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FEUP
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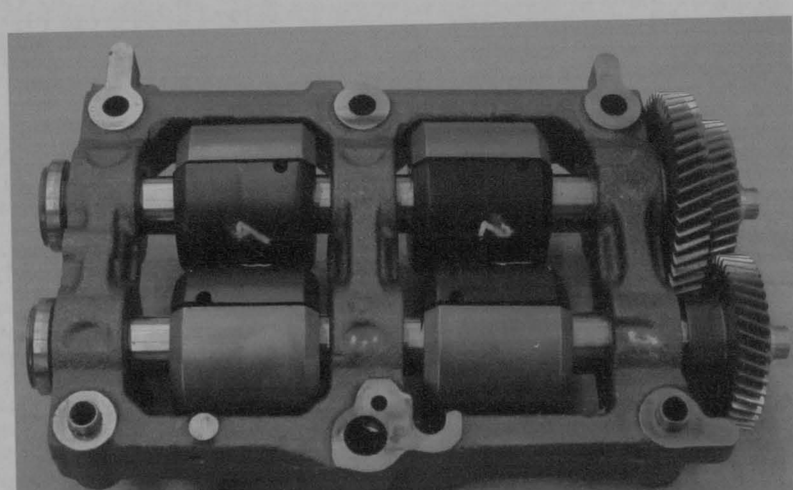
Faculdade de Engenharia

Departamento de Engenharia Mecânica e Gestão Industrial

PROJECTO FIM DE CURSO
2003/2004
PROJECT REPORT

Characterization of Torsional Vibration in a Mass Balancer System



Supervisor:
Eng. José Dias Rodrigues

Author:
António Miguel Figueiredo

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ABSTRACT

Studies of MBS behavior are a constant to achieve the optimization of the system. Vibration and Noise are, actually, one of the most important areas that concerns studies of comfort and silence because these are, more often, exigent requests of automobile buyers.

The use of spatial models is essential to analyze parameters as Natural Frequencies, Critical Speeds, Frequency Response, the importance of inertias, stiffness, and damping to improve the decreasing of torsion vibration.

When proceeding with the analysis of vibration characteristics, the first step is creating a model of the system considering inertias, springs and damping mechanisms. With that model, the creation of a mathematical model is crucial and the definition of differential equations is fundamental to proceed with the analysis of the system vibration behavior.

After proceeding with theory analysis, results must be understood and explained. Results obtained show that the MBS doesn't reach any critical speed what is important to guarantee the torsion resistance under different operating regimes. Another important fact to check is the importance of tooth stiffness of the gears in the values of natural frequencies. If the tooth stiffness of the gears is increased, the last natural frequency will also increase reaching very high values when comparing the last natural frequency with the other five. As so, gears teeth are a very important factor that must be attended in the study of MBS parameters and should have more careful attention in the following project analysis.

ACKNOWLEDGEMENTS

This work was possible with the help of several people that the author would like to acknowledge:

First of all I would like to personally acknowledge Professor Jose Dias Rodrigues, my supervisor at FEUP (Faculdade de Engenharia Universidade do Porto), for his knowledge and several opinions to keep me in the right track to reach the goals of this project.

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Finally, and the most important, to all my friends, parents and sister that always support me giving me strength and encouragement to overcome the difficulties and reach the goals I was proposed to.

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ABBREVIATIONS & ACRONYMS

MBS – Mass Balancer System

DOF – Degree of Freedom

TDC – Top Dead Center

BDC – Bottom Dead Center

K – Stiffness

G – Shear modulus

Ip – Polar moment of inertia

E – Young's modulus

υ – Poisson's coefficient

J – Inertia

C – Damping coefficient

M(t) – Torque

1. INTRODUCTION

"Vibration is the variation with time of the magnitude of a quantity which is descriptive of the motion or position of a mechanical system, when the magnitude is alternately greater and smaller than some average value or reference." (Definition ISO 2041-1975)

Vibrations are the main cause of noise in automobile and mechanisms in general. Since long time ago, constructors are worried and looking forward to solve this problem, but luckily, the advance in technology made the automobiles more comfortable thanks to the great work developed by engineers to control the vibrations.

Vibrations and Noise that we had to tolerate when we were on a car were terrible and are now overcome. The comfort on driving is not only supported on a good suspension that filters the vibrations from the irregularities of the road. It's necessary, beyond that, no noise transmission from the engine, or road, to inside the vehicle.

This is a challenge that constructors and engineers have to face daily, using the last technology to fight the noise and vibrations in all of their car models.

Noise is not only a matter of comfort but also health. It's well known that noise is dangerous to the human ear and physical-psycho stability of the person.

There are different sources that contribute to noise but the most important are: mechanical components and aerodynamics.
Gears, valves, bearings, breaks, and transmissions are some of the systems that enter in resonance with the engine noise and increase a lot the sound level in a mechanism.

Among the different solutions to decrease vibration in automobile engines, MBS is one of the most used systems to minimize these problems. Using twin shafts rotating at twice the crankshaft speed, and eccentric masses, this system is intended to counteract the second order harmonic forces present in the four-cylinder inline engine.

This work consists on the analysis of MBS torsion behavior and it was developed in two stages, both of them in "Vibrations Laboratory" of Mechanical Engineering Department in FEUP (Faculdade de Engenharia da Universidade do Porto).

The first stage consisted on a bibliographic research about engines vibration characteristics, different MBS constructions, methods for dynamic calculations and materials influence in the system behavior.

The second stage was the theory steps of vibration calculation in the components and graphics comprehension with the help of a graphical interface developed by the author, so that users could better understand what it's being analyzed.

Application of different loads at different speeds allows seeing how the system components behave and what's the consequence of impacts in each DOF (Degree of Freedom). Analysis suggest that noise levels are proportional with the impacts intensity if some acoustic parameters are ignored.

2. OBJECTIVES

2.1 Project Goals

The goals of this project are the creation of a model to analyze the torsion vibration of the "Mass Balancer System" (MBS) and characterization of the dynamic properties of the crankcase and the vibratory behavior of the MBS, as well as develop and implement in the Matlab environment some numerical tools to determine the dynamic characteristics of the system and his vibrational response both in time and frequency domains to different excitations.

2.2 Project Plan

Consequently, the direct intervenient and members of FEUP and Renault elaborated a project plan, to reach a realistic and profitable goal to the satisfaction of the needs intended. Of the planning makes part the analysis of the structure of the MBS, as well all their components and its contribution to the elimination of vibration and noise. The steps to reach the goals are:

1. Identification of the system components and their mechanical properties (weight, etc).
2. Modelization of the torsion vibration with base in the discrete system of inertia elements and elastic elements;
3. Formulation of the spatial model including the tooth stiffness of the gears;
4. Implementation of the spatial model in Matlab;
5. Determination of the Modal model in Matlab;
6. Determination of critical speeds (Diagram of Campbell);
7. Characterization and modelization of different excitement forces;
8. Determination of the Frequency Response Model in Matlab;
9. Carry out the study based on the mechanical simulation of the MBS under different operation regimes;

For this study a complete system was supplied by Renault (C.A.C.I.A) consisting of MBS, pinions, bearings and the body that supports them.

Because the project consists in the study of vibration, it was concluded that it would be important to develop a tool to allow the reconstitution of all the vibratory components of the MBS. The tool used was ***MatLab***, a powerful software with plenty potentialities to the materialization of this system. Following that, the components were drawn to enable a better perception of the system in this case, and the modelization that allows to understand the propagation of the vibration in the engine and in the MBS.

3. PROBLEM FORMULATION

The MBS is a product to solve the existence of noise in the engine due to is *"acyclism"*. Looking at the great diversity of engines, in respect of the cylinder capacity, number and disposition of the cylinders, and motor type (gasoline or diesel), it is easily perceptible that all of them have different behaviors and each one of them will produce different loads, torques and power. However, this study is pointed to the MBS in a four-cylinder inline engine, which is the most widely used by automobiles manufacturers. Inside the engine it can be considered two different types of motion for the moving parts:

- Rotational motion which is the case of the crankshaft;
- Translation alternative motion, which is the case of the pistons, even so, there are parts that the motion isn't easy to define, as the connecting-rod, for an example.

3.1 Piston Operation Cycles

The operation of the pistons in a four-cylinder engine can be described:

- ***Admission:*** TDC → BDC: the mixture enters to the cylinder. To increase the admitted mass, the admission valve opens a little before the start of this point and closes after it's finished.
- ***Compression:*** BDC → TDC: The mixture is compressed with the admission and expulsion valves closed. Before reaching TDC, the combustion starts and the pressure and temperature increase more quickly.
- ***Power:*** TDC → BDC: the gases (combustion products) create loads in the piston because of high temperatures and high pressure levels. The energy produced to the crankshaft it's about 5x the energy of compression. Before the piston reaches BDC, the expulsion valve opens, beginning the outlet of the cylinder gases.
- ***Exhaustion:*** BDC → TDC: The gases outlet the cylinder because of the different pressure between the inside cylinder and outlet conduct, and the movement of piston that expel them.

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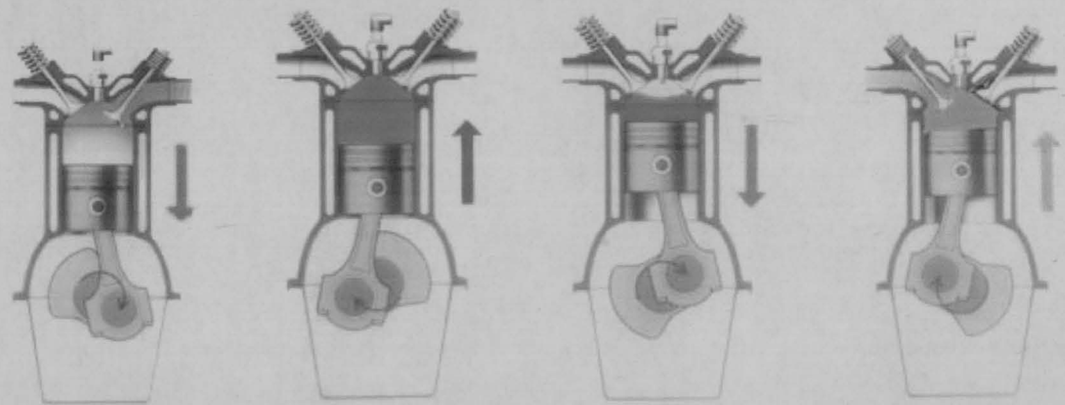


(Admission) *(Compression)* *(Power)* *(Exhaustion)*

Figure 1- Four-cylinder engine cicles

The piston motion is a periodic movement with the frequency equal to the crankshaft frequency, and in the other hand the connecting rod moves at twice the frequency of the crankshaft, and it's for this reason that MBS rotates at twice the speed of the crankshaft

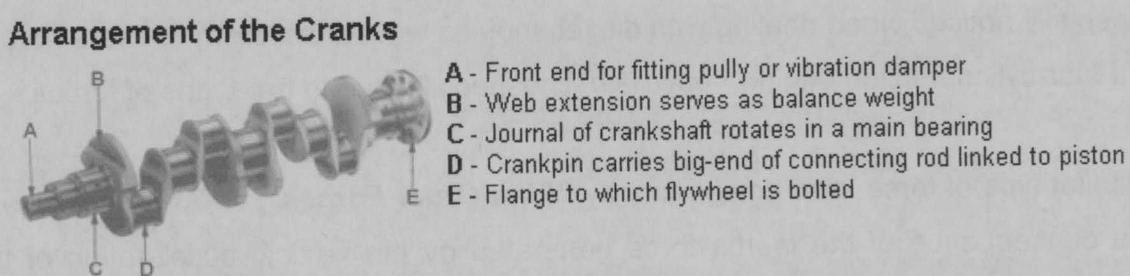


Figure 2 - Crankshaft

It was found that the movement of the piston is not strictly sinusoidal, once a correction is added in the round trip movement of the piston caused by the inclination of the connecting rod that is changing each instant.

The teeth impact forces, shocks and backlash cause the MBS elements to vibrate and to generate rattling noises (low frequencies) and white noises (high frequency)

Gear teeth impacts as a source of pressure waves are related, among other things, with rattle noise levels. Some experimental results suggested that the intensity of the impacts corresponds with the noise level, if some extreme cases of acoustic resonances are ignored.

The major contributor to the MBS's noise production is the mesh between its gears. This problem is enhanced by the fact that the two MBS shafts rotate at twice the speed of the crankshaft, producing something like between 3000 and 16000 individual contacts between teeth pairs per second in an engine speed ranging from 1000 to 5000 rpm.

The ***"backlash"*** is a phenomenon caused by changes in the torque applied to the gears which traduces itself when the meshing teeth are driven across the clearance distance between teeth (existent in all gear mesh contacts) and impact the tooth flank at the other end which cause noise.

The ***"acyclism"*** resultant from the engines operation was always a preoccupying factor because it is reflected in the noise level of the automobile. This factor is especially noticed when dealing with diesel engines whose "acyclism" is more abrupt. In a four-cylinder inline engine, *"acyclism"* is especially due to two types of forces.

The first type of force, also designated by ***"First Order Forces",*** or *"Primary Forces",* is a consequence of the inertia force generated by the vertical acceleration of the mass that constitutes the piston caused by the rotating crankpin motion along the line of stroke due to reciprocating motion of the piston assembly and are those forces of larger magnitude and whose contribution to the vibration is bigger than the others.

However, these forces are eliminated in group, because the engines studied are four-cylinder inline, a fact that allows the symmetry of the crankshaft and consequently an annulment of the forces produced by each one of the pistons, as we can see in the picture

$$\sum_{i=1}^{4} F_i = 0 \text{ And } \sum_{i=1}^{4} M_i = 0$$

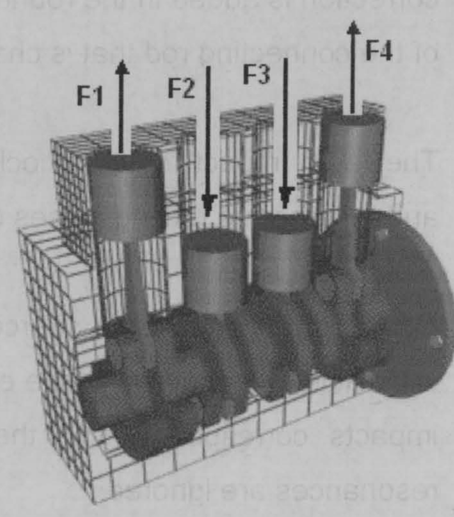


Figure 3 – four-cylinder (Primary Forces)

The sum of "First Order Forces" is zero, and the sum of moments are also null, due to counterbalancing action of piston 2 and 3 on the forces caused by pistons 1 and 4.

The second type of forces, known as **"Second *Order Forces*",** or *"Secondary Forces"* is the one that enable the resource of the MBS due the additional inertia force of the piston and of the connecting rod. These engine part (connecting rod) stays inclined twice, during one crankshaft rotation: one time during the up movement of the piston, and the second time during the down movement of the piston.

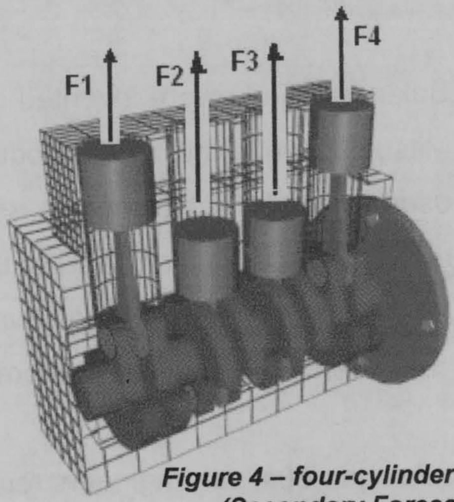


Figure 4 – four-cylinder (Secondary Forces)

These forces are caused by the projected motion perpendicular to the line of stroke caused by the rotating motion of the connecting rod. As so, these loads can be understood, as due to the additional piston acceleration produced by the rotating crankpin increasing or decreasing the inclination of the connecting rod to the line of stroke.

$$\sum_{i=1}^{4} F_i \neq 0 \text{ And } \sum_{i=1}^{4} M_i = 0$$

As it can be explained, the *"Second Order Forces"* increase and decrease magnitude at twice the frequency of the primary force, but their maximum values are only about ¼ of the primary force. The primary forces are absorbed by the stiffness of the crankshaft, while the secondary forces are the cause of vibration and noise in the automobile. As so, MBS is intended to counteract the second order harmonic forces present in the engine.

Due to these types of efforts, the engines pass unpleasant vibration to the vehicles, and so the MBS function is to reduce these vibrations caused by engine cycles.

3.2 "Mass Balancer System"

3.2.1 Historical Review

Balancer shafts were invented by British Frederick Lanchester in early 20th Century. Mitsubishi put it into mass production in the 1976 Colt Celeste 2000, then Fiat group used it in its Lambda engine series, including the 1.6 liters Delta HF Turbo engine and Fiat Croma / Lancia Thema's 2 liter turbo engine. Meanwhile, Saab 9000 and Porsche 944 also introduced it into their powerful inline four-cylinder engine. All these carmakers obtained license from Mitsubishi.

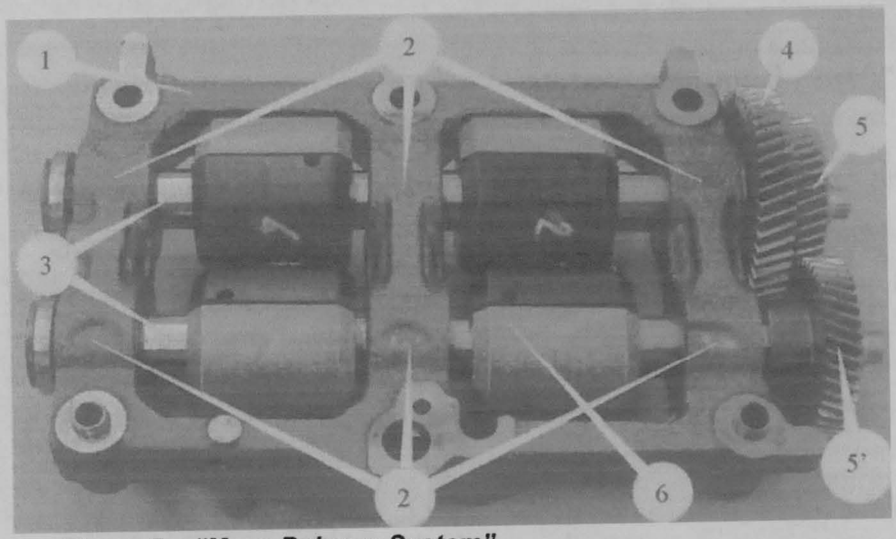
Since the 80s, car engineers regard four-cylinder engines larger than 2 liters capacity had better to be equipped with a balancer system to damp the vibration. Although the strengthening of engine block, the use of hydraulic engine mount and lightweight pistons helped breaking such rule, the trend of pursuing refinement once again led to many engines larger than 2 liters to use balancer systems.

3.2.2 Operation Of MBS

The main idea of a MBS operation is easily comprehensible:

- The mounted gear in the crankshaft puts in action the gear of the MBS having this gear the reason of transmission of 1:2, allowing the system to turn moving at twice the speed of the crankshaft.
- This wheel is in the shaft together in two concentric gear wheels which allows the connection between the two shafts.

As so, the two shafts and respective eccentric masses will turn to double speed of the crankshaft but with opposite movements, a fact that is explained by the gearing between two wheels.



Legend:

1- Body
2- Bearings
3- *Shafts*
4- Entrance wheel
5- and 5' - Wheels that put shafts in movement
6- eccentric mass

Figure 5 – "Mass Balance System"

The engine ***"acyclism"***, referred to, previously, traduces itself in an increase of the noise, a fact that cannot pass unnoticed by the buyers of automobiles and that can discourages them from purchasing the vehicle. This phenomenon is more perceptible in diesel automobiles and engines with less number of cylinders. To allow noise reduce, several constructors fell back upon several techniques from the attempting of decrease noise in the engine adding the MBS that is expected to reduce the engine *"acyclism"* as much as possible.

It is worth pointing out that the MBS cannot balances the engine to 100%, because the system itself constitutes a noise source caused by the movement of gear wheels that constitute this system.

However, this system allows less engine *"acyclism"* and thus less uncomfortable noise.
(The MBS can reduce the noise by about 15 dB and the consumed torque of the engine does not cross the 5 %.)

3.2.3 Models of "Mass Balancer System"

The architecture is the main characteristic that distinguishes the several constructions of *"Mass Balancer System"*. Among the several architectures, there are two most commonly used: the ***"Lanchester"*** (most used) and the **" Cassette"**.

The first (Lanchester) is designed for gasoline engines, where the rotation regimes verified are higher than in others engines. The objective is to create a resistant torque to the torque that causes the natural vibration of the engine. In this method, the MBS are located on each side of the engine but disposed in different horizontal plans.

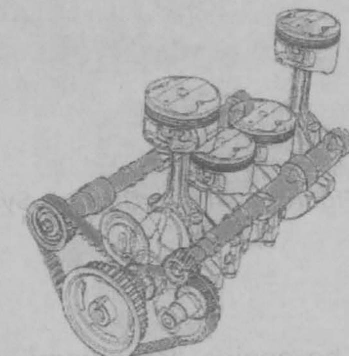


***Figure* 6 – Lanchester MBS**

Inside of this architecture, the set in motion form is the characteristic that distinguishes them:

- Set in motion of the two MBS through the jagged belt in one of the engine sides;
- Set in motion of the two MBS through the jagged belt on both sides, which allows a larger flexibility in the joint between the MBS and the engine.
- One of the MBS is put in motion by current and the other goes by the gearing with the pinion of the oil pump;
- One of the MBS is set in motion by an independent belt and the other goes by the gearing with the pinion of the oil pump;
- Set in motion of the two MBS just through the pinions, in that one of the system gears with the pinion mounted in the crankshaft and it also gears with the other MBS.

NOTE: (The first two are those that the manufacturers frequently appeal for).

The other architecture type "***cassette***" has been developed, and has been used by several automobile constructors. The *"cassette"* is usually fixed to the engine block, meeting inside the oil crankcase.

The disposition of the MBS in this architecture allows the set in motion in several ways:

- Put in motion of the primary shaft for a pinion mounted in the crankshaft, with twice the number of teeth as the pinion of the primary shaft being the cassette fixed to the engine block in the crankcase of the oil (the more common way).
- Set in motion of the primary shaft by current;
- Set in motion of the secondary shaft accomplished by the gearing of the pinions mounted in each one of the MBS, still being able to the same pinion of the primary shaft that receives the movement of the crankshaft to be the same that gears with the pinion of the secondary shaft (triplet system)

The support body can be:

- ✓ in ***"monoblock"***, whose main disadvantage is the difficulty of assembling the eccentric masses in the system;

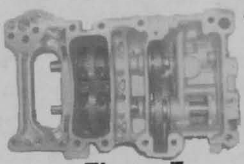


Figure 7

- ✓ in two parts being the main disadvantage, the fact of existing difficulties in the machining and respective assembly and disassemble.

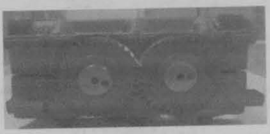


Figure 8

- ✓ ***"Open"***, being necessary the resource to a anti-emulsion plate to allow a better drainage of the oil;

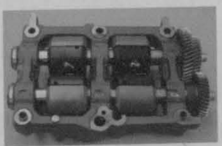


Figure 9

- ✓ ***"Closed"*** (most used), that has as advantage the fact of being more rigid and of not hindering the drainage of the oil in the crankcase;

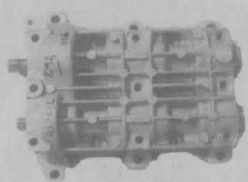


Figure 10

The MBS is, usually, composed by melted iron or steel obtained by casting or forging. On the other hand, the pinions are made of steel alloy (steel alloy chrome-manganese and chrome-molybdenum).

It is of extreme importance that the manufacturing process of the pinions is quite rigorous, and could rely upon the *"shaving"* or a good granding, allowing a good finish surface of the pinion, avoiding the possible gear noise. The noise of the MBS caused by the gearing will be less according to the quality of the teeth.

A vibration system is constituted by components to support potential energy (elastic elements), components to support kinetic energy (inertias) and components to dissipate energy (damping systems). As so, it is achieved a first spatial model considering all these facts, and obtained the next model with 5 DOF's

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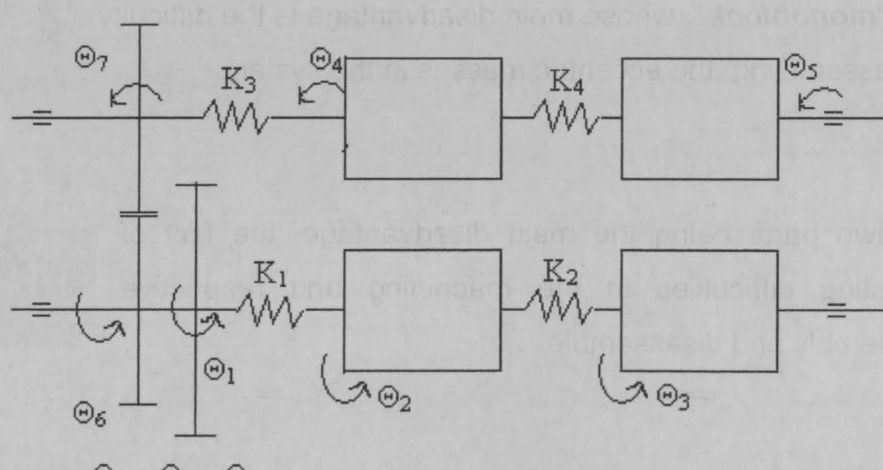


Figure 11 –Spatial Model of MBS (5 DOF's)

The following steps are the determination of material properties and values to the spatial model components.

Determination of the stiffness is based on the following expression: $k = \frac{G \cdot I_p}{\ell}$, and considering: $G = \frac{E}{2(1+\upsilon)}$ the following properties of the material are obtained:

E (Pa)	2,10E+11
υ	0,3
G (Pa)	8,08E+10

Table 1 – Material Properties

Stiffness	Length [m]		K [N/m]
Main Shaft	L1	0,0505	**36782,8**
	L2	0,0868	**21400,2**
Secondary Shaft	L3	0,0522	**35584,9**
	L4	0,0881	**21084,4**

Table 2 – Shaft Stiffness

PINION	Primitive Diameter (mm)	Diameter Hole (mm)	External Diameter (mm)	Diameter Base (mm)	No. of Teeth	Width of the Tooth (mm)	Module	Weights (kg)
Entrance	82,509	21,95	84,42	76,729	49	12	1,55	0,378
Main	61,103	21,55	63,16	56,976	41	12	1,4	0,241
Secondary	61,103	21,55	63,16	56,976	41	12	1,4	0,295

PINION	Volume (≈) (m^3)	Massa Volumic (Kg/m^3)	Ip (m^4)	J ($Kg.m^2$)
Entrance	5,962E-05	6340,100	4,543E-06	**3,46E-04**
Main	3,081E-05	7821,821	1,362E-06	**1,28E-04**
Secondary	3,081E-05	9574,428	1,362E-06	**1,56E-04**

Table 3 – Gears Properties

The following steps are the determination of material properties and values to the spatial model components.

Determination of the stiffness is based on the following expression: [illegible], and considering: [illegible]; the following properties of the material are obtained:

E (Pa)	[illegible]
ν	0,3
G (Pa)	[illegible]

Table 1 – Material Properties

Stiffness		Length [m]	[Nm]
Shaft	L1	[illegible]	35782,6
	L2	[illegible]	21400,2
Secondary Shaft	L3	[illegible]	34504,9
	L4	[illegible]	[illegible]

Table 2 – Shaft Stiffness

PINION	Primitive Diameter (mm)	Diameter Hole (mm)	External Diameter (mm)	Diameter Base (mm)	No. of Teeth	Width of the Tooth (mm)	Module	Weights (kg)
Entrance	[illegible]	[illegible]	[illegible]	[illegible]	40	[illegible]	[illegible]	[illegible]
Main	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Secondary	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

PINION	Volume (m^3)	Mass volume (Kg/m^3)	I (m^4)	J ($Kg \cdot m^2$)
Entrance	[illegible]	[illegible]	[illegible]	[illegible]
Main	[illegible]	[illegible]	[illegible]	[illegible]
Secondary	[illegible]	[illegible]	[illegible]	[illegible]

Table 3 – Gears Properties

4. SPATIAL MODEL

4.1 Lagrange Formalism

The movement equations of a vibratory system can be obtained in a simple way in terms of the generalized coordinates by the use of Lagrange equations that are written as: $\frac{d}{dt}\left(\frac{\partial L}{\partial \dot{q}_j}\right)-\frac{\partial L}{\partial q_j}=Q_j$ (1)

Where L=T-V and so we have: $\frac{d}{dt}\left(\frac{\partial T}{\partial \dot{q}_j}\right)-\frac{\partial T}{\partial q_j}+\frac{\partial V}{\partial q_j}=Q_j$ (2)

The elastic potential energy is expressed as: $V_i=\frac{1}{2}f_i x_i$ (3)

The kinetic energy associated to the mass **m_i** is given by: $T_i=\frac{1}{2}m_i \dot{x}_i^2$ (4)

If generalized coordinates **q_j** j=1...,n were used instead of the physical displacements **x_j**, the expressions (3) and (4) were obtained substituting ***x*** by ***q***.

When the generalized coordinates **q_j** change δq_j, the energy is given by δW_j.

As so, the loads **Q_j** corresponding to the generalized coordinate **q_j** :

$$Q_j=\frac{\delta W_j}{\delta q_j} \quad (5)$$

where δW_j is the work when the generalized coordinates **q_j** have some variation δq_j.

The calculus is made to a system with any number of DOF's, and it has been done to two spatial models: the first, with 5 DOF's and the last with 6 DOF's. It will be presented the calculus to the last spatial model considering 6 DOF's.

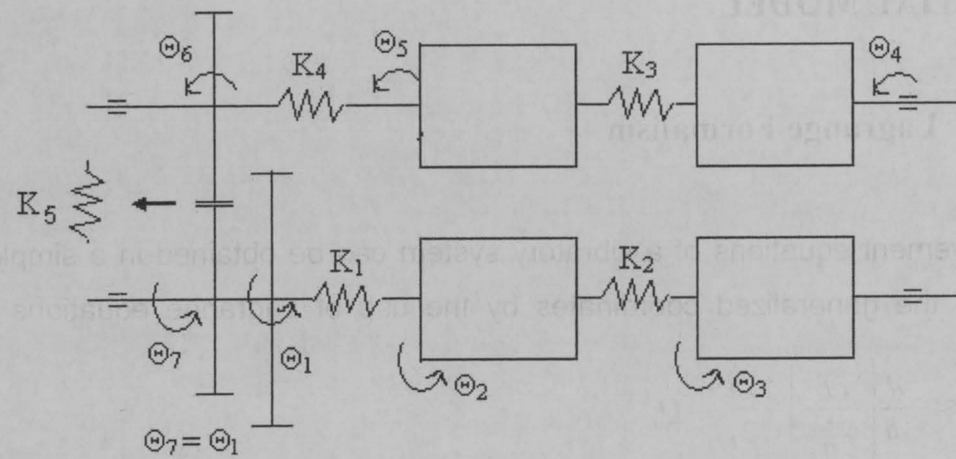


Figure 12 – Spatial Model of the "Mass Balance System" (6 DOF's)

This model is different of the first one, because it has been included the tooth stiffness of the gears which increase the number of DOF's. It will be presented the calculations to 6 DOF's because it's these the model that is more close to the real system, but the calculations are the same for both models.

DOF (Degree of Freedom) can be defined has being an independent coordinate necessary to achieve the component position in the system in all instants of time. It is considered the system as a discrete system with finite number of DOF's (six) because is the enough to characterize the MBS model in a simple way with no massive calculations.

