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APPLICATION OF FFT TO DETECTION AND CANCELLATION OF IMPULSE NOISE ON A G3 POWER LINE CHANNEL

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Resumé

Le réseau électrique comme support de transmission engendre les bruits électromagnétiques de type impulsif suite aux appareils connectés, ceci risque d'absorber une partie du signal utile et crée des perturbations impulsives sur le canal du Courant Porteur en Ligne (CPL). Pour remédier à ce problème, ce papier propose la détection des perturbations impulsives produit grâce à la Transformée de Fourier Rapide à l'aide d'un oscilloscope. Nous avons effectué la simulation sur le logiciel de traitement automatisé (Matlab) pour l'analyse du spectre. Cela a consisté à charger le fichier des bruits électromagnétiques, découper les symboles OFDM (Orthogonal Frequency division Multiplexing), les traiter et les visualiser en fonctions du temps et la fréquence des perturbations impulsives. Nous avons proposé un algorithme qui s'est chargé de détecter la position de l'impulsion et d'effacer les échantillons temporels où l'impulsion a été détectée sur les appareils électriques de Classe 2. L'implémentation de cet algorithme donne des bonnes performances des bruits apériodiques impulsifs sur la densité spectrale de puissance du signal reçu.

Mots clés : Transformée de Fourier Rapide (FFT), Détection, Annulation, Bruit Impulsif et Courant Porteur en Ligne

Abstract

The electrical network, as a transmission medium, generates impulsive electromagnetic noise due to connected devices. This risks absorbing part of the useful signal and creates impulsive disturbances on the Power Line Communication channel. To solve this problem, this paper proposes the detection of impulsive disturbances produced by the Fast Fourier Transform using an oscilloscope. We performed the simulation on the automated processing software (Matlab) for spectrum analysis. This consisted of loading the electromagnetic noise file, cutting the OFDM (Orthogonal Frequency Division Multiplexing) symbols, processing them and visualizing them as functions of time and the frequency of the impulsive disturbances. We proposed an algorithm that was responsible for detecting the position of the pulse and erasing the time samples where the pulse was detected on Class 2 electrical devices. The implementation of this algorithm provides good performance for impulsive aperiodic noise on the power spectral density of the received signal.

Key words : Fast Fourier Transform, Detection, Cancellation, Impulse Noise and PLC (POWER LINE CHANNEL)-G3

1. INTRODUCTION

Smart Grids represent one of the technological directions of network modernization to support the permanent evolutions of the electrical system, following technological advances, there has been a massive deployment of high-speed, transmission techniques that can reach several hundred Mb/s and a high density on electrical outlets in a home.

Internet technologies integrated into the electrical network are transformed into a « Power Line Communication (PLC) which uses the electrical network as a transmission medium [1], [2] ». PLC communication technology superimposes the signal from the computer network to the electrical network, the data is modulated in another frequency range as a two-way field. It is a signal that sends this field in superpositions and the other that collects this signal in computer data.

The transmission of signals over power lines is confronted with several phenomena due to the connected electrical devices. Electrical devices are divided into four classes. These are connected to electrical outlets (for example: ovens, radio, lamps, televisions), they risk generating electromagnetic noise of the impulsive type on the transmission of the PLC signal [3] and have a non-zero impedance which risks absorbing part of the useful signal [4] , which gives a very unstable character and can create an electromagnetic pulse to the electrical channel.

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G3 PLC technology is based on multi-carrier OFDM modulation, which consists of distributing symbols across a large number of carriers. This involves multiplexing several signals of different frequencies and narrow bandwidths [5] to form a wideband signal. The symbols are transmitted in parallel across the entire carrier; the OFDM modulation technique [6], [7] consists of dividing the bandwidth into several orthogonal carriers.

Impulse noise, when it occurs, affects all the subcarriers used during the transmission of an OFDM symbol, which is generally present at the transmission and reception levels, generating disturbances on the transmission channel. In this context, we rely on the detection and cancellation of impulse noise.

To minimize the effect of noise causing significant fading of the useful signal in certain frequency bands, [6] proposes the solution on spread spectrum with Code Division Multiple Access (CDMA) multiplexing, our contribution focuses on OFDM multi-carrier transmission.

Our technique will be applied on the FFT (Fast Fourier Transform) at the receiver side, completely randomizes the impulse noise on the OFDM symbol. OFDM is implemented by the Fast Fourier Transform, the CPL-G3 system operates at a sampling frequency f_s= 1.2KHz and uses an FFT size M=256, which leads to a subcarrier spacing noted Δf=4.6875 KHz.

