Fire Protection, Services and Maintenance Management of Building

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Lecture - 33
Electrical Systems (introduction)

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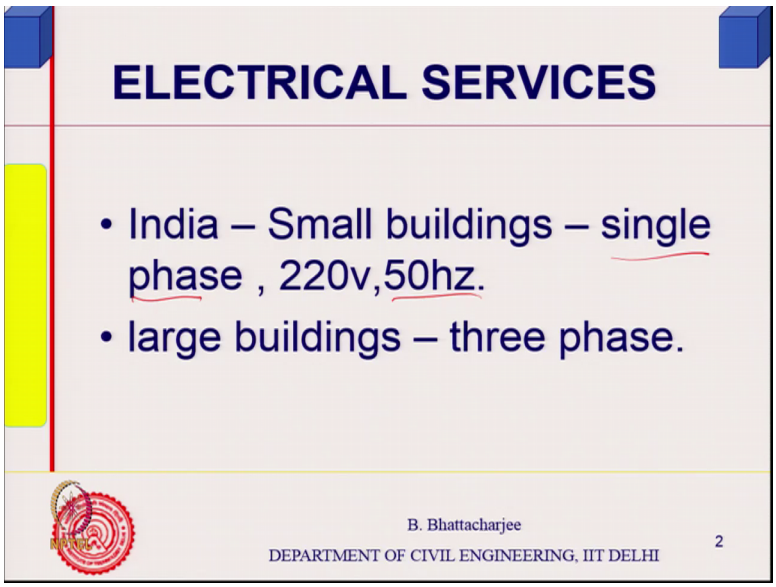

Now, will look into electrical services, some introduction to that. Now, first thing is in India, of course in small buildings we supplies, alternating current single phase, 220 volts, 50 hertz. And of course, large buildings, three phase supply will come, but final all your most of your appliances domestic, all those similar kind, they are all single phase right, they based on single phase supply.

Now, having said that use of solar energy, I mean solar you know use of solar driven solar cell driven electrical system, people would prefer possibly DC, because a photovoltaics, you know they generate DC. And it is been suggested that if the appliances are all DC, then you do not have to conversion, reconversion, etcetera, where there are lot of loses. DCs were used before in previous century or previous you know someone in the beginning of 10th century; because it is more efficient you can you know efficient losses are less etcetera etcetera. And generation is also it is easy to generate three phase supply, rather than DC. So, electrically that is more these are more efficient ok, but will talk about this system only.

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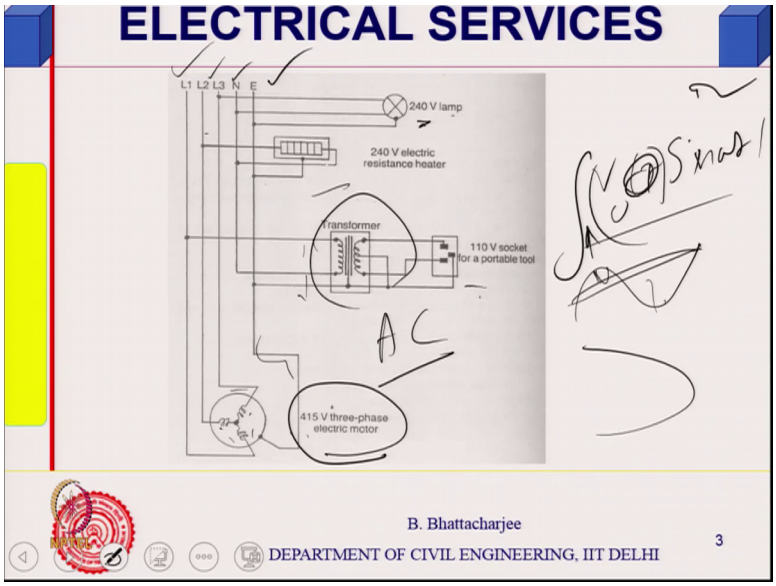

So, if you look at it, typically you will have lamps, which in India would be 220 volts right. Say you might have a three phase supply in a large building. Now, let me see if I have something here more not ready.

