Electrical Measurement And Electronic Instruments
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Lecture – 80
Oscilloscope – I

Hello and welcome. Today, we are going to talk about another interesting topic which is Oscilloscope. And you know these two things function generators and oscilloscope, they are the two I mean very important equipment in any measurement or instrumentation lab. Oscilloscope generally can be of two types, digital oscilloscope DSO, Digital Storage Oscilloscope and another is CRT Cathode Ray Tube type oscilloscope. We shall talk about both of them briefly, ok.

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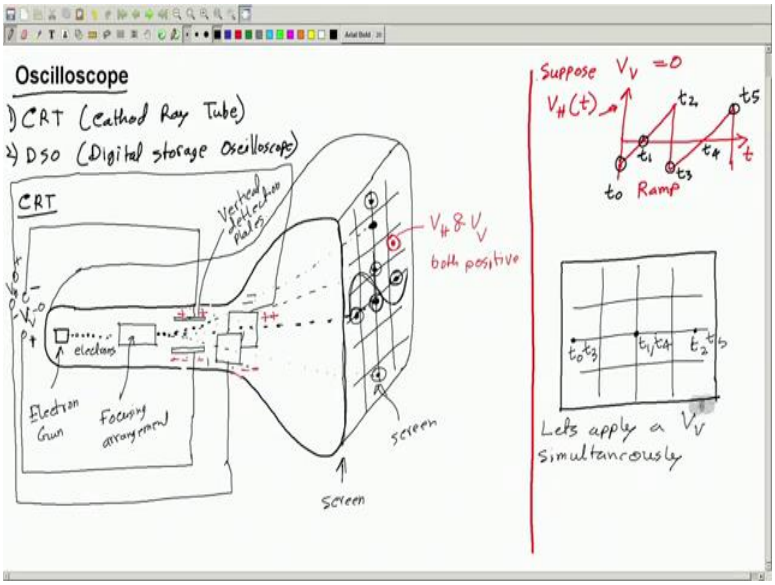

So, let us start with CRT which is which means cathode ray tube oscilloscope, ok, so this is one type. Another is DSO digital storage oscilloscope. So, let us talk about first how a CRT works? All of you might have seen this in your lab, but let us know what is there inside and how it actually works. This is made up of mainly hollow tube like this, ok. So, this is a glass tube and this is evacuated.

So, and in one end we have an electron gun, this is an electron gun and on the other end this side we have a screen, so this side we have this screen. Basically, some phosphor

material is coated on this side of the glass. So, if I try to draw it in 3D this will possibly look like this. I am not good at this drawing, but still let me try, ok.

So, this is the screen and you some I generally have this markings divisions like a graph paper on the screen, and you may have seen nice patterns like sine wave or anything on this screen. This is what is displayed. But what is there inside? One important thing that I already have said is electron gun. What is an electron gun? It emits electrons and then we will have some focusing arrangement.

So, right now I am just talking about as functional diagrams or schematic. So, this is focusing arrangement which will make these electron beam. So, this is a beam of electron, being like something like a laser light which you may might have seen. So, a small narrow light beam emits from a laser light. Similarly, a narrow beam of electron will emit from this particularly the focusing arrangement will also take care of shaping these electron beams.

And after that we have the main two components these are two sets of plates; one is a set of horizontal plates. So, these are the two plates and there are two vertical plates like this this is one and behind that this is another, ok. Now, what we can do is this. So, we can say apply a voltage between these two plates, ok. So, you apply some voltage between these two plates we call it V vertical, V. What will happen? If you apply some voltage here and say if this this side is positive this side is negative, then this plate is positive and this plate is at negative potential.

Now, when this electron is flowing through this through the gap between these two plates, they will get attracted towards the positive plate which is the top plate and therefore, the electron will take a diversion. If you apply no voltage here, so if you have 0 voltage then normally the electron goes in a straight line through these two sets of plates and it hits the centre of the screen and when the electrons hit the centre of this screen because of the coating on the screen you will see some bright spot on the screen at the centre, ok. If no voltage is applied here you will get a bright spot here.

Now, if you apply this voltage then the electron is the path of the electron is diverted and instead of going it straight it goes it takes a diversion and it will hit maybe this point on the screen So, you will have a bright phosphor on the screen here, ok. And if you say make

this more positive by applying a higher voltage then it will go it will take more diversion, it will go further up and the bright spot will come further up.

Similarly, if you have a small voltage see only a small voltage here slightly positive then the electron beam will hit possibly here. And therefore, what you can do by changing this voltage by making it more and more positive you can drag this point up and up or by making it low I mean small positive you can bring it down close to 0.

Similarly, if you say apply a negative voltage, say this is minus this side is plus, then what will happen? This, this plate is positive, so electrons will get attracted by this plate and repelled by this plate. So, the electrons will come and hit down here. So, the bright spot that will see will be here. Now, this is the function of these two plates. This is called a vertical deflection plate.

