Design of the Temperature and Humidity Instrument Based on 1-wire Sensor for Electric Vehicle Motors

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Abstract- This paper is presented a temperature and humidity instrument based on 1-wire sensors. This instrument has simply construction and cheap cost. The sensor is suitable for the installation on the motor for multi-point temperature sensing. It is highly suitable for motor device monitoring and the associated electronic devices. The related circuit is present to show the easy installation of the sensors

I. .INTRODUCTION

The temperature detection for motors is important for the monitoring of the motor performance. The magnetic property and the motor winding are significantly affected by the thermal condition. The torque control and speed control should be programmed with the compensation of the temperature information. Therefore the monitoring of the motor temperature is necessary for all the high performance system [1-2]. The monitoring in the recent years has been reported on sensorless method [3-4] and they are important for environment which does not allow the sensor however it is more reliable a physical sensor is installed.

Temperature sensor has a number of advantages includes the improvement of the control. In vector control, the motor parameters are highly dependent on the environmental condition and the parameter will vary with temperature. This will affect the control stability and the torque and flux regulation of the motors. Therefore temperature compensation with successful temperature measurement is useful. The method has been found applications in temperature compensation in vector control and torque ripple reduction [5-6]. As the development of temperature sensor and humidity sensor, temperature and humidity measurements are becoming easier.

The modern sensor for motor should not only be based resistive type although they are simple but their non-linear characteristics made method not easy to be used and they allows suffer from stability. A sensor should also be with low number of connection wires so as to reduce the wiring, increase the reliability and robustness. In motor control, both temperature and humidity should also be monitoring and their parameter should be feedback to the control system for parameter compensation. The humidity will also affect the isolation, permeability, aging monitoring and therefore they should be monitored as part of the environmental needs.

Fig 1 shows a typical motor and drive system. The transistor or the IGBT is formed by the IGBT or Power MOSFET is used to control the motor. The sensor is needed to provide the temperature condition of the motor and suitable PWM regulation is needed to provide housekeeping, parameter compensation and safety operation.

The temperature sensor can also be used in the associated power condition components for the motor drives including the transistor, and the battery system. In electric vehicle, the battery is important for the robustness of the vehicle. Multiple sensors are needed to monitor individual components for the battery, thermal subsystem and switching devices.

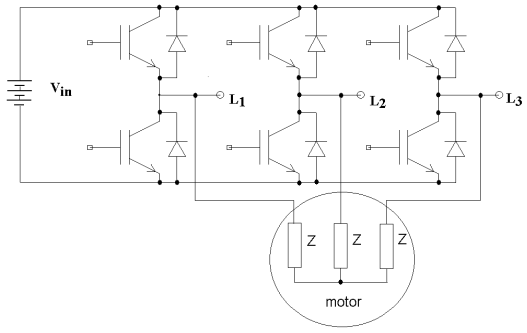

Fig 1: Motor drive system for 3-phase motors

II. TEMPERATURE AND HUMIDITY SENSORS

A. *HS1101 RELATIVE HUMIDITY SENSOR*

HS1101 humidity sensor is produced by HUMIREL company. It is a capacitive relative humidity sensor based on a unique capacitive cell. The sensor is full interchangeability with no calibration required in standard conditions, instantaneous desaturation after a long period in saturation phase. The typical circuit for 555 is shown in Fig. 2 [2].

