Electromagnetic Compatibility, EMC
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Module 6.1 Solutions to EMC Problems Filters and Surge Protectors
Lightning and Electromagnetic Interference (Lightning Protection)

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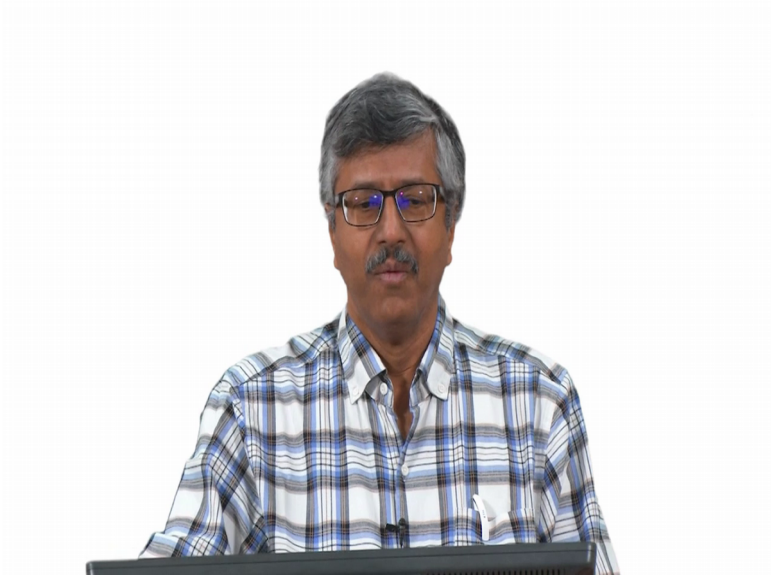

Welcome to this new chapter on Lightning and Electromagnetic Interference. Or in popular terminology we call this chapter as Lightning Protection.

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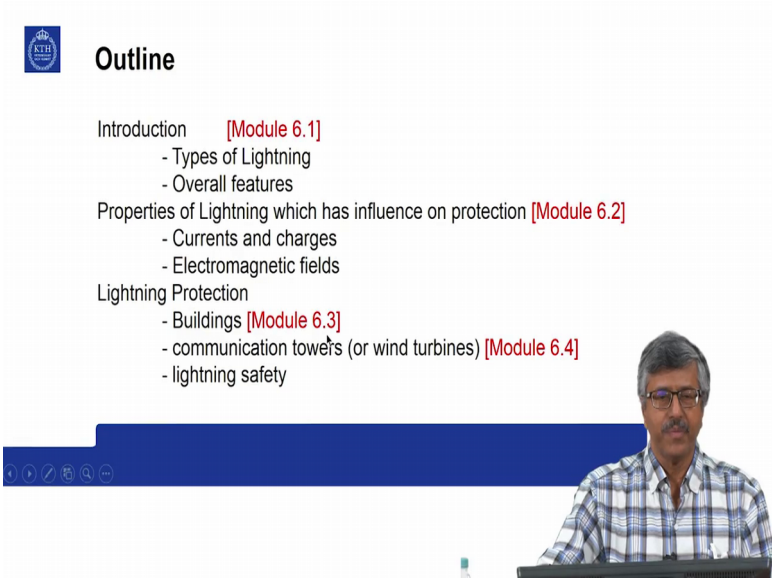

So this chapter is divided into 4 modules. First an introduction on different types of lightning and overall features that are important for understanding its action on man-made systems.

Then properties of lightning which has influence on protection module 6 point 2, especially Current and Charges and Electromagnetic Fields.

Then we introduce some concepts of lightning protection regarding buildings in module 6 point 3 and communication towers or wind turbines in module 6 point 4.

So what we can do in this chapter is very, very short survey in relation to electromagnetic compatibility. So it will not be any comprehensive treatment of lightning protection.

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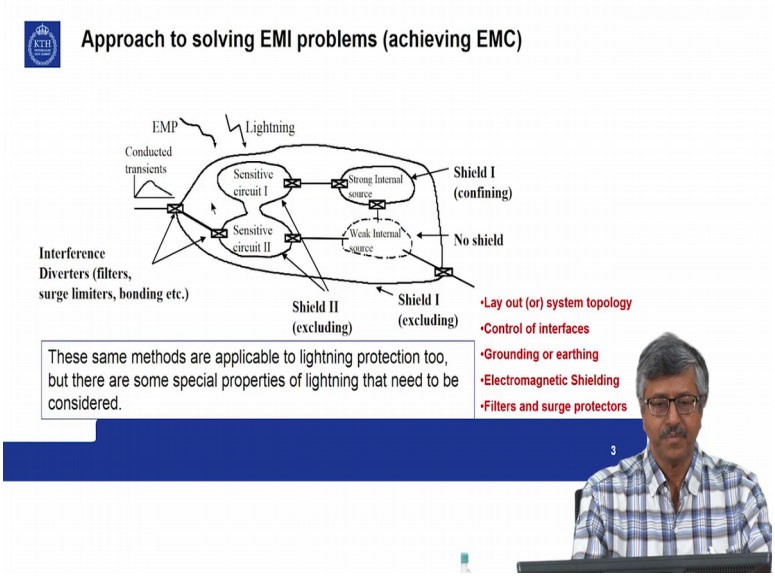

We have seen that the generic approach to solving E M I problems for achieving or achieving E M C, we have seen about zoning principles, that is system topology, control of interfaces, grounding or earthing, electromagnetic shielding, filters and surge protectors.

