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CONTROL SYSTEM TO IMPROVE VEHICLE SAFETY – TIRE PRESSURE MONITORING

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Abstract- This paper presents the tyres pressure monitoring systems in TPMS and DDS. This has the role of warning the driver when the tyre pressure is inferior to the correct pressure; the tyres deflated can lead to an increase of fuel consumption up to 4%, decreasing in the same time, the length of tyre using up to 45%; the tyres can lose pressure between 3% to 6% within a month, pressure loss which cannot be observed by the driver; the deflated tyres are also an important factor in triggering road accidents. So, the paper presents the system's hardware structure and also the software implementation on this. The originality consists in the soft designing for the PIC16F877A, which was performed with the help of PCWH compiler from the CCS Inc.
Keywords – Tire pressure, Monitoring, System, Microcontroller

1. INTRODUCTION

The TPMS and the DDS Tire Pressure Monitoring Systems are designed to alert the driver when the tire pressure is far below optimal pressure because deflated tires can cause an increase in fuel consumption of up to 4% while reducing the tire use time up to 45%; thus, tires can lose 3% to 6% of pressure per month, a loss that may not be noticed by the driver. Deflated tires are also an important factor in causing road accidents, the system being mandatory for car manufacturing starting in 2012.
The TPMS (Tire Pressure Monitoring System) is shown in Fig. 1.

Fig. 1 Tire Pressure Monitoring System (TPMS).

2. TIRE PRESSURE MONITORING SYSTEM

TPMS [1] is a direct tire pressure measurement system that displays the pressure of each tire on the on-board display. Thus, 4 pressure and temperature sensors placed inside the tire continuously monitor the tire conditions during driving, the tire pressure monitoring system being active from the moment the engine is started and the running speed of the vehicle exceeds 30 km/h.
The DDS [2] system is an indirect tire pressure loss detection system that works alongside the TPMS system, helping to detect the problem even when the TPMS sensors stop working. Thus, the DDS system uses the ABS sensors, the working principle being the speed measurement of each wheel. When the car is in motion, the speed of each wheel is permanently monitored; lowering the tire pressure leads to reducing its diameter and implicitly decreasing the wheel speed.
If the system detects a deceleration of the wheel speed, the vehicle's dashboard will display a red light, through its LED symbol corresponding to this system, and if a system error is detected, the indicator light will turn yellow.

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Fig. 2. Tire Pressure Monitoring System -Signaling Different Tire Pressure (DDS).

3. TIRE PRESSURE MONITORINGS

The system contains the following components: sensor / transmitter; RF receiver; low frequency control system (LF); Control unit, tire. Transmitter Sensor (S/TX)

There are usually 5 such units on a vehicle, one for each wheel. Each unit has a unique series that makes a distinction between wheels. When mounted on a vehicle's wheel, the system periodically measures the internal pressure. It transmits the measured pressure to the central unit by radio. The module is made up of an rfPIC12F675 processor and an SP-13 pressure sensor.

The rfPIC12F675 circuit is a low cost circuit that contains all the components needed to make the measurement and radio transmission circuit with a minimum of required external components. The circuit contains a well-calibrated internal oscillator, a few 10-bit ADC ports to assist with the pressure sensor interface. After applying the supply voltage, the processor performs an initialization procedure and enters the sleep mode until it receives information from the pressure sensor. When the information is converted digitally, then this one is transmitted to the central unit, the processor returns to the sleep mode for another 60 seconds.

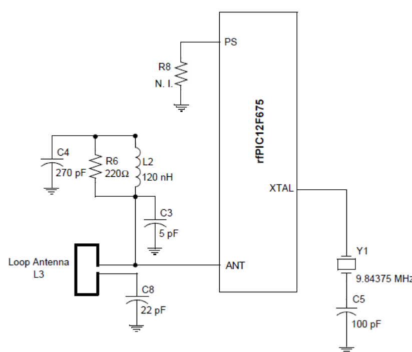


Fig. 3 The RF circuit.