The question of our research is to know which classes of electrical devices disturb the electrical signal the most and how to cancel the noise produced by these devices? Impulsive noise cancellation is a very important task to optimize transmission schemes and improve the performance of PLC systems. Authors [8],[9] addressed this research question using impulsive noise cancellation, the proposed CDMA approach was realized using a retransmission mechanism at the MAC (Medium Access Layer) layer: where receivers must acknowledge the correct reception of a frame. If this acknowledgment is not received at the transmitter, the frame is retransmitted. The main disadvantage of using retransmission solutions for impulsive noise cancellation is the induced delay which can be extremely penalizing for real-time services.

To solve the problem of impulsive disturbances, we propose the use of orthogonal frequency division multiplexing, with the different carriers being orthogonal to each other. With OFDM, it is possible to have overlapping subchannels in the frequency domain, thus increasing the transmission rate.
In this paper focuses on the smart grid domain on G3 power line transmission; impulsive noise motivates research related to temporal and spectral characteristics.

- We describe the class of devices that most disrupt the signal on an electrical channel;
- We use the FFT approach to detect impulsive disturbances on OFDM symbols and propose an algorithm to cancel these disturbances on electronic devices connected to the electrical network (e.g., radio, television, charger, adapter, and computer). This approach addresses the limitations of previous work that neglects data multiplexing on the transmission channel.

We make the following assumptions, referring to [8]:

- Very high amplitude that risks saturating the receiver.
- A long total noise (a few ms) but which is actually a succession of much shorter noises (relatively few OFDM symbols affected).
- A large number of affected cells (erroneously) for each recording.

2. KEY CONCEPTS

a. Impulse Noise

In [10], noise is defined as a parasitic signal that overlaps useful information and causes signal interpretation errors. Many sources of noise are present in electrical networks, as defined above. We distinguish:
Disturbances generated by electrical devices;
Residual signals induced by signals radiated by radiocommunication systems.
The electromagnetic disturbances described in [11] are noises that can affect the electrical network due to temporal phenomena, including: Synchronous Impulse Noise: This type of noise consists of an impulse or a brief series of impulses that occur synchronously and periodically at 50 Hz.

This type of noise is modeled by the superposition of one or more elementary impulses, each of which is modeled by equation (1), which corresponds to a damped sinusoid proposed by.

$$Impulse\,(t) = A * \sin(\mathbf{2\pi f_p}\, t)\, \exp(-\boldsymbol{\alpha} \mathbf{t}) \qquad Eq.\ 1$$

Where: A represents the amplitude, fp represents the pseudo-frequency, and α represents the damping factor.
In the spectral domain, deterministic signals and noise are not commensurable, hence, we can use the signal-to-noise ratio defined by:

$$\frac{S}{N} = \int_0^\infty \frac{2|s(f)|^2 d_f}{S_n(f)} \qquad Eq.\ 2$$

This ratio is the sum of the ratios of the signal energy density to the noise PSD for each frequency. In the numerator of the integrated quantity, the factor 2 restores the power contained in negative frequencies, $s(f)$ being the Fourier transform of $s(t)$ and $S_n(f)$ the noise spectral density.

b. OFDM Signal

OFDM modulation consists of using independent subcarriers for signal transmission adapted to frequency-selective channels while limiting signal transmission in certain subcarriers [12] i.e., multiplexing several signals of different frequencies managed independently. Each frequency, called a carrier (subcarrier), is a sinusoid whose amplitude and/or phase allows information to be encoded. All possible combinations of amplitude and phase form a constellation, each point of which is associated with a certain amount of data.

c. Fourier Transform (FFT)

Fourier theory consists of transforming the time signal into the frequency spectrum (Fourier Transform) and vice versa from the frequency spectrum to the time spectrum (Inverse Fourier Transform). This technique is used to modulate an OFDM signal, the data to be transmitted on each carrier (amplitude and phase) are converted into the time domain using the Discrete Inverse Fourier Transform.

Each carrier in [13] modulates a symbol denoted c_k during a rectangular time window of duration T_{OFDM}. The total signal corresponding to the set of N symbols c_k (forming an OFDM symbol) defined in is given by:

$S(t) = \sum_{k=0}^{N-1} c_k \; e^{2j\pi f_k t}$
Avec $f_k = {}^{k}/_{T_{OFDM}}$
, où $S(t)$ is the Fast Fourier Transform
The Discrete Inverse Fourier Transform is defined by:

$$\boldsymbol{s(t) = \sum_{f=0}^{F-1} S(t) * e^{2i\pi t\frac{f}{F}}} \qquad \textit{Eq. 3}$$

