now, for customer 3 the peak load demand is 50 kilowatt ok. Similarly for customer 4 the peak load demand is again 50 kilowatt and it occurs at different time ok. Now, when we look at this total load demand under this transformer 2 you will see that the peak load demand under this transformer is equal to 140 kilowatt and it occurs at 12:30 to 1:00 when a customer 1 is having a peak load demand ok.

So, for transformer 1 we have seen that this individual peak demand occurs completely different time as compared to the group peak demand whereas, in transformer 2 the group peak demand occurs when customer 1 is at a peak demand. So, any case is possible ok.

So, it may so, happen that all these customer’s peak demand coincides a particular time stamp or it may not happen. So, load demand is something that any possible scenarios possible. Now, look at this problem ok. So, we have to determine this 7 questions; there are 7 questions based upon the table given.

So, first of all we have to determine 30 minute maximum kVA demand for each transformer 30 minute maximum kVA demand you look at kVA demand. So, 30 minute maximum kVA demand for each transformer ok. So, it is already known that for transformer 1 you would get this peak demand as 105; peak demand is 105.

And it is also given this 105 is also in kilowatt because all this load demand data are in kilowatt; so, this total load demand data is also in kilowatt ok. So, it is nothing but summation of individual load demand, simply arithmetic summation ok. Now, this 105 kilowatt is the peak load demand of transformer 1, but it is kilowatt ok.

But here if you look at this question is that 30 minute maximum kVA demand is asked to determine ok. Now, you simply know that power factor is given as 0.8 ok. So, if we know that for transformer 1, let us for transformer 1 write here, and for transformer 2, I write here ok. So, for transformer 1, the peak demand is equal to 105 kilowatt for transformer 2, peak demand is equal to 140 kilowatt.

So, we can find out one is 105 one is 140 ok, but we have been asked to determine 30 minutes maximum kVA demand. Since power factor is known to us, you can simply find out this peak kVA demand equal to this 105 divided by 0.8; whatever will come that will be this peak kVA demand under this transformer 1.

Similarly, for transformer 2, peak kVA demand is equal to 140 divided by 0.8; whatever will come that much kVA. It is not difficult. Now, look at this the second question. In second question non coincident maximum demand is asked; non coincident maximum demand is asked ok.

Now, what do you mean by non coincident maximum demand? It is nothing but the sum total of individual peak demand; it is sum total of individual peak demand and we know that individual peak demand for a transformer 1 is 25, 50, 50 and 40. So, for transformer 1, I am writing this here this non coincident maximum demand, i.e., for question number 2 non coincident maximum demand will be equal to 25 plus 50 plus 50 plus 40 is equal to whatever it will come.

So, 25 is the peak demand of customer 1; for 50 is the peak demand of customer 2 and again 50 kilowatt is the peak demand for customer 3 and 40 kilowatt is the peak demand of customer 4.

So, if you add all these individual peak demands, then you will get non coincident maximum demand ok. So, if you sum up this so, this should come as 165 kilowatt ok. So, similarly for transformer 2 you sum up this individual peak demand which is 50 kilowatt plus 40 kilowatt plus 50 kilowatt plus 50 kilowatt.

So, this will be equal to 50 plus 40 plus 50 yes plus 50. So, this will be equal to 190 kilowatt. So, this non coincident maximum demand for under transformer 1 is 165 kilowatt under transformer 2, it is 190 kilowatt; this is again very simple to find out. So, when the non coincident maximum demand is asked, you have to find out individual peak demand of whatever customers connected to that particular group ok. So, you find out and then you simply arithmetically add this. So, it will whatever this value will come this will represent as non coincident maximum demand ok.

The next is asked as load factor; next is load factor. Now, how do we find this load factor? You know load factor is obtained with load factor is nothing but average demand divided by peak demand ok. Now, peak demand of individual customers we know one is 105 kilowatt another is 140 kilowatt ok.

So, peak demand do we know, but average demand is to be calculated then, you have to take the ratio and that will be you know this load factor ok. Now, what is this average demand how to calculate it? So, you look at this column you look at this simple look at this two columns one is total load demand under transformer 1 another is total load demand under transformer 2.

