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Simulation Study Low Voltage Power Line Carrier Communication in Noisy Environments

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***Abstract*—Studies have shown that there are a lot of low-voltage power line is one of the main obstacles to strong noise limit for data transmission quality. Power line noise can be divided into steady background noise, narrowband interference noise, sudden impulse noise and periodic noise. Background noise is distributed throughout the communication band, low-voltage power line up white Gaussian noise 22dB [133 or more. Sudden noise is generated by the random access or disconnect electrical equipment produced. Studies have shown that pulse interference effects on the quality of the low voltage power line carrier communication maximum. Literature statistics, intensity pulsed interference up 40dBuv.**

Keywords-Low-voltage power lin; Sudden impulse noise; Periodic noise

I. Introduction

With 10KV above high-voltage power lines, compared, 220V / 380V low voltage power line channel with harsh transmission environments, signal attenuation, interference characteristic strong, and time variability and other characteristics, and the power line burst interference seriously impact, making low-voltage power line carrier technology development is hampered. Overall, the low voltage power line carrier communication has the following aspects of the characteristics of children n4 151: 1, the signal attenuation low-voltage distribution network directly to the user, the load situation is complex, each node impedance mismatch, so the signal will produce reflection, resonance phenomena so that signal attenuation becomes extremely complex. For high frequency signals, low-voltage power transmission line is a line of non-uniform distribution of the various properties of the load randomly connected or disconnected at any position in this line. Therefore, the high-frequency signal transmission in low-voltage power line attenuation must exist. Studies have shown that the attenuation of the signal power line affected by the change in distance is fairly obvious, typically 10dB / km to 100dB / km. Meanwhile, the attenuation and the frequency of the signal, the phase of the commercial power supply, in general, as the frequency increases, the attenuation of the signal will also increase. It is reported that, when a communication frequency is greater than 100kHz, the frequency of each additional 1kHz, the attenuation increases O. 25dB [1 mendelevium. In some special frequency bands, due to the reflection, the resonant transmission line effects and the like, there will be a sudden surge attenuation.

Low power is a broad distribution network, and then on a wide range of load, leading to its channel incorporated into a variety of load impedance with constantly changing. Input impedance characteristics are important parameters for low voltage power line channel characteristics, research input impedance requirements for power transmission signal of great significance. Enter the low voltage power line carrier communication channel impedance n cho '173n81'1 cho means receives the signal transmitting device and a signaling device driver point distribution network equivalent impedance, it directly affects the size of the transmitted signal coupling efficiency. Figure 2-1 is a basic circuit diagram of the low voltage power line impedance measurement

Attenuation characteristic signal is a reflection of the communication channel characteristics also an important parameter, which represents the communication from the transmitting end to the receiving end of the signal energy loss, in practice the sake of convenience, in its logarithmic form usually expressed in dB. Channel attenuation characteristic consists of two parts n rip: signal transmitting means coupled between the channel attenuation characteristic signal attenuation characteristic in the channel transmission. Wherein, the coupling attenuation characteristic channel characteristic input impedance and coupling device about the parameters used in the design of the signal transmitting and receiving apparatus must be considered. Here focuses on the transmission channel attenuation characteristics. For high frequency signal, low-voltage power line is a non-uniform distribution of the transmission line, a variety of different properties at an arbitrary position of the load line of this random access or disconnected. Therefore, the high-frequency signal transmission in low-voltage power line will inevitably decline. For low voltage power line communication, the attenuation of the signal is very serious. In general, PLC signal attenuation with frequency rises, increasing distance increases, but not monotonous. Low-voltage power line network branches and more load random access various properties or disconnected, the echo effect of multipath interference caused very serious, with great frequency selective fading. Under normal circumstances, the signal attenuation in 20dB or more, and sometimes reach 60dB. PLC channel to the extent that the various frequency signal attenuation PLC main basis to select the carrier frequency. Signal attenuation is mainly determined by the path through the network and the connected load. Some of the network load on certain frequencies constitutes a resonant circuit, to resonate. When a heavy load on the network, the line impedance can be achieved l Q or less, resulting in high attenuation of the carrier signal.

