INDUCTION MOTOR EFFICIENCY MONITORING SYSTEM

[1]R. Nagalakshmi, [2]J. Johnsi, [3] V. Sunanthini, [4] K.R.Sughashini,[5] T.Surendran

[1,2,3,4,5]*Assistant Professor, Department of EIE, Easwari Engineering College, Chennai*

Nagalakshmi.r@eec.srmrmp.edu.in

ABSTRACT

Energy consumed nowadays plays significant role and the demand of energy is getting increased depending on the growth of population and industrial revolution. The operational energy sources are not sufficient for the energy needed. Induction motors takes a wide range of industrial applications, including compressors, pumps, conveyors, winders, mills, fans, transports, cranes, home appliances, office equipment's, steel and paper industries and etc and consumes more electrical energy. In the total consumption of energy, motors consume 70%. Hence, in order to conserve energy the motors should be operated very efficiently. To measure the efficiency of motor on-line method helps in identifying the motors for replacement, checks the efficiency after rewinding, operating the motor nearer its good efficiency point etc., Monitoring and controlling of the motor operation is important when in view of considering the operating performance of the motor, selection of drive used and replacement of electrical machines in proper strategy. In this paper the main objective is to develop the user friendly interface to monitor the efficiency of the motor through online using web server which will provide the on-the- go-access for the users.

Keywords: **Induction Motor, Netduino Plus**

1. INTRODUCTION

Induction motors are high efficiency machine used in most of the industrial applications because of its reliability, less maintenance, low price and robustness. Traditionally, the detection of fault in industrial systems and monitoring of efficiency in motors are performed offline or by using wired networks. The costs of cables are costlier than sensors used. The wired approach also offers a reduced amount of flexibility, making the network distribution as well as maintenance harder. Sensor of the speed or position in an adjustable speed drive tends to spoil the motor. Only motor terminal quantities and nameplate details are required in olden days. Another method is in which embedded system is integrated with wireless sensor.

But due to lack of proper speed sensing drive, the system is less efficient. This paper presents the "Design and Development of embedded web server for induction motor efficiency monitoring system". It describes about the monitoring system for induction motor by using the Modbus protocol. The software of the system is developed in .Net programming in Netduino Plus. The parameter of motor system are taken from the system transferred to computer over RS485.All the IMEMS nodes are connected to Netduino plus and the Netduino board is connected with IP address. When the IP address is typed in web server, the html pages designed in the web server displayed all the nodes connected to it. When the user selects the IMEMS node it will display the parameter of that particular motor. If some node is not alive it will also be displayed. Thus with Netduino plus we can monitor the efficiency from anywhere.

