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A New Approach to Tyre Pressure Monitoring System

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ABSTRACT: Improper tyre pressure is a safety issue that is usually ignored. But the fact is that a drop in tyre pressure can result in the reduction of mileage, tyre life, vehicle safety and performance. This paper is providing a new approach to tyre pressure monitoring system. The system will take continuous readings of the tyre pressure and temperature and decide if the pressure is within proper inflation. Current pressure in the tyre and under or over inflations will be displayed combined with LED lights for giving proper warning. The system works on wireless sensor network using zigbee and CAN communication protocol. The data received wirelessly through zigbee will be converted to CAN protocol format. Power consumption is reduced by designing a transmitter waking circuit. Also if the tyre pressure is reduced below a threshold limit a warning message will be send to the owner's mobile phone using GSM system.

KEYWORDS*:* TPMS, wireless sensor network, CAN communication,GSM.

I. INTRODUCTION

The automotive electronics industry has made many improvements in vehicle safety in the recent past. One such fast growing application is the tyre pressure monitoring system (TPMS). In simple terminology, TPMS is an electronic safety system that is used to monitor the air pressure inside the tyres of a vehicle and provide the driver with proper warning signal. Thus it can be referred as a driver-assist system.Most of the people ignore their tyres. But tyres are undoubtedly one of the most critical safety components of a vehicle. Whenever the vehicle tyre comes in contact with the road, it affects traction, handling, steering, stability and breaking. Because of this, a sudden tyre failure can have serious consequences especially if it occurs when the vehicle is operating at highway speeds. A tyre can lose about half of its air pressure without appearing to be under inflated. One of the India's largest tyre manufacturers "Apollo Tyres" has released a statement in 2010 that more that 250 deaths occur on our country's roads every day and also 75% of vehicles run on incorrect tyre pressure. Apart from causing a higher risk of accidents due to loss of control, improper pressure in tyre also leads to tyre damage and ultimately leads to faster replacement. Additionally, under-inflated tyres have increased rolling resistance requiring more fuel to maintain the same speed thus affecting fuel efficiency. The level of apathy and ignorance amongst Indian drivers causes fatal accidents. Thus, to avoid such disastrous consequences, proper tyre pressure should be maintained. So if all vehicles are equipped with tyre pressure monitoring systems the fuel consumption can be highly reduced and near about 10,000 injuries can be prevented per year. It can also indirectly reduce the atmospheric pollution through less CO_2 emission. Most of the tyre pressure monitoring systems available today are having less accuracy and high cost. Here is a new design for monitoring the tyre pressure which integrate the wireless and wired communication.

II. DESIGN METHODOLOGY

The controlling device system of the design is a Nuvoton Microcontroller. It is a brand new 32 bit microcontroller from Numicro family. The whole system can be divided into two sub systems, one present in the tyre which helps in sending current values of pressure and temperature of the tyre through Zigbee based wireless communication. The other system is present in the car which is based on CAN protocol that receives the current pressure and continuously monitors it. The data received wirelessly through zigbee transceiver will be converted into wired CAN protocol format. As most of the units in car are connected through CAN protocol, the conversion to CAN protocol will be advantageous. The real time data will be displayed on a user interface. This system is capable of alerting in case of improper tyre pressure. The

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power consumption is reduced by designing a waking circuit for the transmitter. Whenever the data is needed the transmitter will wake up and will send the data. Also if the tyre pressure is very low, a warning message will be send to the owner's mobile using the GSM system. The four wireless transmitters in the tyres and the receiver will form a wireless sensor network to coordinate and send data. To reduce the transmission delay star network topology is established. Wireless sensor network is a network that is made up of a set of wireless sensor nodes and routers through wireless medium. Making use of the ad hoc methods of micro targeted smart sensor nodes, it collects and processes the target information in the coverage areas of the network by the cooperative work of the nodes. The network will be small in size, low in cost and have less power consumption. The entire network is data-centric, so it can completely meet the application requirements of the tyre pressure monitoring system. The structure and design methodology of the entire system is shown in fig.1.

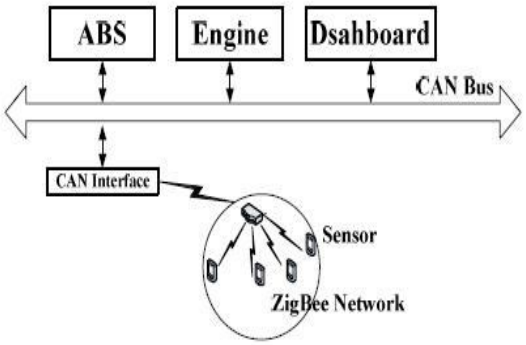

Fig. 1. Structure and design methodology

The objective of the design includes Dynamic tyre pressure setting, usage of wireless technology, using CAN protocol to send data from the receiver to the display, continuous monitoring of tyre parameters in the display, providing alerts about improper tyre pressure, Reduce power consumption by invoking the transmitter only when data is needed and sending warning message to the owner's mobile using GSM .The method will increases safety, comfort and fuel efficiency of the vehicle.