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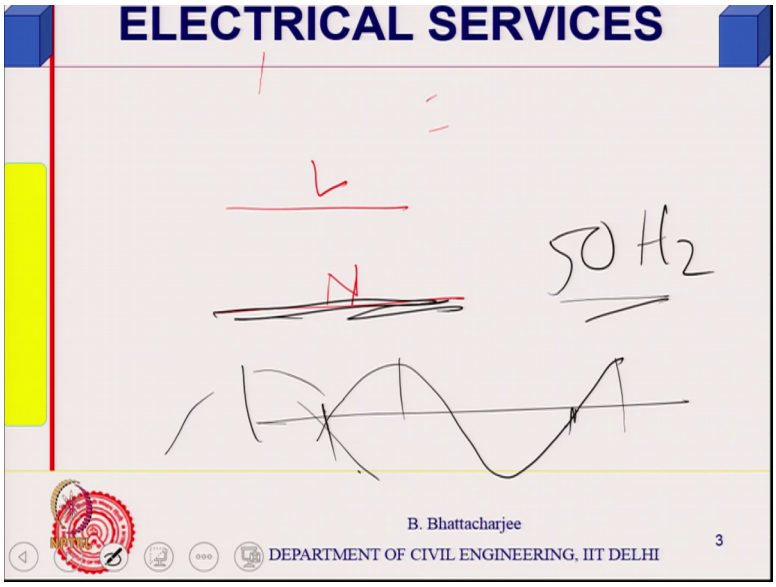

So, in a single phase supply, you have two wires live and neutral, usually this is black this is black, this is red, usually this is black, and this is red. Now, we know that our supply voltage is sinusoidal right sinusoidal. So, single phase means, I have with 50 hertz frequency sinusoidal voltage. Three phase means, I will have three phases, which will be

120 degree out of phase peak to peak would be 120 degree means, 360 is a complete cycle from starting from here to here.

So, this would be 120 out of phase. So, there were three phases, you know they are the peaks appear at different time, because a sinusoidal. So, lamp etcetera, we have single phase connection right. Some three phase motors are used were you know three phase motors should require three phase inputs supply. So, this is as I said 220 volts 50 hertz, and this is a heater that also is similar kind.

Student: (Refer Time: 04:13).

Yeah. And in some cases of course, we do not have any appliances of 110 volt, but supposing you have something of 110 volt, you might use a transformer, which converts which steps down this 220 volts to 110 volts; you know we are see the current will increase right. So, transformer is nothing but a magnetic, you will have a magnetic code, and you have a coil around this side, this primary, this is a secondary.

So, the this one change in you see the in alternating current, there is a change in current or change in what I mean change in voltage as well, so that can induced magnetic that can you know magnetic it can change magnetic, it have induce the magnetic current. And that in turn can induce electric current in the secondary itself right the secondary itself all right, so that is the idea that is the basically idea.

This is transformer is a AC alternating you know machines alternating current machines. Essentially can you can step down your voltage to higher voltage to lower or increase the lower voltage to higher voltage using this magnetic code or you know the transformer is here. So, this is we do not need this much these days, we do not have all of all most of it is (Refer Time: 05:42) standardized to 220 volts.

So, as I said in single phase supply, you have got live and neutral. In three phase supply, you might have a four wire system or six wire system. This is a diagram of the so line 1, line 2, line 3 these are three phases and connects to a three phase electric motor connected in star form. This is called as stared form right. And L 1, L 2, L 3.

Student: (Refer Time: 06:04).

And for single phase system, neutral is of course, neutral is I mean is not connected to the line, it is not it is you know it is actually returned path, it provides the return path. So, neutral provides the return path, and there of course has to be earth. Earth is to avoid getting accidental shock from accidental leakage current. So, the neutral is essentially provides the return path even in single phase scenario. So, you take any line and the neutral that will be a single phase supply that means, you have line voltage, lined to neutral that is the voltage that you will get. Line to line voltage is different between two lines voltages should be different.

And we talk in terms of all RMS voltage (Refer Time: 06:57) because sinusoidal. So, root means square, because you know some of the voltages I mean is periodic. So, when you have periodic situations what you do, you take you depict or speak in terms of what is called root means square values. So, there is an amplitude, there is a peak amplitude values. So, amplitude, peak amplitude value.

Student: (Refer Time: 07:29).

But, then you want to talk in terms of average, if you just take arithmetic average, it will become 0, because there is a positive area and negative areas are all same. So, what I do I integrate this square of this right. So, V at any time because V if it is amplitude, V is sin omega t or whatever it is, square it up square will be always positive, so then divide by the base and take under root, so root means square root means square. So, square it up take mean, the root. And you can calculate out relationship between peak voltage and the RMS voltage. So, when you set 220 volts, we always talk in terms of RMS voltage root means square voltage right.

