Research on High Frequency Signal Transmission Method of Transmission Line under Internet of Things Communication Environment

Zhao Shaokang¹, Zheng Tao², Liu Chenglong², Lu Xin², He Ying²

¹Internet Department, State Grid Hebei Electric Power Co., Ltd.
²Data Operation and Maintenance Center, National Network Hebei Communications Corporation

35dugaoshao@163.com

Abstract: In order to better promote the safety and stability of transmission line signal transmission, a research on transmission line high frequency signal transmission method based on Internet of Things communication environment is proposed. Firstly, the noise interference in the transmission line signal transmission process is removed by combining the wavelet transform algorithm, and the original high-frequency signal is subjected to waveform constraint processing after denoising, so as to realize the safe transmission of the high-frequency signal of the electric line. Finally, the experiment proves that the transmission line high-frequency signal transmission method under the Internet of Things communication environment has higher safety and stability than the traditional method, which fully meets the research requirements.

1. Introduction

According to the current Internet of Things environment research, based on the investigation and analysis of traditional transmission line high-frequency signal transmission methods, this paper puts forward relevant optimization suggestions. Traditional transmission line high-frequency signal transmission methods mostly use MIMO intelligent technology to transmit signals [1]. The method mainly uses hardware equipment such as signal transmission and reception to improve the signal transmission effect. The method has the advantages of simplicity and convenience, but its actual application effect in complex environment is not good [2]. On this basis, SDNA-based multi-element information transmission method is developed. SDNA-based multi-element information transmission method divides signals into access and communication transmission under complex circuit environment by expanding the signal output path and range. The method has high practicability, but the operation is relatively complicated [3]. With the development of modern electronic information technology, the high-frequency signal transmission method guided by PCB principle gradually prevails. This method realizes the transmission of high-frequency data by swimming around the lake to the transmitting or receiving nodes in the separate antenna of the circuit equipment terminal. This method has greatly promoted the development of signal transmission, but there are still many challenges in its implementation. Under this environment background, combining the advantages and disadvantages of traditional methods, a high-frequency signal transmission method for transmission lines under the Internet of Things communication environment is proposed.
2. Transmission method for high-frequency signals of power transmission lines

2.1 De-noising of High Frequency Signals in Transmission Lines

In the Internet of Things communication environment, in order to ensure the effective transmission of high frequency signals, it is necessary to detect and collect the signal output waveform characteristic parameters\[^4\]. In order to ensure the accuracy of feature extraction, high frequency information must be denoised first. In practical engineering, effective signals are usually expressed as low-frequency signals, while noise signals are usually expressed as high-frequency signals\[^5\]. Therefore, the noise can be well suppressed by removing the wavelet transform which mainly reflects the noise frequency scale and combining the information wavelet transform of the remaining scales. Set original signal \( k(a) \) contaminated by additive noise, its model is:

\[
\begin{align*}
    f(a) &= k(a) + \lambda e(a) \\
    k(a) & \text{ is the unknown signal that needs to be collected}^6.
\end{align*}
\]

Where: \( e(a) \) is a Gaussian white noise parameter, \( \lambda \) is the noise interference intensity of operation due to transmission line signal transmission. \( f(a) \) is the unknown signal that needs to be collected\[^6\]. The purpose of separating signal from noise is to suppress noise is \( \lambda e(a) \). By including noise signal \( f(a) \) recover useful signal \( k(a) \). The high frequency signal model of transmission line with noise interference is decomposed by wavelet transform method. Under this scale, the wavelet transform coefficient of the original transmission line signal is submerged by noise coefficient\[^7\]. With the scale gradually strengthening, the original transmission line signal transformation is gradually displayed. Therefore, in the process of signal-to-noise separation of transmission line, the wavelet coefficient needs to be changed so as to eliminate noise and make the retained denoising coefficient controlled by high frequency signal\[^8\]. On this basis, a transmission line signal wavelet is selected, the maximum scale is determined, and the wavelet decomposition of noisy signals at this scale is calculated\[^9\]. The basis function should give priority to noise and prior knowledge of signals, so that signals and noise wavelet coefficients can be distinguished in the field of transmission line signal wavelet transformation. The characteristics of high frequency signals and noise independence are fully considered. Receiving signal \( \delta(x) \) the high frequency function can be expressed as:

