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Temperature Measurement and Monitoring with Wireless Development Tool

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***Abstract*:** *In this paper, a temperature measurement and monitoring with wireless communication kit eZ430-RF2500 is presented. The installation of moving system is practical and easy to use. The kit which contains the temperature sensor is used for this purpose. The kit is placed on a little portable car which can be controlled by a computer. This car is able to measure the temperature of any location. The communication between the car and the computer is provided by RF modules. The measured values are shown on the monitor. The moving system can be used to measure the temperature of cold storages which the temperature must be homogeneous everywhere. This situation is very important for keeping the food fresh. The presented system is a successful prototype.*

Keywords: *Temperature monitoring, Cold storage, Wireless communication, eZ430-RF2500*

1. Introduction

Temperature is a very important quantity in all areas of our lives. In the modern society, temperature control is not only used in medicine, industry or agriculture applications but also widely used in other fields [1]. Today the temperature measurement and monitoring are carried out in different methods such as at one point or multiple point measurement, monitoring with wired or wireless communication. Studies have been done on wireless temperature measurement, as in [2] and [3] which are stable systems. In these systems the measurement can only be done in one location and this is not suitable for temperature measurement of large cold storage.

Lim and Ryoo design a remote monitoring system of temperature control for cold storage of farm produce. Farm produces must remain at a certain temperature. Because it is important to maintain the freshness. The temperature of each cold storage is checked by the temperature sensor fixed point. Also they design the temperature controller to keep the heat value [4].

Wang and Cong design the temperature monitoring system based on 1-wire bus technology. They provide interface circuit concluding 1-wire bus between the computer and the temperature sensor which placed at stable point [5].

Xu and Wang research on monitoring system for cold storage temperature. The temperature sensors are placed at fix multiple point. The temperature values are processed and monitored by computer. The system gives an alarm if necessary [6].

The kit used in this paper is eZ430-RF2500 which is commonly used for wireless temperature measurement. This kit consists of two parts which are access point and end device. There are temperature sensors on the programmed access point and end device. In the presented system, users can measure the temperature of anywhere and be able to create a map of the heat by sending the portable car controlled by the computer with wireless communication. The system can be improved by

adding other sensors such as humidity. Temperature measurement and monitoring with wireless development kit eZ430-RF2500 contain a movable system that can be controlled. The presented system ensures optimum conditions for provisions. The design of the system's software and hardware are presented in this paper.

2. The Overall Design Of The System

The system includes computer, the eZ430-RF2500 wireless development tool which includes RF modules, MSP430F2274, temperature sensors, battery, one little portable car which has permanent magnet dc motor and motor drivers. The kit comprises two parts which are Access Point (AP) and End Device (ED). The system is executed using IAR Embedded Workbench for MSP430.

In the presented system, the end device is placed on a portable car and the access point is connected to the computer. Access point measures the temperature where the computer is located; end device measures the temperature of area where the portable car is sent. It is provided the control of the little portable car by the PC. Buttons which are on the AP provide the car direction and driving. Temperature difference between the two environments is observed on the monitor.

Texas Instruments presents the software and hardware for temperature measurements with the kit. However, necessary software has been updated for the movement of the car.

AP sent data to the PC via UART taking over RF. MSP430F2274 is on the ED and communicates with CC2500 via SPI. The monitor displays temperature and voltage readings. The general structure of the system is shown Fig 1.

