Signal Processing and Analysing Big Mass Data Using LabView

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***Abstract* – With our technology we measure every physical change or phenomena in our world. Using large collection of algorithms, we process, analyse, calculate, and gather results of every measured physical change. In that way a large database of raw data is created. The idea is to make a program that will understand our input data and make all calculations that we need. For that operation, we want to distinguish the "LabView" by National Instruments. LabView creates Virtual Instruments (VI's), so, we can use the same VI's for different type of input data with small change in parameters and filters according to the type of the data.**

***Keywords* – object – Data models, Signal processing, Graphs, Big data applications, Data processing.**

1. Introduction

There are a lot of methods in analyzing and testing some signals. The scientists are doing that for a long time, so, we can't easily develop whole new algorithm for filtering some value from our spectrum such as the frequency of some signal. Now we are trying to make better accuracy of the old models of working with signals, and with computerized methods make that as fast as possible and also re-usable in the future for everybody that is working with similar set of data. We want to show that the type of the data is not the aim and the goal of this study, and we will present some examples with data collected from the earthquakes. Important for mentioning is that, according to the type of the data one is working with, one should know the numerical solutions for that problem in order to make filters in the desired VI according to his needs. With better knowledge about this software, all the researchers that are working with electronic components can also test a lot of the models in LabView [1] or put them to work in a program called "LTspice".

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2. Data Processing

When working in LabView, the users can generate signals and process them or import data from other devices. However, if it is the case as in this study, we should mention that several steps are required to prepare the data for analyzing. The starting point in this case should be defining what is the type of data, how much data we want to import, in which format are the data, and prepare a block diagram in LabView with strictly defined parameters for the input data. [2] LabView works with objects, functions, mathematic calculations and connections between every block or function. If the data is not imported with the right parameters and with precise string, the program will not give accurate results. It will light the error bulb and the user will be informed what the problem is. The data that we were using came for us as a ".CSV" format. Quite amount of work was done to prepare the data for analyzing, because we had a very big amount of measurements for the seismic excitations, near 10 years in several cities and for every single day, single minute of the day there is some little measurement of the instruments. But the main aim of this study is to show the benefits of working with LabView. One of the important things in LabView is that we can set up some measurement system, it will be low budget, and will be usable in the future for some operators that are following some natural phenomena. Also, an alarm system can be adjusted for specific values of some measurements and help the whole process. In the future we can make improvements on every VI in LabView and add some new features. Important for the researchers in this field and LabView is that they must have good experience with this type of issues, know the basics of the signals, also be familiar with data acquisition and hardware components like measurement instruments and have certain knowledge of the mathematical and numerical methods. In our case the FFT (Fast – Fourier transformation) is used, which requires understanding the fundamental problems with transformations and the type of calculations involved in the study.

3. Labview Approach

For FFT-based analysis in LabView, the most important functions to be known are FFT, Power Spectrum and Cross Power Spectrum. By using these functions and building blocks in LabView, we can perform functions such as transfer function, impulse response, coherence, amplitude spectrum, and phase spectrum function. If the problem is related to the frequency, it would be best to use the FFT and Power Spectrum functions. The FFT serves to determine the average frequency over the entire time of the signal.

The basic calculations for analyzing the signals include converting from a two-way power spectrum to a single-sided power spectrum, simultaneously adjusting the frequency resolution and scattering the spectrum, using FFT and converting power and amplitude into logarithmic units.

Most instruments used in the real world only show the positive half of the spectrum of the frequency because the real-world spectrum of the signal is symmetric around DC. So, the information about the negative frequency is redundant.

The two figures below (Figure 1. and Figure 2.) show the power versus the frequency for the time domain signal.

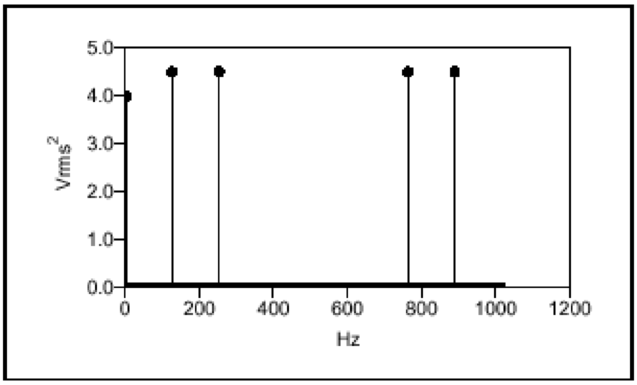

Figure 1. Duplex Power Spectrum.

