EE450 - Electronic Control of Motors

Lab 5 - Simulink Three Phase Rectifier

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Abstract

This is the extra credit lab (formerly lab 5) that was assigned over spring break. This lab is a Simulink recreation of a 3-phase rectifier. Unlike most of the Simulink simulations, this incorporates the use of a multimeter than a scope. Modifications were made to circuit to test the equilibrium change within the results of the upper and lower bounds.

Simulink Results

The simulink is the simulation of a 3-phase rectifier. It contains 3 inputs, all at 100v and 60Hz, with 3 different phases: 0, 120, & -120. The load has a resistance of 1Ω and an inductance of 1mH. The universal bridge is a commutated diode bridge configuration of 3 sets, and is modified to input the 3 AC sources. This diode bridge has a preset of 100kΩ snubber resistance, infinite snubber capacitance, 1mΩ for turn on resistance, and 0 for turn on inductance and forward voltage. This allows for minimal activation resistance and a clear signal by preventing spikes in currents/voltage for when the bridge is activated. When extracted, the result is of the Vout's upper and lower bound located on the ~~RLC~~ RL branch. The branch has a set resistance of 1Ω and an inductance of 1 * 10^-3 H. The schematic of the simulation can be seen below.

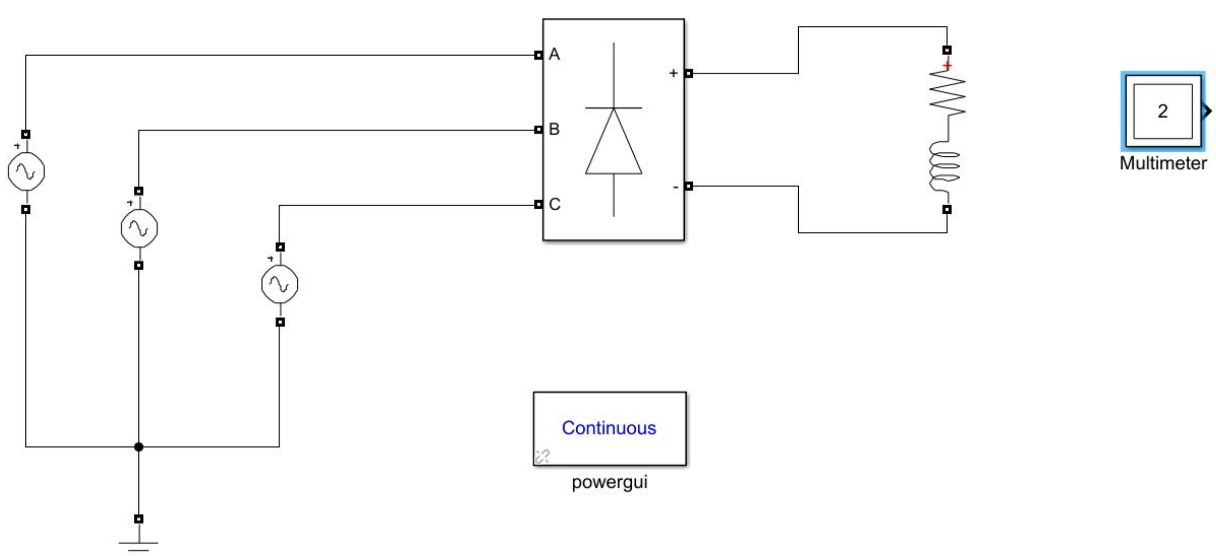

Figure 1: *This is the complete circuit where there are 3 AC inputs flowing into a universal bridge. It is also loaded with an RL load.*

As result in the simulation, the lower shows a clean sinusoid in the lower bound (pre-rectification) and shows a clean and DC signal that in phase with all sweeps matching with the initial input. Given that clarification, there is still a specific detail that can be noticed in the result of the values outputted for the voltage. The results are shown below in the figure.

