Hence, it is desirable to develop a method for acquiring an electrical signal representative of the reflected electromagnetic wave with an advantageous useful signal-to-noise ratio, which is rapid and which can be used without any prior knowledge of the noise parameters.

It should be noted that a similar problem arises in fields other than the field of electro-optical probing of electronic components. In general, the problem arises in any technical field involving an acquisition of highly noisy transient signals.

Embodiments of the invention aim at overcoming the aforementioned problems.

Accordingly, an aspect of the invention provides a method for reconstructing a useful signal from an acquired signal composed by a plurality of samples representative of measured physical quantities, the acquired signal including said useful signal noised by a noise, implemented by a processor of a programmable device.

This method includes:

- a decomposition of the acquired signal on a predetermined wavelet decomposition base, according to a given number of decomposition levels, and the obtainment of corresponding wavelet coefficients representative of said acquired signal,
- an estimation of a value representative of the standard deviation of said noise from at least one portion of the wavelet coefficients,
- an implementation of an iterative method for reconstructing parsimonious signals on the acquired signal, with a dictionary constructed from the wavelet decomposition base, said iterative method having an associated stopping criterion, the stopping criterion being calculated according to the estimated value representative of the noise.

Advantageously, the method of the invention may allow reconstructing a useful signal from a noisy acquired signal, without any prior knowledge of the noise level.

Advantageously, the use of a wavelet decomposition may allow obtaining a spatio-temporal characterization of the acquired signal, regardless of the underlying characteristics of the useful signal.

The method according to embodiments of the invention may present one or more of the features hereinbelow, considered independently or according to any technically feasible combination.

The estimation of a value representative of the standard deviation of said noise includes the estimation of a median value of the absolute values of the amplitude of the considered wavelet coefficients.

When the noise is a white noise characterized by a centered Gaussian distribution, independently distributed for each sample of the acquired signal, the estimation of a value representative of the standard deviation of said white noise

includes the weighting of said median value by a quantile of a centered Gaussian distribution with a variance equal to one.

The stopping criterion is calculated from an estimate of the norm L2 of said white noise.

The method includes a step of automatic determination of the number of wavelet decomposition levels to perform.

The method includes a step of selecting a mother wavelet allowing defining the wavelet decomposition base to use.

The acquired signal is representative of an electrical signal obtained from an opto-electronic signal reflected by an electronic component to be tested.

According to another aspect, the invention provides a device for reconstructing a useful signal from an acquired signal composed by a plurality of samples representative of measured physical quantities, the acquired signal including said useful signal noised by a noise, implemented by a processor of a programmable device. This device includes modules adapted to implement:

- a decomposition of the acquired signal on a predetermined wavelet decomposition base, according to a given number of decomposition levels, and the obtainment of corresponding wavelet coefficients representative of said acquired signal,
- an estimation of a value representative of the standard deviation of said noise from at least one portion of the wavelet coefficients,
- an implementation of an iterative method for reconstructing parsimonious signals on the acquired signal, with a dictionary constructed from the wavelet decomposition base, said iterative method having an associated stopping criterion, the stopping criterion being calculated according to the estimated value representative of the noise.

According to an embodiment, the invention includes a computer program including software instructions which, when implemented by a programmable device, implement a method for reconstructing a useful signal from an acquired signal as briefly described hereinabove.

According to an embodiment, the invention includes a method for processing a plurality of digital signals, each digital signal being composed by a plurality of samples representative of measured physical quantities, including an acquisition of said plurality of digital signals, each acquired digital signal corresponding to a sample of a bi-dimensional digital image, each acquired digital signal including a useful signal noised by a noise, including an implementation of a method, as briefly described hereinabove, for reconstructing the useful signal corresponding to each acquired signal.

According to an embodiment, the processing method includes a step of acquiring a digital signal for a current pixel of the bi-dimensional digital image, and a step of selecting a next pixel to process as a current pixel.

According to an embodiment, after reconstruction of a useful signal corresponding to each acquired signal, the method includes, for at least one portion of the samples of said bi-dimensional digital image, a step of calculating a dominant frequency from the useful signal associated to the sample, so as to form a frequency mapping associated to said bi-dimensional image.

According to an embodiment, each acquired digital signal is representative of an electrical signal obtained from an opto-electonic signal reflected by an electronic component to be tested, the method enabling an analysis of said component.

According to an embodiment, the invention includes a device for processing a plurality of digital signals, each digital signal being composed by a plurality of samples representative of measured physical quantities, including an acquisition of said plurality of digital signals, each acquired digital signal corresponding to a sample of a bi-dimensional digital image, each acquired digital signal including a useful signal noised by a noise, including a device for reconstructing a useful signal from an acquired signal composed by a plurality of samples representative of measured physical quantities as briefly described hereinabove.

