POLITECNICO DI TORINO

Facoltà di Ingegneria

Corso di Laurea in Ingegneria Energetica e Nucleare

Tesi di Laurea Magistrale

Development and integration of methods for vibrational analysis and estimation of the residual useful life of an equipment. Case study.

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SUMMARY

The matter of vibrational analysis is a considerable area of interest in the energy engineering field in order to guarantee high reliability, efficiency of the systems and a continous improvement in terms of :

1. Mechanical equipment failures identification
2. Information about failures causes
3. Optimization of spare parts management
4. Maintenance planning

Vibrations are particular mechanical oscillations around a balance point and presents themselves in the form of signals in time domain. The central problem in vibrational analysis is precisely the time series analysis of the signals. The time series can be composed by data and can be studied using analytical methods to extract deep information about each signals.
In particular, spectral methods have been used as the standard tool to study these type of data.
Traditional spectral methods such as Fourier analysis, is a very efficient tool to analyse vibrations data, it modifies the domain of a vibrational time function (signal) in the frequency domain, thus allowing the study of his composition in terms of frequency, amplitude and phase of the signal itself (Fourier spectrum). Fourier analysis has found wide application in the predictive maintenance in order to verify the machines status and for the anomalies check.
In 1998, Huang et al. presented a new data analysis method, the empirical mode decomposition (EMD) to extract oscillating and symmetric mono components parts of a signal in time domain, known as IMFs (intrinsic mode functions). In other terms, is a method which can reach all the fundamental harmonics (mode of vibrations) using an iterative algorithm. EMD method application is now referred to as a Hilbert-Huang Transform (HHT), which represents the combination of the EMD algorithm and the Hilbert spectral analysis. This method is spreading in the structural health monitoring field. It is able to visualize deeply the signal energy spread as a function of time and instantaneous frequency.
Unlike the Fourier techniques, is also capable of displaying deeply each signals in order to understand the spread of vibrational energy inside their fundamental harmonics.
The main task of this thesis is to study the behaviour of an industrial equipment subjected to vibrations for fault diagnosis, using both the classical FFT (Fast Fourier Transform) method and the experimental one : HHT (Hilbert – Huang transform). The goal was the comparison

between the results obtained by the two techniques, verification of the equipment conditions and his residual life, and maintenance future plans elaboration.

Thanks to my experience in SKF company it was possible to implement my knowledges about the frequency spectra observation identifying and evaluating equipment reliability.

The data to be analysed are relating to signals in the time domain that correspond to periodic deterministic mode of vibrations of a plant composed by electric motors and gearboxes used for the asphalt tires processing.

The MATLAB software was used both for data processing and integration and for the frequency analysis. For the data processing it was connected to the worksheet (.txt) containing the available database. The classical FFT technique was applied in order to transform all the signals from their time domain to their frequency domain, creating the frequency spectrum of each measured vibration.

The spectrum peaks was individually analysed, in order to highlight machine anomalies machine and visualize his status.

The experimental HHT technique was applied in order to decompose all the signals in their intrinsic harmonics (IMFs) to create the Hilbert spectrum, function of the instantaneous frequency, time and vibrational energy density.

In the space generated by these quantities, the vibrational energy distribution was printed out. The evolution of the vibrational energy density, has permitted to highlight bearings anomalies.

The spectra generated by both techniques were compared and hence the bearings criticalities were identified.

The expected results are explained below :

- Historical baselines definition of the selected equipments
- Identification of the main faults and / or degradation phenomena by observing low frequency spectra
- Implementation of high frequency analysis (FFT and HHT) checking bearing failures
- Comparison among the results obtained from the two techniques
- Estimation of the equipment residual useful life

CHAPTER 1 – CLASSICAL AND EXPERIMENTAL METHODS

1.1 INTRODUCTION

A general mass vibrates when it describes an oscillatory mode around a reference position.
The modes of vibrations can be deterministic (knowing some previous data) or stochastic (random vibrations).
In the group of deterministic oscillatory modes there are the vibrations generated by rotating machine, they are mainly characterized by harmonic components with multiple pulsations of rotating trees speed. In the group of random oscillatory modes there are the vibrations generated by: waves, wind, road irregularities.
Vibrations monitoring has a key role in maintenance activities, entering inside the machine to study his behaviour surgically, identifying possible discrepancies from the correct operating conditions and giving us the possibility to prevent possible serious malfunctions. In order to reach this target, the frequency analysis is essential to be able to estimate the contribution provided by the single harmonics that compose the vibration signal. In this field, the FFT algorithm is used to generate the frequency spectrum of a vibrational signal starting from its sampling in a general time interval. The sampling of the signal is described by the DFT (Discrete Fourier Transform) that allows the discretization in time of a continuous signal.
On the other side, the HHT technique is used to put into evidence the vibrational energy density distribution as a function of time and instantaneous frequency, printing out the Hilbert spectrum.

1.2 VIBRATIONS MONITORING

Vibrations measurement can be done in different ways:

a) **Vibration level measurement** : the vibration level of a mechanical system is detected and compared with a prescribed limit to evaluate mechanical stresses induced.
b) **Excitation measurement** : forces or momenta are measured in order to study the external forces that put in vibration the overall mechanical system

c) **System response measurement** : is used to identify the response frequency function of a single or multiple mechanical system in order to estimate the intrinsic frequencies and own vibrational modes (signal spectral analysis).

1.3 MEASUREMENT ARCHITECTURE

Modern systems for the vibrations monitoring are based on a distributed architecture composed by three main operations :

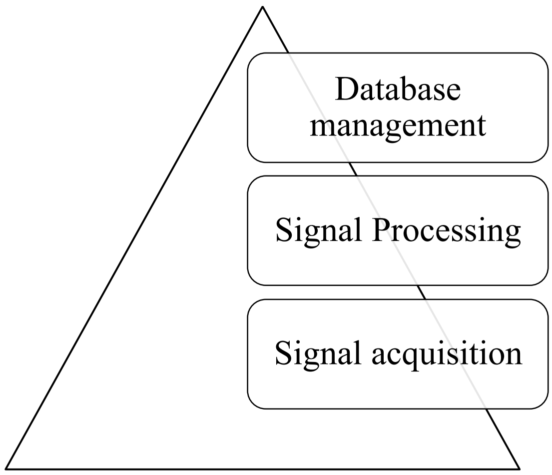


Fig 1 – Measurement levels

The equipment and tools used for these operations constitute the so-called measurement chain.

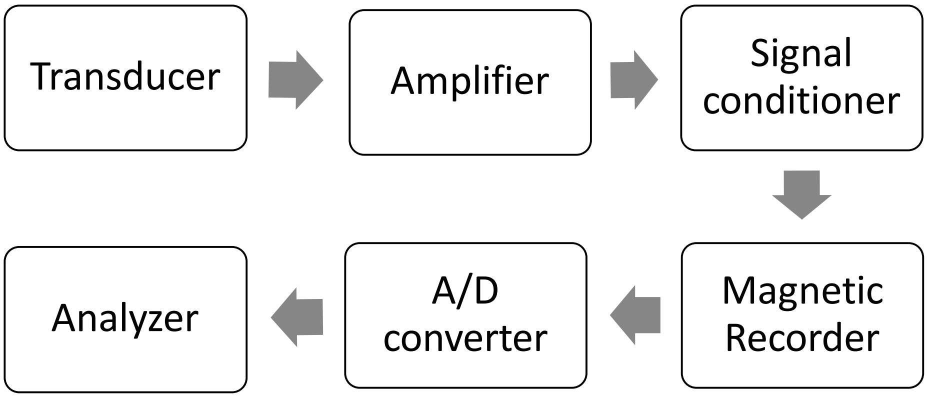


Fig 2 – Measurement chain

Transducer : It is a device that transforms the measurement of a physical phenomenon into an analog signal, according to a relationship between an input and an output. It is usually made of piezoelectric material, which has the property of generating electrical charges when it is subjected to external mechanical stresses.

Amplifier : the amplifier amplifies the amplitude of the signal from the transducer which is usually very weak.

Signal Conditioner : It performs a frequency filtering, allowing the passage of certain frequencies and a further amplification.

Magnetic recorder : keep and record experimental data using his magnetic properties.

A/D Converter : it allows to treat the signal with a computer. The signal coming from the transducer is a continuous analogic signal,. The converter detects the instantaneous value of the signal at regular intervals in time, transforming it into a discrete set of numbers (digital signal). In this way, in the output will have numbers that can be managed and processed by a computer.

Analyser : it is generally a computer designed for the analysis of the acquired data, often linked to external hardware (plotters or printers).

The signal acquisition operation, which is the most important step in vibrations monitoring, can be done continuously or at regular intervals, considering different operating conditions.

1.4 CLASSICAL WAY – FOURIER TRANSFORMATION

1.4.1 INTRODUCTION

The classical way for the vibrational analysis is to consider the Fourier transformations for the frequencies spectral representation. The Fourier transformation is the decomposition of a function into sums of simpler trigonometric functions. Therefore, Fourier transform is the output of such decomposition.

When the input to a Fourier transform is uniformly-spaced samples of a continuous function, the transformation is called discrete-time Fourier transform (DTFT). The input is a discrete samples and the output is a continuous function. If samples of the DTFT output that are equal in length are taken, then the transformation is called Discrete Fourier transform. The direct evaluation of DFT is quite expensive, requesting $O(N^2)$ operations, where each operation consists of multiplication and addition of complex values. The FFT (fast Fourier transform) algorithm extract the frequency spectrum from a discrete signal starting from his DFT (discrete Fourier transform) in a faster way than DFT one , reducing the number of operations from $O(N^2)$ to $O(\mathrm{N}log_2\mathrm{N})$. This big calculation time reduction give a lot of advantages in terms of fields of application:

1. Spectral analysis of digital signals
2. Fast convolution algorithm and correlation algorithm
3. Data compressing for memory and more efficient data transmission.

1.4.2 DFT – DISCRETE FOURIER TRANSFORM

The DFT (Discrete Fourier Transform) plays a key role in physics and engineering because it can be used as a mathematical tool to describe the relationship between the time domain and frequency domain representation of discrete signals. It is the generalization of the Fourier Transform in case of discrete signals.

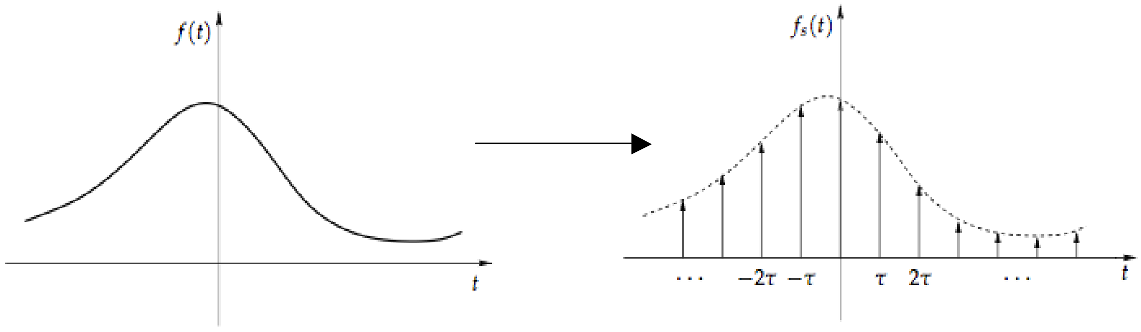


Fig 3 - Discrete Fourier transform

Setting a range of amplitude τ , for each signal *f(t)*, is possible to consider a sample signal ($f_s(t)$) obtained sampling *f(t)* with $n\tau$ times ($-\infty < n < +\infty$) and focusing the energy in each sample point with the impulsive function δ(t) (Dirac delta).

The analytical expression of the new signal will be:

$$f_s(t) = \sum_{n=-\infty}^{+\infty} f(n\tau)\delta(t - n\tau)$$

Transposing $f_s(t)$ from the time domain to the frequency domain with the Fourier Transform properties :

$$F_s(\omega) = \sum_{n=-\infty}^{+\infty} f(n\tau)e^{-j\omega n\tau}$$

From the last result is possible to define the Discrete Fourier Transform (DFT) for the discrete time signal :

$$\mathrm{X}(\Omega) = \sum_{n=-\infty}^{+\infty} x(n)e^{-j\Omega n}$$

- x(n) = f(nτ) ;
- Ω = ωτ .

Ω is the normalized frequency, because the sample frequency is $\upsilon = 1 / \tau$ (measured in Hz). Therefore Ω assumes the meaning of frequency normalized to the sampling one, $X(\Omega)$ represents the decomposition of *x(n)* in his frequency components.

More deeply, the DFT maps a sequence *x(n)* into the frequency domain considering each point as a Dirac impulse in his frequency representation. The development of the DFT originally by Cooley and Tukey followed by various enhancement and modifications by other researchers, has provided the incentive for its rapid and widespread utilization in diverse disciplines :

- Autocorrelation and cross correlation
- Bandwidth compression
- Convolution
- Image watermarking
- Audio watermarking
- Magnetic resonance imaging
- Optical signal processing
- POC (phase only correlation) in medical imaging
- Power spectrum analysis
- Psychoacoustic model for audio coding
- Radio signal processing
- Spectral estimation

1.4.3 RADIX 2 DIT - FFT ALGORITHM

From a computational point of view, the DFTs operations could be very heavy, in fact, for N samples, the complexity of computing the discrete Fourier transform is very high, therefore DFT requires a lot of complex arithmetic operations. This is why the need for algorithms with less complexity (fast algorithms), such as FFT (Fast Fourier Transform). The FFT is a series of optimized operations to calculate the DFT of a signal, reducing number of multiplications and additions of the complex values and the computational complexity. Additional advantages are reduced storage requirements and reduced computational error. Several techniques are developed for the FFT resolution but we focus only in radix – 2 decimation in time (DIT) algorithm. The scheme of this algorithm is :

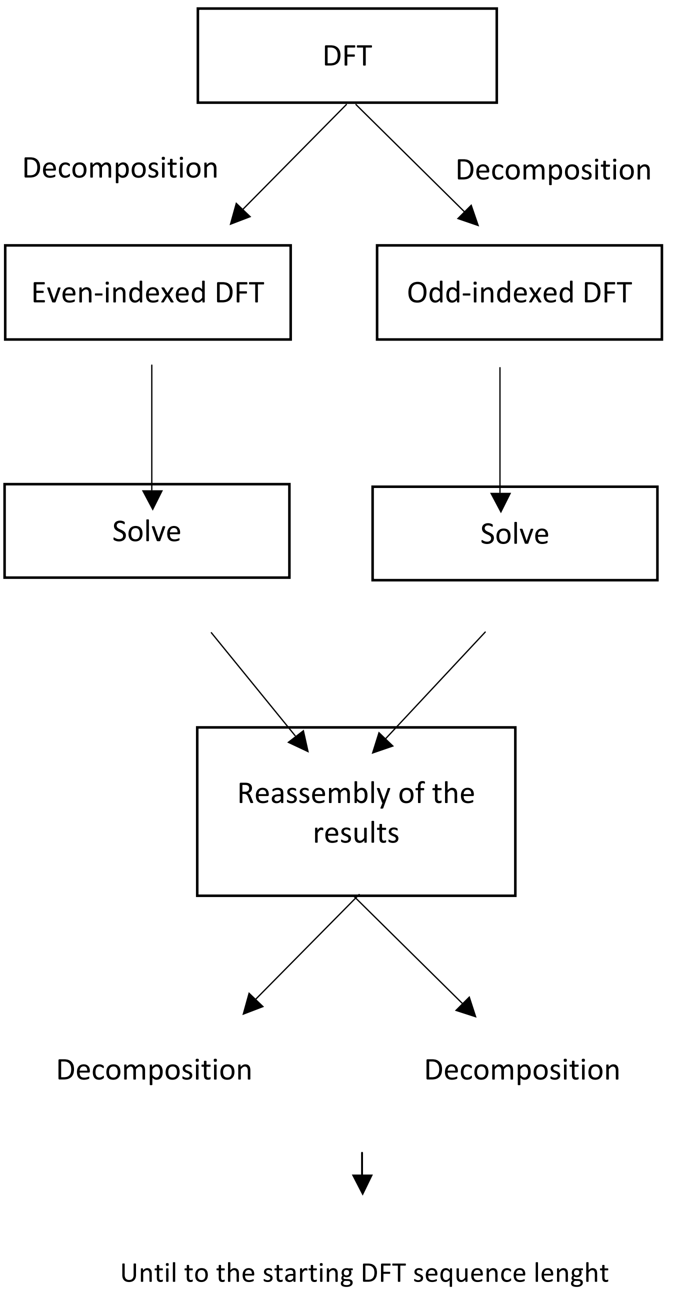


Fig 4 - DIT algorithm

A radix-2 decimation in time (DIT) is the simplest and most commons form of the Cooley-Tukey algorithm for FFT calculation. This algorithm is based on decomposing a DFT of size N into two interleaved DFTs of size N/2 (one of even samples and the other of odd samples). Further savings can be achieved by decomposing each of the two N/2-point sequences into two N/4-point sequences (one of even samples and another of odd samples) and obtaining the N/2 point DFTs in terms of the corresponding two N/4 point DFTs. Radix – 2 DIT first computes the DFTs of the even-indexed inputs and of the odd-indexed inputs, and then combines those two results to produce the DFT of the whole sequence. This idea can then be performed recursively to reduce the overall runtime. More in detail, given a DFT of length N, the Radix-2 DIT algorithm rearranges the DFT of the function x_n into two symmetric half parts : a sum over the even–numbered indices n=2m and a sum over the odd-numbered indices n=2m +1:

$$X_k = \sum_{m=0}^{\frac{N}{2}-1} x_{2m} e^{-\frac{2\pi j}{N}(2m)k} + \sum_{m=0}^{\frac{N}{2}-1} x_{2m+1} e^{-\frac{2\pi j}{N}(2m+1)k}$$

One can factor the common multiplier out of the second sum. Denote the DFT of the even-indexed inputs x_{2m} by E_k and the DFT of the odd-indexed inputs x_{2m+1} by O_k and

we obtain :

$$X_k = \sum_{m=0}^{\frac{N}{2}-1} x_{2m} e^{-\frac{2\pi j}{N/2}mk} + e^{-\frac{2\pi j}{N}k} \sum_{m=0}^{\frac{N}{2}-1} x_{2m+1} e^{-\frac{2\pi j}{N/2}mk} = E_k + e^{-\frac{2\pi j}{N}k} O_k$$

From these results, the final output represents a combination of E_k , O_k and a multiplier. Here, X_k , the N-point DFT of x(n) is expressed in terms of N/2 - point DFTs, E_k and O_k, which are DFTs of even samples and odd samples of x(n) respectively.

X_k : is periodic with period N, $X_k = X_{k+N}$;

E_k, O_k : are periodic with period $N/2$, $E_k = E_{k+N/2}$, $O_k = O_{k+N/2}$;

Considering $e^{-\frac{2\pi j}{N}k} = W_N^k$ we can write :

$X_k = E_k + W_N^k \ O_k$ with $k = 0,1,\dots,N/2 - 1$

$X_{k+N/2} = E_k + W_N^{k+N/2} \ O_k$

$W_N^{N/2} = e^{(\frac{-2j\pi N}{N \ 2})} = e^{-j\pi} = -1$

Since $W_N^{k+N/2} = e^{\frac{-j2\pi}{N}(k+N/2)} = W_N^k \ W_N^{N/2} = -W_N^k$, it follows that

$X_{k+N/2} = E_k - W_N^k \ O_k.$

Therefore, the Radix-2 algorithm DIT, requires four operations, one adds, one substraction and two multiplications, as shown by in the expressions of X_k and $X_{k+N/2}$, which are linked together from these. This algebraic assembly forms a particular diagram (Butterfly Diagram) to display graphically the algorithm.

- **Example**

Data flow diagram with N=8 samples – Butterfly Diagram

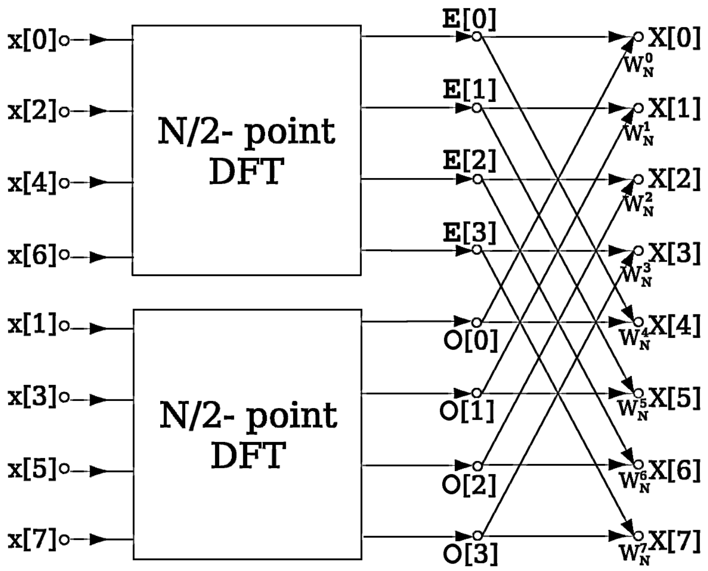


Fig 5 – Butterfly flow diagram for the FFT algorithm

The butterfly symmetry of the algorithm is simply to understand. As shown in the example the X(0) DFT of x(0) sequence, is linked by an arrow pointing downwards to X(4) DFT, X(4) = $X_{k+N/2}$, with k=0, N=8. In the same way from X(4) line, start out an arrow pointing upwards to X(0) line. The final result is X(0)=E(0)- W_N^4 O(0) and X(4) =E(0)+ W_N^4 O(0). The same strategy is followed for all the other DFT calculations, considering that the arrow pointing downwards means an addition and the arrow pointing upwards means a substraction, the horizontal line means a multiplication.

1.5 EXPERIMENTAL WAY – HHT (Hilbert – Huang transform)

1.5.1 INTRODUCTION

The Hilbert – Huang transform is an empirically based data analysis method.
The HHT (Hilbert-Huang Transform) consists of two parts: empirical mode decomposition (EMD) and Hilbert spectral analysis (HSA), which is based on the Hilbert transform application on each IMFs. This method is potentially viable for time - frequency- energy representations of data.
It has been tested and validated exhaustively, but only empirically. In all the cases studied, the HHT gave results much sharper than those from any of the traditional analysis methods in time-frequency-energy representations. The steps of HHT methods are shown below :

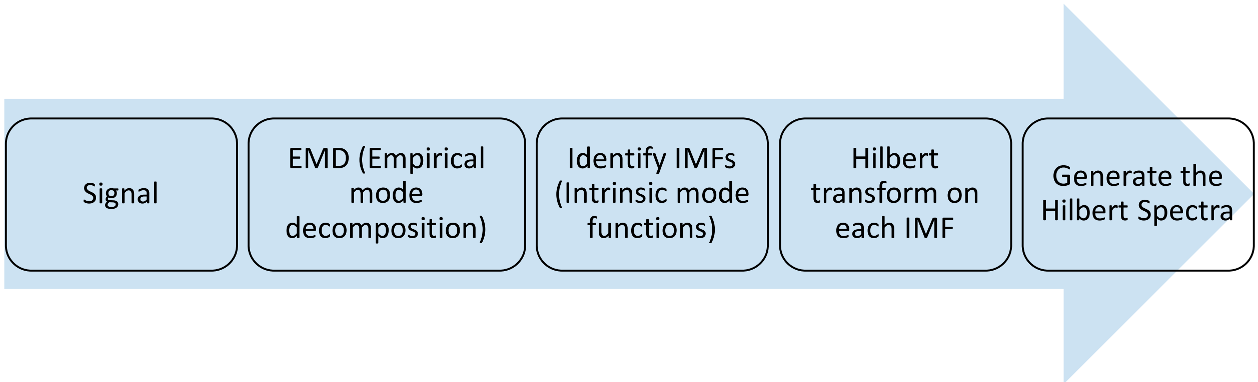


Fig 6 - Hilbert Huang transform flow diagram

1.5.2 EMPIRICAL MODE DECOMPOSITION (EMD)

Empirical Mode Decomposition (EMD) is the main part of the HHT method, widely used to decompose data into a series of intrinsic mode functions (IMFs) and a trend function through the sifting process. The starting point of EMD is to consider oscillatory signals at the level of their local oscillations and to formalize the idea that:

“signal = fast oscillations intrinsically composed by slow oscillations (fundamental harmonics)” and to iterate on the slow oscillation components considered as a new signal. This one - dimensional decomposition technique extracts a finite number of oscillatory components, called intrinsic mode functions (IMFs), directly from the data. The IMFs are obtained from the signal by means of an algorithm (sifting process). The sifting procedure is based on two constraints: *"each IMF has the same number of zero-crossings and extrema, and also has symmetric envelopes defined by the local maxima, and minima, respectively"* . A brief overview of the EMD and sifting process algorithm is displayed below :

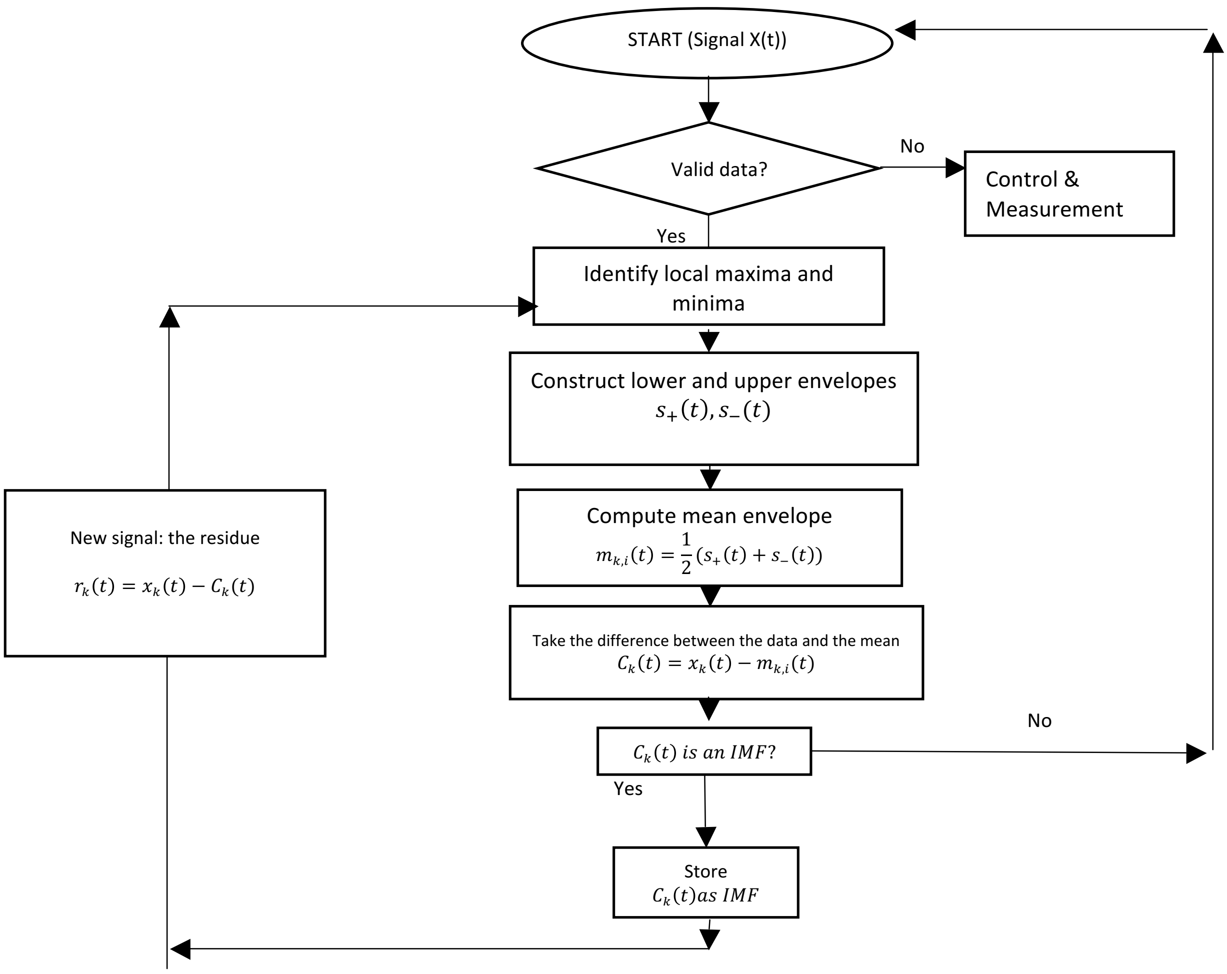


Fig 7 - EMD algorithm

According to the two conditions concerning the IMFs :

1) The difference between the number of its extrema and that of its zero-crossing points is no larger than 1.

2) The upper and lower envelopes are basically symmetric, that is, the mean baseline is very close to zero.

and with a designed stoppage criterion the algorithm is stopped.
The sifting process usually begins with constructing the upper and lower envelopes of the original signal X(t) by performing cubic spline interpolations to fit the local maxima and minima, respectively. The average m(t) of both envelopes can then serve as a temporary baseline, which is subtracted from the original signal to perform the first round of sifting process and obtain the temporary IMF candidate C(t). Such sifting procedures are repeatedly conducted until the stoppage criterion is met at the k^{th} round. The sifting procedure generates a finite (and limited) number of IMFs that are nearly orthogonal to each other.
For N intrinsic mode functions, the original signal is represented as :

$$X(t) = \sum_{i=1}^{N} C_i(t) + r_n(t)$$

1.5.3 STOPPAGE CRITERIA

Stoppage criteria have been studied to stop the empirical mode decomposition algorithm, defining a real mathematical criterion that limits the calculation of the IMFs from the sifting process. There are various types expressed through different mathematical concepts.

1.5.3.1 CAUCHY TYPE

This stoppage criterion is based on the difference between two consecutive rounds. Specifically, the sifting process will stop when the difference SD (standard deviation), computed from two consecutive results, is smaller than a predetermined value:

$$SD = \sum_{t=0}^{T} \frac{[h_{k-1}(t) - h_k(t)]^2}{h_{k-1}(t)^2}$$

If the SD is smaller than a given and assigned small number ε, the convergence is reached and the sifting process will be stopped. The convergence is always satisfied empirically, but rigorous prove is still lacking. The above criterions is a global property , furthermore, the SD value is heavily influenced by small proto – IMF values at particular locations. Taking into consideration this problem, a new definition was formulated :

$$SD = \frac{\sum_{t=0}^{T} [h_{k-1}(t) - h_k(t)]^2}{\sum_{t=0}^{T} {h_{k-1}}^2(t)}$$

Still another variations to have SD defined as to be small everywhere :

$$SD = \frac{[h_{k-1}(t) - h_k(t)]^2}{h_{k-1}(t)^2}$$

1.5.3.2 THE MEAN VALUE CRITERION

The SD (standard deviation) value is defined as single term :

$$SD = m_{i,k}(t)$$

Therefore , the sifting will stop when SD is smaller than a pre- assigned value everywhere. This definition is more better than Cauchy, because it force the envelopes to be symmetric, satisfying one of the two critical characteristics of IMF.

1.5.3.3 THE S-NUMBER CRITERION

This criterion was proposed by Huang et al. (2003) and it is related to the other aspect of the definition of the IMF. The S-number is defined as the number of consecutive sifting iterations in which the number of zero-crossings and extrema stay the same and are equal or differ by one.

1.6 HILBERT SPECTRUM

To facilitate the understanding , we define the Hilbert spectrum quantitatively in terms of energy density as:

The Hilbert energy spectrum is defined as the energy density distribution in a time-frequency space divided into equal-sized bins of $\Delta t \times \Delta\omega$ *with the value in each bin summed and designated as* $a^2(t)$ *at the proper time, t, and proper instantaneous frequency, ω.*

With this definition, one can see that the resolution of the Hilbert spectrum is determined by the bin size selected but not by the total data length and sampling rate as in the Fourier spectral analysis [14].

Having obtained the intrinsic mode function (IMF) components $(c_j(t))$,the signal x(t) becomes:

$$x(t,\omega) = \sum_{j=1}^{n} c_j(t)$$

Also expressed putting into evidence amplitude and phase functions:

$$x(t,\omega) = \sum_{j=1}^{n} a_j(t) \cos \theta_j(t)$$

Hilbert transform on each IMFs is applied and we obtain :

$$x(t,\omega) = \sum_{j=1}^{n} a_j(t) \cos \left(\int_0^t \omega_j(\tau) d\tau\right)$$

where θ_j is the phase function, ω_j is the instantaneous frequency, a_j is the corresponding amplitude as a function of time. Is more convenient to represent the Hilbert spectrum considering the squared value of the amplitude, which is used commonly to represent energy density, therefore the squared values of amplitude can be substituted to produce the Hilbert energy spectrum as well. It represents the cumulated amplitude over the entire data span in a probabilistic sense.

Therefore, the squared signal should be :

$$x(t,\omega) = \sum_{j=1}^{n} a_j{}^2(t)\, cos^2(\int_0^t \omega_j(\tau)d\tau)$$

This final result represents the Hilbert spectrum in a mathematical form. The Hilbert spectrum is defined graphically in the figure below:

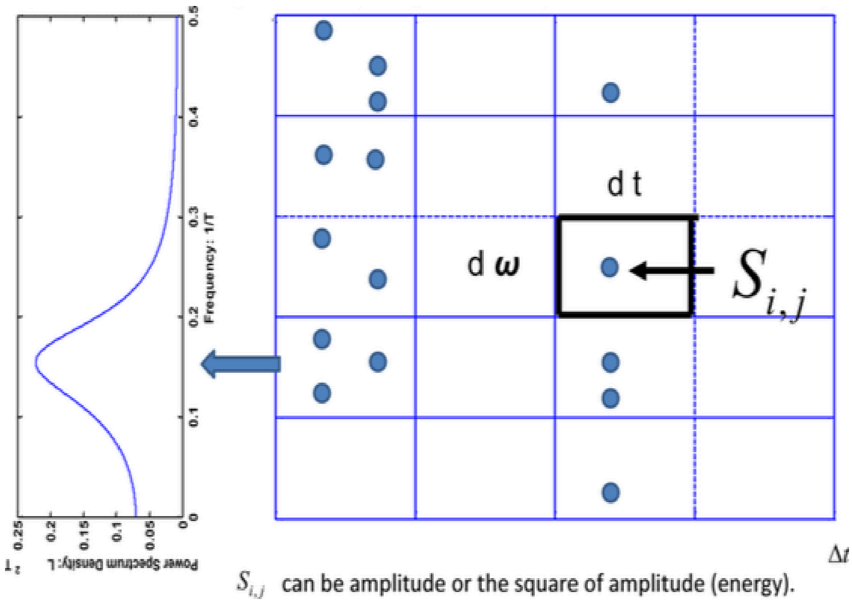


Fig 8 - Hilbert spectra representation

The time-frequency is subdivided into equal-sized bins. Energy density values fall in the bin would be summed. Therefore, the bin size determines the spectral resolution.

Before putting the two techniques into practice, the main problems of rotating machines and gearboxes highlighted by technical experience were analyzed.

CHAPTER 2 – PREDICTIVE MAINTENANCE OF ROTATING MACHINES

2.1 INTRODUCTION

The introduction of industrial equipments allowed to improve the productivity and the quality of work but in order to have the continuity of the service is become important the continuous control and the machines maintenance. It was born the necessity to implement a correct forecasting analysis in order to remove or minimize failures and stops and so an accurate and in-depth prevision of the possible damages and stops of the machines, avoiding very serious damages to the whole productivity of the plant.

2.2 PREDICTIVE MAINTENANCE

Predictive maintenance is a process that aims at determining the actual operating state of the machine by setting parametric alert and alarm limits. These limits are accurately chosen based on the historical trend of the fundamental variables of the machine and on its operating conditions. Checking the variables (e.g. vibrations, temperatures) we can evaluate and support the correct decisions on the interventions to be carried out and analyse the causes that have made them vary from the actual operating conditions of the machine. With the predictive maintenance, malfunctions and maintenance costs (turnovers, orders etc) are drastically reduced and also plant stops are eliminated, thus maintaining productivity in line with the market logics.

Therefore, the main advantages that a predictive maintenance project can obtain are:

1. Maximization of machine productivity
2. Minimization and optimization of unplanned machine downtime
3. Minimization of the number of inspections, dismantlings, repairs and periodic reviews
4. Improvement of the reparation time
5. Increase of machine life and product quality
6. Lower maintenance costs and higher plant safety

2.3 MACHINES CLASSIFICATION

For a correct execution methodology of the predictive maintenance, the equipments are divided based on their single operation or in relation with the whole plant:

1. Essential machines whose stop compromises the entire production (central turbo generators, single compressors)
2. Essential machines but composed by at least two identical units, one with a bypass function (loading/unloading pumps, process pumps)
3. Machines whose stop does not compromise the production (fans, circulation pumps)
4. Machines that works with intermittence

2.4 VIBRATIONAL ANALYSIS IN THE PREDICTIVE MAINTENANCE – VIBRATION CHECK MONITORING

The measure of vibrations is the first step in the machine conditions monitoring to have a correct predictive maintenance. Based on data acquired from vibrational sensors, 3 characteristic quantities are analysed:

- Movement - distance of one point from another taken as reference (e.g. rotating shaft in relation to its housing)
- Speed - measure of the movement variation over time
- Acceleration - measure of the speed variation over time

These data are studied with the frequency analysis techniques and compared with the historical data of the machine and its limits prescribed a priori.
In this way, the identified deviations make it possible to establish the future action plans for the machine, usually 3: machine that can work, machine that can not work and in an alert state. The vibrational excitations detected by the frequency spectra make it possible to highlight the current state of the machine and predict its future evolution..

2.5 PROBLEMS OF THE ROTATING MACHINES (VIBRATION CAUSES)

In the rotating machines (e.g. electric motors, turbo-machines, fans, centrifugal impellers) vibration causes are related to particular events deriving from structural or process problems that lead to material stresses with relative loss of efficiency.

2.6 STRUCTURAL PROBLEMS

2.6.1 UNBALANCING

Unbalancing is one of the most frequent causes of rotating bodies vibration. In a radial sense, from the spectral analysis, a peak will be seen at the frequency relative to the rotation speed of the rotor. It is an event caused by the imbalance between the rotation axis and one of the rotary inertia axes. There is an asymmetrical mass distribution with respect to the rotation axis. It can be caused by an obstruction of the impeller blades that can be the presence of elements deriving from the process or blade material, which cause a centrifugal force, acting as a sinusoidal excitation on the structure with frequency equal to that of rotation.
This involves:

- Additional load on bearings
- Fatigue of constituent materials
- Transmission of vibrations to neighboring structures

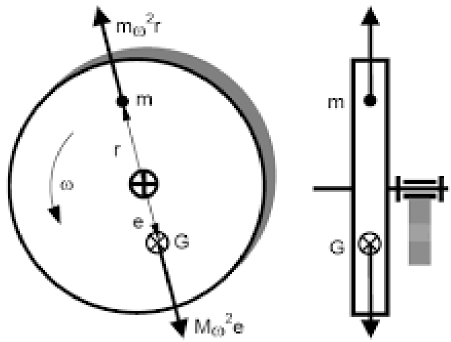


Fig 9 - Rotor unbalance

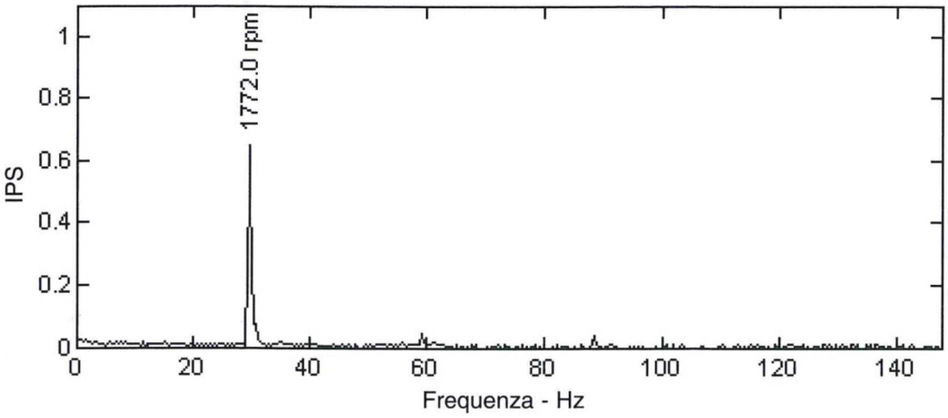


Fig 10 - Unbalance Fourier spectra (from Corrado Cesti - “L’analisi delle vibrazioni nella manutenzione predittiva” *)*

2.6.2 MISALIGNMENT

We have a misalignment when the shafts axes, joints and bearings are not coincident. It is divided into two types: angular and parallel. Angular misalignment occurs when the shafts begin to be stressed by a bending moment created by the clamping forces applied to the joint bolts. Parallel misalignment occurs when the shafts are parallel to each other but not on the same axis. The causes that lead to the phenomenon of misalignment can be:

- Thermal expansions depending on the operational conditions
- Current misalignment during the assembly

- Forces transmitted by the machine
- Substructures (Foundations)

The effects produced by the phenomenon are overloads for the bearings and for the structure of the machine.
Angular misalignment produces axial vibrations at the rotation speed frequency (1x) while parallel misalignment produces radial vibrations at a frequency twice the rotation speed (2x)

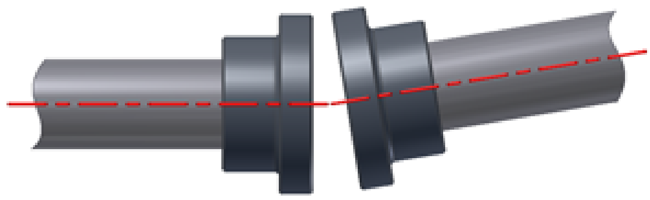


Fig 11 - Angular misalignment

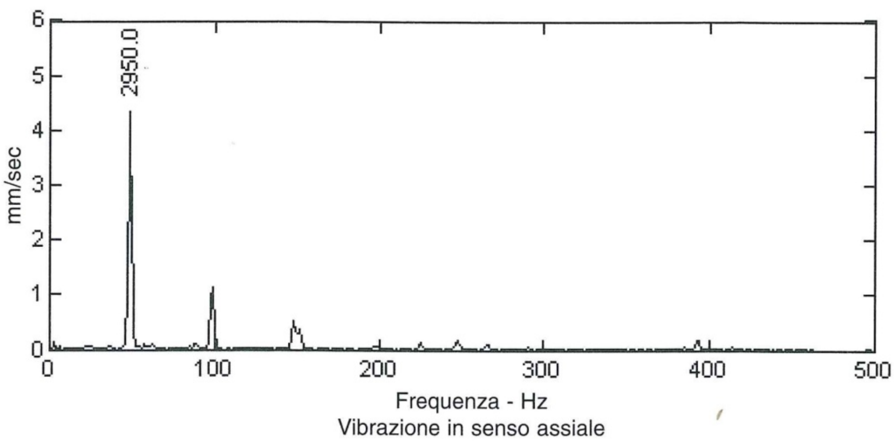


Fig 12 – Angular misalignment Fourier spectra (from Corrado Cesti - "L'analisi delle vibrazioni nella manutenzione predittiva")

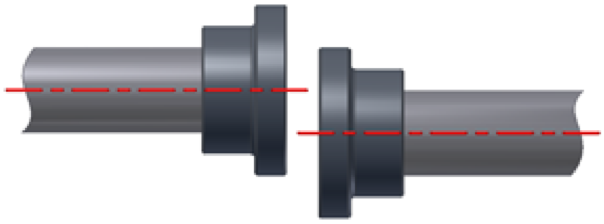


Fig 13 - Parallel misalignment

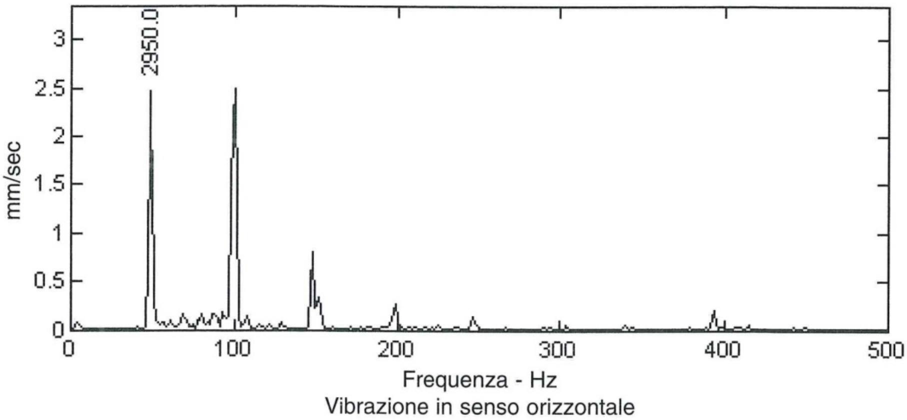


Fig 14 - Parallel misalignment Fourier spectra (from Corrado Cesti - "L'analisi delle vibrazioni nella manutenzione predittiva")

2.6.3 EXCESSIVE GAMES, MECHANICAL LOOSENINGS

Mechanical loosening causes vibrations with proportional frequencies to the rotation speed and consecutive harmonics (1x, 2x, 3x, often even 0.5x). It is caused by badly paired mechanical elements, inaccurate tightening or structural failures of the foundations.

