

Study and Realization of an Alarm System by Coded Laser Barrier Analyzed by the Wavelet Transform

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Abstract

This article introduces the study and realization of the laser barrier alarm system, after the laser is obtained by an electronic card, the wireless control system is connected to the control room to announce the application in real time, and the laser is used in many applications fields, from industry to medicine, in this article on the basis of Industrial applications such as laser barrier. It uses an alarm system to detect and deter intruders. Basic security includes protecting the perimeter of a military base or a safety distance in unsafe locations or near a government location. The first stage secures surrounding access points such as doors and windows; The second stage consists of internal detection with motion detectors that monitor movements, In this article, we adopt the embodiment of a coded laser barrier that is transmitted between two units, processes the signal, compares the agreed conditions, and to be high accuracy, we suggest using wavelet transmission to process the received signal and find out the frequencies that achieve alarm activation considering that the transmitted signal They are pulses, but after analysis with a proposed algorithm, we can separate the unwanted frequencies generated by the differential vibrations in order to arrive at a practically efficient system.

Keywords : Wavelet Transform; Lasers Sources ; Radio Frequency; Laser Coded Barriers; Alarm System.

1- Introduction

In recent years, warning and protection systems have been developed in several fields, similar to the military field, where lasers have been used to detect any attempt to penetrate the wall of military barracks. In addition to the existing technologies in this field, we are working on the use of coded lasers, which means that we send very limited pulses in frequency and periodic ratio, as well as in the number of pulses during a pre-agreed period of time[1].

Laser pulses can be obtained through an electronic circuit with analog processing, and to eliminate any noise in the receiving circuit, we filter the signal using wavelet transformation, thanks to which we get high accuracy and an effective system that works in real time[2].

In addition to activating the alarm, this system can also work to send information via radio waves to the control room so that the leadership can make decisions at the same time[2,3].

2- Photovoltaic Barriers

Photovoltaic barriers are optical or electronic systems consisting of a sensor (receiver) and a light source (emitter). The light source can be an ordinary lamp, an infrared emitter (for example, a pulse), LEDs or a laser emitter [2].

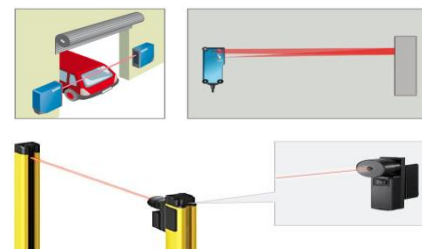


Fig.1 Photovoltaic barriers

3- Laser Barrier Application

Single barriers consist of a separate interacting transmitter and receiver. Reflex barriers and detectors combine sensor and light source in a single box. In reflex barriers, the emitted light beam is returned by a reflector (prism, reflective sheet) to the receiver.. [4] ,Light barriers register an interruption in the light beam and convert the information. If an object passes through the beam of an optoelectronic barrier, the sensor generates a predefined electrical output signal. It triggers an alarm. Detectors send a very fine infrared beam and react to the reflection of light from an object. The maximum detection distance depends largely on the reflectance rate, shape, color and surface quality of the material[5,6,13].

4- System Structure

The corresponding figure shows the stages of transmitting and processing information that determines with high accuracy all the electronic circuits on which this project depends, as it consists of a laser transmitter encoded between two transmitting and receiving units, the processing stage, and the activation of the alarm with the radio wave communication system.

