EE450 - Electronic Control of Motors

Extra Credit - Simulink Single Phase Dual Converter

Simulink developed by Paco Ellaga

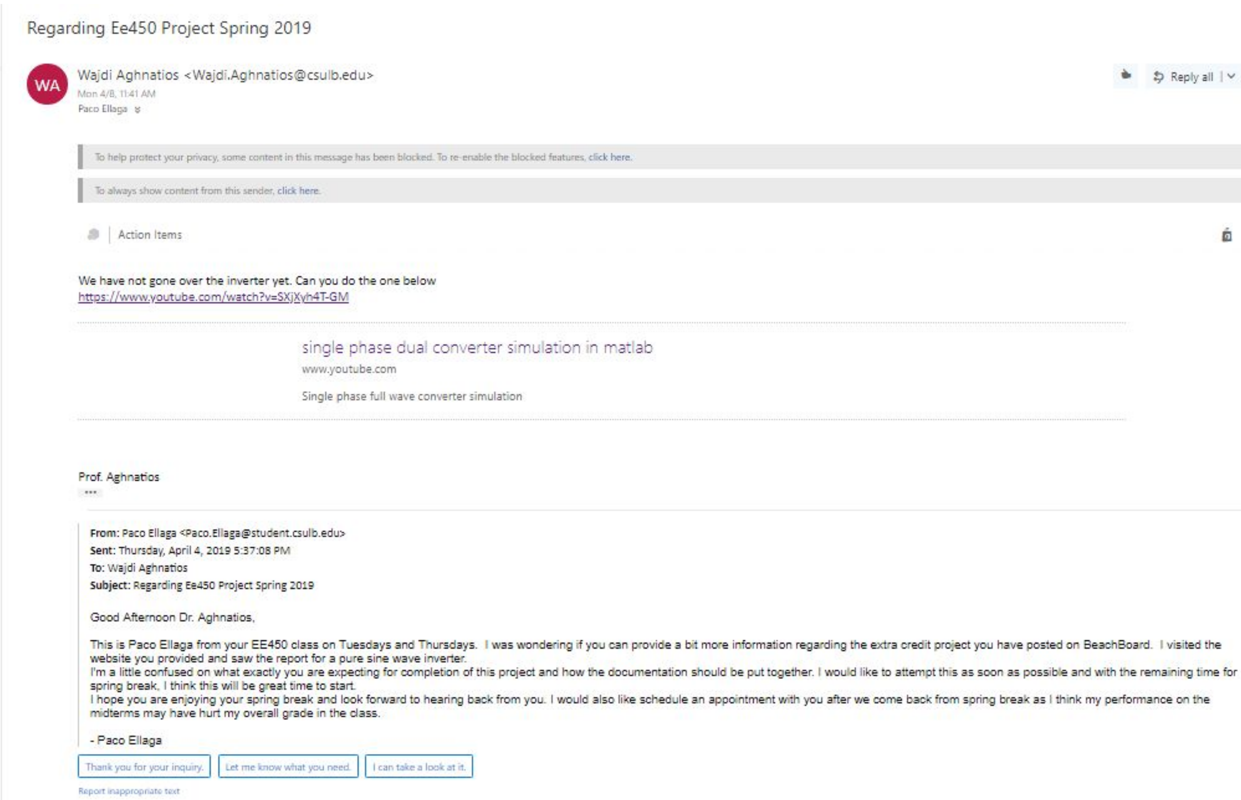
Student ID: 009602331

Course Instructed by Dr. Wajdi Aghnatios

April 12, 2019

Abstract

This lab simulation utilizing Simulink is of the Extra Credit specially assigned by Dr. Wajdi Aghnatios via email in replacement to the extra credit lab shown on Beachboard originally posted on Feb 6th, 2019. On April 8th, 2019, via email, is was reassigned as to complete the simulink of a single phase dual converter. The video link is provided as shown here: <https://www.youtube.com/watch?v=SXjXyh4T-GM>. This lab analyzes the structure and results based through modification of values of the individual components of the entire systems. Below is the snapshot of the email verifying the change:



Regarding Ee450 Project Spring 2019

WA Wajdi Aghnatios <Wajdi.Aghnatios@csulb.edu>
Mon 4/8, 11:41 AM
Paco Ellaga

Reply all

To help protect your privacy, some content in this message has been blocked. To re-enable the blocked features, click here.

To always show content from this sender, click here.

