THYRISTOR FIRING ANGLE CONTROL CIRCUIT

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"Saya / kami akui bahawa telah membaca karya ini pada pandangan saya / kami karya ini adalah memadai dari skop dan kualiti untuk tujuan penganugerahan ijazah Sarjana Muda Kejuruteraan Elektrik (Kuasa Industri)."

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"Saya akui laporan ini adalah hasil kerja saya sendiri kecuali ringkasan dan petikan yang tiap-tiap satunya saya jelaskan sumbernya."

Tandatangan : ....
Nama Penulis : UMAH DEVI MUTHIAH
Tarikh : 09.03.2005

To

My Dearest family, the One, and others that I love

For

Their Love, Sacrifice and Best Wishes.

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ABSTRACT

The proposed of this project is developed to control the speed of DC (Direct Current) motor. This project is also consisting of DC converter, power control circuit and also gate circuit. The input signal from AC (Alternative Current) supply will go through the transformer for stepping down the line voltage to level suitable for the control circuit at the DC converter and also for the DC motor it's self. The power control circuit will produced the smooth with out ripple signal for DC motor input. The power control circuit included with thyristor. The thyristor is a line-commutated converter, therefore the firing angle must be delivered synchronously with the line voltage. The additional circuit called gate circuit is an external circuit that is needed to generate the firing angle. The objectives of this project are to design and integrated the power control circuit for control the speed of DC motor.

ABSTRAK

Matlamat utama Projek Sarjana Muda (PSM) ini adalah untuk mengawal kelajuan motor arus terus dengan menggunakan "thyristor". Projek ini terdiri daripada pengubah voltan tinggi ke rendah, pengubah voltan arus ulang alik ke voltan arus terus, litar pengawal kuasa dan juga litar 'gate'. Pengubah voltan tinggi ke rendah yang akan mengubah voltan ulang alik tinggi ke yang rendah. Projek ini menggunakan thyristor untuk mengawal kelajuan motor arus terus. Thyristor disambungkan secara sesiri dengan motor arus terus untuk mengawal kelajuan motor arus terus. Litar gate digunakan dalam projek ini untuk memberikan isyarat kepada thyristor. Kelajuan thyristor adalah bersandar dengan litar gate.

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CHAPTER 1

INTRODUCTION

1.1 Project Introduction

The proposed of this project is developed to control the speed of DC (Direct Current) motor. This project is also consisting of DC converter, power control circuit and also gate circuit. The input signal from AC (Alternative Current) supply will go through the transformer for stepping down the line voltage to level suitable for the control circuit at the DC converter and also for the DC motor it's self. The power control circuit will produced the smooth with out ripple signal for DC motor input. The power control circuit included with thyristor. The thyristor is a line-commutated converter; therefore the firing angle must be delivered synchronously with the line voltage. The additional circuit called gate circuit is an external circuit that is needed to generate the firing angle.

The objective of this project is to design and integrated the power control circuit. Between that it also to control the speed of DC motor.

1.2 Project Objective

The main objective of this project is to design and integrated the power control circuit. At the same time this power control circuit also will control the DC motor speed.

1.3 Problem Statement

The main problem that can be stated here are, where we could not get the smooth input signal with out ripples for the speed of DC motor and at the same time it is also could not control the speed range of the DC motor.

1.4 Problem Solving

The input signal from AC supply is in sinusoid as in Figure 2.1. After the signal go through the DC converter the signal will be converted as in Figure 2.2. If this signal go through the DC motor, so the speed range of the DC motor will be constant. At the same time the speed of the DC motor also can not be controlled at all. This situation is not good for the DC motor because it will damage the motor it's self. The DC motor or any other motors need to be worm up first with a very slow speed before start with heavy load or speed.

