Palestine Polytechnic University

College of Engineering

Mechanical Engineering Department

Graduation Project

Engine diagnostic based on acoustic emission

By

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Supervisor: Dr. Diya Arafah

Submitted to the College of Engineering in partial

fulfillment of the requirements for the

Bachelor’s degree in Automotive Engineering

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Palestine Polytechnic University

Collage of Engineering

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Supervisor Signature

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Testing Committee Signature

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Chair of the Department Signature

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الاهـــــــــداء

إلهي لا يطيب الليل إلا بشكرك ولا يطيب النهار الا بطاعتك .. ولا تطيب اللحظات إلا بذكرك ... ولا تطيب الاخرة إلا بعفوك ولا تطيب الجنة إلا برؤيتك
الله جل جلاله

...إلى من بلغ الرسالة وأدى الأمانة .. ونصح الأمة.. إلى نبي الرحمة ونور العالمين
سيدنا محمد (صلى الله عليه وسلم)

إلى من جرع الكأس فارغاً ليسقيني قطرة حب إلى من حصد الأشواك عن دربي ليمهد لي طريق العلم إلى القلب الكبير .....(والدي العزيز)

إلى من أرضعتني الحب والحنان إلى رمز الحب وبلسم الشفاء إلى القلب الناصع بالبياض .....(والدتي الحبيبة)

الى القلوب الطاهرة الرفيقة والنفوس البريئه الى ريحان حياتي ....(اخوتي)

الى الارواح التي سكنت تحت التراب الوطن الحبيب......(الشهداء العظام)

لآن تفتح الأشرعة وترفع المرساة لتنطلق السفينة في عرض بحر واسع مظلم هو بحر الحياة وفي هذه الظلمة لا يضيء إلا قنديل الذكريات ذكريات الأخوة البعيدة إلى الذين
أحببتهم وأحبوني...... (أصدقائي)

الى اللذين بذلوا كل الجهد والعطاء لكي اصل الى هذه اللحظة أساتذتي الكرام ولا سيما الدكتور الفاضل...... ضياء عرفه

الى القدس عاصمة فلسطين

إليكم جميعاً أهدي هذا العمل

Abstract:

This project aims to diagnose engine, by determining the source of sound come out from engine, based on these sound signals the failure in the engine will be detected. This process will save working time and effort in diagnostic and prevent to losing time on engine overhaul.

Through this project, we have created a device that records the sound of the engine using a dedicated microphone and then entering the sound signal into a computer and processed used the LabVIEW program. Based on the defect we have done the signal form changes from (1400-1500) Hz to (300- 500) Hz.

يهدف المشروع بشكل اساسي الى تشخيص المحرك، عن طريق تحديد مصدر الصوت الخارج من المحرك، على اساس اشاره الصوت يتم الكشف عن الخلل في المحرك، وهذه العملية تعمل على توفير الوقت والجهد في التشخيص واصلاح المحرك.

من خلال هذا المشروع، قمنا بعمل جهاز يقوم بتسجيل صوت المحرك باستخدام ميكروفون مخصص وثم ادخال اشاره الصوت الى الكمبيوتر وتم تحليلها ومعالجتها من خلال برنامج لابفيو، وبناءاً على الخلل الذي قمنا بعمله تغير شكل الاشارة من Hz (1400-1500) الى Hz (300-500).

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Introduction

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1.1 Background:

The increase in the world population led to an increasing demand on vehicles that can be used in various fields. Moreover, new technologies have been introduced in automotive engineering and transported which aim to improve fuel efficiency and performance.

The development of these technologies increased the complexity of vehicle diagnosis and maintenance of internal combustion engine.

The fault detection of mechanical component in the internal combustion engine is a major concern that affects engine life. So, our project provides the easier, faster and lower cost of fault detection and diagnostic process.

According to the American statistical reports, car owners file thousands of complaints about their car problems to the U.S. Department of Transportation. Table (1.1) and figure (1.1) show the number of problems reported for vehicles manufactured from 1996 to 2017, engine clicking and tapping and squeaking noises problem is a common vehicle problem that happens to most car brands and models [1].

The following chart illustrates the most common problems reported for all car since 1996. The most common car problems involve the vehicle's engine and engine cooling with 114,661 problems reported [1].

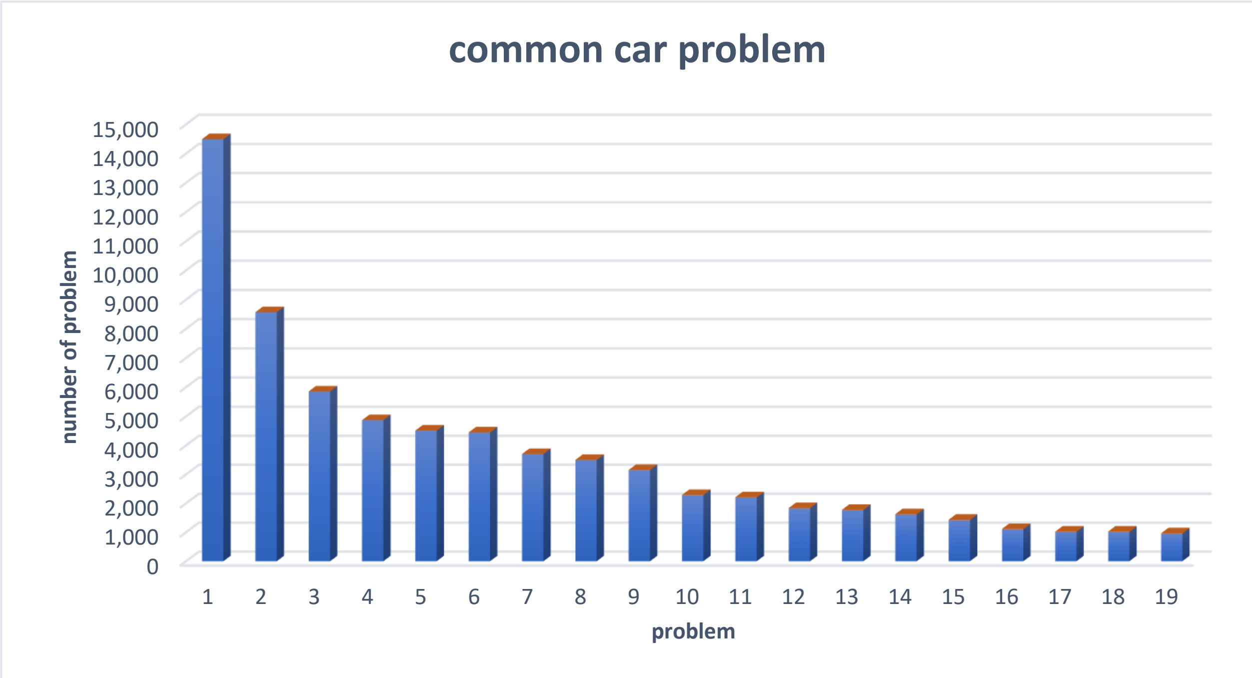


Figure 1.1: List of Problem Category [1].

Table 1.1: List of Problem Category [1].

Number	Problem Category	Number	Problem Category
1	Engine and Engine Cooling problems	11	Radiator problems
2	Car Stall problems	12	Engine Oil Leaking problems
3	Engine problems	13	Engine Shut Off Without Warning problems
4	Engine Cooling System problems	14	Engine Failure problems
5	Check Engine Light On problems	15	Gas Recirculation Valve (EGR Valve) problems
6	Manifold/header/muffler/tail Pipe problems	16	Emission Control problems
7	Gasoline Engine problems	17	Engine Clicking and Tapping Noises problems
8	Engine Belts and Pulleys problems	18	Engine Burning Oil problems
9	Engine Exhaust System problems	19	Catalytic Convertor problems
10	Engine Stall problems		

1.2 Problem definition:

The several problems come out from the vehicles and one of these problems comes from inside the engine resulting from the movement of mechanical internal parts. When a malfunction occurs will probably come out noise and occurs abnormal vibration in the engine. The mechanical problem inside engine needs highly skilled technicians in the diagnosis and maintenance process that means diagnosing this problem is often very hard. Delay of solving these problems causes dramatically effect on engine life.

1.3 Project motivation:

There are many motives and reasons for the work of this project and the most important of these reasons:

1- The ability to identify faults in engine parts through the sounds emitted.

2- Save time and effort to diagnose the moving parts inside the vehicle engine and fix the fault at a high speed.

3- Diagnose the engine without having someone expert in the sounds coming out of the engine.

4- Accuracy and performance in engine fault diagnosis.

1.4 Project objectives:

The main objective of the project is to design a program using LabVIEW to diagnostic the malfunction of the vehicle engine, based on the acoustic emissions coming out from the engine parts.

1.5 Steps of the project

There are many steps that will be done in the project:

1- Identifying the project idea.

2- Literature review.

3- Identifying the tools and equipment used in the project.

4- Proposed System Design.

5- Writing and documentation of the project.

6- Training on the LabVIEW program

7- Programming the special code in the project

8- Testing and experimentation.

9- Discussion of results.

10- Conclusion.