For this system in subject, and considering (3), (4) and (5):

$$T=\frac{1}{2}(J_1+J_7)\dot{\theta}_1^2+\frac{1}{2}J_2\dot{\theta}_2^2+\frac{1}{2}J_3\dot{\theta}_3^2+\frac{1}{2}J_4\dot{\theta}_4^2+\frac{1}{2}J_5\dot{\theta}_5^2+\frac{1}{2}J_6\dot{\theta}_6^2$$

$$V=\frac{1}{2}k_1(\theta_2-\theta_1)^2+\frac{1}{2}k_2(\theta_3-\theta_2)^2+\frac{1}{2}k_3(\theta_4-\theta_5)^2+\frac{1}{2}k_4(\theta_5-\theta_6)^2+\frac{1}{2}k_5\times r^2\times(\theta_6-\theta_7)^2$$

$$\delta W = M_1\delta\theta_1+M_2\delta\theta_2+M_3\delta\theta_3+M_4\delta\theta_4+M_5\delta\theta_5+M_6\delta\theta_6$$

As the torque is applied only in the 1st DOF, it can be concluded that:

$$M_2 = M_3 = M_4 = M_5 = M_6 = 0 \quad \Longrightarrow \quad \delta W = M_1 \delta\theta_1$$

Using the Lagrange equations (2) for each DOF:

$$\begin{cases} (J_1 + J_7)\ddot{\theta}_1 - k_1(\theta_2 - \theta_1) - k_5 \times r^2 \times (\theta_6 - \theta_1) = M_1 \\ J_2\ddot{\theta}_2 + k_1(\theta_2 - \theta_1) - k_2(\theta_3 - \theta_2) = 0 \\ J_3\ddot{\theta}_3 + k_2(\theta_3 - \theta_2) = 0 \\ J_4\ddot{\theta}_4 + k_3(\theta_4 - \theta_5) = 0 \\ J_5\ddot{\theta}_5 - k_3(\theta_4 - \theta_5) + k_4(\theta_5 - \theta_6) = 0 \\ J_6\ddot{\theta}_6 - k_4(\theta_5 - \theta_6) + k_5 \times r^2 \times (\theta_6 - \theta_1) = 0 \end{cases} \tag{6}$$

4.2 Equations of the movement

The derived equations of motion can be rewritten in a matricial form as:

$$[J]\{\ddot{\theta}(t)\} + [c]\{\dot{\theta}(t)\} + [k]\{\theta(t)\} = \{M(t)\} \tag{7}$$

where $[J]$, $[c]$ and $[k]$ are, respectively, the mass, the damping and the stiffness matrices, while $\{\theta(t)\}$, $\{\dot{\theta}(t)\}$, $\{\ddot{\theta}(t)\}$ and $\{M(t)\}$ are, respectively, the displacement, velocity, acceleration and external force vectors of the system.

$$\{\ddot{\theta}(t)\} = \begin{Bmatrix} \ddot{\theta}_1 \\ \ddot{\theta}_2 \\ \cdots \\ \ddot{\theta}_6 \end{Bmatrix} \quad , \quad \{\theta(t)\} = \begin{Bmatrix} \theta_1 \\ \theta_2 \\ \theta_3 \\ \theta_4 \\ \theta_5 \\ \theta_6 \end{Bmatrix} \quad \text{e} \quad \{M(t)\} = \begin{Bmatrix} M_1 \\ M_2 \\ M_3 \\ M_4 \\ M_5 \\ M_6 \end{Bmatrix}$$

For this case, that has 6 DOF's, and considering (6) and (7) we have the following inertia matrix:

$$[J]=\begin{bmatrix} J_1+J_7 & 0 & 0 & 0 & 0 & 0 \\ 0 & J_2 & 0 & 0 & 0 & 0 \\ 0 & 0 & J_3 & 0 & 0 & 0 \\ 0 & 0 & 0 & J_4 & 0 & 0 \\ 0 & 0 & 0 & 0 & J_5 & 0 \\ 0 & 0 & 0 & 0 & 0 & J_6 \end{bmatrix}$$

Inertia matrix is a symmetric and principal diagonal matrix and the main characteristic of it, is:

$$m_{ij}=m_{ji},\quad i\neq j \quad \Longrightarrow \quad [J]=[J]^T$$

Considering (6) and (7), the stiffness matrix is given by:

$$[k]=\begin{bmatrix} (k_1+k_5\times r^2) & -k_1 & 0 & 0 & 0 & (-k_5\times r^2) \\ -k_1 & (k_1+k_2) & -k_2 & 0 & 0 & 0 \\ 0 & -k_2 & k_2 & 0 & 0 & 0 \\ 0 & 0 & 0 & k_3 & -k_3 & 0 \\ 0 & 0 & 0 & -k_3 & (k_3+k_4) & -k_4 \\ (-k_5\times r^2) & 0 & 0 & 0 & -k_4 & (k_4+k_5\times r^2) \end{bmatrix}$$

In the analysis of the stiffness matrix it can be identified some characteristics of this matrix:

$$k_{ij}=k_{ji},\quad i\neq j \quad \Longrightarrow \quad [k]=[k]^T$$

Introducing the respective values in (6), the equation of motion (7) comes,

$$\begin{bmatrix} 4{,}99E\text{-}4 & 0 & 0 & 0 & 0 & 0 \\ 0 & 2.15E\text{-}4 & 0 & 0 & 0 & 0 \\ 0 & 0 & 2.17E\text{-}4 & 0 & 0 & 0 \\ 0 & 0 & 0 & 2.17E\text{-}4 & 0 & 0 \\ 0 & 0 & 0 & 0 & 2{,}17E\text{-}04 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1{,}26E\text{-}04 \end{bmatrix} \begin{Bmatrix} \ddot{\theta}_1 \\ \ddot{\theta}_2 \\ \ddot{\theta}_3 \\ \ddot{\theta}_4 \\ \ddot{\theta}_5 \\ \ddot{\theta}_6 \end{Bmatrix}$$

$$+\begin{bmatrix} 2.971E06 & -36782.8 & 0 & 0 & 0 & -2.935E06 \\ -36782.8 & 58183 & -21400.2 & 0 & 0 & 0 \\ 0 & -21400.2 & 21400.2 & 0 & 0 & 0 \\ 0 & 0 & 0 & 35584.9 & -35584.9 & 0 \\ 0 & 0 & 0 & -35584.9 & 56669.3 & -21084.4 \\ -2.935E06 & 0 & 0 & 0 & -21084.4 & 2.956E06 \end{bmatrix} \begin{Bmatrix} \theta_1 \\ \theta_2 \\ \theta_3 \\ \theta_4 \\ \theta_5 \\ \theta_6 \end{Bmatrix} = \begin{Bmatrix} M_1 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{Bmatrix}$$

5. MODAL MODEL

5.1 Natural Frequencies and Mode Shapes

As can be seen in the bibliography, the natural vibration frequencies are obtained by solving the characteristic problem given by the following equation,

$$\left[[K]-\omega^2[J]\right]\{u\}=\{0\} \tag{8}$$

or by solving the generalized eigenproblem

$$[k]\{\phi\}=\varpi^2[J]\{\phi\} \tag{9}$$

which is more convenient for systems with several degrees of freedom and where the natural frequencies are given by the eigenvalues.

"Natural Frequency" can de defined as the oscillating frequency of the synchronous harmonic movement represented by the corresponding natural mode.

Thus, and solving the eigenvalue problem the following values are obtained for the natural frequencies:

	[rad/s]	[Hz]
ωn1	0	0
ωn2	6805,9	1083,2
ωn3	10080,6	1604,4
ωn4	18549,1	2952,2
ωn5	19872,1	3162,7
ωn6	170974,0	27211,4

Table 4 – Natural Frequencies

The natural forms of vibration (mode shapes) ($\{u\}_j$ j=1. ,n) are given by the eigenvectors.

"Mode shapes" are the spatial configuration of the system during the synchronous movement with the natural frequency ϖ_j.

Thus:

1st Mode Shape

$$\{u\}_1 = \begin{Bmatrix} 25.8982 \\ 25.8982 \\ 25.8982 \\ 25.8982 \\ 25.8982 \\ 25.8982 \end{Bmatrix} \Leftrightarrow \begin{Bmatrix} 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \end{Bmatrix} \Rightarrow$$

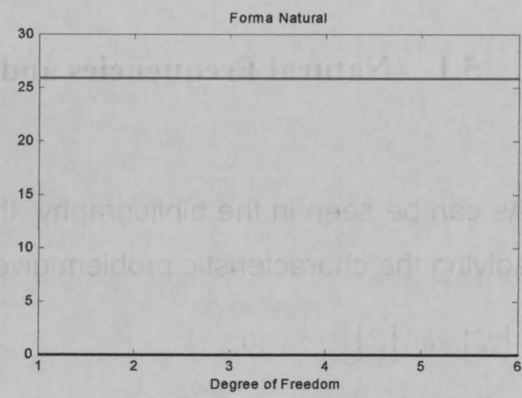


Figure 13- 1st Mode Shape

The system has no connections to the exterior and so the system behaves as a rigid body. In this system, the movement is a combination of rigid body shapes and elastic shapes. The system has, at least, one natural frequency null and a degenerated mode shape with constant components as it can be seen in the figure 13. These system is known because of having a stiffness matrix [k] that is singular (the elastic potential energy of deformation is a quadratic form semi-defined positive and the stiffness matrix is semi-defined positive)

2nd Mode Shape

$$\{u\}_2 = \begin{Bmatrix} -4.420 \\ -20.550 \\ -38.713 \\ 41.745 \\ 29.966 \\ -4.183 \end{Bmatrix} \Rightarrow$$

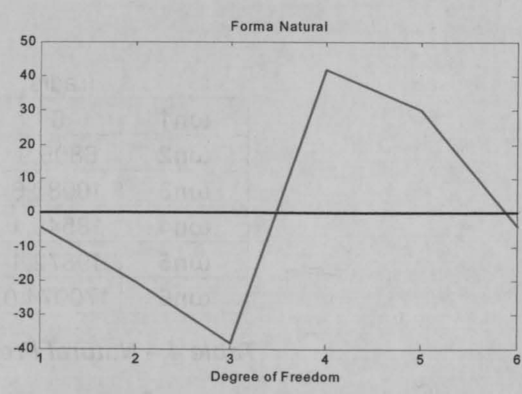


Figure 14- 2nd Mode Shape

The masses oscillate ate frequency: $\omega_{n2} = 6805.85 \text{ rad/s} = 1083.18 \text{ Hz}$.

This mode shape has two "nodes": one between the 3rd and the 4th DOF and the other, between the 5th and 6th DOF. A node is a point where the torsion vibration is null. As so, the 3rd and 4th masses are in opposite phase and the 5th and 6th masses are also in opposite phase.

3rd Mode Shape

$$\{u\}_3 = \begin{Bmatrix} -26.502 \\ -1.272 \\ 43.392 \\ 24.826 \\ 9.459 \\ -26.360 \end{Bmatrix} \Rightarrow$$

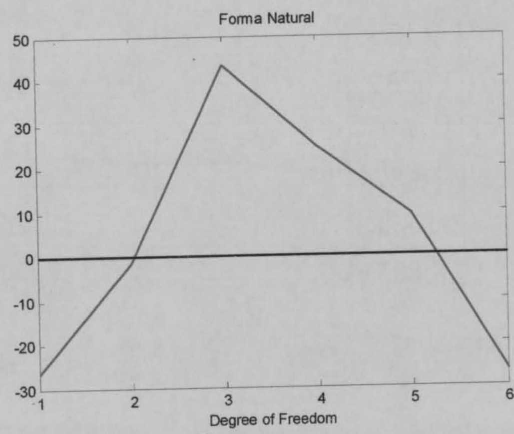


Figure 15 – 3rd Mode Shape

The masses oscillate at frequency: $\omega_{n3} = 10080.6 \text{ rad/s} = 1604.38 \text{ Hz}$.
The 3rd mode shape has two vibration nodes: one between the 2nd and 3rd DOF and the other between the 5th and 6th DOF. Thus, the 2nd and 3rd masses are in opposite phase, and the same happens between the 5th and 6th.

4th Mode Shape

$$\{u\}_4 = \begin{Bmatrix} -11.117 \\ 57.101 \\ -22.977 \\ 14.962 \\ -16.398 \\ -11.322 \end{Bmatrix} \Rightarrow$$

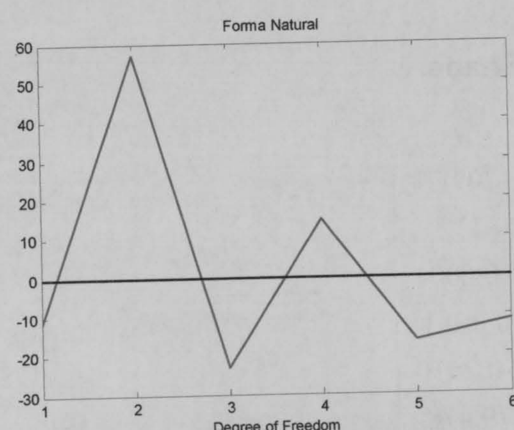


Figure 16- 4th Mode Shape

The masses oscillate at frequency: $\omega_{n4} = 18549.1 \text{ rad/s} = 2952.18 \text{ Hz}$.
This mode shape has 4 nodes: one between the 1st and 2nd DOF, and the others, between the 2nd and the 3rd, between 3rd and 4th and between 4th and 5th DOF which makes these masses to be in opposite phase between those DOF's.

5th Mode Shape

$$\{u\}_5 = \begin{Bmatrix} -9.170 \\ 17.239 \\ -5.746 \\ -36.874 \\ 51.828 \\ -8.885 \end{Bmatrix} \Longrightarrow$$

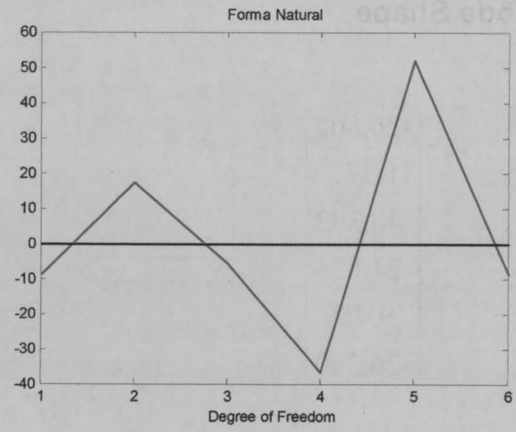


Figure 17- 5th Mode Shape

The masses oscillate at frequency: $\omega_{n5} = 19872.1\ \text{rad/s} = 3162.74\ \text{Hz}$.
The 5th mode shape has 3 nodes, as it can be seen in the figure. As verified before where exists a node that means the masses between those nodes are in opposite phase. In this case, the 1st and the 2nd masses are in opposite phase, as the 2nd and the 3rd. As so, it can be concluded that the 1st and the 3rd masses are in phase. The 5th and 6th masses are also in opposite phase.

6th Mode Shape

$$\{u\}_6 = \begin{Bmatrix} -20.073 \\ 0.112 \\ -0.0004 \\ 0.0013 \\ -0.2510 \\ 79.478 \end{Bmatrix} \Longrightarrow$$

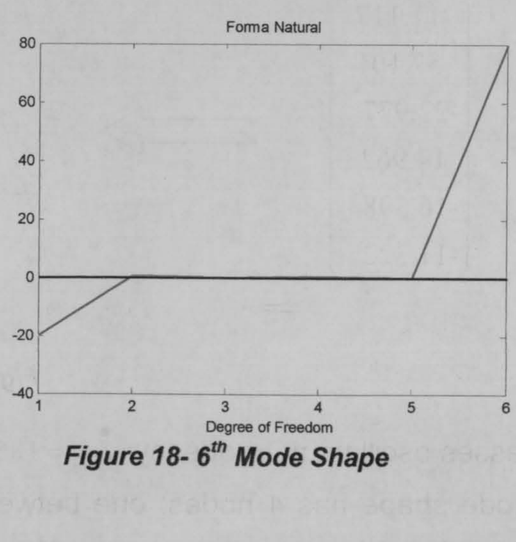


Figure 18- 6th Mode Shape

In this mode shape there are five nodes. The figure is not very clear but the vector coordinates help to better identify the nodes.
The 1st and 2nd masses are in opposite phase and the same happens with the: 2nd and 3rd, the 3rd and 4th, the 4th and 5th, and the 5th and 6th.

5.2 Normalization of the modal vectors

The normalization for unitary modal masses consists on normalizing the modal vectors for the following condition to be verified:

$$\{\phi\}_j^{\mathrm{T}}[m]\{\phi\}_j = 1 \quad j=1, \ldots, n \tag{10}$$

and the vectors $\{\phi\}_j$ represent the modal vectors normalized for unitary modal masses.

With (7) and (9) we can obtain $\{\phi\}_j = \dfrac{1}{\sqrt{\{u\}_j^{\mathrm{T}}[m]\{u\}_j}}\{u\}_j$ (11)

Thus:

$$\{\phi\}_1 = \begin{Bmatrix} 25.8982 \\ 25.8982 \\ 25.8982 \\ 25.8982 \\ 25.8982 \\ 25.8982 \end{Bmatrix} \qquad \{\phi\}_2 = \begin{Bmatrix} -4.420 \\ -20.550 \\ -38.713 \\ 41.745 \\ 29.966 \\ -4.183 \end{Bmatrix} \qquad \{\phi\}_3 = \begin{Bmatrix} -26.502 \\ -1.272 \\ 43.392 \\ 24.826 \\ 9.459 \\ -26.360 \end{Bmatrix}$$

$$\{\phi\}_4 = \begin{Bmatrix} -11.117 \\ 57.101 \\ -22.977 \\ 14.962 \\ -16.398 \\ -11.322 \end{Bmatrix} \qquad \{\phi\}_5 = \begin{Bmatrix} -9.170 \\ 17.239 \\ -5.746 \\ -36.874 \\ 51.828 \\ -8.885 \end{Bmatrix} \qquad \{\phi\}_6 = \begin{Bmatrix} -9.170 \\ 17.239 \\ -5.746 \\ -36.874 \\ 51.828 \\ -8.885 \end{Bmatrix}$$

The modal vectors can be grouped in a matrix where each column is one modal vector. This matrix is named: **Modal Matrix**.

Thus:

$$[\phi] = \begin{bmatrix} 25.898 & -4.420 & -26.502 & -11.117 & -9.170 & 20.0726 \\ 25.898 & -20.550 & -1.272 & 57.101 & 17.239 & 0.1116 \\ 25.898 & -38.713 & 43.391 & -22.977 & -5.746 & -0.0004 \\ 25.898 & 41.745 & 24.826 & 14.962 & -36.874 & 0.0013 \\ 25.898 & 29.966 & 9.459 & -16.398 & 51.828 & -0.2510 \\ 25.898 & -4.1914 & -26.360 & -11.322 & -8.8967 & 79.4778 \end{bmatrix}$$

5.3 Gearing Stiffness

With the increasing of one DOF (5 to 6 DOF's model) it is verified in the previous section that the first five natural frequencies have almost the same values, but the 6th, and last one, is extremely high. If we think in the changes between the two spatial models it will be concluded that the only difference between them is the introducing of tooth stiffness of the gears in the model with 6 DOF's.

Comparing the stiffness of the spatial model components and the tooth stiffness it is possible to check that the tooth stiffness is 1E4x higher than the others. As so, this fact traduces itself in higher values in stiffness matrix where it is being considered the tooth stiffness and as consequence it is achieved a high value to the last natural frequency (6th Natural Frequency).

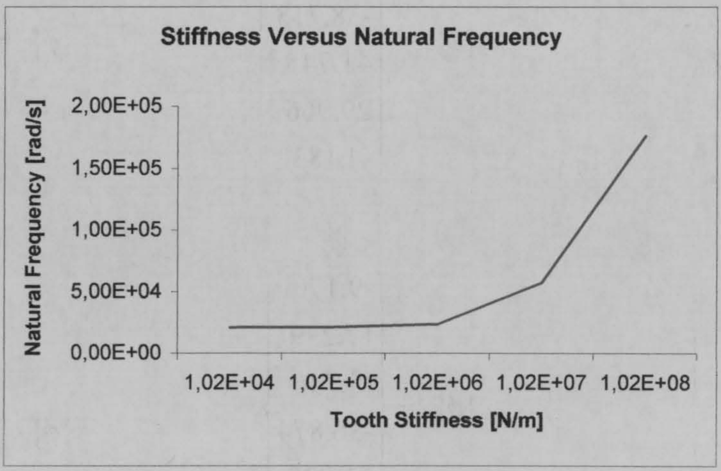


Figure 42- Stiffness versus Natural Frequency

To have an idea how the spatial model would behave if tooth stiffness decreases, it is created a plot where it is possibly to identify that with the decreasing of tooth stiffness (to values near the other stiffness elements), the natural frequency also decreases to values more acceptable and near the other natural frequencies.

As this is a theory analyze and don't have the real values of Renault MBS natural frequencies, we can only refer this as an important fact to have in mind and to check it out with practical tests.

6. SYSTEM TIME RESPONSE

The motion of the system is described by a system of differential equations in the generalized coordinates that has the form

$$[J]\left\{\ddot{\theta}(t)\right\}+[c]\left\{\dot{\theta}(t)\right\}+[k]\{\theta(t)\}=\{M(t)\}$$

with, in the present case, stifness coupling.

In order to solve the system of differential equations to determine the response of the system to an external excitation, the modal analysis technique is used.
Thus, using a coordinate transformation defined by the modal matrix $[\phi]$:

$$\{\theta(t)\}=[\phi]\ \{\eta(t)\}=\left[\{\phi\}_1 \,|\vdots|\, \{\phi\}_i \,|\vdots|\, \{\phi\}_n\right]\begin{Bmatrix}\eta_1(t)\\ \dots\\ \eta_i(t)\\ \dots\\ \eta_n(t)\end{Bmatrix} \qquad (12)$$

and premultiplying all terms by the transpose of the modal matrix, the differential equations in the generalized coordinates are projected in the modal basis, where they are independent and each one represents the equation of motion of one system with one degree of freedom (see bibliography for more details).

Thus, with the modal vector normalized for unitary modal masses, in the modal basis the equations of motion become,

$$\ddot{\eta}_i(t)+2\xi_i\varpi_i\dot{\eta}_i(t)+\varpi_i^2\eta_i(t)=N_i(t) \quad i=1,2,\dots,6$$

where $\eta_i(t)$ represents the modal or natural coordinates and $N_i(t)$ is the force projected in the modal basis.
These equations can easily be solved in the modal basis and after, the response of the system in the generalized coordinates can be achieved by using the transformation (12).

Considering that the solicitation M(t) as an harmonic one, $M(t) = M_0 \cos(\omega t)$, the generalized forces in the modal basis are:

$$\{N(t)\} = [\phi]^T * \{M(t)\}$$

For this type of excitation, the modal equations are written as:

$$\ddot{\eta}_i(t) + 2\xi_i \varpi_i \dot{\eta}_i(t) + \varpi_i^2 \eta_i(t) = \chi_i \cos(\omega t)$$

and their solution is:

$$\eta_i(t) = \eta_i(\omega) \cdot \cos(\omega t - \phi_i)$$

with the amplitude $\eta_i(\omega)$ and the phase ϕ_i given by the following expressions:

$$\eta_i(\omega) = \frac{\chi_i}{\varpi_i^2} \frac{1}{\sqrt{\left(1-\beta_i^2\right)^2 + \left(2\xi_i\beta_i\right)^2}} \qquad \text{and} \qquad \phi_i = \tan^{-1}\left(\frac{2\xi_i\beta_i}{1-\beta_i^2}\right)$$

With the response in the modal or natural coordinates, the response of the system can be expressed in the generalized coordinates as is explained in the next section.

6.1 Modal Superposition

According to the coordinate transformation (eq.12) and as the spatial model in use has 6 DOF's, the response of the system is given by the modal superposition:

$$\begin{Bmatrix} \theta_1(t) \\ \theta_2(t) \\ \theta_3(t) \\ \theta_4(t) \\ \theta_5(t) \\ \theta_6(t) \end{Bmatrix} = \begin{bmatrix} \phi_{11} & \phi_{12} & \phi_{13} & \phi_{14} & \phi_{15} & \phi_{16} \\ \phi_{21} & \phi_{22} & \phi_{23} & \phi_{24} & \phi_{25} & \phi_{26} \\ \phi_{31} & \phi_{32} & \phi_{33} & \phi_{34} & \phi_{35} & \phi_{36} \\ \phi_{41} & \phi_{42} & \phi_{43} & \phi_{44} & \phi_{45} & \phi_{46} \\ \phi_{51} & \phi_{52} & \phi_{53} & \phi_{54} & \phi_{55} & \phi_{56} \\ \phi_{61} & \phi_{62} & \phi_{63} & \phi_{64} & \phi_{65} & \phi_{66} \end{bmatrix} \times \begin{Bmatrix} \eta_1(t) \\ \eta_2(t) \\ \eta_3(t) \\ \eta_4(t) \\ \eta_5(t) \\ \eta_6(t) \end{Bmatrix} = \begin{Bmatrix} \phi_{11} \\ \phi_{21} \\ \phi_{31} \\ \phi_{41} \\ \phi_{51} \\ \phi_{61} \end{Bmatrix} \eta_1(t) + \begin{Bmatrix} \phi_{12} \\ \phi_{22} \\ \phi_{32} \\ \phi_{42} \\ \phi_{52} \\ \phi_{62} \end{Bmatrix} \eta_2(t) + \begin{Bmatrix} \phi_{13} \\ \phi_{23} \\ \phi_{33} \\ \phi_{43} \\ \phi_{53} \\ \phi_{63} \end{Bmatrix} \eta_3(t) + \begin{Bmatrix} \phi_{14} \\ \phi_{24} \\ \phi_{34} \\ \phi_{44} \\ \phi_{54} \\ \phi_{64} \end{Bmatrix} \eta_4(t) + \begin{Bmatrix} \phi_{15} \\ \phi_{25} \\ \phi_{35} \\ \phi_{45} \\ \phi_{55} \\ \phi_{65} \end{Bmatrix} \eta_5(t) + \begin{Bmatrix} \phi_{16} \\ \phi_{26} \\ \phi_{36} \\ \phi_{46} \\ \phi_{56} \\ \phi_{66} \end{Bmatrix} \eta_6(t)$$

which denotes the contribution of each of the natural modes for the system response.

As was already said the system has a rigid body mode (the first one), which can be assimilated as degenerated mode, that doesn't contribute to the vibrational behavior of the system response.

So, removing the first natural mode from the modal superposition, the system response can be expressed for the present system as:

$$\begin{Bmatrix} \theta_1(t) \\ \theta_2(t) \\ \theta_3(t) \\ \theta_4(t) \\ \theta_5(t) \\ \theta_6(t) \end{Bmatrix} = \begin{Bmatrix} \phi_{12} \\ \phi_{22} \\ \phi_{32} \\ \phi_{42} \\ \phi_{52} \\ \phi_{62} \end{Bmatrix} \eta_2(t) + \begin{Bmatrix} \phi_{13} \\ \phi_{23} \\ \phi_{33} \\ \phi_{43} \\ \phi_{53} \\ \phi_{63} \end{Bmatrix} \eta_3(t) + \begin{Bmatrix} \phi_{14} \\ \phi_{24} \\ \phi_{34} \\ \phi_{44} \\ \phi_{54} \\ \phi_{64} \end{Bmatrix} \eta_4(t) + \begin{Bmatrix} \phi_{15} \\ \phi_{25} \\ \phi_{35} \\ \phi_{45} \\ \phi_{55} \\ \phi_{65} \end{Bmatrix} \eta_5(t) + \begin{Bmatrix} \phi_{16} \\ \phi_{26} \\ \phi_{36} \\ \phi_{46} \\ \phi_{56} \\ \phi_{66} \end{Bmatrix} \eta_6(t)$$

where the natural or modal coordinates $\eta_i(t)$ represent the modal contribution for the total response.

6.1.1 Total System Response

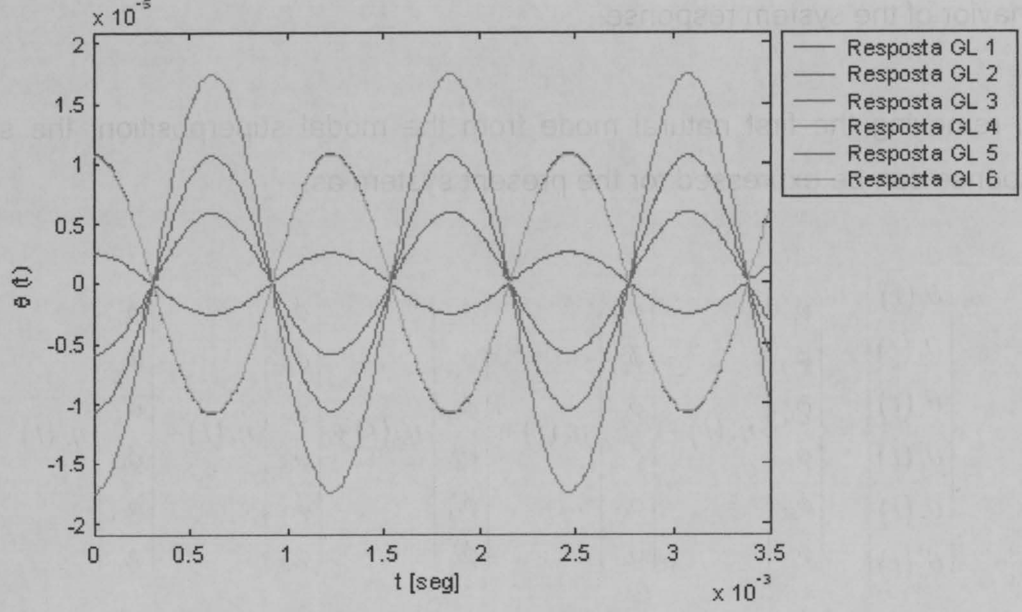


Figure 19- Total Time System Response

This study is made considering as an excitement load, a torque that is 75% of the second natural frequency. $\varpi_{exc} = 0.75 \times \varpi_{n2}$

From the plot analysis it can be concluded that all DOF's will have a harmonic and periodic response with the frequency of MBS as it can de identified in the figure 19. The period of each response is the same as the period of the harmonic solicitation.

6.1.2 Modal Contribution

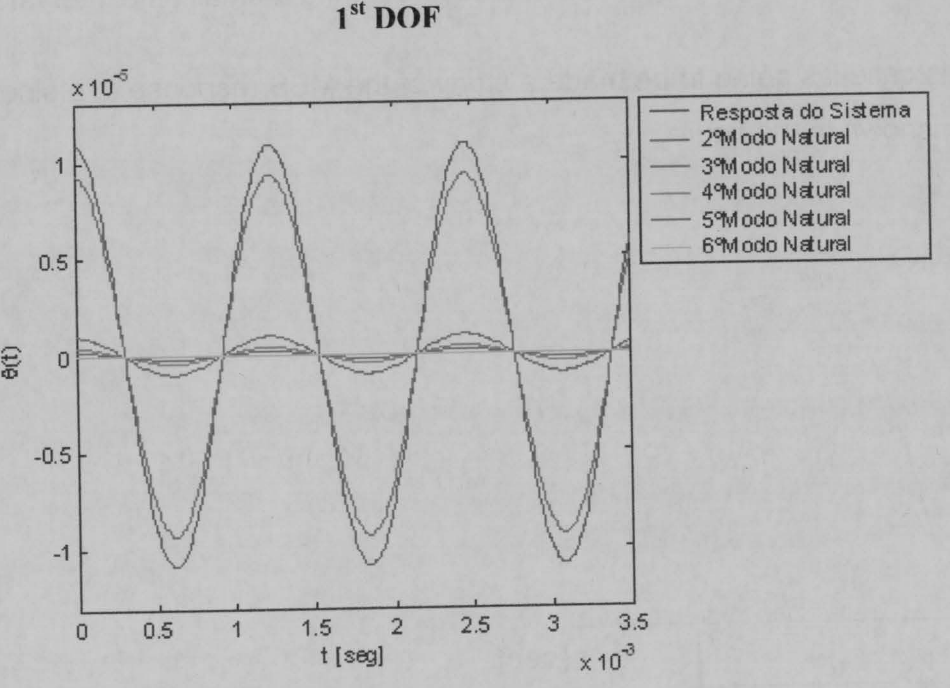


Figure 19- Modal Contribution (1st DOF)

In the plot analysis it's possible to identify the contribution of each natural mode to the system response in the DOF.

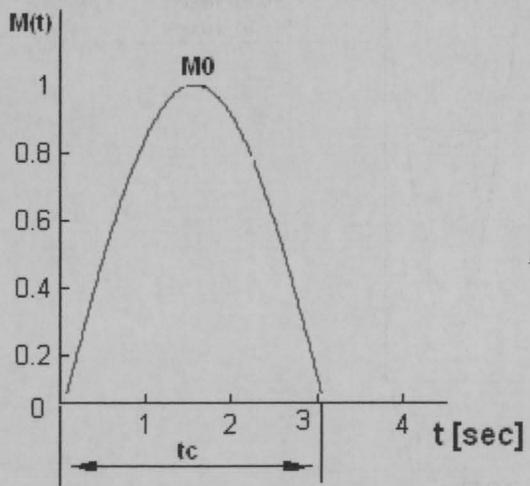
Analyzing the contribution of each natural mode to the system response at the 1st DOF it's easily concluded that it's the third natural mode which contribution to the system response is higher than the others modes. The second natural mode also contributes to the system response but not so much significantly.

The 4th, 5th and 6th natural modes contribution is widely insignificant and doesn't is suggested to analyze this modes in the 1st DOF system response.

6.2 Transient Response

The transient response is the result of an impulsive load application. Impulsive load is a load of high magnitude that occurs during a small time interval Δt.

In this case it's going to be made a study of the MBS response to a sine impulsive load, shown in the figure.



$$M(t)=\begin{cases} M_0 \sin(\varpi t) & 0 \le t \le t_c \\ 0 & t > t_c \end{cases}$$

Figure 20- Transient Response

To a transient load, the characteristic period (t_c) is considered as the duration of the transient.

For this study, it was used: $t_c = 8E-4$, but it can be considered others values for the period of this transient.

From the books, the response in the instant ***t*** is the sum of the responses of each one of the elementary impulses given by:

$x(t)=\int_0^t f(\tau)h(t-\tau)d\tau = \frac{1}{m\varpi_d}\int_0^t f(\tau)e^{-\xi\varpi_n(t-\tau)}\sin(\varpi_d(t-\tau))d\tau$, also known as **Duhamel Integral**.

The total response with initial conditions is given by:

$$x(t)=e^{-\xi\varpi_n t}\left[x_0\cos(\varpi_d t)+\frac{\dot{x}_0+\xi\varpi_n x_0}{\varpi_d}\sin(\varpi_d t)\right]+\frac{1}{m\varpi_d}\int_0^t f(\tau)e^{-\xi\varpi_n(t-\tau)}\sin(\varpi_d(t-\tau))d\tau$$

with $\varpi_d=\varpi_n\sqrt{1-\xi^2}$, and x_0, $\dot{x}_0$ represent the initial conditions of displacement and velocity.

For this load, considering the Duhamel Integer and the initial conditions null, it can be achieved the system response as:

- For $0\leq t\leq t_c$

$$\theta(t)=\frac{1}{J\varpi_d}\int_0^t M(\tau)e^{-\xi\varpi_n(t-\tau)}\sin(\varpi_d(t-\tau))d\tau$$

$$\xi=0 \Longrightarrow \theta(t)=\frac{M_0}{J\varpi_n}\int_0^t \sin(\varpi\tau)\sin(\varpi_n(t-\tau))d\tau$$

$$\theta(t)=\frac{M_0}{k}\frac{1}{\left(1-\left(\frac{\varpi}{\varpi_n}\right)^2\right)}\left(\sin(\varpi t)-\frac{\varpi}{\varpi_n}\sin(\varpi_n t)\right)$$

and

- For $t>t_c$

$$\theta(t)=\frac{1}{J\varpi_d}\int_0^t f(\tau)e^{-\xi\varpi_n(t-\tau)}\sin(\varpi_d(t-\tau))d\tau$$

$$\xi=0 \Longrightarrow \theta(t)=\frac{M_0}{J\varpi_n}\int_0^t \sin(\varpi\tau)\sin(\varpi_n(t-\tau))d\tau$$

$$\theta(t)=\frac{M_0}{k}\frac{\left(\frac{\varpi_n}{\varpi}\right)}{\left(1-\left(\frac{\varpi_n}{\varpi}\right)^2\right)}\left[\sin(\varpi_n t)+\sin(\varpi_n(t-t_c))\right]$$

Note that the above expressions for the transient response were established to use with the modal or natural coordinates.

Using Matlab, it can be easily obtained the response to the sine load for each DOF. The 1st DOF is the chosen to explain the comprehension of the system behavior to an impulsive load.

