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Smart Home

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Day Month Year

Abstract

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Acknowledgements

I want to thank...

Contents

List of Figures

List of Tables

Acronym and Abbreviation

ADC	Analog to Digital Converter
ALU	Arithmetic Logic Unit
CPU	Central Processing Unit
CU	Control Unit
DAC	Digital to Analog Converter
MCU	Microcontroller Unit
MQTT	Message Queue Telemetry Transport
RAM	Random Access Memory
ROM	Read-only Memory

Chapter 1

Introduction

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Chapter 2

Background

2.1 Microcontroller

2.1.1 Theory

Microcontroller Unit (MCU) is a small size, special purpose computer. It is small enough in order to be integrated on a small circuit in which will do specified tasks or applications. MCU itself comes with memory, input, output peripherals and processor. Program to run the MCU is stored in Read-only Memory (ROM) and usually not change in production. A microcontroller is usually designed to run in small size and at low cost, which is compatible to be embedded in other system in order to control actions of the system automatically.

Few advantages of MCU over a microprocessor can be listed as following:

- A MCU is already a standalone microcomputer.
- Because it can be considered as an independent computer, most needed components are integrated on a small size board.
- The above reason leads to the benefit that using MCU can make the system compact, highly mobile and cost efficiency.
- Time reduction because it is programed to run specified set of commands only.
- It is also easy to use and maintain.
- MCU nowadays usually designed to be used with low power in order to last longer under energy-limited condition.

2.1.2 Microcontroller structure

Figure 2.1 demonstrates the basic structure of a microcontroller. It is easily to see the basic design of a microcontroller and its components.

- CPU: is the central unit which is assembled with Arithmetic Logic Unit (ALU) and a Control Unit (CU). Its functions are connect parts of the MCU into a single system by doing fetch, decode and execution.