Action Items

We have not gone over the inverter yet. Can you do the one below
https://www.youtube.com/watch?v=SXjXyh4T-GM

single phase dual converter simulation in matlab
www.youtube.com
Single phase full wave converter simulation

Prof. Aghnatios

From: Paco Ellaga <Paco.Ellaga@student.csulb.edu>
Sent: Thursday, April 4, 2019 5:37:08 PM
To: Wajdi Aghnatios
Subject: Regarding Ee450 Project Spring 2019

Good Afternoon Dr. Aghnatios,

This is Paco Ellaga from your EE450 class on Tuesdays and Thursdays. I was wondering if you can provide a bit more information regarding the extra credit project you have posted on BeachBoard. I visited the website you provided and saw the report for a pure sine wave inverter.
I'm a little confused on what exactly you are expecting for completion of this project and how the documentation should be put together. I would like to attempt this as soon as possible and with the remaining time for spring break, I think this will be great time to start.
I hope you are enjoying your spring break and look forward to hearing back from you. I would also like schedule an appointment with you after we come back from spring break as I think my performance on the midterms may have hurt my overall grade in the class.

- Paco Ellaga

Thank you for your inquiry. | Let me know what you need. | I can take a look at it.

Report inappropriate text

Figure 1: Email transcription between myself and Dr. Aghnatios

Method (Pre Dual Converter attachment)

According to the schematic of the converter tutorial, there was a pause where the circuit was measured and the following report is the results of those measurements. From this, there are preset values for almost of all the components. The load resistor is set to 10Ω, the AC voltage source is set to 230v, and the frequency is set for 50Hz. As for the pulse generators, they are all set to 0.02 seconds/period, having an amplitude of 1, pulse width of 5%, all with varying phase delays. As for all the pulse width generators (if you read the generators 1, 2 , 3, and 4 from left to right, top to bottom row), 1 and 4, and 2 and 3 pair up with their phase delays of 30/360*0.02 and 210/360*0.02 respectively. As shown below in ***Figure 1***, you can see the first half of the converter as a full wave rectifier format.

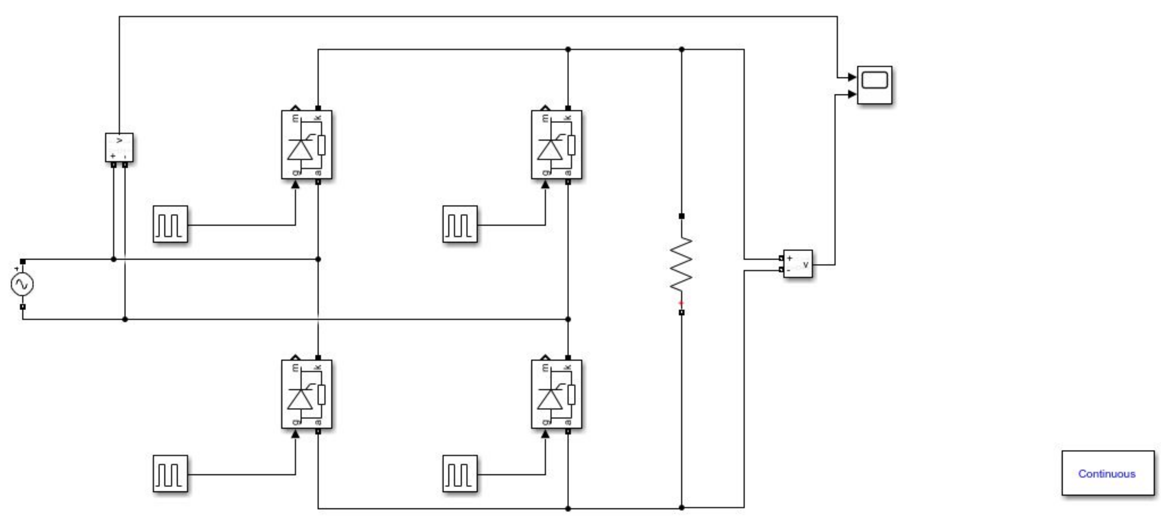


Figure 1: *Original Diagram before conversion set as a full wave rectifier*

For the thyristors, they have preset values and when placed, the values were unchanged. As shown below in ***Figure 2***, you can see the various parameters set up for the thyristor.

