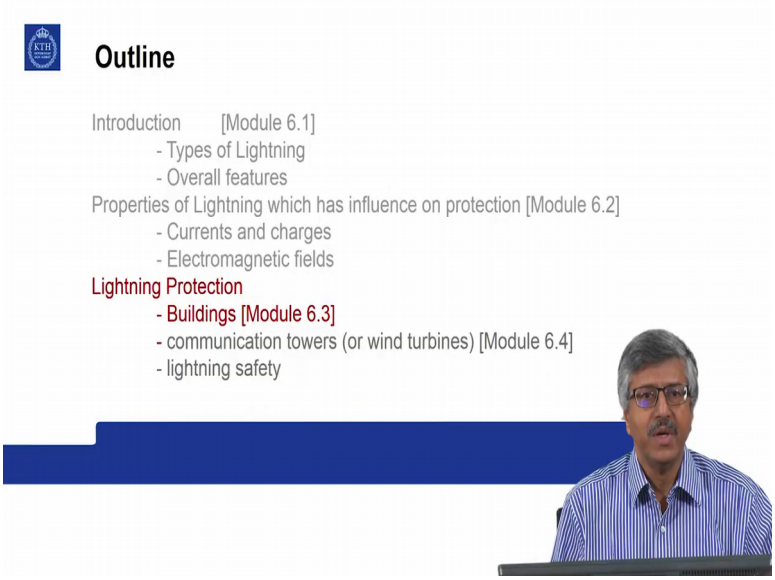
Electromagnetic Compatibility, EMC
Professor Rajeev Thottappillil
KTH Royal Institute of Technology
Module 6.3 Lightning Protection-Buildings
Lightning and Electromagnetic Interference (Lightning Protection)

(Refer Slide Time: 00:14)

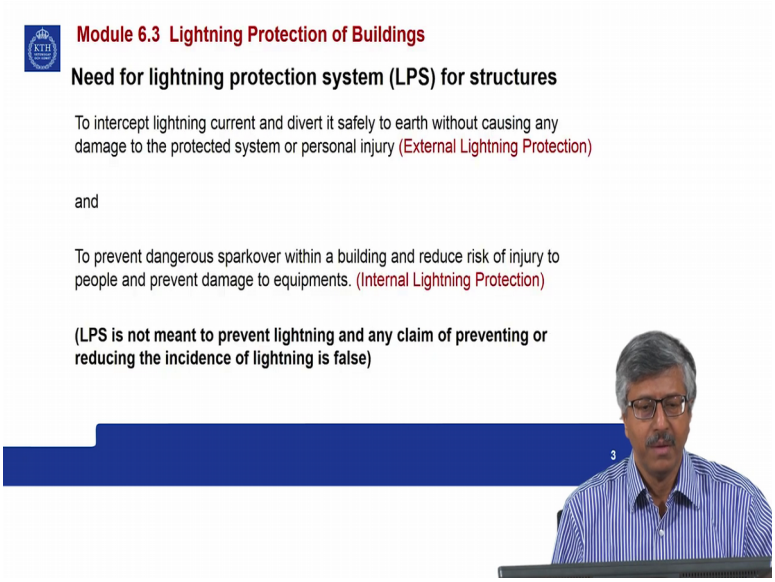
Lightning and Electromagnetic interference module 6 point 3,

(Refer Slide Time: 00:19)



so in this module we will see lightning protection principles applicable to buildings

(Refer Slide Time: 00:31)



So why do we need a lightning protection system for structures? The main purpose of lightning protection is not to scare away lightning or prevent lightning from striking.

Lightning will strike whatever it may be, if there are thunder clouds above and if all the conditions are appropriate. So there are no technology for preventing lightning strike.

So what we can do is that when lightning is striking, you would like it to strike it at a point where you would like it to strike, a preferred point.

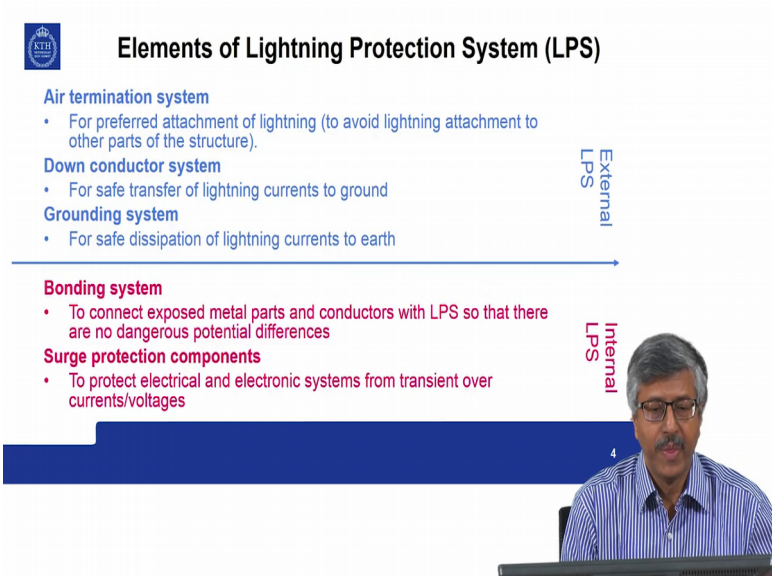
So you provide a preferred point of strike to the lightning then from there you take the lightning currents along the preferred path down to the earth and you dissipate the lightning current along the preferred conductor system buried in the ground.

So this is what one is trying to achieve with lightning protection. So the need for lightning protection system for structures is to intercept the lightning current and divert it safely to earth without causing any damage to the protected system or personal injury. And this is what is called external lightning protection system.

So the protection system is external to the building. But that is not enough. You also need to prevent dangerous sparkovers within a building due to the lightning strike external to the structure and to reduce risk of injury to people and prevent damage to equipment. So this is the reason for internal lightning protection.

So as part of lightning protection you will have something external to the building and some measures internal to the building. So we will quickly go through that. But more concentration will be given in internal lightning protection.

(Refer Slide Time: 03:07)



So what are elements of lightning protection system? So you have Air termination. So this blue writing is part of external lightning protection and this red, internal lightning protection system. So within external lightning protection system we have Air termination system, Down conductor system and Grounding system.

So Air termination system provides a preferred attachment point for lightning so that lightning is not attaching to the other parts of the structure. Then in the Down conductor system, you provide a safe transfer of lightning currents to the ground. And in the Grounding system you provide safe dissipation of lightning currents to earth.

