Designing a Capacitor Charger for Variable Speed Driver of a Cement Manufacturing Processes

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ABSTRACT

This study was carried out at a leading cement company in Sri Lanka. The manufacturing plant of the company is running with several types of motors. Some motors are running slowly and some are running at high speeds. Among the machineries in the plant, the most important equipment is the Variable Speed Driver (VSD) which consists with a capacitor bank. VSD is used to control the motor speed and to provide a delay in the running and stopping processes. In this plant, almost all important motors are running with VSDs. If any of the drivers get failed due to a problem of the capacitor bank, the production will drop down. In this study, the main objective was to provide a solution to this problem by developing a system with electronics to charge the capacitor bank in the VSD step by step with time variation. When the capacitor bank is charged gradually in that manner, the dielectric properties of the capacitor will be protected. By this, the failures of the VSDs can be minimized.

KEY WORDS: Variable Speed Driver, Capacitor Bank, Thyristor, Microcontroller

INTRODUCTION

The company under study is the local branch of a worldwide cement manufacturing network. It operates the only fully integrated cement manufacturing plant in Sri Lanka having a grinding plant in Galle. It is also the largest cement manufacturer in Sri Lanka maintaining a production capacity of nearly one million metric ton annually. It has several product categories with some sub brands which are satisfying the requirements in the infrastructure development in Sri Lanka. The manufacturing plant consists of several motors which are connected to conveyers and several equipments. All motors consist with variable speed drivers (VSD) to control the motor speed and to provide a delay in the running and stopping processes. Company is currently facing a problem of delay in the manufacturing process due to the damages occur in the capacitor bank in the VSDs The main objective of this study was to provide a solution to this problem.

Research Objectives

Every three phase motor in the production lines is controlled using a VSD. The VSD contains a convertor circuit, a capacitor bank and an inverter circuit. The convertor is used to convert AC current in to DC. This DC current is used to charge the capacitor in the capacitor bank. At present, there is no controlling system for charging the capacitors. Therefore, they are undergoing a high charge during a short period of time. Because of that, the capacitors get failed. To avoid this problem, the capacitors must be charged from zero to high voltage providing a time delay. In this study, a solution was proposed to eliminate that problem with the help of the concepts of power electronics using microcontrollers.

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METHODOLOGY

Designing the Circuits

Circuit Block Diagram

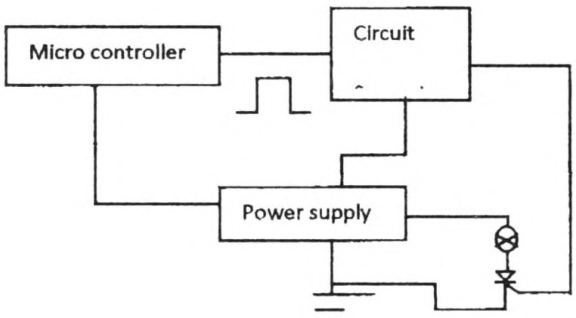

Figure 1: Thyristor Biasing Block Diagram

Above diagram shows the single phase controllable circuit diagram. After supplying power, the micro controller generates a clock pulse. That clock pulse is used to control the thyristor gate which is controlled according to the clock pulse. The thyristor gate voltage is 12 V DC. When high voltage is applied to the thyristor, it will automatically switched. To avoid that problem, opto isolator is used.

Circuit Diagram

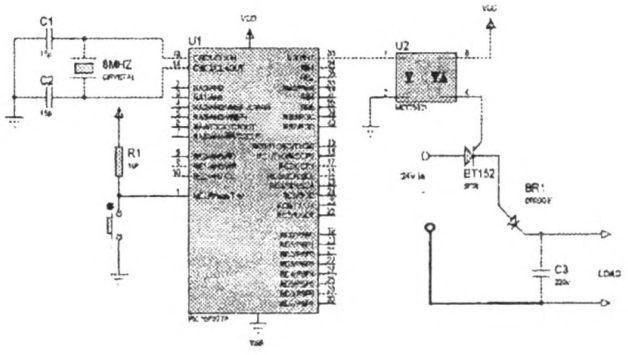

Figure 2: 24V Single Phase Rectifier Circuit Diagram

Circuit Operation

According to Fig. 2, when the circuit is arranged and power is switched on, the microcontroller will generate pulses according to the program.

