Electrical Measurement And Electronic Instruments
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Lecture – 65
Dual slope digital voltmeter - II

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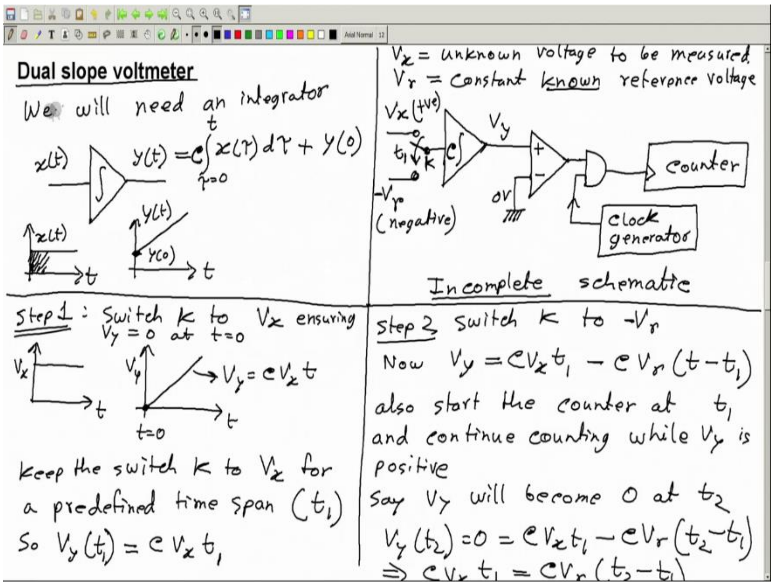

Welcome. So, we were starting Dual slope voltmeter. And, before proceeding on further discussion on this topic, I thought, I would just tell you a small story and the story is like this.

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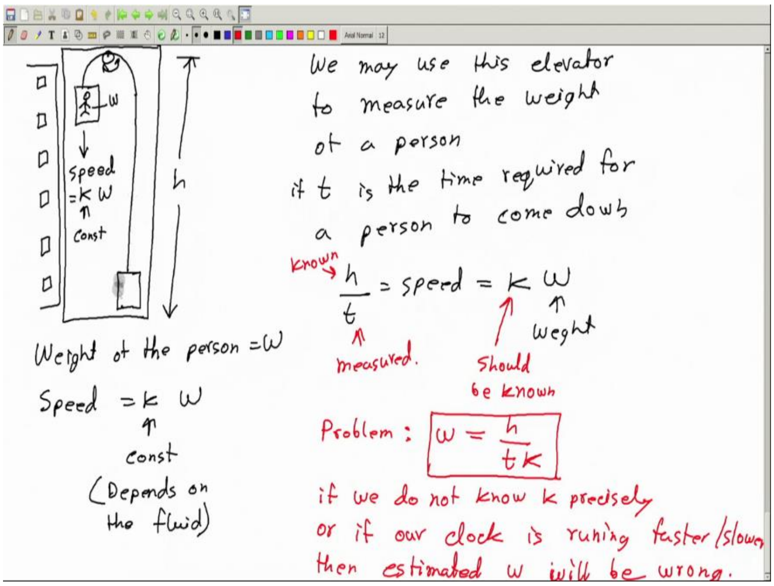

So, suppose there is a building a multi storeyed building. So, this is a multi-storeyed building with many floors and there is an elevator a lift. So, actually there are two lifts; this is one and this is another, both hanging from a pulley ok. So, this is a pulley which can turn and these two are hanging from each other ok. And, actually this give me so, that or the length of this wire or string is so, long that, if 1 elevator is at the ground floor here, then the other elevator is at the top floor ok. And, these two are of equal weight ok. And, you can think that the entire arrangement is somehow sealed into a tight container.

So, some things filled in it, it could be air it could be some viscous liquid water oil anything. So, what happens if these two are of equal weight then, they will just stay as it is they will not move at all, but if I put any extra weight suppose a person enters this elevator, then this elevator becomes heavier and then this will fall down this will go up.