1st DOF Response

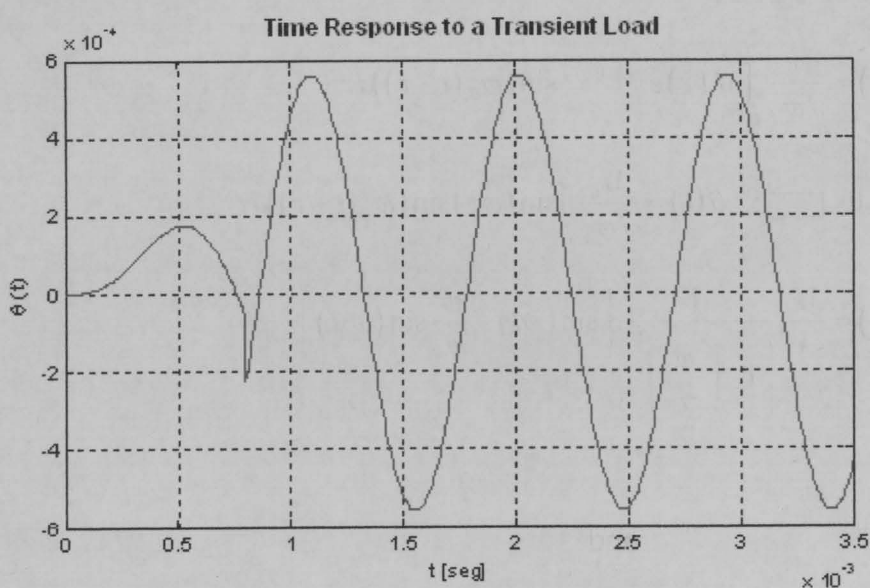


Figure 21- Time Response to a transient load (1st DOF)

In this plot it's identified two sections: the first is the left side of the plot and it can be easily understood to be correspondent to the time of the impulse application; the second is after the impulse load application and it shows that the system retakes the harmonic and periodic response stabilizing and achieving constant magnitude.

7. FREQUENCY RESPONSE MODEL

In this section it is going to be evaluated the system behavior in the frequency domain. Increasing and decreasing frequency, or velocity, is something that must be analyzed to understand how the system behaves in those speed conditions. As so, it will be shown two diagram models to better understand and analyze. They are:

- ***Bode Diagram***: a diagram that relates frequency with magnitude and phase of system response. In this diagram it's possible to identify natural frequencies, anti-resonances and what happens in magnitude ([dB]) and phase [º] in this conditions;

- ***Modal Contribution***: this diagram allows to identify the contribution of each natural mode of vibration to the frequency response;

To proceed with the development of this diagrams it's used appropriates calculations to frequency response that can be found in the bibliographic resources. It will be shown the diagrams of receptance and acelerance, in both diagrams (Bode and Modal Contribution). As the system have 6 DOF's it will be chosen only one DOF (the first DOF because it's where the load is applied) to explain the comprehension of this diagrams, and the diagrams for the other DOF's are represented in ANNEX IV.

7.1 Bode Diagram – Receptance

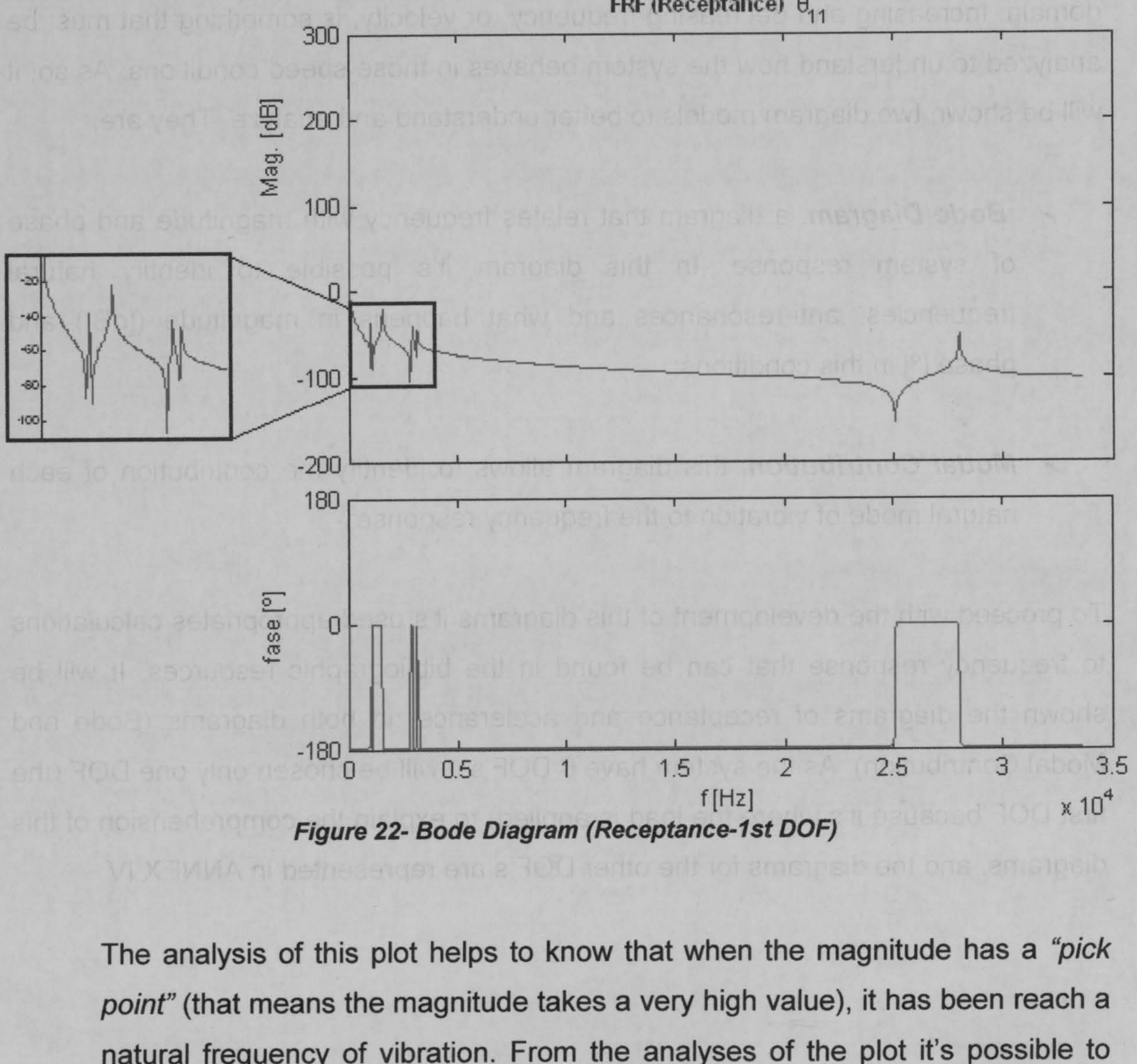


Figure 22- Bode Diagram (Receptance-1st DOF)

The analysis of this plot helps to know that when the magnitude has a *"pick point"* (that means the magnitude takes a very high value), it has been reach a natural frequency of vibration. From the analyses of the plot it's possible to identify five natural frequencies (don't forget that MBS is a semi-defined system and so it has the 1st Natural frequency equal to zero).

As so it's concludes that the system has got five conditions of resonance given to the frequencies:

$\varpi = \varpi_{n2} = 1083.18$ Hz, $\varpi = \varpi_{n3} = 1604.38$ Hz, $\varpi = \varpi_{n4} = 2952.18$ Hz, $\varpi = \varpi_{n5} = 3162.74$ Hz and $\varpi = \varpi_{n6} = 27211.4$ Hz

7.2 Bode Diagram – Acelerance

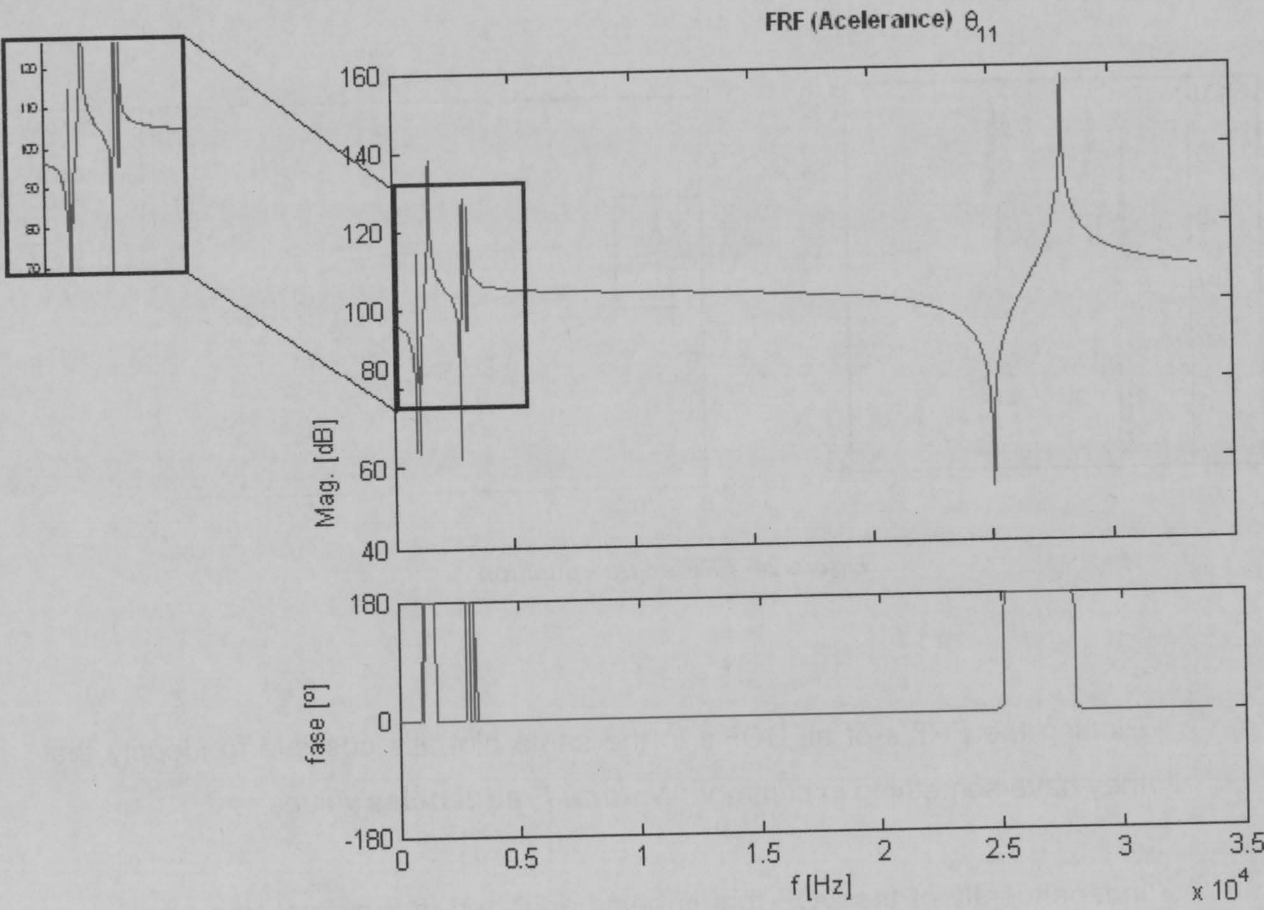


Figure 23- Bode Diagram (Acelerance-1st DOF)

Analyze of this plot is based in the same principles of what is said in the previous comment. The motion of the FRF (acelerance) is different from what is obtained to FRF receptance, but they still have something in common, and that is: *Natural Frequencies*. If superpose the two plots it's possible to check that they have the "pick points" located at the same frequency (natural frequency).

Once more, at the natural frequency, the "pick point" is followed by a change of the phase, a characteristic that allows concluding that it has been reached a natural frequency of vibration.

7.3 FRF's Superposition

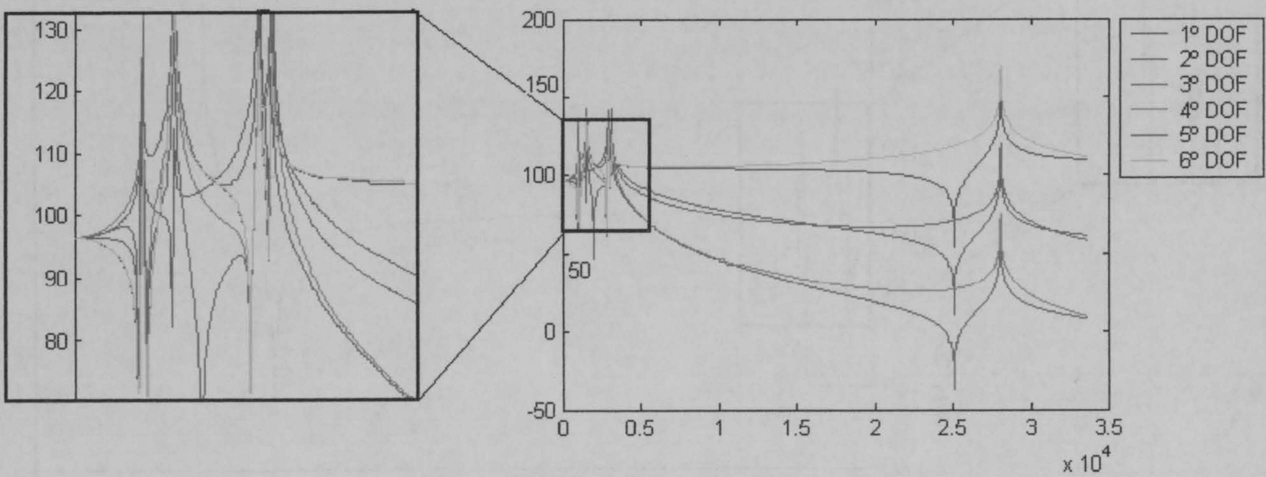


Figure 24- FRF's Superposition

Plotting the FRF's of all DOF's in the same plot, it's possible to identify that they have something in common: ***Natural Frequencies*** values.

Independently of the DOF that is being analyzed, the natural frequency must be the same of the others DOF's because natural frequency is a property of the system and independent of the DOF that is being studied.

7.4 Modal Contribution – Receptance

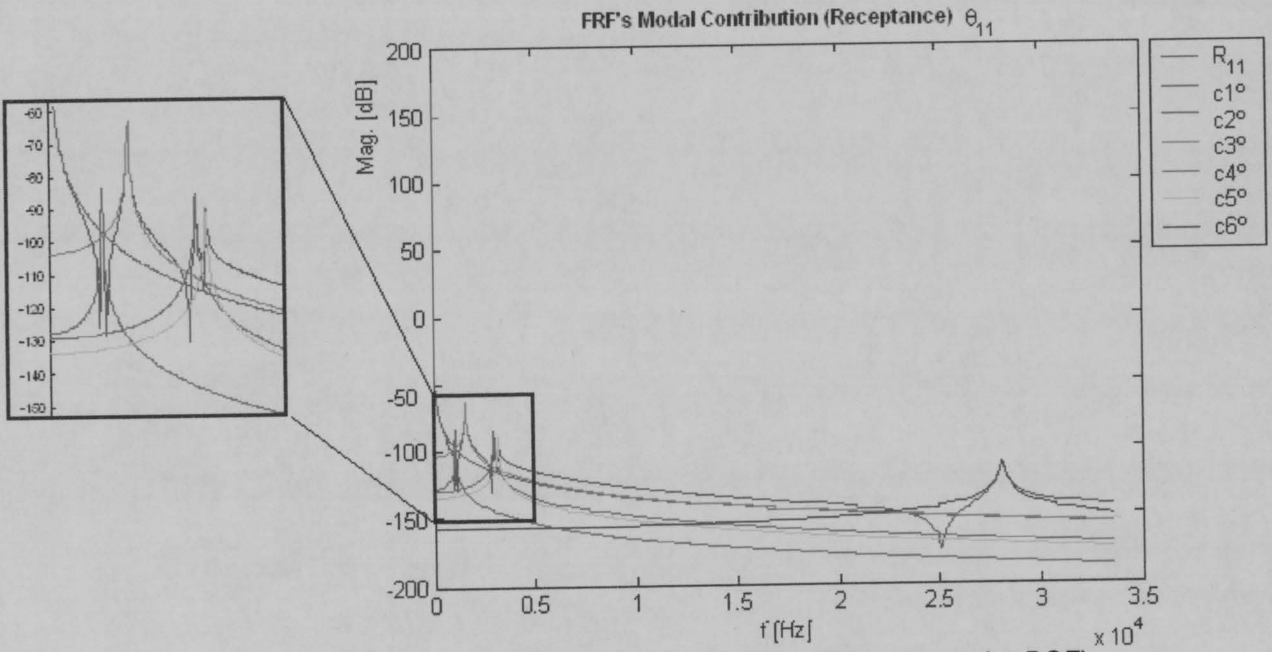


Figure 25- FRF's Modal Contribution (Receptance-1st DOF)

FRF's are very useful to understand the behavior of the system in analyze in order to identify what really happens in any position when the frequency changes, or if you prefer the rotation speed changes.

As so, and to better understand where are located the frequencies or natural modes that most contribute to the FRF response, it is shown the figure above (figure 25). Looking at the picture it's possible to see that when the system reaches a natural frequency, is the natural mode of that frequency that most contributes to the magnitude of the response.

That means for an example: when the system reaches a frequency equal to the 3rd Natural frequency, it's the 3rd natural mode of vibration that contributes most to the frequency response in that point, being almost null the contribution of the others natural models.

8. CRITICAL SPEEDS

When a machine is built, constructors and engineers have to be extremely careful when they are projecting the system. As so, they must be sure that the system supports the loads without failure and with a good behavior.

In the case of MBS's, that is directly connected to the engine and rotating at twice the speed of it, that is one of main preoccupying factors engineers must face is that is making the system does not reach the critical speed or else the system will enter in resonance and could failure their components. Critical speed can be described as the speeds that are coincident with the natural frequency or the frequency from which the system reaches high magnitudes and the components can, or will, crash.

As it was expected, one of these project goals is to be sure that the MBS doesn't reach any of the critical speeds under no conditions, in a normal four-cylinder engine. So, it will be plotted a linear increasing line of speed till the limits of the engine rotations (≈ 8000 rpm) and obtained the following figure:

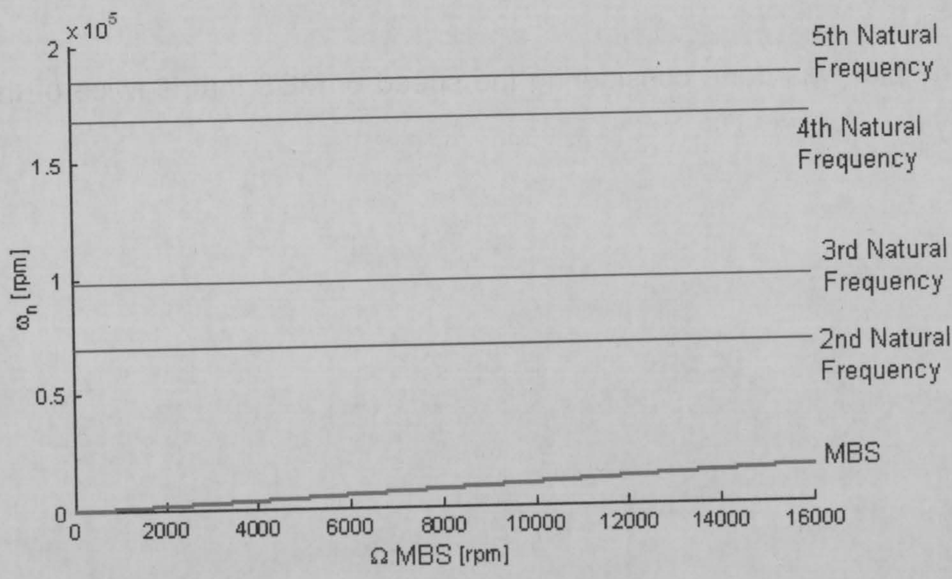


Figure 26- Critical Speeds (5 DOF's)

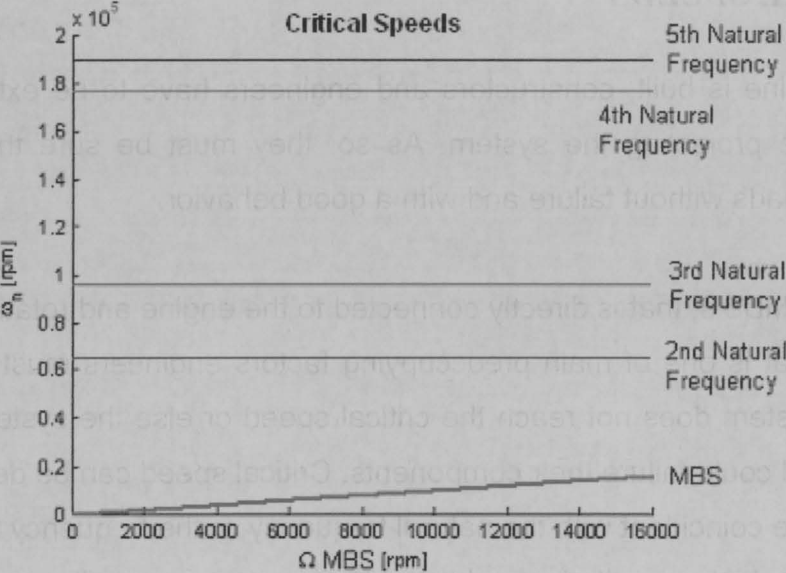


Figure 27- Critical Speeds (6 DOF's)

Proceeding with the study of critical speeds in both of spatial models (5 and 6 DOF's), as it's possible to see in the figures (Figure 26 and 27), in these conditions and with the critical speeds values calculated before, we can conclude that no critical speed is excited during the engine movement.

NOTE: the plot was done considering the speed of MBS that is twice of the engine frequency.

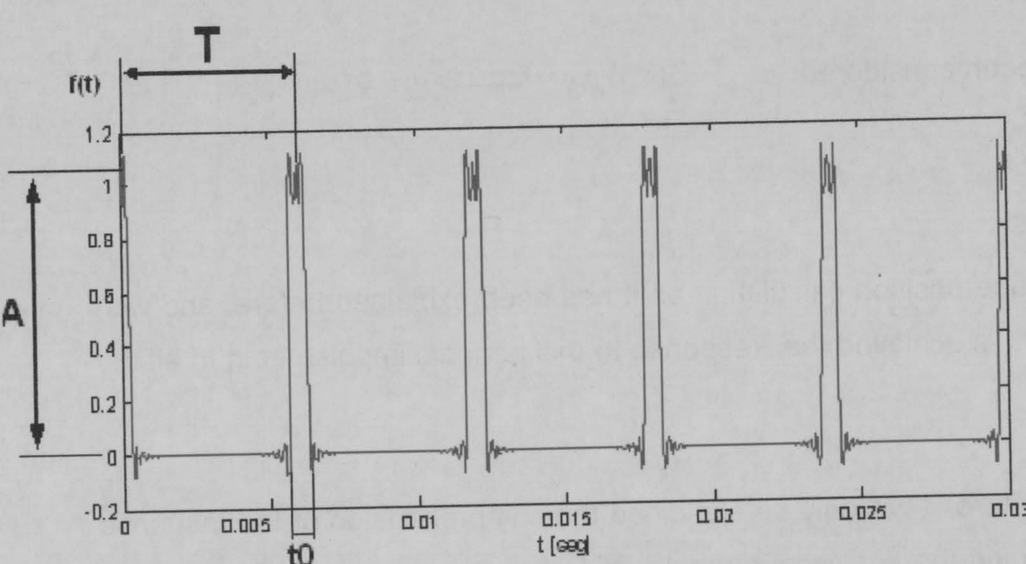
9. RESPONSE TO DIFFERENT EXCITATIONS

A periodic function it's any function that repeats itself in time, that means, any function for which exists a time **T** fixed, named *"Period"*, in a way to verify $f(t)=f(t+nT)$ for all the ***t*** values.

According to the theory developed by Fourier, all periodic functions with period **T**, can be represented by finite series.

Developing the study it will be applied different periodic functions. For all of them it has been used the Fourier series.

9.1 Impulse Train



$$f(t)=\begin{cases} A & 0<t<t_0 \\ 0 & t_0<t<T \end{cases}$$

Figure 28- Impulse Train

For this function, the Fourier series come as:

$$f(t)=\frac{a_0}{2}+\sum_{n=1}^{\infty} a_n \cos\frac{n\square 2\pi}{T}+\sum_{n=1}^{\infty} b_n \sin\frac{n\square 2\pi}{T}$$ knowing that the frequency is: $\varpi=\frac{2\pi}{T}$

Solving the determination of Fourier coefficients:

$$a_n = \frac{2}{T}\int_{-t_0/2}^{t_0/2} A\cos\frac{n\square 2\pi t}{T}\,dt = \frac{2A}{n\pi}\left[\sin\left(n\pi\frac{t0}{T}\right)\right] \qquad b_n = \frac{2}{T}\int_{-t_0/2}^{t_0/2} A\sin\frac{n\square 2\pi t}{T}\,dt = 0$$

$$a_0 = \frac{2}{T}\int_0^T f(t)\,dt = \frac{2}{T}\int_0^{t_0} A\,dt = 2A\frac{t_0}{T}$$

Thus,

$$f(t) = A\frac{t_0}{T} + \left[\sum_{n=1}^{\infty}\frac{2A}{n\pi}\sin\left(n\pi\frac{t_0}{T}\right)\cos\frac{n\square 2\pi}{T}t\right]$$

Knowing that: $\omega_{MBS} = 2\times\omega_{motor} \Longrightarrow T = \dfrac{30}{n_{motor}}$

In this case it has been considered: $n_{motor} = 5000\,rpm \Longrightarrow T = 0.006\,[\text{sec}]$

and $t_0 = \dfrac{T}{10}$

Using the Modal Superposition calculation as it has been explained before, and with the help of Matlab, it is achieved the Response to this periodic impulse train to all the DOF's.

As it is explained before, it will only be explained the comprehension of the response to one DOF, continuing the analyses in the 1st DOF, because it's the DOF where the load is applied. (NOTE: the other DOF's are shown in the ANNEX VIII)

9.1.1 Time Response – 5000 rpm

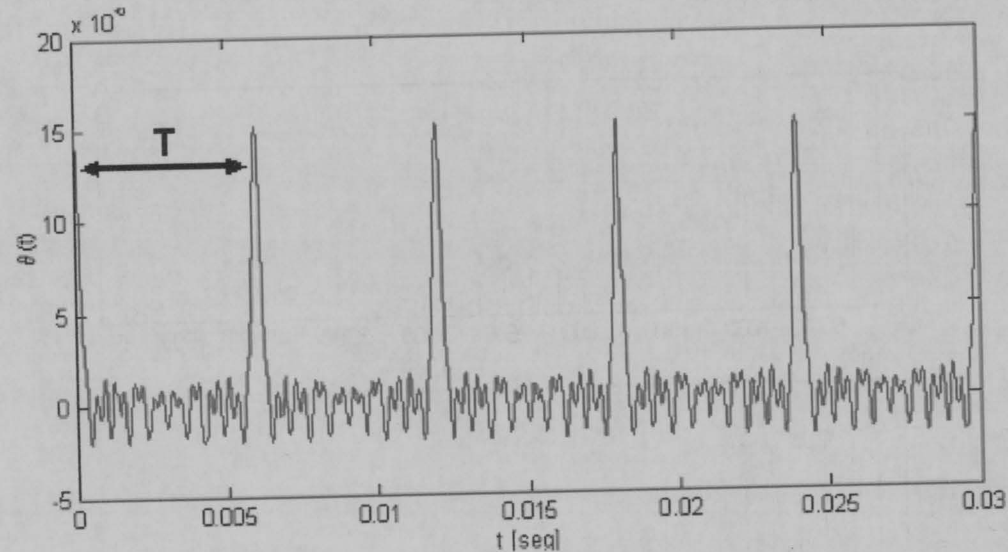


Figure 29- Time Response to impulse train at 5000 rpm (1st DOF)

The figure 29 gives the system response to an impulse train, and it's possible to identify his characteristic. When the impulse is applied the system response with a high magnitude value and when the impulse is over, the system tries to come back to his stability till the next impulse. The system response is, as the load applied, periodic but not harmonic. The period of the response is the same period of the impulse ($T = 0.006\,[\text{sec}]$).

9.1.2 Spectrum

In the equipments project it is usual needed to know the maxim displacement of the system DOF's due to an excitant load. In some cases the project requests for a fixed limit to the maxim displacement of the system and so, that must be known. A way of identifying these is with the help of: **Spectrum**.

Response Spectrum is the representation of the maxim value of the system response in the DOF, function of natural frequency.

It will be now analyzed the spectrum response to the 1st DOF because it's where the load is located.

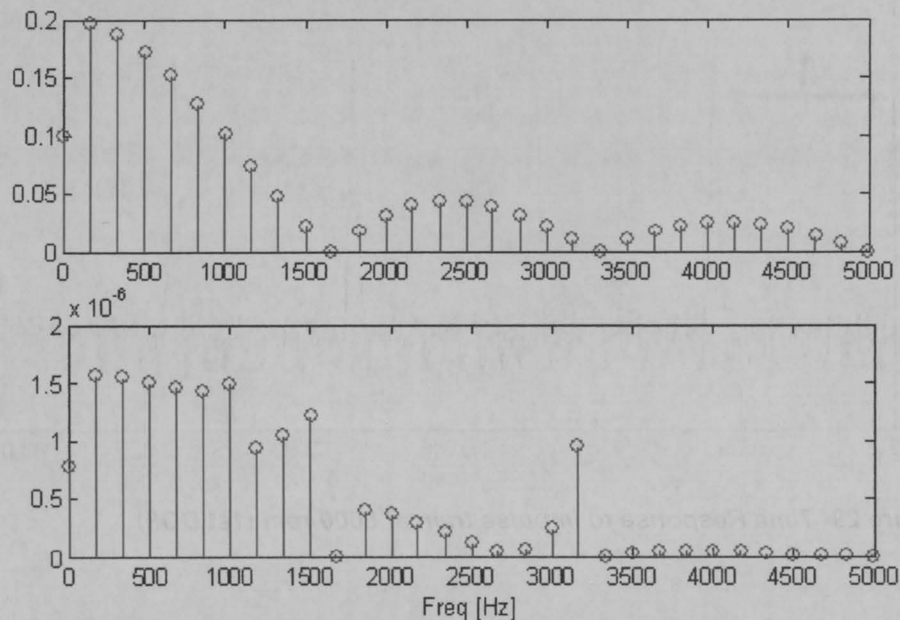
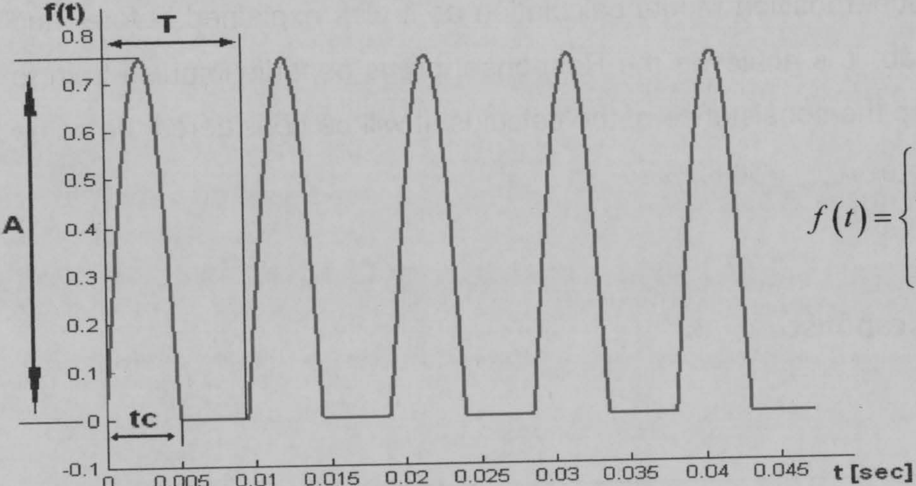


Figure 30- Spectrum of impulse train and response (1st DOF)

Each point in response Spectrum represents the maxim response of the system at this DOF with a given frequency. The first graphic corresponds to the excitement load, and the second graphic is the response spectrum in the 1st DOF to an impulse train. It can be concluded that when the frequency increases to values over 3500 Hz, the magnitude decreases and is considered null.

9.2 Impulse Half-Sine Train



$$f(t)=\begin{cases} A\sin\left(\frac{\pi}{t_c}t\right) & 0<t<t_c \\ 0 & t_c<t<T \end{cases}$$

Figure 31- Half-Sine Impulse

Knowing that: $\omega_{MBS}=2\times\omega_{motor} \Longrightarrow T=\frac{30}{n_{motor}}$

and $t_c=\frac{T}{11}$ (this value can be bigger or smaller depending the impulse duration wanted).

For this function, Fourier series can be expressed s:

$$f(t)=\frac{a_0}{2}+\sum_{n=1}^{\infty}a_n\cos\frac{n\square 2\pi}{T}+\sum_{n=1}^{\infty}b_n\sin\frac{n\square 2\pi}{T}$$ knowing that the frequency is: $\varpi=\frac{2\pi}{T}$

The determination of Fourier coefficients is easy and so:

$$a_0=\frac{2}{T}\int_0^T f(t)\,dt=\frac{2}{T}\int_0^{t_c}A\sin\left(\frac{\pi}{t_c}t\right)dt=\frac{4A}{\pi T}t_c$$

$$a_n=\frac{2}{T}\int_0^T f(t)\cos(n\varpi t)\,dt=\frac{2}{T}\int_0^T A\sin(\varpi t)\cos(n\varpi t)\,dt=-\frac{4T\times t_c}{\pi(T+2n\times t_c)(-T+2n\times t_c)}A\times\cos\left(\frac{\pi n}{T}t_c\right)^2$$

$$b_n=\frac{2}{T}\int_0^T f(t)\sin(n\varpi t)\,dt=\frac{2}{T}\int_0^T A\sin(\varpi t)\sin(n\varpi t)\,dt=-\frac{4T\times t_c}{\pi(T+2n\times t_c)(-T+2n\times t_c)}A\times\sin\left(\frac{\pi n}{T}t_c\right)\times\cos\left(\frac{\pi n}{T}t_c\right)$$

Substituting coefficients in the Fourier series it is achieved the equation that gives the impulse. Using the Superposition Modal calculation as it was explained before, and with the help of Matlab, it is achieved the Response to this periodic impulse train to all the DOF's. To keep the consistence of the calculus, it will be considered the same engine speed as before: $n_{motor} = 5000\,rpm$.

