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Telematics Based Concept Focused to Avoid Engine and Vehicle Trouble due to Overheating

J. SZPYTKO, C. UDOJI
AGH UNIVERSITY OF SCIENCE AND TECHNOLOGY, Av. Mickiewicza 30, 30-059 Krakow, Poland
EMAIL: szpytko@agh.edu.pl

ABSTRACT

Overheating of vehicles is gradually becoming a common problem especially in tropical areas and during tropical seasons in the world. Although there are so many factors can cause overheating, hot weather is the most common cause of overheating. Coolants and thermostats in the radiator are no longer sufficient anymore. Traditional solutions preventing an engine from becoming overheated are: coolant levels must be maintained and without leaks; the oil level and viscosity must have the required properties; accepted technical conditions of radiator hoses and the radiator fan; the engine temperature must be acceptable. Modern cars are equipped with the systems supporting the operation process. The aim of this article is the concept of a solution that uses telematics to minimize engine failures due to overheating and to increase the operational readiness of transport means.

KEYWORDS: transport telematics, transport device availability, overheating, temperature sensor

1. Introduction

Temperature monitoring and control is important in automobiles especially during tropical seasons and in tropical areas of the world. In recent times, most cars producers have put in advanced technologies like the Automatic Temperature Controls (ATC) in place to avoid cases of overheating in vehicles [1]. Automatic Temperature Controls (ATC) are network elements built into many newer car models. These temperature control systems consider several factors when regulating the appropriate temperature inside the cabin of a car. The Automatic Temperature Controls systems use information from inside and outside of the car and look at the overall efficiency of the car and adjust accordingly [1]. The aim of an ATC system is to keep the car at its most ideal temperature to improve safety and reliability. Sadly, most cars produced earlier than 2005 do not have this feature but are still very much in use around the world. The development of a supplementary system to signal overheating to the user (driver) of a vehicle not equipped with ATC is necessary as it will improve safety. This Supplementary Temperature Signal system will comprise of several elements like a temperature sensor, the amplifier, the microcontroller and the LCD or sound notification element. The aim of this paper is to propose an affordable and working system for vehicles not equipped with the Automatic Temperature Controls systems.

2. The Supplementary Temperature Signal System

The aim of the supplementary temperature signal system is to improve safety by preventing overheating in old model vehicles not equipped with the automatic temperature controls signal. This supplementary temperature signal system will consist of a temperature sensor, an amplifier, a microcontroller, an LCD screen and a sound notification. This system tends to be an affordable means of improving safety and preventing overheating in old model vehicles.

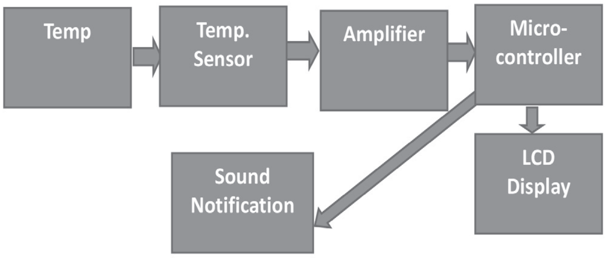

Fig.1. Block diagram for the working process of the Supplementary Temperature Signal System

Working Mechanism of the Supplementary Temperature Signal

- Temperature signal is the input physical signal from the engine
- A sensor like LM35, Thermostat, Resistance Temperature Detectors (RTD) or thermistor accepts the temperature input and converts it into electrical analog signal
- Amplification is an important step in analog-digital conversion (ADC) as it avoids noise and increase clarity of the input signal.
- The analog signal is fed to microcontroller and converted to digital signal at the ADC part of the microcontroller
- The analog-digital conversion (ADC) section consists of three general stages which are Sampling , quantizing and encoding
- Once the signal is converted to digital then it is sent to a notification device like visual (LCD display) or audio (Alarm or sound creating devices)
- Finally the end side will be the user, and will be responsible in taking appropriate action.

In modern cars (cars equipped with the Automatic Temperature Control), the control decision is taken by the Engine Control Unit (ECU) and control is done automatically which makes it easier for the driver (User).

