Field Analysing-Tool for Power Line Communication

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Abstract

In this paper, we developed an filed analyzing-tool to identify problems in PLC transmissions. It combines the strength of a spectrum-analyzer and a protocol-analyzer.

Index Terms

Protocol-Analyzer; Matlab-Analyze; OFDM; Logging-Tool;

I. Introduction

A common way to investigate the quality of service in a powerline communication system, is to examine the channel using a spectrum analyzer and oscilloscope. Thereby, basic events can be examined, such as the strength of the signal or the occurrence of narrowband interference in the used frequency range. Furthermore, protocol analyzers are used to evaluate the transmitted packets, however this procedure offers no conclusive approach to analyze a failed reception of the packet. Moreover, the individual processing steps of the protocol and carry-over method can not be viewed and thus the error leading to the failure can not be identified. We developed an analyzing tool, which combines the strengths of the above-mentioned approaches, as well as introducing a new approach in order to further analyze the transmitted packets by means of detailed protocol-based time-domain and frequency-domain analysis. This approach can moreover provide a powerful error-handling tool, which helps us to identify problem sources in transmission.

II. System design

To capture the data a Picoscope 3205D MSO was used as an analog-to-digital converter (ADC), which provides a sampling rate of $250\,\mathrm{MSa/s}$ for one channel at a resolution of 8 Bit and a timing accuracy of $20\,\mathrm{ppm}$. The captured data with a length from 1 second are filtered by a lowpass-filter with a cutoff-frequency at $40\,\mathrm{MHz}$. At the Output of the filter, the data has still a sampling rate of $250\,\mathrm{MSa/s}$, to reduce the signal-sampling-rate to $50\,\mathrm{MSa/s}$ downsampling with a factor of 5 is performed. The stored values serve as input to the MATLAB evaluation.

III. Matlab-analyzer

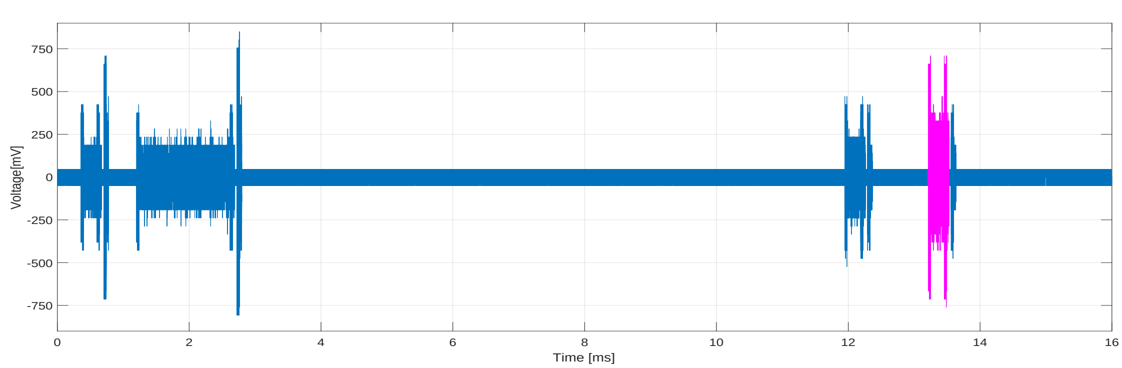

Fig. 1. Part of the total received signal.

Figure 1 shows 16ms of the record of the measurement. The image allows to observe the magnitude of the Signal as well as possible distortions in the measurement. The tool recognizes the respective packages in the recording and marks this in color, for closer inspection, zoom is still possible. Each packet can be more detailed analyst, as shown in figure 2.