Now all these are applicable even for lightning protection. The only difference could be that in lightning protection we are often dealing with huge systems like a big building, a huge railway network or a power network, a nuclear power plant, things like that.

But otherwise the generic principles are the same. And the source is also very different from the generic E M C, E M I problem sources.

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Also it was mentioned earlier that lightning strike to aircraft and the early accidents in the 1950s and 60s prompted lot of research and that led to the development of E M C.

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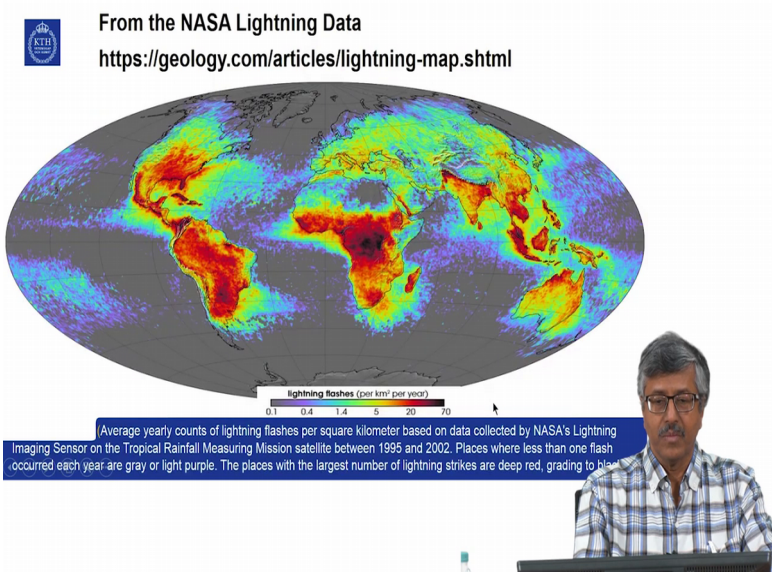

Now if you look at how prevalent lightning is around the world, you can look at this map of lightning data from NASA published at this website.

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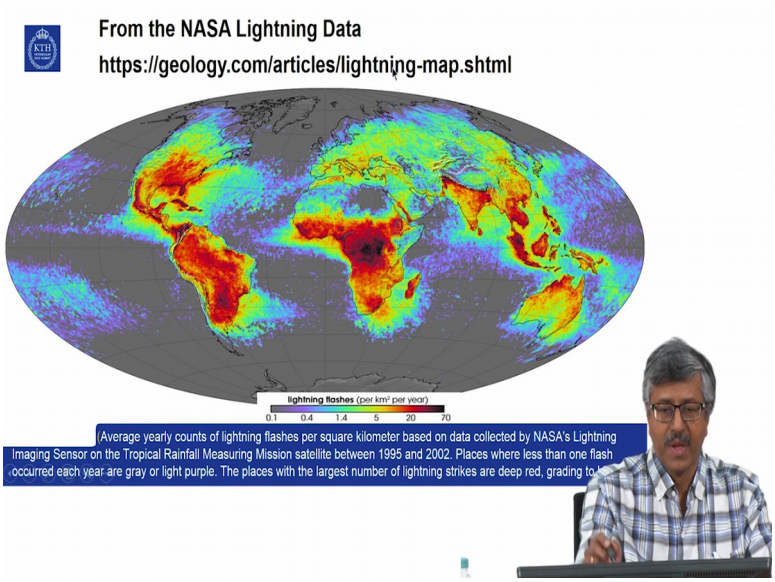

So here this is from the NASA's lightning imaging sensor on the Tropical Rainfall Measuring Mission satellite between 1995 and 2002. So this is average data.

Now the color coding is this. Places where less than 1 flash occurred each year are gray or light purple, and places with the largest number of lightning strikes are deep red or here in this scale and the grading to black. So here blue means that it is less amount of lightning; red means very large number of lightning.

So not surprisingly, you can see that tropical Africa and tropical Asia has the largest number of, the largest lightning flash density per square kilometer per year, around 70. So in India, in some places you have and other places it is much less. In Sweden it is around 1 flash per square kilometer per year.

So lightning is very prevalent. And it is there all around and it will be there for years to come.

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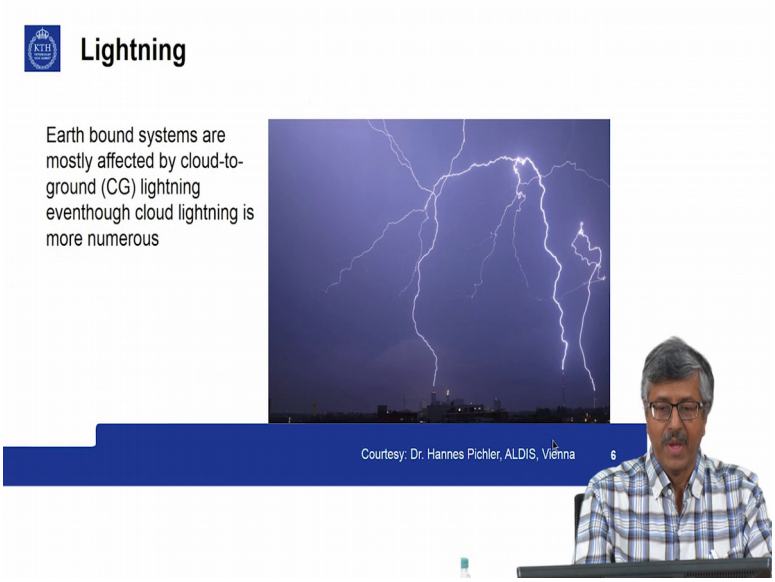

So earth bound systems are mostly affected by cloud to ground lightning. Even though cloud lightning is more numerous.