\[
\begin{align*}
    f_n(y) &= f(a) + f_s(y) = \frac{\lambda^2 f_n(y) \cos(e \cdot y)}{2} + f_s(y) \\
    f_n(y) & \text{ represent a high frequency function of high frequency signal transmission noise of a power transmission line; } f_n(y) \text{ represents a self-contained high-frequency function of a transmission line}^{10}.
\end{align*}
\]

In the formula \( f_n(y) \) represent a high frequency function of high frequency signal transmission noise of a power transmission line; \( f_n(y) \) represents a self-contained high-frequency function of a transmission line\[^10\]. According to probability hypothesis, the high frequency function of high frequency signal of transmission line can be optimized as follows:

\[
\begin{align*}
    f_n(y) &= \begin{cases} 
    1 - \frac{|y|}{T_d}, & 0 \leq |y| \leq T_d \\
    0, & |y| > T_d
    \end{cases}
\end{align*}
\]

In formula (3): \( T_d \) indicates the cell symbol time width. The product of multi-channel high-frequency signal and pseudo-function of transmission line is affected by carrier modulation, and its signal code width is 0. However, in real life, due to the limitation of data processing length, the signal code of transmission line is incomplete. Estimated value \( \hat{f}_n(y) \) A value of 0 will appear. The complex signal form after orthogonal transformation of high frequency signal of transmission line can
be expressed as:

\[ a(n\Delta t) = f_n(y)^* e^{j2\pi fn\Delta t \theta} + g(n\Delta t), n = 1, 2, 3, \ldots \] \quad (4)

In the formula, \( \Delta t \) indicates the sampling time interval after high frequency signal processing of the transmission line; \( f \) indicates the sampling frequency; \( \theta \) indicates the initial phase. Set up \( \Delta t = 1 \), \( g(n\Delta t) \) indicates the transmission line noise sequence. The variance is \( z^2 \). Perform \( a(n\Delta t)^* \) high frequency processing, the obtained results are as follows:

\[ b(k) = \frac{1}{N} \sum_{n=k}^{N+k-1} a(n+1) \times a^* n = \lambda^2 e^{-j2\pi f} + g'(k), \quad k = 1, 2, 3, \ldots \] \quad (5)

According to the formula, \( N \) indicates the accumulated length of transmission line signal detection; \( a^* n \) indicates the conjugate result of the transmission line input signal; \( g'(k) \) indicates the high-frequency operation result including the high-frequency signal noise of the transmission line, and the expression is:

\[ g'(k) = \frac{1}{N} \left[ b(k) \sum_{n=k}^{N+k-1} e^{-j2\pi f} g(n) + \sum_{n=k}^{N+k-1} g(n+1) g'(n) + \sum_{n=k}^{N+k-1} e^{-j2\pi f} g(n+1) \right] \] \quad (6)

In the formula, according to the central limit theorem, the larger the accumulated length \( n \) of transmission line signal detection is, set up \( g'(k) \) as gaussian distribution, the variance is \( z^2 \). So the transmission line The SNR of \( b(k) \)'s algorithm is:

\[ SNR = \frac{NA^2}{2\lambda^2 \sigma^2 + \sigma^2} = \frac{N\lambda^2}{2\lambda^2 + z^2} \times \frac{2\lambda^2}{2\lambda^2 + z^2} \times g'(k) \quad (7) \]

According to the above algorithm, it can be seen that once the relevant output signal-to-noise ratio gain in the transmission line is increased, it will be directly proportional to the signal detection accumulation length \( n \). Therefore, after the signal-to-noise ratio is taken, the power transmission lines of \( b(k) \) Can determine the threshold and effectively detect multi-channel high-frequency signals in the transmission line. Set the detection threshold as: \( S_T = \mu + h\sigma \), Where \( h \) represents the false alarm probability, form \( b(k) \) It can be seen from the calculation formula that \( n \) times of complex multiplication and complex addition are required, which can be converted into real number operation, and the operation amount increases with the increase of signal detection accumulation length \( n \). A calculation amount can be calculated by adopting a recursive calculation method of \( b(k) \), if the calculation amount is greatly reduced, then \( b(k) \) The signal-to-noise ratio does not increase with the increase of the detection accumulation length \( n \).