Figure 3: Microcontroller pulse time generation

The square pulse that is formed as output is used to control the gate in thyristor. The pulse that comes through the opto coupler is fed in to the gate in the thyristor and the 24 V or 12 V stroke AC is inserted into thyristor anode. According to the switching process given by the microcontroller that stroke is broken into the pulse.

Normally a capacitor is charged in the following way (check the line space)

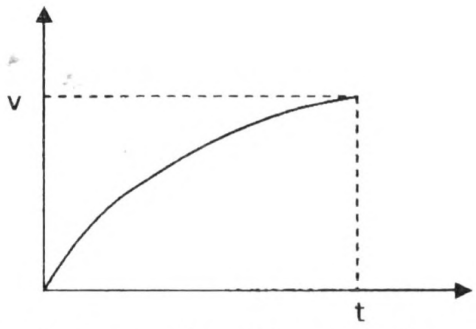

Figure 4: Capacitor Charging Curve

Here the thyristor is controlled by the microcontroller. Then the voltage is increased in the following way.(check the line space)

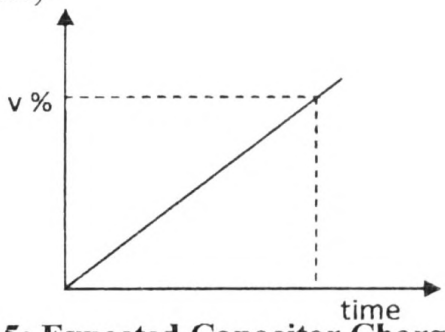

Figure 5: Expected Capacitor Charging Curve

DISCUSSION

Variable speed driver unit which is working on three phase current can fail due to several reasons. . The reasons are as follows,

- Converter unit problem
- Inverter unit problem
- Capacitor bank problem

In this study a circuit was designed to provide a solution to the capacitor bank failure. The reason for the failing of capacitor was found from the details of the VSD. The main reason for the failure was found as the decrease in dielectric properties of the capacitor with time. Due to that reason, capacitor could not hold any voltage in the beginning of the charging. So it cannot maintain the standard properties. To avoid that problem, the capacitor must be charged from zero to high voltage providing time delay (voltage vs time). The voltage must increase with varying time. The capacitors are getting the high voltage approximately up to 600 V. Three phases current must be used to obtain that high voltage. However in this study, single phase rectifier unit was used with 24 V step down voltage transformer to test the solution in single phase.

FURTHER RESEARCH OPPORTUNITIES

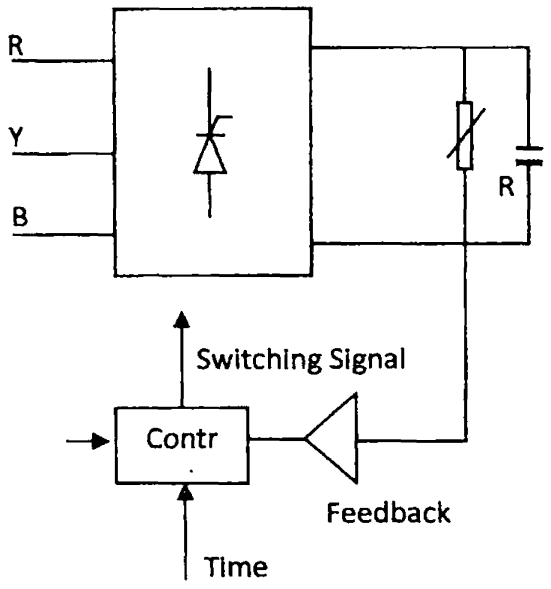

Figure 6: Block Diagram for the 3 Phase Full Bridge Converter Rectifier

The present solution was provided for the single phase voltage.

