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Thyristorised Speed Control of Motors in Various Modes: Review

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Abstract: Power electronics is an area that concerns the applications of electronic principle into situations where the power level is controlled than signal level. Semiconductor power switches such as thyristors, GTOs, MOSEFTS, etc. works on the principal of power electronics. The industrial applications demands the inventions in converter, Pulse width modulation techniques, control and estimations, DSP, ASICs, etc. which also needs contribution of power control operations. This paper provides brief summary of power control device i.e. thyristor working in different modes of operations. Applications of thyristor using different modes to control the speed of motor are also summarized at glance.

Keywords: ASIC, SCRs, IGBT, cycloconverter, chopper, 8255 PPI.

I. INTRODUCTION

The applications of various fields like railway, aircraft, textile mills, refrigeration, vacuum cleaners, transportations, etc demands the power control operations with high efficiency and reliability of systems. The concepts of those studies start with the operation of power control devices i.e. SCRs, MOSFETs, IGBT, etc. The industrial survey observed the use of MOSFETS and IGBT mostly now days because of its high voltage operations. Several researchers have given the technologies invented for most of the AC/DC drive control using these devices [1].

In this paper, thyristor is chosen as the power control device and its all working mode is provided. The thyristor is having different types of modes of operations i.e. rectifier, cycloconverter, chopper and inverter. All these modes are going to use in various fields of applications for different types of drives to control. This paper provides a flash back on all these modes and its applications invented by few researchers.

Initially, all four types of modes of operations are discussed in second section briefly with its respective circuits and output waveforms. In third section, the speed control of DC motor using four quadrant choppers is mentioned. Lastly the speed control of induction motor and power control in multimode operation is provided with its results.

II. MODES OF OPERATION USING THYRISTOR

The thyristor is a power semiconductor device which can be operated in different modes of operations which are explained one by one.

A] Rectifier mode:

A generalized idea of Rectification is already known to everyone as it is used in most of the applications. It is a process of converting an alternating current or a voltage into a direct current or voltage. Simplest method of rectifier mode is as mentioned in fig.1

During the positive half- cycle of the ac supply, i.e. when the terminal A of the transformer is positive with

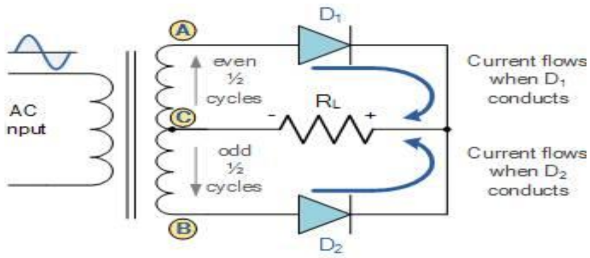

Fig. 1 Rectifier Mode

respective terminal B and C, SCR1(T1) is forward biased and SCR2(T2) is reverse biased. Since node triggering pluses are given to the Gate of the SCRS, initially they are in off-state. When SCR1 is trigger at firing angle (α) ,current would from A through SCR1 , the resistive load R and back to the center-tap of the transformer (i.e. terminal C). This current path is also shown in fig. This current continuous to flow up to the angle (π) when line voltage reverses its polarity and SCR1 is turned-off. Depending open the value (α) and the load circuit parameter, the conduction angle of SCR1 may be any value between 0 and (π).

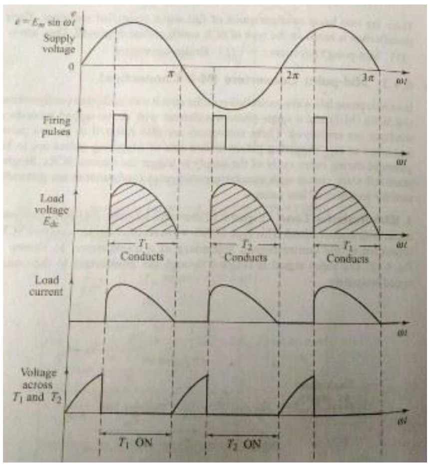

Fig.2 Output Waveform for Rectifier

During the negative half cycle of ac supply, the terminal B of transformer is positive with respect to C.SCR2 is forward-biased. When SCR2 is triggered at an angle (α), current would flow from terminal throughSCR2.This current continues till angle 2(π), and thenSCR2 is turned off. Here thyristors are trigged with the same firing angles; hence they share the load current equally
It is clear from the figure that with purely resistive load, the load current is always discontinuous [2].