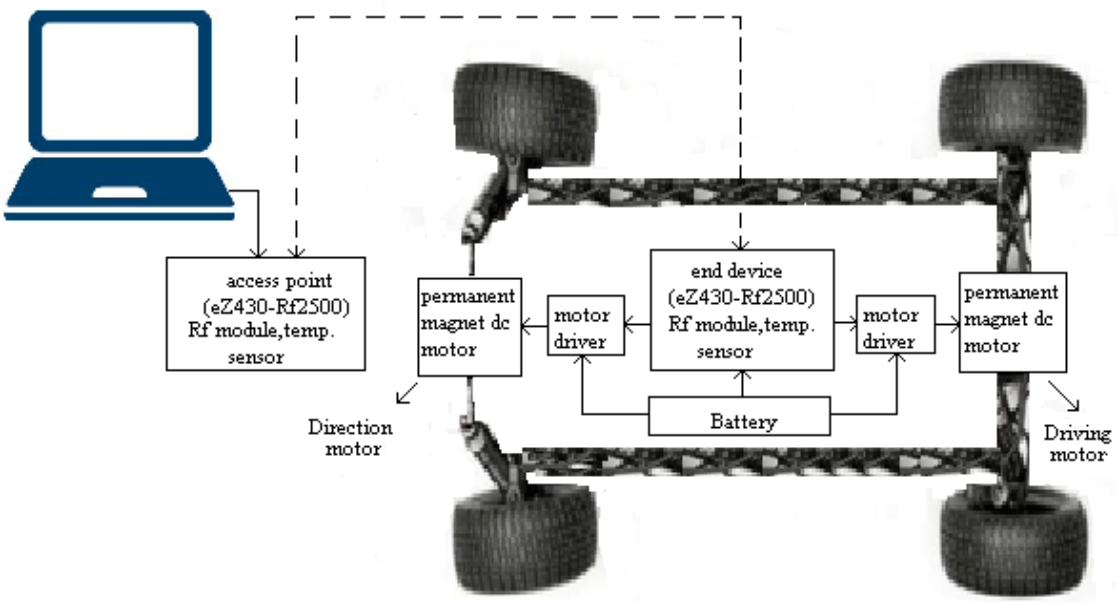

Fig. 1: The general structure of the system

2.1. The eZ430-Rf2500 Development Tool

The eZ430-Rf2500 is a complete USB-based MSP430 wireless development tool. The kit has all the hardware and software to support MSP430F2274 microcontroller and CC2500 2.4 GHz wireless transceiver. The development tool allows user to measure temperature without extra hardware. External sensors such as humidity, heat, pressure sensors may be incorporated into the existing design. It has super low power consumption. The general overview of the kit is shown Fig 2 [7].

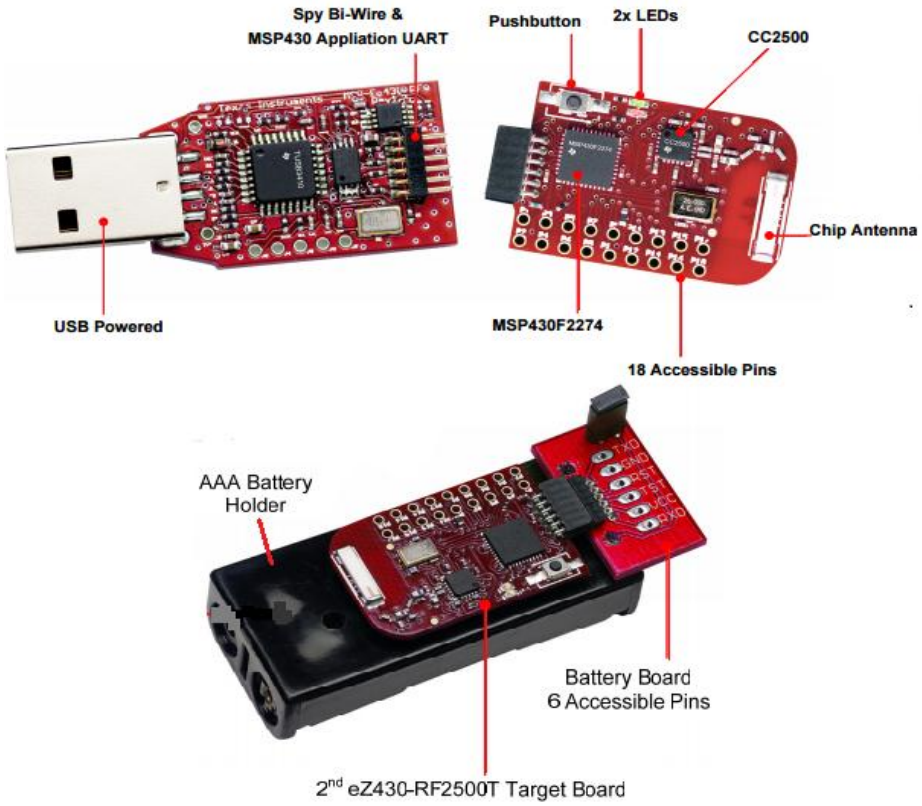

Fig. 2: The eZ430-Rf2500 Development Tool

The kit consists of two modules which are Access Point (AP) and End Device (ED). Modules are programmed via Spy-Bi-Wire. It could send and receive data in real time. The kit come programmed with wireless sensor monitor. It may be reprogrammed at any time for wireless applications. It has 21 available development pins, ultra-low-power MSP430 MCU with 16 MHz performance, digital I/O pins connected to LEDs, interruptible push button, ADC10's internal temperature sensor and CC2500 RF transceiver.

CC2500 is designed for ultra low power RF applications completely. It has 2.4 GHz transceiver for wireless communication. One of the general characteristics of the chip is having the 64-byte Tx/Rx transmit/receive FIFO. It can be controlled via a SPI interface. It has a configurable data rate up to 500 kbps. This rate can be arranged by software. So the chip draws less current. CC2500 simplified block diagram provides extensive hardware support [8].

Using the ADC10's internal temperature sensor, the AP begins to measure the ambient temperature once per second for transmission to the PC. In addition the AP continuously exchanges information from the ED. The sensor can measure the temperature from -50C ° to 150C ° . This temperature gap is very suitable for cold storage. The wireless temperature sensor network application is designed using the combination MSP430 microcontroller and a CC2500 from Texas Instruments.

Using the LEDs the accuracy of the program can be understood. The red LED is related with AP's measurement and the green LED is related with ED's measurement.

IAR Embedded Workbench Kickstart determines the code memory 32kb for MSP430F2274. In addition, there is 1 kb RAM. It's very good feature for MSP430 family. The MSP430F2274 is programmed via Spy-Bi-Wire. It has internal op-amp and work at 16 MHz [9].