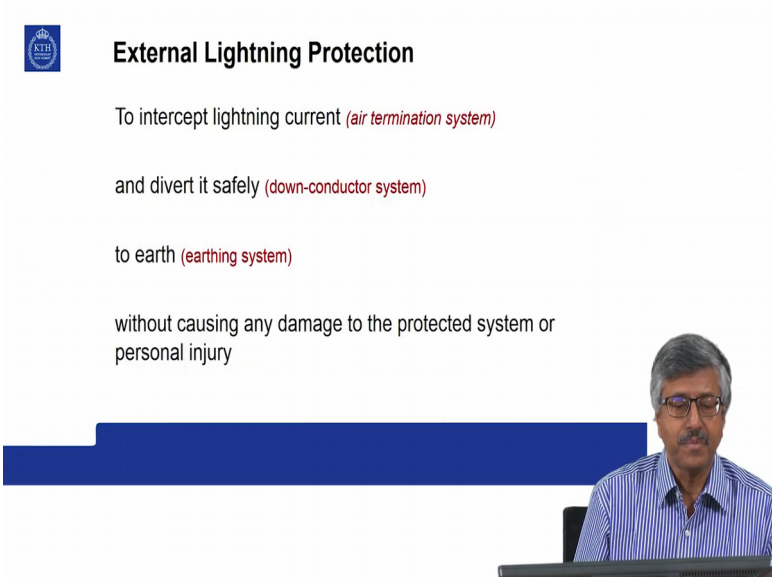
And during this process lightning currents are not entering into the building in uncontrolled way. Now for the internal lightning protection system you have a Bonding system. Then Surge protection components.

Bonding system normally does not carry currents. It is mainly to make exposed metal parts at equal potential when there is a lightning strike.

One big danger during lightning strike is that, may be some part, some of the equipments or some metal parts like railings of a lift or other kind of things may have lightning currents coming into it. But other parts may not. So you create lot of internal potential differences which can create sparking and harmful to people. So you want to prevent that.

So you want to bond everything together. So that is the purpose of bonding. Then surge protection components to protect electrical and electronic systems from transient overcurrents and voltages.

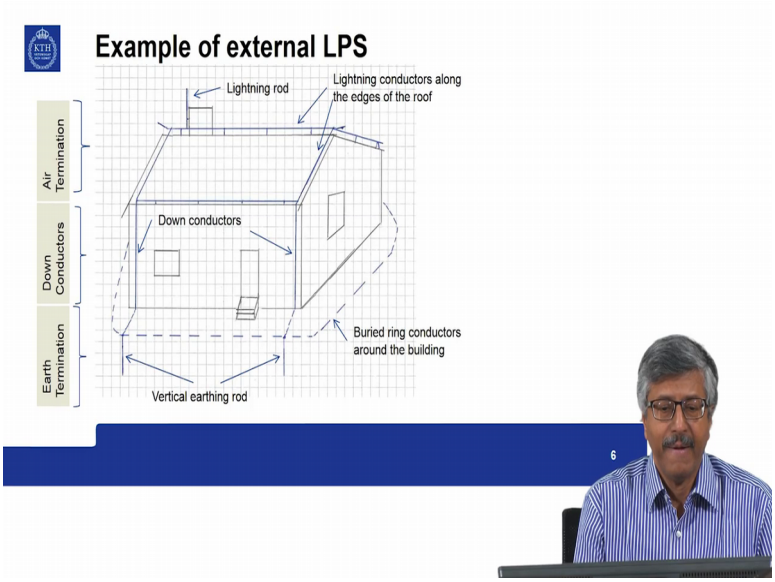
(Refer Slide Time: 05:34)



The external lightning protection, so it is mainly to intercept lightning current, that is air termination system and divert it safely through the down-conductor system to earth and dissipate it, that is earthing system, without causing any damage to the protected system or person or injury.

So this is the totally, the function of external lightning protection.

(Refer Slide Time: 06:10)



A sketch of a small building is shown here. A small residential house, here air termination systems, down conduction system and earth terminations are the basic, system is illustrated. So in terms of air termination system so they are bare conductors without any insulation.

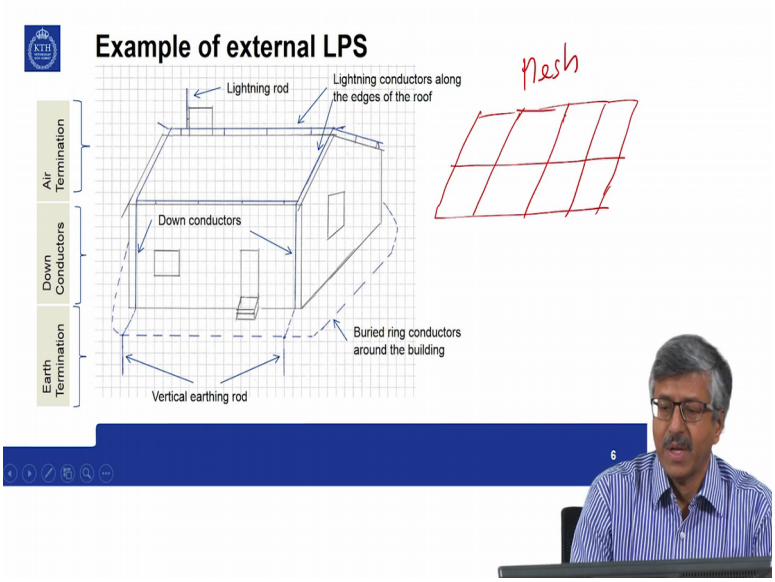
So first of all you can see that at the edges of the roof you have a horizontal conductor mounted and this is mounted here, all these are conductors. So this part is the air termination system. So lightning may strike either this lightning rod or one of this horizontal rods.

So these are the conductors and the roof is generally non-metallic and not conducting. So most likely the upward leaders will be coming off from these conductor systems above.

And you have a lightning rod here mainly to protect this chimney from direct lightning strike. So for example this provides some sort of angle of protection to this chimney.

Then you have, so this lightning protection system forms kind of a mesh. So if you have a big building, may be you will have several meshes. One mesh may not be enough. So you can have a mesh structure like this on the roof.

(Refer Slide Time: 08:27)



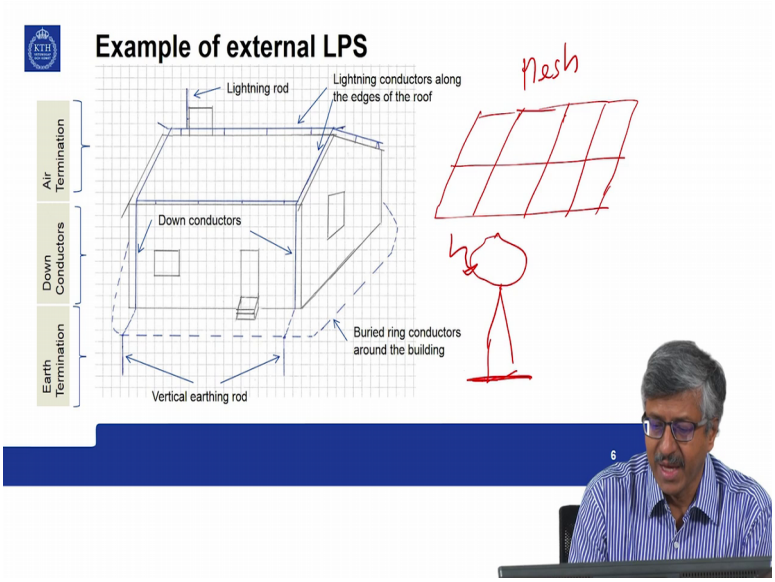
Then you have down conductor systems. Here two down conductor systems are shown and, that can be on the other side also. And this safely carries the lightning currents down.

