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Design of Low Voltage Power Line Carrier Communication System Simulation

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***Abstract*—Noise power line channel is the largest low-voltage power line interference sources, it is not a simple additive white Gaussian noise, but a time-varying noise, and with different environments and change, which is mainly the work of each of the grid kinds of electrical equipment generates, including instant asynchronous impulse noise such as background noise switching power supply or generation of amateur radio and frequency synchronization with the grid and grid-cycle pulse noise generated by the equipment.**

Keywords-Low-voltage power line interference; Channel measurement; Asynchronous impulse noise

I. INTRODUCTION

For the previous three kinds of noise, a narrowband noise due to the second type is usually over time (day or night) change change, OFDM system considering such noise as the background noise, the first three types of periodic pulse noise has a high repetition rate, and very low power spectral density (PSD), it can also be viewed as a background noise. These three types are divided into the background noise, which are the three spectral integrated spectrum, shown in Fig . 2-4. In an OFDM system for the noise or the usual solution is to avoid using these bands, or noise is the use of these bands on a low bit rate sub-channel.

Background noise is relatively stable A noise, but for the type 4 and 5, they are but it is time-varying, variations thereof are usually a few microseconds to several milliseconds. Compared with the fifth type of noise, the noise frequency and the grid frequency noise synchronization category 4, the repetition period is 50Hz or 100Hz, its Q short duration (a few milliseconds), the power spectral density (PSD) increases with frequency reduced. For these reasons, the first four kinds of noise model assumes that no error is generated when building models. And fifth, lasting from a few microseconds to a few milliseconds, the arrival time of a random, PSD sometimes higher than the background noise 50dB.

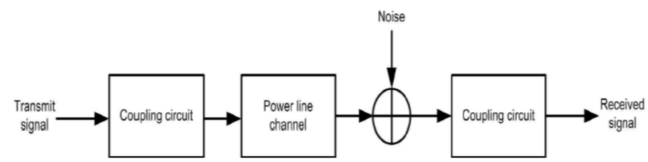

Figure 1. Graphical illustration of the PLC channel

Since the main purpose of this project is to study the low-voltage power lines in high-speed communication networks, so the main use of the high frequency range, typically between 500kHz ~ 20 coral z. The following high-frequency noise in time domain, the frequency-domain and time-varying characteristics were analyzed. First, the time-domain characteristics of high frequency noise of low frequency noise to reduce the influence of high frequency measurements, the selected test filter having high-pass characteristic, while simultaneously testing the selected sampling rate 100M Sample / s, the sampling points 2M points. The length of time for each measured time domain signal is 20ms, the equivalent of 50Hz frequency of a cycle length. Fig. 2-5 is a different place (laboratory and residential) and different times (peak and trough power) of the measured time-domain waveform.

From the high-frequency time-domain waveform measured, not difficult to find high and low voltage power line channel frequency noise has the following characteristics:

background noise: Background noise in residential areas during the peak and trough amplitude substantially identical, about 30mv; laboratory background noise amplitude at the peak time is about 100mV, and in the low power consumption of 30mV about. Amplitude and low frequency background noise when little difference. Impulse noise (2) and Frequency Synchronization: In Figure 2-5 (a), 2-5 (b) and 2-5 (d), the electrical equipment when working with power frequency generated by periodic synchronization impulse noise is very obvious, repetition frequency 100Hz, is also consistent with the low frequency band. Amplitude noise at the same time the laboratory is larger than the neighborhood, the noise amplitude at different times of peak electricity than when a large trough. Among them, the neighborhood at the time of the pulse peak amplitude of the noise about 50mv, and the pulse peak amplitude of the noise when the lab reached 350mv above, even in the low power consumption, impulse noise rates are more than 100mv, from Fig. 2-5 (c), we see that in the ranks。 Man zone electricity trough, basically do not see impulse noise waveform. Thus, the pulse interference lab than to a large residential area.

II. LOW VOLTAGE POWER LINE CARRIER COMMUNICATION CHANNEL UNIVERSAL MODEL

We can see from Fig. 2-6, in a residential area, the periodic impulse noise and single-pulse noise z delete bands below 2.5, a major home appliances produced by interference in peak and trough periods, such interference power spectral difference can be more than 10dB; 2.5 heart z above the background noise is very flat, narrow-band shortwave broadcast signal to noise is a major disturbance in the 12MHz ~ 15 and 17 delete z coral z ~ 20MHz band can be seen narrowband noise, narrowband noise and stronger at night than at any other time, and shortwave radio transmission characteristics of these waves is the same. Background noise difference when peak and trough of about 3dB. From Fig. 2-6 (c) and FIG. 2-6 (d) we can see that, in the laboratory, the main disturbance is periodic impulse noise generated by the switching power supply from the computer, the spectrum performance of a certain discrete frequency reuse spectrum, the maximum magnitude higher than background noise disturbance around 40dB, and is widely distributed in the frequency domain can be achieved 8MHz; 9 deleted z above the background noise is very smooth. In the peak and trough periods, periodic impulse noise and background noise difference of about 10dB.Today, there are many different pairs of conductors of the transmission line, coaxial cable, stripline and the like. They can use the distribution parameter model shown in Figure 2.4 the four configuration will be described. However, for each transmission line parameters have different values, depending on which requires the cable structure, wire timber, type, etc. of insulating material is calculated.