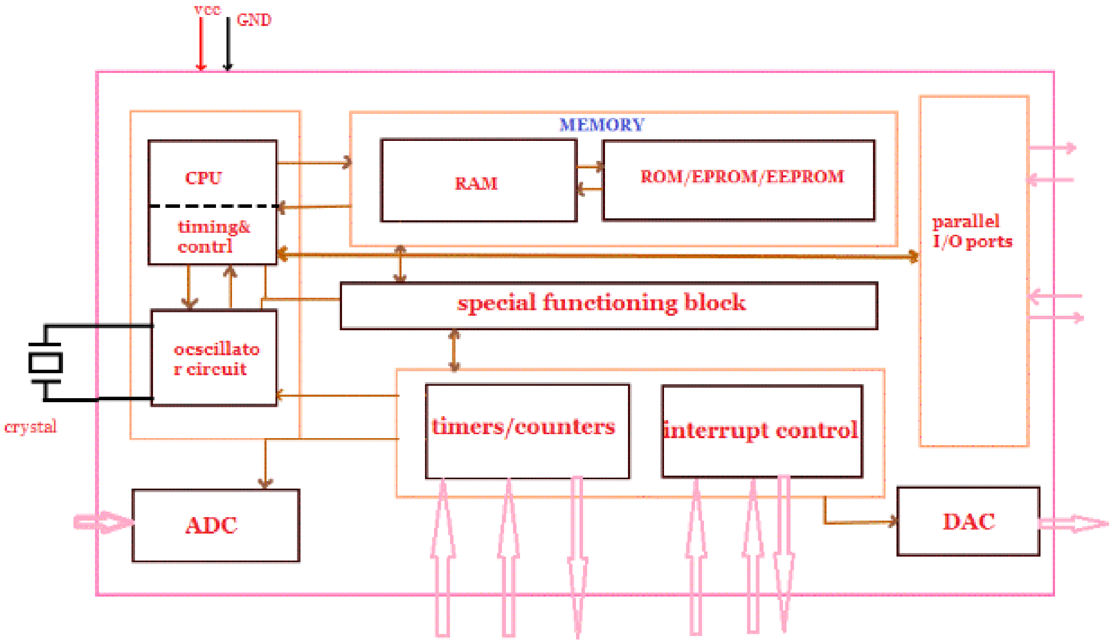

Figure 2.1: Structure of Microcontroller

- Memory: there are two types of Memory that are required, namely ROM and Random Access Memory (RAM). Each type has its own functions, in which ROM will handle the program and the written instructions and RAM can only store temporary data while the program is executing.
- Input/Output: the single board system needs input to execute the program as well as outputs to delivery the information for further handling. The I/O peripherals are the interface of the MCU to communicate with or to control other devices.
- Bus: bus is the system of wires that used to connect the Central Processing Unit (CPU) with other peripherals, which means it plays an important role but rarely discussed.
- Timers/Counters: they are built-in components for microcontroller, which is used to count in order to handle external events.
- Interrupts: is used to interrupt that can be an external or internal one, which helps to execute an instruction(s) while the main program is executing.
- ADC: Analog to Digital Converter (ADC), its name says it all, which is a circuit use to convert analogs signal to digital signals. The reason to use ADC is most sensors available on the market can read only analog signal but CPU of the MCU can read digital signal only, so a ADC is necessary for them to communicate.
- DAC: Digital to Analog Converter (DAC) similar to ADC, DAC is also a circuit which convert digital signals into analog signals for further processing.

2.1.3 Microcontroller market

There exists many microcontrollers on the market which come in various sizes and capacities. The list is only containing very few popular MCU that the author knows of.

- Intel 8051
- STMicroelectronics STM8S (8-bit), ST10 (16-bit) and STM32 (32-bit)
- Atmel AVR (8-bit), AVR32 (32-bit), and AT91SAM (32-bit)
- Freescale ColdFire (32-bit) and S08 (8-bit)
- PIC (8-bit PIC16, PIC18, 16-bit dsPIC33 / PIC24)
- Renesas Electronics: RL78 16-bit MCU; RX 32-bit MCU; SuperH; V850 32-bit MCU; H8; R8C 16-bit MCU
- PSoC (Programmable System-on-Chip)
- Texas Instruments Microcontrollers MSP430 (16-bit), C2000 (32-bit), and Stellaris (32-bit)

2.2 Communication

2.2.1 Introduction

Nowadays, there are various communication protocols can be used for the thesis, namely I2C, ISP, RS232, RS-485, Bluetooth or Wi-Fi. Each protocol is designed to be suitable for specified purpose with different advantages or disadvantages, which means a perfect protocol does not exist. When making a decision to choose suitable protocols for the thesis, the trade-off between the stabilization and the speed of the communication protocol has been considered carefully.

In this thesis, RS-485 is chosen as the main way for components in the system to communicate with each other. RS-485 is defined in 1983 not as a protocol but an electrical interface standard and only specifies the drivers and receivers' characteristics. It is developed in order to make data rate and transmitting distance are inversely proportional. For instance, the data transmitting speed can reach 10 Mbps within distance of 16 meters or if the distance is extended to 1220 meters, the data rate is lower to 100 kbps. The advantage of RS-485 over RS232, which is developed in 1960, is multiple nodes can be parallel connected to a bus. Additionally, the network can be extended in length and number of nodes easily by using simple connectors. Besides, Wi-Fi, Bluetooth, GSM and MQTT are also implemented in the thesis in order to take the advantages of different communication protocols in different circumstances.

2.2.2 RS-485

Table 2.1 shows the remarkable specifications of RS-485. With these characteristics, RS-485 was a robust interface standard and was able to meet the requirements in industries, in which implemented applications that need a stable, fast and reliable connection.

Figure 2.2 demonstrates two ways to implement the connection with RS-485, which are full-duplex and half-duplex. Full-duplex implementations require four-wire (two signal pairs) instead of two-wire in half-duplex implementations; But despite the downside of two-wire implementation is it is limited to half-duplex and needs attention to turn-around delay, in practical applications, half-duplex is most chosen. The reason is full-duplex solution depends on master-slave model, which means the slaves cannot communicate with each other. In modern designs of transceiver, the allowed number of nodes can connect to the bus is up to hundreds.

Name	Detail
Differential	Yes
Number of supported devices	32 transmitters/32 receivers
Operation mode	Half-duplex
Longest supported distance	at 100kbps: 1200 meters
Highest supported transmitting speed	at 10Mbps: 16 meters
Mark (data = 1) condition	1.5V to 5V (A negative towards B)
Space (data = 0) condition	1.5V to 5V (A positive towards B)
Output current capacity	250mA
Receiver input sensitivity	±200 mV
Receiver input range	-7V to 12V

