Fundamentals of Power Electronics
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Lecture – 39
Over current limiting circuits

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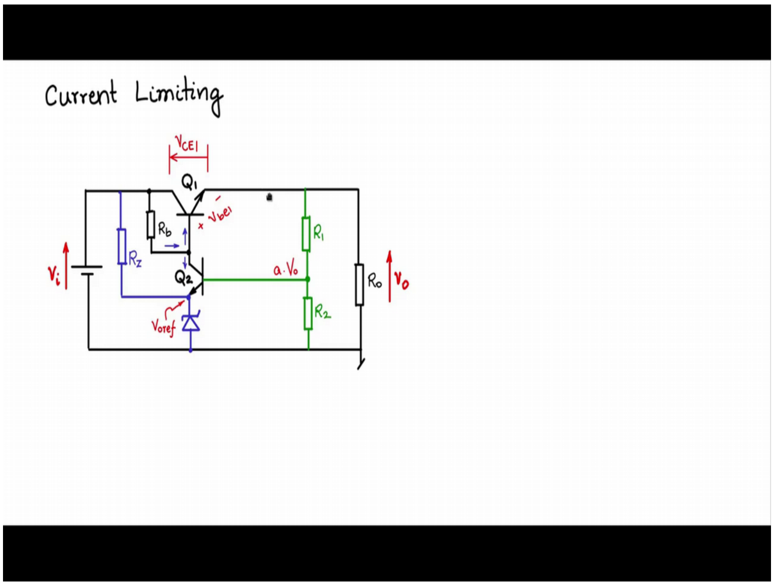

Let us now discuss how to provide current limiting for the series regulator circuit. Now, consider the series regulator circuit and let us introduce some components here such that we limit the current under, overloading or short circuit conditions.

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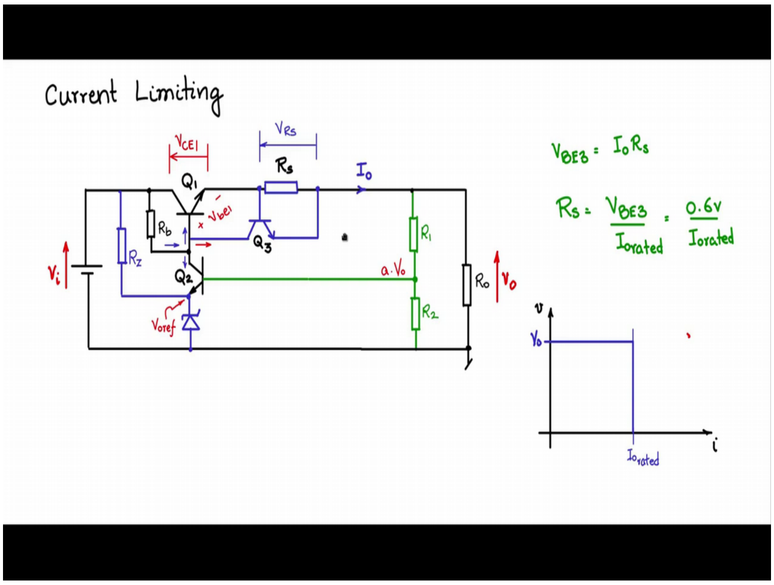

Let us create some space here to introduce some components here. And let me introduce a resistance in this fashion. And across the resistance let me connect the base emitter of a transistor, and the collector the transistor is connected to this point. .

Let us call this transistor Q 3. This is R s and I naught flows here. You can say I naught is the current flowing here is approximately equal to I naught, because the current flowing through this feedback tap point is very, very negligible.

So, let us say this I naught value which is flowing here is dropping across this and you have I naught into R s drop. So, this I naught into R s drop is the one that will start cutting in this transistor Q 3. So, once I naught into R s drop reaches 0.7, so that is where you can design the value of R s for a given I naught rated value. Once it crosses 0.7 at say the I naught rated value flowing through this. The transistor will be almost reaching the saturation stage, and it will be drawing a large amount of current reducing the base drive here. And thereby making this more towards the off region, and it will be withstanding more and more voltage.

Imagine a condition where you short circuited the output, when you short circuit the output the voltage here is 0, a large current is expected to flow. But I R is drop and drive this into saturation and take away all the current I R b current into this and Q 1 will be in off state and withstand all of V i. So, this is the constant current limiting. So, if we take V R, this is V R s. So, V b e 3 across this is nothing but I naught into R s and R s can be selected by V B E 3 divided by I naught rated, whatever is the rated value for which you would like to provide the limit. So, around 0.6 volts for V B E divided by I naught rated will be the value that you select for R s.