3. Temperature Sensor

The selection of a temperature sensor is dependent on several characteristics like

- Sensitivity
- Usable temperature range
- Accuracy
- Availability
- Durability
- Cost

Table 1. Sensors and their characteristics [2, 3]

Sensor	Usable Temperature Range	Accuracy
Positive Temperature Coefficient Thermistor (PTC Thermistor)	-200°C to +800°C	High
Thermocouple	-200°C to +2800°C	High
LM35	-55°C to +150°C	High
Resistance Temperature Detector	-260°C to +650°C	High

It is important to state that the usable temperature range varies based on the element used to make the sensor. Any of the above listed temperature sensors can be used in the supplementary temperature signal system but in this paper, the Resistance Temperature Detector will be used because it is accurate, readily available and more affordable than the sensors listed above. The Resistance temperature detector can be constructed with different materials but in this paper, the Platinum Resistance temperature detector will be used because it is the most common type of RTD and it withstands very high temperatures.

3.1 Platinum Resistance Temperature Detector

A resistance temperature detector (RTD) is a device to measure temperature by relating it to changes in the electrical resistance of a metallic sensing element [4]. The resistance of a typical RTD increases by about 0.3 – 0.4% of its room-temperature value for every degree Kelvin of temperature increase [4]. The traditional RTD element is constructed of a small coil of platinum, copper, or nickel wire, wound to a precise resistance value around a ceramic or glass bobbin [3]. The element the RTD is made of is dependent on what the sensor will be used for because different materials can withstand various temperatures. The table below shows the various that can be used to construct a RTD and the various temperatures they can withstand.

Table 2. RTD sensing element material and Relative Temperature Limits [3]

Rtd Element Material	Usable Temperature Range
Platinum	-260°C to +650°C
Nickel	-100°C to +300°C
Copper	-75°C to +150°C
Nickel/Iron	0°C to +200°C

3.1.1 Temperature Coefficient of Resistance (TCR) or Alpha (α)

The Temperature Coefficient of Resistance (TCR) of RTD is also referred to as its alpha coefficient (α). The TCR or alpha value indicates the average resistance change of the sensor per degree °C over the range of 0°C to 100°C. The TCR or alpha value is also used as an indirect measure of the sensitivity of the resistive wire used in the RTD element. Its units are usually expressed in units of Ω/Ω/°C, or ppm/°C. Its value is derived by dividing the difference between the sensor resistance at 100°C and the sensor resistance at 0°C, by the sensor resistance at 0°C, and then again by 100°C as follows:

$$TCR = \alpha = \frac{[(R_{100^\circ C} - R_{0^\circ C}) / R_{0^\circ C}]}{100^\circ C} in \Omega / \Omega / {}^\circ C$$

The RTD temperature coefficient of resistance is also representative of the sensors' sensitivity to temperature change. That is, the larger the temperature coefficient (α), the larger the resistance change (ΔR) in response to an ambient temperature change (ΔT). Thus, we calculate:

$$\Delta R = \alpha R_o \Delta T,$$

Where: α = TCR in Ω/Ω/°C;

R_o = nominal sensor resistance at 0°C in Ω;

ΔT = temperature change from 0°C in °C.

While the α value indirectly defines the sensitivity of the metallic element, it is normally used to distinguish between resistance/temperature curves of various RTDs.

Metal impurities and stresses during manufacture lower the relative TCR for a given metal element. For example, there are many variations of platinum RTDs available as follows:

Table 3. Various conditions of Platinum and their different Temperature Coefficient of Resistance [9]