The SP-13 [3] sensor can perform several functions, namely: it measures pressure, temperature and generates an interruption when the battery voltage drops below a pre-set value.

The SP-13 sensor also contains a unique factory-set identifier. This unique identification code is used by the central unit to differentiate between the pressure measurement modules.

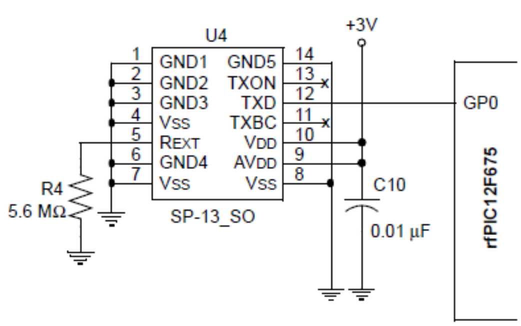


Fig. 4. Mounting The Pressure Sensor.

The RF receiver

A central RF receiving unit receives the transmission from each module separately. The receiver can also be used as a key decoder for accessing the vehicle. The PLL transmission system built with the rfPIC12F675 processor requires a minimum number of external components to build an RF transmitter.

The LF control system

It is designed to transmit specific control commands to the sensor module with a 125 KHz ASK modulated signal. This circuit communicates over a short distance of 1m or less. This circuit is used to transmit the sensor unit control commands to perform certain tasks.

The control unit

It is responsible for initiating communication, interpreting received data, and displaying information on board the vehicle.

The tire

It is used as the system on which the measurement is applied. On it, the pressure sensors are mounted.

4. THE HARDWARE STRUCTURE OF THE TIRE MONITORING SYSTEM

4.1 The system running

The system performs the following functions: monitoring the pressure sensor; reception of wireless information from the four sensors; the information radio transmission to the monitoring and alarm unit; transforming the pressure into useful information via an ADC port; displaying anomalies and transmitting alarm signals if necessary.

The system continuously monitors the four pressure sensors that are mounted in the valves of the four tires and it will act on the on-board warning control system if it is necessary. There are two distinct system running situations, namely: the system does not decode a pressure abnormality, so the pressure values are displayed, respectively the system detects a pressure abnormality, so the system displays distinctly the technical problem tire.

The block diagram of the system contains the following blocks: a power supply block that provides power to the circuits with a stabilized voltage of 5V; pressure sensor, which converts the pressure into an interpretable electric signal; radio receiver, which performs wireless connection with the pressure transmission system; the oscillating circuit, which provides the oscillation frequency required for the operation of the microcontroller; a display that provides the read and predefined information by the operator; The TTL / Rs232 converter, which converts the TTL signal into the RS232 signal; the alarm command block, which contains control circuits of the command systems; pressure conditioning circuit and radio transmission, which amplifies the signal obtained from the pressure sensor and sends it by radio to the processing unit.

The pressure sensor continuously measures the tire pressure and transmits it via the conditioning amplifier to the ADC port of the microcontroller. The microcontroller used is of the rfPIC12F675 type. It contains the hardware subsystem required for the radio transmission in the 315 MHz band. The amplified and converted pressure signal into ADC quanta is packed and transmitted to the receiving unit. The packing is of the following form SINGLE CODE TYPE + PRESSURE VALUE.

The first push factor includes three variables: " to see new things and broaden mental horizons (0.828)", "to experience different culture and ways of life (0.719) and "to share with others after travelling (0.715)", so it is named "knowledge enrichment" factor.

The second push factor includes three variables: "to escape from daily life and change surroundings temporarily (0.829)", "to reward myself because of heavy work pressure (0.755)" and "to escape from loneliness (0.790)", therefore it is named "relaxation and escape" factor.

The third push factor includes two variables: "to appreciate and get close to beautiful natural scenery (0.837)" and "to visit the historical and cultural attractions (0.811)", so it is named "sightseeing" factor.