Then it is connected to a earth termination system. So here you can use both vertical earthing rod and buried ring conductors around the building.

So ring conductors are often used to reduce the step potential. When some people are entering the building and when there is a lightning strike you do not want huge potential differences between the legs.

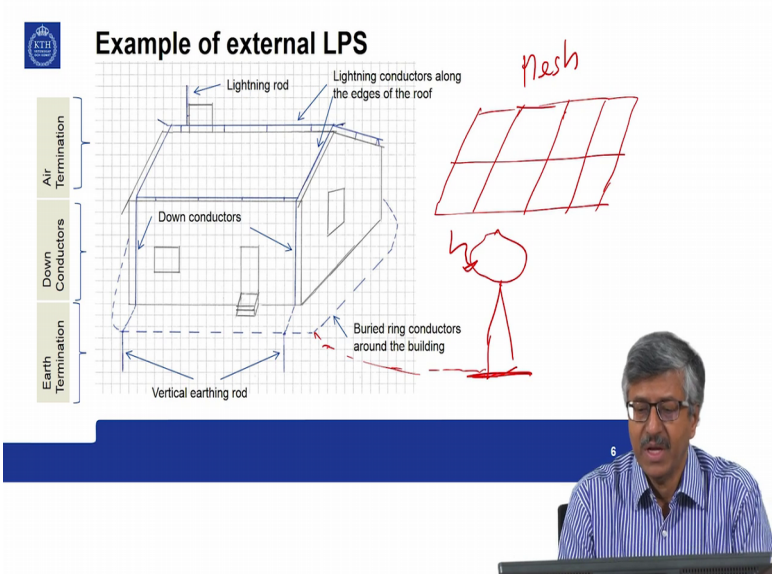
So to control that you have these ring conductors. Not only that if lightning strikes a tree over here, say for example if lightning is striking a tree, and sometimes you can have

(Refer Slide Time: 09:40)



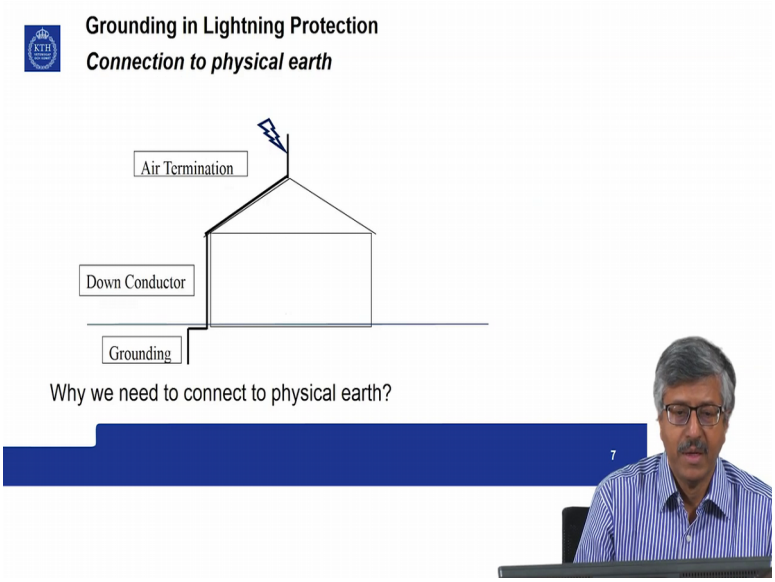
ground flashes from this and it may enter the building.

(Refer Slide Time: 09:50)



So this ring conductor will also protect against surface arcing along the ground from a tree and coming into the building. So that also it will prevent. So this gives some sort of a comprehensive protection against lightning.

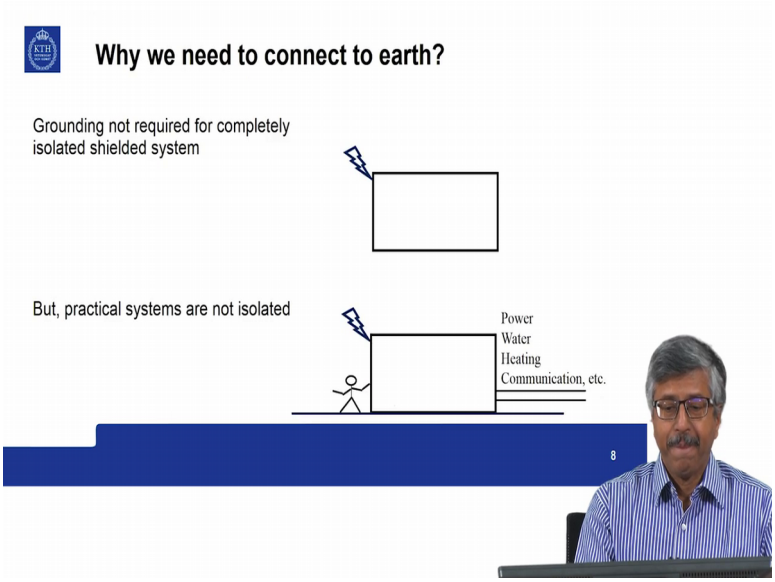
(Refer Slide Time: 10:16)



Now often one may ask why in lightning protection one need to connect to the physical earth. Because in E M C we talk of grounding but we are not really talking of real mother earth for connecting the equipments or systems. So why in lightning protection we always talk of the physical earth?

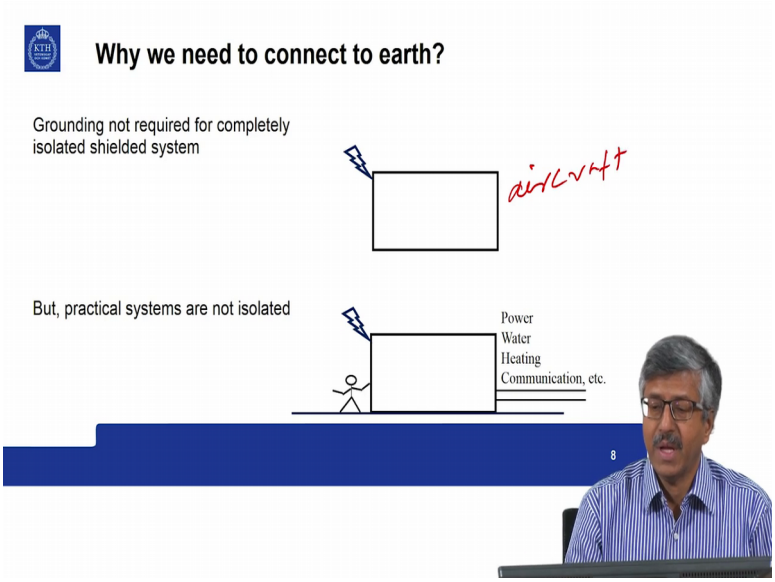
Say for example we know that the lightning striking an aircraft, so aircraft is not grounded to earth. But still people are safe inside. Equipment are safe inside when we design it according to the principles of E M C. So why earth?