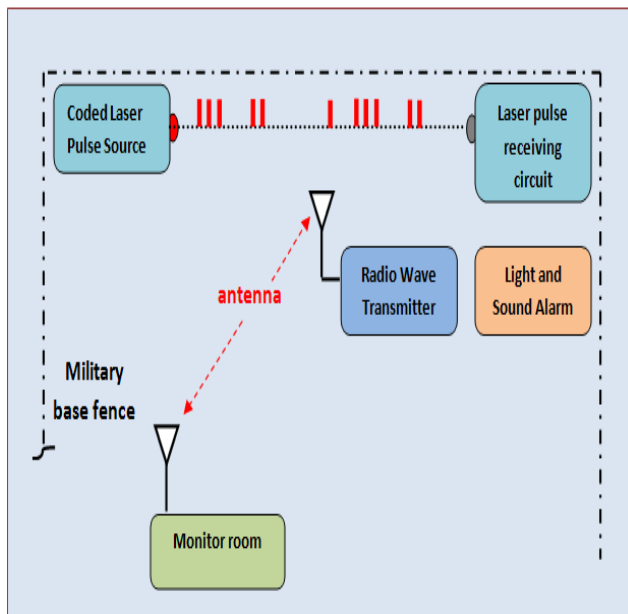


Fig.2 Configuration of the whole system

5- Laser Transmitter Circuit

The corresponding circuit shows the electronic card responsible for producing the laser pulses, with the possibility of changing the frequency and the periodic ratio[7].

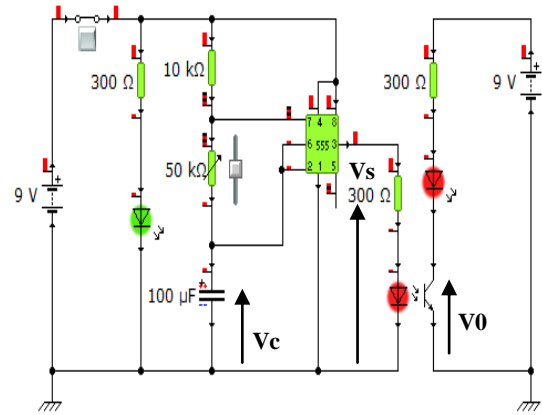


Fig.3 Lasertransmission circuit

Circuit Diagram simulated in Crocodile Technology 607 has shown in Fig-4

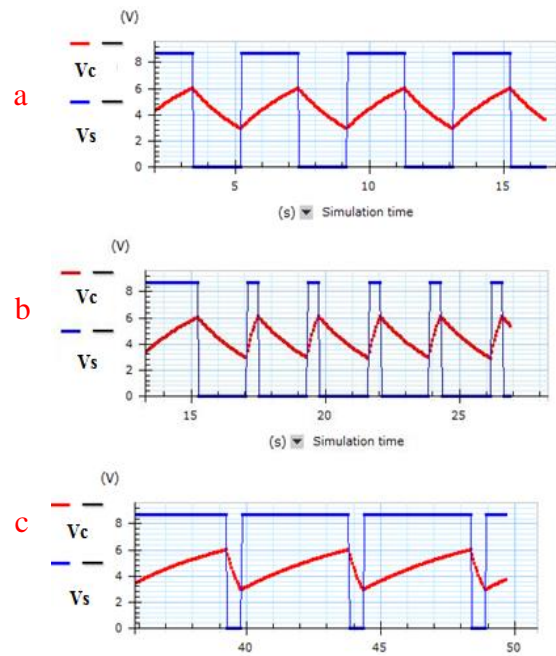


Fig.4 Simulation results of the laser transmitter circuit
 a . square electric signal , b . pulse signal ,
 c . rectangularsignal