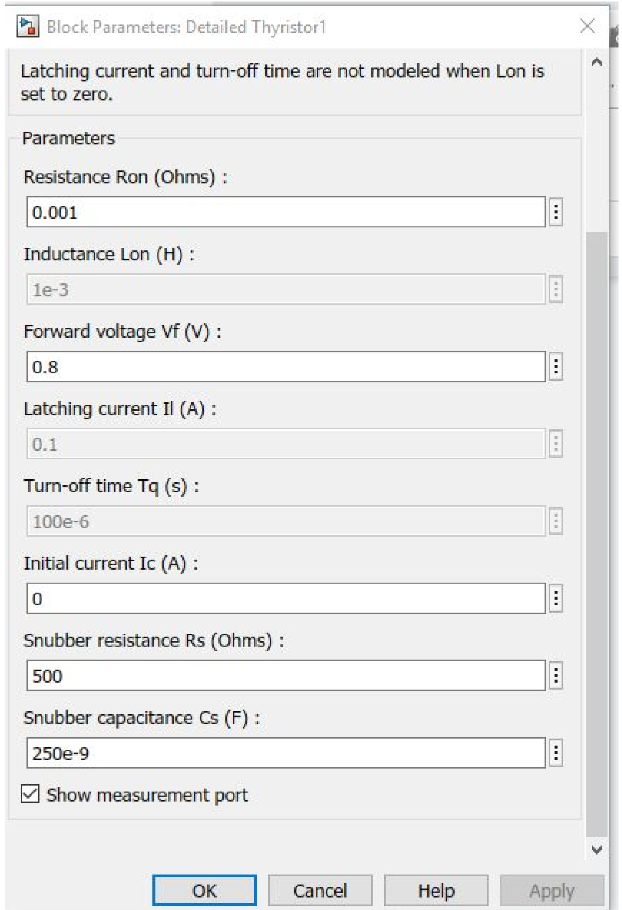


Figure 2: *Basis of the parameters for the thyristor*

By analyzing these values, the thyristor has resistance is set to 1mΩ and the inductance is set to 1mH to turn on. It is also internally set with a forward running voltage is set to 0.8v, a latching current of 0.1A (with an initial current set as 0A), snubber resistance of 500Ω, snubber capacitance 250nF, and turns off within 100µsec. And by taking this into consideration, these values are loaded into every cycle and help shape each AC-DC rectified signal instantaneously with each cycle. As result of this rectification of the 230v-50Hz AC signal, the following graph is shown below.

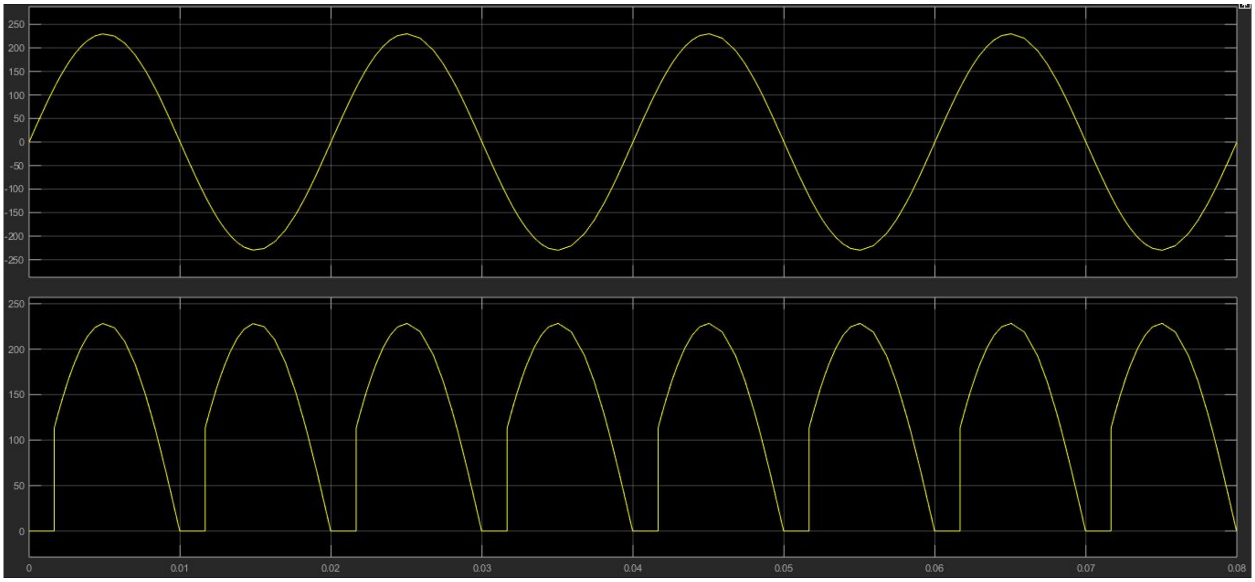


Figure 3: *Result of the single phase converter with the top signal being the AC source and the bottom signal being the output based on the Vout measurement measured from the poles of the resistive load.*

Here, the rectified signal shows a regular response of the full wave rectifier setup. The peak is equal to the original signal of 230v and has a natural response on the return down back to zero. Instead of showing a negative valued response of the signal, the signal is repeated. But, the signal is nulled until reaching the α-value, which then instantaneously spikes to ~113v. This mark is the moment the thyristor turns on and based on the phase determines how long it takes.

