Remote monitoring of BLDC motor using LabVIEW and zigbee

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Abstract. Brushless DC motors (BLDC) are preferred over brushed motors in industries because of many advantages such as increased reliability, reduced noise, higher speed range, better speed-torque characteristics, higher efficiency and high torque to weight ratio. This paper focuses on the remote monitoring of parameters of BLDC motor such as Temperature, Voltage, Current and Speed using Zigbee wireless technology and virtual instrumentation tool, LabVIEW. The results shown during the tests are accurate and the low-cost system is able to efficiently transmit the parameters remotely using ZigBee and display them on the LabVIEW front panel. The system can be of great importance in industries as it is not possible to manually access the motors functioning in hazardous environment. This system can also be used for predictive maintenance where the parameters monitored can be used to study the lifetime of the motor. The hardware requirements of the system are Arduino Microcontroller, two Zigbee (one as coordinator and other as end device), BLDC motor, an optical encoder for determining the speed of the motor, LM35 Temperature sensor for measuring the temperature, Current transducer, ACS712, for measuring the input current and Voltage transformer for stepping down the voltage before giving the input to Arduino to measure the voltage.

1. Introduction

Motors are found to have applications in a wide range of products and devices where their functioning is extremely critical. These motors must be robust, accurate in its functioning and must have least maintenance. There are many types of DC motors currently available in the market including shunt motors, compound motors, Permanent Magnet DC motors, Series motors and BLDC motors. These DC motors have different operational principles that have been developed for various industrial applications [4]. The main advantage of using a BLDC motor over conventional DC motors are that they have high power/torque to weigh ratio, wide range of speed, high reliability and excellent control from the electronic aspects. These motors also find applications in automotive and aircrafts. BLDC motors have permanent magnets that rotate with respect to a fixed armature. The commutator of brushed DC motors is replaced with controllers that are electronic. They keep switching the phase continuously to keep the motor rotating. Figure 1 shows the construction of BLDC motor. Some of the important parameters based on which a motor is chosen are its speed, rated voltage, current and temperature at which it gives optimum performance. The BLDC is no exception to this. Various reasons are there for motor failure. One of them is overheating due to the damage caused to the insulation of windings. This can lead to reduction in isolation between conductors which may further lead to cascaded short circuits and result in motor failure. To avoid such faults, it is always necessary to monitor these motors regularly.
Magdum and Agashe [1] have shown a LabVIEW based design technique to monitor and control different types of motor parameters. Voltage, current, active power, reactive power and temperature are the most common and important parameters being monitored in [2] for determining the performance of the induction motor in industries. The importance of this system is being emphasized because during continuous operation, it becomes risky to control and monitor these machines directly [3]. [4] has a Management Information Base (MIB) that is used to send data via an SMS using a GSM module. [5] deals with the remote monitoring of industrial machines by analysing its features so as to detect abnormalities in the normal operation of these motors. Later on, a report is generated based on the analysis that is conducted. The signature analysis of the motor current and a sequential analysis of its components are some of the methods used to find faults with the motor in [5]. [6] has implemented MATLAB Simulink models of BLDC motor and conventional DC motor for the control of speed, torque and position. [7] dealt with closed loop control of BLDC motor in Electrical vehicles using MATLAB Simulink. [8] discusses about the use of LabVIEW in monitoring wind turbine. [9] proposes a fault diagnosis system based on wireless network for industrial automation. Wireless transmitters that are vibrational are used to monitor the status of target motors continuously. This data is later processed for fault diagnosis. Monitoring of motor parameters is becoming a fast-growing trend in industries to predict initial motor faults. Wired communications such as Ethernet, Modbus and RS232 have been in use for a very long time. These traditional methods at times make more sense than the wireless link. But in recent times, the wireless communications have become continually less expensive and more reliable than the wired ones. LabVIEW has been widely used in the industries for embedded control of advanced manufacturing, monitor and control of manufacturing equipment and for remote monitoring of power signals.