A. Numicro Microcontroller

The proposed system is implemented using Nuvoton's ARM Cortex M0 microcontroller named NuMicro. The ARM Cortex-M0 processor is the smallest ARM processor available with exceptionally small silicon area and low power consumption to achieve 32-bit performance. The NuMicro learning board is shown in fig.2. NuMicro is Nuvoton's brand-new 32-bit Microcontroller family powered by the ARM Cortex-M0 processor which is the smallest, lowest power and most energy efficient ARM processor optimized for a variety of microcontroller applications. The microcontroller is embedded with Controller Area Network (CAN) 2.0B licensed from BOSCH.

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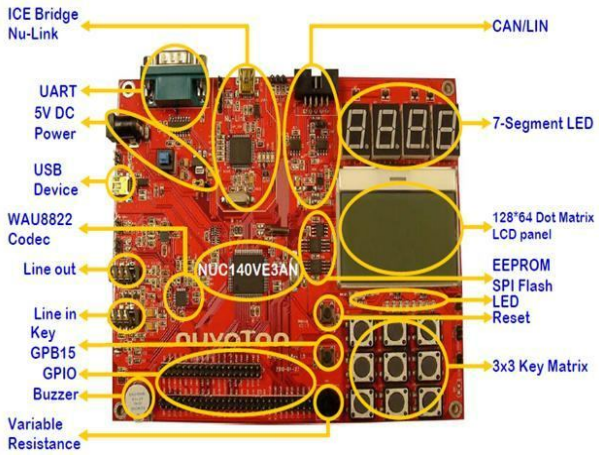

Fig. 2. Numicro learning board

B. Zigbee module

ZigBee is a wireless technology to address the unique needs of low-cost and low power wireless sensor networks. The ZigBee standard operates on the IEEE 802.15.4 physical radio specification and unlicensed bands including 2.4 GHz, 900 MHz and 868 MHz. A zigbee transceiver module is shown in fig.3. Zigbee protocol supports multiple network topologies such as point-to point, point-to-multipoint and mesh networks. The low duty cycle provides long battery life. It can support up to 65,000 nodes per network.

Fig. 3. Zigbee module

C. Wireless Transmission

The whole monitoring system is made up of several sensor nodes which installed in the inner part of the tires and a clustering node inside the vehicle. One sensor node is installed in the internal part of each tire. Fig.4 shows the place in which the sensor nodes are located. The sensor nodes will measure the tire pressure, temperature and other signals through the sensors directly, and transmits the data to the co-ordinator. The co-ordinator will receive the data from the sensor nodes. The data is processed and displayed on a user interface. The parameters such as pressure, temperature and other status information are displayed on the dashboard screen in front of the driver. The system will give proper warning when the internal status of the tyre is abnormal.

Traditional TPMS system can only achieve one way communication. That is the co-ordinator can only receive signal from the sensor nodes. In this system, a two way communication can be achieved between the clustering node and

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sensor nodes. When there is no need to monitor, the sensor nodes, the nodes will be in the sleep state and in the needed moment, the monitoring nodes can be wakened again.

Fig. 4. Transmitter on tyre rim

III. COMMUNICATION MECHANISMS

D. Wireless sensor Network

ZigBee standard provides three types of equipment in a ZigBee wireless sensor network, co-ordinator, router and terminal device. The first node which has coordination ability and choose a idle channel after scanning channels, make sure its 16 bits network address, PAN ID, network topology parameters and so on. Then, it can accept other nodes as its children node. When node A wants to join the PAN, it sends association request to the nodes in the network. If the node which receives the request has ability to accept node A to be its children node, it assigns an unquiet 16 bits network address to and send association respond request to node A. Node A joins the network successfully and receives other node's association request after it receives association respond request. If a node in the network wants to leave the network, it can send remove association request to its parent node. It can leave network after receiving remove association respond request. The node must remove all the association with other nodes before leaving network if it has children nodes. Node will enter system sleep state to reduce power consumption after joining the network. When there is external interrupt, the node will wake up from sleep, and then perform the corresponding action according to the type of interruption.

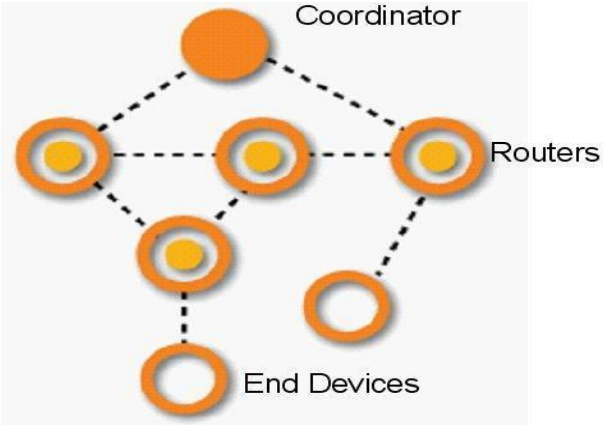

Fig. 5. Wireless sensor network

After finishing the operation, node will return to sleep and wait for a new wake up interrupt. The wireless sensor network can provide better coordination. The structure of a wireless sensor network is shown in fig.5.