Student: RMS.

So, anyway so that is what it is right. So, in this one, so three phase motor should be connected to three phases and the neutral. So, 415 volt three phase motor or some way 440 volt.

Student: (Refer Time: 08:17).

Sorry, it is connected. you there three lines are straight away coming, it is connected to the earth straight away that is because for the safety point of we will look into this. So,

neutral is zero level, so that is what it is. So, lined voltage line to line voltage, of course differs, and line to neutral voltage that is are 220, that is 440, you can calculate out this relationship. We will look into that, if there is a need.

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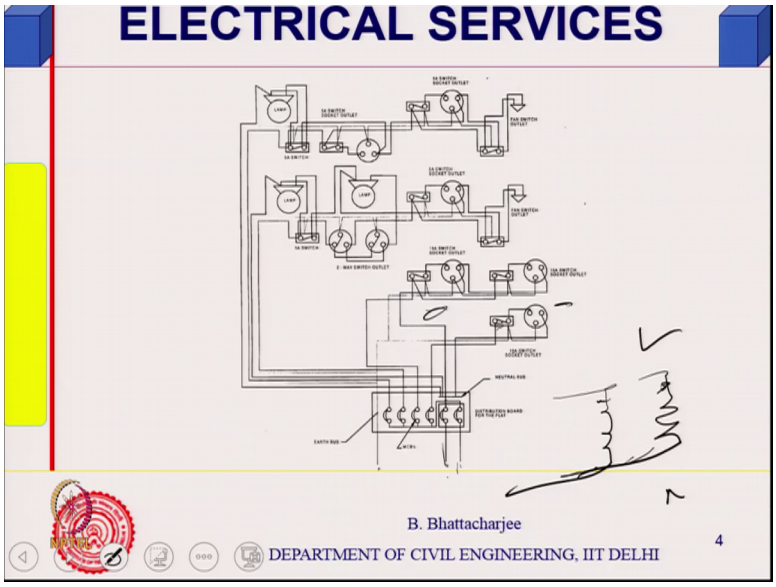

The typical house connections will looks something like this. Typical house connection will look something like this. This is from national building code or similar you know literature you will get. So, essentially this ways these are gone, these are the, what you call earlier fuses or cutouts you know. So, what will they do, you need a safety. So, if the excess current is flowing, this were at they will simply melt at high temperature, you know so temperature would be high and they will simply melt and this connect to the circuits. So, the things do not burn right. So, high current means high square RT. So, it will it will start burning.

Student: (Refer Time: 09:19).

So, if you can see this, so I have got first the you know there is a this is of course, this live is coming, and this is a through fuses maybe I have a another diagram, which will show switches. So, this one connects like this, there is a switch here, this connects to the socket you know.

Like you have two types of socket, 5 ampere and 15 ampere sockets in our domestic lines. So, one is the power, another is the, that will draw higher current, it is only the

sizing, it is single phase only. So, another 5 ampere, the current drawn would be relatively less, so because the appliances are there, they are classified in this manner. Many heaters will be actually 15 ampere or power you know there will be connected to the power, your air-conditioning system air conditioner house air conditioner, they are connect to the power, while you have lamps etcetera connected to simply 5 amperes.

So, all the time you will have a switch here, main switch will be somewhere there actually mains for the whole, and then you will have got fuse, then this a switch. Switch is always connected to the live switch is always connected to the line not to the return circuit, but this is this only skilled people will do that, it is not connected anywhere. And if the current (Refer Time: 10:48) maintained, then it is safety. So, even if you see if you see a pin 5 ampere pin, you look at it I mean 5 ampere pin, you will find that L and N is written. In one pin, it will be written L, another is N, so that is what it is.

So, the pin connect the switch is here, and then it returns right all returns are connected to the neutral. So, live and the neutral two lines right, switch is always on the live line, so this is, you know this. And all of them are connected in parallel, for example, if you have two of them, both will be connected in parallel. So, you have all loads are parallel, the other load is all parallel. The switch will be somewhere here in the live; neutral side, it is the return. So, switch will be somewhere, therefore each individual one right. So, these domestic connections are typically like this right.