The fourth push factor includes two push variables: "to fulfill own interests and hobbies (photographing, painting and so on) (0.779)" and "to do academic research (0.774)", so it is named "cultural training" factor.

The fifth push factor includes two variables: "to enhance the relationship between friends or between family members(0.804)" and "to experience by myself because a lot of friends and families have been to (0.765) ", so it is named "emotional communication" factor.

4.2 Microsystem hardware design with microcontroller

The electrical scheme was performed in the Proteus program (ISIS).

The Proteus ISIS is the best simulation software in the world for various designs with electronics and microcontroller. It is mainly popular because of availability of almost all microcontrollers in it. So it is a handy tool to test programs and embedded designs for electronics hobbyist and expert. You can simulate your programming of microcontroller in Proteus 8 Simulation Software. After simulating your circuit using Proteus Software you can directly make PCB design with it so it could be an all in one package for students, hobbyists and experts.

It was the use a PIC16F877A microcontroller that is presented in the fig. 7.

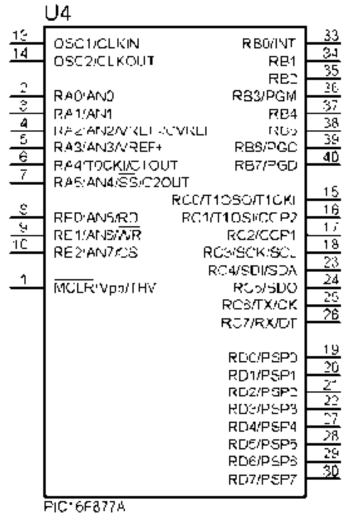
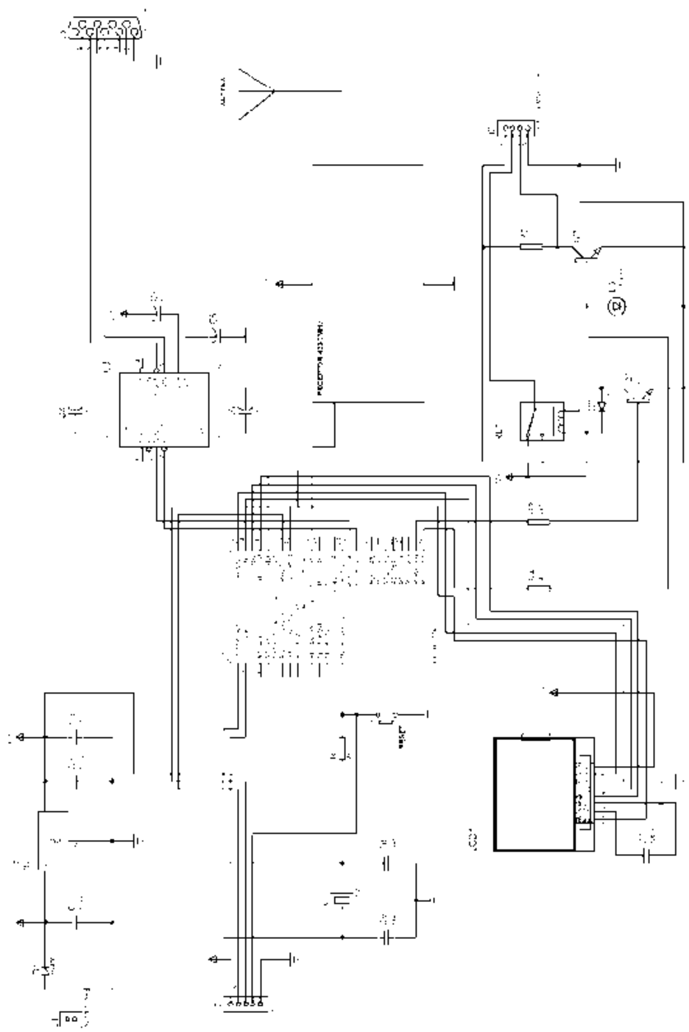


Fig.7 The PIC16F877A microcontroller.



