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Selection and Design of Wireless Communication Module

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Abstract

In order to expand the use of radio communication technology and realize the connection of all things at an early date, the contrast method is mainly adopted in experiment. Based on the expected design index, the performance, power consumption and cost of different equipment in the radio communication module are compared, and after comprehensive consideration and strict comparison, it is found that LoRa (Long Range) spread spectrum technology has the largest coverage area, the strongest sensitivity and the strongest anti-interference ability in the spread spectrum technology. On the radio frequency (RF) chip, Sx1276/7/8 three models have less power consumption, the longest transmission distance and moderate price; on the main control chip, energy consumption of STM32L053C8 is the smallest, and performance is the most abundant. In the absence of equipment, it should be based on the actual situation to consider the accuracy, size and cost of three aspects of the choice. Therefore, LoRa spread spectrum technology, Sx1276/7/8 RF chips and STM32L053C8 main control chip are recommended to use, at the same time according to the actual situation, the edgeless device is selected.

Keywords

Wireless communication; LoRa spread spectrum technology; chip selection; index design.

1. INTRODUCTION

In recent years, with the rapid development of wireless communication technology, intelligent buildings, smart cities, smart homes and wireless meter reading and other network technologies have spread rapidly, and internet of things technology plays an important role in human daily work, life and study. For wireless communication systems, communication is the main function, which is the process of information from the beginning of transmission to being received, and the system that realizes this process is called the communication system [1]. At the transmitter, the information source first recombines the information in the converter, and then transmits the information through the transmitter in the channel. At the receiving end, the receiver processes the received information in the converter and sends it to the receiver to complete the communication. For long-distance wireless communication, mobile cellular network is one of the most widely covered communication technologies at present, which is mainly used for communication between people. But its own carrying capacity is limited, so it is difficult to realize the connection of all things [2]. Perez-Nera et al. (2016) study showed that the maximum distance of wireless communication measured in the open area was only about 3028m, which was mainly due to the large path loss and low energy transmission efficiency in radio frequency (RF) circuits, when the RF output power was 19.7dBm [3]; Malik et al. (2018) study showed that the measured power values of wireless communication were 18.9dBm and 18.5dBm, respectively, and their energy transmission efficiency was only 77.62% and 70.79%, which could only achieve a small range of effective communication [4].

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Therefore, wide coverage, strong anti-interference, low deployment cost, good security performance and low energy consumption are new requirements and challenges in the field of wireless communication [5]. So based on this background, wireless communication module is selected and designed, the expected indexes are proposed, and the various devices of wireless communication module are comprehensively compared. It is expected that the wireless communication module with low cost, long distance, strong anti-interference and low energy consumption can be designed and can provide scientific basis for solving this problem in the future.

2. METHODS

In order to realize the application of communication module in long distance wireless communication system (the basic component of wireless communication is shown in figure 1), and design a wireless communication module with low cost, long distance, strong anti-interference and low energy consumption, contrast method is mainly used in experiment. On the one hand, the performance, power consumption and cost of different equipment are compared; on the other hand, the expected index is used as a reference to make the optimal choice.

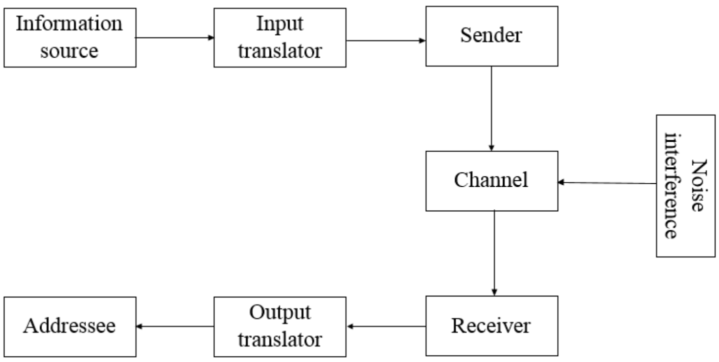

Figure 1. Basic components of wireless communications

For the comparison of experiment to be more scientific, the expected indexes of the wireless communication module are designed as a guide [6], as detailed in Table 1. The indexes are designed from the aspects of communication capability, transmission efficiency, anti-jamming capability, power consumption and cost:

(1) Strong communication capability: In wireless communication systems, communication capability is generally divided into two parts: distance and penetration. The distance is determined by the RF capability of the RF chip itself (including modulation mode, transmitting power) and the link loss of the RF communication system itself (including hardware circuit path loss and wireless link path loss). Penetration is determined by communication distance and anti-interference ability.

(2) High energy transmission efficiency: An important index of RF hardware circuit design is energy efficient transmission. Therefore, reducing the path loss and improving the transmission efficiency is one of the key problems in designing the whole communication module. Because RF chips and the input and output ports of each RF unit are not standard 50Ω, the impedance matching network design between RF units in RF front circuit is the main way to reduce the path loss and ensure the efficient transmission of energy [7].

