Electrical Measurement And Electronic Instruments
Prof. Avishek Chatterjee
Department of Electrical Engineering
Indian Institute of Technology, Kharagpur

Lecture – 82
Emitter follower voltmeter

Hello and welcome, so we are on our last week and we have gone through a long way; but I felt that the course will remain incomplete without one topic. So, far we have talked about amplifiers lot of different circuits made up of op amp; but you know op amp is not a very basic element, it is made up of it is basically an integrated circuit ok. So, it is made up of possibly lots of transistors etcetera, rather a transistor is a more basically made.

So, we talked about op amp from it is functional behavior we did not talk about how it is made; that will be difficult to talk about. So, with I thought that at least let me give you some flavor how we can do some instrumentation with transistors without using op amps ok. So, because transistors are more basic elements than op amp is. So, you will do some small circuits, we will not go too much into the detail. And if you feel it difficult, I promise I will keep it out of the syllabus of the exam ok.

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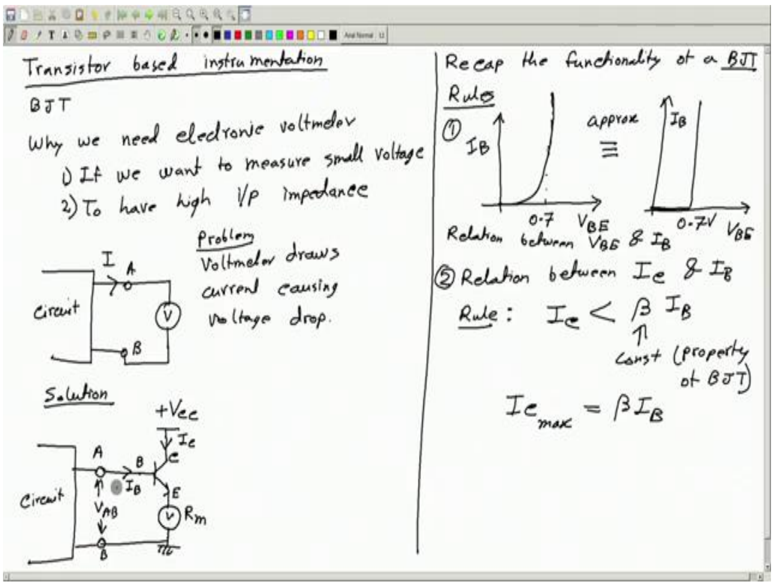

So, transistor-based instrumentation and I shall use only BJT, because this is the transistor that you all might have studied. So, let us first make a voltmeter with an electronic voltmeter with a BJT. Now before that let us recall why we need electronic volt meters.

So, why we need electronic voltmeter, there were two reasons; number 1, if we want to measure small voltage, very small voltage, so that we may need to amplify it. So, that the pointer goes towards the rightmost position in on the display on the dial, so that we do not make much error while taking the reading.

And second important reason is that, if we want to increase the input impedance of the voltmeter circuit to have high input impedance of the voltmeter circuit. Why? Because say, you know if we have a circuit and we want to measure the voltage between say these two points A and B; the moment I connect a voltmeter V, you know this voltmeter will start to draw some current.

Practically and ideally the voltmeter resistance should be high, so that this current is should is low; but you know voltmeters do not have infinite impedance. Therefore, this current is not 0. Therefore, some current is coming out of the circuit which will load the circuit and cause voltage drop; because of the internal resistance of this or impedance of the circuit ok. So, the internal impedance and this current, their product will give the voltage drop between these two terminals when I connect this voltmeter.

Now, say just consider this situation ok. So, voltmeter draws current causing voltage drop. So, this is the problem. I will just show you how we can get rid of this problem using just one BJT, bipolar junction transistor ok. So, solution, a very simple solution ok. So, what we will do is this say, we will take a BJT, this is a NPN BJT and we will apply say, let us take a resistance first, let me apply this voltage.

So, I can redraw the circuit A B, this is the circuit K and I will put here a voltmeter some plus voltage current plus V CC. Now what will happen is this. So, this has some resistance call it R m meter resistance and this voltage is V A B right; before we analyze the circuit I think I should very briefly recap or recap the functional behavior of a transistor, recap the functionality of a transistor, of a BJT ok.

So, BJT is governed by two rules. So, if you know just two rules about a BJT, you pretty much know everything how to analyze a BJT based circuit. So, rule number 1 is. So, this if I call this as the base, this as the emitter and this as the collector ok. So, it has three terminals base emitter collector; then the first rule is this plot, this characteristic plot between the voltage V B E versus the current I B, this current I B ok. Not necessarily in this circuit, in any circuit; we are talking about a BJT only not necessarily in this circuit, and we know that this looks like this ok.

And so, initially no current flows up to some voltage and after that almost any current can flow without much change in voltage ok. So, this is approximately 0.7 volt and we can and for sometimes we can approximate these characteristics like this 0 and then vertical line after 0.7 volt, this is current base current. And so, this is rule number 1, which tells me for what value of V A B how much current will flow, through the base ok.

So, this curve tells me the value of base current as a function of applied voltage between B and E. Now and this is the approximate rule, which says no current flows up to 0.7 volt and any amount of current can flow after that and the voltage will not increase, this is rule number 1. And rule number 2; this is, this says what is the relationship between I C, I C is the collector current which is entering through the collector and I B.

