



SAIIE25 Proceedings, 9th - 11th of July 2013, Stellenbosch, South Africa © 2013 SAIIE

TELEMETRIC DATA LOGGER AND MONITOR FOR MINING VEHICLES

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ABSTRACT

Telemetry is the technology that allows data measurement at a distance. It uses data loggers which record data over time or in relation to location, either with built-in instruments or through instruments and sensors. The system discussed in the paper is based on a Peripheral Interface Controller (PIC18F4550), a series of sensors, a Radio Frequency (RF) link and a Graphical User Interface (GUI) developed using Visual Basic (VB). The system was designed to monitor mining vehicles by measuring engine temperature, transmission temperature, hydraulic oil temperature and hydraulic pressure in pumps and hoist cylinders. The data measured by the sensors in the mining vehicles (the plant) is transmitted to the Supervisory Control And Data Acquisition System (SCADA) through the RF link. The RF link uses a transmission frequency of 433.95 Mega Hertz (MHz) to enable flawless communication between the plant and the SCADA. The developed prototype was simulated using small pressurized containers and heating systems and the results were displayed on the GUI. The whole system development process was a multi-discipline project and it showed that RF communications are very reliable in data transmission.



1 INTRODUCTION:

Telemetry commonly refers to wireless data mechanisms that use radio, hypersonic or infra-red (IR) frequencies to transfer data between sensors and data monitoring stations [1]. The technology also encompasses data transfer over telephones, computer networks, optical links and other wired communication links. Telemetry was used as early as 1914 in the Panama Canal where telemetry systems were used to monitor locks and water level [2]. However, wireless telemetry came into use around the 1930's when Pulse Position Modulation (PPM) was used. PPM was later replaced by Pulse Code Modulation (PCM) and now modern telemetry systems take advantage of the low cost Global System for Mobile Communications (GSM) networks by using Short Message Service (SMS) to receive and transmit telemetry data [3]. Global Positioning Systems (GPS) are also now used to enable the location of equipment while monitoring them. Early developments of mining equipment positioning technologies involved the use of laser sensors as proposed by [4], but with GSM, the limitation of laser beacons is removed and the range is increased.

Measurement without storage is of little use especially in manufacturing, production and other industrial systems. Data loggers become very useful when the measured data is to be used for future planning so as to prevent accident and unnecessary down times [5]. The primary advantage of data loggers is that they can automatically collect data on a twenty four hour basis if required [6]. They are left unattended and record data for the duration of the monitoring period. Standard protocols have been developed to allow some instrumentation to be connected to a variety of data loggers. These include Serial Data Interface at 1200 baud (SDI-12), the MODBUS and the ISO 11897 standards. The data loggers have managed to increase productivity and reduce accidents and unforeseen problems wherever the users give themselves time to study the data trends shown by the records.

When production is to be optimum, especially in the precious minerals mines, the down time has to be minimized. The down time normally increases due to insufficient or inadequate monitoring of critical vehicle systems and parameters [5]. Danger and potential danger conditions are avoided by continuous monitoring and precisely noting any divergence from the norm [7]. It is against this background that a system was developed to monitor the mining equipment parameters with the aim of minimizing the down times and hence increase production.

2 THE TELEMETRIC SYSTEM BUILDING BLOCKS

A number of components, concepts, protocols and systems were integrated in designing the functional data logging and monitoring system. These include sensors, communication systems, a GUI and data storage systems. A microcontroller, the PIC85F4550, has been used as the major communication interface between the plant and the SCADA by allowing data transmission using serial communication to the personal computer (PC) and the RF transmitter.

2.1 Sensors

Two classes of sensors were used on the whole sensing mechanism. The LM35Z temperature sensor was used to measure the temperatures of different plant components. It is a three-pin analogue temperature sensor that can measure temperatures between 0°C and 100°C. The output of the sensor is a voltage which is proportional to the ambient temperature and 10 milli-volts (mV) correspond to a temperature of 1°C [9]. The MPX4115A pressure sensor was used to measure the ambient pressure and is also an analogue sensor. It can measure pressure up to 400kPa. The analogue output voltage is such that 46mV correspond to 1kPa [10].



2.2 Data communication components

The PIC18F4550 microcontroller was used as the major component to enable data communication between the plant and the SCADA. Two of these microcontrollers were used in the project. On the plant, the microcontroller converts analogue sensor outputs to digital values that correspond to the temperature. It has a 10-bit analogue to digital converter to perform this task. It also performs digital signal processing on the data so that accurate values are sent to the SCADA via the RF link. It has a built-in Universal Synchronous Asynchronous Receiver Transmitter (USART) circuit which provides special input/output pins for serial communications. The USART handles all data communications and is configured by the user before it can be used.

