Design and Implementation of AC Soft Starter for 3phase Induction Motor using Microcontroller

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Abstract— ***This paper is portrays the delicate and smooth begin to a 3 phase induction motor. The three phase induction motor amid the underlying beginning condition draws up a lot higher current than its ability and the engine in a split second achieves the full speed. This outcomes in a mechanical twitch and high electrical weight on the windings of the motor. The working prototype consists of anti-parallel SCRs, two for each phase, the output of which is connected to the coils of a 3 phase induction motor ,opto-isolators to trigger the SCRs etc. The soft starter controls the voltage while not steps from a selectable beginning worth upto hundred percent. This ceaselessly will increase the torsion and additionally the present. This means the soft starter enables loaded motors to be started smoothly, without the steps associated with electro-mechanical starters. The soft starter design is based on Thyristors. The soft starter control all the three phases,through reverse parallel connected Thyristors. For voltage control, the applied voltage is optimally controlled by varying the firing angle of Thyristors for achieving required characteristics.***

Keywords—Thyristors,firing angle,trigerring,opto-isolators.

I. INTRODUCTION

Induction motor is that the most widely used motor in industry.The control of speed,force and inpour current will enhance the performance of not solely the motor however conjointly of the system containing it. Performance of assosciate induction motor may be essentially the AC voltage controller and is a part of each trendy tiny induction motor drive. A soft starter provides sleek acceleration that reduces the mechanical stress and will increase the life. Stresses on electrical supply are reduced because of the voltage and inrush current control,burn out condition are eliminated with the assistance of soft starters further start/stop mechanism and speed is varied with the help of a soft starter which basically adjusts the firing angle of thyristors.At start the developed torque of an induction motor has pulsations in it which can be removed by the proper selection of the firing angles of the thyristors as the force developed is directly proportional to stand of the appied voltage.Researchers have urged totally different management methods for soft beginning of induction motors.Use of soft starter has also reduced cost with respect to rotor rheostat starter, primary resistance starter, auto transformer starter, star delta starter.

II. SOFT STARTER

The soft starter is to ensure smooth,jerk free controlled starting and stopping of the associated AC induction motors. The supply for the load is switched over to Electro-Mechanical contactor provided with the overload and other protections,once the terminal voltage across the motor equals the supply voltage has accelerated smoothly to the rated RPM.The firing angle control is provided in different ways as in our case it is provided by microcontroller by generating gate pulse by zero crossing detector.The soft starter hardware implementation was done for controlling the inrush starting current of the motor.

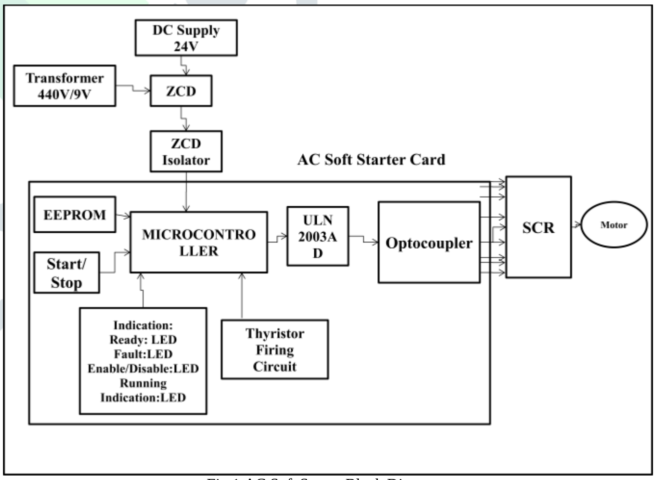

Fig:1 AC Soft Starter Block Diagram

III. PRINCIPLE OF OPERATION

Motors draws a large amount of current when they start up, perhaps six times what they draw during normal operation. This level of current can stress motor components and cause power quality issues on plant electrical systems, particularly for large motors. That is why motors requires soft starting.

The idea behind a soft start is to gradually allow the motor current to rise until the motor reaches its steady state. This reduces start-up current and the damage it can cause.

A. Microcontroller:

Microcontroller accepts Start and Stop commands and gives soft start and soft stop accordingly. On a start command it checks zero crossing of the input and after calculated delay time fires the thyristors as per required ramp up voltage and startup time. Microcontroller generates triggering pulse through ZCD. This trigger pulse is then applied to ULN2003AD.

