Multipoint Remote Temperature Monitoring and Data Acquisition System Using RF Technology

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Abstract

Embedded system and wireless technology has entered in all aspects of life with variety of useful functions. Wireless communication has changed the way data can be transferred and viewed across locations. Industrial wireless modems use electromagnetic waves to transmit modulated data typically using RS-232 standards. The focus of this work is the development of a "Multipoint Remote Temperature Monitoring and Radio Data Acquisition Embedded System" that is taking advantages from embedded microcontroller, such that interaction and processing with the wireless transceivers and the temperature sensors. The multipoint remote temperature monitoring radio data acquisition embedded system project is implemented using DS-18B20 digital thermometers that gives 12-bit resolution, long range 433Mhz HAC-UM96 with serial interface RF modems and the Freescale HCS12 microcontrollers. This hands-on project aims to use the mentioned hardware for remote data acquisition to monitor and collect temperature and report back wirelessly to be further processed by the embedded microcontroller. One RF modems is used to communicate with the rest of the RF modems and receives the temperature from the remote locations. Project is implemented by using the HCS12 Dragon 12 plus Development Board as embedded microcontroller and "Code Warrior", an Integrated Development Environment (IDE) for embedded applications. The software is written in 'C' programming language using the Code Warrior IDE. The Code Warrior IDE has been developed by Freescale Semiconductor Company[1].

Introduction

Industrial wireless modem accepts serial data (typically using RS-232, RS-422, or RS-485 standards) and transmits it without wires to another device which receives and converts it. Data is sent from one end to the other as if there were a cable. Industrial wireless modems use electromagnetic waves to transmit modulated data. This is done using radio modems as access points. Radio modems are radio frequency transceivers for serial data. They transmit to and receive signals from another matching radio modem. Access points are various junctures in the network that enable wireless network connectivity. The systems that enable supervision of remote processes for data collection are normally termed remote data acquisition or remote data collection systems. These systems are designed using PCs and other processor-based input/output modules conforming to RS-232 and RS-485 standards. Multipoint Remote Temperature Monitoring can create accurate and real time reports in an environments where automated temperature monitoring system is required. Application examples of this kind of

device are in automated temperature monitoring in food industries and health care organizations that are extremely regulated when it comes to proper temperature control[2,3].

Project Problem Statement

The main focus of this work has been the development of a remote data acquisition system and embedded microcontroller application in order to enhance and promote experiential learning in undergraduate education for computer engineering students.

System Architecture

"Multipoint remote temperature monitoring and data acquisition system using RF technology" is a project taking advantage of wireless technology and mobility of embedded system. It aims to monitor temperature at various zones and report back wirelessly the temperature of these zones to a master node. It is possible for the master node to monitor the temperatures of different zones for controlling purpose. The system architecture overview is shown in figure 1.