Similarly, I have two more plates which are put horizontally, ok. So, one towards me and this is away from me and I can again apply some voltage between these two plates, like this. So, these two plates let me put it here. So, if I apply a voltage between these two plates call this voltage V H, ok, H for horizontal. Now, say if you make this side positive, this side negative, then what happens? Then this plate is positive and this plate which is closer to me is negative and say there is no voltage here, this these two plates are inactive.

Then what will happen? Then when the electron is coming like this when it comes between these two plates it will get attracted by this plate which is farther from me away from me and therefore, the electron beam will hit here instead of hitting the centre, it will hit here because it is attracted by this plate which is away from me. And similarly, if this plate is positive and this is negative, if this is negative this is positive then the electron beam will come closer to me and will hit here.

And therefore, by that I can change this voltage make it plus minus or make it more plus, less plus, more minus, less minus and therefore, I can control the position where the beam will hit, ok. If this drawing is not cleared let me so the arrangement with a box, ok. So, I have a box assume that this is the inside of the tube, cathode ray tube and inside it I have a electron gun. So, this is assume this is a electron gun and from this electrons come out. So, I keep it here on one side. So, from these electrons come out like these electrons can come out like this and on the other side here I have the screen.

Assume that this blue paper is the screen of the oscilloscope, ok. So, the electrons will come out from this gun and normally hit the centre of the screen and it will create a glow at the centre like this, ok. So, we will have a glowing bright point at the centre of the screen like this, ok. Now, so this is my arrangement here I shall put one plate, here I shall put another plate and this two are going to be my horizontal deflection plates. What I will do? I apply a positive voltage here and negative voltage here, ok.

So, basically, I have this connection, ok. So, I make this plate positive and this plate negative, ok. So, what will happen is this. This electron beam will get attracted by the positive plate and it will hit here instead of hitting this centre. So, it will now hit there and we shall have on the screen we shall have a bright spot towards this side. If you see from the front, so we will have a bright spot here not on the centre, ok.

And now if I make the voltage difference more and more positive, then this will go towards the left further. If I apply more positive voltage it will go further towards the left and if I bring the voltage down to 0 it will come to the centre and if I make it negative it will go towards the right more and more and I can bring it again back to 0 by making the applied voltage 0.

Now, similarly let us see from the top again, ok. So, I have these two plates which deflects the beam horizontally. I will put two more plates, like this say one plate here, this plate is under the electron beam and another plate which I cannot draw, but I will demonstrate it this way. So, this is the other side of the box, ok; so, this is the other side of the box. So, this closes like this. So, here on the top side I will put the other plate, ok. And see I apply a positive voltage here, and a negative voltage here.

This is the electron beam. Now, you can guess what will happen if I close the box, so that this plate is on top of this then what will happen is as follows. The electron beam while going straight it will get attracted upwards, it will come upwards and hit here on the screen, it will hit up here not at the centre, ok. So, this way I can change the position of the electron beam. So, let me tell you once again what happens.

So, you know that there are two sets of plates, one is the vertical deflection plate, another is the horizontal deflection plate. If I apply no voltage in any of them the electron beam hits the centre. If I apply positive voltage only positive voltage to the only to the horizontal plates, then this will go towards the right like this. More positive voltage it will go more

towards the right, less positive voltage it will stay here, and if I apply negative voltage only to the horizontal plates it will go to the left like this, ok.

Similarly, if I apply no voltage to the horizontal plates and a positive voltage in the between the vertical plates then the beam will go up, more positive more up and if I apply negative voltage it will go down, more negative it will go further down, ok. Now, what will happen? If I apply say simultaneously a positive voltage between the positive plates and between the horizontal plates and a positive voltage between the vertical plates, then this beam will move like this and will come here, ok. So, let me just mark the centre. Let this be the centre of the screen from the front, ok.

So, if I apply simultaneously positive voltage between the positive plates and the negative plate between the horizontal plates and the vertical plates, the beam will go like sorry go like this come here, ok. So, what I just have said is that if I apply simultaneously positive voltage here; that means, negative here and if I apply say positive here; that means, negative here. So, then the beam will go up and towards the right, then the spot will be created here. This is for V V H and V V horizontal and vertical both positive.

Now, let us think about what will happen if I apply continuously changing voltage to these plates, ok. Now, suppose V V is equal to 0 and V H is a function of time and it is changing with time and let me tell you how it is changing it is changing in this way. This is time and then initially it is 0 or say initially it is said negative and then it is increasing linearly like this. It goes up to this positive value and then it immediately becomes negative again.

This is time versus V horizontal and then here again it goes like this and then comes back again to negative. So, this is a ramp. So, this is a ramp. This is a ramp signal which we have applied between the two horizontal plates. So, then how will the electron move? So, if we see from the front, so this is the front view, this is the screen, let this be t 0, this time is t 0, let this be t 1, t 2, t 3. So, we want to find out where the electron beam will be on the screen at these different times, ok.

So, this is the screen and you know that the vertical voltage is always 0, so the electron beam will always be centred with respect to the vertical line. At say t equal to 0 horizontal voltage is negative, ok. So, therefore, the electron beam will hit here towards the left, so it will be here at t = 0. At t = 1 this voltage is 0, so it will hit at the centre this is t 1. At t 2 it will hit here because the horizontal voltage is positive, ok.

