Electromagnetic Compatibility, EMC
Professor Rajeev Thottappillil
KTH Royal Institute of Technology
Module 6.4 Lightning Protection - Towers, Lightning safety
Lightning and Electromagnetic Interference (Lightning Protection)

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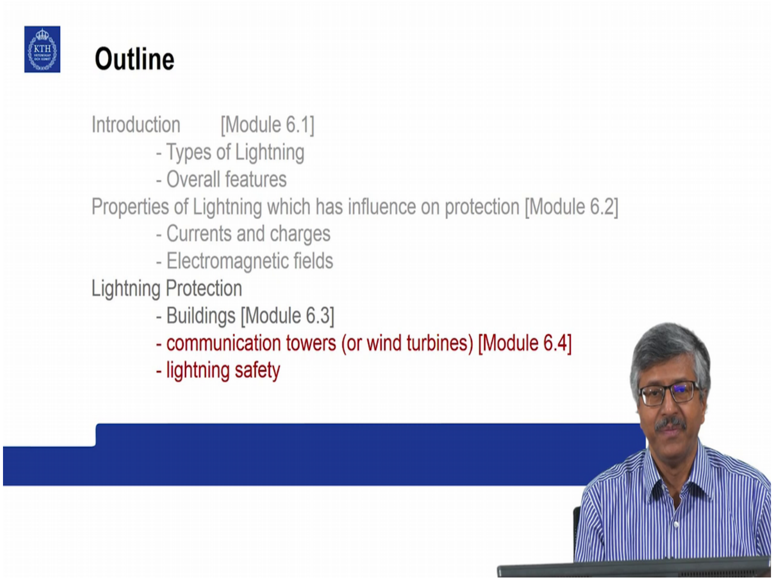

Lightning and electromagnetic interface or lightning protection module 6.4, so here we look at some principle involved or some aspects of the communication towers protection or it could be when turbine protection also and we will end this chapter with a cartoon on lightning safety.

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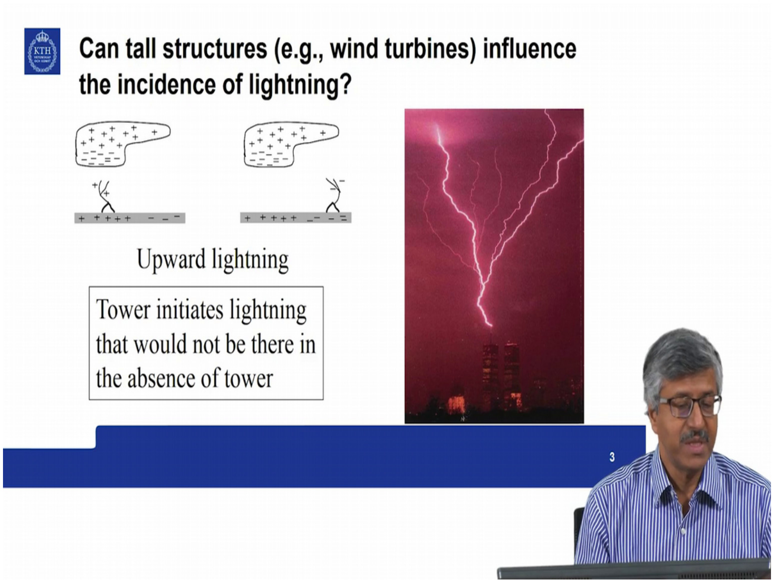

Previously we have introduced upward lightning from tall structures and upward lightning from tall structures are more and more prevalent than 4G or 5G communication tower are coming up and several wind turbines are coming up, tall wind turbines. Say for example wind turbines of 5 megawatts can have heights of the order of 200 meter up to the router tape. So you may have more instance of upward lightning from these towers than downward lightning.