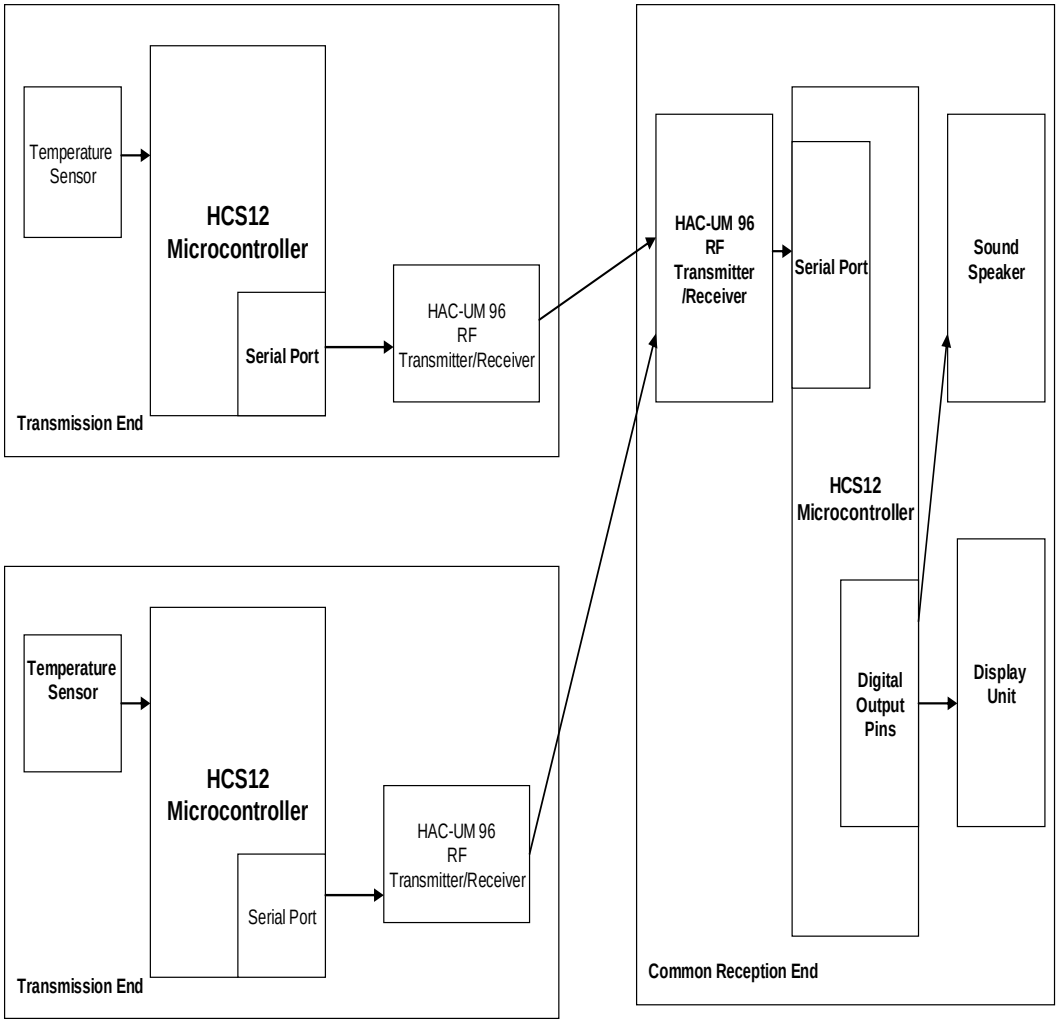

Figure 1 System Architecture

This Project takes advantages from embedded system, such that processing and interaction with the wireless transceivers and the various sensors can be integrated on small board that is easily installed in any place and start working once it takes the power.

In this project Dragon12-plus[4] trainer board is used to perform the following operations:

1. Reading the temperature sensor.
2. Use RS232 serial protocol to load temperature data to the wireless antenna.
3. Use RS232 serial protocol to unload temperature data from the wireless antenna.
4. Display the sent temperature on LCD screen and alerting with sound warning in case of emergency.

The Dragon12-Plus trainer is a low-cost, feature-packed training board from Freescale HCS12 microcontroller family. It incorporates many on-board peripherals that make this board very popular trainer for teaching microcontroller course in universities around the world.

RF Module (HAC-UM96)

The HAC-UM96 is designed to be a low cost and high performance radio modem. It is a UART device; data is framed according to the UART standard, very simple to use and is shown in figure 2. HAC-UM96 has a long transmission distance of more than 300m in the visible range. It support dual serial port and 3 interfaces, with COM1 as TTL level UART interface and COM2 as user defined standard RS-232/RS-485 interface[5,6].

Figure 2 HAC-UM96 RF Modems

Setting of channel, interface and data format

Before using HAC-UM96 RF modem, the user needs to make simple configuration based on its own needs to determine the channel, interface mode and data format as shown in figure 3. There is one group of 5-bit short-circuit jumper wire (JP2) on the upper right corner of HAC-UM, defined as ABCDE respectively. Assuming the open circuit of jumper wire (without short circuited) is mode 1 and short circuit of jumper wire (with short circuited) is mode 0, then the configuration is as follows: ABC jumper wires of JP2 provide 8 options, and the user can choose to use 0-7 channels through ABC jumper wires. Within one small communication network, as long as ABC jumper wire mode is same, there can be mutual communication.