(Refer Slide Time: 11:05)



The reason is this. If it is a totally isolated system like aircraft for example

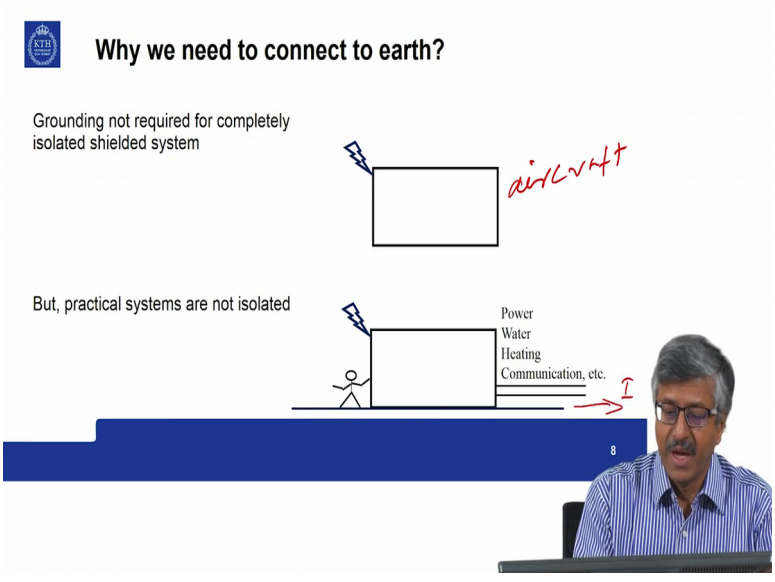
(Refer Slide Time: 11:19)



you do not require any connection to the earth. But earth bound systems are not isolated. They are always connected with something else in terms of power, water, heating, communication etc. And they are in close proximity to people also.

So due to this reason there would be always some currents, lightning currents or lightning surges going through this power, water and heating to the other systems. And this is totally unwanted. And you want to minimize this current flow. So you have this current flow here. So you want to minimize that.

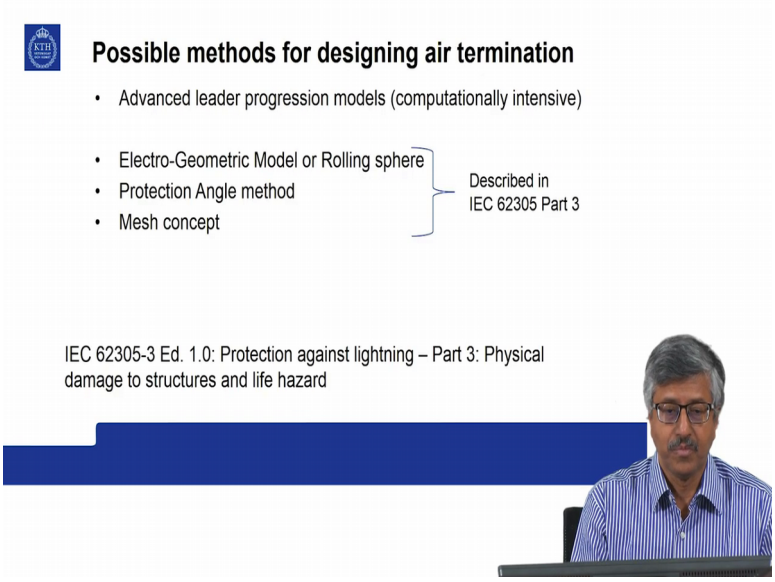
(Refer Slide Time: 12:12)



And for minimizing this you have to connect it to the ground and try to dissipate as much as possible here itself all the currents so that only a small portion is going into the adjacent

building. So this is the reason why we need to have good connection to the earth in non-isolated systems.

(Refer Slide Time: 12:41)



There are several possible methods for designing air termination. This is a vast subject and it is beyond the scope of this course to go into the details. So instead I will give a reference to you.

If you refer to International Electro technical Commission Standards 62305 Protection against lightning Part 3 Physical damage to structures and life hazard you can find all these methods described very well there with illustrations.

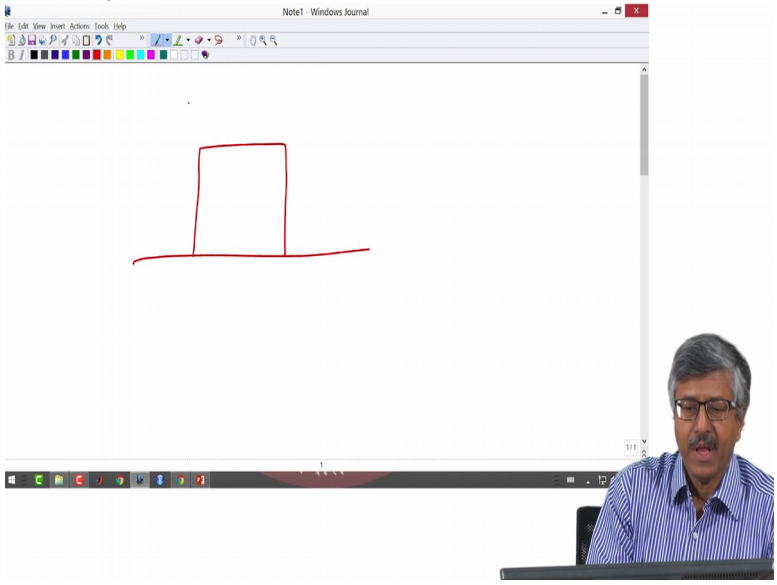
Researchers often use advance leader progression models for designing air terminations. These are quite accurate but computationally very intensive so they are not normally used by engineers.

Engineers are using these three methods, Electro-Geometric Models or Rolling sphere, Protection Angle method and Mesh concept. May be I will very briefly describe what they are.

The Protection Angle method, so it is based on the fact that, suppose you have a rod like this and lightning is striking here. Then most likely, let us remove that. Suppose you have some building. I will take a building instead.

So you have some structure here.

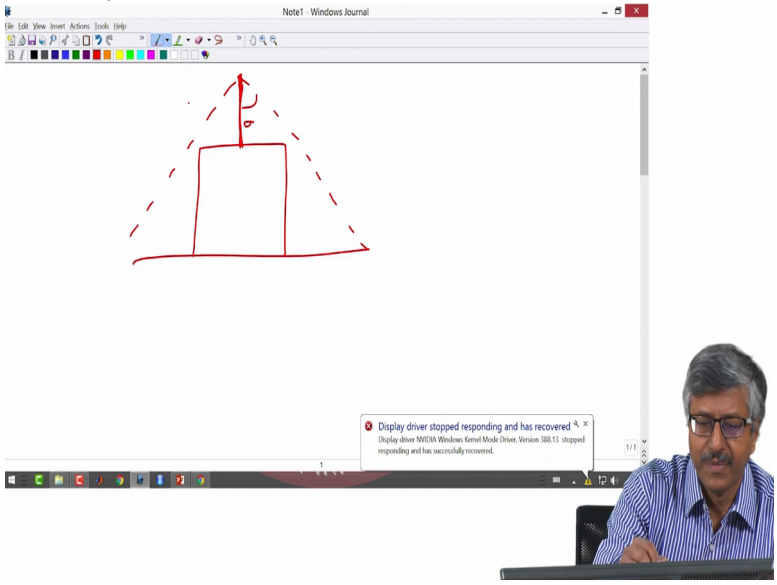
(Refer Slide Time: 14:47)



Now lightning is coming down and you do not know where this is going to strike. But if you are providing a lightning rod here at the top, most likely it will be striking this top of the building.

