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JUDUL: TYRE PRESSURE MONITORING SYSTEM

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TYRE PRESSURE MONITORING SYSTEM

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LIST OF SYMBOLS

V	Voltage
V_{in}	Input voltage
f_{in}	Input frequency
V_{ref}	Reference voltage
R_{in}	Input resistance
C_{ref}	Reference capacitance
Ω	Ohm
g	Piezoelectric voltage coefficient

LIST OF ABBREVIATIONS

TREAD	Transportation Recall Enhancement Accountability and Documentation
NHTSA	The National Highway Traffic Safety Administration
TPMS	Tyre Pressure Monitoring System
MCU	Microcontroller Unit
ID	Identification
I/O	Input/Output
LF	Low frequency
S/TX	Sensor/transmitter
DL	Data line
ABS	Auto-braking system
IEEE	Institute of Electrical and Electronics Engineers
MHz	Megahertz
SAW	Surface acoustic wave
IDT	Interdigital transducer
AC/DC	Alternating current/direct current
DC/DC	Direct current/direct current
V/F	Voltage-to-frequency
F/V	Frequency-to-voltage
LED	Light-emitting diode
NDT	Non-destructive test
PIC	Programmable Interrupt Controller
PCB	Printed board circuit

ABSTRACT

Tyre pressure monitoring system (TPMS) is an electronic system that monitors the air pressure of an automobile tire and alerts the driver by displaying the real pressure or just a warning light. This project is focused on designing and developing a direct TPMS which the measurement of the air pressure is taken directly using pressure sensor. Suitable components are researched to design the prototype. Main components needed are pressure sensor, voltage-to-frequency converter, transmitter, receiver, and frequency-to-voltage converter. To power the prototype, piezoelectric method is chosen instead of using lithium battery. However, due to limitations and problems faced, piezoelectric method will be discussed by assuming the design of power generator. Main components need to be calibrated to ensure the consistency and precision of the prototype in reporting the pressure. Calibration for pressure sensor is performed by simply applying a known value of pressure and the output voltage is measured. For voltage-to-frequency and frequency-to-voltage converters, a known value of voltage or frequency is applied and the output is monitored using voltmeter and oscilloscope. The results show promising data by proving the relationship between the input and output for each component. Piezoelectric method is also discussed but in terms of the design of the circuit. As for the conclusion, although there are many problems and limitations faced, this prototype is a promising product in real world application.

ABSTRAK

Sistem pemantauan tekanan udara dalam tayar ialah satu sistem elektronik yang memantau tekanan udara dalam tayar kenderaan dan menyedarkan pemandu dengan menunjukkan tekanan udara yang sebenar atau lampu amaran. Projek ini tertumpukan kepada mereka dan mencipta sistem pemantauan tekanan udara secara langsung yang bermaksud pengukuran tekanan udara diambil secara langsung daripada pengesan tekanan udara. Komponen-komponen yang sesuai dikaji untuk mereka prototaip. Komponen-komponen utama terdiri daripada pengesan tekanan udara, penukar voltan-kepada-frekuensi, penyampai frekuensi, penerima frekuensi, dan penukar frekuensi-kepada-voltan. Kaedah piezoelektrik digunakan untuk memberi kuasa kepada prototaip sebagai alternatif kepada bateri litium. Walaubagaimanapun, banyak masalah yang dihadapi dan kaedah ini dibincangkan dengan membuat anggapan terhadap penggunaan litar penghasilan kuasa. Komponen-komponen utama perlu dikalibrasi untuk memastikan ketepatan dan betapa konsisten prototaip ini mampu untuk member laporan nilai tekanan udara. Kalibrasi pengesan tekanan udara dilakukan dengan memberi nilai tekanan udara yang diketahui dan voltan yang terhasil direkodkan. Untuk penukar voltan-kepada-frekensi dan frekuensi-kepad-voltan, voltan atau frekuensi yang diketahui nilainya dikenakan dan hasil keluaran diperhatikan menggunakan pengukur voltmeter dan oscilloscope. Keputusan yang ditunjukkan sangat memberangsangkan kerana data yang diambil berjaya menununjukkan hubungan antara masukan dan keluaran untuk setiap komponen. Kaedah piezoelektrik dibincangkan dari segi reka bentuk litar. Sebagai kesimpulan, walaupun ada banyak masalah yang dihadapi, prototaip ini mampu diaplikasikan ke industri.

