Fundamentals of Power Electronics
Prof. L. Umanand
Department of Electronics Systems Engineering
Indian Institute of Science, Bengaluru

Lecture - 34
Non-ideality and solution

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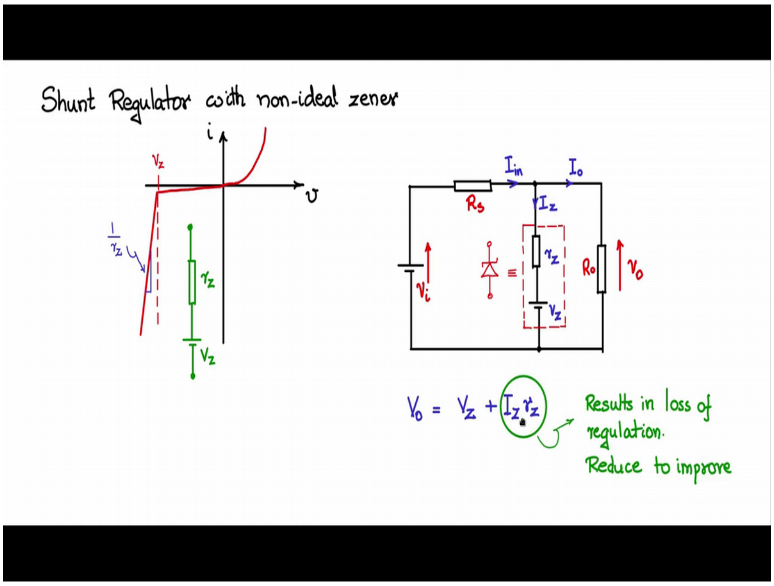

Let us now consider and discuss the same shunt regulator, but a practical one with a non-ideal Zener. Till now in the discussions we had used Zener which was more or less ideal, wherein the Zener did not have any series resistance or the series resistance was 0 in the breakdown region. Consider the static characteristic of the Zener to the forward, but let us consider the reverse characteristic.

We have till now considered the reverse characteristics which is going vertical down at V z. But a more practical Zener will have a follow a slope like this and the slope of that is 1 by R z or the series impedance or the series resistance of the Zener. So, this can equivalently be shown symbolically in this fashion where you have the Zener with an ideal Zener having a V z reference. And in series you have a small resistance R z. Now, this is the practical Zener. Let us try to include that in the shunt regulator circuits. So, you have the V i, you have a R s and you have this Zener and connected across the load as shown like this here. So, this is V z just like here and this will be the Zener series resistance.

Now, this whole thing together this blog is the Zener device and we can say this whole thing is actually is the Zener, practical Zener that you would have placed at this point in the circuit. So, let us mark V i this is V naught, R naught, R s and this is I in and this is I z current flowing through this branch, this is I naught current flowing through the output branch. Now, what is V naught? V naught before it was equivalent to just V z when R z was 0, but now it is V z plus V naught is equal to V z and in the earlier case when you use the ideal Zener R z was 0 and V naught was equal to was equal to V z.

Now, you have an additional term due to the drop across R z, so that drop is I z into R z which is I z into R z. Now, this is the extra portion due to the non-ideality and this is the cause for deregulation or an improper regulation or loss of regulation. So, this results in the loss of regulation. Now, if you want to improve the regulation for the circuit you have to reduce this term. So, reduce I z, R z term to improve this regulator.

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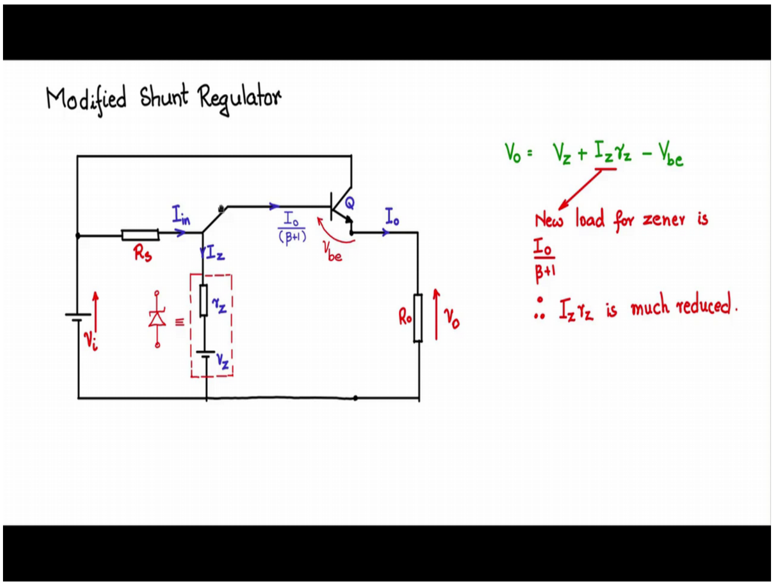

In order to improve the regulation of the practical shunt regulator we now modify it and see how the modified shunt regulator behaves and improves the regulation. Now, this is the regular practical shunt regulator, let us do some modifications, let me push the low to the right, let me join this and here let me include a BJT, an npn BJT. And connect the emitter here to the load and I will connect the collector to the supply and the base is connected to this point this junction point.

So, if this is Q the emitter current is now I naught. So, the base current will be I naught by beta plus 1, where beta is the collector to base ratio I c by I b. So, you have I naught by beta plus 1, I mean in here this is V be base to emitter voltage is around 0.6 volts. So, now, what is V naught? V naught here is equal to V z plus I z r z, then this V be drop. So, plus and minus in this fashion therefore, minus V be is what will come to the output here.

Now, here look at this I z before without putting this transistor BJT the entire I naught was being commutated by I z. I z was used to commutate the entire I naught, but now after having put this BJT I z has to commutate only I naught by beta plus 1 that is the virtual load for this Zener shunt regulator is I naught by beta plus 1 and as a result I z swing is much reduced and it is reduced by beta plus 1. And beta being high if your BJT is chosen where beta is around 100 say then the I z swing is reduced by 100 and which means that I z R z would be reduced by 100. So, therefore, you see that I z r z is very much reduced and as a consequence V naught regulation is greatly improved.

One other thing that you need to note is that V be comes into the picture here as such V be is constant around 0.6 volts, but there is there is a variation with temperature. You know that the P n junction here, this V be will change at minus 2 millivolt per centigrade for every degree centigrade rise in temperature, there is minus 2 millivolt drop. Likewise, Zener is also P-N junction. So, there is a possibility for one to match this P-N junction with the base emitter junction such that temperature compensation can be achieved.

So, by using this modified shunt regulator one can achieve much better regulation than the practical shunt regulator, the one without BJT.