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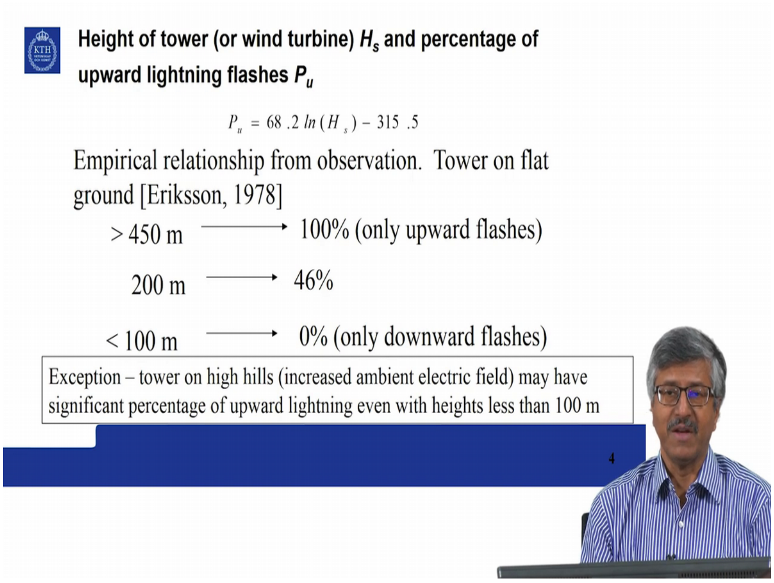

So there are some empirical observations of what is the percentage of what is the percentage of upward lightning from tall objects compared to the downward lightning, so this is provided by Eriksson in 1978, so the empirical relationship states that the percentage of upward flashes from a wind turbine or in those times high tower there were not that many wind turbine then, it is given by 68.2 log of Hs which is the height of the object minus 315.5, so this as an empirically empirical relationship derived from many observations.

So what it means is that if a tower is of around 450 metres or high there are several towers around the world now almost all flashes to that tower are of upward flashes and if its height is around 200 metres on level ground around half of all flashes will be upward flashes and below heights less than 100 metres you do not have many upward flashes mostly this downward flashes. Now there are exceptions to it because if you have a tall mountain and even a tower of 10 meters or 20 metres can produce lot of upper flashes that is mainly because of the field intensification caused by the mountain itself.

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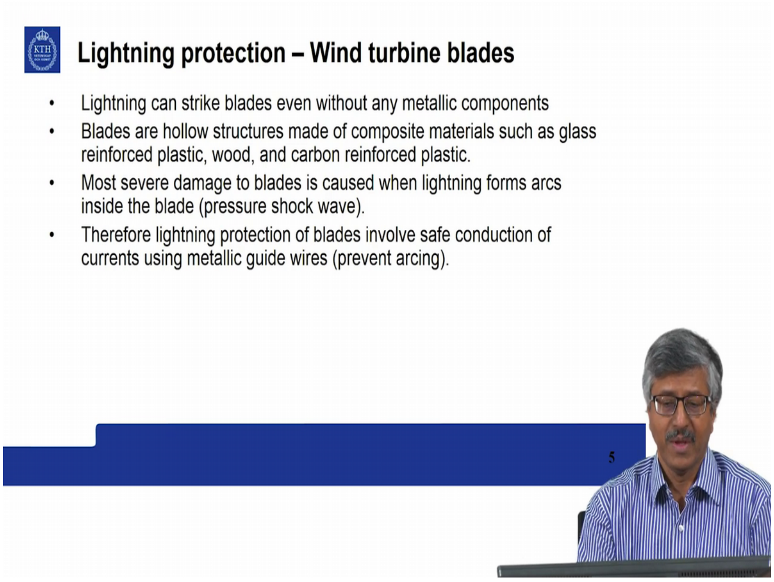

Some aspect of lightning protection wind turbine blades are the most expensive object damage by lightning protection and most difficult to replace also because transporting a turbine blade is enormous task and the out time will be quite large with a wind turbine blade breakdown, so lightning can strike blades even without any metallic components in it because it need not be metal if it is a tall object that object will intensify the electric field around it because it may be wet or something and lighting can strike that object.