2.2 Waveform Constraints of High Frequency Signal Transmission in Transmission Lines

Combined with the above algorithm, the original signal is extracted after signal denoising, and waveform analysis and constraint are carried out. Firstly, the high-frequency signal in the transmission line channel is detected, and the power of 2 is taken as the length basis, so that the value of relevant points are: \( N_1 = 16, N_2 = 32, N_3 = 64 \), the highest threshold value of signal transmission for each channel is shown in table 1, and the noise variance is \( z^2 = 1 \), then:
### Table 1 Transmission Limits of Transmission Line Channel Signals

| N    | 16 Channel | 32 Channel | 64 Channel | Waveform |
|------|------------|------------|------------|----------|
| \( \mu_t \) | 0.2013     | 0.1465     | 0.1105     |
| \( h \)   | 5          | 5          | 5          |
| \( z_t \) | 0.1002     | 0.0735     | 0.0528     |
| \( S_T \) | 0.7023     | 0.5140     | 0.3745     |

According to the above table, if the transmission pulse of high frequency signal is more than 400 points in the transmission line, its fluctuation is prone to instability. Therefore, in order to ensure the accurate transmission of high-frequency signals, the waveform needs to be constrained, and the constraint agreement is set as follows:

1. When high-frequency signals are output from all transmission line channels, the signal is stronger and the width is relatively wider. At this time, the signal exists and the target signal is the initial mean value of the transmission line channel.

2. When intermittent transmission occurs in the information output of the same channel of the
transmission line, the signal width is narrow and the signal output power is weak. This situation shows that the signal exists, but its stability is relatively low, so secondary processing of the signal and waveform constraint of the output signal are required.

In order to ensure the effectiveness of waveform constraint, the potential danger signals in the transmission process are classified and checked according to the safe frequency characteristics of high-frequency signals of the transmission line. Once the frequency of high-frequency signals fluctuates irregularly, the wavelet coefficient $X_i$ needs to be standardized, and the standardized danger signals can reduce some errors. The average value, signal variance and standard expected value thus obtained are:

$$
\overline{X} = SNR_i \sum_{i=1}^{N} X_i / N \quad 1 \leq i \leq N \quad (8)
$$

$$
\sigma = \left( \sum_{i=1}^{N} (X_i - \overline{X})^2 / (N-1) \right) \quad (9)
$$

$$
S_i = (X_i - \overline{X}) / \sigma \quad (10)
$$

Where: $S_i$ indicates the expected value of signal standardization; $\overline{X}$ indicates the average of the signal beams; $\sigma$ indicates variance; $N$ indicates the total number of normalized signals, where $I$ indicates the serial number. After obtaining the standard expectation value, adjust it according to the adaptive theorem to obtain the negative value of the standard expectation. After self-adaptive control, negative error data can be eliminated, and all the data are set to null values, which can be used to locate dangerous signals. According to formula (1), the average value of wavelet coefficients can be calculated, therefore, the length sequence $S$ can be obtained in the frequency window, and the calculation result of the normalized expected value $s$ is as follows:

$$
s_r = \sum_{i=1}^{\alpha} d_n S_i \quad (11)
$$

Where: $d$ represents the frequency of network danger signal generation; $\omega$ represents a sequence in a frequency window. The result is weighted, and the network danger signal is closed according to the weighted result. By introducing a coordinate system for positioning, the positioned signal has strong resistance and provides convenience for the adaptive control of danger signals. In order to increase the effective control of transmission line signals, "0" or "1" is adopted to judge whether the signals are hazardous, thus judging the types of hazards of all signal fluctuations, and performing fluctuation restriction according to the following table.