Applied results of the transmission circuit obtained using an oscilloscope

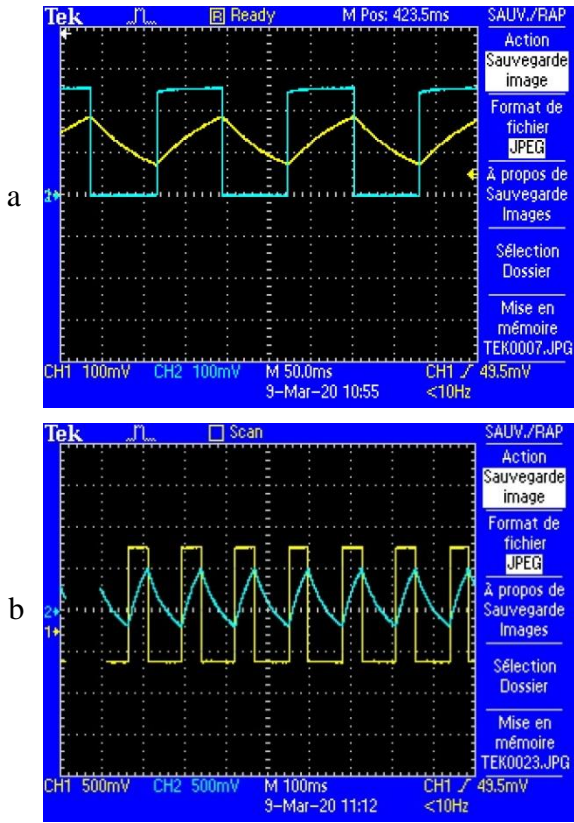


Fig.5 The real results of the laser transmitter circuit
 a . square electric signal, b . pulse signal

6- Laser Receiver Circuit

Comparator is one of the most important components of analog integrated circuits [14], The receiving circuit relies on a practical amplifier that compares the voltages E^+ and E^-

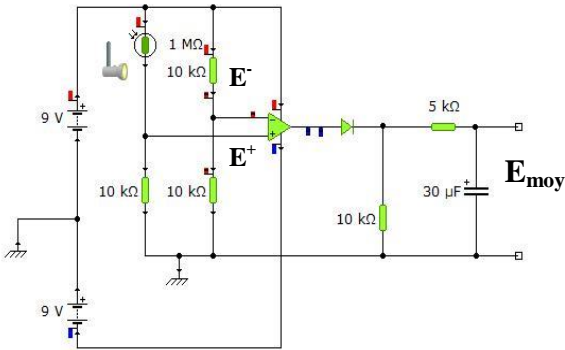


Fig.6 Laser receiving circuit using comparator LM741

After receiving and processing the laser beam, we get the following signal

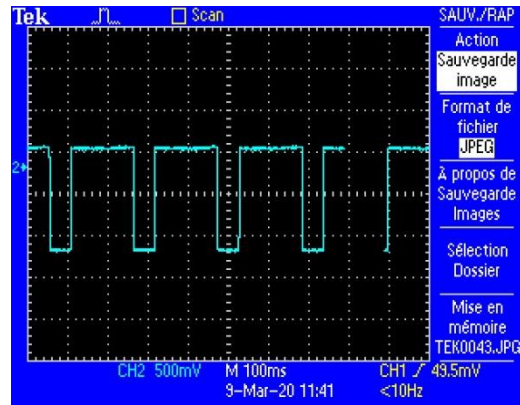


Fig.7 Transmission results by changing the periodic ratio

The signal obtained is either square, rectangular or pulsed, depending on the transmission signal, and accordingly, the average value can be calculated as follows:

$$\bar{E} = \frac{1}{T} \int_0^T E(t).dt \dots \dots \dots (1)$$

$$\bar{E} = \frac{1}{T} \int_0^{t_1} E(t).dt + 0 \dots \dots \dots (2)$$

$$\bar{E} = \frac{1}{T} E.t_1 \dots \dots \dots (3)$$

Knowing that the mean value is proportional to the duration t_1 then

$$\bar{E} = \eta.E \dots \dots \dots (4)$$

η : The Cyclic Report

The following circuit is to compare the average value of the main signal and the reference voltage, to increase the accuracy by adding another practical amplifier and some electronic components

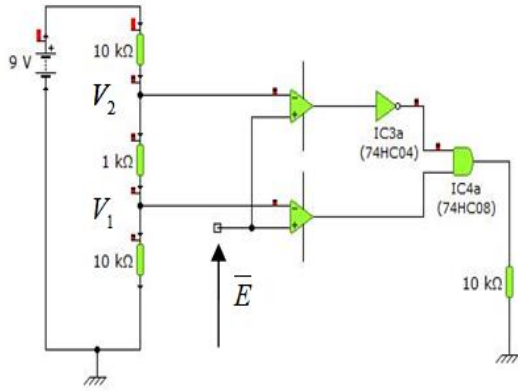


Fig.8 Comparison circuit with two amplifiers LM 741

$$\bar{E} = 2.5V \quad V1 = 2.3V \quad V2 = 2.8V$$

So $V1 < \bar{E} < V2$ for this condition the alarm system in the off state because no laser beam cut between the two cards (transmission & reception).

