



Anti-interference Algorithm of Broadband Wireless Communication Based on Embedded Single Chip Microcomputer

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Abstract. In order to solve the problems of the traditional anti-jamming algorithm of broadband wireless communication, such as poor anti-jamming performance and high bit error rate, an anti-jamming algorithm of broadband wireless communication based on Embedded MCU is proposed. In the broadband wireless communication based on embedded single-chip microcomputer, the m-sequence of communication signal data is constructed, encoded and decoded. Finally, CRC redundancy test and error correction are carried out for the decoded communication data, so far the design of broadband wireless communication anti-interference algorithm based on embedded single-chip microcomputer is completed. Through the contrast experiment, compared with the traditional anti-jamming algorithm of broadband wireless communication, the experimental results show that compared with the traditional anti-jamming algorithm of broadband wireless communication, the proposed anti-jamming algorithm of broadband wireless communication based on Embedded MCU has lower bit error rate, which shows that it has better anti-jamming ability.

Keywords: Singlechip · Wireless communication · Anti-interference

1 Introduction

The research of interference and anti-interference in broadband wireless communication system is more important than that in general wireless communication system. In fact, the modern digital mobile communication system with high communication rate and throughput is broadband to some extent. Broadband wireless communication system occupies a wide range of spectrum, but the spectrum resource of wireless communication system is limited, and the use of wireless spectrum has certain openness. If the spectrum is not used in a standard or unreasonable way, the wider the spectrum range, the easier it is to introduce various broadband or narrow band interference signals, reduce the transmission reliability of the communication link, and form a bad impact on the communication system. Ring. In order to ensure the quality of communication, the research on the interference immunity of broadband wireless communication can not be ignored. It is of great significance to improve the signal quality of broadband wireless communication by using some anti-interference algorithm to implement anti-interference operation for broadband wireless communication.

Based on embedded single chip microcomputer, it can complete wireless communication of data, realize wireless control, data acquisition, alarm and other functions, and has a wide application prospect in many fields of oil, power, light industry, environmental protection and other industries. Generally, the serial I/O port of single chip microcomputer is used to complete data communication, but there are many shortcomings in this method. For example, when using the serial port of single chip microcomputer to send and receive data, the transmitted data can only be parity checked. However, a large number of electromagnetic interference signals inevitably exist around wireless communication equipment, which makes the transmitted data prone to distortion, and parity generally can not detect the burst errors caused by such interference. Therefore, this method can not meet the high requirements of error detection. Moreover, the communication anti-interference ability of SCM serial port is poor, so it is difficult to overcome the errors caused by interference. In order to solve the above problems, an anti-interference algorithm based on embedded single chip microcomputer is proposed. The software coding method is used to realize the anti-interference of broadband wireless communication, and the effectiveness of the method is verified by experiments.

2 Anti-interference Algorithm of Broadband Wireless Communication Based on Embedded Single Chip Microcomputer

Among many coding techniques, Hamming code is intuitionistic and simple, with the highest frequency (information rate) of transmitting information number. It has the ability of error detection and error correction, and is also relatively simple to realize. When the receiving end finds that there is a bit error in the received information, it decodes and completes the error correction at the same time; when there are two bit errors, it can detect and discard in time.

Aiming at the broadband wireless communication based on embedded single chip microcomputer, by constructing the data sequence of broadband wireless communication signal, coding and decoding m sequence, after decoding, CRC redundancy test and error correction are carried out for the communication data, and the anti-interference algorithm of broadband wireless communication based on embedded single chip microcomputer is designed.

2.1 Construct M-Series

In the channel of broadband wireless communication, due to the complexity of wireless channel, especially the large Doppler frequency expansion caused by relative motion and multipath, inter code interference is caused. The time-domain coding technology based on forged sound sequence is adopted to overcome the problem of inter code interference. In the DS-SS system of broadband wireless communication, the transmission signal is expanded by pseudo-random sequence, which is used to compress the signal when it is received, and to spread the interference signal power, so as to improve

the anti-interference ability of the system; in the frequency hopping system, the frequency generated by the frequency synthesizer is controlled by pseudo-random sequence to avoid interference; in the time hopping system, the pulse is controlled by pseudo-random sequence the time and duration of the transmission. The performance of pseudo-random sequence is directly related to the performance of the whole broadband wireless communication system. To construct the m -sequence of broadband wireless communication signal, we must first construct the linear shift register that generates the m -sequence, first determine its primitive polynomial, and its register logical structure is shown in Fig. 1.