2. PROPOSED BLOCK DIAGRAM
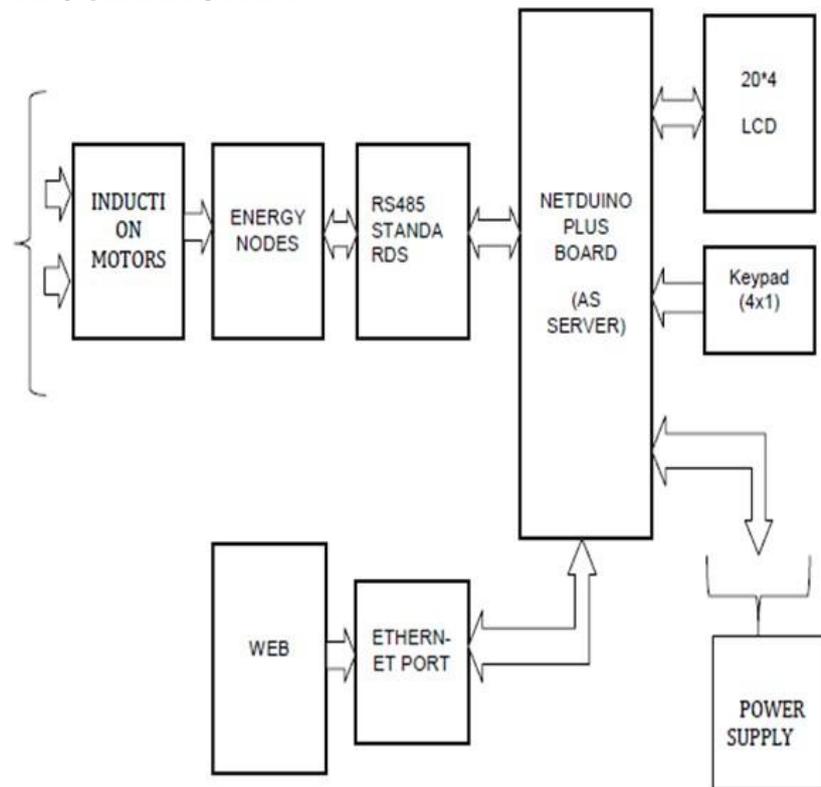
Fig 1: Block diagram of the Process

The block diagram represents the NETDUINO PLUS based web-server setup as shown in the Fig 1. The efficiency of each induction motor is observed by IMEMS node interfaced with it. The parameters such as input, output, losses and efficiency are monitored by each IMEMS node of the corresponding motor. All the IMEMS nodes are networked with NETDUINO PLUS BOARD base web-server via RS485 communication standard. The NETDUINO PLUS board will act as MODBUS master. Each IMEMS node will act as MODBUS slave with unique id ranging from 1 to 255, since the Slave ID uses unsigned char variable to store the Slave ID. The NETDUINO BOARD with pre-assigned IP-ADDRESS can be accessed from anyplace in the world with internet. When the IP address is typed in a web-browser, the html page designed and stored in the memory of NETDUINO Board is displayed which will show the list of IMEMS node connected to it. When the user chooses an IMEMS node from the list all the parameters of each motor will be displayed. The parameters are updated in real time with MODBUS MASTER polling all the slaves connected to it in periodic interval. If some node is not alive, it will be also displayed. Thus with this NETDUINO PLUS board we could monitor the efficiency and other vital parameters of an induction motor.

3. HARDWARE

Netduino is an user friendly electronics platform which makes the programmers to create electronics projects easier. Netduino applications use the framework of .NET. The programming frame work from Microsoft, writing .NET code is similar like creating simple JavaScript animations for a web page which will be easier for learners and for the masses of programmers who already uses .NET code, the .NET Micro Framework provides an extremely powerful set of features like line-by-line debugging and threading. Microsoft provides free software tools to create Netduino apps.

3.1 Atmel ARM microcontroller

This is the main processor, and it contains the code storage space and RAM used by our Netduino app. The microcontroller's pins are wired to the blue pin headers, enabling our Netduino app to connect to external components and expansion shields.
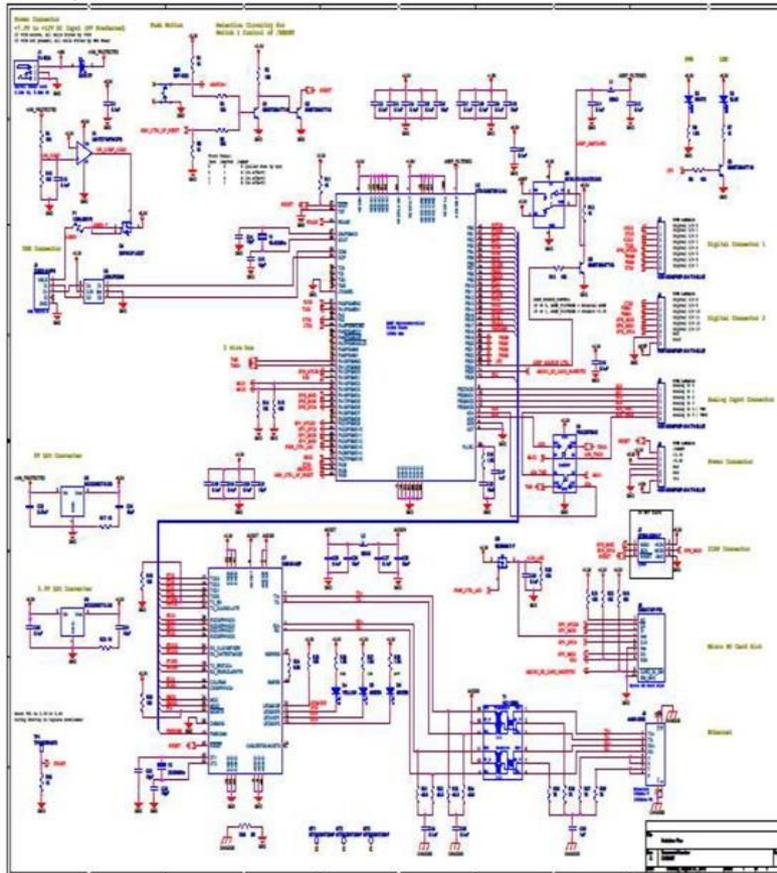
Fig 2 Circuit Diagram of Netduino Plus Board