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Every year, many accidents occurred and for certain cases, accidents are caused by under-inflated tyres. Under-inflated tyres could promote to problems such as blowouts, decreased tyre life, and handling. Due to this awareness of the importance of tyre pressure, US government has introduced Transportation Recall Enhancement Accountability and Documentation (TREAD) Act (www.nhtsa.gov, February 2010). This act requires all passenger cars, van, and light trucks to include low tyre pressure warning systems as standard equipment. The National Highway Traffic Safety Administration (NHTSA) oversees the TREAD Act and has expressed an interest in extending the legislation to other types of vehicle. As a result, NHTSA established Federal Motor Vehicle Safety Standard which requires the installation of tyre pressure monitoring systems (TPMS's) that warn the drivers when a tyre is significantly under-inflated (25% of the right pressure).

The significant of running the tyres at the specified pressure helps provide proper vehicle handling (thus, reducing the chance of accident) while avoiding premature tyre wear. The right pressure for a vehicle is well-stated on the tyre information label or tyre placard located on a door edge or door jamb, or inside the glove-box door. The label also lists maximum load and tire size (including spare). Underinflated tyres wear on the outsides of the tread. Also, the tyres flex excessively which produces extra heat and more rapid wear. Over inflation causes the center of the tread to wear. The tyre cannot flex normally and this puts stress on the sidewalls and plies.

It is not convenient to frequently check the tyre pressure using pressure gauge. For long journey, tyre pressure may vary from time to time due to load, road irregularities, and temperature. Hence, one could not possibly know the condition of the tyre and that had caused many tyre blowouts especially for heavy trucks. Hence, TPMS is introduced. TPMS is an electronic system that observes and monitors the air pressure. Certain TPMS also monitors the temperature of the automobile tyre. The system alerts the driver of the vehicle of the air pressure inside the tyres by displaying the real pressure or just a warning light. Some of the car manufacturers already installed their own TPMS on their vehicles.

TPMS has two styles of indicating the tyre is underinflated or overinflated, that is directly and indirectly. In direct TPMS, pressure sensor is used where the measurement is directly taken from the tyre pressure itself. Generally, a direct TPMS consists of transmitting and detection unit at each tyre (temperature and pressure sensor, microcontroller unit (MCU), transmitter, battery, and protective casing) and a receiving and display unit (battery, receiver, MCU, display unit, casing, switch set, and display screen). The transmitting and detection unit will take the reading of the tyre pressure and temperature and transmit it via radio signals to receiving and display unit. This unit will process the data and show in display or just give a warning light (LI Wei, & Chen Hongling., 2005).

Indirect TPMS uses existing sensors and software algorithm to identify the tyre's condition (under/over-inflated). There are many on-going researches and development projects on this method and could be classified into two main classes. The first class is by using vibration analysis. It treats the tyre as a spring that is excited by the road irregularities. The concept is to monitor the resonance frequency which is correlated to the tyre pressure. The second class is by using wheel radius analysis which based on the fact that the tyre pressure affects the effective rolling radius of the tyre (N. Persson, & F. Gustafsson., 2002).

The method used for this project is direct TPMS. It will be discussed further in Chapter 3 and Chapter 4.

1.2 PROBLEM STATEMENTS

The first problem statement is the location of the sytem. The transmitting and detection unit will be located inside the tyre. The location of the system is crucial for safety aspect and precision of the data that will be gained. The second problem statement is the size of the system which the size of the transmitting and detection unit needs to be small enough if it were to locate inside the tyre. The third is wireless transmission; when tyre is rotating, the transmitting and detection unit will be transposed. Tyre identification might be miscorrelated and the information displayed on the screen about the pressure and temperature as correlated with the tyre is wrong.

The fourth problem statement is sensor is using battery. Traditional direct TPMS requires battery in each tyre to power the sensor and the circuits, but the use of batteries raise potential problems including limited life span, temperature-dependent capability, added weight, environmental concerns, and larger maintenance cost. The fifth and the last problem statement is self-generating power. In this project, self-generating power system is to be designed to replace the battery's function as main power supply.

1.3 OBJECTIVE

The objective of this project is to design and develop direct tyre pressure monitoring system.

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