So, this is how it works? So, people can only come down through these elevators no 1 can go up it is useless but let us see it ok. So, somebody can enter this elevator, then this elevator will come down, this elevator will go up and so, it is like this will go up, this one will come down ok.

And, then another person can enter this one, this man can leave. So, then this one will come down, this one will go up. Now, the two elevators, when they are vacant, they are empty, they are of equal weight. So, the weight difference is the same as the weight of this person ok. See call the weight of this man is w ok. And, now how fast this elevator will fall, that will depend on the weight of the person entering or leaving the elevator ok.

So, if a person with weight w enters here. So, these men has a weight of w, then the speed at which this will fall is it is proportional to w call it KW, K is a constant ok. And, K depends so, let me write first that speed of falling speed of coming down is equal to k times the weight, K is a constant and it may depend on the say the fluid with which this chamber is filled air or water or oil whatever.

So, it depends on the fluid, depends on the viscosity of fluid and other factors ok. Now, this elevator is in a sense useless, because you know people can only come down from top no one can go up, but this elevator is useful because one can use it to measure the weight of a person. So, we may use this elevator to measure the weight of a person. How? It is simple.

So, say this height is h ok, then a one may measure the time required for the this elevator with the person to come down through this height of h ok. If, t is the time required for a person to come down, then you will know that h / t this is the speed and this must be equal to according to this K times weight. So, this is the weight. Now, h is known so, this h is known we know the height of the building, this can this time required for the person to come down can be measured and K should also be known. So, this constant should be known. So, then you can measure w ok.

So, this is basically we can measure the weight or how heavy a person is by measuring the time required for him to come down. If, the person is heavier he will need smaller time and vice versa ok. So, this is the idea. So, with which we can measure the weight by measuring time right. Now, there is a problem. The problem is the weight, which we measure as this factor h/ t K ok. The problem is if we do not know K precisely or if our clock or stopwatch is running faster or slower, then w will be wrong estimated w will be wrong right.

So, this is the problem, because if say the clock is running faster, then we will measure the time required to be smaller and then w will be of course, wrong. If, say this is filled with I mean some fluid whose viscosity say depends on like a temperature etcetera and if you say this viscosity is changing the factor K will change. So, therefore, this will also change and we will encounter an error.

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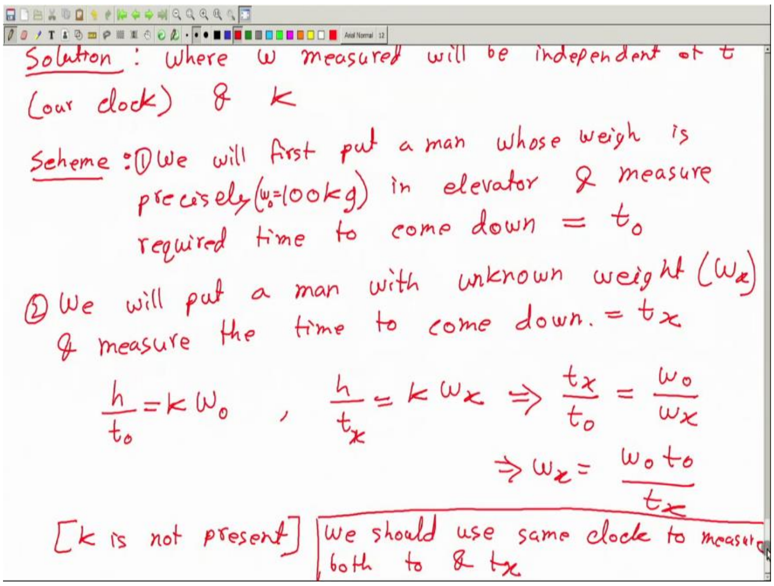

Now, we propose modified scheme a solution where this w will be or w measured will be independent of t; that means, our clock with a that is fast or slow does not matter. So, it will be independent of the clock and k; that means our knowledge of k ok. When you will somehow make the measured value of w independent of these two factors, how?.