The Power Spectrum function shows the power as the main amplitude of a square at each frequency line. This function does not display any phase information. Accordingly, if it is necessary to obtain phase information, it is necessary to use FFT so that both phase and frequency signal information can be seen.

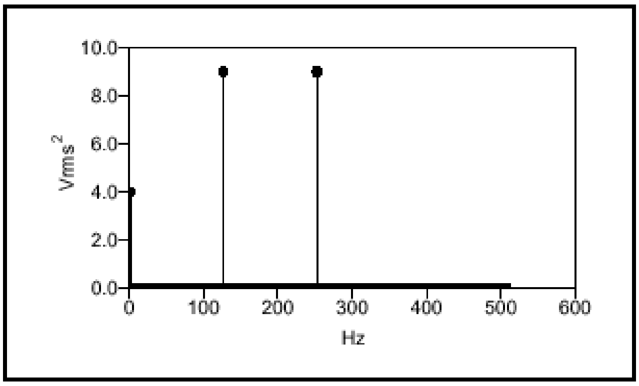

Figure 2. One-sided Power Spectrum.

On the other hand, in most cases it is important to obtain the relative phase between the components, or the phase difference between the two signals obtained simultaneously, which can be displayed only through advanced FFT functions.

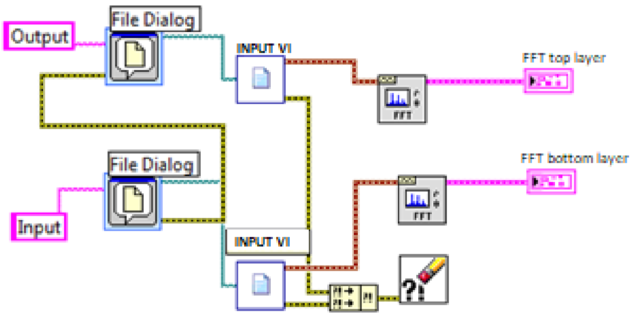

Figure 3. Blog diagram for FFT for input and output simultaneously

FFT in LabView displays a two-sided spectrum in a complex form (real and imaginary part), which must be scaled and converted to a polar form to display the magnitude and phase. The axis of the frequency is the same as that of the two-sided power spectrum. The FFT amplitude is related to the number of points in the time domain signal. Equations (1) and (2) can calculate the amplitude and the phase versus the frequency of the FFT.

$$Amplitude\ Spectrum = \frac{\text{Magnitude}\left[\text{FFT}\left(\text{A}\right)\right]}{\text{N}} = \frac{\sqrt{\left[real[FFT(A)]\right]^2 + \left[imag[FFT(A)]\right]^2}}{N} \quad (1)$$

$$Phase\ Spectrum(rad) = Phase[FFT(A)] = \arctan\left(\frac{imag[FFT(A)]}{real[FFT(A)]}\right) \quad (2)$$

The arctangent function in equation (2) returns values for the phase between -π and π, a full range of 2π radians.

Most often, the amplitude and phase spectrum are shown in the logical unit decibel (DB). Using this feature can be easily detected on a wide scale. This provides an opportunity to look at smaller components of the signal between the presence of the larger ones. The dibit is a unit representing a ratio and is calculated by the equation (3).

$$\text{Power in DB}=10\log 10\ \frac{\text{Measured Power}}{\text{Referent Power}} \tag{3}$$

To calculate the ratio in decibels between amplitude values, we can use the equation (4):

$$\text{Amplitude in DB}=20\log 10\ \frac{\text{Measured Power}}{\text{Referent Power}} \tag{4}$$

