Fundamentals of Power Electronics
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Lecture – 24
Simulation – 3 phase rectifier capacitor filter

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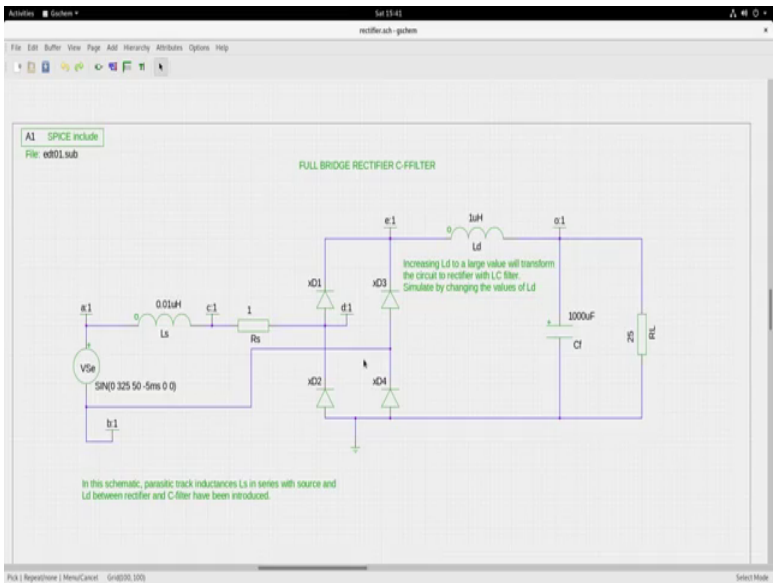

Let us now develop the spice simulation model for a Three-phase Full Bridge Rectifier Capacitor Filter.

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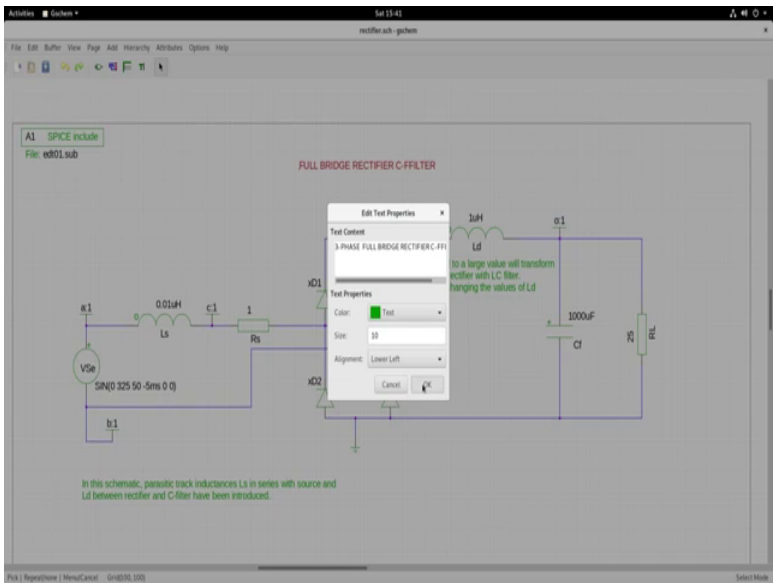

So, first let me change this title. I will make it as a three-phase full bridge rectifier capacitor filter and place it there. We will remove this, remove this.

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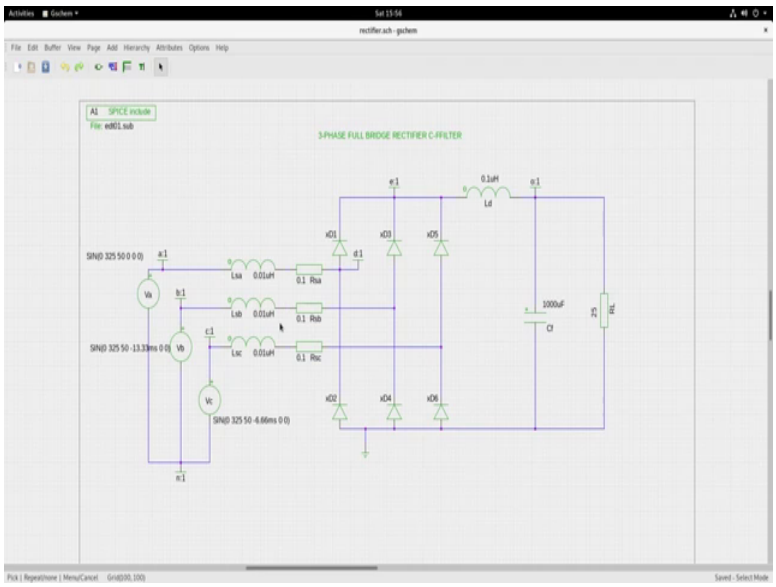

