ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 4, April 2015

Real Time Monitoring of Spartan-6 FPGA Based BLDC Motor Drive Using Lab VIEW

S.M.Ramesh Balaji[1], C.Muniraj[2]

PG Student [PED], Electrical Drives and Control Laboratory, Dept. of EEE, K.S.Rangasamy College of Technology, Namakkal, India[1]

Associate Professor, Electrical Drives and Control Laboratory, Dept. of EEE, K.S.Rangasamy College of Technology, Namakkal, India[2]

ABSTRACT: In recent development of science and technology we need to reduce the complexity of motor controller and simple construction of BLDC motor has gives several advantages but the brushed DC motor has a maintenance requirement is higher, because of the presence of commutator and brushes. To avoid the more complexity we need to move brushless DC motor. In this paper has analysis and experimentally investigation of the BLDC motor in real time of SPARTAN-6 FPGA processor, it gives the efficient and accurate monitoring of the motor. In this control are high speed processor and Xilinx SPARTAN-6 FPGA processor is main role to analysis of current, voltage, speed and vibration. These parameters are measured by using Lab VIEW software; it precedes the real time digital values and accurate analysis of the BLDC motor.

KEYWORDS: Brushless dc (BLDC), Field-Programmable Gate Arrays (FPGAs), Inverters, Lab VIEW.

I.INTRODUCTION

Brushless DC (BLDC) motors are synchronous motors with armature windings on the stator and permanent magnets on the rotor. The most understandable benefit of the brushless configuration is the removal of the brushes, it reduce sparking and maintenance. Armature winding on the stator helps the diffusion of heat from the windings, because it has no windings on the rotor in BLDC motor. In rotor have low electrical losses. BLDC motor compares positively with induction motors in the fractional HP range. Hence, from a construction view point, they are the similar as DC motors, armature windings on the rotor and permanent magnets or field windings on the stator. In BLDC Motor mechanical commutator is replaced by electronic commutator, and electronic circuits are mainly used for commutation, it develops the efficiency of system and decreases the mechanic losses. In earlier have higher efficiency and superior power factor and, therefore, a larger output power; because the field excitation is contributed by the Permanent magnets and armature current does not have to be supplied. In BLDC motor has a high efficiency compared then the brushed DC motor.

The variation of radial force distribution leads to mechanical vibration. To implement position and current controllers in a single FPGA chip in this system to improve a high-performance, compact, and flexible of BLDCM control system [1]. Under varies condition of load disturbance, reduction in processor capability, potential stability issues due to the simplicity of this control to be investigated. The closed loop system of stability to be analysed by using Lyapunov stability criteria [5]. [11] Proposed the analytic wavelet transform of the stator-current signal is proposed for detecting dynamic eccentricity in brushless direct current (BLDC) motors operating under rapidly varying speed and load conditions. The BLDC motor control based on rotor position sensing scheme and phase currents that the modified PWM signals to reduce the current and hence resulting lower torque ripples in [3]. In this work PI controller is used for control the speed of BLDC motor. Torque indicator is used in this work to measure BLDC motor torque; Hall Effect current and voltage sensor are monitoring the real time signals through data acquisition system. The Spartan-6 FPGA processor control algorithm used to developed and tested in the voltage, current, speed and vibration analysis of BLDC motor drive system.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 4, April 2015

II.XILINX SPARTAN-6 FPGA PROCESSOR

Xilinx SPARTAN-6 FPGA processor is the advanced processor and leading system integration capabilities with the low cost application. In recently most of the application using the SPARTAN-6 FPGA processer because of the real time monitoring and accurate monitoring. It has a 512 MB SDRAM with upto 4GB expandable flash memory and it has advanced i.MX515 (ARM) CPU. It contains the four set of transceiver connected with common ports. The main advantages is accurate, higher speed range processing, better efficient, low delay time, and real time monitoring. The blocks are shown in the Fig.1.