<u>Method Manipulation (Pre Dual Converter attachment)</u>

As per analysis of the circuit, if the voltage is increased or decreased, the max voltage of the AC input and the DC rectified version both proportionally increase or decrease. If the frequency the system is drastically changed as omega is present everywhere from the reactance, theta, etc. and if the frequency is increased, the signal extends. This conversion will cause the signal to take extensively longer to loop over and over. If decreased, the signal will repeat very quickly and have tighter frames to calculate α and there will be obvious signs of voltage leakage.

As for the load resistance, the load directly affects the DC nulling frequency and the peak voltage depending how it is manipulated. It was discovered if the load resistance is increased, the chance for nulling will be eliminated and the chances for α to activate will turn on the thyristor repeatedly upon where the system may not have fully cooled down to 0v, thus creating a minimum nulling value above 0v. This will cause power to be drained substantially as current will be very minimal due to such a high resistance flowing through the system. In the other scenario, where the resistance is lowered substantially, the rectification actually results in voltage and power loss. This is due the thyristor not operating at full potential, thus hurting overall performance. The result of these events can be seen in the figures below.

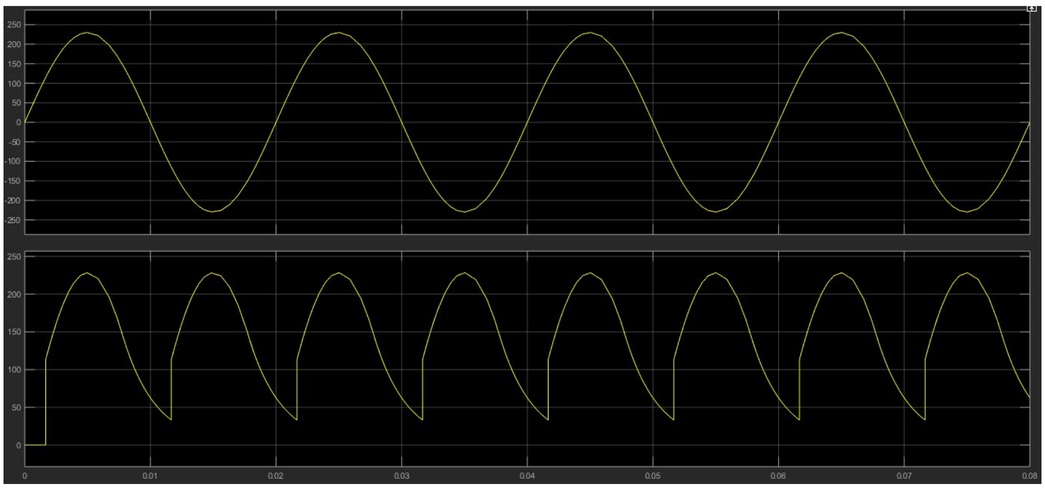


Figure 4: *This the result of the load resistance increasing to 10KΩ from 10Ω. As shown, the period of null frequency to α is practically non-existent.*

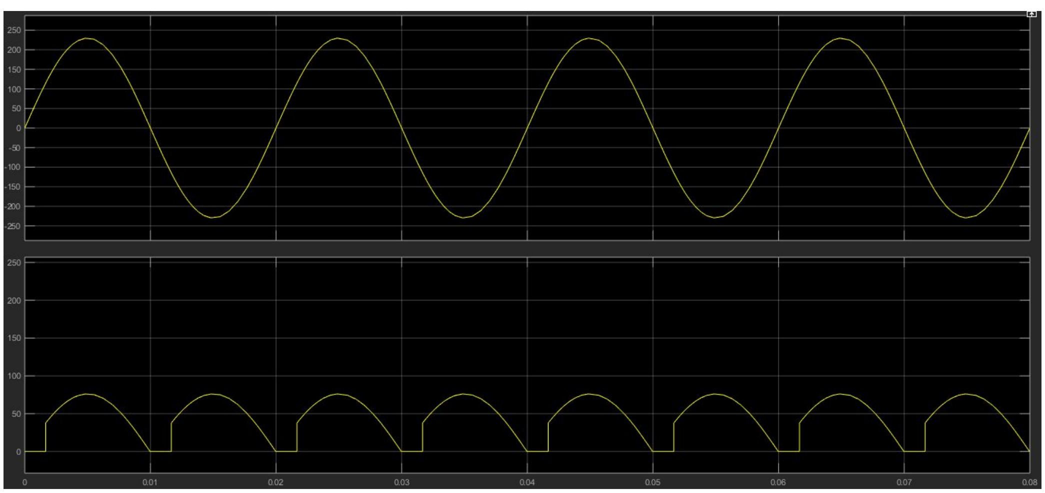


Figure 5: *This is the result of the load resistance decreasing to 1mΩ from 10Ω. As shown the voltage dropped from ~230v to ~38v.*