7- Processing Circuit

The main processing circuit consists of the following electronic components

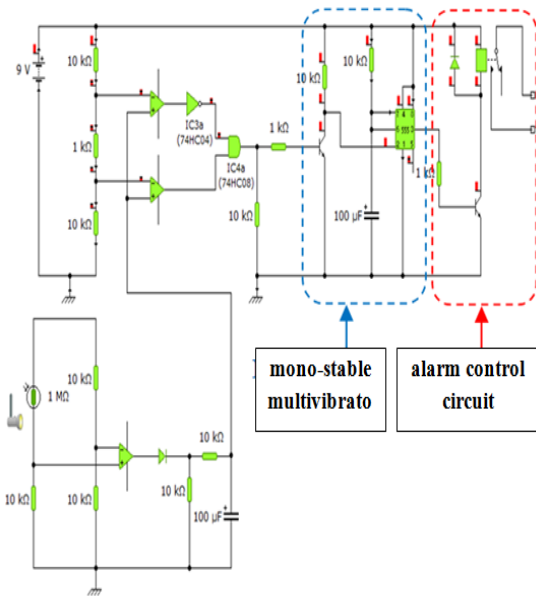


Fig.9 Electronic circuit of the project

The corresponding figure represents the printed circuit of the project using ExpressPCB software and electronic components CMS

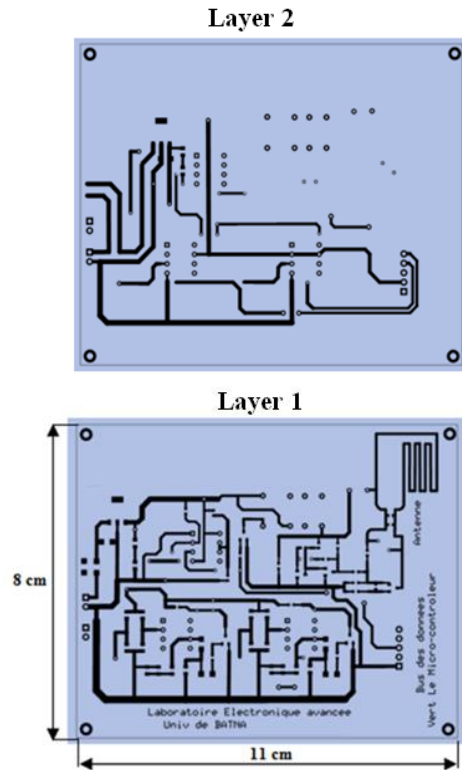


Fig.10 The mother card for the project

The following figure shows the real picture of the project with the processing circuit and data transmission using radio waves.

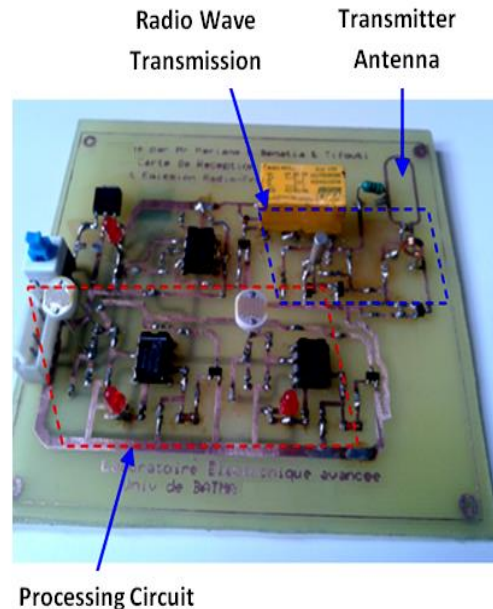


Fig.11 The final electronic card for the project

8- Experimental Results

The figures above show the transmit and receive signal with duty cycle approximately 25% & 75% respectively

