International Journal of Trend in Research and Development, Volume 2(3), ISSN: 2394-9333
www.ijtrd.com

Tire Pressure Monitoring System Based on SPI Protocol Using MSP 430

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ABSTRACT

The paper proposes a method to implement Tire pressure monitoring using MSP430 which include the facility of SPI. The TPMS measures the air pressure, Temperature inside tire of vehicles, it also check alcohol percentage taken by Driver. The system indicates the threat of accidents by showing the data on dashboard as well as alarm. The proposed TPMS in which Transmitter unit directly screws onto the stem of tire. The Transmitter unit includes integrated silicon pressure sensor, Temperature sensor, RF transmitter and MSP430 with long life battery. An on-dashboard receiver unit includes RF receiver, LCD, MSP430 and also Alcohol sensor. The receiver unit gets data from all four tires by RF communication displays& monitors it. To improve the system performance SPI protocol supported by MSP430 is used.

Keyword- RF transmitter, SPI, MSP430, RF receiver.

1. INTRODUCTION

Safety of the person depends on vehicles condition. Vehicles condition includes tire pressure and tire temperature which should be in proper level. Vehicles moving with low tire pressure consume more fuel. Leakage of air from tire if not detected can cause a serious problem during running of vehicle i.e bursting of tires.[1] Research shows that tire burst is mainly caused by higher tire temperature thus traffic accidents can be prevented if tire pressure & temperature is regularly monitored during driving. Also driver's alcohol intake percentage is higher than specific level chances of accidents are increased. The proposed system monitors these three parameters regularly and in situation if one of the three parameters exceeds the predefined limit an alarm switch on. [2] In case of vehicles two methods are used for pressure measurements Direct and Indirect method. In the proposed system Direct method is implemented i.e. Pressure measurement by pressure sensor of transmitter unit that directly screws onto stem of the tire. [3]

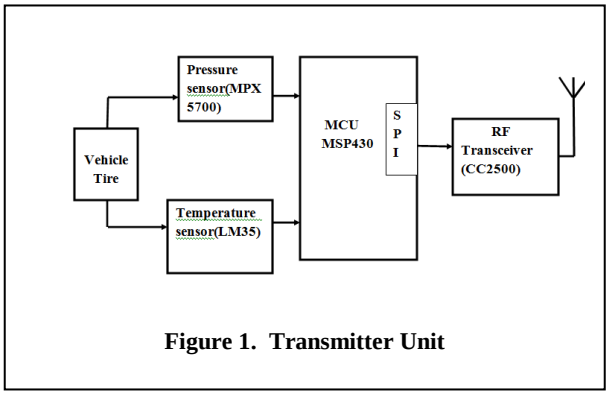

Figure 1. Transmitter Unit

2. SYSTEM STRUCTURE

2.1 Transmitter Unit

The Tire pressure monitoring module or transmitterUnit composed of MPX5700 intigrated silicon pressure sensor, LM35 Temperature sensor and MCU(MSP430).The MCU is main block of a systemwhich takes the input as tire Pressure from pressure sensor and temperature from temperture sensor.

The MSP 430 receives signal from both the sensors and transmits the data to host receiver via wireless RF Transceiver(CC2500). Figure 1 shows the transmitter Unit of TPMS.

2.1.1 Sensors

In this sytem MPX5700 is used for the pressure measurement.The MPX5700 series piezoresistive transducer is a state-of-the-art monolithic silicon pressure sensor designed for a wide range of applications. single element transducer combines advanced micromachining techniques, thin-film metallization, and bipolar processing to provide an accurate, high level analog output signal that is proportional to the applied pressure.The chip can measure tire pressure upto 200 kPa and is tempeeature compensated over 0 to 85^0C.

The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 thus has anadvantage over linear temperature sensors calibrated in° Kelvin, as the user is not required to subtract a largeconstant voltage from its output to obtain convenient Centigrade scaling.