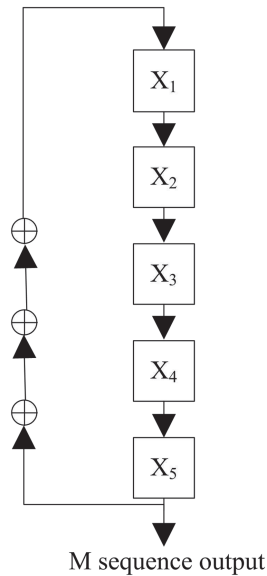


Fig. 1. m -sequence generator

The m -sequence of broadband wireless communication signal data is generated by the m -sequence generator in Fig. 1.

The maximum possible period of the sequence generated by the sequence generator composed of n -level shift registers is $2^n - 1$. Under a certain n , the sequence with the maximum period is called the maximum length sequence, also called the m sequence. The autocorrelation characteristic curve of m series is a periodic triangle curve with sharp correlation peak, as shown in Fig. 2.

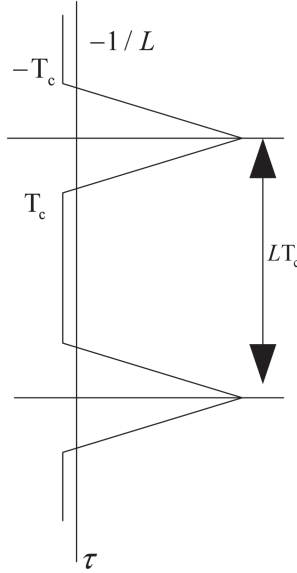


Fig. 2. Normalized autocorrelation curve of m -series

In Fig. 2, T_c is the symbol duration; τ is the phase difference of two sequences, τ is continuous, and L is the code length. The mathematical expression of the normalized autocorrelation function is as follows:

$$R(\tau) = \begin{cases} 1 - \frac{|\tau|}{T_c} \left(1 + \frac{1}{L}\right) & |\tau| \leq T_c \\ -\frac{1}{L} & T_c < |\tau| \leq \frac{LT_c}{2} \end{cases} \quad (1)$$

Formula (1) shows that the autocorrelation function of m -sequence only has peak value when the phase difference of two sequences is in the range of positive and negative symbols, showing sharp autocorrelation characteristics. Therefore, it is possible to determine whether the relative positions of the two sequences are in a positive or negative symbol according to whether there is a peak value in the correlation output.

m -sequence is a kind of pseudo-random sequence. According to the theory of stationary random process, its average power spectral density is its autocorrelation Fourier transform, that is, it is easy to get its power spectral density from the autocorrelation function of m -sequence through Fourier transform: $S_R(\omega)$

$$S_R(\omega) = \int_{-\infty}^{+\infty} R(\tau) e^{-j\omega\tau} d\tau \quad (2)$$

In formula (2), $R(\tau)$ is the autocorrelation function, in a period, that is, $0 \leq \tau \leq pT_c$. j represents the parameter, ω represents the spectral density parameter.

The discrete spectrum can be rewritten as follows:

$$S_R(f) = \sum_{m=-\infty}^{\infty} p_m \delta(f - mf_0) \quad (3)$$

In formula (3), band f represents frequency, band p represents period and band δ represents spectrum parameter. Among them,

$$p_m = \begin{cases} \frac{1}{p^2} & m = 0 \\ \frac{1 \pm p}{p^2} \sin^2\left(\frac{m}{p} \pi\right) & m \neq 0 (m = \pm 1, \pm 2, \dots) \\ f_0 = \frac{1}{pT_c} \end{cases} \quad (4)$$

Through the above formulas, we can get the characteristics of m -sequence of broadband wireless communication data, and determine the best m -sequence according to its characteristics.