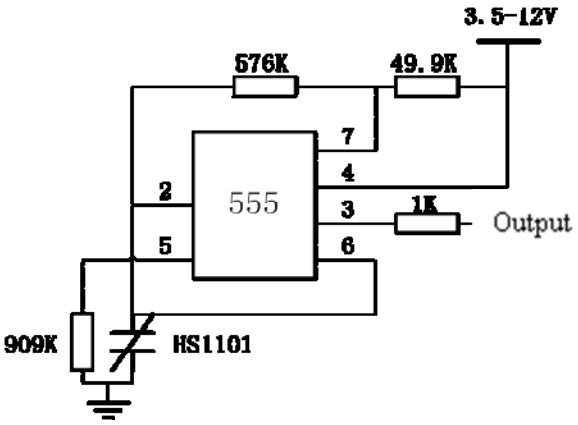

Fig 2: The typical circuit for 555

The capacitance of HS1101 is changed when the environment relative humidity is changed. The output frequency of the typical circuit is changed due to the capacitance of HS1101. When the relative humidity of environment is increasing, the capacitance value of HS1101 is increasing, and the output frequency of the typical circuit is decreasing. The typical characteristics for frequency output circuit is listed in Table 1.

Table 1. Typical characteristics for frequency output circuit [8]

Relative Humidity (%)	0	10	20	30	40
Output Frequency(Hz)	7351	7224	7100	6976	6853

50	60	70	80	90	100
6728	6600	6468	6330	6186	6033

B. 8B20 TEMPERATURE SENSOR

DS18B20 is the digital temperature sensor produced by Maxim Company. This sensor can provide 9 to 12 bits centigrade temperature measurements. It has an alarm function with user-programmable upper and lower trigger points. 1-wire bus is adopted by DS18B20. Only one data line is required for communication. This sensor can be powered by two ways, parasite power and external power. The power supply ways are shown in Figures 3 and 4. The power units can also be provided by an isolated version such as flyback converter which provides the low cost and small size stable power source. Each power unit can provide multiple power output using multiple secondary sides of the isolated coupled inductor as shown in Fig 5. Each of the V_{o1} and V_{o2} are isolated and can be programmed by the N_{S1} and N_{S2} through inductor turns windings.

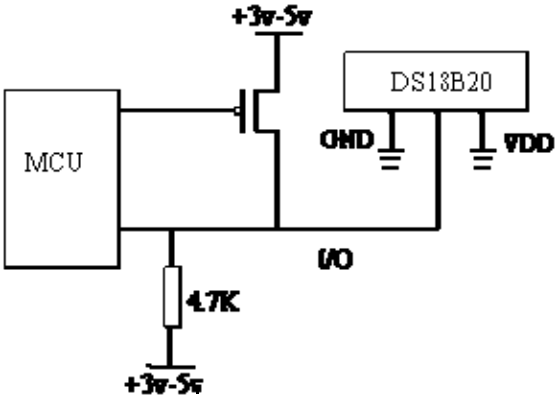

Fig 3: Parasite power supply

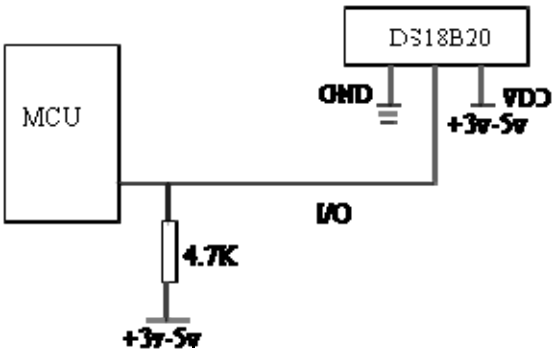

Fig 4: External power supply

The operating temperature range is from -55 °C to +125 °C. In the range of -10 °C to +85 °C, the temperature measurement is accurate to ±0.5°C [3]. When the environment temperature is higher than 100 °C, external power supply should be selected due to the increasing drain current.

There are five ROM function commands and six memory function commands. The ROM function commands are SEARCH (F0H), READ (33H), SKIP (CCH), ALARM (ECH) and MATCH (55H). The memory function commands are CONVERT T(44H), WRITE SCRATCHPAD (4EH), READ SCRATCHPAD (BEH), COPY SCRATCHPAD (48H), RECALL E^2 (B8h) and READ POWER SUPPLY (B4H).