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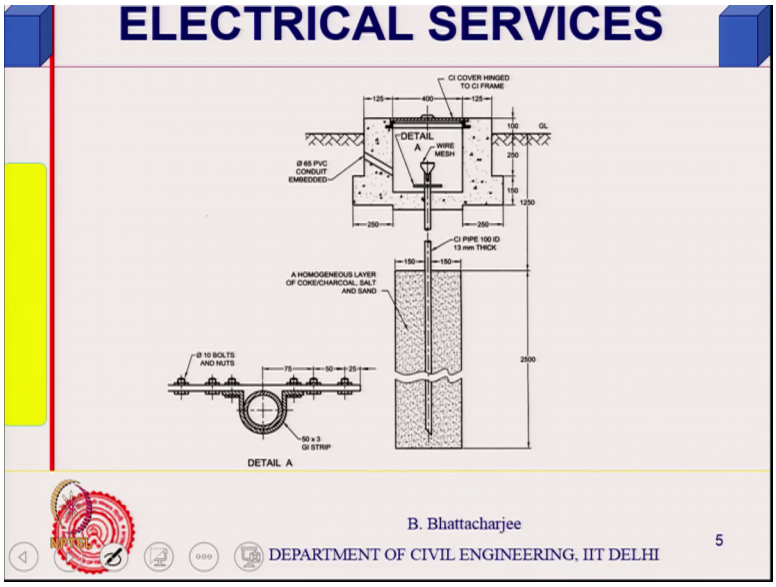

The earth is important. This is the typical diagram of a earthling system.

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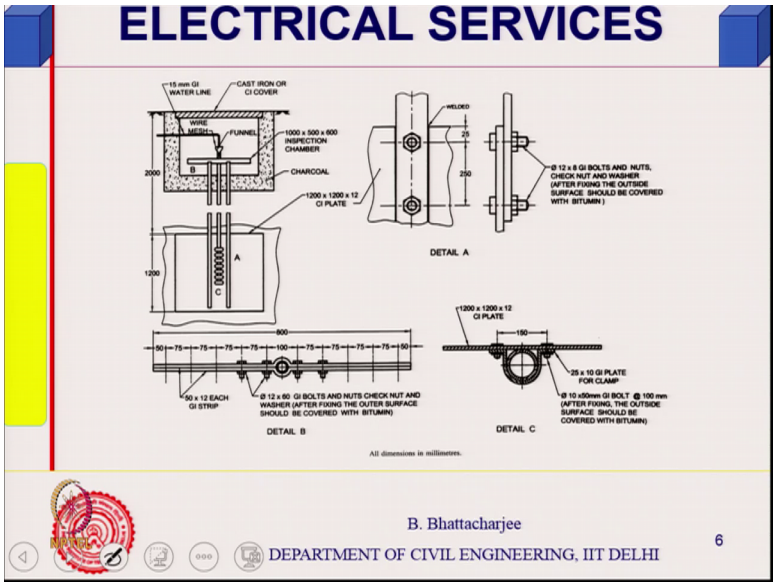

Now, why I need a earth first, let us come to this ok, this is the diagram given in national building code. I hope, I have got earth here, not ready no diagram for earth ok, no not really no diagram for earth ok.

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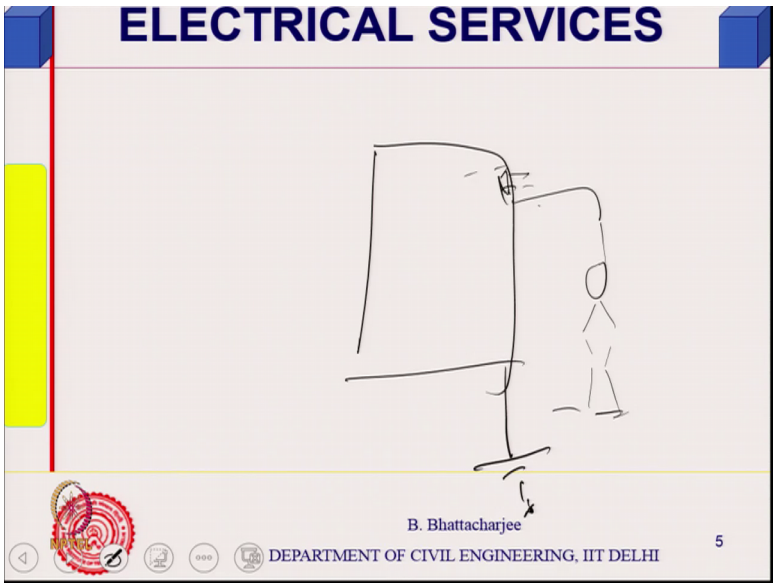

Earth is needed basically by chance by mistake if you this is your appliance, and if there is a leakage current right, if there is a leakage current somewhere, and the human body touch, so you know you touch.