(3) Strong anti-interference ability: In RF front-end circuit, filter is an important RF component shared by transceiver link, it can filter interference and noise to meet the

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requirements of RF system and communication protocol for signal-to-noise ratio, and then improve the reception sensitivity of communication module. From the hardware design point of view, because RF microwave circuit is distributed parameter circuit, it is easy to produce coupling effect and skin effect. Hence, PCB design should be handled from the perspective of stacked structure, layout and wiring, balancing advantages and disadvantages to seek a compromise point to improve the anti-interference ability of RF circuits [8].

(4) Low power consumption: With the rapid development of intelligent networks and the Internet of things, the demand for access to their devices have also increased significantly, and therefore the energy demand will certainly increase. Thus, reducing the power consumption of the whole network is one of the great challenges facing the whole internet of things research system, Therefore, the design of communication equipment needs to be considered comprehensively from the point of view of energy consumption.

(5) Micro volume, low-cost: To reduce manufacturing costs and energy losses on transmission lines and to improve energy transmission efficiency, the volume of communication modules needs to be minimized. At the same time, based on the consideration of realistic factors and feasibility, the cost is also one of the important factors to be considered in the design of communication modules, including not only the price, but also the selection and packaging of chips, devices and the effective utilization of resources.

Table 1. Expected indexes for wireless communication modules

Type of indexes	Energy transfer efficiency	Communications capability			Anti-jamming capability	Power consumption			
-	-	Communication distance	Wall piercing capacity	Floor piercing capacity	-	Finishing machines power consumption	Dormancy power consumption	Average power consumption	3s Timing wake-up power consumption
Expected indexes	Higher	Better, maintain effective communications			Strong	Small, low power consumption			
Specific requirements	>90%	Distance >5 000m, and packet loos rate<10%	Through 7 walls and packet loss rate<10%	Through 5 walls and packet loss rate<10%	Passed national EMI grade 2(test site strength 3V/m) standard test	Transmit status: less than 150 m A; receive status: less than 60mA (@3.3v)	Low power mode full machine power consumption: less than 30uA (@3.3v)	Average power consumption of the whole machine in transmit state: less than 20mA (@3.3V)	Average power consumption in receiving state: less than 10mA (@3.3V)

3. RESULTS

3.1. Selection of Spread Spectrum Technology

The LPWAN (low power wide area network) technology of unauthorized spectrum mainly includes LoRa (Long range), Sigfox (Ultra-narrow band technology), N-Wave (Narrow band modulation technology), Platanus (Ultra-high node density technology) and so on. Table 2 shows the performance comparison of LPWAN different technologies based on current unauthorized spectrum.

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Table 2. Comparison of different technology performance LPWAN unauthorized spectrum

	Distance/km	Frequency/MHz	Maximum number of nodes	Data rate	Support OTA
LoRa	15-25 (Villages) 3-8 (Cities)	433/470-510; 868/902-928	Millions /hub	0.3-50kb/s	Yes
Sigfox	40 (Villages) 10 (Cities)	868/902	Millions /hub	100b/s	No
N-Wave	10	sub-GHz	Millions /base	100b/s	Yes
Platanus	0.1-0.7	sub-GHz	50000	500kb/s	Yes
Telensa	8	868/915; 470	150000/Server	Low speed	Yes

Through the comparison of Table 2, it can be seen that the distance of Lora technology is far, frequency is diverse, data rate is fast at the same time, and OTA is supported, so LoRa technology is undoubtedly the best choice after synthesizing the characteristics of distance, frequency, speed and so on. Meanwhile, LoRa technology has been combined with the forward error correction (FEC) technology to improve its anti-jamming ability and sensitivity, which makes it an optimal modulation technology with the characteristics of low price, low energy consumption and stabilization. Compared with the traditional FSK (frequency shift keying) modulation technology [9], the LoRa technology not only increases the coverage area of the wireless communication link, but also improves the robustness of the communication chain, making it the new wind vector of the current modulation technology.

3.2. Selection of RF Chip

Silicon Labs, Semtech, Texas Instruments and other companies have introduced a number of different characteristics and are consistent with the Sub-GHz frequency band of RF chips. For example Silicon Labs company launches Si4432, Si4438, Si4463 series of chips. Texas Instruments company's CC1125 chips and Semtech companies have Sx1276/7/8 and Sx1212. As shown in Table 3, the different RF chips are compared with each other in terms of modulation mode, data rate and transmit power.

