Impulse Noise Cancellation Using a Reference Pair

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Abstract

Impulse noise is still a major threat to powerline communications, where such disturbances can easily ramp up to the volts range measured at inhouse power outlets. Hence, for system robustness, countermeasures have to be in place. In the typical 3-wire inhouse cabling, we naturally have two wire pairs, e.g., L-N and N-PE that may, of course, be used for MIMO systems just as in HomePlug-AV2. However, impulse noise appears strongly related on both wire pairs. We will hence show some cancellation results using one of the pairs, e.g., N-PE, as a reference to cancel impulse noise from the other pair, e.g., L-N.

Index Terms

PLC, impulse noise

I. Introduction

Wireline communication, be it on twisted pairs or on power lines is since long known to be heavily affected by impulse noise which threatens communication, even with some coding in place.

In [1], Zimmermann and Dostert classified impulse noise as follows:

1) periodic impulsive noise asynchronous to the mains frequency with a repetition rate between 50 and 200 kHz,
2) periodic impulsive noise synchronous to the mains frequency with a repetition rate of 50 or 100 Hz,
3) asynchronous impulsive noise caused by switching transients.

More recently, some illustrations were shown in [2]. From some own measurements at power outlets, we know that asynchronous impulse noise is the most damaging, leading to amplitudes in the volts range. Some impulse noise might still occur in a periodic fashion dependent on periodic operations of some appliances or engines, but one might still see them as belonging to the asynchronous type. Zimmermann and Dostert describe the frequency-domain characteristics and also duration and inter-arrival times, also introducing a Markov model, comparable to our own works in [3] for twisted pairs.

In [4], [5], we already described cancellation possibilities using the common mode. Likewise, the following section describes cancellation using another loop as a reference.

II. Cancellation of powerline impulse noise

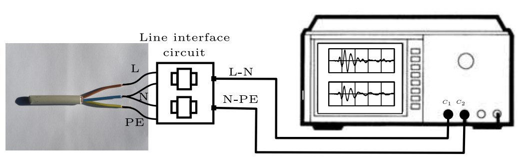

Fig. 1: Measurement setup for power line disturbances

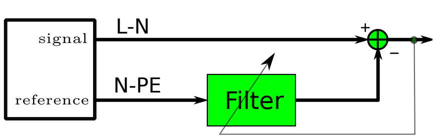

Fig. 2: Power line impulse-noise canceler

Instead of a common mode, as a cancellation reference, we use a second pair. Anyhow, a common-mode definition is a bit tricky in a non-symmetric powerline system. Figure 1 sketches the measurement setup, where we, of course, used specially designed coupling units with baluns to adapt to the characteristic impedance of typical inhouse power line cables of around 80 ohms (plus some protective measures).

Similar to our earlier works on impulse-noise cancellation [4], [5], we developed the normalized least mean squares (NLMS) canceler for power line disturbances as illustrated in Fig. 2. The canceler with the N-PE loop signal used as a reference partly provides sufficient impulse noise suppression. We used a standard LMS algorithm, gated when the impulse noise was exceeding a certain threshold. The cancellation outcome is shown in blue in the upper plots. The sampling rate (after down-sampling) was 60 MHz, i.e., we used a bandwidth of almost 30 MHz. The actual original measurement bandwidth was 450 MHz, but contributions at frequencies higher than 30 MHz can be neglected, unless strong RFI disturbers would be present.

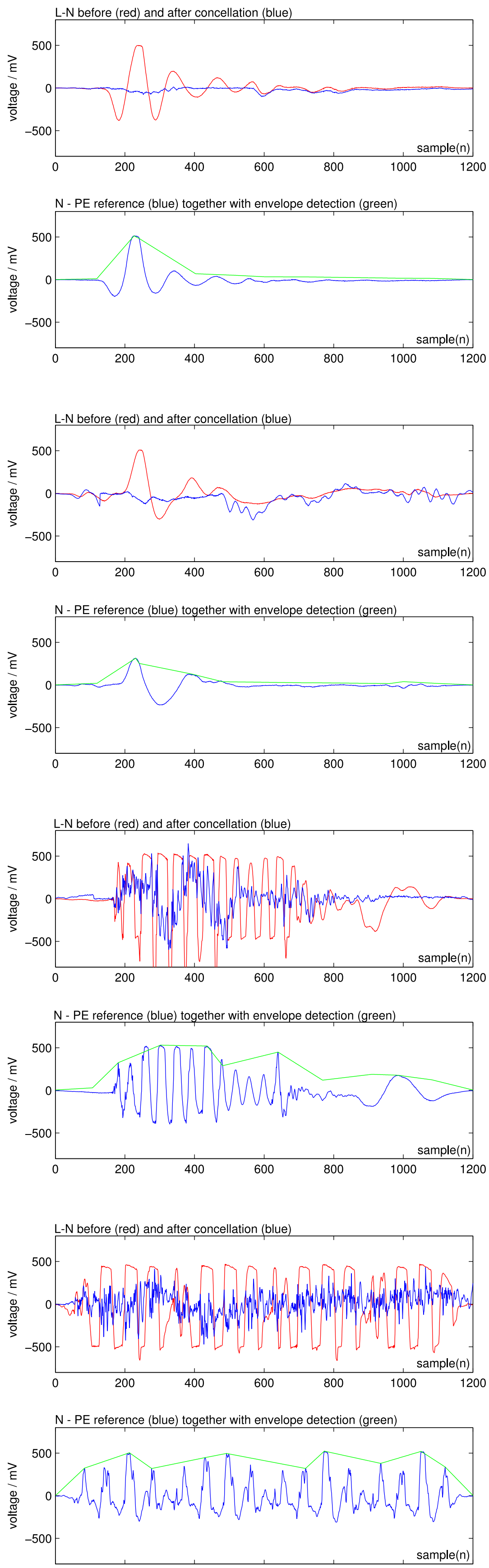

Fig. 3: Exemplary power line impulse noise (red) together with cancellation result (blue)

Figure 3 also clearly outlines the limitations of the simple canceler. The upper two examples show a significant suppression, the lower two show the sudden appearance of different impulse types, where the canceler is not trained sufficiently and will lead to significant residual disturbances. In home environments, one encounters even more different impulse shapes directly related to the switched appliances, even small LED lights show impressive impulse noise when they are turned on or off. Essentially, every switching event and mechanical contacts, especially, of course, engines, show significant and characteristic impulse noise. The variation of impulse types and location of origin asks for more advanced cancellation concepts than a single LMS-trained canceler.

Nevertheless, the simple canceler results are already promising, since in industrial settings, we often find a single dominant impulse-noise type, allowing for this simple procedure. One should note that in industrial settings, typically, a machine has a dedicated connection to a fuse box with a kind of star-fashion power provisioning, whereas in private homes, some power outlets and appliances might be connected to the same fuse.

III. Conclusions and Further Research

The simple cancellation has already shown significant impulse-noise suppression. Cancellation for multi-source impulse noise will have to rely on classification to adapt to different impulse noise origins. Instead of cancellation, one can, of course, also utilize the reference loop for just detecting the occurrence of impulse noise and use it for erasure marking, or more generally, as another source of "extrinsic" information. In the twisted pair application, erasure marking had proven to lead to comparable performances [6], [7].

References

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