Now, this column represents this 30 minutes average demand of under this one transformer ok. Now, if you want to determine this average demand under a particular transformer then you have to multiply this individual load demand with its duration. So, duration is half hour that is 30 minute so, 30 has to be multiplied by half.

So, basically if you solve this in excel then it would be easier to you to calculate. So, you simply multiply this whole column by a factor of half that is 0.5 and then whatever you will be getting that will be kilowatt hour demand under this transformer 1 ok. So, you multiply 30 with half 85 with half 105 with half and all these things whatever you will be getting that will be this; if you sum up this whole then you will get the kilowatt hour demand and that total duration is from 12:00 to 4:00'O clock; so, that is 4 hours. So, this total kilowatt hour divided by this 4 hour will give you average demand.

So, in order to find this load factor we need average demand divided by peak demand. So, in order to find this average demand you find out total kilowatt hour demand divided by 4 hours that is the total duration divided by this peak demand peak demand for transformer 1 is already given that is 105 so, you simply put this 105 ok.

So, whatever this will come we will give you this load factor and this answer you can verify with answer given over here. So, one for transformer 1 it is found out as 0.77; for transformer 2 it is found out as 0.72 ok. So, this is very simple I repeat it again. So, you simply find out this overall kilowatt hour demand under a particular transformer. How we can do? You find out simply that demand multiplied by its duration that is half hour.

So, if you multiply 30 kilowatt with half hour you will get 15 kilowatt hour that is the energy demand in this particular time stamp. Similarly you find out for all; we find out for all by multiplying by half then you add then whatever this summation will come you multiplied by half to all and then you take the summation of all these things then whatever this value will come that will be total kilowatt hour demand under this transformer 1.

This total kilowatt hour demand is to be divided by this total duration total duration, i.e., 4 hour. So, you divide by 4 hour. So, you will get the average demand; this average demand divided by this 105 that is the peak will give you load factor ok; so, this is not difficult. Now, next is diversity factor; how to calculate diversity factor ok.

This diversity factor, again, we obtain that it is a ratio of sum total of non coincident maximum demand to the diversified demand which is the peak demand of the group ok now here you can see already we determine this sum total of non coincident maximum demand for both the transformers. Now, this would be the numerators of the diversity factor of the individual transformer.

And the denominator will be this two peak values one is 105 one is 140 ok so; that means, this diversity factor diversity factor DVF for transformer 1 is equal to this 165 kilowatt divided by 105 kilowatt. So, 165 is divided by 105. So, definitely this will be greater than 1. So, already, I calculated and it should come at 1.57 ok.

Similarly, for under transformer 2, this diversity factor will be thts; this is the numerator; that is sum total of individual maximum demand or non coincident maximum demand divided by this group peak demand that is 140 kilowatt. So, for transformer 2, DVF will be equal to 190 divided by this peak demand 140; whatever will come that will be the diversity factor under transformer 2 ok.

Now, next is suggested transformer rating which is somewhat new. I have not talked about previously that how to choose the transformer rating from this load demand data ok. So, this is normal practice of power distribution engineers that form this type of table they can compute this; they can choose or they can select that what should be the rating of the transformer that we are going to install ok.

Now, how to decide this transformer rating? Four possible ratings are given here. So, it is expected that one out of these should be chosen for transformer 1 and one should be chosen for transformer 2. Now, the question is how to choose this transformer rating? how to choose the transformer rating? Look at this table. This table particularly this column basically gives you an idea that how much peak demand will sustain under this transformer 1.

And we got it at 105 kilowatt ok, but you look at this rating; this transformer rating is usually specified in kVA not in kilowatt ok. So, obvious reason that one you may be knowing that it depends upon the temperature rise which depends upon the losses; one loss depends upon the voltage another loss depends upon the current. So, that the overall transformer rating is dependent on the kVA.

So, we have to find out that 105 kilowatt corresponds to how much kVA; Already we determined here this is equal to 105 divided by 0.8, some value ok and that value is bit higher than 100. So, I can choose either 100 or 150 as the transformer rating and I can choose it 100 also provided that I know that during peak time the transformer will be overloaded.