Channel No.	Frequency	Channel No	Frequency
CBA=000(0)	430.2000 MHz	CBA=100(4)	434.6940 MHz
CBA=001(1)	431.4288 MHz	CBA=101(5)	434.2332 MHz
CBA=010(2)	431.7360 MHz	CBA=110(6)	433.1580 MHz
CBA=011(3)	430.5072 MHz	CBA=111(7)	433.9260MHz

Figure 3 Corresponding frequency points of 0~7 channels

The frequency points corresponding to each channel can be adjusted based on the user's needs.

1=Unplugging short circuitry
0 =Plugging in circuitry

The HAC-UM96 pin description is shown in figure 4. The serial ports COM1 (Pin3 and Pin4 of JP1) is fixed as UART serial port of TTL level; COM2 (Pin6 and Pin7 of JP1) can choose non-standard RS232/485 interface mode through D of JP2:

D=1 (Unplugging short circuitry) COM2 = RS-485
D=0 (Plugging in short circuitry) COM2 = RS-232

HAC-UM96 can support no-parity or even parity modes of the serial communication UART, i.e. 8N1/8E1, which can be chosen through E of JP2:
E=1 (Unplugging short circuited) Parity: 8E1 (even parity)
Then the used configuration in the project is:
A = 1 B = 1 C = 1 D = 0 E = 0

PIN	SIGNAL NAME	FUNCTION
1	GND	Ground
2	VCC	Power supply DC
3	RxD/TTL	Serial data input to the transceiver
4	TxD/TTL	Transmitted data out of the transceiver
5	SGND	Signal
6	A(TxD)	TxD of RS-232
7	B(RxD)	RxD of RS-232
8	SLEEP	Sleep control (input)
9	RESET	Reset signal (input)

Figure 4 HAC UM96 Pin Descriptions

Temperature Sensor (DS18B20)
The DS18B20 digital thermometer shown in figure 5 provides 9-bit to 12-bit Celsius temperature measurements. It communicates over a 1-wire bus that by definition requires one data line to

communicate with the HCS12 processor. Each DS18B20 has a unique 64-bit serial code, which allows multiple DS18B20s to function on the same one wire-1 data bus[7].

The 1-Wire bus system uses a single bus master to control one or more slave devices. The DS18B20 is always a slave. When there is only one slave on the bus, the system is referred to as a "single-drop" system; the system is "multi drop" if there are multiple slaves on the bus. All data and commands are transmitted least significant bit first over the 1-Wire bus. 1-Wire bus system is broken down into three parts: hardware configuration, transaction sequence, and 1-Wire signaling (signal types and timing). Hardware Configuration can be defined as the 1-Wire bus has by definition only a single data line. Each device (master or slave) interfaces to the data line via an open-drain or 3-state port. This allows each device to "release" the data line when the device is not transmitting data so the bus is available for use by another device. Therefore, one master microprocessor can control many DS18B20s at different location. This feature is very useful in HVAC environmental temperature controls or any other temperature monitoring control systems[2].

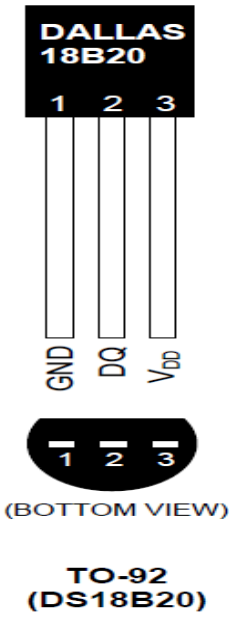

Figure 5 Temperature Sensor

The transaction sequence for accessing the DS18B20 is as follows:
Step1. Initialization
Step2. ROM Command (followed by any required data exchange)
Step3. DS18B20 Function Command (followed by any required data exchange)

It is very important to follow this sequence every time the DS18B20 is accessed, as the DS18B20 will not respond if any steps in the sequence are missing or out of order. Exceptions to this rule are the Search ROM [F0h] and Alarm Search [ECh] commands. After issuing either of these ROM commands, the master must return to Step 1 in the sequence.