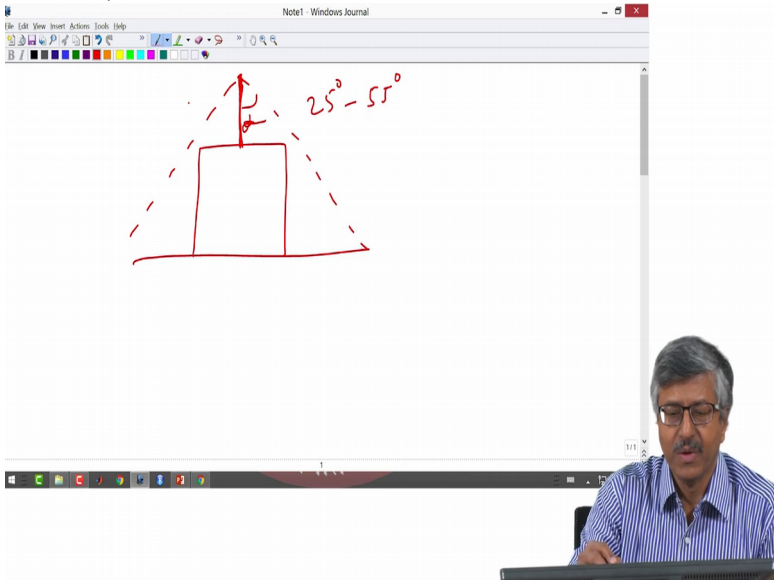
And what protection angle method states that it gives certain angle of protection. So this angle alpha

(Refer Slide Time: 15:31)



around can be some 25 degrees to say 55 degrees. So

(Refer Slide Time: 15:39)

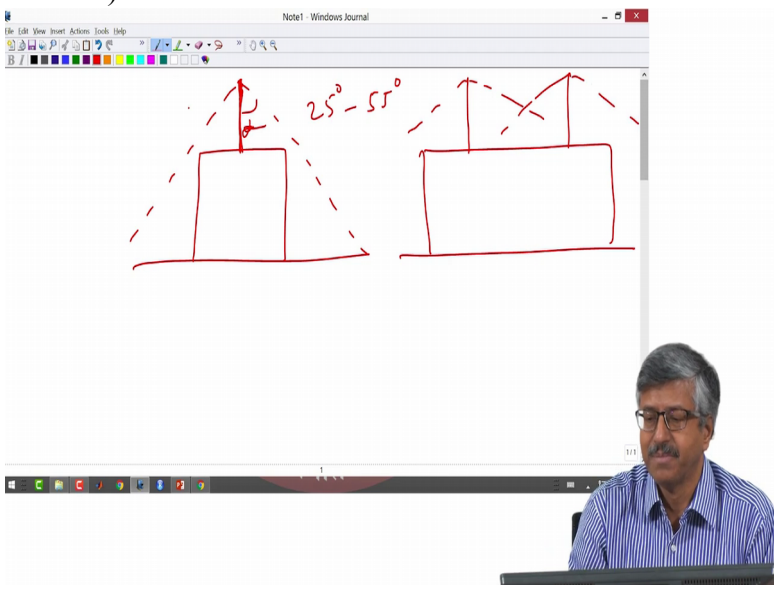


anything within that is kind of protected from direct strike.

Say for example lightning is unlikely to strike this building over here. It is most likely to strike over here. So this is the protection angle method.

So if you have structures you can try to determine how big lightning rods we have to erect, and how, if it is a big structure, like this you may want to erect say maybe 2 lightning rods like this so that the protection angles are overlapping with each other.

(Refer Slide Time: 16:20)

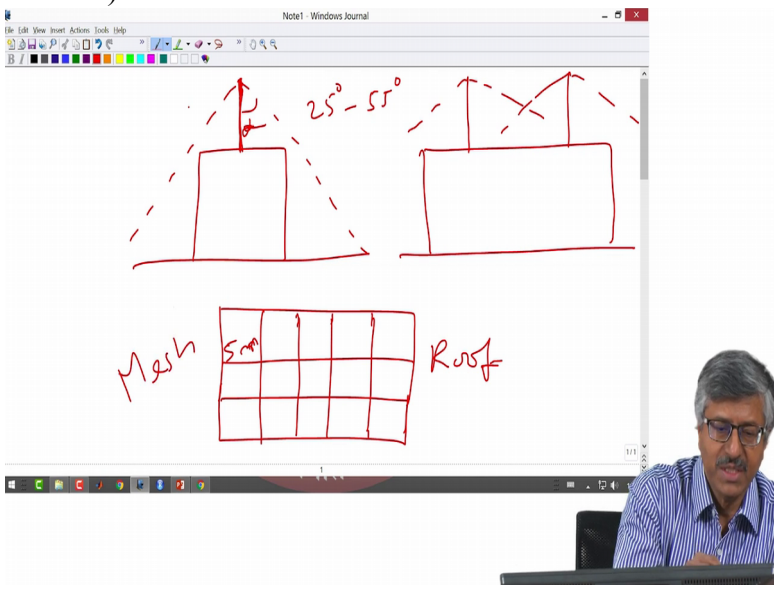


So this is the protection angle method. Now if you take the roof of the building then this is the roof of some building.

Then lightning is coming down. Then the bold (()) (16:52) roof you can divide into several meshes. So the distance from, between these meshes may be of 5 meter or something like that depending upon the protection glass.

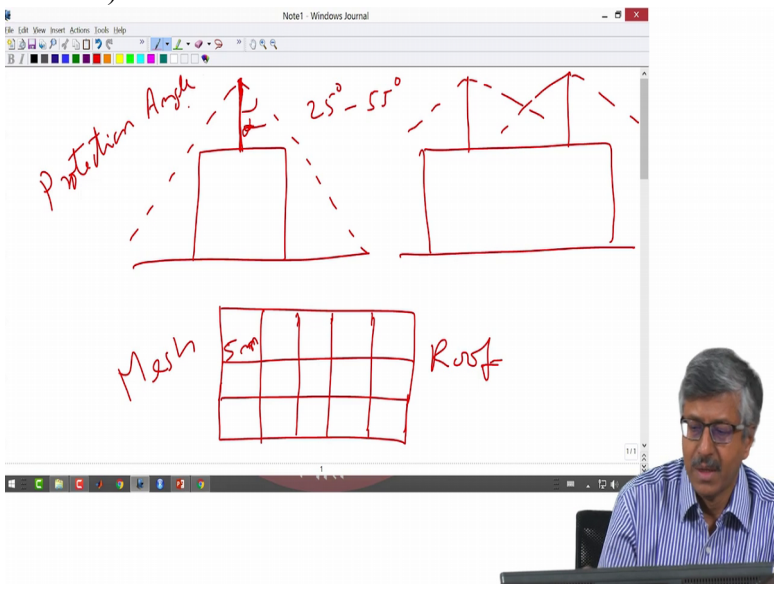
And this most likely lightning will be striking the upward leaders coming from these conducting meshes and the building below is protected. So this is the mesh method.

