Fundamentals of Power Electronics
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Lecture - 36
Series regulator

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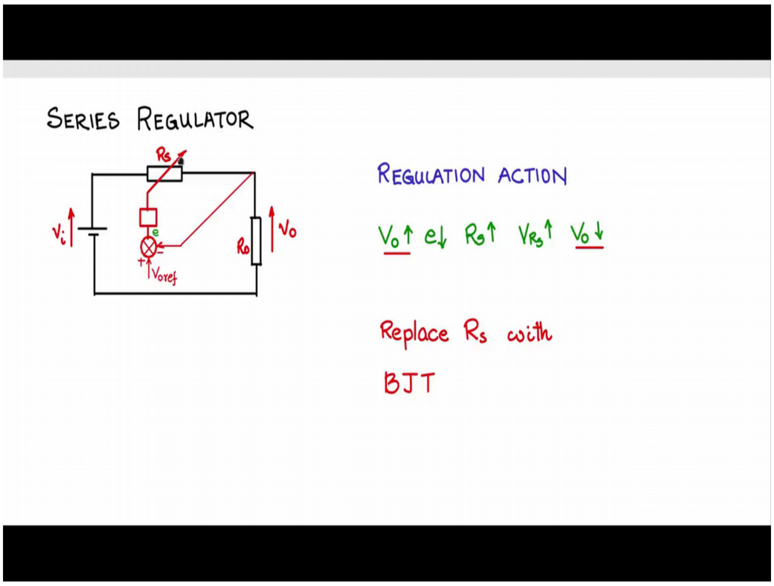

Till now we have been discussing about the shunt regulator, shunt linear DC-DC converter. Now, we will discuss the other type that is the Series Regulator. The Series Regulator is much more popular and then is useful for more higher powers. The structure is like this, I have an input unregulated input V i connected through a series element and you have the output load. So, this is V i unregulated, this is V naught, this is R naught and there is a series element R s.

Now, the principle of operation is that we try to control the value of R s is V regulate or V change R s value based on the output feedback. So, let us say we have a controller and the job the controller is to check a reference value. So, let us say we have a reference value V naught reference and checks also with the output V naught and then uses that to control the value of R s. Idea is like this if R s value is increased then the drop across that one will increase and the drop across this will decrease. If the R s value is decrease then the drop across that one will decrease and that drop across the output will increase. So, in this way by adjusting the value of R s we can bring about regulation in the output.

So, if you see the regulation action it is something like this. We have V naught, now let us say for some reason it may be due to V i increasing or change in the R naught. Let us say V naught increases for some reason. So, if the potential here increases then the potential at this point increases V naught ref is a reference constant therefore, e has to decrease. So, the error here will decrease and if the error decreases, we would like to increase R s such that the drop across R s V R s will increase. So, once the drop across V R s increases in this outer loop applying Kirchhoff's law, as this increases V naught will reduce.

So, if you look at the regulation action because of an increase in V naught finally, it has resulted in a decrease in V naught bringing it back to its original position by this regulation action. So, in the practical circuit we replace R s with BJT, so that this change in the impedance is automatic.

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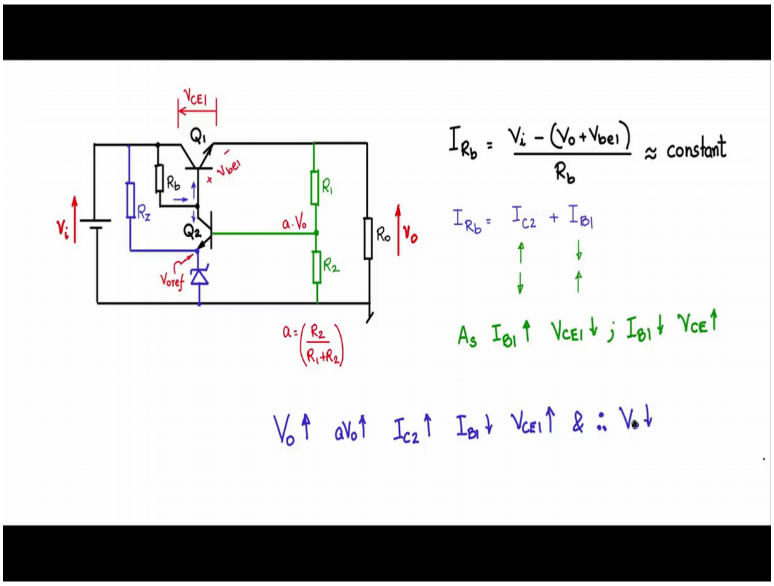

