Real-Time Remote Monitoring with Data Acquisition System

Ahmad Faizal Zainal Abidin$^{1,2}$, Mohammad Huzaimy Jusoh$^{1,2}$, Elster James$^2$, Syed Abdul Mutalib Al Junid$^2$ and Ahmad Ihsan Mohd Yassin$^2$

$^1$Applied Electromagnetic Research Group, Advance Computing and Communication Communities of Research, Faculty of Electrical Engineering, Universiti Teknologi MARA, Shah Alam, Selangor, Malaysia
$^2$Faculty of Electrical Engineering, Universiti Teknologi MARA, Shah Alam, Selangor, Malaysia

Email: huzaimy@salam.uitm.edu.my

Abstract. The purpose of this system is to provide monitoring system for an electrical device and enable remote monitoring via web based application. This monitoring system allow the user to monitor the device condition from anywhere as the information will be synchronised to the website. The current and voltage reading of the monitored equipment, ambient temperature and humidity level are monitored and recorded. These parameters will be updated on the web page. All these sensor are connected to the microcontroller and the data will saved in micro secure digital (SD) card and send all the gathered information to a web page using the GPRS service connection synchronously. The collected data will be displayed on the website and the user enable to download the data directly from the website. The system will help user to monitor the device condition and ambient changes with ease. The system is successfully developed, tested and has been installed at residential area in Taman Cahaya Alam, Section U12, Shah Alam, Selangor, Malaysia.

1. Introduction

Real time data monitoring is an important support application in order to monitor supported electrical device conditions especially when the observed parameters influence the supported equipment electrical device operation such as temperature, humidity, voltage, current and wind condition [1]. Internet embedded technology makes data transferring and accessibility around the globe possible where machine could communicate with computer in performing its operation [2]. The idea of wireless data transmission is to provide device simplicity instead of wired system and lower cost for long range communication [3]. In some cases, the frequent human site visit is not permissible due to a number of factors such as safety, rough terrain, huge cost per visit, weather condition and danger wildlife. To overcome the issues, a long-term long-range wireless monitoring system, which required low maintenance essential to be established [4]. In nowadays Internet of Things (IoT) era, the sensor data sampling can be live fed into website and can be accessed anywhere as long as internet access is permissible [5]. In taking the advantage of nowadays technology achievement, an unmanned monitoring system can be established in order to overcome the stated difficulties. On top of that, by establishing the real time monitoring system, the human site visits for configuration and maintenance could be minimized. Hence, project and manpower costs could be also minimized. In this research project, a real time remote data monitoring sensors device is developed along with web based data acquisition (DAQ) system for user friendly data access.
2. System Design and Operation
The real-time data monitoring device is consists of six inputs and two outputs. All electronics operation is controlled by a single microcontroller unit, which is programmed on how the all peripherals should be behaved. In this device, it consists of five sensors; temperature and humidity (integrated in a single module), two current and two voltage sensors. The temperature and humidity sensors are responsible to detect ambient changes. One of the current sensors is used to detect current of equipment to be monitored while the other one is used to detect the real-time data monitoring device. The same operation also applied to both voltage sensors, where one of the voltage sensors is used for the real-time data monitoring device and the other one is used for main equipment monitoring. All of the sensors data reading will register into the microcontroller unit along with date and time stamp synchronously. The data will be uploaded over GSM/GPRS module to remote monitoring database to provide user the real time data, at the same time the data is logged into microSD module. The data is accessible anywhere through web base application where the data stored inside cloud storage application. The web base application serve as remote data acquisition application which shows real-time numerical data and graphical data plotting. Hence, the data is accessible anywhere and any form of internet capable electronic gadgets such as lap top, desktop and smartphone. The data collected by the sensors will be uploaded into website server and these data will be updated at the website specific channel and displayed for viewing [10]. The data will be updated every 30 minutes. The system design architecture can be referred in Figure 1 as follow.

![Figure 1. Real-time monitoring device system architecture](image)

2.1 Microcontroller Unit
A microcontroller behaves as a small capacity computer on electronic hardware architecture. The microcontroller will determine on how the electronics peripherals that attached to it operate and act as integrated system which therefore programmed and burn into the microcontroller flash memory. The electronic peripherals that attached to the microcontroller communicate with each other via serial communication either via Inter Integrated Circuit (I2C), Serial Peripheral Interface (SPI) or Universal Asynchronous Receiver/Transmitter (UART). In this project, Atmel Atmega2560 microcontroller is chosen to perform the hardware operation control and serial data processing task. The microcontroller consists of 54 digital input/output pins where 15 of it can be used as pulse width modulation (PWM), 4
UARTs interface, 16 10-bit analog digital converter (ADC) input pins, 256 kB flash memory (which 8 kB contain bootloader) and 8 kB Static Random Access Memory (SRAM). 16 MHz crystal oscillator is attached along with the microcontroller as clock speed generator.

