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Review on Design and Implementation using Cosine control Scheme in Firing Circuit

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ABSTRACT: As many variety of firing circuits available in market, there are two control circuits, ramp signal and cosine signal are most popular. Gate pulses obtained by cosine control scheme have been effectively utilized to control the dc output single phase fully controlled bridge rectifier on both resistive load and motor load. The control scheme provides linear control transfer characteristics between input and output i.e., firing angle is directly proportional to the dc control voltage. The experimental are in coordination with the simulation Thus, presented control scheme can be successfully utilized to get the controlled dc voltage for industrial applications. The paper is focused on firing circuit for a converter. The necessity of getting synchronized firing pulses for the gate of the thyristor is discussed. Description and functioning of each block is explained along with the waveforms at the output of the blocks. Important points of the circuits are discussed with the help of oscillographic displays. Fabricate a hardware circuit which implements the cosine control technique, test the circuit and also check that desired gate pulses for the thyristors. Pulse amplification and isolation circuitry may be replaced by driver ICs. Monostable are may be replaced by zero-crossing detector gates to avoid the false triggering due to output.

Keywords: Synchronized firing pulses, thyristors SCR, Gate Bipolar Transistors, Conversion.

I. INTRODUCTION

Thyristors or Silicon Controlled Rectifiers (SCRs) are widely used as a switching device in the medium and large power levels starting from few kilowatts to several mega watts at voltage levels of few hundred to several kilo volt levels. Bipolar Junction Transistors [1] (BJTs) and Metal Oxide Semiconductor Field Effect Transistors (MOSFETs) although have very fast switching characteristics compared to SCRs, their uses are limited to medium power levels at few hundred volts. Insulated Gate Bipolar Transistors (IGBTs) are switching Devices which have positive points over the MOSFETs and thyristors. However, their higher cost and inability to work at very high voltages makes SCR a better choice even today, so far as line commutated converters are concerned. In this paper we have designed to implement low cost firing circuit for a single phase line commuted converters. A thyristor or SCR is a four layer device having three junctions J1, J2 and J3. Essentially three terminals named anode, cathode and gate are available as shown in (below) for external connections. Under the conditions a thyristor either conduct or not conduct, i.e., it allows current either to flow or not, is pictorially depicted in Fig.1. A thyristor will be in reverse blocking mode if VAK < 0, irrespective of the fact that a gate pulse is present or not. On the other hand the thyristor is said to be in the forward blocking mode, when VAK > 0 in absence of any gate pulse, some current will flow through the thyristor. In case of the thyristor is turning on either by exceeding the forward break-over voltage or by applying a gate pulse between gate and cathode, called forward conduction mode. Therefore if we want to use a SCR as a switching device [1]-[5], we must ensure that appropriate gate pulse is supplied between gate and cathode at desired instant of time.

Line Commutated Converters

Conversion of line frequency (50 Hz) a.c. to d.c. [1]-[5] is carried out either by using a single phase bridge converter using four thyristors or 3-phase converter using six thyristors. A single phase fully controlled bridge with four thyristors is shown in Fig. 1 [15]. Appropriate pulses between the gates and cathodes of the thyristors T1 to T2 are to be supplied with a provision to vary the firing angle α.

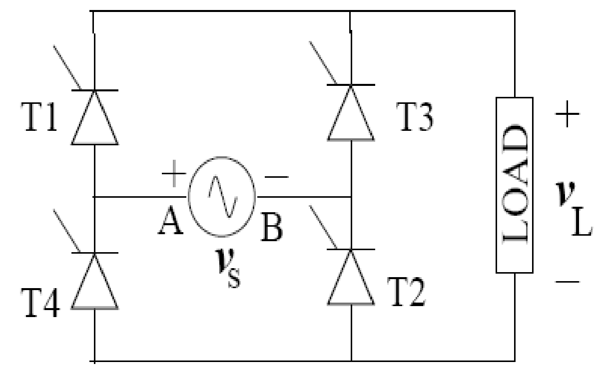

Fig. 1. Fully Controlled Converter.