(Refer Slide Time: 17:26)



So this is the protection angle.

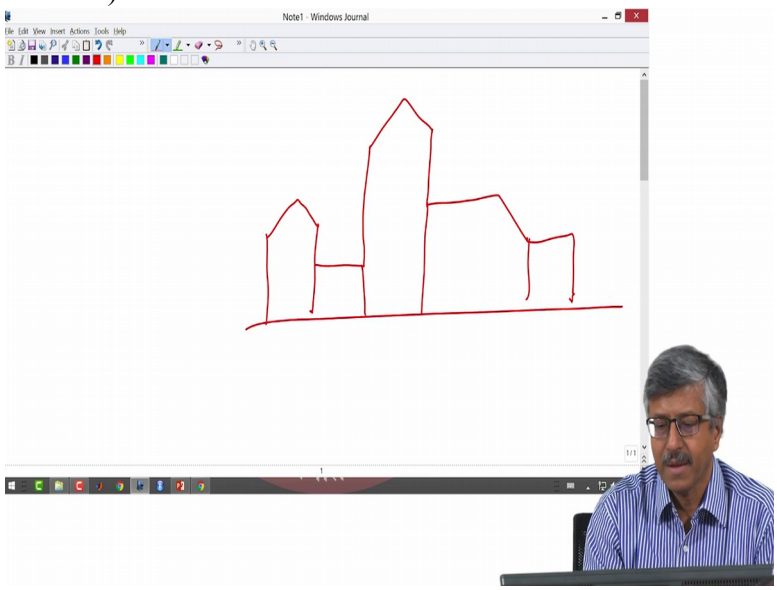
(Refer Slide Time: 17:34)



Now I can, there are even more sophisticated method if it is a very complicated method. It is called the rolling sphere. So this can be illustrated by this.

Say, for example suppose you have a structure like this, then below that you have a small roof and another structure like that, you know some form of structures like this, let us say.

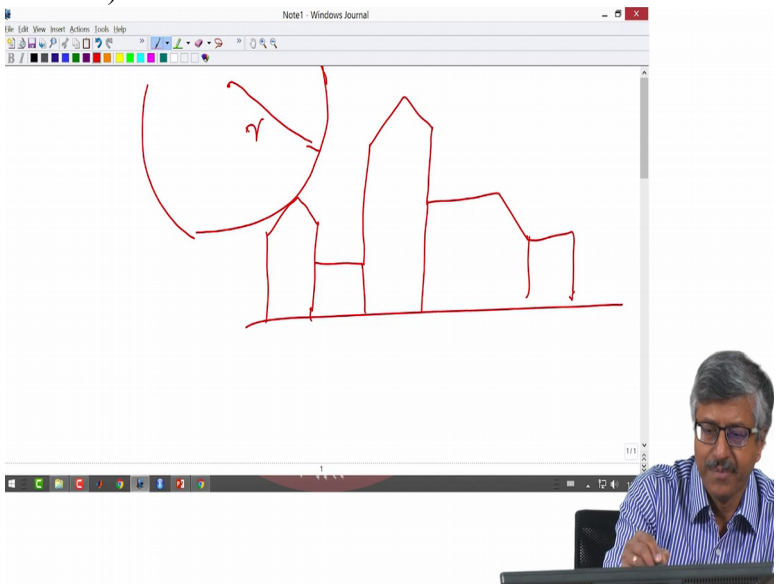
(Refer Slide Time: 18:34)



Then what the rolling spheres says is that, depending upon the peak current, so the peak current and the charge has got some proportionality. It is not linear using some exponential relationship.

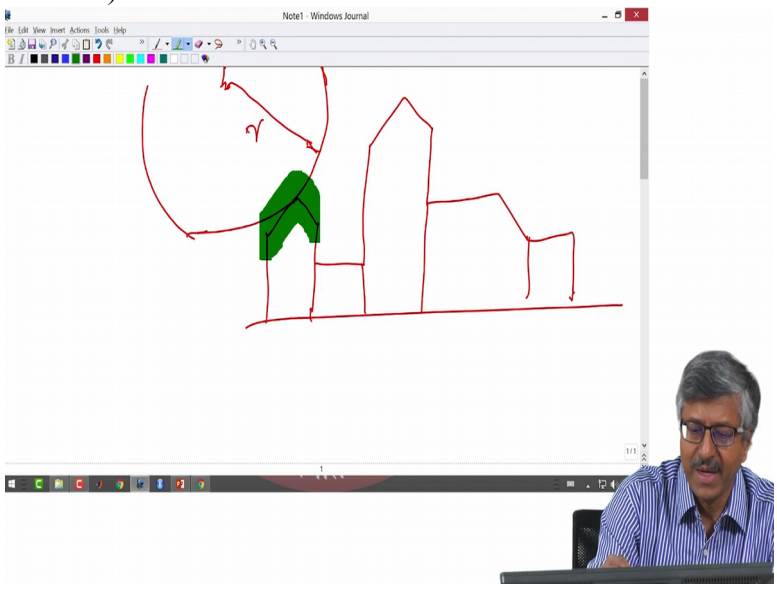
Then due to that you know that if lighting has reached at certain distance most likely, so if lightning has reached here, most likely it will strike a point at certain distance and you can form some sort of a sphere of radius r.

(Refer Slide Time: 19:17)



Now this lightning can come anywhere along this in space. So if you roll the sphere along this structure in all directions and if you look at where all this structure will touch, it is too thick line, then

(Refer Slide Time: 19:54)

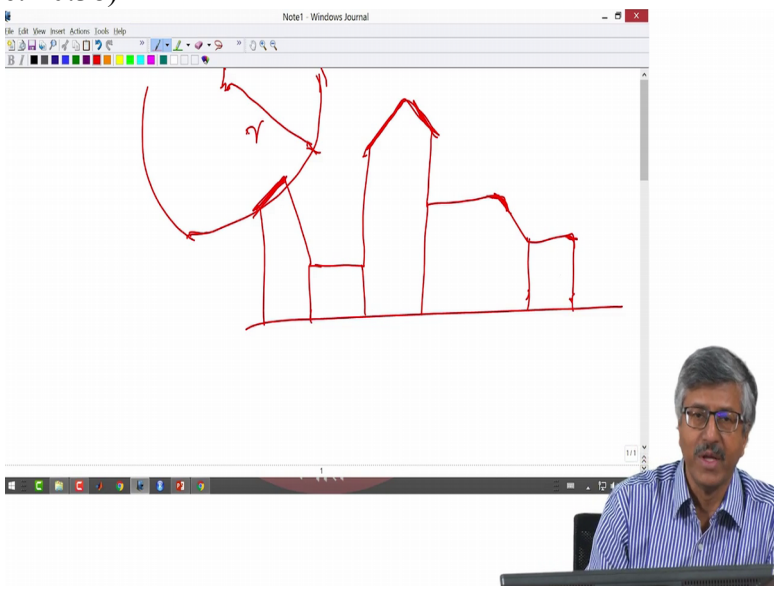


here it will not be, so the, let me redraw that, so that part you need to protect lightning protection say, if it is over here.