So, based upon that 100 is chosen, but, obviously, one can also choose 150, but 150 would be a costlier option because as you know if the transformers kVA rating becomes higher and higher the cost of its installation and its commissioning is also be high and cost of the transformer will be also high.

So, based upon that we can choose 100 kVA rating transformer and for this you know transformer 2; since the peak demand is at 140 kilowatt that is equivalent to 140 divided by 0.8 kVA, which is higher than 150. So, I can choose any value in between 150 and 200; 150 and 200; I can choose 150; I can choose 150 provided that again my transformer will be overloaded for some few minutes of time when your peak load sustains ok, but of course, one can also choose 200 kVA ok.

Now, if you choose this 100 and 100 kVA and 150 kVA as the transformer rating for both the transformer then the utilization factors will be equal to 131 that will be that is basically a 105 divided by 0.8 divided by this 100 that is the rating of the transformer. So, its utilization is higher than you know 1 ok, similarly utilization factor is higher than 1.

Similarly, for transformer 2, it will be equal to 140 divided by 0.8 which is approximately equal to 175 divided by this transformer rating that is 150. So, that will be again higher than 1 so, that will be the utilization factor or transformer 2. Now, finally the last question is to determine the energy demand that is the kilowatt hour demand ok; for both the transformers again already we determine this energy demand while calculating this average load.

How we determine this simply multiplying by a half with this particular column; similarly here you multiply it with half for each column and then sum up total; it will give you this total kilowatt hour demand ok. So, if you do it in excel so, it will be easily calculated within a fraction of second ok. So, this is how this problem is all about; we determined all these questions and it is not very difficult to do all these things; only simple calculations are enough ok.

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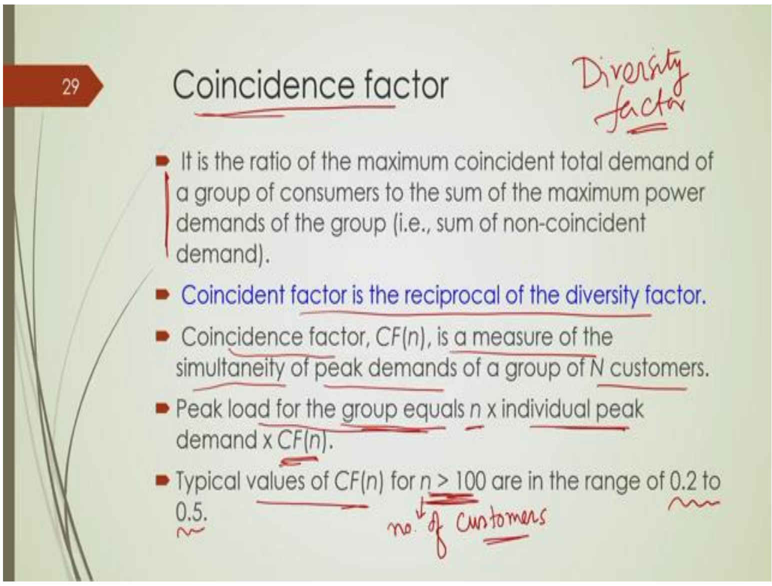

Now, next we will go for different other types of indices; one is coincidence factor ok. So, you already we know that diversity factor. So, which is the measure that how much diversity we have under in a group of customers. Similarly, coincidence factor is just a reciprocal of diversity factor; it means that in diversity factor what was in the numerator this numerator was sum of the individual non coincident demand and the denominator is the diversified demand or group peak demand ok. So, here we will just take the reciprocal of diversity factor in order to find out this coincidence factor.

So, diversity and coincidence as you know, they are reciprocal to each other. So, the formal definition of coincidence factor is, it is ratio of the group peak demand to the sum total of non coincident peak demand ok. So, here numerator and denominator will be just reverse than the diversity factor ok. Now what is the significance of coincidence factor? So, coincidence factor is a measure of the simultaneity of peak demands of a group of n customers ok.

As you know this diversity factor is a measure that how much diversity we have among in a particular group or among a group of customers. So, coincidence factor is a measure that how much coincidence we have ok. And the peak load. In fact, you know sometimes this peak load of the group or diversified demand of the group can be determined if you know that coincidence factor if you know the individual peak demand and if you know the how many numbers of customers we have in that particular group ok.