3.2 Analog Input headers

The sensors are plugged into headers (light, temperature, motion, Pressure,etc.). Analog Input headers can also operate in digital I/O mode (explained next).

3.3 Power and user LEDs

The white power LED is illuminated while the Netduino is powered. The blue user LED turns on briefly when the Netduino is first powered and then shuts off to know that the board has booted.

3.4 Power barrel jack

The Netduino may be powered by an AC-to-DC power adapter with a Standard 5.5mm (outer)/2.1mm (inner) plug. Allowable voltages are from 7.5V to12V, and the plug polarity must be centre pole positive. This fuse will auto reset once it cools down.

3.5 Power regulation circuitry

Onboard power regulators convert inward high voltage into the3.3V.Needed by the microcontroller. They also provide power to the 5Vand 3.3V pin headers, for use by external components and expansion shields.

3.6 MIcroUSB port

The MicroUSB port connects the Netduino to computer's USB port. Netduino can also be powered from computer (or USB power supply) over the MicroUSB port. By default, the MicroUSB connection is used to deploy apps to Netduino and to interactively debug those apps.

3.7 Ethernet jack

The Ethernet jack allows Netduino Plus to connect to the Internet through a network router.After connecting your Netduino Plus to the Internet, can post sensor data, interact with a mobile phone app; communicate with far- away Netduino etc.

3.8 MicroSD slot

The MicroSD slot lets to add persistent storage to the Netduino app. Log environmental data, store web pages (to serve to the Internet), and much more. Advanced users can store compiled code on MicroSD cards, for execution by the Netduino Plus or a Netduino with an add-on card reader. Netduino uses a routine runtime designed particularly for microcontrollers. This also contains many specific features to the development boards of Netduino, such as the capability to give input, output signals. To create Netduino apps, three software packages should be installed on the system which is used:

- The Visual Studio development environment.
- The .NET Micro Framework Software Development Kit.
- The Netduino software development kit (SDK).

3.9 RS485 Circuit Diagram

RS485 is used to permit the configuration of efficient communications links and local networks. It deals with data communication speed of 35 Mbit/s for 10m whereas it is 1200m in 100 kbit/s. The differential well-adjusted line over twisted pair is used, which makes to extent relatively large distances for a maximum of 4,000 feet.

3.10 Master Slave Arrangements

In a master-slave arrangement the master initiates all communication activity, and provides the bias. Here, the master tool is characteristically positioned at center with the set of RS-485 wires, which makes two slave devices placed at the end of wires. The master can also be able to provide the termination if it were located at a physical end of the wires, but it is not a good design.
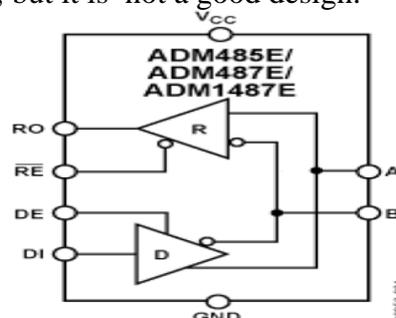
Fig 3: IC LAYOUT DIAGRAM

