Enhancing Power factor with Power Saving in Induction Motor Drive

Sayyad Naimuddin[1], Dr. D.R. Tutakne[2], Dr. P.M. Daigawane 3

[1] Research scholar, Electrical Engineering, G.H.Raisoni College Of Engineering, Nagpur , India
[2] Associate Professor , Electrical Engineering, Shri Ramdeobaba College Of Engineering and Management, Nagpur
[3] Professor, Electrical Engineering, G.H.Raisoni College Of Engineering, Nagpur , India

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Abstract - ***A novel topology of variable voltage control of Induction Motor has been designed and fabricated which uses only two high frequency PWM controllable switches. VVVF drives are popularly used for speed control of induction motor in many Industrial Applications. The technique proposed gives leading input power factor. The devices are turned on at zero crossing and turned off at desired instant in every half cycle. In this scheme the drive can operate in entire range of controllable speed and torque unlike conventional phase angle control scheme. The additional advantage in this method is that supply current from AC source becomes leading. The motor voltage is controllable in the entire range from zero to full voltage. The proposed scheme is very useful for various Industrial Applications like Fans, blowers, pumps, Paper mills, textile mills, rolling mills and many more.***

Key Words: *A variable voltage control scheme, High frequency PWM pulses, high power factor, single phase induction motor, VVVF drive*

1. INTRODUCTION

AC voltage converters are widely used as one of the power electronic device to control output AC voltage in which a variable AC voltage is obtained from fixed AC voltage for power ranges from few watts to fractions of megawatt. Phase angle control (PAC) line commutated voltage controllers and integral cycle control of thyristors have been extensively employed in this type of regulators for many applications.
Induction motors are simple and rugged in construction, are relatively economical and require little maintenance. Hence, induction motors are preferred in most of the industrial applications such as in Lathes, Drilling machines, Lifts, Cranes, Conveyors etc. The speed control of such motors can be achieved by controlling the applied voltage on the motor by the use of power electronic devices [1]. AC voltage controllers as power converters are also used as induction motor soft starter. But this suffers from several drawbacks like retardation of firing angle, poor input power factor, complex control techniques and large no of switches.[2-3]. A variable voltage control scheme is proposed in this paper employing with two high frequency PWM controllable switches instead of using four switches. The smooth starting and speed control of induction motor is possible with high efficiency and high power factor. The advantages of proposed scheme are high input power factor, high converter efficiency and only four number of controlled power semiconductor switches.

1.1 Effects of low power factor

1. If Power Factor is low the current rating of the electrical machinery increases which result in higher loss and overheating, thereby increasing the cost of maintenance.
2. For system with a low power factor the transmission of electric power in accordance with existing standards results in higher expenses both for the supply distribution companies and the consumer.
3. As power Factor of system decreases, the current rises. The heat dissipation in the system rises proportionately by a factor equivalent to the square of the current rise.
4. Low power factor reduces an electrical system's distribution capacity by increasing current flow and causing voltage drops.
5. Reduce hunting capacity of system.
6. Low power factor shortens the lifespan of electrical appliances and causes power system losses to power supplying company.

1.2 Methods of Power factor Improvement

Industrial, commercial, and domestic customers want to get the most cost effective electrical installation to serve their machinery. Low power factor mean extra losses and penalty payments to the utility for excessive reactive power. This can be achieved by following equipment:
1) Static capacitor
2) Synchronous condenser
3) Phase advancers

2. CIRCUIT DETAIL AND OPERATION

The power circuit is the main circuit providing power (with a controlled voltage) to the single phase Induction Motor. The voltage control employed for the speed control of motor is obtained by controlling the conduction time of a Power MOSFET. The figure 2.1 below shows the schematic of the power circuit.