So, the first rule this is this was relation between V B E and I B and second rule will talk about the relation between collector current and the base current. And the rule is I C is less than some beta which is a constant time I B. This constant is a property of the BJT ok. So, the second rule says the approximately, the max, the current that can flow through the collector is less than this.

So, I can say I C max, maximum value of the I C is therefore beta I B; it can be less than this and it cannot be greater than this, because of this rule ok. So, this is the second rule. Now let me just give you some example before I come back to this circuit, I will come back before that.

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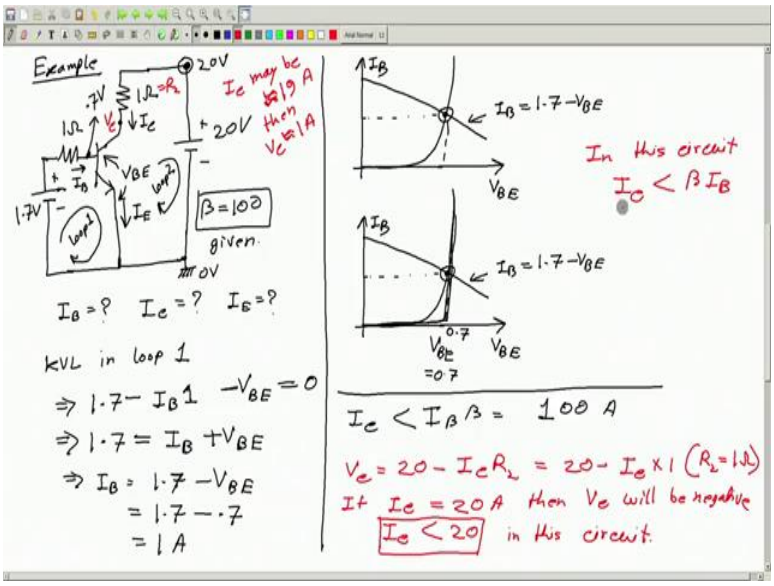

So, let us take. So, let me say apply a voltage between this a like this; say and a voltage between this like this ok. For simplicity I will put the resistance here, for simplicity of calculation, this is the simple example plus minus plus minus. I give you that this resistance is 1 ohm ok. This voltage is saying 20 volt, this voltage is say 1.7 volt ok, this resistance say this is 1 ohm. Now so, solve this circuit; to solve this circuit means I have to find all the voltage and currents.

So, say I B, this is I C, this is I E emitter current, taking in this direction ok. So, what are these values first; I B is how much, I C is how much, I E is how much all these things I will ask ok. Now let us apply a KVL in this loop, call it loop 1 ok. So, KVL in loop 1 tells me this,

1.7 volt – IB 1 ohm – VBE=0

1.7 = IB +VBE

Now how can you find I B? So, what we can do let us first draw this curve, this is V B E versus I B, this relationship comes from the property of the BJT and this is from the external circuit; this is another relationship between I B and V B E. You see this is a here ok, from this you can I B = 1.7 - V B E.

So, this is a straight-line y equal to minus x plus c. So, that will be a line with slope one, this is I B ok and this intersection point will tell me the value of V B E and the value of I B. Now you know what we will do, we will do an approximation; this is a very useful approximation which you always do, copy paste. Instead of having this curve, we will approximate it like this, vertical and then horizontal; then you know this intersection is directly given by the point that V B E is equal to 0.7 volt, this is 0.7 volt, this is the approximation I have done and from this I can get the value of I B.

How? So, let us put this value here. So, I will get 1.7 - 0.7. So, this will come out to be 1 ampere. I have taken the numbers in a way, so that write the calculation becomes easy; because I do not have a calculator ok. So, I B comes out to be this. Now suppose it is given that, beta is equal to 100, given ok.

So, what can we say about I C? So, I C is therefore, should be must be should be less than I B into beta which is same as I B is 1, 1 ampere multiplied by 100, which is 100 amperes. It should be less than this ok, it cannot be more than this; but will it be equal to this; that will depend on this circuit ok. So, in this circuit you see, so from here to here. So, let us think about this second loop, loop 2. So, here from here if I consider this as my reference point 0 volt, then this voltage is 20 volt then from here to here there is no voltage drop.

Vc= 20 – Ic R2 = 20 – Ic 1

Now, I C if I C is 100 ampere ok, if I see is 100 ampere; then definitely it is not going to work, I mean because then V C is going to be negative. If I C is equal to 20 amperes, then V C will be negative and this is not possible. So, what will happen, I C will be much less than 20 ampere in this circuit ok; where R 2 = 1 ohm ok, but say if I modify this.

