Fundamentals of Power Electronics
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Lecture - 22
Inrush current limiting – Relay, contactor

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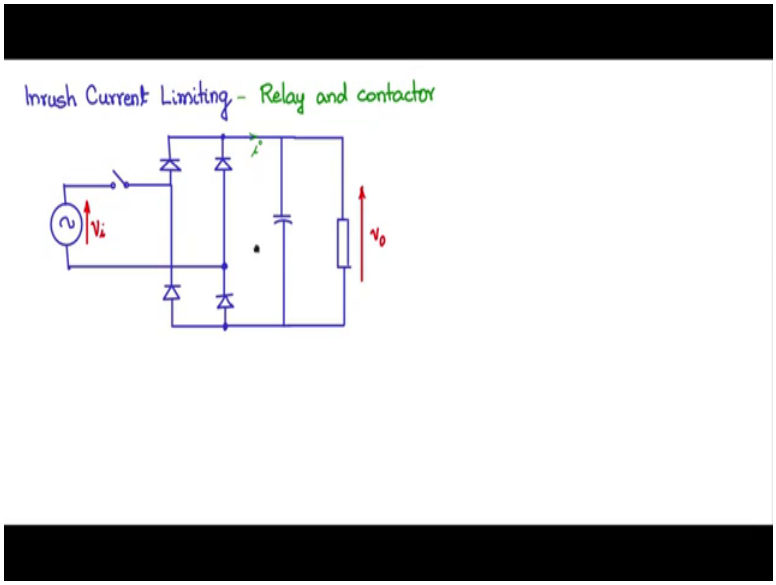

Another very popular method of Inrush current limiting is by use of the Relay and Contactor. This is a very robust and reliable method and this is very well suited for high power application where the power flow is very large and you will see that even though the circuit may look a bit complicated it is a very very reliable.

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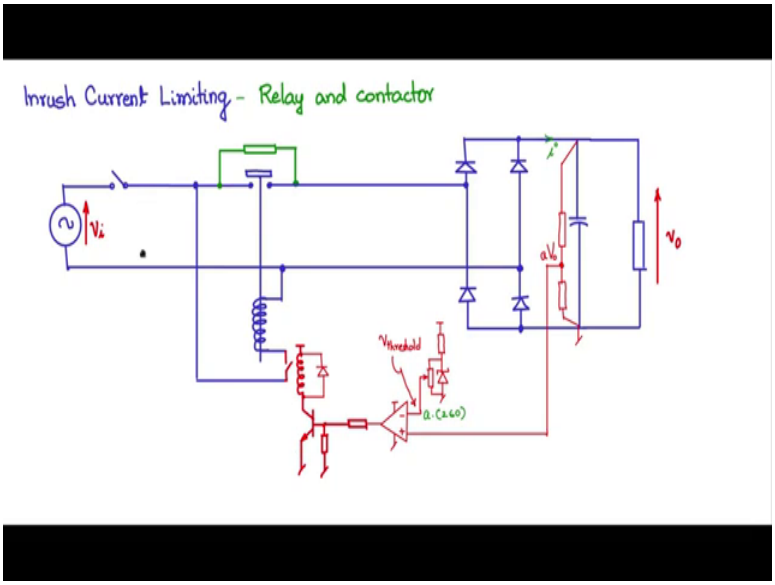

Now, let us introduce this relay and contactor into the circuit. I will explain the operation of the relay and contactor a bit later, let us first now introduce let us understand the concept of introducing this is relay into the circuit.

Now, I am getting a resistance here and connected a resistance like this. Now, this is the typical first inrush current limiting circuit that we discuss that is putting a series resistance, same circuit. So, here the moment the switch is closed you will see that the inrush current is limited by this resistance here and as a consequence all these design values are safe and after sometime it will go into the steady state the first cycle inrush current limiting is done by this.

But we do not want this resistor to be present after it has done its job of limiting the inrush current. So, after one or two cycles we want this to be removed from the picture. So now, that is where the relay and contactors come into the picture. So, let me introduce these two terminals. The idea is that for the first few cycle, first one or two cycles this resistor is in the picture limits the inrush current, steady state is achieved, after that I would like to short this terminals and bypass this resistor and the resistors out of the picture and there is no loss, no dissipation.

Now, here let me introduce the contactor. Contactors and relays both are electromagnetic devices they have a core and around the core you have a coil bound, so like a solenoid. So, in the coil is energized the core is pulled attracted and because of this moment this

core which is conductive will make contact with this terminals and ah establish short circuit between these two terminals. If the coil is not energised due to the presence of this spring this will be released and it will not may contact with these two terminals and the terminals of the open circuit.

Now, how to energize this coil? This coil comes in different Voltages available commercially you get 24 Volt, 48 Volts, 230 Volts. I will right now choose a 230 Volt coil which means if I connect 230 Volts across this coil, the coil is energized, contactor is energized, it will attract the core the core will be pull down it will make contacts with these two terminal and short circuited and there by bypass this resistor.

So, let us make that push to the circuit. I will take this 230 from here itself tap it and connected to this coil through a switch. I will put a switch here let me explain that later why I am putting the switch and finish the connection on that side. So, if this switch is closed 230 comes directly across this coil. Coil is energized it will attract this, this will short circuit these terminals and bypass the resistor, that is idea. So, how do I close the switch? Now, this switch is actually coupled to the coil of the relay. So, there is a relay; the relay basically is for low Voltages. So, these are low Voltage devices contact was generally use for high Voltages these are high Voltages contact switches.