B] Inverter mode:
An inverter is a circuit which converts a DC power into an AC power at desired output voltage and frequency. The thyristor is used for high power outputs. The bridge inverter operates in two modes in one –cycle of output.

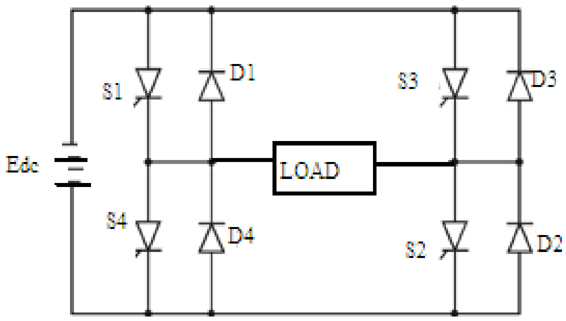

Fig 3Thyristor as an inverter

Mode1 (0<t<T/2): In this mode, SCR 1and SCR 2 conducts simultaneously. The load voltage is +Edc and load current flows from P to Q. The equivalent circuit for mode 1 is shown in fig a. At t=T/2, SCR1 and SCR2 are turned off and SCR3 and SCR4 is turned on.
Mode2 (T/2<t<T): AT t=T/2, SCR3 and SCR4 are turned on and SCR1 and SCR2 are turned off. The load voltage is –Edc and load current flows from Q to P. At t=T, SCR3 and SCR4 turned off and SCR1 and SCR 2 are turned on again [1].

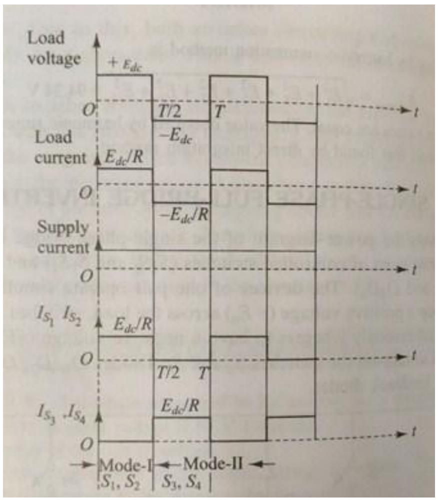

Fig.4 Voltage and Current waveform for inverter

C] Cyclo-converter:
A **cycloconverter** (CCV) or a **cycloinverter** converts a constant voltage, constant frequency AC waveform to another AC waveform of a lower frequency by synthesizing the output waveform from segments of the AC supply without an intermediate DC link. The above power converter circuit can be operated in cycloconverter mode for $f_{out} = 1/3\ f_{in.}$

In the first positive half cycle of AC input voltage, the secondary induced voltage is such that point A is positive with respect to center tap O, and B is negative with respect to O. Therefore the SCR 1 and 4 are forward biased, out of which, SCR 1 is turned ON at angle α. Thus the load voltage is positive and equal to V_{ao}. SCR 1 is turned OFF at the end of this half cycle i.e. (wt=π) due to natural commutation.

In the second half cycle of input sypply (π to 2π), V_{ao} is negative whereas V_{bo} is positive. Therefore SCR2 & 3 are forward biased out of which S_3 is turned on at instant (π+α).

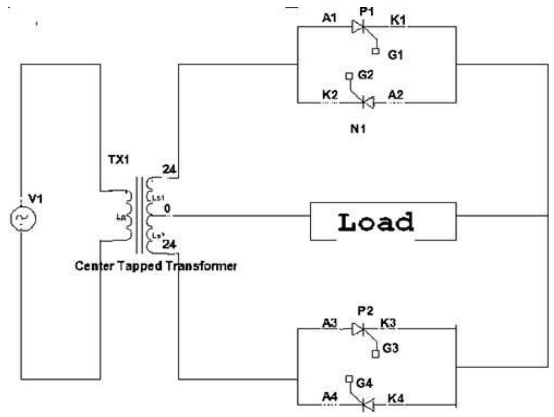

Fig.5 Single Phase Cycloconverter

This will make the load voltage positive equal to V_{bo} from (π+α to 2π). SCR 3 is turned OFF at 2π to natural commutation.
In the third half cycle of AC supply 2π to 3π, the polarities of secondary voltage are identical to those in the first half cycle. Again SCR 1 is turned ON making the load voltage positive equal to V_{ao}.