Student: (Refer Time: 12:21).

So, it will it normally flows to the least resistance path. So, you touch this, it might go through the body, but supposing is all connected to the earth. So, instead of following this path, it will straight away go there. So, it is a safety device, essentially provided everywhere, and that wire is usually green. So, three pin socket if you look at it, it has to be three color; single phase L stands for live, N stands for neutral, and the green is a earth green is the earth. So, wherever you need you know appliances are connected, that should connected following this principle.

Code gives you the code gives you the code gives you the, you know dimensions of earth. What is done is all earth wires are connected together, they are all connected together, and then they are connected to this kind of a system, which is buried deep into the soil, deep into the soil.

Student: Soil.

So, typical constructions are given, in fact you should have a sand layer, you know different layers are given actually, what should be the material, how much depth below the earth is there, this I suggested. And this is buried, and all are connected to that. So, this essentially ensures that you know the current flows through the mother earth, which is the ground 0, you know it can absorb or anything, so that is what it is. So, earthling is very important right. So, this is some other diagram of the earthling, it is given ok. So, details of such earthling for different cases, these are given again, we do not have to do much about them, but these are available in building code or similar produce, it has to be added too.

The other one is the other one, of course is a important issue is of course, related to breaking the circuit in case of high current. So, earlier we are using fuses, and which would have at some kind of a current rating, so what you will do, as the as in a reaction time of such system is very important. As the high current comes after how much time actually it breaks of the circuit was important. Previous one should be used in metals, which will get heated up and then melt, and disconnect the circuit.

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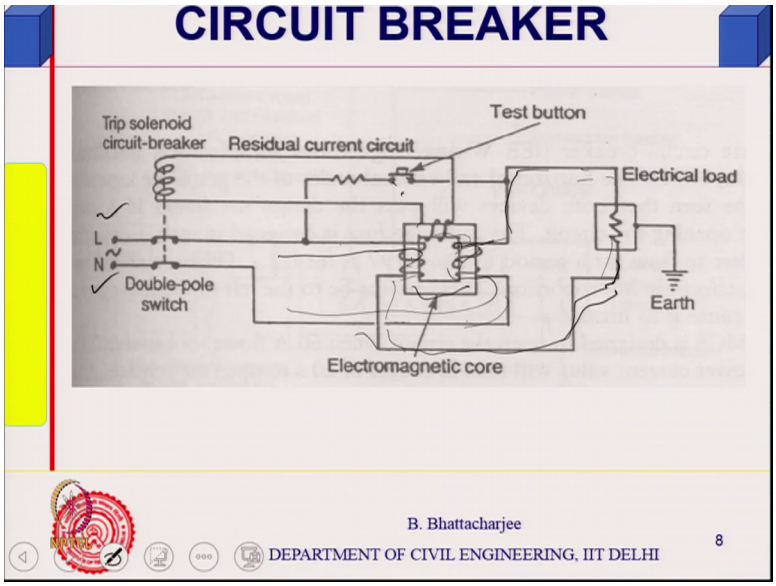

But, current ones are essentially based on you know solenoid principles. I will come to the site one next solenoid principles and look something like this; I mean principle looks something like this. So, what you have actually this is your you have a switch double pole switch, this is the live and neutral wire, double-pole switch, now it is connected to a electromagnetic core right electromagnetic core. So, live wire goes like this, and this goes to the load, this goes to the load right. Similarly, in neutral wire comes like this, it is wrapped on to the secondary. So, this is the primary, and this is the you know other side of the magnetic core.

Now, basic principle of a transformer that when you have a coil wrapped around a magnetic field, and you have the current is varying right, according to you know all those laws Lansiyar's laws if you recollect Faraday's laws etcetera. It will you know it will induce, the current induce a magnetic field, and there is a magnetic core, so there is a there is a you know kind of this magnetic magnetism induced magnetism will flow through this. So, magnetic circuit is completed through the whole core.