So, this relay can be operated from DC sources. So, I will connect a DC vcc maybe 15 Volts and use a semiconductor device like a BJT and connect it to the ground in this fashion. And the BJT I will provide a simple resistive based drive circuit in this fashion. Across the relay coil you need to put a diode, you will have to give a freewheeling path for the relay coil is inductive and once the switch is off; switched off there is a current flow and that should find a freewheeling path to dissipate its energized, its energy through the l by r constant the r being the resistance of the coil itself.

So, you can go and buy relay coils having 100 ohm resistance, 200 ohm resistance, 12 Volt 100 ohm like that. So, there are very many number of different specs available in the market you can look at the data sheet and purchase of coil accordingly, probably a 15 Volt 100 ohm coil can be used appropriately for this particular circuit.

Now, how do I energize this here? So, let me energize this by connecting it to an op-amp and the op-amp output, output will drive this BJT. So, let me power of this op-amp power supply plus and minus terminal to the minus terminal I will give the threshold

Voltage. How do I give the threshold Voltage here? Let me set up a threshold Voltage I have a resistance I will use Zener diode and across the Zener diode let me connect a potentiometer. So, by adjusting this potentiometer, I can get various, now let us say I use a he told Zener 8.2 Volt Zener. So, you have 15 Volts; 8.2 Volts come across this it is a stiff reference and by adjusting the potentiometer I can get any particular Voltage from 0 to 8.2 Volts.

Now, this let me connect it here and that will form the V threshold for this circuit. So, what does it mean? So, let me explain what do we connect here. So, here let me connect the feedback from the output that is V naught. So, the V naught let me step it down through an attenuator and pick it off at this point you can choose the value of the resistor such that you get any particular desired attenuation let us say a is attenuation, so that is connected to this point. And let us say the attenuation here is a and therefore, a V naught is the potential that will come at this point here. So, V naught is here, a V naught comes in here at this point.

Let me choose at V naught 260 Volts. So, a into 260 value will be the potential I will set here through pot. Now, this becomes the V threshold reference. What it means is that I close the switch the input is charging the capacitor through this resistor. Why? Because this is low, this is off, this is off, coil is not energize therefore, this switch is open and as this is open this coil is not energize and therefore, this is in the release not connected position this is open and therefore, the only path is through this resistance and into the capacitance to charge it up and this Voltage is building up.

And as this Voltage is building up you will see this Voltage a V naught is raising so, as this a V naught is a raising and reaches 260 Volts, as V naught reaches 260 Volt this potential will cross this V threshold point at which point the out the op-amp becomes high and this will drive; the base drive, base current through this BJT, and the BJT will turn on. Once the BJT turns on there is a current flow through this relay coil.

Now, once there is a current flow through the relay coil this will switch on among the switch is on the 230 Volts comes across this coil and energizes this coil which will attract this core of the contactor and this contactor will make contacts with this two terminals short circuited and thereby effectively bypasses this inrush surge limiting resistor.

So, this way this circuit will operate and when you switch off this the Voltage here will decrease and as a V naught decreases and comes below 260 this will go low switch off. This will free wheel through it and the energize, this will open and once it opens this coil is the energized and you will see this will get released and this will get open and surge limiting resistor again back in action immediately.

So, this is the circuit which is most popular and reliable and used in majority of the high-power circuits. In order to complete this circuit, we should see how we get this DC power supply here only then the circuit becomes complete. So, we will get this DC power supply from this means 230 Volts itself. So, how do we do that?

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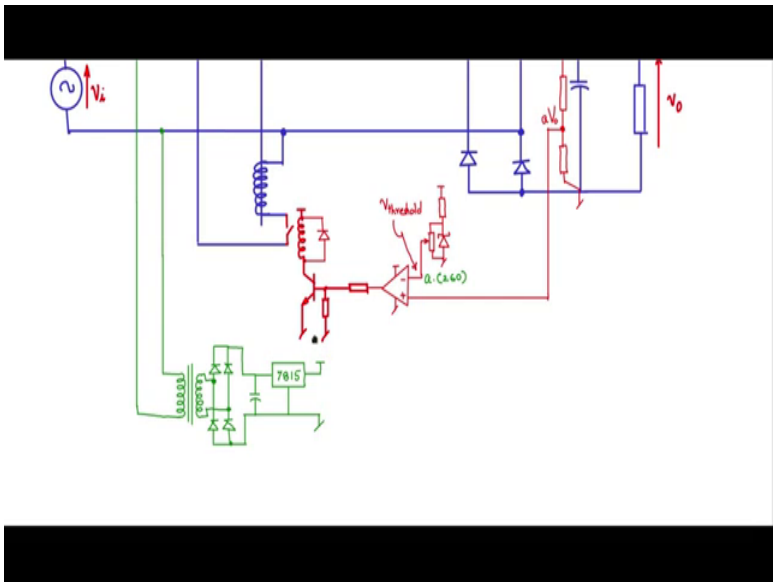

So, let me draw this portion here, the circuit and let me tap it from this. Let me put a transformer. Now, you see I do not want to put another surge limiting type of circuit active surge limiting circuit. I will use a passive surge limiting circuit like a transformer for a low power application because all these power put together will be very very small compared to the load power therefore, one is justified in using a transformer based rectifier capacitor filter where isolation and inrush current limiting will happen.

So, connect it in this fashion we know how to connect this this is the full bridge diode and output the full bridge diode you connect a capacitor and across the capacitor. The load here will be a linear regulator and outer the linear regulator will give you the power supply.

And say we have 15 Volt power supply, there are various linear regulator ICs which can be used to generate the 15 Volt power supply. You can use the 7-8 series; you can use the lm 317 lm 350. For example, here I can say that we can use a 7815 to generate a 15 Volt supply here and this will be connected across these two points, these are the common points here and the ground, yeah. So, that way all this portion will get power. Now, the circuit becomes completely operational and self contained.