1.6 Schedule time

Table (1.2) shows the time of works that did through the first semester:

Table 1.2: Schedule Time-First Semester.

task / week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Identifying the project idea																
literature review																
Identifying the tools and equipment																
Proposed System Design																
Writing and documentation																

Table (1.3) shows the time of working that will achieves through the second semester:

Table 1.3: Schedule Time-Second Semester.

task / week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Training on the LabVIEW program																
Programming the special code in the project																
Testing and take reading of the experiment																
Discussion of results																
Conclusion																

1.7 Project budget:

Table 1.4: Total cost.

Item	Number	Price per unit ($)
Microphone	1	100
NI myDAQ	1	500
Wires	_	20
Laptop	1	400
Total cost	_	1020

Chapter 2

Literature review

2.1 Introduction

2.2 Engine part failure

2.3 Acoustic emission from engine

2.4 Monitoring malfunction

2.1 Introduction

Several techniques have been reported in the literature for engine fault detection. Based on the type of the measured signals, they can be classified into: acoustic, temperature, cylinder pressure, electrical current, and vibration. The vibration of normally aspirated engine contains valuable information the health of combustion chamber components. It could be used to detect the incipient faults in the engine [2].

Vibration and acoustic emission signals are often used for fault diagnosis of mechanical systems since they carry dynamic information. These signals normally consist of a combination of the fundamental frequency with a narrow band frequency and the harmonics. Most of these are related to the revolutions of the rotating system since the energy of acoustic and vibration signal is increased when mechanical element is damaged or worn out [2].

The next section describes the common mechanical failures of engine parts.

2.2 Engine part common failure

Previous studies have identified several malfunctions within internal engine that can produce sounds and are obtained by classifying sound signals. These faults include:

1. Cam Chain Noise(CCN):

The cam chain is the element within the engine which transfers the drive from the crank shaft to the cam shaft. The cam chain rides along two riders. The tension on the cam chain can be adjusted by pushing the slider inwards or outwards. This can be done using the tension adjuster, which is accessible. Whenever cam chain is under tension, it produces the cam chain noise [2], figure (2.1) shows cam chain.

Figure 2.1: Cam Chain.

2. Tappet noise:

Tappet is only that part of a rocker arm which makes contact with an intake or exhaust valve stem above the cylinder head of an IC engine. Technically, the nominal distance (clearance) between the tappet surface and the valve's contact surface was maintained by means of an adjustment screw on the rocker arm [2], figure (2.2) shows tappet.

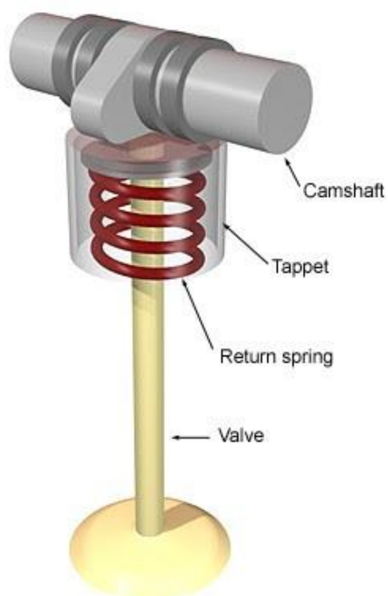


Figure 2.2: Tappet.

Tappet noise appears whenever the tappet clearance is too high. Under ideal setting the inlet and outlet tappet clearance are kept close to 0.07/0.08 mm. Any deviation from these set values results in generation of tappet noise [2].

3. Cylinder Head Noise (CHN):

In an internal combustion engine, the cylinder head above the cylinders and consists of a platform containing part of the combustion chamber and the location of the valves and spark plugs. Any noise emanating from the cylinder head which is not produced by the tappet clearance is termed as the cylinder head noise [2].

4. Primary Gear Damage (PGD):

The gear assembly is located within the crank case, it comprises a set of drive gear and driven gears assembly. Any abnormality in these gears in the form of tooth damage, tooth profile error, eccentric/inclined bore, results in typical impact kind of noise [2].

5. Primary Gear Whining (PGW):

The origin of gear whining is gear mesh (misalignment), which may be designed, manufacture assembly and operation related cause. The level of perceived noise depends on the dynamic properties of all gear bore components and the interfaces between them. Gear whining signal had the character of a sinusoidal signal and its frequency is velocity dependent, the noise level decreases as the speed decreases. This noise can be captured more efficiently when the engine runs the gears [2].

Figure (2.3) shows the distribution of the above mentioned faults over the frequency band, note that, all of these faults (if occurs) include in the measured signal.

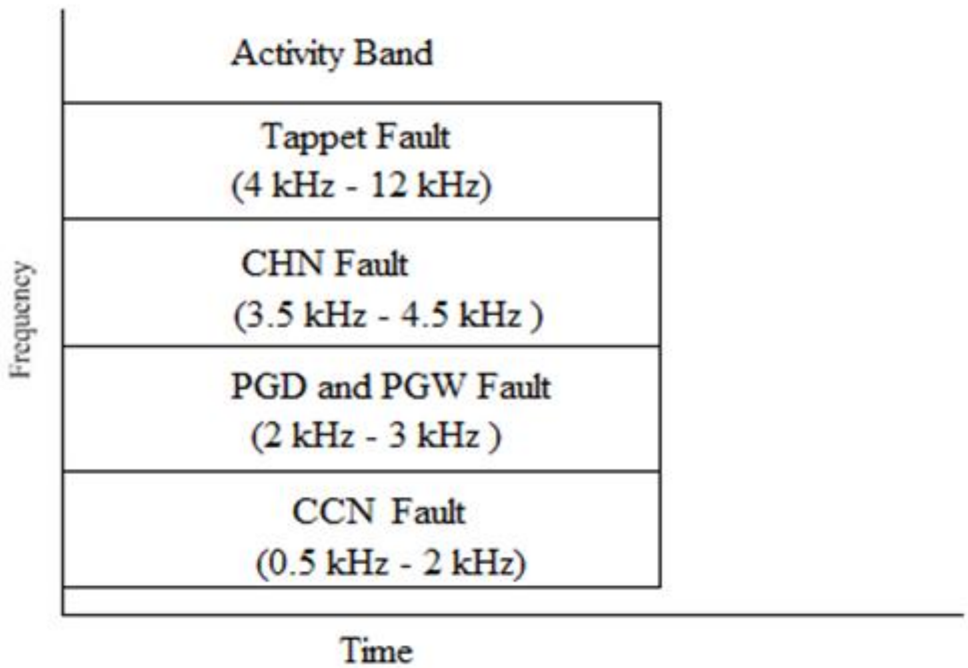


Figure 2.3: Activity Band for Different Faults [2].

2.3 Acoustic emission from engine

2.3.1 Engine noises

There are several noises that come out from the internal parts of the engine due to various reasons. Table (2.1) shows the noise description and possible source:

Table 2.1: Noise diagnostics [3].

Noise description	**Possible source**
Tap	Valve clearances out of adjustment, cam followers or cam lobes worn.
Rattle	A loose component, broken piston ring or component.
Light knock	Small end bearings worn, cam or cam follower.
Deep knock or thud	Big end bearings worn.
Rumble	Main bearings worn.
Slap	Worn pistons or bores.
Vibration	Loose or out of balance components.
Clatter	Broken rocker shaft or broken piston rings.

Hiss	Leak from inlet or exhaust manifolds or connections.
Roar	Air intake noise, air filter missing, exhaust blowing or a seized viscous fan drive.
Clunk	Loose flywheel, worm thrust bearings or a loose front pulley/damper.
Whine	Power steering pump or alternator bearing.
Shriek	Dry bearing in an ancillary component.
Squeal	Slipping drive belt.

2.3.2 Treatment of engine noise

Table (2.2) shows some sources of noise, its causes and methods of treatment:

Table 2.2: Engine noises [3].

Sources of engine noise	**Possible cause**	**Required action**
Misfiring/backfiring	Ignition system faulty. Carbon deposits in the combustion chamber starts to glow and causes misfiring. Timing incorrect, which causes misfiring in the intake/exhaust system.	Determine which type of fuel was last put in the tank. Check the ignition system. Check the engine cooling system. Remove the carbon deposits by using fuel additives and driving the vehicle carefully. Check the timing.

Valve train faulty	Valve clearance too large due to faulty bucket tappets or incorrect adjustment of valve clearance. Valve timing incorrectly adjusted, valves and pistons are touching. Timing belt broken or damaged.	Adjust valve clearance if possible and renew faulty bucket tappets – check cam condition. Check the valve timing and adjust if necessary. Check timing belt and check pistons and valves for damage – renew any faulty parts.
Engine components faulty	Pistons, piston rings, cylinder head gasket, big end and/or main bearing journals.	Disassemble the engine check components.
Ancillary components	Engine components or ancillary components loose or broken.	Check that all components are secure, tighten/ adjust as required Renew if broken.

2.4 Monitoring malfunction

The traditional methods of diagnosing the vehicle where the technician diagnosis the vehicle through an eye examination by looking at the engine and guessing the problem and hearing the sound of the engine and identify the defect through previous experiences in order to decide engine overhaul [3].

The necessary knowledge of the automotive systems together with a logical diagnostic routine will help in finding the mechanical fault easily [3].

In the present study, a computer based system is proposed to help the technicians in determining the mechanical fault in the engine based on sound emissions.

Chapter 3

Proposed System Design

3.1 Introduction

3.2 Project components

3.3 Project operation

3.4 Signal processing using LabVIEW

3.1 Introduction

In this chapter we discuss the details of the proposed computer-based diagnosis system, the main sensor is the microphone, the processing of the input signal that done on laptop using LabVIEW software.