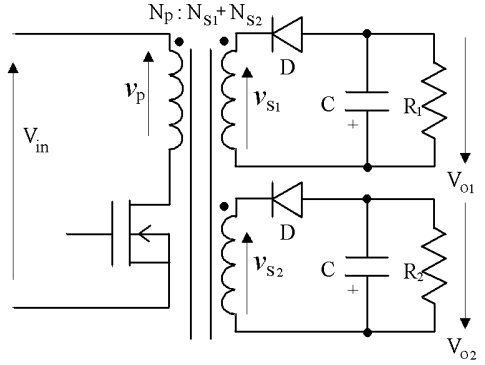

Fig 5: The isolated power source to the sensors.

III. DESIGN TEMPERATURE AND HUMIDITY SYSTEM

A. STRUCTURE OF SYSTEM

In this system, HS1101 humidity sensor and DS18B20 temperature sensor are selected to measure humidity and temperature. Six 7-segment LED modules are used to display humidity and temperature values. AT89C52 is selected to use as a processor. AT89C52 is 8-bit MCU of ATMEL company. It is compatible with MCS51. There are 8 K bytes of in-system reprogrammable flash memory [1].

P0 of AT89C52 is used to control segments of LED modules. P1.7 is connected with DS18B20, and P3.4 is connected with

the output of typical circuits (Fig. 2). The circuits of system are shown in Figure 6.