Circuit programming of the microcontroller was performed with the help of an ICD-S programmer via an ICSP connector. Figure. 8 shows the electrical scheme of the receiving system.

5. CONTROL OF TIRE PRESSURE MONITORING SYSTEMS

5.1 Microcontroller software design from

For the proper functioning of the microsystem, a software was implemented in the PIC16F877A microcontroller [4].

The working logic on which the microcontroller software has been designed has the following steps: initialize the input / output circuits; initiating the instrument panel control circuits; initiating the graphical LCD module; the pressure values of the four tires are monitored permanently; the data reception of the radio module is monitored; data is displayed on a graphical display; the user is alerted when a pressure problem occurs.

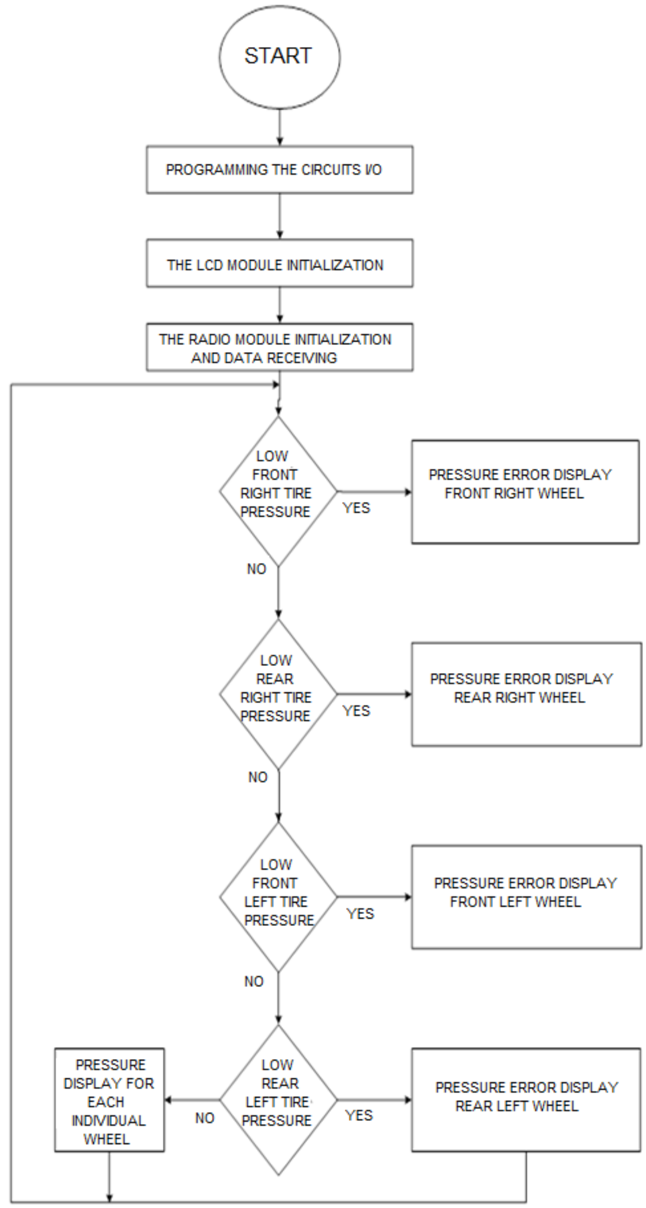


Fig. 9 Microcontroller program organizing.

5.2 Software implementing

The PIC16F877A software was made using the PCWH compiler from the CCS Inc.

At first the PIC16F877A processor was set, the 20MHz working frequency was set. Configuration words have been set. The HS mode (high speed crystal -20MHz) is used, the WDT timer (NOWDT) is not used. The microcontroller has been set to be unable to be programed at 5V (NOLVP), and no readout protection has been enabled (NOPROTECT). An ADC port has been set without the ADC, as well as the data reception interruptions.

