EVALUATION OF THERMAL COMFORT CONDITIONS. CAN SYSTEM FOR ESTIMATING THE LEVEL OF THERMAL COMFORT IN AUTOMOBILES

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REZUMAT. Lucrarea de fata trateaza un subiect actual si important, cel al confortului termic in interiorul autovehiculelor.Lucrarea isi propune ca si obiectiv imbunatatirea confortului termic in interiorul autovehiculului, prin dezvoltarea de noi abordari, tehnici de monitorizare a confortului termic, precum si prin conceperea si realizarea unui sistem CAN (Controller Area Network) de estimare a nivelului de confort termic in automobile. Pentru evaluarea confortului termics-a utilizat metoda ASHRAE 55-92, metoda ISO 7730 si metoda bazata pe indicele de incalzire HI (Heat Index).

Cuvinte cheie: comfort termic, temperatura, umiditate, CAN.

ABSTRACT. This paper is focussed on the thermal comfort issues inside the vehicle. The main objective of this paper consists in improving the thermal comfort inside the vehicle. In this regard were developed new approaches of thermal comfort monitoring techniques and was designed and implemented a CAN (Controller Area Network) system in order to estimate the level of thermal comfort in vehicles. The evaluation of the level of thermal comfort was realized using the ASHRAE 55-1992 method, ISO 7730 method and a method based on the heat index HI (Heat Index).

Keywords: thermal comfort, temerature, humidity, CAN.

1. INTRODUCTION

The human sense of thermal comfort is very complex, and involves both the physiological and the psychological states of a person in specific conditions. In uniform environments, sensation and comfort correlate well: a neutral sensation corresponds to the best comfort; warmer or cooler sensations correspond to reduced comfort.[1]

The study of thermal comfort in transport has started and has been developed in conformity with the analysis of thermal comfort in buildings.

In literature [1], there is a reduced number of scientific studies made on the thermal comfort of the car. Therefore, new investigations and developments of accurate systems are needed in order to characterize the thermal comfort inside the vehicle[1-3]. The level of satisfaction in terms of thermal environment is quite subjective [2] being easily understood but difficult expressed in physical parameters. This means that the thermal comfort is a function of many parameters, as temperature and humidity [1-3].

Based on ASHRAE 55-1992 definition, on a certain level of comfort, only 80 % of people occupying the same space have the same opinion [2].

Nowadays, there are several methods that define thermal comfort zones. Three basic methods suitable in determining the thermal comfort in closed spaces are known as: ASHRAE 55-1992 method, ISO 7730 method and the method based on heat index (HI) [4-8].

ASHRAE 55-1992 method

ASHRAE method [2] defines two comfort zones, one for winter and one for summer. These areas are shown in Figure 1.

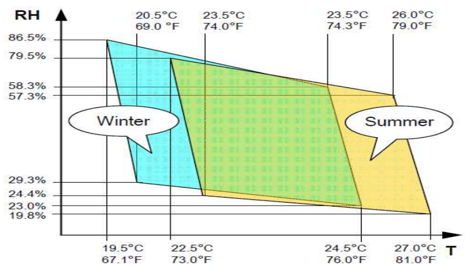

Fig.1. Relative humidity (RH) / temperature (T) according to ASHRAE 55 -1992 [11].

ISO 7733 method

The ISO 7733 method [11] defines two rectangular areas of comfort. These areas are shown in Figure 2.

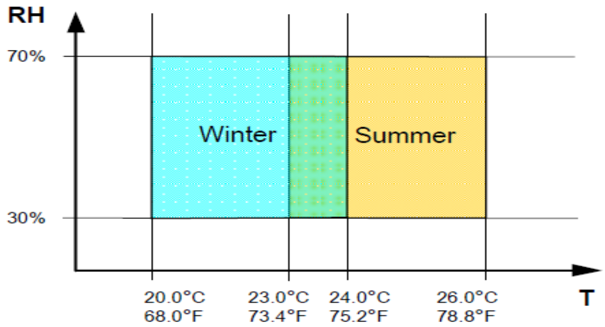

Fig.2. R/T diagram according to ISO7733 [11].