So, if you have another coil there, the variation of a magnetic field would result in inducing current inducing current. For example, if you remember, good old age people would have shown you an experiment, you know in B Tech or even school level, they have shown you. If you have a coil, suddenly you put a magnet inside. Inside a magnet between there will be a galvanometer, which will show there is a deflection. So, if the

magnet you know so there is a variation of the magnetic field, because the when you insert a magnet, magnetic field is varying, and it induces current into the (Refer Time: 16:43). So, this would this is what would have would happen here.

Now, in case of normal condition, when there is no high current flow right so, live goes like this equals, and then it goes to the load; neutral goes like this, and its coil goes to the goes to the goes to the electric load right. And there is another connector there is a residual circuit. So, if there is if there if the situation is balanced, if the current is not too high, you know this current passing is not too high, what will happen is, what is what will happen is actually you know there is a there is of course, this one, which is connected to a solenoid circuit breaker the residual current circuit actually.

So, normally if you for example, you know that supposing it is going directly supposing it is going directly supposing it is going directly, this is the test what near, it is going directly to the electric load right, so the short circuit would occur. If there is a short circuit, for example, this is causing a short circuit, this is this switch is on would cause a kind of short circuit, it is going to the live back again. In such situation what will happen, the neutral will not operate, this will magnetic field will operate, this will induce a magnetic field there, and the solenoid will break the circuit.

When there is a normal condition, this is not operating or there is no short circuiting or something happening, this would the current will flow like this, this current flows like this, I mean this live current flows like this right. And the neutral current flows through this, they balance each other, the balance you know the neutral current flows (Refer Time: 18:33) balance each other, there will be no residual magnetic magnetism available there, because this whatever it generates this neutralize by this whatever it generates, because the neutral is also coming through the same right. Return current and direct current is also going through the same. So, this is all balanced, there is nothing no residuals you know residual current is not generated there.

In case of residual current in this that means, live current and neutral current, there is something has happened here, maybe there is a short circuit or something that excess current flowing, they would be differing, and that would result in residual current circuit to act and activate a top solenoid, which is again a magnetic device, which will break the circuit, so that is that breaks it here, the straight away breaks the switch level, so that is

how a circuit break a works, and which a much more efficient. Anyway, today the other ones have already got you know there absolute.

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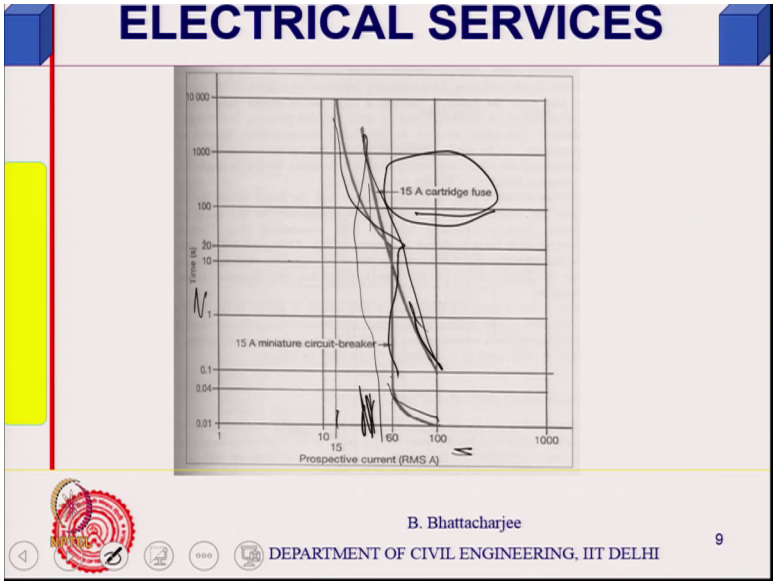

So, so if you if one looks at it, the reaction time right so RMS current versus 15 ampere cartridge earlier once, this is time response time 15 ampere. As soon as current goes above 15 ampere, this should you know this should break off. So, 15 ampere circuit breaker, it it is the time required is you can see that time required is this would you know time required for this is the circuit breaker. As soon as your current is of 15 ampere current, current goes higher, you know 60 ampere or something right. It would the time, instantaneously the time is shown, it would react within this is this is the one 15 ampere, 10, this is how much this is 1 second 15 amperes.