| Control wave frequency | Sequence | Constraint setting                  | Coding                  |
|------------------------|----------|-------------------------------------|-------------------------|
| 0                      | Be disturbed | "0" does not interfere | "1" is disturbed       |
| 1                      | Be subjected to suppression interference | "0" does not interfere | "1" is disturbed       |
| 2                      | Affected by long pulse interference | "0" does not interfere | "1" is disturbed       |
| 3                      | Affected by short pulse interference | "0" does not interfere | "1" is disturbed       |
| 0                      | Wideband interference | "0" does not interfere | "1" is disturbed       |
| 1                      | Be disturbed by fluctuations | "0" does not interfere | "1" is disturbed       |

According to the information in the above table, the high-frequency signals in the transmission line are regulated and controlled. Through the analysis of the formation process of the control word, the
specific transmission content of the signals can be intercepted. Through the self-adaptive anti-danger signal identification module, the intercepted signals can be scanned to ensure that the danger signals without noise interference can be obviously displayed, thus achieving the goal of stable transmission of the high-frequency signals of the transmission line.

2.3 Realization of High Frequency Signal Transmission in Transmission Line
After the denoising of high-frequency signal information and wave frequency control are completed, further optimization is carried out for the phenomenon that each period of signal transmission in the power transmission line is different, and different pulse signals are generated in the process of transmitting the high-frequency signal, so different operation behaviors need to be adopted for sequencing and maintaining the high-frequency signal transmission for different power transmission lines, thereby ensuring that the signal will not interfere and the time delay phenomenon will be minimized in the transmission process. The specific steps are as follows:

\[ S = \sum_{i=0}^{r-1} 4^i S(i) = \sum_{i=0}^{r-1} 4^i S(i) + S(0) \] (12)

In the formula, R and L are variables, which can be obtained by reduction calculation according to the above algorithm:

\[ S' = 4 \sum_{i=0}^{r-1} 4^i S(i) + \left[ \sum_{i=0}^{r-1} S(i) \right] \mod 4 \] (13)

Where \( s' \) and \( s \) are opposite, order \( a = \sum_{i=0}^{r-1} 4^i S(i) \), \( b = \left[ \sum_{i=0}^{r-1} S(i) \right] \mod 4 \), we can get: \( S' = 4a + b \).

According to the above, the wave frequency of high-frequency signal can be effectively mapped and controlled, the transmission path can be selected according to the algorithm, and the baud rate binary digital signal can be provided on the transmission address, thus achieving the goal of effectively controlling the transmission of high-frequency signal. The design block diagram is shown in the figure.

![Fig. 1 high frequency signal transmission control block diagram of transmission line](image)

The high-frequency signal transmission control address of the power transmission line can be divided into a plurality of regions, and the sample values of each region in the path are basically the same, in this case, the number of output bits to the high-frequency signal is also the same. Therefore, in the process of information transmission, compared with the selection of high-frequency information transmission path of power transmission lines, it is more important to first judge the sample characteristic values and classify the characteristic regions. For specific methods, refer to the first chapter. After the feature judgment and classification are completed, the parallel pseudo code of the feature parameter sequence is integrated, input and transmitted. The specific transmission principle is
as follows:

Fig. 2 selection principle of high frequency signal transmission path

According to the above principle, the high-frequency information transmission path is reasonably selected, the optimal information accumulation address is obtained, and all high-frequency digital signals which need to be output for transmission can be obtained. In order to ensure the safety and stability of signal transmission, the wave frequency key mapping control generated under different periods in the high-frequency information transmission process is combined with a quaternary calculation method, and the purpose of controlling the effective transmission of phase information is achieved by controlling input data.