Heat Index (HI) method

The HI index [11] characterize the manner in which the body behave to a warm environment. A major importance is accorded to the temperature index higher than 25 ° C and the relative humidity index higher than 40 % [8]. In Figure 3 are plotted the curves of the HI heat index.

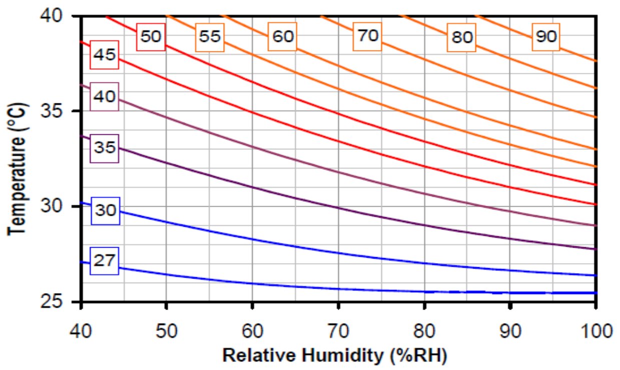

Fig.3. R/T according to HI (Heat Index) [11].

All the methods used in analysing the thermal comfort level are mainly concerned in measuring the temperature and relative humidity coefficients.

2. CAN PROTOCOL

Nowadays, there are several communication protocols used for automotive systems like: RS-232, Serial Peripheral Interface (SPI), Controller Area Network (CAN), Inter-Integrated Circuit (I2C) and others.

The CAN interface originally designed for applications in automotive industry has the ability of reducing the volume and the complexity of connecting cables. Also, the interface increase the efficiency and reliability of data transfers.

A wide variety of communication systems are used in the car.

Possible application have a range from the electronic engine control to the application of some assistance systems and management mechanisms. The CAN protocol is oriented on messages instead of addresses.

Nodes don't have addresses attached and between these nodes there isn't any predetermined priorities. The priority is established only between messages using the identifier value. Interface messages are received by all the receiving nodes. The HCS12 microcontroller is equipped with one MSCAN block responsible for controlling the CAN interfaces.

These blocks provide compatibility with CAN specification 2.0 part A and part B. The connection of the CAN interface determines the use of a conversion circuit to adapt CANH and CANL of interface lines to the TXCAN and RXCAN line levels of the microcontroller. In this process are used the MC33889 and MC33989 conversion circuits made (produced) by Freescale company.

3. PROPOSED SYSTEM

The proposed system was made using two identical hardware nodes. Each node is done using a PH-HCS12C32 module and the connections are made according to the scheme from Figure 4. The nodes and the programs provided can be used to analyse all the applications based on CAN communication.

The system consists in: temperature and humidity data sensors, a microcontroller and a computer data display. The data collection and the transmitting are completed by the HCS12 microcontroller as the core of the master, monolithic intelligent humidity/temperature sensor as the slave.

The hardware design of the system includes the HCS12 control unit, the SHT11 monolithic intelligent temperature/humidity sensor as the acquisition part, the MC33889 circuit, the PK-HCS12C32 process block (modul de dezvoltare) and the PC host computer.

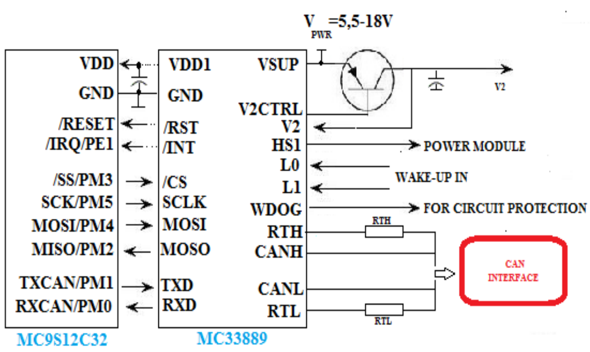

Fig.4. The calibration of the MC33889 circuit to the microcontroler and CAN interface

4.EQUIPMENT

The equipment was incorporated into a single system and consists in the following components: the temperature sensor (12-14 bit temperature and humidity sensor SHT11)[10], two PK-HCS12C32 hardware process blocks, two microcontrollers, two MC33889 conversion circuits a RS232 adapter device, a PRC1602A data display device and a PC.