So, this is this starts you know immediately 0 second does the current start increasing, this is time is 10 second 20, 100, 1,000, 10,000 seconds. So, if it is just 15,000, it would require 10 seconds right. Here it will not act even at 15 ampere; it will only act at somewhere around something like that you know something like that 60 or 70 ampere. So, 60 ampere this will possibly straight away within 0.01 second it will react, it will react it will react within 0.01s, you know 04 second 0.04 seconds, so is 60 ampere.

If it is 100 ampere, 0.01 second whereas, (Refer Time: 21:13) 100 you know at 100 ampere, it will take 0.1 second. So, this is the curve for the old ones cartridges 15 ampere cartridges. This one as something like this so, 62 62 you know like 62 62 this is how

much 62 15 ampere you know 60 ampere straight away, it cuts off within this period of time, and if it is somewhat less, then it takes 20 seconds or 10 seconds. So, actually its time wise, it is much more efficient. This curve gives you the time wise performance of the two. This is for the 15 ampere cartridge; this is for the circuit breaker, so that is why, it is got all replaced by circuit breakers. Today you do not see any more, this cartridges any more ok. So, this is one issue.

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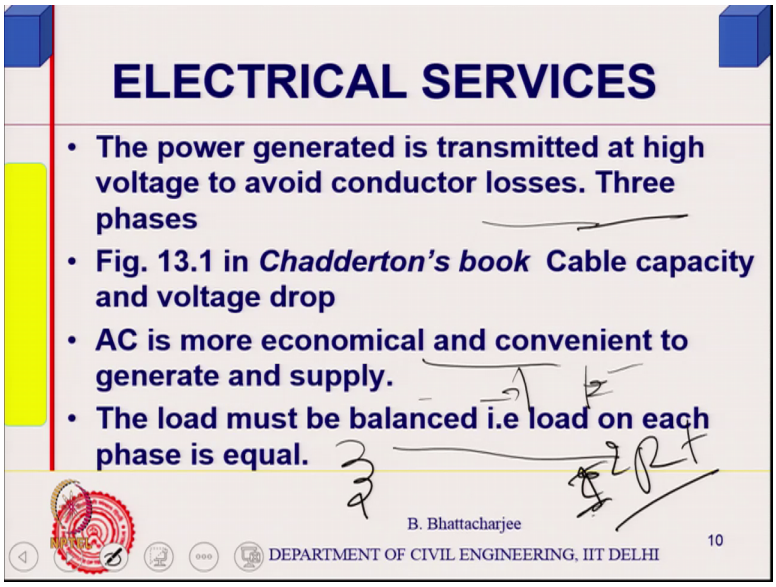

The other issue is important, the power generated why alternating currents are used actually. The power generated is transmitted at high voltage to avoid conductor losses. Very high voltage, low current right so three phase generation is easier, transmission is easier. Cable capacity you can calculate out very easily, but this (Refer Time: 22:32) also.

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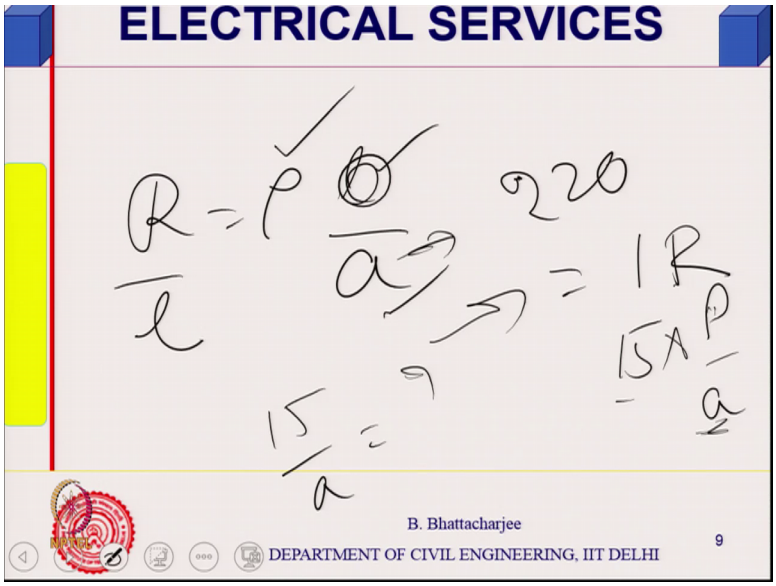

For example is pretty simple, Cable capacity you want to calculate out, we know that resistance is equals to rho into l over a.