Cloud lightning is lightning within the cloud. You can see that when you look up but there is no flash coming down to the earth whereas in cloud to ground lightning there is a flash coming down to the earth and striking the objects on the ground.

So we will be concentrating on cloud to ground lightning. So this picture is provided by Doctor Hannes Pichler.

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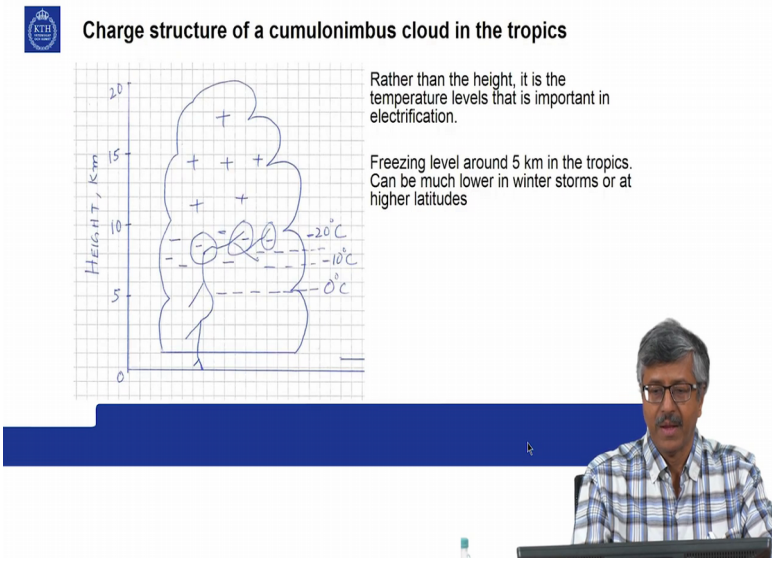

So this is a charge structure in a cumulonimbus cloud in the tropics.

Understand like this. On the top there are positive charges and at

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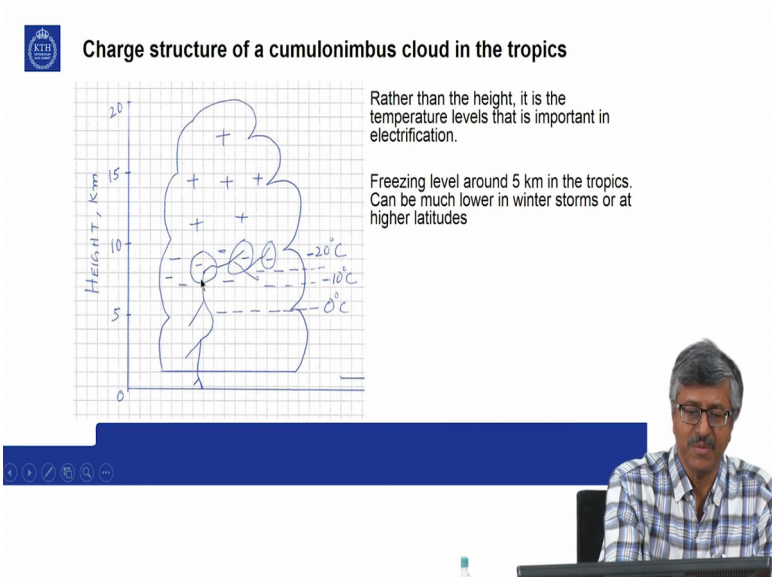

the bottom there are negative charges. We will not go into the details on how these charges are produced and all. But it is enough to understand that most of the lightning

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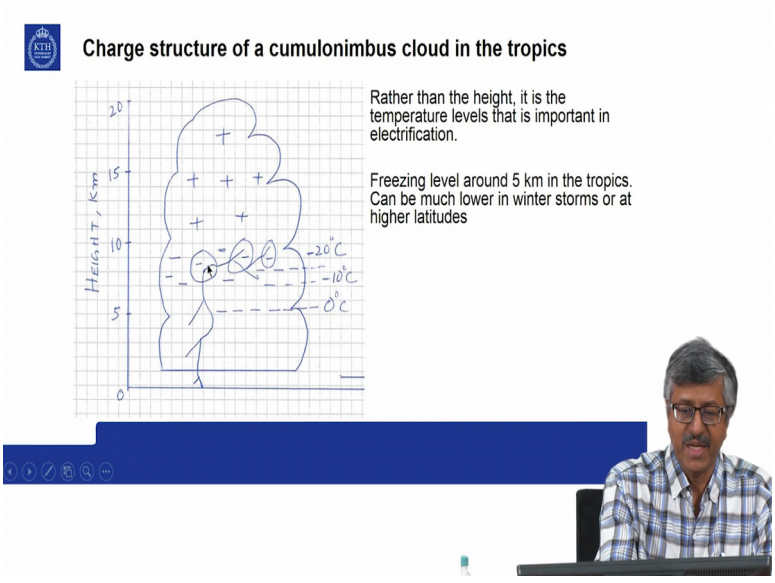

originates from around this region, the negatively charged region.