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E. CAN communication

CAN is a serial communications bus defined by International Standardization Organization and originally developed for the automotive industry to replace the complex wiring harness with a two-wire bus. The specification provides high immunity to electrical interference and the ability to self-diagnose and repair data errors. These features led to CAN's popularity in a variety of industries including building automation, medical, and manufacturing.

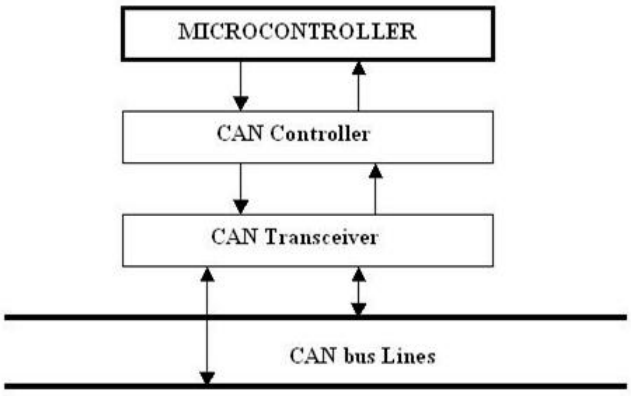

Fig. 6. CAN bus communication

The CAN communications protocol, ISO-11898:2003, describes how information is passed between devices on a network and conforms to the Open Systems Interconnection model that is defined in terms of layers. CAN bus is Message Oriented Transmission Protocol, so that each node can act as a transmitter and receiver. A sender transmits information to all devices on the bus, so that all the nodes can read the message. The nodes then decide whether it is relevant to them. All nodes acknowledge for reception of the message. In CAN protocol the message is send with a message ID and it determines the priority of the message.

F. GSM SYSTEM

GSM is a cellular network. It is developed by European Tele-communication Standard Institute. GSM networks operate in four different frequency ranges. Most GSM networks operate in the 900 MHz or 1800 MHz bands. GSM uses a variation of Time Division Multiple Access and it is widely used. The tyre pressure will not be noticed if the car is not used for a long time. Then it is important to notify the driver about the tyre pressure by sending a warning message to his mobile using GSM technology. A SIM 300 GSM transmitter module is shown in Fig .7. It is used to transmit a warning message to the driver if the tyre pressure is below a threshold value.

Fig. 7. GSM transmitter

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IV. ANALYSIS AND RESULTS

Network simulator is used for the performance evaluation of the ZigBee Star topology. Parameters used in simulations are as following; Traffic sources are CBR (continuous bit-rate), MAC protocol is IEEE 802.15.4, simulate time is 500 simulation seconds, data packet is 70 bytes. The result is shown in Fig.8. From the result, we can see the stability of transmission in the star network is high. Because as the number of variations increase, the packet deliver fraction is almost 99.8 percent. And because of the test bit used in the data frame, the network transmission reliability is high.According to the simulation, the average data transmission delay remained at 0.015 ~ 0.020s, which is very small.

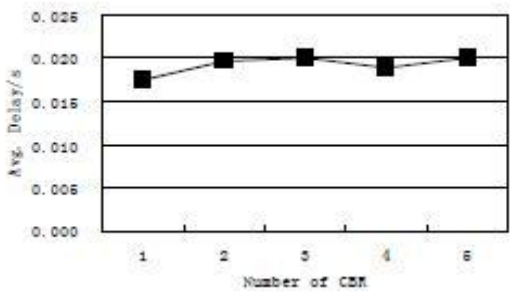

Fig. 8. Zigbee star network performance

G. User interface

A user interface is needed to make the system user friendly. The pressure and temperature values of the tyre will be displayed on the display and the user will be allowed to set the pressure threshold values to provide proper warning. Fig.9 shows the tyre pressure display unit. The data received through wireless sensor network is processed and send to the display unit through the CAN bus.

Fig. 9. Tyre pressure display

V. SUMMARY

In recent years, Tyre Pressure Monitoring System is a hotspot in the research of vehicle detection system. This paper presents the tire pressure monitoring systems based on the wireless sensor network technology, and gives a detailed description towards the design of hardware and communication protocols. We can make further research to improve the energy supply for sensor nodes of the present system, design and develop a sensor node which does not use battery, so that the sensor nodes can rely on inertia of the tire movement to generate power. The system can effectively monitor the tire parameters. It will provide flexibility for drivers. This is also a better option to reduce road accidents. With the

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improvement of various standards in our country and with people's increasing emphasis on safe driving, the monitoring of the real-time pressure and temperature of tires and alarm system will become one of the necessary functions in the vehicle safety system.

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