So, this scheme as this so, we will first put a man whose weight is precisely known say it is a precisely 100 kg maybe two heavies, but he or she is, but so, we will put first a man with weight 100 kg in the elevator and measure a required time to come down. Say that man with weight 100 kg comes down in t 0 time right ok. Then, then so, this is step 1 and in step 2, what we will do we will put the a man with the unknown weight, a man with unknown weight call it w x and you can call this weight of the previous man as w 0 ok.

So, now we will put the man with unknown weight w x and measure the time for him to come down. Now, what we will do you can guess we will basically compare this two times. How fast the map the previous man the standard man reference man whose weight is precisely known it is 100 kg. So, how long he took to come down versus how long this unknown man took to come down.

So, we will compare these two time ok. And, from this we will estimate the unknown weight ok. And, then it will be independent of whether our clock is running faster or slower or whether we know the this constant k precisely or not, it will be immaterial how let us see?. So, we can write so, you see from this previous rule height by let us call it t 0, this is the speed for the a man reference man to come down, this is equal to KW 0 which is 100 kg we know.

$\frac{h}{t0}$ = k W0

$\frac{h}{tx}$ = k Wx

$\frac{tx}{t0} = \frac{W0}{Wx}$

And, you see the factor k is gone factor k is gone k is not present. So, we do not need to know the value of k at all. And, secondly, you see that we have a ratio of two times ok. So, now, if we measured both this time with the same clock, then whether the clock is actually running faster or slower does not matter, because if because we are measuring with the same clock.

So, if this is faster, this is also faster, this their ratio will remain same ok. So, also let me write that we should use same clock to measure both t 0 and t x. So, these are the two observations. So, this is how we can make the measurement of weight independent of this whether our clock is correct whether we know the factor k correctly or not ok.

So, this was a thought experiment, fictitious I do not really know whether it really works like this or not, but this is only to understand our scheme of voltage measurement with a dual slope, voltmeter digital voltmeter. So, what do we have in a dual slope voltmeter?. Now, let us look at go back and look at ok. So, this was kind of a schematic of our dual slope voltmeter, this is yet incomplete schematic ok, this is incomplete schematic, we will complete it soon ok. So, let me take it from here to here ok.

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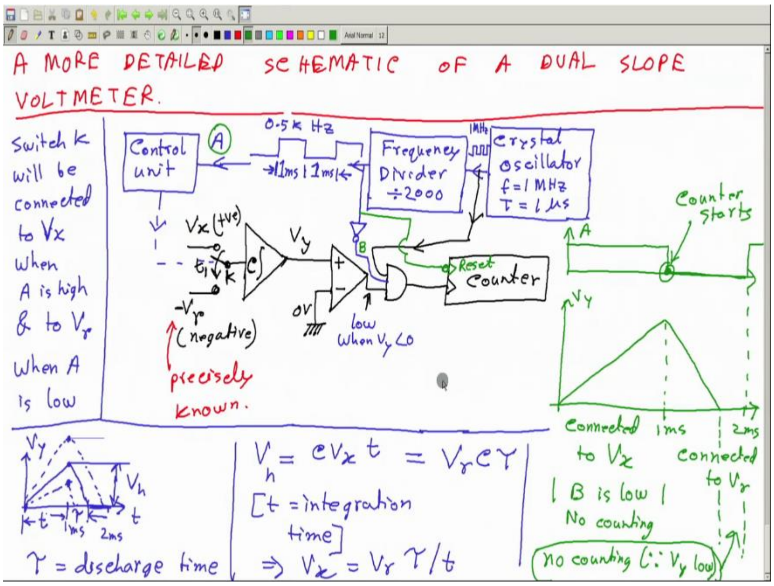

So, just you see what we do?. So, we have two voltages; one is known V r this is precisely known, V r this one is precisely known or we assume that this is precisely known. If, it is not precisely known then we will half some error ok. This is assumptions, this is precisely known, this is unknown. Now, what we do, we first connect it to say this switch this integrator, we connect it here to the unknown. And, then let this voltage increase for a fixed amount of time.

Now, so, this voltage will increase by some amount, which depends on V x higher the V x is the slope will be higher. So, it will go further, if V x is lower the final value will be smaller. This is a fixed time interval for which the integration is carried out right. And then we switched this switch or integrator up to the reference voltage and then we measure how long will this integrator take to discharge. This is negative; this is positive, that was the assumption.