$$s_k = s(kT/N) = \sum_{i=0}^{N-1} d_i \exp(\frac{j2\pi ik}{N}), 0 \le k \le N-1 \tag{1}$$

High-frequency power spectrum graphical comparison residential and laboratories in different periods can be found, the peak, the background noise power spectral density laboratory higher residential 10dB; trough when the electricity, the power spectral density of the background noise is almost the same . Above we see the performance of low voltage power line communication channel variability high frequency noise during long periods during the day and night, as well as peak and trough periods of time variability at low frequencies with the same kind of noise also showed short time degeneration. In order to observe this instantaneous time variability, we also add test data during the time window of the power spectrum estimation were calculated for each section of the power spectrum, and draw its power spectrum changes over time three-dimensional graphics. When the length of the time window 100us added, that the length of each segment is 10000. Figure 2-7 is a frequency characteristics at high frequencies corresponding figure.

III. NOISE DETAILED ANALYSIS AND MODELING

From Fig .2-7, we can more clearly see the power line noise channel with grid 50Hz frequency changes, changes in the power spectrum of the noise frequency is still 100Hz. This is observed in the time domain waveform is consistent with ours, this cyclical mainly by high-frequency noise and frequency synchronous periodic pulse noise. Frequency high frequency characteristics graph further observation and control of the power spectrum graphic Figure 2-6, at high frequencies, we can draw the following conclusions: (1) residential peak, impulse noise generated by electrical equipment can affect 2.5 delete z, within 10ms, impulse noise power spectral density at 10dB below; and 2.5 puncturing z above the background noise power spectrum is flat, changed slowly, within 24 hours of the power spectral density the magnitude of change in 5dB within; another less impulsive noise at night, when the broadcast signal is stronger, we can clearly see that the presence of narrowband noise (c) in Figure 2-7, it does not vary with the magnitude of the change in power frequency change.

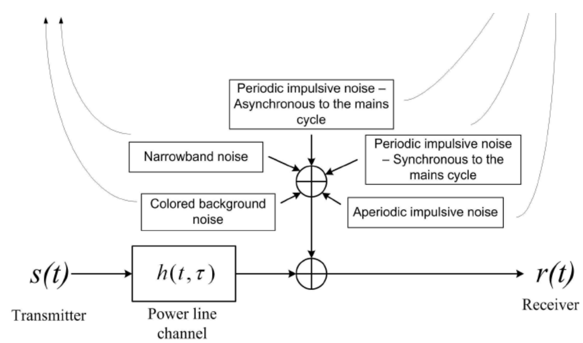

Figure 2. Noise Type observed in PLC systems

$$d_i = \sum_{k=0}^{N-1} s_k \exp(\frac{-j2\pi ik}{N}), 0 \le i \le N-1 \tag{2}$$

$$v_{guard} = 10\log_{10}(\frac{T_g}{T}+1) \tag{3}$$

$$x_g(n) = \begin{cases} x(n) & n = 0, \ldots, N-1 \\ x(N+n) & n = -N_g, \ldots, -1 \end{cases} \tag{4}$$

$$y_g(n) = x_g(n) \otimes h(n) + w(n) \tag{5}$$

$$Y(k) = \sum_{n=0}^{N-1} y(n) e^{-j2\pi kn/N}, k = 0,\ldots, N-1 \tag{6}$$

OFDM technology has the following advantages:

(1) the high rate data traffic through the serial-parallel conversion, so that the relative increase in each sub-carrier data symbols on the persistence length, so as to effectively reduce the radio channel time dispersion caused by ISI, equalization of the receiver is reduced within complexity, sometimes even without using the equalizer, but only to eliminate the adverse effects of ISI by employing a method of inserting a cyclic prefix.

(2) a conventional frequency-division multiplexing method, a frequency band is divided into a number of disjoint sub-frequency band transmitting data in parallel, to retain a sufficient guard bands between the respective sub-channels. The OFDM system due to the orthogonality between the subcarriers, allowing subchannel spectral overlap, as compared with the conventional frequency division multiplexing system, OFDM system can maximize the use of spectrum resources. When very large number of sub-carriers, the spectrum efficiency of the system can become 2Baud / Hz [4].