The communication link between the microcontroller and the PC is a USB connection. The circuit uses USB type A connection to transfer data from the EEPROM of the microcontroller developed to allow smooth communication between the RF side and the USB side. A phase locked loop is used to drive the 48MHz CPU of the microcontroller using an 8MHz clock.

RF communication uses the RadioMetrixTXL2[®] RF transmitter connected to the microcontroller using the USART and generates a 433.95MHz signal. The transmitter uses a quarter wave antenna to transmit its signal.

2.3 The SCADA GUI

The developed hardware has to communicate with the user who monitors the system. A GUI was developed to allow the human operator to have access to the process. The GUI is used to initialize communication, set the communication parameters and to test for connectivity. The database and the buffers are configured in the software of the GUI. The database developed is a Microsoft Access database and the data from the plant is first stored and then displayed on the screen. The database updates itself whenever new data records are available. Visual meters show the level of the measured values on the GUI.

3 SYSTEM DEVELOPMENT

The system was developed under three sections. The sections were developed first in sequence and then in parallel. The GUI was developed first until it was ready to be used for displaying data. This was followed by the development of the microcontroller software and the drivers until one was ready to be connected to the PC and the other was ready to be connected to the plant. The PIC to PIC RF link was then designed and the three sections were then integrated for the development of the whole system. The sensors were connected to the plant and the system was then designed for data communication at last. The system block diagram is shown in Fig.1 below

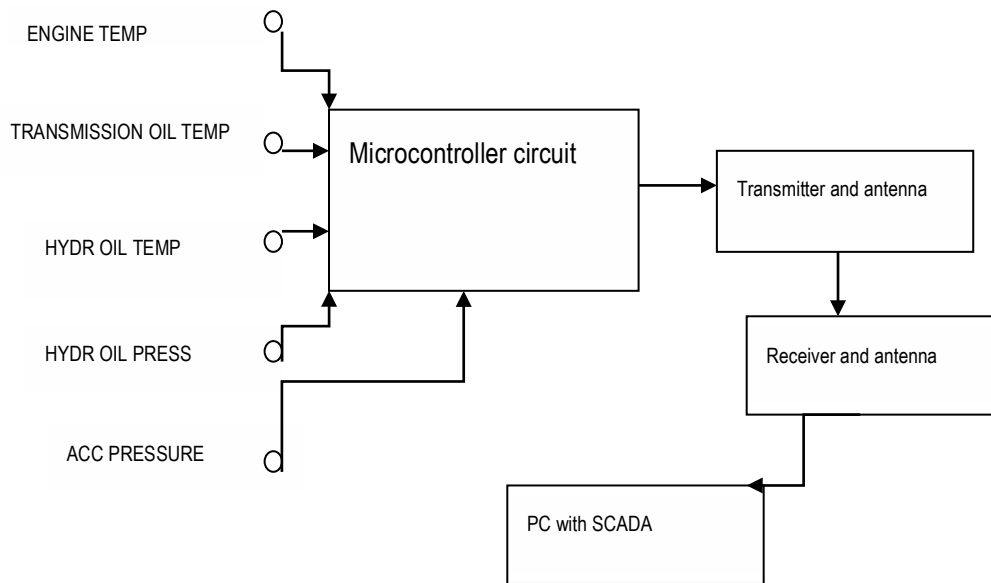


Figure 1: System block diagram

3.1 Development of the SCADA GUI

The man-to-machine interface was developed using VB. The design followed the flow chart shown in Fig.2. The processes involved in the SCADA system are described briefly in the following sub sections.

3.1.1 Initialization

The variables are declared and the PIC, the USB and the database drivers are initialized. Initialization includes defining variables, setting serial communication baud rate and setting microcontroller pins for input and output. Most settings were done using the mikroC integrated development environment. The drivers were designed and customized for the hardware used in the project.

3.1.2 Hardware checking and sensor reading

The system checks whether it is connected to the communication module or to the plant directly. The plant and the communication modules have embedded identification data which enables them to be differentiated by the SCADA system. If the data communication module is detected, the SCADA starts reading the USB buffers but if it is the plant, the system requests for data and then reads the buffers.