So, when we connected here the voltage increases and when we connected here the voltage decreases. So, after this voltage will come down ok. And this will come down with a fixed slope, because this is our constant voltage known voltage. So, this slope is constant now how long it takes to come down, that will tell me how large this V x was, because if V x was larger, then for the same amount of time this voltage will go further up ok.

And then when it comes down it comes down with the fixed load. So, it will take longer time. So, if V x is larger it will take longer time to discharge. That is how we measure a the this unknown voltage. And, in this way we make a the measurement independent of this constant C, which is somehow get multiplied with this input voltage whatever it is here or here and that defines these rates or the slope. Now, you know if C is the same C is applied for both integration and deintegration time.

So, if the effect of C gets cancelled. Just like the effect of this factor k in this experiment ok. Similarly, the effect of C will not matter. Similarly, this counter is now driven by some clock generator. Now, if the clock generator starts to run faster or slower, what will happen is that, this time and this time, they will be get they will be sorting or elongated by equiproportion, by equal proportion. So, therefore, it will not affect the measurement.

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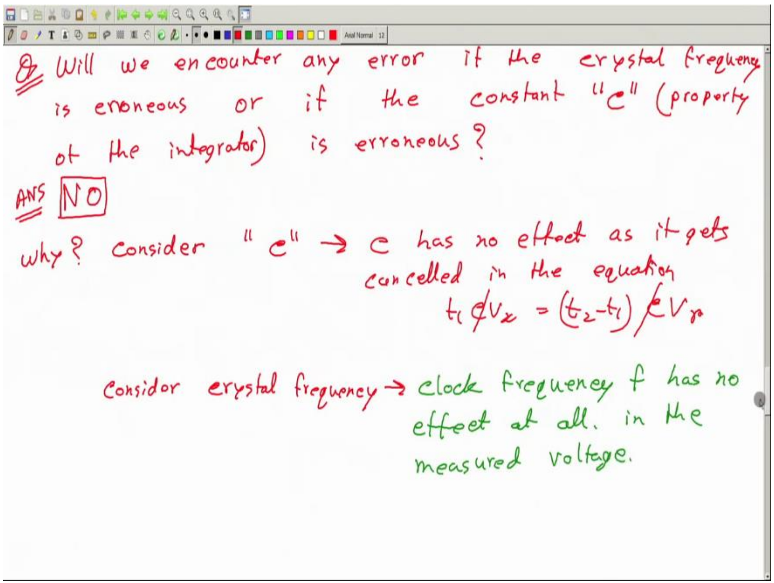

And, that we have seen in our previous day with thorough derivation.

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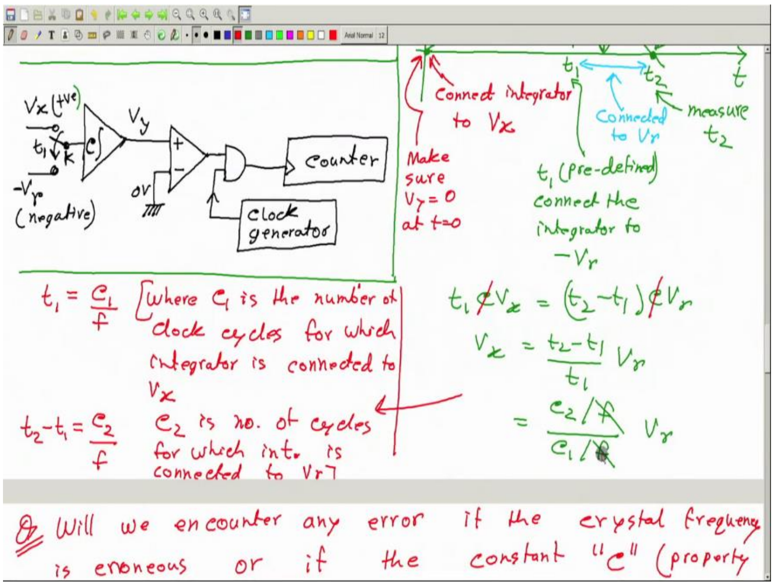

So, we have seen how the frequency of the clock does not matter it gets cancelled, but the best way to understand it I think maybe if you think about this hypothetical experiment ok. It is a help you to understand the principle of this dual slope integrator; dual slope voltmeter. Now, the next thing that we will do is this. We will draw a better schematic, this is a schematic and I already told you that this is incomplete schematic.