For the signal $s(t)$ to be real, it is necessary

$$\boldsymbol{s(-f) = S^*(f)} \qquad \textit{Eq. 4}$$

3. LITERAL CONTEXT

G3 PLC technology is part of the narrowband PLC family, which best meets current needs in terms of data rates and transmission robustness, while ensuring an open standard.
This standard describes layer 1 of the OSI model, called the physical layer. It includes the mechanisms for selecting frequency bands, modulation types, transmission powers, and masking groups of carrier frequencies.
G3 PLC is based on multi-carrier modulation, where the symbols denoted c_k are distributed across a large number of carriers. This involves multiplexing (adding) several signals of different frequencies and narrowbands to form a wideband signal. These symbols are transmitted in parallel across all carriers. Each symbol occupies the entire transmission duration. Multi-carrier modulation makes it possible to cope with impulsive noise generating disturbances on multi-path channels characterized by their selectivity and their considerable time spread [14].
Impulse noise represents the most severe transmission constraint for PLC signals. Usually, this type of noise is defined by a train of pulses characterized by short durations, high PSD (Power Spectral Density) and random repetition frequency.

The duration of the pulses can vary from a few µs to milliseconds. This noise mainly comes from random switching on and off operations of electrical devices. In the frequency domain as described in the original work [16], [18], it has been observed that the PSD of the pulses exceeds in the majority of the frequency band. At the time of occurrence of the pulses, this PSD increases considerably in a short and rapid manner. In the time domain, the impulse noise of [18] can be modeled by damped sinusoids or by the superposition of damped sinusoids allowing to approximate the general shape of the pulses observed in the channel.

Originality of the work

The indoor electrical network in [16],[18] is particularly disturbed by impulsive noise due to the large number of devices connected to it. These types of noise are suppressed by the retransmission mechanism called Automatic Repeat reQuest (ARQ) whose solutions have essentially consisted of implementing a signaling procedure between the transmitter and the receiver, where the receiver requests the retransmission of a data unit that has not been received correctly. A positive or negative acknowledgment (ACK or NACK) is sent to the transmitter.
Previous research [18] defines the parameters for the applicability of the PLC G3 standard, listed in the table below:

Table 1 : G3 CPL parameters

Parameter	¨PLC G3
Frequency Band	[159.4-478.1] Khz
OFDM symbol duration	695 μs
Sampling frequency $\boldsymbol{f_s}$	1.2 Mhz
Spectrum spacing Δf	4.6875 Khz
Modulation	DBPSK, DQPSK
Maximum flow	207.6 Kbit/s

4. METHODOLY
4.1 OFDM signal

G3 PLC modems use OFDM multi-carrier modulation. The OFDM signal of [13] consists of N subcarriers of frequencies $f_k = f_0 + k\Delta_f$, $k \in [0{:}\,N-1[$, used for the parallel transmission of N symbols, denoted c_k . The symbols c_k are complex elements taking their value in a finite alphabet corresponding to a given digital modulation, such as for example a phase modulation and uses the function π as a shaping function. According to [14], [15], [17], this technique consists of dividing the bandwidth into several spaced orthogonal carriers (subbands) denoted $\Delta_{f={}^{1}/_{t}}$.

4.2 Fast Fourier Transform approach

The principle of OFDM modulation consists of sending the information on n subcarriers in parallel [19], then applying a Fourier transform to them. The fast Fourier transform is an algorithm for quickly calculating the discrete Fourier transform of a digital signal. To apply the Fourier transform to a signal or a block of data, it is sufficient to divide it into n small blocks, n being a power of two. Note that X_n represents the Fourier transform of the digital signal x_n and « N_e » the number of samples.

$$\boldsymbol{X_n(k) = \sum_{n=0}^{N_e-1} x_n . e^{-2j\pi\frac{nk}{N_e}}} \qquad \textit{Eq. 5}$$

où $0 < k < N_e$

5. EXPERIMENTAL DATA

To compare our proposed method with the original approach [18] impulse noise can be broadly classified into frequency domain, which captures the average noise spectrum, and time domain, which captures the impulse amplitude.
Starting from noise detection and suppression, we evaluate the transmission and reception data for the error on each carrier. Our goal is to use the FFT approach, when the impulse noise is added to the time samples of the OFDM signal, its influence is distributed by the Fast Fourier Transform over all OFDM symbols.

Our experiments are based on the following factors:
Impact of total disturbance duration on the number of errored OFDM symbols, duration of disturbance on the number of

errored OFDM symbols for each carrier.
Impulsive noise suppression on the number of errored cells.
We performed the simulation on impulsive disturbances with:

- ✓ The duration of an OFDM symbol: 10 µs
- ✓ The duration of the disturbance: 40.96 µs
- ✓ The bandwidth affected by a disturbance: 25.4 kHz
- ✓ An errored cell corresponds to a carrier whose value is 25.4 kHz.