When the pulse generator is manipulated by the phase delays, the overall signal will appear different based by how much is increased/decreased by thyristor 1 & 4 or 2 & 3. With thyristor 1 & 3, every odd numbered signal from the beginning will be affected and for the even numbered signals 2 & 3. The result shown is the overall result of the entire signal being emitted as when the thyristors are on the other is off, and it will show that it continuously is a DC pulse measured in the form of a AC signal where the moment of activation is measured by the α-value in the direct spike shown on the first half of the signal. If the value of the phase is increased, the signal will take longer to be activated, but still retain the remaining signal till it nulls out. And since it is in phase with the period, the DC will show only the remaining parts and not shift out of alignment. The vice versa will happen when the phase is reduced. This is because the α-value to activate the signal will occur sooner giving more of the actual signal. The figure below shows visual of this proof.

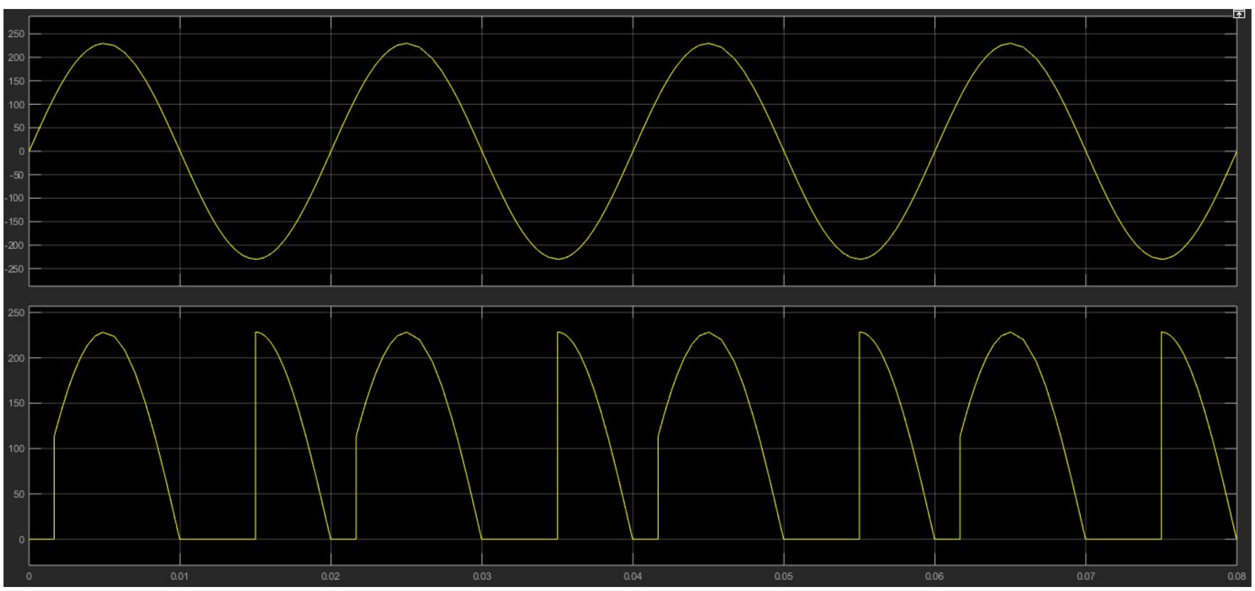


Figure 4: *Here, thyristor 2 & 3 were increased from 210/360*0.02 to 270/360*0.02. Thyristor 1 & 4 were unchanged and the differences are very clear to what happens when phase distorts.*

When comparing the figure in relation to the formula, this is where the α-value in terms of degree/rad is increased. With a bigger alpha, it would take longer for the signal to activate. This would also mean a smaller alpha means the rectification would also turn on the thyristor faster.

Method (With Dual Converter applied)

As for the fully completed lab circuit of the lab, the following figure below illustrates the single phase dual converter design. This is the same as the full wave rectifier, but there another rectified set where it is converted back into AC through the use of a thyristor loop similar of the full wave rectifier, but with the phase delays of 150/360*0.02 for 5 & 8 and 330/360*0.02 for 6 & 7 (if you read the them left to right from top to bottom on the right hand side only). The Simulink figure is provided below for visual representation.