Now, we have to add three sources, let us redesign these arcs. So, let me take that out. Now, let us copy paste because we need a third arm and I will put that there. Now, you need to expand this a bit more. Let me pull it down, so that you can accommodate more space here to accommodate a three-phase star connection, then make this connections proper completed complete this. Let me center this. Yes, now we can move this together. We will make duplicates copy, control paste, control paste. So, we have three sources remove you can rearrange them accordingly so that does not clatter up.

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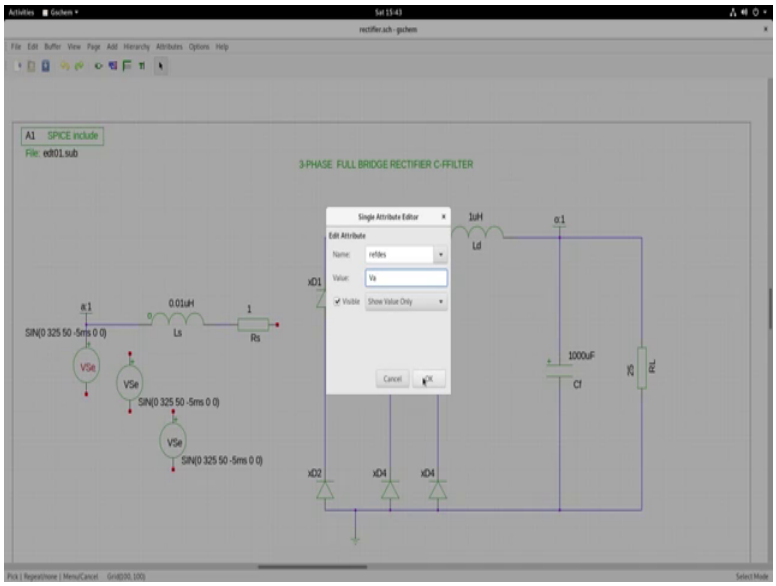

You have to name them. Let say we name them as V a, V b, V c or V s a V v s, VSe. So, V b, V c, then rename this diodes 5 and 6. So, you have to give unique names for the components those that you have copied and then make this one as sin 0, sin omega t and this one 13.3 milliseconds and 6.66 milliseconds. So, you will have tha. You will have to duplicate this and connect control copy, control paste, copy, control paste, control paste. So, let us rearrange and connect this.

So, after rearranging and then properly connecting the entire three-phase circuit looks like this. So, you have V a, V b, V c, these are phase voltages with respect to the neutral, V b with respect to the neutral, V c with respect to neutral. So, the phase voltages are 325 volts peak ok, and they are all delayed 120 degrees apart and you have Lsa, Lsb, Lsc as the lumped non-ideality in the AC line or Rsa, Rsb, Rsc are the surge limiting 0.5 0.5 0.5 ohm surge limiting resistors.

Then this is another non-ideality. This extra diode set that we have put here, these two are the same. Now, we will simulate I have observed the node points that I have labelled this is node a, node b, node c, node n. So, if I say V a comma n it will be between these two, if say V a comma b it will be the line voltage between a and b, V b comma c would be the line voltage between b and c, c and a, so on. So, between this and this it is line voltage, this and this it is line voltages. So, what you expect here? It is the peak value of the line voltage which will be which will be 560. The voltages V a, V b, V c are with

respect to the neutral. So, this node will be 325 volts peak, 325 volts peak, 325 volts peak or 230 volt rms. Now, the line to line voltage is root three times which will be 400 volts rms and root 2 of that around 560 volts will be the peak and you will be expecting 560 volts approximately about in that range across the output.

So, now, let us see how we go about simulating and let us see the various waveforms. I like to see the current at this point current at this point, would like to see this voltage, like to see all these three voltages. So, let us modify the rectifier dot c i r circuit, so that automatically it calls ngspice, runs and then plots the first draft waveforms.