2.2 GSM/GPRS Module
For long range remote duplex data communication, General Packet Radio Service (GPRS) communication is suitable candidate to execute the task\cite{Amin, A. & Khan, M. N. A. 2014. A Survey of GSM Technology to Control Remote Devices. International Journal of u- and e- Service, Science and Technology, vol. 7, no. 6, pp. 153-162}. The data packet will be sending over GPRS and uploaded into data storage cloud. A quad-band 850/900/1800/1900 MHz GSM module is chosen to perform the data transmitter. The GSM module embedded with TCP stack which allows data upload into web server. With existing telco network service on wide spreading the network areas and satellite communication, the data could be sent and received most location on the globe.

2.2 Temperature and humidity sensor
DHT11 is a low cost temperature and humidity sensor that comprises a calibrated digital signal output for temperature and humidity \cite{4}. The sensor has ±5% accuracy for 20-80% humidity range and ±2ºC accuracy for temperature from 0-50ºC \cite{4}. 5 VDC required to operate this sensor.

2.3 Analog Voltage Divider
The Analog Voltage Divider V2 by DFRobot capable to detect voltage from 0.0245V to 25V. The module communicates with the microcontroller via ADC channel, which the Atmel Atmega2560 serves 10-bit ADC. The sensor is based on the concept of voltage divider, which the measured voltage is scale reduced by five times, converted into digital reading, ratio over 1024 (10-bit) and times with maximum 25V as perform in equation (1) as follows.

\[
V_m = \frac{D_v}{1024} \times 25 V
\]

Where, \(V_m\) = measured voltage
\(D_v\) = converted digital in decimal value

The module communicates with the microcontroller via ADC channel, which the Atmel Atmega2560 serve 10-bit ADC.

2.4 Current Sensor (AC/DC)
In this project, the ACS758 current sensor based on Hall Effect magnetic sensing capable to measure from -50A to 50 A AC and DC current with the peak voltage measuring up to 1000 V for AC and 500V for DC. This module will produce analog voltage output based on magnetic perturbation onto the Hall Effect sensor. The output analog voltage will supply into ADC channel of microcontroller unit and the current reading will be interpreted based on the equation (3).

\[
I = \left( \frac{D_i - D_r}{D_f} \right) \times V_f \times \text{sensitivity} - \text{offset value}
\]

Where, \(D_i\) = converted detected decimal digital value
\(D_r\) = raw decimal digital value when input = 0 A, in this case \(D_r\) equal to 510
\(D_f\) = full digital value, in this case 10-bit ADC equal to 1024
\(V_m\) = maximum voltage at full ADC bit
Sensitivity = 0.04 V/A
Offset value = 0.04 A

\[ I = \left( \frac{D_l - 510}{1024} \times 5 \times 0.04 \frac{V}{A} \right) - 0.04 \, A \]  

(3)

3. Methodology

First, the GSM/GPRS module will attempt to establish the connection with GPRS network. Once GPRS connection is established, the GSM/GPRS module will verify the established connection by receiving the network information of the signal strength and network registration through the user interface window. Then, real time clock (RTC) module is accessed through I2C interface to obtain the current time. The SD card is accessed via SPI interface and a new csv spreadsheet file is created. If the file is already existed, the data inside the file will be overwritten. All five sensors started taking measurement on the indicated parameter; temperature and humidity, monitored equipment voltage and current and the project device voltage and current. The recorded measurements are saved in the csv file along with date and time stamp. The recorded measurement will be sent over GPRS connection to the remote monitoring database. If the data sending fail, the microcontroller will retransmit the data to the remote monitoring server. The remote monitoring database server will received the obtained data and display these data accordingly based on the parameter assigned. The website is public accessed but the data from the remote monitoring database can be accessed by the authorized user only. The real-time device monitoring system flow can be referred in Figure 2.

Figure 2. Real-time device monitoring system flow
4. Results

A device running and testing had been performed on 2nd May 2015 at 3.19 p.m. until 4th May 2015 at 6.56 a.m. at Cahaya Alam, Section U12, Shah Alam, Selangor, Malaysia residence area to evaluate the device workability in real situation. For the results, the measurements are categorised into three parameters: humidity and temperature, voltage and current analysis.