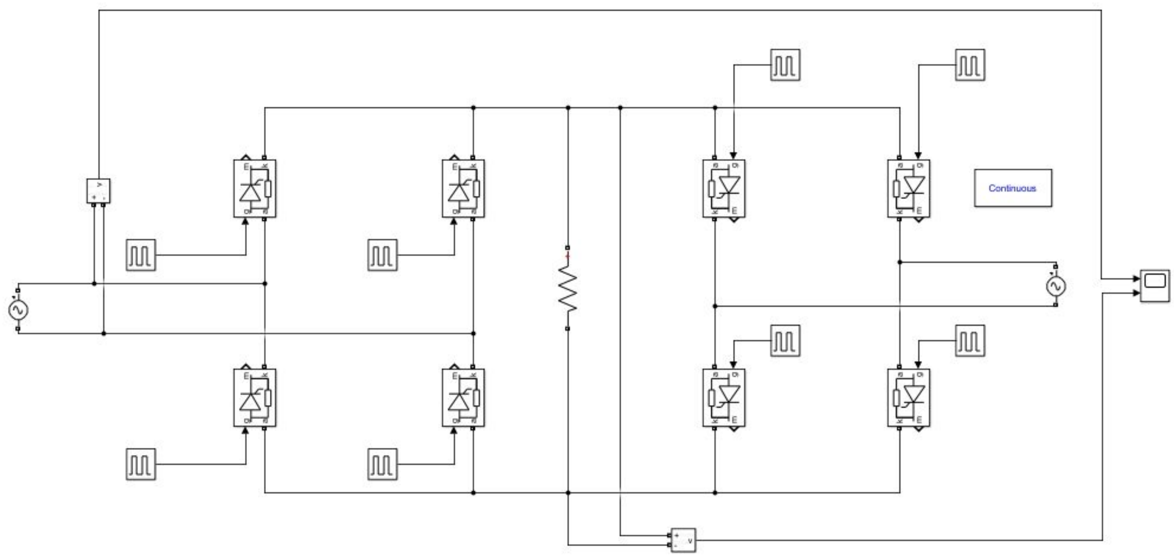


Figure 4: *Full design of the single phase dual converter*

As result, the signal is sent and activated at an specific α-value as shown before from the previous circuit. The signal then flows as it nulls out again as only the positive values are being recorded. But, since the signal is being converted back to AC, there is another variable included called ß. This changes the overall look of the system as shown below in the figure provided.

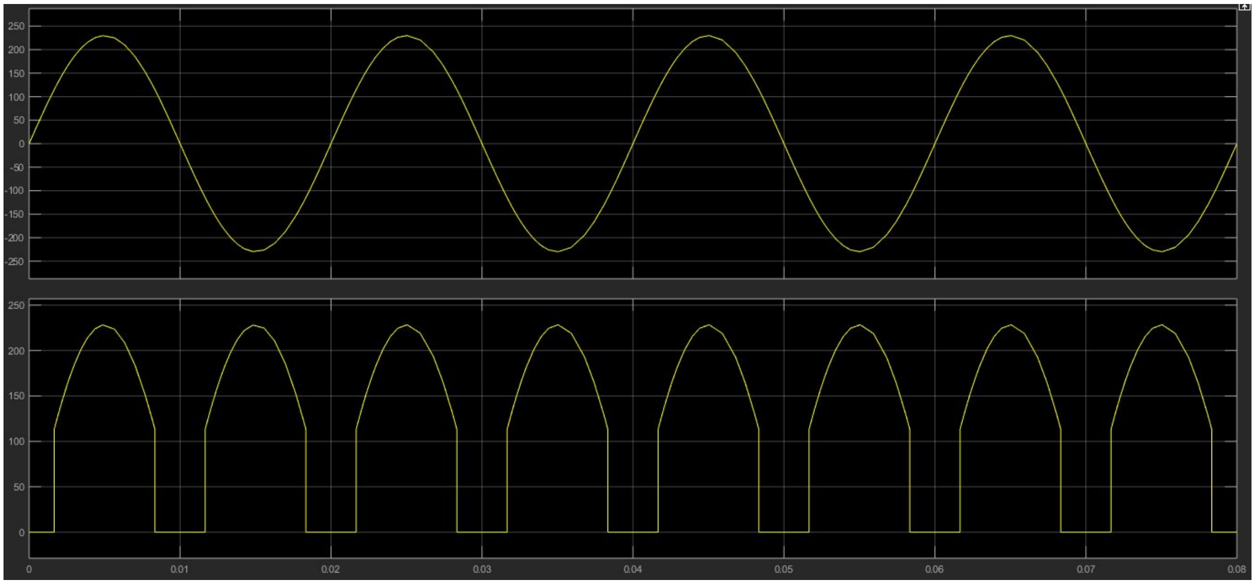


Figure 5: *Result as of the full design where the top signal is the AC source and the bottom signal is the stabilized version of the wavelength as produced by the converter*

While comparing back to the full wave rectifier, previously, the signal would just drop off as a natural sinusoid signal after the α-value started the rectification. Now, that the ß-value is implemented, the signal has clear changes where the signal now has a ending point where it will induce the nulling frequency and will essentially turn off the thyristor. It will only turn on again until the next cycle and until the new α-value is found again in the following loop.