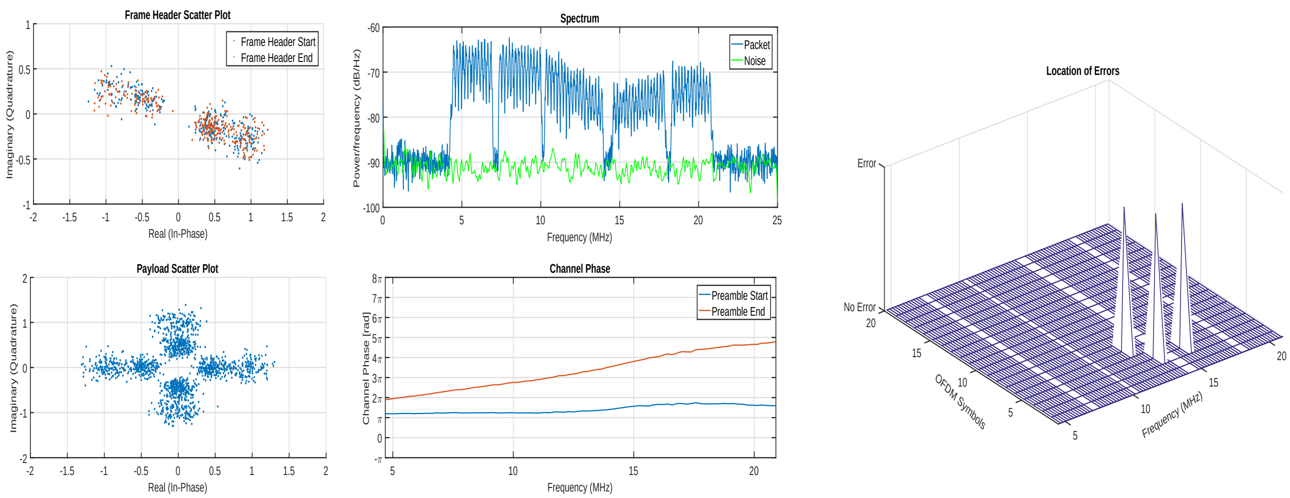

Fig. 2. Result Graphic.

The used protocol, has 2 MAC-layer frame control headers which are each modulated with coherent BPSK(Binary-Phase-shift keying). One directly after the preamble and one at the end of the packet. The first sub-figure in 2, top left corner, shows the scatter plot of the received header signals after OFDM demodulation and phase correction. In this recording, the point clouds are concentrated in two places, which indicates a correct transfer, since the modulation is BPSK. Equivalent as the first Image, the second Image, lower left corner, the payload is displayed and has been modulated in our case with differential QPSK(Quadrature phase-shift keying). This figure illustrates the scatter plot of the received signal constellation after adjusting the differential phase shifts. Consistent with the first image, the cloud of points would blur into each other in the event of a bad transmission. Even unintended phase rotations of the symbols in developed chips can be evaluated at this point. The channel phase is determined by calculating the difference of the received phase of the preamble and the transmitted phase of the preamble, which is known at the receiver. The figure below in the middle shows the received phase of the preambles over the frequency range.

The figure at the top center shows the spectrum of the received packet. The blue line shows the entire packet and the green line shows the spectrum of the noise. This figure shows whether the SNR (signal-to-noise ratio) is high enough to distinguish the packet from the noise on the channel. The measurement shows, a lower SNR in the range from $10\,\mathrm{MHz}$ - $18\,\mathrm{MHz}$. This may be an indication for an problem.

The last figure, right outside, shows the position where the bit errors occurred in the transmission. For this purpose, the output of the Viterbi decoder is encoded using the convolutional encoder. Subsequently, the input of the Viterbi is compared with the output of the convolutional encoder, if these two vectors are unequal in the respective place a bit error is entered. The same procedure is applied to the RS (Reed-Solomon) encoder and also shown in the figure. This figure shows whether the forward error correction used is strong enough to eliminate the errors caused by the channel.

All results such as the payload modulation used, the length of the packet and the calculated bit errors are stored in a result file. This is used for later automatic evaluation of several measurements.

IV. Conclusion

The presented tool offers the possibility of a more detailed consideration than any tool currently available on the market. Due to the large number of individual analyzes within the protocol, errors can be detected quickly. With the help of the result file it is possible to make an automated evaluation over several measurements.

Acknowledgment

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