2.2 m -sequence Coding

In order to change the information of all wideband wireless communication signals into deformed codes conveniently, firstly, the m -sequence is encoded. The generation matrix of the code is required. According to the relationship between the generation matrix and the consistent supervision matrix, and through the consistent supervision matrix, the generation matrix is obtained. The specific method is as follows:

The consistent supervision matrix is recorded as $H=(Q, 1)$, where 1 is the unit matrix and Q is the remaining part matrix. Then the generated matrix is $G = (1, P)$, where, $P = Q^T$. It is known that the 4-bit information in the broadband wireless communication signal information is C_1, C_2, C_3, C_4 , then the corresponding 8-bit codeword can be obtained by the following formula:

$$(C_1 C_2 \dots C_8) = (C_1 C_2 C_3 C_4) \quad (5)$$

H^* is transformed into a standard form by matrix equivalence.

$$H^* = \begin{pmatrix} 0 & 1 & 1 & 1 & 1 & 0 & 0 & 0 \\ 1 & 0 & 1 & 1 & 0 & 1 & 0 & 0 \\ 1 & 1 & 0 & 1 & 0 & 0 & 1 & 0 \\ 1 & 1 & 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix} = (Q, 1) \quad (6)$$

Among,

$$Q = \begin{pmatrix} 0 & 1 & 1 & 1 \\ 1 & 0 & 1 & 1 \\ 1 & 1 & 0 & 1 \\ 1 & 1 & 1 & 0 \end{pmatrix} \quad (7)$$

$$P = Q^T = \begin{pmatrix} 0 & 1 & 1 & 1 \\ 1 & 0 & 1 & 1 \\ 1 & 1 & 0 & 1 \\ 1 & 1 & 1 & 0 \end{pmatrix} \quad (8)$$

Corresponding, generate matrix

$$G = (1, P) = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 1 & 1 & 1 \\ 0 & 1 & 0 & 0 & 1 & 0 & 1 & 1 \\ 0 & 0 & 1 & 0 & 1 & 1 & 0 & 1 \\ 0 & 0 & 0 & 1 & 1 & 1 & 1 & 0 \end{pmatrix} \quad (9)$$

Substitute formula (5) to get:

$$\begin{aligned} (C_1 C_2 \cdots C_8) &= (C_1 C_2 C_3 C_4) \\ &= \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 1 & 1 & 1 \\ 0 & 1 & 0 & 0 & 1 & 0 & 1 & 1 \\ 0 & 0 & 1 & 0 & 1 & 1 & 0 & 1 \\ 0 & 0 & 0 & 1 & 1 & 1 & 1 & 0 \end{pmatrix} \end{aligned} \quad (10)$$

It can be seen from formula (10) that the first four bits of the code word are the information of the broadband wireless communication signal, and the last four bits are the supervision bits, and there are $C_5 = C_2 \oplus C_3 \oplus C_4$, $C_6 = C_1 \oplus C_3 \oplus C_4$, $C_7 = C_1 \oplus C_2 \oplus C_4$, $C_8 = C_1 \oplus C_2 \oplus C_3$. The coding program block diagram is shown in Fig. 3:

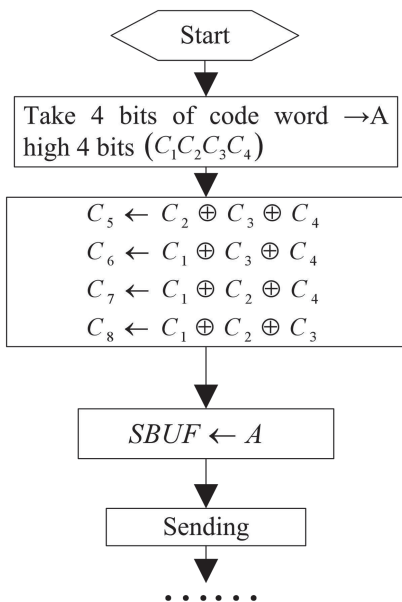


Fig. 3. Coding flow chart

As shown in Fig. 3, the coding flow of m sequence of broadband wireless communication data is completed.