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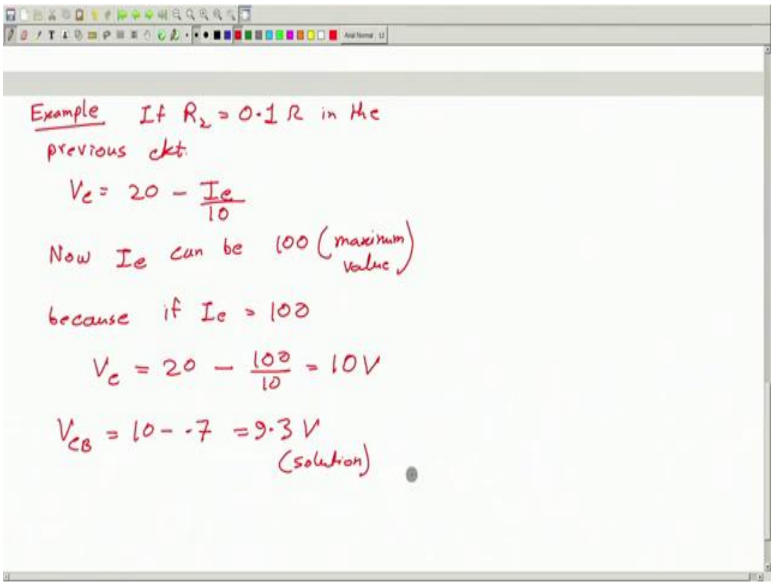

Vc= 20 - $\frac{Ic}{10}$

If Ic=100

Vc = 20-10 =10 V

VCB =10-0.7= 9.3V

So, this will be the solution ok. But in the previous circuit it was not possible ok, because V C was going to a negative value; if 100 ampere flows here, then hundred volt drop. So, the current that will flow here is much less, maybe in this case I C maybe equal to around half volt half ampere or maybe not half maybe sorry.

So, maybe around to sorry not, maybe around 20 ampere, less than 20 ampere actually maybe let me just call it maybe 19 ampere maybe. Then what will happen, if this is 19 ampere; then this 19 ampere into 1 ohm there will be 19 volt drop. So, if there is a 19 volt drop, then V C will be 20 - 19 is it will be, 1 ampere and maybe this 0.3 ampere will, remaining 0.3 ampere will drop across this ok.

Exactly what will be the value for that we need another curve, which gives me the value of I C as a function of I B and this voltage V C P X or V C E ok. So, but I am not going. So, this circuit, I am not going to give you the exact answer ok; that is going to be I mean that going to take more discussion. So, but what I say, the important point I want to say that, in this circuit I C is less than, is strictly less than beta I B. Because I mean we do not have sufficient voltage in this path to have this much current; because voltage drop is becoming very high; if I have 100 ampere current.

But here important fact is I C =β I B in this case. So, this is the rule, I mean basically if I B amount of current is flowing here; then beta I B times current at max, at maximum can flow here. And then this current will be I B + β I B, which is (β+ 1) I B; that is the maximum current which can flow. If I have sufficient voltage drop in this path; otherwise current that will flow is much less. So, that is the behavior of a transistor.

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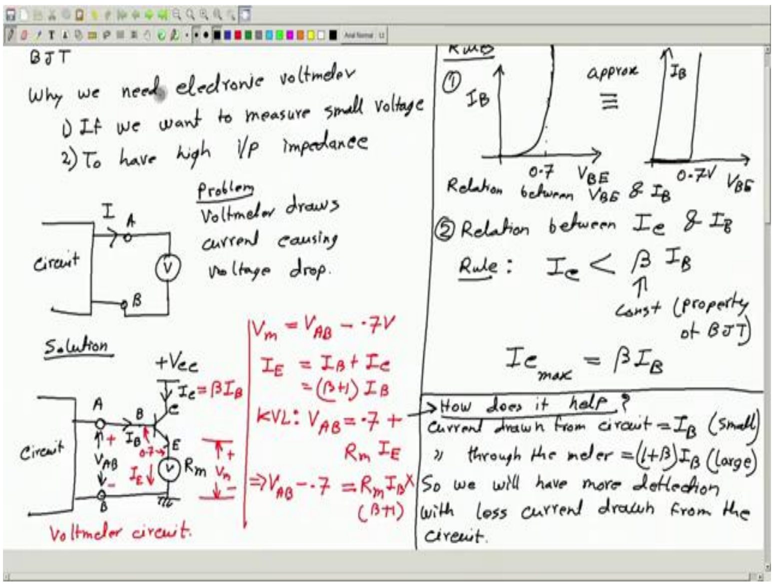

Now, let us go back to our voltmeter circuit. So, this is our voltmeter circuit. So, I am applying a voltage V A B here, the resistance that is here is R m and it will draw definitely some current;

because you know I mean this point is at a higher potential than this. So, it will draw some current and in the active region you know, this voltage will be around 0.7volt, V B E will be around 0.7 volt ok. So, therefore, what will happen is this, the voltage that we will have across the meter.

So, let me just write the solution and you please verify whether my solution is correct, just think yourself. So, I am saying V m plus minus, this is my reference will be VAB - 0.7 volt, this is this will be the voltage across the meter; the current that will flow in this circuit or say I B. Now I B I will write this is this ok, before I can find I B; if this is I B, the current that will flow in this branch it will be β I B, it will be, I mean if it works properly, it will be β I B, it will not be less than β I B.