And the parameters listed in the following table:

Table 2 : Parameters used for viewing the CPL G3

Parameter	Value
Sampling frequency f_s	1.2 Mhz
Symbol disturbance duration OFDM	40.96 μs
Size FFT	4096 points
Simulated channels	Measurements performed on the PLC adapter CPL
Noise injected for simulation	Recordings performed on the electrical network
Bandwidth affected by the disturbance	25,4 Khz
Number of erroneous cells	(1 cells =1 carrier) of 25,4 Khz

5.1. Visualization of the time signal

a. Description of Impulse Noise

The disturbances measured on the impulse noise are the electrical signals sampled using the oscilloscope, the temporal shape of the signal is observed by the FFT used to generate the frequency spectrum associated with the time signal defined in Fig. 1. The PSD of the impulse noises obtained using FFT is shown in Fig. 2.

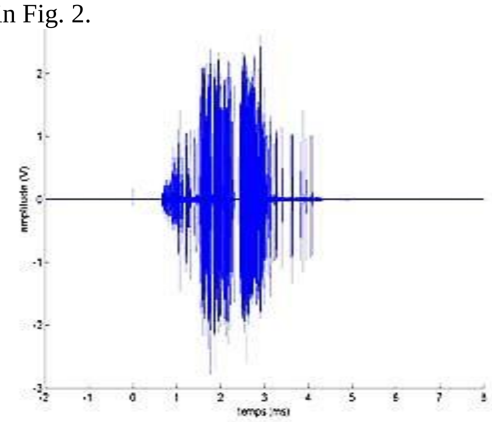


Figure 1: Impulsive noise

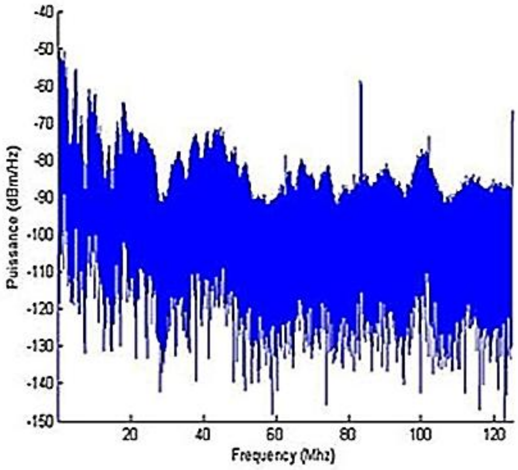


Figure 2: Impulse noise DSP

The impulse noise shown in Fig. 1 and the power spectral density shown in Fig. 2 are estimated at two different short instants instead of a single instant (represented by instant t1 and instant t2 in Fig. 3).

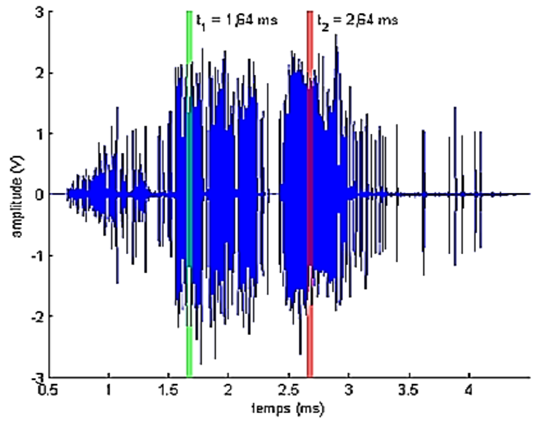


Figure 3: Aperiodic impulse noise

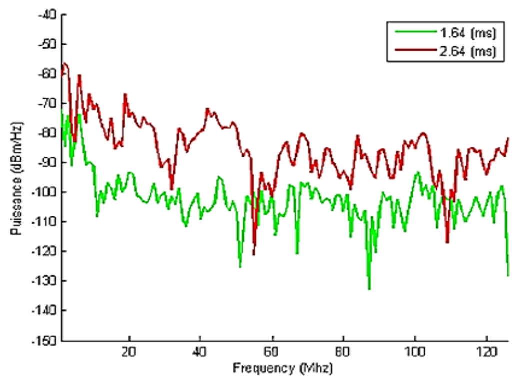


Figure 4: PSD Measurement for 2 instants

b. Application of OFDM system

The impact of impulsive noise is addressed by the system approach, whose acquisition is sliced using the OFDM symbol, with each OFDM symbol, the FFT is used to measure the noise level on each carrier [20]. The term cell is used to define the unit corresponding to a carrier on an OFDM symbol shown in fig. 5.