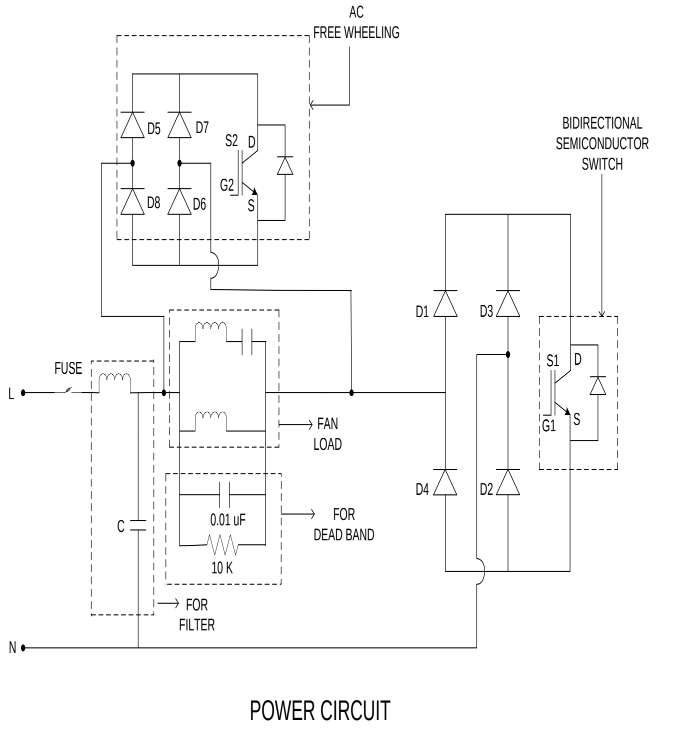

Fig. 2.1 Power Circuit Of Proposed Drive

A single phase 230V, 50 Hz AC input is rectified by a full wave rectifier bridge. The output is smoothened and the positive end of the bridge connects to the drain terminal of the MOSFET, while the negative end connects to source. The other end of the armature and the diode cathode is joined to the source terminal of MOSFET. The pulses generated through the control circuit feed the gate of MOSFET to control its conduction period.

During positive half of supply cycle, MOSFET (S1) is kept ON from 0 to π-β. As a result load draws power from the source and inductor gets positively charged. At π-β, S1 is switched OFF and inductive load reverses its polarity and D7 and D8 are forward biased hence S2 is switched ON and free-wheeling becomes possible. The load current remains in same direction. The use of freewheeling switch results in continuous power flow through the motor even when the power is drawn intermittently from the source. It also helps in improving the input power factor and the load current waveform is improved. As a result the load performance is better.

3. EXPERIMENTAL SETUP

This section presents the performance evaluation of the proposed scheme with the high frequency PWM technique. The hardware of the proposed work is prepared and tested to obtain the desired result. The complete model for soft starting and speed control of induction motor using MOSFET is shown in Figure 3.1.

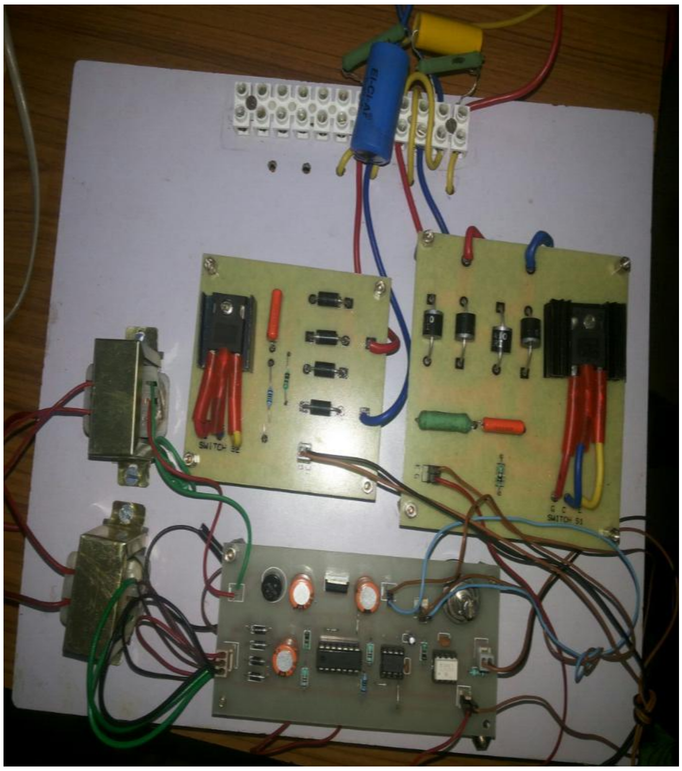

Fig -3.1: Experimental Hardware

4. OBSERVATIONS

This section presents the performance evaluation of the proposed scheme with existing Triac control for speed control of Induction Motor. The observations obtained from triac control is compared with the proposed drive. The tables shown below gives the readings obtained during experimentation.