Student: A.

Right. So, a is important; rho is the resistivity. So, the conductor that you are using or resistance material that you are using so, you will take talk in terms of resistance per unit length R by l right rho into a. So, area or mass current rating you know, so this is current rating. So, b is my V is fixed 220 volts, V equals to I R, and R is nothing but R per meter length. So, if I have 15 ampere current let us say, then for you know 15 ampere current is flowing. So, this is I, and for 1 meter length of the wire let me say, this should be rho by a. So, how much area I need, that I can find out how much area I need I can find out, how much area I can need that means, size of the metal or cable size that would be that would be known to us right.

So, ratings of cables are given in terms of ampere, but actually area increases with rating area, area increases with rating in a area increases with rating. In fact, you know I n I n 15 by a right, so resistivity is constant, so 15 by a is equals to if I increase the area, rating also increases. So, it is directly proportional depend upon grow per meter you know rho it will depend upon rho, and rest of the thing voltage etcetera (Refer Time: 24:24) current rating. So, current rating is directly proportional to area current rating is directly proportional to area.

So, this is given in tabular form. In fact, this is given in a book this is given in a book, which are given you in reference is given in cable capacity. So, it gives you capacitor value. And voltage drop across that you can find out, which will be equals to I R, I into R is a voltage drop about for a given length. So, voltage drop per meter length how much voltage drop you expect, that you can you know, so you can calculate also. This is given cable capacity voltage drop for given areas, this is given actually.

AC is more economical and convenient supply. The load must be you know when you have AC, then one thing is it in alternating current, energy can be stored, all the energies not dissipated or converted into work anyway. For example, you can generate heat, and also or current you know electrical energy can be used to do direct work in a magnetic field, the motor can rotate and things like that, so direct work. Now, you know also I mean I cannot DC motors as well. So, therefore, motors can be either DC or alternating the sort of problem. But, in alternating current, I generally you know I can store the energy, not all are converted into energy, the amount of energy that can be converted is basically I square R watts or I square RT.

So, resistances can generate heat or consume the electrical energy or were energy is converted into electric you know electric I mean work or something of that kind; it is essentially the resistive energy. While if you have a coil in a coil, if the current varying current is passing, it can generate magnetic field around it. A study current generate in a study magnetic field (Refer Time: 26:43) make any difference. But, if you have a coil, where varying current is been produced, then this varying current, current would actually generate a varying magnetic field a back EMF etcetera etcetera. So, this is an inductor is based on this principle, which is generated back EMF, and it is stores the electrical energy into magnetic energy.

Similarly, a capacitor stores the electrical energy and it as charges and releases it. Now, this can only happen, when there is a variation. For example, example of a capacitor is like this, you know you if you have a steady current, the plate will get charged, and then it will remain as long as you have applied the voltage. When you put it off, it will get discharged. But, in alternating current, it will once get positively charged, next time it will get negatively charged, so therefore the current can flow. Current is basically vibration of the electron about their mean position (Refer Time: 27:43) which can occur.

So, actually in capacitor do not consume an energy, but it stores the electric field, you know stores the electrical energy, so that have do not consume. So, you have equivalent what you call impedances; reactances, and I combine them, I get what is called impedance. So, in case of in case of alternating current, I may have some inductive load in the circuit.

For example, earlier days if you have seen your florescent lamp tube lamp, you will have a choke, now the choke is actually nothing but a inductor. You will have a starter, which will give a voltage initial voltage for starting the voltage, so that the you know it will it can it can actually work between the electrode, so that was a capacitor essentially. So, when you have such loads number of them, lot of actually energies not utilized rather stored, and it is not a good thing, because they have voltage supply voltage or supply V I, voltage into current will be high, because this somewhat some somewhat you know some of it will be actually stored.

Now, this aspect is taken care of or rather you know looked into so, ratio of the resistive ratio of the resistance to totally impedance, that we call as power factor. More the resistive load more is actually utilization of the electrical energy. More is a inductive load, less is the utilization of the energy, where you have V I required, will be higher. So, it is written in terms of V I cos theta, I will discuss this some may be next class. So, essentially power factor is an important ratio, you would like to have high power factor because, you will like to have higher utilization of the energy ok. So, I think we will stop here.