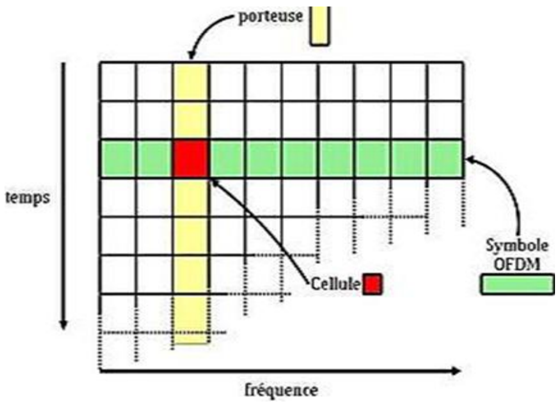


Figure 5: Terms used for estimating the impact of disturbances

Recordings of these disturbances are performed by the Spectrographic software under Matlab, a cell is considered erroneous if it exceeds 6 dB on the noise level with each OFDM symbol. Fig.6 shows the erroneous cell on adjacent carriers or adjacent OFDM symbols.

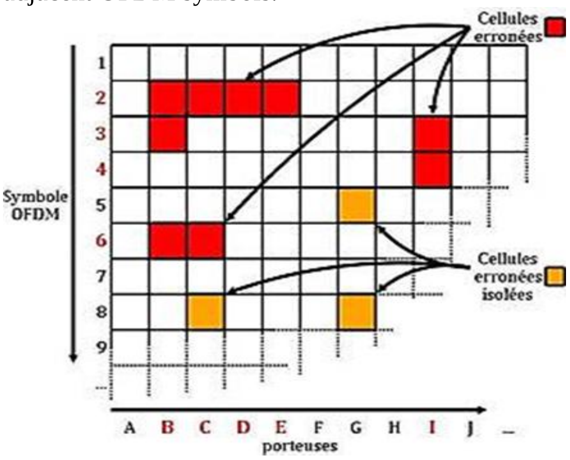


Figure 6: Erroneous cells and isolated erroneous cells.

The impact of the disturbance along several complementary axes is determined from the estimation on different erroneous cells. Previous work described in [21] shows that the disturbed frequencies and the time of the disturbance deduce the data of the erroneous cells. That being said an OFDM symbol is disturbed if and only if at least one cell is erroneous regardless of the carrier. OFDM symbols #2, 3, 4 and 6 are considered erroneous.
Similarly, a carrier is said to be affected by impulsive noise if and only if at least one cell is erroneous regardless of the OFDM symbol. Carriers B, C, D, E and I are therefore considered erroneous based on Figure 6, there are 9 erroneous cells for each recording.

5.2 Impulse noise cancellation on an OFDM symbol.

Referring to [22], we detected an OFDM symbol disturbed by a pulse. We propose an algorithm by localizing the disturbances obtained in frequencies, then canceling them as a function of time.

Proposed algorithm for canceling impulsive noise

Input

- Transmitted signal : float
- Received signal : float
- f [] : frenquencies (carrier)
- $\mathbf{A_{ref}(f)}$ (Amplitude at carrier f) : float
- $\boldsymbol{\varphi_{per}(f)}$ (Phase de perturbation à la porteuse f) : float
- $\boldsymbol{\varphi_{ref}(f)}$ (Phase du symbole perturbé à la porteuse f) : float
- $\mathbf{A_{ref}(f)}$ (Carrier amplitude f) : float

Output :

- S_received(f) Fourier transform of the noisy signal: float
- corrected_signal (The signal cleaned in the previous iteration): float
- new_corrected_signal (The signal cleaned in the current iteration): float
- corrected_signal (Corrected signal without impulse
- noise): float

Internal variables

- $\mathbf{\Delta t}$: (Time shift estimate): (float)
- $\boldsymbol{\Delta\varphi(f)}$: offset de phase
- $\boldsymbol{\Delta\varphi_{est}(f)}$: (Phase shift estimate): float
- $\mathbf{P_{est}(f)}$: (Noise estimate): float
- error (error between two iterations): float
- c.a (stopping criterion): float
- max_iter(maximum number of iterations):int
- iteration (iteration counter): int
- error (error between two iterations): float
- max_iter (maximum number of iterations): int
- iteration (iteration counter): int

1. Initialize iteration ← 0
2. Initialize t.c ← 0.001
3. Initialize max_iter ← 100
4. Initialize error ← ∞
5. Initialize corrected_signal ← received_signal
6. while (error > c.a) and (iteration < max_iter) do:
7. Apply FFT on corrected_signal → s_received(f)
8. For each frequency f :

a: $\boldsymbol{\Delta\varphi(f) = \varphi_{per}(f) - \varphi_{ref}(f)}$ (Eq.6)

b: $\boldsymbol{\Delta t = \Delta\varphi(f) \;/\; (2\pi f)}$ (Eq.7)

c: $\boldsymbol{\Delta\varphi(f) = 2\pi * \Delta t * f}$ (Eq.8)

d: $\boldsymbol{P_{est}(f) = A_{ref}(f) * e^{i\pi(\varphi_{ref}(f))} + \Delta\varphi_{est}(f)}$ (Eq.9)

End For

9/ Apply IFFT (S_received(f) - P_est(f)) = new_corrected_signal

10. error ← sqrt (corrected_signal - new_corrected_signal)
11. corrected_signal ← new_corrected_signal
12. iteration ← iteration + 1

End while

Complexy of an algorithm

We evaluated the complexity of the proposed algorithm at each step of frequency and time estimation and the number of operations performed as a function of the number of subcarriers (at n samples).