With reference to the single phase converter circuit shown in Fig. 2 We note that when VAB > 0 or positive, two diagonally opposite thyristors T1 and T2 are forward biased and other two thyristors T3 and T4 are reversed biased. Therefore during intervals (i.e. 00 to 1800) gate pulses are simultaneously applies to T1 and T2, both start conducting and load voltage V_L = VAB and also T3 and T4 are reversed biased and cannot conduct at that period of time and vice versa (When T3 and T4 are switched on, V_L = VBA). Necessity of getting synchronizing pulses Typical waveform of the supply voltage, gate pulses necessary are

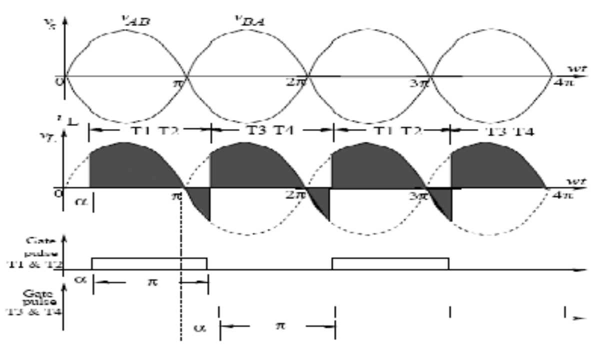

Fig. 2. Typical waveforms of a single phase converter.

For T1 and T2, α is to be measured from the instant when VAB is zero and going towards positive. Similarly T3 and T4, α is to be measured from the instant VBA is zero and going towards positive. Thus we see that for successful operation of the fully controlled bridge, the gate pulses to be properly synchronized with the a.c. power supply [11-14].

It is noted that each thyristor conducts for 1800 only. Assuming the rms value of the supply voltage to be Vs, the output voltage V_0 can be obtained below. The output current has been assumed to be continuous which is true for most of the cases. ω is the angular frequency of supply a.c. voltage.

Using ramp signal: In this scheme a ramp signal is generated in synchronism with the a.c. supply. Vs by using two comparators and an approximate ramp generator circuit using a transistor and capacitors

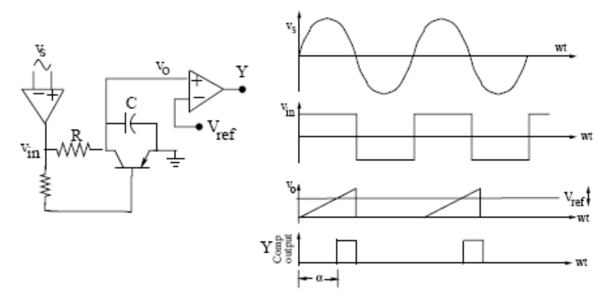

Fig. 3. Basic idea of ramp scheme.

The first comparator translates the input sinusoidal voltage into a square wave voltage. When the square wave voltage is high, the transistor (P-N-P type) collector-base junction is forward biased; the transistor is non conducting stage (off) and the capacitor charges exponentially giving ramp rise of the voltage at the output. However, [10] as soon as the square voltage is negative, transistor becomes on due to collector-base junction is reverse biased and the capacitor discharges sharply giving a saw tooth like waveform. This triangular voltage can now be compared by the second comparator with a variable reference d.c. voltage (V_{ref}) to get the firing pulse signal at Y. The value of α can be varied in the range 00≤ α ≤ 1800 by changing the value of the reference voltage (V_{ref}).Using cosine control: In this interesting scheme, the supply voltage Vs is first integrated to [8] obtain a cosine wave as The cosine wave so obtained is compared with a reference d.c. voltage (V_{ref}). Therefore square pulses will be generated at the output terminal Y of the comparator. The signal at Y is synchronized with the pulse and is delayed from the supply zero crossing by an angle α. Obviously, the value of α can be varied a range of 00≤ α ≤ 18