So there is often a misconception that okay since the blade are not conducting it will not be struck, so that is not the case. Blades are followed structures made of composite materials such as glass reinforced plastic, wood and carbon reinforced plastic and because of this hollow structure most severe damage to blades is cost when lightning forms arc inside the blade because then you create a very strong pressure shockwave and the (())(5:10) blade can explode into small parts and cause injuries to people nearby or objects nearby.

So the lightning protection of blades involves safe conduction of the lightning current away from the blade so that it is not allowed to form any arc and safely to Earth, so it is almost like building protection except that blades are rotating so you need to take care of the connection from the blade to the rotating hub then from there to the earth and you need some special consideration in blade production also that will see in a moment.

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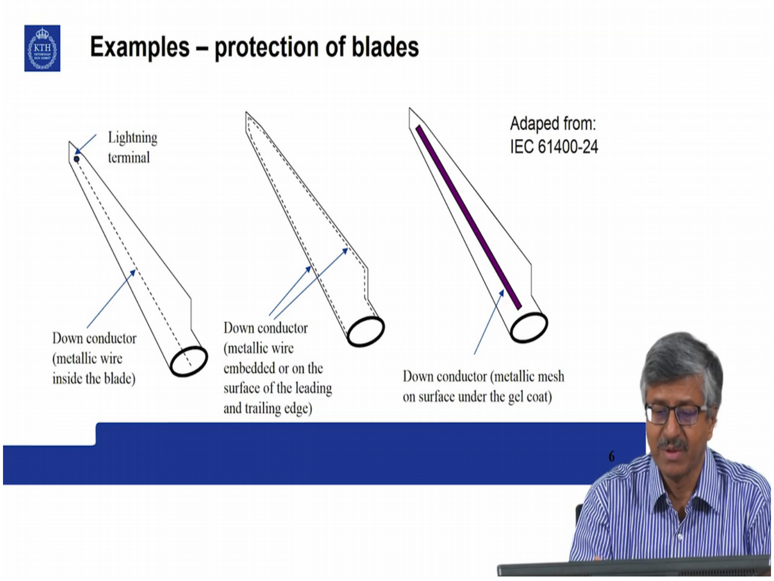

So these are some of the possible designs used in blade protection this is adapted from IEC standard 61400-24 which is describing about protection of wind turbines from lightning. One of the main consideration is that installation of down conductor along the blade should not affect the air or dynamic properties of the blade that is very important and here in this example you know this is a small lightning terminal then you have down conductor system, so most likely lightning will attach to this small terminal over here at the tip of the blade and this is a metallic wire inside the blade. Now another example is that along the edge of the blade you have metallic wire embedded or on the surface of the leading and trailing edge of the blade, so here you have a strip, a metallic mesh on surface under the gel coat of the blade, so there are several blade designs.

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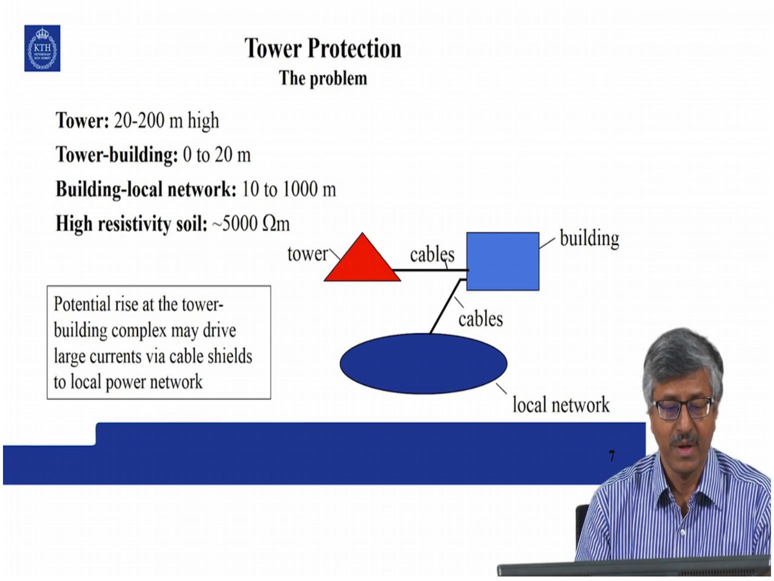