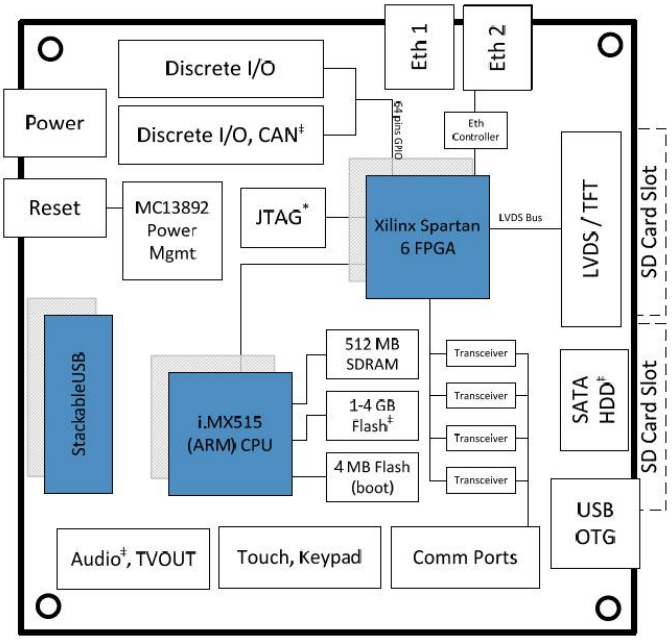

Fig. 1 Block Diagram of SPARTAN-6 FPGA Processor

III.INTELLEGIENT POWER MODULE (IPM)

IPM (Intelligent power Modules) has contain the inverter and converter circuits with the self protection circuits. In this inverter and converter circuits has using the IGBT power devices, because of it higher switching frequency, mostly power circuits have IGBT devices are dominated. In these protection have sophisticated built-in protection circuits that prevent the power devices from being damaged should the system multifunction or be over stressed IPM internally builded the fault detection and shut down schemes that allow maximum utilization of power device capability without compromising reliability Control supply under -voltage, over temperature, over-current, and short-circuit protection are all provided by the IPM's internal gate control circuits. A fault output signal is provided to alert the system controller if any of the protection circuits are activated. M57140- 01 is an isolated DC-to-DC converter designed to drive IPMs (Intelligent Power Modules) with an input of DC 20V, the module supplies four 15V outputs. Isolation is provided from primary to Secondary and also between the secondaries. Inter winding isolation is designed for driving the IPM. IPM power supply output is connected to the power pin of IPM PM25RSB120. The M57410-01is used under excessive Load condition and output side rectifying diodes will be damaged. Care should be exercised so as not to operate the device above the rated maximum Load current. Intelligent power module output voltage and current is not directly feed to control (Protection) circuits. Intelligent power module output voltage is very high but control circuit operated in Minimum voltage, so necessary for IPM output high voltage is converting into very low Voltage and current transducer sense from high voltage and output of transducer is low voltage (max 5V).

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 4, April 2015

IV. LAB VIEW

Lab VIEW (short for Laboratory Virtual Instrumentation Engineering Workbench) is a platform and Development environment for a Visual programming Language from National Instruments. The graphical Language is Named "G". Originally released for the Apple Macintosh in 1986 Lab VIEW is commonly used for data acquisition and industrial automation on a variety of platforms including Microsoft Windows and various flavors of Linux, Mac OS X and UNIX. The latest version of Lab VIEW is version Lab VIEW 2014. The code files have the extension "VI", which is an abbreviation for "Virtual Instrument". Lab VIEW offers lots of additional Toolkits. The scope of these applications varies from controlling a few instruments to monitoring assembly lines to test beam experiments in particle physics. In this course, students will follow step by step instructions to write programs first to become familiar with some of the basics of Lab View. Then they will construct two simple DAQ setups utilizing Lab View. Some debugging and DAQ system management utilities will be introduced at the end of the course. Students are expected to do some investigative work on the programs by experimenting with menus, online help topics and notes for real time monitoring.

Using Lab VIEW monitoring the real time data's with interface with the NI c DAQ is an eight slot chassis which is used for measurement purpose. Eight NI C Series I/O modules can be used for a custom analog input and output and counter/timer measurement system.