2. System under study

Figure 2 shows the block diagram of the setup of a remote monitoring system that monitors the BLDC motor parameters such Temperature, Current, voltage and Speed. The Arduino microcontroller is placed close to the motor which is placed in a remote location whose parameters are to be measured. Connected to the Arduino are the sensors, Optical encoder and LM35, current transformer and voltage transformer for measuring the parameters speed, temperature, current and voltage of the motor respectively. One of the two Zigbee modules is also placed close to the Arduino. This Zigbee is configured to work as a coordinator using the XCTU software. The coordinator Zigbee sends out signal from the remote location to the Computer with a receiver Zigbee and LabVIEW. The Zigbee placed close to the Computer is configured to work as a receiver using the XCTU software. A graphical interface on the LabVIEW displays these parameters which can later be used for scheduling maintenance.
The Zigbee wireless protocol was preferred over Wi-Fi and Bluetooth because of its low cost, capability to incorporate large number of nodes, flexible network architecture and low power consumption. Zigbee devices are generally of three types – Coordinator, Router and an end device.

Zigbee Coordinator – The Zigbee configured to work as a coordinator initiates the network by configuring the communication and network IDs. It also contains a security key only with which other devices can communicate through this network.

ZigBee Router – The Zigbee configured to work as a router is an intermediate device whose main function is to participate in the mesh routing of network messages.

ZigBee End Device – A Zigbee configured to work as an end device has only one functionality of communicating with the node which is the parent node.

The Zigbee can also functions in three main topologies that is the tree, star or the mesh topology, which are shown in Figure 3. In this paper, there is only one Coordinator Zigbee and one End device Zigbee. Unlike the traditional programming languages, the LabVIEW supports the use of graphical notation, connecting functional nodes through wires. LabVIEW also eases the software overhead thus providing an industrial visualization and simplifying system design. In this paper, LabVIEW is used to acquire the remote parameters and display them in the screen using graphical notations so that later, these parameters acquired can be used for maintenance purposes.
Accessing the parameters of motor remotely can be used for improved equipment usage tracking, predicting maintenance expenses, to get a complete picture of the machinery usage and state and for decreasing unanticipated. At times when the industrial person is not available, automatically generated messages can be sent if parameters are not within a specific range. LabVIEW has a web publishing tool which is used for automation of motors using different sensors. For temperature measurement [1], LM 35 sensor is used. It has a linear scale factor of +10-mV/°C and it can work at a temperature lying between −55°C to 150°C. In LabVIEW, the Mask and Limit can be used to set the threshold value of temperature and sound an alarm if this value is exceeded. An optical encoder is used to measure the speed of the motor. The ACS712 having a high current rating, which works on the principle of Hall Effect has been chosen for measuring the current. The specifications of the BLDC motor used are shown in Table 1.

Table 1. Specifications of BLDC Motor

| Parameter            | Specification |
|----------------------|---------------|
| Rated Voltage        | 48V           |
| Rated Speed          | 3000 RPM      |
| Peak Current         | 37 A          |
| Peak Torque          | 4.2 N.m       |
| Rated Torque         | 1.4 N.m       |
| Torque Constant      | 0.133 N.m/A   |
| Body Length          | 96 mm         |
| Mass                 | 3.15 Kg       |

3. Hardware Implementation

Figure 4 shows the hardware setup of the remote monitoring system which has a Laptop with LabVIEW installed, Brushless DC motor with power supply, LM35 temperature sensor, Optical encoder to measure speed, Current transformer to measure current, Voltage transformer to measure voltage, Arduino Microcontroller, Zigbee Coordinator and Zigbee End device.

4. LabVIEW Implementation

The parameter monitoring system is divided into several separate modules such as temperature monitoring, speed monitoring, voltage monitoring, and current monitoring. Figure 5 shows the block diagram of the temperature measurement module in LabVIEW, where the VISA serial configuration port acts as the input. The VISA resource name block will help in controlling the COM port to which the Arduino is connected. A constant baud rate of 9600 is added now. This is then connected to a find first error block, which gives error in connection between Arduino and LabVIEW. A digital indicator is added with a NOT gate to show the error. If there is no error, the light glows, else it is off. The
error output from the find first error block is connected to the error input terminal of the VISA read block. A byte count of 100 is given to the VISA read block to make it good and stable. A digital temperature display can be added with a colour ramp. As the VISA read block value has to be cleared in every loop execution, a VISA clear and a VISA clock block are added outside the While loop. Figure 6 shows the LabVIEW front panel of temperature measurement.