So rather than the height it is the temperature levels that is important in the electrification. So you need to be above the freezing level. So this is a cloud in the tropics and winter clouds in other places can be much lower altitude.

So freezing level around 5 kilometers in the tropics can be much lower in winter storms or at higher altitudes. So it will have a horizontal portion, the lightning channel and the vertical portion.

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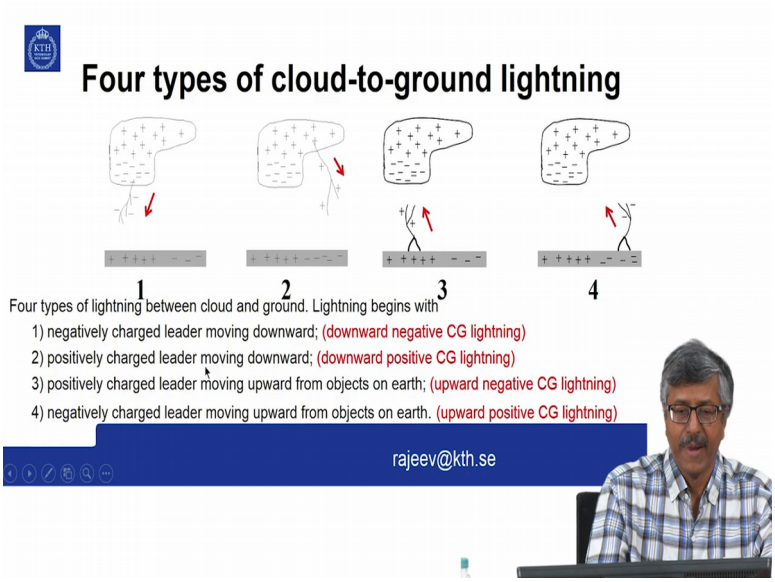

Now these are the four types of cloud to ground lightning. So based on the initial direction of the leader, you call it as downward lightning or upward lightning, 3 and 4 upward lightning, these are downward lightning.

And depending upon the polarity of the charge that is neutralized in the end you have negative lightning as well as positive lightning. So let us take the first example.

You have this negative charge here so around the ground it is positively charged and here there can be some negative charges. So lightning, here the lightning is beginning with a negatively charged leader moving downward. And this is downward negative cloud to ground lightning.

So at the end of the lightning you have neutralized these negative charges. Because as this is coming down and making connection to the ground positive charges are moving up. And you are neutralizing this part. So effectively negative charge is neutralized. So you call it negative cloud to ground lightning.

In the second one you have the positively charged leader moving downwards from this positive charge source and coming to the ground.

So this is a downward positive cloud to ground lightning. Because at the end of the lightning you will have this positive charge neutralized or lowered to earth. So downward positive cloud to ground lightning.

So here from tall structures or mountains you have upward positive leader. And in response there will be a negative leader coming down. And in the end you will end up removing these negative charges in the cloud.

So it is upward negative cloud to ground lightning. And the fourth one, negative leaders are going up connecting to this positive charge. And positive charge will be coming down. And in the end of the process this positive charge is removed or neutralized, not fully but only partly in all these cases.

So negative charged leader moving upwards from objects on earth, they are upward positive cloud to ground lightning. So of this lightning, the most important for us are this negative lightning. Almost 90 percent of the lightning, cloud to ground lightning that we see is, see are negative C G lightning.

And there are some, may be around 10 percent or so of positive C G lightning. Upward lightning used to be usually from mountain tops but nowadays there are much more incidents of upward lightning mainly because of tall towers either in the form of communication mast or in the form of wind turbines.

So the, the proliferation of communication mast and wind turbines has created new interest in lightning protection.

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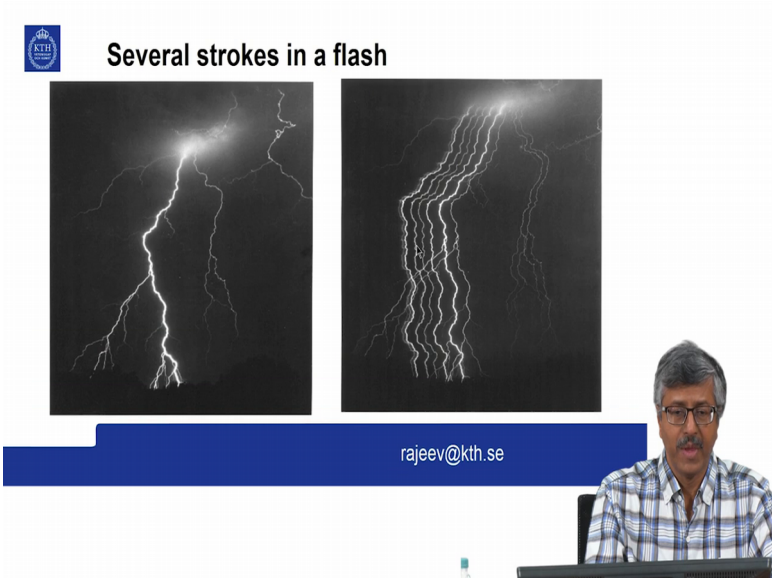

Within a lightning, this is a still picture of close to a second, you have several strokes that you can see in the picture next the differences are; this picture is taken on the same event but with a camera that is moved sideways so that the axis, the movement is like a time axis.