Because you know there is no resistance here. So, there will be no voltage drop ok. So, beta I B will flow through this and this current therefore, which is

$I_E = I_B + I_C = (\beta + 1) I_B$

$V_{AB} = 0.7 + R_m I_E$

$V_{AB} - 0.7 = R_m I_B \times (\beta + 1)$

So, this is the solution ok, this is the solution. Now how does it help? It helps, because you see only the current that is drawn from the circuit is I B; but the current that flows through the meter is $(\beta + 1)$ I B ok. Current drawn from circuit is equal to I B; but current through the meter is equal to $(\beta + 1)$ I B. Now this I B is a small number or a smaller number, but this is a bigger number, large number.

So, more current is flowing through the meter; which means, we can have more deflection, because we know that any for any normal meter more current flows through it, the coil will be deflected more. So, we will get more deflection. So, we will have; we will have more deflection, because the meter current is more with less current drawn from the circuit, from the circuit being measured. So, the voltage drop also in the circuit will be small, because we are drawing small current, low current here ok.

So, we are drawing low current. So, voltage drop will be small; but the deflection of the meter will be high, because the current that is flowing through the meter is high. And if know, the extra current; extra current is coming from here; this is I B and we are getting extra current beta times I B from this source which is coming through this meter.

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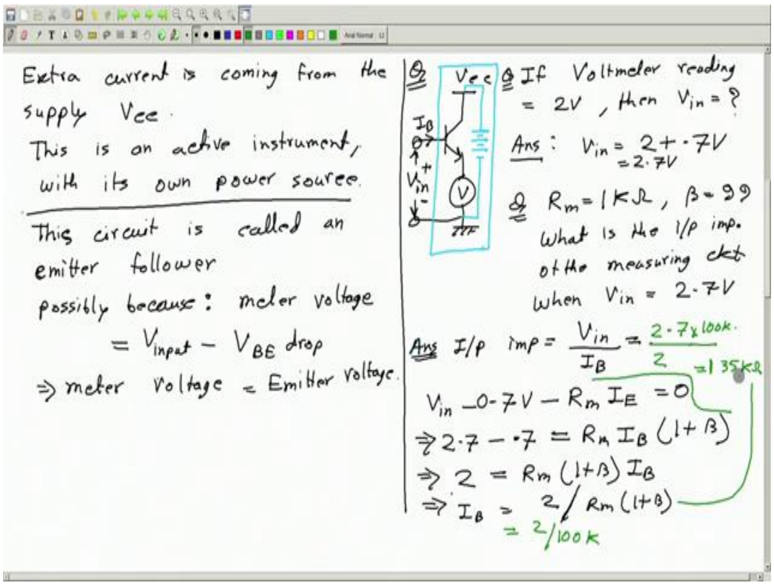

So, the important; so, the important point I will say is that, extra current is coming from the supply V CC ok. So, that is why this is an active measuring, this part is an active measuring instrument, it has its own power source, it is not dependent on the power from the circuit only, it has its own power source. So, this is an active instrument, with its own power source. So, it takes less power from the circuit, let less current actually and the remaining more current is supplied from the power source of the measuring instrument only.

So, this is the measuring instrument together ok. So, this is my measuring instrument ok. So, that is the beauty of an active circuit, ok. So, it will not take current from the circuit being measured, it will take very less current, it will take less current and proportional amount of large amount of current will be delivered by this voltage source ok.

So, this way you know we are drawing little current from the circuit, I am repeating; we are drawing little current from the circuit and I am essentially getting the current amplified ok, not the voltage amplified, but the current amplified this is like a current amplification you can say.

So, this way it helps. So, this is the important to understand; how these circuit helps, this is a simple circuit. I repeat this is a simple circuit, where the by virtue of the rule of the transistor which says the current that will flow through I C is beta times the I B; therefore, this current will be more than the current being drawn ok. This circuit is called an emitter follower; I do not know exactly why, but I guess this is because.

So, possibly because and you can also remember this in this way, possibly because the meter voltage or the voltage that we are measuring, meter voltage is give is equal to the input voltage =V input - V B E drop, So, essentially in other words I can say that, meter voltage is same as the emitter voltage; maybe that is why it is called an emitter follower. I am not very sure ok; but this is how you can remember, by essentially we have this that the voltage that appears across the meter is same as the emitter voltage, which is same as the input voltage minus 0.7 volt.

Now, let us ask some question ok. So, question, some numerical problem. See in this circuit, I draw it again. So, the voltage is applied here V in plus minus if. So, the question is, if voltmeter reading is equal to 2 volt, then V in is equal to how much? And the answer is simple. We know that this voltage drop V B E is approximately 0.7 volt ok, it does, so it does not, you know I mean this voltage is I mean it changes very small here, it may be around point 6.9, 7.1, but very close to 0.7, I am it can be 0.69 or 0.71 maybe, but very close to 0.7.

So, approximately, so it is a good estimation to say that, V in = 2 + 0.7 volt, it is a acceptable approximation that we do ok. Now let us ask next question; what is the input impedance of the circuit ok? And let me also give you some numbers like say R m is equal to let us take it 1 kilo ohm and beta is given as 100 or let me take 99 ok. And so, what is the input impedance? What is the input impedance of the measuring circuit, when V in is equal to this 2.7 volt ok?