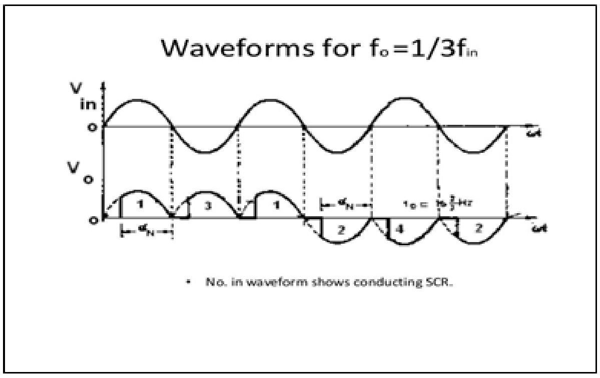

Fig. 6 Working of cycloconverter for each cycle.

In fourth fifth and sixth half cycle, the SCR 2 and 4 respectively turned ON to make the load voltage negative, the firing angle of this SCRs is identical to that of SCR1 & 3. The triggering of SCR 2 and 4 in fourth, fifth and sixth half cycle will produced negative three half cycle across the load.

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Table 1: Triggering of Thyristor for each half cycle

Half Cycle	1	2	3	4	5	6	7	8	9.....
Conduc-ting SCR	S1	S3	S1	S2	S4	S2	S1	S3	S1...

D] Chopper
Chopper is high speed on or off high power semiconductor switch. In several applications the need of power form dc voltage source occur then chopper used to convert the fixed dc voltage to adjustable dc voltage directly. As it is smooth control, high efficiency and have fast response Example: subway cars, trolley buses, electric vehicle, mini haulers. The chopper is used in high power circuit .Chopper is parallel capacitor turn off chopper.

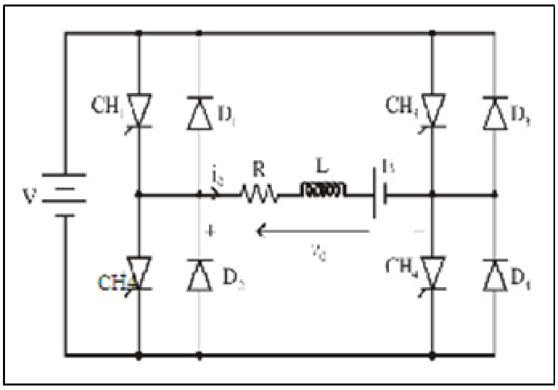

Fig.7 Four Quadrat Chopper

The operation of four quadrant chopper circuit is explain below

(i) First quadrant
Here, CH4 and CH1 are ON and CH1 is operated and CH3 is kept OFF. So load voltage V0=Vs, and load current I0 begin to flow as V0 and I0 are positive it give first quadrant operation. When CH1 is turned OFF, positive current freewheel through CH4, D2 so first quadrant operation for controlling V0, I0 can be obtain

(ii) Second quadrant
Here CH2 is operated; CH1, CH4 and CH3 are kept OFF. AS CH2 is ON reverse current is flow through L,CH2,D4 and E. Inductance store energy and As CH2 is turned OFF, current is feedback to source result in V0 is positive and I0 is negative. So in this way second quadrant operate as step up chopper.

(iii)Third quadrant
For third quadrant CH1 is kept OFF, CH2 is kept ON while CH3 is operated. Ppolarity of load emf E must be reversed while working. When CH3 is ON, load gets connected to source Vs so both V0, I0 current free-while through CH2, D4. In this manner the controlling V0 and I0 chopper act as step down chopper.

(iv)Fourth quadrant
Here CH4 is operated and other devices kept turned OFF. With CH4 is ON positive current flow through CH4, D2, L and E. Hence inductance L store energy. When CH4 is turned OFF current fed to source via D2, D3. Here load voltage is negative, load current is positive and chopper act as step up chopper [2].