V. HARDWARE SETUP

The development control system is tested on a FPGA based BLDC Motor drive setup in Electrical Drives and Control laboratory at K.S.Rangasamy college of technology. The BLDCM is a Trapezoidal type machine and diode rectifier with VSI is assembled in a BLDCM intelligent power module. A Hall Effect voltage and current sensor was used to provide accurate information for the angle control as in the form of voltage pulses. A load cell is used to measure the torque and its values are indicated in torque indicator. Vibration signals are measured by using accelerometer using Lab VIEW, which produce accurate data's. The total drive system is controlled by SPARTAN-6 FPGA processor. The block diagram of Experimental setup and FPGA controlled BLDCM drive is shown in Fig.2.

Fig. 2 Pictorial View of Hardware Setup of BLDC Motor

VI. RESULT AND DISCUSSION

1. Current analysis: The current analysis of the BLDC motor with different speed condition, in these different speed condition the motor current will be increased gradually when speed of the motor increased. When the motor reaches rated speed the current will be increased and achieved his rated current in sometime current may be larger the rated

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 4, April 2015

current motor windings will be damaged. In fig.3 shows the current analysis of BLDC motor with 500rpm in this condition the current level is 0.9A will be attained.

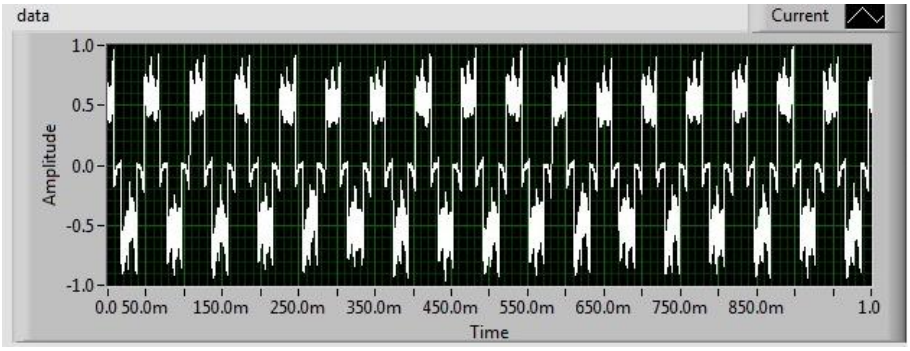

Fig. 3 Current analysis with 500rpm

In fig.4 shows the current analysis of BLDC motor with 1000rpm in this condition the current level is increased gradually to attained 1.2A.

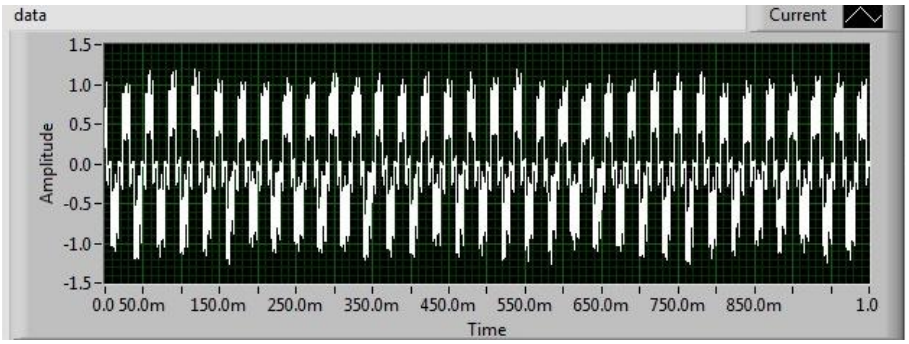

Fig. 4 Current analysis with 1000rpm

In fig.5 shows the current analysis of BLDC motor with 2000rpm in this condition the current level is increased gradually to attained 1.5A.