- Emission signal
- Reception signal +/- 12

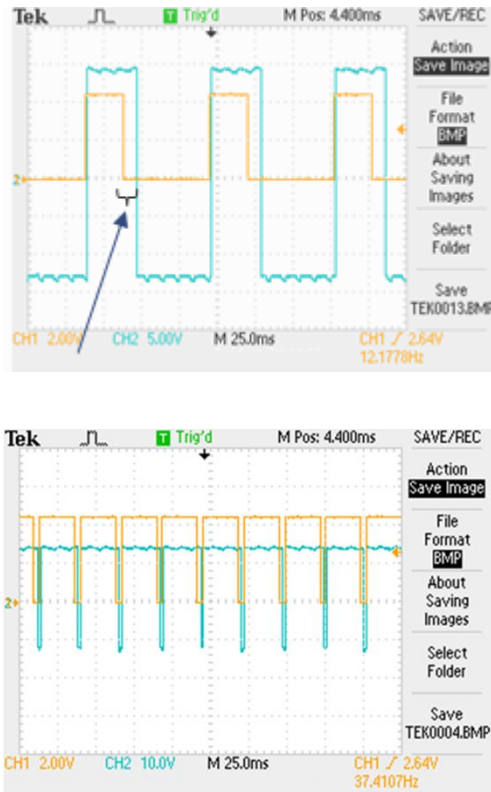


Fig.12 Experimental results

9- Analysis of the Reception Signal by Wavelet Transformation

In recent years, it has widely adopted wavelet transform (WT) and various signal analysis measures in the TF field, and can guarantee the temporal and spectral accuracy in the entire frequency range, as WT has been used in many applications, such as signal deconvolution, imaging processing, noise removal and speed improvement sound classification, etc. [8]. Chu and Kim applied the Morlett wavelet transform to analyze the effect of noise.

Wavelets have two important properties: firstly, the scaling factor, and secondly, the transformation and the relationship between them roughly agrees to the scaling process. Compressed waves are used. When high-

bandwidth waves are extended, they correspond to low-frequency signals [9], in low-bandwidths, they correspond to rapidly changing physical signals and magnitudes consisting of high frequencies. In contrast to other theories such as (Fourier transforms, etc.) used in signal processing, waves allow signals to be analyzed in both frequency and time domains. There are two types of wavelet transfers: continuous and discrete existent transports. Both transformations are continuous in time (analog), and with their help analog signals can be represented [10].

10- General Theory of CWT

In this work, we only touched upon some of the basic equations, definitions and concepts of wavelet transform, and a more rigorous mathematical treatment of this topic can be found in [10,11]. The time continuous wavelet transform of $f(t)$ is defined as:

$$CWT_{\psi} f(a,b) = \frac{1}{\sqrt{a}} \int_{-\infty}^{+\infty} f(t) \psi^* \left(\frac{t-b}{a} \right) dt \dots \dots (5)$$

Here $a, b \in R, a \neq 0$ and they are dilating and translating coefficients, respectively. This multiplication of $|a|^{-1/2}$ is for energy normalization purposes so that the transformed signal will have the same energy at every scale. The analysis function $\Psi(t)$, the so-called mother wavelet has to satisfy that it has a zero net area, which suggest that the transformation kernel of the wavelet transform is a compactly support function[10].

We can say that a disadvantage of CWT is that the representation of the signal is often redundant, because a and b are continuous over R (the real number). As the original signal can be completely reconstructed by a model copy of $Wf(b, a)$. Usually, we try $Wf(b, a)$ in a binary network i.e., $a = 2^{-m}$ and $b = n \cdot \Delta$, $n \in Z^+$. Substituting the last one into

$$DWT_{\psi} f(a,b) = \int_{-\infty}^{+\infty} f(t) \psi^*(t) dt \dots \dots (6)$$

where $\Psi_{m,n}(t) = 2^{-m} \Psi(2^m t - n)$ is the dilated and translated version of the mother wavelet $\Psi(t)$ [10,11].

11- Temporal and Spectral Resolutions in the CWT

Resolutions in the time and frequency domains are critical for evaluation of performance of different wavelets. The temporal resolution in the time domain σ_t and the spectral resolution in the frequency domain σ_w of the CWT can be defined as[5]:

$$\sigma_t^2(\gamma) = \int_{-\infty}^{+\infty} (t - u\gamma)^2 |\phi_\gamma(t)|^2 dt \quad \dots\dots(7)$$

DWT is a mathematical tool for decomposing data in a top-down manner. DWT represents a function in terms of a rough overall form, and a wide range of details. Despite of the requirement and type of function i.e., signals images etc. DWT offers sublime methodology and technique for representing the amount of detail present.

