A low cost Microcontroller Based Engine Status Monitoring System

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Abstract

In this paper a low cost engine status monitoring system (Black Box) is described as a safety equipment to record all the data of railway engine WAP-7 with real date and time. A voice recorder is also used with this system for safety and investigation of accidents. There various types of sensors are used for measuring parameters of electric engine. In this system signal processing is done by microcontroller 89C52. This device having the 8 hours recording capability with real date ad time and operated at 5-12V with 3 ampere current ratings. Recorded data of memory can be retrieved by the HyperTerminal of PC.

Keywords- Engine status monitors (ESM), sensors, microcontroller, and real time.

1. Background

Sensors are essential components in much application. Not only in the industries for process control but also in daily life for buildings safety and security monitoring, traffic flow measuring, whether condition monitoring etc. In engine status monitor (ESM) system, for instance parameters such as temperature, vibration, speed, direction, airflow in BP and FP, braking pressure, wheel slip, and vigilance need to be measured thus sensors have always been giving the task for doing so. Railway engine play an important role for proper operations of railway. Electric engine is equipped with various analogous and digital devices. These equipments have a particular temperature range in which they worked properly. [1, 2]

Indian Railways operate on gigantic dimensions covering over 63,000 route kilometers with daily loading of 1.6 million tones of freight and daily transporting of 14 million passengers by logging more than 2 million train kilometers per day. Safety is of paramount importance to Indian railways. Highest priority is accorded to safety and the rail mode in India continues to be the safest means of transportation for public. No compromise is tolerated in Safety of Rail users and all levels of management keep reviewing the Safety performance from time to time. [3-8] In the present work a engine status monitoring system (Black Box) is proposed as a safety equipment to record all the data of railway engine WAP-7 and a voice recorder is also used with this system for safety and investigation of accidents.

The paper aims to build a low cost, yet reliable, engine status monitoring system capable of acquiring and recording data. The proposed system has nine sensors that measure the airflow in BP and FP, temperature, braking pressure, wheel slip, vigilance, speed, direction, vibration and voice of pilot and copilot. Most of these sensors provide digital data. Some sensors provide analog data. This data is converted into digital form using analog to digital converter for further processing by

microcontroller action as data logger. The logged data can be transfer to a PC having a hyper terminal for further analysis or printing the measurements and simple circuiting, the system should be beneficial in providing a low cost and reliable remote ESM system.

2. Engine Status Monitoring System

The system is divided into four main parts, namely, the sensor circuit, the data logging circuit, the time keeping circuit and the serial interfacing circuitry. The sensor circuit contains the IC temperature sensors, pressure sensor, voice sensor, airflow sensor, wheel slip sensor, vigilance sensor. A part from temperature and pressure sensor each sensor have digital output. The analog data of temperature and pressure sensor is converted into digital signal by ADC before being fed into the data logging circuit which encompass a microcontroller. The current time for data logging purpose is provided by the time keeping circuit using real time IC while the serial interfacing circuit facilities the data transfer between the data logger and PC. The internal and external architecture of the present system is depicted in Fig. 1.

Fig. 1: External and Internal Architecture of the system

2.1 The sensor circuit

For temperature sensing, an integrated circuit temperature sensor LM 35 is used. The output voltage of the sensor is linearly proportional to the temperature (in Kelvin or Celsius) with the gradient of 10mV/°C and able to operate in the range of -55°C to 150 °C. As the device is to be used in electric engine where the temperature range in between 0°C to 70°C. The braking pressure measurement is performed by the barometric pressure sensor, MPX4115A. Its output voltage in the range of 0.2 to 4.8V is linearly translated into pressure measurement of 15KPa to 115KPa. [9] This sensor is also compensated from -40°C to 125°C, thus suitable to be used with this system. Measurement of train vibration is done by smart sensor based on variable

capacitance theory. The output of this sensor is in the form of frequency having the range 0 Hz to 64 KHz. [10, 11] For speed and airflow measurement MOC7811 sensor used which provide output in the form of frequency. For sensing of voice of pilot and copilot electorate type microphones are used with melody controller APR6016. [12]

An ADC performs the conversion of all analogous outputs from the sensors into digital signal to be fed to the microcontroller. Amplification and offset adjustment (as in temperature sensor) of these signals are provided by the LM 358 operational amplifier. Although amplification is necessary to suit the input range of the ADC, noise from sensors is also amplified. To alleviate this problem and to maintain consistency of the sensing system, a noise filtering circuit is added before the operational amplifier. Fig.2 shows the various sensors used in the present system.

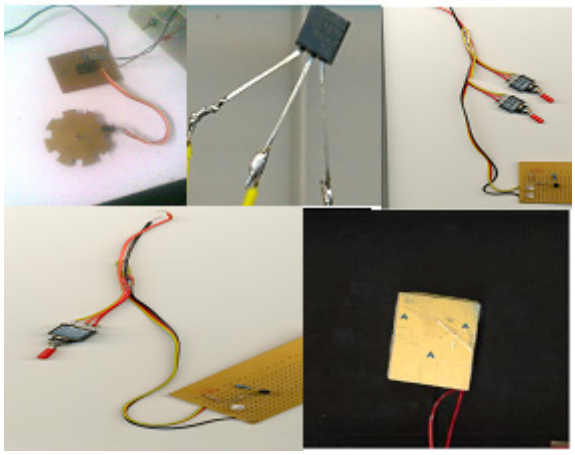

Fig. 2: sensors used with ESM

2.2 Data logging circuit

The main component here is the AT 89C52 microcontroller, which is equipped with 8KB of flash memory and 0- 24MHz processing speed. This microcontroller not only controls the system but also synchronizes all the module operation. An EEPROM with 1024 KB capacity is connected to the microcontroller for storing the sensors reading up to eight hours (for 30 second sampling interval) the interfacing of the EEPROM and microcontroller is based on the I2C bus. The I2C bus provides a simple bi- directional 2 wire bus for efficient inter IC control. An LCD module is also connected to the microcontroller to display the measurement of the sensors and the current time. The data logger also allows the user to browse through the recorded data and change the sampling interval. Fig. 3 shows the interfacing card of the present system.