3.2 Project components

A set of tools for diagnosing engine were used in this project as follows:

1. Microphone device:

A microphone is a transducer that converts sound into an electrical signal, microphones are used in many applications such as telephones, sound recording and in computers for recording voice, and for non-acoustic purposes such as ultrasonic sensors or knock sensors.

The microphone function in the project is to record the sound of the engine and convert it from the physical state to the electrical state and send the sound signal to the myDAQ.

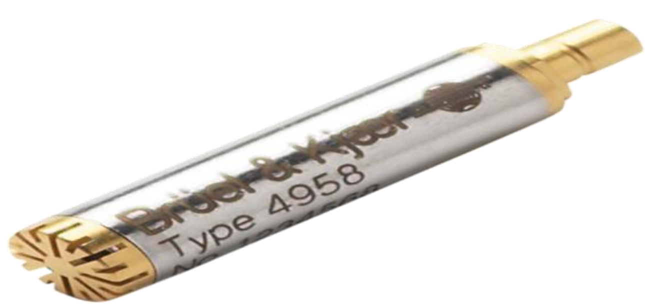


Figure 3.1: Microphone [4].

2. Connecting wires:

The wires were used to connect the sensors with myDAQ and laptop.

3. DAQ:

Data acquisition is the process of sampling signals that measured real world physical conditions and converting the resulting samples into digital numeric values that can be manipulated by a computer. Data acquisition systems, abbreviated by the acronyms DAS or DAQ, typically convert analog waveforms into digital values for processing [5].

Data acquisition applications are usually controlled by software programs developed using various general-purpose programming languages such as Assembly, BASIC, C, C++, C#, Fortran, Java, LabVIEW, Lisp, Pascal, etc. [5].

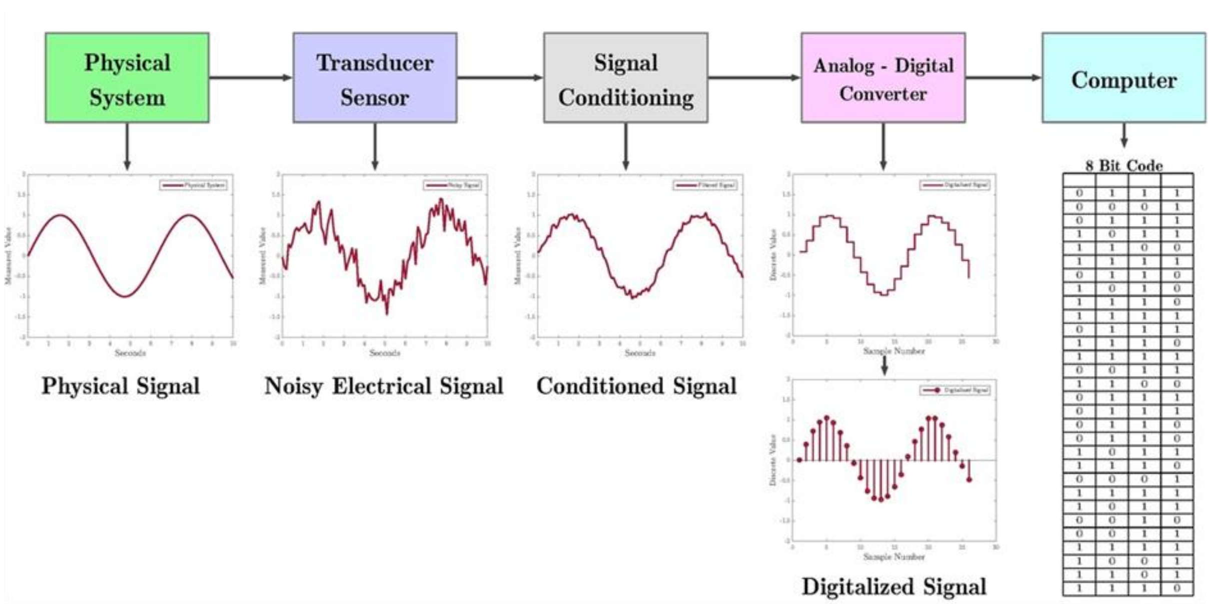


Figure 3.2: Digital Data Acquisition System [5].

4. Laptop:

The Laptop is used as a link between the LabVIEW program and DAQ through USB connection, also, the LabVIEW software was installed on the laptop.

5. LabVIEW program:

Laboratory Virtual Instrument Engineering Workbench (LabVIEW) is a system-design platform and development environment for a visual programming language from National Instruments.

LabVIEW is commonly used for data acquisition, instrument control, and industrial automation on a variety of Operating Systems (OSs).

The purpose of using LabVIEW program is to analyze the sound signal and detect the error if found. This was done by building a control program (using blocks) to carry out the diagnosis.

3.3 Project operation

The sound of the engine was recorded by a microphone that converts the physical state of the sound into an electrical signal, and both the microphone signals were provided to the NI myDAQ which converts the electrical signal to analog and then to digital signal and send the signal to the laptop. The LabVIEW program was processed these signals within the laptop as shown in figure (3.4).

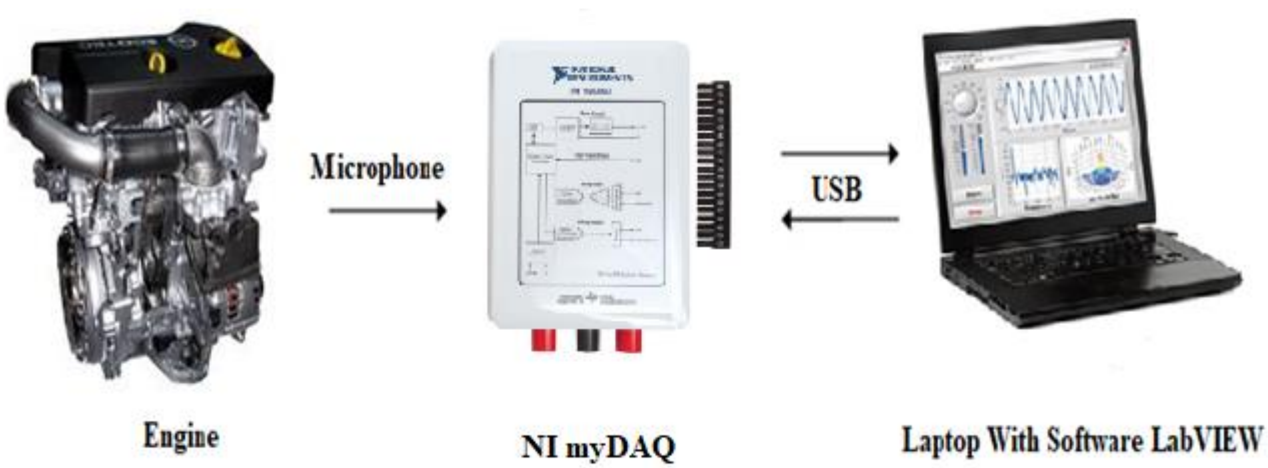


Figure 3.3: Connecting Project Parts [4].

3.4 Signal processing using LabVIEW

The LabVIEW program was used to perform signal processing on the sound signal of the engine. The program analyzes the signals using Fast Fourier Transform (FFT), Which bases its principles on converting signals from time domain to frequency domains see figure (3.5).

The Fourier Transform(FT) is defined by the following equation (3.1) [6]:

$$X(f) = f\{x(t)\} = \int_{-\infty}^{\infty} x(t)\, e^{-j\pi f t}\, dt \qquad \text{Equation (3.1) [6].}$$

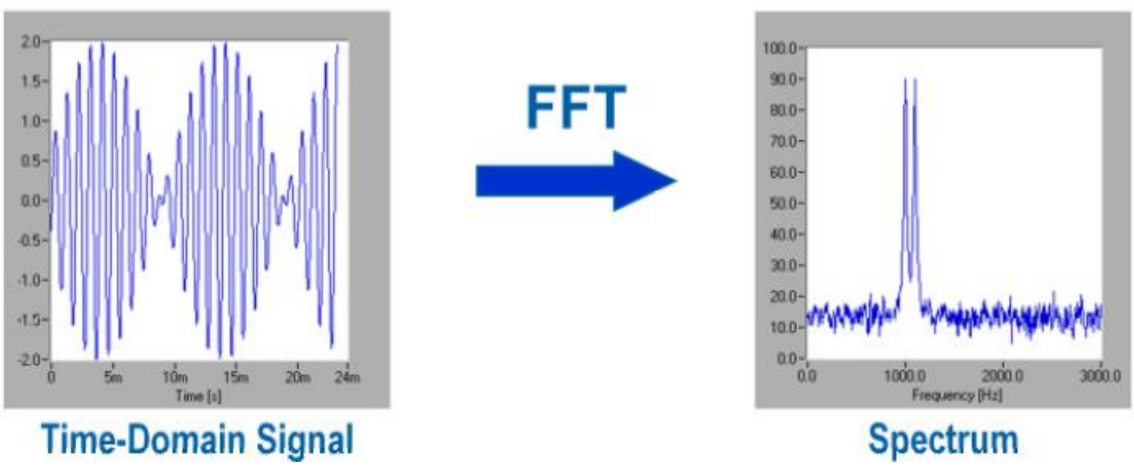


Figure 3.4: Fast Fourier Transform.