Now, let me include the BJT a semiconductor impedance variable impedance rather than fixed R s. So, I am going to put a BJT there in place of R s and you have the load connected in this fashion. Now, here I will try to put some kind of biasing circuit for biasing the BJT such that it operates automatically.

Now, at this point I will include V naught reference and to include V naught reference I will use the shunt regulator. We are familiar now with the shunt regulator. See this is the resistance and that is connected here. This blue portion is nothing but the shunt regulator which will define the potential here in that we can call it as V naught reference, related directly to the Zener voltage.

Next let us obtain the feedback from the output. I will use the potential divider resistive divider tapped from the midpoint and then use it to drive this BJT here. So, let us then we include one more resistor here to bias, to give bias current for this BJT like this. So, I will call that one as R b, I will this an R z I will call this one as R 1, R 2, R naught. This is V i unregulated, V naught which we want to regulate this is Q 1 and this is Q 2. So, this is a V naught, a is nothing but the step down or attenuation ratio which is R 2 divided by R 1 plus R 2.

So, under steady state condition let me look at this current here. This will give you the crucial operating operation of this linear regulator. This current I R b what is it equal to? On one end we have V i potential V i at this end. Let me put it at V I, minus at this end what is the potential? Here it is V naught V naught plus V be minus V naught plus V be. So, V be is nothing but this drop across transistor Q 1 V be 1. So, that is what I have used here. Now, that divided by this value R b will give you the current through this. Now, this current here if you see V i is fixed value constant, V naught is constant, V be is constant R b is a fixed value therefore, I R b is approximately a constant value here.

The only variation is due to variations in V i because V i is unregulated. So, if I R b there is constant, this I R b divides into two parts, one part goes to goes to Q 1 as a base current base drive and another part goes down through Q 2 as collector current of Q 2. So, let us say I R b equals this is I C 2, we will call this one I C 2, I f collector C 2, then this is I B 1 . Now, as I C 2 increases I B 1 has to decrease because the sum has to same as I R b which is a constant. If I C 2 decreases then I R b has to increase, so that the sum is the fixed value I R b. Now, this herein lies the regulation action.

Another thing that you may have to notice let us say you have the voltage across V CE of Q 1 will call that V CE 1. And as V CE, now we need to control V CE, so as I B 1 increases as the base drive to that is increased more drive, it will go more towards saturation V CE 1 will decrease. So, V CE 1 decreases and as I B 1 decreases you will see that the drive is lesser as comes out of saturation moves more towards cut off V CE 1 will increase. So, this is our basic control or regulation action.

The control action is like this. As V naught increases, as V naught increases here due to any reason it could be change in R naught load resistance or it could be change in V i, you will see that this point the tap off point a V naught will also increase a is a constant. So, a V naught increases the V be of this one will increase, because you are increasing this point and this point is fixed at V v z reference voltage. So, as this voltage increases V be increases the drive increases and therefore, I C 2 will increase and therefore, I C 2 increase.

If I C 2 increases you see that I R b is a constant current, if I C 2 increases I B 1 has to reduce. So, I B 1 will reduce. If I B 1 reduces you see that V CE will increase, V CE will increase. And as V CE increases in this loop apply Kirchhoff's law V i is fixed as V CE increases V naught has to come down. Therefore, V naught comes down. So, this is the regulation action. Any increase where the regulation action comes into picture and brings back V naught to the original value, if there is a decrease in V naught you will see that V naught will again increase and will be brought back to the original set value and thereby the regulation action. So, this is the operation of a series regulator.