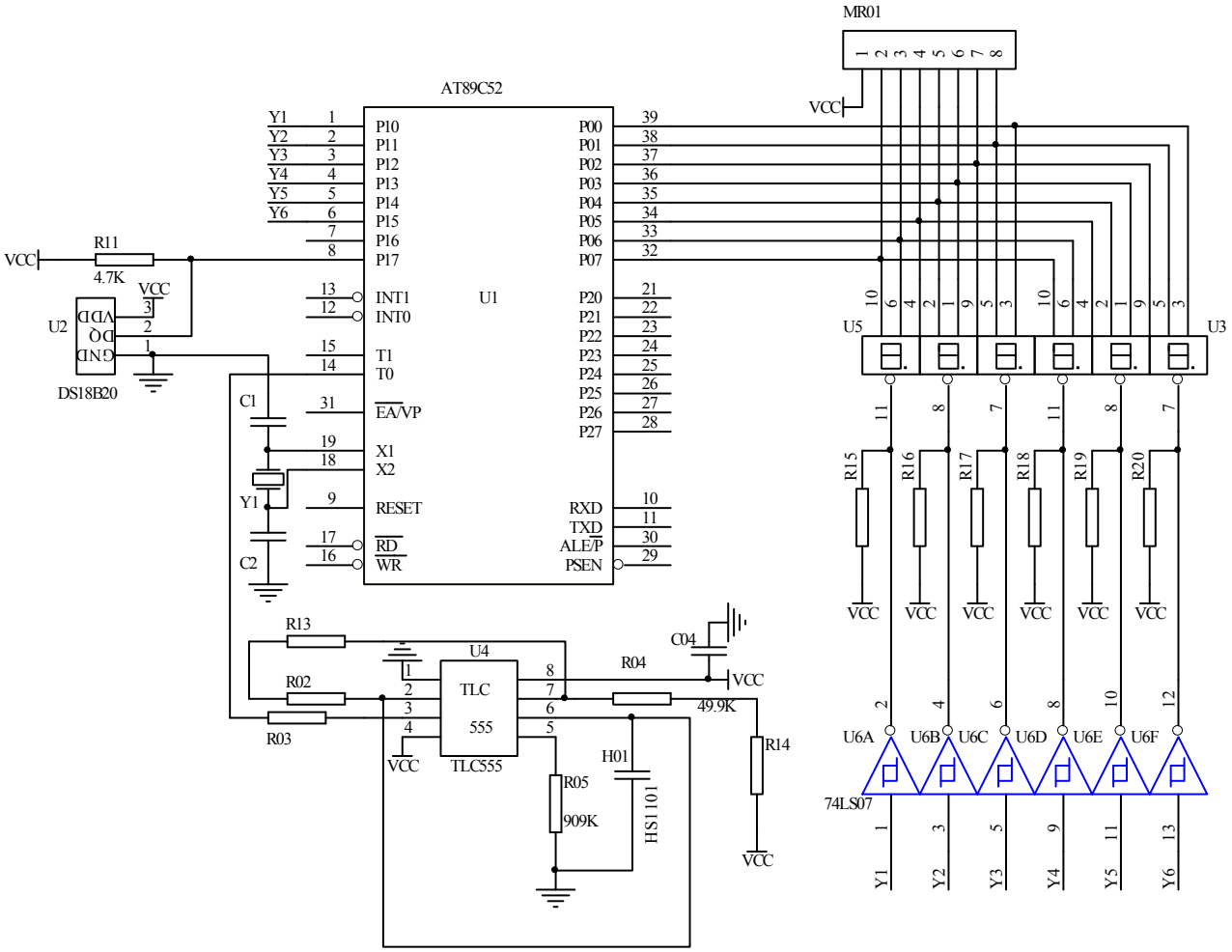

Figure 6. The circuits of system

B. Temperature measurements

DS18B20 is used to measure temperature and provides 12 bits centigrade temperature measurements. External power supply is adopted. AT89C52 reads and writes DS18B20 through 1-wire bus. All interrupts are forbidden during reading and writing period. The operation flow chart of DS18B20 is shown in Figure 7. The reading and writing DS18B20 flow chart is shown in Figure 8.

Figure 9 shows that the high 5 bits in MSB is sign. When temperature is larger/equal than/to 0 °C, the high 5 bits are '0'. When temperature is lower than 0 °C, the high bits are '1'. +25.0625 °C is '0000 0001 1001 0001', and -25.0625 °C is "1111 1110 0110 1111'.

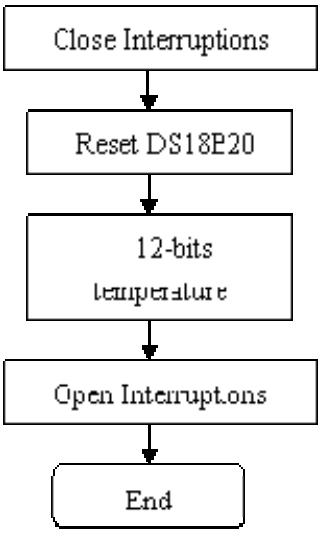

Fig 7: The operation flow chart of DS18B20

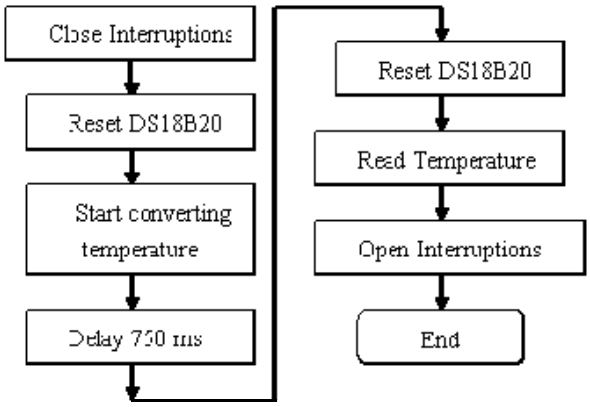

Fig 8: The reading and writing DS18B20 flow chart

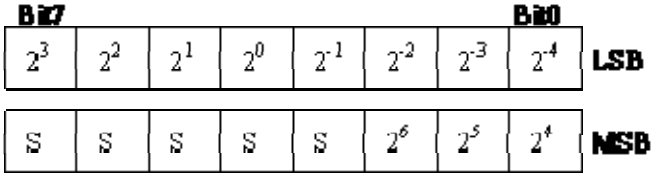

Fig 9: The definition of two-byte temperature data

C. Humidity measurements

The relative humidity is detected by HS1101 sensor. When relative humidity is measured, Timer0 is used to record the output of Figure 1 in one second. The output frequency can be obtained. According to Table 1, the relative humidity is acquired. The flow chart of humidity measurements is shown in Figure 10.