So, if you plot the, I versus I naught versus V naught, so at V naught whatever be the load V naught is going to be constant till it reaches a rated I naught rated current value. Beyond I naught rated current value, this would be draining out the drive for Q 1, and Q 1 will support the entire voltage.

So, even if you short circuit it this is the short circuit with 0 V naught point that is here. So, it will limit the current to I naught rated. So, this is the constant current limiting type of a circuits, very nice circuit, it can be used in most of the series regulator type of configurations.

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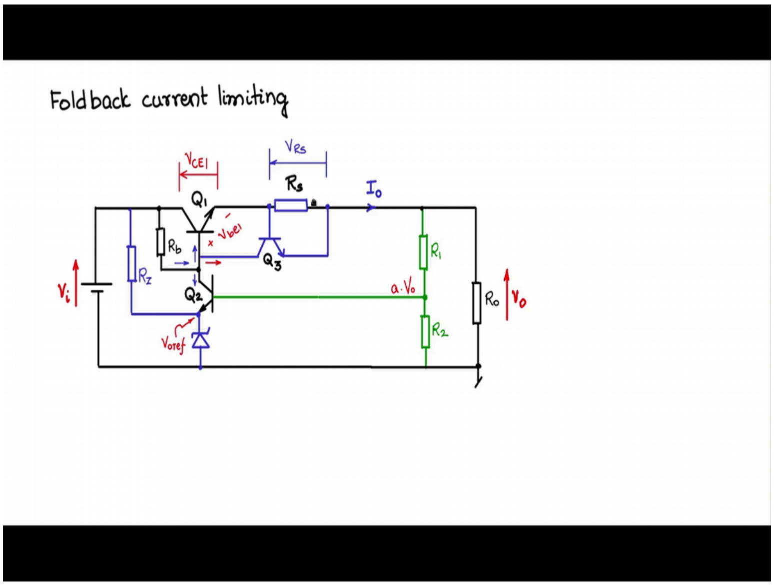

Let us look at another interesting current limiting technique called the fold back current limiting. We had seen this constant current limiting by putting these set of components one BJT Q 3 and R s. Now, let me modify this slightly, and you will get this fold back current limiting.

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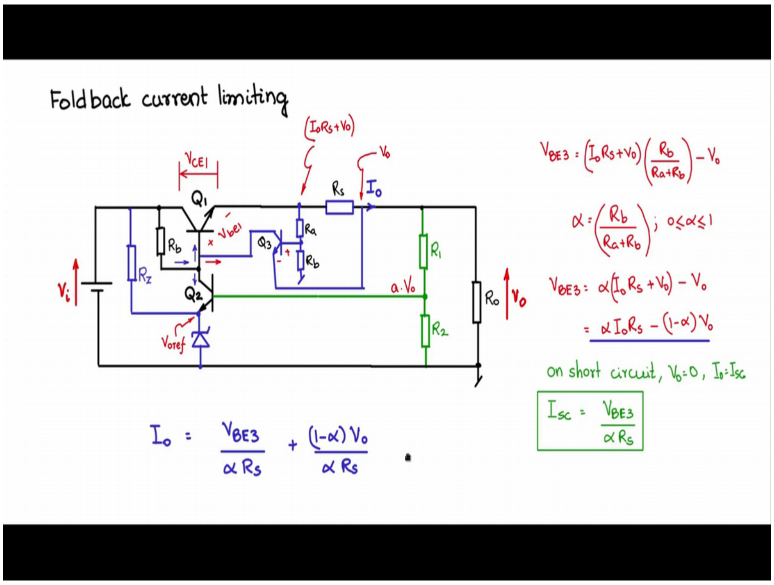

Now, let me explain this. Let me remove this portion make a bit more space and I will put the resistance R s here. And from this point, I will tap a voltage divider to ground. And to the centre point of that, I will connect to the base of the BJT Q 3. So, the collector I connect it in the same way and the emitter also I connect in the same way to this point output point. .

So, by making this small modification you will find an interesting way of current limit we will call this Q 3, we will call this R a, R b, and this is R s.