So, for a typical values of this coincidence factor if this number of n is of course, number of customers ok and if is n is greater than 100; that means, if we have more than 100 customers in a group then the typical range for this coincidence factor is within 0.2 to 0.5 ok. If you take the reciprocal again you will be getting the range of the diversity factor; typical range of the diversity factor ok.

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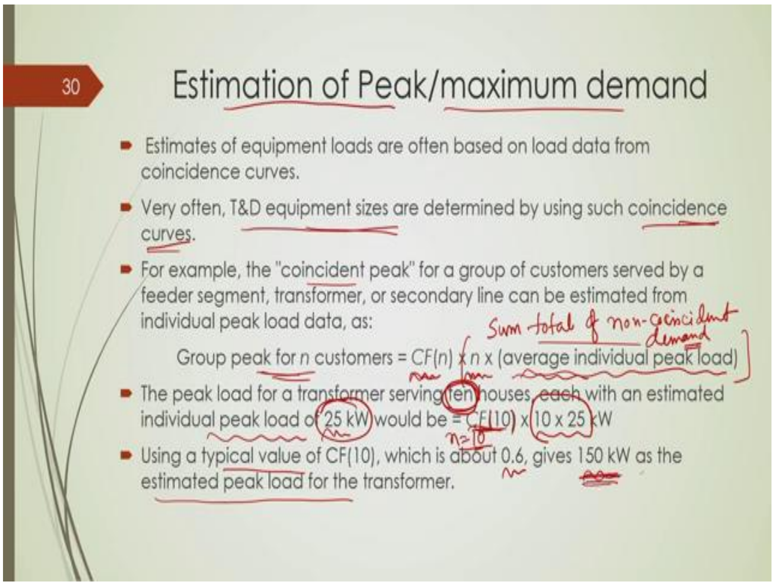

Now, this coincidence factor as I said, its significance is that it is used to estimate the peak or maximum demand of a group. It is used for a peak of maximum demand of a group. And here we have an example that and it is very often used to determine the equipment size from this coincidence curve. What is coincidence curve? I will show you in the next slide. Coincidence curve is how this coincidence factor varies with the number of customers in the group increases ok.

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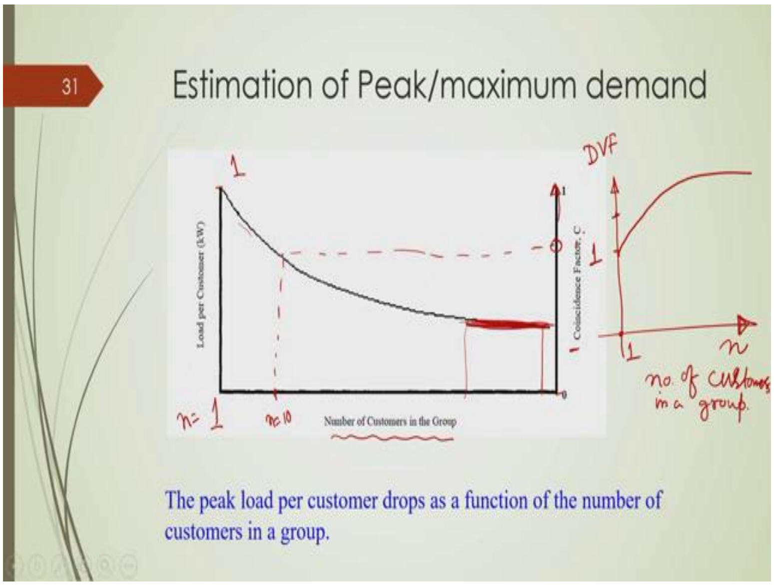

Now, based upon this characteristic, one can understand. I can show it in the next slide. So, here this axis is basically coincidence factor; it varies from 0 to 1 as you know diversity factor it is normally greater than 1. So, coincidence factor is normally lesser than 1. So, it varies between any values between 0 to 1.

Now, when we have this number of customer increases in a group this coincidence factor normally reduces to some value and it becomes constant even if that number of customer increases; this coincidence factor normally becomes constant or it becomes saturated ok. And this typical value as I have shown you it is around you know 0.2-0.5 or it is saturated at 0.2 to 0.3 ok.