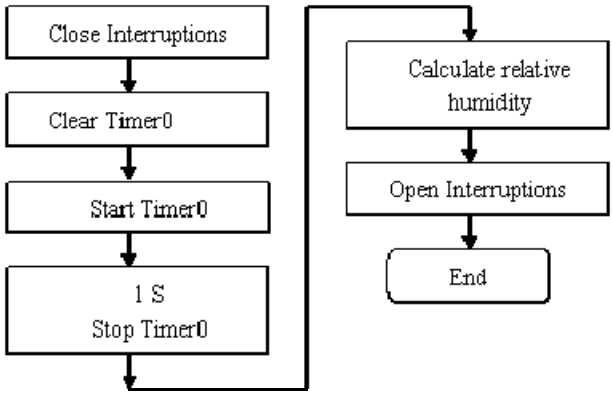

Fig 10: The flow chart of humidity measurements

D. Display

Six 7-segment LED modules are used to display temperature and relative humidity dynamically. P0 is used to transfer data to LED. The P1.0-P1.5 is used to control LED. In order to provide large current, 74LS07 is connected with P0. In display period, the first LED is selected, and P0 transfers data and maintains 1ms. Then the second LED is selected and display 1ms. Each LED displays 1 ms.

IV. DISCUSSION

In this system, the circuits are simply. High precise temperature and relative humidity values are acquired. Especially for temperature measurements, more temperature sensors can be installed in 1-wire bus. Multi-point temperature measurements can be easily realized.

Multiple point of monitoring is needed for the motor temperature monitoring. The monitoring includes the various chassis, magnetic core and also in the wiring of the motor windings as well. It can eliminate any problem of hot spot in the wire and it can eliminate the problem local hot spot and could provide warning and protection against the wiring isolation danger.

Fig 11 shows the possible location of the temperature sensors added. The sensor includes the core and the copper wire. As the sensor is only 1-wire bus, a number of units can be added to provide multi-point sensing and protection. The power supply for the sensors is simple and a very low voltage is needed. An isolated power supply can be used for the power. The isolated supply is a low power one with capability of isolation for higher than the voltage used in the motors. Usually for electric vehicle, this is higher than

the battery voltage or the DC bus voltage. For industrial drive, the voltage is higher than the DC link voltage of the inverter.

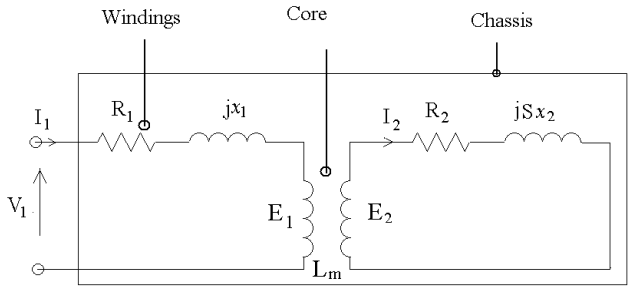

Fig 11: Location of the proposed sensors

V. CONCLUSION

The paper presents a simple and low cost temperature sensor and humidity sensor base don 1-wire bus method. The sensors have been applied in motor drive system for the detection of the machines core, wires and chassis temperature for the control unit. The temperature compensation can be easily implemented. Multiple points of measurement is realized easily using the 1-wire bus. Isolated power unit is used to provide point to the sensors which can be derived from the DC bus of the motor drives. The new method provides an alternative method as compared with the resistive sensor and is a simple and high performance sensing method.

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