The next thing we will learn how to draw a better schematic? Better means, of course, that only the best, but that will be better than this, because that will have more information more detail than this schematic has. This is fine for understanding some basic things, but to make it more complete we will put more detail in this. And at the same time we will keep our thoughts going on. So, let me write a more detailed schematic of dual slope voltmeter ok.

So, just listen it carefully ok. Otherwise, you may get lost. Firstly, what we will do we will take a clock generator or a crystal oscillator. For example, say it generates a generates signal a generates a square wave with the frequency say 1 mega Hertz. So, let me just take also an example. So, this will also help you in solving numerical problem if you follow this carefully.

So, called say this is 1 mega Hertz. So, this is frequency. So, if this is the frequency what can we write about time period time period will be a 1 microsecond right, 1 microsecond. Now, we can take frequency divider, what is the function of the frequency divider?.

The function of frequency divider is as follows so, it takes a high frequency input and it gives out a low frequency output ok. So, this is high frequency input and this is the output, which is of much lower frequency. See, I take that this is divide by 1000. So, then this is 1 mega Hertz, here I write 1 mega Hertz, then this will become 1 kilo Hertz right. If, it is divided by 1000 ok, I am just taking arbitrary numbers as far as an example. So, this is 1 kilo Hertz signal.

Now, if this is 1 kilo Hertz signal which means, say from here to here this is 1 time period, how much will be this will be 1 kilo Hertz. So, this will be 1 millisecond ok. Let me do this let me make it divide by 2000, then this will be half 0.5 kilo Hertz and then this will be 2 milliseconds ok. I do it on purpose so, that calculations becomes easy so, this is 2 millisecond and then this half of it. So, this is the on time ok, from here to here this will be 1 millisecond.

So, this is 1 millisecond and here another 1 millisecond so, 1 millisecond on time, 1 millisecond off time. Now, what we will do we will feed the signal, say to call it a control unit, which will control this switch position ok. So, by this dotted arrow I mean that this control unit will control this switch position, how?. Let me write that so, the switch the switch which is k, switch k will be with V x will be connected to V x, that is unknown voltage when say this is high, this signal when this signal is high. Call this a what can I call this signal as A, when A is high and connected to V x V r; that means, here when A is low.

So; that means, so, this input comes here and this control unit will accordingly change the switch, it will for say first 1 millisecond. So, first 1 millisecond it will connect it here to V x and next 1 millisecond here, when this is low it will connect to this minus V r ok. So, for first 1 millisecond it will be here and for next 1 millisecond, it will be two connected 2, V r this is the task of this control unit ok. Now, so, if so, then what will happen?. Then, in first 1 millisecond, let this be time call this is V y right.

So, first 1 millisecond, this is 1 millisecond, this is 2 millisecond. So, starting from here this will go up, this is V y ok, this voltage it will go up and it will depend on how much it will go up and that will depend on the value of V x. So, it can go up like this or this depending on the value of V x, then next 1 millisecond here, it is connected to V r, V r is negative.

So, now V y will discharge. So, if it is here it will come down like this. If, it is here then it will come down like this and if it was here after 1 millisecond, then it will come down like this ok. And, we will basically measure how long it takes to come down. So, if this is the time ok, call this what can I call τ. So, τ is the discharge time or d integration time. So, if τ is larger; that means, V x is larger, if τ is smaller then V x is smaller right ok.

And, let me for you just do the derivation with match, once again which we did in the previous day ok. So, how much is this value or call sorry this ok, let me make this let me make just one of them solid and other as dotted. So, this solid one is a particular case, that is a particular value of V x. So, what is this value these height ok, this height is called this what can I call it V h this height, V h this voltage.