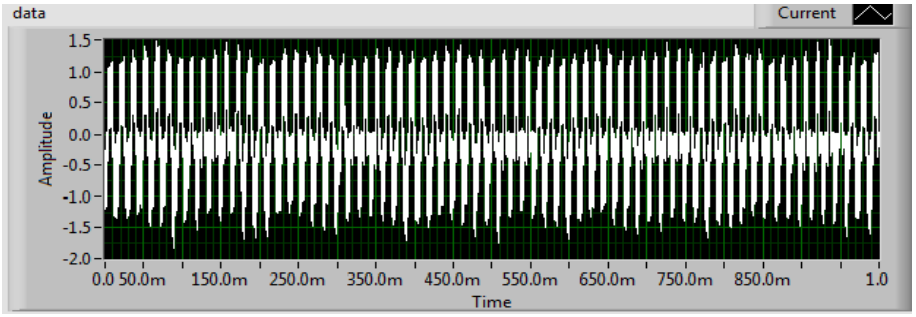

Fig. 5 Current analysis with 2000rpm

2. Voltage analysis: The voltage analysis of the BLDC motor with different speed condition, in these different speed condition the motor voltage will be increased gradually when speed of the motor increased. To give the rated voltage as constant, motor performance will be good and higher efficiency. The voltage analysis of BLDC motor with speed at 500rpm, the voltage level will be 75V shown in Fig 6.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 4, April 2015

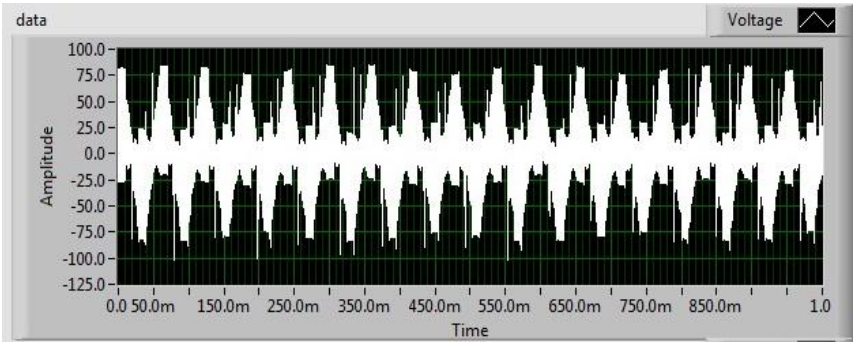

Fig. 6 Voltage analysis with 500rpm

In fig.7 shows the speed of BLDC motor is 1000rpm when the speed of motor increased also the voltage level is increased gradually.

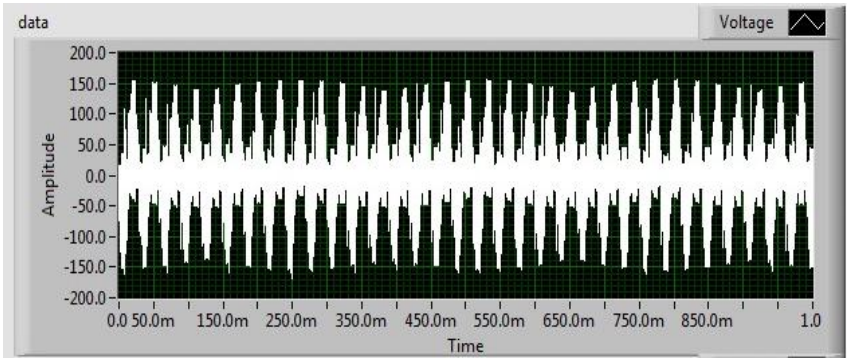

Fig. 7 Voltage analysis with 1000rpm

In fig.8 shows the speed of BLDC motor is 2000rpm when the speed of motor increased also the voltage level is increased gradually. In this waveform shows the voltage level is related to rated speed of the motor.