All transactions on the 1-Wire bus begin with an initialization sequence. The initialization sequence consists of a reset pulse transmitted by the bus master followed by presence pulse(s) transmitted by the slave(s). The presence pulse lets the bus master know that slave devices (such as the DS18B20) are on the bus and are ready to operate.

HAC-UM96 interface with HCS12

Proper connections need to be done as shown in figure 6 so that communication between master and slave board takes place. Two HCS12 boards are named as slave boards 1 and slave board 2 respectively. One HCS12 board is named as master board. The slave board will read the temperature and sent it to the master board wirelessly through the help of RF module.

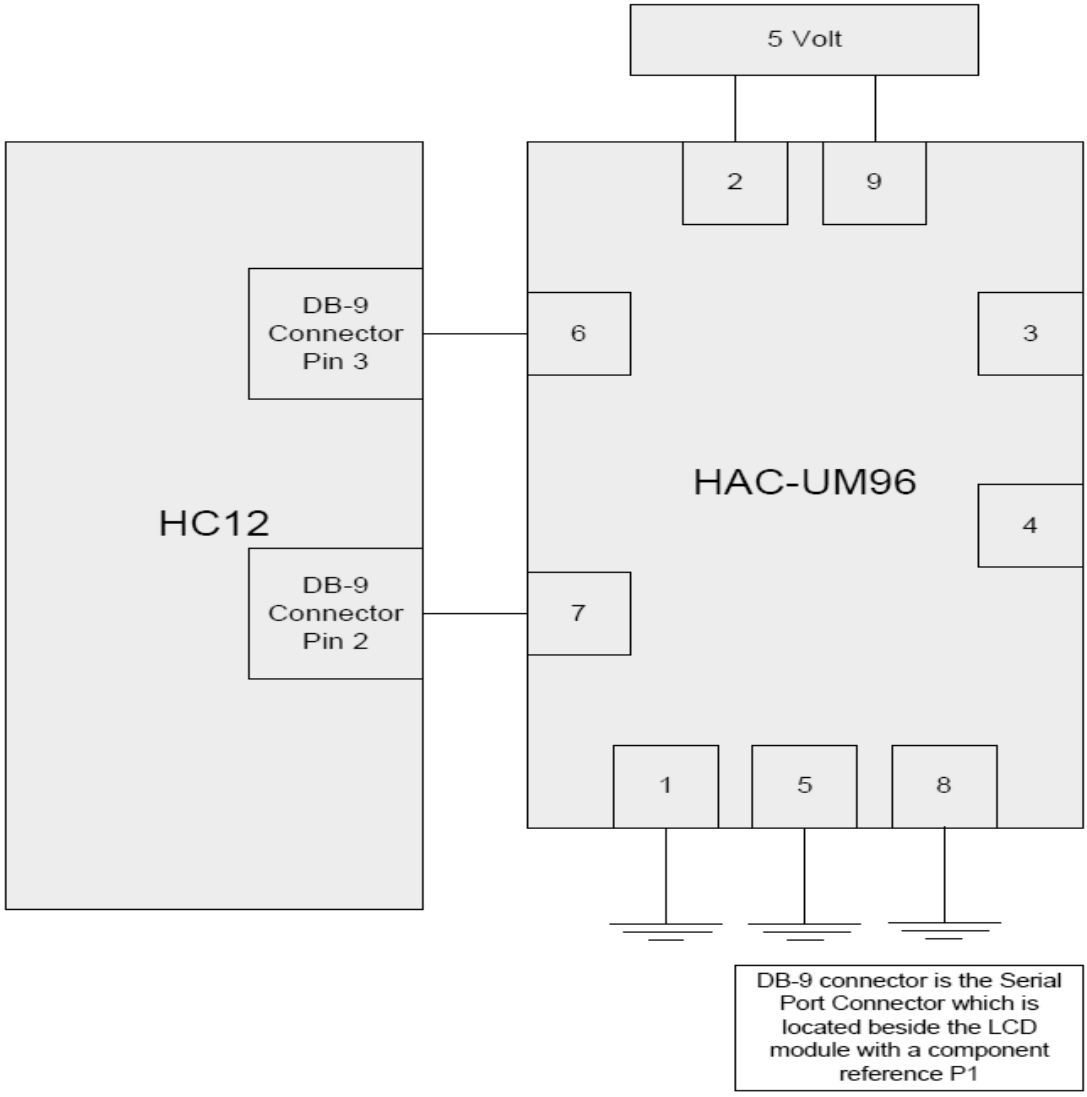

Figure 6 HAC-UM96 interface with HCS12

Pins 3 and 4 will not be connected to the HCS12 microcontroller and the connection remains open. Make sure Pins 1, 5 and 8 are properly grounded. Pin 6 and Pin 7 i.e. Transmitter and

Receiver of HAC-UM96 will be connected to the Receiver and Transmitter of HCS12 board respectively.

Temperature Sensor interface with HCS12

Temperature sensor interface with HCS12 is shown in figure 7. Pin 1 of temperature sensor is properly grounded. Pin 2 i.e. Data Input/output pin is connected to PE4 of HCS12. Pin 3 is connected to voltage supply of 5v from HCS12 board.