Then at t 2 and t 3 this is the same time, same time actually practically. So, this is t 2 also same as t 3, then I have t 4 it will come back again here, at t 5 it will be sorry at t 4, I made a mistake this is not t 3. So, t 2 and t 3 which is almost very close time practically same time almost, at t 3 it will be negative it will be sure, this is t 3. At t 4 it will be again here, at t 5 it will be positive. So, this way it will oscillate. So, starting from 0, 1 2, 3, 4, 5, 6, 7, 8 so on.

So, it will move like this slowly from left to right and then suddenly to left, slowly to right suddenly to left, ok. So, this is how the electron beam will move. And if we see if I try to animate this will look like this. So, centre front please. So, here say initially the electron beam is here at t 0, this is t 0, then t 1, t 2 here and then back. Then again gradually like this and back suddenly, again gradually slowly like this and suddenly back, ok.

This is how the electron beam will move like. Now, say what we do we apply simultaneously a voltage between these two plates, ok. So, let us apply voltage let us apply V V simultaneously. Previously it was 0 not simultaneously, and how V V will vary let us draw that, ok.

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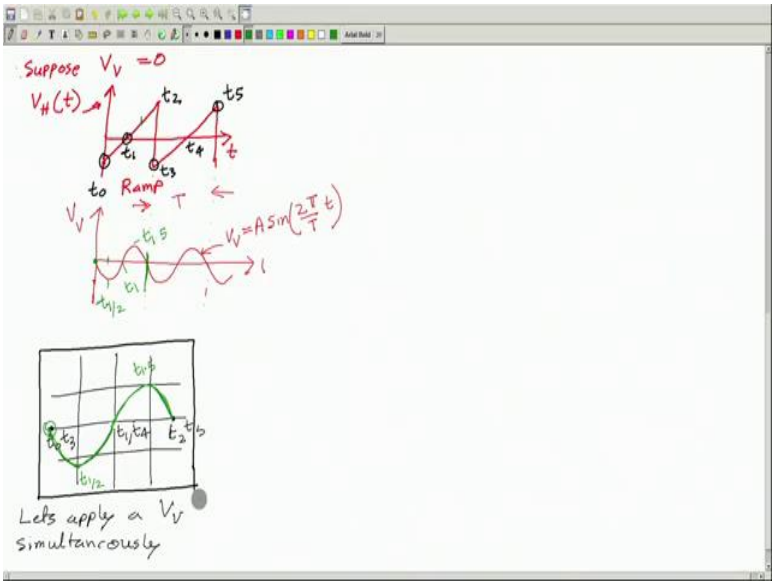

So, let us draw V V. V V will look like this, time versus V V. This I will take it like this, I will take it like a sine wave which is like this. It completes one cycle in exactly same time as it is taken by this horizontal voltage to complete one cycle from negative to positive, this is this is one cycle, this is also one cycle.

Now, I apply this this type of voltage, ok. If I call this time this time period is T ok, then the equation of this voltage should be V V is equal to some amplitude times sin omega T omega is $2\pi/T$. Where, this t time period is same as this time period, multiplied by time. This is how it varies. If so, how will the electron be move like? So, let us see how it will move like. At t 0 at this instant you see horizontal voltage is negative, so the electron beam will be here towards the left somewhere here definitely. And what will be its horizontal position? Horizontal position will be 0. So, this will be the position at t 0.

Now, they after that you see this voltage, horizontal voltage is increasing gradually. So, the electron will move from left to right, but simultaneously the vertical voltage is going down. So therefore, as this beam is going towards the right it will also come down. So therefore, say here call it t half at this time this is t half, so the electron beam will come here like this. It will come like this; this is t half. Then after that it will go further towards the right, because this is increasing and it will go up because this voltage is now increasing. So, here it will go like this this is t 1, this is t 1.

And after that you will go towards the right again, but now it will go up also like this. This time you call it t 1.5, so this is t 1.5. After that what will happen? So, this this time is actually this time, after that it will go further towards the right, but simultaneously will come down. So, it will come down like this. So, this is what has happened after this moment, here.

And what will happen next? After that you see the horizontal voltage is 0 slightly before this and slightly after this. So, the electron will remain on this middle line, but this voltage is becoming suddenly negative. So, after this the electron beam will come immediately to here. And then it will strays trace the same path again and then come immediately back here, and then again, this sine wave and so on.

If I try to animate this for you; so how it will look like is this. Initially the beam is here then it goes down like a sine, wave half wave then up and again down and then immediately back. Once again down and up and then immediately back. If I could repeat this process very fast if the frequency is high then you shall see a sine wave actually like this. If I can do this very fast or what you can do you can repeat this part of the video by playing it very fast in your media player, then you possibly will see that it looks like a sine wave traced on the screen or on the paper.

So, this is how the cathode ray tube oscilloscope works. We shall talk about talk more about it in our next class. We shall also talk about slightly briefly about digital storage oscilloscope.

Thank you.