The effects are seen in the long run, in particular on the bearings, which will start to suffer from the inner ring.

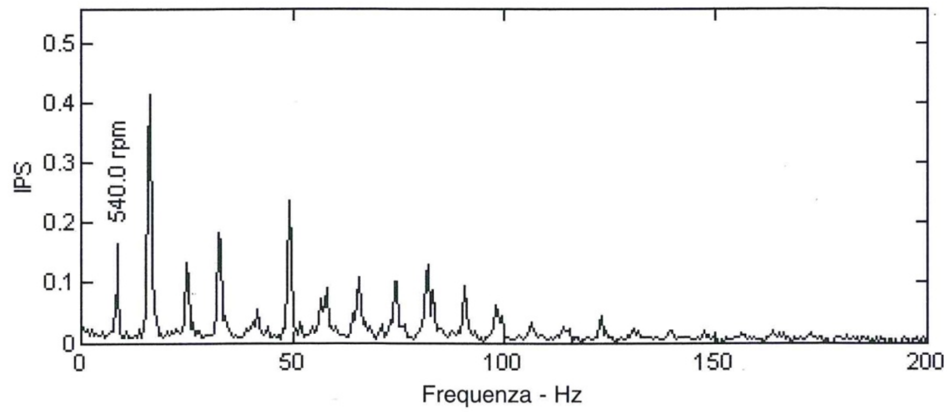


Fig 15 - Mechanical loosenings Fourier spectra (from Corrado Cesti - "L'analisi delle vibrazioni nella manutenzione predittiva")

2.6.4 ROTORS PROBLEMS

Impeller blade problems appear with high vibrations to the harmonics of the rotation speed, (i.e. the rotation speed multiplied by the number of blades). The causes that arouse the above-mentioned phenomenon can be various:

- Surface wear of the blades
- Cavitation: in some areas of the blade, it can appear localized hollows which favour the formation of bubbles, they implode instantaneously causing wear of the material constituting the blade
- Regulation of the unsuitable machine
- Special process conditions

Fig 16 - Centrifugal Pump Cavitation

2.6.5 ELECTRICAL PROBLEMS

In the electrical motors, vibrations can be generated by structural or electromagnetic problems. Electromagnetic problems can be caused by a non-uniformity of the electromagnetic field generated inside the stator case : in fact it does not spread uniformly according to the design parameters but it generates vibrations at 100 Hz frequency (2x harmonic) in the radial direction. Moreover, one of the main causes is copper stator coils badly assembled or weakly destructured. Even the short circuits can destabilize the ferromagnetic structure of the machine causing the unevenness of the generated electromagnetic field. Structural problems can be linked to the motor base.

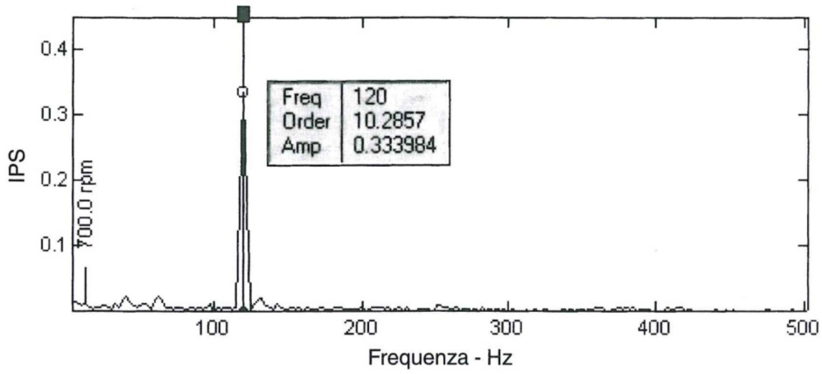


Fig 17 - Electrical problems Fourier spectra (from Corrado Cesti - "L'analisi delle vibrazioni nella manutenzione predittiva")

2.7 PROCESS PROBLEMS

Problems related to the process that lead to the increase of the machine vibrations are often related to the regulation. For example, in some plants where two machines are placed in parallel but only one of them should work and the other acts as a support to cover some maintenance periods. Often, both machines work together to guarantee greater production under certain conditions imposed by plant requests. This situation brings suffering to the process lines and to the machines themselves, thus increasing the relative vibrations. Another example is the density variation of a fluid treated by the machine (e.g. centrifugal pump) due to particular thermal variations: there will be frequencies peaks at 4x, 5x and in the long period machine suffering during its cycle of work.

2.8 VIBRATIONAL ANALYSIS OF GEARBOXES AND GEARS

The vibration analysis of gearboxes and gears is very complex because it takes into consideration a system composed by a lot of elements and forces that interact each other.
In the frequency analysis, the one that must be verified is the frequency of the meshing GMF (Gear Mesh frequency). It is equal to:

$$GMF = \frac{n * z}{60}$$

n : rotation speed (r/min)

z : number of teeth

This value is fundamental during the spectral analysis because it can indicate problems such as tooth wear, inefficient lubrication, incorrect interference. The presence of the side bands characterizes the real alarmed bell of the onset of a problem. Often they depend on a possible misalignment of the toothed shafts / wheels or the non-coincidence of the rotation axis with that of the primitive.

2.8.1 TEETH WEAR

The main indicator of tooth wear is the excitation of the natural frequency of the gears with side bands around it. GMF will have a consistent width and we can observe the side bands surrounding it. Also it is possible to observe the 2x GMF (second harmonic) and 3x GMF(third harmonic) peaks.

2.8.2 TEETH STRESSES

The load on the tooth is often highlighted with high peaks of GMF. The 2x GMF and 3x GMF often occur at lower amplitudes.

Fig 18 - Worn tooth

2.8.3 ECCENTRICITY OF THE GEARS

Side bands of rather high amplitude will be observed around the harmonics of GMF. This phenomenon is an indication of gears eccentricity, games or non-parallel shaft that lead to inaccurate gears and in the long period to the wear of the teeth. Furthermore, the 1x RPM level of the eccentric gear will normally be quite high.

2.8.4 MISALIGNMENT

The misalignment phenomenon is observable by the 2x GMF and higher harmonics.
In particular, the peak at the second harmonic of GMF will be raised. It could also be caused by a problem with the coupling between the electric motor and the gearbox, for this reason it would be advisable to analyse the state of the electric machine upstream.

2.8.5 BROKEN TOOTH

A cracked or broken tooth will generate an high amplitude (1x RPM) in the time domain and will excite the gear natural frequency with spaced lateral bands of rotation speed. We can better identify it in the time domain which will manifest a pronounced peak each time the faulty tooth attempts to mesh on the teeth of the conjugated gear.

2.8.6 PHASE PROBLEMS

During its work cycle, the gear may exhibit problems as regards the phase. This means that the toothed wheels do not mesh perfectly with each other and this will cause, in the frequency spectrum, quasi-periodic impulsive peaks with consistent side bands.
The causes of an imperfect mesh can be :

- Surface wear of the cogged wheel
- External elements that create localized friction forces

2.8.7 COUPLING OF LOOSEN BEARING

An excessive play of the gear support bearings also high amplitude to GMF, 2x GMF and 3x GMF. These high GMF amplitudes are in fact a reaction of the loosening of the bearings support This excessive mechanical game can be caused by considerable wear or an improper coupling of the bearing during installation. If it is not corrected it can cause excessive wear of the gear and it can also damage other components.

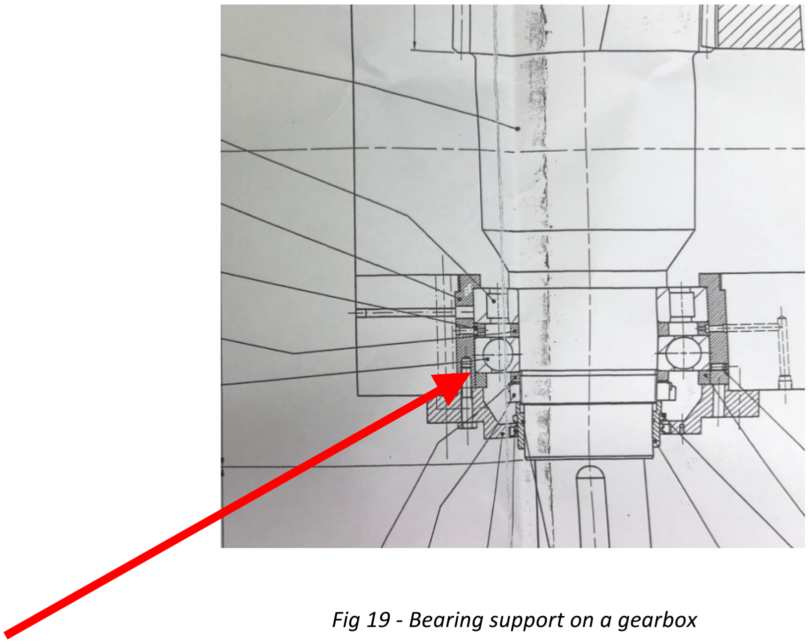


Fig 19 - Bearing support on a gearbox

CHAPTER 3 – CASE STUDY AND FFT APPLICATIONS

3.1 CASE STUDY

The plant under analysis consists of a series of electric motors and gearboxes, used for the asphalt tires processing. The vibrational data were measured radially, in different periods and in different years. The measurements were taken in acceleration with unit of measure *"g"* in a time interval from 0 to 1 second.

The 25000 acceleration values measured in a range between 0 and 1 s with a Δt of 4e-5, represent the signal sampled in the time domain (fig.3).

For the gearboxes, the measured points were two : the point 1 corresponding to the drive wheel and point 2 corresponding to the operating wheel ; as far as measurements on electric motors are concerned, point 1 corresponds to the fan side of the motor and point 2 to the coupling side (between motor and gearbox).

The groups of machines are 6 thus constituted :

Group 0	MI	Motor (n.2)
	MI	Gearbox
	HD1	Gearbox
	HD2	Gearbox
Group 1	MI	Motor
	MI	Gearbox
	HA13	Gearbox
	HD14	Gearbox
	HD15	Gearbox
	HD16	Gearbox
Group 2	MI	Motor
	MI	Gearbox
	HA23	Gearbox
	HD24	Gearbox
	HD25	Gearbox
	HD26	Gearbox
Group 4	MI	Motor (n.2)
	MI	Gearbox
	HA40	Motor
	HA40	Gearbox
	HD41	Gearbox
	HD42	Gearbox

Group 5	MI	Motor (n.2)
	MI	Gearbox
	HA51	Motor
	HA51	Gearbox
	HD53	Gearbox
	HD54	Gearbox
	HD55	Gearbox
	HD56	Gearbox
Group 6	MI	Motor (n.2)
	MI	Gearbox
	HA61	Gearbox
	HA62	Gearbox
	HD61	Gearbox
	HD62	Gearbox
	HD63	Gearbox
	HD64	Gearbox

The data were processed and integrated into vectors and matrices with MATLAB.
Using the "*fft*" function of the software, which contains the Fast Fourier algorithm in itself, the signals were transported from the time domain to the frequency domain, thus explicating the individual spectra. The analysis was carried out first on the vibrational velocities, obtained through the integration of the same measured accelerations. Then, directly on the latter, at high frequencies. For the low frequency analysis the obtained results was based on the predictive maintenance rules explained in the chapter 2.
A monitoring report has been printed, useful for the operators in planning the machine maintenance and rolling bearings control.
Subsequently, the Hilbert transform has been applied to the acceleration measurements of the critical bearings reported by the high frequencies FFT analysis, through three fundamental functions coded on MATLAB :

1. The “*findpeaks*” function (signal peaks evaluation)
2. The “*imf*” function, allows the extraction of the intrinsic mode functions from each signal, performs the cubic spline interpolation troughout the peaks and ,calculate the mean value. (fig. 8)

3. The “*plot_hht*” function allows the Hilbert spectrum creation of each IMFs and print on the screen the plots

The application method is shown here :

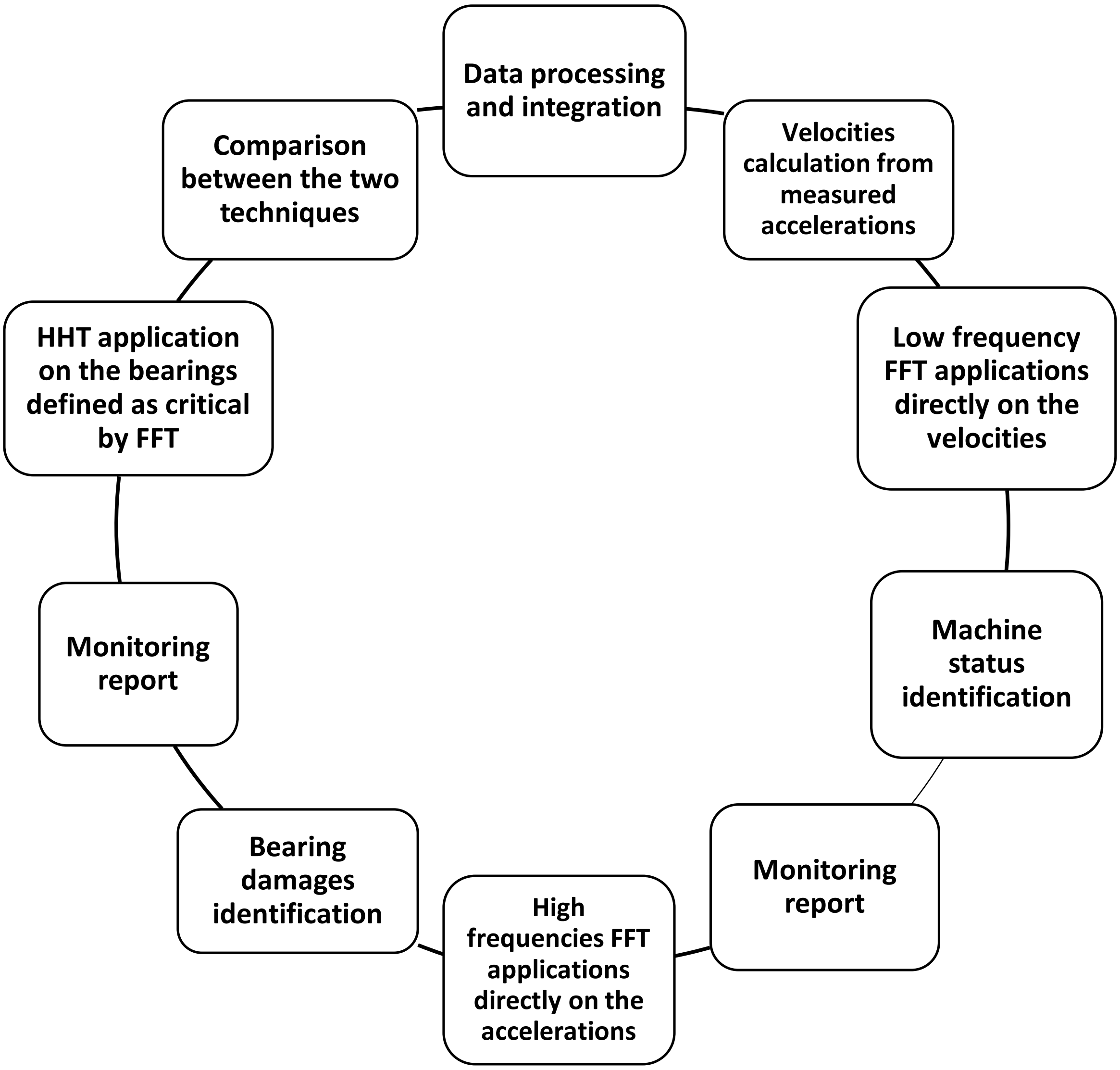


Fig 20 - Application method

In the first part of the analysis, were selected machines for which it was possible, to create a historical baseline in order to verify the evolution of the equipment status and consequently the evolution of frequency peaks , based on the database at our disposal.

3.2 LOW FREQUENCY FFT APPLICATIONS

Initially, the selected machines acceleration measurements were transformed into vibrational velocities (mm/s) by integration operation and, subsequently the FFT technique was applied, transforming the same velocities from the time domain to the frequency domain. The spectral observation field was restricted with a low-pass filter (0 - 600 Hz), in order to highlight any structural or process anomalies related to the machine. To this end, the FFT technique has proved to be fundamental in the characterization of the machine status, at least until the last measurement and, for the future prediction of the improvement actions to be carried out in order to maintain high system reliability.

Below, there is the list of the machines selected for the analysis, evaluated on the basis of data availability in order to create the historical baseline of the each equipment :

- Gearbox HD15 Group 1
- Gearbox HD14 Group 1
- Gearbox HD26 Group 2
- Gearbox HA40 Group 4
- Gearbox HD53 Group 5
- Gearbox HD54 Group 5
- Gearbox HD55 Group 5
- Gearbox HD61 Group 6

The input gearboxes velocities are 200 rpm. These velocities have made it possible to know the peak frequency corresponding to the rotation speed, equal to about 4 Hz, calculating with this operation :

$$v = \frac{rpm}{50\ Hz}$$

From the spectral observations, the 1x GMF (gear mesh frequency - first harmonic) of the single gearbox, is located between 30 and 50 Hz. This is an hypothesis, because we don't know exactly the number of gearboxes teeth but we can consider a value around 15.

3.2.1 RESULTS

The gearbox HD 15 from the group 1 has a spectrum indicating problems of tooth wear and, observing the periodicity of the first harmonics, it explains a phenomenon of mechanical loosening and eccentricity of the gears. The 1x GMF peak express also an unbalance phenomenon.

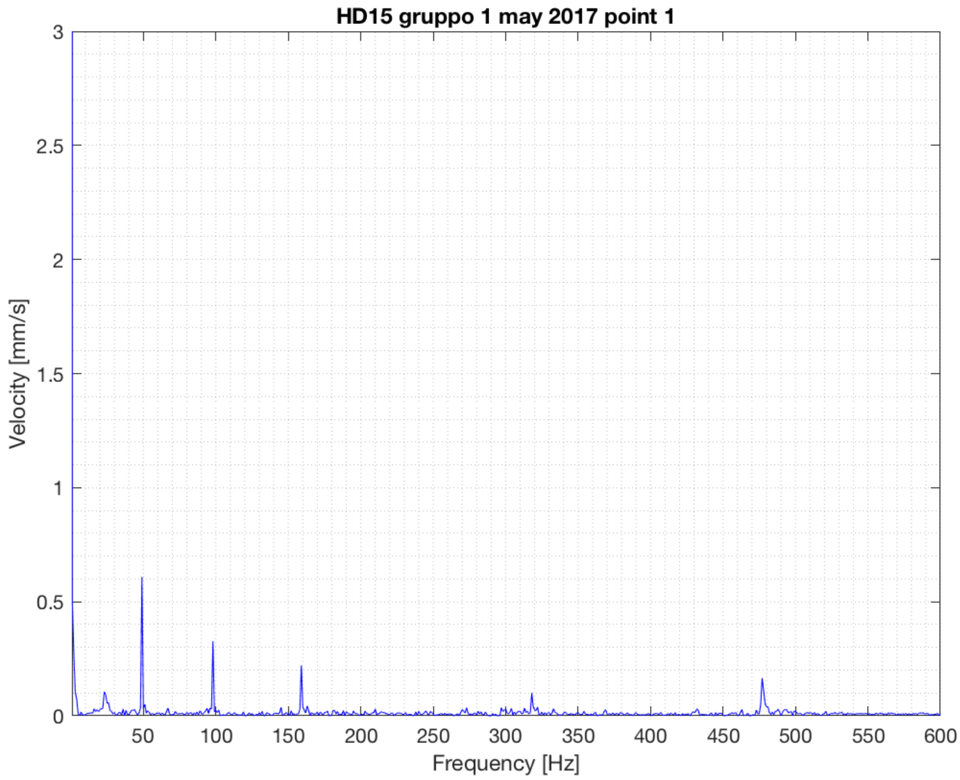


Fig 21 – Low FFT spectra HD15 may 2017 point 1

The latest measures show a stabilization, probably due to maintenance work. It is however advisable to check the tightening during the operating conditions under load. In the point 2 the spectrum has a peak at 3x GMF: coupling of the loose bearing.

Therefore it would be advisable to check the bearing support.

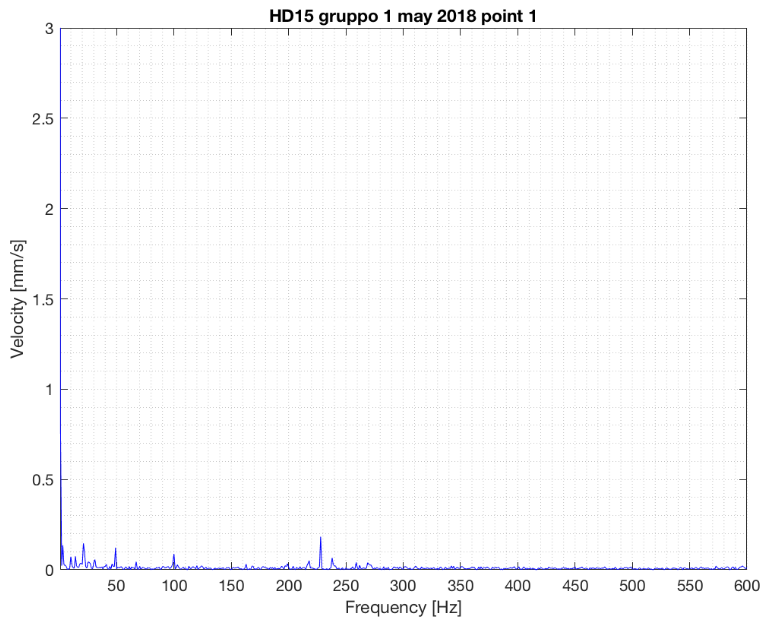


Fig 22 - Low FFT spectra HD15 may 2018 point 1

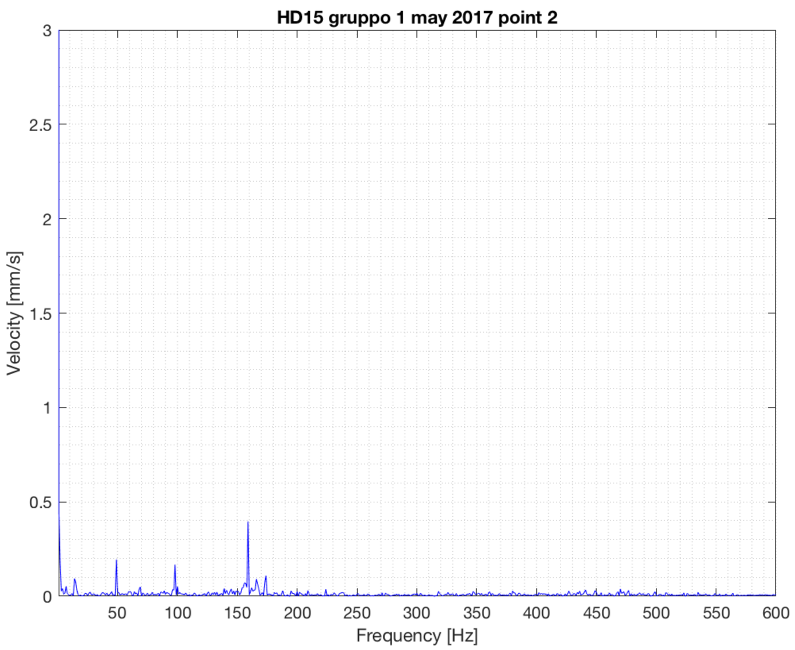


Fig 23 - Low FFT spectra HF15 may 2017 point 2

The point 1 measurements on the HD14 gearbox, show a spectrum with a notable peak at the 1x GMF from the year 2016 to 2018 indicating wear on the teeth. In 2018 there is a small increase in the background noise characteristic of the beginning of lubrication problems. We can notice a 1x GMF peak reduction probably due to machine regulation but the teeth wear problem remains. For this reason it would be advisable to do an inspection but also an unbalancing verification.

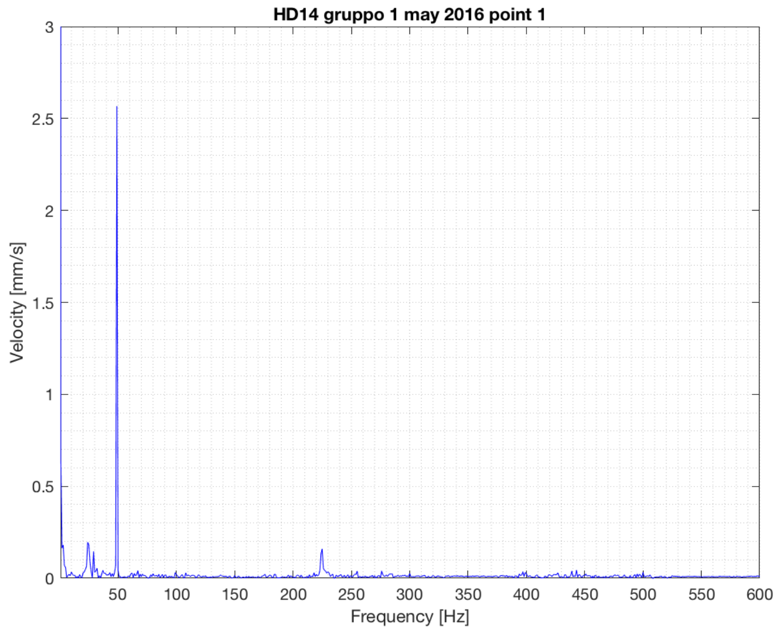


Fig 24 - Low FFT spectra HD14 may 2016 point 1

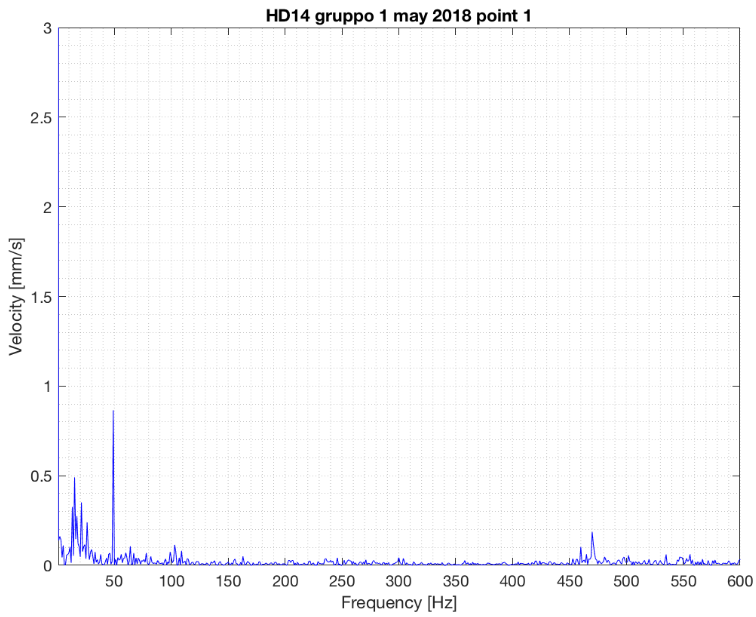


Fig 25 - Low FFT spectra HD14 may 2018 point 1

Up to the last measurements, even the spectrum of the HD26 gearbox, has a high peak at 1x GMF accompanied by side bands indicating a tooth wear. For this reason an inspection of the toothed wheels and an unbalancing verification is advisable.

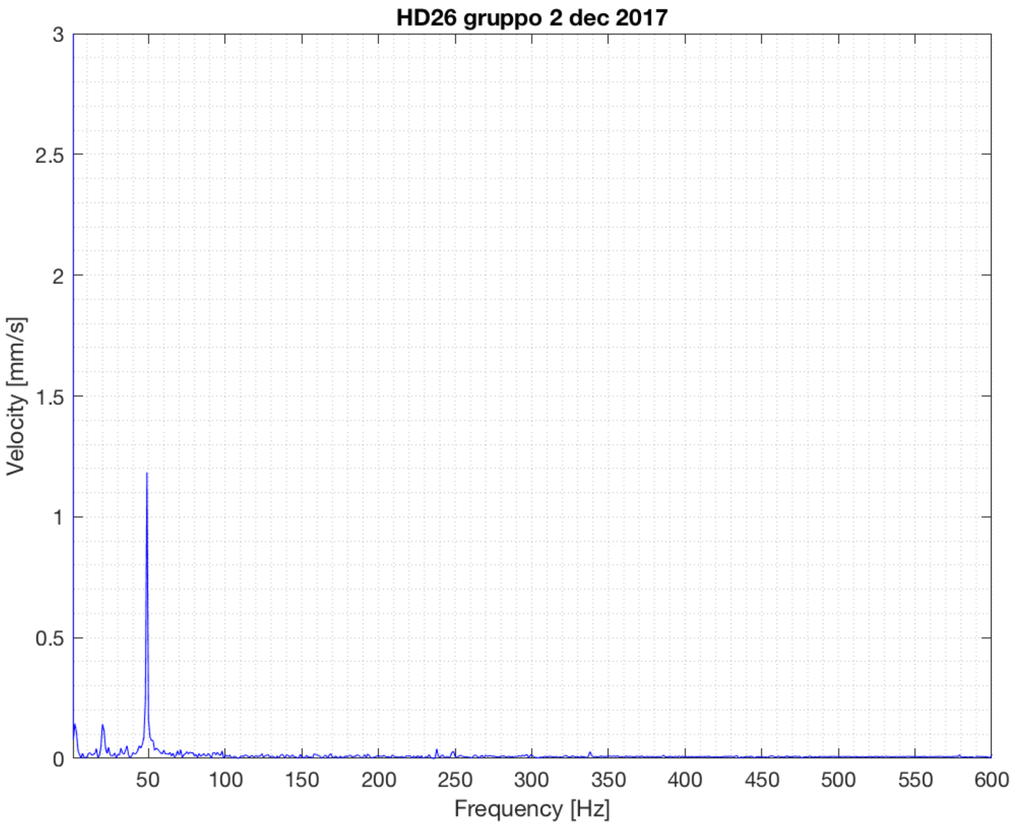


Fig 26 - Low FFT spectra HD26 december 2017

The HD53 gearbox has tooth wear and mechanical loosening from 2016 to 2018. In addition, the spectral conformation is typical of the gears eccentricity, in fact, side bands, are observed and are consistent throughout the period.

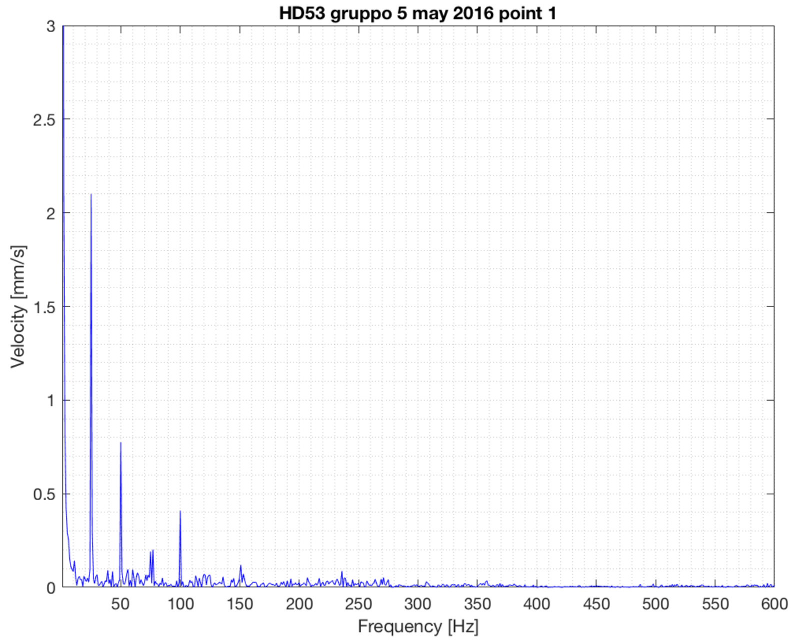


Fig 27 - Low FFT spectra HD53 may 2016 point 1

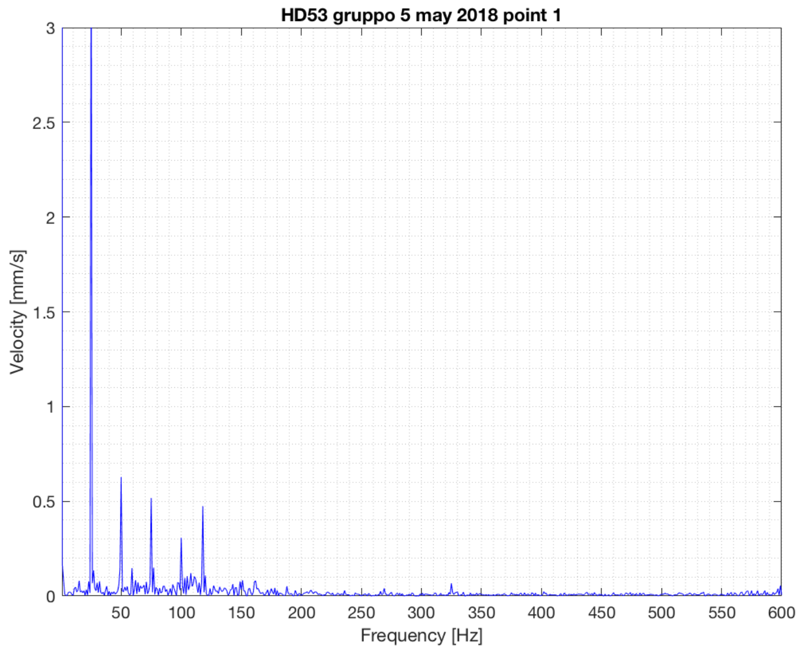


Fig 28 – Low FFT spectra HD53 may 2018 point 1

Also in point 2 the spectrum conformation shows the same phenomena described previously for point 1. As we can observed , from 2016 to 2018, the HD53 point 2 spectra described an increasing of the mechanical loosening phenomenon.

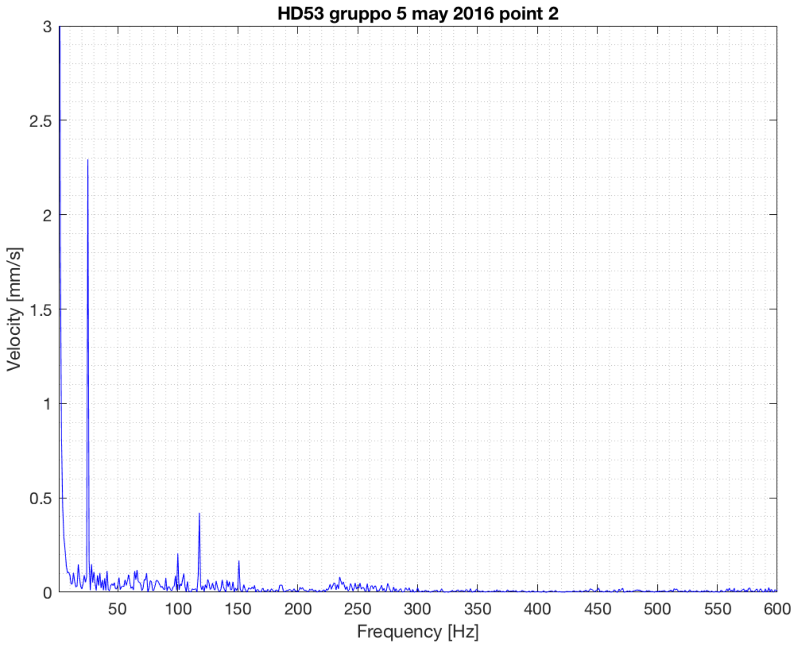


Fig 29 – Low FFT spectra HD53 may 2016 point 2

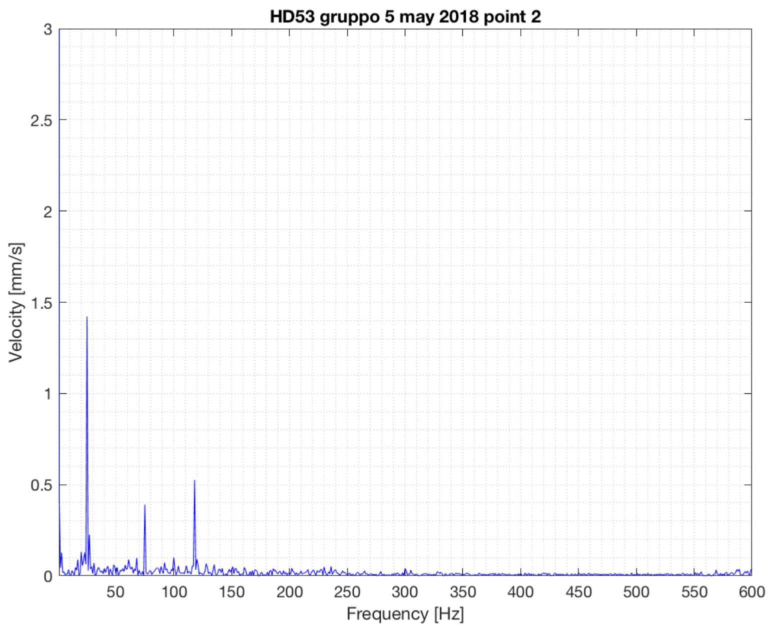


Fig 30 – Low FFT spectra HD53 may 2018 point 2

The HD55 and HD54 gearboxes are those that are worse than others in terms of vibrational distribution. The spectra highlight lubrication problems, in fact a background noise is quite developed on both measuring points. It would be advisable to control the oil level of the machine.

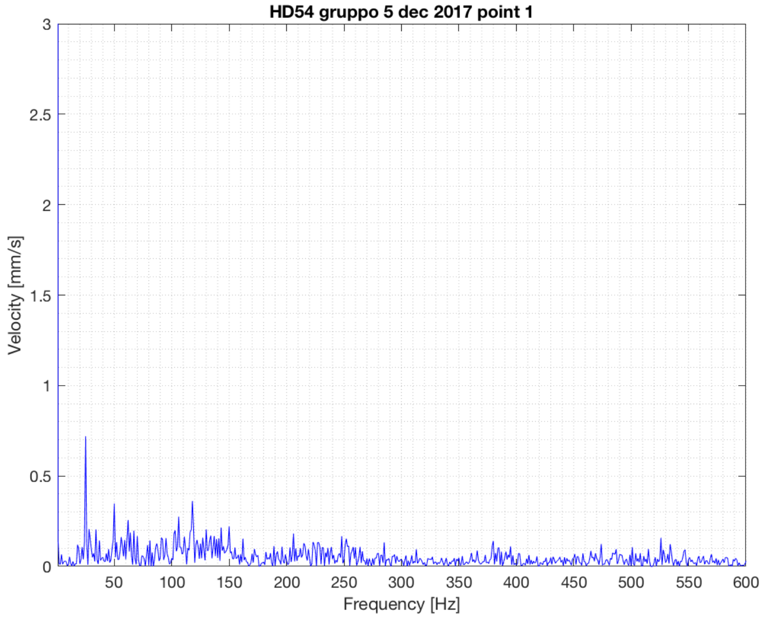


Fig 31 – Low FFT spectra HD54 december 2017 point 1

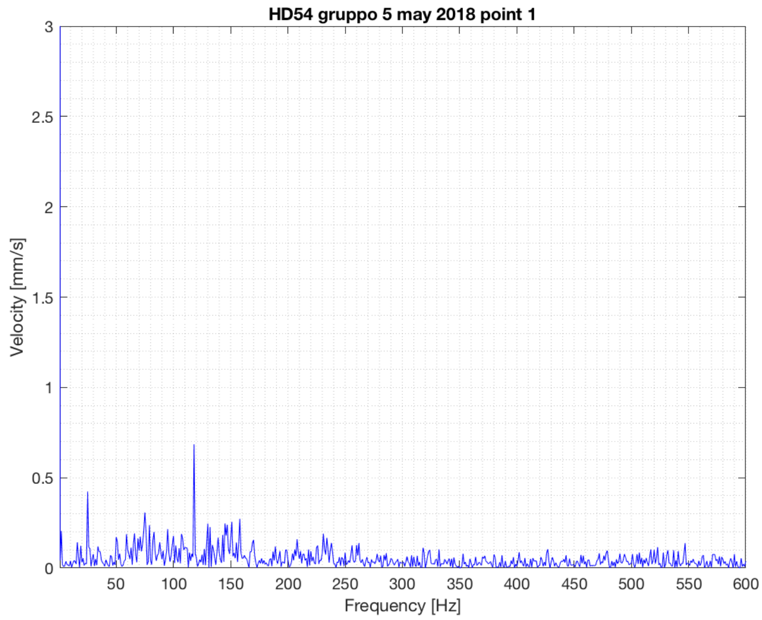


Fig 32 – Low FFT spectra HD54 may 2018 point 1

In the gearbox HD54 instead go forward a 3x GMF peak, indicating a bearing support problem, the side bands show eccentricity. On the other hand,

the HD55 gearbox proposes mechanical loosening, eccentricity and tooth wear.