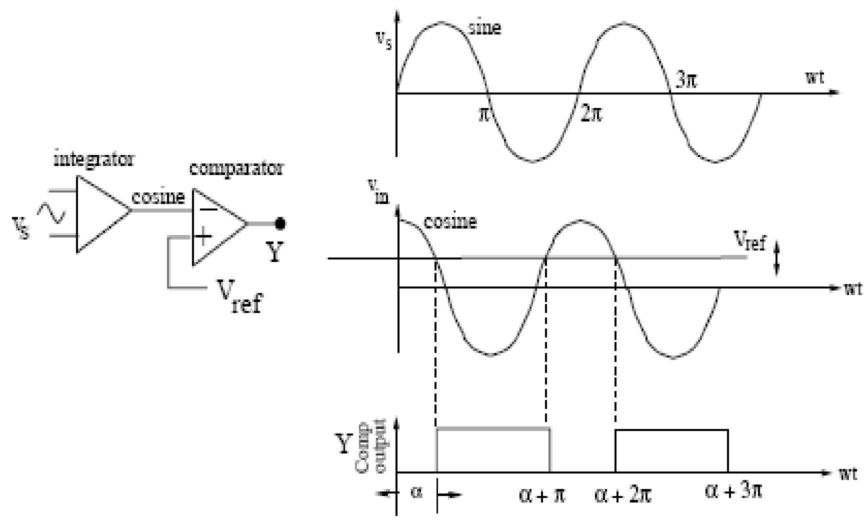

Fig. 4. Basic idea of cosine control scheme.

Basic blocks which will be necessary to implement any firing control scheme in a converter circuit are. The figure demonstrates with the help of a single line diagram, the major blocks necessary to generate firing pulses for any scheme. The converter is organized from [16] a.c. power. Since the firing pulses must be synchronized with the a.c. supply, a.c. power also goes to the isolation and synchronizing blocks.

Isolation is essential as because the control circuit uses very low power devices such as various chips, logic gates etc. The logic circuit block uses few logic gates to implement a particular firing scheme. The strength of the pulse obtained from logic gates may not be sufficient to drive the gate of a thyristor, so amplification of the pulse along with isolation is used.

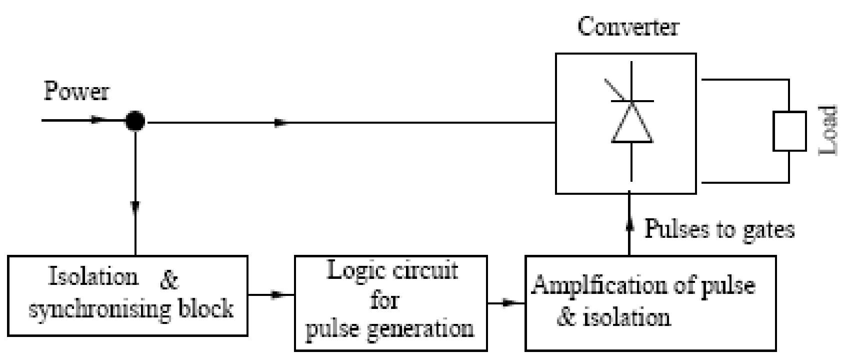

Fig. 5. Basic block of firing control circuit.

The emphasis of this paper is the implementation of cosine control scheme. We shall first outline the scheme in terms of block diagram and then explain each block in detail [9]. Vab be the supply voltage feeding [6] the converter for which the control pulses are to be generated. With the help of a step down centre tapped transformer, V_{ab} is transformed into two power level voltage V_{a0} and V_{b0}. For obvious reason V_{a0} and V_{b0} will be 1800 out of phase T1 & T2 are to be fired when Va0 is positive and T3 & T4 are to be fired when Vb0 is positive.