2.3 Implementation of Decoding

After encoding the data of broadband wireless communication, when the data is transmitted to the receiver, the encoded data should be decoded. At the data receiving end, the program is designed so that the MCU at the receiving end can detect the received data bit by bit at a fixed time interval (3.6), and record the number of high and low level detected in each data bit cycle (906) (this number actually reflects the different durations of high and low level of the waveform). Finally, it is determined that the received data bits are “0”, “1” or start bits by judging the occurrence times of high and low levels.

This method overcomes the disadvantage that when using serial port for data communication, each data bit is sampled only three times, which is easy to be misjudged. Because it does not determine that the received data bits are ‘0’, ‘1’ or start bits by simply sampling three times. It needs to sample hundreds of times (the period of data bits divided by the interval of sampling time), which greatly avoids the possibility of data misjudgment due to the interference signal in the process of data transmission.

When sending data, the sender uses the circular right shift with carry to realize, so as long as the value of carry flag bit is read, the data of 8 bits can be read successively from low position to high position, which facilitates the reading of data bits and the subsequent operation. Each frame of data starts with a start signal and then transmits 8-bit data bits. The number of data bits to be sent is stored in register R6 in advance,

and the sending operation of 8-bit data bits is realized by performing 8 times of cyclic right shift operation with carry. Finally, the last bit of the transmitted data is determined to be '0' or '1' and sent.

The receiver also uses the cyclic right shift with carry to receive data. The received data is detected bit by bit at a fixed time interval, and the number of high and low levels detected in each data bit cycle is recorded, which are stored in variables I and J respectively. Through the values in i and j , it is determined that the received data bits are '0', '1' or the start bit signal. If it is a start signal, the count unit num (received data bits) is assigned an initial value of 8, and 8 times of cyclic right shift operation with carry is started to realize the storage operation of data bits. Before each cycle to the right, the data bits need to be detected and discriminated by the same method as above. The discriminating result is achieved by operating the flag bit STATUS. The flag bit STATUS is the 0-bit status $\langle 0 \rangle$ of status register in PIC single chip microcomputer: carry and borrow flag. It controls the value of the carry flag bit of the rotate right operation to be '0' or '1'.

2.4 CRC Redundancy Check

CRC redundancy check is widely used because of its simplicity and strong anti-interference ability. It not only can effectively resist random interference, but also can effectively resist burst interference. Therefore, it is not only applied to ordinary wireless channels, but also has been successfully applied in broadband wireless communication. Especially by nesting with convolutional coding, it can greatly improve the performance of broadband wireless communication under the condition of limited power.

The basic steps of CRC verification are as follows: using linear coding theory, according to the k -bit binary code sequence to be transmitted (converted from m -bit sequence), a supervision code (CRC code) R -bit for verification is generated with certain rules, and attached to the information, forming a new binary code sequence with a total of $(k + r)$ bits, and finally sent out. At the receiving end, it checks according to the rules between the information code and the CRC code to determine whether there is an error in the transmission. In order to reduce the storage space and calculation, a 16 bit CRC redundancy check based on the look-up table method is adopted. For single byte CRC-16 coding, in order to shorten the coding time, the check code words corresponding to 256 numbers of $0 \sim FFH$ are often calculated in advance and stored in a table. In the case of CRC check coding, double byte check codeword can be obtained by looking up the table according to the single byte content, and then the single byte source information and double byte check codeword are combined to form CRC-16 coded codeword.

For the CRC-16 verification codeword table with single byte source information, the space needed to store the table can be reduced by using the regularity. Take the CRC check code word (32b) of 16 numbers corresponding to $0 \sim F$ in the first row and the CRC check code word (32b) of 16 numbers corresponding to $0 \sim F$ in the first column. For any single byte number, it can be taken as 14. Make the binary value corresponding to the high 4 bits as the row number of the table and the CRC corresponding to the low 4 bits as 1231, and the binary value corresponding to the column number of the table as 4084, then the CRC corresponding to 14 is $I \text{ XOR } J = 52b5$, and

52b5 is the check code word of the single byte number. The calibration block diagram is shown in Fig. 4.