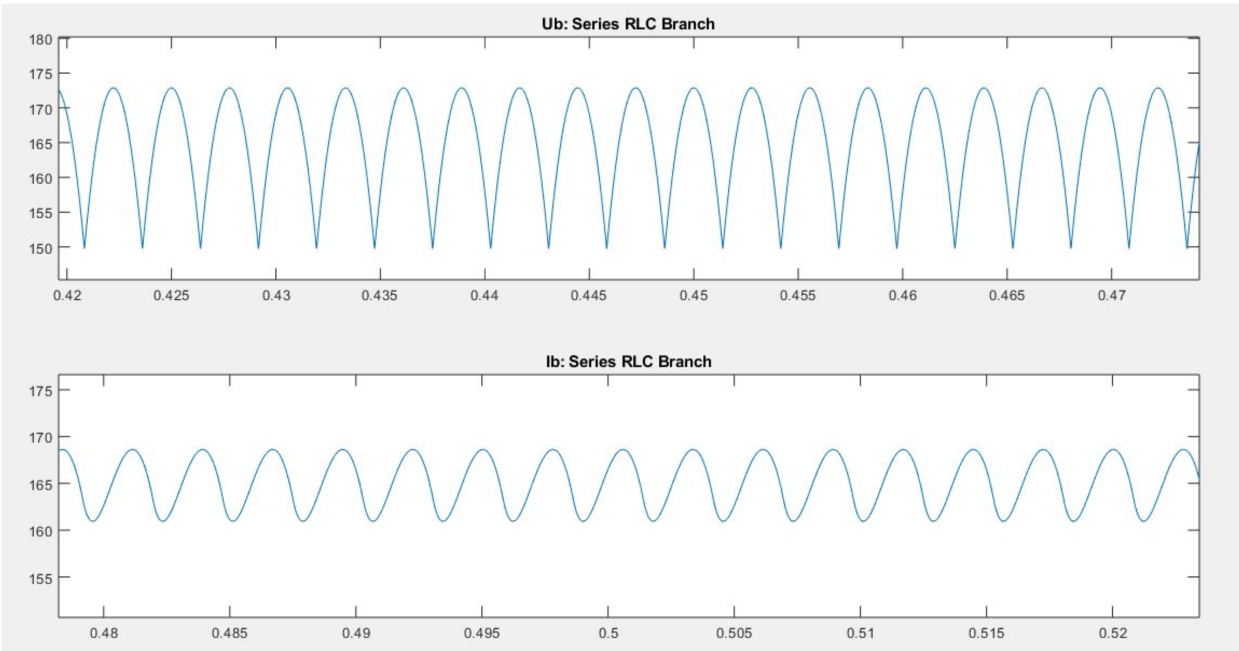

Figure 2: *The results of the preset parameters. The Lb (lower bound) is the signal before rectification and the Ub (upper bound) is the rectified signal.*

As shown, the signal is initially balanced at 165v and has an amplitude of ~4v. After rectification, the signal becomes amplified, but drops in initial voltage. This is because the signal mixed with 3 AC signals overlaying on one another where the 1st, 2nd, and 3rd signal is consecutively read and displayed. In the sweep, the 1st sweep is input from the far left AC signal, the 2nd is the from the middle AC signal, and the 3rd sweep is the far right AC signal. As the conversion is balanced, the DC is in phase and results in a appropriation of the signal giving only the positive sweeps of the signal. This acts as a magnitude and also has an amplitude that has increased by six times.

Simulink Modifications

Now, given this balance, we must see how this system works by modifying the values. The signal has various effects and let's start with the load resistance. This will affect the initial current and voltage output as they are directly correlated nasad will also affect the reactance since there is also inductance involved in this setup. A simulation of the increased resistance is shown below.