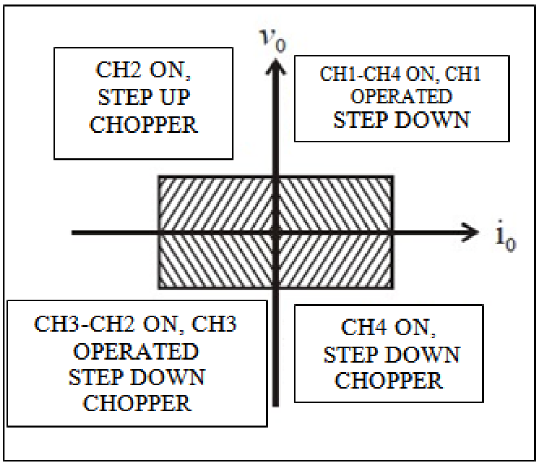

Fig. 8 Working of Four Quadrant Chopper

III. SPEED CONTROL OF DC MOTOR USING THYRISTOR

Speed control of DC motor using four-quadrant chopper In four quadrant DC chopper drives there are four modes to control the DC motor .The circuit consist of four chopper, four diodes and a separately –excited DC motor as follow

A] Forward motoring mode (first quadrant):
In this mode CH2, CH3 are kept off, ch1and CH4 are on but only CH1 is operated. So both motor voltage and armature current are positive. As the armature current get rises, the speed of DC motor is increases. When CH1 is turned off, positive armature current free-wheels and decreases as it flow through CH4, D2 [3].

B] Forward regenerative-breaking mode:
A DC motor can work in this mode only if motor generated emf is made to exceed the source voltage. In this mode CH1, CH4, CH3are kept off whereas CH2 is operated. When CH2 is turned on, negative armature current get rise and flow through CH2, D4, Ea, La, ra. When CH2 is turned off, diode D1, D4 are turned on and the motor acting as generator returned energy to DC source [4].

C] Reverse motoring mode:
This operating mode is opposite to forward operating mode. In this mode, CH1, CH4 are kept off and CH2and CH3 is on but CH3 is operated, armature gets connected to source voltage Vs so both armature voltage and armature current are negative. Armature current is reversed, motor torque is reversed.

D] Reverse regenerative-braking mode:
For this mode, CH1, CH2 and CH3 are kept off whereas CH4 is operated. When CH4 is turned on, positive armature current rises. Polarily of motor emf Ea must be opposite. When CH4 is turned off, diode D2, D3 being to conduct and motor act as generative. The chopper used is done to agree with the quadrants in which this are operated i.e. CH1 is operated for first quadrant [5].

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IV. SPEED CONTROL OF SINGLE PHASE INDUCTION MOTOR

The speed control of induction motor is very much important for industrial applications. The speed of the induction motor i.e. Ns= 120f/p cam be controlled either by varying the number of poles or by varying the input frequency. Under running conditions, varying the number of poles is a critical one. But, in running conditions the frequency can be varied which causes no change in size of the motor. Hence the second method is mostly used for controlling the speed of induction motor. For the speed control of induction motor, a constant frequency first has to be change in variable one which is nothing but the operation of cycloconverter mode. The timing of firing angle controls the cycloconverter to produce an alternating output voltage [6].

A modeling of split phase induction motor is as given in fig.9. It consists of two windings on the stator side and squirrel cage winding in the rotor side. A rotating field is produces by auxiliary winding to start the motor which is placed 90 degree electrical ahead of the main winding [7].

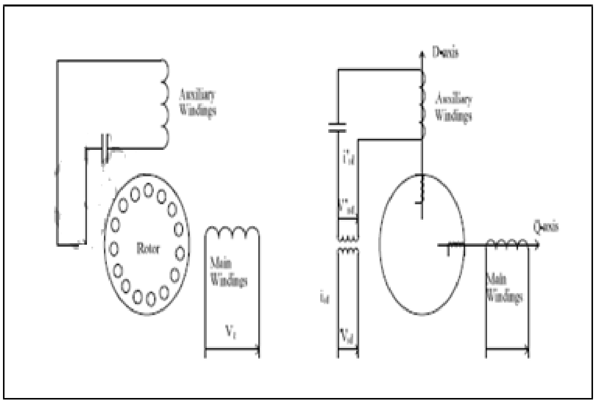

Fig9. Split phase induction motor modeling

Two windings of stator i.e. main and auxiliary coils have different turns and mutual reactance. So, to transfer auxiliary to an equivalent winding with same number of turns as that of mail coil, a transformation is used [8].

V. THYRISTORISED POWER CONTROL IN MULTIMODE OPERATION

The increasing demand of today's technologies in automation and all sectors requires best quality production which reduces cost. Every time maintaining separate drive control of AC/DC becomes the difficult task. Also the application of thyristor in all four modes requires separate drive control in each. To overcome this limitation, a technology is given in fig 10.as Power Control with Multimode Operation.