Soft starter can be configured for input and output ramp time and voltage settings for specified motor using potentiometers fitted on the panel.These settings will be saved in internal EEPROM of the microcontroller IC.

B. Zero Crossing Detection:

ZCD(Zero Crossing Detection) block gives a trigger pulse to microcontroller on every instance of input crossing zero from positive to negative and vice versa.(One pulse each phase).ZCD generates a voltage of 15V.

C. ZCD Isolation:

An opto-isolator which is a semiconductor device that uses a short trasnsmission path to transfer an electrical signal between circuits while keeping them electrically isolated from each other. This ZCD isolator basically provides 5V ZCD to the AC soft starter card.

D. Thyristor triggering/Firing circuit:

For a soft start the average voltage applied to a motor has to increase gradually from a predefined low voltage to 100% of the input voltage so that the starting current of the motor can be controlled.The triggering circuit for the thyristor is an optocoupler based design and gives optical isolation and triggers it with specified firing angle.

IV DETAILED CIRCUIT DESCRIPTION

A.Power Scheme

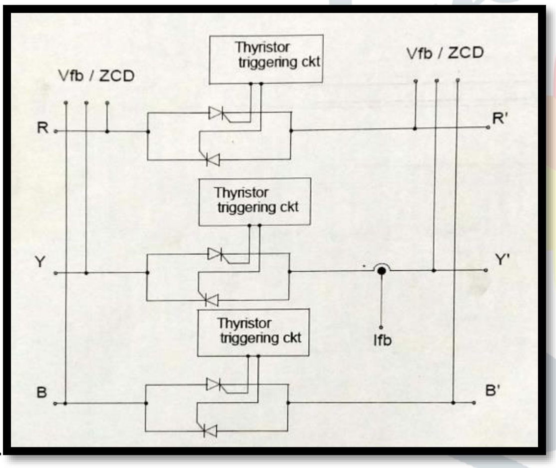

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Fig:2 Power scheme

The Ac Soft Starter Power comprises of three pairs of antiparallel thyristors connected in each phase of the input supply,triggering circuit and CT module as shown in the above schematic.Use of antiparallel thyristor in each AC supply .The thyristors are actuated during the start-up phase such that their tur-on is successively delayed for each ac half cycle.The delayed switching effectively ramps up the typical ac voltage to the motor till the motor sees full line voltage. Once the motor hits its rated speed, the thyristor switching circuit is bypassed.

Soft starter also provides a soft stop function and the soft stop sequence uses the same power semiconductors employed for soft starting and gradually reducing average voltage applied voltage to zero.

B. Software Flow Chart

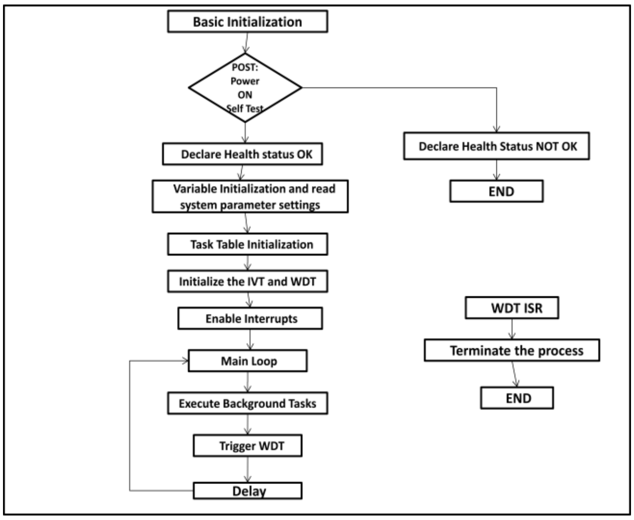

Fig:3. Software Flowchart

Software execution starts with power on, the power on reset is generated in hardware and it is given to processor. Thus the processor is gracefully reset on every power condition.

After this the microcontroller performs the basic intiallization of on chip peripherals. Now the processor is ready for performing the on board diagnostics. It starts diagnostics process with Power On Self Test, it performs write and read operations for the RAM checks and all register checks.

If POST fails, it declares the status and process is terminated.