(3) each subchannel quadrature modulation and demodulation by using inverse discrete Fourier transform (IDFT, Inverse Discrete Fourier Transform) and discrete Fourier transform (DFT, Discrete Fourier Transform) method to achieve. In a large number of subcarriers of the system, may be implemented by a Fast Fourier Transform (FFT, Fast Fourier Transform). [5] With the development of large scale integrated circuit technology and DSP technology, IFFT and FFT are very easy to implement.

(4) the presence of wireless data services are typically asymmetric, i.e., the amount of downlink data transmission link is greater than the amount of uplink data transmission, which requires the physical layer supports asymmetric high-speed data transmission, OFDM system by using different number of subchannels to achieve uplink and downlink in a different transmission rate.

$$Y = XH + W \tag{7}$$

$$D_f \le \frac{1}{\tau_{\max} \Delta f} \tag{8}$$

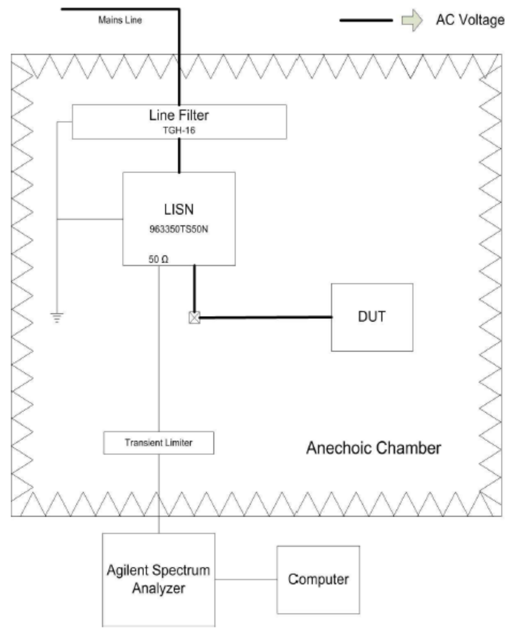

Figure 3. Pictorial description of the measurement setup

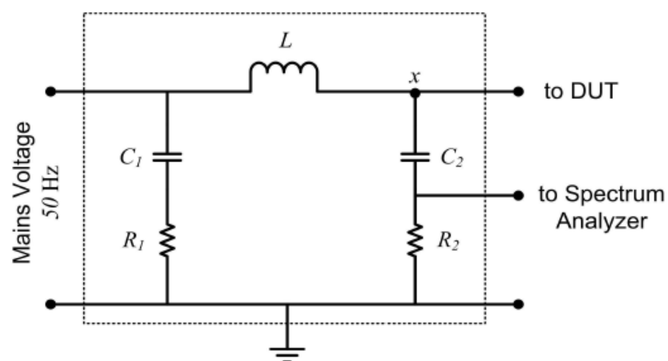

Figure 4. Block diagram of LISN

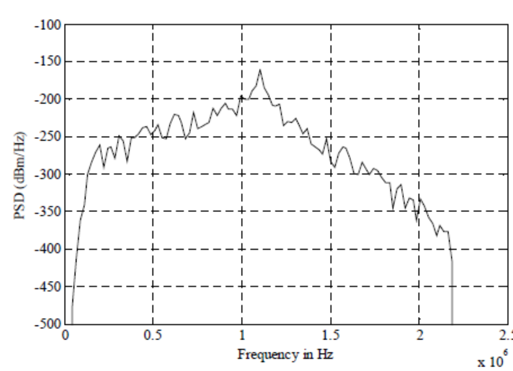

Figure 5. Measured PSD

IV. CONCLUSION

This chapter begins from the spread spectrum technology, analyzes the feasibility of spread spectrum communication in power line carrier communication, and the principle of spread spectrum technology for analysis. Reference TD-SCDMA system basic midamble sequence, designed for the detection of power line broadband channel characteristic measurement signal. Using broadband reference signal combined vector signal generators, network analyzers, and other software and hardware equipment, power line broadband channel sounding build and validate semi-physical simulation platform, as in the actual distribution network environment, the power line broadband channel characteristic measuring the accumulation of experience .

The use of semi-physical simulation platform for school laboratory and classroom building scene a lot of field measurements, analysis of power line channel transmission characteristics of the different environments, and features a three-dimensional graphic display of variable power line channel under different scenarios. At the same time in order to improve the efficiency of the data analysis, the use of MATLAB simulation software design based on off-line data analysis software GUI interface. It receiving end signal processing module integrated into the GUI interface, to implement graphical data analysis and processing, and at the same time from multiple dimensions of the channel parameters display.

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