In this technology, a microprocessor with 8255PPI is working as a heart of the system. A single power converter circuit is sufficient to operating in rectifier mode, AC voltage controller and cycloconverter mode. The firing angles of thyristors for each mode are control by driver circuit which indirectly control the ON/OFF of thriystor through gate terminal. Following observation shows result of 0.25 HP DC motor controls in rectifier mode.

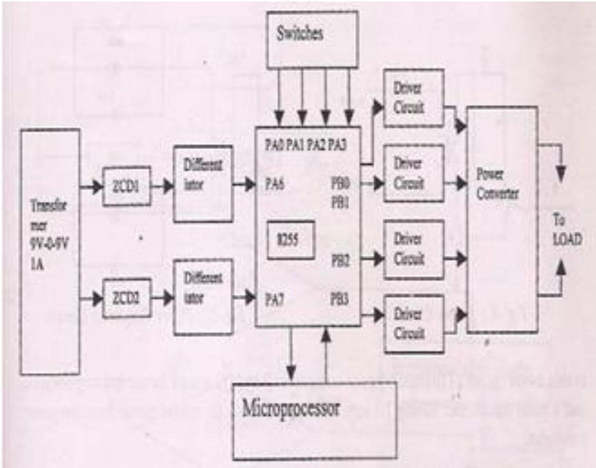

Fig.10 Multimode Power Control

Table.2 Result of Speed vs. Firing Angle

Sr. no	Firing Angle	DC output voltage	Speed (RPM)
1.	16°	68.4	1050
2.	33°	59.4	850
3.	44°	48	770
4.	54°	37.6	600
5.	63°	28.3	550
6.	80°	18.9	360

This system is implemented and tested for different mode of operations with different loads.

VI. CONCLUSION

Whenever the concept of AC/DC drive control comes under working, the very first objective is to understand the concept of power control devices like thyristor. In this paper, a brief review is provided on the working of thyristor in all four modes. Similarly, the application of AC/DC drive control is also mentioned using cycloconverter, rectifier and in multimode operation. From the whole study it is observed that the multimode technology is more efficient than all other separate drive control.

VII. FUTURE WORK

The operation of multimode technology is presented using microprocessor with 8255 PPI, thyristor and transformers. So in the future, if microcontroller is used with CISC architecture will replace the need of 8255 PPI. Similarly instead of thyristor, one can use IGBT for more efficient and high voltage output.

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REFERENCES

[1] P. S. Bhimbhra, Power Electronic, Khanna publishers, 2010.
[2] M.D. Singh & K.B. Khanchandani, Power Electronics, Tata McGraw-Hill, Second Edition.
[3] Rohit Gupta, Ruchika Lamba, Subhransu Padhee, "Thyristor Based Speed Control Techniques of DC Motor: A Comparative Analysis" International Journal of Scientific and Research Publications, Volume 2, Issue 6, June 2012 1 ISSN 2250-3153.
[4] D. A. staton, M. I. McGilp and T. J. E. Miller, "DC machine teaching experiment," in proceedings of the European Power Electronics Association EPE, Brighton, pp. 35 – 40, 1993
[5] S. J. Chapman, Electric Machinery Fundamentals, New York: WCB/McGraw-Hill, 1998.
[6] W. M. Daniels and A. R. Shaffer, "Re-inventing the electrical machines curriculum," IEEE Transactions on Education, vol. 41, pp. 92-100, May 1998.
[7] B. Sai Sindura, B. N. Kartheek, "Speed Control of Induction Motor using Cycloconverter", International Journal of Engineering Trends and Technology (IJETT) Volume 4 Issue4 - April 2013.
[8] Vinamra Kumar Govil, Yogesh Chaurasia "Modeling & Simulation of PWM Controlled Cycloconverter FED Split Phase Induction Motor" International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, Vol. 1, Issue 3, September 2012.
[9] E A Lewis "Cycloconverter Drive Systems" Power Electronics and Variable Speed Drives, Conference Publication No. 429, IEEE, 1996.
[10] S.T. Sanamdikar, V.G. Asutkar, "Power Controller With Multimode Operation", International of Research in Engineering, IT and Social Science, Volume 2, Issue 11 (November 2012), ISSN:2250-0588

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