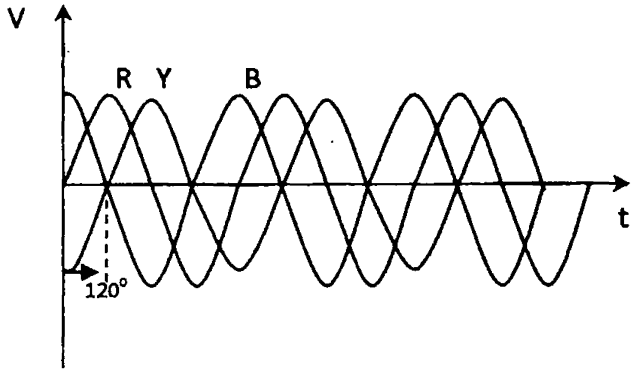

Figure 7: Three Phase Wave Form

But considering more details, the circuit can be implemented into three phase current. Then, a method has to be used to control the firing angle of phases.

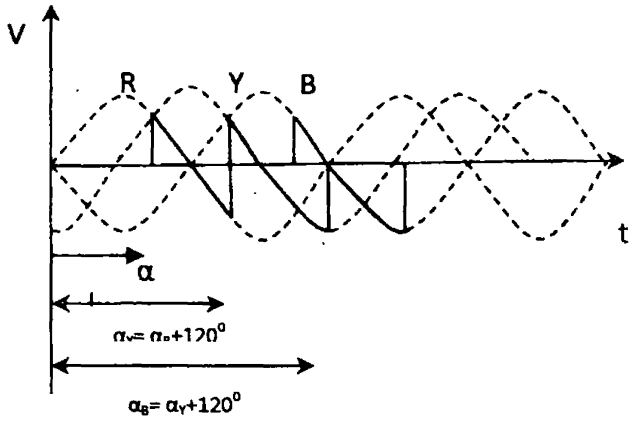

Figure 8: Firing Angle, α Changing With Time

Six thyristors may have to be used for the full bridge rectifier unit.

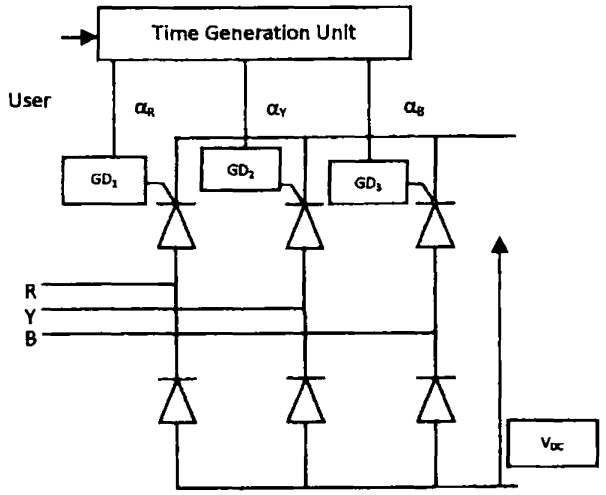

Figure 9: Circuit Diagram of the Three Phase Rectifier

Each thyristor must have a gate controller circuit. A driver IC can be used for the gate control circuit. The gate control circuits will be operated by the control unit. Microcontroller circuit can be used for the control circuit.

CONCLUSION

In this study, it was able to design a solution for the failures in the VSD with a PIC base electronic system. The designed circuit charges the capacitors in the VSD capacitor bank. That process is carried out by using thyristor biasing method which is used to increase the voltage of the capacitors. When the system is developed to three phase, it can be used to solve the problem of failures of the VSDs in the production lines.

REFERENCES

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- Julion Dixion ,Three phase controlled rectifiers (more details are required)