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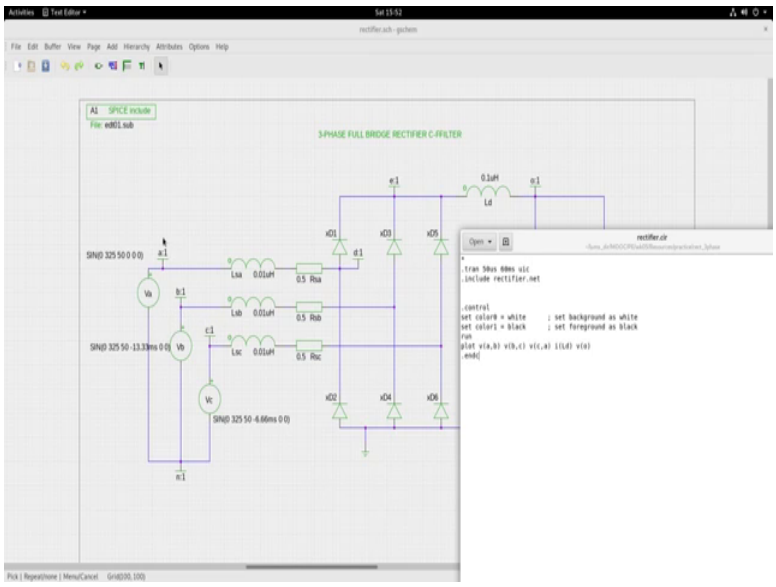

So, look at this. I have opened the rectifier dot cir. These are the standard tran statement and include the net list statement. I have included between the dot control and dot end c. The control statements to be operated within the ngspice environment automatically; I am setting the foreground background colour as white and foreground as dark black.

Then asking ngspice to run the simulation on the net list and plot v a b that is the line voltage a to b away from here to hear plot b c that is this to this and c to a. And I would like to see the inductor current here, so that I will get this branch current and I have also would like to see v naught. So, let us have a look at all these waveforms in ngspice after the simulation has been concluded. So, for that let us open a terminal.

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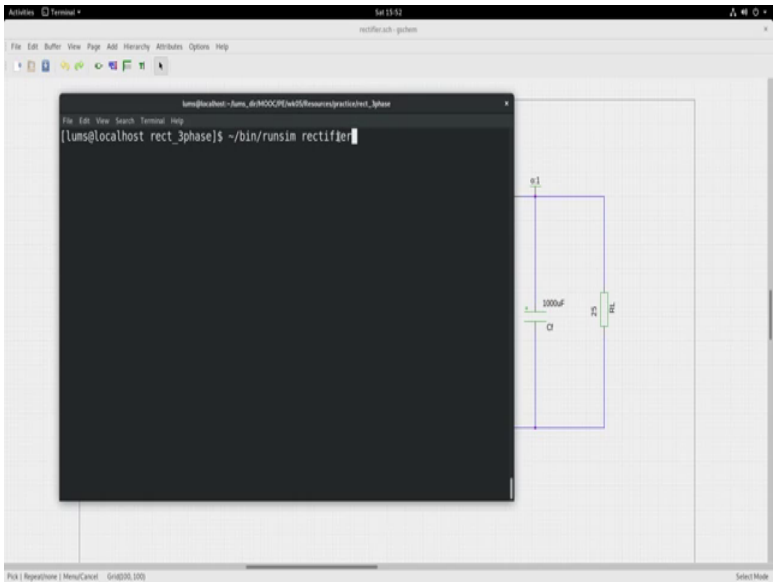

So, we have opened the terminal and let us run this simulation I am calling a runsim and rectifier.