So, V h is how much this is nothing, but so, the valve voltage increases with C V x t. What is t? T is this time integration time; t is integration time or charging time integration time ok. So, t is integration time τ is deintegration time, discharge time, this is charging time, this is discharged time ok. So, this is V h right and from this side I can also write that this V h is also same as reference voltage Vr C τ right. This is the rate of fall here, rate of fall multiplied by this time is the total fall, this is the rate of rise multiplied by time is the total rise.

And this rise this fall are equals so, i equate this and from this I can write V x is how much V x is so, C C cancels, V x is V r τ/t, ok. So, that was the rule ok. So, now the next thing is that, how do we measure this τ?. We will basically measure this tau by measuring the number of cycles of this signal ok. So, what we can do let me erase this, let me connect it to here ok.

So, then what happens this crystal oscillator is or this clock generator is also driving this counter. And then by watching the value of this counter I can measure time elapsed right. Now, one important thing is that, this counter must start a what do I want to measure I want to measure this time, this d integration time right. So, I must keep this counter on only during this time from here to here.

So, I actually have this comparator, what is the task of this comparator? When the value of V y goes below 0 then this will become output will become low. So, this is low when V y less than 0. So; that means, after this point so, after this point; that means, in this region here the counter will not continue to count ok. So, this is the task of this comparator. So, the comparator stops counting after this de integration is complete, after V y has reach the value of 0 ok.

And, what I will do I will, I also have to make sure that the counter is not counting in this region right. Because, I only want to measure the time in this region here see my pointer. I do not want to measure the time here. So, for that what I will do, I will take, I can take this is some very easy what you can do you just can take this signal and if so, if this is 1, if this is 1 means what in this region, the control unit will connect the switch to V x ok; that means, this is the integration time.

So; that means, this part is the integration time ok. This is the position, this is the time, when the integrator input is connected to V x. So, here I do not want the counter to count the time. So, what I can do I can connect a not get and then connected here so; that means, the counter will count only if this is only if here it is it should be high; that means, here it should be low, then only the counter will count.

So, here it low means here so; that means, only in this region ok. So, after so, from 1 millisecond to 2 millisecond in this region, this will be on ok. So, let me draw it bigger the same diagram I will draw bigger as big I can draw here. So, this is 1 millisecond this is 2 millisecond ok, this and this 1 millisecond V y increases and here connected to V x unknown source. And here we have connected to V r right, this vapour is voltage, this is the d integration time ok.

Now, in this region this value call this a signal what can I call this B. In this part B is low ok. So, counter does not count no counting, because B is low in this part ok. And also in this is basically let me also draw this signal on the same axis. So this is this signal I have named A. So, this is this A, let me draw this here ok. So, this is high and low here up to 2 millisecond and they needs high again.

So, this is signal A right. So, this is signal A, which is here and in this region I am repeating again and again. So, that it is clear to you, I know I am repeating many a times ok. So, in this region switch is connect it to unknown voltage in this region switch is connected to V x. Now, out of the this part here ok, in this part counting will the counting happen no, so, here also no counting.

Since, V y is low. So, this is in this part. So, in this part in this time output from the comparator is low. So, no counting happens, here due to this input the counter will not work, only in this part the counter works. So, here so, the counter value tells me this time right. The counter value will tell me only this time, note it very carefully. And, now one more functionality you may require is that so, at this moment when the counter starts so, at this moment. So, this is the in stand so, this is counter starts.

So, at this moment we may need to reset the counter. So, how can you do that? So, you can so, there are many possibilities, you can just possibility t clock reset input and you see so, this is a moment where we have a falling edge of the signal A. So, we can take a negative edge triggered reset based counter and then you can connect this. So, this will ensure that at this falling edge when the counter starts the counter is reset ok.

So, this is a better schematic in a since it contains more detailed. So, I request you that you read this also from the book try to understand if you do not follow, you can ask in the forum we will try to help. And, solve some problems that we will get in the tutorial, because you often find students are confused in this topic all this is very simple if once you understand it. So, that is about the that is the main thing about the dual slope for voltmeters digital voltmeters.

Thank you.