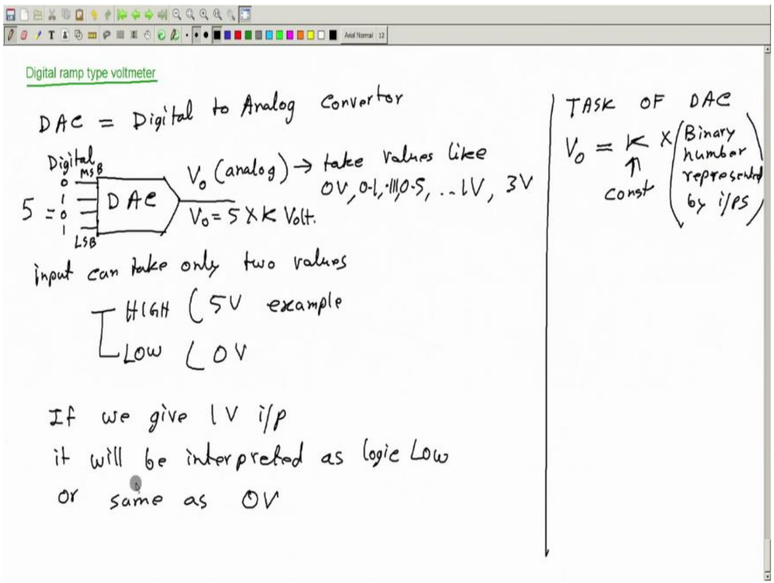
Electric Measurement And Electronic Instruments

Prof. Avishek Chatterjee
Department of Electrical Engineering
Indian Institute of Technology, Kharagpur

Lecture- 67
Digital ramp type voltmeter

Hello. So, in this part where we are talking about various digital Voltmeters, so we have studied linear ramp type Voltmeter and dual slope Voltmeter. The last thing that we will study now, in this part is Digital Ramp Type Voltmeter.

(Refer Slide Time: 00:48)



So, before we start I will briefly talk about ADC and DAC, particularly DAC, ok, DAC. DAC stands for Digital to Analog Converter, ok. We will study it in more detail later, but for now, we just need to understand what it is. It is, ok; you can think of it like this. It is a black box which has one output call it V o and it has many inputs, and the output is analog output. Analog means what? Analog means the output can take any continuous value like 0 Volt, 0.1 Volt, 1 Volt, then 0.001 Volt; so, it can take any value, ok.

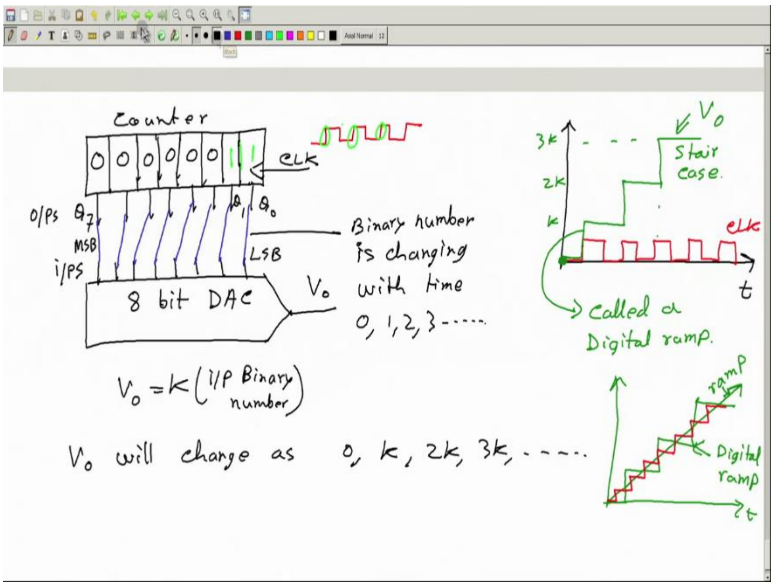
So, and this inputs these are digital inputs, there are many of them, here I have 4 of them. And digital means this can take only two values, logic 0 and logic 1. For example, a logic 0 can correspond to 0 Volt and logic 1 can correspond to 5 Volt anything in between is meaningless; meaningless means what can you not apply 2.5 Volt here, yes you can, but that will be interpreted either as logic high or logic 1. For example, if you give 1 Volt that may be interpreted as logic 0 or same as 0 Volt. So, if, so this can take only say input can take only two values high or low for example, 5 Volt and 0 Volt.

Now, if we give 1 Volt input that will mean it will be interpreted as same as low because 1 Volt is close to 0 Volt, ok. So, it will be interpreted as, it will be interpreted as logic 0, logic low or same as or equivalent as 0 Volt, ok. Similarly, if we give say for example, 4.5 Volt that will be treated same as 5 Volt, logic high. So, this device will not distinguish between 4.5, 4.6, 4.55 those small values, ok; all they will be treated as, all those values will be treated as same because these are digital inputs. But the output is analog, it can take any value like. So, this can take values like say 0 Volt, 1 Volt, 3 Volt even in something in between 0.5 Volt, 0.1 Volt, 0.111 Volt everything is possible. The output can take in all those possible values.