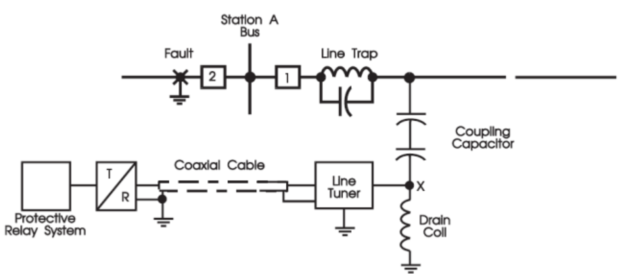

Figure 1. Basic Power Line Carrier

II. CHANNEL FADING CHARACTERISTICS

In general, the farther the signal transmission distance, the more severe attenuation, but because they do not match the load impedance, signal transmission occurs reflection, standing waves, scattering and other complex phenomena, these combinations of complex phenomena that signal attenuation with changes in the relationship between the distance becomes very complex, there may be larger than the attenuation at close distance dots. Distribution network directly to the user, the load situation is complex, does not match the impedance of each node, so that the signal can result in reflection, the resonance and other phenomena, so that the signal attenuation becomes extremely complex. In general, the pressure line signal attenuation 10dB / km, the low pressure can reach 100dB / km. Mainly related to the following four factors:

(1) the time-dependent signal attenuation;

(2) frequency-dependent signal attenuation;

(3) the distance related signal attenuation;

(4) the signal distribution network between different phases of decay; Q-phase signal attenuation values between 2-15dB. In addition, many parallel load distribution networks also have a great impact on the attenuation of the signal, especially those large capacitor for power factor adjustment; and when the load is small distribution networks (such as at midnight), you should consider disaster resistance coupled circuit, it will partition a considerable portion of power.

$$S(f)=\begin{cases}\dfrac{1}{\pi f_d\sqrt{1-(\dfrac{f}{f_d})^2}} & |f|<f_d\\ 0 & \text{else}\end{cases} \tag{1}$$

In general, loss of signal transmission is a function of frequency, as the frequency increases, the attenuation of the signal will also increase, which is the opposite of the noise, so the high frequency loss is greater than low frequency loss. However, in some special band, due reflection, resonance and transmission line effects and other factors, there will be a sudden surge attenuation. Single-phase test, for example, in the 140kHz, the hospital building power lines and industrial buildings difference signal attenuation 5dB, 20dB difference when 160kHz, 240kHz when in slow rise of 27dB. In different time periods, the same measurement parameter points will have different attenuation characteristics. In general, the attenuation was significantly higher than in the white decay phase. From the above analysis, the low-voltage power line on the attenuation characteristics of the signal is quite complex, it is difficult to find a simple formula to calculate the attenuation of the signal, but it also has its regularity can use, let the attenuation characteristics of the power line to conclude:

Attenuation size (1) is closely related to the time signal, i.e., a strong day / night sensitivity. For example, industrial areas, daytime than at night attenuation large, and in residential areas at night from 18:00 to 22:00 attenuation is greatest.

$$s(t)=\begin{cases}\sum_{i=0}^{N-1} d_i \operatorname{rect}(t-t_s-T/2)\exp(j2\pi f_i(t-t_s)) & t_s\le t\le t_s+T\\ 0 & t<t_s \wedge t>t_s+T\end{cases} \tag{2}$$

$$\frac{1}{T}\int_0^T \exp(j\omega_n t)\exp(j\omega_m t)dt=\begin{cases}1 & m=n\\ 0 & m\ne n\end{cases} \tag{3}$$

$$\begin{aligned}\hat{d}_j&=\frac{1}{T}\int_{t_s}^{t_s+T}\exp(-j2\pi\frac{k}{T}(t-t_s))\sum_{i=0}^{N-1} d_i\exp(j2\pi f_i(t-t_s))\\&=\frac{1}{T}\sum_{i=0}^{N-1} d_i\int_{t_s}^{t_s+T}\exp(2\pi j\frac{i-k}{T}(t-t_s))dt=d_j\end{aligned} \tag{4}$$

(2) signal attenuation and the frequency of the signal magnitude, in general, the signal attenuation with respect to increasing frequency increases, although this increase is not monotonic. For frequencies greater than 100KHz signal, M. 1. Chen and R. w. Donadlson derive frequency for each additional 1KHz, signal attenuation increases O. 25dB.

III. SIMULATION RESULTS

Transmission distance (3) signal attenuation and signal related, in general, the longer the distance signal transmission, the greater the signal attenuation. In the actual measurement, signal attenuation at 1 km and can even reach loodB.