3.11 Power Supply

The circuit in electronics needs a smooth dc power supply in order to function properly. Analyzed the performance of two different types of SMPS Load testing was performed with rheostat for both. The SMPS transformer of SMPS-1 and SMPS-2 were removed from circuit and was given to a vendor for manufacturing the same type of transformer to be used for our Testing. SMPS circutry-1 based on SMPS-1 was made in General purpose board. Since some components in original SMPS-1 got damaged, the SMPS-1 transformer manufacture by vendor was tested in SMPS hardware circuitry-1 made in gen purpose board. The expected output as per design from it is 12V whereas we get only 6V. The SMPS2 transformer was replaced in the place of original one in SMPS-2 model and the output obtained was 11.85V.

4. SOFTWARE

The software used here is .NET Framework which is a framework developed by Microsoft.

The software includes:
- The .Net Framework Class Library
- ASP.Net and ASP.Net AJAX
- Common Language Specification
- Common Language Runtime (CLR)
- Common Type System
- Metadata and all Assemblies
- Windows

Modbus simplifies communication for many devices connected to the common network. Modbus have its application mostly to associate a supervisory computer with a remote terminal unit (RTU) in supervisory control and data acquisition (SCADA) systems. The types of data are termed with its use in driving relays: where a single-bit of physical output is a coil and a single-bit physical input is known as discrete input or a contact. There are many modems and gateways that provide provision to Modbus, as it is a very simple and derived protocol. Modbus protocol uses 19 serial communication lines that connect a Modbus master to slave using a Modbus network. The master can support till 247 slave devices on one serial communication network. RS-482 is the Modbus protocol variant that uses an RS-485 link.

The Uno program is done using the Arduino Integrated Development Environment. The ATmega328 in the Uno approaches preprogrammed with a boot loader that helps to upload novel code without the use of an external hardware. The ATmega16U2 firmware source code is available in the Arduino origin. The Uno varies from all earlier boards in that it and does not use the FTDI USB-to-serial driver chip.

5. RESULTS AND DISCUSSION

Arduino's analog inputs can be used to measure DC voltage in 5V range and this range can be maximized by two resistors that are connected to make it as a voltage divider.

The voltage divider circuit decreases the voltage that is measured within the assortment of the Arduino analog inputs. Code in the Arduino is then used for the calculation of the actual voltage being measured.

The method for computing values in a potential divider is:

$$V_O = (R_1 + R_2)) *Vin$$

Fig 4: Circuit Diagram for Arduino Uno Board

The voltage divider for the Arduino voltmeter is checked and if its working good then Vout will be a maximum of 5V, therefore to calculate the maximum input voltage we use:

$$Vm = 5.0 / (R_2 / (R_1 + R_2))$$

Fig 5: Circuit to Measure Voltage with Arduino

To convert the range of 0V–5V numerals into a evaluation that redirects the span of values that can be noted using the circuit. The resistors need to be taken into justification in the method that is done to determine the maximum voltage of the implemented circuit.