Same thing is applicable for diversity factor; if we plot this diversity factor this is DVF diversity factor and this is n that is number of customers in a group. So, if number of customer is 1, diversity factor will be equal to 1 and then this diversity factor increases and it gets saturated at some value even if this number of customer is higher; it gets saturated at some value.

Similarly, here you can see coincidence factor if number of customers in the group is 1 is equal to 1 and then it gets reduced meaning that there is more and more diversity in that particular group and then it gets saturated at some point. And that happens to be true for practical load characteristics.

For this coincident peak demand in a group, as we said, we can easily compute this peak demand of the group or diversified of the group if you know that coincidence factor number of customers an average individual peak load. So, average individual peak load multiplied by number of customers, it gives you sum total of total of non-coincident demand.

So, if you multiply this with coincidence factor then it will give you this group peak demand or diversified demand or group peak demand whatever you can call ok. So, typical example I had given to you. Suppose that individual peak demand average peak demand is 25 kilowatt under a particular transformer which is serving 10 houses, number of customer n is equal to 10. So, n is equal to 10 and the average peak demand of the individual customer is given as 25 kilowatt. So, if you multiply 25 with 10 then you will get whatever this value that is basically sum total of this non-coincident demand. This if you multiply with this coincidence factor when number of customer is equal to 10, that means, coincidence factor corresponds to number of customer 10. From this type of characteristic you can typically find out this for customer n is equal to 1.

And so, for n is equal to 10, this is suppose this value of this coincidence factor and suppose this value as given as 0.6. So, you can find out this group peak demand for this particular transformer is 0.6 multiplied by 10 multiplied by 25. So, this will come as 150 kilowatt. So, 150 kilowatt is the estimated peak load demand of the transformer and as you have seen my previous example this peak load demand under a transformer it is an important factor based upon that we can choose the rating of the transformer.

So, here from this calculation, you can understand that we can roughly estimate that how much peak demand will be under a particular distribution transformer, provided that you know that approximately how many customers will be connected and what would be the average peak demand of these customers ok. Then, you can find out this typical value of coincidence factor multiply this with this multiplication of this average peak demand and this number of customers you can get this group peak demand which is an important factor ok.

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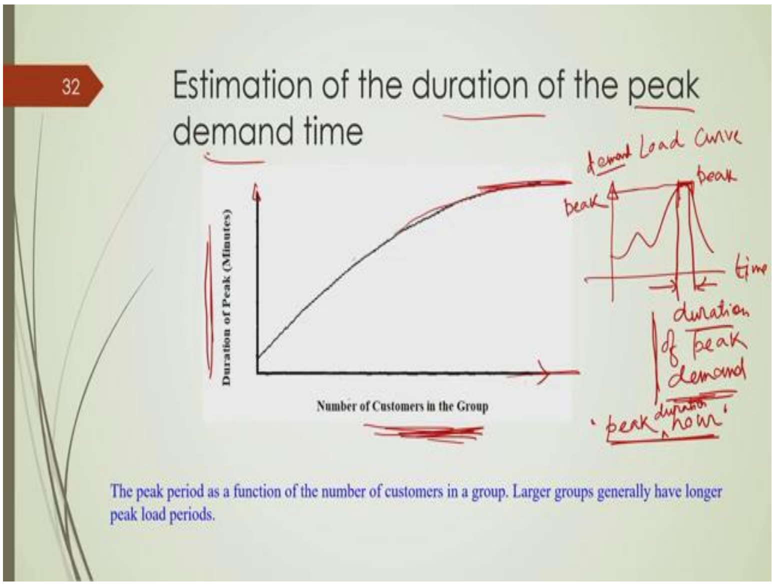

Similarly, we can also find out this duration of this peak demand; it is also a certain parameter that if you go ahead with number of customers in the group. So, it increases and after certain point it gets saturated; that means, even if your number of customers in the group increases this peak duration is basically remains same.

What do you mean by peak duration by the way? The duration of the peak demand as you know that if our load characteristic or load curve is something like that it is something like that then this will be the peak demand. So, this is demand and this is you know time ok. Now, this is the peak demand; you know this is the peak demand. Now, these peak demands sustains for a certain duration this duration is called this duration of peak demand; duration of peak demand and this duration characteristic with respect to number of customers in a group is shown over this slide ok.