2.1.2 MSP430

The Texas Instruments MSP430 family of ultralow-power microcontrollers combined with five low-power modes is optimized to achieve extended battery life in portable measurement applications. The device features a powerful 16-bit RISC CPU, 16-bit registers, and constant generators that contribute to maximum code efficiency. The digitally controlled oscillator (DCO) allows wake-up from low-power modes to active mode in less than 6 µs. Typical applications include sensor systems that capture analog signals, convert them to digital values, and then process the data for display or for transmission to a host system. Standalone radio frequency (RF) sensor front end is another area of application. The I/O port inputs provide single slope A/D conversion capability on resistive sensors.MSP 430 Controllers important feature is to support SPI(Serial Peripheral Interface) protocol.

2.1.3 RF Transceiver

In the system, the major issue is how effectively the wireless radio frequency signal is transmitted because the RF transmission consumes most of the power [5]. Thus,
when choosing a wireless radio frequency chip, power consumption is major issue along with the transmission bandwidth. In this design the IC CC2500 is used as radio frequency transceiver. It is a low-cost 2.4 GHz transceiver designed for very low-power wireless applications. The circuit can be used for the frequency range of 2400 to 2483.5 MHz i.e. ISM frequency band with the help of an onboard antenna. The biggest advantage of using this frequency is that it does not require license from government and this frequency is freely available. This chip is mainly selected because the main operating parameters and the transmit/receive FIFO register of CC2500 can be controlled via an SPI interface. It can transmitand receive the data in range of 30 meters without requiring any external antenna. , can modulate and transmit digital signals.It also supports FSK and ASK modulation modes. This RF transceiver also supports Manchester Coding which helps to improve the noise immunity. [4]

2.2 Receiver Unit

Receiver unitconsists of RF transceiver (CC2500), MCU MSP430, LCD Display unit and alcohol sensor(MQ-3) also Buzzer unit.Besides Pressure and temperature data from transmitter unit MCU also takes data from alcohol sensor. It compares the predefined levels for each data i.e pressure, temperature and alcohol level and if any one data value is exceeds then MCU turn on the buzzer.

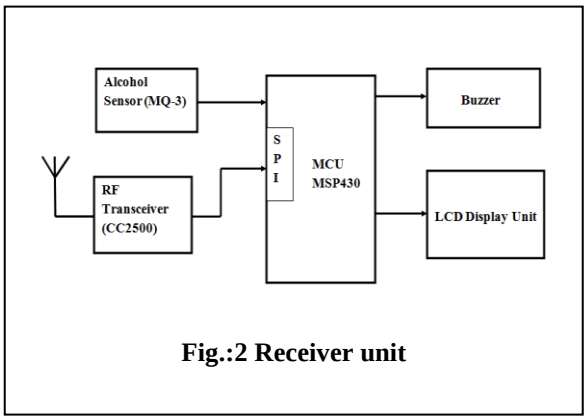

Fig.:2 Receiver unit

2.2.1 Sensor

MQ-3 is a special gas sensor having sensitive material SnO2. When the target alcohol gas exist, the sensor's conductivity is higher along with the gas concentration rising.MQ-3 gas sensor has high sensitivity to Alcohol, and has good resistance to disturb of gasoline, smoke and vapor. The sensor could be used to detect alcohol with different concentration, it is with low cost and suitable for different application. It's sensing resistor has value over 2KΩ-20KΩ/l alcohol.MQ-3 gives the output in the form of resistance which is converted into voltage and gives to MCU unit. This voltage is calibrated for the Alcohol.

2.2.2 Buzzer Unit

A buzzer circuit can be interfaced with the receiver or master module along with the LCD display in order to alert the driver regarding the ups and downs in the pressure of the tire. The LCD display indicates the real time values of the tire pressure. Whenever the

pressure value exceeds the predetermined values in any one of the tires, the buzzer circuit gets activated. Accordingly the driver can take the corrective action.