$$V_2 = V / (R_2 / (R_1 + R_2))$$

Fig 6: Hardware for Measuring Voltage with Arduino

The Arduino's Input Pins used for analog will work between 0 and Vref value - which is in the range of 0 to 5 volts. The digital numeral is between 0 to 1023 and hence the digitally determined value is 1023/5 = 204 per volt. If this is correlated to 10mV per amp on or after the shunt, it is seen that the least step difference in the current can be resolved with the Arduino is 0.5 amps. The Instrumentation Amplifier - AD623AN is a modest Op-Amp which is presented in a typical standard of 8-pin DIL package.
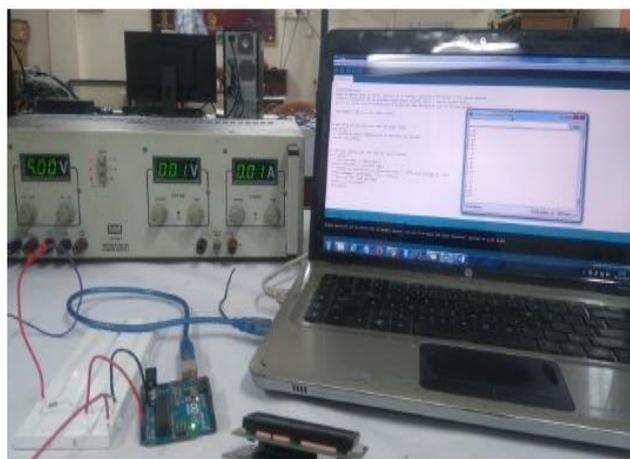
Fig 7: Measuring Current With Arduino
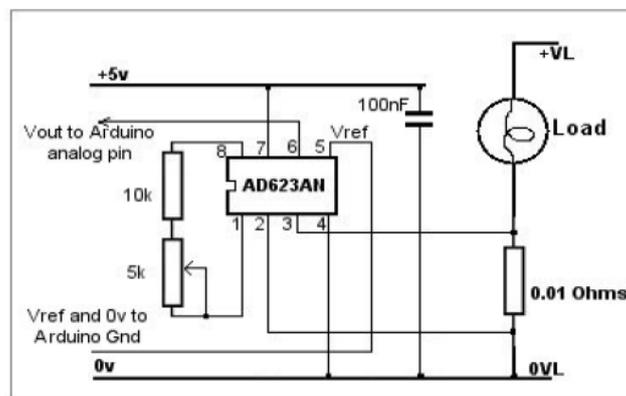
Fig 8: Circuit Diagram for Current Measurement using Arduino
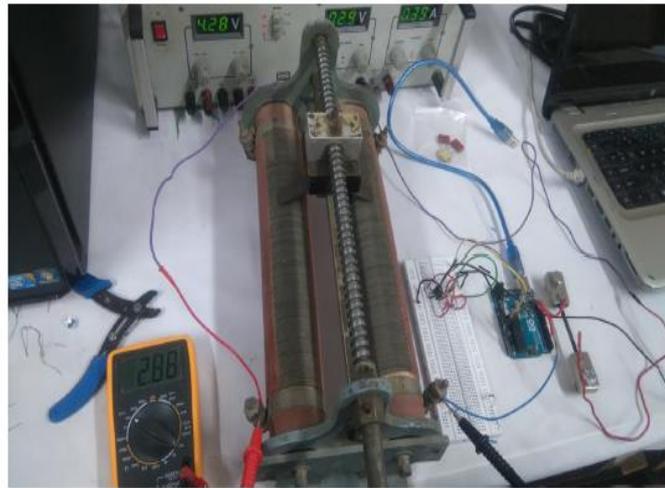
Fig 9: Hardware of Current Measurement Using Arduino

5.1 HARDWARE CALIBRATION FOR VOLTAGE MEASUREMENT

Table 1 Voltage calibration

V_{set} (V)	V_{msrd}(V)	DEVIATION	%(error)
2.2	2.031	-0.169	-0.112666667
2.4	2.818	0.418	0.26125
2.6	2.713	0.113	0.066470588
2.8	2.941	0.141	0.078333333
3	2.991	-0.009	-0.00476842
3.2	2.641	-0.559	-0.2795
3.4	2.871	-0.529	-0.251904762
3.6	2.694	-0.906	-0.411818182
3.8	2.594	-1.206	-0.524347826
4	2.89875	-1.10125	-0.458854167
4.2	3.497	-0.703	-0.2812
4.6	3.89875	-0.70125	-0.269711538
5	4.642	-0.358	-0.13592593