Table 3. Comparison of RF chip performance

	Modulation	Optimal reception sensitivity (dBm)	Max Data Rate (bps)	Transmission power (dBm)	Optimal transmission distance (m)
Si4463	4(G)FSK	-126	1M	20	2000
Si4432	FSK	-121	256K	20	1800
Si4438	(G)FSK	-124	500K	20	1800
Sx1276/7/8	LoRa, FSK	-148	LoRa:37.5k FSK:300K	20	3000
Sx1212	FSK	-110	150K	12.5	400
CC1125	GFSK	-129	200K	16	1200

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It can be seen from the above table that the Sx1276/7/8 three chips based on LoRa technology have the farthest transmission distance compared with other types of chips under the same transmission power, and their advantages can be seen. Moreover, the characteristics of its low data rate are very suitable in wireless sensor networks, such as smart grid, smart building. Based on the above characteristics of different chips, sensitivity, transmission distance and other indexes as assessment elements, it is recommended to select any of the Sx1276/7/8 as the RF chip design.

3.3. Selection of Main Control Chip

The "brain" of a wireless communication system is the main control unit, which could control and manage the whole system, but it needs communication protocol, interface control program and data storage and analysis program. When selecting MCU, the parameter requirements of MCU needs (as shown in Table 4) and the commonly used MCU in fields such as internet of things (as shown in Table 5) are compared and analyzed.

Table 4. Parameter requirements of MCU

Parameters	Requirements	
	Standard requirements	Minimum requirements
RAM	8KB	4KB
Flash	64KB	32KB
Interrupt pin	4 interrupt IRO pins (DIO 0, DIO 1, DIO 2, DIO 3)	3 interrupt IRO pins (DIO 0, DIO 1, DIO 3)
GPIO interface	4	2
Tim timer	2	1
Software debugging interface	1	1
Operating voltage	1.65V-3.6V	1.65V-3.6V

Table 5. Parameters for different MCU

Model	STM32F103RB	STM32L053C8	EFM32G232F64	MSP430F6638
Operating voltage	2-3.6V	1.65-3.6V	1.98-3.8V	1.80-3.6V
FLASH/RAM	128K/20K	64K/8K	64K/16K	256K/16K
Package	LQFP64	LQFP48	LQFP64	LQFP100
Power consumption (mode)	Stop:13.5uA Standby:2.4uA Active:680μA/MHz	Stop:0.4uA Standby:0.27uA Active:88μA/MHz	Stop:0.6uA Sleep:45 uA/Mhz Active:180uA/Mhz	Stop:0.3uA Standby:2.1uA Active:270μA/MHz
Price	15	25	32	43

Table 5 shows that STM32L053C8 is the lowest-power micro-controller chip, and it have 64 KB flash memory and 8 KRAM, and meets the memory requirements of the MCU in Table 4. In contrast, the Flash and RAM of the other chips are relatively large, which is not only a waste of

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resources to some extent, but also causes unnecessary energy consumption. Moreover, the STM32L053C8 working voltage also meets requirements for MCU; and its price is moderate. As a result, after considering the performance, energy consumption and cost, STM32L053C8 is proposed as the main control chip.

3.4. Choice of the Edgeless Devices

It is well known that capacitors and inductors are one of the most important components in high frequency analog circuits and signal processing. These edgeless devices can be filtered by a variety of signals, adjust the circuit, also have impedance mismatch. Therefore, edgeless device needs to be carefully selected, mainly from the installation of the choice.

There are many kinds of capacitive inductors, but usually in RF circuit design and application, the packaging form of the missing device is mainly patch packaging, and Table 6 shows the index of different packaging patches of the missing device.

Table 6. Indexes of different encapsulated patches

Package	Long size (mm)	Wide dimensions (mm)	parasitic inductance (n H)	Parasitic resistance (Ω)
0201	0.60± 0.03	0.30± 0.03	0.2	0.045
0402	1.00± 0.10	0.50± 0.10	0.4	0.06
0603	1.60± 0.15	0.81± 0.15	0.5	0.079
0805	2.01± 0.20	1.25± 0.20	0.6	0.098
1206	3.20± 0.20	1.60± 0.20	1.0	0.12

It can be found from Table 6 that there is a positive correlation between package size and parasitic inductance and resistance, that is, parasitic inductance and resistance increased with the increase of package size. Therefore, this further illustrates that the most suitable encapsulation mode allowed in the precision and size range need to be selected during practical application and design. Through the family planning resistance and parasitic inductance, it can be found that in general, the the accuracy is higher, the performance is better. However, it should be noted that the selection of the packaging mode of the inductance capacitor should not only consider the precision and encapsulation, but also consider its properties under different encapsulation, operability during installation and cost.

4. CONCLUSION

To sum up, in order to design a wireless communication module with low cost, long distance, strong anti-jamming and low energy consumption, the LoRa spread spectrum technology is selected in the spread spectrum technology after comprehensive consideration and strict comparison. For RF chips, one of the Sx1276/7/8 is selected; on main control chip, STM32L053C8 is selected. In the selection of edgeless devices, the precision, size and cost should be considered according to the different actual situation, and then make the choice. It is believed that this kind of design can solve the problem of high energy consumption and insufficient anti-jamming for wireless communication, and can provide scientific basis for future research in radio field.

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