Table -1: Observation using Triac Control

SN .	SPEED (RPM)	POWER FACTOR	POWER (WATT)
1	341	0.438(lagging)	10.86
2	479	0.507(lagging)	13.93
3	1162	0.542(lagging)	16.55
4	1276	0.636(lagging)	25.77

Table -2: Observation using Proposed Drive

S.N	EXTINCTION ANGLE (DEGREE)	SPEED (RPM)	POWER FACTOR	POWER (WATT)
1.	81	341	0.871(leading)	6.37
2.	72	479	0.915(leading)	7.51
3.	36	1162	0.94(lagging)	15.98
4.	18	1276	0.9(lagging)	21.75

The table 1 results are obtained using Triac control of Induction Motor and table 2 shows the reading of the proposed drive. The readings itself shows improvement in power factor along with power saving in Induction motor using the developed proposed drive.

5. RESULTS

The supply power factor as shown in fig 5.3 becomes leading because of extinction angle control method of speed control. The proposed method would be useful to compensate for existing lagging power factor loads. The results obtained from the proposed drive has been compared with Triac control technique. The results obtained from Triac control is shown in fig 5.1-and fig.5.2. The Triac control gives lagging power factor whereas the proposed designed drive gives leading power factor which is useful for many Industrial applications.

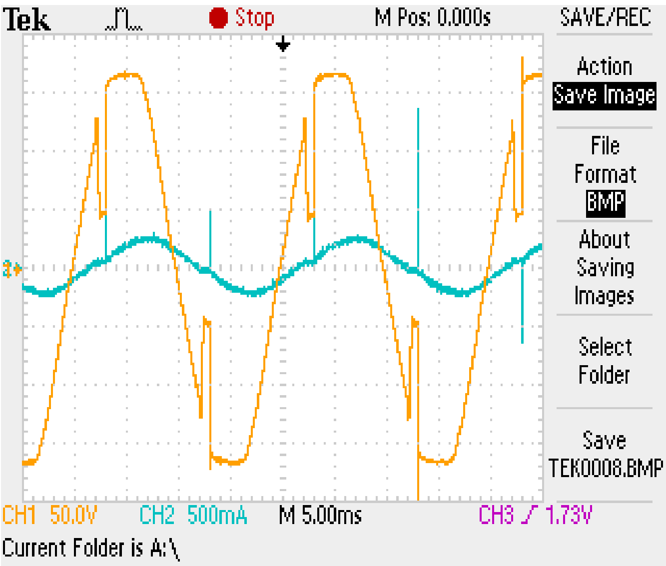

Fig5.1 Triac Control of Induction Motor

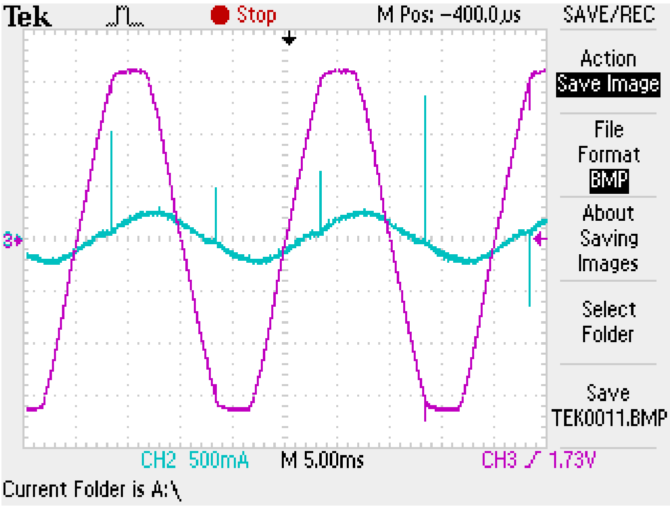

Fig 5.2 Triac Control of Induction Motor

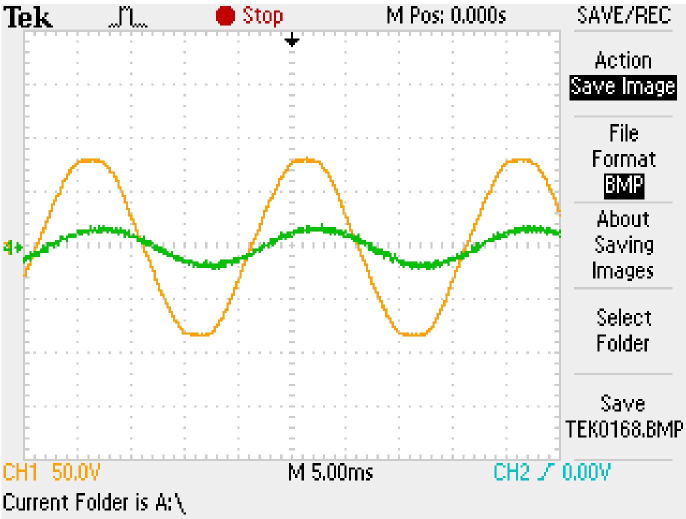

Fig 5.3 Proposed Drive Control of Induction Motor

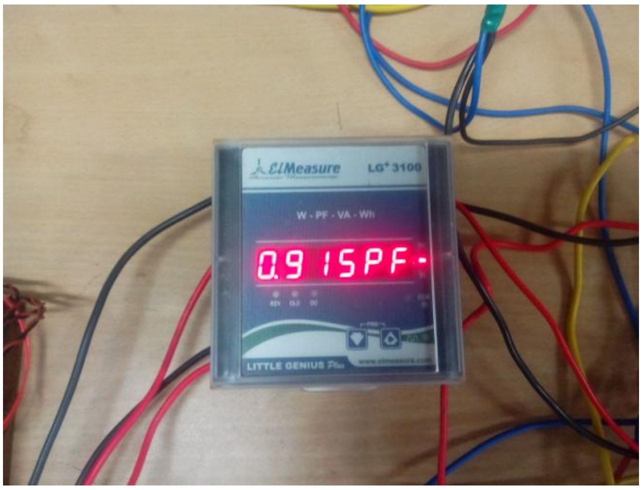

Fig 5.4 Power factor of Induction Motor using Proposed drive

6. CONCLUSIONS

Using proposed drive, the motor takes leading power factor and continuous speed control is possible simultaneously. This paper presents the extinction angle control technique for single phase Induction Motor. The extinction angle control technique provides a considerable improvement in the input power factor. With this scheme the motor performs with less noise as compared to conventional drives, EMI radiation and interference are eliminated. Reduced voltage stress with longer life & reliability of motor is possible. This technique is suitable for most Industrial application like lathes, fans, blowers, pumps and many other where speed control of single-phase induction motor is required.

REFERENCES

[1] Ahmed NA, El-Zohri EH (2003). "Power factor improvement of single phase ac voltage controller employing extinction angle control technique," IEEE conf. Proc. MWSCAS 3: 1075-1080.