In order to read the temperature and pressure values, a special program was written in C code and a snippet of the code is shown below.

```
IntGetTemperature(int pin) //read temperature
{
Float Vin;
int Temperature;
Vin = Adc_Read(pin); //Read from channel 0(AN0)
Vin = 488*Vin; // Scale up the results
Temperature = Vin/10; //Convert to temperature in °C
```



Return Temperature;

}

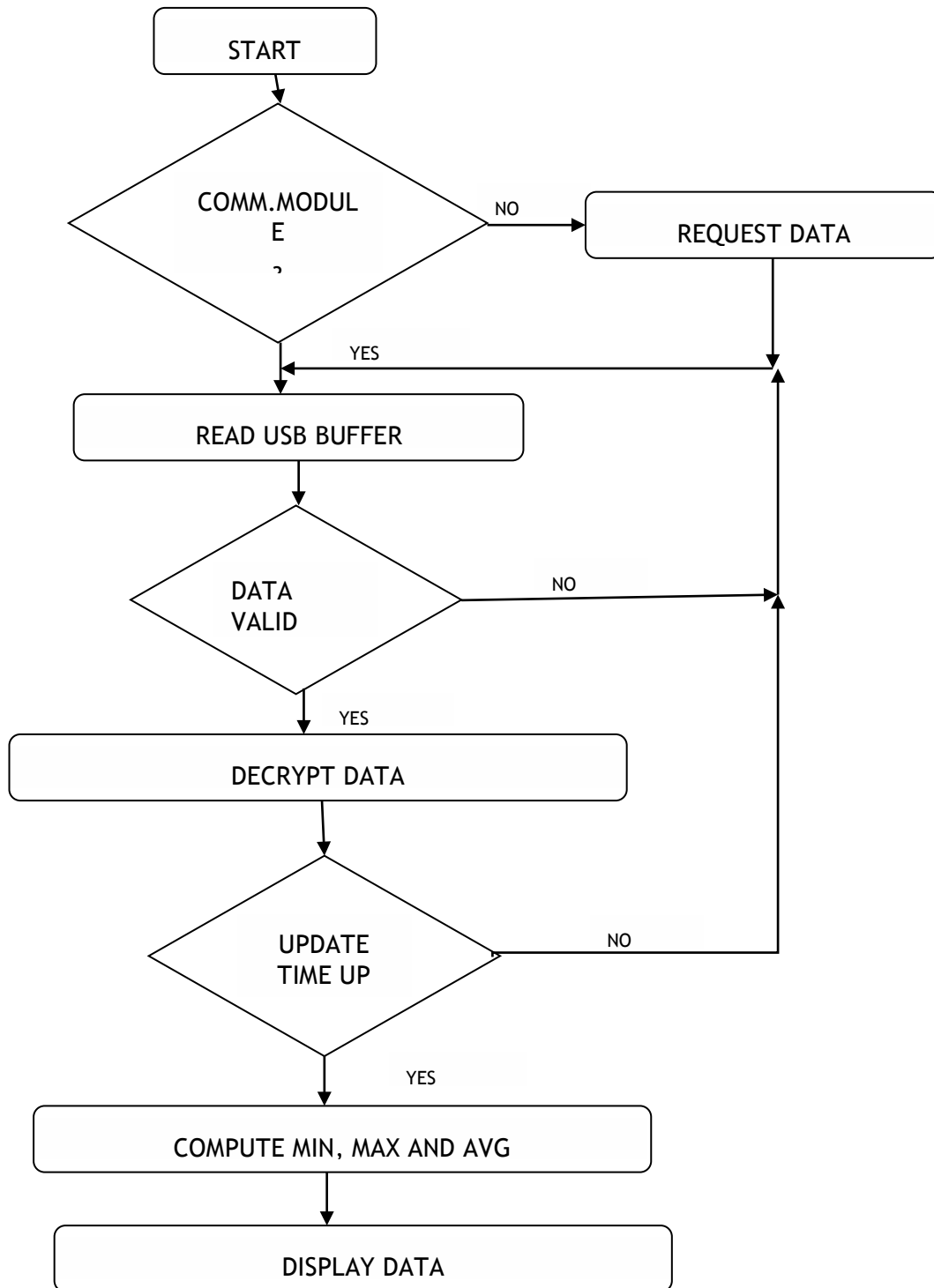


Figure 2: SCADA GUI design flow chart

The above code starts the analogue to digital conversion and receives the converted data which it converts to °C. The code differs from the one for reading pressure in that the pressure conversion uses a different formula to convert the data to mB measurement. The code is as follows:



```
{  
...  
...  
mV = (Vin*5000)/1024;  
V = mV/1000;           //Pressure in Volts  
Pressure = (2*V+0.95)/0.09; //Pressure in 10mB  
Return Pressure;  
}
```

The data read from the sensors is sent to the SCADA for further processing and display.