Most likely you do not require anywhere over here but here you may need, here you may need, this part you may need.

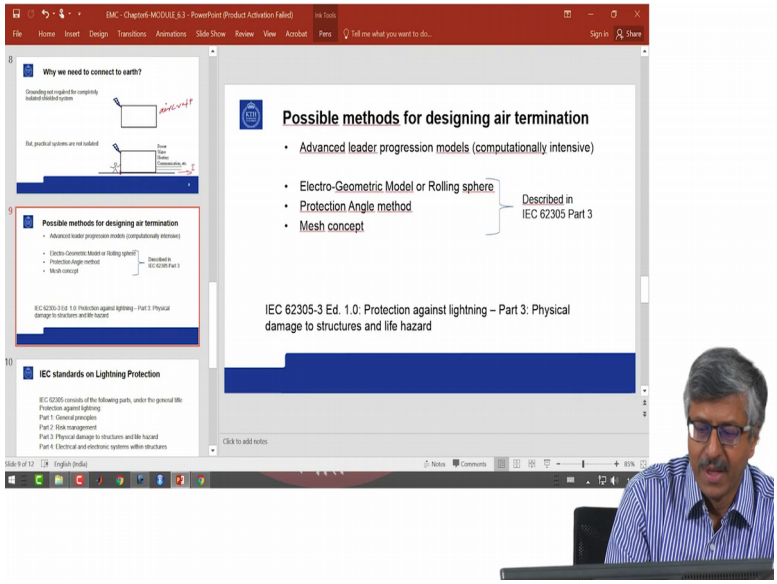
So likewise wherever this sphere is touching you need to provide air termination. So that is the rolling sphere

(Refer Slide Time: 20:38)



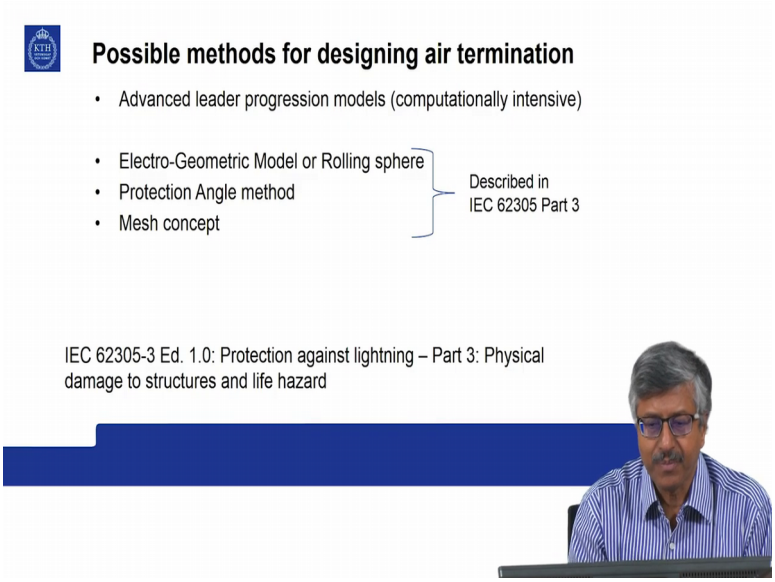
method. Now all the radius of the rolling sphere, the dimensions between the measures, the angles to be used, all these things are given in the lightning protection standards.

(Refer Slide Time: 20:53)

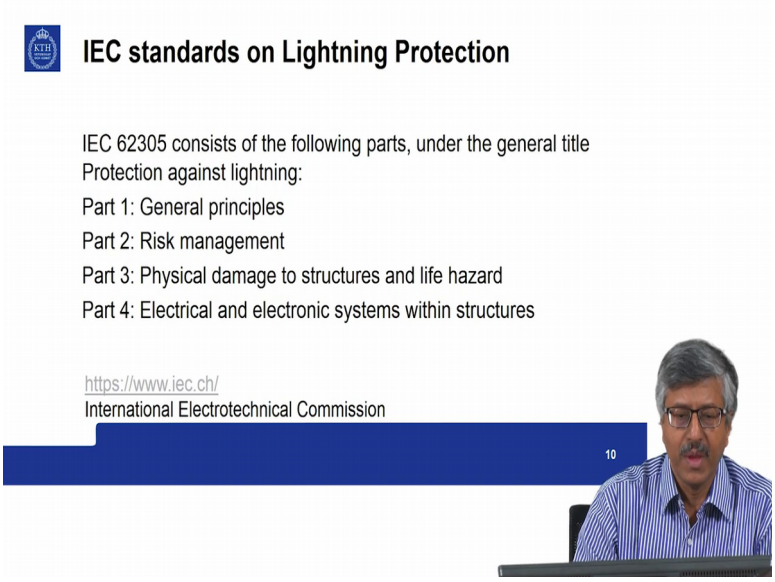


Now coming back to this,

(Refer Slide Time: 20:57)



(Refer Slide Time: 20:59)



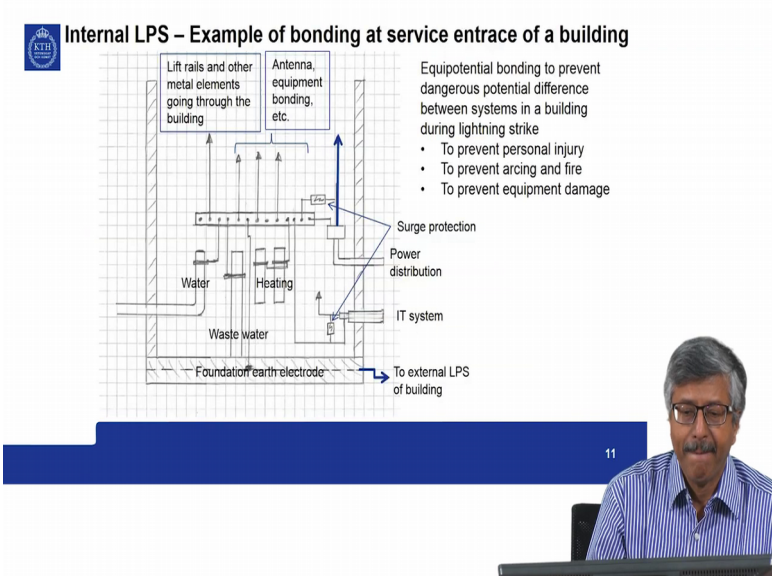
these are the basic standards available. One of the most reliable information regarding lightning protection; part 1 gives general principles.