[2] Saracoglu, B.; Kale, M.; Ozdemir, E." A novel technique for optimal efficiency control of induction motor fed by PWM IGBT ac chopper" IEEE conf. Proc. PESC 04, pp.3353 – 3358, 2004

[3] Ahmed, N.A.; Mivatake. M.; Hyun Woo Lee; Nakaoka, M." A Novel Circuit Topology of Three-Phase Direct AC-AC PWM Voltage Regulator", Industry Applications Conference, 2006. 41st IAS Annual Meeting. Conference Record of the 2006 IEEE, vol 4, no., pp.2076,2081

[4] Bilal Saracoglu." Supply power factor and load current harmonic performance improvement of three phase AC voltage controller," Scientific Research and Essays,4 may 2006, Vol. 5(9), pp. 862-868

[5] Eltamaly AM, Alolah AI, Hamouda RM."Performance evaluation of three-phase induction motor under different ac voltage control strategies, Part I," Electrical Machines and Power Electronics, ACEMP '07. International Aegean, Conference, pp. 770-774. Bodrum- Turkey.

[6] Bose, U.; Divya, K.; Jyothi, V.; Sreejith, S." Performance analysis of four-switch three-phase inverter-fed induction motor drive", Power and Energy Systems Conference Towards Sustainable Energy, March 2014, , vol. 2,Issue 3, pp.1,6.

[7] Khushboo Arora, Vivek Saxena, Sanjeev Saini." A Comparative Study and Analysis of Power Factor Correction Methods", International Journal of Emerging Technology and Advanced Engineering, May 2014, Volume 4, Issue 5

[8] A-R A. M. Makky, G. M. Abdel-Rahim, and N. A. Ahmed, "A Novel DC Chopper Drive for Single-Phase Induction Motors," IEEE Trans.Ind. Electron. vol. 42, no. 1, pp. 33-39, Feb. 1995.

[9] Nabil A. Ahmed, K. Amei and M. Sakui, "A New Configuration of Single-Phase Symmetrical PWM AC Chopper Voltage Controller,"IEEE Trans. Ind. Electron., vol. 46, no. 5, pp. 942-952, Oct. 1999.

[10] Nabil A. Ahmed, Kenji Amei and Masaaki Sakui, "AC Chopper Voltage Controller-Fed Single-Phase Induction Motor Employing Symmetrical PWM Control Technique," Electrical Power Systems Research Journal, Vol. 55, no. 1, pp. 15-25, July 2000.

BIOGRAPHIES

Sayyad Naimuddin received the B.E. and M.Tech degrees in Electrical Engineering from R.T.M Nagpur University Nagpur in 2000 and 2008 respectively. He has industrial experience of about 02 years and academic experience of about 10 years. He is presntly working in the Research Laboratory, Department of Electrical Engineering, G.H. Raisoni College Of Engineering, Nagpur, India. His research interest include the field of power electronics and drives.

D. R. Tutakne was born in India on July 7, 1956. He received the B.E. degree in electrical engineering from College of Engineering and Technology, Raipur, India, in 1977 and the M.Tech. degree in electrical engineering from Maulana Azad College of Technology, Bhopal, India, in 1983.He has an Indian patent for the invention of High Sensitivity Electric Shock-Preventer of 2 mA sensitivity. He has industrial experience of design and development of electrical equipments. He has worked in the Research Laboratory, department of Electrical Engineering, Visvesvaraya National Institute of Technology, Nagpur, India. He is presently working as Associate Professor in department of Electrical Engineering at Shri Ramdeobaba College Of Engineering & Management Nagpur.

Dr. Prema Daigavane. obtained the B.E Degree from Govt College of Engineering, Amravati, Maharashtra, India in the year 1988. She received the M.S. Degree in Electronics and Control Engineering from Birla Institute of Technology and Science, Pilani (Raj) India in 1996. Since 1988, she has been with the Department of Electrical and Electronics Engineering, B. D. College of Engineering, Sewagram (Wardha), affiliated to the Nagpur University, India. Since July 2007 to April 2009, she was working as an Assistant Professor in Electronics and Electrical Engineering, Disha Institute of Mgmt. and Tech., Raipur (C.G.). She is working as Professor & Head, Electrical Engineering at G.H.Raisoni College of Engineering, Nagpur (M.S.), where she is engaged in teaching and research work leading to Ph.D from R.T.M Nagpur University, Nagpur. Her main areas of interest are MATLAB applications, fuzzy logic& image processing. She is a Member of the Institution of Engineers (India) and a Life Member of the Indian Society for technical Education.