3. SERIAL PERIPHERAL INTERFACE (SPI)

In this design of tire pressure monitoring system SPI protocol is used to communicate between the microcontroller unit and radio frequency transceiver module. Data is exchanged between
transmitter and receiver sections by using SPI. This protocol is mainly used because it allows serial communication between twoor more devices at a high speed up to 10 Mbps. It is reasonably easy to implement as it is only 4 wired bus [1] [5]. In SPI is also
called as 4 wired protocol. The MOSI (Master Out Slave In) and MISO (Master In Slave Out) lines transfer the data to and fro
between the microcontroller unit and RF transceiver module. SCK (Serial Clock) line provides clock for synchronization between transmitter and receiver because data transfer depends on clock.

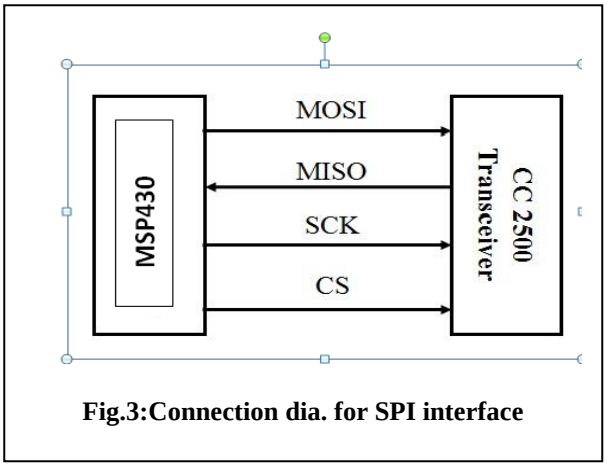

Fig.3:Connection dia. for SPI interface

The last line CS (Chip Select) is used for selecting the slave device [5]. Figure 3. shows connections between MCU (MSP430)
& RF receiver

4. SYSTEM PERFORMANCE ANALYSIS

While Testing the parameters such as tire pressure, Temperature and alcohol percentage the system gives the output as per the design requirement Figure 4 shows the linear relationship graph of pressure in psi Vs sensor output voltage as per the design the system buzzer when that pressure drop below predefined low pressure cutoff value and it also buzzers when the pressure is above higher cut of value.
The output voltage of sensor depends upon offset voltage, pressure applied and sensitivity of sensor**.**

$$\boldsymbol{Vout = Vs \times (0.0012858 + 0.04) \pm Error}$$

Where $\boldsymbol{Vs = 5.0Vdc}$

$Voffset = 0.04$

$P = PressureinPsi$

For MPX5700 pressure sensor used in this system the sensitivity is found to be 6.4 mV/kPa and offset voltage is 0.2V at 25^0C when sensor is supplied with 5V. The full scale voltage span of MPX5700 is 4.5 V

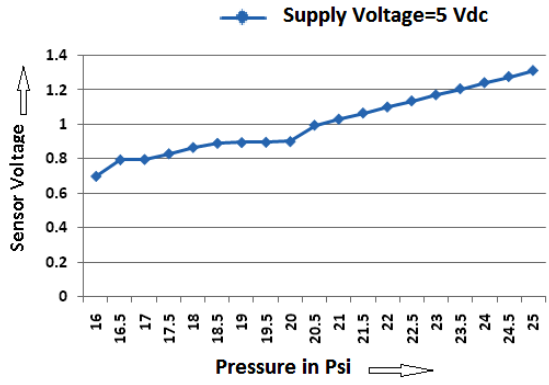

Figure 4. Applied Pressure Vs Sensor output Voltage

CONCLUSION

The proposed system is quit suited for the low power unit using MSP430.It also support SPI protocol which is inbuIlt feature of MSP430. By expanding the parameter such as alcohol percentage consumed by driver this system gives additional security. One advantage of this system is we can easily remove the transmitting unit from the stem of the tire.

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