For solve this problem we need to add power control circuit to control the speed of DC motor and to produce a smooth input signal for DC motor. In this power control circuit there is a thyristor which will firing the angle of control circuit. As we know the speed of DC motor is consist of voltage, current and also angle. Thyristor is the only component that provides a controllable power output by "phase angle control", so called because the firing angle (a point in time where the thyristor is triggered into conduction) is synchronized with the phase rotation of the AC power source. If the device is triggered early in half cycle, maximum power is delivered to the motor; late triggering in the half cycle provides minimum power. The effect is similar to a very high speed switch, capable of being turned on and "conducted" off at an infinite number of points within each half cycle. The efficiency of this form of power control is extremely high since a very small amount of triggering energy can enable the thyristor to control a great deal of output power in DC motor. The final signal input at DC motor speed is as in Figure 2.3.

This power control circuit needs another additional external circuit called gate circuit to generate the firing angle at thyristor. This is because the thyristor it self with three leads, there are anode, cathode and gate. We need this gate circuit to be connected to the gate lead.

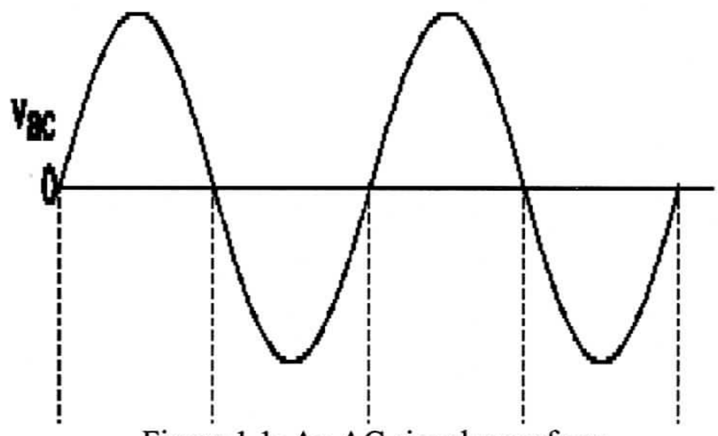

Figure 1.1: An AC signal waveform

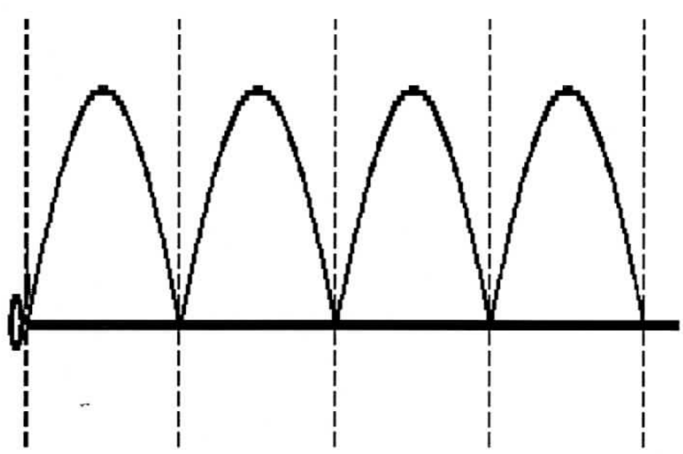

Figure 1.2: The waveform after DC converter

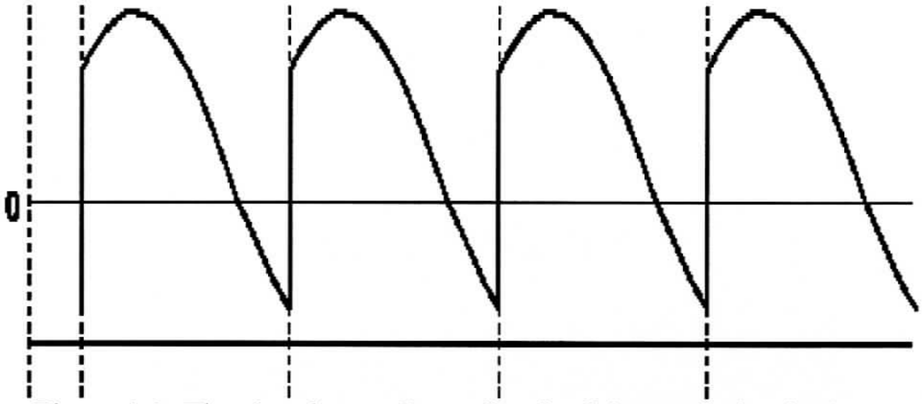

Figure 1.3: The signal waveform after the firing angle by thyristor.