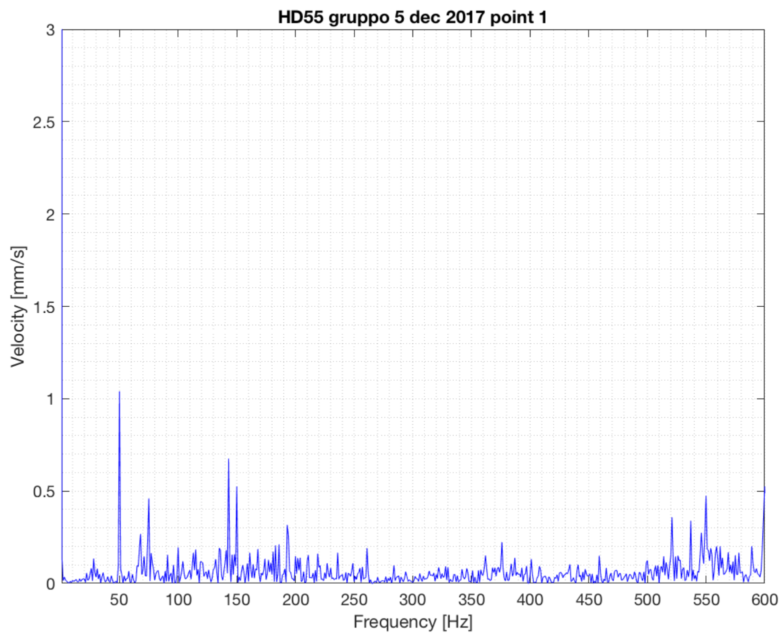


Fig 33 – Low FFT spectra HD55 december 2017 point 1

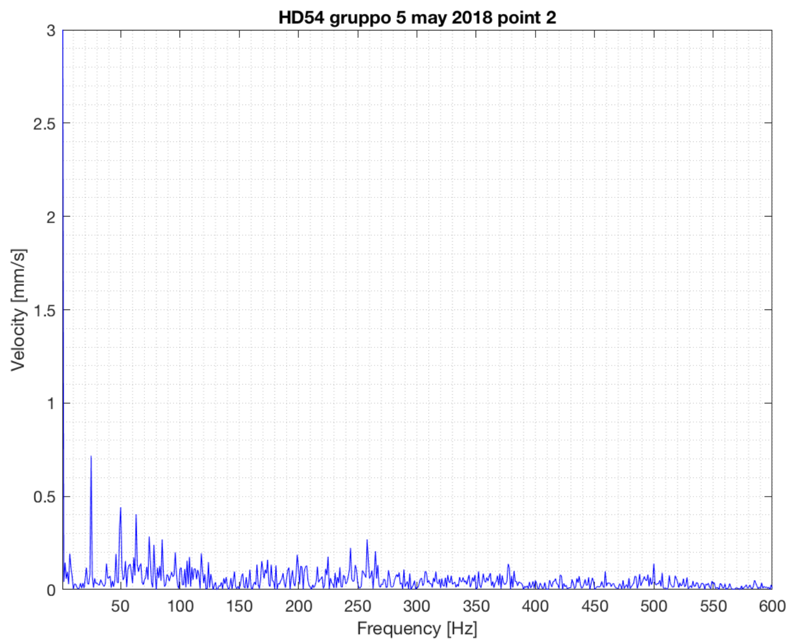


Fig 34 – Low FFT spectra HD54 may 2018 point 2

On the other hand, the HD40 and HD61 gearboxes, are the healthiest ones. The spectra are quite flat and do not present particular problems or particular phenomena in progress.

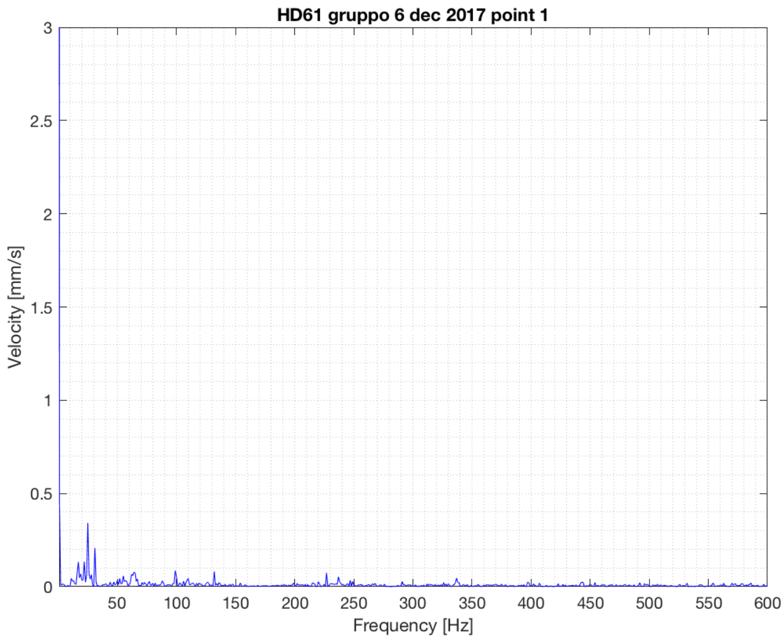


Fig 35 – Low FFT spectra HD61 december 2017

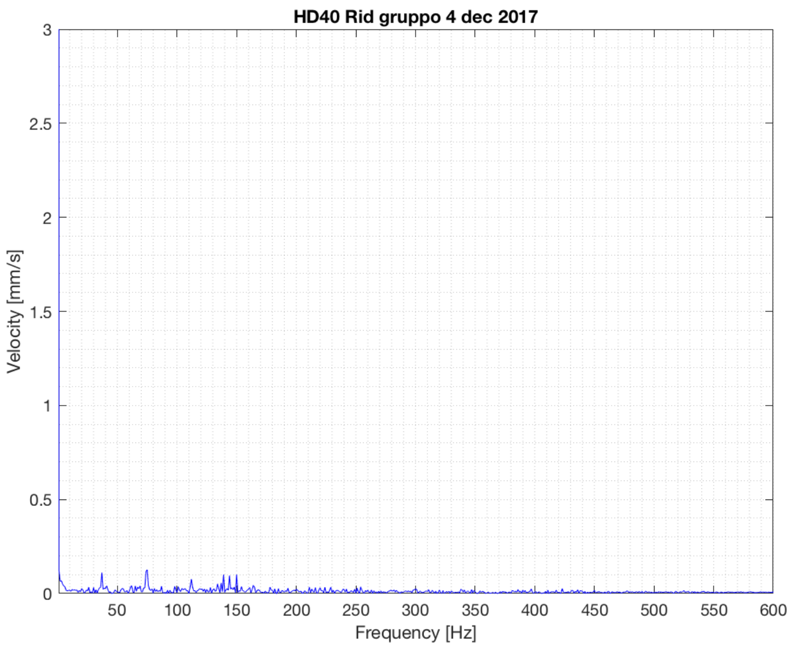


Fig 36 – Low FFT spectra HD40 Gearbox december 2017

3.3 HIGH FREQUENCY FFT APPLICATIONS

In this second part of our analysis the FFT technique was applied in a frequency range between 0 and 12000 Hz (high frequencies) directly on the measured accelerations, in order to highlight the machines rolling bearings failures. For the checking, the vibrational severity charts, have been used. They set the limit values of alert, alarm or good condition considering each peak of the spectrum.

Status	Peak G (> 2 kHz)
Rough	> 0.1
Slightly rough	0.1 - 0.01
Good	< 0.01

From the obtained spectra , the maximum values were evaluated for each individual bearings, and comparing them with the prescribed limits, a monitoring report was printed out.

3.3.1 RESULTS

From the report the status in December 2017 is as follows:

Alert - Slighty rough

- Check bearing 1 MI motor group 1

Alarm – Rough

- Check bearing 2 MI motor group 1

Alarm – Rough

- Check bearing 1 MI motor group 2

Alert - Slighty rough

- Check bearing 2 MI motor group 2

The fan side bearing 1 of the group 1 electric motor MI is in the alert state (slightly rough).
The coupling side bearing 2 of the group 1 electric motor MI results in the alarm state (rough).
The fan side bearing of the group 2 MI motor is also in the alarm state and the coupling side bearing of the group 2 electric motor MI is in the alert one.
Below, from the obtained spectra it is possible to observe the frequency image of a typical damaged or suffering bearings.
This is mainly composed by : impulsive and repetitive peaks trough the high frequencies and the onset of peaks and side bands above 6000 Hz.

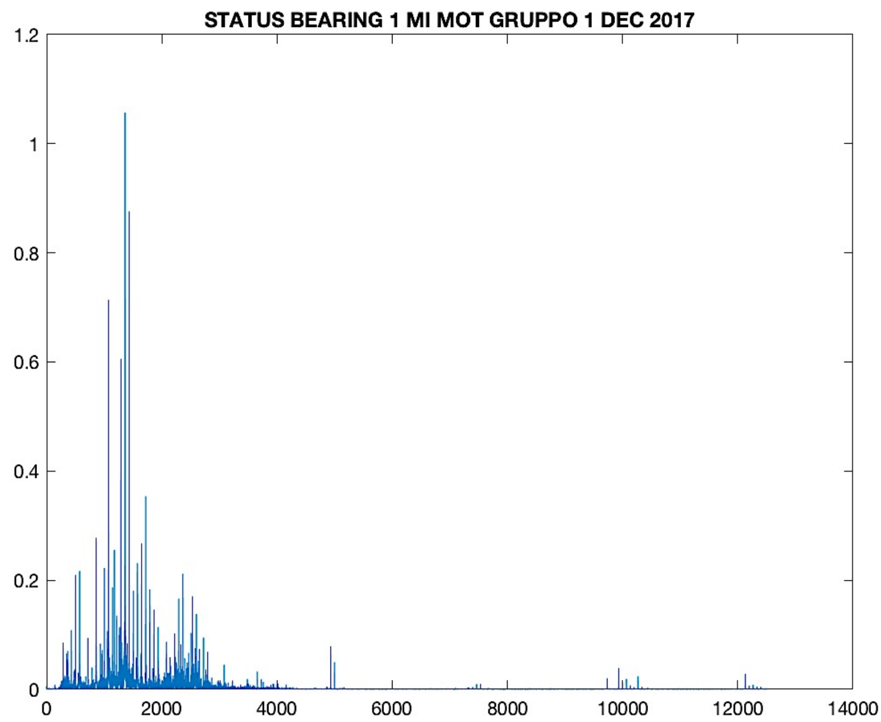


Fig 37 – High FFT spectra bearing 1 MI motor group 1 december 2017

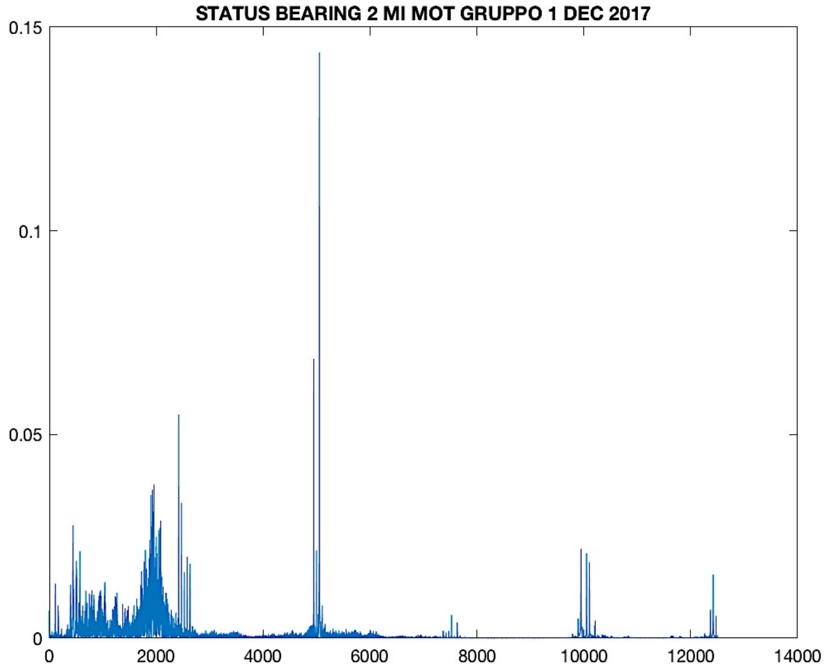


Fig 38 – High FFT spectra bearing 2 MI motor group 1 december 2017

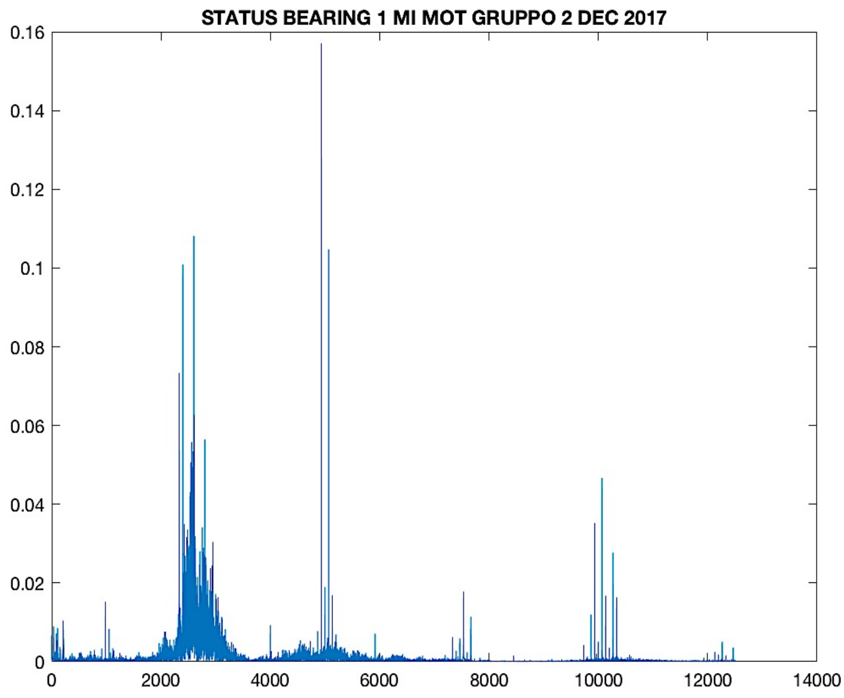


Fig 39 – High FFT spectra bearing 1 MI motor group 2 december 2017

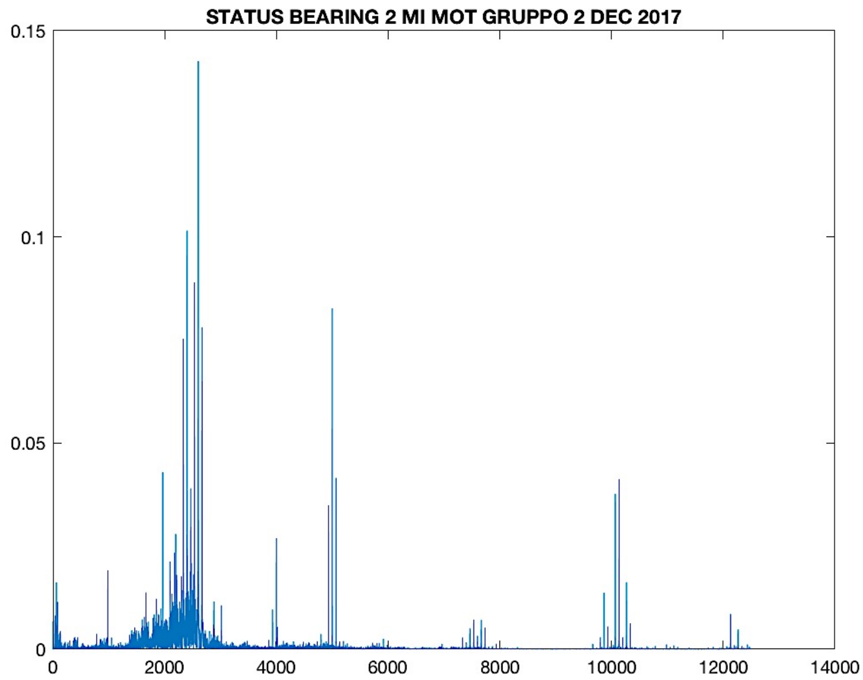


Fig 40 – High FFT spectra bearing 2 MI motor group 2 december 2017

Below there is an healthy bearing spectrum. Is possible to highlight lower peaks values There aren't onset of sidebands and peaks at high frequencies**.**

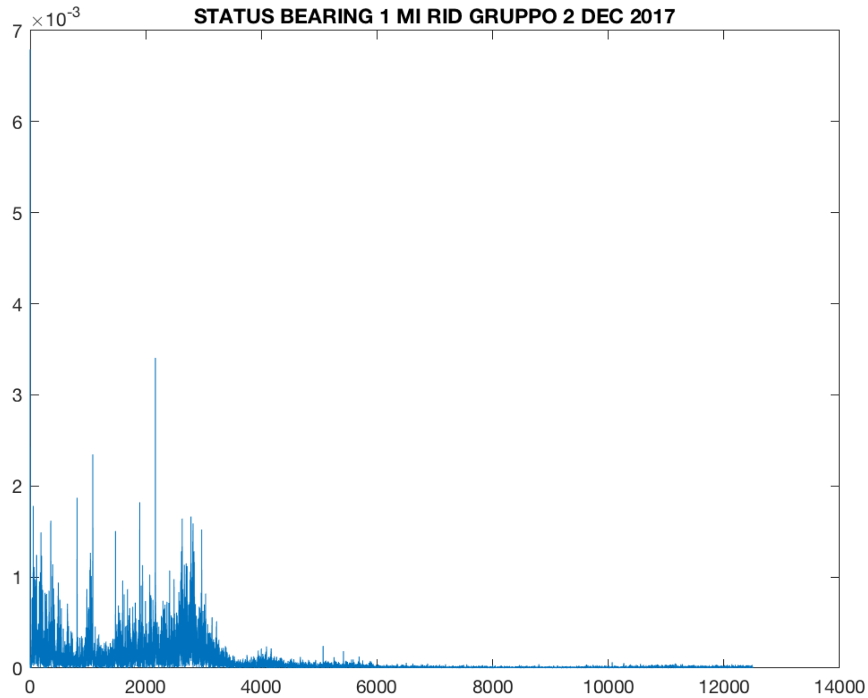


Fig 41 - Healthy bearing spectrum

CHAPTER 4 – HHT APPLICATIONS

The HHT technique was applied on the bearings defined as critical by the FFT :

1. Bearing 1 MI motor group 1
2. Bearing 2 MI motor group 1
3. Bearing 1 MI motor group 2
4. Bearing 2 MI motor group 2

Calculation functions were created within the software used for the simulation, in order to process the EMD (empirical mode decomposition) algorithm and extract the intrinsic harmonics (IMFs - intrinsic mode functions) from the starting measured signal *(see the attachements)*.

The statistical stoppage criteria used for the subsequent IMFs extraction, has imposed a standard deviation equal to 0.1. Through subsequent iterative cycles, as long as the standard deviation did not reach the value 0.1, the IMFs were extracted up to the order 12.

From the first to the fourth IMFs, the Hilbert spectrum was constructed, function of : instantaneous frequency, time and vibrational energy.

4.1 RESULTS

4.1.2 ALERT BEARING – BEARING 1 MI MOTOR GROUP 1 DECEMBER 2017

The bearing 1 spectrum of the MI motor from group 1, is classified as alert state from FFT, presents already more substantial vibrational energy values and the Hilbert energy distribution begins to be seen, starting from the fourth IMF up to the first, where the spectrum shows a fractured non linear structure around 2000 - 4000 Hz. Being still in an alert state the second IMF shows us the real bearing suffering and how it is evolving over time.

The problem is not yet advanced and irreversible, the third and fourth IMFs spectra are not clearly visible and the energy distribution in the first IMF spectrum is not diffuse in the high frequencies area.

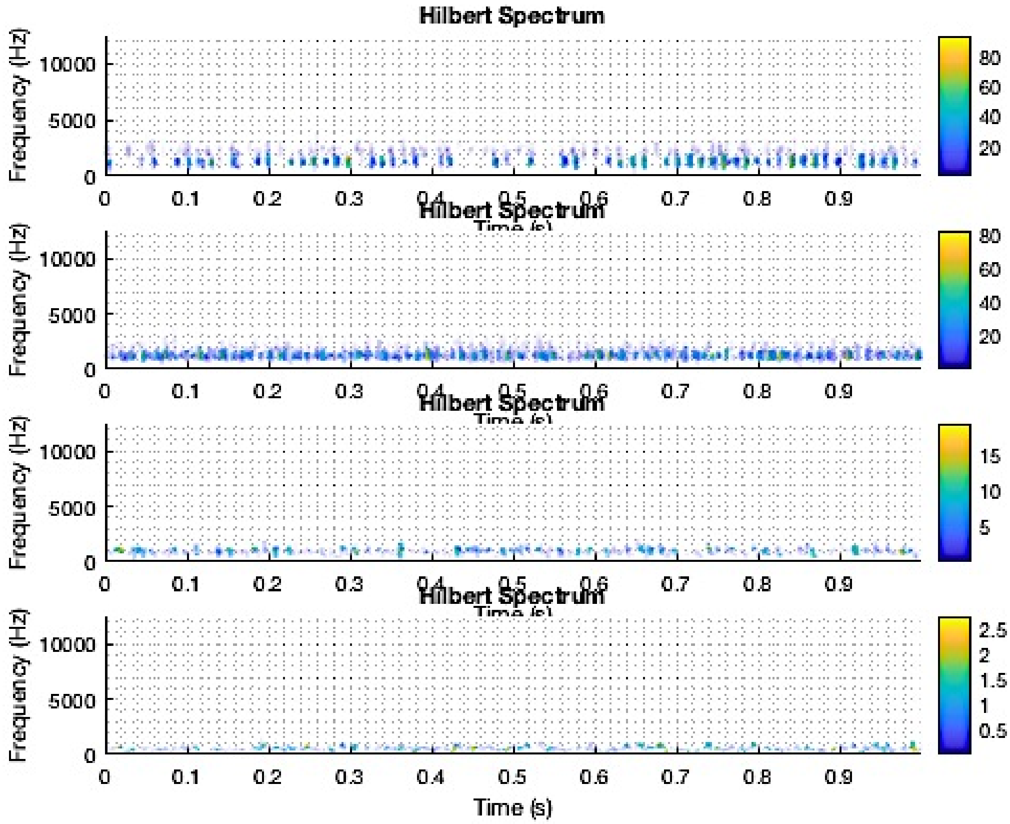
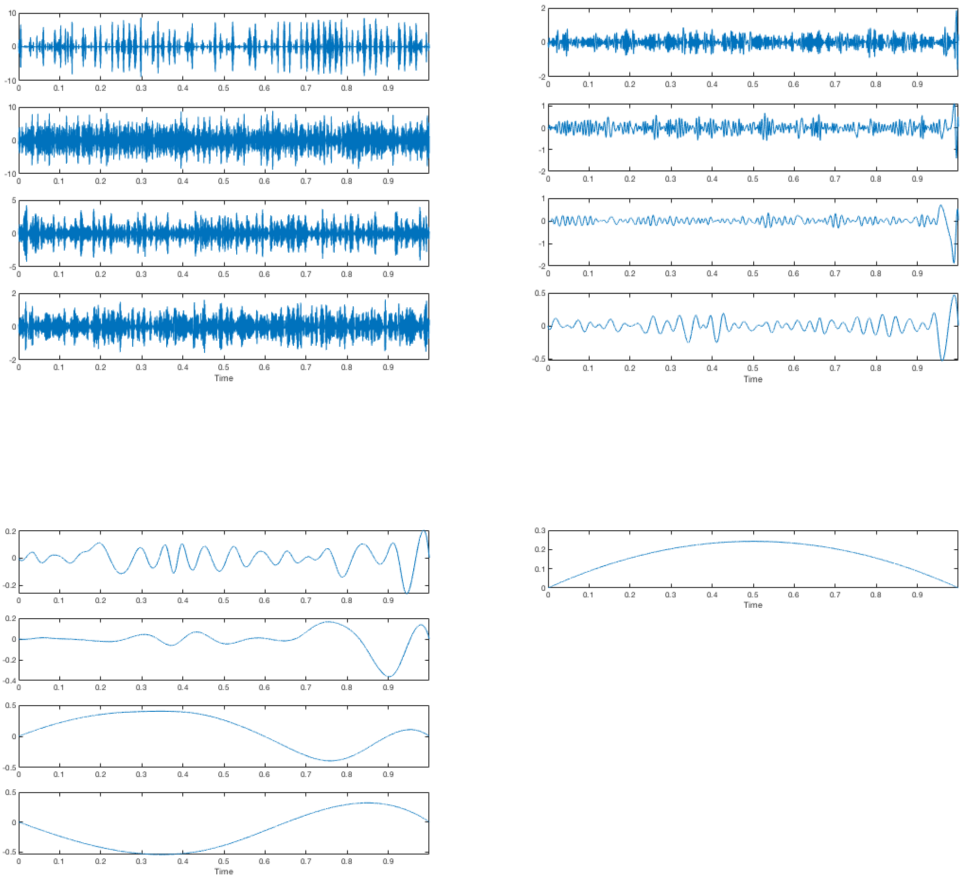


Fig 42 - Hilbert spectra bearing 1 MI motor group 1 december 2017

4.1.3 BEARING 1 MI MOTOR GROUP 1 DECEMBER 2017 EXTRACTED IMFs



4.1.4 ALARM BEARING – BEARING 2 MI MOTOR GROUP 1 DECEMBER 2017

The bearing 2 spectrum of the MI motor from group 1, is classified as alarm state, presents the energy distributed in all the high frequencies in the first IMF spectrum.

From the spectrum of the third IMF we can notice the onset of the problem between 0.2 and 0.3 seconds where the vibrational energy reaches its maximum peak (in yellow).

The problem is in advanced state because the energy distribution is totally concentrated on the first IMF spectrum and distributed on all the high frequencies.

The third and fourth IMFs spectra are clearly visible and the means is that the innermost levels are vibrating.

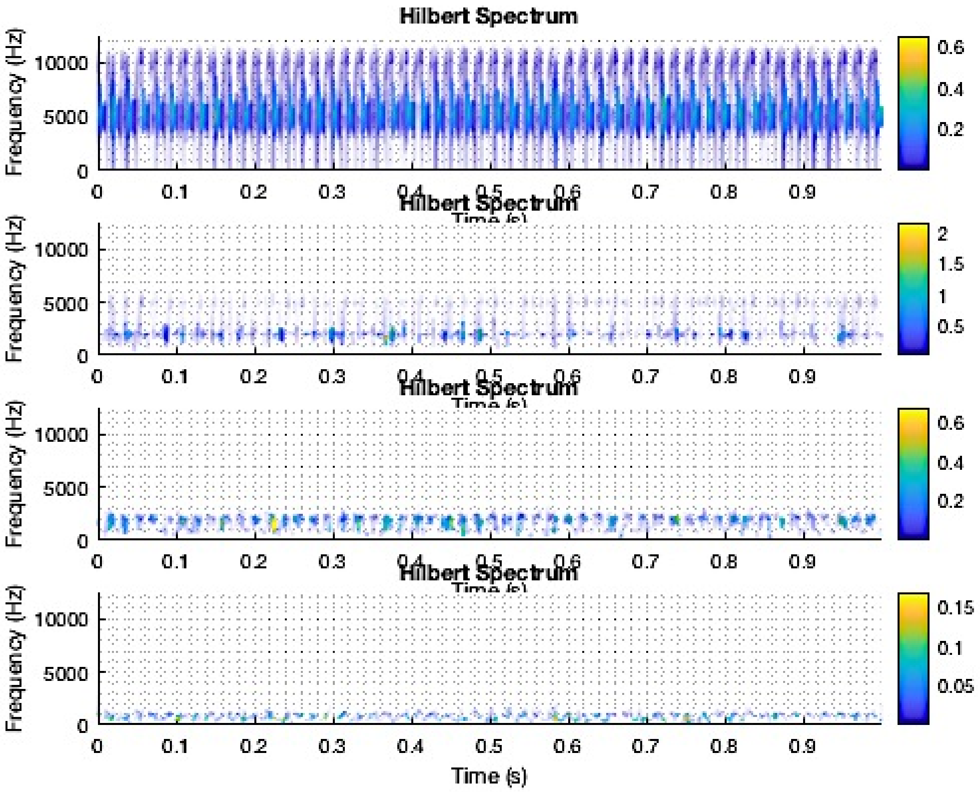
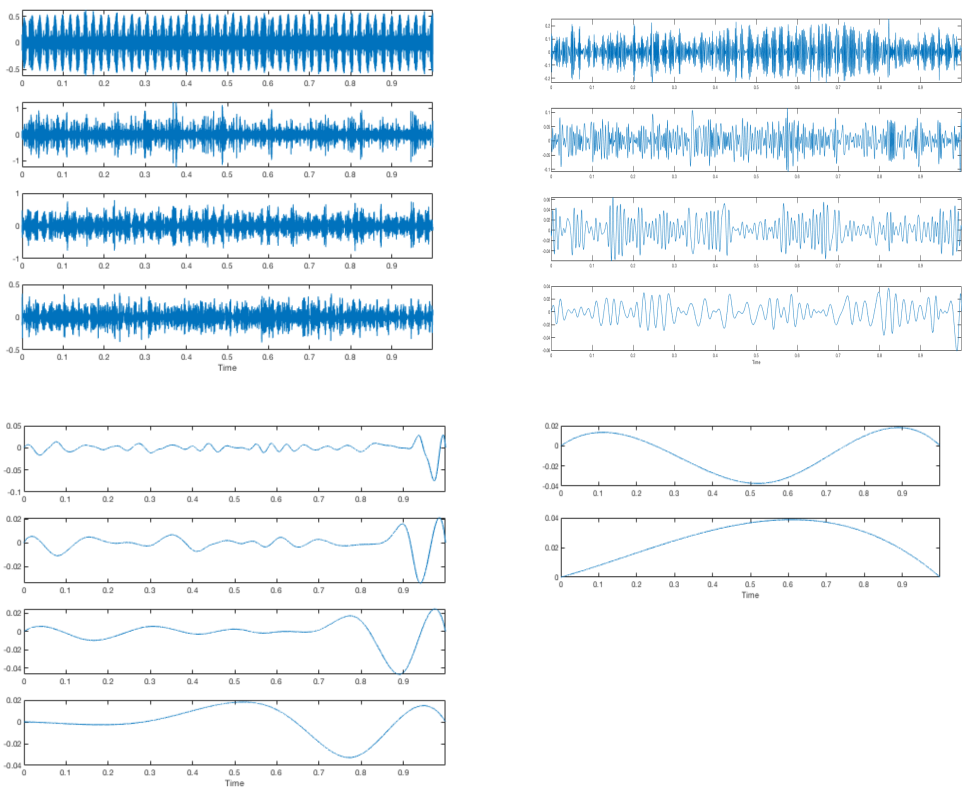


Fig 43 - Hilbert spectra bearing 2 MI motor group 1 december 2017

4.1.5 BEARING 2 MI MOTOR GROUP 1 DECEMBER 2017 EXTRACTED IMFs



4.1.6 ALARM BEARING – BEARING 1 MI MOTOR GRUPPO 2 DECEMBER 2017

Here the bearing spectrum presents an high distribution of the energy to the first IMF, in the high frequencies area, that represents the image of a suffered structure.
A concentrated energy around 0.7 s localizes the onset of the problem from the third IMF.
We can observe an energy distribution beginning up to the 5000 Hz from the first IMF spectrum. Here the third and fourth IMFs spectra are less clearly visible than the previous alarm bearing. Is possible to deduce that the bearing 2 MI motor group 1 is more critical than the bearing 1 MI motor group 2 despite being identified in the same alarm state.

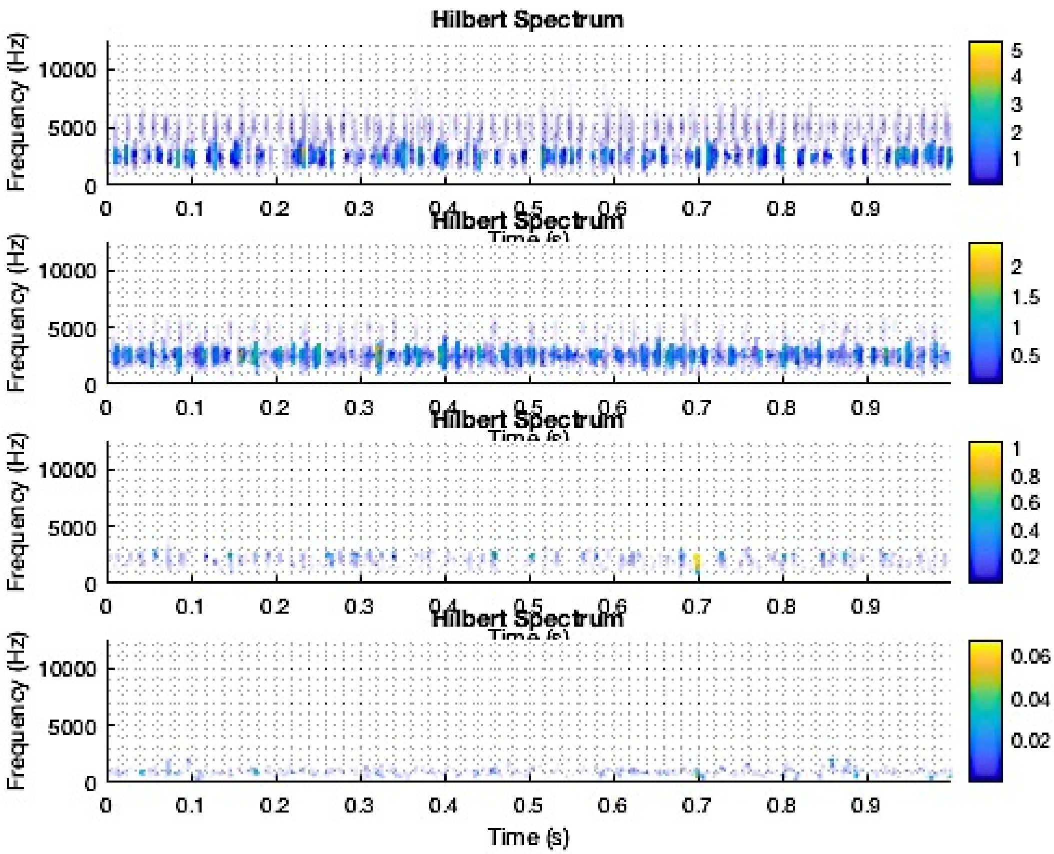
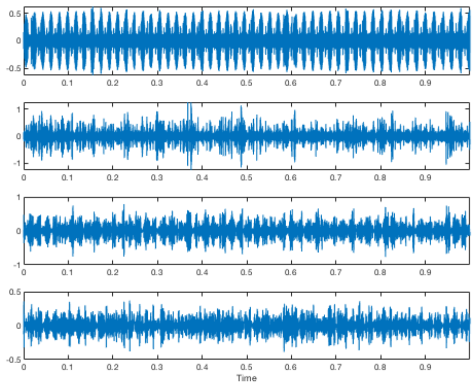
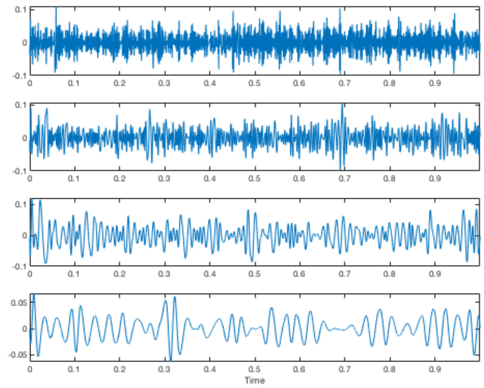
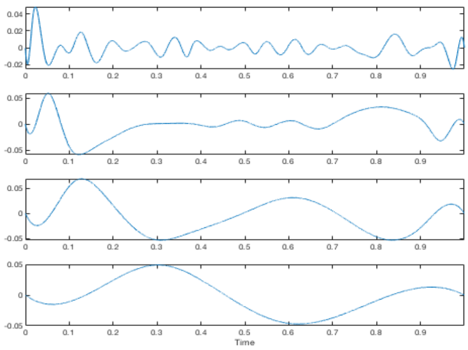


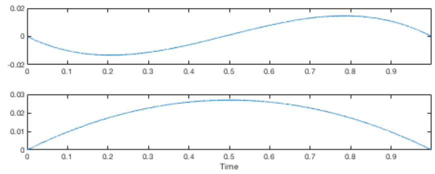
Fig 44 - Hilbert spectra bearing 1 MI motor group 2 december 2017

4.1.7 BEARING 1 MI MOTOR GROUP 2 DECEMBER 2017 EXTRACTED IMFs









4.1.8 ALERT BEARING – BEARING 2 MI MOTOR GROUP 2 DECEMBER 2017

This bearing is in a more advanced alert state than the previous alert one.

The vibrational energy density begins to evolve from the second IMF to the first IMF. From the first IMF spectrum is possible to identify a uniform energy distribution (quasi periodic) in the 2000 Hz area with an initial concentration in the high frequencies area above 4000 Hz.

The spectra of the third and fourth are clearly visible with the energy peaks located at certain points in the time interval.

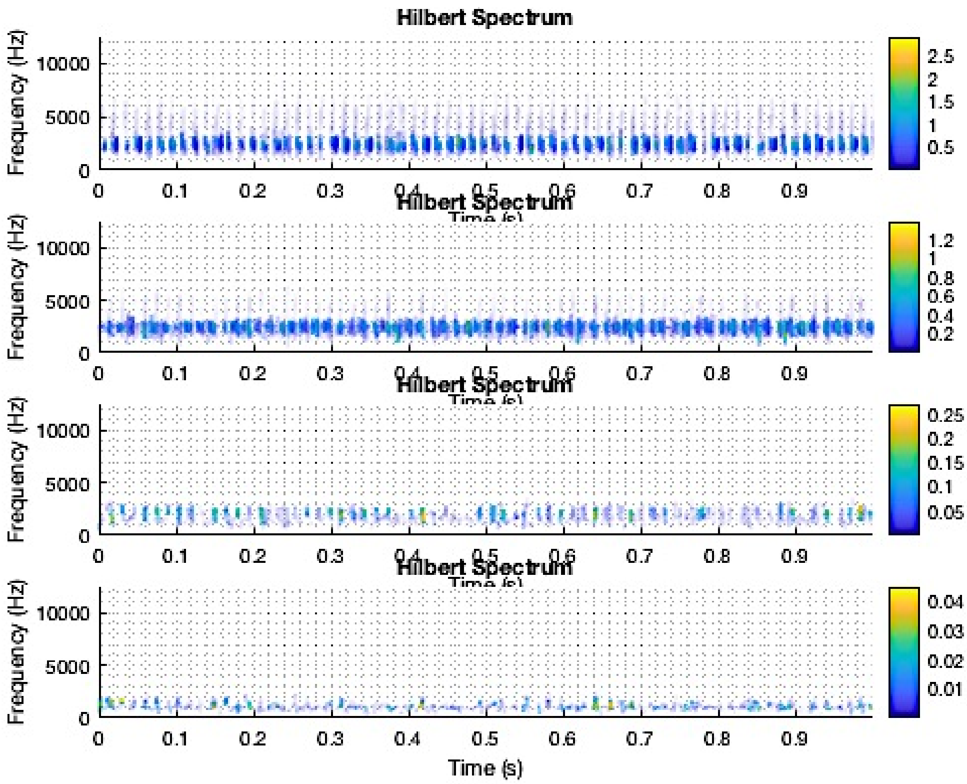
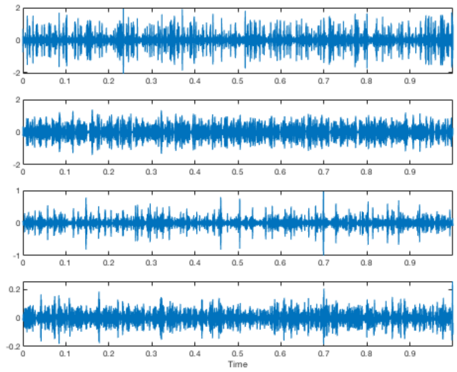
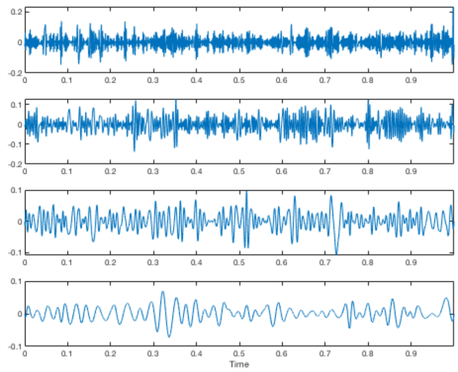
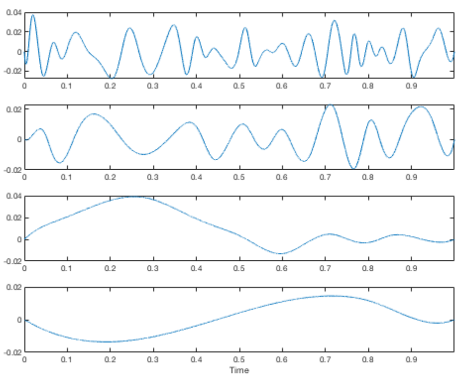


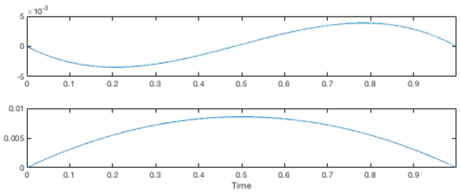
Fig 45 - Hilbert spectra bearing 2 MI motor group 2 december 2017

4.1.9 BEARING 2 MI MOTOR GROUP 2 DECEMBER 2017 EXTRACTED IMFs









CHAPTER 5 – RESIDUAL USEFUL LIFE ESTIMATION

For the estimation of the residual useful life of the involved machines, was not possible to estimate a real numerical evaluation of this quantity, since it would be necessary to collect statistical information regarding the probabilities of historical failures of each equipments.
Furthermore, the database should be updated with new under load measurements and information on each machine service life.
In any case, the spectra observation allows us to study the machine conditions and to estimate its long-term status. Considering the bath tube curve of a general industrial component, all the analysed machines, with the exception of HD40 and HD61 gearboxes and all the critical rolling bearings, fall into the "increasing failure rate" area.
Considering a continous working cycle, if the predictive maintenance plans studied in this work are not carried out, it is easy to foresee a rapid shift in the upper part of the "increasing failure rate" area, until the final break.
For example, gearboxes that have lubrication problems are more likely to decrease their useful life because a non-regular lubrication causes a lot of mechanical stresses in all the gears and consequently the bearings suffering, in their overall structure.