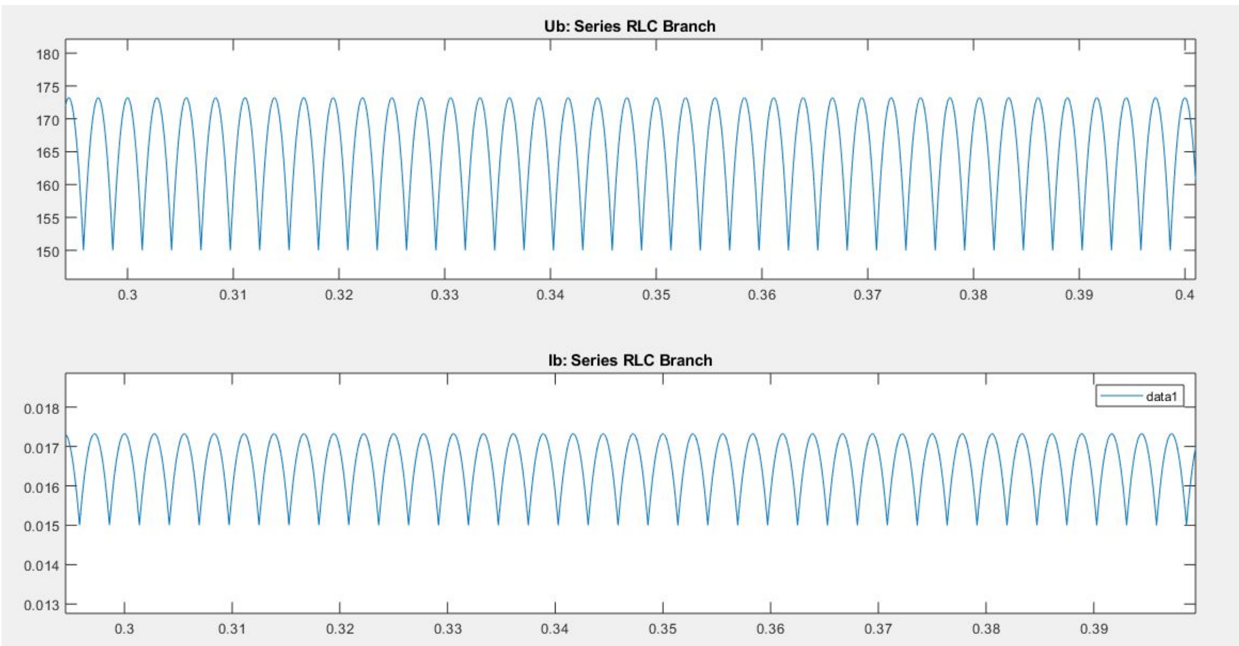

Figure 3: *The result of the load resistance changing 10kΩ from 1Ω.*

Here, the resistance was drastically increased and it affects both the Lb and Ub in different ways. Since there is a massive increase in resistance this creates an increase in voltage activation causing a lot of energy to be sent in to activate the diode and leaving very little voltage and current to be emitted from the initial signals as shown in the Lb. As result, this also increases the oscillation of the frequency due to reactance increasing as shown in both the charts. The reverse happens when reducing the resistance, but throws off the signal if drops below the activation resistance set within the diode.

The signal also becomes very thrown off for the inductance if it is modified. If the value of inductance is changed, the signal sweeps very slowly and the take longer to read. The result is shown in the diagram below.

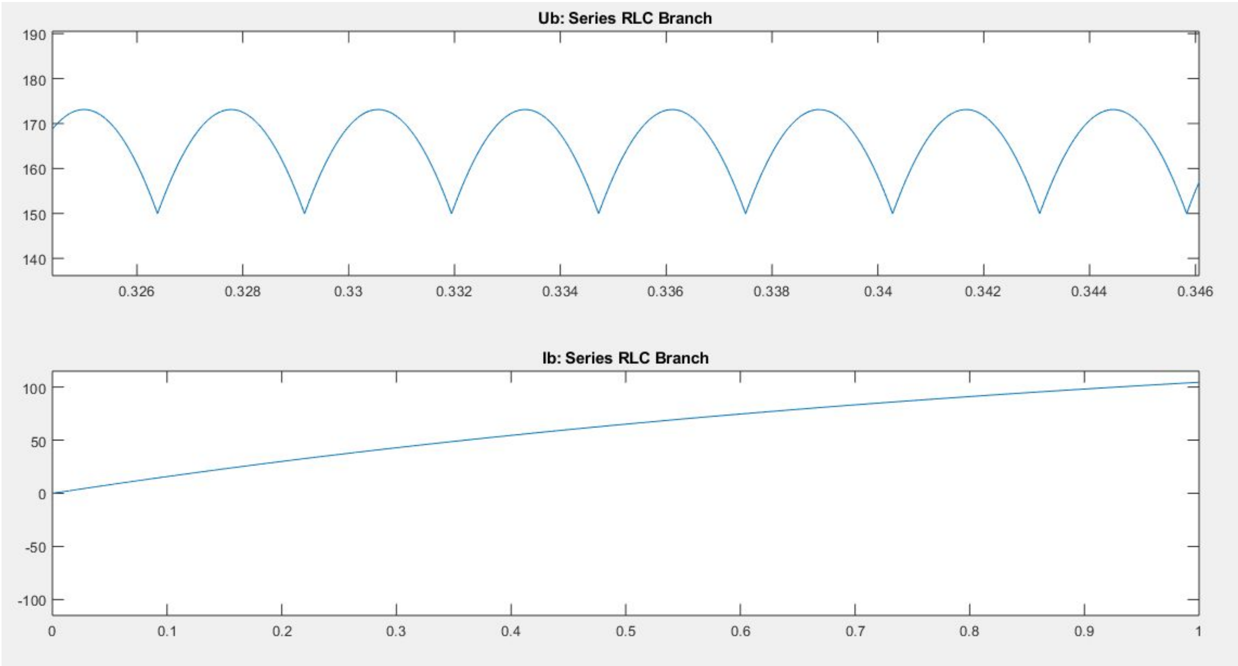

Figure 4 : *With regular resistance and the load inductance changed to 1H from initially being 1mH.*

As shown, the sweep take only sweep across 0.005 units for signal 1, 2, and 3 in the Ub and is exponentially extended in the Lb. This is because inductance has a inverse effect when compared to resistance. In reactance, the resistance is the physical (real) component and the inductance is the imaginary component. Specifically, they orthographically are specific in their measurement and thus affect the signal in inverse ways where if one shortens, the other lengthens the signal.