CHAPTER 2

LITERATURE REVIEW

2.1 Review Of Control Speed Motor System

A new GTO due converter is proposed by Khan et al. (1988). The two converters which constitute the dual converter are always operated simultaneously permitting a free flow of current from the load of the converter. The getting pulse pattern is such that no circulating currents flow through the converters at any time. This disperses with the need for dc choke and avoids over-rating of the thyristors, two major drawbacks of a circulating current dual converter, while maintaining good dynamic response and continuity of the load current.

The main objective of this control scheme by Wilson. W.J et al. (1991) is to analyze the mathematical behavior of the system and use this knowledge to advantage in the control of armature current. After the firing control algorithm is executed, the DSP compares of real value of current with the expected one and the corresponding error is processed with the variable-gain PI regulator. The output of this stage combined with the predictive control is used to decide how to control the converter during the next sampling period. This control structure allows the effective control to high bandwidth system using a relatively long sampling period. The current controller can easily be incorporated in a speed or position control scheme since calculations for the current control and firing angle require only a fraction of the control period.

The performance characteristics of a dc series motor by Abdel - Raheem, G.M et al.(1989) having a modulated phase-angle controlled single triac or thyristor in series with one of the motor ac supply line are presented. The motor current is unified using a rectifier bridge. The mathematical model describing the performance of the motor in the different modes of operation is given. Saturation in iron parts, iron losses, mechanical losses and the dependence of the motor inductance on the motor current are considered. The practical feasibility of the new proposed method of control is demonstrated be comparing the theoretically predicted and the experimentally obtained dynamic and steady state performance. The way in which the N/T ratio and the phase angle α are chosen, so as to have a certain motor average speed together with a given maximum permissible speed ripple is explained.

The designer Schlabach. L.A. (1989) cannot choose the motor armature inductance as it is inherent in a motor, but he may choose the value of inductance in the interphase reactor. While he might choose a large value of interphase inductance to minimize the ripple to the dc motor, this leads to difficulties in keeping the bridge currents balanced well enough to avoid saturation in the interphase reactor, and providing reliable and fast drive output current reversals. For these and other reasons, he may magnitude of each of the discontinuous current components as well as the total dc output current due to the discontinuous current ranges were developed and described in term of the interphase and armature inductances.

Interesting equipment and a procedure for applying automatic control and computer science theories to industrial applications have been presented by Fellah. M.K. et al. (1991). They allow the students to combine theory with reality and attract their enthusiasm. Some improvements (interface with PC, statistic identification…) are being realized.

Industrial application of motor control systems in Japan were outlined in this paper by Hori. T. (1994). The constant speed motor have been replaced by the variable speed motor for improving performance function, energy saving, light weight, small size, maintenance, comfortableness and so on. The purposes introducing variable speed motor are various and depend on the customers (user) needs (requests) maker proposal and social background. This flow will be continued and motor control systems will become more familiar to our life, with the 'light' and 'dark' parts.

Olivier. G.et al. (1997) analytical expressions of dc harmonics generated by unbalanced phase-controlled converters have been derived using symmetrical voltage sequences. Thorough evaluation of the distortion in the converter output under unbalance supply conditions has been presented. The increase in the output distortion under unbalance has been primarily attributed to the appearance of the second harmonic component. This paper demonstrates that the elimination of the second harmonic in the dc output voltage of the phase-controlled converter under unbalance can be accomplished by using an individual asymmetrical firing angle. Evaluation of the proposed cancellation approach for various degrees of input unbalanced has been presented. Significant reduction in the distortion of the converter output voltage with the proposed cancellation approach has been noted. The reduction of second-order distortion factor of dc output voltage shows that the experimental results obtained are consistent with the simulation prediction. However, the proposed method can increase as well as decrease the harmonic factor of the input currents.