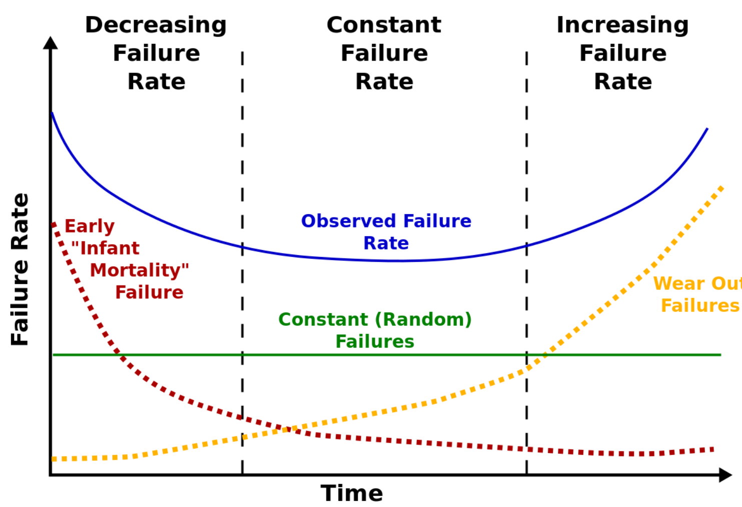


Fig 46 - Bath tube curve

CONCLUSIONS

From the carried out study, the Fourier technique turns out to be very useful in the low frequencies vibrational analysis (0 : 600 Hz), because it allows to verify actual machine conditions and to predict his future trend. This type of analysis is widely used and diffused for the purpose of a reliable prevention of machine failures in a plant.

In SKF group, where I currently carry out my first working experience in the predictive maintenance field , low frequency Fourier analysis is the basis of an ordinary working day and, from the obtained spectra observations are sent warnings about machines reliability status. In our case the equipments are : centrifugal pumps, reciprocating or axial volumetric compressors, turbines, vertical pumps, used for oil refining processes. In this thesis, the gearboxes velocity spectra observations, has led to conclusions about machine reliability degree and to a correct maintenance plans evaluation. In the second part, the two frequency analysis techniques were applied directly on the acceleration measurements in order to verify the rolling bearings status.

The frequency range for the diagnosis was restricted to the interval (0 : 12000 Hz), called high frequencies area. The results obtained by the two techniques are similar but, while the FFT allows the identification of the bearing status in an advanced phase, as it is based on the observation of local damage peaks and on the observation of how the spectrum is distributed in the frequency range used; the Hilbert Huang allows the identification of the bearing suffering beginning, breaking down the signal into its fundamental harmonics and verifying the intrinsic level of the vibrational energy associated to each mode of vibrations which compose the overall vibrational signal, locally in time and instantaneous frequency.

In fact, as we observed, two bearings classified in the same alert state by FFT (Fast Fourier Transform) are different from the HHT point of view (Hilbert Huang Transform). It allows us to check which alert state, is more critical between the two and, study better the damage, in order to predict its future evolution and prepare the right maintenance measures.

The Fourier technique turns out to be less adaptive than the Hilbert technique and more uncertain, as it provides global information on the basis of spectrum observation in its entirety. On the other hand, the Hilbert technique, focuses locally, in the considered time interval and instantaneous frequency, highlighting the vibrational energy density distribution. For this reason, it was more precise in the damage beginning or bearing suffering identification and in the criticality level study.

Can be an useful basis for the item history reconstruction up to the critical moment and failures causes identification. From a computational point of view is more expensive than FFT technique and requires a lot of operations.

	Fourier	**Hilbert**
Frequency	Global	Local
Presentation	Energy –frequency	Energy –time –frequency
Feature extraction	No	Yes
Theoretical base	Theory complete	Empirical
Criticalities level identification	No	Yes

Fig 47 - Fourier transform vs. Hilbert transform

The proposed objectives have been achieved except for the quantitative evaluation of the equipment residual useful life due to the lack of statistical data. The elaborated code allows a continuous and efficient monitoring of vibrational data guaranteeing the maintenance control of the machines. Experimental work is part of the data science area for system reliability. This field is truly innovative for the systems digitalisation and lays the foundation for further future developments.

The possible future developments of this thesis are fundamentally 3. The first two is referred to an update of the existing database and to a more accurate and precise analysis of the system.

1. Evaluation of the electric motors status with the low frequencies FFT code, in order to check : electrical problems, connection joint problems, imbalances, misalignments.

2. Database update considering the machines under load and use of the developed codes in order to perform a new condition monitoring.

3. Collect of statistical information regarding each machine failures probabilities. Is useful to look at the individual technical manuals provided by the manufacturers. This is a good starting point for the quantitative estimation of the equipment residual useful life.

4. The third development could have an interesting implication in the plant digitalization under the famous voice of Industry 4.0 : the coding and creation of a mobile app for the operators.
   Through this one they can access to information about the machines status directly from the field.
   This would decrease the conditions monitoring time : a notification should arrive to the operator's device by communicating the three possible machines conditions : good, alert, alarm, together with the maintenance advices to be implemented.
   This operation is currently carried out from the maintenance offices, that send the reports to the plant control room which warns the operators about the actions to be carried out.
   The development of a mobile app would drastically reduce the check and maintenance time increasing the reliability of the entire monitoring system.

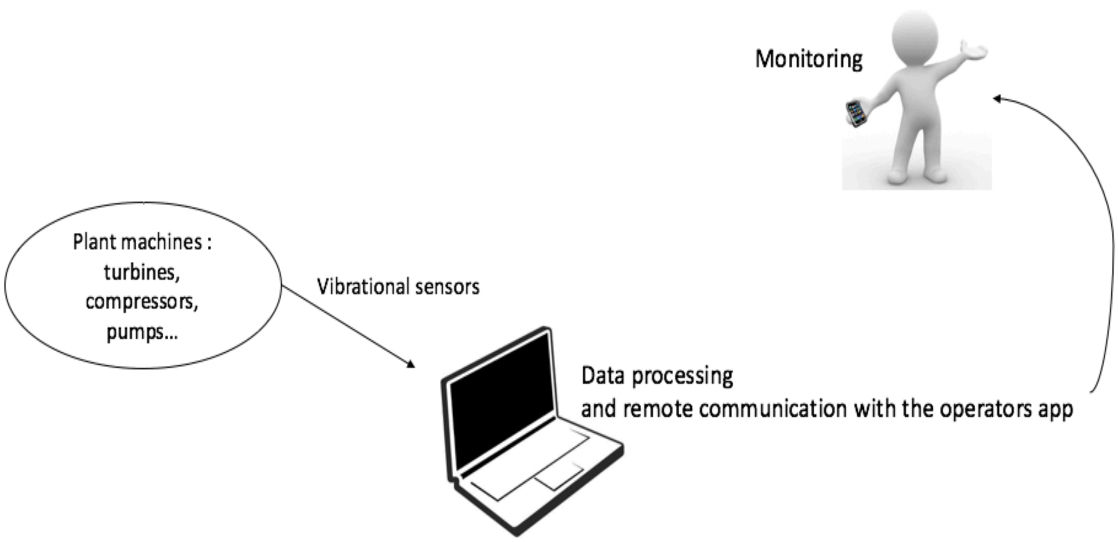


Fig 48 - Future development – Mobile app integrated system

ACKNOWLEDGMENTS

I would like to thank Paolo Tarasco engineer for giving me the possibility to deepen the vibrational analysis for the predictive maintenance and for having followed me in this experimental work.

The SKF group for their support, the great availability and their collaboration in the verification of this work.

My family who was with me and supported me during these years.

People who have supported me during this period in Turin, in front of the obstacles, encouraging me to overcome them and to look beyond.

The colleagues and all the people i met during this Master degree journey and who left an indelible mark in me.

People who are no longer here but who have contributed with their deep energy from far away.

THANKS SO MUCH !

ATTACHEMENTS

PLOT HHT FUNCTION :

```
function plot_hht(x,Ts)

imf = emd(x);

for k = 1:length(imf)
   b(k) = sum(imf{k}.*imf{k});
   th   = angle(hilbert(imf{k}));   %
   d{k} = diff(th)/Ts/(2*pi);
end

[u,v] = sort(-b);
b     = 1-b/max(b);


%Set IMF plots.
T  = 4e-5;
Fs = 1/T;
M = length(imf);
N = length(x);
c = linspace(0,(N-1)*Ts,N);

for k1 = 0:4:M-1
   figure
   for k2 = 1:min(4,M-k1), subplot(4,1,k2); set(gca,'FontSize',8,'XLim',[0
c(end)]);
       hht(imf{k1+k2},Fs); grid minor;    %Hilbert spectra for each IMFs

   end


end


end
```

PLOT IMF FUNCTION :

```
function plot_hht_imf(x,Ts)

imf = emd(x);

for k = 1:length(imf)
   b(k) = sum(imf{k}.*imf{k});
   th   = angle(hilbert(imf{k}));
   d{k} = diff(th)/Ts/(2*pi);
end

[u,v] = sort(-b);
b     = 1-b/max(b);

%Set time-frequency plots.
N = length(x);
c = linspace(0,(N-2)*Ts,N-1);
```

```
for k = v(1:2)
   figure
   plot(c,d{k},'r.','Color',b([k k k]),'MarkerSize',3);
   colormap summer
   set(gca,'FontSize',8,'XLim',[0 c(end)],'YLim',[0 1/2/Ts]),
xlabel('Time'), ylabel('Frequency');
end

%Set IMF plots.
T  = 4e-5;
Fs = 1/T;
M = length(imf);
N = length(x);
c = linspace(0,(N-1)*Ts,N);
for k1 = 0:4:M-1
   figure
  for k2 = 1:min(4,M-k1), subplot(4,1,k2), plot(c,imf{k1+k2});
set(gca,'FontSize',8,'XLim',[0 c(end)]); end
   xlabel('Time');
   end

end
```

EMPIRICAL MODE DECOMPOSITION FUNCTION :

```
function imf = emd(x)

x   = transpose(x(:));
imf = [];
while ~ismonotonic(x)
   x1 = x;
   sd = Inf;
   while (sd > 0.1) | ~isimf(x1)
      s1 = getspline(x1);
      s2 = -getspline(-x1);
      x2 = x1-(s1+s2)/2;

      sd = sum((x1-x2).^2)/sum(x1.^2);
      x1 = x2;
   end

   imf{end+1} = x1;
   x          = x-x1;
end
imf{end+1} = x;


function u = ismonotonic(x)

u1 = length(findpeaks(x))*length(findpeaks(-x));
if u1 > 0, u = 0;
else,      u = 1; end

function u = isimf(x)

N  = length(x);
u1 = sum(x(1:N-1).*x(2:N) < 0);
u2 = length(findpeaks(x))+length(findpeaks(-x));
```

```
if abs(u1-u2) > 1, u = 0;
else,              u = 1; end

function s = getspline(x)

N = length(x);
p = findpeaks(x);
s = spline([0 p N+1],[0 x(p) 0],1:N);
```

FINDPEAKS FUNCTION :

```
function n = findpeaks(x)
% Find peaks.


n    = find(diff(diff(x) > 0) < 0);
u    = find(x(n+1) > x(n));
n(u) = n(u)+1;
```

HIGH FREQUENCY FAST FOURIER TRANSFORM CODE :

```
clear all
close all
clc

%%Limits definition%%

lim1=0.1;
lim2=0.01;

%% Vibrations monitoring May 2016 %%

datiRidgruppo0=load('CuscRidgruppo0may.txt');
datimotBgruppo0=load('Cusc1motoreBgruppo0may.txt');

datiCusc1HF14gruppo1=load('Cusc1HF14gruppo1may.txt');
datiCusc1HF15gruppo1=load('Cusc1HF15gruppo1may.txt');
datiCusc2HF14gruppo1=load('Cusc2HF14gruppo1may.txt');
datiCusc2HF15gruppo1=load('Cusc2HF15gruppo1may.txt');

datiCuscHA40ridgruppo4=load('CuscHA40gruppo4may.txt');

datiCuscHF53gruppo5=load('CuscHF53gruppo5may.txt');
datiCusc1HF53gruppo5=load('Cusc1HF53gruppo5may.txt');
datiCuscHF54gruppo5=load('CuscHF54gruppo5may.txt');
datiCuscHF55gruppo5=load('CuscHF55gruppo5may.txt');
datiCusc2HA51ridgruppo5=load('Cusc2HA51ridgruppo5may.txt');


%%%% Vettore dei tempi,frequenza,numero di campioni %%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
T  = 4e-5;                  %% intervallo di tempo tra i campionamenti %%
Fs = 1/T;                   %% frequenza         %%
L  = 25000;                 %% numero campioni   %%
t = (0:L-1)*T;              %% vettori dei tempi %%
```

```
%creazione vettore accelerazione misure maggio

acc1_may=zeros(size(datiRidgruppo0(:,1)));
acc2_may=zeros(size(datimotBgruppo0(:,1)));
acc3_may=zeros(size(datiCusc1HF14gruppo1(:,1)));
acc4_may=zeros(size(datiCusc1HF15gruppo1(:,1)));
acc5_may=zeros(size(datiCusc2HF14gruppo1(:,1)));
acc6_may=zeros(size(datiCusc2HF15gruppo1(:,1)));
acc7_may=zeros(size(datiCuscHA40ridgruppo4(:,1)));
acc8_may=zeros(size(datiCuscHF53gruppo5(:,1)));
acc9_may=zeros(size(datiCusc1HF53gruppo5(:,1)));
acc10_may=zeros(size(datiCuscHF54gruppo5(:,1)));
acc11_may=zeros(size(datiCuscHF55gruppo5(:,1)));
acc12_may=zeros(size(datiCusc2HA51ridgruppo5(:,1)));

for ii=1:size(datiRidgruppo0)
    acc1_may(ii)=datiRidgruppo0(ii,2);
    acc2_may(ii)=datimotBgruppo0(ii,2);
    acc3_may(ii)=datiCusc1HF14gruppo1(ii,2);
    acc4_may(ii)=datiCusc1HF15gruppo1(ii,2);
    acc5_may(ii)=datiCusc2HF14gruppo1(ii,2);
    acc6_may(ii)=datiCusc2HF15gruppo1(ii,2);
    acc7_may(ii)=datiCuscHA40ridgruppo4(ii,2);
    acc8_may(ii)=datiCuscHF53gruppo5(ii,2);
    acc9_may(ii)=datiCusc1HF53gruppo5(ii,2);
    acc10_may(ii)=datiCuscHF54gruppo5(ii,2);
    acc11_may(ii)=datiCuscHF55gruppo5(ii,2);
    acc12_may(ii)=datiCusc2HA51ridgruppo5(ii,2);
end

acceleration1=[acc1_may acc2_may acc3_may acc4_may acc5_may acc6_may
acc7_may acc8_may acc9_may acc10_may acc11_may acc12_may];
fs= Fs*(0:(L/2))/L;
RMSacc_may2016 = rms(acceleration1);

disp(' STATUS MAY 2016 ')
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING RID gruppo 0%%
fourier_may=real(fft(acceleration1,L));
Pmay1_2_1 = abs(fourier_may(:,1)/L);
Pmay1_1_1 = Pmay1_2_1(1:L/2+1);
Pmay1_1_1(2:end-1) = 2*Pmay1_1_1(2:end-1);
[Peakacc1may Ind_Peakacc1may]=max(Pmay1_1_1(5000:10000));
figure(1)
plot(fs,Pmay1_1_1);
title('STATUS BEARING RID GRUPPO 0 MAY 2016')
print -dpng -f1 bearingRIDgruppo0may2016.png
disp(['Peak frequency : '  num2str(Ind_Peakacc1may-1)])
disp(['Peak BEARING RID gruppo 0: ' num2str(Peakacc1may)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING MOT B gruppo 0%%
Pmay1_2_2 = abs(fourier_may(:,2))/L;
Pmay1_1_2 = Pmay1_2_2(1:L/2+1);
Pmay1_1_2(2:end-1) = 2*Pmay1_1_2(2:end-1);
[Peakacc2may Ind_Peakacc2may]=max(Pmay1_1_2(5000:10000));
figure(2)
plot(fs,Pmay1_1_2);
title('STATUS BEARING MOT B GRUPPO 0 MAY 2016')
print -dpng -f2 bearingMOTBgruppo0may2016.png
disp(['Peak frequency: ' num2str(Ind_Peakacc2may-1)])
disp(['Peak BEARING MOT B gruppo 0: ' num2str(Peakacc2may)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
```

```
%%ANALISI IN ACCELERAZIONE BEARING 1 HF14 gruppo 1%%
Pmay1_2_3 = abs(fourier_may(:,3))/L;
Pmay1_1_3 = Pmay1_2_3(1:L/2+1);
Pmay1_1_3(2:end-1) = 2*Pmay1_1_3(2:end-1);
[Peakacc3may Ind_Peakacc3may]=max(Pmay1_1_3(5000:10000));
figure(3)
plot(fs,Pmay1_1_3);
title('STATUS BEARING 1 HF14 GRUPPO 1 MAY 2016')
print -dpng -f3 bearing1HF14gruppo1may2016.png
disp(['Peak frequency: ' num2str(Ind_Peakacc3may-1)])
disp(['Peak BEARING 1 HF14 gruppo 1: ' num2str(Peakacc3may)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 1 HF15 gruppo 1%%
Pmay1_2_4 = abs(fourier_may(:,4))/L;
Pmay1_1_4 = Pmay1_2_4(1:L/2+1);
Pmay1_1_4(2:end-1) = 2*Pmay1_1_4(2:end-1);
[Peakacc4may Ind_Peakacc4may]=max(Pmay1_1_4(5000:10000));
figure(4)
plot(fs,Pmay1_1_4);
title('STATUS BEARING 1 HF15 GRUPPO 1 MAY 2016')
print -dpng -f4 bearing1HF15gruppo1may2016.png
disp(['Peak frequency: ' num2str(Ind_Peakacc4may-1)])
disp(['Peak BEARING 1 HF15 gruppo1: ' num2str(Peakacc4may)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 2 HF14 gruppo 1%%
Pmay1_2_5 = abs(fourier_may(:,5))/L;
Pmay1_1_5 = Pmay1_2_5(1:L/2+1);
Pmay1_1_5(2:end-1) = 2*Pmay1_1_5(2:end-1);
[Peakacc5may Ind_Peakacc5may]=max(Pmay1_1_5(5000:10000));
figure(5)
plot(fs,Pmay1_1_5);
title('STATUS BEARING 2 HF14 GRUPPO 1 MAY 2016')
print -dpng -f5 bearing2HF14gruppo1may2016.png
disp(['Peak frequency: ' num2str(Ind_Peakacc5may-1)])
disp(['Peak BEARING 2 HF14 gruppo1: ' num2str(Peakacc5may)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 2 HF15 gruppo 1%%
Pmay1_2_6 = abs(fourier_may(:,6))/L;
Pmay1_1_6 = Pmay1_2_6(1:L/2+1);
Pmay1_1_6(2:end-1) = 2*Pmay1_1_6(2:end-1);
[Peakacc6may Ind_Peakacc6may]=max(Pmay1_1_6(5000:10000));
figure(6)
plot(fs,Pmay1_1_6);
title('STATUS BEARING 2 HF15 GRUPPO 1 MAY 2016')
print -dpng -f6 bearing2HF15gruppo1may2016.png
disp(['Peak frequency: ' num2str(Ind_Peakacc6may-1)])
disp(['Peak BEARING 2 HF15 gruppo1: ' num2str(Peakacc6may)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING HA40 rid gruppo 4%%
Pmay1_2_7 = abs(fourier_may(:,7))/L;
Pmay1_1_7 = Pmay1_2_7(1:L/2+1);
Pmay1_1_7(2:end-1) = 2*Pmay1_1_7(2:end-1);
[Peakacc7may Ind_Peakacc7may]=max(Pmay1_1_7(5000:10000));
figure(7)
plot(fs,Pmay1_1_7);
title('STATUS BEARING 1 HA40 RID GRUPPO 4 MAY 2016')
print -dpng -f7 bearing1HA40ridgruppo4may2016.png
disp(['Peak frequency: ' num2str(Ind_Peakacc7may-1)])
disp(['Peak BEARING 1 HA40 rid gruppo4: ' num2str(Peakacc7may)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING HF53 gruppo 5%%
Pmay1_2_8 = abs(fourier_may(:,8))/L;
Pmay1_1_8 = Pmay1_2_8(1:L/2+1);
Pmay1_1_8(2:end-1) = 2*Pmay1_1_8(2:end-1);
```

```
[Peakacc8may Ind_Peakacc8may]=max(Pmay1_1_8(5000:10000));
figure(8)
plot(fs,Pmay1_1_7);
title('STATUS BEARING 1 HF53 GRUPPO 5 MAY 2016')
print -dpng -f8 bearing1HF53gruppo5may2016.png
disp(['Peak frequency: ' num2str(Ind_Peakacc8may-1)])
disp(['Peak BEARING 1 HF53 gruppo5: ' num2str(Peakacc8may)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 2 HF53 gruppo 5%%
Pmay1_2_9 = abs(fourier_may(:,9))/L;
Pmay1_1_9 = Pmay1_2_9(1:L/2+1);
Pmay1_1_9(2:end-1) = 2*Pmay1_1_9(2:end-1);
[Peakacc9may Ind_Peakacc9may]=max(Pmay1_1_9(5000:10000));
figure(9)
plot(fs,Pmay1_1_9);
title('STATUS BEARING 2 HF53 GRUPPO 5 MAY 2016')
print -dpng -f9 bearing2HF53gruppo5may2016.png
disp(['Peak frequency: ' num2str(Ind_Peakacc9may-1)])
disp(['Peak BEARING 2 HF53 gruppo5: ' num2str(Peakacc9may)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 1 HF54 gruppo 5%%
Pmay1_2_10 = abs(fourier_may(:,10))/L;
Pmay1_1_10 = Pmay1_2_10(1:L/2+1);
Pmay1_1_10(2:end-1) = 2*Pmay1_1_10(2:end-1);
[Peakacc10may Ind_Peakacc10may]=max(Pmay1_1_10(5000:10000));
figure(10)
plot(fs,Pmay1_1_10);
title('STATUS BEARING 1 HF54 GRUPPO 5 MAY 2016')
print -dpng -f10 bearing1HF54gruppo5may2016.png
disp(['Peak frequency: ' num2str(Ind_Peakacc10may-1)])
disp(['Peak BEARING 1 HF54 gruppo5: ' num2str(Peakacc10may)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 1 HF55 gruppo 5%%%
Pmay1_2_11 = abs(fourier_may(:,11))/L;
Pmay1_1_11 = Pmay1_2_11(1:L/2+1);
Pmay1_1_11(2:end-1) = 2*Pmay1_1_11(2:end-1);
[Peakacc11may Ind_Peakacc11may]=max(Pmay1_1_11(5000:10000));
figure(11)
plot(fs,Pmay1_1_11);
title('STATUS BEARING 1 HF55 GRUPPO 5 MAY 2016')
print -dpng -f11 bearing1HF55gruppo5may2016.png
disp(['Peak frequency: ' num2str(Ind_Peakacc11may-1)])
disp(['Peak BEARING 1 HF55 gruppo5: ' num2str(Peakacc11may)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 2 HA51 rid gruppo 5%%
Pmay1_2_12 = abs(fourier_may(:,12))/L;
Pmay1_1_12 = Pmay1_2_12(1:L/2+1);
Pmay1_1_12(2:end-1) = 2*Pmay1_1_12(2:end-1);
[Peakacc12may Ind_Peakacc12may]=max(Pmay1_1_12(5000:10000));
figure(12)
plot(fs,Pmay1_1_12);
title('STATUS BEARING 2 HA51 RID GRUPPO 5 MAY 2016')
print -dpng -f12 bearing2HA51ridgruppo5may2016.png
disp(['Peak frequency: ' num2str(Ind_Peakacc12may-1)])
disp(['Peak BEARING 2 HA51 rid gruppo5: ' num2str(Peakacc12may)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
controlmatrix1=[Peakacc1may Peakacc2may Peakacc3may Peakacc4may Peakacc5may
Peakacc6may Peakacc7may Peakacc8may Peakacc9may Peakacc10may Peakacc11may
Peakacc12may];
corr=[Ind_Peakacc1may Ind_Peakacc2may Ind_Peakacc3may Ind_Peakacc4may
Ind_Peakacc5may Ind_Peakacc6may Ind_Peakacc7may Ind_Peakacc8may
Ind_Peakacc9may Ind_Peakacc10may Ind_Peakacc11may Ind_Peakacc12may];
figure(13)
stem(corr,controlmatrix1,'r')
```

```
for ii=1:length(controlmatrix1)
    if controlmatrix1(ii)>lim1
        disp("Alarm - Rough")

        if ii==1
            disp("Check bearing rid gruppo 0")
        end
        if ii==2
            disp("Check bearing 2 mot B gruppo 0")
        end
        if ii==3
            disp("Check bearing 2 HF14 gruppo 1")
        end
        if ii==4
            disp("Check bearing 2 HF15 gruppo 1")
        end
        if ii==5
            disp("Check bearing bearing 3 HF14 gruppo 1")
        end
        if ii==6
            disp("Check bearing 3 HF15 gruppo 1")
        end
        if ii==7
            disp("Check bearing 1 HA40 gruppo 4")
        end
        if ii==8
            disp("Check bearing 1 HF53 gruppo 5")
        end
        if ii==9
            disp("Check bearing 2 HF53 gruppo 5 ")
        end
        if ii==10
            disp("Check bearing 1 HF54 gruppo 5")
        end
        if ii==11
            disp("Check bearing 1 HF55 gruppo 5")
        end
        if ii==12
            disp("Check bearing 3 HA51 rid gruppo 5")
        end
    else if controlmatrix1(ii)<=lim1 & controlmatrix1(ii)>=lim2
            disp("Alert - Slightly Rough")
            if ii==1
            disp("Check bearing rid gruppo 0")
        end
        if ii==2
            disp("Check bearing 2 mot B gruppo 0")
        end
        if ii==3
            disp("Check bearing 2 HF14 gruppo 1")
        end
        if ii==4
            disp("Check bearing 2 HF15 gruppo 1")
        end
        if ii==5
            disp("Check bearing bearing 3 HF14 gruppo 1")
        end
        if ii==6
            disp("Check bearing 3 HF15 gruppo 1")
        end
        if ii==7
            disp("Check bearing 1 HA40 gruppo 4")
        end
```

```
        if ii==8
            disp("Check bearing 1 HF53 gruppo 5")
        end
        if ii==9
            disp("Check bearing 2 HF53 gruppo 5 ")
        end
        if ii==10
            disp("Check bearing 1 HF54 gruppo 5")
        end
        if ii==11
            disp("Check bearing 1 HF55 gruppo 5")
        end
        if ii==12
            disp("Check bearing 3 HA51 rid gruppo 5")
        end
        else
            disp("Good")
        end
        end


end


%% Vibrations monitoring May 2017 %%

%%GRUPPO1 HF15
datiCuscHF15gruppo1may2=load('May2017CuscHF15gruppo1.txt');
datiCusc1HF15gruppo1may2=load('May2017Cusc1HF15gruppo1.txt');

%%GRUPPO1 HF16
datiCusc2HF16gruppo1may2=load('May2017Cusc2HF16gruppo1.txt');

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%creazione vettore accelerazione misure maggio2017
acc1_may2=zeros(size(datiCuscHF15gruppo1may2(:,1)));
acc2_may2=zeros(size(datiCusc1HF15gruppo1may2(:,1)));
acc3_may2=zeros(size(datiCusc2HF16gruppo1may2(:,1)));


%%Accelerazioni GRUPPO 1 May2017%%
for ii=1:size(datiCuscHF15gruppo1may2)
    acc1_may2(ii)=datiCuscHF15gruppo1may2(ii,2);
    acc2_may2(ii)=datiCusc1HF15gruppo1may2(ii,2);
    acc3_may2(ii)=datiCusc2HF16gruppo1may2(ii,2);
end


acceleration2=[acc1_may2 acc2_may2 acc3_may2];
fs= Fs*(0:(L/2))/L;
RMSacc_may2017 = rms(acceleration2);

disp(' STATUS MAY 2017 ')
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 1 HF15 gruppo1%%
fourier_may2=real(fft(acceleration1,L));
Pmay2_2_1 = abs(fourier_may2(:,1))/L;
Pmay2_1_1 = Pmay2_2_1(1:L/2+1);
Pmay2_1_1(2:end-1) = 2*Pmay2_1_1(2:end-1);
[Peakacc1may2 Ind_Peakacc1may2]=max(Pmay2_1_1(5000:10000));
figure(14)
plot(fs,Pmay2_1_1);
```

```
title('STATUS BEARING 1 HF15 GRUPPO 1 MAY 2017')
print -dpng -f14 bearing1HF15gruppo1may2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc1may2-1)])
disp(['Peak BEARING 1 HF15 gruppo 1: ' num2str(Peakacc1may2)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 2 HF15 gruppo1%%
Pmay2_2_2 = abs(fourier_may2(:,2))/L;
Pmay2_1_2 = Pmay2_2_2(1:L/2+1);
Pmay2_1_2(2:end-1) = 2*Pmay2_1_2(2:end-1);
[Peakacc2may2 Ind_Peakacc2may2]=max(Pmay2_1_2(5000:10000));
figure(15)
plot(fs,Pmay2_1_2);
title('STATUS BEARING 2 HF15 GRUPPO 1 MAY 2017')
print -dpng -f15 bearing1HF15gruppo1may2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc2may2-1)])
disp(['Peak BEARING 2 HF15 gruppo 1: ' num2str(Peakacc2may2)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 2 HF16 gruppo1%%
Pmay2_2_3 = abs(fourier_may2(:,3))/L;
Pmay2_1_3 = Pmay2_2_3(1:L/2+1);
Pmay2_1_3(2:end-1) = 2*Pmay2_1_3(2:end-1);
[Peakacc3may2 Ind_Peakacc3may2]=max(Pmay2_1_3(5000:10000));
figure(16)
plot(fs,Pmay2_1_3);
title('STATUS BEARING 2 HF16 GRUPPO 1 MAY 2017')
print -dpng -f16 bearing2HF16gruppo1may2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc3may2-1)])
disp(['Peak BEARING 2 HF16 gruppo 1: ' num2str(Peakacc3may2)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
controlmatrix2=[Peakacc1may2 Peakacc2may2 Peakacc3may2];

for ii=1:length(controlmatrix2)
    if controlmatrix2(ii)>lim1
        disp("Alarm - Rough")
    if ii==1
        disp("Check Bearing 1 HF15 gruppo 1")
    end
    if ii==2
        disp("Check Bearing 2 HF15 gruppo 1")
    end
    if ii==3
        disp("Check Bearing 2 HF16 gruppo 1")
    end
 else if controlmatrix1(ii)<=lim1 & controlmatrix1(ii)>=lim2
            disp("Alert - Slightly Rough")
    if ii==1
        disp("Check Bearing 1 HF15 gruppo 1")
    end
    if ii==2
        disp("Check Bearing 2 HF15 gruppo 1")
    end
    if ii==3
        disp("Check Bearing 2 HF16 gruppo 1")
    end
     else
         disp("Good")
     end
    end
end


%% Vibrations monitoring December 2017 %%
```

```
%GRUPPO0 MI%
datiCuscMIridgruppo0dec=load('Dec_CuscMIridgruppo0.txt');
datiCusc1MIridgruppo0dec=load('Dec_Cusc1MIridgruppo0.txt');

datiCuscMImotoreBgruppo0dec=load('Dec_CuscMImotoreBgruppo0.txt');
datiCusc1MImotoreBgruppo0dec=load('Dec_Cusc1MImotoreBgruppo0.txt');

datiCuscMImotoreAgruppo0dec=load('Dec_CuscMImotoreAgruppo0.txt');
datiCusc1MImotoreAgruppo0dec=load('Dec_Cusc1MImotoreAgruppo0.txt');

%GRUPPO0 HF2%
datiCuscHF2gruppo0dec=load('Dec_CuscHF2gruppo0.txt');
datiCusc1HF2gruppo0dec=load('Dec_Cusc1HF2gruppo0.txt');

%GRUPPO0 HF1%
datiCuscHF1gruppo0dec=load('Dec_CuscHF1gruppo0.txt');
datiCusc1HF1gruppo0dec=load('Dec_Cusc1HF1gruppo0.txt');
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%GRUPPO1 MI
datiCuscMIridgruppo1dec=load('Dec_CuscMIridgruppo1.txt');
datiCusc1MIridgruppo1dec=load('Dec_Cusc1MIridgruppo1.txt');

datiCuscMImotgruppo1dec=load('Dec_CuscMImotgruppo1.txt');
datiCusc1MImotgruppo1dec=load('Dec_Cusc1MImotgruppo1.txt');

%GRUPPO1 HF17
datiCuscHF17gruppo1dec=load('Dec_CuscHF17gruppo1.txt');

%GRUPPO1 HF16
datiCuscHF16gruppo1dec=load('Dec_CuscHF16gruppo1.txt');

%GRUPPO1 HF15
datiCuscHF15gruppo1dec=load('Dec_CuscHF15gruppo1.txt');

%GRUPPO1 HF14
datiCuscHF14gruppo1dec=load('Dec_CuscHF14gruppo1.txt');

%GRUPPO1 HA13
datiCuscHA13ridgruppo1dec=load('Dec_CuscHA13ridgruppo1.txt');

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%GRUPPO2 MI
datiCuscMIridgruppo2dec=load('Dec_CuscMIridgruppo2.txt');
datiCuscMImotgruppo2dec=load('Dec_CuscMImotgruppo2.txt');
datiCusc1MImotgruppo2dec=load('Dec_Cusc1MImotgruppo2.txt');

%GRUPPO2 HF27
datiCuscHF27gruppo2dec=load('Dec_CuscHF27gruppo2.txt');

%GRUPPO2 HF26
datiCuscHF26gruppo2dec=load('Dec_CuscHF26gruppo2.txt');

%GRUPPO2 HF25
datiCuscHF25gruppo2dec=load('Dec_CuscHF25gruppo2.txt');

%GRUPPO2 HF24
datiCuscHF24gruppo2dec=load('Dec_CuscHF24gruppo2.txt');

%GRUPPO2 HA23
datiCuscHA23ridgruppo2dec=load('Dec_CuscHA23ridgruppo2.txt');
```

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

%GRUPPO4 MI

datiCuscMIridgruppo4dec=load('Dec_CuscMIridgruppo4.txt');
datiCusc1MIridgruppo4dec=load('Dec_Cusc1MIridgruppo4.txt');
datiCuscMImot2gruppo4dec=load('Dec_CuscMImotore2gruppo4.txt');
datiCusc1MImot2gruppo4dec=load('Dec_CuscMImotore2gruppo4.txt');
datiCuscMImotore1gruppo4dec=load('Dec_CuscMImotore1gruppo4.txt');
datiCusc1MImotore1gruppo4dec=load('Dec_Cusc1MImotore1gruppo4.txt');

%GRUPPO4 HF42
datiCuscHF42gruppo4dec=load('Dec_CuscHF42gruppo4.txt');
datiCusc1HF42gruppo4dec=load('Dec_CuscHF42gruppo4.txt');

%GRUPPO4 HF41
datiCuscHF41gruppo4dec=load('Dec_CuscHF41gruppo4.txt');
datiCusc1HF41gruppo4dec=load('Dec_Cusc1HF41gruppo4.txt');

%GRUPPO4 HA40
datiCuscHA40motgruppo4dec=load('Dec_CuscHA40motgruppo4.txt');
datiCuscHA40ridgruppo4dec=load('Dec_CuscHA40ridgruppo4.txt');
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

%GRUPPO5 MI
datiCuscMIridgruppo5dec=load('Dec_CuscMIridgruppo5.txt');
datiCusc1MIridgruppo5dec=load('Dec_Cusc1MIridgruppo5.txt');
datiCuscMImotoreBgruppo5dec=load('Dec_CuscMImotoreBgruppo5.txt');
datiCusc1MImotoreBgruppo5dec=load('Dec_Cusc1MImotoreBgruppo5.txt');
datiCuscMImotoreAgruppo5dec=load('Dec_CuscMImotoreAgruppo5.txt');
datiCusc1MImotoreAgruppo5dec=load('Dec_Cusc1MImotoreAgruppo5.txt');

%GRUPPO5 HF56
datiCuscHF56gruppo5dec=load('Dec_CuscHF56gruppo5.txt');
datiCusc1HF56gruppo5dec=load('Dec_Cusc1HF56gruppo5.txt');

%GRUPPO5 HF55
datiCuscHF55gruppo5dec=load('Dec_CuscHF55gruppo5.txt');
datiCusc1HF55gruppo5dec=load('Dec_Cusc1HF55gruppo5.txt');
datiCusc2HF55gruppo5dec=load('Dec_Cusc2HF55gruppo5.txt');

%GRUPPO5 HF54
datiCuscHF54gruppo5dec=load('Dec_CuscHF54gruppo5.txt');
datiCusc1HF54gruppo5dec=load('Dec_Cusc1HF54gruppo5.txt');
datiCusc2HF54gruppo5dec=load('Dec_Cusc2HF54gruppo5.txt');

%GRUPPO5 HF53
datiCuscHF53gruppo5dec=load('Dec_CuscHF53gruppo5.txt');
datiCusc1HF53gruppo5dec=load('Dec_Cusc1HF53gruppo5.txt');
datiCusc2HF53gruppo5dec=load('Dec_Cusc2HF53gruppo5.txt');

%GRUPPO5 HA51
datiCuscHA51ridgruppo5dec=load('Dec_CuscHA51ridgruppo5.txt');
datiCuscHA51motgruppo5dec=load('Dec_CuscHA51motgruppo5.txt');
datiCusc1HA51motgruppo5dec=load('Dec_Cusc1HA51motgruppo5.txt');
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

%GRUPPO6 MI
datiCuscMIridgruppo6dec=load('Dec_CuscMIridgruppo6.txt');
datiCusc1MIridgruppo6dec=load('Dec_Cusc1MIridgruppo6.txt');
datiCuscMImotore2gruppo6dec=load('Dec_CuscMImotore2gruppo6.txt');
datiCusc1MImotore2gruppo6dec=load('Dec_Cusc1MImotore2gruppo6.txt');
```

```
datiCuscMImotore1gruppo6dec=load('Dec_CuscMImotore1gruppo6.txt');
datiCusc1MImotore1gruppo6dec=load('Dec_Cusc1MImotore1gruppo6.txt');

%GRUPPO6 HF64
datiCuscHF64gruppo6dec=load('Dec_CuscHF64gruppo6.txt');

%GRUPPO6 HF63
datiCuscHF63gruppo6dec=load('Dec_CuscHF63gruppo6.txt');
datiCusc1HF63gruppo6dec=load('Dec_Cusc1HF63gruppo6.txt');

%GRUPPO6 HF62
datiCuscHF62gruppo6dec=load('Dec_CuscHF62gruppo6.txt');

%GRUPPO6 HF61
datiCuscHF61gruppo6dec=load('Dec_CuscHF61gruppo6.txt');
datiCusc1HF61gruppo6dec=load('Dec_Cusc1HF61gruppo6.txt');

%GRUPPO6 HA62
datiCuscHA62gruppo6dec=load('Dec_CuscHA62gruppo6.txt');
datiCusc1HA62gruppo6dec=load('Dec_Cusc1HA62gruppo6.txt');

%GRUPPO6 HA61
datiCuscHA61gruppo6dec=load('Dec_CuscHA61gruppo6.txt');
datiCusc1HA61gruppo6dec=load('Dec_Cusc1HA61gruppo6.txt');



%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%creazione vettore accelerazione misure dicembre

acc1_dec=zeros(size(datiCuscMIridgruppo0dec(:,1)));
acc2_dec=zeros(size(datiCusc1MIridgruppo0dec(:,1)));
acc3_dec=zeros(size(datiCuscMImotoreBgruppo0dec(:,1)));
acc4_dec=zeros(size(datiCusc1MImotoreBgruppo0dec(:,1)));
acc5_dec=zeros(size(datiCuscMImotoreAgruppo0dec(:,1)));
acc6_dec=zeros(size(datiCusc1MImotoreAgruppo0dec(:,1)));
acc7_dec=zeros(size(datiCuscHF2gruppo0dec(:,1)));
acc8_dec=zeros(size(datiCusc1HF2gruppo0dec(:,1)));
acc9_dec=zeros(size(datiCuscHF1gruppo0dec(:,1)));
acc10_dec=zeros(size(datiCusc1HF1gruppo0dec(:,1)));
acc11_dec=zeros(size(datiCuscMIridgruppo1dec(:,1)));
acc12_dec=zeros(size(datiCusc1MIridgruppo1dec(:,1)));
acc13_dec=zeros(size(datiCuscMImotgruppo1dec(:,1)));
acc14_dec=zeros(size(datiCusc1MImotgruppo1dec(:,1)));
acc15_dec=zeros(size(datiCuscHF17gruppo1dec(:,1)));
acc16_dec=zeros(size(datiCuscHF16gruppo1dec(:,1)));
acc17_dec=zeros(size(datiCuscHF15gruppo1dec(:,1)));
acc18_dec=zeros(size(datiCuscHF14gruppo1dec(:,1)));
acc19_dec=zeros(size(datiCuscHA13ridgruppo1dec(:,1)));
acc20_dec=zeros(size(datiCuscMIridgruppo2dec(:,1)));
acc21_dec=zeros(size(datiCuscMImotgruppo2dec(:,1)));
acc22_dec=zeros(size(datiCusc1MImotgruppo2dec(:,1)));
acc23_dec=zeros(size(datiCuscHF27gruppo2dec(:,1)));
acc24_dec=zeros(size(datiCuscHF26gruppo2dec(:,1)));
acc25_dec=zeros(size(datiCuscHF25gruppo2dec(:,1)));
acc26_dec=zeros(size(datiCuscHF24gruppo2dec(:,1)));
acc27_dec=zeros(size(datiCuscHA23ridgruppo2dec(:,1)));
acc28_dec=zeros(size(datiCuscMIridgruppo4dec(:,1)));
acc29_dec=zeros(size(datiCusc1MIridgruppo4dec(:,1)));
acc30_dec=zeros(size(datiCuscMImot2gruppo4dec(:,1)));
acc31_dec=zeros(size(datiCusc1MImot2gruppo4dec(:,1)));
acc32_dec=zeros(size(datiCuscMImotore1gruppo4dec(:,1)));
```