Also, one of the more important functions in our case is the "transfer function". This function is used for determining the ratio of system input and output to Laplace domain considering for the starting conditions as also equilibrium to be zeros. If we assume the two functions X (t) (input) and Y (t) (output), we define the transfer function H (s) to be:

$$H(t) = X(t)/Y(t) \tag{5}$$

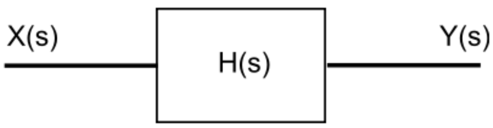

Figure 4. Transfer Function

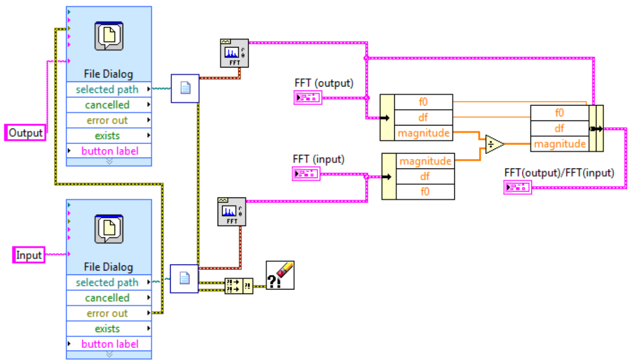

Figure 5. Blog diagram for calculating the H transfer function

The transfer function in other words is the connection between the exit and the input of a single system represented in a complex Laplace domain.

What has been processed in LabView so far is the measurement of the instruments placed on VN7SH (Van Nuys Hotel) located in California at scenario "1994 Northridge Earthquake" [3], [4], [5]. This project is regarded as a beginning in the creation of a complex application that receives data and returns some key features of the measured characteristics of that trigger either of a natural or artificial character of the very origin.

LabView allows us to create a work environment composed of "Front Panel" and "Block Diagram". They represent two panels that create the functions and desired tasks and at the same time see the results of the functions themselves. The software is perfected to the point where you can connect all the acquisition and instrumentation with the different VI's, and, generate artificial signals and make them according to your needs. [6]

After creating a block of functions that represents your instrument, it can be saved as a virtual instrument (VI) and used anytime in the future.

Table 1. Specific values for the concrete

Concrete (regular weight, 150 pcf^1)		
Location of the structure	Minimum specified compressive strength $f_c - psi^{(2)}$	Modulus of elasticity $E - psi^{(2)}$
Columns, 1^{st} to 2^{nd} floors	5,000	$4.2\ x\ 10^6$
Columns, 2^{nd} to 3^{rd} floors	4,000	$3.7\ x\ 10^6$
Breams and slabs, 2^{nd} floors	4,000	$3.7\ x\ 10^6$
All other concrete, 3^{rd} floor to roof	3,000	$3.3\ x\ 10^6$

The monitoring of any signal from a seismic nature is either artificial or naturally initiated, and, is carried out most often through a piezoelectric device that is placed in the appropriate place according to what kind of analysis you want to perform. [7]

Table 2. Specific values for the concrete

Reinforced steel			
Location in the structure	Grade	Minimum specified yield strength $f_y - ksi^{(3)}$	Modulus of elasticity $E - psi^2$
Beams and slabs	Intermediate grade deformed billet bars (ASTM A-15 and A-305)	40	$29x10^{16}$
Column bars	Deformed billet bars (ASTM A-432)	60	$29x10^{16}$

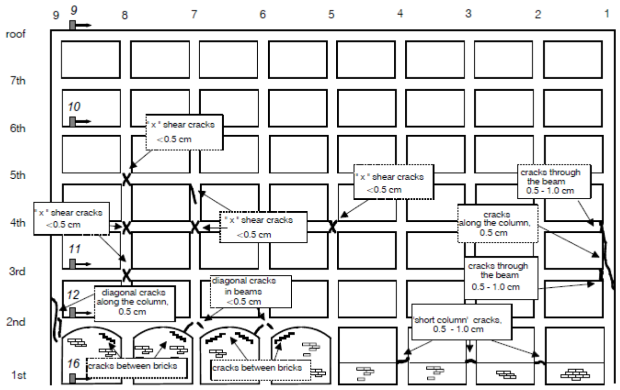

Figure 6. Building graphical display of the Northridge earthquake in 1994.

If it is a 7 layers type of building, instruments can be placed on each layer respectively from first to the last layer itself, while measuring the movement at some point. Since displacement, as amplitude, phase and frequency data are obtained as well as the other characteristics of a particular scenario. Later, an analysis of the H transfer function can be made, which is also of great importance for any object. For now, science has not come to that level for it to know what kind of seismic to be expected and where to be expected. To obtain data, instruments must be placed on some objects and simply to observe the data provided by those instruments.