9.2.1 Total Response

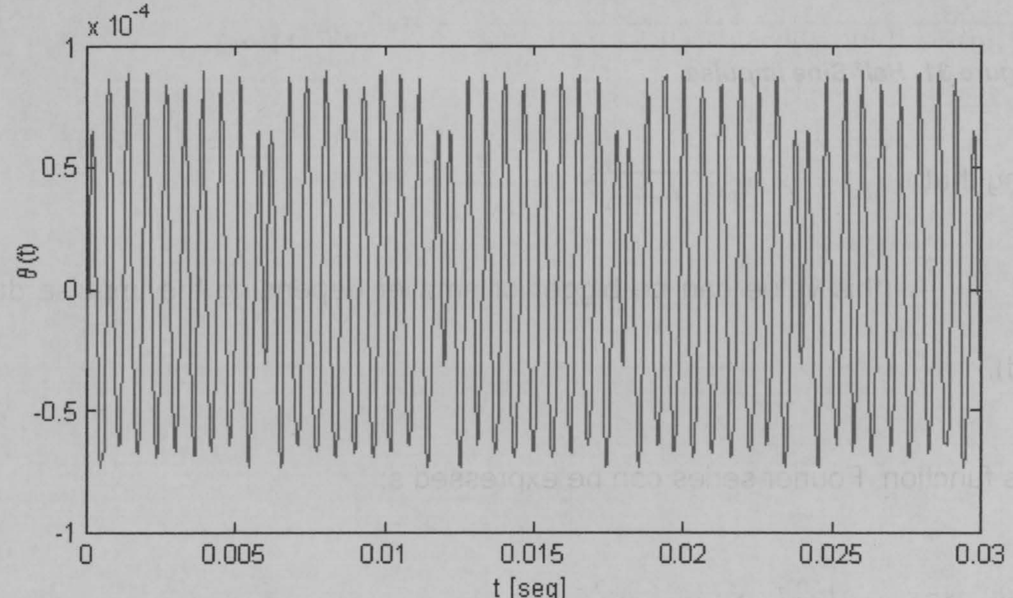


Figure 32- Total response to a half-sine impulse (1st DOF)

The figure 32 shows the system response to a half-sine impulse train, and it's possible to conclude that it is periodic. When the impulse is applied the system responses with a high magnitude value and when the impulse is over, the system tries to come back to his stability till the next impulse. The period of the response is the same period of the impulse (As $n_{motor} = 5000\,rpm \Longrightarrow T = 0.006\,[\text{sec}]$)

9.2.2 Spectrum

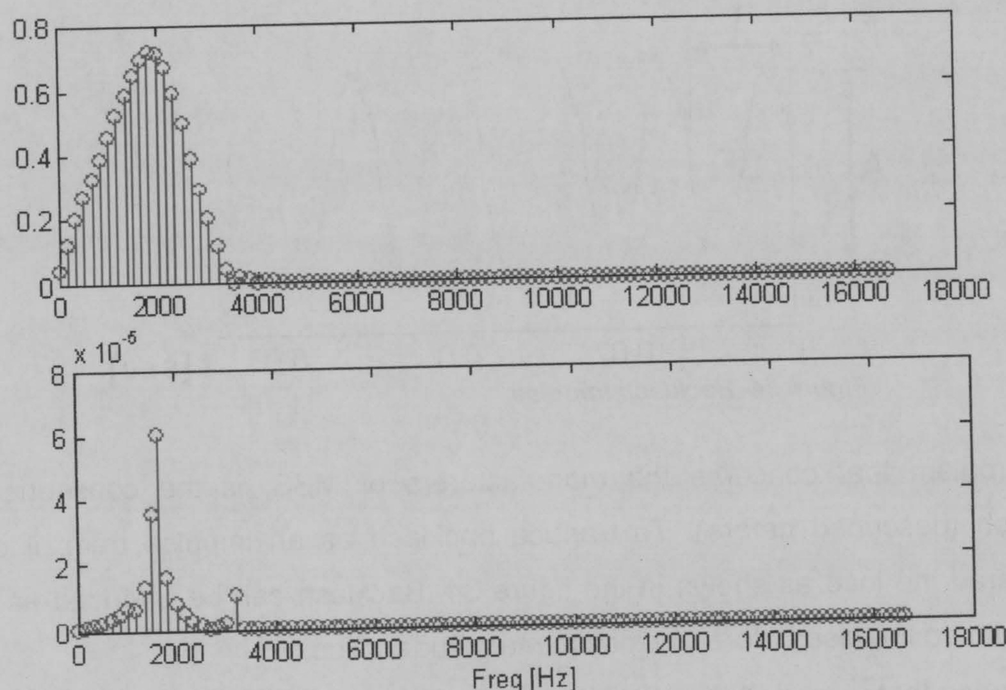


Figure 33- Spectrum of a sine-half impulse (1st DOF)

Each point in response Spectrum represents the maxim response of the system at this DOF with a given frequency. The first graphic corresponds to the excitement load, and the second graphic is the response spectrum in the 1st DOF to a half-sine wave impulse train. It is well noticed that the spectrum of excitation has the shape of a sine wave and while that sine wave exists, the system response has almost the same shape. The response spectrum takes the higher value when the excitant response reaches the higher magnitude.

It can be concluded that when the frequency increases to values over 3500 Hz the magnitude of spectrum response takes null values.

9.3 Sine + Impulse Train (Backlash)

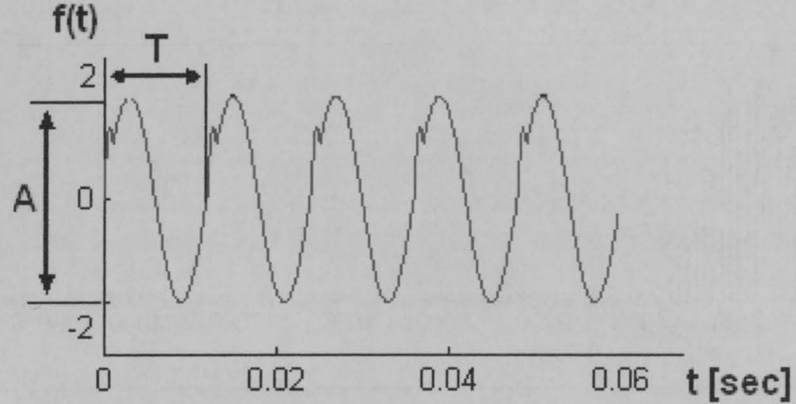


Figure 34- Backlash Impulse

One problem that concerns the manufacturers of MBS, is the consequence of Backlash (described before). To traduce backlash as an impulse train, it can be considered the load as shown in the figure 34. Backlash can be traduced as a sine wave with an impulse before the maxim magnitude value.

Considering that $n_{motor} = 5000\, rpm$ and $\omega_{MBS} = 2 \times \omega_{motor}$, thus:

$$T = \frac{30}{n_{motor}} = 0.006$$

The magnitude of impulse considered is unitary.

It is obtained the graphics of system response in all DOF's, but it will only be shown and explained what happens in 1st DOF.

9.3.1 Time Response

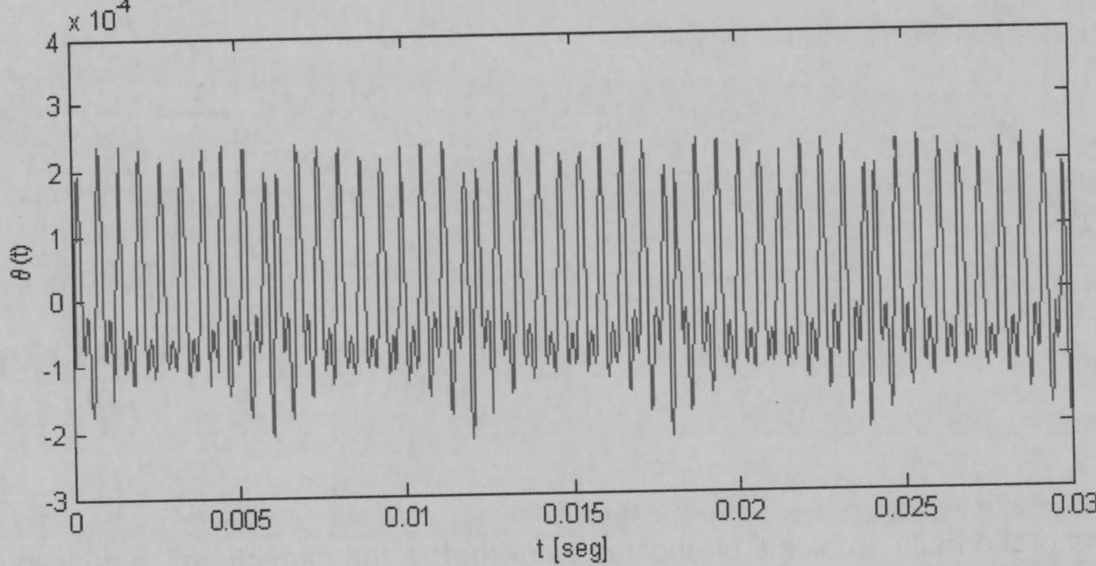


Figure 35- Time Response to backlash (1st DOF)

The figure 35 shows the system time response to backlash, and it's possible to conclude that it is periodic. The period of the response is the same period of the impulse (As $n_{motor} = 5000\, rpm \Longrightarrow T = 0.006\,[\text{sec}]$)

9.3.2 Spectrum

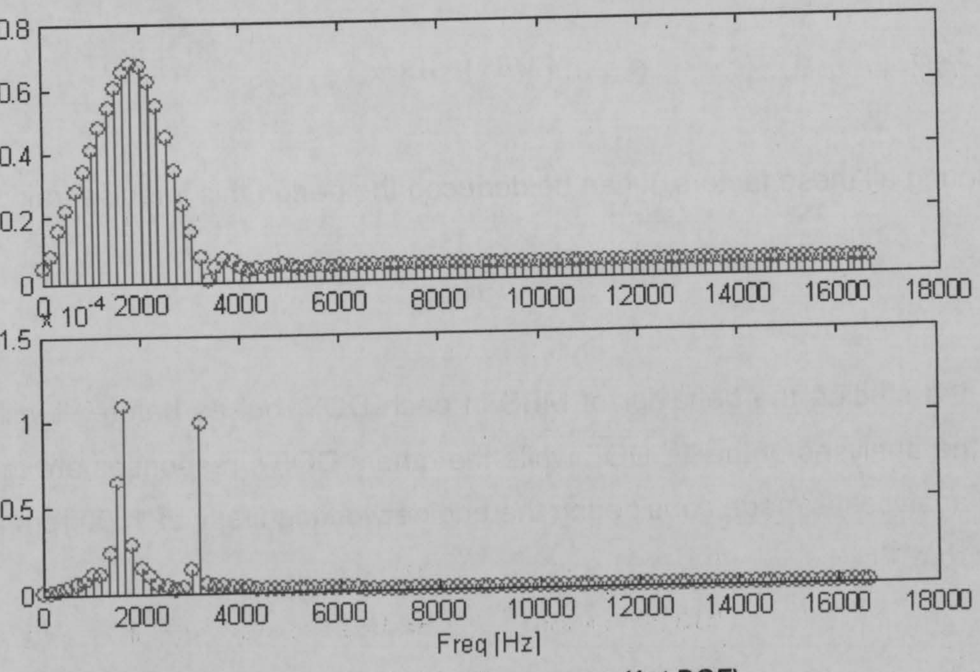
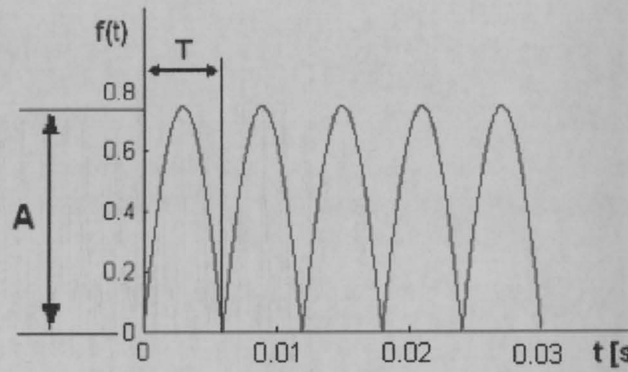


Figure 36- Spectrum of backlash and response (1st DOF)

9.4 Acyclism

$$f(t) = A\sin(\varpi t) \quad 0 < t < T$$



One of the main problems of engines crankshaft is the ***"acyclism"***, a consequence of firing pulses. ***"Acyclism"*** can be traduced as an impulse train as it's shown at the picture above (figure 37), with the characteristic that the frequency is twice the engine speed, because firing pulses show up twice per engine revolution in a four-cylinder engine.

Thus: $\varpi_{Acyclism}(motor) = 2 \times \varpi_{motor}$

But the MBS rotates at twice the engine speed and so:

$$\varpi_{MBS} = 2 \times \varpi_{motor} \quad \Longrightarrow \quad \varpi_{acyclism}(MBS) = 4 \times \varpi_{motor}$$

Considering all these factors, it can be deduced the period this impulse train:

$$T = \frac{15}{n_{motor}}$$

As so, it is studied the behavior of MBS in each DOF, but as before, it will be only shown the analyses of the 1st DOF while the others DOF's responses are in ANNEX XI. The analyses is made considering the engine working firstly at 1000 rpm and then at 5000 rpm.

9.4.1 Time Response

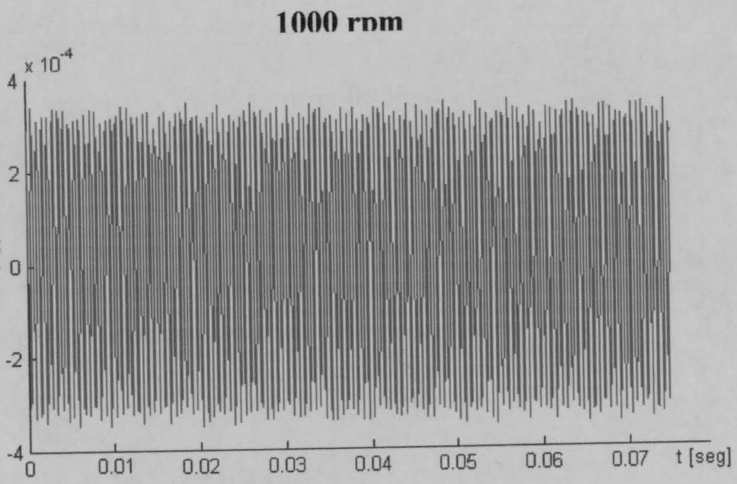


Figure 38- Time Response to acyclism at 1000 rpm (1st DOF)

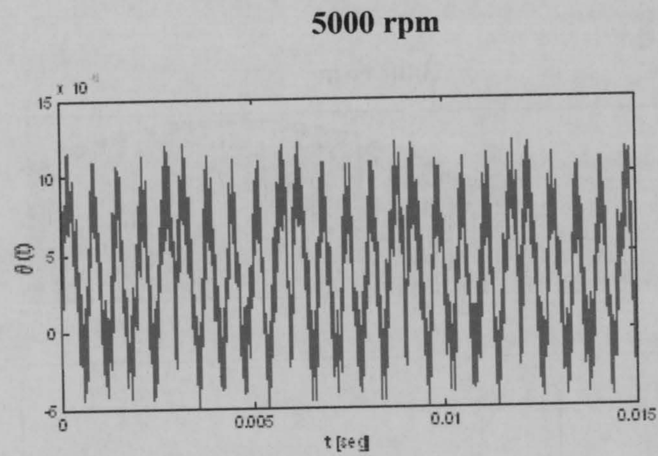


Figure 39- Time Response to acyclism at 5000 rpm (1st DOF)

Due to what is said about acyclism, it seems important to study the MBS behavior under different operation regimes of engine, which means, under different speed.
As so, it is obtained the two figures above (figure 38 and 39). As it can be concluded the magnitudes are not the same in both graphics. We can see that when the engine is working at 1000 rpm, the highest magnitude is given to higher values than when working at 5000 rpm. As so, it can be concluded that the acyclism is more noticed when working at low speed, and when increasing speed the acyclism doesn't reach so high values.

As a conclusion of this section, it can be said that the main problem of acyclism is when working at low speeds, a fact that must be carefully study.

9.4.2 Spectrum

1000 rpm

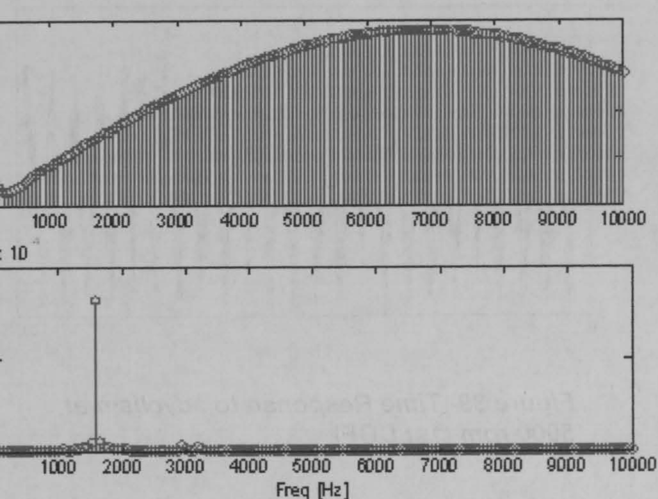


Figure 40- Spectrum to acyclism at 1000 rpm (1st DOF)

5000 rpm

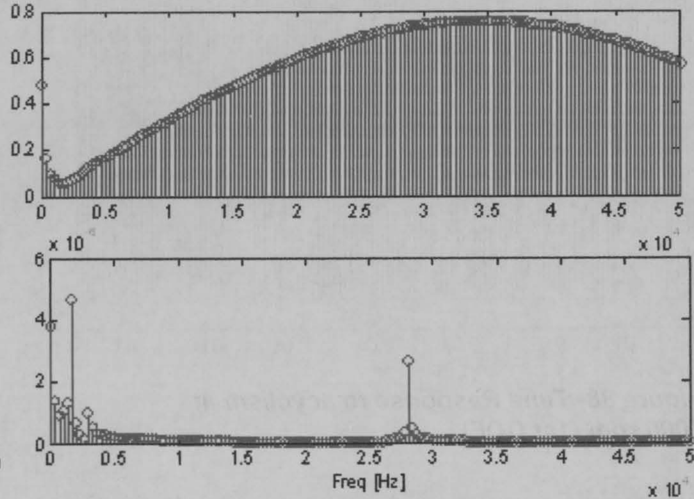


Figure 41- Spectrum to acyclism at 5000 rpm (1st DOF)

Each point in response Spectrum represents the maxim response of the system at this DOF with a given frequency. The first graphic corresponds to the excitement load (acyclism), and the second graphic is the response spectrum in the 1st DOF to a half-sine wave impulse train, both to 1000 and 5000 rpm. It is well noticed that the spectrum of excitation has the same shape independently of the speed, but not in the same scale.

When the engine is working at 1000 rpm, the higher value of response is given to a frequency near the 1500 Hz and at the others frequencies of the spectrum, magnitude is null.

At 5000 rpm we also achieved a higher magnitude in response near the 1500 Hz but smaller than the verified when working at 1000 rpm.

These conclusions also helped to conclude that the main problem of acyclism is verified when working at low regimes of speed.

10. CALCULUS SOFTWARE

To improve the possibility to users have access to the results obtained in this project, the author developed an interface in MatLab, and that is going to be described with the help of the some images selected from the interface.

The main window of the program shows the project title, the university and author that develop this project and this interface. In this window, users can choose if they want to see the calculations results or if they prefer to see graphical analyses. Besides that, users have access to the project report where they can see the details and the descriptions of calculations steps and graphics analyzes.

Figure 43- Main Menu

If users choose the "Calculations" icon, a new window will appear and give them the access to the main results obtained.

Natural Frequencies, inertia, stiffness and modal matrix are the choices and results that users could easily obtain. In these menus users will have access to full information about this, and if the concepts aren't well known, they have the possibility to obtain a simple description of each concept meaning. If they want a more complex description it's always possible to consult the report to better understand the concepts referred in this project.

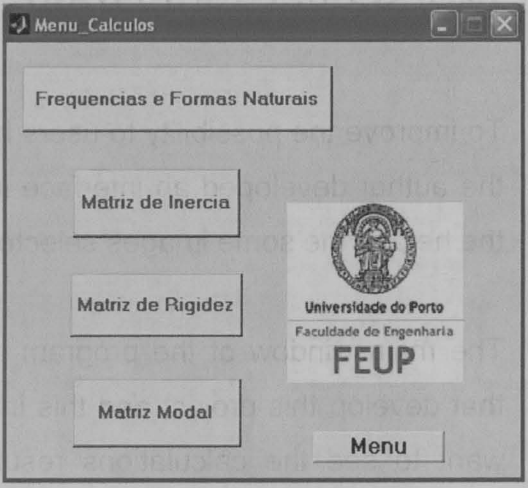


Figure 44- Calculus Menu

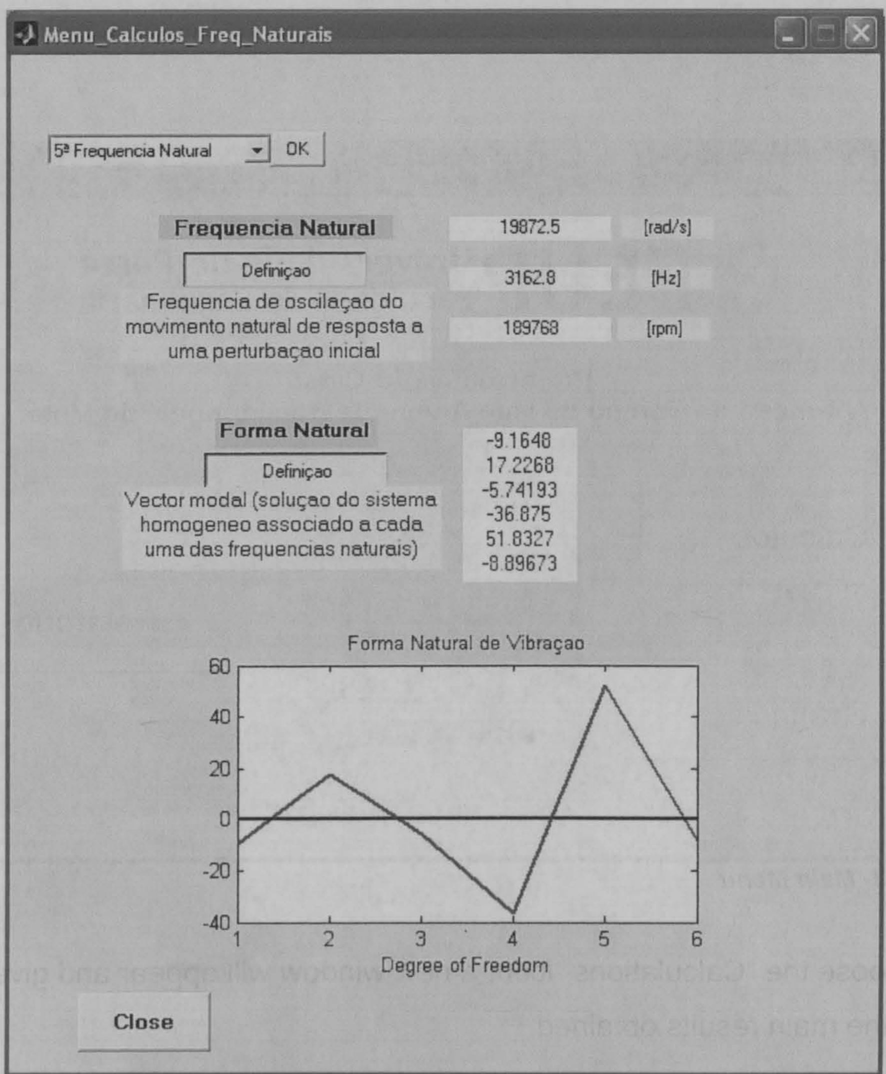


Figure 45- Calculus Menu (Natural Frequencies and Mode Shapes)

If users prefer to see the graphical results a window will appear as the figure:

Here it's possible to choose and see all important graphics to vibration analyzes. Among them we can refer: response to an impulse load, frequency response and critical speeds. All the graphics are followed with the spatial model used and where users could easily identify the DOF that is being analyzed having the possibility to understand the system behavior under different regimes.

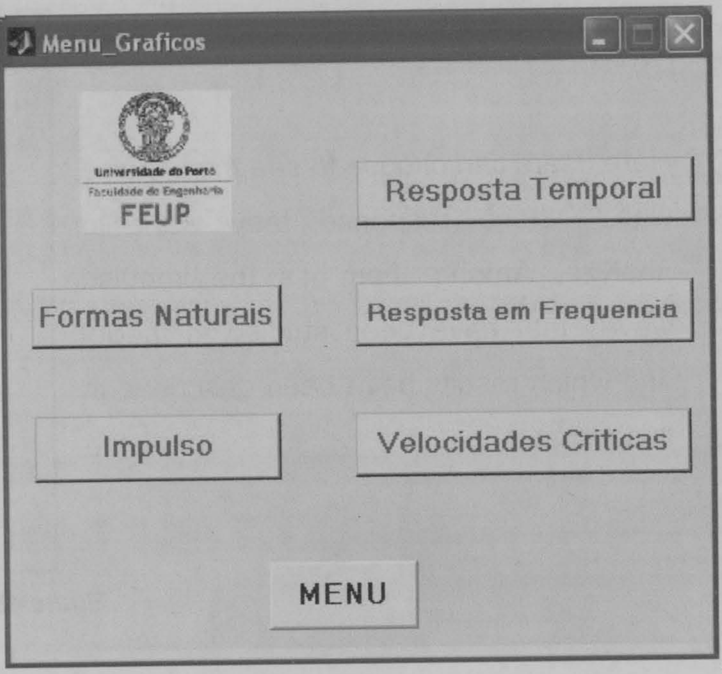


Figure 46- Graphic Menu

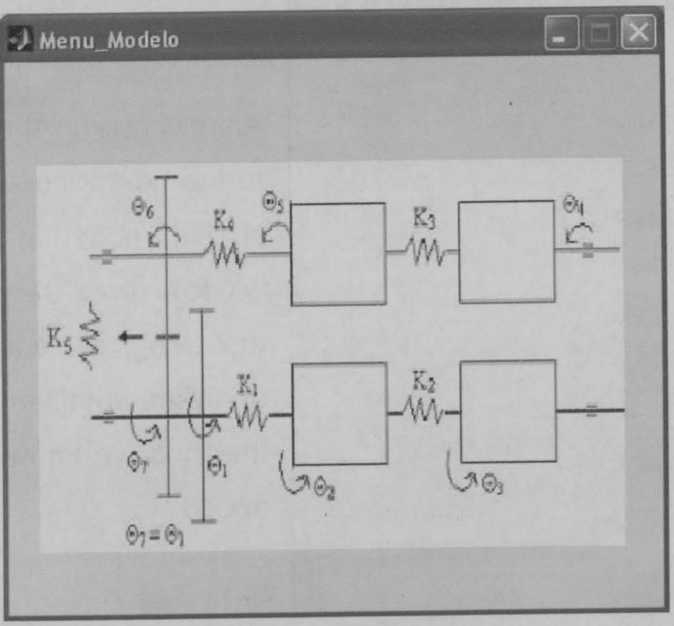


Figure 47-Spatial Model

As an example of it is being described, it has been chosen the "impulse menu" icon, which will open a new window:

Here users can choose to see the impulse wave whose response they want to analyze. Among them it's the impulse waves that have been studied in theory and which results have been described in this report.

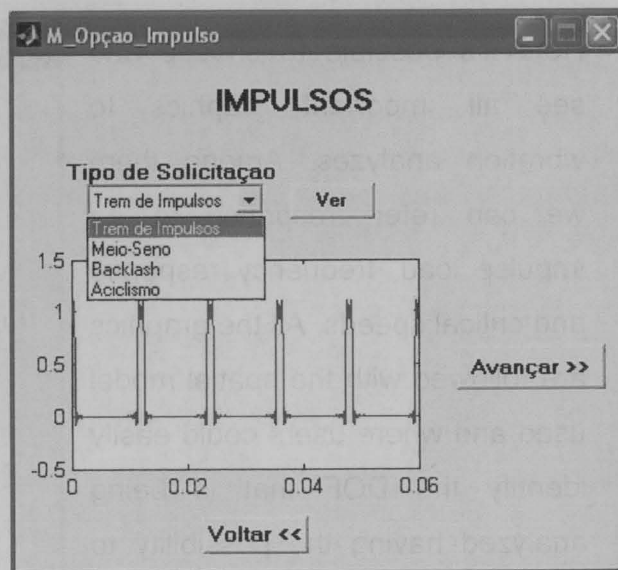


Figure 48- Impulses Menu Option

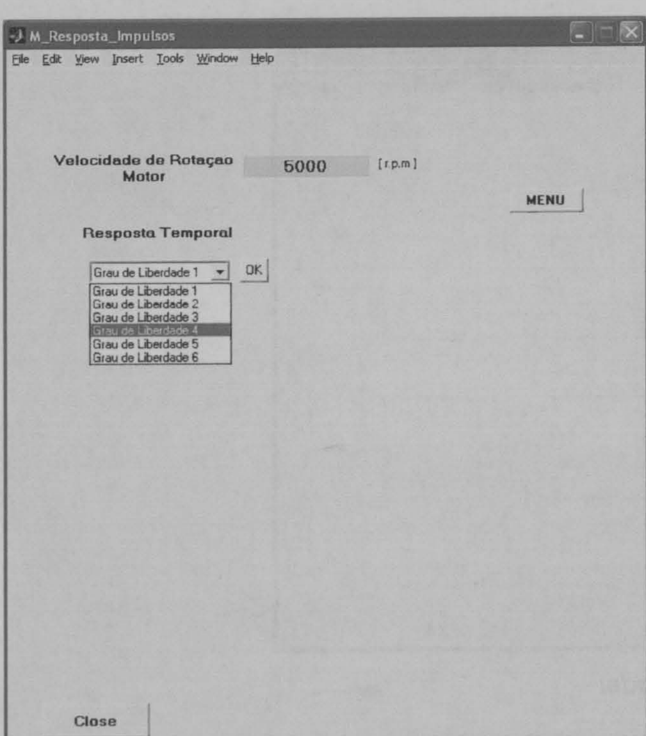


Figure 49- Impulses Menu

After choosing the impulse and going to the next window, users can see the spatial model in study and another window gives the possibility to choose the engine speed because this analyses is influenced by MBS speed, that has we know is twice the engine speed.

After choosing the option and DOF to study, users have access to all the graphics necessary to proceed with the analysis of MBS components behavior under different impulses waves and speed regimes.

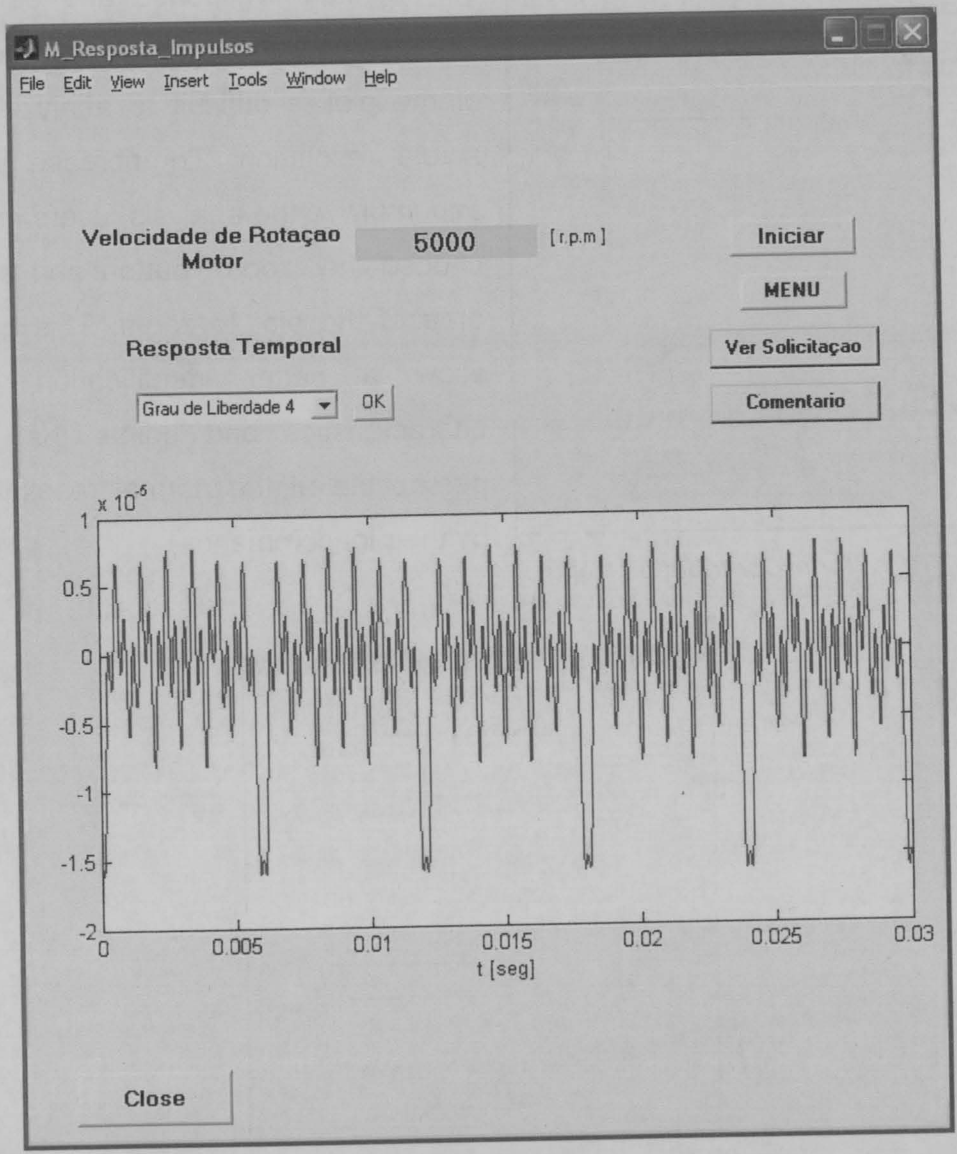


Figure 50- Impulses Menu Response

This menu is prepared to give comments to the graphics obtained but this option is going to be a further development to be made.

Among other options, users can use "ZOOM" icon, if necessary, to better analyze the graphic and to have a better perception of values in each position of the plot.

As an example, the next menu can be analyzed:

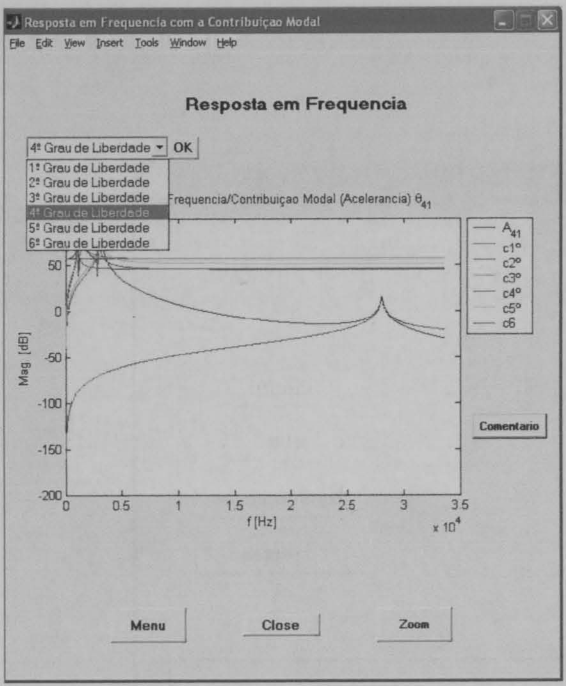


Figure 51- FRF's Modal Contribution Menu

In this menu (Modal Contribution FRF's analyzes), users can identify the variation of magnitude response and each modal contribution with frequency, but the left side of the plot is difficult to analyze with the actual resolution. To increase resolution and improve the analysis, users are able to choose the "zoom" button and select the area of the plot to zoom. This option will allow a better identification of plots characteristics and points that are not perceptible at the normal resolution used by the plot commands.