```
acc33_dec=zeros(size(datiCusc1MImotore1gruppo4dec(:,1)));
acc34_dec=zeros(size(datiCuscHF42gruppo4dec(:,1)));
acc35_dec=zeros(size(datiCusc1HF42gruppo4dec(:,1)));
acc36_dec=zeros(size(datiCuscHF41gruppo4dec(:,1)));
acc37_dec=zeros(size(datiCusc1HF41gruppo4dec(:,1)));
acc38_dec=zeros(size(datiCuscHA40motgruppo4dec(:,1)));
acc39_dec=zeros(size(datiCuscHA40ridgruppo4dec(:,1)));
acc40_dec=zeros(size(datiCuscMIridgruppo5dec(:,1)));
acc41_dec=zeros(size(datiCusc1MIridgruppo5dec(:,1)));
acc42_dec=zeros(size(datiCuscMImotoreBgruppo5dec(:,1)));
acc43_dec=zeros(size(datiCusc1MImotoreBgruppo5dec(:,1)));
acc44_dec=zeros(size(datiCuscMImotoreAgruppo5dec(:,1)));
acc45_dec=zeros(size(datiCusc1MImotoreAgruppo5dec(:,1)));
acc46_dec=zeros(size(datiCuscHF56gruppo5dec(:,1)));
acc47_dec=zeros(size(datiCusc1HF56gruppo5dec(:,1)));
acc48_dec=zeros(size(datiCuscHF55gruppo5dec(:,1)));
acc49_dec=zeros(size(datiCusc1HF55gruppo5dec(:,1)));
acc50_dec=zeros(size(datiCusc2HF55gruppo5dec(:,1)));
acc51_dec=zeros(size(datiCuscHF54gruppo5dec(:,1)));
acc52_dec=zeros(size(datiCusc1HF54gruppo5dec(:,1)));
acc53_dec=zeros(size(datiCusc2HF54gruppo5dec(:,1)));
acc54_dec=zeros(size(datiCuscHF53gruppo5dec(:,1)));
acc55_dec=zeros(size(datiCusc1HF53gruppo5dec(:,1)));
acc56_dec=zeros(size(datiCusc2HF53gruppo5dec(:,1)));
acc57_dec=zeros(size(datiCuscHA51ridgruppo5dec(:,1)));
acc58_dec=zeros(size(datiCuscHA51motgruppo5dec(:,1)));
acc59_dec=zeros(size(datiCusc1HA51motgruppo5dec(:,1)));
acc60_dec=zeros(size(datiCuscMIridgruppo6dec(:,1)));
acc61_dec=zeros(size(datiCusc1MIridgruppo6dec(:,1)));
acc62_dec=zeros(size(datiCuscMImotore2gruppo6dec(:,1)));
acc63_dec=zeros(size(datiCusc1MImotore2gruppo6dec(:,1)));
acc64_dec=zeros(size(datiCuscMImotore1gruppo6dec(:,1)));
acc65_dec=zeros(size(datiCusc1MImotore1gruppo6dec(:,1)));
acc66_dec=zeros(size(datiCuscHF64gruppo6dec(:,1)));
acc67_dec=zeros(size(datiCuscHF63gruppo6dec(:,1)));
acc68_dec=zeros(size(datiCusc1HF63gruppo6dec(:,1)));
acc69_dec=zeros(size(datiCuscHF62gruppo6dec(:,1)));
acc70_dec=zeros(size(datiCuscHF61gruppo6dec(:,1)));
acc71_dec=zeros(size(datiCusc1HF61gruppo6dec(:,1)));
acc72_dec=zeros(size(datiCuscHA62gruppo6dec(:,1)));
acc73_dec=zeros(size(datiCusc1HA62gruppo6dec(:,1)));
acc74_dec=zeros(size(datiCuscHA61gruppo6dec(:,1)));
acc75_dec=zeros(size(datiCusc1HA61gruppo6dec(:,1)));


%Accelerazioni GRUPPO 0 December
for ii=1:size(datiCuscMIridgruppo0dec)
acc1_dec(ii)=datiCuscMIridgruppo0dec(ii,2);
acc2_dec(ii)=datiCusc1MIridgruppo0dec(ii,2);
acc3_dec(ii)=datiCuscMImotoreBgruppo0dec(ii,2);
acc4_dec(ii)=datiCusc1MImotoreBgruppo0dec(ii,2);
acc5_dec(ii)=datiCuscMImotoreAgruppo0dec(ii,2);
acc6_dec(ii)=datiCusc1MImotoreAgruppo0dec(ii,2);
acc7_dec(ii)=datiCuscHF2gruppo0dec(ii,2);
acc8_dec(ii)=datiCusc1HF2gruppo0dec(ii,2);
acc9_dec(ii)=datiCuscHF1gruppo0dec(ii,2);
acc10_dec(ii)=datiCusc1HF1gruppo0dec(ii,2);
end

acceleration0_dec=[acc1_dec acc2_dec acc3_dec acc4_dec acc5_dec acc6_dec
acc7_dec acc8_dec acc9_dec acc10_dec];
fs= Fs*(0:(L/2))/L;
RMSacc_dec2017 = rms(acceleration0_dec);
```

```
disp(' STATUS DECEMBER 2017 ')
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 1 MI rid gruppo0%%
fourier0_dec=real(fft(acceleration0_dec,L));
Pdec2_1 = abs(fourier0_dec(:,1))/L;
Pdec1_1 = Pdec2_1(1:L/2+1);
Pdec1_1(2:end-1) = 2*Pdec1_1(2:end-1);
[Peakacc1dec Ind_Peakacc1dec]=max(Pdec1_1(5000:10000));
figure(17)
plot(fs,Pdec1_1);
title('STATUS BEARING 1 MI RID GRUPPO 0 DEC 2017')
print -dpng -f17 bearing1MIRIDgruppo0dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc1dec-1)])
disp(['Peak BEARING 1 MI rid gruppo 0: ' num2str(Peakacc1dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 2 MI rid gruppo0%%
Pdec2_2 = abs(fourier0_dec(:,2))/L;
Pdec1_2 = Pdec2_2(1:L/2+1);
Pdec1_2(2:end-1) = 2*Pdec1_2(2:end-1);
[Peakacc2dec Ind_Peakacc2dec]=max(Pdec1_2(5000:10000));
figure(18)
plot(fs,Pdec1_2);
title('STATUS BEARING 2 MI RID GRUPPO 0 DEC 2017')
print -dpng -f18 bearing2MIRIDgruppo0dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc2dec-1)])
disp(['Peak BEARING 2 MI rid gruppo 0: ' num2str(Peakacc2dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 1 MI motore B gruppo0%%
Pdec2_3 = abs(fourier0_dec(:,3))/L;
Pdec1_3 = Pdec2_3(1:L/2+1);
Pdec1_3(2:end-1) = 2*Pdec1_3(2:end-1);
[Peakacc3dec Ind_Peakacc3dec]=max(Pdec1_3(5000:10000));
figure(19)
plot(fs,Pdec1_3);
title('STATUS BEARING 1 MI MOT B GRUPPO 0 DEC 2017')
print -dpng -f19 bearing1MIMOTBgruppo0dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc3dec-1)])
disp(['Peak BEARING 1 MI mot B gruppo 0: ' num2str(Peakacc3dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 2 MI motore B gruppo0%%
Pdec2_4 = abs(fourier0_dec(:,4))/L;
Pdec1_4 = Pdec2_4(1:L/2+1);
Pdec1_4(2:end-1) = 2*Pdec1_4(2:end-1);
[Peakacc4dec Ind_Peakacc4dec]=max(Pdec1_4(5000:10000));
figure(20)
plot(fs,Pdec1_4);
title('STATUS BEARING 2 MI MOT B GRUPPO 0 DEC 2017')
print -dpng -f20 bearing2MIMOTBgruppo0dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc4dec-1)])
disp(['Peak BEARING 2 MI mot B gruppo 0: ' num2str(Peakacc4dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 1 MI motore A gruppo0%%
Pdec2_5 = abs(fourier0_dec(:,5))/L;
Pdec1_5 = Pdec2_5(1:L/2+1);
Pdec1_5(2:end-1) = 2*Pdec1_5(2:end-1);
[Peakacc5dec Ind_Peakacc5dec]=max(Pdec1_5(5000:10000));
figure(21)
plot(fs,Pdec1_5);
title('STATUS BEARING 1 MI MOT A GRUPPO 0 DEC 2017')
print -dpng -f21 bearing1MIMOTAgruppo0dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc5dec-1)])
disp(['Peak BEARING 1 MI mot A gruppo 0: ' num2str(Peakacc5dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
```

```
%%ANALISI IN ACCELERAZIONE BEARING 2 MI mot A gruppo0%%
Pdec2_6 = abs(fourier0_dec(:,6))/L;
Pdec1_6 = Pdec2_6(1:L/2+1);
Pdec1_6(2:end-1) = 2*Pdec1_6(2:end-1);
[Peakacc6dec Ind_Peakacc6dec]=max(Pdec1_6(5000:10000));
figure(22)
plot(fs,Pdec1_6);
title('STATUS BEARING 2 MI MOT A GRUPPO 0 DEC 2017')
print -dpng -f22 bearing2MIMOTAgruppo0dec2017.png
disp(['Peak frequency: ' num2str(Ind_Peakacc6dec-1)])
disp(['Peak BEARING 2 MI mot A gruppo 0: ' num2str(Peakacc6dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 1 HF2 gruppo0%%
Pdec2_7 = abs(fourier0_dec(:,7))/L;
Pdec1_7 = Pdec2_7(1:L/2+1);
Pdec1_7(2:end-1) = 2*Pdec1_7(2:end-1);
[Peakacc7dec Ind_Peakacc7dec]=max(Pdec1_7(5000:10000));
figure(23)
plot(fs,Pdec1_7);
title('STATUS BEARING 1 HF2 GRUPPO 0 DEC 2017')
print -dpng -f23 bearing1HF2gruppo0dec2017.png
disp(['Peak frequency: ' num2str(Ind_Peakacc7dec-1)])
disp(['Peak BEARING 1 HF2 gruppo 0: ' num2str(Peakacc7dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 2 HF2 gruppo0%%
Pdec2_8 = abs(fourier0_dec(:,8))/L;
Pdec1_8 = Pdec2_8(1:L/2+1);
Pdec1_8(2:end-1) = 2*Pdec1_8(2:end-1);
[Peakacc8dec Ind_Peakacc8dec]=max(Pdec1_8(5000:10000));
figure(24)
plot(fs,Pdec1_8);
title('STATUS BEARING 2 HF2 GRUPPO 0 DEC 2017')
print -dpng -f24 bearing2HF2gruppo0dec2017.png
disp(['Peak frequency: ' num2str(Ind_Peakacc8dec-1)])
disp(['Peak BEARING 2 HF2 gruppo 0: ' num2str(Peakacc8dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 1 HF1 gruppo0%%
Pdec2_9 = abs(fourier0_dec(:,9))/L;
Pdec1_9 = Pdec2_9(1:L/2+1);
Pdec1_9(2:end-1) = 2*Pdec1_9(2:end-1);
[Peakacc9dec Ind_Peakacc9dec]=max(Pdec1_9(5000:10000));
figure(25)
plot(fs,Pdec1_9);
title('STATUS BEARING 1 HF1 GRUPPO 0 DEC 2017')
print -dpng -f25 bearing1HF1gruppo0dec2017.png
disp(['Peak frequency: ' num2str(Ind_Peakacc9dec-1)])
disp(['Peak BEARING 1 HF1 gruppo 0: ' num2str(Peakacc9dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 2 HF1 gruppo0%%
Pdec2_10 = abs(fourier0_dec(:,10))/L;
Pdec1_10 = Pdec2_10(1:L/2+1);
Pdec1_10(2:end-1) = 2*Pdec1_10(2:end-1);
[Peakacc10dec Ind_Peakacc10dec]=max(Pdec1_10(5000:10000));
figure(26)
plot(fs,Pdec1_10);
title('STATUS BEARING 2 HF1 GRUPPO 0 DEC 2017')
print -dpng -f26 bearing2HF1gruppo0dec2017.png
disp(['Peak frequency: ' num2str(Ind_Peakacc10dec-1)])
disp(['Peak BEARING 2 HF1 gruppo 0: ' num2str(Peakacc10dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
controlmatrixdec_1=[Peakacc1dec Peakacc2dec Peakacc3dec Peakacc4dec
Peakacc5dec Peakacc6dec Peakacc7dec Peakacc8dec Peakacc9dec Peakacc10dec];

for ii=1:length(controlmatrixdec_1)
```

```
if controlmatrixdec_1(ii)>lim1
    disp("Alarm - Rough")
    if ii==1
        disp("Check bearing 1 MI rid gruppo 0")
    end
    if ii==2
        disp("Check bearing 2 MI rid gruppo 0")
    end
    if ii==3
        disp("Check bearing 1 MI mot B gruppo 0")
    end
    if ii==4
        disp("Check bearing 2 MI mot B gruppo 0")
    end
    if ii==5
        disp("Check bearing 1 MI mot A gruppo 0")
    end
    if ii==6
        disp("Check bearing 2 MI mot A gruppo 0")
    end
    if ii==7
        disp("Check bearing 1 HF2 gruppo 0")
    end
    if ii==8
        disp("Check bearing 2 HF2 gruppo 0")
    end
    if ii==9
        disp("Check bearing 1 HF1 gruppo 0")
    end
    if ii==10
        disp("Check bearing 2 HF1 gruppo 0")
    end
else if controlmatrixdec_1(ii)<=lim1 & controlmatrixdec_1(ii)>=lim2
         disp("Alert - Slightly Rough")
            if ii==1
        disp("Check bearing 1 MI rid gruppo 0")
    end
    if ii==2
        disp("Check bearing 2 MI rid gruppo 0")
    end
    if ii==3
        disp("Check bearing 1 MI mot B gruppo 0")
    end
    if ii==4
        disp("Check bearing 2 MI mot B gruppo 0")
    end
    if ii==5
        disp("Check bearing 1 MI mot A gruppo 0")
    end
    if ii==6
        disp("Check bearing 2 MI mot A gruppo 0")
    end
    if ii==7
        disp("Check bearing 1 HF2 gruppo 0")
    end
    if ii==8
        disp("Check bearing 2 HF2 gruppo 0")
    end
    if ii==9
        disp("Check bearing 1 HF1 gruppo 0")
    end
    if ii==10
        disp("Check bearing 2 HF1 gruppo 0")
    end
```

```
        else disp("Good")
        end
    end
end


%Acceleration GRUPPO1 December 2017
for ii=1:size(datiCuscMIridgruppo0dec)
acc11_dec(ii)=datiCuscMIridgruppo1dec(ii,2);
acc12_dec(ii)=datiCusc1MIridgruppo1dec(ii,2);
acc13_dec(ii)=datiCuscMImotgruppo1dec(ii,2);
acc14_dec(ii)=datiCusc1MImotgruppo1dec(ii,2);
acc15_dec(ii)=datiCuscHF17gruppo1dec(ii,2);
acc16_dec(ii)=datiCuscHF16gruppo1dec(ii,2);
acc17_dec(ii)=datiCuscHF15gruppo1dec(ii,2);
acc18_dec(ii)=datiCuscHF14gruppo1dec(ii,2);
acc19_dec(ii)=datiCuscHA13ridgruppo1dec(ii,2);
end
acceleration1_dec=[acc11_dec acc12_dec acc13_dec acc14_dec acc15_dec
acc16_dec acc17_dec acc18_dec acc19_dec];
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 1 MI RID gruppo1%
fourier1_dec=real(fft(acceleration1_dec,L));
Pdec2_11 = abs(fourier1_dec(:,1))/L;
Pdec1_11 = Pdec2_11(1:L/2+1);
Pdec1_11(2:end-1) = 2*Pdec1_11(2:end-1);
[Peakacc11dec Ind_Peakacc11dec]=max(Pdec1_11(5000:10000));
figure(27)
plot(fs,Pdec1_11);
title('STATUS BEARING 1 MI RID GRUPPO 1 DEC 2017')
print -dpng -f27 bearing1MIRidgruppo1dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc11dec-1)])
disp(['Peak BEARING 1 MI rid gruppo 1: ' num2str(Peakacc11dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZONE BEARING 2 RID gruppo1%%
Pdec2_12 = abs(fourier1_dec(:,2))/L;
Pdec1_12 = Pdec2_12(1:L/2+1);
Pdec1_12(2:end-1) = 2*Pdec1_12(2:end-1);
[Peakacc12dec Ind_Peakacc12dec]=max(Pdec1_12(5000:10000));
figure(28)
plot(fs,Pdec1_12);
title('STATUS BEARING 2 MI RID GRUPPO 1 DEC 2017')
print -dpng -f28 bearing2MIRidgruppo1dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc12dec-1)])
disp(['Peak BEARING 2 MI rid gruppo 1: ' num2str(Peakacc12dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 1 MI MOT gruppo1%%
Pdec2_13 = abs(fourier1_dec(:,3))/L;
Pdec1_13 = Pdec2_13(1:L/2+1);
Pdec1_13(2:end-1) = 2*Pdec1_13(2:end-1);
[Peakacc13dec Ind_Peakacc13dec]=max(Pdec1_13(5000:10000));
figure(29)
plot(fs,Pdec1_13);
title('STATUS BEARING 1 MI MOT GRUPPO 1 DEC 2017')
print -dpng -f29 bearing1MImotgruppo1dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc13dec-1)])
disp(['Peak BEARING 1 MI mot gruppo 1: ' num2str(Peakacc13dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 2 MI MOTORE gruppo1%$%
Pdec2_14 = abs(fourier1_dec(:,4))/L;
Pdec1_14 = Pdec2_14(1:L/2+1);
Pdec1_14(2:end-1) = 2*Pdec1_14(2:end-1);
[Peakacc14dec Ind_Peakacc14dec]=max(Pdec1_14(5000:10000));
figure(30)
```

```
plot(fs,Pdec1_14);
title('STATUS BEARING 2 MI MOT GRUPPO 1 DEC 2017')
print -dpng -f30 bearing2MOTgruppo1dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc14dec-1)])
disp(['Peak BEARING 2 MI mot gruppo 1: ' num2str(Peakacc14dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 1 HF17 gruppo1%%
Pdec2_15 = abs(fourier1_dec(:,5))/L;
Pdec1_15 = Pdec2_15(1:L/2+1);
Pdec1_15(2:end-1) = 2*Pdec1_15(2:end-1);
[Peakacc15dec Ind_Peakacc15dec]=max(Pdec1_15(5000:10000));
figure(31)
plot(fs,Pdec1_15);
title('STATUS BEARING 1 HF17 GRUPPO 1 DEC 2017')
print -dpng -f31 bearing1HF17gruppo1dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc15dec-1)])
disp(['Peak BEARING 1 HF17 gruppo 1: ' num2str(Peakacc15dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 1 HF16 gruppo1%%
Pdec2_16 = abs(fourier1_dec(:,6))/L;
Pdec1_16 = Pdec2_16(1:L/2+1);
Pdec1_16(2:end-1) = 2*Pdec1_16(2:end-1);
[Peakacc16dec Ind_Peakacc16dec]=max(Pdec1_16(5000:10000));
figure(32)
plot(fs,Pdec1_16);
title('STATUS BEARING 1 HF16 GRUPPO 1 DEC 2017')
print -dpng -f32 bearing1HF16gruppo1dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc16dec-1)])
disp(['Peak BEARING 1 HF16 gruppo 1: ' num2str(Peakacc16dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 1 HF15 gruppo1%%
Pdec2_17 = abs(fourier1_dec(:,7))/L;
Pdec1_17 = Pdec2_17(1:L/2+1);
Pdec1_17(2:end-1) = 2*Pdec1_17(2:end-1);
[Peakacc17dec Ind_Peakacc17dec]=max(Pdec1_1(5000:10000));
figure(33)
plot(fs,Pdec1_17);
title('STATUS BEARING 1 HF15 GRUPPO 1 DEC 2017')
print -dpng -f33 bearing1HF15gruppo1dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc17dec-1)])
disp(['Peak BEARING 1 HF15 gruppo 1: ' num2str(Peakacc17dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZONE BEARING 1 HF14 gruppo1%%
Pdec2_18 = abs(fourier1_dec(:,8))/L;
Pdec1_18 = Pdec2_18(1:L/2+1);
Pdec1_18(2:end-1) = 2*Pdec1_18(2:end-1);
[Peakacc18dec Ind_Peakacc18dec]=max(Pdec1_18(5000:10000));
figure(34)
plot(fs,Pdec1_18);
title('STATUS BEARING 1 HF14 GRUPPO 1 DEC 2017')
print -dpng -f34 bearing1HF14gruppo1dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc18dec-1)])
disp(['Peak BEARING 1 HF14 gruppo 1: ' num2str(Peakacc18dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 1 HA13 rid gruppo1%%
Pdec2_19 = abs(fourier1_dec(:,9))/L;
Pdec1_19 = Pdec2_19(1:L/2+1);
Pdec1_19(2:end-1) = 2*Pdec1_19(2:end-1);
[Peakacc19dec Ind_Peakacc19dec]=max(Pdec1_19(5000:10000));
figure(35)
plot(fs,Pdec1_19);
title('STATUS BEARING 1 HA13 RID GRUPPO 1 DEC 2017')
print -dpng -f35 bearing1HA13riddec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc19dec-1)])
```

```
disp(['Peak BEARING 1 HA13 rid gruppo 1: ' num2str(Peakacc19dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
controlmatrixdec_2=[Peakacc11dec Peakacc12dec Peakacc13dec Peakacc14dec
Peakacc15dec Peakacc16dec Peakacc17dec Peakacc18dec Peakacc19dec];

for ii=1:length(controlmatrixdec_2)
    if controlmatrixdec_2(ii)>lim1
        disp("Alarm - Rough")
        if ii==1
            disp("Check bearing 1 MI rid gruppo 1")
        end
        if ii==2
            disp("Check bearing 2 MI rid gruppo 1")
        end
        if ii==3
            disp("Check bearing 1 MI mot gruppo 1")
        end
        if ii==4
            disp("Check bearing 2 MI mot gruppo 1")
        end
        if ii==5
            disp("Check bearing 1 HF17 gruppo 1")
        end
        if ii==6
            disp("Check bearing 1 HF16 gruppo 1")
        end
        if ii==7
            disp("Check bearing 1 HF15 gruppo 1")
        end
        if ii==8
            disp("Check bearing HF14 gruppo 1")
        end
        if ii==9
            disp("Check bearing 1 HA13 rid gruppo 1")
        end
    else if controlmatrixdec_2(ii)>=lim2 && controlmatrixdec_2(ii)<=lim1
            disp("Alert - Slighty rough")
            if ii==1
            disp("Check bearing 1 MI rid gruppo 1")
        end
        if ii==2
            disp("Check bearing 2 MI rid gruppo 1")
        end
        if ii==3
            disp("Check bearing 1 MI mot gruppo 1")
        end
        if ii==4
            disp("Check bearing 2 MI mot gruppo 1")
        end
        if ii==5
            disp("Check bearing 1 HF17 gruppo 1")
        end
        if ii==6
            disp("Check bearing 1 HF16 gruppo 1")
        end
        if ii==7
            disp("Check bearing 1 HF15 gruppo 1")
        end
        if ii==8
            disp("Check bearing HF14 gruppo 1")
        end
        if ii==9
            disp("Check bearing 1 HA13 rid gruppo 1")
        end
```

```
        else disp("Good")
        end
    end
end




%Acceleration GRUPPO 2 December
for ii=1:size(datiCuscMIridgruppo0dec)
acc20_dec(ii)=datiCuscMIridgruppo2dec(ii,2);
acc21_dec(ii)=datiCuscMImotgruppo2dec(ii,2);
acc22_dec(ii)=datiCusc1MImotgruppo2dec(ii,2);
acc23_dec(ii)=datiCuscHF27gruppo2dec(ii,2);
acc24_dec(ii)=datiCuscHF26gruppo2dec(ii,2);
acc25_dec(ii)=datiCuscHF25gruppo2dec(ii,2);
acc26_dec(ii)=datiCuscHF24gruppo2dec(ii,2);
acc27_dec(ii)=datiCuscHA23ridgruppo2dec(ii,2);
end

acceleration2_dec=[acc20_dec acc21_dec acc22_dec acc23_dec acc24_dec
acc25_dec acc26_dec acc27_dec];
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 1 MI rid GRUPPO 2 DECEMBER%%
fourier2_dec=real(fft(acceleration2_dec,L));
Pdec2_20 = abs(fourier2_dec(:,1))/L;
Pdec1_20 = Pdec2_20(1:L/2+1);
Pdec1_20(2:end-1) = 2*Pdec1_20(2:end-1);
[Peakacc20dec Ind_Peakacc20dec]=max(Pdec1_20(5000:10000));
figure(36)
plot(fs,Pdec1_20);
title('STATUS BEARING 1 MI RID GRUPPO 2 DEC 2017')
print -dpng -f36 bearing1MIridgruppo2dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc20dec-1)])
disp(['Peak BEARING 1 MI rid gruppo 2: ' num2str(Peakacc20dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 1 MI mot GRUPPO 2 DECEMBER%%
Pdec2_21 = abs(fourier2_dec(:,2))/L;
Pdec1_21 = Pdec2_21(1:L/2+1);
Pdec1_21(2:end-1) = 2*Pdec1_21(2:end-1);
[Peakacc21dec Ind_Peakacc21dec]=max(Pdec1_21(5000:10000));
figure(37)
plot(fs,Pdec1_21);
title('STATUS BEARING 1 MI MOT GRUPPO 2 DEC 2017')
print -dpng -f37 bearing1MImotgruppo2dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc21dec-1)])
disp(['Peak BEARING 1 MI mot gruppo 2: ' num2str(Peakacc21dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 2 MI mot GRUPPO 2 DECEMBER%%
Pdec2_22 = abs(fourier2_dec(:,3))/L;
Pdec1_22 = Pdec2_22(1:L/2+1);
Pdec1_22(2:end-1) = 2*Pdec1_22(2:end-1);
[Peakacc22dec Ind_Peakacc22dec]=max(Pdec1_22(5000:10000));
figure(38)
plot(fs,Pdec1_22);
title('STATUS BEARING 2 MI MOT GRUPPO 2 DEC 2017')
print -dpng -f38 bearing2MImotgruppo2dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc22dec-1)])
disp(['Peak BEARING 2 MI mot gruppo 2: ' num2str(Peakacc22dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 1 HF27 GRUPPO 2 DECEMBER%%
Pdec2_23 = abs(fourier2_dec(:,4))/L;
Pdec1_23 = Pdec2_23(1:L/2+1);
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Pdec1_23(2:end-1) = 2*Pdec1_23(2:end-1);
[Peakacc23dec Ind_Peakacc23dec]=max(Pdec1_23(5000:10000));
figure(39)
plot(fs,Pdec1_23);
title('STATUS BEARING 1 HF27 GRUPPO 2 DEC 2017')
print -dpng -f39 bearing1HF27gruppo2dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc23dec-1)])
disp(['Peak BEARING 1 HF27 gruppo 2: ' num2str(Peakacc23dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 1 HF26 GRUPPO 2 DECEMBER%%
Pdec2_24 = abs(fourier2_dec(:,5))/L;
Pdec1_24 = Pdec2_24(1:L/2+1);
Pdec1_24(2:end-1) = 2*Pdec1_24(2:end-1);
[Peakacc24dec Ind_Peakacc24dec]=max(Pdec1_24(5000:10000));
figure(40)
plot(fs,Pdec1_24);
title('STATUS BEARING 1 HF26 GRUPPO 2 DEC 2017')
print -dpng -f40 bearing1HF26gruppo2dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc24dec-1)])
disp(['Peak BEARING 1 HF26 gruppo 2: ' num2str(Peakacc24dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 1 HF25 GRUPPO 2 DECEMBER%%
Pdec2_25 = abs(fourier2_dec(:,6))/L;
Pdec1_25 = Pdec2_25(1:L/2+1);
Pdec1_25(2:end-1) = 2*Pdec1_25(2:end-1);
[Peakacc25dec Ind_Peakacc25dec]=max(Pdec1_25(5000:10000));
figure(41)
plot(fs,Pdec1_25);
title('STATUS BEARING 1 HF25 GRUPPO 2 DEC 2017')
print -dpng -f41 bearing1HF25gruppo2dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc25dec-1)])
disp(['Peak BEARING 1 HF25 gruppo 2: ' num2str(Peakacc25dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 1 HF24 GRUPPO 2 DECEMBER%%
Pdec2_26 = abs(fourier2_dec(:,7))/L;
Pdec1_26 = Pdec2_26(1:L/2+1);
Pdec1_26(2:end-1) = 2*Pdec1_26(2:end-1);
[Peakacc26dec Ind_Peakacc26dec]=max(Pdec1_26(5000:10000));
figure(42)
plot(fs,Pdec1_26);
title('STATUS BEARING 1 HF24 GRUPPO 2 DEC 2017')
print -dpng -f42 bearing1HF24gruppo2dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc26dec-1)])
disp(['Peak BEARING 1 HF24 gruppo 2: ' num2str(Peakacc26dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 1 HA23 rid GRUPPO 2 DECEMBER%%
Pdec2_27 = abs(fourier2_dec(:,8))/L;
Pdec1_27 = Pdec2_27(1:L/2+1);
Pdec1_27(2:end-1) = 2*Pdec1_27(2:end-1);
[Peakacc27dec Ind_Peakacc27dec]=max(Pdec1_27(5000:10000));
figure(43)
plot(fs,Pdec1_27);
title('STATUS BEARING 1 HA23 RID GRUPPO 2 DEC 2017')
print -dpng -f43 bearing1HA23ridgruppo2dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc27dec-1)])
disp(['Peak BEARING 1 HA23 rid gruppo 2: ' num2str(Peakacc27dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
controlmatrixdec_3=[Peakacc20dec Peakacc21dec Peakacc22dec Peakacc23dec
Peakacc24dec Peakacc25dec Peakacc26dec Peakacc27dec];

for ii=1:length(controlmatrixdec_3)
    if controlmatrixdec_3(ii)>lim1
        disp("Alarm - Rough")
        if ii==1
```

```
            disp("Check bearing 1 MI rid gruppo 2")
        end
        if ii==2
            disp("Check bearing 1 MI mot gruppo 2")
        end
        if ii==3
            disp("Check bearing 2 MI mot gruppo 2")
        end
        if ii==4
            disp("Check bearing 1 HF27 gruppo 2")
        end
        if ii==5
            disp("Check bearing 1 HF26 gruppo 2")
        end
        if ii==6
            disp("Check bearing 1 HF25 gruppo 2")
        end
        if ii==7
            disp("Check bearing 1 HF24 gruppo 2")
        end

    else if controlmatrixdec_3(ii)>=lim2 && controlmatrixdec_3(ii)<=lim1
            disp("Alert - Slighty rough")
            if ii==1
            disp("Check bearing 1 MI rid gruppo 2")
        end
        if ii==2
            disp("Check bearing 1 MI mot gruppo 2")
        end
        if ii==3
            disp("Check bearing 2 MI mot gruppo 2")
        end
        if ii==4
            disp("Check bearing 1 HF27 gruppo 2")
        end
        if ii==5
            disp("Check bearing 1 HF26 gruppo 2")
        end
        if ii==6
            disp("Check bearing 1 HF25 gruppo 2")
        end
        if ii==7
            disp("Check bearing 1 HF24 gruppo 2")
        end

        else disp("Good")
        end
    end
end


%%Acceleration GRUPPO 4 December %%

for ii=1:size(datiCuscMIridgruppo0dec)
acc28_dec(ii)=datiCuscMIridgruppo4dec(ii,2);
acc29_dec(ii)=datiCusc1MIridgruppo4dec(ii,2);
acc30_dec(ii)=datiCuscMImot2gruppo4dec(ii,2);
acc31_dec(ii)=datiCusc1MImot2gruppo4dec(ii,2);
acc32_dec(ii)=datiCuscMImotore1gruppo4dec(ii,2);
acc33_dec(ii)=datiCusc1MImotore1gruppo4dec(ii,2);
acc34_dec(ii)=datiCuscHF42gruppo4dec(ii,2);
acc35_dec(ii)=datiCusc1HF42gruppo4dec(ii,2);
acc36_dec(ii)=datiCuscHF41gruppo4dec(ii,2);
```

```
acc37_dec(ii)=datiCusc1HF41gruppo4dec(ii,2);
acc38_dec(ii)=datiCuscHA40ridgruppo4dec(ii,2);
acc39_dec(ii)=datiCuscHA40motgruppo4dec(ii,2);
end

acceleration3_dec=[acc28_dec acc29_dec acc30_dec acc31_dec acc32_dec
acc33_dec acc34_dec acc35_dec acc36_dec acc37_dec acc38_dec acc39_dec];

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 1 MI rid GRUPPO 4%%
fourier3_dec=real(fft(acceleration3_dec,L));
Pdec2_28 = abs(fourier3_dec(:,1))/L;
Pdec1_28 = Pdec2_28(1:L/2+1);
Pdec1_28(2:end-1) = 2*Pdec1_28(2:end-1);
[Peakacc28dec Ind_Peakacc28dec]=max(Pdec1_28(5000:10000));
figure(44)
plot(fs,Pdec1_28);
title('STATUS BEARING 1 MI RID GRUPPO 4 DEC 2017')
print -dpng -f44 bearing1MIridgruppo4dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc28dec-1)])
disp(['Peak BEARING 1 MI rid gruppo 4: ' num2str(Peakacc28dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 2 MI rid GRUPPO 4%%
Pdec2_29 = abs(fourier3_dec(:,2))/L;
Pdec1_29 = Pdec2_29(1:L/2+1);
Pdec1_29(2:end-1) = 2*Pdec1_29(2:end-1);
[Peakacc29dec Ind_Peakacc29dec]=max(Pdec1_29(5000:10000));
figure(45)
plot(fs,Pdec1_29);
title('STATUS BEARING 2 MI RID GRUPPO 4 DEC 2017')
print -dpng -f45 bearing2MIridgruppo4dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc29dec-1)])
disp(['Peak BEARING 2 MI rid gruppo 4: ' num2str(Peakacc29dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 1 MI mot2 GRUPPO 4%%
Pdec2_30 = abs(fourier3_dec(:,3))/L;
Pdec1_30 = Pdec2_30(1:L/2+1);
Pdec1_30(2:end-1) = 2*Pdec1_30(2:end-1);
[Peakacc30dec Ind_Peakacc30dec]=max(Pdec1_30(5000:10000));
figure(46)
plot(fs,Pdec1_30);
title('STATUS BEARING 1 MI MOT2 GRUPPO 4 DEC 2017')
print -dpng -f46 bearing1MImot2gruppo4dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc30dec-1)])
disp(['Peak BEARING 1 MI mot2 gruppo 4: ' num2str(Peakacc30dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 2 MI mot2 GRUPPO 4%%
Pdec2_31 = abs(fourier3_dec(:,4))/L;
Pdec1_31 = Pdec2_31(1:L/2+1);
Pdec1_31(2:end-1) = 2*Pdec1_31(2:end-1);
[Peakacc31dec Ind_Peakacc31dec]=max(Pdec1_31(5000:10000));
figure(47)
plot(fs,Pdec1_31);
title('STATUS BEARING 2 MI MOT 2 GRUPPO 4 DEC 2017')
print -dpng -f47 bearing2MImot2gruppo4dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc31dec-1)])
disp(['Peak BEARING 2 MI mot2 gruppo 4: ' num2str(Peakacc31dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 1 MI mot1 GRUPPO 4%%
Pdec2_32 = abs(fourier3_dec(:,5))/L;
Pdec1_32 = Pdec2_32(1:L/2+1);
Pdec1_32(2:end-1) = 2*Pdec1_32(2:end-1);
[Peakacc32dec Ind_Peakacc32dec]=max(Pdec1_32(5000:10000));
figure(48)
```

```
plot(fs,Pdec1_32);
title('STATUS BEARING 1 MI MOT 1 GRUPPO 4 DEC 2017')
print -dpng -f48 bearing1MImot1gruppo4dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc32dec-1)])
disp(['Peak BEARING 1 MI mot1 gruppo 4: ' num2str(Peakacc32dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 2 MI mot1 GRUPPO 4%%
Pdec2_33 = abs(fourier3_dec(:,6))/L;
Pdec1_33 = Pdec2_33(1:L/2+1);
Pdec1_33(2:end-1) = 2*Pdec1_33(2:end-1);
[Peakacc33dec Ind_Peakacc33dec]=max(Pdec1_33(5000:10000));
figure(49)
plot(fs,Pdec1_33);
title('STATUS BEARING 2 MI MOT 1 GRUPPO 4 DEC 2017')
print -dpng -f49 bearing2MImot1gruppo4dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc33dec-1)])
disp(['Peak BEARING 2 MI mot1 gruppo 4: ' num2str(Peakacc33dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 1 HF42 GRUPPO 4%%
Pdec2_34 = abs(fourier3_dec(:,7))/L;
Pdec1_34 = Pdec2_34(1:L/2+1);
Pdec1_34(2:end-1) = 2*Pdec1_34(2:end-1);
[Peakacc34dec Ind_Peakacc34dec]=max(Pdec1_34(5000:10000));
figure(50)
plot(fs,Pdec1_34);
title('STATUS BEARING 1 HF42 GRUPPO 4 DEC 2017')
print -dpng -f50 bearing1HF42gruppo4dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc34dec-1)])
disp(['Peak BEARING 1 HF42 gruppo 4: ' num2str(Peakacc34dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 2 HF42 GRUPPO 4%%
Pdec2_35 = abs(fourier3_dec(:,8))/L;
Pdec1_35 = Pdec2_35(1:L/2+1);
Pdec1_35(2:end-1) = 2*Pdec1_35(2:end-1);
[Peakacc35dec Ind_Peakacc35dec]=max(Pdec1_35(5000:10000));
figure(51)
plot(fs,Pdec1_35);
title('STATUS BEARING 2 HF42 GRUPPO 4 DEC 2017')
print -dpng -f51 bearing2HF42ridgruppo4dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc35dec-1)])
disp(['Peak BEARING 2 HF42 gruppo 4: ' num2str(Peakacc35dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 1 HF41 GRUPPO 4%%
Pdec2_36 = abs(fourier3_dec(:,9))/L;
Pdec1_36 = Pdec2_36(1:L/2+1);
Pdec1_36(2:end-1) = 2*Pdec1_36(2:end-1);
[Peakacc36dec Ind_Peakacc36dec]=max(Pdec1_36(5000:10000));
figure(52)
plot(fs,Pdec1_36);
title('STATUS BEARING 1 HF41 GRUPPO 4 DEC 2017')
print -dpng -f52 bearing1HF41gruppo4dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc36dec-1)])
disp(['Peak BEARING 1 HF41 gruppo 4: ' num2str(Peakacc36dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 2 HF41 GRUPPO 4%%
Pdec2_37 = abs(fourier3_dec(:,10))/L;
Pdec1_37 = Pdec2_37(1:L/2+1);
Pdec1_37(2:end-1) = 2*Pdec1_37(2:end-1);
[Peakacc37dec Ind_Peakacc37dec]=max(Pdec1_37(5000:10000));
figure(53)
plot(fs,Pdec1_37);
title('STATUS BEARING 2 HF41 GRUPPO 4 DEC 2017')
print -dpng -f53 bearing2HF41gruppo4dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc37dec-1)])
```

```
disp(['Peak BEARING 2 HF41 gruppo 4: ' num2str(Peakacc37dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING  HA40 rid GRUPPO 4%%
Pdec2_38 = abs(fourier3_dec(:,11))/L;
Pdec1_38 = Pdec2_38(1:L/2+1);
Pdec1_38(2:end-1) = 2*Pdec1_38(2:end-1);
[Peakacc38dec Ind_Peakacc38dec]=max(Pdec1_38(5000:10000));
figure(54)
plot(fs,Pdec1_38);
title('STATUS BEARING HA40 RID GRUPPO 4 DEC 2017')
print -dpng -f54 bearingHA40ridgruppo4dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc38dec-1)])
disp(['Peak BEARING HA40 rid gruppo 4: ' num2str(Peakacc38dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING HA40 mot GRUPPO 4%%
Pdec2_39 = abs(fourier3_dec(:,12))/L;
Pdec1_39 = Pdec2_39(1:L/2+1);
Pdec1_39(2:end-1) = 2*Pdec1_39(2:end-1);
[Peakacc39dec Ind_Peakacc39dec]=max(Pdec1_39(5000:10000));
figure(55)
plot(fs,Pdec1_39);
title('STATUS BEARING HA40 MOT GRUPPO 4 DEC 2017')
print -dpng -f55 bearingHA40motgruppo4dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc39dec-1)])
disp(['Peak BEARING HA40 mot gruppo 4: ' num2str(Peakacc39dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
controlmatrixdec_4=[Peakacc28dec Peakacc29dec Peakacc30dec Peakacc31dec
Peakacc32dec Peakacc33dec Peakacc34dec Peakacc35dec Peakacc36dec
Peakacc37dec Peakacc38dec Peakacc39dec];

for ii=1:length(controlmatrixdec_4)
    if controlmatrixdec_4(ii)>lim1
        disp("Alarm - Rough")
        if ii==1
            disp("Check bearing 1 MI rid gruppo 4")
        end
        if ii==2
            disp("Check bearing 2 MI rid gruppo 4")
        end
        if ii==3
            disp("Check bearing 1 MI mot2 gruppo 4")
        end
        if ii==4
            disp("Check bearing 2 MI mot2 gruppo 4")
        end
        if ii==5
            disp("Check bearing 1 MI mot1 gruppo 4")
        end
        if ii==6
            disp("Check bearing 2 MI mot1 gruppo 4")
        end
        if ii==7
            disp("Check bearing 1 HF42 gruppo 4")
        end
        if ii==8
            disp("Check bearing 2 HF42 gruppo 4")
        end
        if ii==9
            disp("Check bearing 1 HF41 gruppo 4")
        end
        if ii==10
            disp("Check bearing 2 HF41 gruppo 4")
        end
        if ii==11
```