So, what which is my measuring instrument, please identify that clearly; this is my measuring instrument. Together with this voltmeter, transistor, this power supply. So, this power supply although I have drawn symbolically, I actually have a power supply like this, a voltage source which gives me this voltage V C C. So, what is the input impedance answer? So, how do we find input impedance? Input impedance means, voltage applied divided by current. If this current I am calling I B, base current; then input impedance is nothing but

i/p imp =V in / I B

Vin-0.7-Rm IE=0

2.7-0.7 = Rm $(\beta + 1)$ IB

IB= 2/100 k

i/p imp = 2.7* 100k /2 = 1.35 k ohm

So, this is I cannot have a calculator, but I can write this is greater than 100 kilo ok. So, you see that the input impedance is greater than 100 kilo ohm. Let me just write ok, I can write the exact value, why not, it is not difficult; this is this will be equal to 1.35 into 00. So, 135 kilo ohm that will be the resistance ok. So, this is the answer.

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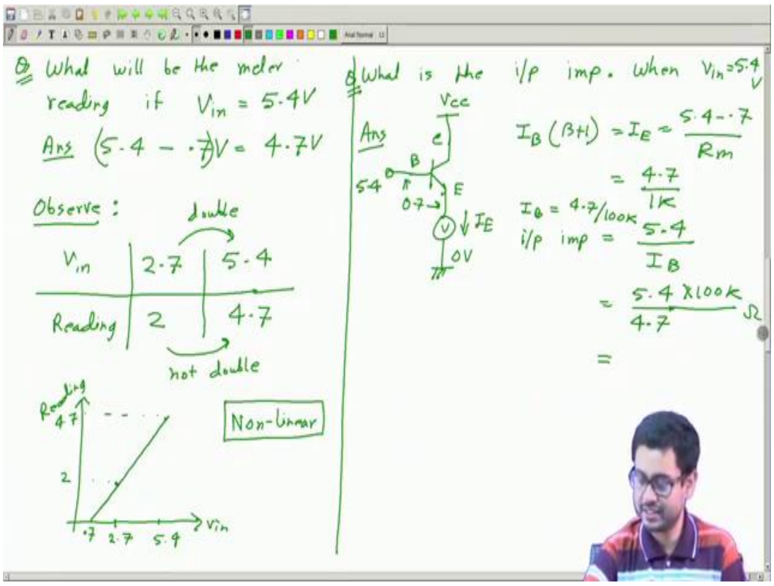

So, what will be the meter reading, if V in = 5.4 volt. In the previous circuit here ok. So, if this is 5.4, what will be the meter reading? Simple 5.4 - 0.7 simple, answer is 5.4 - 0.7 this will be 4.7 volt. So, you observe one fact which is this. So, V in if I make a table versus reading. So, for V in equal to 2.7 meter reading was 2 volt and this for 5.4 the meter reading is 4.7; this is double, 2.7 times 2 is 5.4, but this is not double.

So, you see if I draw a curve V in versus reading. So, at 2.7, this is 2 and at 5.4, this is higher 4.7. So, if you join these different plots we will get a straight line like this, this point will be 0.7; if you give a 0.7 input, then the reading will be 0, because 0.7 minus 0.7 nothing will possibly remain theoretically.

So, this you see is a straight line not passing through the origin. So, we call we say that the input output relationship is not proportional or not linear, it is straight line; but not passing through the origin that is why we call it is non-linear. So, this is a bad thing, this is a bad thing about the circuit ok. So, let us take another example, I mean let us continue this question. So, what is the input impedance when V in = 5.4 volt ok? So, for this case what is the input impedance, this is the question and the answer let us find it out ok.

Let me draw the circuit once again or you draw it together with me for ready reference. So, we have voltmeter which is following this emitter, this always follows, this voltage is always following this emitter base collector V CC, this should be a high enough voltage to supply the extra current demanded by this voltmeter.

IB $(\beta + 1)$ =IE = $\frac{5.4-0.7}{Rm}$ = 4.7 / 1k

IB = 4.7 / 100k

i/p imp = 5.4/ IB = 5.4 * 100 k /4.7 ohm

So, that is I, so here 4.7 into 100 kilo. So, that will be in ohm, please forgive me for not writing the units properly ok. So, this will be something which you can calculate; but this will not be same as the input impedance which we got previously here ok.

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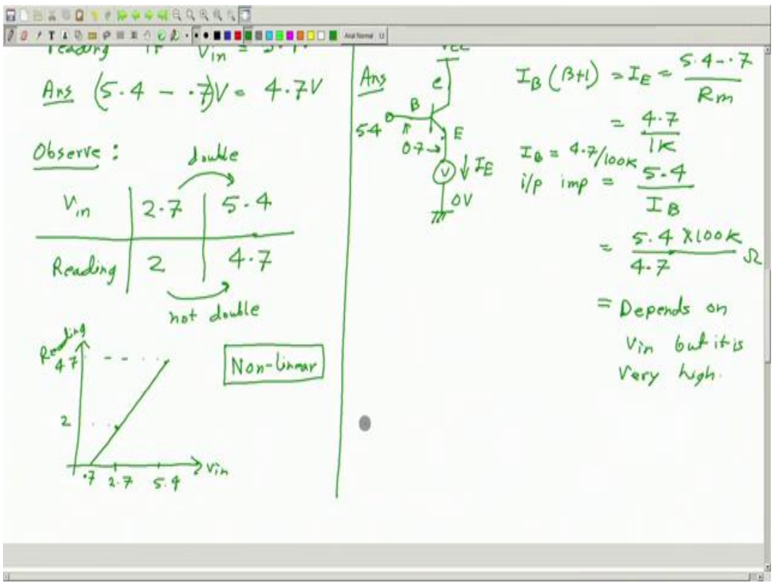

It will depend. So, it also depends. So, you see depends on V in. So, input impedance is not constant, but anyway this is a high number; it depends on V in, but it is very high. And it is higher than, much higher than the impedance of the voltmeter; that was R m = 1 kilo ohm, but with this arrangement we are getting nearly I mean more than 100 kilo ohm right.