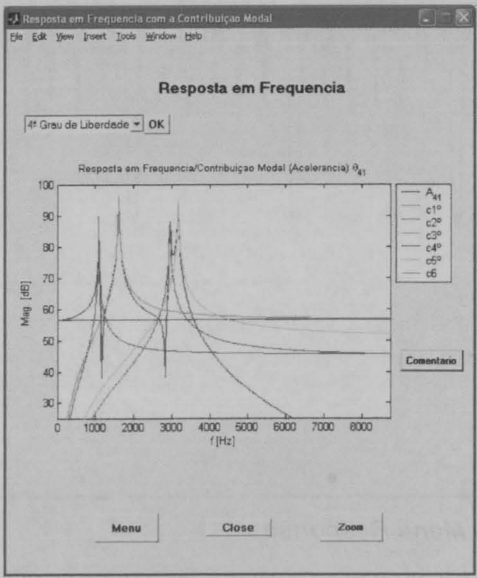


Figure 52- FRF's Modal Contribution Menu

These are some of the profits that the interface gives to users allowing them to have a better analyze of the system. This interface can be found in a CD-ROM existent in this report.

11.CONCLUSION

11.1 Final Conclusions

As final conclusions it is possible to say that the MBS doesn't reach any torsion critical speed. In the other hand, it's important to contrast the values obtained with practical tests executed by Renault with measurements and resistant tests.

Another important conclusion is the fact of the tooth stiffness of the gears to be extremely high and that increases the last natural frequency values to a higher level.

Also a numerical tool to determine the dynamical characteristics of the system as well as his response, both in the time and frequency domains for several types of excitation was developed and implemented in a user-friendly package.

After the analysis of all calculations it's possible to conclude that the project goals were reached. The knowledge about systems vibration study and comprehension has been developed and it was very profit to the author.

11.2 Future Work

In the following, there are some tasks that can be developed, namely:

- Introduction of real values of engine characteristics (as power, torque, etc) which allows obtaining real magnitudes and values in this analyzes;
- Study of the tooth stiffness of the gears attempting to achieve the most real value as possible.

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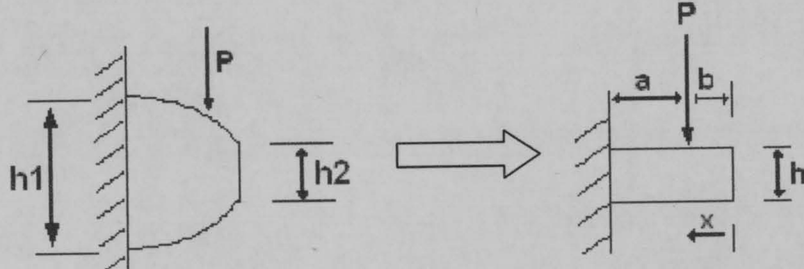
ANNEXES

ANNEX I - Tooth stiffness of the gears

Supposing the tooth as shown in the figure and the load **P**, resultant from the projection of the load produced by the gearing between the teeth of two gears we have the following procedure:

For the first stage of calculation we adopted an approximation of what happens in the real tooth. As so, we used a beam fixed at one side and free at the other side as we show in the figure:



$$h = h_{med} = \frac{h_1 + h_2}{2}$$

$$L = a + b$$

Next step is the calculation of the deflection under the load according to the equation:

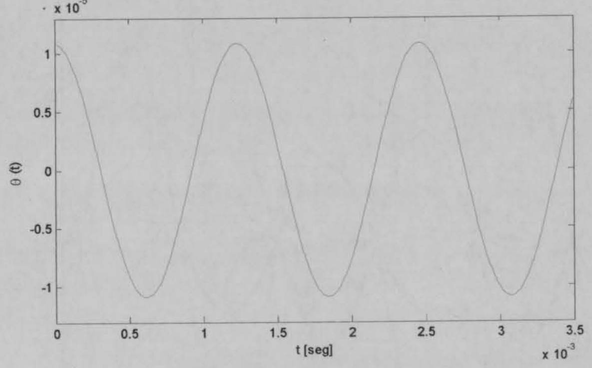
$\frac{\partial^2 y}{\partial x^2} = \frac{Mf(x)}{EI}$, where **y** is the deflection.

Knowing that the bending moment is given by the equation: $Mf(x) = -P(x-a)$ and proceeding to the calculations we achieved: $y(a) = -\frac{Pa^3}{3EI}$ (at the point where the load is applied)

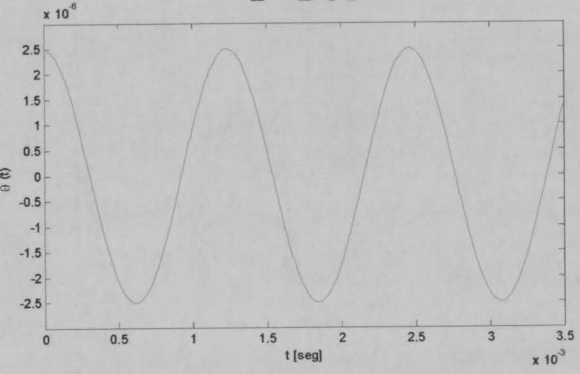
As we know, $k = abs\left(\frac{P}{y}\right)$, we get the tooth stiffness of the gear as: $k = \frac{3EI}{a^3}$

ANNEX II – Time Response

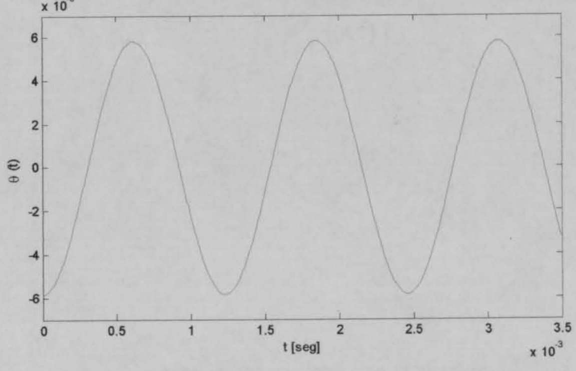
1st DOF



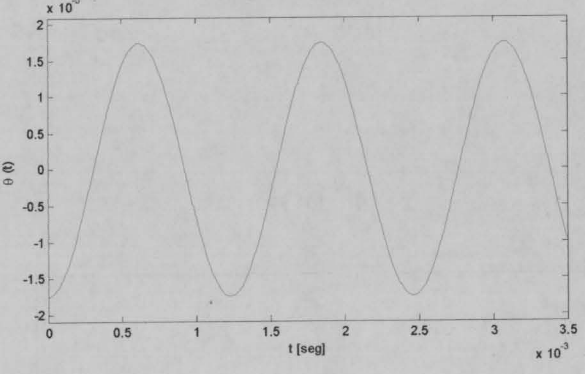
2nd DOF



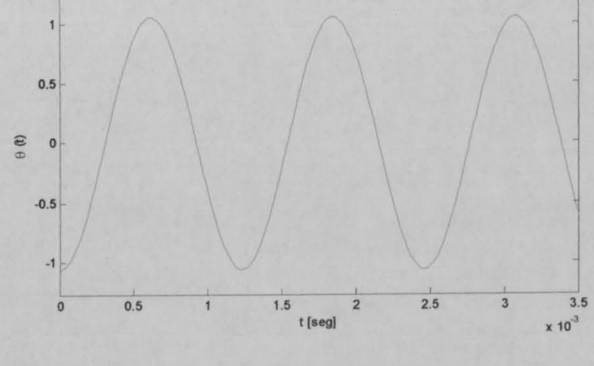
3rd DOF



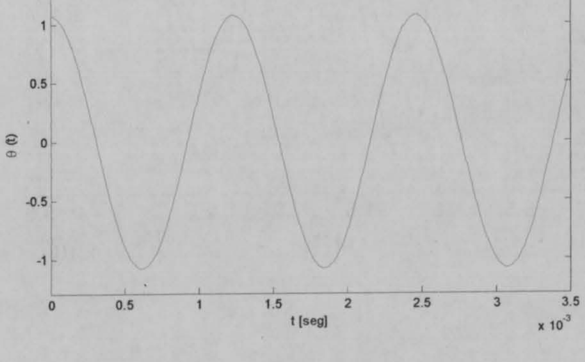
4th DOF



5th DOF

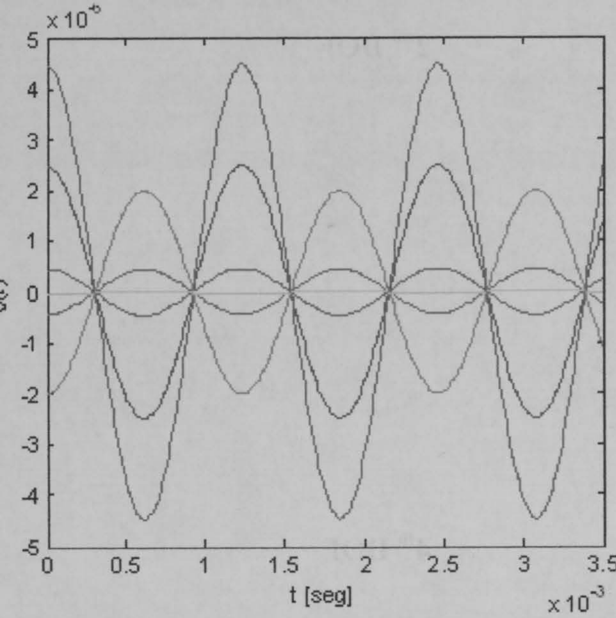


6th DOF



Modal Contribution

2nd DOF



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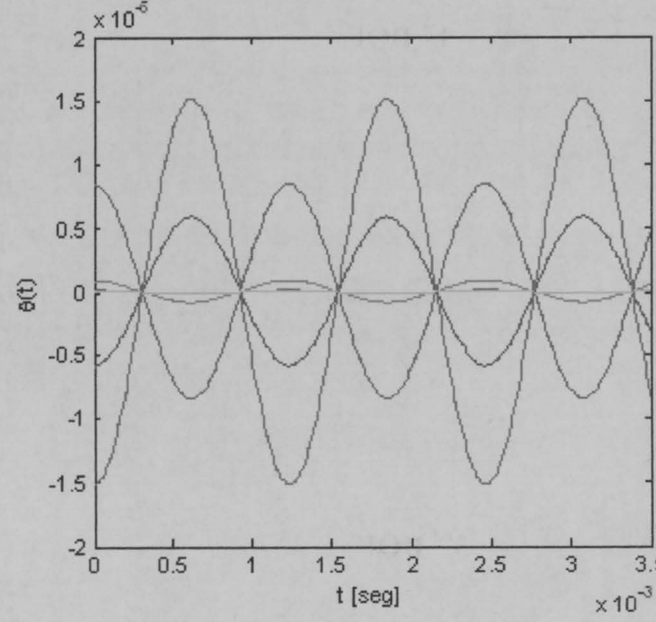

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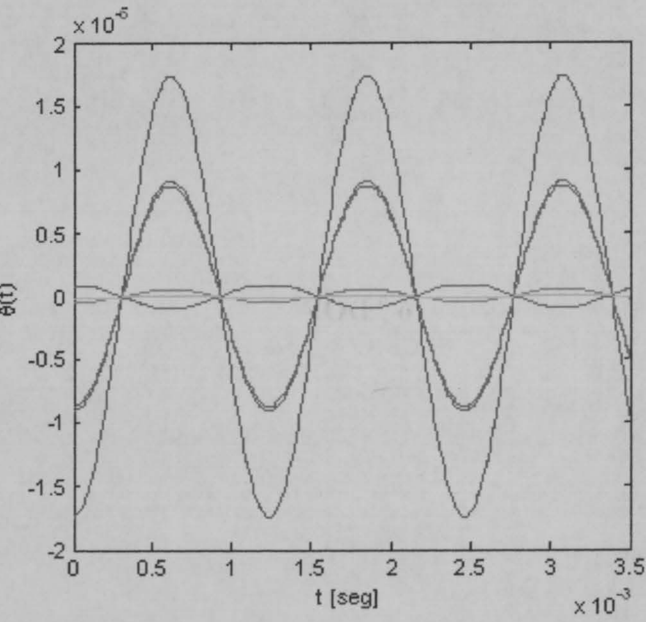

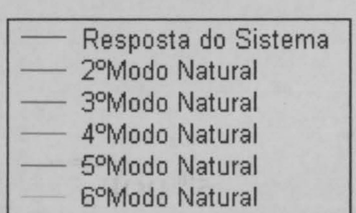

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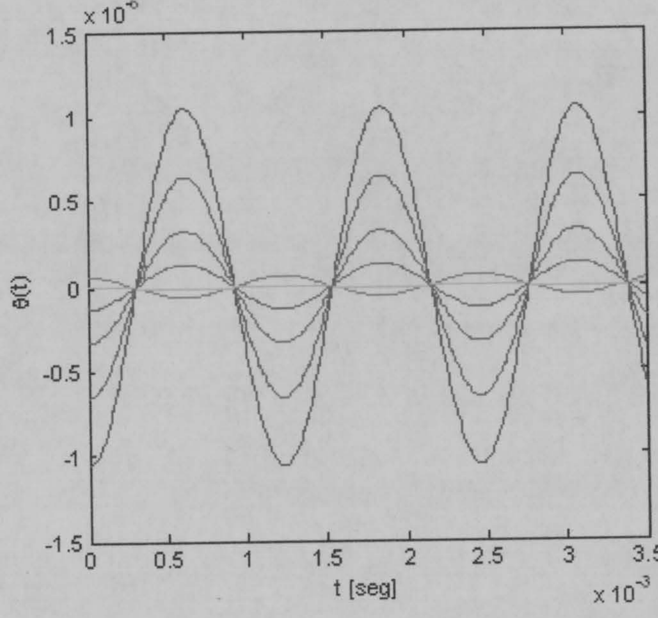

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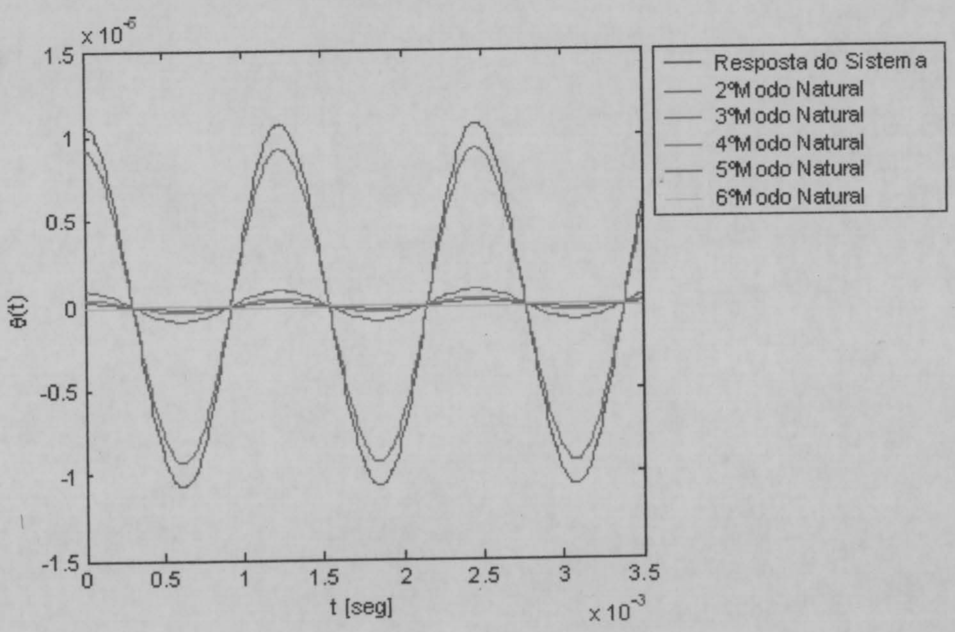
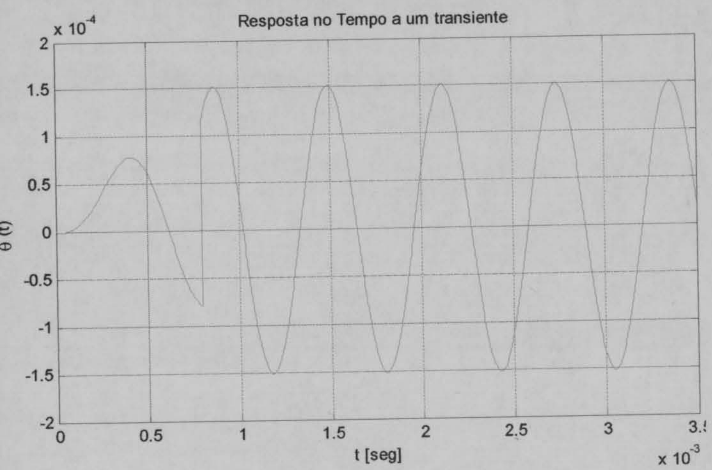


ANNEX III – Transient Response

3rd DOF



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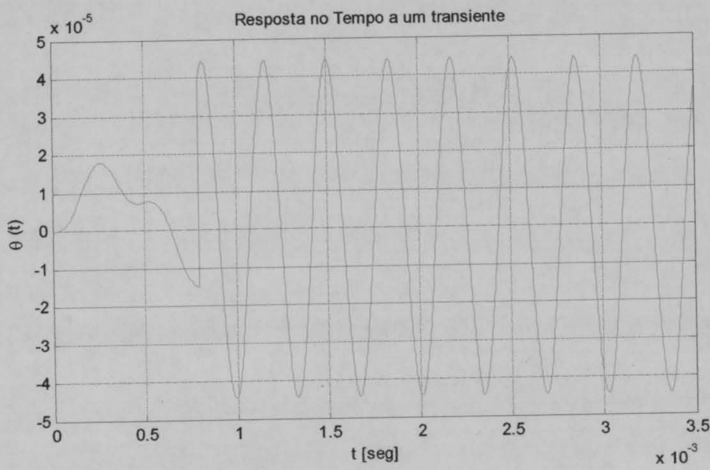

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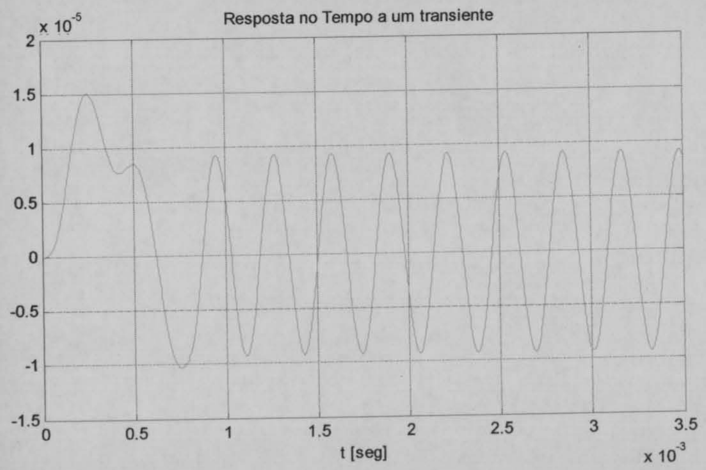
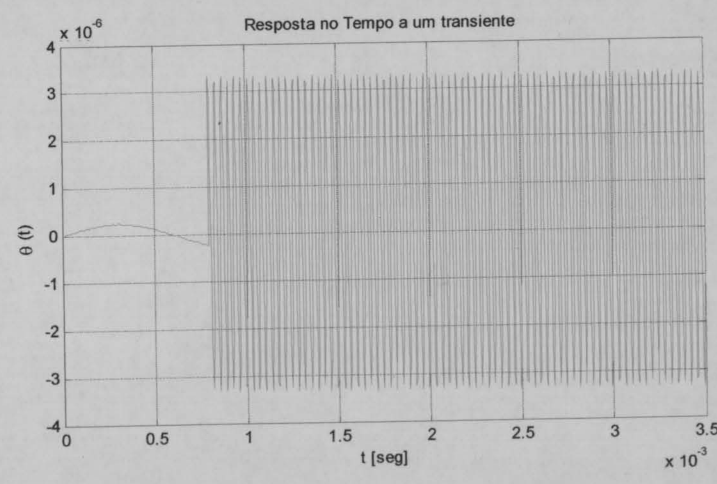
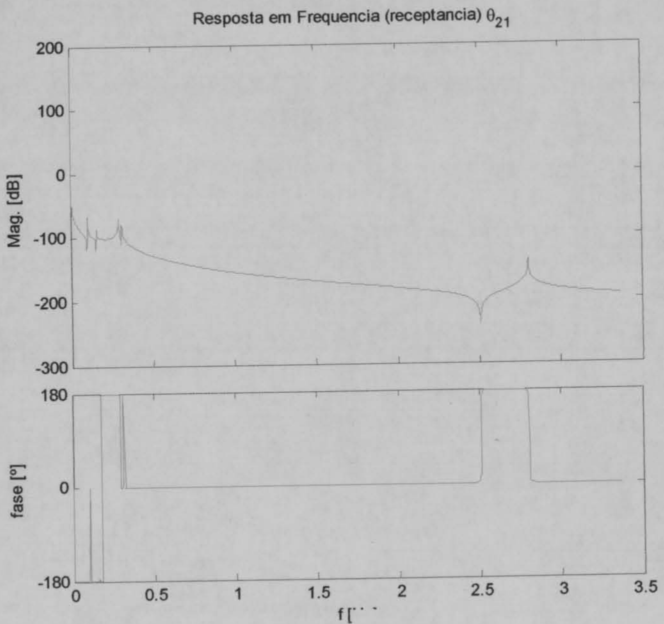


6th DOF

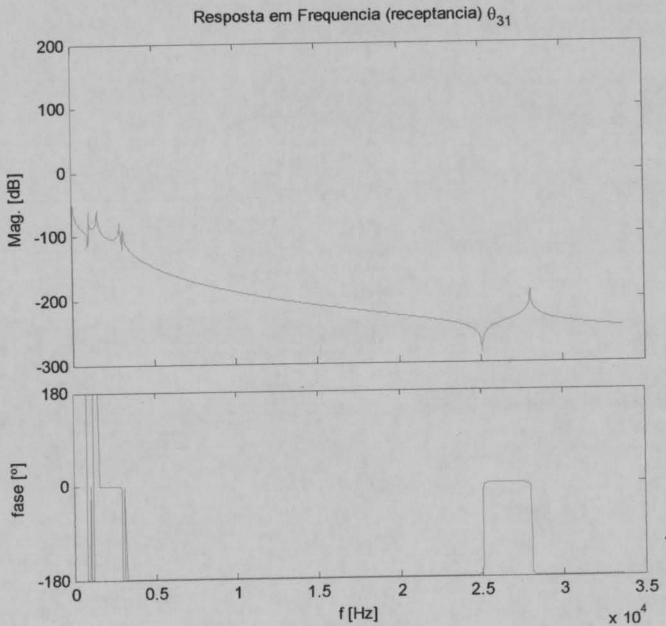


ANNEX IV – Frequency Response (Receptance)

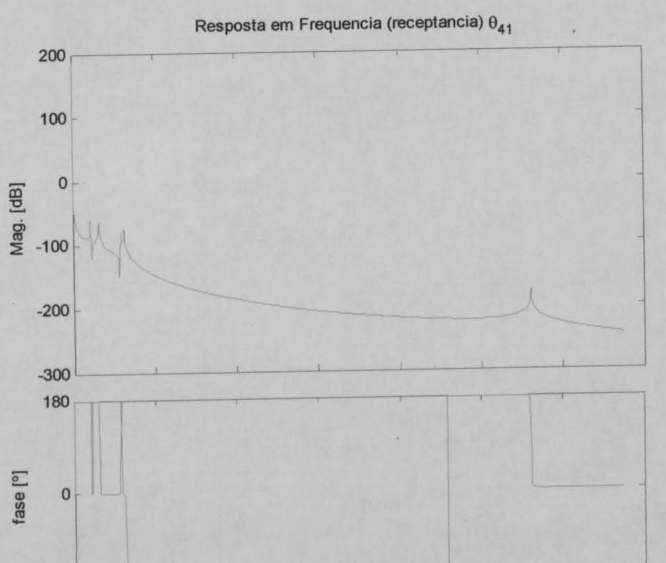
2^{nd} DOF



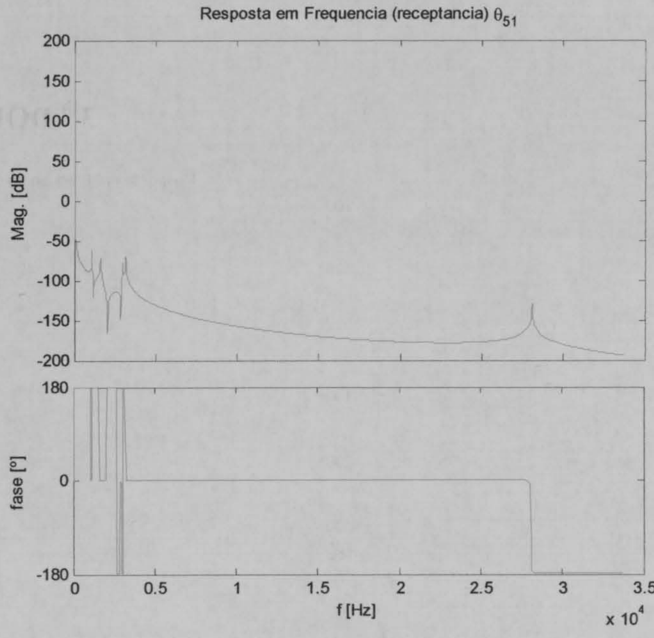
3^{th} DOF



4^{th} DOF



5th DOF



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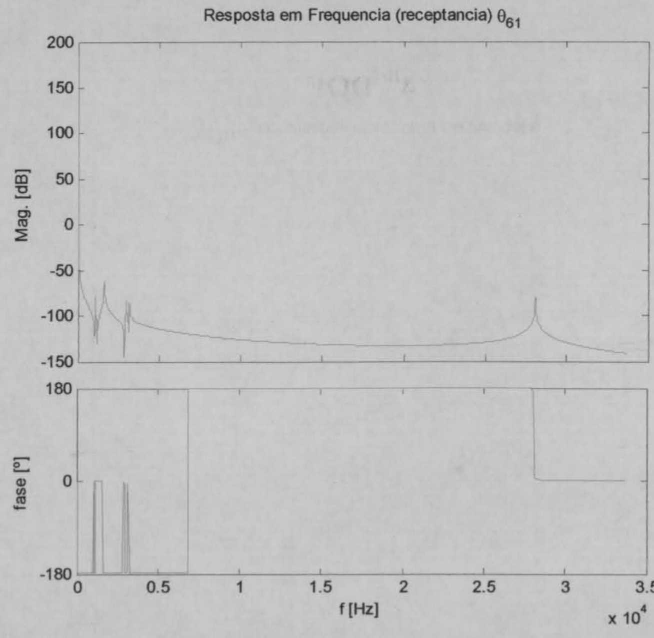
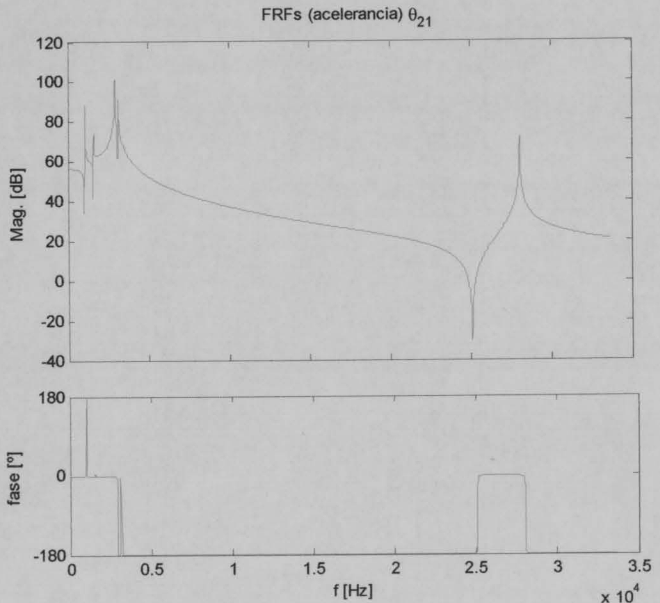


ANNEX V – Frequency Response (Acelerance)

2^{nd} DOF



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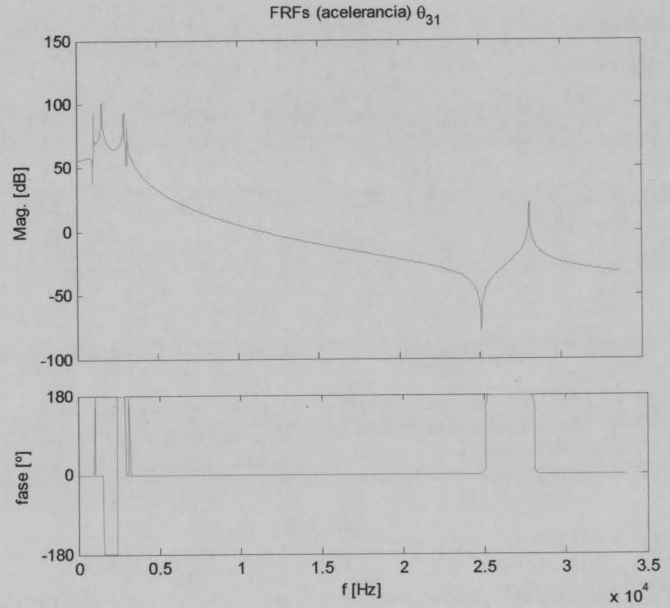

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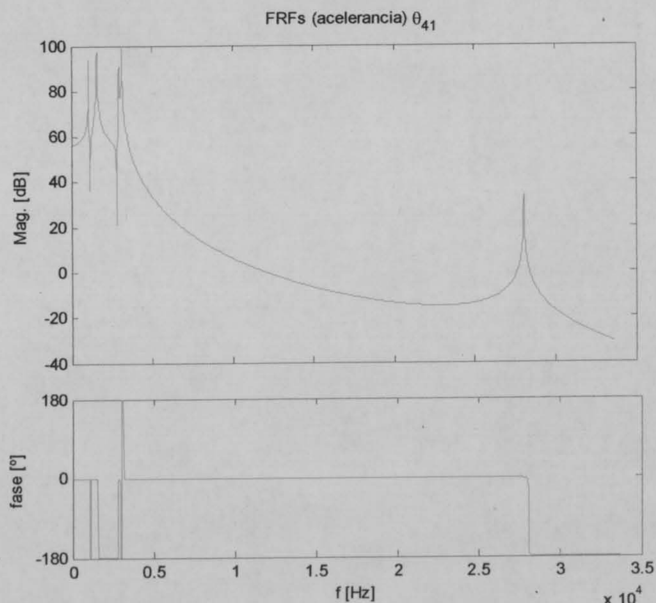

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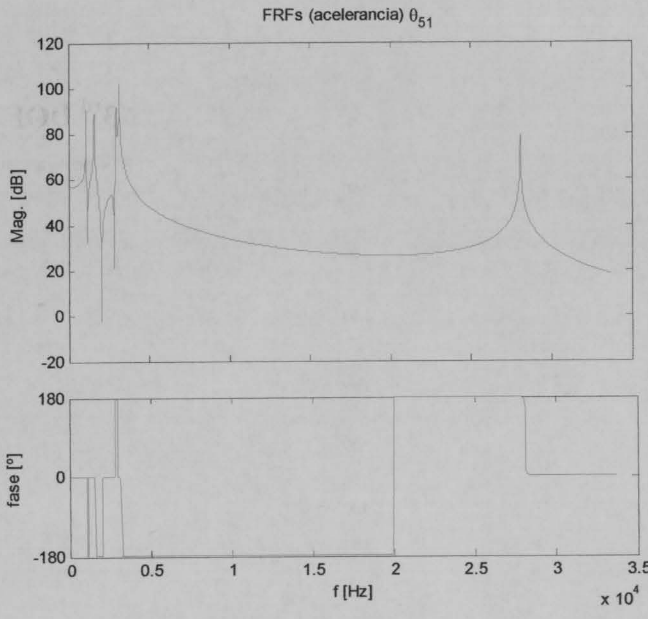

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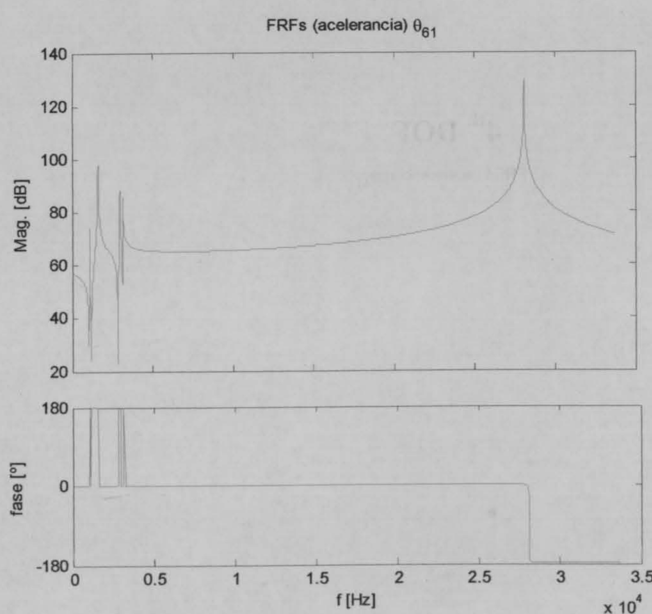
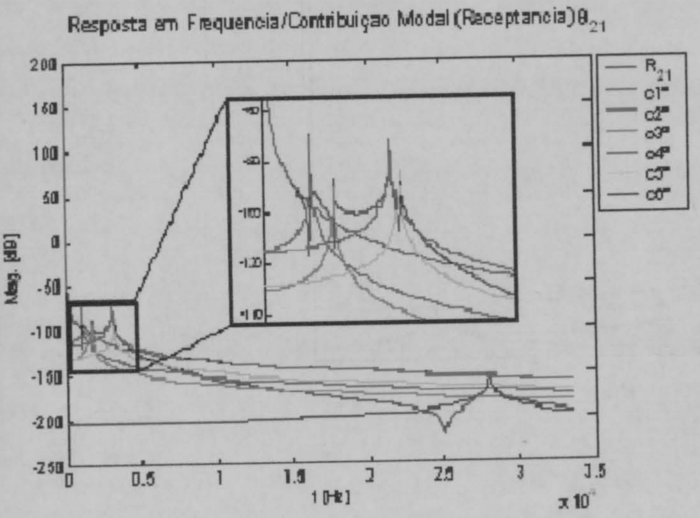


