Anti-interference Algorithm for Broadband Wireless Communication based on Embedded Microcontroller

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Abstract. In order to improve the reliability of broadband wireless communication, the anti-interference design of broadband wireless communication in embedded environment is carried out, and an anti-interference algorithm of broadband wireless communication based on embedded microcontroller is proposed. The hardware of the anti-interference device is mainly composed of the communication modulating module, ARM main control system module and the single chip microcomputer main control module. The anti-interference algorithm is designed by using inter-symbol interference suppression algorithm, and the data transmission channel distribution model of broadband wireless communication is constructed. The interference filtering of broadband wireless communication is based on the decision feedback equalization method. The simulation results show that the anti-interference design of broadband wireless communication using this method has strong anti-interference ability, the output SNR is higher than that of the traditional method, and the communication quality is improved.

Keywords: Embedded, MCU, Broadband Wireless Communication, Anti-Interference Algorithm

1. Introduction
As the main communication mode, broadband wireless communication adopts optical fiber communication and wireless sensor communication technology to realize the communication of text, voice and image information. In broadband wireless communication system, encoder is used to digitize the information and decode the digital information to receive and process audio, text and picture information [1]. Communication performance is far better than cable, microwave communication transmission, broadband wireless communication in data transmission has a wide range of applications. Broadband wireless communication is prone to multipath effect in the transmission channel, resulting in symbol interference and inter-symbol interference. It is necessary to suppress interference and enhance the resistance of broadband wireless communication to external inferences, thus ensuring the communication quality of broadband wireless communication system [2].

Traditionally, in the anti-interference design method of broadband wireless communication, the correlation matched filter detector, wavelet filter detector or time-frequency filter method are used to
filter interference signal [3]. Using channel adaptive equalization method, the anti-interference effect of broadband wireless communication can be achieved. However, in the design of traditional anti-interference algorithm, it is necessary to add each branch signal of communication channel in the same phase [4]. It is easy to generate channel amplitude attenuation and reduce the fidelity of communication data. Aiming at the above problems, an anti-interference algorithm based on embedded microcontroller is proposed in this paper. The effectiveness of this proposed method in improving the anti-interference capability of broadband wireless communication is verified.

2. The Design Framework and Functional Module Composition of Anti-Interference Device

Broadband this work investigates the design framework of anti-interference device and the principle of anti-interference in broadband wireless communication. The design of anti-interference device for broadband wireless communication mainly includes channel equalization design and multipath expansion design [5]. Inter-symbol interference design and channel equalization modulation design, combining with direct sequence spread spectrum method are used to suppress inter-symbol interference in transmission. By adopting an adaptive link forwarding protocol, a routing transmission protocol for broadband wireless communication system is constructed. The optimal design of the anti-interference device in the communication system is carried out under the embedded environment [6]. In the upper computer module of anti-interference device for broadband wireless communication, the dynamic gain anti-interference method is used to amplify the output power gain, and the baud interval equalization method is adopted to suppress the inter-symbol interference in the communication channel. An adaptive learning method is applied to improve the internal oscillation of anti-interference device as to enhance the anti-interference ability of communication system. Linux is used as the embedded kernel of microcomputer, and the development platform of broadband wireless communication anti-interference device is constructed. The steady-state and channel equalization of the anti-interference device are improved. The embedded microcontroller is adopted to realize anti-interference design of broadband wireless communication. The function module of the anti-interference device for broadband wireless communication based on embedded MCU is composed of the communication modulating module, arm main control system module and the single chip microcomputer main control module [7]. The structure of anti-interference system for broadband wireless communication based on embedded microcontroller is shown in figure 1.

![Figure 1. Structure of anti-interference system for broadband wireless communication based on embedded microcontroller.](image-url)
3. Design of Anti-Interference Algorithm for Broadband Wireless Communication

3.1. Channel Equalization
Based on the framework design and functional module structure of the anti-interference device for broadband wireless communication, the equalization design of the communication channel is implemented [8], and the transfer function of the broadband wireless communication channel is constructed as follows:

\[ h(t) = H \sum_{m=1}^{M} \sum_{k=1}^{K(m)} \alpha_{mk} \delta(t - T_m - \tau_{mk}) \]  

Where, \( H \) is the characteristic transfer function of signal multipath recombination, \( M \) is the scale of channel multipath expansion, \( K(m) \) is the delay of channel \( m \), \( \alpha_{mk} \) is the inter-symbol interference intensity of path \( n \) in channel \( k \), \( T_m \) is the Boltzmann constant, and \( \tau_{mk} \) is power gain. Combined with time-domain equalization and frequency-domain equalization, the output spectral density of communication channel is obtained as follows:

\[ s(t) = \sum_{i}^{N} b_{i} \sum_{j=0}^{N-1} p(t - iT_i - jT_i - c_iT_i) \]  