The spectrum of the sound signal was used to search for the common mechanical failure of engine parts, therefore, diagnose the engine.

3.4.1 Sound filter

The filter processed the sound signals coming from the engine through the microphone, the filtering was done within LabVIEW program in order to facilitate the detection of the frequencies needed in the diagnostic process and the filter is used to eliminate background noise, figure (3.6) shows the sound signal filter process.

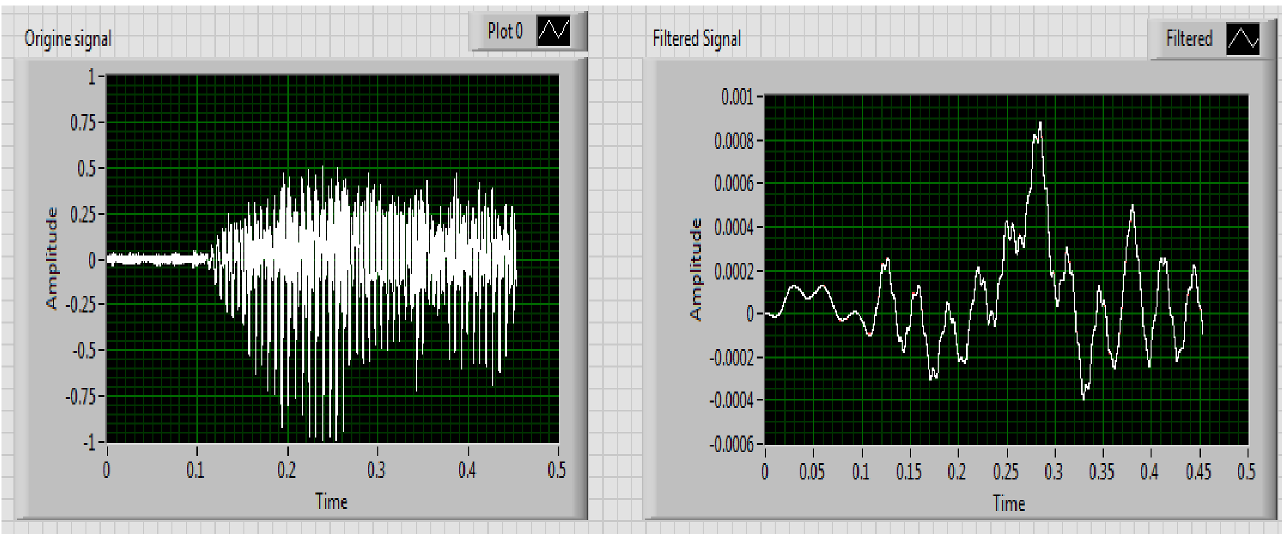


Figure 3.5: Sound Signal Filter.

Chapter 4

System Control Using LabView

4.1 Introduction

4.2 LabVIEW software

4.3 System control

4.1 Introduction

In this chapter, the software code of the project was built using the LabVIEW program, where will be used a group of blocks, so that we can insert the sound coming from the microphone to the LabVIEW program using a NI-DAQ.

4.2 LabVIEW software

LabVIEW is system engineering software for applications that require test, measurement, and control with rapid access to hardware and data insights.

LabVIEW is a graphical programming language that uses icons instead of lines of text to create applications. In contrast to text-based programming languages, where instructions determine program execution, LabVIEW uses dataflow programming, where the flow of data determines execution.

In LabVIEW the user interface is known as the front panel with controls and indicators. Controls are knobs, push buttons, dials, and other input mechanisms. Indicators are graphs, LEDs, and other output displays. You then add code using graphical representations of functions to control the front panel objects. The block diagram contains this code. In some ways, the block diagram resembles a flowchart.

4.3 System control

In this part of the chapter will be explained the software code and stages in the LabVIEW program:

1. Acquire sound signal:

a. NI-DAQ select channel:

The input is selected for inserting the audio signal from the microphone to the NI-DAQ through DAQ Assistant block, so that they are first identified the acquire signals then we choice of the analog input and choice of voltage and choice of analog input channel (ai0) and finally select the signal input rang and rate, and it is also read sound through this block.

b. Sound signal filter:

The filter processed the sound signals coming from the engine through the microphone from using filter block, and choice of filtering type is lowpass filter because it is give a required signal compare with another filtering type and select the Butterworth because it is the appropriate quality for such sound signals issued from the engine, and choice the order to absorb as much of the signal.

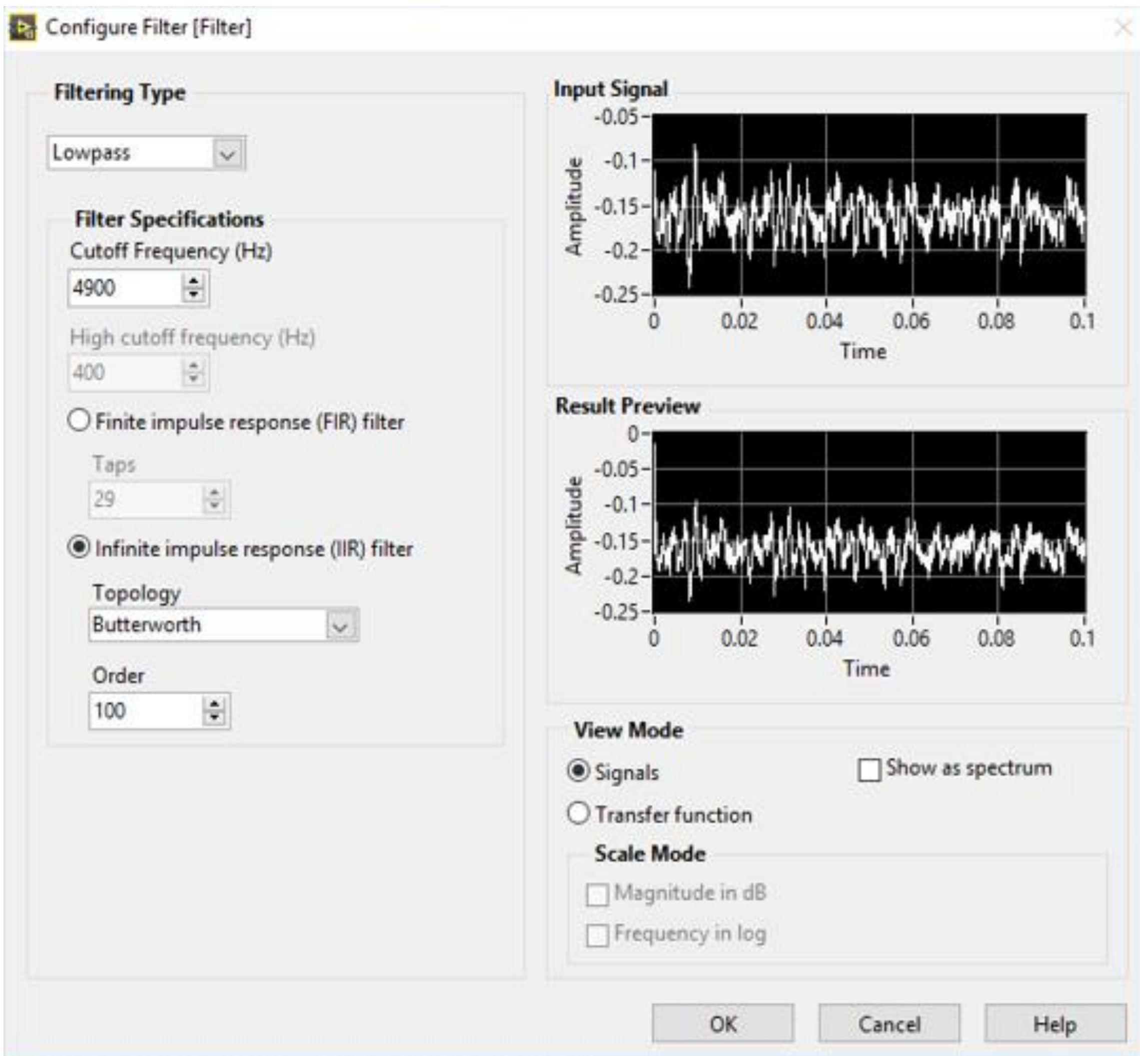


Figure 4.1: Configure Filter.

2. processing of sound wave

After filter the sound in the filter block the sound is sent to the spectral measurements block which converts from time domain to frequency domain, and we have been selected power spectrum because it gives the appropriate signal without interference compared to another options and was chosen of the linear to be the result of the signal other than an option dB because it gives the frequency using linear scale.