So in tower protections what are the importance…so wind turbine is also a tower so after the blade then basically the rest is like a tower. Then lightning current is coming down, so what are the issues involved in that? You might have seen several people reports when a 5G or 4G or even 3G towers are coming in neighbourhood, the mobile operator has installed the tower connected everything then houses around that tower complaints about damage TV and other equipment during lighting storm were as they never faced those problems before, so part of the reasons of these things are not enough lightning protection for those towers or not enough integrated lighting connection.

So we will see why and what are the problems involved and how those things can be prevented? So the basic problem is like this, so you have some tower when you have a building that houses equipment to that tower, sometimes these buildings may not be there instead it will be just a box in the tower itself. Then you have the local network or power network because the tower may be powered by the common transformer connecting to the local network, so there is a local connection to the tower. So often what happens could be that lightning is striking the tower then from there some part of the current may be going to the ground but other part of the lightning current may go to the transformer and from there it get into the power cables to the local community network and enter into the buildings as conducted transients.

So lightning striking the tower and then as conducted transients it is getting distributed to the local network. This maybe what could be happening when people are complaining about damage TV and equipment after the tower has come up, so there is huge potential rise at the

Tower building complex during lighting strike and this main drive currents via cable shields to local power network.

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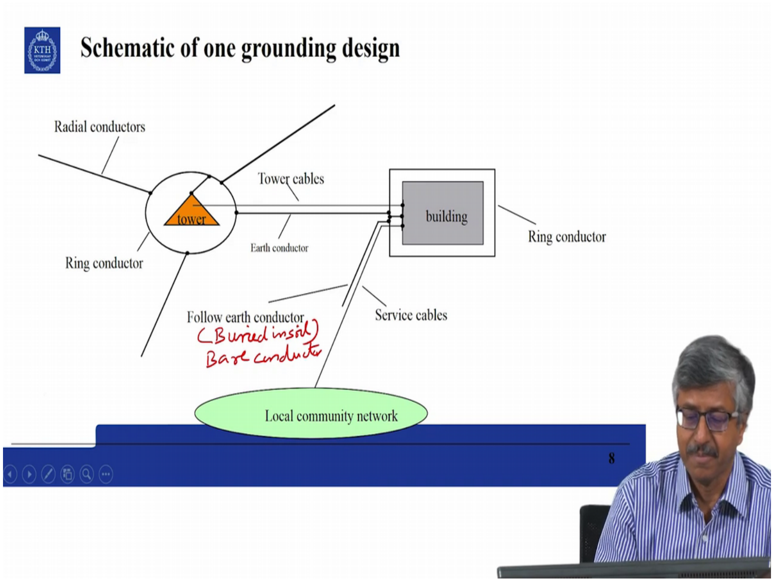

So for protection so this is one schematic diagram, say for example what tower operators could provide is that they have to provide very good lightning protection. Mainly it is not enough to install their equipment at the tower by installing (())(10:56) and all, they need to dissipate most of lightning current to the ground, so often towers are placed in rocky grounds or in small hilltops and all, so you will not be able to provide deep ground rods very often, so even if you do not have… It is not possible to provide vertical ground rods.

Instead of vertical ground rods or in addition to that you can provide ring conductor and horizontal bar read it radial conductors as lightning earthing system but can dissipate lot of lightning currents. Then if you have electronics house in a separate building you need to bond those buildings together by earth conductor and the building also require ring conductors and its equipotential system are connected to those. When you have the service cables going into the building the shields are connected to the equipotential bar.