Complexity is 0(n log n) for the FFT on the noisy signal and 0(n) on each calculation carried out among others $\Delta\varphi(f)$, Δt , $\Delta\varphi(f)$,$P_{est}(f)$ with =1024 subcarriers.
Hance, the total complexity is 0(n log n) + 0(n)= 0(n log n)

6. RESULT AND DISCUSSION

6.1 Impulse noise detection

Operating devices generate very short-term disturbances whose characteristics are essentially related to time, the pulse duration, and the time between two pulses. The total duration of the disturbance is defined as the time between the first and last OFDM symbols containing an error regardless of the affected carrier.
In Fig. 6, this duration should be estimated at 204.80 µs, based on the time elapsed between the start of the second (first affected symbol) and the end of the sixth (last affected symbol) OFDM symbol.

This duration provides an accuracy that corresponds to the duration of the OFDM symbol (i.e., 40.96 µs) and does not exceed 10 ms over the acquisition duration, four symbols are considered affected (numbers 2, 3, 4, and 6). This corresponds to a cumulative duration of 163.84 µs across all of our recordings. Half of the recordings affect fewer than three OFDM symbols. This analysis shows that the impulsive noise is contained in multiple recordings.

- Average duration of the disturbance for each carrier

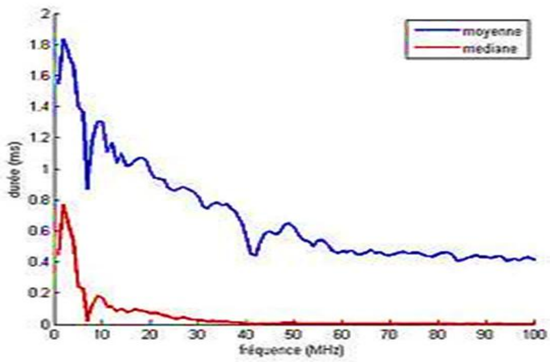


Figure 7: Average duration of the disturbance for each carrier.

For a given carrier, the duration of the disturbance for each carrier corresponds to the time between the first and last erroneous cell, Carriers D and E have a duration of 40.96 µs over 1 symbol, carrier I has a duration of 81.92 µs over 2 symbols, and carriers B and C have a duration of 204.80 µs over 5 OFDM symbols.
The average duration measurements of the disturbance for each frequency are presented in Fig. 7. We note that the pulse duration decreases with respect to frequency. The PSD of the pulses at the disturbance decreases with frequency. The channel transfer function between the disturbance and the receiver decreases with frequency.

- Number of erroneous symbols for each carrier

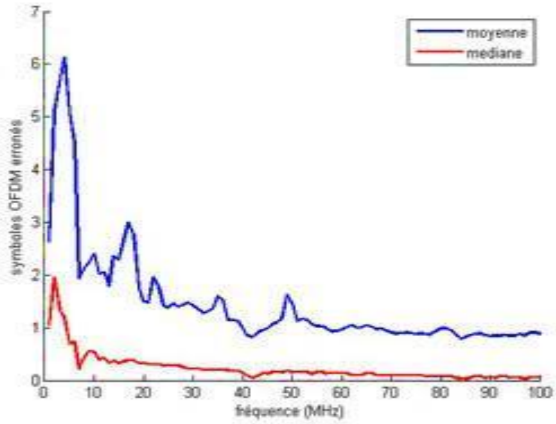


Figure 8: Number of erroneous symbols for each frequency band.

The indicator of the impact of interference as a function of frequency is the number of erroneous symbols for each carrier. Carrier B contains 3 erroneous symbols carriers C and I contain 2 erroneous symbols and carriers D and E contain 1 erroneous symbol. The similar curve is observed for the number of erroneous symbols and we notice that, high frequencies are less likely to be affected by impulse noise.

The transmitted signal level for high frequencies is lower if the effect of impulse noise is also lower this significantly limits the channel capacity.