So, we are getting much higher than 100 times higher than the actual meter resistance with this arrangement. So, that is the nice thing; that is the beauty of this circuit, but this is the deficiency of this circuit, the input output relationship is not linear ok.

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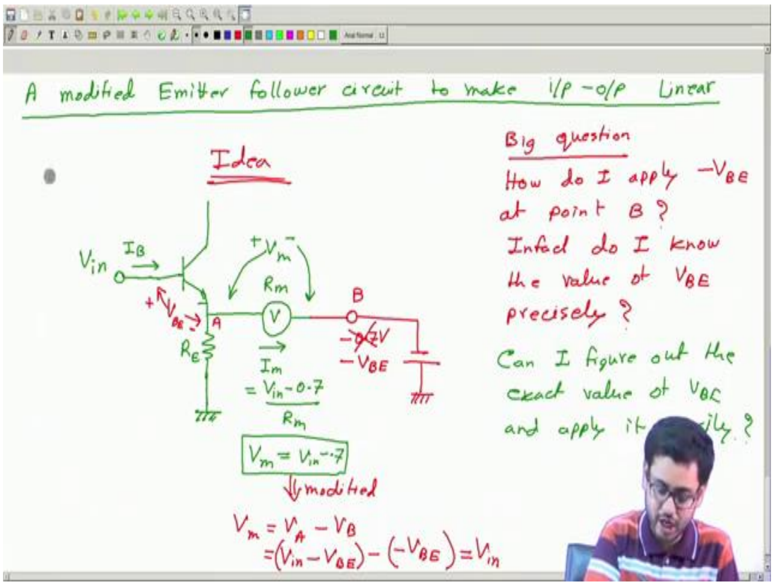

So, we can see a new circuit, modified emitter follower circuit, this is also called a practical emitter follower circuit to make input output relation linear or proportional ok. So, this is called a practical emitter follower circuit. Let me just first draw the circuit and you will realize the beauty yourselves. I will take two BJT's; one here and I will take the voltmeter, I will start from the previous circuit and then you see how I modify it ok.

So, I this is the previous circuit, and here you apply V in; the beauty of the circuit is that, here the current that will flow is IB right, but the current that will flow here is more ok. Now I can do this instead of connecting this voltmeter like this; I will connect the voltmeter like this, I will put a resistance here and the voltmeter here.

So, these are in parallel they are in parallel right. So, now, what will happen; this is equivalent to the previous circuit. Why? You know the current that will flow through this call it I m through this voltmeter, it is given by this voltage divided by meter resistance.

Im = (Vin -0.7)/Rm

So, here also you know the meter current is given by V in minus 0.7 divided by R m. So, if I connect the voltmeter like this way, then also the meter this meter get same current. So, its reading will be same ok. So, for same input, if I think about the input output characteristic; then if I put the voltmeter here or here, the input output characteristic is not going to change ok. Because this is the relationship between the meter current and the input voltage or I can also write meter voltage V m.

So, V m is this plus minus I can write V m = V in - 0.7 and this relationship input output meter voltage or meter reading and input voltage; this relationship is same, no matter whether I connect it here or I connect it here, no problem right. So, this cycle circuit is same as before ok. Now I will apply some modification and this modification I will apply with a different color. On this side I will.

So, previously it was grounded, 0 at 0 potential; now I will make a modification and I will apply a voltage which is minus 0.7 volt or better I will write it this is equal to minus V B E. This is V B E this drop this can be 0.7 I mean 0.69, 0.71 whatever is that value, I will apply the same voltage here ok.

So, I know this value I can know this value, say I can know this value; then the same value negative of that if this voltage drop is 0.7 volt, then I shall apply minus 0.7 volt here; if this is 0.6 volt I shall apply minus 0.6 volt; if this is 0.8 volt I shall apply minus 0.8 volt here with a battery, think I will do that; if I do this then this equation will get modified like this.

So, what will be the meter voltage? Voltage across the meter, this will be, let me call this point A and this point B then I can write V m = V A - V B ok and then I can write this as, V A is how much?

$$V_m = V_A - V_B = V_{in} - V_{BE} - (-V_{BE}) = V_{in}$$

So, at this point how do I apply this? And I mean, in fact do I know the value of V B E precisely. I know it is around 0.7 volt, but could it be 0.71, 0.69; then to be precise I should apply that value only, to be more precise, to be more accurate not 0.7. If it is 0.71, I should apply 0.71; if it is 0.69, I should apply 0.69.