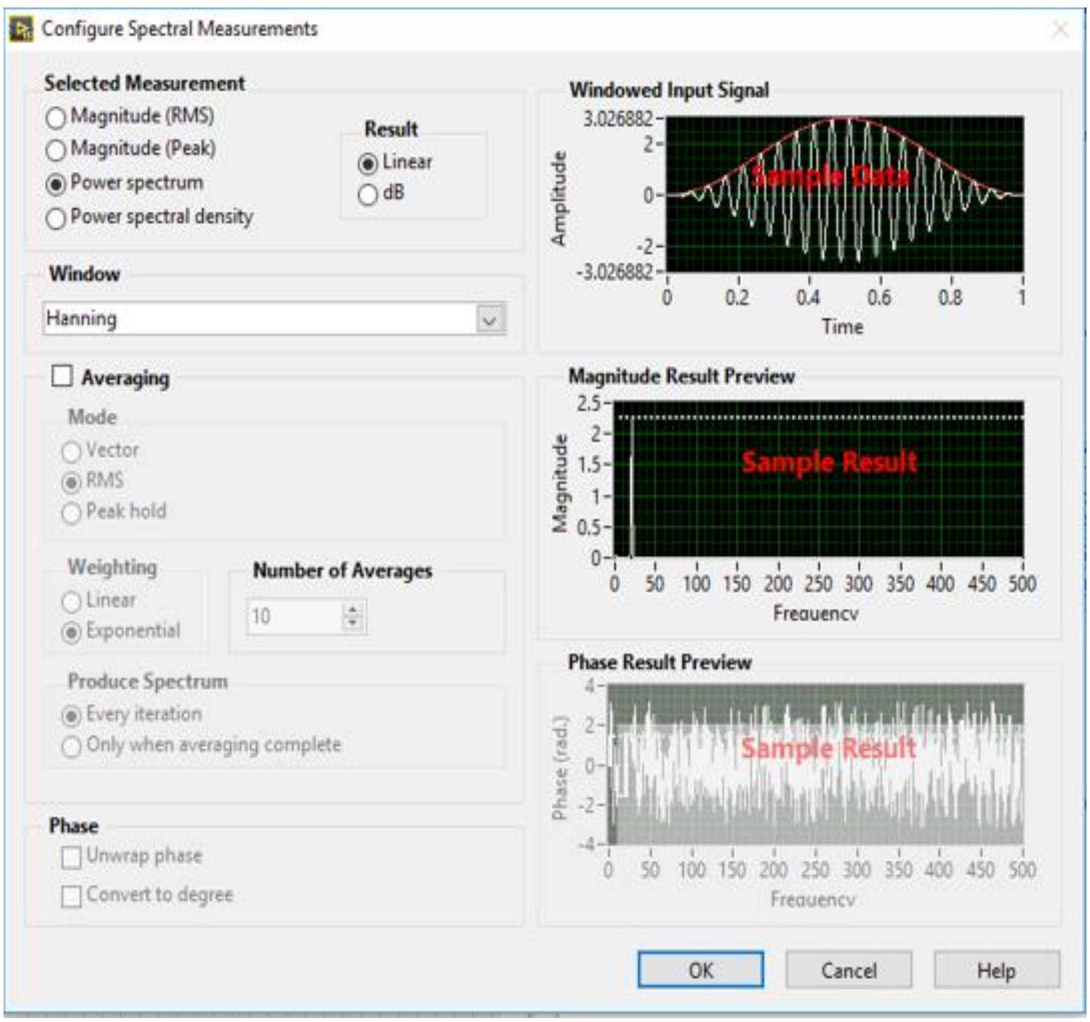


Figure 4.2: Configure Spectral Measurements.

3. Block Diagram

The figure (4.3) show the block diagram which explain the interface of the programmer.

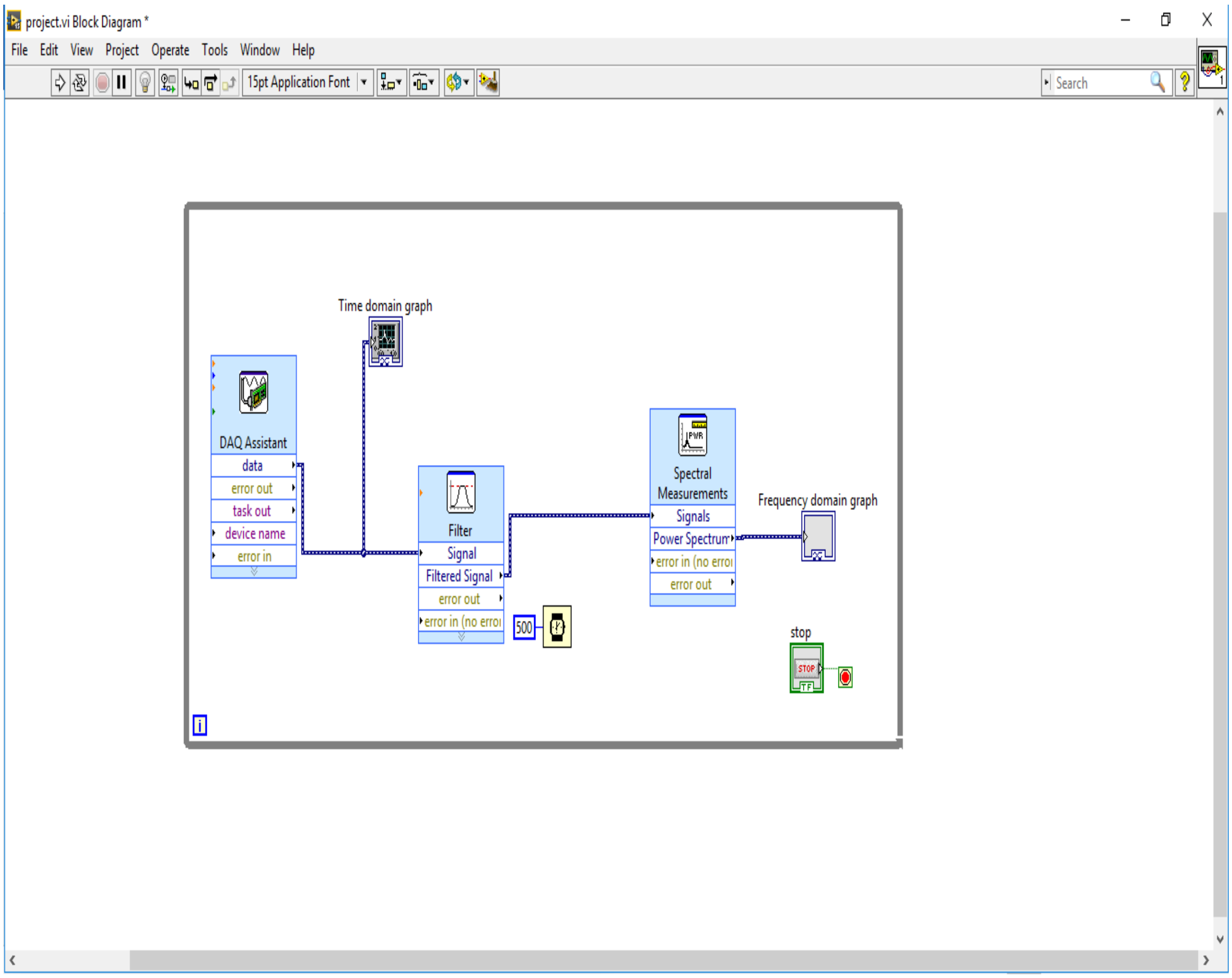


Figure 4.3: Block Diagram

4. Front Panel

The figure (4.4) show the front panel which explain the interface of the user.

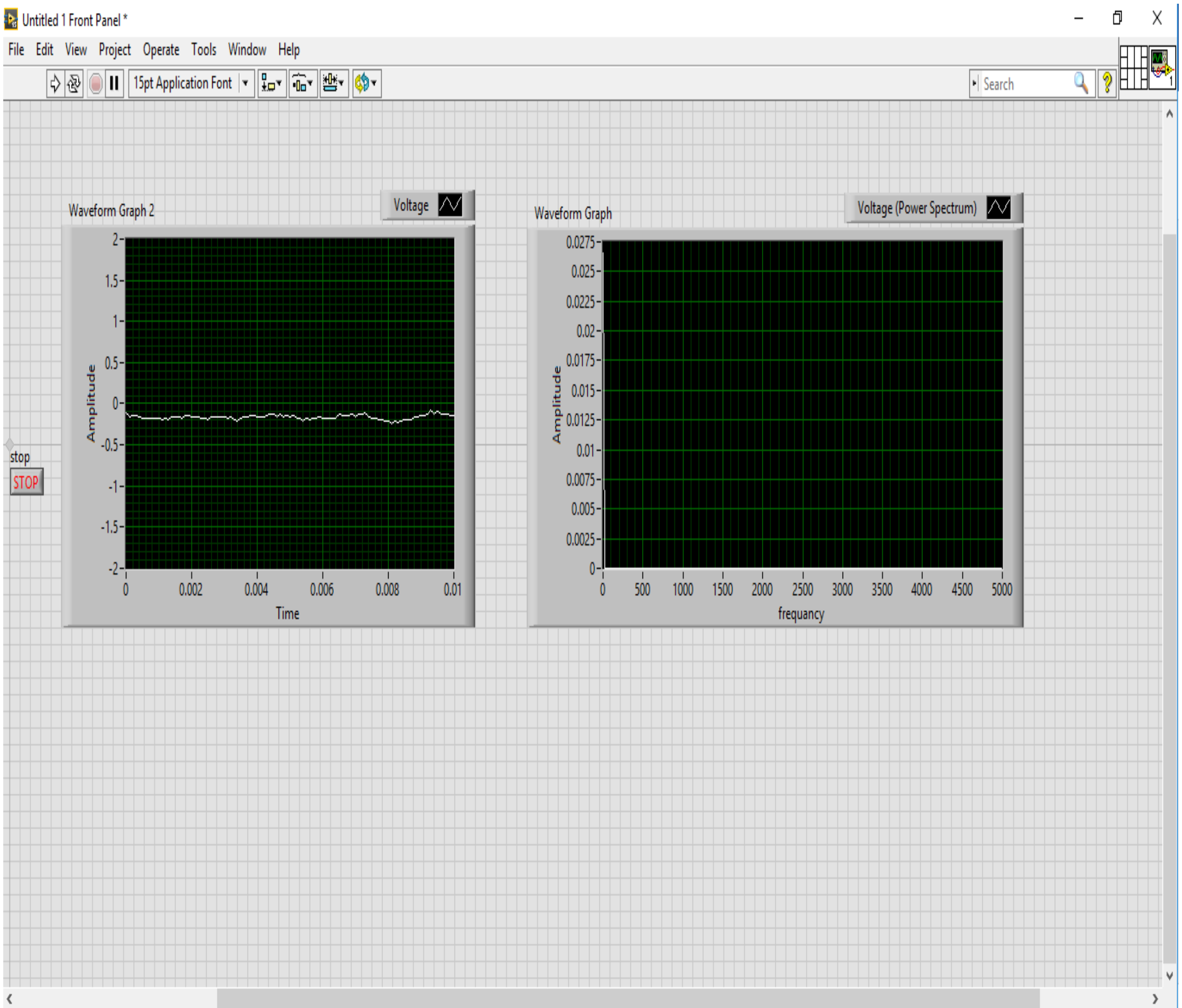


Figure 4.4: Front Panel.