The below figure from 10 to 12 depicts the graphical values for voltage measurement Vset with deviation and error.
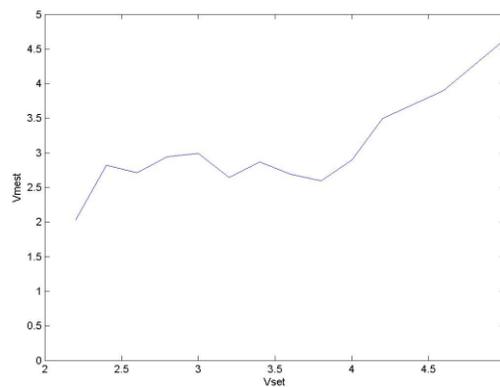
Fig.10. Vset(v) and Vmsrd(v)
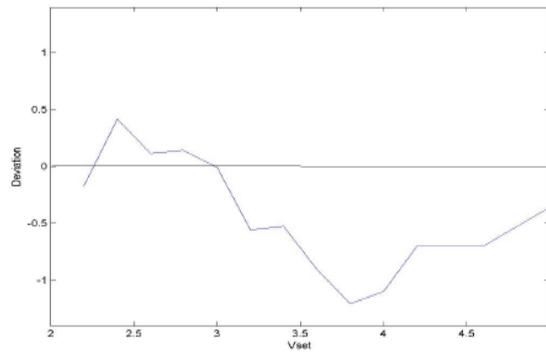
Fig.11. Vset(v) and deviation
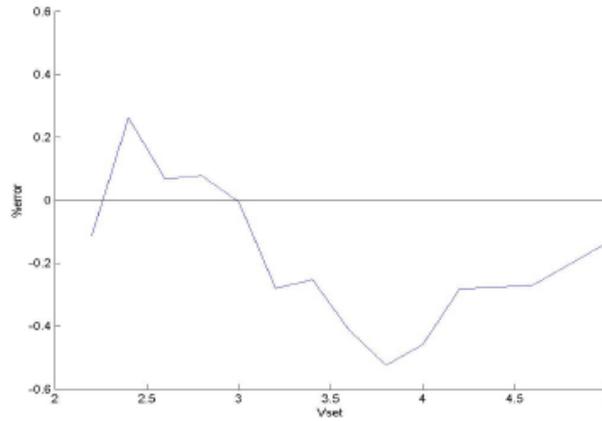
Fig.12. Vset(v) and %error

5.2 HARDWARE CALIBRATION FOR CURRENT MEASREMENT

Table 2 Current calibration

Cset(A)	C_{msrd}(A)	DEVIATION	%(error)
0.1	-0.17	-0.27	-0.3375
0.2	0.0012	-0.1988	-1.988
0.4	0.294	-0.106	-0.6625
0.6	0.645	0.045	0.225
0.8	0.781	-0.019	-0.06333
1	0.885	-0.115	-0.2875
1.2	1.026	-0.174	-0.348
1.4	1.091	-0.381	-0.635
1.5	1.071	-0.429	-0.6128

The below figure from 13 to 15 depicts the graphical values for current measurement Cset with deviation and error.
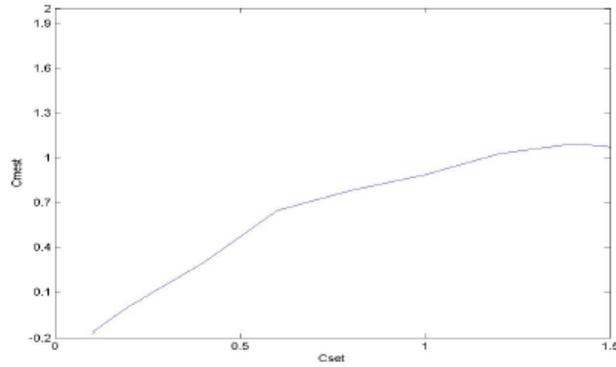
Fig.13. Cset(A) and Cmsrd(A)
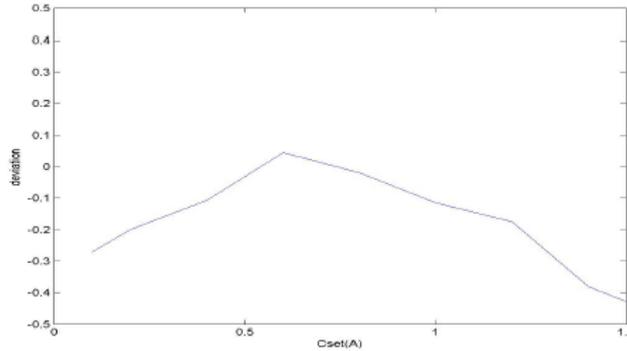
Fig.14. Cset(A) and deviation
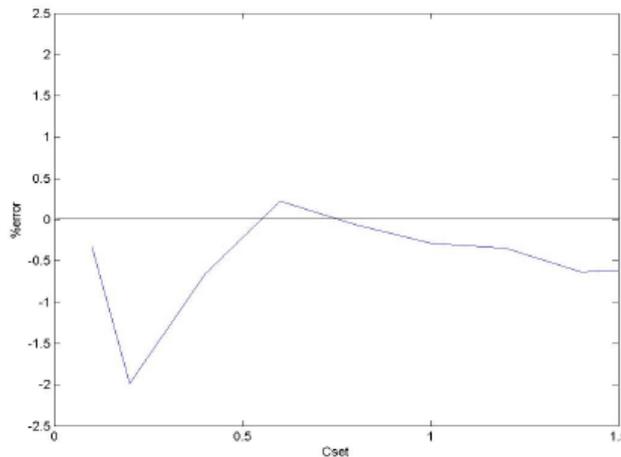
Fig.15. Cset(A) and %error