4.1 Temperature and Humidity

The Figure 3 shows the temperature (Figure 2 (top)) and humidity (Figure 2 (below)) reading samples taken once for every 30 minutes. The measurements had been ran for over 79 samplings, which the device had been ran for 39 hours and 30 minutes continuously. The temperature reading shows 31˚C max and 30˚C min, where the temperature during night is obviously drop by 1˚C at first day, constantly at 31˚C during days and roughly during night for second day. For humidity sensing, the humidity is higher during night and lower during day generally. During night, the humidity percentage varies in the range of 63% to 74%. The humidity percentage drop reach at 59% and varies in the range of 59% to 68%.

![Temperature and Humidity Graph](image)

**Figure 3.** Humidity (top) and temperature (below) versus time. Samplings continuously taken for over 39 hours and 30 minutes

4.2 Voltage

Voltage reading monitoring is vital to identify the real time power supply voltage, where the power storage left can be identified. In voltage monitoring, the Figure 4 (top) shows the voltage monitoring on power supply of supported device and Figure 4 (below) shows the power supply of real-time monitoring voltage magnitude. For device testing, the voltage measurement was done on battery power supply of portable security system device that was installed at the site. The real-time monitoring device is powered up by 9V battery, the Figure 4 (below) shows the power supply voltage magnitude taken for every 30 minutes.
4.3 Current

The Figure 5 shows the current consumption sampling taken on supported device (Figure 5 (top)) and real-time monitoring device (Figure 5 (below)) versus local time. The supported device has sleep mode features which will be partially hibernated during inactivity, where it will be fully activated when triggered by passive infrared sensor (PIR) pulse. The 0 A current consumption in Figure 4 (top) shows the inactivity of supported device, which from the figure it can give the details of device activity. For the real-time device monitoring current consumption, the device constantly consume 200 mA from 1519 hour until 1119 hour, fluctuate between 100 mA and 200 mA from 1149 hour until 0019 hour and constantly consume 99 mA from 0049 hour until 0649 hour.

Figure 4. Supported equipment (top) and real-time device monitoring (below) power supply voltage reading versus time

Figure 5. Supported electrical device (top) and real-time monitoring device current consumption (below) versus time
5. Conclusion

The idea of this system is to enable unmanned monitoring remotely. The system is designed to monitor any electrical device voltage and current magnitude, the system self-voltage, self-current, surrounding temperature and humidity magnitude. User enable to acknowledge the electrical device conditions anywhere and anytime without site visit. Thus the device could give time and cost beneficial. Furthermore, the device could assist user in planning for future upgrade or maintenance of the equipment. Overall, the system has been received positive remarks from industrial panel from electronic engineering solution company, which who also provide remote monitoring technology to North-South Expressway (PLUS) Malaysia.

References

[1] Nhivekar, G. S. & Mudholker, R. R. 2011. Data Logger and Remote Monitoring System for Multiple Parameter Measurement Applications. e-Journal of Science & Technology, vol.3, no.6, pp. 55-62

[2] Singh, J. S. & Padmalatha, L. 2013. Development of Http Server for Remote Data Monitoring and Recording System. International Journal of Computer & Technology, vol. 11, no. 4, pp. 2440-2445

[3] Ghayvat, H., Mukhopadhyay, S., Gui, X., & Suryadevara, N. 2015. WSN- and IOT-Based Smart Homes and Their Extension to Smart Buildings. Sensors 2015, vol. 15, no., pp. 10350-10379

[4] Lazarescu, M. T. 2015. Design and Field Test of a WSN Platform Prototype for Long-Term Environmental Monitoring. Sensors 2015, vol.15, no., pp. 9481-9518

[5] Ling, N. & Mei-Xia, D. 2015. Design of a Remote Data Monitoring System based on Sensor Network. International Journal of Smart Home, vol. 9, no. 5, pp. 23-30

Acknowledgements

The authors would like to acknowledge the chief executive officer of Luimewah (M) Sdn. Bhd., Mr. Shamry Mubdi Subra Mullisi and his team for providing us very brief technical consultancy and support. The authors would like to say thanks for the cooperation from resident of Taman Cahaya Alam, Section U12, Shah Alam, Selangor, Malaysia. Last but not least, the authors would like to acknowledge 600-RMI/DANA 5/3/REI (8/2014) and Faculty of Electrical Engineering, UiTM Shah Alam for financial and facilities support.