So, it gives you the idea that how not only you know that how much peak demand which is an important parameter, but also how long it sustains that is also an important factor ok. So, now, how long it sustains you can easily find out if you know that this type of characteristic that how many customers you have in a group.

And if you have this characteristic then you can easily calculate or have a rough idea that how much would be the peak demand duration of peak demand. Sometimes we call this duration of this peak demand as peak hour or peak duration hour; peak duration hour ok. So, it is can be 30 minutes; it can be 15 minutes; it can be 45 or whatever that value you will can calculate if you know this characteristics ok.

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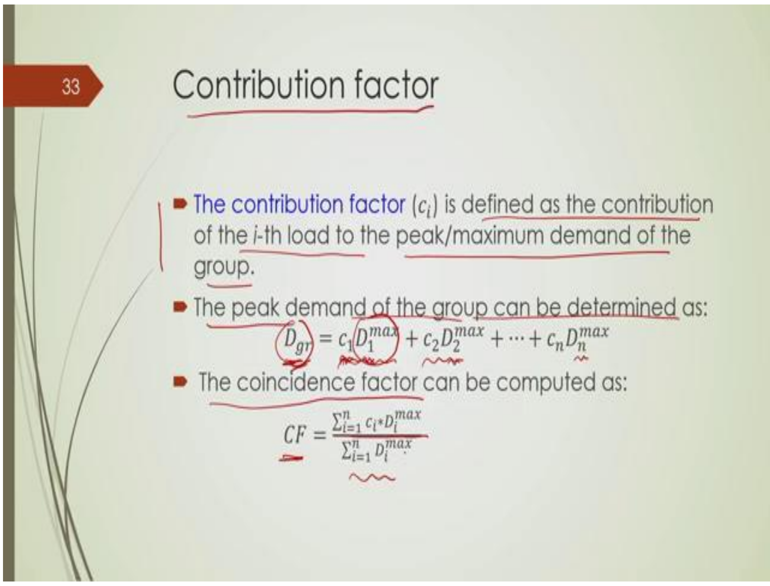

Now, next we will be having another factor which is called contribution factor which is contribution factor. Now, what is contribution factor? The contribution factor is defined as the contribution of the ith load to the peak or maximum demand of the group ok. So, contribution factor is defined as the contribution of any individual load to the peak demand of the group ok; as you know that in diversity factor this denominator is diversified demand which is peak demand of the group ok. At this peak demand what is the contribution of individual load to that peak demand?

As we know coincidence factor this numerator is your group peak demand that is this D_{gr} group peak demand which is a summation of this contribution factor multiplied by your individual peak and denominator is sum of the non coincident demand which is similarly sum up of all individual customers peak demand ok. So, whatever value will come that will be contribution factor.

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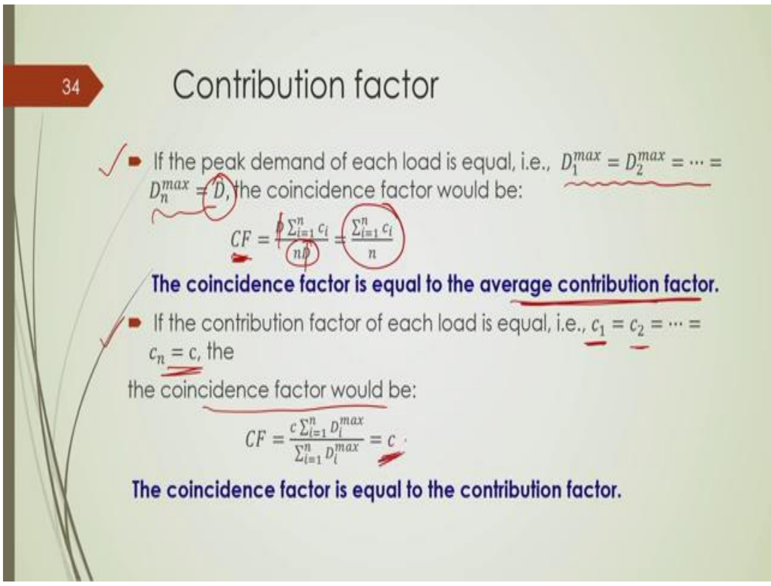

Now, we can find out two cases; we can derive one is when your individual peak demands are equal; individual peak demands are equal. Then the coincidence factor will be equal to if this individual D1 max D2 max they are equal to D and that D will be cancelled out because anyway this denominator is sum total of individual demand which is summation of D1 max plus D2 max all are same and they are considered to be capital D.