Table 2.1: RS-485 Remarkable Specifications

Working principle of RS-485 is different in comparison to other standard; Instead of using a zero ground as the voltage reference, which will cause noise over the communication length, it uses floating voltage between two wires of the signal pairs, A and B or (+) and (-). After transmitting, the receiver compares the different of voltage between two wires and achieved the correct data with the lowest noise may cause. Figure 2.3 illustrates an example of the RS-485 waveforms transmitting one byte which has Mark, Space, and Idle phases. In most network, there will be one node acting as the master and the rest work as the slaves. At this point, the master sends command frame over the connection, and all slaves receive the data, then each slave with different functionality will work as programmed with different received data and also response to the master as programmed. The best practical result is obtained with the use of twisted pair of wires because some of the noise current will flow in the opposite direction with the current in the cable. In case using the straight cable, the noise current flows straightly along the cable in the same direction which will cause a loop current. Combined with the twisted pairs of wires, the cable also comes with shield, which is an accepted approach to restrain the noise, is used in applications that need higher noise resistance.

As written in the introduction, RS-485 can connect with multiple transmitters and receivers in the same network. For instance, using input resistance around 12kΩ,the numbers of devices can connect to the system is up to 32. Besides, with

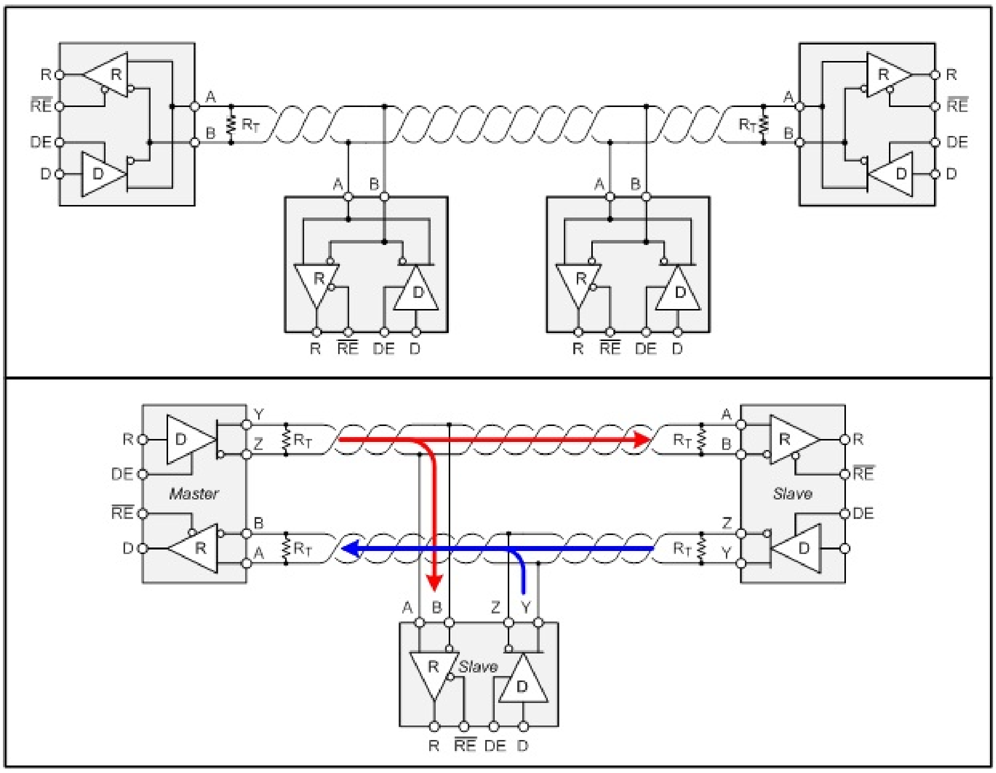

Figure 2.2: Half-duplex(upper) and Full-duplex(below) implementations

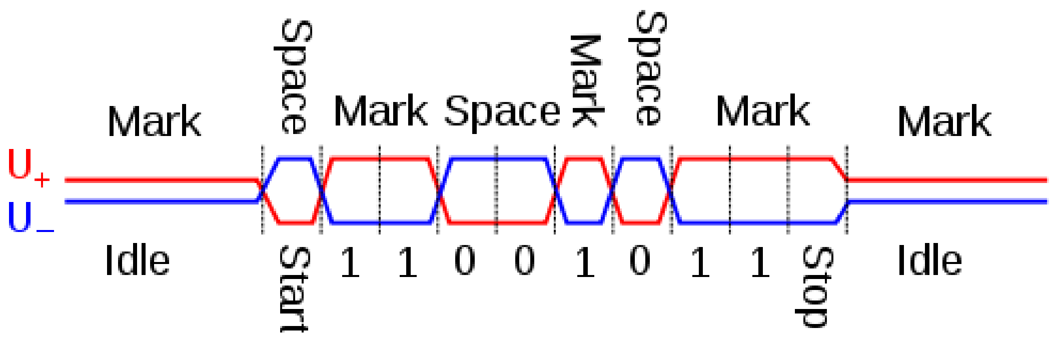

Figure 2.3: RS-485 waveform

the connecters, this number can increase significantly to the number of thousands and the transmitting distance can be also extended to kilometers. In addition, the network implemented with RS-485 needs termination, usually with a 120Ω resistance at the end of two wires. This is applied to terminate or minimize the reflection in order to avoid the fraud of sending data. Furthermore, it usually included pull up and pull down resistors for fail-safe bias in each wire in case that any wire is not