$R_{0°C}$ OHMS	ALPHA α (Ω/Ω/°C)	REFERENCE
100	0.00393	Highest purity Platinum
	0.003927	
	0.003926	ITS-90 Lab Standard Pt RTD, Requires ≥ 99.999% Purity. This is the laboratory standard platinum RTD which requires the high purity platinum wire (≥ 99.999%) and must be wound in a strain-free configuration which is difficult to achieve. However, some manufacturers come close and offer nominal TCR's of 0.00392 or 0.003923.
	0.003925	Very Pure Platinum for High Precision RTDs
	0.003923	SAMA
	0.003920	Old US Standard
	0.003916	Per JIS C1604-1981 and US Standard Curve, Common in US and Japan where it is the accepted standard
	0.00392	
	0.003911	This is the "American" or "US Industrial Standard" platinum RTD which has a lower TCR due to the imposition of strain imposed on the platinum wire from the high-temperature ceramic materials used in its construction.
	0.00391	
	0.003902	Another US Industrial Standard
	0.003900	Per BS 2G 148, Originally Specified for British Aircraft Industry
	0.00389	
	0.00385	Per IEC Publication 751-1983, DIN 43760, DIN-IEC-761, Majority standard outside US and Japan. This is the standard platinum RTD defined via DIN43760 and IEC 751 and the most popular one recognized nationally and internationally.
	0.00375	This is a low-cost alternative to the more expensive platinum RTDs outlined above.

From the numbers, there is little advantage to specifying one platinum TCR over another, as they are so close in magnitude for different grades of platinum. But laboratory measurement systems will tend to use the highest-grade platinum wire (purest metal), while industrial applications will tend to choose an RTD TCR that has the greatest standardization. The resistance-temperature coefficient of platinum wire typically used in RTD manufacturing is 0.00385 Ω/Ω/°C at 0°C. Another frequently mentioned value of α is 0.00392 Ω/Ω/°C at 0°C, which represents the resistance-temperature coefficient of chemically pure platinum wire used for standards. In any case, it is important to make sure that the sensor TCR you select is compatible with your choice of measuring instrument. In general, and with respect to industrial users, the 0.00385 TCR RTD sensors will be most compatible with the broadest range of measurement equipment from the largest number of manufacturers.

To illustrate the use of alpha α to calculate the resistance of an RTD at some other temperature, consider an ideal 100Ω RTD that has a resistance of 100.000 Ω at 0°C. Therefore, at +1°C the RTD resistance will be:

$$R_T = [R_o + (\alpha R_o \Delta T)] = 100\Omega + (0.00385\Omega/\Omega/°C)(100\Omega)(1°C) = 100.385\Omega.$$

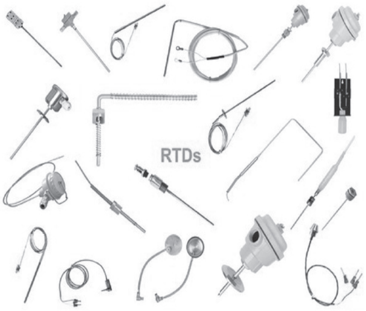

Fig. 2. Different types of Platinum RTD [8]

4. Amplifier

An amplifier is an electronic device that increases the voltage, current, or power of a signal**.** The type of amplifier to be used is either the discrete amplifier or the Operational Amplifier needs to be carefully selected because good drift stability is required to prevent recalibration of the Platinum RTD at frequent intervals. This makes the chopper and instrumentation type of amplifier preferable for the Supplementary Temperature Signal System.

5. Microcontroller

This serves as the brain and heart of the Supplementary Temperature Signal System. It is an integrated circuit designed to govern a specific operation in an embedded system. A typical microcontroller includes a processor, memory and input/output (I/O) peripherals on a single chip. This device configured to specification to send signal to the sound notification device or LCD.

The PIC16F877A microcontroller was selected for the Supplementary Temperature Signal system because it is readily available, easy to configure and very affordable.

Fig. 3. The PIC16F877A microcontroller [10]

The PIC16F877A microcontroller has the following properties;

- Only 35 single-word instructions to learn
- Operating speed:
  - DC – 20 MHz clock input
  - DC – 200 ns instruction cycle
- Up to 8K x 14 words of Flash Program Memory, Up to 368 x 8 bytes of Data Memory (RAM), Up to 256 x 8 bytes of EEPROM Data Memory
- 10-bit, up to 8-channel Analog-to-Digital Converter (A/D)
- 100,000 erase/write cycle Enhanced Flash program memory typical
- 1,000,000 erase/write cycle Data EEPROM memory typical
- Data EEPROM Retention > 40 years

6. The Signal (Sound notification device or LCD Display)

This is very important for the Supplementary Temperature Signal System because this system does not have a an automatic control feature so the user (Driver) has to be notified to take necessary actions immediately. The driver can either be notified via sounds (alarms) or an LCD display unit. Blow are the features of our choice of devices.