3.1.3 Data transmission, reception, validation, decryption and display

After the values has been captured and assigned to their respective variables, they are sent to the USART for transmission. A dummy signal was sent first to tune the receiver to the appropriate signal level and then the data is sent, followed by the checksum to check for errors. The PIC18F4550's 256 byte EEPROM stores the values and sends the values to the USB buffers. The computer triggers the USB to read from the microcontroller EEPROM and store the data in the buffers. The USB buffers are mapped in the SCADA. The data they receive is encrypted for security reasons and the SCADA has to decrypt it before is sends the data values to the display. For the data communication module, four data buffers are read for the plant. The system checks two bytes in the received data to decide on the identity of the connected component. The first byte is an ASCII character 'P' in both cases and the second byte is used to determine which module is connected. The character 'T' is located in the in the fifth byte for the data communication component and in the sixth byte for the plant. The data is decrypted and then it can be identified with the correct parameter for display. The hardware sends numbers to denote the parameter type using 'n' as the variable representing the parameter type. After correct identification, the values are displayed on the gauges in the GUI.

4 RESULTS

During the development of the system, the EasyPIC development kit was used to program the microcontroller. The MikroC IDE was used to develop the communication drivers and VB was used to develop the SCADA. Each sensor was tested to see the variation in output voltage with the physical quantity being measured. The results of the tests were used to calibrate the sensors.

The plant was then tested for communication by sending known values and checking them on the SCADA display. Accurate results were given at the transmission frequency of 433.95MHz. Fig. 3 is a snap short view of results displayed on the GUI for monitoring the mining equipment.

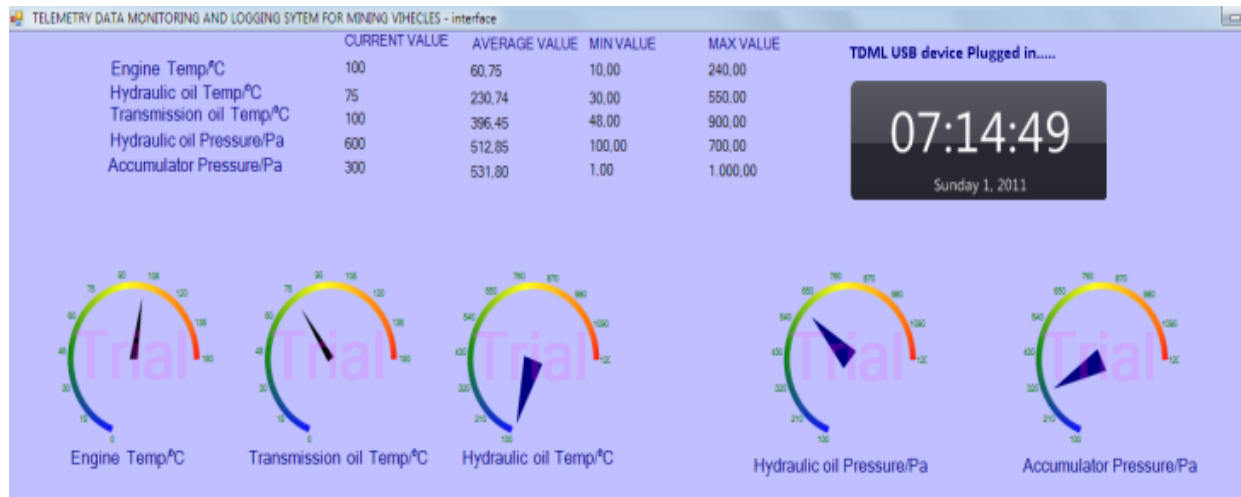


Figure 3: The visual display of the equipment operational values of temperature and pressure

5 DISCUSSION AND CONCLUSION

The project prototype was tested and displayed at the Zimbabwe International Trade Fair exhibitions. It was a multi-discipline project involving research in automobile engineering, machine maintenance, hydraulics and electronic engineering. Such a project enabled the development of many skills essential for an engineer and these include project management and electronic system design and development.

It can be concluded from the results that with dedicated research, RF communications can bring industrial systems management back into the office for proper monitoring and even control without necessarily having to be physically checking systems on site. This is very useful for the management of processors by planners and other interested stake holders.

However, there is need to research on the applicability of the used sensors in the actual mining environments and the effects of noise and distance also need to be analysed.

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