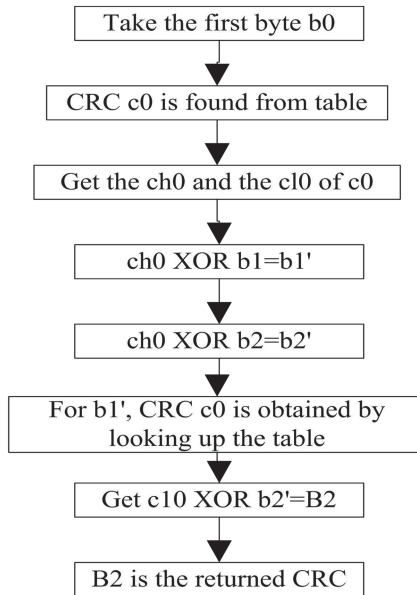


Fig. 4. CRC block diagram

For multi byte CRC-16 encoding, set the information of any byte as $b_0, b_1, b_2, b_3, b_4, b_5, \dots$. First of all, the check word c_0 is obtained by looking up the table of b_0 . Take the high byte ch_0 and b_1 of c_0 for XOR operation to get b_1' , and take the low byte cl_0 and b_2 of c_0 for XOR operation to get b_2' . Then the information to be coded after the CRC Coding of B_0 is $b_0', b_1', b_2', b_3', b_4', b_5', \dots$. After that, an operation similar to b_0 is performed on b_1' . In this way, until all bytes are executed, the final check code word is CRC check word of all information bytes. According to the above rules, the coding verification of broadband wireless communication signal data is obtained.

2.5 Error Correction

In broadband wireless communication, to correct the communication signal of the receiver is to discard the interference signal. The data packet of broadband wireless communication signal is copied twice (3 times in total). The first coded communication information is detected for error. If there is any error, the remaining two backups are used to correct the error. Error correction is by comparing the bits in the three backup data. If two or more bits are '0', the correct one should be '0'.

For example:

00001110CP1(Error byte)
 11111010CP2
 01011010CP3
 01011010Corrected bytes

Its logical expression is: $\text{correction byte} = (CP1 \oplus CP2 \oplus CP3) \oplus (CP1 \oplus CP2)$. The program block diagram for correcting the error is shown in Fig. 5.

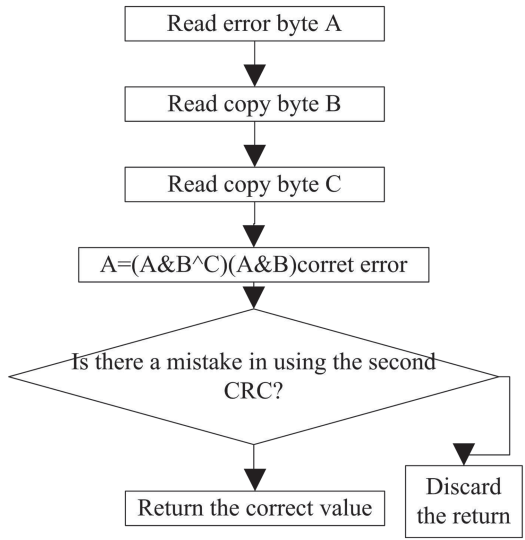


Fig. 5. Error correction program chart

Through Fig. 4, the wireless communication signal is corrected and the interference signal is removed.

So far, the design of anti-interference algorithm for broadband wireless communication based on embedded single chip microcomputer has been completed.

3 Experiment

By comparing the anti-interference algorithm based on Embedded MCU with traditional anti-interference algorithm, it is verified that the anti-interference algorithm based on Embedded MCU can effectively improve the anti-interference ability of broadband wireless communication.

3.1 Experimental Process

First, set up the experimental environment, and the parameters of the experimental environment are shown in Table 1.