As for the rectified signal is still paired the same format of thyristor 1 & 4 correlating to 5 & 8 is set for odd numbered signals on the result, and 2 & 3 correlates to 6 & 7 for the even numbered for the rectified response. Since it is balanced, the signal is only registering the positive values of the signal and the negative portion of the original signal is only measured as positive as a magnitude-like value.

Method Manipulation (With Dual Converter applied)

For signal manipulation, the previous changes with the AC input, load resistance, and first four thyristors affect in the same way. The changes shown are found primarily in thyristors 5-8 and changing the AC signal output on the right hand section. They correlate as similarly in modifications from the full wave as well. If 5 & 8 are modified, the loop connected for 1 & 4 is changed and 6 & 7 change for the one for 2 & 3. If the AC signal is changed, the overall resulting signal is changed but during only the nulling period.

For the AC signal, the AC signal has to be the same as the original because if it isn't, the point of null will fall or settle below/above the initial point of the start of the signal causing leakage in the system. This leakage will not fully cause the system to turn off and the system will constantly be running voltage during the supposed nulling frequency period. This is shown below in both scenarios where voltage is increased or decreased.

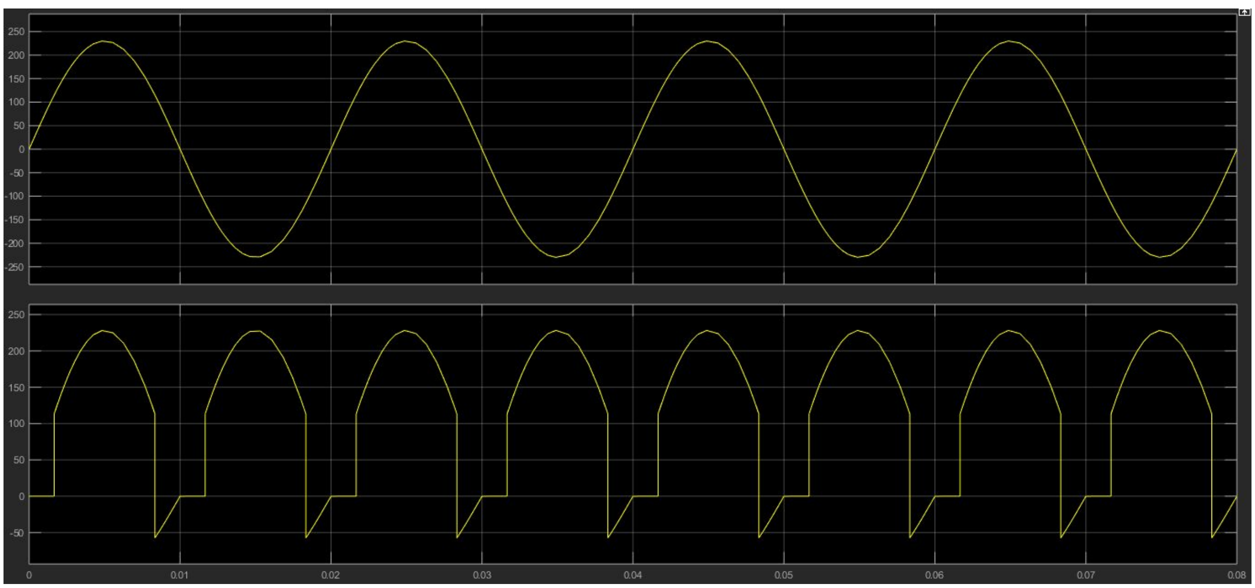


Figure 6: *This is the result of increasing the AC signal on the right. The change is adjusted from 230v to 460v and the point of nulling is set to -58v, but requires it to be 0v to settle.*