After the successful POST, processor initializes all variables including system parameters set in hardware. Now the task table is imtialized, up till now all interrupt are disabled, processor then initializes the Interrupt Vector Table and Watch Dog Timer and then it enables interrupts before going to the main loop.

In the main loop the processor continuously executes the scheduled in predefined sequence. At every periodic interval;s it will trigger the Watch Dog Timer to indicate healthiness of execution process. It remains in main loop forever.

In case WDT is not triggered periodically due to mal functioning of hardware or software the WDT interrupts the main loop. The main loop and control will then diverts to WDT Interrupt service Routine. In this the control is forcefully taken back and perform soft reset.

While executing main loop controller also executes some background tasks .In the background tasks processor compares set systems variable with actual feedbacks and controls the voltage ramp using voltage and current PI loops.

When the feedback value exceeds the predefined value of current,processor enters in current PI loop and try to keep current within the range by reducing the conduction angle of the thyristors.

IV. HARDWARE IMPLEMENTATION

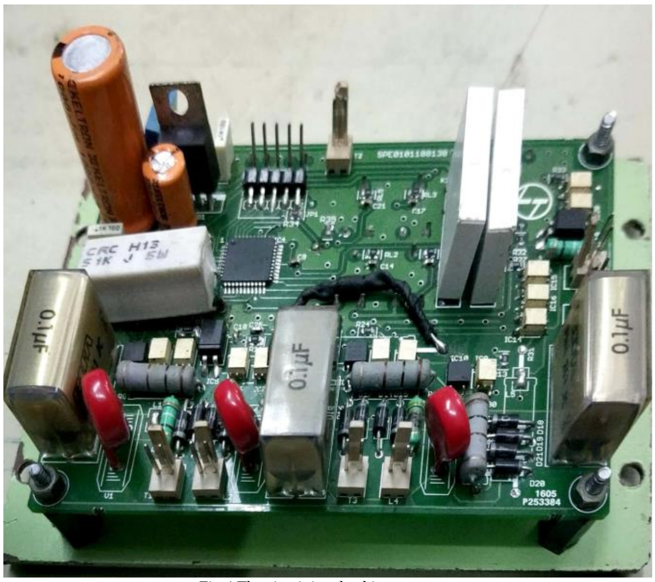

Fig:4 The circuit involved in prototype

The prototype has been developed as shown in the fig4 & Fig5. The same has been tested for load resembles the induction motor.

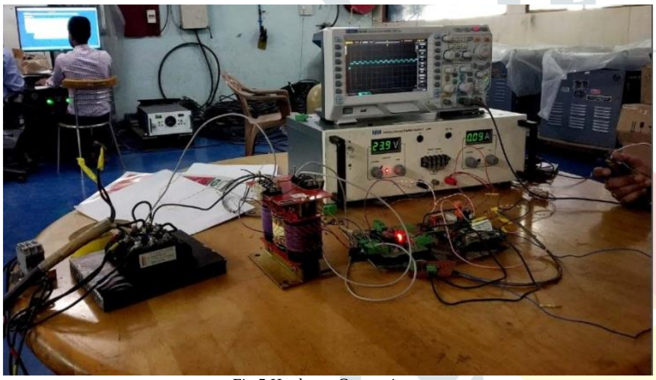

Fig:5 Hardware Connection.

The circuit involved in this prototype provides firing pulse to SCR and controls the starting of the motor.
The AC soft starter card is provided with 24V AC supply through regulator. Another ZCD card is provided with 9V AC as well as 24V supply to drive the ZCD card. This ZCD card generates 15V pulse which is then supplied to the ACSS card through ZCD isolator which converts 15Vto 5V and then this 5V is provided to ACSS card at pin no 42 of microcontroller. Microcontroller generates the triggering pulse. The motor is then turned on by using toggle switch as soon as the toggle switch is pushed to start the motor gets a soft start and when turned off the motor experiences soft stop. The motor used is 3phase,0.25KW ,Star connected, Induction Motor.