And if we have n number of such customers so, total demand will be equal to n multiplied by capital D. So, this D and this D will be cancelled out. So, you know coincidence factor will come as this summation of the contribution factor divided by n ok. So, this is nothing but average contribution factor ok; summation of the individual load contribution factor divided by total number of customers.

Similarly, if we have another case this contribution factors are equal. When contribution factors are equal then coincidence factor will be equal to nothing but this contribution factor ok. So, these are two possible cases that we can derive from the relations of contribution factor and coincidence factor ok.

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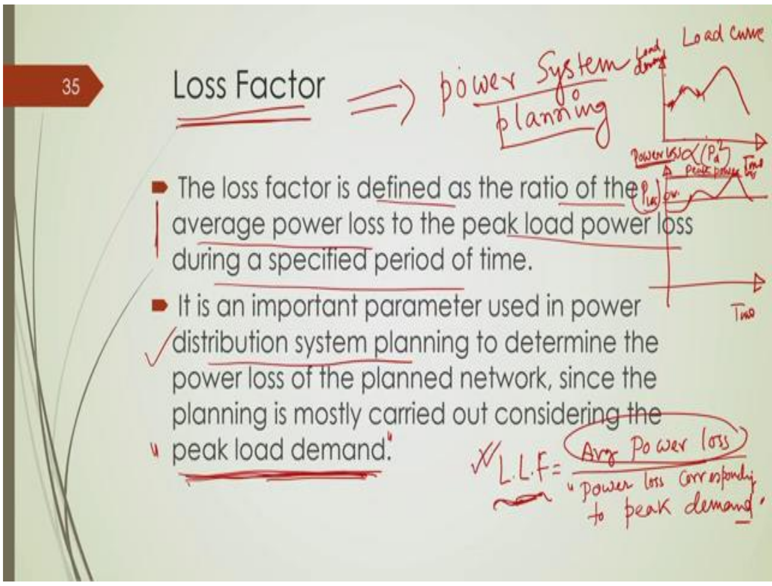

Now, next we will also go through another important load index that is loss factor. This is the last load index that we will be studying ok. So, loss factor is an important load index. It is an important load index and it is used widely for planning for power system planning ok. So, it is a useful tool for power system planners ok. So, they should know that how much loss factor should be there.

Now, what is the loss factor? Loss factor is basically defined as the ratio of the average power loss to the peak demand power loss during a specified period of time ok. So, it is basically like a load factor; it was a ratio of average load demand to the peak load demand. Similarly, loss factor is defined as the ratio of average power loss to the power loss corresponding to the peak demand.

Now, as I said it is an important factor and we will be also using this in distribution system planning. Why it is important? I will come to that. Now, what it is particularly let us understood fist ok. Now, in order to find out this loss factor, we need to have idea of the load curve ok. So, suppose this is my load curve, so, this is our load demand and this is the time ok and typical load curve you can see like this ok; that means, at each interval of time this that much of load demand we have ok.

Now, for determination of loss factor sometimes some people say it load loss factor in some book you can find out. So, what we need to do? Corresponding to each load demand we need to find out there the power loss ok. So, corresponding to each load demand we need to find out the power loss, this power loss what is power loss everybody is know it is basically the for transmission and distribution system it is basically the transmission and distribution loss ok.

For distribution system it is basically the sum total of the losses the which take place. And normally you know it is we kept is a summation of the i square r loss of the all distribution lines ok. Because all distribution lines they are having certain conductor which is having certain resistivity and due to that certain amount of ohmic loss takes place i square r loss if you sum up this all lines losses then whatever you will be getting that is roughly distribution loss.