6.1 16x2 Lcd Display Unit

- Ground (0V) Earth
- Supply voltage; 5V (4.7V – 5.3V)
- Contrast adjustment through a variable resistor
- Back light
- 8- data Pins

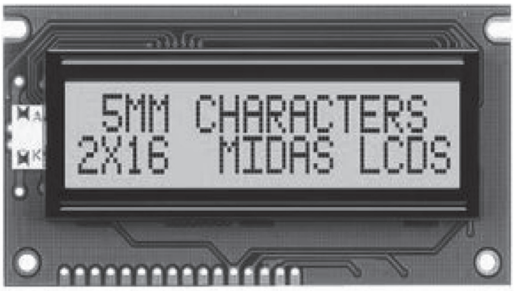

Fig. 4. 2X16 LCD Display Unit [11]

6.2 Alarm

Any alarm that operates with 5 -12 V input and loud enough to be heard can be used in this system. It will be connected with the microcontroller so that it can give a sound when it receives a decision from the microcontroller.

Fig. 5. Alarm System Speaker [12]

7. Conclusion

Advantages

- It improves Safety in Automobiles by preventing overheatung and fire outbreaks
- Opportunity for the user to continually track the condition of the engine
- Cheap and easy to implement it

Limitations

- Microcontroller is the heart of such system, hence if it fails or a bug occurs, then wrong information can be delivered to the user (driver).

Cost of implementation

It is important to mention the target of this paper are those cars which are not equipped with the Automatic temperature Control Unit like those produced in recent times but those cars which are not equipped with Automatic Temperature Control especially automobiles manufactured before 2005 because they are still in use especially in the third world countries. Surprisingly, the system proposed here would only cost about $60 to implement it without considering the human involvement which is cheap as compared to its advantages.

Challenges

- People awareness towards the importance of safety
- There are millions of cars out there in operation and would be so hard to bring this proposal to project in a bulk mode
- It can be conflict of interest with giant companies which are involved in Mass production of cars because this kind of proposal basically interferes with their business .
- This system can be seen as expensive to some individuals especially in developing countries. This could be also a challenge to fund for this project.

Future research works

The future works will be aimed towards creating a Supplementary Temperature Control System for easier use and also controlling the limitations of the system in this paper.

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Bibliography

[1] www.water-io.com [date of access: 20.12.2018]
[2] TIETZE U., SCHENK C., GAMM E.: Sensors and Measurement Systems. In: Electronic Circuits. Springer, Berlin, Heidelberg, 2008

[3] Criteria for Temperature Sensor Selection of T/C and RTD Sensor Types. Acromag. www.acromag.com [date of access: 20.12.2018]

[4] DAMES C.: Resistance Temperature Detectors. In: Li D. (eds) Encyclopedia of Microfluidics and Nanofluidics. Springer, Boston, MA, 2014

[5] MESSANA C., et al.: Proc. 23rd FISITA Congress, Torino (Italy), ATA, Torino, Vol. 2, 901, 1990

[6] ENGELHARDT T., et al.: Analysis of the effects of high coil temperatures on performance and drivability of electric sports cars. In: Bargende M., Reuss HC., Wiedemann J. (eds) 16. Internationales Stuttgarter Symposium. Proceedings. Springer, Wiesbaden, 2016

[7] POHL K.D.: Cable Fire in Automobiles: Causes, Effects and Prevention. In: Wallentowitz H., Amsel C. (eds) 42 V-PowerNets. Springer, Berlin, Heidelberg, 2003

[8] dir.indiamart.com [date of access: 20.12.2018]

[9] www.acromag.com [date of access: 20.12.2018]

[10] www.circuitstoday.com [date of access: 20.12.2018]

[11] pl.farnell.com [date of access: 20.12.2018]

[12] www.marketersupply.com [date of access: 20.12.2018]