Figure 5. LabVIEW block diagram for temperature monitoring module

![LabVIEW block diagram for temperature monitoring module](image1.png)

Figure 6. LabVIEW front panel for temperature monitoring module

![LabVIEW front panel for temperature monitoring module](image2.png)

Figure 7 shows the block diagram of the speed module in LabVIEW, which is similar to the temperature monitoring module. The only difference is that a Digital speed display with a ramp is used instead of a temperature display. This will give the value of the speed, which is displayed graphically on a scaled meter in RPM. Figure 8 shows the front panel for speed monitoring module.

Figure 7. LabVIEW block diagram for speed monitoring module

![LabVIEW block diagram for speed monitoring module](image3.png)

Figure 8. LabVIEW front panel for speed monitoring module

![LabVIEW front panel for speed monitoring module](image4.png)
The input voltage of a BLDC motor is measured by a voltage transformer. The voltage transformer is connected to the Arduino that sends the value to the PC with LabVIEW via Zigbee. Figure 9 depicts the LabVIEW block diagram of the Voltage monitoring module and Figure 10 shows the front panel of the voltage monitoring module.
The Input current of the BLDC motor is measured using an ACS712 current transducer. The current transducer is connected to the Arduino that is placed remotely near the motor in a remote location. The signal from the current transducer is sent to the PC with LabVIEW via the Zigbee Module. Figure 11 depicts the LabVIEW block diagram of the current measuring module and Figure 12 shows the front panel of the current monitoring module.
5. Conclusion
This paper has successfully implemented the software and hardware for monitoring the parameters of the BLDC motor such as Temperature, Speed, Current and Voltage using the tool LabVIEW. The results show that the system is accurate and reliable. The blocks in the front view panel of LabVIEW have made monitoring very easy because of the graphical representations and value blocks which directly give the parameters of the motor.

References

[1] Magdum A D and Agashe A A 2016 Monitoring and controlling the industrial motor parameters remotely using LabVIEW IEEE Int. Conf. on Recent Trends in Electronics Information & Communication Technology (Bangalore).

[2] Badmera M S and Pradip M Ambore June 2016 An efficient parameter monitoring & controlling system for three phase induction motor based on PLC & SCADA Technology Int. Journal of Advanced Research in Electrical Electronics and Instrumentation Engineering Vol. 5 Issue 6.

[3] Lu B and Gungor V CNov 2009 Online and remote motor energy monitoring and fault diagnostics using wireless sensor networks IEEE Transactions on Industrial Electronics Vol. 56 no. 11 pp. 4651-59.

[4] Yang G, Zhou J, Su X and Zhang Z 2010 Remote monitoring system of the motor in GPRS based on LabVIEW and embedded TCP/IP Int. Conf. on Internet Technology and Applications (Wuhan).

[5] Datta J, Bera J and Chowdhuri S 2016 Development of remote monitoring analysis and reporting system for industrial machines 2nd Int. Conf. on Control Instrumentation, Energy & Communication (Kolkata).

[6] Stefán Baldursson May 2005 BLDC motor modelling and control – A Matlab/Simulink implementation Master Thesis.
[7] Vishnu Sidharthan P, AS Suyampulingam and Vijith K 2015 Brushless DC motor driven plug in electrical vehicle Int. Journal of Applied Engineering Research Vol. 10 No.55 pp.3420-24.

[8] V Aiswarya and N Krishna Prakash 2013 Wind turbine instrumentation system using LabVIEW IEEE Global Humanitarian Technology.

[9] Yanyu Zhang, Peng Zeng, Guang Yang and Jinying Li 2013 Online and remote machine condition monitoring and fault diagnosis system using wireless sensor networks 15th IEEE Int. Conf. on Communication Technology (Guilin).