Table 1. Experimental environment parameters

Experimental parameters	Tester parameters	Interference source
Signal bandwidth	1 MHz	20, 40, 80 MHz
Sensitivity	-81 dBm	
Agreement	FHSS	Noise
Connection rate	1 Mbit/s	
Working condition	Single channel frequency locking: 1 MHz	20 MHz
	Limited bandwidth: 34 MHz	
	Full frequency band: 79 MHz	75 MHz
	Limited frequency band: 79 MHz	
Loading rate	125 byte/500 ms	

In the experimental environment of Table 1, the effectiveness of the anti-interference algorithm of broadband wireless communication based on Embedded MCU is tested.

By using the coding anti-interference algorithm, the anti-interference algorithm is implemented for the broadband wireless communication based on the embedded MCU, and compared with the other two uncoded anti-interference algorithms, the anti-interference ability of broadband wireless communication is obtained.

3.2 Experimental Result

The comparison results of BER of the three wideband wireless communication anti-interference algorithms with SNR of -9 dB and Sir of -35 dB are shown in Fig. 6 and Fig. 7 respectively.

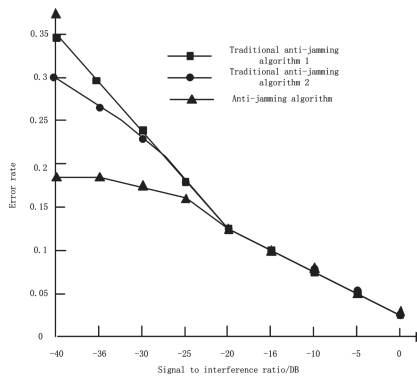


Fig. 6. Comparison results of bit error rate under different signal to noise ratio of -9 dB and signal to interference ratio

It can be seen from Fig. 6 that when the SNR is set to -9 dB and the SNR is lower than -25 dB, the proposed anti-interference algorithm for broadband wireless communication based on Embedded MCU has obvious advantages, and its bit error rate is significantly reduced compared with the other two traditional anti-interference algorithms. When the signal to interference ratio is -40 dB, the bit error rate is reduced by about one time by using the anti-interference algorithm of broadband wireless communication based on Embedded MCU. The experimental results show that the anti-jamming algorithm of broadband wireless communication based on Embedded MCU has better anti-jamming ability.

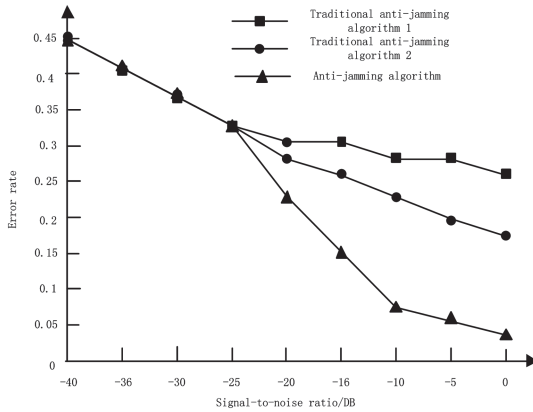


Fig. 7. Comparison results of bit error rate under different SNR and snr -35 db

As shown in Fig. 7, when the signal to interference ratio is set to -5 dB and the signal-to-noise ratio is greater than -25 dB, the proposed anti-interference algorithm for broadband wireless communication based on Embedded MCU has obvious advantages, and its bit error rate is significantly reduced compared with the other two traditional anti-interference algorithms. With the increase of signal-to-noise ratio, the bit error rate of Wideband Wireless Communication Anti-jamming algorithm based on embedded single-chip microcomputer is reduced more and more.

In conclusion, the experimental results show that the anti-interference algorithm based on Embedded MCU has better anti-interference ability.

4 Concluding Remarks

In view of the high bit error rate of the traditional anti-jamming algorithm for broadband wireless communication based on embedded single chip microcomputer, this paper proposes an anti-jamming algorithm for broadband wireless communication

based on embedded single chip microcomputer. Compared with the traditional anti-interference algorithm of broadband wireless communication based on Embedded MCU, the experimental results show that the proposed anti-interference algorithm of broadband wireless communication based on Embedded MCU has better anti-interference ability.

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