4. Examples and Results

We will consider few examples in LabView. The examples in this case are considered from displacements invoked by seismic excitations. As we have mentioned above, we don't want the reader to focus on the type of the results and example taken for processing, the main goal for us is to show that LabView can be used in very different examples and with using this software we can make predictions and take certain steps for avoiding or preparing for some disasters that can sometimes be of a catastrophic character. It is very important to have as many measurement instruments as we can. The following example is about a building that, luckily for the scientist, had been equipped with 5 measurement instruments that were working in real time. The importance of the results will be considered in some other study were the main aim will be the seismic excitations. [8]

Examples are done with accuracy of 3000 steps (time step of 0.02) for better accuracy. Few waveforms are generated that show the results. From the results, it can be seen the difference between the bottom layer and the top layer. On the vertical axis is represented the amplitude in centimeters and on the horizontal axis is represented the time in seconds. For every measurement a block diagram is presented. [9]

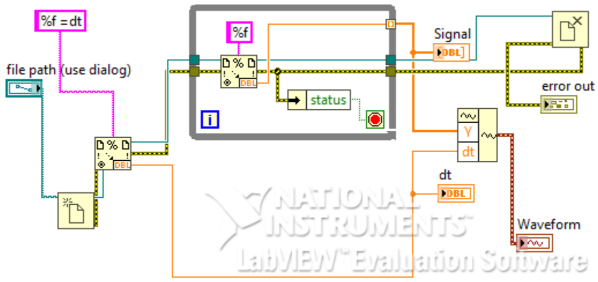

Figure 7. Object – oriented model of block diagram for the VI that is used for reading and importing the data in LabView

If you look closely at the block diagram in Figure 3. that represents the input and output and also shows the FFT signal – process, you can see one element labeled as "INPUT VI". INPUT VI presents another VI which function is to allow to the user to import the data from some .csv file which we have also mentioned before. From this we want to point that the VI "INPUT VI" can be used whenever in the future there is a need for import of that type of data, which is one of the most useful functions in LabView. [10], [11]

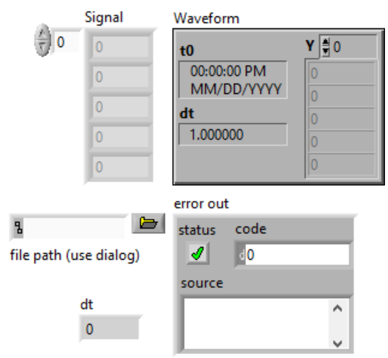

Figure 8. Front – Panel for the block diagram in Figure 7.

The block diagram for the FFT measurements consists of input and output functions, file dialogs for input and output, INPUT VI for both input and output, FFT function that comes with the LabView itself, and two waveform graphs that represent the results.

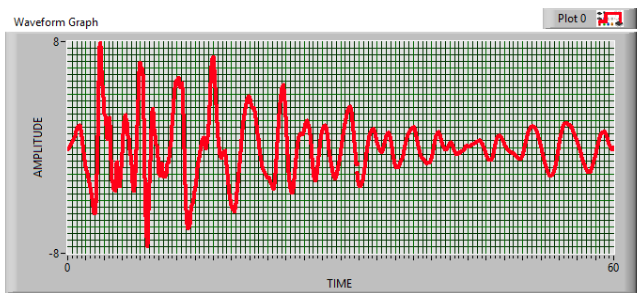

Figure 9. Waveform graph that represents the actual movement of the building at the top layer with amplitude (cm) and time (s).

The waveforms also give us a lot of freedom in defining the scales and the signals. Every parameter is editable, the styles of the graph and the time step is editable and the fonts and background are also editable.

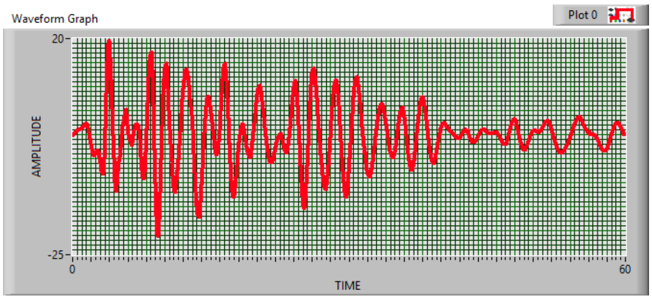

Figure 10. Waveform graph that represents the actual movement of the building at the bottom layer with amplitude (cm) and time (s).