```
            disp("Check bearing HA40 rid gruppo 4")
        end
        if ii==12
            disp("Check bearing HA40 mot gruppo 4")
        end

    else if controlmatrixdec_4(ii)>=lim2 && controlmatrixdec_4(ii)<=lim1
            disp("Alert - Slighty rough")
            if ii==1
            disp("Check bearing 1 MI rid gruppo 4")
        end
        if ii==2
            disp("Check bearing 2 MI rid gruppo 4")
        end
        if ii==3
            disp("Check bearing 1 MI mot2 gruppo 4")
        end
        if ii==4
            disp("Check bearing 2 MI mot2 gruppo 4")
        end
        if ii==5
            disp("Check bearing 1 MI mot1 gruppo 4")
        end
        if ii==6
            disp("Check bearing 2 MI mot1 gruppo 4")
        end
        if ii==7
            disp("Check bearing 1 HF42 gruppo 4")
        end
        if ii==8
            disp("Check bearing 2 HF42 gruppo 4")
        end
        if ii==9
            disp("Check bearing 1 HF41 gruppo 4")
        end
        if ii==10
            disp("Check bearing 2 HF41 gruppo 4")
        end
        if ii==11
            disp("Check bearing HA40 rid gruppo 4")
        end
        if ii==12
            disp("Check bearing HA40 mot gruppo 4")
        end

        else disp("Good")
        end
    end
end

%Acceleration GRUPPO 5 December
for ii=1:size(datiCuscMIridgruppo0dec)
acc40_dec(ii)=datiCuscMIridgruppo5dec(ii,2);
acc41_dec(ii)=datiCusc1MIridgruppo5dec(ii,2);
acc42_dec(ii)=datiCuscMImotoreBgruppo5dec(ii,2);
acc43_dec(ii)=datiCusc1MImotoreBgruppo5dec(ii,2);
acc44_dec(ii)=datiCuscMImotoreAgruppo5dec(ii,2);
acc45_dec(ii)=datiCusc1MImotoreAgruppo5dec(ii,2);
acc46_dec(ii)=datiCuscHF56gruppo5dec(ii,2);
acc47_dec(ii)=datiCusc1HF56gruppo5dec(ii,2);
acc48_dec(ii)=datiCuscHF55gruppo5dec(ii,2);
acc49_dec(ii)=datiCusc1HF55gruppo5dec(ii,2);
acc50_dec(ii)=datiCusc2HF55gruppo5dec(ii,2);
acc51_dec(ii)=datiCuscHF54gruppo5dec(ii,2);
```

```
acc52_dec(ii)=datiCusc1HF54gruppo5dec(ii,2);
acc53_dec(ii)=datiCusc2HF54gruppo5dec(ii,2);
acc54_dec(ii)=datiCuscHF53gruppo5dec(ii,2);
acc55_dec(ii)=datiCusc1HF53gruppo5dec(ii,2);
acc56_dec(ii)=datiCusc2HF53gruppo5dec(ii,2);
acc57_dec(ii)=datiCuscHA51ridgruppo5dec(ii,2);
acc58_dec(ii)=datiCuscHA51motgruppo5dec(ii,2);
acc59_dec(ii)=datiCusc1HA51motgruppo5dec(ii,2);
end

acceleration5_dec=[acc40_dec acc41_dec acc42_dec acc43_dec acc44_dec
acc45_dec acc46_dec acc47_dec acc48_dec acc49_dec acc50_dec acc51_dec
acc52_dec acc53_dec acc54_dec acc55_dec acc56_dec acc57_dec acc58_dec
acc59_dec];

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 1 MI rid GRUPPO 5%%
fourier4_dec=real(fft(acceleration5_dec,L));
Pdec2_40 = abs(fourier4_dec(:,1))/L;
Pdec1_40 = Pdec2_40(1:L/2+1);
Pdec1_40(2:end-1) = 2*Pdec1_40(2:end-1);
[Peakacc40dec Ind_Peakacc40dec]=max(Pdec1_40(5000:10000));
figure(56)
plot(fs,Pdec1_40);
title('STATUS BEARING 1 MI RID GRUPPO 5 DEC 2017')
print -dpng -f56 bearing1MIridgruppo5dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc40dec-1)])
disp(['Peak BEARING 1 MI rid gruppo 5: ' num2str(Peakacc40dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 2 MI rid GRUPPO 5%%
Pdec2_41 = abs(fourier4_dec(:,2))/L;
Pdec1_41 = Pdec2_41(1:L/2+1);
Pdec1_41(2:end-1) = 2*Pdec1_41(2:end-1);
[Peakacc41dec Ind_Peakacc41dec]=max(Pdec1_41(5000:10000));
figure(57)
plot(fs,Pdec1_41);
title('STATUS BEARING 2 MI RID GRUPPO 5 DEC 2017')
print -dpng -f57 bearing2MIridgruppo5dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc41dec-1)])
disp(['Peak BEARING 2 MI rid gruppo 5: ' num2str(Peakacc41dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 1 MI mot B GRUPPO 5%%
Pdec2_42 = abs(fourier4_dec(:,3))/L;
Pdec1_42 = Pdec2_42(1:L/2+1);
Pdec1_42(2:end-1) = 2*Pdec1_42(2:end-1);
[Peakacc42dec Ind_Peakacc42dec]=max(Pdec1_42(5000:10000));
figure(58)
plot(fs,Pdec1_42);
title('STATUS BEARING 1 MI MOT B GRUPPO 5 DEC 2017')
print -dpng -f58 bearing1MImotBgruppo5dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc42dec-1)])
disp(['Peak BEARING 1 MI mot B gruppo 5: ' num2str(Peakacc42dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 2 MI mot B GRUPPO 5%%
Pdec2_43 = abs(fourier4_dec(:,4))/L;
Pdec1_43 = Pdec2_43(1:L/2+1);
Pdec1_43(2:end-1) = 2*Pdec1_43(2:end-1);
[Peakacc43dec Ind_Peakacc43dec]=max(Pdec1_43(5000:10000));
figure(59)
plot(fs,Pdec1_43);
title('STATUS BEARING 2 MI MOT B GRUPPO 5 DEC 2017')
print -dpng -f59 bearing2MImotBgruppo5dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc43dec-1)])
disp(['Peak BEARING 2 MI mot B gruppo 5: ' num2str(Peakacc43dec)])
```

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 1 MI mot A GRUPPO 5%%
Pdec2_44 = abs(fourier4_dec(:,5))/L;
Pdec1_44 = Pdec2_44(1:L/2+1);
Pdec1_44(2:end-1) = 2*Pdec1_44(2:end-1);
[Peakacc44dec Ind_Peakacc44dec]=max(Pdec1_44(5000:10000));
figure(60)
plot(fs,Pdec1_44);
title('STATUS BEARING 1 MI MOT A GRUPPO 5 DEC 2017')
print -dpng -f60 bearing1MImotAgruppo5dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc44dec-1)])
disp(['Peak BEARING 1 MI mot A  gruppo 5: ' num2str(Peakacc44dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 2 MI mot A GRUPPO 5%%
Pdec2_45 = abs(fourier4_dec(:,6))/L;
Pdec1_45 = Pdec2_45(1:L/2+1);
Pdec1_45(2:end-1) = 2*Pdec1_45(2:end-1);
[Peakacc45dec Ind_Peakacc45dec]=max(Pdec1_45(5000:10000));
figure(61)
plot(fs,Pdec1_45);
title('STATUS BEARING 2 MI MOT A GRUPPO 5 DEC 2017')
print -dpng -f61 bearing2MImotAgruppo5dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc45dec-1)])
disp(['Peak BEARING 2 MI mot A gruppo 5: ' num2str(Peakacc45dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 1 HF56 GRUPPO 5%%
Pdec2_46 = abs(fourier4_dec(:,7))/L;
Pdec1_46 = Pdec2_46(1:L/2+1);
Pdec1_46(2:end-1) = 2*Pdec1_46(2:end-1);
[Peakacc46dec Ind_Peakacc46dec]=max(Pdec1_46(5000:10000));
figure(62)
plot(fs,Pdec1_46);
title('STATUS BEARING 1 HF56 GRUPPO 5 DEC 2017')
print -dpng -f62 bearing1HF56gruppo5dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc46dec-1)])
disp(['Peak BEARING 1 HF56 gruppo 5: ' num2str(Peakacc46dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 2 HF56 GRUPPO 5%%
Pdec2_47 = abs(fourier4_dec(:,8))/L;
Pdec1_47 = Pdec2_47(1:L/2+1);
Pdec1_47(2:end-1) = 2*Pdec1_47(2:end-1);
[Peakacc47dec Ind_Peakacc47dec]=max(Pdec1_47(5000:10000));
figure(63)
plot(fs,Pdec1_47);
title('STATUS BEARING 2 HF56 GRUPPO 5 DEC 2017')
print -dpng -f63 bearing2HF56gruppo5dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc47dec-1)])
disp(['Peak BEARING 2 HF56 gruppo 5: ' num2str(Peakacc47dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 1 HF55 GRUPPO 5%%
Pdec2_48 = abs(fourier4_dec(:,9))/L;
Pdec1_48 = Pdec2_48(1:L/2+1);
Pdec1_48(2:end-1) = 2*Pdec1_48(2:end-1);
[Peakacc48dec Ind_Peakacc48dec]=max(Pdec1_48(5000:10000));
figure(64)
plot(fs,Pdec1_48);
title('STATUS BEARING 1 HF55 GRUPPO 5 DEC 2017')
print -dpng -f64 bearing1HF55gruppo5dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc48dec-1)])
disp(['Peak BEARING 1 HF55 gruppo 5: ' num2str(Peakacc48dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 2 HF55 GRUPPO 5%%
Pdec2_49 = abs(fourier4_dec(:,10))/L;
Pdec1_49 = Pdec2_49(1:L/2+1);
```

```
Pdec1_49(2:end-1) = 2*Pdec1_49(2:end-1);
[Peakacc49dec Ind_Peakacc49dec]=max(Pdec1_49(5000:10000));
figure(65)
plot(fs,Pdec1_49);
title('STATUS BEARING 2 HF55 GRUPPO 5 DEC 2017')
print -dpng -f65 bearing2HF55gruppo5dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc49dec-1)])
disp(['Peak BEARING 2 HF55 gruppo 5: ' num2str(Peakacc49dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 3 HF55 GRUPPO 5%%
Pdec2_50 = abs(fourier4_dec(:,11))/L;
Pdec1_50 = Pdec2_50(1:L/2+1);
Pdec1_50(2:end-1) = 2*Pdec1_50(2:end-1);
[Peakacc50dec Ind_Peakacc50dec]=max(Pdec1_50(5000:10000));
figure(66)
plot(fs,Pdec1_50);
title('STATUS BEARING 3 HF56 GRUPPO 5 DEC 2017')
print -dpng -f66 bearing3HF56gruppo5dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc50dec-1)])
disp(['Peak BEARING 3 HF56 gruppo 5: ' num2str(Peakacc50dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 1 HF54 GRUPPO 5%%
Pdec2_51 = abs(fourier4_dec(:,12))/L;
Pdec1_51 = Pdec2_51(1:L/2+1);
Pdec1_51(2:end-1) = 2*Pdec1_51(2:end-1);
[Peakacc51dec Ind_Peakacc51dec]=max(Pdec1_51(5000:10000));
figure(67)
plot(fs,Pdec1_51);
title('STATUS BEARING 1 HF54 GRUPPO 5 DEC 2017')
print -dpng -f67 bearing1HF54gruppo5dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc51dec-1)])
disp(['Peak BEARING 1 HF54 gruppo 5: ' num2str(Peakacc51dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 2 HF54 GRUPPO 5%%
Pdec2_52 = abs(fourier4_dec(:,13))/L;
Pdec1_52 = Pdec2_52(1:L/2+1);
Pdec1_52(2:end-1) = 2*Pdec1_52(2:end-1);
[Peakacc52dec Ind_Peakacc52dec]=max(Pdec1_52(5000:10000));
figure(68)
plot(fs,Pdec1_52);
title('STATUS BEARING 2 HF54 GRUPPO 5 DEC 2017')
print -dpng -f68 bearing2HF54gruppo5dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc52dec-1)])
disp(['Peak BEARING 2 HF54 gruppo 5: ' num2str(Peakacc52dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 3 HF54 GRUPPO 5%%
Pdec2_53 = abs(fourier4_dec(:,14))/L;
Pdec1_53 = Pdec2_53(1:L/2+1);
Pdec1_53(2:end-1) = 2*Pdec1_53(2:end-1);
[Peakacc53dec Ind_Peakacc53dec]=max(Pdec1_53(5000:10000));
figure(69)
plot(fs,Pdec1_53);
title('STATUS BEARING 3 HF54 GRUPPO 5 DEC 2017')
print -dpng -f69 bearing3HF54gruppo5dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc53dec-1)])
disp(['Peak BEARING 3 HF54 gruppo 5: ' num2str(Peakacc53dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 1 HF53 GRUPPO 5%%
Pdec2_54 = abs(fourier4_dec(:,15))/L;
Pdec1_54 = Pdec2_54(1:L/2+1);
Pdec1_54(2:end-1) = 2*Pdec1_54(2:end-1);
[Peakacc54dec Ind_Peakacc54dec]=max(Pdec1_54(5000:10000));
figure(70)
plot(fs,Pdec1_54);
```

```
title('STATUS BEARING 1 HF53 GRUPPO 5 DEC 2017')
print -dpng -f70 bearing1HF53gruppo5dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc54dec-1)])
disp(['Peak BEARING 1 HF53 gruppo 5: ' num2str(Peakacc54dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 2 HF53 GRUPPO 5%%
Pdec2_55 = abs(fourier4_dec(:,16))/L;
Pdec1_55 = Pdec2_55(1:L/2+1);
Pdec1_55(2:end-1) = 2*Pdec1_55(2:end-1);
[Peakacc55dec Ind_Peakacc55dec]=max(Pdec1_55(5000:10000));
figure(71)
plot(fs,Pdec1_55);
title('STATUS BEARING 2 HF53 GRUPPO 5 DEC 2017')
print -dpng -f71 bearing2HF53gruppo5dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc55dec-1)])
disp(['Peak BEARING 2 HF53 gruppo 5: ' num2str(Peakacc55dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 3 HF53 GRUPPO 5%%
Pdec2_56 = abs(fourier4_dec(:,17))/L;
Pdec1_56 = Pdec2_56(1:L/2+1);
Pdec1_56(2:end-1) = 2*Pdec1_56(2:end-1);
[Peakacc56dec Ind_Peakacc56dec]=max(Pdec1_56(5000:10000));
figure(72)
plot(fs,Pdec1_56);
title('STATUS BEARING 3 HF53 GRUPPO 5 DEC 2017')
print -dpng -f72 bearing3HF53gruppo5dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc56dec-1)])
disp(['Peak BEARING 3 HF53 gruppo 5: ' num2str(Peakacc56dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING HA51 rid GRUPPO 5%%
Pdec2_57 = abs(fourier4_dec(:,18))/L;
Pdec1_57 = Pdec2_57(1:L/2+1);
Pdec1_57(2:end-1) = 2*Pdec1_57(2:end-1);
[Peakacc57dec Ind_Peakacc57dec]=max(Pdec1_57(5000:10000));
figure(73)
plot(fs,Pdec1_57);
title('STATUS BEAERING HA51 RID GRUPPO 5 DEC 2017')
print -dpng -f73 bearingHA51ridgruppo5dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc57dec-1)])
disp(['Peak BEARING HA51 rid gruppo 5: ' num2str(Peakacc57dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 1  HA51 mot GRUPPO 5%%
Pdec2_58 = abs(fourier4_dec(:,19))/L;
Pdec1_58 = Pdec2_58(1:L/2+1);
Pdec1_58(2:end-1) = 2*Pdec1_58(2:end-1);
[Peakacc58dec Ind_Peakacc58dec]=max(Pdec1_58(5000:10000));
figure(74)
plot(fs,Pdec1_58);
title('STATUS BEARING 1 HA51 MOT GRUPPO 5 DEC 2017')
print -dpng -f74 bearing1HA51motgruppo5dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc58dec-1)])
disp(['Peak BEARING 1 HA51 mot gruppo 5: ' num2str(Peakacc58dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 2  HA51 mot GRUPPO 5%%
Pdec2_59 = abs(fourier4_dec(:,20))/L;
Pdec1_59 = Pdec2_59(1:L/2+1);
Pdec1_59(2:end-1) = 2*Pdec1_59(2:end-1);
[Peakacc59dec Ind_Peakacc59dec]=max(Pdec1_59(5000:10000));
figure(75)
plot(fs,Pdec1_59);
title('STATUS BEARING 2 HA51 MOT GRUPPO 5 DEC 2017')
print -dpng -f75 bearing2HA51motgruppo5dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc59dec-1)])
disp(['Peak BEARING 2 HA51 mot gruppo 5: ' num2str(Peakacc59dec)])
```

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
controlmatrixdec_5=[Peakacc40dec Peakacc41dec Peakacc42dec Peakacc43dec
Peakacc44dec Peakacc45dec Peakacc46dec Peakacc47dec Peakacc48dec
Peakacc49dec Peakacc50dec Peakacc51dec Peakacc52dec Peakacc53dec
Peakacc54dec Peakacc55dec Peakacc56dec Peakacc57dec Peakacc58dec
Peakacc59dec];

for ii=1:length(controlmatrixdec_5)
    if controlmatrixdec_5(ii)>lim1
        disp("Alarm - Rough")
        if ii==1
            disp("Check bearing 1 MI rid gruppo 5")
        end
        if ii==2
            disp("Check bearing 2 MI rid gruppo 5")
        end
        if ii==3
            disp("Check bearing 1 MI mot B gruppo 5")
        end
        if ii==4
            disp("Check bearing 2 MI mot B gruppo 5")
        end
        if ii==5
            disp("Check bearing 1 MI mot A gruppo 5")
        end
        if ii==6
            disp("Check bearing 2 MI mot A gruppo 5")
        end
        if ii==7
            disp("Check bearing 1 HF56 gruppo 5")
        end
        if ii==8
            disp("Check bearing 2 HF56 gruppo 5")
        end
        if ii==9
            disp("Check bearing 1 HF55 gruppo 5")
        end
        if ii==10
            disp("Check bearing 2 HF55 gruppo 5")
        end
        if ii==11
            disp("Check bearing 3 HF56 gruppo 5")
        end
        if ii==12
            disp("Check bearing 1 HF54 gruppo 5")
        end
        if ii==13
            disp("Check bearing 2 HF54 gruppo 5")
        end
        if ii==14
            disp("Check bearing 3 HF54 gruppo 5")
        end
        if ii==15
            disp("Check bearing 1 HF53 gruppo 5")
        end
        if ii==16
            disp("Check bearing 2 HF53 gruppo 5")
        end
        if ii==17
            disp("Check bearing 3 HF53 gruppo 5")
        end
        if ii==18
            disp("Check bearing HA51 rid gruppo 5")
        end
```

```
    if ii==19
        disp("Check bearing HA51 mot gruppo 5")
    end
    if ii==20
        disp("Check bearing 2 HA51 mot gruppo 5")
    end

else if controlmatrixdec_5(ii)>=lim2 && controlmatrixdec_5(ii)<=lim1
        disp("Alert - Slighty rough")
       if ii==1
        disp("Check bearing 1 MI rid gruppo 5")
    end
    if ii==2
        disp("Check bearing 2 MI rid gruppo 5")
    end
    if ii==3
        disp("Check bearing 1 MI mot B gruppo 5")
    end
    if ii==4
        disp("Check bearing 2 MI mot B gruppo 5")
    end
    if ii==5
        disp("Check bearing 1 MI mot A gruppo 5")
    end
    if ii==6
        disp("Check bearing 2 MI mot A gruppo 5")
    end
    if ii==7
        disp("Check bearing 1 HF56 gruppo 5")
    end
    if ii==8
        disp("Check bearing 2 HF56 gruppo 5")
    end
    if ii==9
        disp("Check bearing 1 HF55 gruppo 5")
    end
    if ii==10
        disp("Check bearing 2 HF55 gruppo 5")
    end
    if ii==11
        disp("Check bearing 3 HF56 gruppo 5")
    end
    if ii==12
        disp("Check bearing 1 HF54 gruppo 5")
    end
    if ii==13
        disp("Check bearing 2 HF54 gruppo 5")
    end
    if ii==14
        disp("Check bearing 3 HF54 gruppo 5")
    end
    if ii==15
        disp("Check bearing 1 HF53 gruppo 5")
    end
    if ii==16
        disp("Check bearing 2 HF53 gruppo 5")
    end
    if ii==17
        disp("Check bearing 3 HF53 gruppo 5")
    end
    if ii==18
        disp("Check bearing HA51 rid gruppo 5")
    end
    if ii==19
```

```
            disp("Check bearing HA51 mot gruppo 5")
        end
        if ii==20
            disp("Check bearing 2 HA51 mot gruppo 5")
        end

        else disp("Good")
        end
    end
end



%Acceleration GRUPPO6 DECEMBER
for ii=1:size(datiCuscMIridgruppo0dec)
acc60_dec(ii)=datiCuscMIridgruppo6dec(ii,2);
acc61_dec(ii)=datiCusc1MIridgruppo6dec(ii,2);
acc62_dec(ii)=datiCuscMImotore2gruppo6dec(ii,2);
acc63_dec(ii)=datiCusc1MImotore2gruppo6dec(ii,2);
acc64_dec(ii)=datiCuscMImotore1gruppo6dec(ii,2);
acc65_dec(ii)=datiCusc1MImotore1gruppo6dec(ii,2);
acc66_dec(ii)=datiCuscHF64gruppo6dec(ii,2);
acc67_dec(ii)=datiCuscHF63gruppo6dec(ii,2);
acc68_dec(ii)=datiCusc1HF63gruppo6dec(ii,2);
acc69_dec(ii)=datiCuscHF62gruppo6dec(ii,2);
acc70_dec(ii)=datiCuscHF61gruppo6dec(ii,2);
acc71_dec(ii)=datiCusc1HF61gruppo6dec(ii,2);
acc72_dec(ii)=datiCuscHA62gruppo6dec(ii,2);
acc73_dec(ii)=datiCusc1HA62gruppo6dec(ii,2);
acc74_dec(ii)=datiCuscHA61gruppo6dec(ii,2);
acc75_dec(ii)=datiCusc1HA61gruppo6dec(ii,2);
end

acceleration6_dec=[acc60_dec acc61_dec acc62_dec acc63_dec acc64_dec
acc65_dec acc66_dec acc67_dec acc68_dec acc69_dec acc70_dec acc71_dec
acc72_dec acc73_dec acc74_dec acc75_dec];


%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 1 MI rid GRUPPO 6 %%
fourier5_dec=real(fft(acceleration6_dec,L));
Pdec2_60 = abs(fourier5_dec(:,1))/L;
Pdec1_60 = Pdec2_60(1:L/2+1);
Pdec1_60(2:end-1) = 2*Pdec1_60(2:end-1);
[Peakacc60dec Ind_Peakacc60dec]=max(Pdec1_60(5000:10000));
figure(76)
plot(fs,Pdec1_60);
title('STATUS BEARING 1 MI RID GRUPPO 6 DEC 2017')
print -dpng -f76 bearing1MIridgruppo6dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc60dec-1)])
disp(['Peak BEARING 1 MI rid gruppo 6: ' num2str(Peakacc60dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%% %%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 2 MI rid GRUPPO 6 %%
Pdec2_61 = abs(fourier5_dec(:,2))/L;
Pdec1_61 = Pdec2_61(1:L/2+1);
Pdec1_61(2:end-1) = 2*Pdec1_61(2:end-1);
[Peakacc61dec Ind_Peakacc61dec]=max(Pdec1_61(5000:10000));
figure(77)
plot(fs,Pdec1_61);
title('STATUS BEARING 2 MI RID GRUPPO 6 DEC 2017')
print -dpng -f77 bearing2MIridgruppo6dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc61dec-1)])
disp(['Peak BEARING 2 MI rid gruppo 6: ' num2str(Peakacc61dec)])
```

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%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 1 MI mot 2 GRUPPO 6 %%
Pdec2_62 = abs(fourier5_dec(:,3))/L;
Pdec1_62 = Pdec2_62(1:L/2+1);
Pdec1_62(2:end-1) = 2*Pdec1_62(2:end-1);
[Peakacc62dec Ind_Peakacc62dec]=max(Pdec1_62(5000:10000));
figure(78)
plot(fs,Pdec1_62);
title('STATUS BEARING 1 MI MOT 2 GRUPPO 6 DEC 2017')
print -dpng -f78 bearing1MImot2gruppo6dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc62dec-1)])
disp(['Peak BEARING 1 MI mot 2 gruppo 6: ' num2str(Peakacc62dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 2 MI mot 2 GRUPPO 6 %%
Pdec2_63 = abs(fourier5_dec(:,4))/L;
Pdec1_63 = Pdec2_63(1:L/2+1);
Pdec1_63(2:end-1) = 2*Pdec1_63(2:end-1);
[Peakacc63dec Ind_Peakacc63dec]=max(Pdec1_63(5000:10000));
figure(79)
plot(fs,Pdec1_63);
title('STATUS BEARING 2 MI MOT 2 GRUPPO 6 DEC 2017')
print -dpng -f79 bearing2MImot2gruppo6dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc63dec-1)])
disp(['Peak BEARING 2 MI mot 2 gruppo 6: ' num2str(Peakacc63dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 1 MI mot 1 GRUPPO 6 %%
Pdec2_64 = abs(fourier5_dec(:,5))/L;
Pdec1_64 = Pdec2_64(1:L/2+1);
Pdec1_64(2:end-1) = 2*Pdec1_64(2:end-1);
[Peakacc64dec Ind_Peakacc64dec]=max(Pdec1_64(5000:10000));
figure(80)
plot(fs,Pdec1_64);
title('STATUS BEARING 1 MI MOT 1 GRUPPO 6 DEC 2017')
print -dpng -f80 bearing1MImot1gruppo6dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc64dec-1)])
disp(['Peak BEARING 1 MI mot 1 gruppo 6: ' num2str(Peakacc64dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 2 MI mot 1 GRUPPO 6 %%
Pdec2_65 = abs(fourier5_dec(:,6))/L;
Pdec1_65 = Pdec2_65(1:L/2+1);
Pdec1_65(2:end-1) = 2*Pdec1_65(2:end-1);
[Peakacc65dec Ind_Peakacc65dec]=max(Pdec1_65(5000:10000));
figure(81)
plot(fs,Pdec1_65);
title('STATUS BEARING 2 MI MOT 1 GRUPPO 6 DEC 2017')
print -dpng -f81 bearing2MImot1gruppo6dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc65dec-1)])
disp(['Peak BEARING 2 MI mot 1 gruppo 6: ' num2str(Peakacc65dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 1 HF64 GRUPPO 6 %%
Pdec2_66 = abs(fourier5_dec(:,7))/L;
Pdec1_66 = Pdec2_66(1:L/2+1);
Pdec1_66(2:end-1) = 2*Pdec1_66(2:end-1);
[Peakacc66dec Ind_Peakacc66dec]=max(Pdec1_66(5000:10000));
figure(82)
plot(fs,Pdec1_66);
title('STATUS BEARING 1 HF64 GRUPPO 6 DEC 2017')
print -dpng -f82 bearing1HF64gruppo6dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc66dec-1)])
disp(['Peak BEARING 1 HF64 gruppo 6: ' num2str(Peakacc66dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 1 HF63 GRUPPO 6 %%
Pdec2_67 = abs(fourier5_dec(:,8))/L;
Pdec1_67 = Pdec2_67(1:L/2+1);
```

```
Pdec1_67(2:end-1) = 2*Pdec1_67(2:end-1);
[Peakacc67dec Ind_Peakacc67dec]=max(Pdec1_67(5000:10000));
figure(83)
plot(fs,Pdec1_67);
title('STATUS BEARING 1 HF63 GRUPPO 6 DEC 2017')
print -dpng -f83 bearing1HF63gruppo6dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc67dec-1)])
disp(['Peak BEARING 1 HF63 gruppo 6: ' num2str(Peakacc67dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 2 HF63 GRUPPO 6 %%
Pdec2_68 = abs(fourier5_dec(:,9))/L;
Pdec1_68 = Pdec2_68(1:L/2+1);
Pdec1_68(2:end-1) = 2*Pdec1_68(2:end-1);
[Peakacc68dec Ind_Peakacc68dec]=max(Pdec1_68(5000:10000));
figure(84)
plot(fs,Pdec1_68);
title('STATUS BEARING 2 HF63 GRUPPO 6 DEC 2017')
print -dpng -f84 bearing2HF63gruppo6dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc68dec-1)])
disp(['Peak BEARING 2 HF63 gruppo 6: ' num2str(Peakacc68dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 1 HF62 GRUPPO 6 %%
Pdec2_69 = abs(fourier5_dec(:,10))/L;
Pdec1_69 = Pdec2_69(1:L/2+1);
Pdec1_69(2:end-1) = 2*Pdec1_69(2:end-1);
[Peakacc69dec Ind_Peakacc69dec]=max(Pdec1_69(5000:10000));
figure(85)
plot(fs,Pdec1_69);
title('STATUS BEARING 1 HF62 GRUPPO 6 DEC 2017')
print -dpng -f85 bearing1HF62gruppo6dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc69dec-1)])
disp(['Peak BEARING 1 HF62 gruppo 6: ' num2str(Peakacc69dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 1 HF61 GRUPPO 6 %%
Pdec2_70 = abs(fourier5_dec(:,11))/L;
Pdec1_70 = Pdec2_70(1:L/2+1);
Pdec1_70(2:end-1) = 2*Pdec1_70(2:end-1);
[Peakacc70dec Ind_Peakacc70dec]=max(Pdec1_70(5000:10000));
figure(86)
plot(fs,Pdec1_70);
title('STATUS BEARING 1 HF61 GRUPPO 6 DEC 2017')
print -dpng -f86 bearing1HF61gruppo6dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc70dec-1)])
disp(['Peak BEARING 1 HF61 gruppo 6: ' num2str(Peakacc70dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 2 HF61 GRUPPO 6 %%
Pdec2_71 = abs(fourier5_dec(:,12))/L;
Pdec1_71 = Pdec2_71(1:L/2+1);
Pdec1_71(2:end-1) = 2*Pdec1_71(2:end-1);
[Peakacc71dec Ind_Peakacc71dec]=max(Pdec1_71(5000:10000));
figure(87)
plot(fs,Pdec1_71);
title('STATUS BEARING 2 HF61 GRUPPO 6 DEC 2017')
print -dpng -f87 bearing2HF61gruppo6dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc71dec-1)])
disp(['Peak BEARING 2 HF61 gruppo 6: ' num2str(Peakacc71dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 1 HA62 GRUPPO 6 %%
Pdec2_72 = abs(fourier5_dec(:,13))/L;
Pdec1_72 = Pdec2_72(1:L/2+1);
Pdec1_72(2:end-1) = 2*Pdec1_72(2:end-1);
[Peakacc72dec Ind_Peakacc72dec]=max(Pdec1_72(5000:10000));
figure(88)
plot(fs,Pdec1_72);
```

```
title('STATUS BEARING 1 HA62 GRUPPO 6 DEC 2017')
print -dpng -f88 bearing1HA62gruppo6dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc72dec-1)])
disp(['Peak BEARING 1 HA62 gruppo 6: ' num2str(Peakacc72dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 2 HA62 GRUPPO 6 %%
Pdec2_73 = abs(fourier5_dec(:,14))/L;
Pdec1_73 = Pdec2_73(1:L/2+1);
Pdec1_73(2:end-1) = 2*Pdec1_73(2:end-1);
[Peakacc73dec Ind_Peakacc73dec]=max(Pdec1_73(5000:10000));
figure(89)
plot(fs,Pdec1_73);
title('STATUS BEARING 2 HA62 GRUPPO 6 DEC 2017')
print -dpng -f89 bearing2HA62gruppo6dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc73dec-1)])
disp(['Peak BEARING 2 HA62 gruppo 6: ' num2str(Peakacc73dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 1 HA61 GRUPPO 6 %%
Pdec2_74 = abs(fourier5_dec(:,15))/L;
Pdec1_74 = Pdec2_74(1:L/2+1);
Pdec1_74(2:end-1) = 2*Pdec1_74(2:end-1);
[Peakacc74dec Ind_Peakacc74dec]=max(Pdec1_74(5000:10000));
figure(90)
plot(fs,Pdec1_74);
title('STATUS BEARING 1 HA61 GRUPPO 6 DEC 2017')
print -dpng -f90 bearing1HA61gruppo6dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc74dec-1)])
disp(['Peak BEARING 1 HA61 gruppo 6: ' num2str(Peakacc74dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 2 HA61 GRUPPO 6 %%
Pdec2_75 = abs(fourier5_dec(:,16))/L;
Pdec1_75 = Pdec2_75(1:L/2+1);
Pdec1_75(2:end-1) = 2*Pdec1_75(2:end-1);
[Peakacc75dec Ind_Peakacc75dec]=max(Pdec1_75(5000:10000));
figure(91)
plot(fs,Pdec1_75);
title('STATUS BEARING 2 HA61 GRUPPO 6 DEC 2017')
print -dpng -f91 bearing2HA61gruppo6dec2017.png
disp(['Peak frequency : '  num2str(Ind_Peakacc75dec-1)])
disp(['Peak BEARING 2 HA61 gruppo 6: ' num2str(Peakacc75dec)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
controlmatrixdec_6=[Peakacc60dec Peakacc61dec Peakacc62dec Peakacc63dec
Peakacc64dec Peakacc65dec Peakacc66dec Peakacc67dec Peakacc68dec
Peakacc69dec Peakacc70dec Peakacc71dec Peakacc72dec Peakacc73dec
Peakacc74dec Peakacc75dec];

for ii=1:length(controlmatrixdec_6)
    if controlmatrixdec_6(ii)>lim1
        disp("Alarm - Rough")
        if ii==1
            disp("Check bearing 1 MI rid gruppo 6")
        end
        if ii==2
            disp("Check bearing 2 MI rid gruppo 6")
        end
        if ii==3
            disp("Check bearing 1 MI mot 2 gruppo 6")
        end
        if ii==4
            disp("Check bearing 2 MI mot 2 gruppo 6")
        end
        if ii==5
            disp("Check bearing 1 MI mot 1 gruppo 6")
        end
```

```
    if ii==6
        disp("Check bearing 2 MI mot 1 gruppo 6")
    end
    if ii==7
        disp("Check bearing 1 HF64 gruppo 6")
    end
    if ii==8
        disp("Check bearing 1 HF63 gruppo 6")
    end
    if ii==9
        disp("Check bearing 2 HF63 gruppo 6")
    end
    if ii==10
        disp("Check bearing 1 HF62 gruppo 6")
    end
    if ii==11
        disp("Check bearing 1 HF61 gruppo 6")
    end
    if ii==12
        disp("Check bearing 2 HF61 gruppo 6")
    end
    if ii==13
        disp("Check bearing 1 HA62 gruppo 6")
    end
    if ii==14
        disp("Check bearing 2 HA62 gruppo 6")
    end
    if ii==15
        disp("Check bearing 1 HA61 gruppo 6")
    end
    if ii==16
        disp("Check bearing 2 HA61 gruppo 6")
    end

else if controlmatrixdec_5(ii)>=lim2 && controlmatrixdec_5(ii)<=lim1
        disp("Alert - Slighty rough")
    if ii==1
        disp("Check bearing 1 MI rid gruppo 6")
    end
    if ii==2
        disp("Check bearing 2 MI rid gruppo 6")
    end
    if ii==3
        disp("Check bearing 1 MI mot 2 gruppo 6")
    end
    if ii==4
        disp("Check bearing 2 MI mot 2 gruppo 6")
    end
    if ii==5
        disp("Check bearing 1 MI mot 1 gruppo 6")
    end
    if ii==6
        disp("Check bearing 2 MI mot 1 gruppo 6")
    end
    if ii==7
        disp("Check bearing 1 HF64 gruppo 6")
    end
    if ii==8
        disp("Check bearing 1 HF63 gruppo 6")
    end
    if ii==9
        disp("Check bearing 2 HF63 gruppo 6")
    end
    if ii==10
```

```
            disp("Check bearing 1 HF62 gruppo 6")
        end
        if ii==11
            disp("Check bearing 1 HF61 gruppo 6")
        end
        if ii==12
            disp("Check bearing 2 HF61 gruppo 6")
        end
        if ii==13
            disp("Check bearing 1 HA62 gruppo 6")
        end
        if ii==14
            disp("Check bearing 2 HA62 gruppo 6")
        end
        if ii==15
            disp("Check bearing 1 HA61 gruppo 6")
        end
        if ii==16
            disp("Check bearing 2 HA61 gruppo 6")
        end


        else disp("Good")
        end
    end
end


%% Vibration Monitoring Novembre 2016

%GRUPPO0 MI motore B
datiCuscMImotoreBgruppo0nov=load('Nov_2016_CuscMImotoreBgruppo0.txt');

%GRUPPO1 MI RID
datiCuscMIridgruppo1nov=load('Nov_2016_CuscMIridgruppo1.txt');

%GRUPPO1 HA13
datiCuscHA13ridgruppo1nov=load('Nov_2016_CuscHA13ridgruppo1.txt');

%GRUPPO1 HF25
datiCusc1HF25gruppo1nov=load('Nov_2016_Cusc1HF25gruppo1.txt');

%GRUPPO2 HF26
datiCusc2HF26gruppo2nov=load('Nov_2016_Cusc2HF26gruppo2.txt');

%GRUPPO2 HA23
datiCusc1HA23ridgruppo2nov=load('Nov_2016_Cusc1HA23ridgruppo2.txt');

%GRUPPO5 MI motore A
datiCusc1MImotoreAgruppo5nov=load('Nov_2016_Cusc1MImotoreAgruppo5.txt');

%GRUPPO6 HF61
datiCuscHF61gruppo6nov=load('Nov_2016_CuscHF61gruppo6.txt');
datiCusc2HF61gruppo6nov=load('Nov_2016_Cusc2HF61gruppo6.txt');

%GRUPPO6 HA62
datiCusc1HA62ridgruppo6nov=load('Nov_2016_CuscHA62ridgruppo6.txt');

%GRUPPO6 HA61
datiCuscHA61ridgruppo6nov=load('Nov_2016_CuscHA61ridgruppo6.txt');
```

```
%GRUPPO6 HF62
datiCusc2HF62gruppo6nov=load('Nov_2016_Cusc2HF62gruppo6.txt');
datiCusc1HF62gruppo6nov=load('Nov_2016_Cusc1HF62gruppo6.txt');



%creazione vettore accelerazione misure novembre

acc1_nov=zeros(size(datiCuscMImotoreBgruppo0nov(:,1)));
acc2_nov=zeros(size(datiCuscMIridgruppo1nov(:,1)));
acc3_nov=zeros(size(datiCuscHA13ridgruppo1nov(:,1)));
acc4_nov=zeros(size(datiCusc1HF25gruppo1nov(:,1)));
acc5_nov=zeros(size(datiCusc2HF26gruppo2nov(:,1)));
acc6_nov=zeros(size(datiCusc1HA23ridgruppo2nov(:,1)));
acc7_nov=zeros(size(datiCusc1MImotoreAgruppo5nov(:,1)));
acc8_nov=zeros(size(datiCuscHF61gruppo6nov(:,1)));
acc9_nov=zeros(size(datiCusc2HF61gruppo6nov(:,1)));
acc10_nov=zeros(size(datiCusc1HA62ridgruppo6nov(:,1)));
acc11_nov=zeros(size(datiCuscHA61ridgruppo6nov(:,1)));
acc12_nov=zeros(size(datiCusc2HF62gruppo6nov(:,1)));
acc13_nov=zeros(size(datiCusc1HF62gruppo6nov(:,1)));


disp('STATUS NOVEMBER 2016')

%Accelerazioni GRUPPO 0 November

for ii=1:size(datiCuscMImotoreBgruppo0nov)
acc1_nov(ii)=datiCuscMImotoreBgruppo0nov(ii,2);
end

acceleration1_nov =[acc1_nov];

%%ANALISI IN ACCELERAZIONE BEARING 1 MI mot B GRUPPO 0%%
fourier1_nov=real(fft(acceleration1_nov,L));
Pnov2_1 = abs(fourier1_nov(:,1))/L;
Pnov1_1 = Pnov2_1(1:L/2+1);
Pnov1_1(2:end-1) = 2*Pnov1_1(2:end-1);
[Peakacc1nov Ind_Peakacc1nov]=max(Pnov2_1(5000:10000));
figure(92)
plot(fs,Pnov1_1);
title('STATUS BEARING 1 MI MOT B GRUPPO 0 NOV 2016')
print -dpng -f92 bearing1MImotBgruppo0nov2016.png
disp(['Peak frequency : '  num2str(Ind_Peakacc1nov-1)])
disp(['Peak BEARING 1 MI mot B gruppo 0: ' num2str(Peakacc1nov)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%



%Accelerazioni GRUPPO 1 e 2 November

for ii=1:size(datiCuscMImotoreBgruppo0nov)
acc2_nov(ii)=datiCuscMIridgruppo1nov(ii,2);
acc3_nov(ii)=datiCuscHA13ridgruppo1nov(ii,2);
acc4_nov(ii)=datiCusc1HF25gruppo1nov(ii,2);
end

acceleration2_nov=[acc2_nov acc3_nov acc4_nov];

%%ANALISI IN ACCELERAZIONE BEARING 1 MI rid GRUPPO 1%%
fourier2_nov=real(fft(acceleration2_nov,L));
```

```
Pnov2_2 = abs(fourier2_nov(:,1))/L;
Pnov1_2 = Pnov2_2(1:L/2+1);
Pnov1_2(2:end-1) = 2*Pnov1_2(2:end-1);
[Peakacc2nov Ind_Peakacc2nov]=max(Pnov2_2(5000:10000));
figure(93)
plot(fs,Pnov1_2);
title('STATUS BEARING 1 MI RID GRUPPO 1 NOV 2016')
print -dpng -f93 bearing1MIridgruppo1nov2016.png
disp(['Peak frequency : '  num2str(Ind_Peakacc2nov-1)])
disp(['Peak BEARING 1 MI rid gruppo 1: ' num2str(Peakacc2nov)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 1 HA13 rid GRUPPO 1%%
Pnov2_3 = abs(fourier2_nov(:,2))/L;
Pnov1_3 = Pnov2_2(1:L/2+1);
Pnov1_3(2:end-1) = 2*Pnov1_3(2:end-1);
[Peakacc3nov Ind_Peakacc3nov]=max(Pnov2_3(5000:10000));
figure(94)
plot(fs,Pnov1_3);
title('STATUS BEARING 1 HA13 RID GRUPPO 1 NOV 2016')
print -dpng -f94 bearing1HA13ridgruppo1nov2016.png
disp(['Peak frequency : '  num2str(Ind_Peakacc3nov-1)])
disp(['Peak BEARING 1 HA13 rid gruppo 1: ' num2str(Peakacc3nov)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 2 HF25 GRUPPO 1%%
Pnov2_4 = abs(fourier2_nov(:,3))/L;
Pnov1_4 = Pnov2_4(1:L/2+1);
Pnov1_4(2:end-1) = 2*Pnov1_4(2:end-1);
[Peakacc4nov Ind_Peakacc4nov]=max(Pnov2_4(5000:10000));
figure(95)
plot(fs,Pnov1_4);
title('STATUS BEARING 2 HF25 GRUPPO 1 NOV 2016')
print -dpng -f95 bearing2HF25gruppo1nov2016.png
disp(['Peak frequency : '  num2str(Ind_Peakacc4nov-1)])
disp(['Peak BEARING 2 HF25 gruppo 1: ' num2str(Peakacc4nov)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

%Accelerazioni GRUPPO 2 November

for ii=1:size(datiCuscMImotoreBgruppo0nov)
acc5_nov(ii)=datiCusc2HF26gruppo2nov(ii,2);
acc6_nov(ii)=datiCusc1HA23ridgruppo2nov(ii,2);
end

acceleration3_nov=[acc5_nov acc6_nov];


%%ANALISI IN ACCELERAZIONE BEARING 2 HF26 GRUPPO 2%%
fourier3_nov=real(fft(acceleration3_nov,L));
Pnov2_5 = abs(fourier3_nov(:,1))/L;
Pnov1_5 = Pnov2_5(1:L/2+1);
Pnov1_5(2:end-1) = 2*Pnov1_5(2:end-1);
[Peakacc5nov Ind_Peakacc5nov]=max(Pnov2_5(5000:10000));
figure(96)
plot(fs,Pnov1_5);
title('STATUS BEARING 2 HF26 GRUPPO 2 NOV 2016')
print -dpng -f96 bearing2HF26gruppo2nov2016.png
disp(['Peak frequency : ' num2str(Ind_Peakacc5nov-1)])
disp(['Peak BEARING 2 HF26 gruppo 2: ' num2str(Peakacc5nov)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 2 HA23 rid GRUPPO 2%%
Pnov2_6 = abs(fourier3_nov(:,2))/L;
Pnov1_6 = Pnov2_6(1:L/2+1);
Pnov1_6(2:end-1) = 2*Pnov1_6(2:end-1);
```

```
[Peakacc6nov Ind_Peakacc6nov]=max(Pnov2_6(5000:10000));
figure(97)
plot(fs,Pnov1_6);
title('STATUS BEARING 2 HA23 RID GRUPPO 2 NOV 2016')
print -dpng -f97 bearing2HA23ridgruppo2nov2016.png
disp(['Peak frequency : ' num2str(Ind_Peakacc6nov-1)])
disp(['Peak BEARING 2 HA23 rid gruppo 2: ' num2str(Peakacc6nov)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%


%Accelerazioni GRUPPO 5 November

for ii=1:size(datiCuscMImotoreBgruppo0nov)
acc7_nov(ii)=datiCusc1MImotoreAgruppo5nov(ii,2);
end

acceleration4_nov=[acc7_nov];

%%ANALISI IN ACCELERAZIONE BEARING 2 MI mot A GRUPPO 5%%
fourier4_nov=real(fft(acceleration4_nov,L));
Pnov2_7 = abs(fourier4_nov(:,1))/L;
Pnov1_7 = Pnov2_7(1:L/2+1);
Pnov1_7(2:end-1) = 2*Pnov1_7(2:end-1);
[Peakacc7nov Ind_Peakacc7nov]=max(Pnov2_7(5000:10000));
figure(98)
plot(fs,Pnov1_7);
title('STATUS BEARING 2 MI MOT A GRUPPO 5 NOV 2016')
print -dpng -f98 bearing2MImotAgruppo5nov2016.png
disp(['Peak frequency : ' num2str(Ind_Peakacc7nov-1)])
disp(['Peak BEARING 2 MI mot A gruppo 5: ' num2str(Peakacc7nov)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%


%Accelerazioni GRUPPO 6 November

for ii=1:size(datiCuscMImotoreBgruppo0nov)
acc8_nov(ii)=datiCuscHF61gruppo6nov(ii,2);
acc9_nov(ii)=datiCusc2HF61gruppo6nov(ii,2);
acc10_nov(ii)=datiCusc1HA62ridgruppo6nov(ii,2);
acc11_nov(ii)=datiCuscHA61ridgruppo6nov(ii,2);
acc12_nov(ii)=datiCusc2HF62gruppo6nov(ii,2);
acc13_nov(ii)=datiCusc1HF62gruppo6nov(ii,2);

end
acceleration5_nov=[acc8_nov acc9_nov acc10_nov acc11_nov acc12_nov
acc13_nov];


%%ANALISI IN ACCELERAZIONE BEARING 1 HF61 GRUPPO 6%%
fourier5_nov=real(fft(acceleration5_nov,L));
Pnov2_8 = abs(fourier5_nov(:,1))/L;
Pnov1_8 = Pnov2_8(1:L/2+1);
Pnov1_8(2:end-1) = 2*Pnov1_8(2:end-1);
[Peakacc8nov Ind_Peakacc8nov]=max(Pnov2_8(5000:10000));
figure(99)
plot(fs,Pnov1_8);
title('STATUS BEARING 2 MI MOT A GRUPPO 6 NOV 2016')
print -dpng -f99 bearing1HF61gruppo6nov2016.png
disp(['Peak frequency : ' num2str(Ind_Peakacc8nov-1)])
disp(['Peak BEARING 1 HF61 gruppo 6: ' num2str(Peakacc8nov)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 3 HF61 GRUPPO 6%%
```

```
Pnov2_9 = abs(fourier5_nov(:,2))/L;
Pnov1_9 = Pnov2_9(1:L/2+1);
Pnov1_9(2:end-1) = 2*Pnov1_9(2:end-1);
[Peakacc9nov Ind_Peakacc9nov]=max(Pnov2_9(5000:10000));
figure(100)
plot(fs,Pnov1_9);
title('STATUS BEARING 3 HF61 MOT A GRUPPO 6 NOV 2016')
print -dpng -f100 bearing3HF61gruppo6nov2016.png
disp(['Peak frequency : ' num2str(Ind_Peakacc9nov-1)])
disp(['Peak BEARING 3 HF61 gruppo 6: ' num2str(Peakacc9nov)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 2 HA62 rid GRUPPO 6%%
Pnov2_10 = abs(fourier5_nov(:,3))/L;
Pnov1_10 = Pnov2_10(1:L/2+1);
Pnov1_10(2:end-1) = 2*Pnov1_10(2:end-1);
[Peakacc10nov Ind_Peakacc10nov]=max(Pnov2_10(5000:10000));
figure(101)
plot(fs,Pnov1_10);
title('STATUS BEARING 2 HA62 RID GRUPPO 6 NOV 2016')
print -dpng -f101 bearing2HA62ridgruppo6nov2016.png
disp(['Peak frequency : ' num2str(Ind_Peakacc10nov-1)])
disp(['Peak BEARING 2 HA62 rid gruppo 6: ' num2str(Peakacc10nov)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 1 HA61 rid GRUPPO 6%%
Pnov2_11 = abs(fourier5_nov(:,4))/L;
Pnov1_11 = Pnov2_11(1:L/2+1);
Pnov1_11(2:end-1) = 2*Pnov1_11(2:end-1);
[Peakacc11nov Ind_Peakacc11nov]=max(Pnov2_11(5000:10000));
figure(102)
plot(fs,Pnov1_11);
title('STATUS BEARING 1 HA61 RID GRUPPO 6 NOV 2016')
print -dpng -f102 bearing1HA61ridgruppo6nov2016.png
disp(['Peak frequency : ' num2str(Ind_Peakacc11nov-1)])
disp(['Peak BEARING 1 HA61 rid gruppo 6: ' num2str(Peakacc11nov)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 3 HF62 GRUPPO 6%%
Pnov2_12 = abs(fourier5_nov(:,5))/L;
Pnov1_12 = Pnov2_12(1:L/2+1);
Pnov1_12(2:end-1) = 2*Pnov1_12(2:end-1);
[Peakacc12nov Ind_Peakacc12nov]=max(Pnov2_12(5000:10000));
figure(103)
plot(fs,Pnov1_12);
title('STATUS BEARING 3 HF62 GRUPPO 6 NOV 2016')
print -dpng -f103 bearing3HF62gruppo6nov2016.png
disp(['Peak frequency : ' num2str(Ind_Peakacc12nov-1)])
disp(['Peak BEARING 3 HF62 gruppo 6: ' num2str(Peakacc12nov)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%ANALISI IN ACCELERAZIONE BEARING 2 HF62 GRUPPO 6%%
Pnov2_13 = abs(fourier5_nov(:,6))/L;
Pnov1_13 = Pnov2_13(1:L/2+1);
Pnov1_13(2:end-1) = 2*Pnov1_13(2:end-1);
[Peakacc13nov Ind_Peakacc13nov]=max(Pnov2_13(5000:10000));
figure(104)
plot(fs,Pnov1_13);
title('STATUS BEARING 2 HF62 GRUPPO 6 NOV 2016')
print -dpng -f104 bearing2HF62gruppo6nov2016.png
disp(['Peak frequency : ' num2str(Ind_Peakacc13nov-1)])
disp(['Peak BEARING 2 HF62 gruppo 6: ' num2str(Peakacc13nov)])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
controlmatrixnov=[Peakacc1nov Peakacc2nov Peakacc3nov Peakacc4nov
Peakacc5nov Peakacc6nov Peakacc7nov Peakacc8nov Peakacc9nov Peakacc10nov
Peakacc11nov Peakacc12nov Peakacc13nov];

for ii=1:length(controlmatrixnov)
```

```
if controlmatrixnov(ii)>lim1
    disp("Alarm - Rough")
    if ii==1
        disp("Check bearing 1 MI mot B gruppo 0")
    end
    if ii==2
        disp("Check bearing 1 MI rid gruppo 1")
    end
    if ii==3
        disp("Check bearing 1 HA13 rid gruppo 1")
    end
    if ii==4
        disp("Check bearing 2 HF25 gruppo 1")
    end
    if ii==5
        disp("Check bearing 2 HF26 gruppo 2")
    end
    if ii==6
        disp("Check bearing 2 HA23 rid gruppo 2")
    end
    if ii==7
        disp("Check bearing 2 MI mot A gruppo 5")
    end
    if ii==8
        disp("Check bearing 1 HF61 gruppo 6")
    end
    if ii==9
        disp("Check bearing 3 HF61 gruppo 6")
    end
    if ii==10
        disp("Check bearing 2 HA62 rid gruppo 6")
    end
    if ii==11
        disp("Check bearing 1 HA61 rid gruppo 6")
    end
    if ii==12
        disp("Check bearing 3 HF62 gruppo 6")
    end
    if ii==13
        disp("Check bearing 2 HF62 gruppo 6")
    end


else if controlmatrixdec_5(ii)>=lim2 && controlmatrixdec_5(ii)<=lim1
        disp("Alert - Slighty rough")
           if ii==1
        disp("Check bearing 1 MI mot B gruppo 0")
    end
    if ii==2
        disp("Check bearing 1 MI rid gruppo 1")
    end
    if ii==3
        disp("Check bearing 1 HA13 rid gruppo 1")
    end
    if ii==4
        disp("Check bearing 2 HF25 gruppo 1")
    end
    if ii==5
        disp("Check bearing 2 HF26 gruppo 2")
    end
    if ii==6
        disp("Check bearing 2 HA23 rid gruppo 2")
    end
    if ii==7
```

```
            disp("Check bearing 2 MI mot A gruppo 5")
        end
        if ii==8
            disp("Check bearing 1 HF61 gruppo 6")
        end
        if ii==9
            disp("Check bearing 3 HF61 gruppo 6")
        end
        if ii==10
            disp("Check bearing 2 HA62 rid gruppo 6")
        end
        if ii==11
            disp("Check bearing 1 HA61 rid gruppo 6")
        end
        if ii==12
            disp("Check bearing 3 HF62 gruppo 6")
        end
        if ii==13
            disp("Check bearing 2 HF62 gruppo 6")
        end
        else disp("Good")
        end
    end
end
```