So shifted in time you can see this individual strokes, interspersed with some interval, time interval between the strokes. So each lightning event will contain several strokes.

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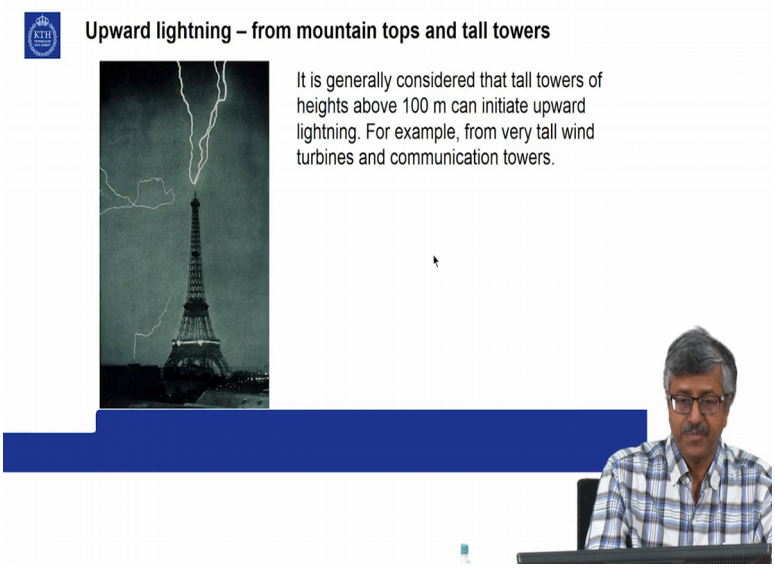

Upward lightning from mountain tops and all top towers, it is generally considered that towers of height above 100 meter can initiate upward lightning.

For example very tall wind turbines and communication towers, so below that it is less likely

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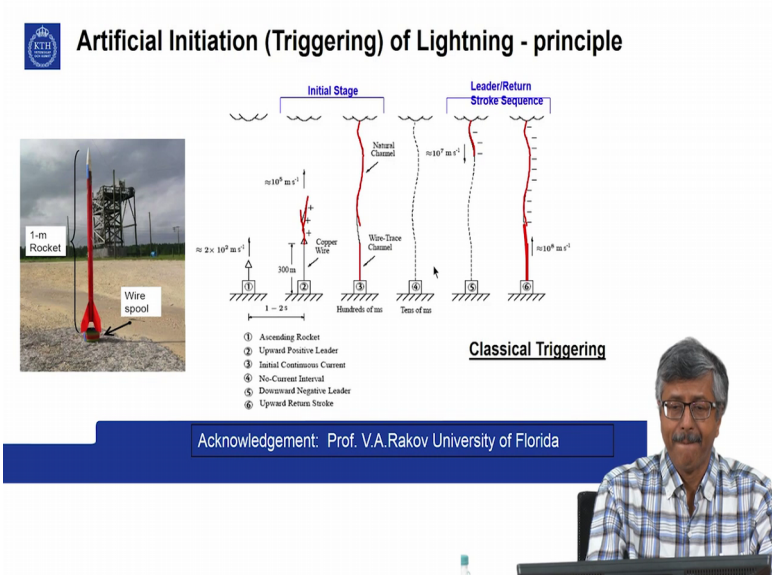

Lot of studies on lightning are done by artificial initiation of lightning by shooting small rocket upwards, and these rockets carry, carry a wire pole at the end.

This is taken from the experiments that University of Florida in Gainesville, U S A, courtesy of Professor V. A. Rakov.

So a rocket is shot upwards and due to the highly intense phase it produces charges. It is a charged leader.

And in response to that there is a negative, you know channel, there is a channel coming down from there and finally you have a normal kind of a channel established. Then after sometime the wire is burning.

Then you have created a plasma channel. And through that channel a negative leader is coming down to the place where we want the lightning to come down. Then you have a return stroke.

You have to remember that the bright light that we see is not from the part that is coming down but from the part going up. Because earth being conducting can collect amount of charges in a short time and you have a potential wave going upward at one third to one half the speed of light.

So it is this that we see as a bright flash and expansion of the air and later collapse will appear as a thunder. So this is called the return stroke, the upward going part and that is what normally we see with our naked eye.

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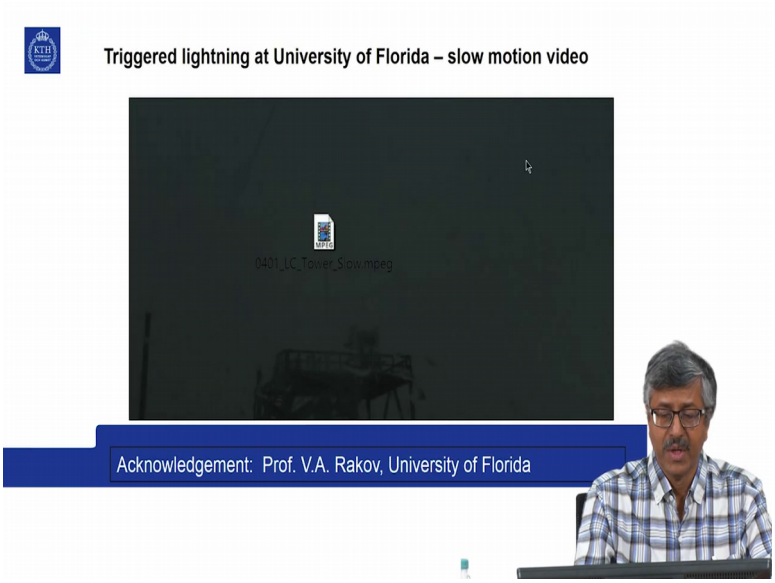

So I will show one video from University of Florida how to get lightning.