In addition you can provide a buried earth conductor that is travelling along the service cables but this has to be buried and it is not enough if it was just lying on a trench isolated, so this has to be buried in the soil in touch with the soil, so this follow-on earth conductors… this is buried in soil, so this is bare conductor also. So then this follow-on earth conductor will take a large portion of the current and dissipate into the ground and the current on the cable shields will be very small, so that will save the local community network from lightning related (())(13:20) even when the tower is struck by lightning.

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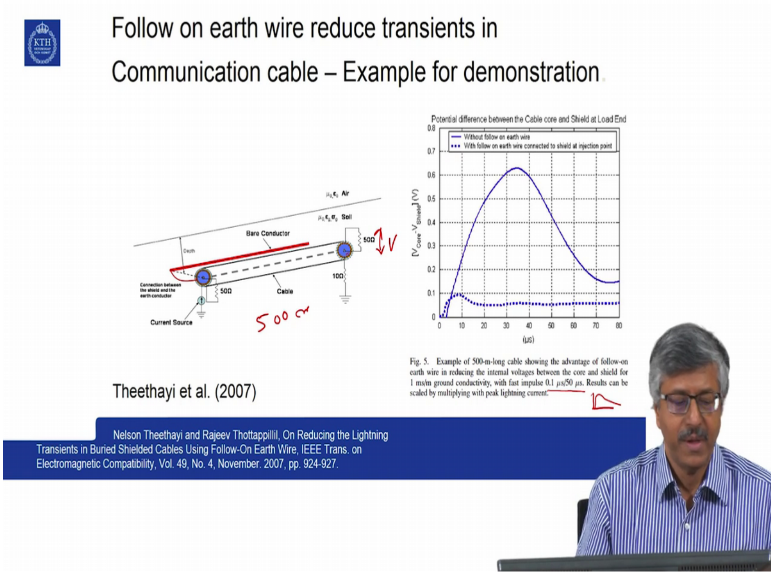

Now this can be shown by this simulation, this is actually a simulation illustrating the principal. Suppose you have a buried cable so in this case this particular cable is around say 500 metre cable, in this simulation it is terminated into 50 ohms at both places and this is 10 ohms that represents the local community network roughly then you have the possibility of connection between the shield and earth conductor, so this is an microsecond so here a current source is connected with a fast symbols of 0.1 microsecond by 50 microseconds, 50 microseconds the fall time so an impulse current like this is given.

Then you give kind of 1 ampere current then you can extrapolate it to say 1000 ampere or something like that by multiplying the results by 1000. So the first curve this is…the curves shows the potential difference between the cable core and cable shield at lower end, so this voltage V is shown here between the core and the shield at the far end of this 500 metre. So the first thick curve what is shown here is without follow-on earth wire, so this is the follow-on earth wire and the daughter curve is shown with follow-on earth wire connected to shield at injection point over here, so you can see that when this wire is connected this voltage appear here, the differential mode voltages appearing over here due to the (())(16:15) of the cable due to the current flow along the cable is reduced very much.

So the curves represents the voltage appearing between the inner conductor and the shield at the other end, so the thick line shows without the follow-on earth wire, so if you have just a cable and this is the case mostly normally when towers are erected very rarely people put this bare conductor. Now if you were conducted is buried in soil and connected at this end of the cable shield one can reduce the induced voltage and the other end drastically and that is shown over here, so this is a very effective strategy in reducing the transfer of lightning energy to the local network. So this 10 ohms impedance roughly represents the local network.