The following cases can be distinguished:

Case 1: the right front tire pressure is low, an LCD alarm is displayed corresponding to the right front wheel as well as a readable alarm message. The individual pressure data for each tire disappear and these ones are replaced by a pressure error message.

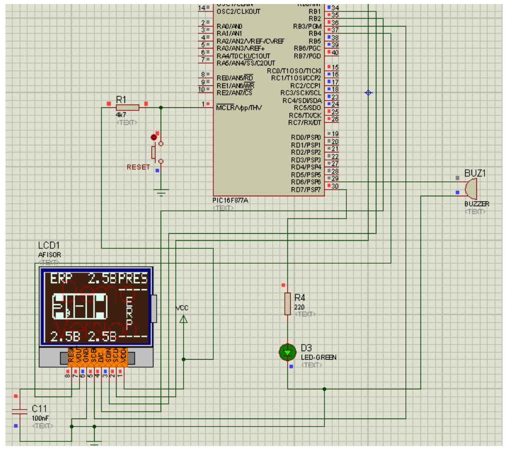


Fig. 10 Front right tire pressure error simulation.

Case 2: the rear right tire pressure is low, an LCD alarm is displayed corresponding to the right rear wheel, as well as a readable alarm message. The individual pressure data for each tire disappears and these ones are replaced by a pressure error message.

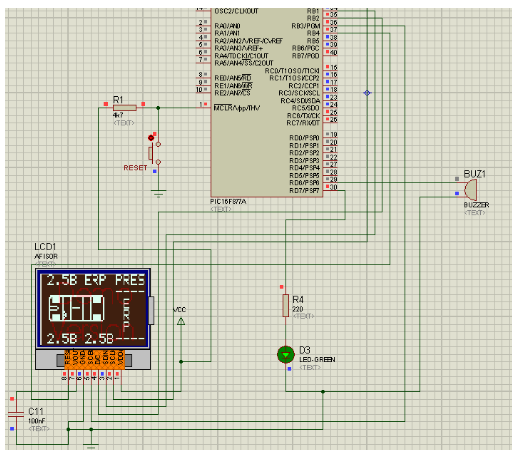


Fig. 11 Rear right tire pressure error simulation.

Cases 3 and 4 relating to the right front tire pressure, respectively the right rear, are similar to cases 1 and 2 seen above.
Case 5 – tire pressures are within the normal range: individual tire pressure is displayed on the LCD corresponding to each wheel, as well as a pressure table. The individual pressure data for each tire appear on the right side of the display.

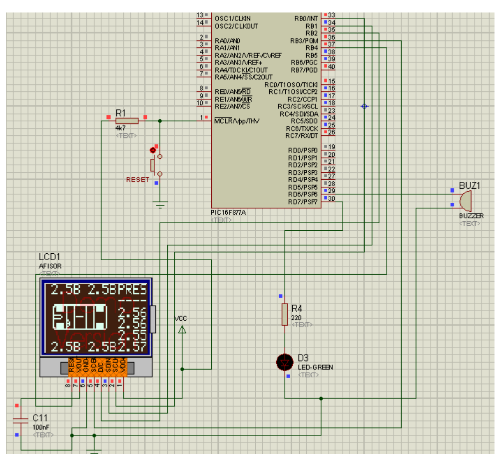


Fig. 14 Normal value pressure simulation.

6. CONCLUSIONS

Implementing a tire pressure monitoring system pursued and improved the on-board warning systems. This system alerts the driver in the event of a pressure problem in one of the tires.

Following the tests, it was found that the system performs the following functions: monitoring the pressure sensors for each tire; driver alarming in the event of a pressure abnormality; reading the pressure value and transmitting it wirelessly to the vehicle's computer; pressure value displaying for each tire.

This tire pressure monitoring system improves vehicle performance and reduces tire wear. It also improves traffic safety by reducing the braking distance and by maintaining a stable trajectory of the vehicle during braking.

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