LOW FREQUENCY FAST FOURIER TRANSFORM CODE :

```
clear all
close all
clc

%% Limits definitions for the vibration check %%

lim1=2;  %mm/sec
lim2=4;  %mm/sec

%% Vibrations monitoring May 2016 %%

datiRidgruppo0=load('CuscRidgruppo0may.txt');
datimotBgruppo0=load('Cusc1motoreBgruppo0may.txt');

datiCusc1HF14gruppo1=load('Cusc1HF14gruppo1may.txt');
datiCusc1HF15gruppo1=load('Cusc1HF15gruppo1may.txt');
datiCusc2HF14gruppo1=load('Cusc2HF14gruppo1may.txt');
datiCusc2HF15gruppo1=load('Cusc2HF15gruppo1may.txt');

datiCuscHA40ridgruppo4=load('CuscHA40gruppo4may.txt');

datiCuscHF53gruppo5=load('CuscHF53gruppo5may.txt');
datiCusc1HF53gruppo5=load('Cusc1HF53gruppo5may.txt');
datiCuscHF54gruppo5=load('CuscHF54gruppo5may.txt');
datiCuscHF55gruppo5=load('CuscHF55gruppo5may.txt');
datiCusc2HA51ridgruppo5=load('Cusc2HA51ridgruppo5may.txt');


%%%% Vettore dei tempi,frequenza,numero di campioni %%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
```

```
T  = 4e-5;                  %% intervallo di tempo tra i campionamenti %%
Fs = 1/T;                   %% frequenza          %%
L  = 25000;                 %% numero campioni    %%
t = (0:L-1)*T;              %% vettori dei tempi %%

%creazione vettore accelerazione misure maggio

acc1_may=zeros(size(datiRidgruppo0(:,1)));
acc2_may=zeros(size(datimotBgruppo0(:,1)));
acc3_may=zeros(size(datiCusc1HF14gruppo1(:,1)));
acc4_may=zeros(size(datiCusc1HF15gruppo1(:,1)));
acc5_may=zeros(size(datiCusc2HF14gruppo1(:,1)));
acc6_may=zeros(size(datiCusc2HF15gruppo1(:,1)));
acc7_may=zeros(size(datiCuscHA40ridgruppo4(:,1)));
acc8_may=zeros(size(datiCuscHF53gruppo5(:,1)));
acc9_may=zeros(size(datiCusc1HF53gruppo5(:,1)));
acc10_may=zeros(size(datiCuscHF54gruppo5(:,1)));
acc11_may=zeros(size(datiCuscHF55gruppo5(:,1)));
acc12_may=zeros(size(datiCusc2HA51ridgruppo5(:,1)));

for ii=1:size(datiRidgruppo0)
    acc1_may(ii)=datiRidgruppo0(ii,2);
    acc2_may(ii)=datimotBgruppo0(ii,2);
    acc3_may(ii)=datiCusc1HF14gruppo1(ii,2);
    acc4_may(ii)=datiCusc1HF15gruppo1(ii,2);
    acc5_may(ii)=datiCusc2HF14gruppo1(ii,2);
    acc6_may(ii)=datiCusc2HF15gruppo1(ii,2);
    acc7_may(ii)=datiCuscHA40ridgruppo4(ii,2);
    acc8_may(ii)=datiCuscHF53gruppo5(ii,2);
    acc9_may(ii)=datiCusc1HF53gruppo5(ii,2);
    acc10_may(ii)=datiCuscHF54gruppo5(ii,2);
    acc11_may(ii)=datiCuscHF55gruppo5(ii,2);
    acc12_may(ii)=datiCusc2HA51ridgruppo5(ii,2);
end

acceleration1=[acc1_may acc2_may acc3_may acc4_may acc5_may acc6_may
acc7_may acc8_may acc9_may acc10_may acc11_may acc12_may];


%ANALISI IN VELOCITA' PER BASSE FREQUENZE (SBILANCIAMENTI)
velocita_may = cumtrapz(acceleration1);    %micro/sec
velocita_c_may = velocita_may;
fourier_may=real(fft(velocita_c_may,L));

%Generazione single amplitude spectrum for each velocity
Pmay1_2_1 = abs(fourier_may(:,1))/L;
Pmay1_1_1 = Pmay1_2_1(1:L/2+1);
Pmay1_1_1(2:end-1) = 2*Pmay1_1_1(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pmay1_2_2 = abs(fourier_may(:,2))/L;
Pmay1_1_2 = Pmay1_2_2(1:L/2+1);
Pmay1_1_2(2:end-1) = 2*Pmay1_1_2(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pmay1_2_3 = abs(fourier_may(:,3))/L;
Pmay1_1_3 = Pmay1_2_3(1:L/2+1);
Pmay1_1_3(2:end-1) = 2*Pmay1_1_3(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pmay1_2_4 = abs(fourier_may(:,4))/L;
Pmay1_1_4 = Pmay1_2_4(1:L/2+1);
Pmay1_1_4(2:end-1) = 2*Pmay1_1_4(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pmay1_2_5 = abs(fourier_may(:,5))/L;
Pmay1_1_5 = Pmay1_2_5(1:L/2+1);
```

```
Pmay1_1_5(2:end-1) = 2*Pmay1_1_5(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pmay1_2_6 = abs(fourier_may(:,6))/L;
Pmay1_1_6 = Pmay1_2_6(1:L/2+1);
Pmay1_1_6(2:end-1) = 2*Pmay1_1_6(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pmay1_2_7 = abs(fourier_may(:,7))/L;
Pmay1_1_7 = Pmay1_2_7(1:L/2+1);
Pmay1_1_7(2:end-1) = 2*Pmay1_1_7(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pmay1_2_8 = abs(fourier_may(:,8))/L;
Pmay1_1_8 = Pmay1_2_8(1:L/2+1);
Pmay1_1_8(2:end-1) = 2*Pmay1_1_8(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pmay1_2_9 = abs(fourier_may(:,9))/L;
Pmay1_1_9 = Pmay1_2_9(1:L/2+1);
Pmay1_1_9(2:end-1) = 2*Pmay1_1_9(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pmay1_2_10 = abs(fourier_may(:,10))/L;
Pmay1_1_10 = Pmay1_2_10(1:L/2+1);
Pmay1_1_10(2:end-1) = 2*Pmay1_1_10(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pmay1_2_11 = abs(fourier_may(:,11))/L;
Pmay1_1_11 = Pmay1_2_11(1:L/2+1);
Pmay1_1_11(2:end-1) = 2*Pmay1_1_11(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pmay1_2_12 = abs(fourier_may(:,12))/L;
Pmay1_1_12 = Pmay1_2_12(1:L/2+1);
Pmay1_1_12(2:end-1) = 2*Pmay1_1_12(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
fs = Fs*(0:(L/2))/L;
RMSvel_may1 = rms(velocita_c_may);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

spectmatrix1=[Pmay1_1_1 Pmay1_1_2 Pmay1_1_3 Pmay1_1_4 Pmay1_1_5 Pmay1_1_6
Pmay1_1_7 Pmay1_1_8 Pmay1_1_9 Pmay1_1_10 Pmay1_1_11 Pmay1_1_12];
[PEAK_May2016,Ind_Peak_may2016]=max(spectmatrix1(2:600,:));
%%massimi picchi alle armoniche fondamentali




%% Vibrations monitoring May 2017 %%

%%GRUPPO1 HF15
datiCuscHF15gruppo1may2=load('May2017CuscHF15gruppo1.txt');
datiCusc1HF15gruppo1may2=load('May2017Cusc1HF15gruppo1.txt');

%%GRUPPO1 HF16
datiCusc2HF16gruppo1may2=load('May2017Cusc2HF16gruppo1.txt');

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%creazione vettore accelerazione misure maggio2017
acc1_may2=zeros(size(datiCuscHF15gruppo1may2(:,1)));
acc2_may2=zeros(size(datiCusc1HF15gruppo1may2(:,1)));
acc3_may2=zeros(size(datiCusc2HF16gruppo1may2(:,1)));


%Accelerazioni GRUPPO 1 May2017
for ii=1:size(datiCuscHF15gruppo1may2)
    acc1_may2(ii)=datiCuscHF15gruppo1may2(ii,2);
```

```
    acc2_may2(ii)=datiCusc1HF15gruppo1may2(ii,2);
    acc3_may2(ii)=datiCusc2HF16gruppo1may2(ii,2);
end


acceleration1_may2=[acc1_may2 acc2_may2 acc3_may2];

%ANALISI IN VELOCITA' PER BASSE FREQUENZE GRUPPO1 MAY2017 (SBILANCIAMENTI)

velocita_may2 = cumtrapz(acceleration1_may2);
velocita_c_may2 = velocita_may2/1;
fourier_may2=real(fft(velocita_c_may2,L));

%Generazione single amplitude spectrum for each velocity
Pmay2_2_1 = abs(fourier_may2(:,1))/L;
Pmay2_1_1 = Pmay2_2_1(1:L/2+1);
Pmay2_1_1(2:end-1) = 2*Pmay2_1_1(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pmay2_2_2 = abs(fourier_may2(:,2))/L;
Pmay2_1_2 = Pmay2_2_2(1:L/2+1);
Pmay2_1_2(2:end-1) = 2*Pmay2_1_2(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pmay2_2_3 = abs(fourier_may2(:,3))/L;
Pmay2_1_3 = Pmay2_2_3(1:L/2+1);
Pmay2_1_3(2:end-1) = 2*Pmay2_1_3(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

RMSvel_may2 = rms(velocita_c_may2);
spectmatrix2=[Pmay2_1_1 Pmay2_1_2 Pmay2_1_3];
[PEAK_May2017, Ind_Peak_may2017]=max(spectmatrix2(30:600,:));
%%massimi picchi alle armoniche fondamentali




%% Vibrations monitoring December 2017 %%


%GRUPPO0 MI%
datiCuscMIridgruppo0dec=load('Dec_CuscMIridgruppo0.txt');
datiCusc1MIridgruppo0dec=load('Dec_Cusc1MIridgruppo0.txt');

datiCuscMImotoreBgruppo0dec=load('Dec_CuscMImotoreBgruppo0.txt');
datiCusc1MImotoreBgruppo0dec=load('Dec_Cusc1MImotoreBgruppo0.txt');

datiCuscMImotoreAgruppo0dec=load('Dec_CuscMImotoreAgruppo0.txt');
datiCusc1MImotoreAgruppo0dec=load('Dec_Cusc1MImotoreAgruppo0.txt');

%GRUPPO0 HF2%
datiCuscHF2gruppo0dec=load('Dec_CuscHF2gruppo0.txt');
datiCusc1HF2gruppo0dec=load('Dec_Cusc1HF2gruppo0.txt');

%GRUPPO0 HF1%
datiCuscHF1gruppo0dec=load('Dec_CuscHF1gruppo0.txt');
datiCusc1HF1gruppo0dec=load('Dec_Cusc1HF1gruppo0.txt');
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%GRUPPO1 MI
datiCuscMIridgruppo1dec=load('Dec_CuscMIridgruppo1.txt');
datiCusc1MIridgruppo1dec=load('Dec_Cusc1MIridgruppo1.txt');
```

```
datiCuscMImotgruppo1dec=load('Dec_CuscMImotgruppo1.txt');
datiCusc1MImotgruppo1dec=load('Dec_Cusc1MImotgruppo1.txt');

%GRUPPO1 HF17
datiCuscHF17gruppo1dec=load('Dec_CuscHF17gruppo1.txt');

%GRUPPO1 HF16
datiCuscHF16gruppo1dec=load('Dec_CuscHF16gruppo1.txt');

%GRUPPO1 HF15
datiCuscHF15gruppo1dec=load('Dec_CuscHF15gruppo1.txt');

%GRUPPO1 HF14
datiCuscHF14gruppo1dec=load('Dec_CuscHF14gruppo1.txt');

%GRUPPO1 HA13
datiCuscHA13ridgruppo1dec=load('Dec_CuscHA13ridgruppo1.txt');

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%GRUPPO2 MI
datiCuscMIridgruppo2dec=load('Dec_CuscMIridgruppo2.txt');
datiCuscMImotgruppo2dec=load('Dec_CuscMImotgruppo2.txt');
datiCusc1MImotgruppo2dec=load('Dec_Cusc1MImotgruppo2.txt');

%GRUPPO2 HF27
datiCuscHF27gruppo2dec=load('Dec_CuscHF27gruppo2.txt');

%GRUPPO2 HF26
datiCuscHF26gruppo2dec=load('Dec_CuscHF26gruppo2.txt');

%GRUPPO2 HF25
datiCuscHF25gruppo2dec=load('Dec_CuscHF25gruppo2.txt');

%GRUPPO2 HF24
datiCuscHF24gruppo2dec=load('Dec_CuscHF24gruppo2.txt');

%GRUPPO2 HA23
datiCuscHA23ridgruppo2dec=load('Dec_CuscHA23ridgruppo2.txt');
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

%GRUPPO4 MI

datiCuscMIridgruppo4dec=load('Dec_CuscMIridgruppo4.txt');
datiCusc1MIridgruppo4dec=load('Dec_Cusc1MIridgruppo4.txt');
datiCuscMImot2gruppo4dec=load('Dec_CuscMImotore2gruppo4.txt');
datiCusc1MImot2gruppo4dec=load('Dec_CuscMImotore2gruppo4.txt');
datiCuscMImotore1gruppo4dec=load('Dec_CuscMImotore1gruppo4.txt');
datiCusc1MImotore1gruppo4dec=load('Dec_Cusc1MImotore1gruppo4.txt');

%GRUPPO4 HF42
datiCuscHF42gruppo4dec=load('Dec_CuscHF42gruppo4.txt');
datiCusc1HF42gruppo4dec=load('Dec_CuscHF42gruppo4.txt');

%GRUPPO4 HF41
datiCuscHF41gruppo4dec=load('Dec_CuscHF41gruppo4.txt');
datiCusc1HF41gruppo4dec=load('Dec_Cusc1HF41gruppo4.txt');

%GRUPPO4 HA40
datiCuscHA40motgruppo4dec=load('Dec_CuscHA40motgruppo4.txt');
datiCuscHA40ridgruppo4dec=load('Dec_CuscHA40ridgruppo4.txt');
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
```

```
%GRUPPO5 MI
datiCuscMIridgruppo5dec=load('Dec_CuscMIridgruppo5.txt');
datiCusc1MIridgruppo5dec=load('Dec_Cusc1MIridgruppo5.txt');
datiCuscMImotoreBgruppo5dec=load('Dec_CuscMImotoreBgruppo5.txt');
datiCusc1MImotoreBgruppo5dec=load('Dec_Cusc1MImotoreBgruppo5.txt');
datiCuscMImotoreAgruppo5dec=load('Dec_CuscMImotoreAgruppo5.txt');
datiCusc1MImotoreAgruppo5dec=load('Dec_Cusc1MImotoreAgruppo5.txt');

%GRUPPO5 HF56
datiCuscHF56gruppo5dec=load('Dec_CuscHF56gruppo5.txt');
datiCusc1HF56gruppo5dec=load('Dec_Cusc1HF56gruppo5.txt');

%GRUPPO5 HF55
datiCuscHF55gruppo5dec=load('Dec_CuscHF55gruppo5.txt');
datiCusc1HF55gruppo5dec=load('Dec_Cusc1HF55gruppo5.txt');
datiCusc2HF55gruppo5dec=load('Dec_Cusc2HF55gruppo5.txt');

%GRUPPO5 HF54
datiCuscHF54gruppo5dec=load('Dec_CuscHF54gruppo5.txt');
datiCusc1HF54gruppo5dec=load('Dec_Cusc1HF54gruppo5.txt');
datiCusc2HF54gruppo5dec=load('Dec_Cusc2HF54gruppo5.txt');

%GRUPPO5 HF53
datiCuscHF53gruppo5dec=load('Dec_CuscHF53gruppo5.txt');
datiCusc1HF53gruppo5dec=load('Dec_Cusc1HF53gruppo5.txt');
datiCusc2HF53gruppo5dec=load('Dec_Cusc2HF53gruppo5.txt');

%GRUPPO5 HA51
datiCuscHA51ridgruppo5dec=load('Dec_CuscHA51ridgruppo5.txt');
datiCuscHA51motgruppo5dec=load('Dec_CuscHA51motgruppo5.txt');
datiCusc1HA51motgruppo5dec=load('Dec_Cusc1HA51motgruppo5.txt');
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

%GRUPPO6 MI
datiCuscMIridgruppo6dec=load('Dec_CuscMIridgruppo6.txt');
datiCusc1MIridgruppo6dec=load('Dec_Cusc1MIridgruppo6.txt');
datiCuscMImotore2gruppo6dec=load('Dec_CuscMImotore2gruppo6.txt');
datiCusc1MImotore2gruppo6dec=load('Dec_Cusc1MImotore2gruppo6.txt');
datiCuscMImotore1gruppo6dec=load('Dec_CuscMImotore1gruppo6.txt');
datiCusc1MImotore1gruppo6dec=load('Dec_Cusc1MImotore1gruppo6.txt');

%GRUPPO6 HF64
datiCuscHF64gruppo6dec=load('Dec_CuscHF64gruppo6.txt');

%GRUPPO6 HF63
datiCuscHF63gruppo6dec=load('Dec_CuscHF63gruppo6.txt');
datiCusc1HF63gruppo6dec=load('Dec_Cusc1HF63gruppo6.txt');

%GRUPPO6 HF62
datiCuscHF62gruppo6dec=load('Dec_CuscHF62gruppo6.txt');

%GRUPPO6 HF61
datiCuscHF61gruppo6dec=load('Dec_CuscHF61gruppo6.txt');
datiCusc1HF61gruppo6dec=load('Dec_Cusc1HF61gruppo6.txt');

%GRUPPO6 HA62
datiCuscHA62gruppo6dec=load('Dec_CuscHA62gruppo6.txt');
datiCusc1HA62gruppo6dec=load('Dec_Cusc1HA62gruppo6.txt');

%GRUPPO6 HA61
datiCuscHA61gruppo6dec=load('Dec_CuscHA61gruppo6.txt');
```

```
datiCusc1HA61gruppo6dec=load('Dec_Cusc1HA61gruppo6.txt');



%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%creazione vettore accelerazione misure dicembre

acc1_dec=zeros(size(datiCuscMIridgruppo0dec(:,1)));
acc2_dec=zeros(size(datiCusc1MIridgruppo0dec(:,1)));
acc3_dec=zeros(size(datiCuscMImotoreBgruppo0dec(:,1)));
acc4_dec=zeros(size(datiCusc1MImotoreBgruppo0dec(:,1)));
acc5_dec=zeros(size(datiCuscMImotoreAgruppo0dec(:,1)));
acc6_dec=zeros(size(datiCusc1MImotoreAgruppo0dec(:,1)));
acc7_dec=zeros(size(datiCuscHF2gruppo0dec(:,1)));
acc8_dec=zeros(size(datiCusc1HF2gruppo0dec(:,1)));
acc9_dec=zeros(size(datiCuscHF1gruppo0dec(:,1)));
acc10_dec=zeros(size(datiCusc1HF1gruppo0dec(:,1)));
acc11_dec=zeros(size(datiCuscMIridgruppo1dec(:,1)));
acc12_dec=zeros(size(datiCusc1MIridgruppo1dec(:,1)));
acc13_dec=zeros(size(datiCuscMImotgruppo1dec(:,1)));
acc14_dec=zeros(size(datiCusc1MImotgruppo1dec(:,1)));
acc15_dec=zeros(size(datiCuscHF17gruppo1dec(:,1)));
acc16_dec=zeros(size(datiCuscHF16gruppo1dec(:,1)));
acc17_dec=zeros(size(datiCuscHF15gruppo1dec(:,1)));
acc18_dec=zeros(size(datiCuscHF14gruppo1dec(:,1)));
acc19_dec=zeros(size(datiCuscHA13ridgruppo1dec(:,1)));
acc20_dec=zeros(size(datiCuscMIridgruppo2dec(:,1)));
acc21_dec=zeros(size(datiCuscMImotgruppo2dec(:,1)));
acc22_dec=zeros(size(datiCusc1MImotgruppo2dec(:,1)));
acc23_dec=zeros(size(datiCuscHF27gruppo2dec(:,1)));
acc24_dec=zeros(size(datiCuscHF26gruppo2dec(:,1)));
acc25_dec=zeros(size(datiCuscHF25gruppo2dec(:,1)));
acc26_dec=zeros(size(datiCuscHF24gruppo2dec(:,1)));
acc27_dec=zeros(size(datiCuscHA23ridgruppo2dec(:,1)));
acc28_dec=zeros(size(datiCuscMIridgruppo4dec(:,1)));
acc29_dec=zeros(size(datiCusc1MIridgruppo4dec(:,1)));
acc30_dec=zeros(size(datiCuscMImot2gruppo4dec(:,1)));
acc31_dec=zeros(size(datiCusc1MImot2gruppo4dec(:,1)));
acc32_dec=zeros(size(datiCuscMImotore1gruppo4dec(:,1)));
acc33_dec=zeros(size(datiCusc1MImotore1gruppo4dec(:,1)));
acc34_dec=zeros(size(datiCuscHF42gruppo4dec(:,1)));
acc35_dec=zeros(size(datiCusc1HF42gruppo4dec(:,1)));
acc36_dec=zeros(size(datiCuscHF41gruppo4dec(:,1)));
acc37_dec=zeros(size(datiCusc1HF41gruppo4dec(:,1)));
acc38_dec=zeros(size(datiCuscHA40motgruppo4dec(:,1)));
acc39_dec=zeros(size(datiCuscHA40ridgruppo4dec(:,1)));
acc40_dec=zeros(size(datiCuscMIridgruppo5dec(:,1)));
acc41_dec=zeros(size(datiCusc1MIridgruppo5dec(:,1)));
acc42_dec=zeros(size(datiCuscMImotoreBgruppo5dec(:,1)));
acc43_dec=zeros(size(datiCusc1MImotoreBgruppo5dec(:,1)));
acc44_dec=zeros(size(datiCuscMImotoreAgruppo5dec(:,1)));
acc45_dec=zeros(size(datiCusc1MImotoreAgruppo5dec(:,1)));
acc46_dec=zeros(size(datiCuscHF56gruppo5dec(:,1)));
acc47_dec=zeros(size(datiCusc1HF56gruppo5dec(:,1)));
acc48_dec=zeros(size(datiCuscHF55gruppo5dec(:,1)));
acc49_dec=zeros(size(datiCusc1HF55gruppo5dec(:,1)));
acc50_dec=zeros(size(datiCusc2HF55gruppo5dec(:,1)));
acc51_dec=zeros(size(datiCuscHF54gruppo5dec(:,1)));
acc52_dec=zeros(size(datiCusc1HF54gruppo5dec(:,1)));
acc53_dec=zeros(size(datiCusc2HF54gruppo5dec(:,1)));
acc54_dec=zeros(size(datiCuscHF53gruppo5dec(:,1)));
acc55_dec=zeros(size(datiCusc1HF53gruppo5dec(:,1)));
acc56_dec=zeros(size(datiCusc2HF53gruppo5dec(:,1)));
```

```
acc57_dec=zeros(size(datiCuscHA51ridgruppo5dec(:,1)));
acc58_dec=zeros(size(datiCuscHA51motgruppo5dec(:,1)));
acc59_dec=zeros(size(datiCusc1HA51motgruppo5dec(:,1)));
acc60_dec=zeros(size(datiCuscMIridgruppo6dec(:,1)));
acc61_dec=zeros(size(datiCusc1MIridgruppo6dec(:,1)));
acc62_dec=zeros(size(datiCuscMImotore2gruppo6dec(:,1)));
acc63_dec=zeros(size(datiCusc1MImotore2gruppo6dec(:,1)));
acc64_dec=zeros(size(datiCuscMImotore1gruppo6dec(:,1)));
acc65_dec=zeros(size(datiCusc1MImotore1gruppo6dec(:,1)));
acc66_dec=zeros(size(datiCuscHF64gruppo6dec(:,1)));
acc67_dec=zeros(size(datiCuscHF63gruppo6dec(:,1)));
acc68_dec=zeros(size(datiCusc1HF63gruppo6dec(:,1)));
acc69_dec=zeros(size(datiCuscHF62gruppo6dec(:,1)));
acc70_dec=zeros(size(datiCuscHF61gruppo6dec(:,1)));
acc71_dec=zeros(size(datiCusc1HF61gruppo6dec(:,1)));
acc72_dec=zeros(size(datiCuscHA62gruppo6dec(:,1)));
acc73_dec=zeros(size(datiCusc1HA62gruppo6dec(:,1)));
acc74_dec=zeros(size(datiCuscHA61gruppo6dec(:,1)));
acc75_dec=zeros(size(datiCusc1HA61gruppo6dec(:,1)));


%Accelerazioni GRUPPO 0 December
for ii=1:size(datiCuscMIridgruppo0dec)
acc1_dec(ii)=datiCuscMIridgruppo0dec(ii,2);
acc2_dec(ii)=datiCusc1MIridgruppo0dec(ii,2);
acc3_dec(ii)=datiCuscMImotoreBgruppo0dec(ii,2);
acc4_dec(ii)=datiCusc1MImotoreBgruppo0dec(ii,2);
acc5_dec(ii)=datiCuscMImotoreAgruppo0dec(ii,2);
acc6_dec(ii)=datiCusc1MImotoreAgruppo0dec(ii,2);
acc7_dec(ii)=datiCuscHF2gruppo0dec(ii,2);
acc8_dec(ii)=datiCusc1HF2gruppo0dec(ii,2);
acc9_dec(ii)=datiCuscHF1gruppo0dec(ii,2);
acc10_dec(ii)=datiCusc1HF1gruppo0dec(ii,2);
end

acceleration0_dec=[acc1_dec acc2_dec acc3_dec acc4_dec acc5_dec acc6_dec
acc7_dec acc8_dec acc9_dec acc10_dec];

%ANALISI IN VELOCITA' PER BASSE FREQUENZE GRUPPO 0 DECEMBER %%

velocita0_dec = cumtrapz(acceleration0_dec);
velocita0_c_dec = velocita0_dec/1;
fourier0_dec=real(fft(velocita0_c_dec,L));

%Generazione single amplitude spectrum for each velocity
Pdec2_1 = abs(fourier0_dec(:,1))/L;
Pdec1_1 = Pdec2_1(1:L/2+1);
Pdec1_1(2:end-1) = 2*Pdec1_1(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_2 = abs(fourier0_dec(:,2))/L;
Pdec1_2 = Pdec2_2(1:L/2+1);
Pdec1_2(2:end-1) = 2*Pdec1_2(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_3 = abs(fourier0_dec(:,3))/L;
Pdec1_3 = Pdec2_3(1:L/2+1);
Pdec1_3(2:end-1) = 2*Pdec1_3(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_4 = abs(fourier0_dec(:,4))/L;
Pdec1_4 = Pdec2_4(1:L/2+1);
Pdec1_4(2:end-1) = 2*Pdec1_4(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_5 = abs(fourier0_dec(:,5))/L;
Pdec1_5 = Pdec2_5(1:L/2+1);
```

```
Pdec1_5(2:end-1) = 2*Pdec1_5(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_6 = abs(fourier0_dec(:,6))/L;
Pdec1_6 = Pdec2_6(1:L/2+1);
Pdec1_6(2:end-1) = 2*Pdec1_6(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_7 = abs(fourier0_dec(:,7))/L;
Pdec1_7 = Pdec2_7(1:L/2+1);
Pdec1_7(2:end-1) = 2*Pdec1_7(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_8 = abs(fourier0_dec(:,8))/L;
Pdec1_8 = Pdec2_8(1:L/2+1);
Pdec1_8(2:end-1) = 2*Pdec1_8(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_9 = abs(fourier0_dec(:,9))/L;
Pdec1_9 = Pdec2_9(1:L/2+1);
Pdec1_9(2:end-1) = 2*Pdec1_9(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_10 = abs(fourier0_dec(:,10))/L;
Pdec1_10 = Pdec2_10(1:L/2+1);
Pdec1_10(2:end-1) = 2*Pdec1_10(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

%Acceleration GRUPPO1 December 2017
for ii=1:size(datiCuscMIridgruppo0dec)
acc11_dec(ii)=datiCuscMIridgruppo1dec(ii,2);
acc12_dec(ii)=datiCusc1MIridgruppo1dec(ii,2);
acc13_dec(ii)=datiCuscMImotgruppo1dec(ii,2);
acc14_dec(ii)=datiCusc1MImotgruppo1dec(ii,2);
acc15_dec(ii)=datiCuscHF17gruppo1dec(ii,2);
acc16_dec(ii)=datiCuscHF16gruppo1dec(ii,2);
acc17_dec(ii)=datiCuscHF15gruppo1dec(ii,2);
acc18_dec(ii)=datiCuscHF14gruppo1dec(ii,2);
acc19_dec(ii)=datiCuscHA13ridgruppo1dec(ii,2);
end
acceleration1_dec=[acc11_dec acc12_dec acc13_dec acc14_dec acc15_dec
acc16_dec acc17_dec acc18_dec acc19_dec];

%ANALISI IN VELOCITA' PER BASSE FREQUENZE GRUPPO 1  DECEMBER %%

velocita1_dec = cumtrapz(acceleration1_dec);
velocita1_c_dec = velocita1_dec/1;
fourier1_dec=real(fft(velocita1_c_dec,L));


%Generazione single amplitude spectrum for each velocity
Pdec2_11 = abs(fourier1_dec(:,1))/L;
Pdec1_11 = Pdec2_11(1:L/2+1);
Pdec1_11(2:end-1) = 2*Pdec1_11(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_12 = abs(fourier1_dec(:,2))/L;
Pdec1_12 = Pdec2_12(1:L/2+1);
Pdec1_12(2:end-1) = 2*Pdec1_12(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_13 = abs(fourier1_dec(:,3))/L;
Pdec1_13 = Pdec2_13(1:L/2+1);
Pdec1_13(2:end-1) = 2*Pdec1_13(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_14 = abs(fourier1_dec(:,4))/L;
Pdec1_14 = Pdec2_14(1:L/2+1);
Pdec1_14(2:end-1) = 2*Pdec1_14(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_15 = abs(fourier1_dec(:,5))/L;
```

```
Pdec1_15 = Pdec2_15(1:L/2+1);
Pdec1_15(2:end-1) = 2*Pdec1_15(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_16 = abs(fourier1_dec(:,6))/L;
Pdec1_16 = Pdec2_16(1:L/2+1);
Pdec1_16(2:end-1) = 2*Pdec1_16(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_17 = abs(fourier1_dec(:,7))/L;
Pdec1_17 = Pdec2_17(1:L/2+1);
Pdec1_17(2:end-1) = 2*Pdec1_17(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_18 = abs(fourier1_dec(:,8))/L;
Pdec1_18 = Pdec2_18(1:L/2+1);
Pdec1_18(2:end-1) = 2*Pdec1_18(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_19 = abs(fourier1_dec(:,9))/L;
Pdec1_19 = Pdec2_19(1:L/2+1);
Pdec1_19(2:end-1) = 2*Pdec1_19(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

%Acceleration GRUPPO 2 December
for ii=1:size(datiCuscMIridgruppo0dec)
acc20_dec(ii)=datiCuscMIridgruppo2dec(ii,2);
acc21_dec(ii)=datiCuscMImotgruppo2dec(ii,2);
acc22_dec(ii)=datiCusc1MImotgruppo2dec(ii,2);
acc23_dec(ii)=datiCuscHF27gruppo2dec(ii,2);
acc24_dec(ii)=datiCuscHF26gruppo2dec(ii,2);
acc25_dec(ii)=datiCuscHF25gruppo2dec(ii,2);
acc26_dec(ii)=datiCuscHF24gruppo2dec(ii,2);
acc27_dec(ii)=datiCuscHA23ridgruppo2dec(ii,2);
end

acceleration2_dec=[acc20_dec acc21_dec acc22_dec acc23_dec acc24_dec
acc25_dec acc26_dec acc27_dec];

%ANALISI IN VELOCITA' PER BASSE FREQUENZE GRUPPO 2 DECEMBER %%

velocita2_dec = cumtrapz(acceleration2_dec);
velocita2_c_dec = velocita2_dec/1;
fourier2_dec=real(fft(velocita2_c_dec,L));

Pdec2_20 = abs(fourier2_dec(:,1))/L;
Pdec1_20 = Pdec2_20(1:L/2+1);
Pdec1_20(2:end-1) = 2*Pdec1_20(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_21 = abs(fourier2_dec(:,2))/L;
Pdec1_21 = Pdec2_21(1:L/2+1);
Pdec1_21(2:end-1) = 2*Pdec1_21(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_22 = abs(fourier2_dec(:,3))/L;
Pdec1_22 = Pdec2_22(1:L/2+1);
Pdec1_22(2:end-1) = 2*Pdec1_22(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_23 = abs(fourier2_dec(:,4))/L;
Pdec1_23 = Pdec2_23(1:L/2+1);
Pdec1_23(2:end-1) = 2*Pdec1_23(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_24 = abs(fourier2_dec(:,5))/L;
Pdec1_24 = Pdec2_24(1:L/2+1);
Pdec1_24(2:end-1) = 2*Pdec1_24(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_25 = abs(fourier2_dec(:,6))/L;
Pdec1_25 = Pdec2_25(1:L/2+1);
```

```
Pdec1_25(2:end-1) = 2*Pdec1_25(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_26 = abs(fourier2_dec(:,7))/L;
Pdec1_26 = Pdec2_26(1:L/2+1);
Pdec1_26(2:end-1) = 2*Pdec1_26(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_27 = abs(fourier2_dec(:,8))/L;
Pdec1_27 = Pdec2_27(1:L/2+1);
Pdec1_27(2:end-1) = 2*Pdec1_27(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

%%Acceleration GRUPPO 4 December %%

for ii=1:size(datiCuscMIridgruppo0dec)
acc28_dec(ii)=datiCuscMIridgruppo4dec(ii,2);
acc29_dec(ii)=datiCusc1MIridgruppo4dec(ii,2);
acc30_dec(ii)=datiCuscMImot2gruppo4dec(ii,2);
acc31_dec(ii)=datiCusc1MImot2gruppo4dec(ii,2);
acc32_dec(ii)=datiCuscMImotore1gruppo4dec(ii,2);
acc33_dec(ii)=datiCusc1MImotore1gruppo4dec(ii,2);
acc34_dec(ii)=datiCuscHF42gruppo4dec(ii,2);
acc35_dec(ii)=datiCusc1HF42gruppo4dec(ii,2);
acc36_dec(ii)=datiCuscHF41gruppo4dec(ii,2);
acc37_dec(ii)=datiCusc1HF41gruppo4dec(ii,2);
acc38_dec(ii)=datiCuscHA40ridgruppo4dec(ii,2);
acc39_dec(ii)=datiCuscHA40motgruppo4dec(ii,2);
end

acceleration4_dec=[acc28_dec acc29_dec acc30_dec acc31_dec acc32_dec
acc33_dec acc34_dec acc35_dec acc36_dec acc37_dec acc38_dec acc39_dec];

%ANALISI IN VELOCITA' PER BASSE FREQUENZE GRUPPO 4 DECEMBER %%

velocita4_dec = cumtrapz(acceleration4_dec);
velocita4_c_dec = velocita4_dec/1;
fourier4_dec=real(fft(velocita4_c_dec,L));

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_28 = abs(fourier4_dec(:,1))/L;
Pdec1_28 = Pdec2_28(1:L/2+1);
Pdec1_28(2:end-1) = 2*Pdec1_28(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_29 = abs(fourier4_dec(:,2))/L;
Pdec1_29 = Pdec2_29(1:L/2+1);
Pdec1_29(2:end-1) = 2*Pdec1_29(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_30 = abs(fourier4_dec(:,3))/L;
Pdec1_30 = Pdec2_30(1:L/2+1);
Pdec1_30(2:end-1) = 2*Pdec1_30(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_31 = abs(fourier4_dec(:,4))/L;
Pdec1_31 = Pdec2_31(1:L/2+1);
Pdec1_31(2:end-1) = 2*Pdec1_31(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_32 = abs(fourier4_dec(:,5))/L;
Pdec1_32 = Pdec2_32(1:L/2+1);
Pdec1_32(2:end-1) = 2*Pdec1_32(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_33 = abs(fourier4_dec(:,6))/L;
Pdec1_33 = Pdec2_33(1:L/2+1);
Pdec1_33(2:end-1) = 2*Pdec1_33(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_34 = abs(fourier4_dec(:,7))/L;
```

```
Pdec1_34 = Pdec2_34(1:L/2+1);
Pdec1_34(2:end-1) = 2*Pdec1_34(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_35 = abs(fourier4_dec(:,8))/L;
Pdec1_35 = Pdec2_35(1:L/2+1);
Pdec1_35(2:end-1) = 2*Pdec1_35(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_36 = abs(fourier4_dec(:,9))/L;
Pdec1_36 = Pdec2_36(1:L/2+1);
Pdec1_36(2:end-1) = 2*Pdec1_36(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_37 = abs(fourier4_dec(:,10))/L;
Pdec1_37 = Pdec2_37(1:L/2+1);
Pdec1_37(2:end-1) = 2*Pdec1_37(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_38 = abs(fourier4_dec(:,11))/L;
Pdec1_38 = Pdec2_38(1:L/2+1);
Pdec1_38(2:end-1) = 2*Pdec1_38(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_39 = abs(fourier4_dec(:,12))/L;
Pdec1_39 = Pdec2_39(1:L/2+1);
Pdec1_39(2:end-1) = 2*Pdec1_39(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

%Acceleration GRUPPO 5 December
for ii=1:size(datiCuscMIridgruppo0dec)
acc40_dec(ii)=datiCuscMIridgruppo5dec(ii,2);
acc41_dec(ii)=datiCusc1MIridgruppo5dec(ii,2);
acc42_dec(ii)=datiCuscMImotoreBgruppo5dec(ii,2);
acc43_dec(ii)=datiCusc1MImotoreBgruppo5dec(ii,2);
acc44_dec(ii)=datiCuscMImotoreAgruppo5dec(ii,2);
acc45_dec(ii)=datiCusc1MImotoreAgruppo5dec(ii,2);
acc46_dec(ii)=datiCuscHF56gruppo5dec(ii,2);
acc47_dec(ii)=datiCusc1HF56gruppo5dec(ii,2);
acc48_dec(ii)=datiCuscHF55gruppo5dec(ii,2);
acc49_dec(ii)=datiCusc1HF55gruppo5dec(ii,2);
acc50_dec(ii)=datiCusc2HF55gruppo5dec(ii,2);
acc51_dec(ii)=datiCuscHF54gruppo5dec(ii,2);
acc52_dec(ii)=datiCusc1HF54gruppo5dec(ii,2);
acc53_dec(ii)=datiCusc2HF54gruppo5dec(ii,2);
acc54_dec(ii)=datiCuscHF53gruppo5dec(ii,2);
acc55_dec(ii)=datiCusc1HF53gruppo5dec(ii,2);
acc56_dec(ii)=datiCusc2HF53gruppo5dec(ii,2);
acc57_dec(ii)=datiCuscHA51ridgruppo5dec(ii,2);
acc58_dec(ii)=datiCuscHA51motgruppo5dec(ii,2);
acc59_dec(ii)=datiCusc1HA51motgruppo5dec(ii,2);
end

acceleration5_dec=[acc40_dec acc41_dec acc42_dec acc43_dec acc44_dec
acc45_dec acc46_dec acc47_dec acc48_dec acc49_dec acc50_dec acc51_dec
acc52_dec acc53_dec acc54_dec acc55_dec acc56_dec acc57_dec acc58_dec
acc59_dec];

%ANALISI IN VELOCITA' PER BASSE FREQUENZE GRUPPO 5 DECEMBER %%

velocita5_dec = cumtrapz(acceleration5_dec);
velocita5_c_dec = velocita5_dec/1;
fourier5_dec=real(fft(velocita5_c_dec,L));

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_40 = abs(fourier5_dec(:,1))/L;
Pdec1_40 = Pdec2_40(1:L/2+1);
Pdec1_40(2:end-1) = 2*Pdec1_40(2:end-1);
```