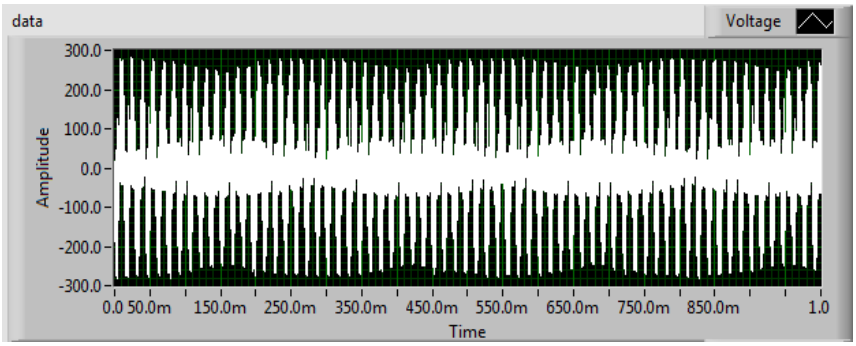

Fig. 8 Voltage analysis with 2000rpm

3. Vibration analysis: Monitoring the vibration characteristics of a machine gives us an understanding of the 'health' condition of the machine. We can use this information to detect problems that might be developing. The frequency spectrum is derived from the data in the time domain the relationship between time and frequency is very important.In fig 9. Its shows the vibration analysis of the BLDC motor with speed of 500rpm, in these speed condition the motor vibration will be increased gradually when speed of the motor increased.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 4, April 2015

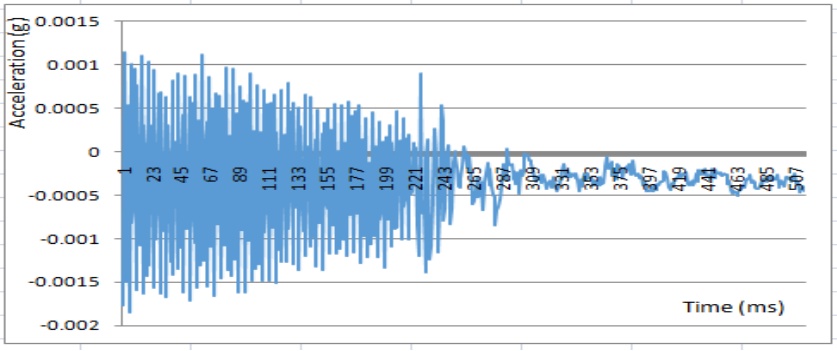

Fig. 9 Vibration analysis with 500rpm

Understanding the basics and fundamentals of vibration analysis are very important in forming a solid background to analyze problems on rotating machinery then switching between time and frequency is a common tool used for analysis. In fig.10 shows the vibration level is increased compare to the 500rpm vibration signals.

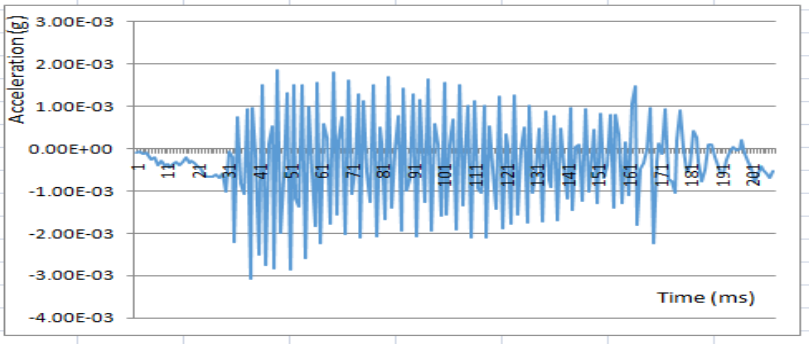

Fig. 10 Vibration analysis with 1000rpm

In fig.11 shows the vibration analysis of BLDC motor with 2000rpm in this condition vibration level is higher than the other speed condition, when speed of the motor is increased the flow of current in motor is higher and also vibration signals is increased.

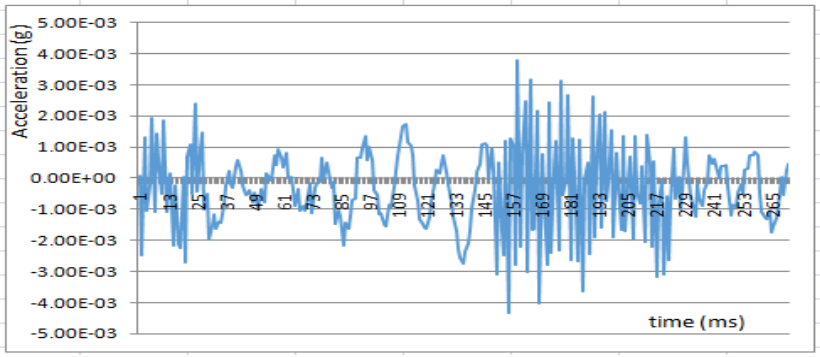

Fig. 11 Vibration analysis with 2000rpm

VII.CONCLUSION

In this paper reviewed real time monitoring of voltage, current, speed, and vibration in BLDC Motor. FPGAs based on speed control of this system reveal the used, because of its reliable and lower cost controller. Using FPGAs gives us flexibility of implementing different algorithms quickly and without complications. The speed of BLDCM is controlled by duty cycle and frequency of the simple Pulse Width Modulation (PWM) techniques. The proposed system is