The PK-HCS12C32 process block

This module is equipped with a MC9S12C32 microcontroller embedded with 80 QPF pin. From the physical point of view, the module is made of four sections that have the following functions:

- Section 1 realize the adapting process between the USB interface of the computer and the BKGD pins of the BDM block of the microcontroller.
- Section 2 contains the elements of a program that demonstrate the operation;
- Section 3 is the section in which the microcontroller is assambled with the related components;
- Section 4 has the purpose of developing the applications.

The MC33889 adaptation circuit

The circuit consists in different sections: power supply, SPI interface, adaptive block CAN, Watchdog circuit and various control circuits. The MC33889 circuit is a programmable via SPI interface. The adaptation block CAN interface provides the control and the conversion levels. The connections of the microcontroller are done using RX (out) and TX (input) connections. In Figure 4 is given the connection module of the circuit MC33889 to the microcontroller and the CAN interface.

The HCS12 Micro Controller

This type of microcontroller perfectly fits many applications [8], from automotive industries and controlling home appliances to industrial instruments, remote sensors, electric door handles and security devices. It is also ideal for smart cards as for battery supplied devices because of its low consumption.

This application uses MCS12C32 micro controller produced by Freescale Semiconductors [13]. The MC9S12C microcontroller features a 16-bit CPU, up to 128K bytes of Flash EEPROM, 4K bytes of RAM, serial communications interface (SCI), serial peripheral interface (SPI), 8-channel 10-bit analog-to-digital converter (ADC), 6-channel 8-bit pulse width modulation (PWM), and a 8-channel 16-bit timer module (TIM) [13].

The system programmability of this chip (along with using only two pins in data transfer) enables the flexibility of this product after the assembling and testing have been completed. This capability can be used to create production assembly line, to store calibration data available only after final testing, or may be used to improve the software in the final products.

Single-chip Intelligent Temperature/Humidity Sensor SHT11

This design uses intelligent temperature/humidity sensor SHT11 produced by Sconsirion company in Switzerland [10]. SHT11 is widely used in HVAC, automotive, consumer electronics, automatic control and other fields. As a slave, SHT11 is connected with the host micro controller.

The modality in which is connected the sensor to the MC9S12C32 microcontroller is shown in Figure 5.

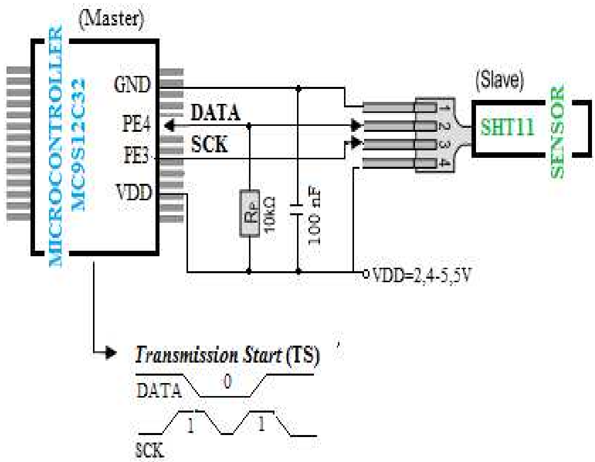

Fig.5. The calibration of the sensor to the microcontroler.