So, can I have a provision, so that I can easily figure out what this voltage is and apply the same voltage here ok? So, can I figure out the exact value of V BE and apply it easily, experimentally practically when using the meter can I do it.

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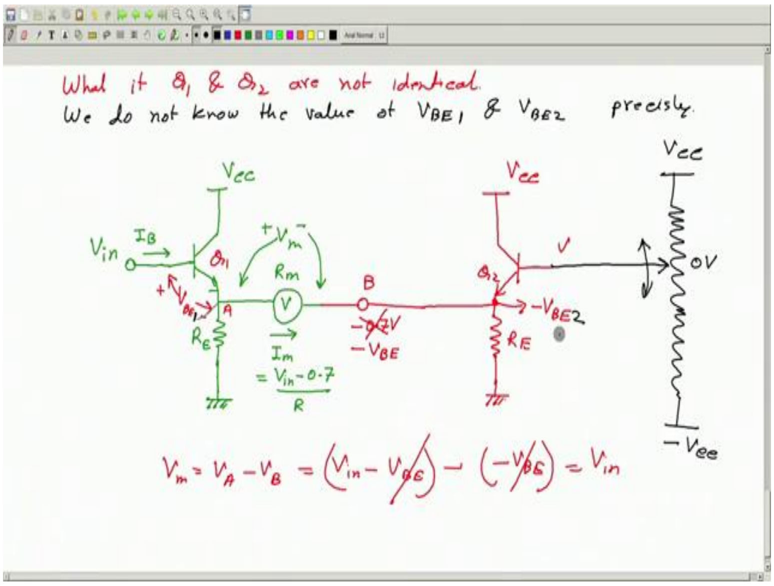

So, that we shall see now, what I will do is this; I will take another circuit like this ok. Another circuit like this to generate the required voltage here, which will be also controllable and adjustable; if I want to change it, I can change it that is the beauty. So, let us take an. So, you know. So, this circuit has generated here a voltage of minus 0.7 volt. So, I need to generate minus 0.7 volt here. So, I will take a similar circuit. So, what I can do is this, I will let me take this color.

So, I will take this, R E, same circuit I am drawing, this is a mirror image of the same; I for actually forgot one important thing here, this power supply sorry for that here also. So, V CC, so you see this circuit and this circuit is same identical and therefore, say if I now apply 0 volt, if I apply 0 volt and if these two transistors are identical, then the voltage at this point, this will be - V BE.

$V_m = V_A - V_B = V_{in} - V_{BE} - (-V_{BE}) = V_{in}$

So, this and this will cancel, I will remain with V in only ok. Now you should ask, what if these two transistors are not identical; what if call it Q, 1 Q 2; Q 1 and Q 2 are not identical ok. So, for maybe this drop for this transistor is 0.7 volt, but here maybe this drop is 0.71, let me write I will just erase.

So, this is equal to 0.7 volt this drop so; that means, this point is at minus 0.7 volt, but maybe this drop is 0.71. So, then this point is at minus 0.71. The easy solution is that in that case just apply a bit more voltage here, apply point 1 volt at the base. So, 0.1 - 0.71 will give me 0.7 only fine so; that means, I can change the base voltage.

So, I need a provision to change the base voltage. I will erase this and what I will do is this; I will take a long potential divider, give V C C here, give some minus voltage here V E E, this point you can vary. Normally you keep it around 0 volt, normally you keep it around 0 volt and if you require you can move it up and keep it at 0.1 volt or maybe at minus 0.1 volt, this point you can vary ok. But how do you know exactly where to bring it; that you will know only if you know the value of V B E for this transistor and V B E for this transistor precisely.

Then you can compute where to put it ok; so, but the fact is that, we do not know the value of V B E, call it V B E 1 and call it V B E 2; V B E for V B E is the draw for this transistor, this is the draw for this transistor, V B E 1 and V B E 2 precisely. So, what we will do is this, we will not try to find out the value of V B E 1 or V B E 2, we do not need it, we do not need it at all; what we will do is this. So, before we start our measurement.

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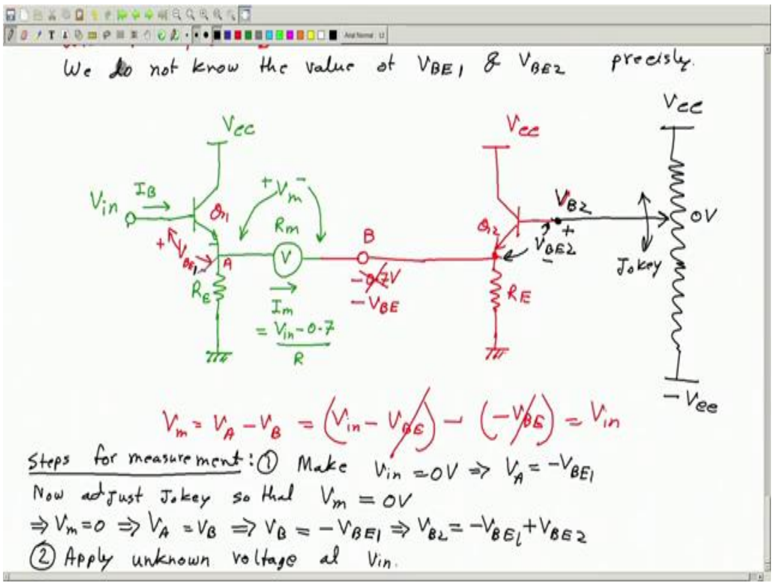

Vin = 0 , VA= - VBE1

If Vm =0 , VA= VB , VB = -VBE1

VB2 = -VBE1+ VBE2

So, I mean the idea is whatever is the error or wrong, I mean V B drop here, you want to get it compensated by generating the same value on the other side and for that you make it 0. So, this is minus V B E 1 and then you adjust it until and unless this is also equal to V B E 1 and then you can make it sure by checking that these two are at same potential, so that the meter reading is 0 ok.