Lastly, the 3-phase input has the most dynamic way of changing the signal as it sets the overall parameters for the shape of the signal. The 3 components that are modifiable are the voltages, frequencies, and the phases. If by changing one, all are changed with fluctuating results. For this modification, the far left signal was changed to 230v from 100v, the middle signal was changed to 120Hz from 60Hz, and the far right signal had the phase modified from 120 degrees to 30 degrees. As result, the figure below shows the changes.

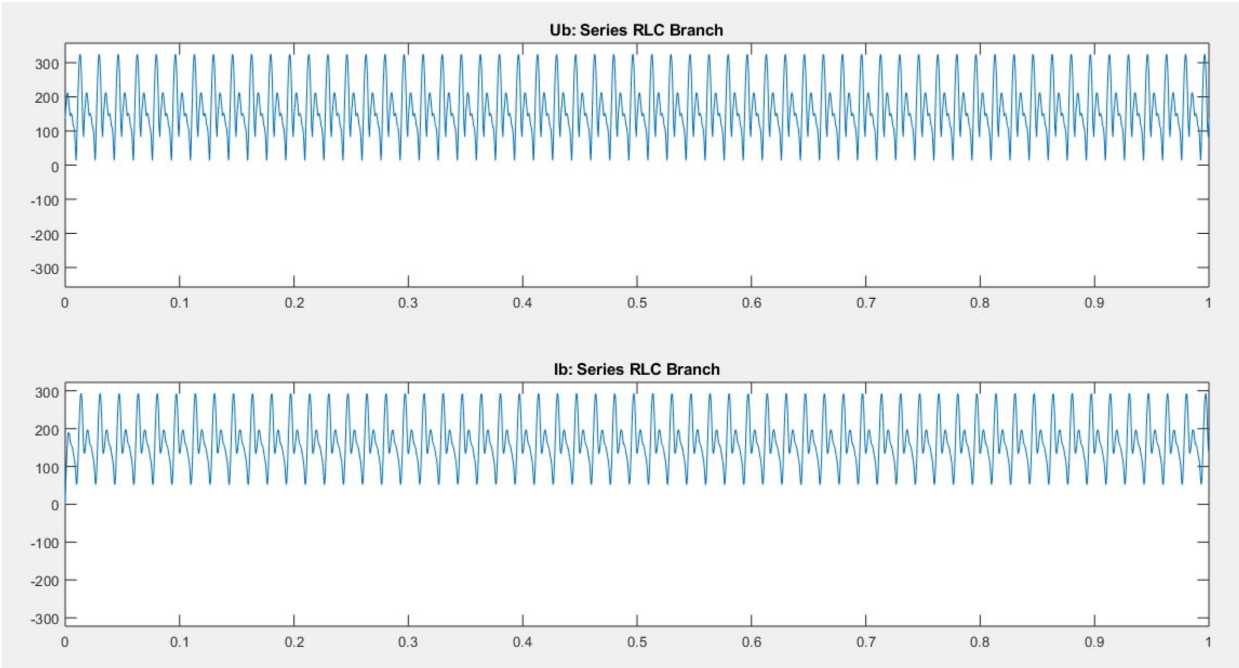

Figure 5: *In this result the AC change in the far left signal was changed from 100v to 230v, the middle signal was changed from 60Hz to 120Hz, and the far right signal had it's phase changed to 30 degrees from 120.*

In short, this substantially changes many factors. First with the voltage, the initial amplitude of the voltage is magnified by several fold and concludes to direct proportional increase when one is increased, the result also increases. When the frequency increased, the oscillation drastically increased as well. This is because with every sweep regarding the frequency, the time is still the same, thus increasing the frequency count equates to more sweep within the same time frame. If the frequency is lowered, the effect happens similarly when increasing the inductance and the signal becomes slower taking longer times to sweep the signal once. As for the phase, this affects both the Ub and Lb signal formation creating a signal that is inconsistent in the amplitude and the isolation of the DC signal. Essentially, if the phase gets thrown off, the signal will pass through un-rectified and unamplified. This creates essentially a short and unprocessed signal.

Conclusion

Overall, this signal very tightly packed in the format it is set and by having it set as 3-phase acts a very finicky setup where the voltage, frequencies, and phases must be appropriately aligned or the signal will not be able to be rectified and amplified. However, the when successfully created result becomes very clean and defined. There are trade offs, but given this scenario, the use of a RL load creates a lot of dynamics in controlling the output whether you need a slow or fast response given the need for a high power factor or low power factor response. If an fast signal is needed the inductance or the frequency can be modulated and the input/output needs to be modified, given the scenario, the input voltage or resistive load could be modified.