Chapter 5

Experimental work

5.1 Introduction

In this chapter we discuss the details of project implementation process in practice, the connection and interfacing of the microphone explained with NI myDAQ and details about which engine will be used and the process of taking readings.

5.2 Interfacing microphone with NI myDAQ

A GY-MAX9814 - type microphone was used and connected to the myDAQ controller by special wires and Figure (5.1) as shown NI-myDAQ used in this project.

Figure 5.1: NI myDAQ.

Microphone Features:

- Automatic Gain Control (AGC).
- Three Gain Settings (40dB, 50dB, 60dB).
- Programmable Attack Time.
- Programmable Attack and Release Ratio.
- 2.7V to 5.5V Supply Voltage Range.
- Low Input-Referred Noise Density of 30nV/√Hz.
- Low THD: 0.04% (type).
- Low-Power Shutdown Mode.
- Internal Low-Noise Microphone Bias, 2V.
- Available in the Space-Saving, 14-Pin TDFN (3mm x 3mm) Package.
- specified over the -40°C to+85°C extended temperature range.

The microphone is connected to the NI myDAQ through the channel (AI), where the ground black line was connected to the ground line of the channel and the red voltage line is connected to the microphone with the number one line in the 5 volt channel and the blue gain line is connected to the ground in the channel and connect the output line from the yellow microphone to channel 3 inlet, Figure (5.2) shows interfacing the microphone with the NI myDAQ channel (AI).

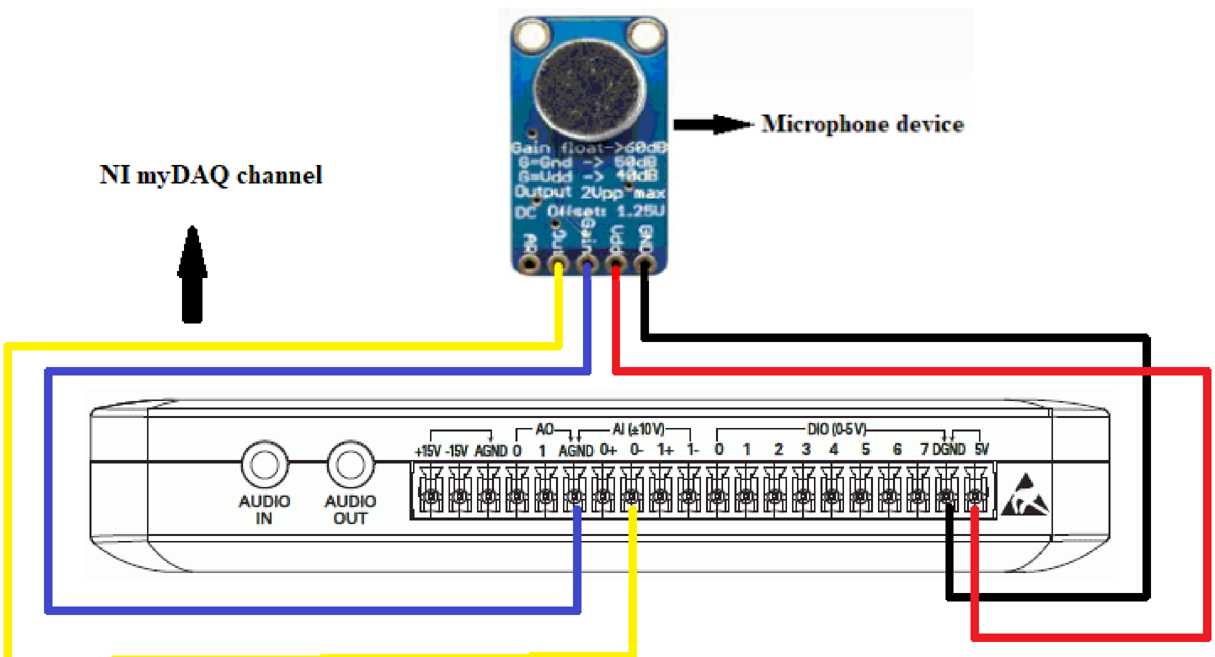


Figure 5.2: Interfacing Microphone with Channel NI myDAQ.

5.3 Engine specifications

A Honda GX160 5.5 HP engine was used in the experiment as shown in figure (5.3), that single cylinder engine was used because for simple testing and the experiment needs to disable part of the engine and this generator will be better handling when a problem occurs.

Figure 5.3: Honda GX160 5.5 [8].

The GX160 engine is suitable for a wide range of heavy duty applications such as in construction equipment, tillers, generators, welders, pumps and another industrial application, Table (5.1) shows some specifications of the engine and Figure (5.4) as shown engine internal parts.

Engine features:

- OHV design enhances combustion efficiency
- High power-to-displacement ratio
- Easy starting with an automatic decompression system and an easy-to-grip soft recoil starter handle
- High quality materials and purpose-built components which ensure reliable, long-term use
- Meets world's most stringent environmental legislation
- Low fuel and oil consumption
- Reduced vibration and noise levels

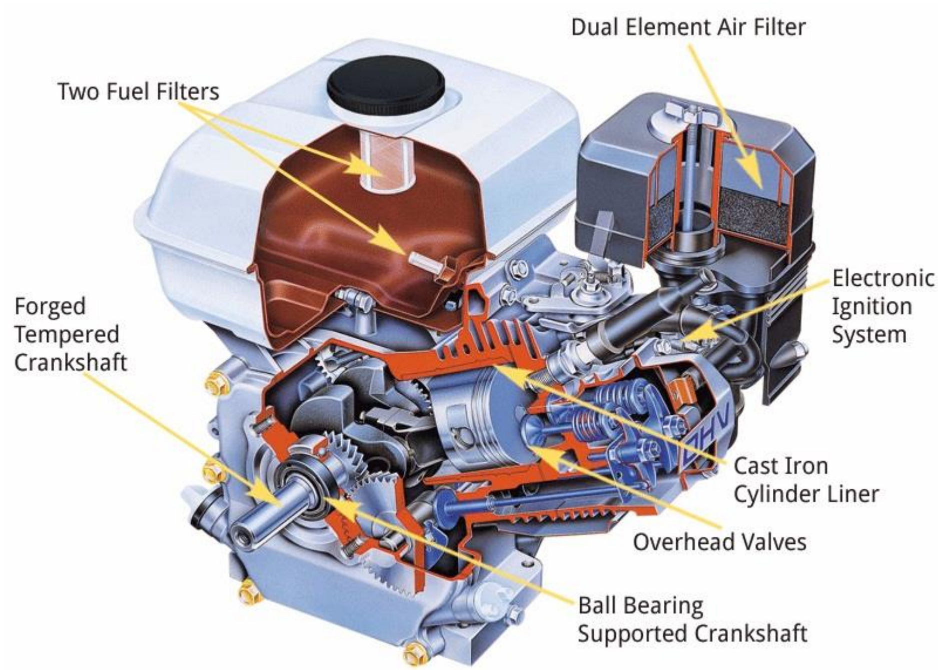


Figure 5.4: Engine Inside Parts [8].

Table 5.1: Engine specifications Model GX 160 [8].

Engine type	4-stroke single cylinder OHV petrol engine 25° inclined cylinder horizontal shaft
Cylinder sleeve type	Cast iron sleeve
Bore x Stroke	68 x 45 mm
Displacement	163 cm^3
Compression ratio	9.0: 1
Net power	3.6 kW (4.8 HP) / 3600 rpm
Cont. rated power	2.5 kW (3.4 HP) / 3000 rpm 2.9 kW (3.9 HP) / 3600 rpm
Max. net torque	10.3 Nm / 1.05 kg/m / 2500 rpm
Ignition system	Transistorized
Starter	Recoil (el. starts optional)
Fuel tank capacity	3.1 Liter
Fuel cons. at cont. rated power	1.4 L/h - 3600 rpm
Engine oil capacity	0.6 Liter
Dimensions (L x W x H)	312 x 362 x 346 mm
Dry weight	15.1 kg

5.4 Experimental work

The principle of operation depends mainly in this project based on acoustic emissions from the engine, so that the engine status diagnosed through the sound, in order to be able to work experimental and take readings, the sound coming out of the engine must be changed, so we have a malfunction in one part of the engine , and was working on separated the ignition coil wire from spark plug partially and Figure (5.5) as shown ignition coil wire and spark plug, in this case there was a misfire in the engine, so that the engine's sound changes when there is a malfunction.