Wavelets perform and offer scale based analysis for a given data. A wide range of applications and usage has been found for these wavelets including signal processing, mathematics and numerical analysis and, for its better performance in signals and image processing it is considered an alternative to Fast Fourier Transform as DWT provide time frequency representation When there is a need for processing and analyzing non stationary tool, DWT can be used .Study shows that discrete wavelets transform have a high performance in speech signal processing so far [9,12].

Computer-assisted experiment (CAM) is not fundamentally different from experimentation as it has been traditionally performed using different measuring instruments and laboratory equipment, but the integration of the new algorithms in the signal processing of the laser pulses brings many advantages. The data acquisition process can be automated, and the measurement results can be easily saved and manipulated by various software tools. In addition, the presentation of the results in a graphical form is greatly simplified, which facilitates the analysis and use of wavelet transform on the obtained signal.

12- Acquisition of Reception Signal with Cooledit

CoolEdit program is used to record electrical signals that are proportional to the physical quantities to be processed and will be recorded in a one-dimensional matrix at a sampling frequency of 64 kHz using a 16 transducer called the sampling period.

$$T_e = \frac{1}{F_e} = \frac{1}{64 \times 10^3} = 0.015 \times 10^{-3} s \quad \dots\dots(8)$$

The following design represents how to record the electrical signal from the receiving circuit using computer-assisted experiments.

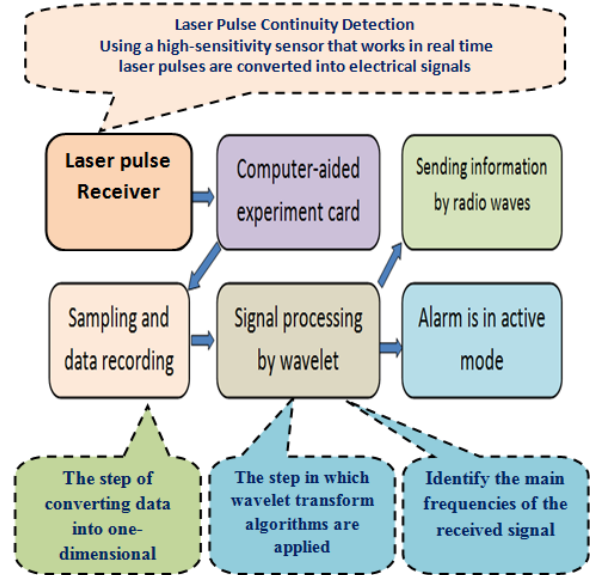


Fig.13 Diagram of the proposed method

The signal obtained is considered a non-stationary signal and it is also made up of several signals which cannot be recorded using the oscilloscope because it is technically unable to track and oscillate instantaneous signals of very high frequency. Response time, although it is very infinite, and also takes a slow motion until it stabilizes, and this is called differential vibration.

The molar figure shows the difference between the signal recorded by the cathode oscilloscope and the one recorded by Computer-assisted experiment.