The DATA link must be polarized by an external resistance (10kΩ typical value) or by the microcontroller and between Vdd and GND connection a decoupling capacitor (100nF typical value) must be coupled. The protocol used for communication between the sensor and microcontroller is similar to the I2C interface. Any communication is initiated by the Master (MC9S12C32) by generating Transmission Start sequence (TS). Aceasta transmisie se realizeaza printr-un impuls in 0 al semnalului DATA si doua impulsuri in 1 ale semnalului SCK. After the TS sequence was transmitted, the microcontroller sends to the sensor the control word (1 byte). This word specifies to the sensor the work that need to be performed. Control words have these meanings: temperature measurement (0000011), measuring relative humidity (00000101), reading the status register (00000111), writing in the status register (00000101), software reset (00,011,110).

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4.SOFTWARE

In developping the application was integrated the programming environment used by Metrowerks CodeWarrior Integrated Development Environment software. The connection between the PC that runs Codewarior Metrowerks IDE programming environment and the development mode SofTec Microsystems hardware type (in this case PK-HCS12C32 module) is made through the USB interface. The software for the CAN nodes is written in C and installed onto the MCUs using Microchip's MPLAB IDE [12].

The communication between microcontroler and SHT11 has three parts, SHT11 initialization, SHT11 identification and data exchange.

5. MEASUREMENT SYSTEM

The temperature T (°C) and the relative humidity RH (%) are the main parameters measured in thermal comfort level tests [6-7]. In the application of estimating the thermal comfort which is presented in this paper is used the system based on the CAN interface. The system is made on two nodes: the CAN_sensor node and the CAN_monitor node.

The CAN_sensor node is made on a CAN device adaptation (PK-HCS12C32 module and conversion circuit MC33889) at which was attached a SHT11 sensor [8]. The informations of measuring the temperature and the humidity generated by the sensor, are sent regularly through the CAN interface, to the CAN_Monitor.

The CAN_Monitor module is also made from one CAN device adaptation (PK-HCS12C32 module and conversion circuit MC33889) at which was attached a PRC1602A display device and a RS232 adaptation device [8]. The CAN_Monitor node performs the following operations:

- receives the temperature and relative humidity informations from CAN interface;
- Calculates the relative humidity RH, the temperature T, the dew point DP and the heat index HI;
- Determines the comfort zones based on the comfort index HI;
- Shows the results on a LCD display and on a Terra Term Pro window display.

6. CONCLUSIONS AND RESULTS

The problem studied refers to the thermal comfort estimation level. In this regard are measured the relative humidity and the temperature using a SHT11 sensor. The obtained information is transmitted by a CAN node (sensor_node) to another CAN node (monitor_node) for data processing and display[8-9-10]

Based on the information received, the monitor node calculates the temperature, humidity, dew point and heat index. In the end, is estimated the comfort level and is performed the display of the results on a computer and a device LCD. In Figure 6 is presented an example of displaying the results in Tera Term Pro window [8-10].

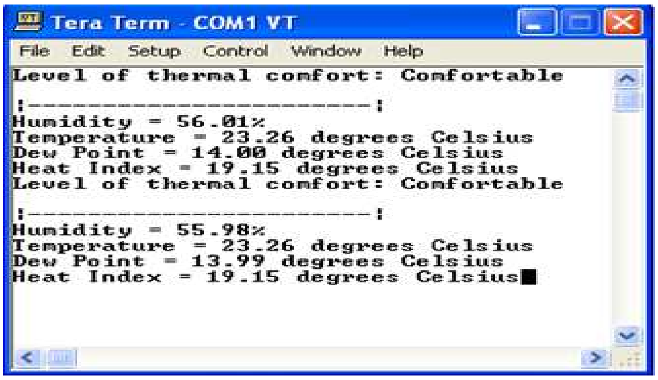

Fig.6. The example of displaying the results

Taking into consideration the varied activities of international involvement in indoors environments, it was quite necessary a deep research report about thermal comfort models and the implementation of a system based on ASHRAE 55-1992, ISO 7733 and HI methods for estimating the thermal comfort. Further, several improvements will be provided in the software program, in order to increase the program capacity and to expand the program for developing the current system method.

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