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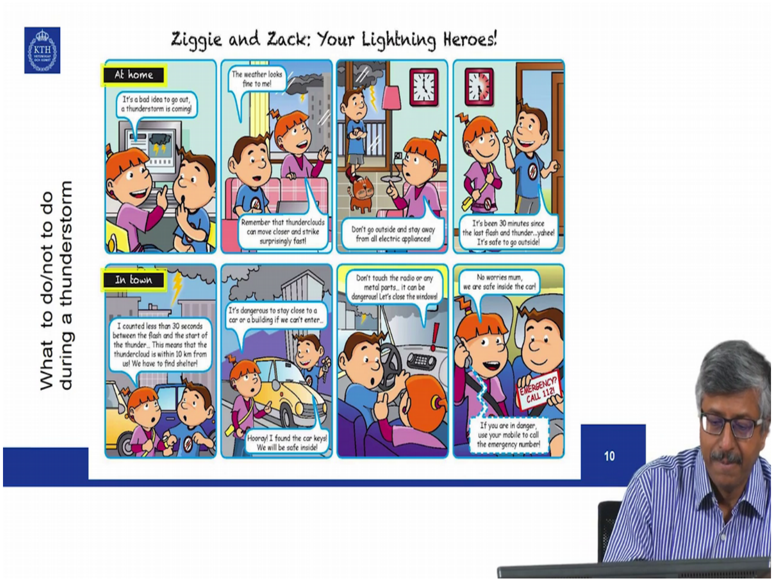

Now one can come to lightning safety, so this lightning safety is described or presented here in the form of a cartoon. This cartoon was produced by a European Union Project that we were all involved about 15 years ago. So it shows 2 cartoon characters Ziggie and Zack talking about what to do during lightning whether you are at home or in town or in a park outside and the terms used here are not really scientific terms but in terms of lay man so that people can understand that, so but it shows generally the principal to be adopted during lightning strike, so that personal safety can be safeguarded.

Say at home, so it is a bad idea to go out if thunderstorm is coming, yes that is true. If you see a thunderstorm coming better to keep yourself at home especially if your home is a normal proper structure concrete building because that offers some protection but if it is a small hut it does not make much of a difference whether you are inside a small tent without lightning protection or you are outside but a proper brick or concrete structure even without lightning protection offer some protection.

The weather looks fine to me remember that the thunder clouds can move closer and strike surprisingly fast, that is true because even though, sometimes you have this thunderstorms that comes from one side to your town and pass the town like that, so this part may be very clear sunny and thunderstorm is approaching and very fast you will be in the middle of a thunderstorm, so you have to really watch out. Do not go outside and stay away from all electrical appliances, so this is what you can do when there is a thunderstorm outside you do not want to be close to electrical appliances because those appliances are connected to the electrical lines.

It could be that lightning may strike somewhere else and something can get into the electrical network and that may have…and if you come close to it or touch it you may get an electrical shock because of that transcend lightning. It has been 30 minutes since the last flash and thunder, yes it is safe to go outside. So you really have to wait out the thunderstorm to be out again, so this is if you want to be absolutely safe. Then if you are caught in thunderstorm while you are in the town you can determine how close the thunderstorm is, so that can be done by counting the seconds between the flash and the thunder.

Remember that the sound travels at speed of around 300 metres per second were as lightning is almost instantaneous 3 into 10 to the power of 8 metres per second and both thunder and lightning flash are produced simultaneously, so you will 1st see lightning then when you start counting approximately you can take that if you count 3 it is 1 kilometre. 6 seconds means that 2 kilometre like that you can count, so you can see that from the number of seconds divided by 3 you can see that how far lightning is a way, so 30 seconds means that lightning is approximately 10 kilometres away.

So it is approaching close so you need to look for a shelter because it takes some time to find the shelter, so you do not want to stay close to a car because that is a metallic body. It can produce upward… Lightning may strike it or you do not want to be close to building standing outside because building may be struck by lightning but if you are inside a car or inside a building that is the safest place to be because inside the car you are almost like a Faraday cage it does not matter you have a rubber tyre and all. If flash can come through insulating air all this way from the cloud it is no problem for it to break down across the tyre.