There is no differential vibration

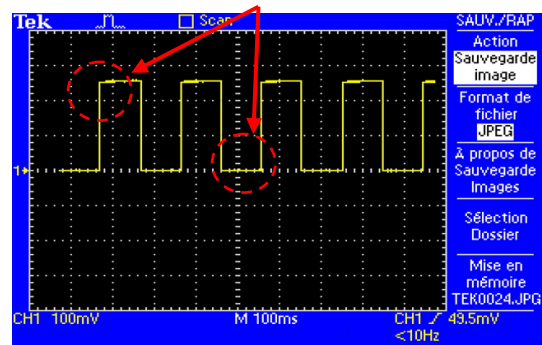


Fig.14 The results of the transmitter circuit by the oscilloscope

The presence of differential vibration

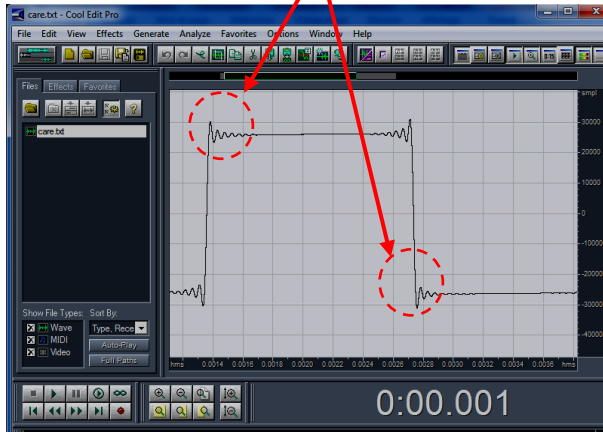


Fig.15 Real results of the transmitter circuit by CoolEdit

The fluctuation of laser signals is a very important measure. CWT is often applied to detect the singularity numerical of a transient signal at each stage of a simulation, standard procedures for wavelet computation have been used coefficients (in the case of continuous as well as discrete wavelet transitions), which are integral parts of the MATLAB program. For these results we used the CWT function.

After processing the stored matrix, we get the following figure, after applying the wavelet transform with the selection of the Haar wavelet algorithm to analyze the signal in several levels, where we can know the basic frequencies of the received laser signal.

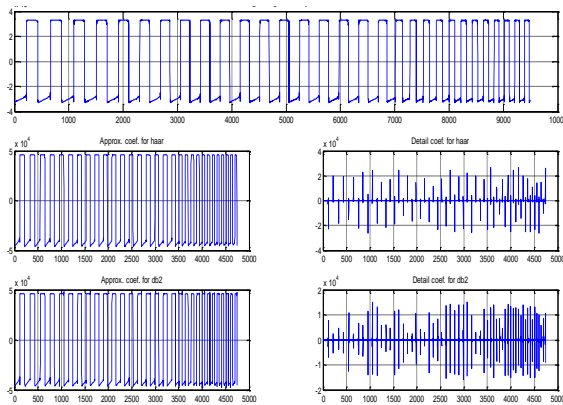


Fig.16Simulation results of wavelet transformation on the receiving signal at an increased frequency

The following figure shows how to deconstruct the signal obtained in the receiving circuit, showing the frequency resulting from the differential vibration, which we would not have obtained without applying the wavelet theory.

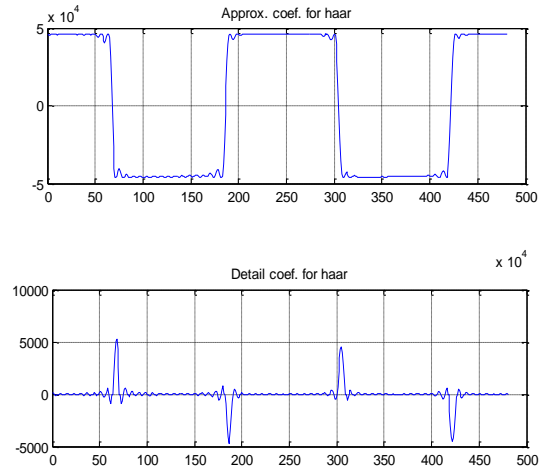


Fig.17 the Haar wavelet transform on the received signal

13- Conclusions

In this work, we relied on processing the unstable signals sent between the transmitter and the receiver, which are coded laser pulses that control a sophisticated alarm system that can be used in the military field. In order for this system to be effective, we decided to analyze the received signal by converting waves, which have proven successful in several areas. In practice, whenever we can decompose the received signal using wavelet transformation, the results are perfect. It can be said that the transmitted pulses consist of several signals with different frequencies, and this leads to the lack of dependence on this signal in controlling any of them. The system, especially if it requires high accuracy or efficiency in performance such as controlling the speed of the DC motor or transmitting digital information by wireless communication, especially if it is high frequency. On this basis, we proposed an algorithm to disassemble and filter the received signal in order to have effective and satisfactory results.

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