A novel bridge converter with by-pass thyristor technique is presented by A. A. Aboul-Naga'et al. (1990) Simulation and experimental results from theoretical model and laboratory test setup are in reasonable agreement and illustrate typical performance characteristics. A comparison of the results with by-pass thyristor arrangement and conventional arrangement indicates that the input power factor is improved and the harmonic content of AC line current is reduced of a wide range of DC output voltage control. The input power can be changed from a lagging to possibly leading condition.

J. S. Lawler J. M. Bailey (1999) proved that the DMIC provides a very broad CPSR that is compatible with a wide range of motor inductance and supply voltage. In addition, the DMIC inverter has better failure mode protection than that of the common VFI used with conventional phase advance.

A. Mansoor (1989) proved that most voltage sags are characterized by an rms voltage variation for a specific duration, without regard to number of phases involved, phase angle jump, and waveform degradation. Most sag, however, are single-phase events due to SLGF and therefore experience asymmetry and phase jump. Also, most sagged voltage waveforms are not sinusoidal. The distortion, phase jump, and asymmetry cause a great problem for adjustable speed motor drive. Although sag related equipment mal-operation are usually deemed energy related, these voltage waveform anomalies have a tremendous affect on the drive's ride-through behavior. Although random in nature, the characteristics are well-known and documented and should be taken into account during the design stage. If the supply voltage sag is deep enough and the failure is due to energy shortage then only alternative is power conditioning. But many of the failures are due to waveform anomalies. These failure mechanisms can be mitigated during the design stage if the design engineer has a good understanding of the characteristics of the supply voltage during momentary disturbances.

N. S. Tunaboylu et al. (1997) proved that voltage sags are a normal occurrence in today's power systems. These sags cannot be eliminated since they are caused by phenomena that are beyond the control of the utility. In fact, many types of sag occur because protective devices operate properly during a system abnormality. Modern industrial processes have extensive electronic devices in their machines. These electronic devices can be extremely sensitive to voltage disturbances, especially sags. DC drives are particularly sensitive to voltage sags due to their inherent lack of energy storage. To improve the ability of dc drives to ride-through voltage sags, one of two choices can be made. One is to prevent equipment from exposure to sag. This can be done by using UPS-type ac supplies. These UPSs must handle the entire load current, so these are not usually viable solutions. Secondly, the drives themselves can be altered to improve their ride-through capability. This solution is the preferred one since it minimizes the sensitivity to the sag instead of preventing the sag's occurrence. To implement this solution, the thyristor firing strategy can be altered to provide rectifier operation during balanced sags. Furthermore, an advanced scheme could utilize predictive algorithms to actively fire the thyristors on an independent basis. This method would provide a suitable output voltage for the motor operation during most unbalanced and balanced sags. This type of approach would eliminate the effect of the sag on the motor's speed or would minimize its deceleration.

A microprocessor- based firing scheme for thyristor working under a variable-frequency three phase supply is introduced by H.M.EL.BOLOK (1999). All problems cause by harmonic distortion is eliminated and the required hardware is reduced. The firing angle is kept constant for a wide range of variations in supply frequency. The suggested scheme quickly responds to changes in supply frequency. The required hardware is considerably reduced by using a zero crossing detector for only the one-phase voltage of the three phase supply. The suggested system operates satisfactorily when the supply frequency changes from about 1 to 270Hz. Although the prototype has been implemented using a 16-bit microprocessor, the system can easily be built using cheaper 8-bit microprocessor.

A new optimal nonlinear firing angle control scheme suitable for series and shunt- connected DC motor drive systems is proposed by A.T.Alexandridis (2000). The design procedure obtains an equivalent linear modal of the system by exact state transformations and feedback rather than by linear approximations about a particular set-point. Therefore, large changes of the operating point through the command input or of the external load can be applied successfully. In both cases the simulation results verify an excellent performance.