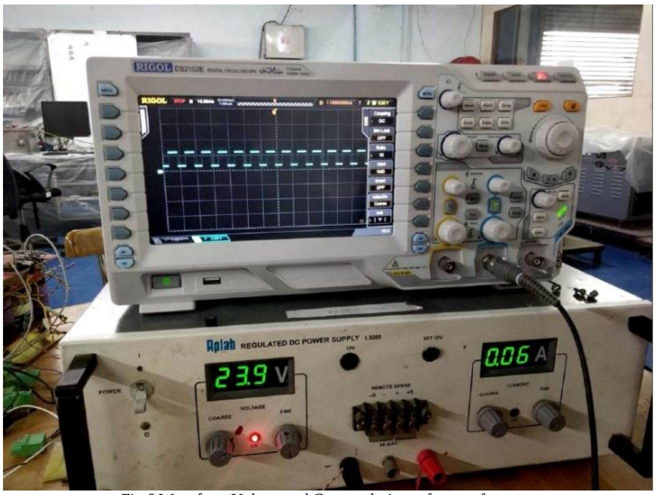

Fig:6 Waveform,Voltage and Current during soft start of motor

The expected outcome in the form of waveform has been shown in fig6. The waveform seen in the CRO are the voltage variation at pin no.42 of the microcontroller i.e. the triggering pulse required for soft start of motor.
The voltage shown is the applied voltage to drive AC soft starter card as well as ZCD card. This the current after switching the toggle switch to Start.

V. RESULT

Table!: Before and After Switching Condition

Parameters	Toggle Switch ON	Toggle Switch OFF
Applied Voltage	23.9V	23.9V
Current	0.09	0.06

VI. CONCLUSION

Realization of this prototype will enhance the safety of induction motor and solve the problem related with its starting .Use of this technology makes induction motor more cost effective and efficient. So it can be implemented for small scale industries also. Further improvement may be done by utilization of IGBT which can reduce the harmonics and create it more practical and efficient for industries..

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REFERENCES

[1] G. Bhuvaneswari, Charles. S and Manjula G. Nair. "Power Quality Studies on a Soft Start for an Induction Motor".2008 IEEE.

[2] Ahmed Riyaz, Atif Iqbal, Shaikh Moinoddin, SK. MoinAhmed and Haitham Abu-Rub "Comparative Performance Analysis of Thyristor and IGBT primarily based induction motor soft starters". International journal of engineering, Science and Technology Vol.1, No.1, 2009, pp. 90-105.A. M.

[3] Squirrel-Cage Induction MotorsV. Petrushin, R. Yenoktaiev, J Plotkin'Comparative Analysis of ways for Starting' Squirrel-Cage Induction MotorsV. Petrushin, R. Yenoktaiev, J. Plotkin .

[4] Shihong Ganl, Wei Gu2, Jianxin Chu2, Yuan Yu1 'Soft Starting High-voltage Induction Motors with the Optimum Performance' 1 Electrical Engineering Department. Shanghai Ocean University. Shanghai. China 2Electrical Engineering Department. Shanghai Maritime University. Shanghai. China IEEE2016.

[5] Aleksandar Damjanovic Ph.D. E.E ., E.E .IEEE Member Motortronics Inc. 1600 Sunshine Drive Clearwater 'Protection of Medium Voltage SCR Driven Soft-Starter from High Frequency Changing Transients,' FL, 33765, USA 2016IEEE.

[6] Adjusting XIAO Yi-ping School of Information Engineering University of Technology Wuhan,China 'An Integrated System of Wound Rotor Induction Motor Soft Starting and Doubly-fed Speed 978-0-7695-4031-3/10 4.00 © 2010 IEEE DOI 10.1109/iCECE.2010.1423.

[7] P. Zhang; Y. Du ; B. Lu ; T.G.Habetler, “A DC Signal Injection-Based Thermal Protection Scheme for Soft-Starter-Connected Induction Motors”, IEEE Trans. on Ind. Appl., vol. 45, Issue: 4, pp. 1351-1358, 2009.

[8] José de Oliveira, Ademir Nied, Rogério P. Dias, Luiz C. de Souza Marques Electrical Engineering Department - Universidade do Estado de Santa Catarina ‘DIRECT TORQUE CONTROL OF INDUCTION MOTOR SOFT STARTING’– UDESC-Joinville, SC, Brasil. Power Electronics and Control Research Group - Universidade Federal de Santa Maria - UFSM, RS, Brasil. 978-1-4244-3370-4/09/2009 IEEE.

[9] Eltamaly, A.I. Alolah and R.M.Hamouda “Performance Evaluation of Three Phase Induction Motor under Different AC Voltage Control Strategies”. 2007 IEEE.