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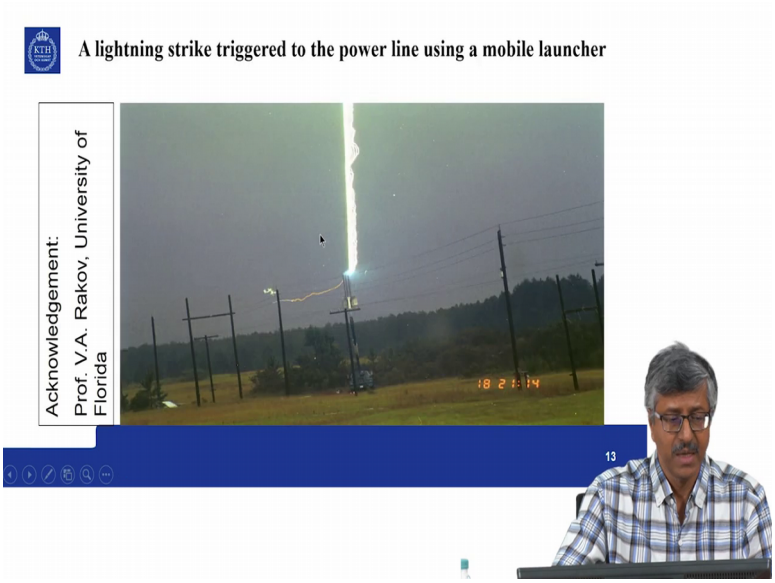

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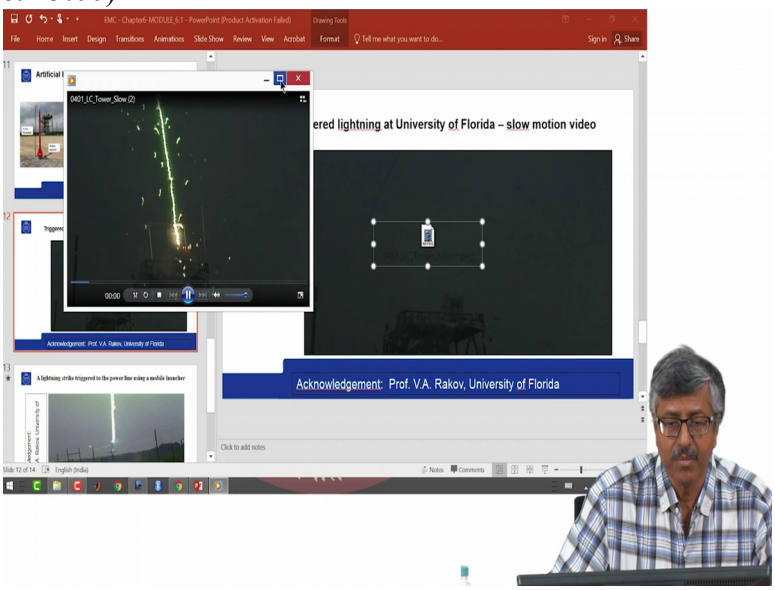

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0:15:12 video ends

So we will

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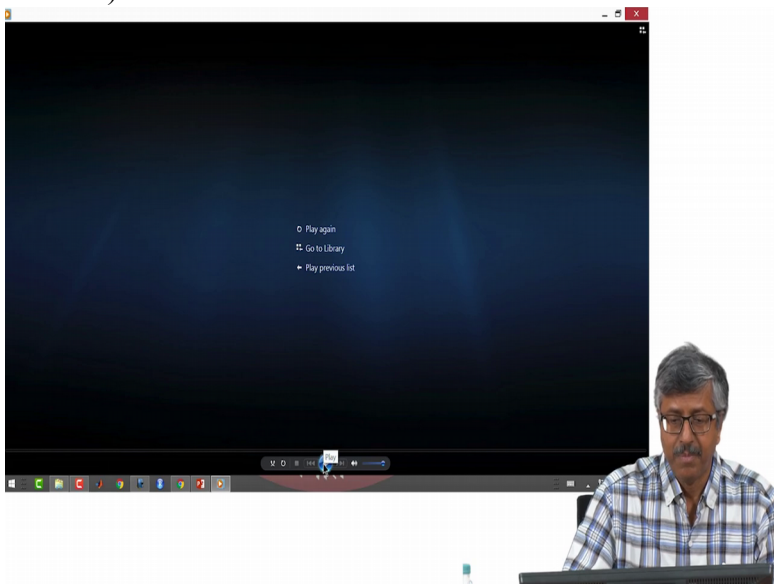