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 4, April 2015

analyzed the voltage, current, speed, and vibration in with different speed. In this real time monitoring we have get detailed information about the BLDC motor. The results are obtained by using Lab VIEW analysis of both time domain and frequency domain.

REFERENCES

[1] Alfoni Jose, "Implementation of FPGA based 3-Phase Inverter FED BLDC Motor", International Journal of Applied Sciences, Engineering and Technology Vol. 01, No. 01, pp.26-30, Dec 2012
[2] Adrian Młot, "Comparison vibration due to Maxwell forces and magnetostriction in BLDC motor – dynamic analysis" Journal of Electrical Engineering, 2008
[3] Dahaman Ishak "PWM Switching Strategy for Torque Ripple Minimization in BLDC Motor" Journal of Electrical Engineering, VOL. 62, NO. 3, Nov 2011.
[4] Kirti B. Satale, "Analysis of Different Speed Controllers and Implementation of Novel Speed Controller using FPGA for BLDC Motor", International Journal of Soft Computing and Engineering, Volume-4, Issue-2, pp.131-134, May 2014
[5] Lee, "Experimental Measurement and Simulated Verification of the Unbalanced Magnetic Force in Brushless DC Motors" IEEE Transactions on Magnetics, Vol. 44, No. 11, November 2008.
[6] Nikola Milivojevic, "Stability Analysis of FPGA-Based Control of Brushless DC Motors and Generators Using Digital PWM Technique", IEEE Transactions on Industrial Electronics, Vol. 59, No. 1, pp.343-352, January 2012
[7] Pindoriya, "Speed Control of BLDC Motor using Sinusoidal PWM Technique", National Conference on Emerging Trends in Computer & Electrical Engineering, pp.151-155, 2014.
[8] Satomi Hattori, "Suppression Control Method of Torque Vibration for Brushless DC Motor Utilizing Repetitive Control with Fourier Transform" Trans. of the Society of Instrument and Control Engineers Vol.E-2, No.1, 42/53, 2002.
[9] Serdar Uygur, " An FPGA Based BLDC Motor Control System" Thesis of the Graduate School of Natural and Applied Sciences of Middle East Technical University, February 2012.
[10] Seyong Yoon "Magnetically Induced Vibration in a Permanent-Magnet Brushless DC Motor with Symmetric Pole-Slot Configuration" IEEE Transactions on Magnetics, Vol. 41, No. 6, June 2005.
[11] Shyu, "Novel Loss Reduction Pulse Width Modulation Technique for Brushless DC Motor Drives Fed by MOSFET Inverter," IEEE Trans. Power Electron., Vol. 19, No. 6, Pp. 1646–1652, Nov. 2004.

BIOGRAPHY

S.M.Ramesh Balaji was born in Salem, Tamilnadu. He received diploma in electrical and electronics engineering from Muthayammal Polytechnic College, Rasipuram, Tamilnadu, in 2007, and B.E. degree from Vidyaa Vikas College of Engineering and Technology, Tiruchengode, Tamilnadu, in 2010 and pursuing M.E power electronics and drives in K.S.Rangasamy College of Technology, Tiruchengode. Tamilnadu.

Muniraj.C was born in India, in 1980. He received B.E., M.E and Ph.D, degrees in Electrical Engineering at Bharathiyar University and Anna University in 2003, 2006 and 2012 respectively. He has been working as Associate professor in K.S. Rangasamy college of Technology in the Department of Electrical and Electronics Engineering. His researches interests include condition monitoring of power apparatus and systems, power electronics and drives, signal processing and intelligence controller application in electrical drives.