Figure 5.5: Ignition Coil Wire and Spark Plug.

Then we started the engine in case of misfire and place the microphone device near the engine and the sound was transferred directly through the microphone to the NI myDAQ and Figure (5.6) shows the Signal transfer process, the LabVIEW program processed the signal as was explained in the previous chapter and after the processing process the program displays the sound signal form through the frequency.

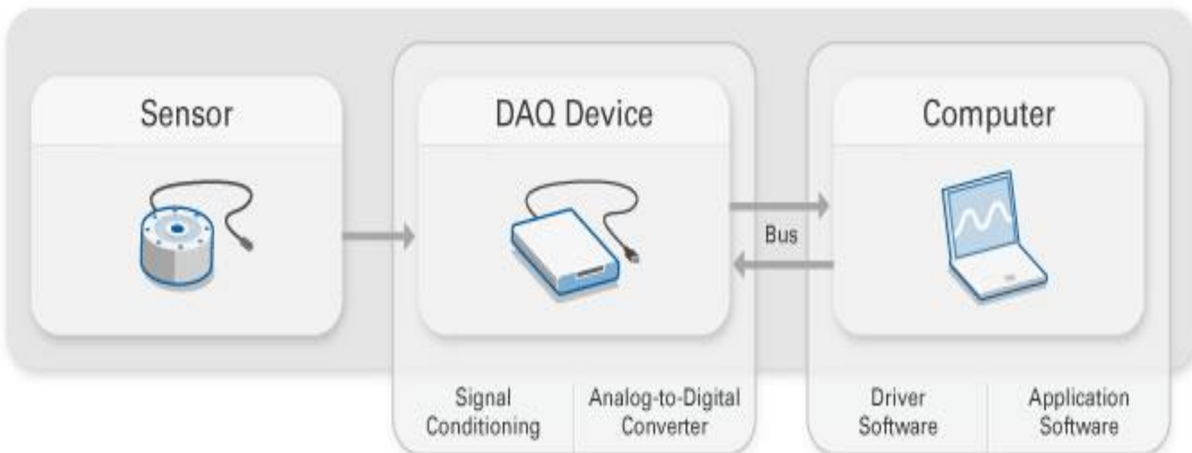


Figure 5.6: Signal transfer process.

We took readings in two cases, the first when the engine was working normally without any defect and the second case was taking the readings after the defect and the engine was not working properly and the sound was different.

The experiment was done on the number of revolution per minute (RPM) of the engine, it was calculated by a stroboscope device as shown Figure (5.7), and the following steps explain the measurement process:

1. We placed the measuring device on a flat surface with the engine.
2. We put the outside light of the device on the crankshaft, and the light was oscillating.
3. Increased the rpm staging on the measuring device.
4. After increasing the staging on the measurement panel, the light begins to stabilize, and when the light stops on the column, this reading is correct.

Figure 5.7: Stroboscope Device.

At the end we got two signals through the program, the first was when the engine was working properly and the second was when the engine was not working properly when we switched off the spark plug, by comparing the two signals we diagnose the condition of the engine, this will be explained and discussed in the next chapter through the results section.

Chapter 6

Results analysis and conclusion

5.1 Introduction

5.2 Results analysis and discussion

5.3 Conclusion

5.4 Recommendation

6.1 Introduction

In this chapter was presented the results of the signals obtained through the experiment, also were discussed these results and we compared the two sound signals of the engine in two different cases, also make recommendations for future development of the project.

6.2 Results analysis and discussion

In our experience, we got two types of signals, the sound signal and the engine normally work on the number of engine cycles (1700-1800) RPM without any load and sound signal when we caused misfire, and the number of engine cycles became at the moment of the problem (750-950) RPM, so we can diagnose the condition of the engine when comparing the two signals that were recorded directly from the engine.

We've done the experiment more than once to check the correct signals and put the microphone in more than one area on the engine's in this section we will present some of the signals obtained during the experiment.

During the process of recording the sound of the engine we obtained the two signals from the program and Figure (6.1) and (6.2) as shown of the signals form, we obtained by the microphone placed near the engine body.

First, when the engine was in good condition and number of engine cycles (1700-1800) RPM, the frequency reached (1400_1500) Hz, Figure (6.1) as shown the frequency value obtained in the X axis.

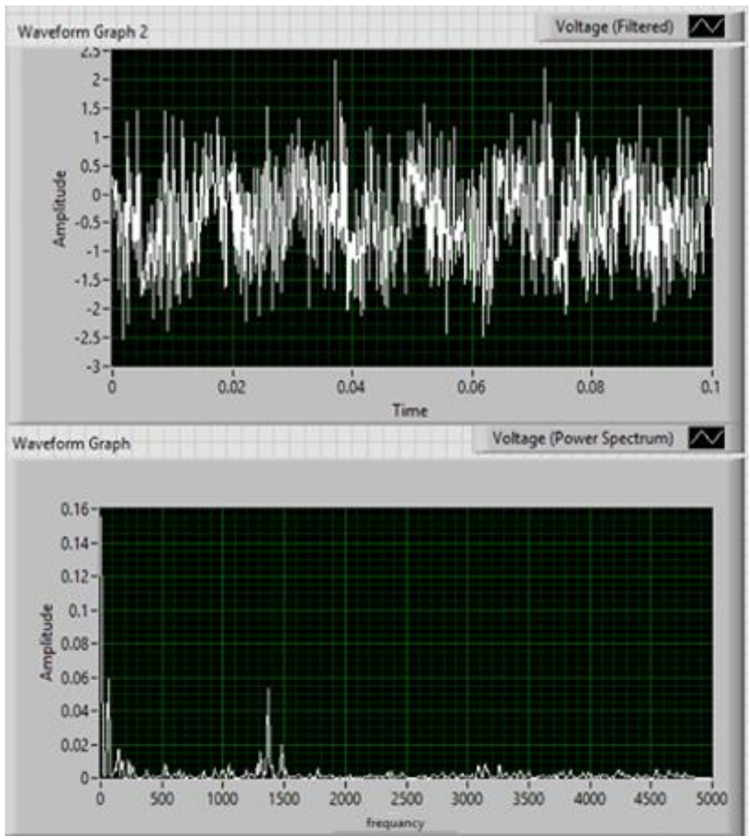


Figure 6.1: Front Panel for Signal Form.

Figure (6.1) as shown in a set of frequencies that reflect the output sounds signal from engine, such as the sound of the crankshaft and camshaft and the sound of the explosion internal the combustion chamber, when measured the engine speed was measured by the speed of the crankshaft and was in normal state (1700-1800) RPM.

Second, when the engine was in a bad condition, the frequency reached (300_500) Hz and the number of engine cycles became at the moment of the problem (750-950) RPM, Figure (6.2) as shown in the frequency value obtained in the X-axis.

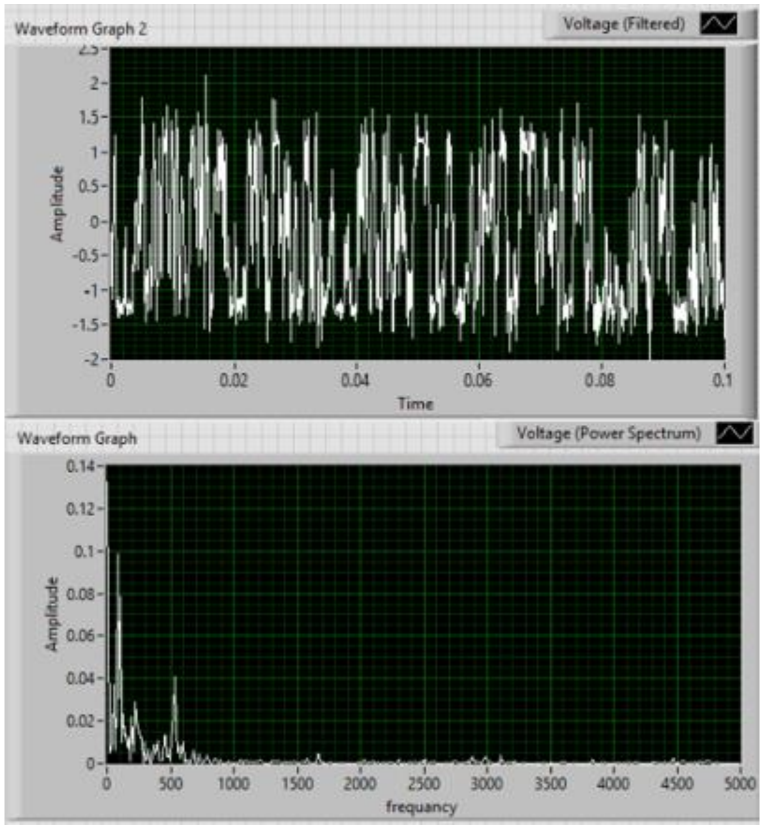
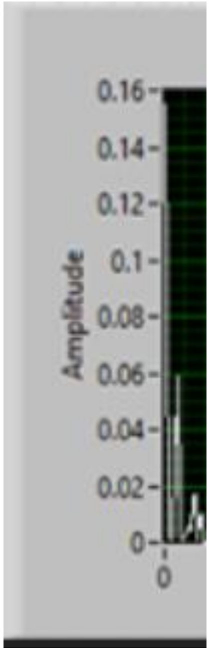


Figure 6.2: Front Panel for Signal Form.