Now once this is done, then step 2; remove the short circuit and apply unknown voltage at V in ok. So, that is the idea. So, let me just summarize in 2 minutes these things ok.

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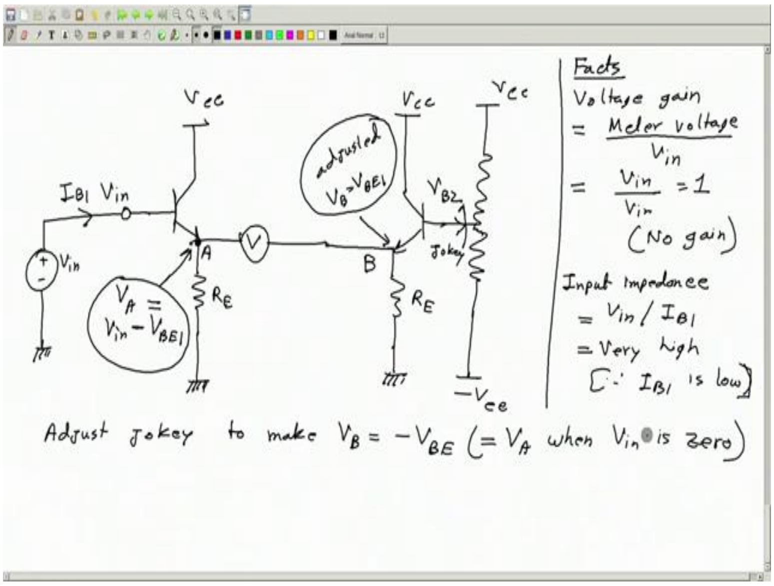

So, this is my primary circuit, emitter follower circuit, I have the voltmeter here; if I apply a voltage V in here, I know the voltage that will come at this point call it A, at this point V A = V in -V B E 1 ok. This is what I know, this will always happen, this I connect here and therefore, I want to get this same value on the other side for that I just take a similar circuit. I do not need this to be exactly same; it does not come in the theory at all.

So, this may not be exactly equal fine, these two transistors also need not be exactly equal and what I do, call this V B2 this point is B minus V EE. So, it can vary between these two oks. So, adjust Jokey, this jokey adjust Jokey to make this voltage this is point B. So, you call this V B, adjust Jokey to make V B is equal to this voltage V A not V A, is equal to minus V BE1, which is same as the value of V A when V in = 0 and we are done.

So, essentially I needed to correct for this voltage by applying same voltage on the other side ok; same voltage I want to apply on the other side and I do it by experimentally changing and finding the what is the position of this jokey which gives 0 voltage across the meter, this is how to use it ok.

So, that is it about this topic. I will just ask, I will just point out two facts. So, facts number, facts are; what is the voltage gain of the circuit? Voltage gain means, this will be the meter voltage. Why are you talking about voltage gain, because we know that in an electronic voltmeter one of the purpose is to amplify a small voltage, so that it becomes easier to measure; another purpose is to increase the input impedance, these are the two important purposes right.

So, let us check whether those purposes are satisfied. So, let us check if there is a gain in voltage. So, voltage gain will be the meter voltage, the voltage that appears across the meter divided by the input voltage V in. But you see in this circuit this is equal to 1; why? Because this point is at this voltage, V in -V BE1, we have also adjusted to make this equal to V BE1 adjusted. So, this is V BE1 and this is this; now what is the difference, the difference is just V in ok, because meter voltage is same as V in.

So, V in / V in this is equal to 1, so no gain. So, this circuit does not amplify a small voltage at all ok; which is one of the required purposes, requirement of a electronic voltmeter, it does not do it, but that is fine, it serves the other purpose ok. The input impedance, how much is the input impedance? This is very high. Why?

Because input impedance is nothing but I can write, so you know I will connect some circuit here, V in plus minus ok. So, if this current is I B1, then the input impedance is nothing but V in, the voltage applied divided by the current I B1 and this is very high ok, since this is low, since normally base current is low for a transistor is low.

And more importantly you know the current that will flow through the meter, majority of it comes from this power supply. If IB1 amount of current flowing through is flowing through this; then beta times IB1 can be drawn from this part ok, I B1 part of it goes through this, part of it may go through the voltmeter.

So, if only a small amount of current is drawn from here, a large amount of current can be supplied by this; which will partly go through this and partly growth through the meter. So, the meter can current can be larger than this ok. So, input impedance is very high. So, this circuit is an electronic voltmeter, which serves one of the purposes of having high input impedance; but it does not serve the purpose of voltage amplification ok.

Thank you.