Part 2 risk assessment or risk management, whether you need to have lightning protection or not and how good that lightning protection has to be. So that is, the method for that is given in part 2.

Part 3 gives practical principles and examples on how to manage physical damage to structures and life hazard.

Then Part 4 is electrical and electronic systems within structures, how to protect, regarding that. So these standards you can find at this website International Electro technical Commission.

(Refer Slide Time: 22:00)



Now coming to internal lightning protection I would like to give one example of bonding at service entrance of a building. It was, this is very crucial for internal lightning protection.

Often most of the damages inside a building from lightning is done by electric shock, sparking and the resulting fire because of the uncontrolled entry of currents and uncontrolled development of overvoltages.

So bonding is very important for that. For example this is the periphery of a structure. It is not to scale. Just to show the principles. So this is the foundation, earth electrode and that is connected to external lightning protection system of the building. Then you have several services coming into the building.

So this can be water coming into the building, I T system and computer, power distribution system coming into the building, heating if it is cold place, waste water piping from toilets, kitchen etc. You have so many systems.

Now these are distributed systems and coming from somewhere. It could well be that lightning is striking a water pipe somewhere several 100 meters away and a lightning flash is

coming here. Now suppose these are all bonded together. This is an equipotential bonding bar, a bare copper bus bar where all these systems are connected together.

Suppose if they are not connected together then you will have a big potential difference between this water pipe and the waste water, or water pipe and the heating, or water pipe and the power distribution system etc.

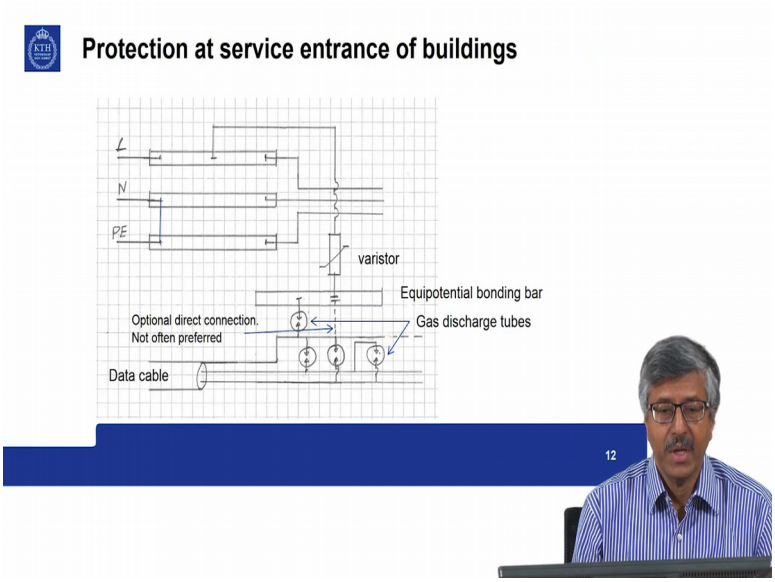
But when you connect all of them together, all of them will be at the same potential as this water pipe. Even though water pipe is now at a higher potential, all of them will be there and this is safer than isolating them. Then similarly lift rails and other metal elements going through the building, antenna equipment and bonding etc all of them are there, and all this has to be bonded together.

And in power distribution system you cannot connect the live wires directly to the bonding system. So you provide such protection. So when there is a lightning even that wire is connected and becomes same potential, same thing with I T system.

So during lightning strike everything inside this building rises up in potential at the same time and falls down in potential at the same time so that there is no dangerous potential difference.

So equipotential bonding is to prevent dangerous potential difference between systems in a building during lightning strike to prevent personal injury, to prevent arcing and fire and to prevent equipment damage.

(Refer Slide Time: 25:43)

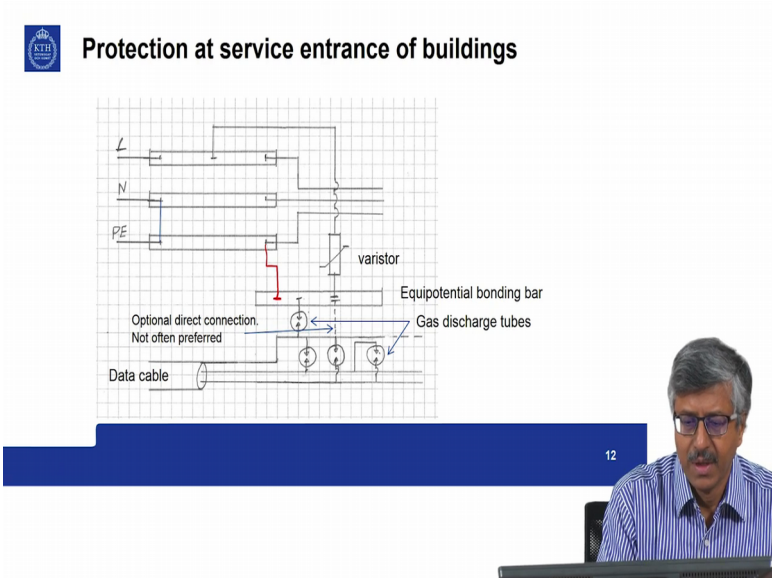


Now protection at service entrance of buildings. So there you have, say in this particular case only 2 services are shown, the power and data cables or I T and often they are coming close together in an equipment or even in an outlet they are close together.

So definitely you need to have some sort of bonding between your power system and data cable and I T system, and communication system. Without that there can be dangerous overvoltages appearing across that during lightning strike.

So how do you provide that? Say data cable have a shield. So one possibility is that you have an equipotential bar as before and you connect your system to say, this neutral and P E are connected together at this service entrance. And you have, yeah so this connection was missing,

(Refer Slide Time: 27:18)



so earth is, P E is connected to equipotential bonding bar.

Then you have a surge arrestor between the line in case of a lightning surge, this surge arrestor will operate. Then in some cases you can connect the shield of data cable directly to the equipotential bar

But often it is not done because you can have large stray currents along the earthing system and these stray currents can get into the cable shield and through transfer impedance of the cable shield you can have disturbances in the lines, communication lines.

So often direct connection is not often preferred. So instead you connect using a spark gap. The reason is that when there is an overvoltage here, this whole system is going up in potential due to a lightning, then this spark gap will operate and they will equalize the connection. And once the lightning surge has passed again you have this isolated system.

Then this spark gap produce the protection against differential mode of transients. Here we are showing spark gap and here we are showing varistor. One reason is that, well it can be diodes and other things also but spark gaps provide very low capacitance and at high frequency capacity capacitance is quite important.

So this can be one protection at service entrance. More complicated versions also you can get. You can get in module form from different type of equipment manufacturers. So this is generally a small introduction to protection of the buildings, various elements.