Figure (6.2) as shown in a set of frequencies that reflect the output sounds signal from engine, but when he was in fault, such as the sound of the crankshaft and camshaft and the sound of the explosion internal the combustion chamber, when measured the engine speed was measured by the speed of the crankshaft and was in normal state (750-950) RPM, it turns out that when the speed of the engine is reduced, the frequency decreases.



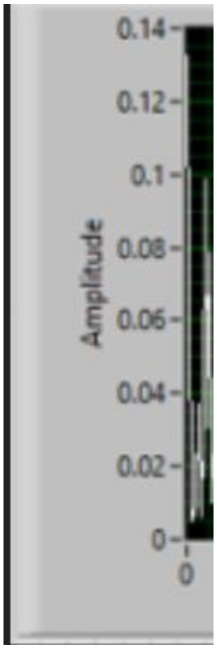


Figure A Figure B

Figure (A) taken from Figure (6.1) as shown the crankshaft sound signal at value 28.2 Hz with amplitude 0.06 dB based on number of engine cycles (1700-1800) RPM and show the camshaft sound signal at value 14.1 Hz with amplitude 0.16 dB by number of engine cycles (1700-1800) RPM.

Figure (B) taken from Figure (6.2) as shown the crankshaft sound signal at value 12.5 Hz with amplitude 0.1 dB based on number of engine cycles (750-950) RPM and show the camshaft sound signal at value 6.25 Hz with amplitude 0.13 dB by number of engine cycles (750-950) RPM.

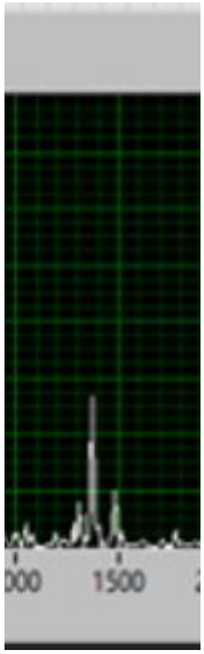


Figure C

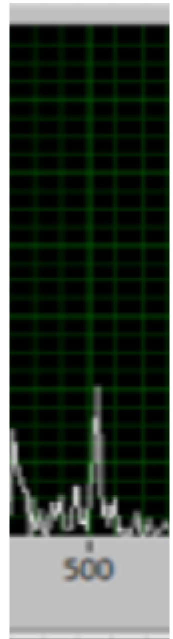


Figure D

Figure (C) taken from Figure (6.1) as shown the flame speed ignition sound signal at value 1400 Hz with amplitude 0.06 dB based on number of engine cycles (1700-1800) RPM it has been determined the flame speed value 63 m/s and the value of stroke engine 45 mm.

Figure (C) taken from Figure (6.1) as shown the flame speed ignition sound signal at value 500 Hz with amplitude 0.04 dB based on number of engine cycles (750-950) RPM it has been determined that flame speed value 22.5 m/s when value of stroke engine 45 mm.

In the third experiment we changed the location of the microphone and changed the process of signal processing in the program to show the signal with the noise as shown in Figure (6.3), This process was done to confirm the frequency value we obtained from the first experiment, the result was the same as the frequency between (1400_1500) Hz with the interference of the signal, when (1700-1800) RPM.

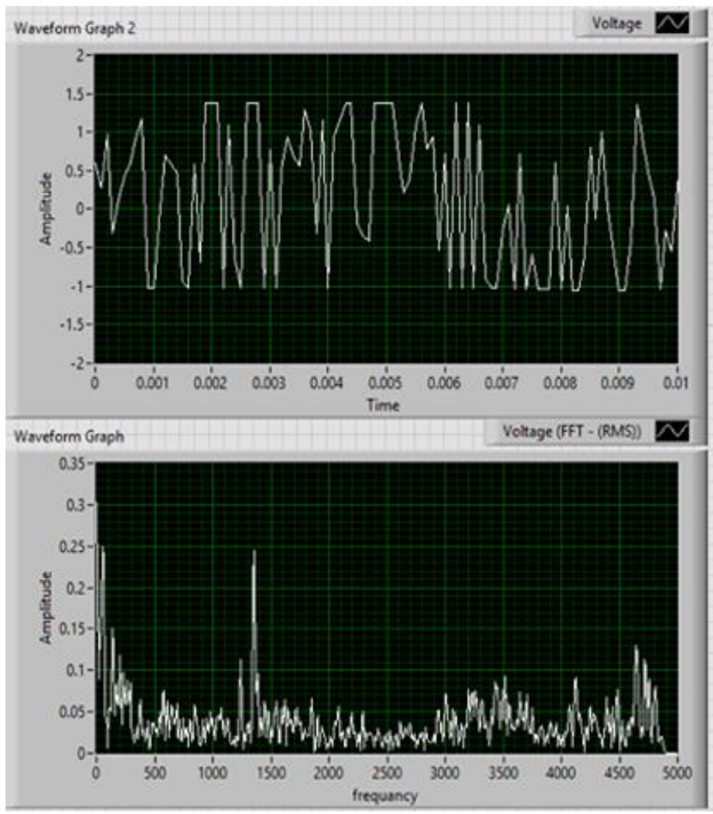


Figure 6.3: Front Panel for Signal Form.

Also, we did another experiment with the wire winding of the coil slightly less than the spark plug, the result was almost the same as the frequency change at (300-500) Hz when (750-950) RPM, Figure (6.4) as shown in the frequency value, this value is close to the previous value in the first experiment. This indicates the success of the operation taking the readings in the project.

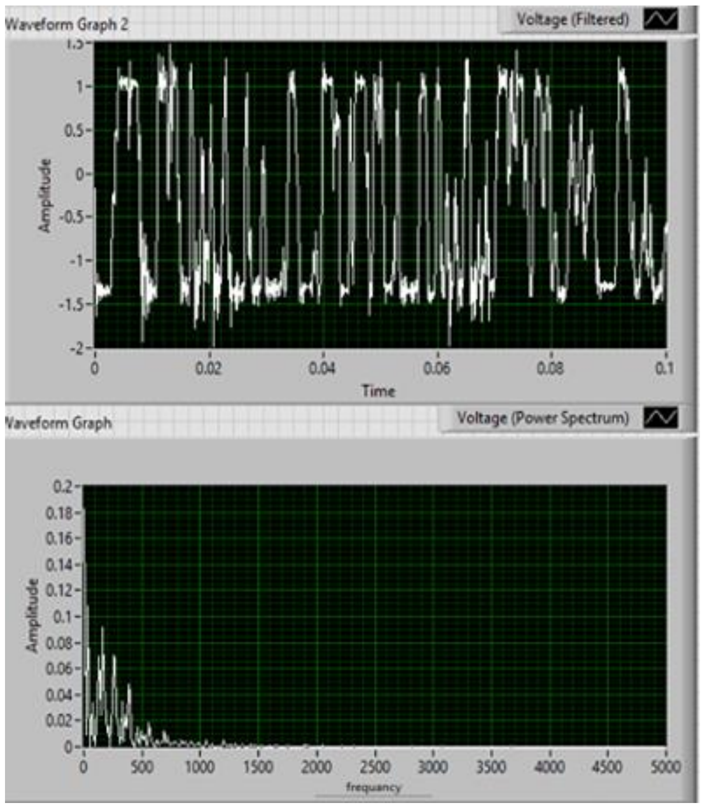


Figure 6.4: Front Panel for Signal Form.

In this experiment, we find that the change in frequency of the value of (300-500) Hz and when (750-950) RPM, means that there is a defect in the engine is misfire and one of the causes of the spark plug and the coil wires, this helps us in diagnosis any other engine by keeping this value from frequency and comparing it with any other signal in the process of diagnosing another engine on the same process and this is the main objective of our project.

6.3 Conclusion

Our project in general is a tool that diagnoses the condition of the engine, the diagnosis is based on acoustic emissions coming out of the engine, so that the tool takes the engine sound through the microphone and transfer to the NI myDAQ, which is working on the signal processing and sent to the program of LabVIEW, which works on the analysis of the signal to know the condition of the engine on the basis of the signal shown on the program.

From the results we obtained from the diagnostic process of the engine we conclude the following:

1) When the engine is working properly the frequency has reached (1400-1500) Hz when (1700-1800) RPM.
2) When the engine is not working properly the frequency has reached (300-500) Hz, when (750-950) RPM.
3) After comparing the results, it was determined that the change in the frequency value at (300-500) Hz there is a defect in the engine which is misfire.

6.4 Recommendation

1) To confirm the diagnostic information, you must use the accelerometer sensor, because when there is a malfunction, the engine will vibrate abnormally.
2) Work from this project a tablet device, so that the diagnosis process is easy and fast
3) Work experiments on the engines of vehicles and use more than a different engine in taking readings.
4) Experimenting with different engine failures and studying each malfunction.
5) Storage of acoustic emission signals for the engine in the library within the program as a reference for the diagnostic process.
6) Use more than microphone in the process, until the sound signal is taken accurately and from different locations of the engine.

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