Vo = K x (binary number represented by i/p)

Like for example, if the input is 0 1 0 1 and if this is treated as the least significant bit and this is treated as most significant bit then this input 0 1 0 1, means low high low high 0 Volt, 5 Volt, 0 Volt, 5 Volt, this input will be treated as a binary number same as, how much? This is 1 plus 1, 1 plus 4, 5, ok. So, this is 5, decimal 5, right. So, in this case the output will be 5 times K in Volt. So, this is the task of a DAC. It takes a binary number in as a input and gives a continuous output. And this K is a property of this DAC, ok it is a constant, ok.

(Refer Slide Time: 07:22)



So, now, what we will do is this let us see. Suppose, if we have a counter, ok, so we have a counter and it has a clock and so say this is 8 bit counter, ok. So, 1, 1, 2, 3, 4, ok. So, these are 8 bits 1, 2, 3, 4, 5, 6, 7, 8, that means, 8 flip flops. So, it will have 8 numbers, 8 binary numbers as output, each of them can be either 0 or 1, ok. You can call this as Q 0, Q 1 up to Q 7, 2, 3, 4, 5, 6, 7, right. So, each of this can take the value of logical 0 or logical 1, high or low.

Now, what I will do? I will take a DAC, 8 bit DAC digital to analogue converter. Often we draw a DAC with this symbol, with a small arrow like this, this is the output. So, this is an 8 bit DAC means what? It has 8 inputs 1, 2, 3, 4, 5, 6, 7, 8, ok. So, these are inputs. 8 bit means it will have 8 input; 4 bit means like we did previously that will have 4 inputs. That is what it means. Output is always 1, so number of output is always 1.

Now, what we will do? We will connect the output of the counter. So, these are the outputs of the counter we will just connect them to the input of the DAC like this. Then what will happen? Then here we are getting this clock pulses, right and if you are getting this clock pulses like that, then the counter value will change over time like this. So, it will start from all 0 that means, all these outputs are logical low. Then as soon as this is positive edge trigger as I have drawn. So, as soon as this edge comes this will change to value 1, then as soon as this edge comes this will change to 0 1, sorry 1 0, then when this next stage comes this will become 1 1, right.

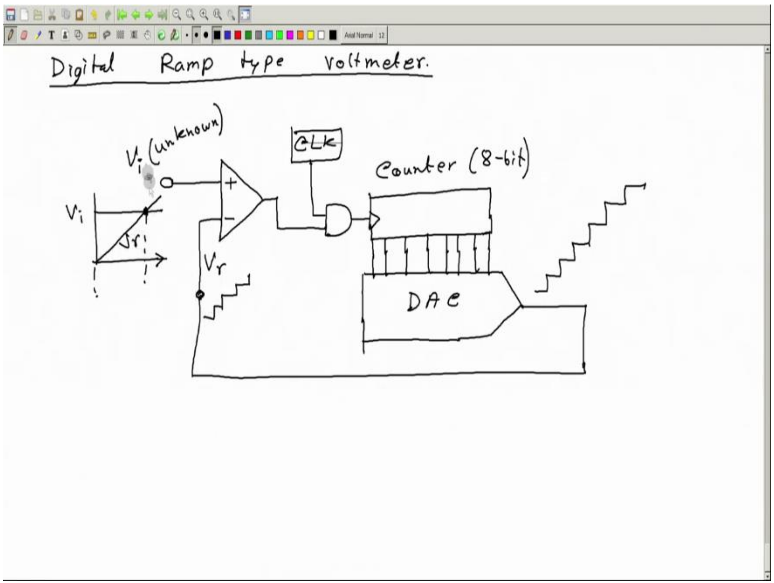
So, this way this counting will go on. It will count the number of edges 0, 1, 2, 3, 4, so on. And if so, you see the input which is a you can think as a binary number with this as the LSB on this side as the MSB. So, then the binary number, ok; so, this binary number is changing with time like 0, 1, 2, 3, and so on. And if so, what will happen to the output? Output you we know is same as K some constant multiplied by the input binary number. So, V o will change as 0, then K, then 2 K, then 3 K, and so on.

Now, if I draw a graph, say this is time versus something and let me first draw this clock signal. So, this is the clock which is coming at the input, then you see that the output of this DAC is initially 0, when the counter is 0, and then every rising edge causes the counter to increment and therefore, the output will also increase like this, it will initially be 0 and then here it will go to value K, then it will remain like that. Here it will become 2 K, so this is K, this is 2 K, then here it will become 3 K, so this is V o. So, V o changes like this, like a staircase signal, ok. So, this is like a staircase, ok. So, this we call a digital ramp. This is called a digital ramp. Why? What is a ramp? What is a ramp voltage?