play it again

0:15:15 video starts

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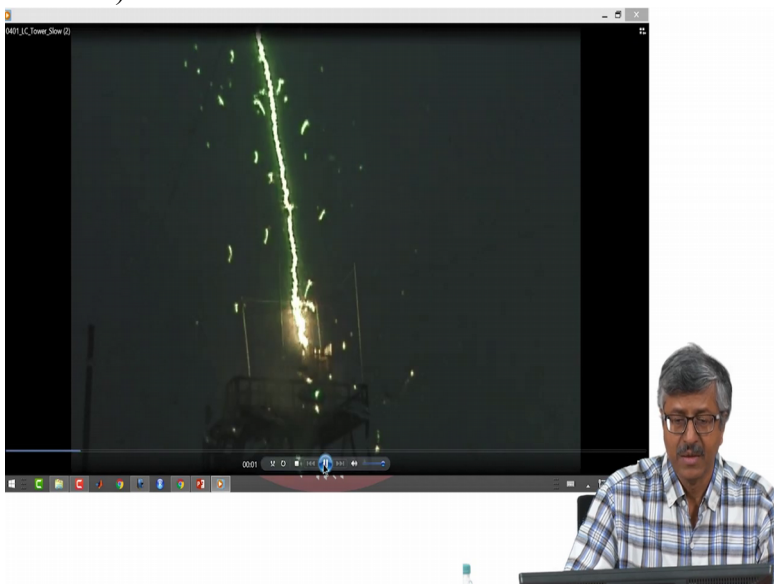

0:15:19 video ends

So that was the rocket launcher and this is the lightning rod. So these are the various strokes within the lightning. Only the bottom portion is shown over there.

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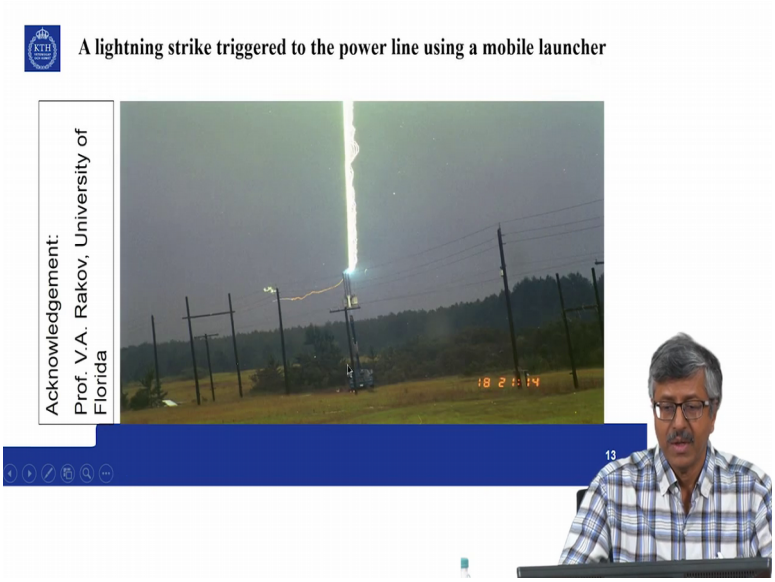

So with this type of technology you can make lightning strike any object that you want.

So this is a giraffe, a truck with a giraffe and on that the launch pad and the rocket is going up and creating a lightning.

So of course there has to be thunder clouds above for successful to give a (()) (16:03) lightning. And lightning can struck to power lines or big transformers or something for testing purposes.

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Similar experiments are also done at a tower, communication tower of above 100 meters, about 100 meter on a big mountain near Salzburg in Austria, courtesy of ALDIS in Vienna and Doctor Gerhard Diendorfer.

So this is

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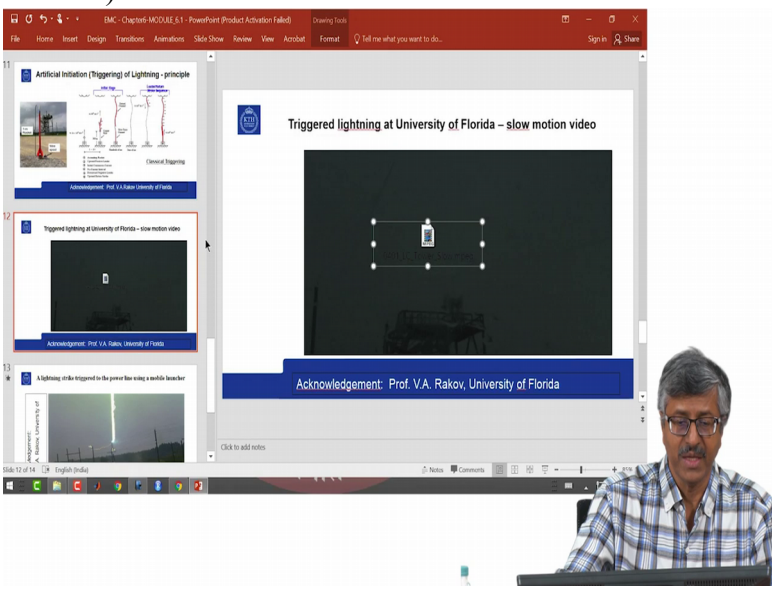

a lightning strike to that tower. So here one can

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point out several interesting features.