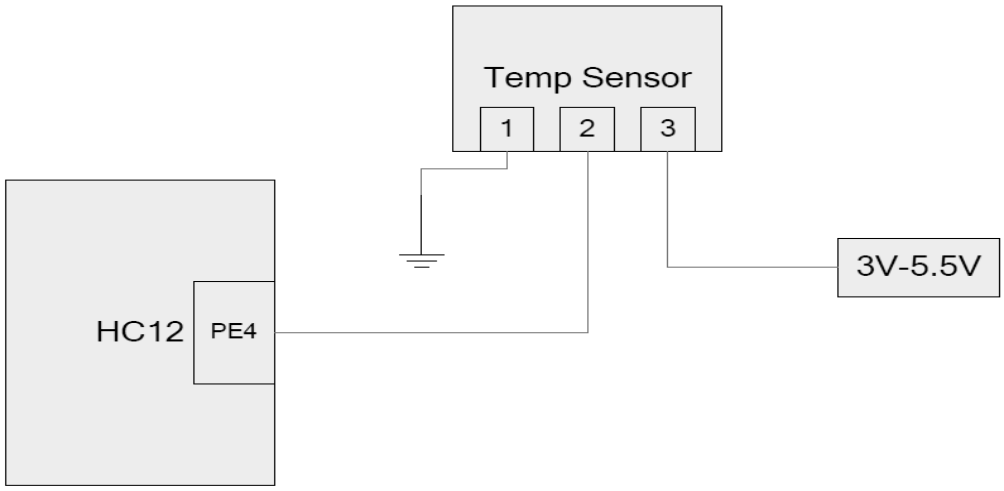

Figure 7 Temperature Sensor Interface

Operation and Conclusions

In conclusion, when the board is powered on and a reset is pressed on the Slave Board 1, the temperature sensor connected to the HCS12 reads the room temperature. Similarly when the board is powered on and a reset is pressed on the Slave Board 2, the temperature sensor connected to the HCS12 reads the room temperature. Now the Master board is powered on and a reset is pressed. The UM-96 connected to the master board will try to make a contact with slave board1 and 2 respectively requesting the HAC UM96 connected to the slave boards to transmit the data i.e. temperature to the master board. The master board will read the temperatures sent by both the boards and display it on the LCD of the microcontroller. If the temperature of the particular zone increases above certain defined range, an alert will be there through the help of a speaker. This project can be implemented with higher range of modem and expanding the current network of 2 zones to a network of several zones so that master board can read temperature from different locations.

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Biography

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