According to an embodiment, the invention includes a computer program including software instructions which, when implemented by a programmable device, implement a method for processing a plurality of digital signals as briefly described hereinabove.

Other features and advantages of the invention will come out from the description which is given hereinbelow, for an indicative and non-limiting purpose, with reference to the appended figures, among which:

- Figure 1 schematically illustrates an electro-optical system for analyzing an electronic component in which the invention finds application;
- Figure 2 illustrates an example of an acquired signal and an estimate of the corresponding useful signal;
- Figure 3 is a flowchart of the main steps of a method for reconstructing a useful signal according to an embodiment of the invention;
- Figure 4 is a diagram representing the functional blocks of a programmable device capable of implementing the invention;
- Figure 5 is a flowchart of the main steps of a method for processing signals implementing a method for reconstructing useful signals according to the invention;

CLAIMS

1. A method for reconstructing a useful signal from an acquired signal composed by a plurality of samples representative of measured physical quantities, the acquired signal including said useful signal noised by a noise, implemented by a processor of a programmable device, wherein the method includes:

– a decomposition of the acquired signal on a predetermined wavelet decomposition base, according to a given number of decomposition levels, and the obtainment of corresponding wavelet coefficients representative of said acquired signal,

– an estimation of a value representative of the standard deviation of said noise from at least one portion of the wavelet coefficients,

– an implementation of an iterative method for reconstructing parsimonious signals on the acquired signal, with a dictionary constructed from the wavelet decomposition base, said iterative method having an associated stopping criterion, the stopping criterion being calculated according to the estimated value representative of the noise.

2. The reconstruction method according to claim 1, wherein the estimation of a value representative of the standard deviation of said noise includes the estimation of a median value of the absolute values of the amplitude of the considered wavelet coefficients.

3. The reconstruction method according to claim 2, wherein said noise is a white noise characterized by a centered Gaussian distribution, independently distributed for each sample of the acquired signal, wherein the estimation of a value representative of the standard deviation of said white noise includes the weighting of said median value by a quantile of a centered Gaussian distribution with a variance equal to one.

4. The reconstruction method according to any one of claims 1 to 3, wherein the stopping criterion is calculated from an estimate of the norm L2 of said noise.

5. The reconstruction method according to any one of claims 1 to 4, wherein the method includes a step of automatic determination of the number of wavelet decomposition levels to perform.

6. The reconstruction method according to any one of claims 1 to 5, wherein the method includes a step of selecting a mother wavelet allowing defining the wavelet decomposition base to use.

7. The reconstruction method according to any one of claims 1 to 6, wherein the acquired signal is representative of an electrical signal

obtained from an opto-electronic signal reflected by an electronic component to be tested.

8. A method for processing a plurality of digital signals, each digital signal being composed by a plurality of samples representative of measured physical quantities, including an acquisition of said plurality of digital signals, each acquired digital signal corresponding to a sample of a bi-dimensional digital image, each acquired digital signal including a useful signal noised by a noise, including an implementation of a method according to any one of claims 1 to 7 for reconstructing the useful signal corresponding to each acquired signal.

9. The processing method according to claim 8, wherein the method includes a step of acquiring a digital signal for a current pixel of the bi-dimensional digital image, and a step of selecting a next pixel to process as a current pixel.

10. The processing method according to claim 9, wherein the method includes, after reconstruction of a useful signal corresponding to each acquired signal, for at least one portion of the samples of said bi-dimensional digital image, a step of calculating a dominant frequency from the useful signal associated to the sample, so as to form a frequency mapping associated to said bi-dimensional image.

11. The processing method according to any one of claims 8 to 10, wherein each acquired digital signal is representative of an electrical signal obtained from an opto-electonic signal reflected by an electronic component to be tested, the method enabling an analysis of said component.

12. A device for reconstructing a useful signal from an acquired signal composed by a plurality of samples representative of measured physical quantities, the acquired signal including said useful signal noised by a noise, implemented by a processor of a programmable device, characterized in that it includes modules adapted to implement:

- a decomposition of the acquired signal on a predetermined wavelet decomposition base, according to a given number of decomposition levels, and the obtainment of corresponding wavelet coefficients representative of said acquired signal,
- an estimation of a value representative of the standard deviation of said noise from at least one portion of the wavelet coefficients,
- an implementation of an iterative method for reconstructing parsimonious signals on the acquired signal, with a dictionary constructed from the wavelet decomposition base, said iterative method having an associated stopping criterion, the stopping criterion being calculated according to the estimated value representative of the noise.