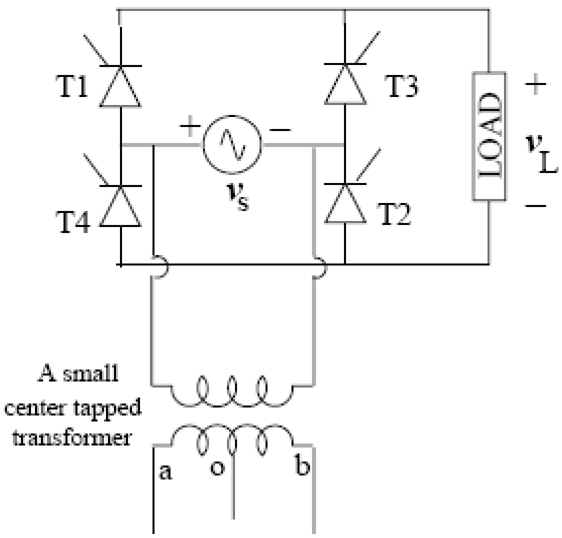

Fig. 6. Generating Va0 and Vb0.

For T1 & T2 the firing angle α is to be measured from the instant when Va0 is zero and increasing in the positive direction. The range of variation of α is 00 to 1800. Similarly for T3 & T4 the firing angle α is to be measured from the instant when Vb0 is zero and increasing in the positive direction. Basic idea for generating necessary pulses for T1 & T2 and T3 & T4 can be understood by referring With reference to the signal Va0 is integrated with the help of Integrator -1 and a cosine wave will be obtained. This cosine wave is compared with a variable d.c. voltage Vr using a comparator-1.Noting that Vr is connected to the +ve terminal of the comparator-1, the output of the comp-1 will be square wave and it goes to high state from the instant when Vr becomes greater than the cosine voltage value. However the width of the pulse will vary as Vr is varied. Our first aim will be to make the width of the pulse to be 1800. This is achieved in the following way. The output of the Comp-1 is fed to a block mono-1. Output of the mono will be a pulse of small width at positive going edge of the input square wave. The output of mono-1 will thus give small pulses separated by 3600. The quality of a product is of high concern. A flexible, reliable, robust system is necessary to carry out the process. An electrical drive can be defined as a power conversion means characterized by its capability to efficiently convert electrical power from an electrical power source (voltage and current) into mechanical power (torque and speed) to control a mechanical load or process. Electrical drives form the link between the energy supply and the mechanical processes. Variable speed DC Drive consists of the power electronic converters (phase controlled thyristor), control unit for control and operation purposes. Although AC motors are mainly used in industry for high speed operation (over 2500 rpm) because they are smaller, lighter, less expensive, require virtually no maintenance comparing to their DC counterparts, the latter are still used. The reasons for this are that they exhibit wide speed range, good speed regulation, starting and accelerating torques in excess of 400% of rated, less complex control and usually less expensive drive Inherently straight forward operating characteristics, flexible performance and efficiency encouraged the use of D.C. motors in many types of industrial drive application. Most multi-purpose production machines benefit from adjustable speed control, since frequently their speeds must change to optimize the machine process or adapt it to various tasks for improved product quality, production speed. Developments in the design of controlled rectifiers and DC–DC converters, has made the realization of control of DC motors easier.

CONCLUSIONS

Gate pulses obtained by cosine control scheme have been effectively utilized to control the dc output single phase fully controlled bridge rectifier on both resistive load and motor load. The present control scheme provides linear control transfer characteristics between input and output i.e., firing angle is directly proportional to the dc control voltage. The experimental are in coordination with the simulation Thus, presented control scheme can be successfully utilized to get the controlled dc voltage for industrial applications. In order to produce steady and smooth DC, a filter may be introduced at the output [7]. Pulse amplification and isolation circuitry may be replaced by driver ICs. Monostable are may be replaced by zero-crossing detector gates to avoid the false triggering due to output.

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