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_41 = abs(fourier5_dec(:,2))/L;
Pdec1_41 = Pdec2_41(1:L/2+1);
Pdec1_41(2:end-1) = 2*Pdec1_41(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_42 = abs(fourier5_dec(:,3))/L;
Pdec1_42 = Pdec2_42(1:L/2+1);
Pdec1_42(2:end-1) = 2*Pdec1_42(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_43 = abs(fourier5_dec(:,4))/L;
Pdec1_43 = Pdec2_43(1:L/2+1);
Pdec1_43(2:end-1) = 2*Pdec1_43(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_44 = abs(fourier5_dec(:,5))/L;
Pdec1_44 = Pdec2_44(1:L/2+1);
Pdec1_44(2:end-1) = 2*Pdec1_44(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_45 = abs(fourier5_dec(:,6))/L;
Pdec1_45 = Pdec2_45(1:L/2+1);
Pdec1_45(2:end-1) = 2*Pdec1_45(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_46 = abs(fourier5_dec(:,7))/L;
Pdec1_46 = Pdec2_46(1:L/2+1);
Pdec1_46(2:end-1) = 2*Pdec1_46(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_47 = abs(fourier5_dec(:,8))/L;
Pdec1_47 = Pdec2_47(1:L/2+1);
Pdec1_47(2:end-1) = 2*Pdec1_47(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_48 = abs(fourier5_dec(:,9))/L;
Pdec1_48 = Pdec2_48(1:L/2+1);
Pdec1_48(2:end-1) = 2*Pdec1_48(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_49 = abs(fourier5_dec(:,10))/L;
Pdec1_49 = Pdec2_49(1:L/2+1);
Pdec1_49(2:end-1) = 2*Pdec1_49(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_50 = abs(fourier5_dec(:,11))/L;
Pdec1_50 = Pdec2_50(1:L/2+1);
Pdec1_50(2:end-1) = 2*Pdec1_50(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_51 = abs(fourier5_dec(:,12))/L;
Pdec1_51 = Pdec2_51(1:L/2+1);
Pdec1_51(2:end-1) = 2*Pdec1_51(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_52 = abs(fourier5_dec(:,13))/L;
Pdec1_52 = Pdec2_52(1:L/2+1);
Pdec1_52(2:end-1) = 2*Pdec1_52(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_53 = abs(fourier5_dec(:,14))/L;
Pdec1_53 = Pdec2_53(1:L/2+1);
Pdec1_53(2:end-1) = 2*Pdec1_53(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_54 = abs(fourier5_dec(:,15))/L;
Pdec1_54 = Pdec2_54(1:L/2+1);
Pdec1_54(2:end-1) = 2*Pdec1_54(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_55 = abs(fourier5_dec(:,16))/L;
Pdec1_55 = Pdec2_55(1:L/2+1);
Pdec1_55(2:end-1) = 2*Pdec1_55(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_56 = abs(fourier5_dec(:,17))/L;
Pdec1_56 = Pdec2_56(1:L/2+1);
Pdec1_56(2:end-1) = 2*Pdec1_56(2:end-1);
```

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_57 = abs(fourier5_dec(:,18))/L;
Pdec1_57 = Pdec2_57(1:L/2+1);
Pdec1_57(2:end-1) = 2*Pdec1_57(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_58 = abs(fourier5_dec(:,19))/L;
Pdec1_58 = Pdec2_58(1:L/2+1);
Pdec1_58(2:end-1) = 2*Pdec1_58(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_59 = abs(fourier5_dec(:,20))/L;
Pdec1_59 = Pdec2_59(1:L/2+1);
Pdec1_59(2:end-1) = 2*Pdec1_59(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

%Acceleration GRUPPO6 DECEMBER
for ii=1:size(datiCuscMIridgruppo0dec)
acc60_dec(ii)=datiCuscMIridgruppo6dec(ii,2);
acc61_dec(ii)=datiCusc1MIridgruppo6dec(ii,2);
acc62_dec(ii)=datiCuscMImotore2gruppo6dec(ii,2);
acc63_dec(ii)=datiCusc1MImotore2gruppo6dec(ii,2);
acc64_dec(ii)=datiCuscMImotore1gruppo6dec(ii,2);
acc65_dec(ii)=datiCusc1MImotore1gruppo6dec(ii,2);
acc66_dec(ii)=datiCuscHF64gruppo6dec(ii,2);
acc67_dec(ii)=datiCuscHF63gruppo6dec(ii,2);
acc68_dec(ii)=datiCusc1HF63gruppo6dec(ii,2);
acc69_dec(ii)=datiCuscHF62gruppo6dec(ii,2);
acc70_dec(ii)=datiCuscHF61gruppo6dec(ii,2);
acc71_dec(ii)=datiCusc1HF61gruppo6dec(ii,2);
acc72_dec(ii)=datiCuscHA62gruppo6dec(ii,2);
acc73_dec(ii)=datiCusc1HA62gruppo6dec(ii,2);
acc74_dec(ii)=datiCuscHA61gruppo6dec(ii,2);
acc75_dec(ii)=datiCusc1HA61gruppo6dec(ii,2);
end

acceleration6_dec=[acc60_dec acc61_dec acc62_dec acc63_dec acc64_dec
acc65_dec acc66_dec acc67_dec acc68_dec acc69_dec acc70_dec acc71_dec
acc72_dec acc73_dec acc74_dec acc75_dec];

%ANALISI IN VELOCITA' PER BASSE FREQUENZE GRUPPO 6 DECEMBER %%

velocita6_dec = cumtrapz(acceleration6_dec);
velocita6_c_dec = velocita6_dec/1;
fourier6_dec=real(fft(velocita6_c_dec,L));

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_60 = abs(fourier6_dec(:,1))/L;
Pdec1_60 = Pdec2_60(1:L/2+1);
Pdec1_60(2:end-1) = 2*Pdec1_60(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_61 = abs(fourier6_dec(:,2))/L;
Pdec1_61 = Pdec2_61(1:L/2+1);
Pdec1_61(2:end-1) = 2*Pdec1_61(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_62 = abs(fourier6_dec(:,3))/L;
Pdec1_62 = Pdec2_62(1:L/2+1);
Pdec1_62(2:end-1) = 2*Pdec1_62(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_63 = abs(fourier6_dec(:,4))/L;
Pdec1_63 = Pdec2_63(1:L/2+1);
Pdec1_63(2:end-1) = 2*Pdec1_63(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_64 = abs(fourier6_dec(:,5))/L;
Pdec1_64 = Pdec2_64(1:L/2+1);
```

```
Pdec1_64(2:end-1) = 2*Pdec1_64(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_65 = abs(fourier6_dec(:,6))/L;
Pdec1_65 = Pdec2_65(1:L/2+1);
Pdec1_65(2:end-1) = 2*Pdec1_65(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_66 = abs(fourier6_dec(:,7))/L;
Pdec1_66 = Pdec2_66(1:L/2+1);
Pdec1_66(2:end-1) = 2*Pdec1_66(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_67 = abs(fourier6_dec(:,8))/L;
Pdec1_67 = Pdec2_67(1:L/2+1);
Pdec1_67(2:end-1) = 2*Pdec1_67(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_68 = abs(fourier6_dec(:,9))/L;
Pdec1_68 = Pdec2_68(1:L/2+1);
Pdec1_68(2:end-1) = 2*Pdec1_68(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_69 = abs(fourier6_dec(:,10))/L;
Pdec1_69 = Pdec2_69(1:L/2+1);
Pdec1_69(2:end-1) = 2*Pdec1_69(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_70 = abs(fourier6_dec(:,11))/L;
Pdec1_70 = Pdec2_70(1:L/2+1);
Pdec1_70(2:end-1) = 2*Pdec1_70(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_71 = abs(fourier6_dec(:,12))/L;
Pdec1_71 = Pdec2_71(1:L/2+1);
Pdec1_71(2:end-1) = 2*Pdec1_71(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_72 = abs(fourier6_dec(:,13))/L;
Pdec1_72 = Pdec2_72(1:L/2+1);
Pdec1_72(2:end-1) = 2*Pdec1_72(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_73 = abs(fourier6_dec(:,14))/L;
Pdec1_73 = Pdec2_73(1:L/2+1);
Pdec1_73(2:end-1) = 2*Pdec1_73(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_74 = abs(fourier6_dec(:,15))/L;
Pdec1_74 = Pdec2_74(1:L/2+1);
Pdec1_74(2:end-1) = 2*Pdec1_74(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pdec2_75 = abs(fourier6_dec(:,16))/L;
Pdec1_75 = Pdec2_75(1:L/2+1);
Pdec1_75(2:end-1) = 2*Pdec1_75(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%



%% Vibration Monitoring Novembre 2016

%GRUPPO0 MI motore B
datiCuscMImotoreBgruppo0nov=load('Nov_2016_CuscMImotoreBgruppo0.txt');

%GRUPPO1 MI RID
datiCuscMIridgruppo1nov=load('Nov_2016_CuscMIridgruppo1.txt');

%GRUPPO1 HA13
datiCuscHA13ridgruppo1nov=load('Nov_2016_CuscHA13ridgruppo1.txt');

%GRUPPO1 HF25
datiCusc1HF25gruppo1nov=load('Nov_2016_Cusc1HF25gruppo1.txt');
```

```
%GRUPPO2 HF26
datiCusc2HF26gruppo2nov=load('Nov_2016_Cusc2HF26gruppo2.txt');

%GRUPPO2 HA23
datiCusc1HA23ridgruppo2nov=load('Nov_2016_Cusc1HA23ridgruppo2.txt');

%GRUPPO5 MI motore A
datiCusc1MImotoreAgruppo5nov=load('Nov_2016_Cusc1MImotoreAgruppo5.txt');

%GRUPPO6 HF61
datiCuscHF61gruppo6nov=load('Nov_2016_CuscHF61gruppo6.txt');
datiCusc2HF61gruppo6nov=load('Nov_2016_Cusc2HF61gruppo6.txt');

%GRUPPO6 HA62
datiCusc1HA62ridgruppo6nov=load('Nov_2016_CuscHA62ridgruppo6.txt');

%GRUPPO6 HA61
datiCuscHA61ridgruppo6nov=load('Nov_2016_CuscHA61ridgruppo6.txt');

%GRUPPO6 HF62
datiCusc2HF62gruppo6nov=load('Nov_2016_Cusc2HF62gruppo6.txt');
datiCusc1HF62gruppo6nov=load('Nov_2016_Cusc1HF62gruppo6.txt');

%creazione vettore accelerazione misure novembre

acc1_nov=zeros(size(datiCuscMImotoreBgruppo0nov(:,1)));
acc2_nov=zeros(size(datiCuscMIridgruppo1nov(:,1)));
acc3_nov=zeros(size(datiCuscHA13ridgruppo1nov(:,1)));
acc4_nov=zeros(size(datiCusc1HF25gruppo1nov(:,1)));
acc5_nov=zeros(size(datiCusc2HF26gruppo2nov(:,1)));
acc6_nov=zeros(size(datiCusc1HA23ridgruppo2nov(:,1)));
acc7_nov=zeros(size(datiCusc1MImotoreAgruppo5nov(:,1)));
acc8_nov=zeros(size(datiCuscHF61gruppo6nov(:,1)));
acc9_nov=zeros(size(datiCusc2HF61gruppo6nov(:,1)));
acc10_nov=zeros(size(datiCusc1HA62ridgruppo6nov(:,1)));
acc11_nov=zeros(size(datiCuscHA61ridgruppo6nov(:,1)));
acc12_nov=zeros(size(datiCusc2HF62gruppo6nov(:,1)));
acc13_nov=zeros(size(datiCusc1HF62gruppo6nov(:,1)));


%Accelerazioni GRUPPO 0 November

for ii=1:size(datiCuscMImotoreBgruppo0nov)
acc1_nov(ii)=datiCuscMImotoreBgruppo0nov(ii,2);

end
acceleration1_nov =[acc1_nov];

%ANALISI IN VELOCITA' PER BASSE FREQUENZE GRUPPO 0 NOVEMBER %%

velocita1_nov = cumtrapz(acceleration1_nov);
velocita1_c_nov = velocita1_nov/1;
fourier1_nov=real(fft(velocita1_c_nov,L));

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pnov2_1 = abs(fourier1_nov(:,1))/L;
Pnov1_1 = Pnov2_1(1:L/2+1);
Pnov1_1(2:end-1) = 2*Pnov1_1(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
```

```
%Accelerazioni GRUPPO 1 e 2 November

for ii=1:size(datiCuscMImotoreBgruppo0nov)
acc2_nov(ii)=datiCuscMIridgruppo1nov(ii,2);
acc3_nov(ii)=datiCuscHA13ridgruppo1nov(ii,2);
acc4_nov(ii)=datiCusc1HF25gruppo1nov(ii,2);
end

acceleration2_nov=[acc2_nov acc3_nov acc4_nov];

%ANALISI IN VELOCITA' PER BASSE FREQUENZE GRUPPO 1 NOVEMBER %%

velocita2_nov = cumtrapz(acceleration2_nov);
velocita2_c_nov = velocita2_nov/1;
fourier2_nov=real(fft(velocita2_c_nov,L));

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pnov2_2 = abs(fourier2_nov(:,1))/L;
Pnov1_2 = Pnov2_2(1:L/2+1);
Pnov1_2(2:end-1) = 2*Pnov1_2(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pnov2_3 = abs(fourier2_nov(:,2))/L;
Pnov1_3 = Pnov2_2(1:L/2+1);
Pnov1_3(2:end-1) = 2*Pnov1_2(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pnov2_4 = abs(fourier2_nov(:,3))/L;
Pnov1_4 = Pnov2_4(1:L/2+1);
Pnov1_4(2:end-1) = 2*Pnov1_4(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

%Accelerazioni GRUPPO 2 November

for ii=1:size(datiCuscMImotoreBgruppo0nov)
acc5_nov(ii)=datiCusc2HF26gruppo2nov(ii,2);
acc6_nov(ii)=datiCusc1HA23ridgruppo2nov(ii,2);
end

acceleration3_nov=[acc5_nov acc6_nov];

%ANALISI IN VELOCITA' PER BASSE FREQUENZE GRUPPO 2 NOVEMBER %%

velocita3_nov = cumtrapz(acceleration3_nov);
velocita3_c_nov = velocita3_nov/1;
fourier3_nov=real(fft(velocita3_c_nov,L));

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pnov2_5 = abs(fourier3_nov(:,1))/L;
Pnov1_5 = Pnov2_5(1:L/2+1);
Pnov1_5(2:end-1) = 2*Pnov1_5(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pnov2_6 = abs(fourier3_nov(:,2))/L;
Pnov1_6 = Pnov2_6(1:L/2+1);
Pnov1_6(2:end-1) = 2*Pnov1_6(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%


%Accelerazioni GRUPPO 5 November

for ii=1:size(datiCuscMImotoreBgruppo0nov)
acc7_nov(ii)=datiCusc1MImotoreAgruppo5nov(ii,2);
```

```
end

acceleration4_nov=[acc7_nov];

%ANALISI IN VELOCITA' PER BASSE FREQUENZE GRUPPO 5 NOVEMBER %%

velocita4_nov = cumtrapz(acceleration4_nov);
velocita4_c_nov = velocita4_nov/1;
fourier4_nov=real(fft(velocita4_c_nov,L));

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pnov2_7 = abs(fourier4_nov(:,1))/L;
Pnov1_7 = Pnov2_7(1:L/2+1);
Pnov1_7(2:end-1) = 2*Pnov1_7(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%


%Accelerazioni GRUPPO 6 November

for ii=1:size(datiCuscMImotoreBgruppo0nov)
acc8_nov(ii)=datiCuscHF61gruppo6nov(ii,2);
acc9_nov(ii)=datiCusc2HF61gruppo6nov(ii,2);
acc10_nov(ii)=datiCusc1HA62ridgruppo6nov(ii,2);
acc11_nov(ii)=datiCuscHA61ridgruppo6nov(ii,2);
acc12_nov(ii)=datiCusc2HF62gruppo6nov(ii,2);
acc13_nov(ii)=datiCusc1HF62gruppo6nov(ii,2);

end
acceleration5_nov=[acc8_nov acc9_nov acc10_nov acc11_nov acc12_nov
acc13_nov];

%ANALISI IN VELOCITA' PER BASSE FREQUENZE GRUPPO 6 NOVEMBER %%

velocita5_nov = cumtrapz(acceleration5_nov);
velocita5_c_nov = velocita5_nov/1;
fourier5_nov=real(fft(velocita5_c_nov,L));

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pnov2_8 = abs(fourier5_nov(:,1))/L;
Pnov1_8 = Pnov2_8(1:L/2+1);
Pnov1_8(2:end-1) = 2*Pnov1_8(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pnov2_9 = abs(fourier5_nov(:,2))/L;
Pnov1_9 = Pnov2_9(1:L/2+1);
Pnov1_9(2:end-1) = 2*Pnov1_9(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pnov2_10 = abs(fourier5_nov(:,3))/L;
Pnov1_10 = Pnov2_10(1:L/2+1);
Pnov1_10(2:end-1) = 2*Pnov1_10(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pnov2_11 = abs(fourier5_nov(:,4))/L;
Pnov1_11 = Pnov2_11(1:L/2+1);
Pnov1_11(2:end-1) = 2*Pnov1_11(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pnov2_12 = abs(fourier5_nov(:,5))/L;
Pnov1_12 = Pnov2_12(1:L/2+1);
Pnov1_12(2:end-1) = 2*Pnov1_12(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pnov2_13 = abs(fourier5_nov(:,6))/L;
Pnov1_13 = Pnov2_13(1:L/2+1);
Pnov1_13(2:end-1) = 2*Pnov1_13(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
```

```
spectmatrix4=[Pnov1_1 Pnov1_2 Pnov1_3 Pnov1_4 Pnov1_5 Pnov1_6 Pnov1_7
Pnov1_8 Pnov1_9 Pnov1_10 Pnov1_11 Pnov1_12 Pnov1_13];
[PEAK_Nov2016,Ind_Peak_nov2016]=max(spectmatrix4(2:600,:));
%%massimi picchi alle armoniche fondamentali




%% Grafici FFT velocit‡ historical baseline HF15

figure(1)
plot(fs,Pmay1_1_4,'b')
title({'HF15 gruppo 1 may 2016 point 1'});
xlim([0.733797401825683 600]);
ylim([0 3]);
grid minor
print -dpng -f1 HF15gruppo1may2016point1.png
figure(2)
plot(fs,Pmay2_1_1,'b')
title({'HF15 gruppo 1 may 2017 point 1'});
xlim([0.733797401825683 600]);
ylim([0 3]);
grid minor
print -dpng -f2 HF15gruppo1may2017point1.png

figure(3)
plot(fs,Pdec1_17,'b')
title({'HF15 gruppo 1 december 2017 point 1'});
xlim([0.733797401825683 600]);
ylim([0 3]);
grid minor
print -dpng -f3 HF15gruppo1december2017point1.png



figure(4)
plot(fs,Pmay1_1_6,'b')
title({'HF15 gruppo 1 may 2016 point 2'});
xlim([0.733797401825683 600]);
ylim([0 3]);
grid minor
print -dpng -f4 HF15gruppo1may2016point2.png
figure(5)
plot(fs,Pmay2_1_2,'b')
title({'HF15 gruppo 1 may 2017 point 2'});
xlim([0.733797401825683 600]);
ylim([0 3]);
grid minor
print -dpng -f5 HF15gruppo1may2017point2.png



%% Grafici FFT velocit‡ historical baseline HF14

figure(6)
plot(fs,Pmay1_1_3,'b')
title({'HF14 gruppo 1 may 2016 point 1'});
xlim([0.733797401825683 600]);
ylim([0 3]);
```

```
grid minor
print -dpng -f6 HF14gruppo1may2016point1.png

figure(7)
plot(fs,Pdec1_18,'b')
title({'HF14 gruppo 1 dec 2017 point 1'});
xlim([0.733797401825683 600]);
ylim([0 3]);
grid minor
print -dpng -f7 HF14gruppo1dec2017point1.png

%% Grafici FFT velocit‡ historical baseline HF26

figure(8)
plot(fs,Pnov1_5,'b')
title({'HF26 gruppo 2 nov 2016'});
xlim([0.733797401825683 600]);
ylim([0 3]);
grid minor
print -dpng -f8 HF26gruppo2nov2016.png
figure(9)
plot(fs,Pdec1_24,'b')
title({'HF26 gruppo 2 dec 2017'});
xlim([0.733797401825683 600]);
ylim([0 3]);
grid minor
print -dpng -f9 HF26gruppo2dec2017.png

%% Grafici FFT velocit‡ historical baseline HA40 rid

figure(10)
plot(fs,Pmay1_1_7,'b')
title({'HA40 Rid gruppo 4 may 2016'});
xlim([0.733797401825683 600]);
ylim([0 3]);
grid minor
print -dpng -f10 HA40Ridgruppo4may2016.png
figure(11)
plot(fs,Pdec1_38,'b')
title({'HA40 Rid gruppo 4 dec 2017'});
xlim([0.733797401825683 600]);
ylim([0 3]);
grid minor
print -dpng -f11 HA40Ridgruppo4dec2017.png

%% Grafici FFT velocit‡ historical baseline HF53

figure(12)
plot(fs,Pmay1_1_8,'b')
title({'HF53 gruppo 5 may 2016 point 1'});
xlim([0.733797401825683 600]);
ylim([0 3]);
grid minor
print -dpng -f12 HF53gruppo5may2016point1.png
figure(13)
plot(fs,Pdec1_54,'b')
title({'HF53 gruppo 5 dec 2017 point 1'});
xlim([0.733797401825683 600]);
ylim([0 3]);
grid minor
print -dpng -f13 HF53gruppo5dec2017point1.png
figure(14)
plot(fs,Pmay1_1_9,'b')
```

```
title({'HF53 gruppo 5 may 2016 point 2'});
xlim([0.733797401825683 600]);
ylim([0 3]);
grid minor
print -dpng -f14 HF53gruppo5may2016point2.png
figure(15)
plot(fs,Pdec1_55,'b')
title({'HF53 gruppo 5 dec 2017 point 2'});
xlim([0.733797401825683 600]);
ylim([0 3]);
grid minor
print -dpng -f15 HF53gruppo5dec2017point2.png

%% Grafici FFT velocit‡ historical baseline HF54
figure(16)
plot(fs,Pmay1_1_10,'b')
title({'HF54 gruppo 5 may 2016 point 1'});
xlim([0.733797401825683 600]);
ylim([0 3]);
grid minor
print -dpng -f16 HF54gruppo5may2016point1.png
figure(17)
plot(fs,Pdec1_51,'b')
title({'HF54 gruppo 5 dec 2017 point 1'});
xlim([0.733797401825683 600]);
ylim([0 3]);
grid minor
print -dpng -f17 HF54gruppo5dec2017point1.png


%% Grafici FFT velocit‡ historical baseline HF55
figure(20)
plot(fs,Pmay1_1_11,'b')
title({'HF55 gruppo 5 may 2016 point 1'});
xlim([0.733797401825683 600]);
ylim([0 3]);
grid minor
print -dpng -f20 HF55gruppo5may2016point1.png
figure(21)
plot(fs,Pdec1_48,'b')
title({'HF55 gruppo 5 dec 2017 point 1'});
xlim([0.733797401825683 600]);
ylim([0 3]);
grid minor
print -dpng -f21 HF55gruppo5dec2017point1.png



%% Grafici FFT velocit‡ historical baseline HF61
figure(22)
plot(fs,Pnov1_8,'b')
title({'HF61 gruppo 6 nov 2016 point 1'});
xlim([0.733797401825683 600]);
ylim([0 3]);
grid minor
print -dpng -f22 HF61gruppo6nov2016point1.png
figure(23)
plot(fs,Pdec1_70,'b')
title({'HF61 gruppo 6 dec 2017 point 1'});
xlim([0.733797401825683 600]);
ylim([0 3]);
grid minor
print -dpng -f23 HF61gruppo6dec2017point1.png
```

```
%% Vibrations monitoring May2018 %%

%GRUPPO1 HF14
datiCusc1HF14may2018=load('May2018HF14cusc_1.txt');

%GRUPPO1 HF14
datiCusc2HF14may2018=load('May2018HF14cusc_2.txt');

%GRUPPO1 HF15 1
datiCusc1HF15may2018=load('May2018HF15cusc_1.txt');

%GRUPPO1 HF15 2
datiCusc2HF15may2018=load('May2018HF15cusc_2.txt');

%GRUPPO1 HF15 3
datiCusc3HF15may2018=load('May2018HF15cusc_3.txt');

%GRUPPO5 HF53 1
datiCusc1HF53may2018=load('May2018HF53cusc_1.txt');

%GRUPPO5 HF53 2
datiCusc2HF53may2018=load('May2018HF53cusc_2.txt');

%GRUPPO5 HF54 1
datiCusc1HF54may2018=load('May2018HF54cusc_1.txt');

%GRUPPO5 HF54 2
datiCusc2HF54may2018=load('May2018HF54cusc_2.txt');

%GRUPPO5 HF55 1
datiCusc1HF55may2018=load('May2018HF55cusc_1.txt');

%GRUPPO5 HF55 2
datiCusc2HF55may2018=load('May2018HF55cusc_2.txt');

%GRUPPO6 HF61 1
datiCusc1HF61may2018=load('May2018HF61cusc_1.txt');

%GRUPPO6 HF61 2
datiCusc2HF61may2018=load('May2018HF61cusc_2.txt');

%GRUPPO6 HF61 3
datiCusc3HF61may2018=load('May2018HF61cusc_3.txt');

%creazione vettore accelerazione misure maggio 2018

acc1_may18=zeros(size(datiCusc1HF14may2018(:,1)));
acc2_may18=zeros(size(datiCusc2HF14may2018(:,1)));
acc3_may18=zeros(size(datiCusc1HF15may2018(:,1)));
acc4_may18=zeros(size(datiCusc2HF15may2018(:,1)));
acc5_may18=zeros(size(datiCusc3HF15may2018(:,1)));
acc6_may18=zeros(size(datiCusc1HF53may2018(:,1)));
acc7_may18=zeros(size(datiCusc2HF53may2018(:,1)));
acc8_may18=zeros(size(datiCusc1HF54may2018(:,1)));
acc9_may18=zeros(size(datiCusc2HF54may2018(:,1)));
acc10_may18=zeros(size(datiCusc1HF55may2018(:,1)));
acc11_may18=zeros(size(datiCusc2HF55may2018(:,1)));
acc12_may18=zeros(size(datiCusc1HF61may2018(:,1)));
acc13_may18=zeros(size(datiCusc2HF61may2018(:,1)));
acc14_may18=zeros(size(datiCusc3HF61may2018(:,1)));
```

```
%Accelerazioni GRUPPO 1 May2018
for ii=1:size(datiCusc1HF14may2018)
acc1_may18(ii)=datiCusc1HF14may2018(ii,2);
acc2_may18(ii)=datiCusc2HF14may2018(ii,2);
acc3_may18(ii)=datiCusc1HF15may2018(ii,2);
acc4_may18(ii)=datiCusc2HF15may2018(ii,2);
acc5_may18(ii)=datiCusc3HF15may2018(ii,2);

end
acceleration1_may18 =[acc1_may18 acc2_may18 acc3_may18 acc4_may18
acc5_may18];

%ANALISI IN VELOCITA' PER BASSE FREQUENZE GRUPPO 1 MAY %%

velocita1_may18 = cumtrapz(acceleration1_may18);
velocita1_c_may18 = velocita1_may18/1;
fourier1_may18=real(fft(velocita1_c_may18,L));

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pmay18_2_1 = abs(fourier1_may18(:,1))/L;
Pmay18_1_1 = Pmay18_2_1(1:L/2+1);
Pmay18_1_1(2:end-1) = 2*Pmay18_1_1(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pmay18_2_2=abs(fourier1_may18(:,2))/L;
Pmay18_1_2=Pmay18_2_2(1:L/2+1);
Pmay18_1_2(2:end-1)=2*Pmay18_1_2(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pmay18_2_3=abs(fourier1_may18(:,3))/L;
Pmay18_1_3=Pmay18_2_3(1:L/2+1);
Pmay18_1_3(2:end-1)=2*Pmay18_1_3(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pmay18_2_4=abs(fourier1_may18(:,4))/L;
Pmay18_1_4=Pmay18_2_4(1:L/2+1);
Pmay18_1_4(2:end-1)=2*Pmay18_1_4(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pmay18_2_5=abs(fourier1_may18(:,5))/L;
Pmay18_1_5=Pmay18_2_5(1:L/2+1);
Pmay18_1_5(2:end-1)=2*Pmay18_1_5(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

%Accelerazioni GRUPPO 5 May2018
for ii=1:size(datiCusc1HF14may2018)
acc6_may18(ii)=datiCusc1HF53may2018(ii,2);
acc7_may18(ii)=datiCusc2HF53may2018(ii,2);
acc8_may18(ii)=datiCusc1HF54may2018(ii,2);
acc9_may18(ii)=datiCusc2HF54may2018(ii,2);
acc10_may18(ii)=datiCusc1HF55may2018(ii,2);
acc11_may18(ii)=datiCusc2HF55may2018(ii,2);
end
acceleration2_may18 =[acc6_may18 acc7_may18 acc8_may18 acc9_may18
acc10_may18 acc11_may18];

%ANALISI IN VELOCITA' PER BASSE FREQUENZE GRUPPO 5 MAY2018 %%

velocita2_may18 = cumtrapz(acceleration2_may18);
velocita2_c_may18 = velocita2_may18/1;
fourier2_may18=real(fft(velocita2_c_may18,L));

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pmay18_2_6 = abs(fourier2_may18(:,1))/L;
Pmay18_1_6 = Pmay18_2_6(1:L/2+1);
```

```
Pmay18_1_6(2:end-1) = 2*Pmay18_1_6(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pmay18_2_7=abs(fourier2_may18(:,2))/L;
Pmay18_1_7=Pmay18_2_7(1:L/2+1);
Pmay18_1_7(2:end-1)=2*Pmay18_1_7(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pmay18_2_8=abs(fourier2_may18(:,3))/L;
Pmay18_1_8=Pmay18_2_8(1:L/2+1);
Pmay18_1_8(2:end-1)=2*Pmay18_1_8(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pmay18_2_9=abs(fourier2_may18(:,4))/L;
Pmay18_1_9=Pmay18_2_9(1:L/2+1);
Pmay18_1_9(2:end-1)=2*Pmay18_1_9(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pmay18_2_10=abs(fourier2_may18(:,5))/L;
Pmay18_1_10=Pmay18_2_10(1:L/2+1);
Pmay18_1_10(2:end-1)=2*Pmay18_1_10(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pmay18_2_11=abs(fourier2_may18(:,5))/L;
Pmay18_1_11=Pmay18_2_11(1:L/2+1);
Pmay18_1_11(2:end-1)=2*Pmay18_1_11(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

%Accelerazioni GRUPPO 6 May2018
for ii=1:size(datiCusc1HF14may2018)
acc12_may18(ii)=datiCusc1HF61may2018(ii,2);
acc13_may18(ii)=datiCusc2HF61may2018(ii,2);
acc14_may18(ii)=datiCusc3HF61may2018(ii,2);
end
acceleration3_may18 =[acc12_may18 acc13_may18 acc14_may18];

%ANALISI IN VELOCITA' PER BASSE FREQUENZE GRUPPO 6 MAY2018 %%

velocita3_may18 = cumtrapz(acceleration3_may18);
velocita3_c_may18 = velocita3_may18/1;
fourier3_may18=real(fft(velocita3_c_may18,L));

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pmay18_2_12 = abs(fourier3_may18(:,1))/L;
Pmay18_1_12 = Pmay18_2_12(1:L/2+1);
Pmay18_1_12(2:end-1) = 2*Pmay18_1_12(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pmay18_2_13=abs(fourier3_may18(:,2))/L;
Pmay18_1_13=Pmay18_2_7(1:L/2+1);
Pmay18_1_13(2:end-1)=2*Pmay18_1_13(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Pmay18_2_14=abs(fourier2_may18(:,3))/L;
Pmay18_1_14=Pmay18_2_14(1:L/2+1);
Pmay18_1_14(2:end-1)=2*Pmay18_1_14(2:end-1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%


%% Grafici FFT May2018

figure(24)
plot(fs,Pmay18_1_1,'b')
title({'HF14 gruppo 1 may 2018 point 1'});
xlim([0.733797401825683 600]);
ylim([0 3]);
grid minor
print -dpng -f24 HF14gruppo1may2018point1.png

figure(25)
```

```
plot(fs,Pmay18_1_3,'b')
title({'HF15 gruppo 1 may 2018 point 1'});
xlim([0.733797401825683 600]);
ylim([0 3]);
grid minor
print -dpng -f25 HF15gruppo1may2018point1.png

figure(26)
plot(fs,Pmay18_1_4,'b')
title({'HF15 gruppo 1 may 2018 point 1'});
xlim([0.733797401825683 600]);
ylim([0 3]);
grid minor
print -dpng -f26 HF15gruppo1may2018point1.png


figure(27)
plot(fs,Pmay18_1_4,'b')
title({'HF15 gruppo 1 may 2018 point 1'});
xlim([0.733797401825683 600]);
ylim([0 3]);
grid minor
print -dpng -f27 HF15gruppo1may2018point1.png

figure(28)
plot(fs,Pmay18_1_6 ,'b')
title({'HF53 gruppo 5 may 2018 point 1'});
xlim([0.733797401825683 600]);
ylim([0 3]);
grid minor
print -dpng -f28 HF53gruppo5may2018point1.png

figure(29)
plot(fs,Pmay18_1_7 ,'b')
title({'HF53 gruppo 5 may 2018 point 2'});
xlim([0.733797401825683 600]);
ylim([0 3]);
grid minor
print -dpng -f29 HF53gruppo5may2018point2.png

figure(30)
plot(fs,Pmay18_1_8,'b')
title({'HF54 gruppo 5 may 2018 point 1'});
xlim([0.733797401825683 600]);
ylim([0 3]);
grid minor
print -dpng -f1 HF54gruppo5may2018point1.png

figure(31)
plot(fs,Pmay18_1_9,'b')
title({'HF54 gruppo 5 may 2018 point 2'});
xlim([0.733797401825683 600]);
ylim([0 3]);
grid minor
print -dpng -f30 HF54gruppo5may2018point2.png

figure(32)
plot(fs,Pmay18_1_10,'b')
title({'HF55 gruppo 5 may 2018 point 1'});
xlim([0.733797401825683 600]);
ylim([0 3]);
grid minor
print -dpng -f31 HF55gruppo5may2018point1.png
```

```
figure(33)
plot(fs,Pmay18_1_12,'b')
title({'HF61 gruppo 6 may 2018 point 1'});
xlim([0.733797401825683 600]);
ylim([0 3]);
grid minor
print -dpng -f32 HF61gruppo6may2018point1.png
```

FIGURES INDEX

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