3. Analysis of experimental results

In order to verify the effectiveness of transmission line high frequency signal transmission method under the Internet of Things communication environment, simulation experiments are carried out, and signal transmission tests are respectively carried out under different signal frequency characteristic environments. The sampling points of signal wave frequency are respectively set to 12kHz; 24kHz; 48 kHz; 96 kHz. Then observe the effect of signal de-noising and transmission under different wave frequency environments as follows:

(a) 12kHz  (b) 24kHz
It is not difficult to see from the above figure that under different wave frequency environments, the information transmission effect varies to some extent, but the overall transmission state tends to be relatively stable, so there is no need to explain too much. However, when the signal wave frequency reaches 96kHz, the autocorrelation function value in the signal transmission process fluctuates unstably. In this case, the signal transmission is prone to some delay. In order to further study the method, the signal transmission effect of the traditional method and the method in this paper is compared under the 96kHz environment, and the specific detection results are shown in the following figure:

Observing the above detection results, it can be found that the traditional signal transmission method has relatively narrow wave frequency channel when the wave frequency is as high as 96kHz. In this case, it can transmit relatively little information, in other words, there will be great delay,
jamming and other phenomena in the information transmission process. Compared with the traditional method, the transmission line high frequency signal transmission method in the Internet of Things communication environment proposed in this paper can be used in the network environment when the wave frequency is as high as 96kHz. It can still ensure that the information transmission path is relatively wide, avoid the phenomenon of Caton delay, and effectively solve the problems in the traditional method. However, the United States and China have the disadvantage that although this method can ensure the effective transmission of high-frequency signals, there are still problems such as large signal fluctuation range, which means that its stability still needs further control, but compared with the current existing signal transmission method, this method has made great progress.

4. Concluding remarks
In order to effectively transmit high-frequency signals of power transmission lines, the traditional methods are investigated, analyzed and investigated, and the signal transmission methods are studied in combination with the Internet of Things communication environment. The high-frequency signal is denoised to improve the accuracy of signal transmission, and the wave frequency of signal transmission is further controlled to improve the stability of signal transmission. Finally, the high-frequency signal is effectively transmitted.

References
[1] Hu Xianzhe, Wang Tao, Li Yanping. Remote Switching Control Technology for Multi-band Signal Sources of Internet of Things Communication and Transmission Equipment [J]. Computer Measurement and Control, 2018, 26(12):101-104.
[2] Xing pengkang, yang wenbo. Remote Switching Control Technology for Multi-band Signal Sources of Internet of Things Communication and Transmission Equipment [J]. Computer Measurement and Control, 2018, 26(12):101-104.
[3] Xie Chao, Li Fengting, Wang yanpeng, et al. active protection of transmission lines based on high frequency signals [J]. power system protection and control, 2017, 45(7):6-12.
[4] Ma Lin, Chen fuyang, Jiang bin. Research on Single Point Signal Timing Based on Improved Webster Method in Transportation Internet of Things [J]. Journal of Internet of Things, 2018, 12(04):53-59.
[5] Yang Nan, Hu Zhi, Guo Taiping. Research on Disaster Monitoring and Early Warning Technology for Overhead Transmission Lines Based on Internet of Things [J]. Science and Technology Vision, 2017,14(5):167-167.
[6] Ma Shiling. Research on Signal Reconstruction Algorithm of Internet of Things Based on Compressed Sensing in Ship Information Center [J]. Ship Science and Technology, 2017,25(20):153-155.
[7] Guo Haokun, Wu Junji. Design of Dynamic Capacity Increase Monitoring System for Transmission Lines Based on Internet of Things [J]. Power Information and Communication Technology, 2017(8):37-42.
[8] Liu Yushun, Zhou Wenjun, Allen, et al. Denoising Method for Partial Discharge UHF Signals Based on Generalized S-Transform Modulus Time-Frequency Matrix [J]. Journal of Electrical Technology, 2017, 32(9):211-220.
[9] Wang Yongqiang, Li Changyuan, Hu Fangfang, et al. Study on Noise Reduction Method of GIS Partial Discharge UHF Signal Based on Improved EMD [J]. Electrical Measurement and Instrument, 2017, 54(9):1-5.
[10] He Zhiman, Wang Jianfei, Jiang Xinchuan. Study on Time Delay Calculation Method of UHF Signal of Switch Cabinet Partial Discharge Based on EMD Optimized Bispectrum [J]. Smart Power, 2018, 46(11):59-64.