ANNEX VI – Frequency Response (Modal Contribution-Receptance)

2nd DOF



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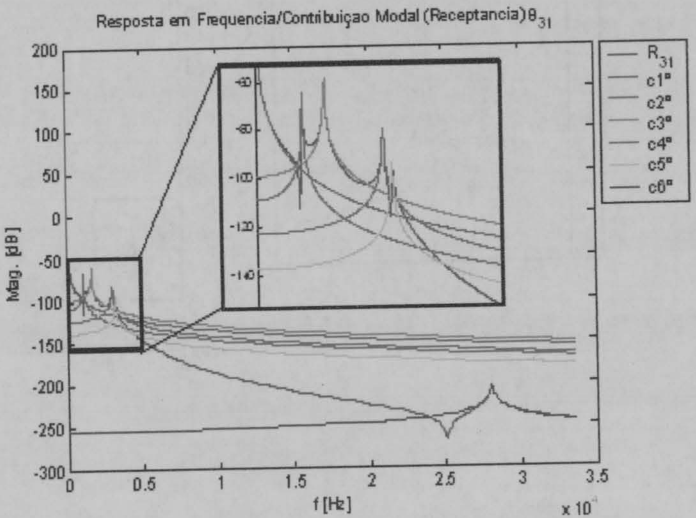

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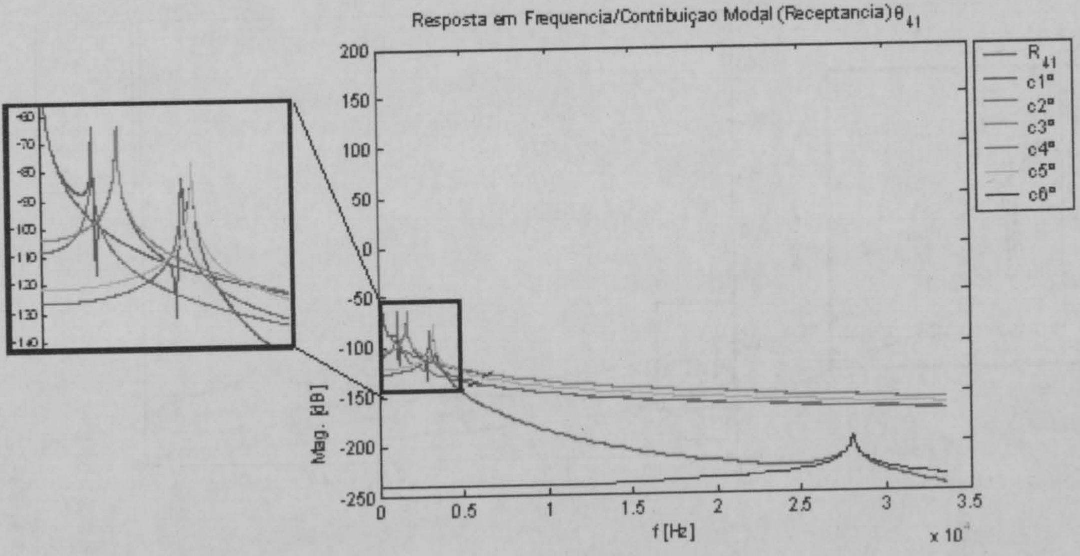

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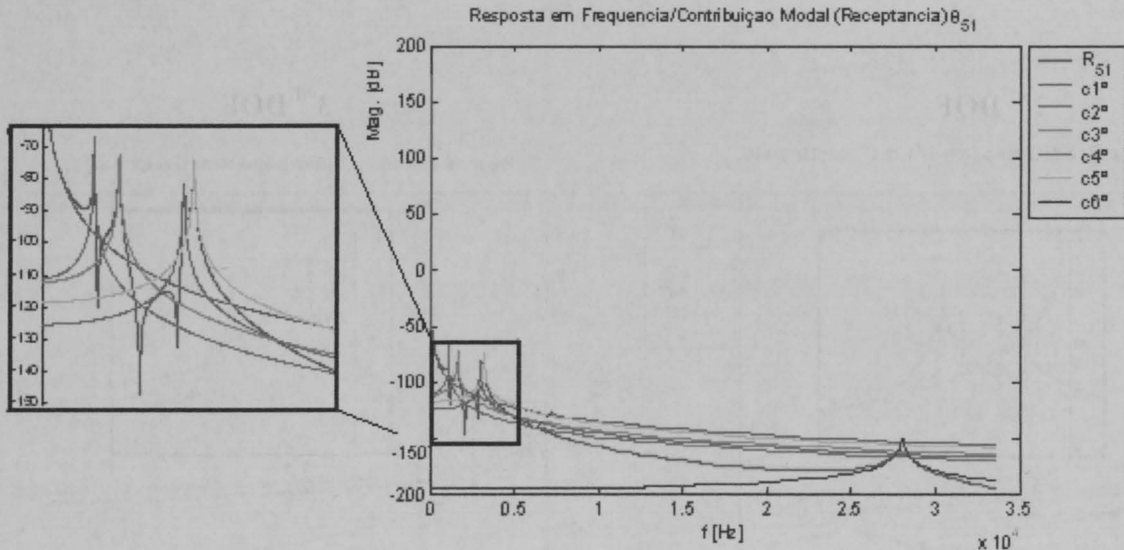
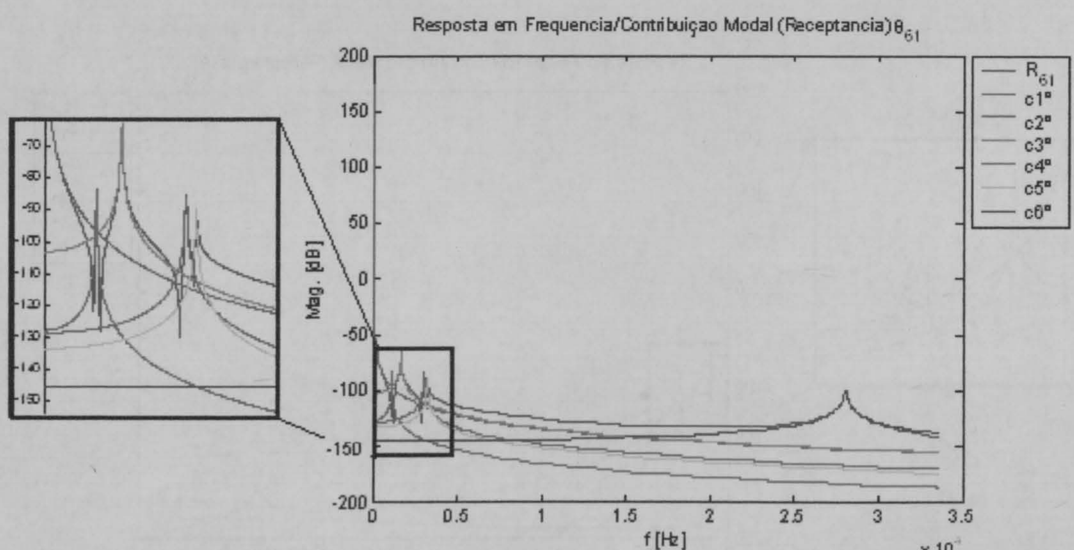
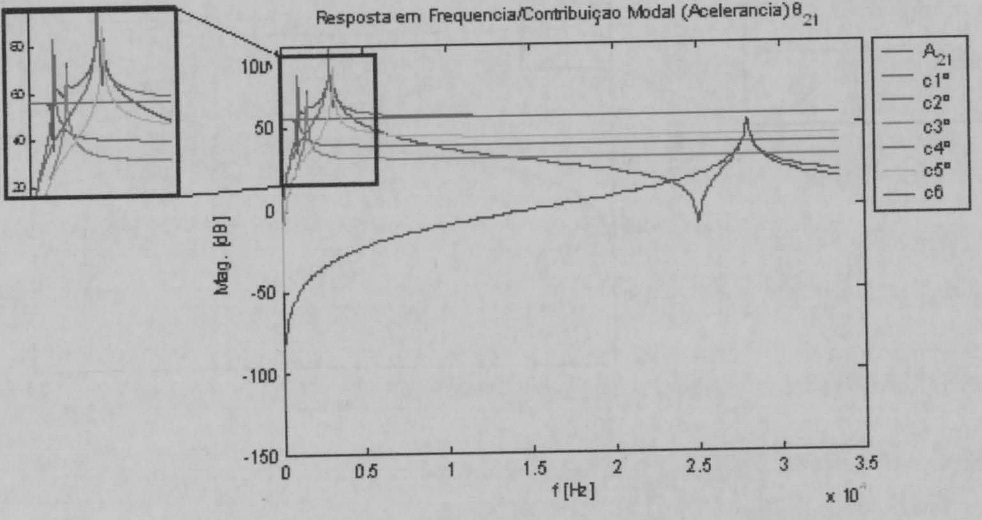


6th DOF



ANNEX VII – Frequency Response (Modal Contribution - Acelerance)

2nd DOF



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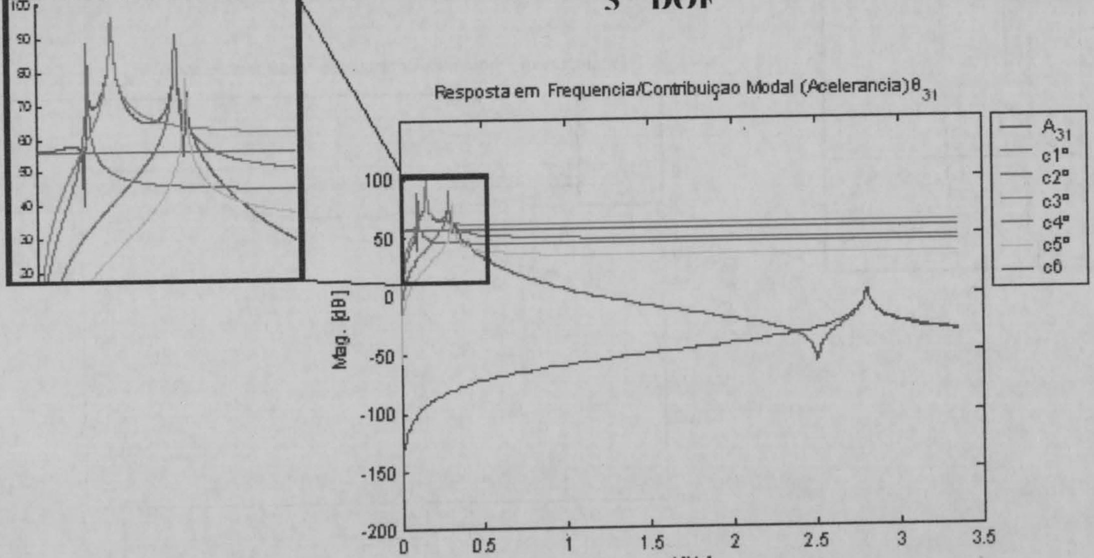

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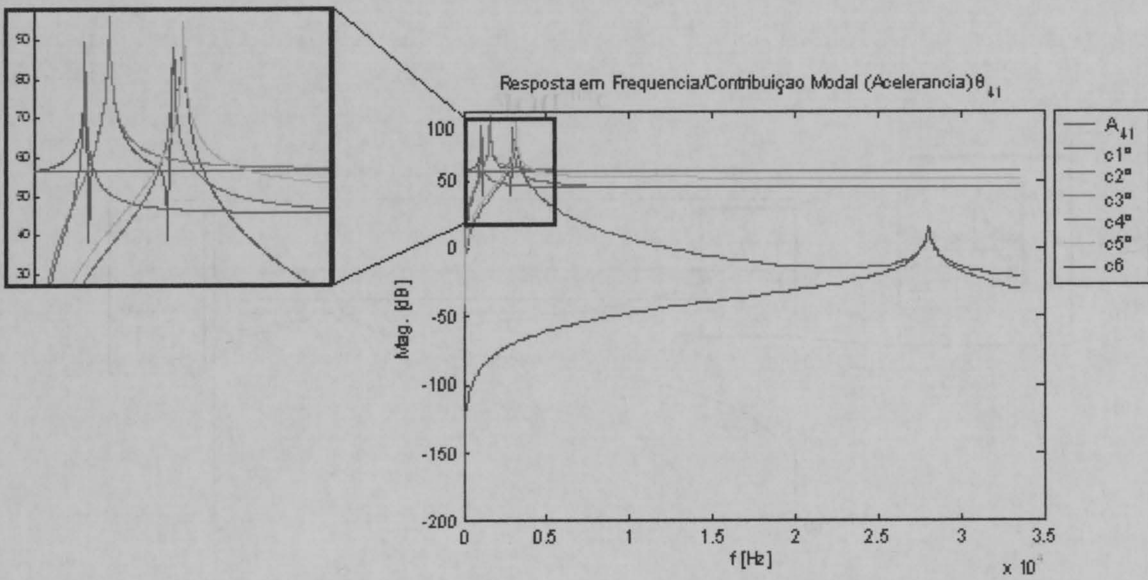

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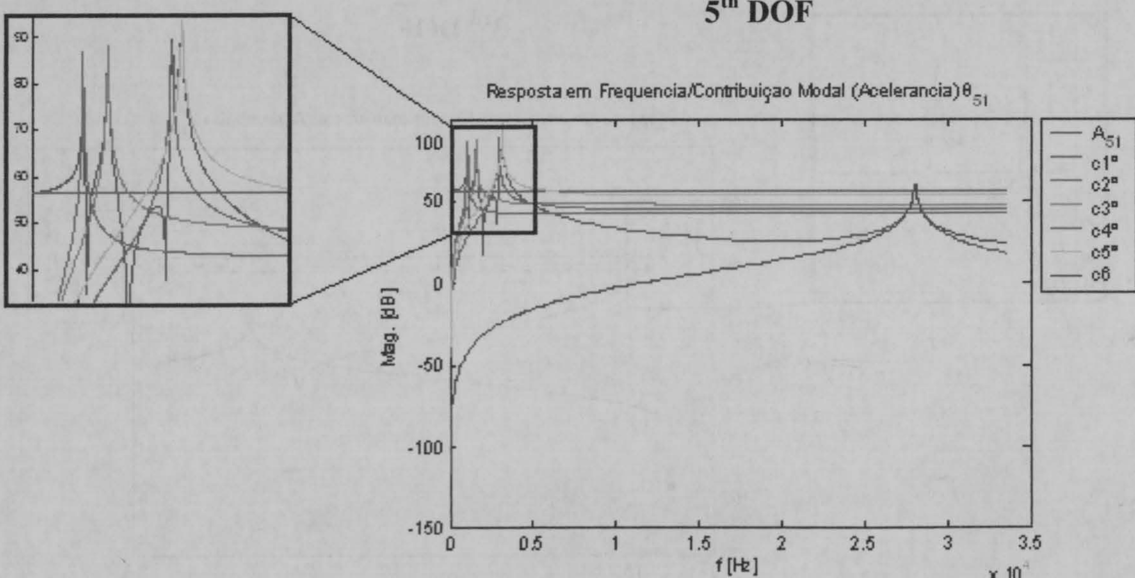
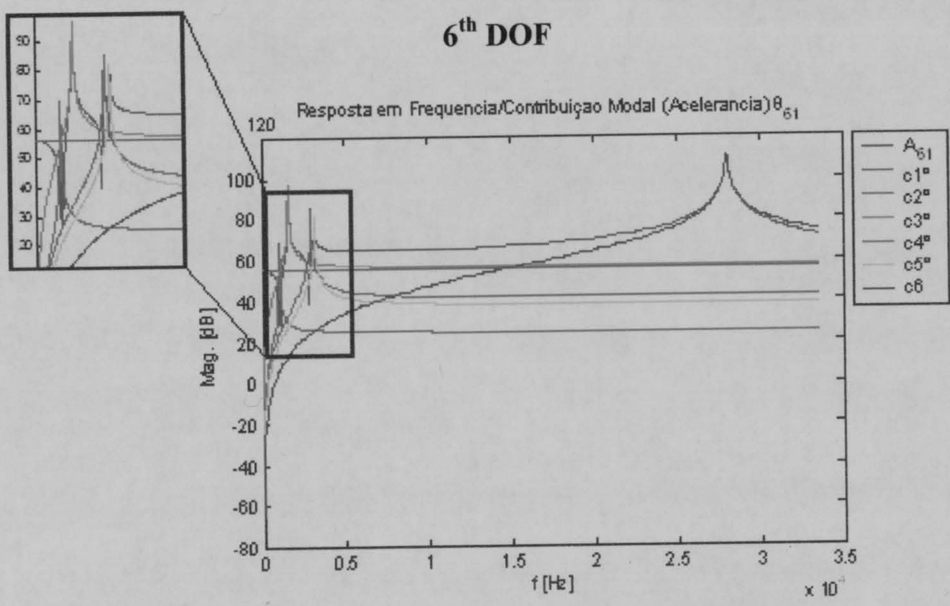


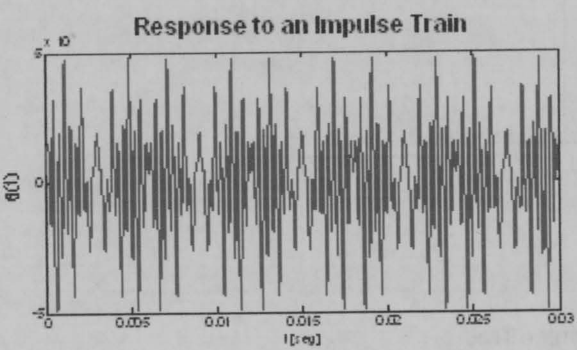
6th DOF


Resposta em Frequencia/Contribuiçao Modal (Acelerancia)θ61
Mag. [dB]
f [Hz]
x 10
A61
c1º
c2º
c3º
c4º
c5º
c6

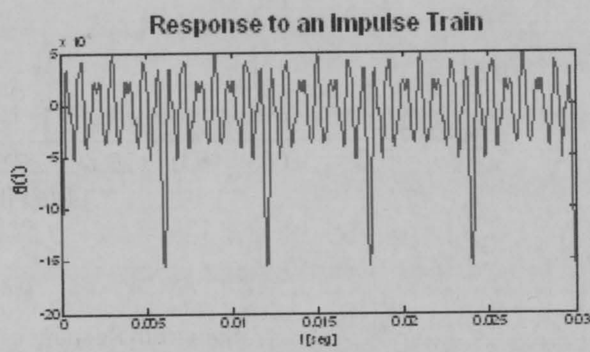
ANNEX VIII – Response to an impulse train

Total response

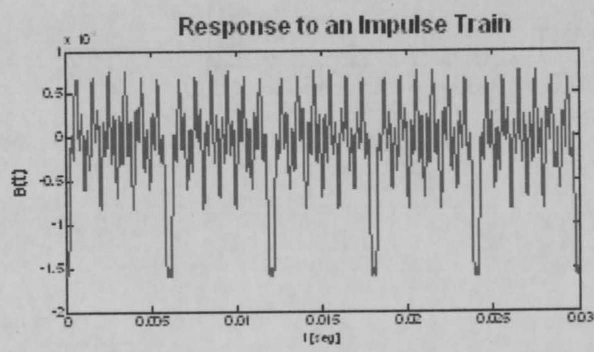
2nd DOF



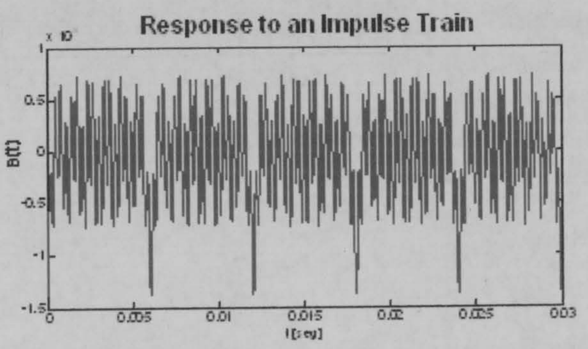
3rd DOF



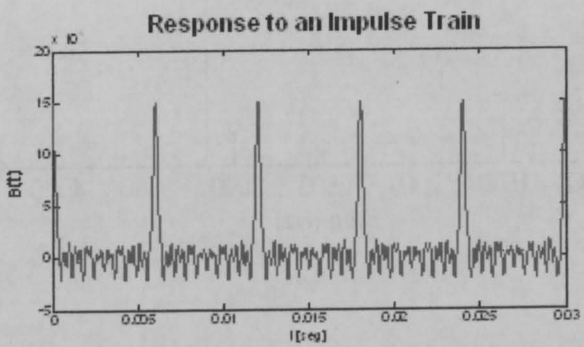
4th DOF



5th DOF

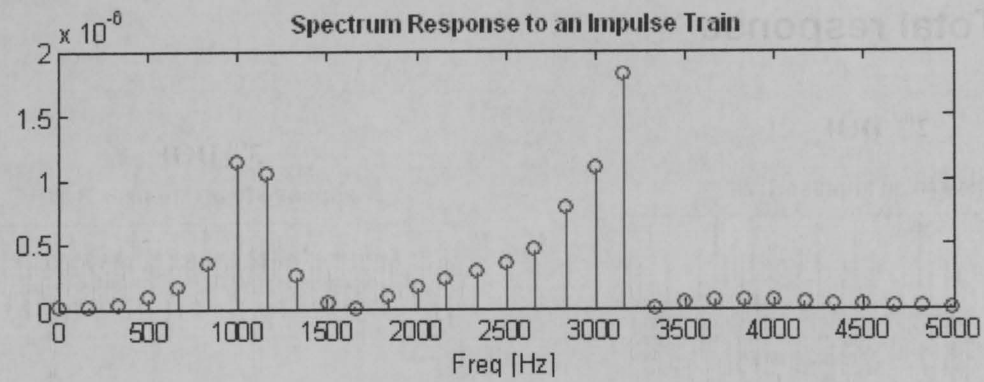


6th DOF

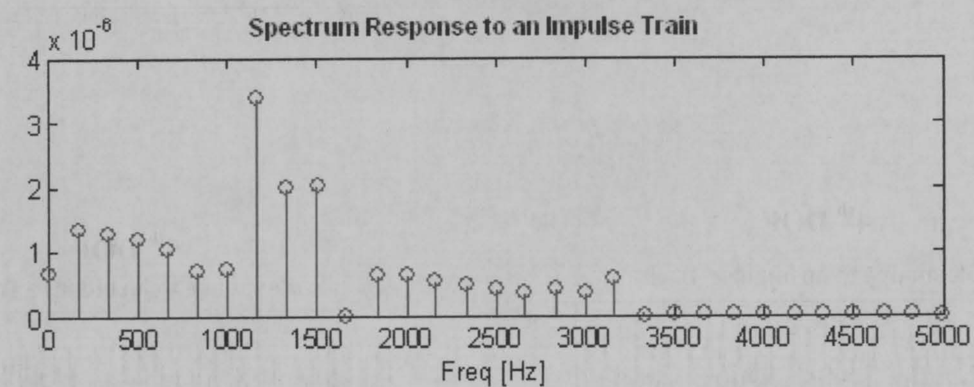


Spectrum

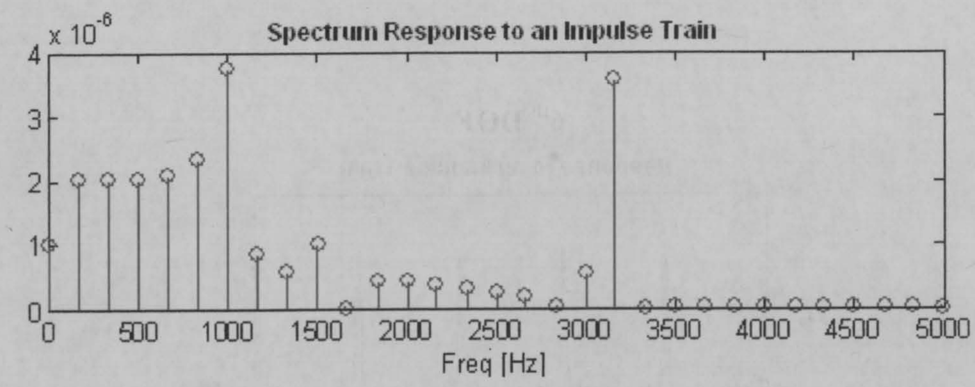
2^{nd} DOF



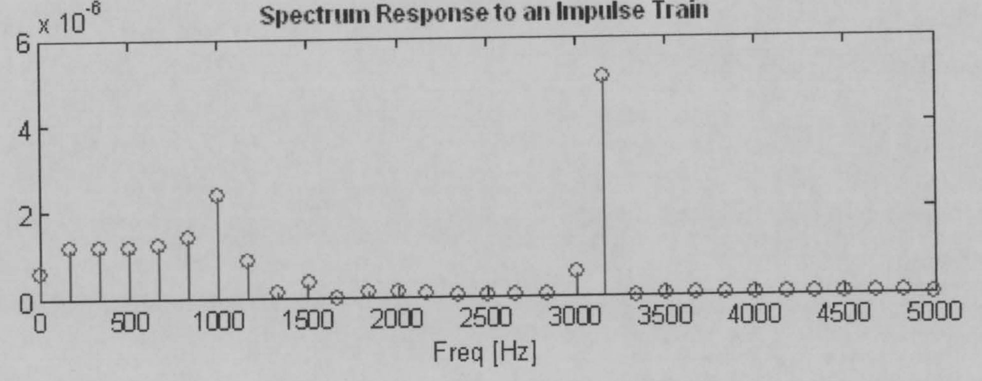
3^{rd}DOF



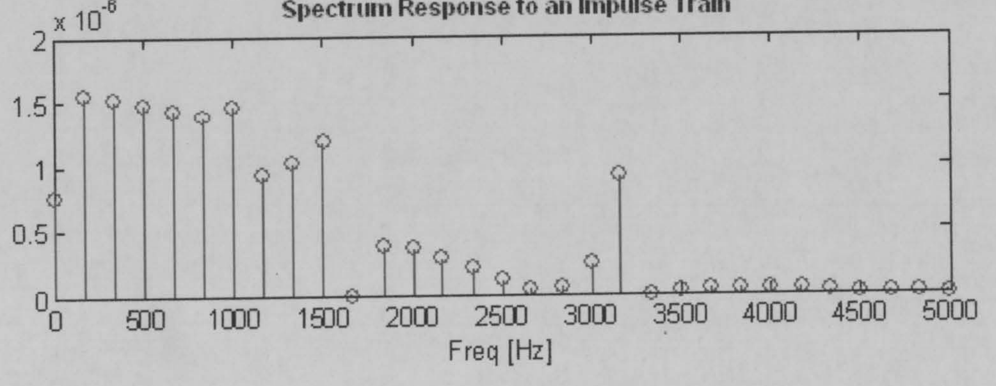
4^{th} DOF



5^{th} DOF



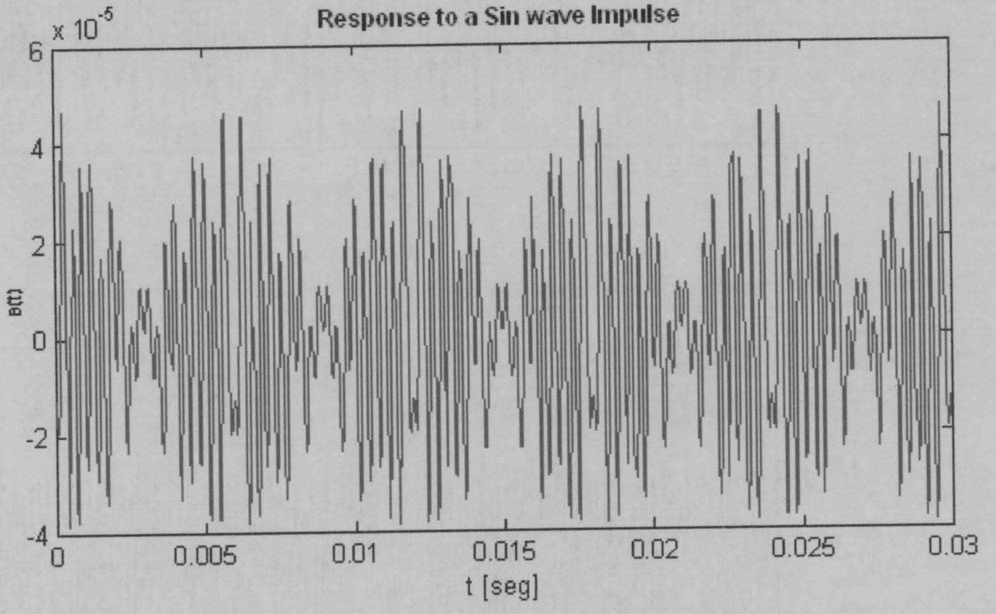
6^{th} DOF



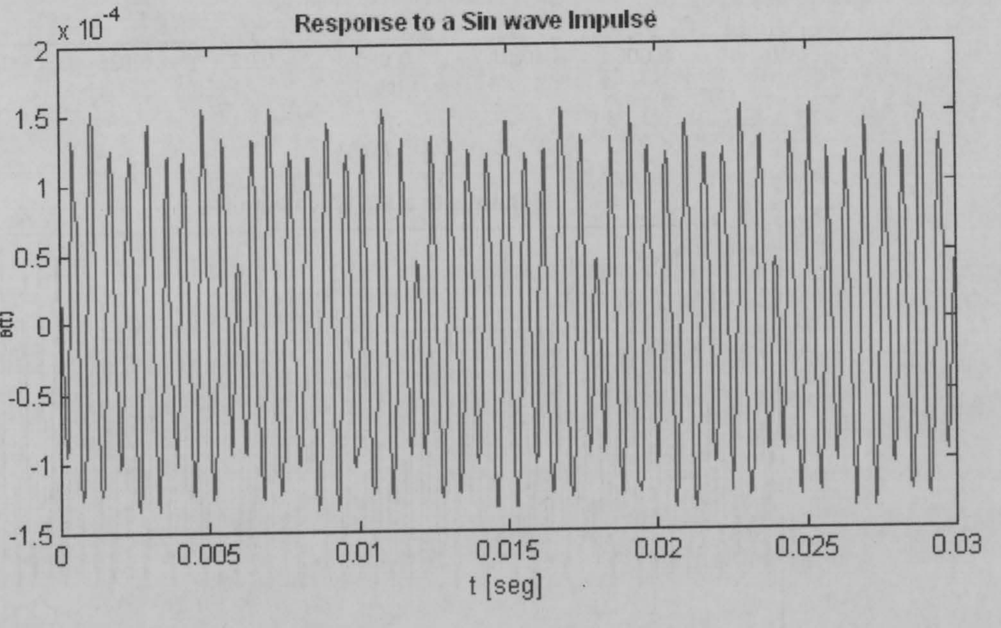
ANNEX IX – Response to a Sine Wave Impulse