So if you are inside a car that is quite safe but then try to keep away from the steering and other metallic parts of the car if possible because in case the cars is struck you do not want all those currents to get into you but you can use mobile phone and call people, so if you want to make any calls use mobile phones and not the landline, mobile phones are safe because you do not have any physical connection to that. You may have crackling noise and all but that is not dangerous.

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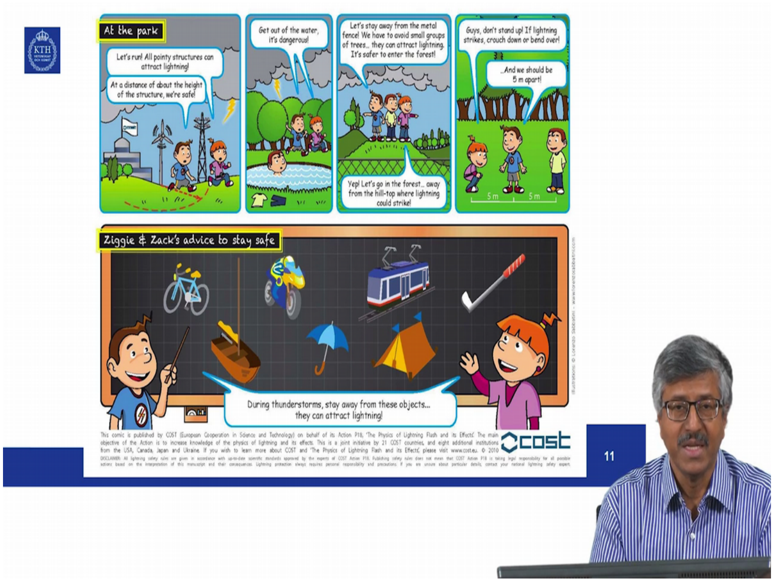

Now if you are at the park or outside you need to find a safe place it is dangerous to be close to big towers and all because very likely those towers may be struck by lightning and you can have…and if it is struck by lightning or I would not say most likely there is a possibility that towers can be struck by lightning and in case it is struck by lightning you can have very large radial currents and this radial currents can produce lot of step potential which can electrocute people, so that is why you have to keep away from tall objects and tall towers and you do not want to be in the water because if you can be electrocuted if anywhere in the water is struck, what is a fairly good conductor and that is not good.

So you have to be out of the water and you do not want to be on top of a hill or near to a fence or on isolated clumps of trees either because lightning can strike any part of the fence you can get an arcing to you or hill is a prominent place… a protruding place so you can be struck by lightning and clumps of trees are also like that whereas if you are in the middle of a forest everywhere it is tall trees and all that is much better you are not sticking out, the principal is not to stick out, so there is the same principle being when you say that okay do not have your raise umbrella like that because you do not want to stick out too much.

The best position to be is if you cannot take a shelter be in a crouching position like that if possible, so that you are not sticking out. Then you keep a distance from the other person do not crowd together because even if one person is struck it is not affecting the other person, so direct line strikes are rare events but still a lot of people are getting killed by lightning not always direct but somewhat indirect in the sense that it may be striking a fence for maybe striking a tree nearby and then you get caught with it.

Tram are safe you are inside the tram or inside a bus or something like that but while… because tram are connected with lines or trains and anywhere line is strike anywhere can affect the train but when you are…but since it is like a metallic body you are safe, a (()) (27:29) cage but when you are so stepping out or in you may be in danger because of the large potential differences so that you need to avoid during a thunderstorm.

So these are some of the principles to be used. Well sailboat is very dangerous because of the tall mast and all. So this cartoon is produced by the cost P18 action of the European Union were several groups of lighting such as exchanging ideas and conducting joints research projects. So for the public information this brochure was produced which was translated into several languages, so that is something about lightning safety, so this will end at the chapter over here. Thank you.