Mentioning this one more time, this measurements and processing of this signal are chosen to be a little different from our everyday working with dc – dc converters. Sometimes, it can be of very big importance working with measurements from natural phenomena in order to take some precautions in future if there is similar scenario as the example of the Van Nuys Hotel building.

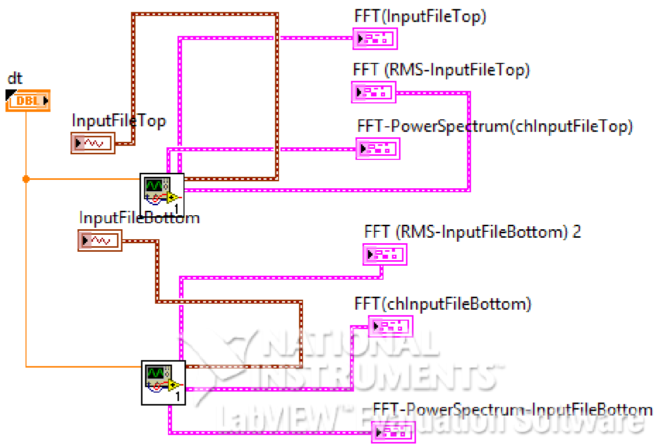

Figure 11. Object – oriented model that represents block diagram for FFT function of two measurement files in the same time

There is a real question for the scientists that are highly affected by the results of the study, what if we simulate another result in this example, change the displacements to be a little bigger and adjust a bigger magnitude. What type of damage will happen in that case and how big the human casualties will be? We let them to use and test this model and try to make better researching in their field, but, with the help of LabView and us that are working with processing signals in environment such as LabView. [12]

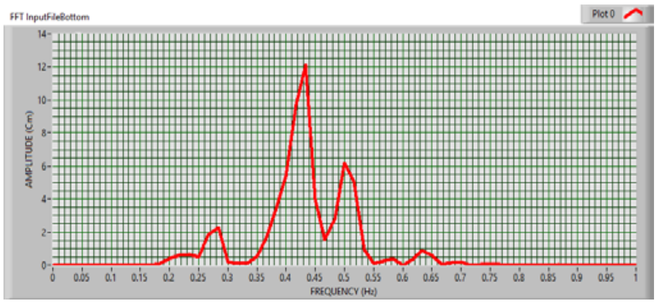

Figure 12. Waveform graph that represents the actual movement of the building at the secong layer with amplitude (cm) and frequency (Hz).

All the processings are done in LabView 2018 evaluating software because it is one of the latest editions, we have a licensed version at the laboratory, but it is an older and we wanted to do this in one of the latest versions.

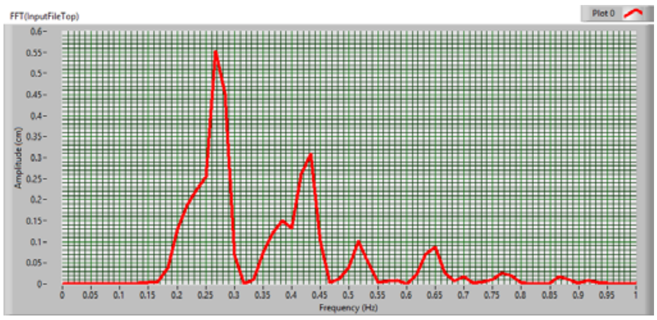

Figure 13. Waveform graph that represents the actual movement of the building at the top layer with amplitude (cm) and frequency (Hz).

5. Conclusion

The software technology is growing exponentially. It is so fast that now we are reading about going outside the earth in 2022 as a tourist. That type of evolving is forcing the researchers and scientist to work harder and harder in order to keep the growth of the technology without any bigger problems, like for example, exploding the Samsung batteries in one of their models. The main attention is how to produce more green energy and lower the air polluting. But, sometimes, we must remember that, while we are trying to make a battery or a charger that will be better from the old one, some scientists struggle with the natural phenomena caused by mother nature. With this study we want to point that software like LabView can be used in very different fields of investigation and gain a lot of good and different results from the past numerical calculations that are often made in environment, like a "Fortran".

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