The Dc power monitoring node (DPMN) using arduino for voltage and current measurement on DC Side was developed and the Parameters data can be shown through a display. The DPMN will have RS485 network connectivity to the Web Server. In phase II the RS485 connectivity to the IMEMS and PC and check communication using MODBUS communication protocol will be established and through Implementation of Netduino web server the parameters of motor can be monitored effectively in online and using data loggers these values can be stored and testing and evaluation can be done in real time.

6. **REFERENCES**

[1] Geethi P. and V.Saravanan (2012),'Online Parameter Monitoring Of Induction Motors Using Wireless Network', IEEE, Vol.1.

[2]   Liu Yanfei1. Wang Cheng. Yu Chengbo.Qiao Xiaojun1,' Research on ZigBee Wireless Sensors Network Based on ModBus Protocol' (2009), IEEE International Forum on Information Technology and Applications.

[3]   Mohaseeena Shaikh, Nadeem Shaikh (2016)," Embedded System for Online Monitoring of Induction Motors" IJCSN International Journal of Computer Science and Network, Volume 5, Issue 2.

[4]   Prof. Sandip R. Aher, Manisha Khairnar, Kaustubh Kher, Harshda Shinde (2017), " Wireless Electrical Motor Parameter Monitoring System for Three Phase Induction Motor" International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering ISO 3297:2007 Certified Vol. 5, Issue 5.

[5]   Ramazan BAYINDIR, Mehmet ŞEN (2011)," A Parameter Monitoring System for Induction Motors Based on Zigbee Protocol", Gazi University Journal of Science GU J Sci24(4):763-771.

[6]   R. R. Patil.T. N. Date.B. E. Kushare (2014),' ZigBee Based Parameters Monitoring System for Induction Motor' (2014), IEEE Conference on Electrical, Electronics publication.

[7]   R. R. Patil.T. N. Date.B. E. Kushare (2014),' ZigBee Based Parameters Monitoring System for Induction Motor', IEEE Conference on Electrical, Electronics publication.

[8]   Yanyu Zhang.Peng Zeng. Guang Yang,.Jinying Li(2013),'online and remote machine condition monitoring and fault diagnosis system using wireless sensor networks' , IEEE International conference publication.

[9]   Yasar Birbir. and. H.SelcukNogay(2008), 'Design and Implementation of PLCBased Monitoring Control System for Three-Phase Induction Motors Fed by PWM Inverter', Vol 2.

[10] http://henrysbench.capnfatz.com/henrysbench/the-acs712-current-sensor-with-anarduino/

[11] http://www.electroschematics.com/9351/arduinodigital-voltmeter/

[12] http://www.induino.com/2013/07/lcd-interfacing-working-with-simple.html