6.2 Implementation of the algorithm

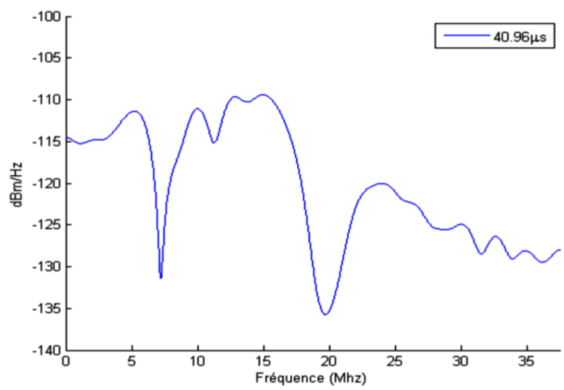


Figure 9: Shows the PSD corresponding to this reference perturbed symbol

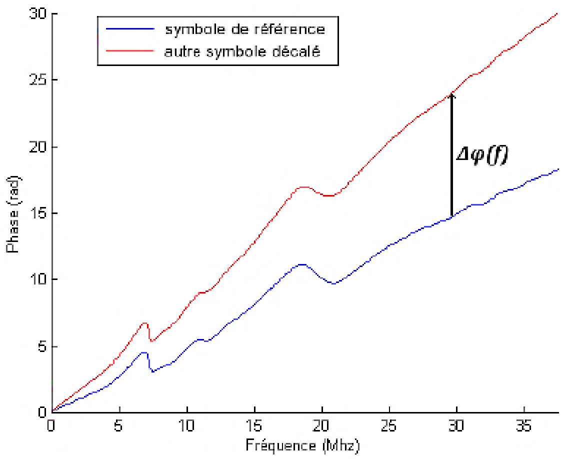


Figure 10: shows an example of this phase shift

In terms of phase, the time shift Δt between the two pulses will introduce a shift $\Delta\varphi(f)$in the phase of the disturbance $\varphi_{per}(f)$relative to the phase of the disturbed reference symbol $\varphi_{ref}(f)$. This algorithm was proposed for the case of asynchronous periodic disturbances that repeat in a completely similar manner from one pulse to the next, when the repetition period of these noises is less than the period of the OFDM symbol, the elementary pulse is likely to occur N to N+1 times (where N corresponds to the integer value of the ratio between the duration of the OFDM symbol and the period of the disturbance).

For these disturbances it is sufficient to record two reference waveforms, corresponding to these two possible cases. Thus, for the disturbance in fig. 11 which is repeated at 39 kHz (likely to be repeated 1 or 2 times for a symbol of 40.96 µs) we will define, in addition to the waveform in fig. 10, a reference waveform with two pulses:

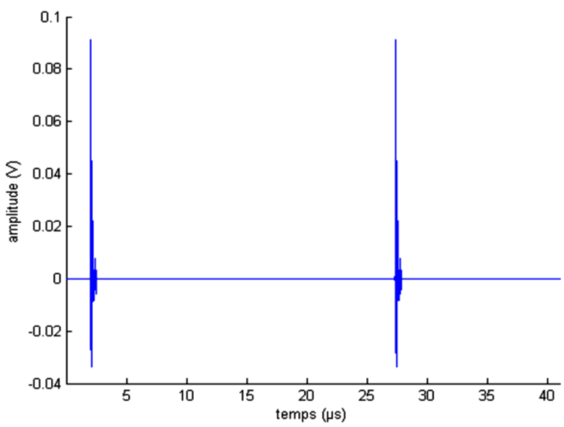


Figure 11: Waveform with two pulses offset by 39 kHz.

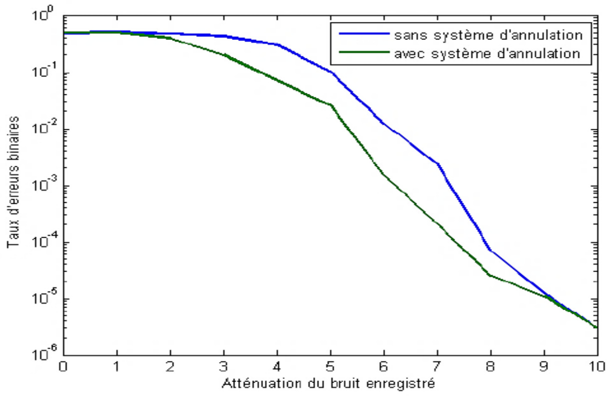
After applying this cancellation algorithm to various noise recordings, we discovered two minor limitations. First, we noticed that the repetition frequency of asynchronous periodic impulse noise could vary over time, these variations can cause errors in the estimation of different waveforms since we are attempting to subtract noise whose frequency is not identical to that of the original noise.

Second, if the pulse is located at the beginning or end of the OFDM symbol it is possible that it will be truncated. In this case, the system is disturbed by a different waveform. Recording new waveforms, corresponding to higher repetition frequencies and truncated pulse shapes overcomes these limitations.

