1. Introduction

In this report, the design process of the AC-DC converter is analyzed. The simulations and the data obtained while implementing and demonstrating the hardware project are shown in the report with explanations on the component selection are included. In the project, we have used rectifiers, buck converter, gate drivers, capacitances, and isolators. The problems encountered in the demonstration of the project are discussed and possible explanations for the failures of the hardware project are analyzed.

1. Topology Discussion

When all the topologies are compared, 3-phase full-bridge diode rectifier topology is selected. The high output voltage ripple and comparatively lower output voltage value of the single-phase rectifiers are the reasons why single phase rectifiers are not selected. Also, in the single-phase rectifiers there are higher order harmonics and as a result the THD of the rectifier is greater, while the 3-phase rectifiers eliminate the third order harmonics completely and the THD is lower than the single-phase rectifiers. The edge of the 3-phase full-bridge diode rectifier over the thyristor rectifier is simplicity and easier control. Each thyristor would need a gate signal, which would complicate the system by both cabling and control standpoint. The relative simplicity and superior qualities of the 3-phase full-bridge rectifier topology were the main reasons in the selection of it as the AC-DC rectifier topology. To realize this topology, 6 diodes are needed, and these diodes are selected according to the simulations, which will be discussed in the component selections and simulations parts.

1. Failures of the Project

Throughout the implementation of the project, several different errors were encountered. Although most of them were identified and corrected, at both project demonstrations some new problems have occurred which resulted in the failure of the hardware project. Regardless, in this report these new errors have been analyzed and possible solutions to them are proposed.

* 1. Clearance

When the circuit was given input voltage for the first time, current has jumped and exploded two of the input paths of the 3-phase full-bridge rectifier. After the malfunction, it is analyzed that either the lack of clearance of those paths provided a jumping opportunity for the current, or the soldering was not done properly such that current has jumped between the paths. This meant high amounts of voltage difference between two points, which almost don’t have any resistance. This high current exploded two of the input paths of the rectifier.

* 1. Wrong PCB Layout

While drawing the layout, the freewheeling diode was drawn in the opposite direction. This would cause short circuit on the circuit when the switch was turned on, so X volts of potential would flow on a path with minimum resistance. This high amount of current would be too much for the components of the system and the path of current on the PCB would explode, together with the MOSFET and freewheeling diode. After PCB was severely damaged, the decision to transfer the project to pertinax was taken.

* 1. Wrong Topology

The DC motor we were aiming to drive can be modelled as a high inductive load. In the first proposed topology, the capacitor was placed after the buck converter as parallel to the DC motor. However, this would not be meaningful because the aim of putting a capacitor in the system was to increase the output voltage characteristics and make it smoother. This output voltage would then be transmitted to the buck converter and this steady voltage would be critical to eliminate voltage differences between each switch, which would amount to high current values at each switching. For this purpose, the capacitor was moved to the output of the rectifier such that the output voltage would be smoother, and ripple would be minimal.

* 1. Soft Start Problem

At first demonstration, the soft starting was aimed to be done by adjusting a pot by hand. However, this method proved to be unhealthy, as trying to soft start the DC motor manually is prone to human error. In the demonstration, pot was adjusted faster than it’s optimum rate, so a huge inrush current traversed the system and as a result two of the three fuses and MOSFET blew up. After the identification of this problem, a soft starting code was implemented into the Arduino such that there would be no human element in the soft starting. An optimal soft starting would mean no inrush current to disrupt the system. Indeed, in the final demonstration soft starting would not be a problem as the DC motor would start to run without any problem at low voltages.

* 1. False Component Selection

After correcting the four abovementioned errors in the converter system, the trials were made at low voltage to understand whether the system would work at low voltages or not. It was concluded that with R load and RL load the system would work however high voltage was never tested. When high voltage was applied in the demonstration, the diode exploded and the system stopped working. Analysis of the system after the demonstration proved that 300V rating of the freewheeling diode was not sufficient for the operation and thus the system malfunctioned. This was the final error. Given that the system would manage to start the motor and run at low voltages without any problem, it is concluded that the voltage rating of the freewheeling diode was the only error remaining in the system and only possible future malfunction could be caused by thermal properties.

1. Conclusion

In this report, all the preparations and the demonstration data obtained for the DC motor driver hardware project have been discussed. This project has been beneficial for each group member to amalgamate the knowledge obtained from the EE463 course into a real-world product. Although at the end of the day the product couldn’t function as planned, the project has been particularly helpful for the members to understand possible engineering errors they might encounter in their professional lives. To drive the DC motor, we have first transformed the AC obtained from the grid to DC signal by a 3-phase full-bridge diode rectifier and then use a buck converter to create the necessary voltage level to feed the DC motor.