Attenuation of a transmitting end and receiving end (4) is connected to the signal related to the same phase, when the transmitter and receiver connected to the same phase, the attenuation is generally on a different phase than smaller 2 to 15dB, in some cases next, the difference can even reach 40dB.

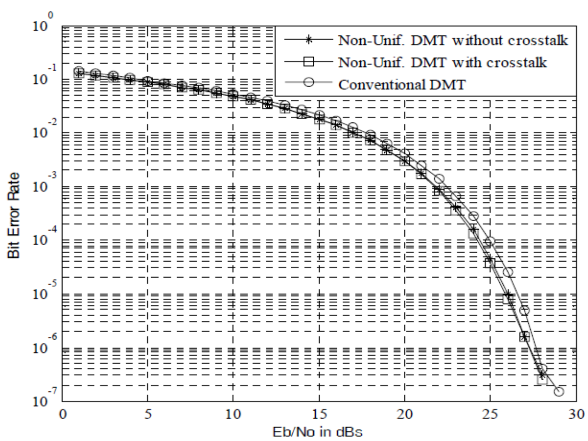

Figure 2. BER Performance comparison

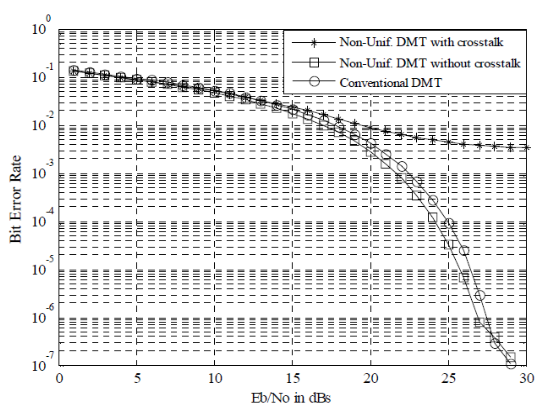

Figure 3. BER Performance comparison

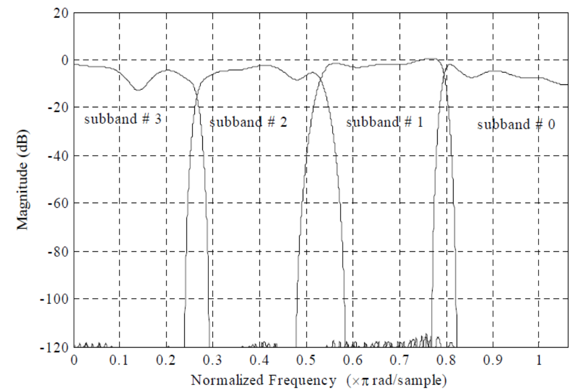

Figure 4. The Uniform bandwidth subbands of the in-home power line channel

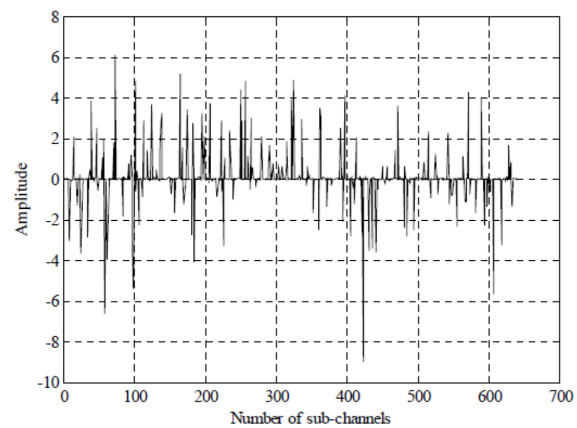

Figure 5. Impulse noise

IV. CONCLUSION

Noise on the power line noise into artificial and man-made noise. Artificial noise is a natural phenomenon, such as noise in the power line caused by lightning; artifacts from a variety of electrical, mechanical and electrical products and power lines themselves. The main power line noise is not additive white Gaussian noise pop child called larvae, its features are likely to change in a very short period of time. According to the band powerline communication studies at different stages of the power line noise z within 30 sampan classification can be divided into two parts: lookHz below and 100k a 30MHz. This paper studies a man-made noise in the 1MHz frequency range 30Hz.

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