Apart from that, we have the individual losses in the individual equipment also ok. Now what we need to do, corresponding to each of this load demand, we need to plot this power loss characteristic. Suppose this is the characteristic power loss with respect to time then corresponding to each load demand suppose corresponding to this loss demand I got this power loss this; corresponding to this power loss I got this.

And then, roughly it will follow the similar characteristic because power loss is you know it is approximately proportional to power demand square. So, its characteristic will be something like that and then similar to your load curve it will have some average power loss. It will have some average power loss P loss average and it will also have some power less corresponding to peak demand that is peak power loss.

So, basically so, this is peak power loss. So, basically this loss factor we represent LLF. So, for us LF is load factor so, LLF is the loss factor, line loss factor or loss factor whatever you can say or load loss factor. So, this load loss factor is basically representing you average power loss divided by this power loss corresponding to peak demand.

Now, as I said it is mostly used for this power system planning; why it is mostly used in power system planning? Because most of the power system planning is done based upon considering the peak load demand; because when we will perform that an infrastructural planning then that infrastructure should be capable enough when your load demand is at peak load ok.

So, that is why all these you know power system planning normally we carry out considering this peak load demand. And you know if this peak load demand loss or power loss corresponding to the peak load demand and if we know this loss factor then if you multiply these two then you will get the average power loss which is important factor to calculate or compute the overall energy loss of a particular network. So, this will be using many times in our future exercise in power system planning ok.

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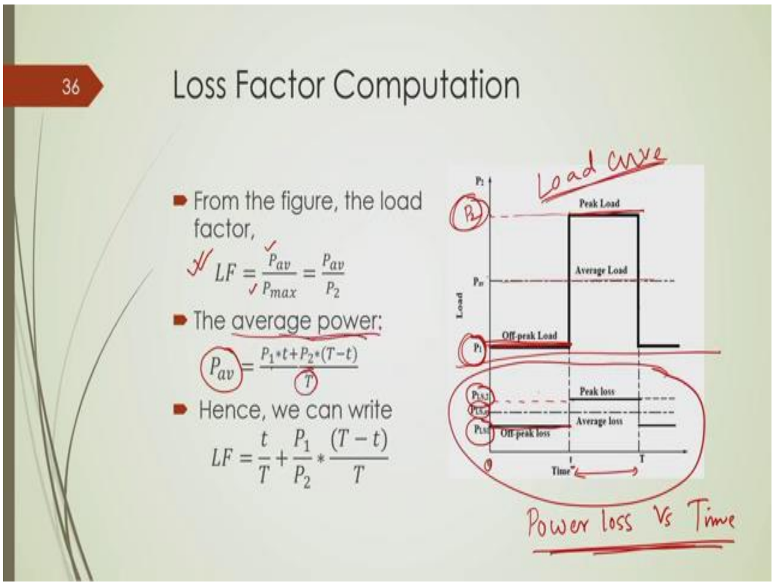

Now, here we have a typical example. So, this is, suppose, load curve. So, this is load curve and there exists two sets of load; one is off peak load another is peak load ok. From for duration 0 to small t load demand is at off peak load that is equal to P_1 and in the duration t_2 small t to capital T this is basically peak duration I was talking about few minutes before. So, during this duration the peak load demand is this so, this is P_2 ok.

So, off peak demand is P_1 and peak demand is P_2 ok and this shows you average load demand ok. Now, corresponding to that load curve here we derived a power loss verses time characteristics similar to what I discussed in the last slide ok, like off peak load demand how much power loss will take place that is plotted over here.

So, this PLS_1 represents the power loss during off peak hour ok. Similarly, during peak load demand power loss is represented by PLS_2 ok and average power loss is $PLS_{average}$ ok. Now, from this we will determine first this expression for load factor; expression for load factor. What is that load factor? This load factor is equal to $P_{average}$ divided by P_{max} ok.

As you know this is average power demand divided by power demand corresponding to peak hour ok. Now what is the average power demand? Average power demand you can find out easily simply multiplying that this individual power demand with this duration divided by the total duration.

So, P_1 sustains for you know 0 to t time and P_2 sustains for T minus t times ok. So, hence this load curve is basically this average power demand. So, if we divide it by this then we will get this total duration; we will get this average power ok.

I will continue this from the next lecture.