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You can see first, one channel then you can see several channels in it.

So this is upward lightning. So this is slow motion video. Previous video was also slow motion. That is why; always the phenomenon lasts lesser than a second. You will not be able to see anything.

See all those branches were not visible but the plasma channel was still active that is why repeatedly

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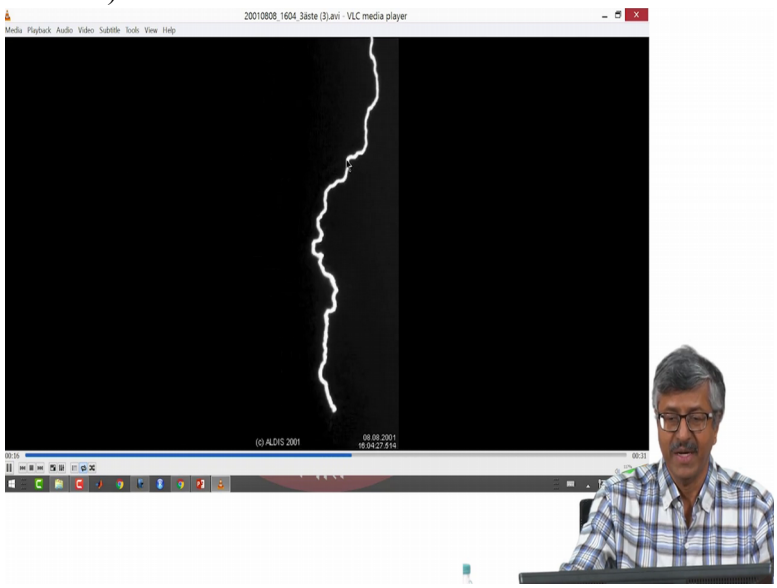

leaders are coming down and little strokes are happening within that.

And sometimes it may just be a pulse coming down. So this tower is also used for, not only of research on lightning but even for investigating the effect of lightning on engineering systems.

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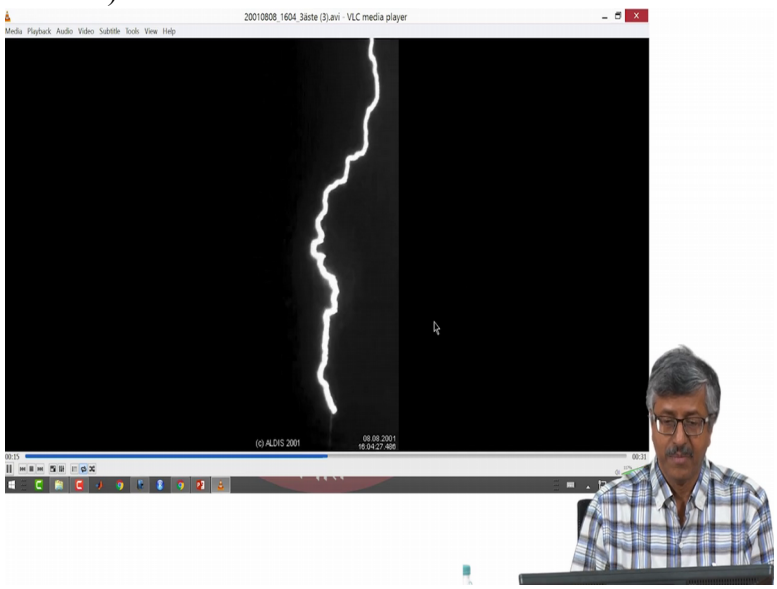

So only some of this brightening are return stroke. Others are just pulses coming down the channel called M components.

Ok I will stop it over here. So this is just a brief introduction to the phenomena of lightning. That is not the focus of our

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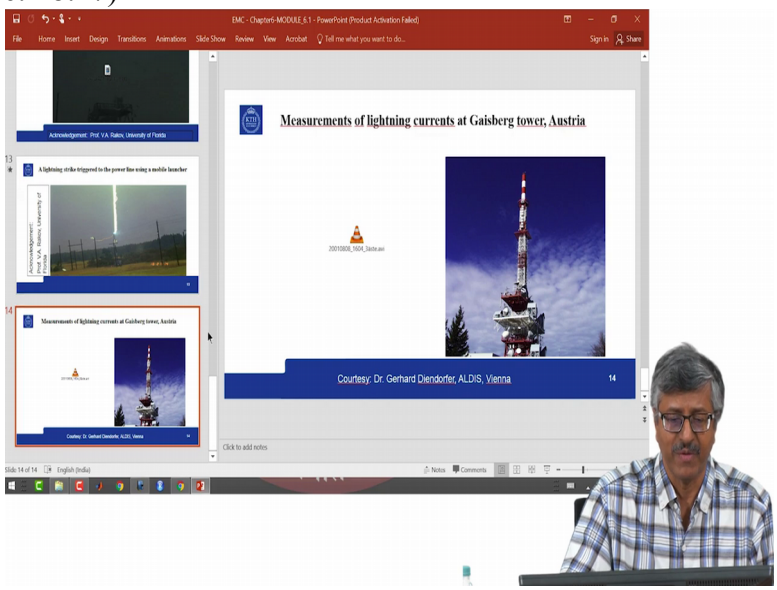

study, and that we will come to the next stage, what are the real properties of lightning important for protection of engineering systems.