Total response

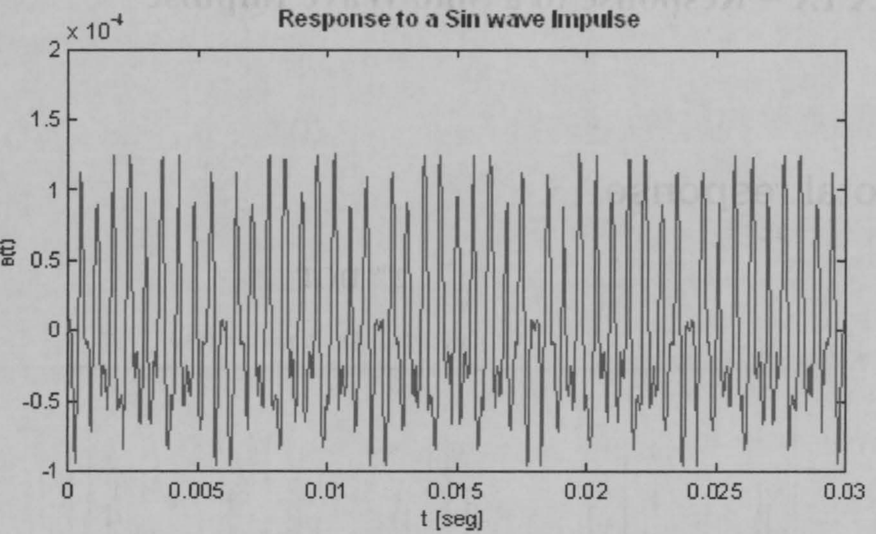
2nd DOF



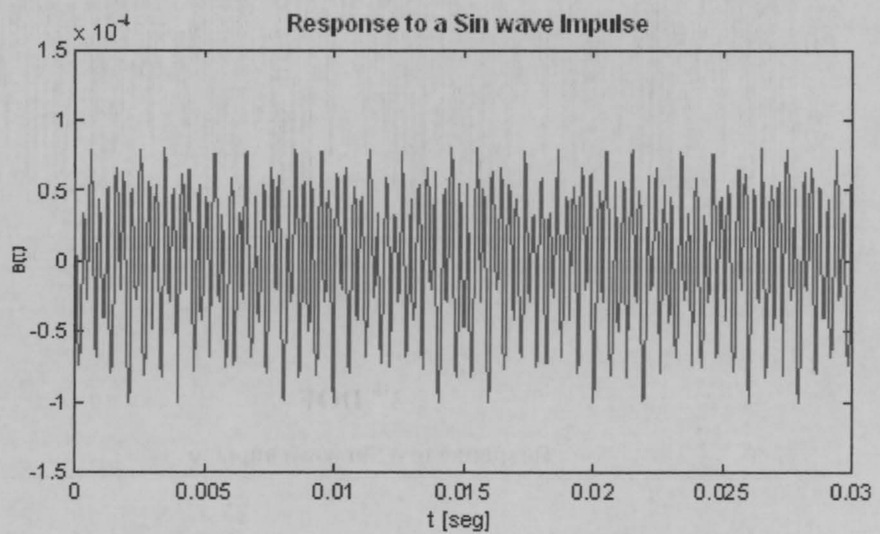
3th DOF



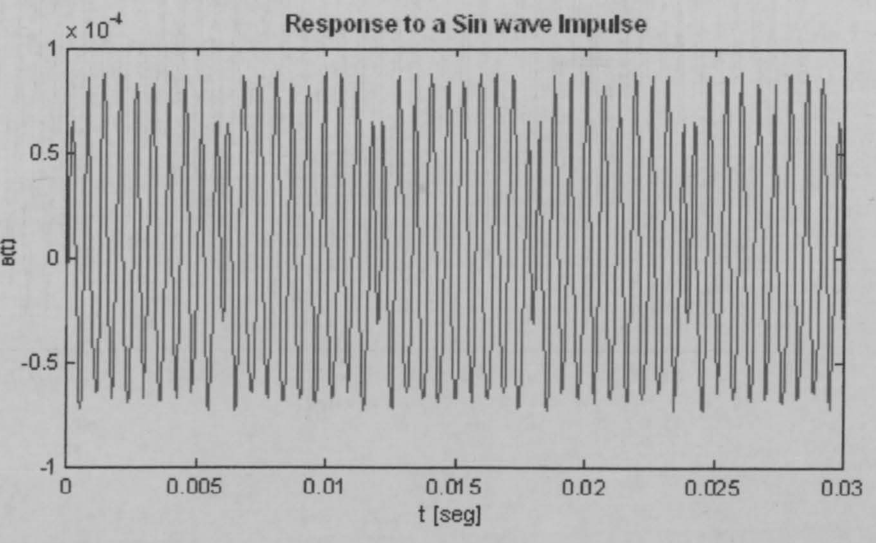
4th DOF



5th DOF

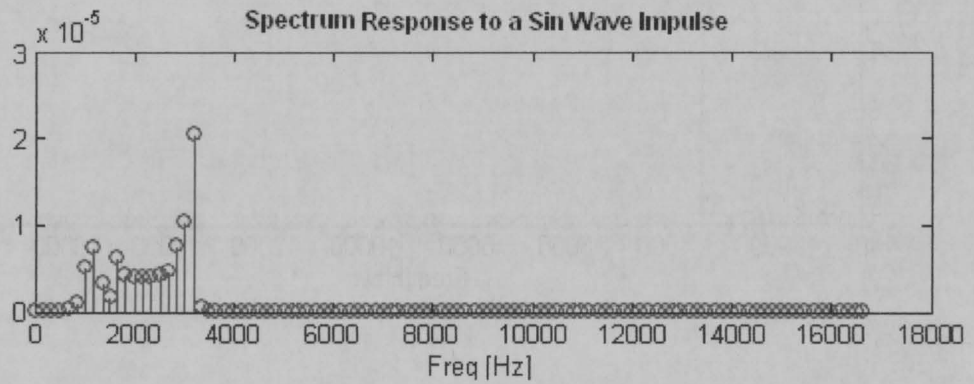


6th DOF

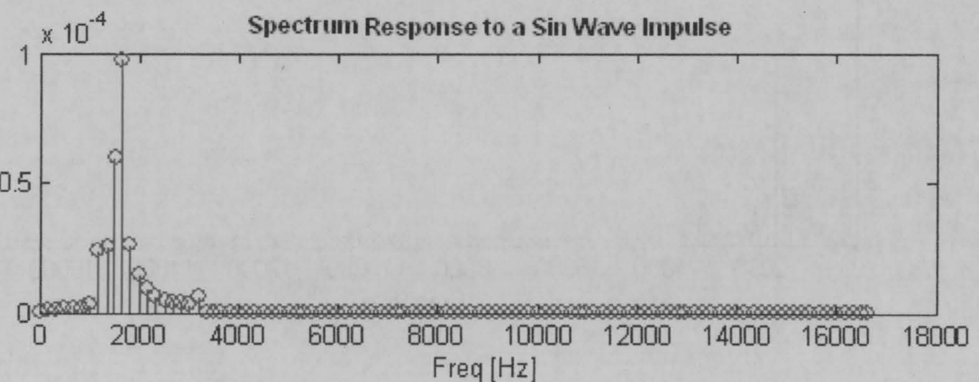


Spectrum

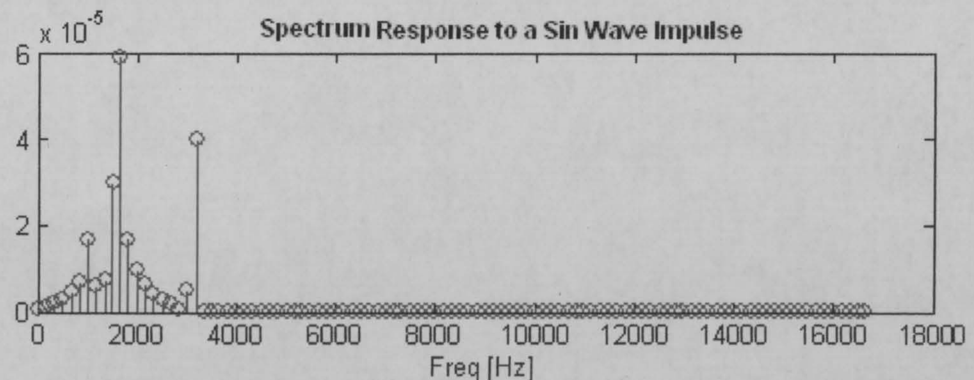
2^{nd} DOF



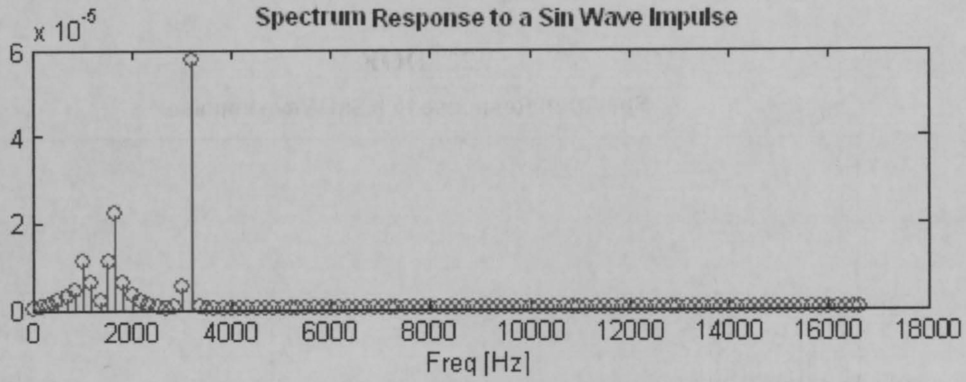
3^{rd} DOF



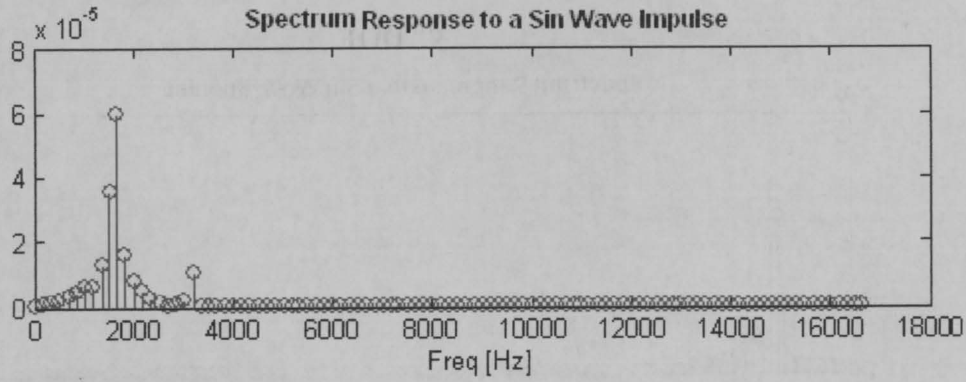
4^{th} DOF



5th DOF



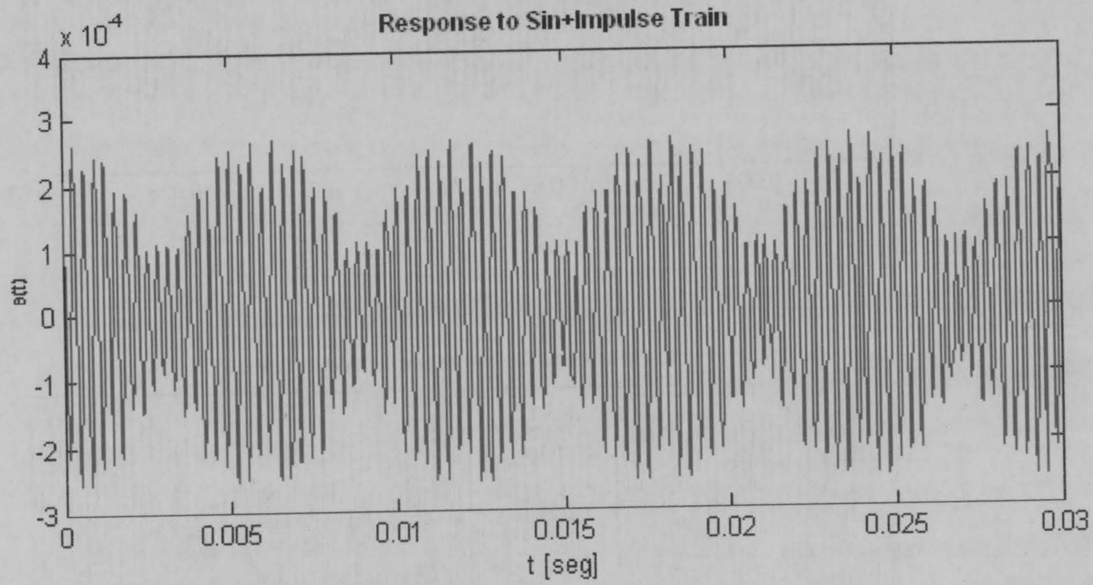
6th DOF



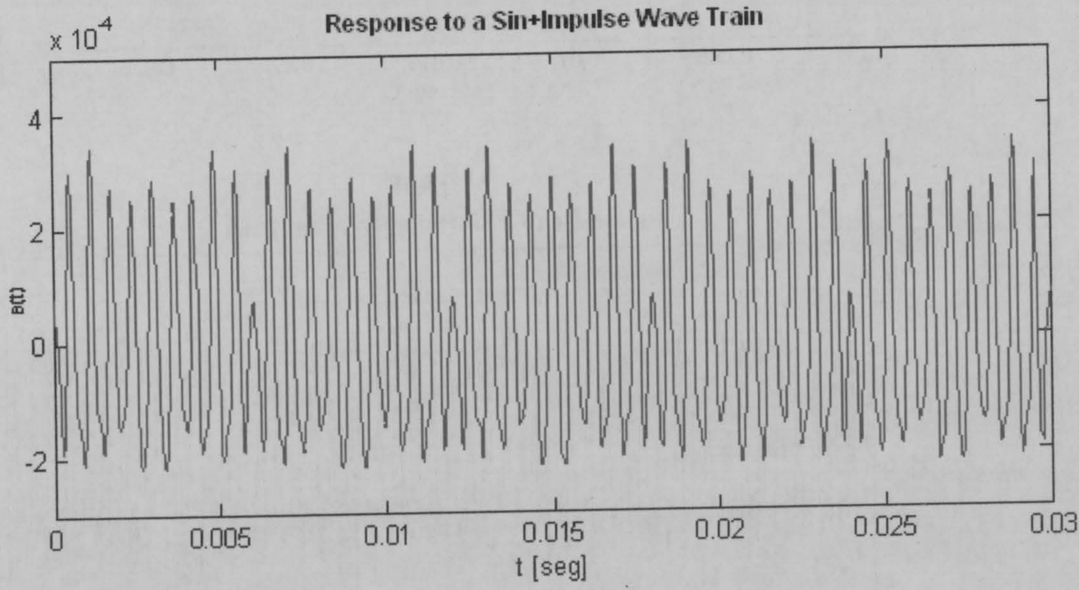
ANNEX X – Response to a Sine + Impulse Train (Backlash)

Total response

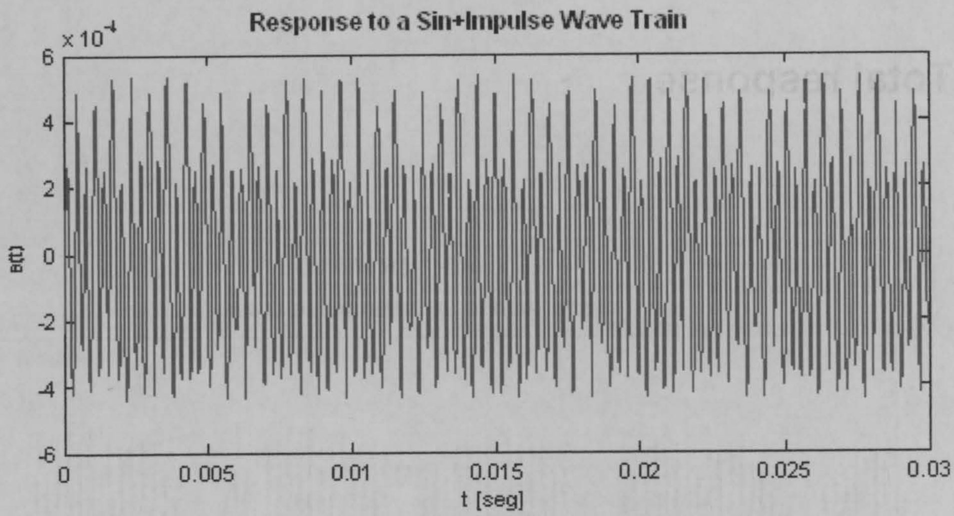
2^{nd} DOF



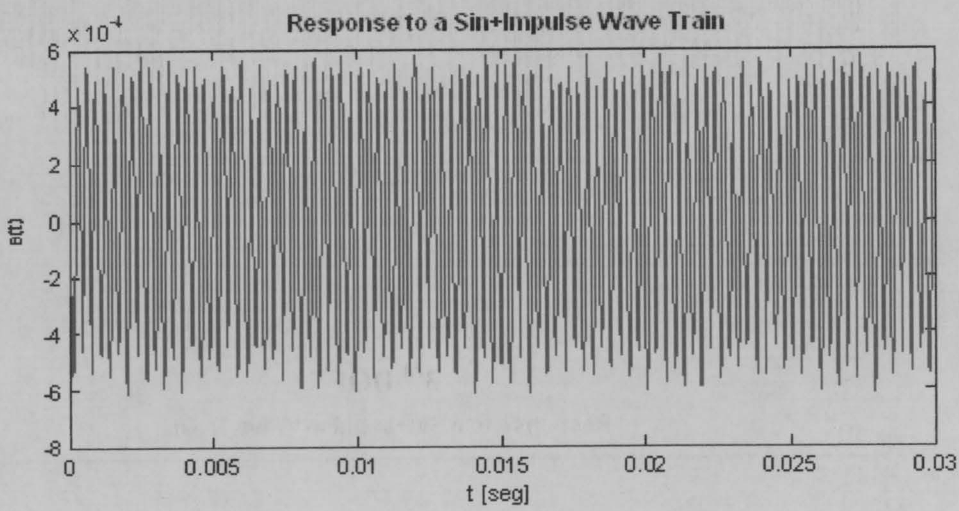
3^{rd} DOF



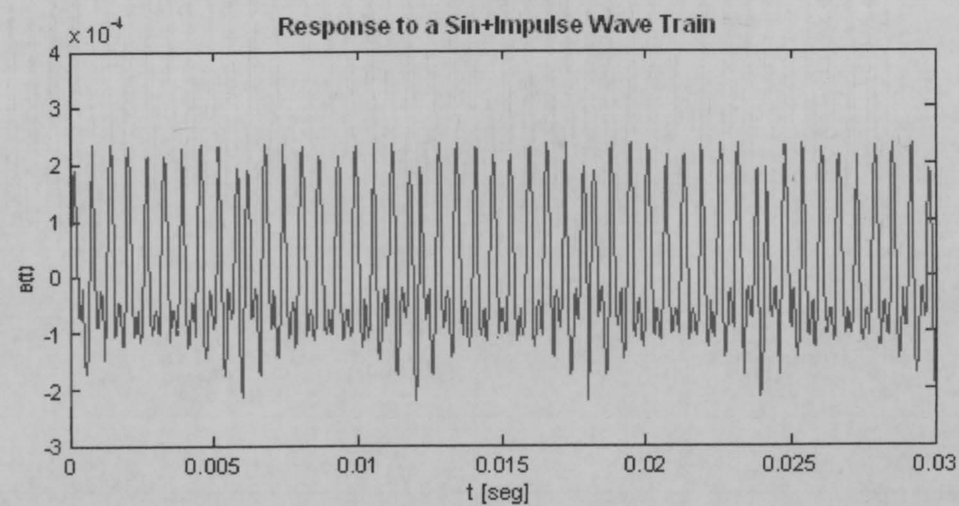
4th DOF



5th DOF

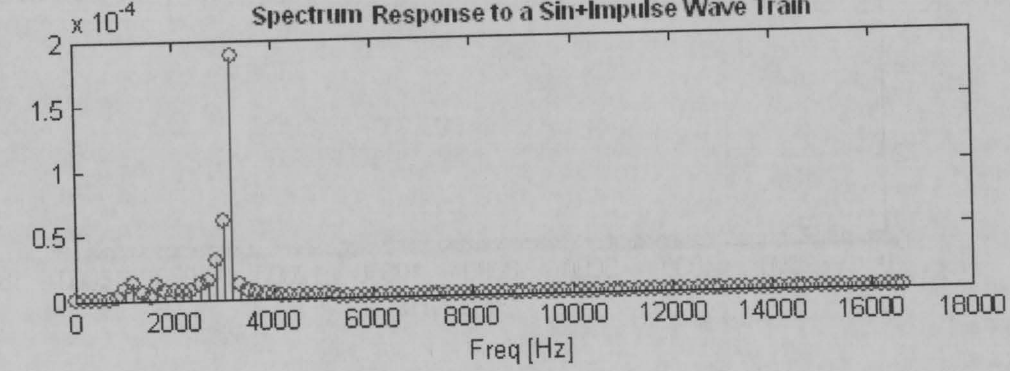


6th DOF

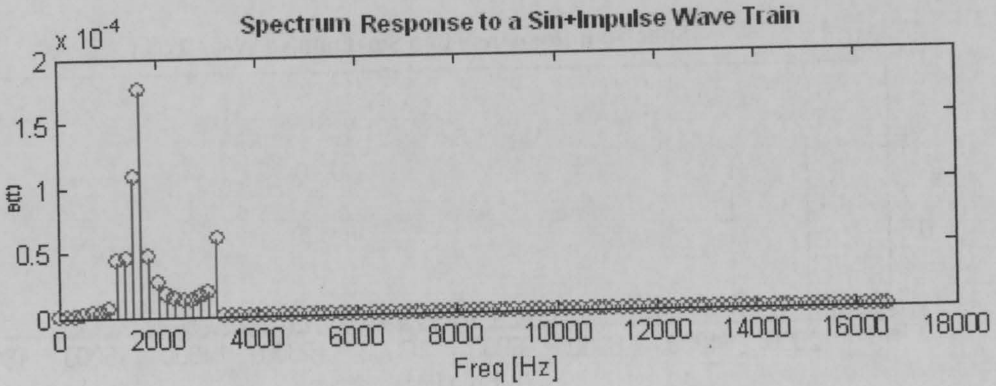


Spectrum

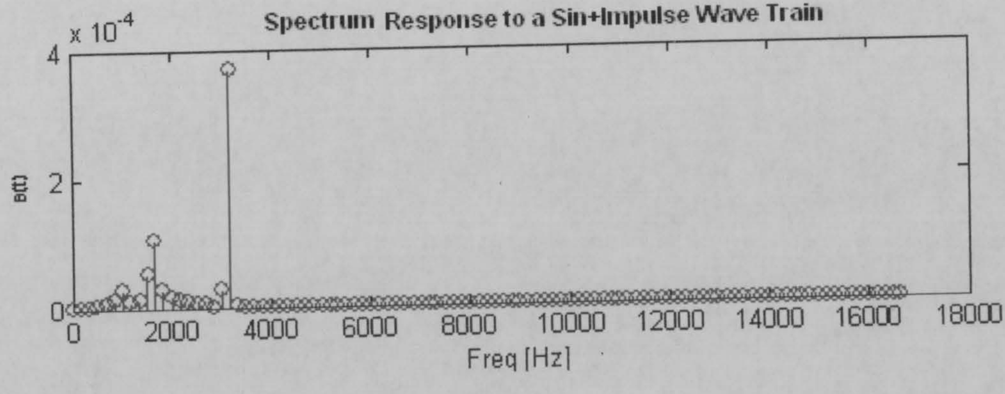
2^{nd} DOF



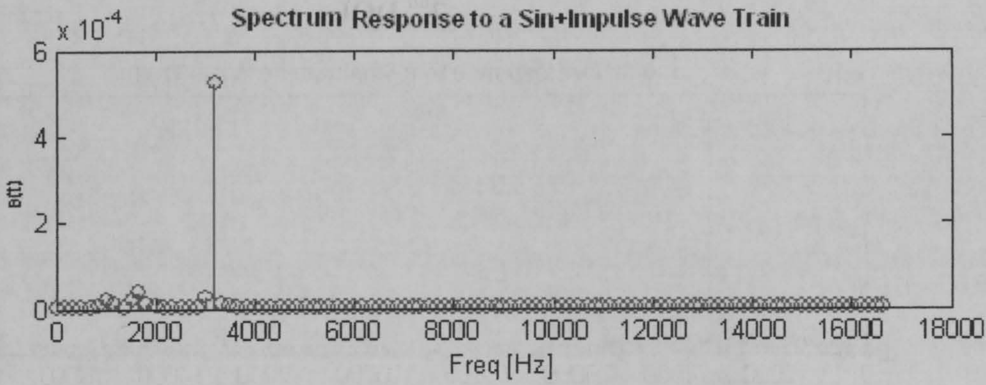
3^{rd} DOF



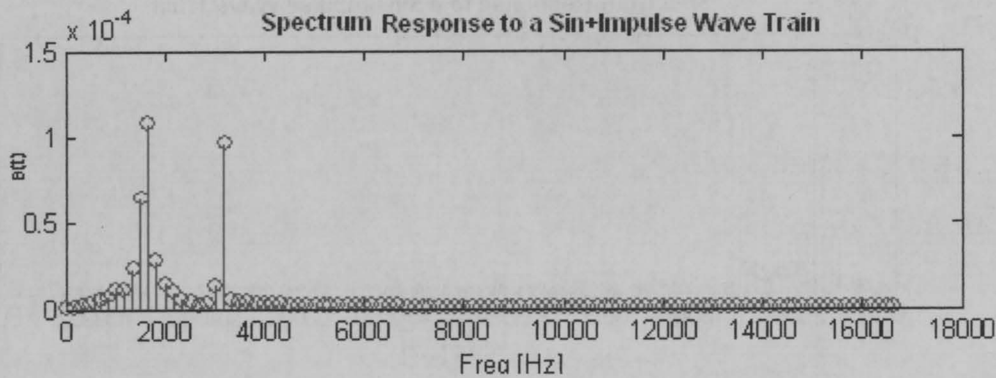
4^{th} DOF



5th DOF

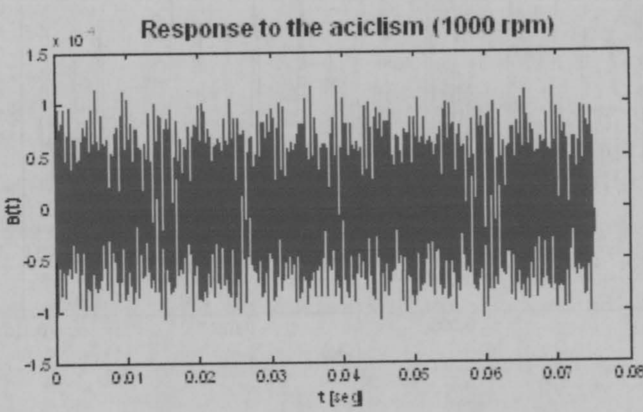


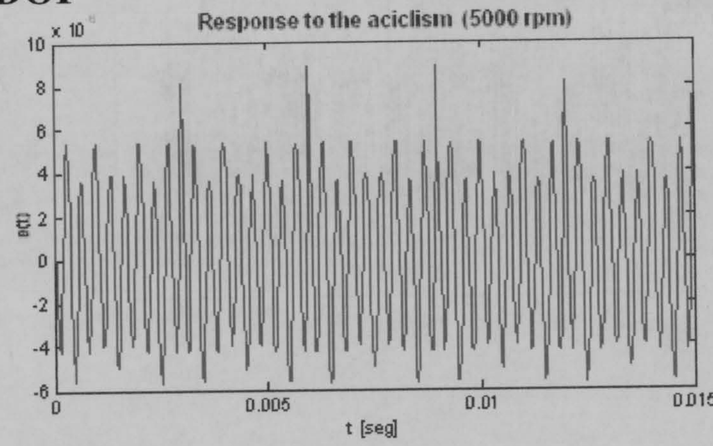
6th DOF



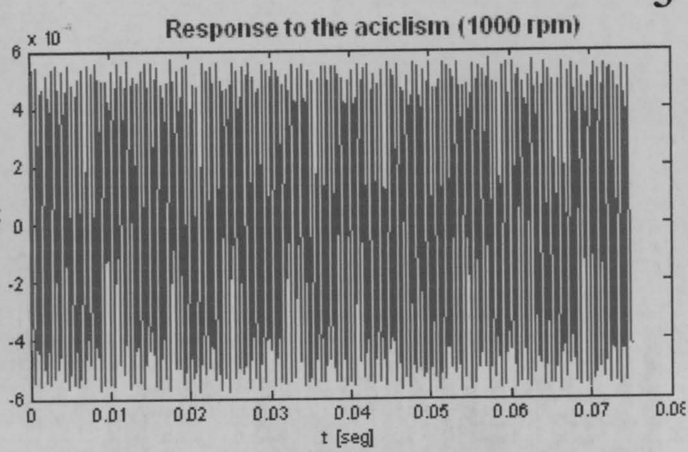
ANNEX XI – Acyclism (Total Response)

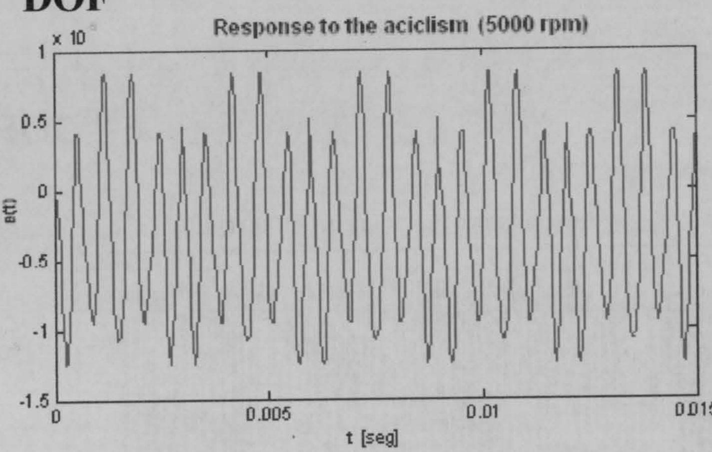
2nd DOF



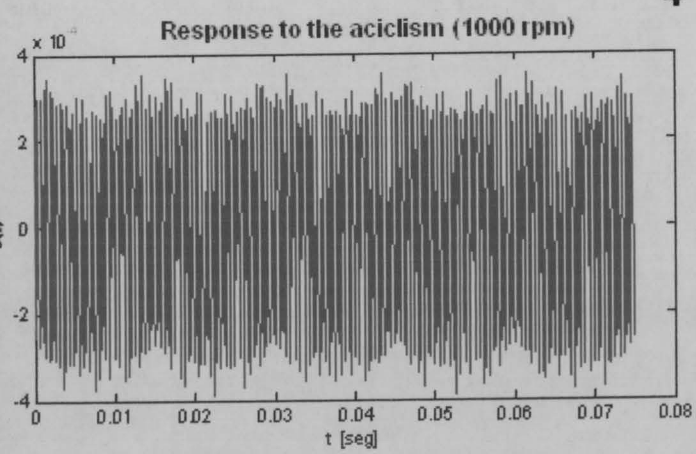


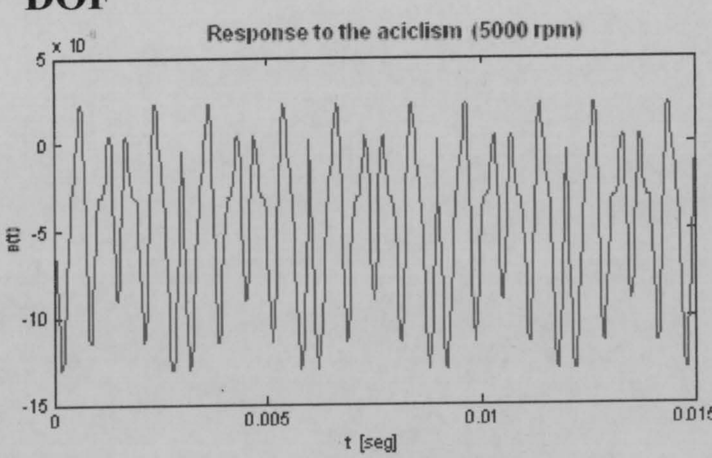
3rd DOF



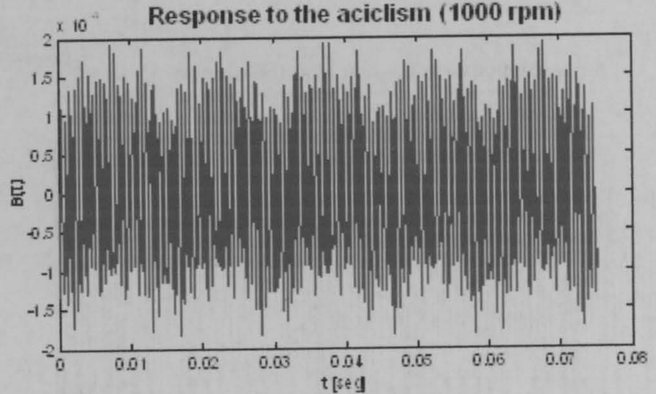


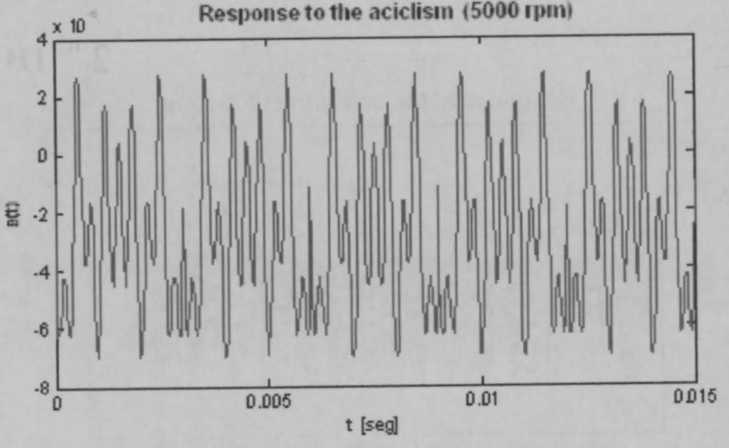
4th DOF



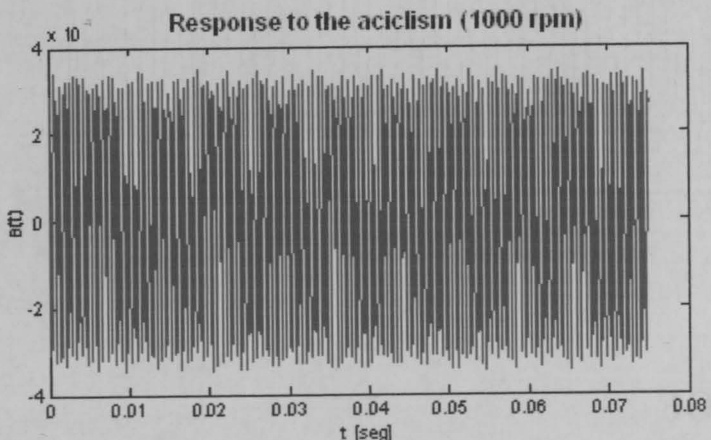


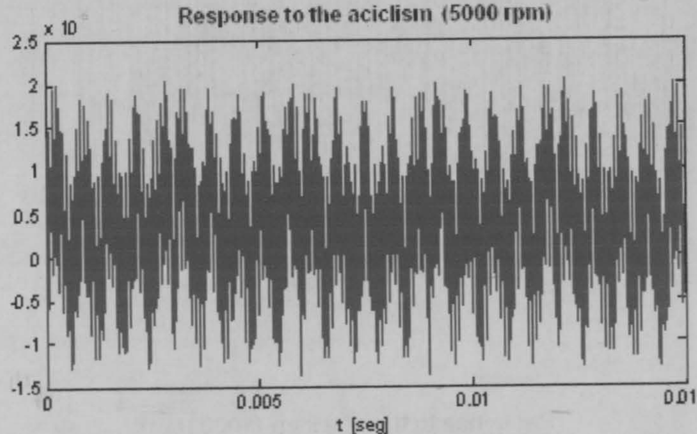
5th DOF





6th DOF





Universidade do Porto
Faculdade de Engenharia

Departamento de Engenharia Mecânica e
Gestão Industrial

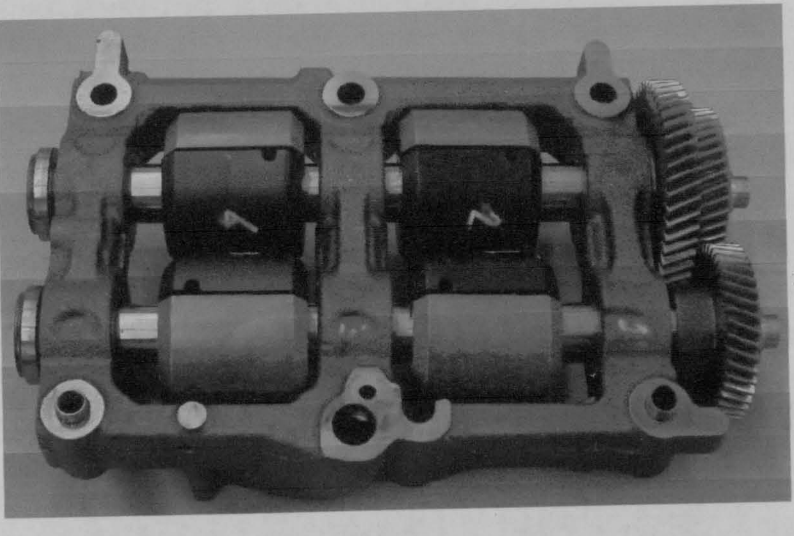
PROJECTO FIM DE CURSO

2003/2004

PROJECT REPORT

ANNEX XII – MATLAB CODE

Characterization of Torsional Vibration in a
Mass Balancer System



Supervisor:
Eng. José Dias Rodrigues

Author:
António Miguel Figueiredo

July 2004

DEMEGI

ANNEX XII – Matlab Code

Dados

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%DADOS DA ARVORE DE EQUILIBRAGEM DE MOTOR %%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
warning off MATLAB:divideByZero;
%%%%%%%%% RODAS DENTADAS%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%RODA 1
dprimit1=82.509/1000;
dfuro1=21.95/1000;
dext1=84.42/1000;
dbase1=76.729/1000;
nrdentes1=49;
largdent1=12/1000;
mod1=1.55;
massaroda1=0.378;
volum1=pi*((dprimit1/2)^2-(dfuro1/2)^2)*largdent1;
massavolum1=massaroda1/volum1;
Ip1=pi*((dprimit1/2)^4-(dfuro1/2)^4)/2;
J1=Ip1*massavolum1*largdent1;
% J1=3.456E-4;