The potential here is this drop I naught into R s plus V naught. So, I naught into R s plus V naught will be the potential of this point with respect to ground, potential of this point with respect to ground is V naught itself. Now, let us look at the potential of base emitter of Q 3. So, we will call that one as V B E; V B E is equal to this potential which is whatever this potential I naught R s plus V naught with voltage divider action of R a, R b..

So, which will be I naught plus I naught into R s plus V naught multiplied by this ratio R b by R a plus R b will be the potential at this point minus the potential of this point which is V naught . So, we will get that as the voltage across V B E 3. .

Now, I will define the symbol alpha for this R b by R a plus R b, so that equation becomes simpler to write. And we know that alpha is less than one varies is between 0 and 1. . Now, V B E 3 can now be written as alpha I naught R s plus V naught minus V naught ok. .

Now, you can simplify it a bit further alpha I naught R s I will take it and this V naught and V naught, I will take it common and write it as 1 minus alpha V naught note the sign change here accordingly to take care of this.

So, now on short circuiting, let us say I short circuit this. So, V naught becomes 0. On short circuiting V naught becomes 0; and I naught we will call it as I s c short circuit current ok. Here again assume that the current flowing through R 1, R 2 is negligible and therefore this value is I naught itself whatever is flowing through the load. .

So, under short circuit condition look at this equation V naught is 0. So, this part this term goes off and you have only this term. So, therefore, I s c this I replace by I s c which is equal to V B E 3 divided by alpha R s. So, this is a design equation for choice of R s and appropriate choice of the design parameter alpha. You can also design what should be the short circuit current.

Now, this importance will become clear as we go to the next steps. Now, consider this equation. So, I can now write I naught equals V B E 3 divided by alpha R s plus I am bringing this term on to this side 1 minus alpha V naught by alpha R s.

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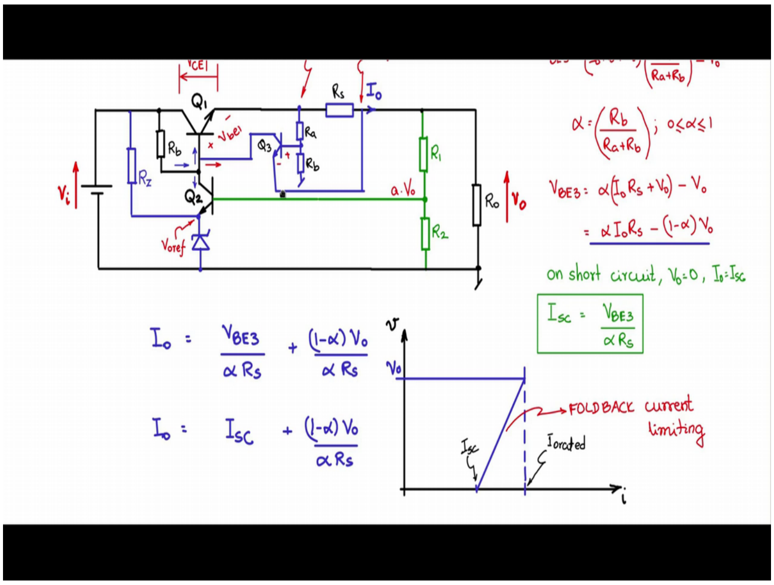

Now, this equation you have V B E 3 by alpha R s, V B E 3 by alpha R s we have defined it as I s c short circuit current. So, I will write I naught as I s c short circuit current plus 1 minus alpha V naught by alpha R s. So, this equation interesting equation if you plot V and I, I naught and V naught you find this interesting. So, this region V naught, so this region as whatever be the load change here I naught change, V naught is constant till it reaches I naught rated. So, this is I naught rated ok.

This circuit will operate in the normal mode, regulation mode for all the loads which appear here till I naught rated. Now, let us say I apply a short across the output R naught is made 0. So, the moment R naught is made 0, V naught becomes 0, this term vanishes. So, I naught reduces to I s c actually I naught when I naught when it was operating in the normal operating mode, a value of I naught here is I s c plus something. And now V naught is made zero under short circuit condition, you will see that this would be the operating point I s c because V naught is now 0. And this is the fold back.

So, when it was operating at I naught rated and something happens a short circuit happens, you will see that the current that flows will be lesser than the rated thereby protecting the devices. And this is called fold back current limiting or current protection, a interesting circuit which can be used by you for any series regulator.