A ramp voltage is a voltage which increases with time like this. So, this is ramp voltage. And what is a digital ramp? Digital ramp also increases with time, but does not increase it smoothly it increases like this stepped, ok. So, this is ramp and this is digital ramp. It also increases with time and it can be sometimes smoother, sometimes coarser, so sometimes we can have a digital ramp which is like this which has. So, you can say this is a better ramp, this is smoother because this is closer to the straight line, actual ramp, steps are finer, ok. And this is a coarser ramp, but still that is a ramp.

Now, once we know this now we will make our Volt meter. Now, we will go to the digital ramp type voltmeter, ok.

(Refer Slide Time: 14:54)



So, let us first draw the normal ramp type voltmeter, linear ramp type voltmeter. You just recall with me that a normal ramp type Voltmeter is essentially made up of a comparator and a counter. So, these are the main two ingredients, main two components of our ramp type digital voltmeter. And what do we do. Here we give the input unknown V i or so this is unknown.

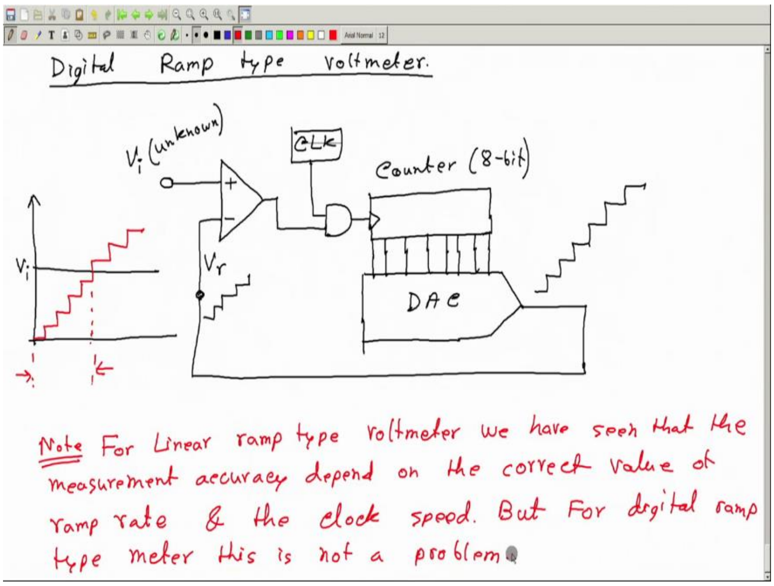
And here we used to give a ramp signal, at this point to form a ramp generator, call it ramp generator and then we use. So, you know that this voltage, ok, let me write call it V r, this is V i. So, V i is constant over time, this is V i and V r increases like this, so this is V r and we measure this time. The time required for the V r to cross V i, that will tell us how large how big the value of V i is.

And you know the moment V r crosses V i, the output here will become positive to negative and this we used to drive a counter, so this goes; let me erase this. So, this goes to the counter, this is the clock of the counter and here we have the clock generator I mean a clock signal could be a crystal oscillator, ok. So, the moment this value goes down the counter will stop, which means when V r will become larger than V i the counter will stop. So, counter will tell me the time required for V r to cross V i, right. This is normal ramp type, normal linear ramp type voltmeter.

Now, we will do a small modification. What is the small modification? From this counter; so, we will take the output 1, 2, 3, 4, 5, 6, 7, 8 say these are the, this is an 8 bit counter and we will connect this to a DAC. So, the output, suppose when this measurement is going on you know this is constant, this voltage is increasing and clock pulses are coming here the counter value is increasing, right with time. So, how will this value look like? This will also look like this, right, this is also keep increasing because the counter value is increasing.

Now, you see that we actually have a digital ramp signal and here this signal is like this. This is a normal ramp, this is a digital ramp. Can we not use this signal in place of this ramp normal ramp, because why do we need this? We need to compare the unknown voltage with various different known voltages generated by the ramp, but we can also get various different known voltages from this and connect here to compare this with the unknown voltage, ok. So, that is the idea. So, we erase this, we do not need it, we will simply connect this. So, this signal you know, this is increasing like this, ok.

(Refer Slide Time: 20:08)



So, here in place of instead of drawing it like this, let me draw the comparison like this. Say this is V i which is constant and this V r is increasing with time like this and this is the time required for this V r to cross V i and this will tell me the value of V i this will indicate the value of V i, right. And so this is the scheme. And you also see that the moment this counter stops that means, the moment this voltage has gone higher than V i, this counter will stop and therefore, there for that value will indicate how large the V i is.

I will stop at this point because I want you to think about this scheme and particularly you just recall a few important points. So, number 1, note for linear ramp type voltmeter we have seen that the measurement accuracy depend on the correct value of ramp, ramp rate or ramp slope, ramp rate, and the clock speed. But I will just make a comment, but, ok. In this digital ramp type voltmeter, there is no ramp generator. So, we do not depend on ramp generator.

Of course, there is no ramp generator. And here this clock frequency will also not create any error, ok. You just think about it, ok. I will discuss this again in the next class, but for digital ramp type meter this is not a problem, ok. So, before we meet next time just think about it. We will meet again.

Thank you.