Assuming that \( h(n) \) stands for the impulse response of the output channel, the Doppler frequency is shifted to \( n(n) \), the equalization time domain output of signal is \( y(n) \), and the expansion term is \( s(n) \). Combined with adaptive weighted anti-interference, it can be expressed as:

\[ S(t) = a_0 \sum_{i=1}^{N} a_i \delta(t - \tau_i)e^{j\omega_i t} \]  

The carrier modulation of broadband wireless communication is carried out by using linear transverse equalization method, and the carrier and modulation waves output by broadband wireless communication channels are obtained as follows:

\[ S_c = E[x^3(t)] + \sqrt{b(u[v(t - \tau_0)]]} \]

\[ K_c = E[x^4(t)] - 3E^2[x^2(t)]b \]

Where the characteristic attenuation of \( E[x^3(t)] \) is the output of baud interval equalization, and \( b \) is the coefficient of adaptive baud interval sampling. The anti-interference design of broadband wireless communication under channel distortion can be realized, and the output after channel equalization is obtained as follows:

\[ r(t) = \sum_{i=1}^{M} r_i(t)^* p(t) = S(t)^* p(t)^* p(-t)^* \sum_{i=1}^{M} h_i(t)^* h_i(-t) + \sum_{i=1}^{M} n_i(t) \]

Above all, the sampling decision method is adopted to realize the adaptive anti-interference and channel equalization design for broadband wireless communication [9].

3.2. Anti-Interference Filtering
In the broadband wireless communication channel under embedded MCU, a simplified multipath model is used to construct the pure communication channel. The multipath components of the broadband wireless communication channel can be expressed as follow:
Where, \( A[S(t);J(t)] \) is the phase offset of receiver received signal and \( n(t) \) represents the noise.

The multi-path extended coverage method is adopted to evaluate the channel characteristics in the single frame data transmission time, and the training sequence received is shown as follows:

\[
X = X - E\{X\} \quad (8)
\]

The ISI intensity of broadband wireless communication can be obtained by counting the number of symbols covered by channel multipath spread, which is shown as equation (9):

\[
E\left[ (X - E\{X\}) [X - E\{X\}]^T \right] = D \Lambda D^T \quad (9)
\]

In order to compensate the channel distortion, the whitening signal is obtained by decomposing the eigenvalue of the signal:

\[
z = \Lambda^{-\frac{1}{2}} D^T \left[ X - E\{X\} \right] \quad (10)
\]

The channel response expansion time and steep gradient function are obtained by separating interference noise from maximum likelihood detection:

\[
\frac{\partial k(W^T z)}{\partial W} = \text{sign}(k(W^T z)) \ast \left[ E\left( z(W^T z) \right) - 3W \|W\|^2 \right] \quad (11)
\]

\[
k(x) = E\left( x^4 \right) - 3E\left( x^2 \right) \quad (12)
\]

The interference filtering of broadband wireless communication is carried out by decision feedback equalization method [10], and the single frame data in the embedded microcontroller is detected and normalized as follow:

\[
W = E\left( z(W^T z) \right) \quad (13)
\]

By inserting W into the linear equalizer, the iterative formula of anti-interference filtering for broadband wireless communication is obtained as follows:

\[
W(k+1) = E\left( z(W^T z) \right) \quad (14)
\]

\[
W(k+1) = \frac{W(k+1)}{W(k+1)} \quad (15)
\]

The anti-interference design of broadband wireless communication based on embedded microcontroller is carried out, the maximum likelihood detector is weighted linearly and adaptively, and a high gain is set near the spectrum zero of channel frequency response to improve the intensity of interference suppression.

4. Simulations and Result Analysis

Simulations are carried out I to verify the effectiveness of the proposed method in realizing the anti-interference function of broadband wireless communication. The signal-to-noise ratio (SNR) is -15 dB ~ 0 dB, the path bar number \( N=12 \), the order of filter is 24, the iterative step size is 0.01, and the channel allocation iterative step is 200. Based on these parameters, simulations of anti-interference capacity of communication system is carried out. The output communication signals before and after interference filtering are obtained as shown in figure 2.
Figure 2. Anti-interference processing of broadband wireless communication signal.

Figure 2 shows that the proposed method did a excellent job in realizing anti-interference suppression of broadband wireless communication and has a strong filtering ability for noise signals. The output SNR is measured, as shown in figure 3.

Figure 3 shows that the output SNR is improved effectively, and the communication quality is enhanced.

5. Conclusions

In this work, an embedded microcontroller-based anti-interference algorithm is proposed for broadband wireless communication system [11, 12]. The hardware of the anti-interference device is mainly composed of the communication modulating module, arm main control system module and the single chip microcomputer main control module. The interference filtering is realized based on the decision feedback equalization method. It is verified that the proposed method can realize the anti-interference design of broadband wireless communication by enhancing the output SNR and the communication quality, which is of good application value in anti-interference device design.
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