6.3 Performance Analysis

We implemented our noise cancellation system on the simplified transmission chain by varying the power of recorded asynchronous periodic pulses. The elementary form was manually defined based on a graphical analysis of the recordings with Matlab, pulse position detection is performed solely by measuring Δα (f) on the off carriers.

We proposed an algorithm whose efficiency was measured by the square error between the received symbol and the decoded symbol is performed. I
f this mean square error has increased with the algorithm we return to the original received symbol (which avoids deteriorating performance if no pulse is present or if the pulse is not detected), The raw bit error rate between the transmitted data and the decoded data is then calculated with or without the algorithm in place.



This curve shows a significant improvement in BER. This good performance was achieved for noise where the contribution of asynchronous periodic pulses is significant to the PSD of the received signal.
If the pulse energy is not significantly greater than the rest of the impulsive noise the system may fail to locate the pulse position, this limitation is not problematic, since low-energy asynchronous periodic pulses have a much lesser impact on throughput. This algorithm is therefore of particular interest since its efficiency increases with the power and the effect of the disturbance.

Figure 12: shows the evolution of the binary error rate with ans without the algorithm

Table 3: This table presents the different authors who have worked on impulsive noise, we have detailed their objectives, their contributions as well as the limits of the methods used in each study.

Authors	Objective	Contributions of the study	Limitations
Mouhcine Mendil et all. [16]	Study the robustness of the CSMA/CA mechanism in congestion situations. Afert a random waiting time (bockoff) G3 modems check, before transmitting, that the channe lis free based on the detection of preamble symbols to identify a competing transmission.	Proposed adding noise level detection to PCS (Physical Carrier Sence). This channel listening process consists of detecting at least two preambule symbols of a frame, sent at the beginning of a transmission. if no preambule is decoded, the modem considers that no transmission is in progress, and that the channe lis available. Conversely, preambule symbols are decoded, a complementary mechanism called VCS(Virtual Carrier Sense) follows the state of the communication until its end, to avoid interfering with transmission and related transmissions.	The CSMA/CA methos is inefficient in the noise detection mechanism on subcarriers and less good when multiple modems try to access the channel at the same time.
Samir Laksir et all. [18]	If coding algorithms are not used in recording of impulsive noise, error correction and interleaving systems may be sufficient to ensure correction of affected data.	This study proposes a system for acknowledging and retransmitting erroneous data of the ARQ (Automatic Repeat Quest) type to retransmit the information once the disturbance is over. It is a more reliable system since even very large noises can be corrected, and offers less latency in the absence of impulsive noises.	The retransmission sytem is limited when there is an increase in the number of availabe services and the increase in the flow rate required for each of these services requires optimizong each of these processes.
Wendyida Abraham Kabore et all. [21]	Presents signals from multicarrier transmission such as those encountered in PLC can be represented in matrix form where errors can occur in blocks : either on a row or on a column (these errors are know as cris-cross), the column of the matrix is a OFDM symbol	To combat impuse noise and/or narrowband interference in PLC, these authors proposed the coding system known as rank-based metric coding, in particular Gabidulin codes used for the correction of errors exhibiting a criss-cross pattern.	Impossible to transform OFDM signals matrix form to map row to users and column to carriers (subcarriers) time domain

7. CONTRIBUTION

The contribution of this study was to detect impulsive disturbances in the frequency domain based on the spectrum and the time domain based on the pulse amplitude. This study integrates the FFT approach, which made it possible to detect these different disturbances in a home network on different devices connected to the electrical grid.

We proposed an algorithm that eliminates these disturbances using the OFDM technique. The orthogonal subcarriers obtained using this frequency technique ensure that the signal from one subcarrier does not disturb another subcarrier.

8. CONCLUSION

In this study, we used the OFDM approach which demonstrates that the OFDM approach showed that recorded impulsive noise, class 2 noise, has a significant impact on signal transmission. We used the OFDM approach to generate the impulsive noise by splitting the symbol into subcarriers implemented by the Fourier Transform.

These impulsive noise detection techniques represent a significant improvement over existing techniques both in terms of performance and complexity. By leveraging the noise measurements we conducted on the electrical network, it was possible to define detection systems for off-carriers, and the proposed cancellation algorithm aims to combat asynchronous periodic disturbances by learning the waveforms of these impulses.

A measurement of the mean square error between the received symbol and the decoded symbol was performed to determine the algorithm's effectiveness.
In the future, however, the separate study of conducted and radiated disturbances would be interesting to evaluate the advantage of a new type of shielded or twisted electrical cable which would avoid the appearance of radiated disturbances or of a circuit breaker isolating external disturbances.

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