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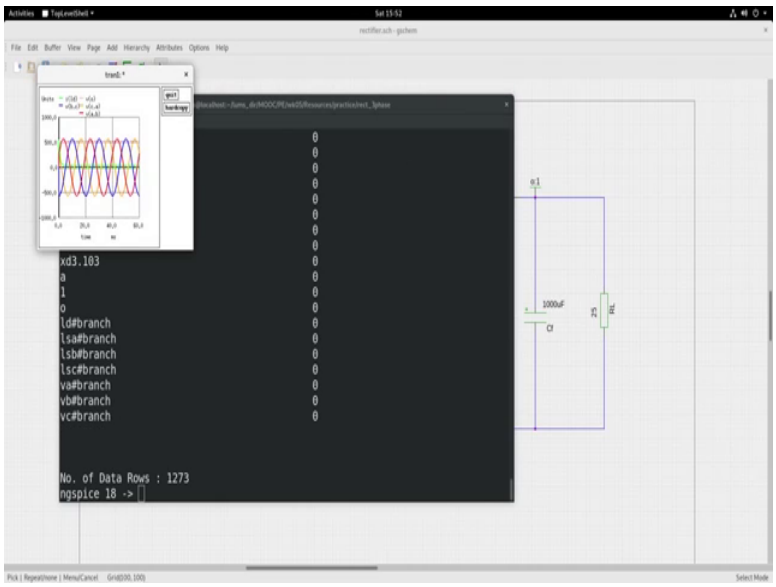

So, if you do that goes in the ngspice runs the simulation plots.

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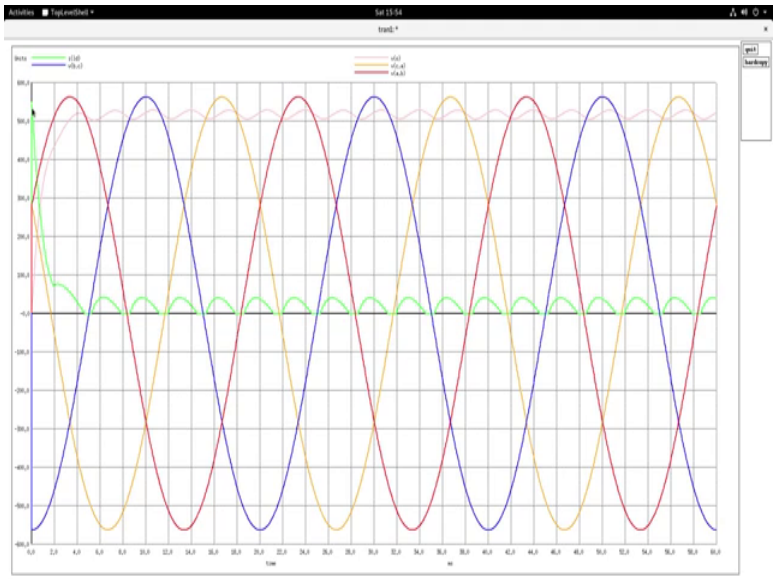

Let me maximize that. So, you see whole lot of plots here, you see. These are the line voltage red this one, where my cursor is travelling through that is v a to b, blue that is v b to c and this yellowish colour will v c to a. Green, green is the current in the branch just before the capacitor. You see after one cycle steady state is reached see that at every at every point where there is a repel where the output conducts you will see the conduction here. You will see this drop here is due to the resistive surge limiting otherwise this surge would be very very highurge limiting circuits are similar, even in the case of three-phase you can use the circuits that we discussed for surge in rush current limiting given here.

So, after the first cycle surge limiting you see that it goes in to the steady state you will see that there are 1, 2, 3, 4, 5, 6, ripple 6 ripples in a fundamental cycle. So, the ripple frequency is 6 times and this is the output wave shape. If you would like to see what would be the inrush current limit when we remove or when we reduce the surge limiting resistor value, then you will see that the inrush surge limit can go to very very large large current values. Let us have a look at that also.

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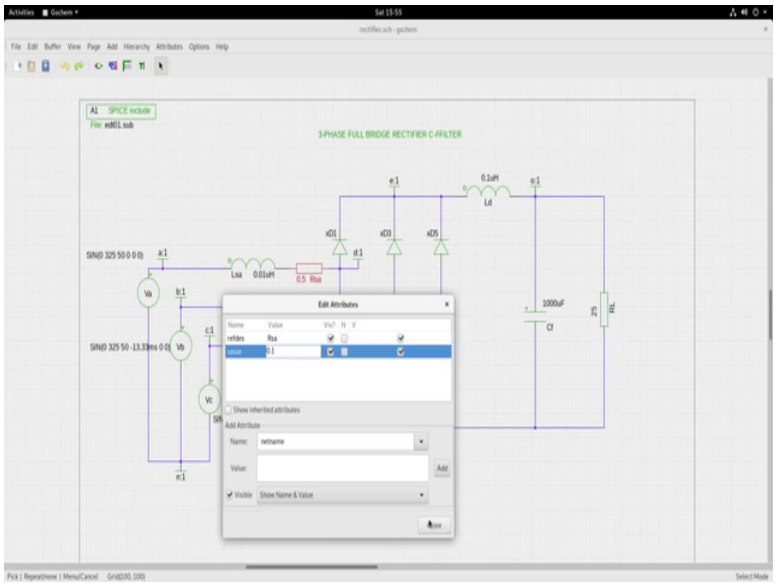