controlled by any device. When input voltage ranging from -200mV to +200mV, receiver understands as "undefined" state, which caused by several reasons such as system is shutdown, connection from receiver to network is lost, or cable has an open or short part. In this case, fail-safe biasing is applied in order to confirm that the receivers receive defined states only.

2.2.3 MQTT

MQTT is abbreviation of Message Queuing Telemetry Transport, which is a protocol laid in Application layer of OSI model. It is designed as a machine-to-machine and remarkably lightweight protocol that helps communication between constrained devices becomes effortless in comparison to other wireless protocols. In detail, its working principle based on publish and subscribe methodology in order to reduce the amount of transmitting data which leads to the reduction of used bandwidth, latency and power consumption.

A Message Queue Telemetry Transport (MQTT) system is the combination of a server, but usually named broker, and the clients, in which can acts as either a publisher, subscriber or both. One broker can have numerous clients connect to and each client can subscribe to any topic it is programmed. These subscribers are following and watching for the changes of data of the subscribed topics, once other clients which are defined as the publisher publishes message to the topics, then the broker distributed the payload of message to other clients who had subscribed to those topics. In this scenario, the publisher and subscribers do not need to know the information of each other, the only needed are the topics for publishing and subscribing. Figure 2.4 refers a simple example of a MQTT system consists of one broker and four clients, in which three clients are the publishers and one is the subscriber that subscribes to three topics the publishers publish to. To be specific, three publishers are the sensor nodes publish to three topics, temp1, temp2 and temp3; the last client acts as the subscriber that follows three topics mentioned previously. At once, the subscriber will receive the message whenever a publisher broadcasts the message to any of those topics.

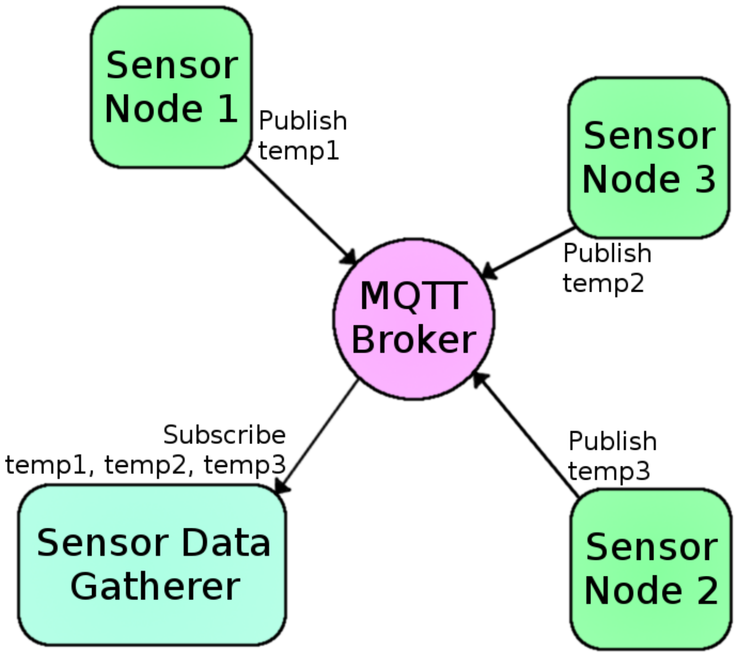

Figure 2.4: Simple example of a MQTT system

2.2.4 Websocket

Chapter 3

Chapter Three Title

Chapter 4

Chapter Four Title

Chapter 5

Conclusion