Fundamentals of Power Electronics
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Lecture – 33
Example on shunt regulator

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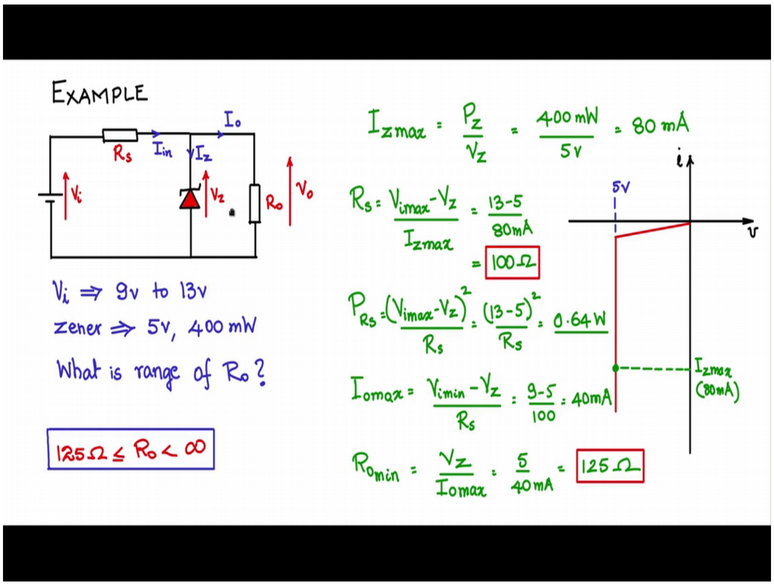

Let us now look at an example of this shunt regulator circuit and try to gain more insight into this by putting in some numbers. So, let us say that V i the unregulated voltage V i varies from 9 volts to 13 volts, this is the spec. So, this is a unregulated V i varies from 9 to 13 volts. Then this Zener, let us say the Zener is the 5 volt Zener, because we want 5 volt at the output so we need to take a 5 volt Zener and let us say the Zener has a spec of 400 milliwatts. What is the range of output R naught? So, let us try to work it out and find out.

So, let us say I z, I z is the current. What is I z max? I z max should be such that the max power dissipation of the Zener 400 milliwatts is not exceeded. So, P z if I take P z 400 milliwatts divided by V z, V z into I z is P z, which is 400 milliwatts by 5 volts this will give you 80 milliamps. So, I z max or I z the current through this branch should not exceed 80 milliamps, if it exceeds 80 milliamps then the power dissipation limit of this Zener is crossed and it will blow.

So, this is one limiting value that you would get and if you actually plot it on the Zener reverse characteristic, as this is a Zener reverse characteristic this is 5 volts here and let us say this is the I z max operating point this is I z max and that is 80 milliamps as calculated like this here.

So, now, R s let us try to find what is this R s. V i max take V i max which is 13 volts minus this node potential which is V z divided by I in. Now, I in I will take it as I z max assuming that I naught is 0. This is one of the extreme conditions that we saw earlier. So, that would be 13 minus 5 divided by 80 milliamps and which is 100 ohms.

So, what it means is that under worst case condition when there is no load and R naught is infinity all the current I in flows into I z, and that would be I z max. Now, that current I in is maximum and V i is max, so V i max minus V z by I z max will give you the value of R s and what should be the power rating of R s. So, the power rating of R s is given by V i max minus V z that is voltage potential difference across R s square by the value of R s which is 13 minus 5 square by R s which is 100 and this turns out to be 0.64 Watts. So, we have selected R s.

Next let us look at R naught. So, first what is the maximum value of R naught I naught that can be allowed through R naught? So, I naught max is even under minimum input voltage condition V i min minus V z divided by R s will be the I in that flows here under minimum input condition. And at that condition what is the minimum R naught that you can apply. 9 minus 5 divided by 100 and that is 40 milliamps, that is the maximum I naught that you can allow through the output and therefore, R naught min if it is max I naught you write down the R naught min which is V z V naught potential is V z divided by I naught max which is 5 volts divided by 40 milliamps this one and comes to 125 ohms.

So, therefore the range of R naught is 125 ohms on one side, on the other side it is open circuit or infinite. So, this implies that R naught can take a minimum value of 125 ohms and a maximum value of open circuit. So, this is the range of R naught for this particular circuit for this kind of specification.

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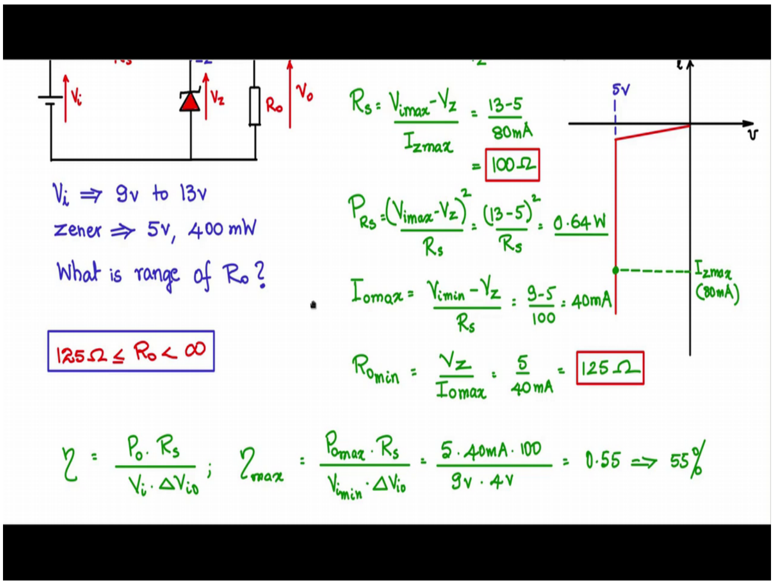

What is efficiency? You can calculate the efficiency of this to complete the understanding. So, efficiency is we have found out that V naught into R s by V i into delta V io or the delta input output differential.

Now, let us say efficiency max. What is the max efficiency? P naught is max. So, we will make P naught max, R s is a fixed value calculated for this particular circuit, V i min take V i min and delta V io. When you take V i min delta V io will naturally be smaller minimum of and therefore the efficiency would be the max possible that you would get.

So, if you calculate V naught max which is V naught 5 volts into I naught max 40 milliamp into R s which is 100 ohms divided by V i min which is 9 volts. Delta V io, when it is 9 volts and the output is 5 volts V io will be 9 minus 5, 4 volts and this turns out to be 0.55 or 55 percent. So, the efficiency of this circuit for these specifications is 55 percent at max load condition.