I will change these values to 0.1 ohms; almost no surge limiting resistor there. These 0.1 ohms would represent all the line resistances are no more.

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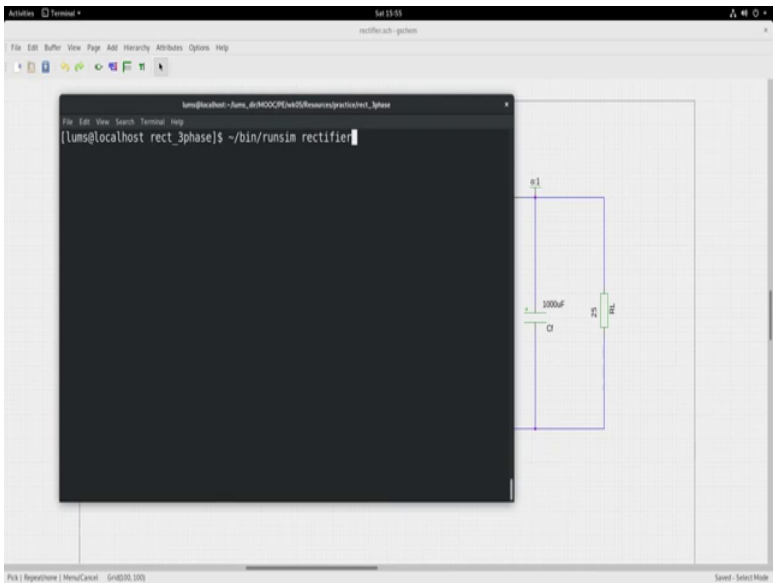

So, let me save this, and let us go to the command line called rectifier, run that.

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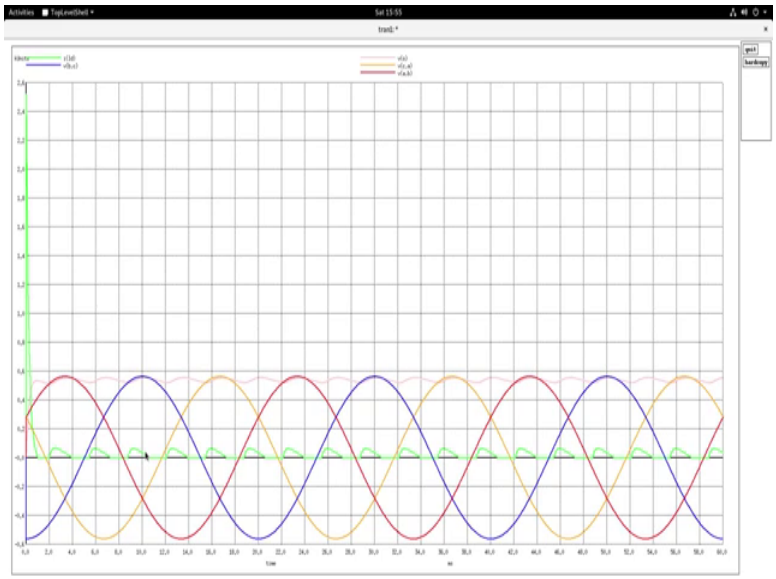

And you see the; you see the first cycle inrush current 2.6 kilo units, say the 2.6 kilo amps and then immediately in the next cycle you see that it has achieved steady state. And observe the drop because we have reduced r s the surge limiting resistor the drops are much lesser, if you want to zoom to any particular place right click drag that and you could see the zoomed values at that point.

So, this way I will recommend that you try to study the three-phase circuit and the various waveforms branch currents node voltage waveforms at various points to understand gather more insight into this three-phase full bridge rectifier c-filter circuit; very very similar to the single-phase full bridge rectifier c-filter circuit.