2.3 The time keeping circuit

A real time clock (RTC) chip is employed for time keeping purpose. Communication between the chip and the microcontroller is achieved via a simple serial interface. The time will be displayed on the LCD. A separate battery source supplies the power required by the chip hence enables its operation kept undisturbed in the event of main power sources failure.

2.4 The interfacing circuit and the HyperTerminal

Data stored into EEPROM can be accessed directly with a personal computer (PC) through serial interface RS -232. This connection established via a serial interfacing

IC named MAX 232. The recorded data is retrieved by using HyperTerminal of Laptop or computer.

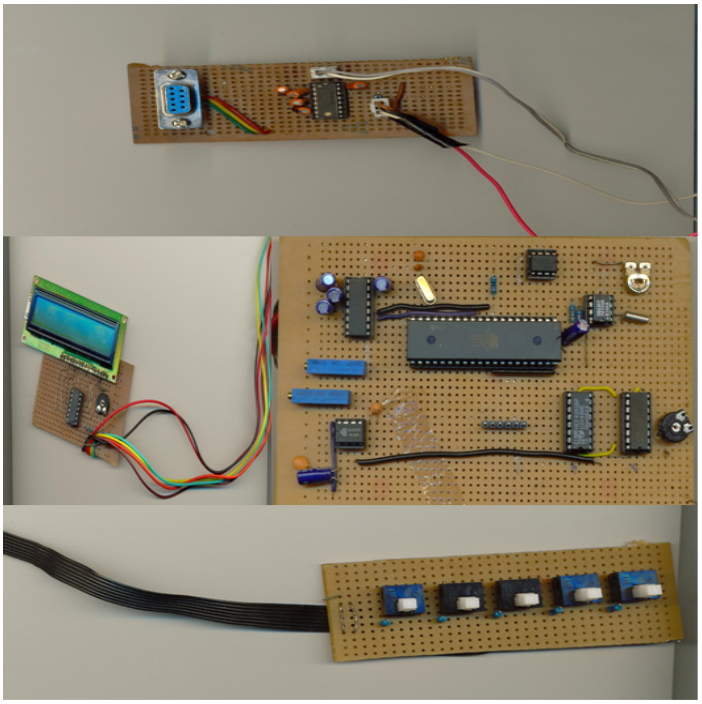

Fig. 3: Interfacing card of the system

3. Hardware and software specification

The internal and external layout of black box is depicting in fig. 9. This circuit diagram is consist of sensor unit (SU), crash survival memory unit (CSMU), engine data acquisition unit (EDAU), Display Unit(DU), Retriever unit(RU), Real time unit (RTU), power supply unit (PSU). Basically the memory unit is proposed to fit inside the crash survival shell which can tolerate the Crash impact, Pin drop, Static crush, Fire test, Deep-sea submersion, Fluid immersion and Salt-water submersion tests. In black box data from various parameters is collected in electric signal form using sufficient sensors. These electrical signals are in analog or digital form. If signals are digital then these signals directly applied to the microcontroller and if the signals coming from sensor is analog the firstly it converted into digital form using ADCs. Almost WAP-7 engine are digitalized and the digital data of electric engine can be directly taken and send to the microcontroller. Microcontroller processes the data of sensors with real date and time using RTC 1307 and records it into external memories. This recorded data display on 16 X 2 LCD. The information of recorded data retrieved using hyper terminal of computer and switching device. The microcontrollers are programmed in C language using Keil compiler. The simulations of the circuits are further tested by Protinus software after that they designed for the system. The layout formation of the circuits has done by Orcad software. [13]

4. Technical specification

1. Power supply - +5V, +12V
2. Operating frequency – 50Hz
3. Current – 3A

4. Power consumption – 2.6A
5. Recording capability – 8 hrs
6. Temperature range – 0-70°C
7. Sampling time- 15 seconds
8. Vibration Frequency – 0 to 64 KHz
9. Speed Sensor range – 2000RPM
10. serial interface with PC

5. Proposal for fitting:

In the present system sensor unit is proposed to attached with their respective parameters in the cabin desk of engine as shown in fig. 4 at point A speed sensor, point B airflow sensor, at point C throttle positing sensor, at point D vigilance, at point E wheel slip sensor are proposed to placed. Temperature, vibration and voice sensors are used at multiple sensitive places of engine.

Fig. 4: loco pilot cabin of WAP-7 engine

6. Result and discussions

In the present work a engine status monitoring system (black-box) is designed for railway electric engine WAP-7. This system is an application of sensor technology and embedded system. This black-box is useful for recording the status of engine with respect to read date and time for getting the real status of engine and its sensitive apparatus during its operating period.

In away when any type of accident occurs due to any reason. It provides necessary data to generate the report of accident and about its causes. The recorded data of parameters are easily transferred to hyper terminal of laptop/ computer with real date and time. Thus it provides help to monitor the status of several parameters of electric engine which are responsible for proper movement of railway engine.

Cabin voice data recorder also gives the important clues about accident. With the help of this device investigation team get the required data for reach the conclusion whether this accident occurs due to equipment failure of or due to human error and taking appropriate decision.

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