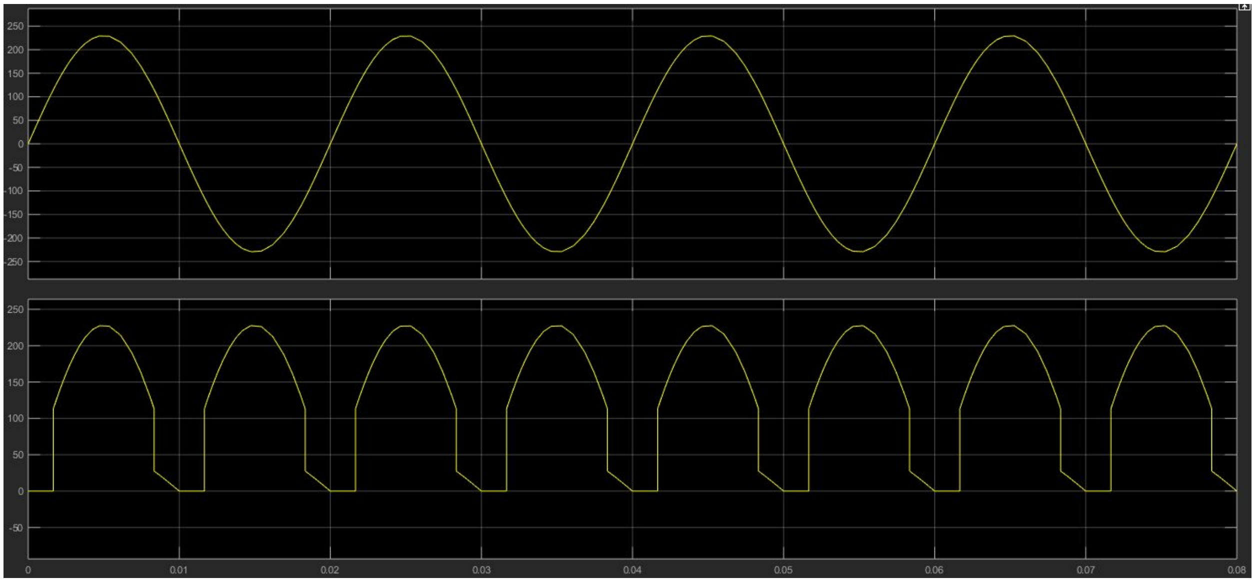


Figure 7: *This is the result of decreasing the AC signal on the right. The change is adjusted from 230v to 120v and the point of nulling is set to 28v, but requires it to be 0v to settle.*

As this affects the voltage and the nulling frequency, this does not change the thyristor values. This however will affect the overall current, power and power factor of efficiency. As indirect correlation, the thyristors however are changed in terms of efficiency especially if the phase is modified. As described, the phase delay marks the point of where the α and ß-values are set. If the α > ß then everything will be fine and will just reduce the signal conversion to show only limited amounts of the DC signal as shown below in the figure. But, if α < ß, then the DC signal that is rectified will become completely eliminated and result in an dead signal.

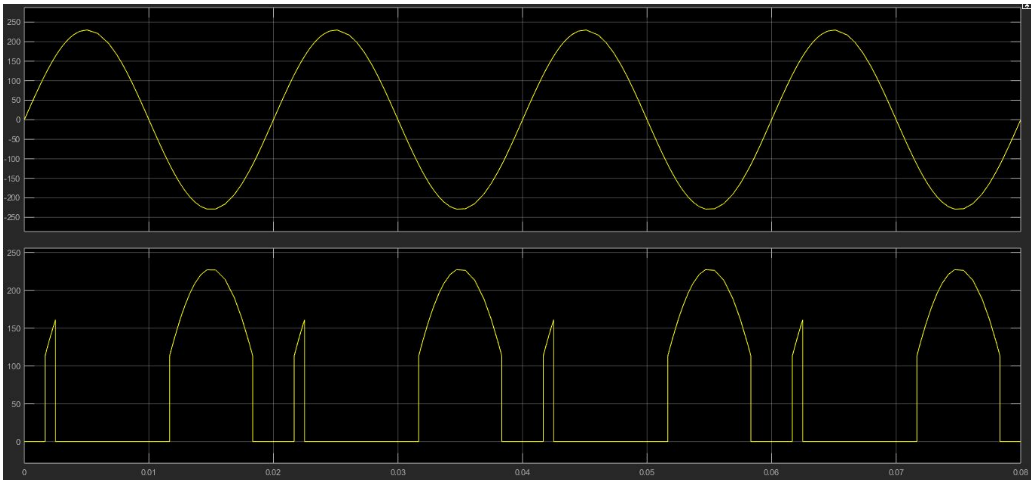


Figure 8: *The result of the signal modified when thyristor 5 & 8 have the phase delay reduced to 45/360*0.02 from 150/360*0.02. The spike upwards is α and the spike back down is ß.*

Results

As result of this whole simulation, the full wave rectifier provided basis and through modification, a lot of the single phase dual converter provided insight on how rectifiers work. This means that in terms of stabilizing an AC signal, the ratio of the phase delays from the thyristors need to be in sync with the shape, of the original signal. A larger α value will equate to an very cutoff DC signal and very small ß signal will equate in a very cut-off signal as well. This will affect the signal in various ways such as gain margin, appropriating bandwidth for power dissipation, and control for optimization of the original signal.

Conclusion

By simulating through MATLAB's Simulink, this provides a very safe and clear way of predicting signal output and prototyping design. This however is only for perfect scenarios and eliminates faulty components and percent error. If this were completed through analog purely, there are chances of power dissipation, that chance of damage to the components may occur and cause a dangerous situation, especially if the system were running high voltages within a condensed area. The system is very straightforward and can even allow for an inductor for complete reactance control and variation. As this just a single phase dual converter, the need for it isn't absolutely necessary for the design.