Normally, MSP430 do not easy communicate with SPI. Spent current may be excessive because of software. To solve this problem, Texas Instruments has created SimpliciTI. With SimpliciTI one or more end device modules network communicate with each other. So the wireless development tool eZ430-RF2500 is very suitable for this system. The system has become cheaper and more practical.

2.2. Permanent Magnet Dc Motor

The permanent magnet DC motor consists of two parts which are rotor and stator. Magnetic field is provided with magnets which are at the poles. Torque occurs because of the current passing through the motor windings.

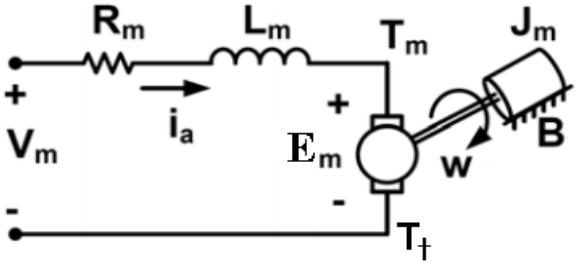

Fig. 3: Permanent magnet Dc motor equivalent circuit

The electrical parameters of the permanent magnet DC motor are described by the equations:

$$V_m = R_m i_a + L_m di_a / dt + E_m \quad (1)$$

$$E_m = K_V W \quad (2)$$

$$T_m = J_m dw/dt + Bw + T_t \quad (3)$$

$$T_m = K_t i_a \quad (4)$$

Where; V_m is the voltage applied on the armature, i_a is the armature current, R_m and L_m are the armature resistance and inductance respectively, E_m is induced voltage, ω is the rotationally velocity of the armature, T_m is the motor driving torque, T_t is the mechanical torque load, J_m and B are the moment of inertia and damping coefficient at the motor shaft respectively, K_v is the voltage constant and K_t is the torque constant [10].

The system includes two motors which used for direction and back-forth movement. The desired movement is achieved by H-bridges. 3.5-volt battery is sufficient for the motors.

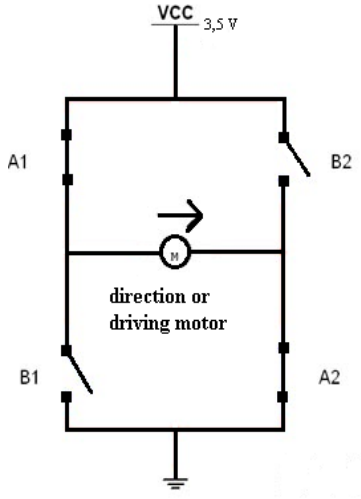

Fig. 4: H-bridge to provide movement

3. Software Implementation and Temperature Monitor

Firstly the software of the system is uploaded to the kit. This software includes temperature measurement and remote control of the portable car. The movement of the car is controlled by the kit which is connected to the PC and the results are shown on the monitor as in Fig. 5. The kit can control more than one end device. If there are multiple programmed end devices, the temperature data of each one can be monitored from the computer.

Access point sent data to the computer. The monitor displays temperature and voltage system where the PC is located. Access point communicates with end device which is on the portable car with battery. The temperature of area is shown on the monitor where the car is sent.

Fig. 5: The communication between the car and computer

The big bubble in Fig. 6 shows the ambient temperature of the AP's location, the little one shows the ambient temperature of ED's location. As the distance between the car and the monitor increases, the sensor temperature bubbles start to depart from each other.

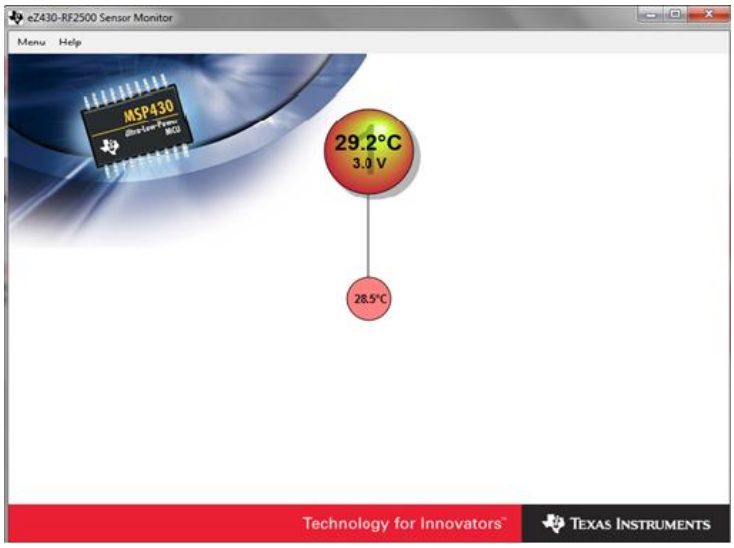

Fig. 6: Temperature measurement results

4. Conclusion

In this paper, temperature measurement and monitoring system is presented. The system is used in applications that need to control the temperature. The portable car is controlled remotely and temperature value can be monitored. The moving system is a successful prototype to measure temperature of cold storage.

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