%RODA 6
dprimit6=61.103/1000;
dfuro6=21.55/1000;
dext6=63.16/1000;
dbase6=56.976/1000;
nrdentes6=41;
largdent6=12/1000;
mod6=1.4;
massaroda6=0.241;
volum6=pi*((dprimit6/2)^2-(dfuro6/2)^2)*largdent6;
massavolum6=massaroda6/volum6;
Ip6=pi*((dprimit6/2)^4-(dfuro6/2)^4)/2;
J6=Ip6*massavolum6*largdent6;
% J6=1.278E-4;

%RODA 7
dprimit7=61.103/1000;
dfuro7=21.55/1000;
dext7=63.16/1000;
dbase7=56.976/1000;
nrdentes7=41;
largdent7=12/1000;
mod7=1.4;
massaroda7=0.295;
volum7=pi*((dprimit7/2)^2-(dfuro7/2)^2)*largdent7;
massavolum7=massaroda7/volum7;
Ip7=pi*((dprimit7/2)^4-(dfuro7/2)^4)/2;
J7=Ip7*massavolum7*largdent7;
% J7=1.565E-4;
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%% MASSAS %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

%MASSA 1
valorlibra=0.454;
massavolum1=7.1/1E-3;
massavolum2=1.29/1E-3;
%SEM CONSIDERAR MASSA 2
massalibra=[0.852,0;0.853,0;0.85,0;0.854,0];

% massalibra=[0.852,0.067;0.853,0.068;0.85,0.067;0.854,0.068];
```

```
%SEM CONSIDERAR MASSA 2
diamextmassa=[0.059,0;0.0591,0;0.0591,0;0.0591,0];

% diamextmassa=[0.059,0.0587;0.0591,0.0587;0.0591,0.0581;0.0591,0.0581];

%SEM CONSIDERAR MASSA 2
diamintmassa=[0.023,0;0.0231,0;0.0231,0;0.0231,0];

% diamintmassa=[0.023,0.051;0.0231,0.051;0.0231,0.051;0.0231,0.051];

%SEM CONSIDERAR MASSA 2
compmassa=[0.0521,0;0.0522,0;0.0522,0;0.0522,0];

%compmassa=[0.0521,0.0525;0.0522,0.052;0.0522,0.0515;0.0522,0.0515];

%SEM CONSIDERAR MASSA 2
espmassa=[0.018,0;0.018,0;0.018,0;0.018,0];

% espmassa=[0.018,0.00385;0.018,0.00385;0.018,0.00355;0.018,0.00355];

nrpesos=4;
for i=1:nrpesos
    for jc=1:2
        massakg(i,jc)=valorlibra*massalibra(i,jc);
        Ipmassa(i,jc)=pi*((diamextmassa(i,jc)/2)^4-(diamintmassa(i,jc)/2)^4)/4;
        if jc==1
            volumassa(i,jc)=massakg(i,jc)/massavolum1;
            J(i,jc)=Ipmassa(i,jc)*massavolum1*compmassa(i,jc);
        end
        if jc==2
            volumassa(i,jc)=massakg(i,jc)/massavolum2;
            J(i,jc)=Ipmassa(i,jc)*massavolum2*compmassa(i,jc);
        end
    end
    Jtotal(i)=J(i,1)+J(i,2);
end
J2=Jtotal(1);
J3=Jtotal(2);
J4=Jtotal(3);
J5=Jtotal(4);
% J2=2.319E-4;
% J3=2.336E-4;
% J4=2.319E-4;
% J5=2.319E-4;

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%VEIOS%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

%VEIO PRINCIPAL
massaveio1=0.763;
diamveio1=0.022;
comprveio1=0.2754;
volumveio1=pi*((diamveio1/2)^2)*comprveio1;
massavolumveio1=massaveio1/volumveio1;
Ipveio1=pi*(diamveio1^4)/32;
Jveio1=Ipveio1*massavolumveio1*comprveio1;
%VEIO SECUNDARIO
massaveio2=0.763;
diamveio2=0.022;
comprveio2=0.2754;
volumveio2=pi*((diamveio2/2)^2)*comprveio2;
massavolumveio2=massaveio2/volumveio2;
Ipveio2=pi*(diamveio2^4)/32;
Jveio2=Ipveio2*massavolumveio2*comprveio2;

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%RIGIDEZ%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
```

```
ModYoung=210E9;
coefpoisson=0.3;
ModG=ModYoung/(2*(1+coefpoisson));
comprimK1=5.05*10/1000;
comprimK2=8.68*10/1000;
comprimK3=5.22*10/1000;
comprimK4=8.81*10/1000;
k1=ModG*Ipveio1/comprimK1;
k2=ModG*Ipveio1/comprimK2;
k3=ModG*Ipveio2/comprimK3;
k4=ModG*Ipveio2/comprimK4;
% k1=3.6783E4;
% k2=2.14E4;
% k3=3.558E4;
% k4=2.108E4;

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%RIGIDEZ DO ENGRENAMENTO %%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

alturamedia=(3.1/1000+1.4/1000)/2;
bdente=dext7-dprimit7;
adente=dprimit7-dbase7;
compdente=dext7-dbase7;
MomInercia7=largdent7*alturamedia^3/12;
% flecha=(1/(ModYoung*MomInercia7))*(bdente^3/3+bdente*compdente^2-
bdente^2*compdente-compdente^3/3);
flecha=abs(-(adente^3)/(3*ModYoung*MomInercia7));
% flecha=abs(-(1/(3*ModYoung*MomInercia7))*((compdente-bdente)^3));
flecha=abs((1/(ModYoung*MomInercia7))*((bdente^3-compdente^3)/3+bdente*compdente^2-
(bdente^2)*compdente));
k5=1/flecha;
% k5=1.02E4;
raio=dprimit7/2;
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

nrGL=6;

% Mt=M0*cos(w*t);
M0=100;

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%% 5 GRAUS DE LIBERDADE %%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

 if nrGL==5
     %MATRIZ DE MASSA
     MM=[J1+J6+J7,0,0,0,0;0,J2,0,0,0;0,0,J3,0,0;0,0,0,J4,0;0,0,0,0,J5];

     %MATRIZ DE RIGIDEZ
     k=[k1+k3,-k1,0,-k3,0;-k1,k1+k2,-k2,0,0;0,-k2,k2,0,0;-k3,0,0,k3+k4,-k4;0,0,0,-
 k4,k4];
     warning off MATLAB:nearlySingularMatrix;

     F=[M0;0;0;0;0];
 end

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%% 6 GRAUS DE LIBERDADE %%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
 if nrGL==6
     %MATRIZ DE MASSA
 MM=[J1+J7,0,0,0,0,0;0,J2,0,0,0,0;0,0,J3,0,0,0;0,0,0,J4,0,0;0,0,0,0,J5,0;0,0,0,0,0,J
 6];
     %MATRIZ DE RIGIDEZ
     k=[k1+k5*raio,-k1,0,0,0,-k5*raio;-k1,k1+k2,-k2,0,0,0;0,-k2,k2,0,0,0;0,0,0,k3,-
 k3,0;0,0,0,-k3,k3+k4,-k4;-k5*raio,0,0,0,-k4,k4+k5*raio];
     warning off MATLAB:nearlySingularMatrix;
     % Mt=M0*cos(w*t);
     F=[M0;0;0;0;0;0];
```

```
end
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
GL=size(MM,1);
%FREQUENCIAS E FORMAS NATURAIS
[uu,w]=eig(k,MM);
[wn,ip]=sort(sqrt(diag(w)));
% disp('Frequencias naturais [Hz]');
% fprintf('%6.3g \n',wn/2/pi);
for i=1:GL
    u(:,i)=uu(:,ip(i));
end
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%NORMALIZAÇAO DOS VECTORES MODAIS PARA MASSAS MODAIS UNITARIAS
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
for i=1:GL
    fnor=transpose(u(:,i))*MM*u(:,i);
    fi(:,i)=(1/sqrt(fnor))*u(:,i);     %MATRIZ MODAL
end

for i=2:1:GL
    fi2(:,i-1)=fi(:,i);    %MATRIZ MODAL SEM O PRIMEIRO MODO NATURAL
    wn2(i-1)=wn(i);
end
```

Fourier Serie

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%COEFICIENTES DA SERIE DE FOURIER%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
clear all;clc;
t=sym('t');
T=sym('T');
tc=sym('tc');
w=sym('w');
A=sym('A');
n=sym('n');
A0=2/T*int(A*sin(pi/T*t),t,0,T)
An=2/T*int(A*sin(pi/T*t)*cos(n*2*pi/T*t),t,0,T)
Bn=2/T*int(A*sin(pi/T*t)*sin(n*2*pi/T*t),t,0,T)
```

FRF Acelerancia

```
%%%%%%%%%%%%%%%%%%%%%%%%PROJECTO DE FIM DE CURSO%%%%%%%%%%%%%%%%%%%%%%%%%%
%CARACTERIZAÇAO DA VIBRAÇAO E RUIDO DE UMA ARVORE DE EQUILIBRAGEM DE MOTOR%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%% FRF ACELERANCIA %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

run('Dados');
warning('off');
% mc=0.05*10E-4*k;
mk=k*(1+j*0.0005);
%Resposta em frequencia
w=linspace(0,wn(GL)*1.2,2048);
teta=zeros(GL,length(w));
for i=1:length(w)
    teta(:,i)=(-w(i)^2*MM+mk)\F;
%     teta(:,i)=(-w(i)^2*MM+j*w(i)*mc+k)\F;
end
tetamag=20*log10(abs(teta));
tetaf=angle(teta)*180/pi;
for i=1:GL
    tetamagA(i,:)=20*log10(abs(-teta(i,:).*w.^2));
    tetafA(i,:)=angle(-teta(i,:).*w.^2)*180/pi;
end
for i=1:GL
   index=([num2str(i),'1']);
   figure(i)
   subplot(1.4,1,1);
   plot(w/2/pi,tetamagA(i,:));
```

```
    set(gca, 'XTickLabel',' ');
    ylabel('Mag. [dB]');
    title(['Resposta em Frequencia (acelerancia) \theta_{',index,'}']);
    subplot(3,1,3);
    plot(w/2/pi,tetafA(i,:));
    set(gca, 'YLim', [-180 180]);
    set(gca, 'YTick', [-180 0 180]);
    xlabel('f [Hz]'); ylabel('fase [°]');
    back=uicontrol('style','pushbutton','units','normal','position',[0.91 0.5 0.090
0.095],...
        'string','Menu','callback','close all,Graficos');
end
```

FRF Receptance

```
%%%%%%%%%%%%%%%%%%%%%%PROJECTO DE FIM DE CURSO%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%CARACTERIZAÇAO DA VIBRAÇAO E RUIDO DE UMA ARVORE DE EQUILIBRAGEM DE MOTOR%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%% FRF RECEPTANCIA %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
run('Dados');
warning('off');
% mc=0.05*10E-4*k;
mk=k*(1+j*0.0005);

%Resposta em frequencia
w=linspace(0,wn(GL)*1.2,2048);
teta=zeros(GL,length(w));
for i=1:length(w)
    teta(:,i)=(-w(i)^2*MM+mk)\F;
%     teta(:,i)=(-w(i)^2*MM+j*w(i)*mc+k)\F;
end
tetamag=20*log10(abs(teta));
tetaf=angle(teta)*180/pi;
for i=1:GL
    tetamagA(i,:)=20*log10(abs(-teta(i,:).*w.^2));
    tetafA(i,:)=angle(-teta(i,:).*w.^2)*180/pi;
end
for i=1:GL
   index=([num2str(i),'1']);
   figure(i)
   subplot(1.4,1,1);
   plot(w/2/pi,tetamag(i,:));
   set(gca, 'XTickLabel',' ');
   ylabel('Mag. [dB]');
   title(['Resposta em Frequencia (receptancia) \theta_{',index,'}']);
   subplot(3,1,3);
   plot(w/2/pi,tetaf(i,:));
   set(gca, 'YLim', [-180 180]);
   set(gca, 'YTick', [-180 0 180]);
   xlabel('f [Hz]'); ylabel('fase [°]');
 end
```

Menu Formas Naturais

```
function varargout = respostatemp(varargin)
% Begin initialization code - DO NOT EDIT
gui_Singleton = 1;
gui_State = struct('gui_Name',       mfilename, ...
    'gui_Singleton',  gui_Singleton, ...
    'gui_OpeningFcn', @M_Formas_Naturais_OpeningFcn, ...
    'gui_OutputFcn',  @M_Formas_Naturais_OutputFcn, ...
    'gui_LayoutFcn',  [] , ...
    'gui_Callback',   []);
if nargin & isstr(varargin{1})
```

```
    gui_State.gui_Callback = str2func(varargin{1});
end
if nargout
    [varargout{1:nargout}] = gui_mainfcn(gui_State, varargin{:});
else
    gui_mainfcn(gui_State, varargin{:});
end
% End initialization code - DO NOT EDIT

clc;
% --- Executes just before M_Formas_Naturais is made visible.
function M_Formas_Naturais_OpeningFcn(hObject, eventdata, handles, varargin)
% This function has no output args, see OutputFcn.
% hObject    handle to figure
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
% varargin   command line arguments to M_Formas_Naturais (see VARARGIN)
% Choose default command line output for M_Formas_Naturais
handles.output = hObject;
% Update handles structure
guidata(hObject, handles);
% UIWAIT makes M_Formas_Naturais wait for user response (see UIRESUME)
% uiwait(handles.figure1);

% --- Outputs from this function are returned to the command line.
function varargout = M_Formas_Naturais_OutputFcn(hObject, eventdata, handles)
% varargout  cell array for returning output args (see VARARGOUT);
% hObject    handle to figure
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Get default command line output from handles structure
varargout{1} = handles.output;

scnsize = get(0,'ScreenSize');
pos1  = [scnsize(3)/12,6,scnsize(3)/9,scnsize(4)/20];
set(hObject, 'Position',pos1, 'Visible','on');

set(hObject, 'Units', 'pixels');
handles.banner = imread('fundo.jpg'); % Read the image file banner.jpg
info = imfinfo('fundo.jpg'); % Determine the size of the image file
position = get(hObject, 'Position');
axes(handles.background);
image(handles.banner)
set(handles.background, ...
    'Visible', 'off', ...
    'Units', 'pixels',...
    'Position', [0 0 15*info.Width 15*info.Height]);
% --- Executes during object creation, after setting all properties.
function popupmenu1_CreateFcn(hObject, eventdata, handles)
% hObject    handle to popupmenu1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    empty - handles not created until after all CreateFcns called
% Hint: popupmenu controls usually have a white background on Windows.
%       See ISPC and COMPUTER.
run('Dados');
if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end

if nrGL==5
    set(hObject, 'String', {'1ª Forma Natural', '2ª Forma Natural', '3ª Forma
Natural', '4ª Forma Natural', '5ª Forma Natural'});
end
if nrGL==6
    set(hObject, 'String', {'1ª Forma Natural', '2ª Forma Natural', '3ª Forma
Natural', '4ª Forma Natural', '5ª Forma Natural','6ª Forma Natural'});
end
```

```
% --- Executes on selection change in popupmenu1.
function popupmenu1_Callback(hObject, eventdata, handles)
% hObject    handle to popupmenu1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hints: contents = get(hObject,'String') returns popupmenu1 contents as cell array
%        contents{get(hObject,'Value')} returns selected item from popupmenu1

% --- Executes on button press in pushbutton1.
function pushbutton1_Callback(hObject, eventdata, handles)
% hObject    handle to pushbutton1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

set(handles.text1,'Visible','off');
axes(handles.axes1);
cla;
run('Dados');
popup_sel_index = get(handles.popupmenu1, 'Value');
switch popup_sel_index
    case 1
        iGL=1;
        set(handles.text1, 'String','Forma Natural de Corpo Rigido em que todos os
valores do vector modal sao iguais');
    case 2
        iGL=2;
        if nrGL==5
            set(handles.text1, 'String','Forma Natural que apresenta 1 nodo natural
de vibraçao localizado entre o 3° e 4° GL');
        end
        if nrGL==6
            set(handles.text1, 'String','Forma Natural que apresenta 2 nodos
naturais de vibraçao localizado entre o 3° e 4° GL e entre o 5° e o 6° GL');
        end
    case 3
        iGL=3;
        if nrGL==5
            set(handles.text1, 'String','Forma Natural que apresenta 3 nodos
naturais de vibraçao localizados no 2° GL e na periferia do 4°GL');
        end
        if nrGL==6
            set(handles.text1, 'String','Forma Natural que apresenta 2 nodos
naturais de vibraçao');
        end
    case 4
        iGL=4;
        if nrGL==5
            set(handles.text1, 'String','Forma Natural que apresenta 2 nodos
naturais de vibraçao localizados entre o 2° e 3° GL e entre o 4° e 5° GL');
        end
         if nrGL==6
            set(handles.text1, 'String','Forma Natural que apresenta 4 nodos
naturais de vibraçao');
        end

    case 5
        iGL=5;
        if nrGL==5
            set(handles.text1, 'String','Forma Natural que apresenta 4 nodos
naturais de vibraçao');
        end
         if nrGL==6
            set(handles.text1, 'String','Forma Natural que apresenta 4 nodos
naturais de vibraçao');
        end


    case 6
```

```
        iGL=6;
        set(handles.text1, 'String',' ....... ');
end
x=1:1:GL;
eixo=zeros(GL,GL);
eixo(:,iGL)=0;
valormax=abs(max(fi(:,iGL)));
valormin=min(fi(:,iGL));
plot(x,fi(:,iGL),x,eixo(:,iGL),'k','LineWidth',1.5);hold on;grid off;
xlabel('Degree of Freedom');
set(gca,'xtick',1:1:GL)
title('Forma Natural');

set(handles.togglebutton1, 'Visible', 'on');
set(handles.pushbutton4, 'Visible', 'on');

% --- Executes on button press in togglebutton1.
function togglebutton1_Callback(hObject, eventdata, handles)
% hObject    handle to togglebutton1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hint: get(hObject,'Value') returns toggle state of togglebutton1

button_state = get(hObject,'Value');
if button_state == get(hObject,'Max')
    set(handles.text1,'Visible','on')   % toggle button is pressed
elseif button_state == get(hObject,'Min')
    set(handles.text1,'Visible','off');  % toggle button is not pressed
end
```

M_G_Espectro

```
function varargout = respostatemp(varargin)
% Begin initialization code - DO NOT EDIT
gui_Singleton = 1;
gui_State = struct('gui_Name',       mfilename, ...
                   'gui_Singleton',  gui_Singleton, ...
                   'gui_OpeningFcn', @M_G_Espectro_OpeningFcn, ...
                   'gui_OutputFcn',  @M_G_Espectro_OutputFcn, ...
                   'gui_LayoutFcn',  [] , ...
                   'gui_Callback',   []);
if nargin & isstr(varargin{1})
    gui_State.gui_Callback = str2func(varargin{1});
end

if nargout
    [varargout{1:nargout}] = gui_mainfcn(gui_State, varargin{:});
else
    gui_mainfcn(gui_State, varargin{:});
end
% End initialization code - DO NOT EDIT

clc;


% --- Executes just before M_G_Espectro is made visible.
function M_G_Espectro_OpeningFcn(hObject, eventdata, handles, varargin)
% This function has no output args, see OutputFcn.
% hObject    handle to figure
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
% varargin   command line arguments to M_G_Espectro (see VARARGIN)

% Choose default command line output for M_G_Espectro
handles.output = hObject;

% Update handles structure
guidata(hObject, handles);
```

```
% UIWAIT makes M_G_Espectro wait for user response (see UIRESUME)
% uiwait(handles.figure1);



% --- Outputs from this function are returned to the command line.
function varargout = M_G_Espectro_OutputFcn(hObject, eventdata, handles)
% varargout  cell array for returning output args (see VARARGOUT);
% hObject    handle to figure
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Get default command line output from handles structure
varargout{1} = handles.output;

refresh
set(hObject, 'Units', 'pixels');
handles.banner = imread('fundo.jpg'); % Read the image file banner.jpg
info = imfinfo('fundo.jpg'); % Determine the size of the image file
position = get(hObject, 'Position');
% set(hObject, 'Position', [position(1:2) info.Width+100 info.Height+100]);
axes(handles.background);
image(handles.banner)
set(handles.background, ...
    'Visible', 'off', ...
    'Units', 'pixels',...
    'Position', [0 0 10*info.Width 10*info.Height]);

% --- Executes during object creation, after setting all properties.
function popupmenu1_CreateFcn(hObject, eventdata, handles)
% hObject    handle to popupmenu1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    empty - handles not created until after all CreateFcns called

% Hint: popupmenu controls usually have a white background on Windows.
%       See ISPC and COMPUTER.
if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end
set(hObject, 'String', {'1° Grau de Liberdade', '2° Grau de Liberdade', '3° Grau de
Liberdade', '4° Grau de Liberdade', '5° Grau de Liberdade'});


% --- Executes on selection change in popupmenu1.
function popupmenu1_Callback(hObject, eventdata, handles)
% hObject    handle to popupmenu1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hints: contents = get(hObject,'String') returns popupmenu1 contents as cell array
%        contents{get(hObject,'Value')} returns selected item from popupmenu1


% --- Executes on button press in pushbutton1.
function pushbutton1_Callback(hObject, eventdata, handles)
% hObject    handle to pushbutton1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

popup_sel_index = get(handles.popupmenu1, 'Value');
switch popup_sel_index
    case 1
        iGL=1;
        wmotor=1000;
        wrot=2*wmotor;
        run('RespostaImpulsoPeriodico2');
        axes(handles.axes1);
```

```
        set(handles.axes1,'Visible','on');
        stem(Swh/2/pi,abs(Spr(iGL,:)));
        xlabel('\omega rotacao [Hz]');
        title('1000 rpm');
        wmotor=2000;
        wrot=2*wmotor;
        run('RespostaImpulsoPeriodico2');
        axes(handles.axes3);
        set(handles.axes3,'Visible','on');
        stem(Swh/2/pi,abs(Spr(iGL,:)));
        xlabel('\omega rotacao [Hz]');
        title('2000 rpm');
        wmotor=3000;
        wrot=2*wmotor;
        run('RespostaImpulsoPeriodico2');
        axes(handles.axes4);
        set(handles.axes4,'Visible','on');
        stem(Swh/2/pi,abs(Spr(iGL,:)));
        xlabel('\omega rotacao [Hz]');
        title('3000 rpm');
        wmotor=4000;
        wrot=2*wmotor;
        run('RespostaImpulsoPeriodico2');
        axes(handles.axes5);
        set(handles.axes5,'Visible','on');
        stem(Swh/2/pi,abs(Spr(iGL,:)));
        xlabel('\omega rotacao [Hz]');
        title('4000 rpm');
        wmotor=5000;
        wrot=2*wmotor;
        run('RespostaImpulsoPeriodico2');
        axes(handles.axes6);
        set(handles.axes6,'Visible','on');
        stem(Swh/2/pi,abs(Spr(iGL,:)));
        xlabel('\omega rotacao [Hz]');
        title('5000 rpm');
    case 2
        iGL=2;
        wmotor=1000;
        wrot=2*wmotor;
        run('RespostaImpulsoPeriodico2');
        axes(handles.axes1);
        set(handles.axes1,'Visible','on');
        stem(Swh/2/pi,abs(Spr(iGL,:)));
        xlabel('\omega_rotacao [Hz]');
        title('1000 rpm');
        wmotor=2000;
        wrot=2*wmotor;
        run('RespostaImpulsoPeriodico2');
        axes(handles.axes3);
        set(handles.axes3,'Visible','on');
        stem(Swh/2/pi,abs(Spr(iGL,:)));
        xlabel('\omega rotacao [Hz]');
        title('2000 rpm');
        wmotor=3000;
        wrot=2*wmotor;
        run('RespostaImpulsoPeriodico2');
        axes(handles.axes4);
        set(handles.axes4,'Visible','on');
        stem(Swh/2/pi,abs(Spr(iGL,:)));
        xlabel('\omega rotacao [Hz]');
        title('3000 rpm');
        wmotor=4000;
        wrot=2*wmotor;
        run('RespostaImpulsoPeriodico2');
        axes(handles.axes5);
        set(handles.axes5,'Visible','on');
        stem(Swh/2/pi,abs(Spr(iGL,:)));
        xlabel('\omega rotacao [Hz]');
        title('4000 rpm');
```

```
        wmotor=5000;
        wrot=2*wmotor;
        run('RespostaImpulsoPeriodico2');
        axes(handles.axes6);
        set(handles.axes6,'Visible','on');
        stem(Swh/2/pi,abs(Spr(iGL,:)));
        xlabel('\omega rotacao [Hz]');
        title('5000 rpm');
    case 3
        iGL=3;
        wmotor=1000;
        wrot=2*wmotor;
        run('RespostaImpulsoPeriodico2');
        axes(handles.axes1);
        set(handles.axes1,'Visible','on');
        stem(Swh/2/pi,abs(Spr(iGL,:)));
        xlabel('\omega_rotacao [Hz]');
        title('1000 rpm');
        wmotor=2000;
        wrot=2*wmotor;
        run('RespostaImpulsoPeriodico2');
        axes(handles.axes3);
        set(handles.axes3,'Visible','on');
        stem(Swh/2/pi,abs(Spr(iGL,:)));
        xlabel('\omega rotacao [Hz]');
        title('2000 rpm');
        wmotor=3000;
        wrot=2*wmotor;
        run('RespostaImpulsoPeriodico2');
        axes(handles.axes4);
        set(handles.axes4,'Visible','on');
        stem(Swh/2/pi,abs(Spr(iGL,:)));
        xlabel('\omega rotacao [Hz]');
        title('3000 rpm');
        wmotor=4000;
        wrot=2*wmotor;
        run('RespostaImpulsoPeriodico2');
        axes(handles.axes5);
        set(handles.axes5,'Visible','on');
        stem(Swh/2/pi,abs(Spr(iGL,:)));
        xlabel('\omega rotacao [Hz]');
        title('4000 rpm');
        wmotor=5000;
        wrot=2*wmotor;
        run('RespostaImpulsoPeriodico2');
        axes(handles.axes6);
        set(handles.axes6,'Visible','on');
        stem(Swh/2/pi,abs(Spr(iGL,:)));
        xlabel('\omega rotacao [Hz]');
        title('5000 rpm');
    case 4
        iGL=4;
        wmotor=1000;
        wrot=2*wmotor;
        run('RespostaImpulsoPeriodico2');
        axes(handles.axes1);
        set(handles.axes1,'Visible','on');
        stem(Swh/2/pi,abs(Spr(iGL,:)));
        xlabel('\omega_rotacao [Hz]');
        title('1000 rpm');
        wmotor=2000;
        wrot=2*wmotor;
        run('RespostaImpulsoPeriodico2');
        axes(handles.axes3);
        set(handles.axes3,'Visible','on');
        stem(Swh/2/pi,abs(Spr(iGL,:)));
        xlabel('\omega rotacao [Hz]');
        title('2000 rpm');
        wmotor=3000;
        wrot=2*wmotor;
```

```
        run('RespostaImpulsoPeriodico2');
        axes(handles.axes4);
        set(handles.axes4,'Visible','on');
        stem(Swh/2/pi,abs(Spr(iGL,:)));
        xlabel('\omega rotacao [Hz]');
        title('3000 rpm');
        wmotor=4000;
        wrot=2*wmotor;
        run('RespostaImpulsoPeriodico2');
        axes(handles.axes5);
        set(handles.axes5,'Visible','on');
        stem(Swh/2/pi,abs(Spr(iGL,:)));
        xlabel('\omega rotacao [Hz]');
        title('4000 rpm');
        wmotor=5000;
        wrot=2*wmotor;
        run('RespostaImpulsoPeriodico2');
        axes(handles.axes6);
        set(handles.axes6,'Visible','on');
        stem(Swh/2/pi,abs(Spr(iGL,:)));
        xlabel('\omega rotacao [Hz]');
        title('5000 rpm');
    case 5
        iGL=5;
        wmotor=1000;
        wrot=2*wmotor;
        run('RespostaImpulsoPeriodico2');
        axes(handles.axes1);
        set(handles.axes1,'Visible','on');
        stem(Swh/2/pi,abs(Spr(iGL,:)));
        xlabel('\omega_rotacao [Hz]');
        title('1000 rpm');
        wmotor=2000;
        wrot=2*wmotor;
        run('RespostaImpulsoPeriodico2');
        axes(handles.axes3);
        set(handles.axes3,'Visible','on');
        stem(Swh/2/pi,abs(Spr(iGL,:)));
        xlabel('\omega rotacao [Hz]');
        title('2000 rpm');
        wmotor=3000;
        wrot=2*wmotor;
        run('RespostaImpulsoPeriodico2');
        axes(handles.axes4);
        set(handles.axes4,'Visible','on');
        stem(Swh/2/pi,abs(Spr(iGL,:)));
        xlabel('\omega rotacao [Hz]');
        title('3000 rpm');
        wmotor=4000;
        wrot=2*wmotor;
        run('RespostaImpulsoPeriodico2');
        axes(handles.axes5);
        set(handles.axes5,'Visible','on');
        stem(Swh/2/pi,abs(Spr(iGL,:)));
        xlabel('\omega rotacao [Hz]');
        title('4000 rpm');
        wmotor=5000;
        wrot=2*wmotor;
        run('RespostaImpulsoPeriodico2');
        axes(handles.axes6);
        set(handles.axes6,'Visible','on');
        stem(Swh/2/pi,abs(Spr(iGL,:)));
        xlabel('\omega rotacao [Hz]');
        title('5000 rpm');
end
```

M_Resp_Freq_Bode_Acelerancia.m

```
function varargout = respostatemp(varargin)
% Begin initialization code - DO NOT EDIT
gui_Singleton = 1;
gui_State = struct('gui_Name',       mfilename, ...
    'gui_Singleton',  gui_Singleton, ...
    'gui_OpeningFcn', @M_Resposta_Freq_Bode_Acelerancia_OpeningFcn, ...
    'gui_OutputFcn',  @M_Resposta_Freq_Bode_Acelerancia_OutputFcn, ...
    'gui_LayoutFcn',  [] , ...
    'gui_Callback',   []);
if nargin & isstr(varargin{1})
    gui_State.gui_Callback = str2func(varargin{1});
end

if nargout
    [varargout{1:nargout}] = gui_mainfcn(gui_State, varargin{:});
else
    gui_mainfcn(gui_State, varargin{:});
end
% End initialization code - DO NOT EDIT


% --- Executes just before M_Resposta_Freq_Bode_Acelerancia is made visible.
function M_Resposta_Freq_Bode_Acelerancia_OpeningFcn(hObject, eventdata, handles,
varargin)
% This function has no output args, see OutputFcn.
% hObject    handle to figure
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
% varargin   command line arguments to M_Resposta_Freq_Bode_Acelerancia (see
VARARGIN)

% Choose default command line output for M_Resposta_Freq_Bode_Acelerancia
handles.output = hObject;

% Update handles structure
guidata(hObject, handles);

% UIWAIT makes M_Resposta_Freq_Bode_Acelerancia wait for user response (see
UIRESUME)
% uiwait(handles.figure1);



% --- Outputs from this function are returned to the command line.
function varargout = M_Resposta_Freq_Bode_Acelerancia_OutputFcn(hObject, eventdata,
handles)
% varargout  cell array for returning output args (see VARARGOUT);
% hObject    handle to figure
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Get default command line output from handles structure
varargout{1} = handles.output;

scnsize = get(0,'ScreenSize');
pos1  = [scnsize(3)/12,5,scnsize(3)/8.7,scnsize(4)/15];
set(hObject, 'Position',pos1, 'Visible','on');

refresh
set(hObject, 'Units', 'pixels');
handles.banner = imread('fundo.jpg'); % Read the image file banner.jpg
info = imfinfo('fundo.jpg'); % Determine the size of the image file
position = get(hObject, 'Position');
% set(hObject, 'Position', [position(1:2) info.Width+100 info.Height+100]);
axes(handles.background);
image(handles.banner)
```

```
set(handles.background, ...
    'Visible', 'off', ...
    'Units', 'pixels',...
    'Position', [0 0 15*info.Width 15*info.Height]);



% --- Executes during object creation, after setting all properties.
function popupmenu1_CreateFcn(hObject, eventdata, handles)
% hObject    handle to popupmenu1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    empty - handles not created until after all CreateFcns called

% Hint: popupmenu controls usually have a white background on Windows.
%       See ISPC and COMPUTER.
run('Dados');
if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end
if nrGL==5
    set(hObject, 'String', {'Grau de Liberdade 1', 'Grau de Liberdade 2', 'Grau de
Liberdade 3', 'Grau de Liberdade 4', 'Grau de Liberdade 5','Sobreposiçao'});
end
if nrGL==6
    set(hObject, 'String', {'Grau de Liberdade 1', 'Grau de Liberdade 2', 'Grau de
Liberdade 3', 'Grau de Liberdade 4', 'Grau de Liberdade 5','Grau de Liberdade
6','Sobreposiçao'});
end



% --- Executes on selection change in popupmenu1.
function popupmenu1_Callback(hObject, eventdata, handles)
% hObject    handle to popupmenu1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hints: contents = get(hObject,'String') returns popupmenu1 contents as cell array
%        contents{get(hObject,'Value')} returns selected item from popupmenu1


% --- Executes on button press in pushbutton1.
function pushbutton1_Callback(hObject, eventdata, handles)
% hObject    handle to pushbutton1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

cla;
run('Dados');
run('FRFDacelerancia');
sobrep=0;
popup_sel_index = get(handles.popupmenu1, 'Value');
switch popup_sel_index
    case 1

        iGL=1;
        set(handles.text2,'String','...........');
        set(handles.text3,'String','...........');
    case 2
        iGL=2;
        set(handles.text2,'String','...........');
        set(handles.text3,'String','...........');
    case 3
        iGL=3;
        set(handles.text2,'String','...........');
        set(handles.text3,'String','...........');
    case 4
        iGL=4;
```

```
        set(handles.text2,'String','...........');
        set(handles.text3,'String','...........');
    case 5
        iGL=5;
        set(handles.text2,'String','...........');
        set(handles.text3,'String','...........');
    case 6
        if nrGL==5
            sobrep=1;
        end
        if nrGL==6
            iGL=6;
            set(handles.text2,'String','...........');
            set(handles.text3,'String','...........');
        end
    case 7
        sobrep=1;


end

if sobrep==1
    set(handles.axes3,'Visible','off');
    axes(handles.axes1);
    if nrGL==5

plot(w/2/pi,tetamagA(1,:),w/2/pi,tetamagA(2,:),w/2/pi,tetamagA(3,:),w/2/pi,tetamagA
(4,:),w/2/pi,tetamagA(5,:));
        legend('A_1_1', 'A_2_1', 'A_3_1', 'A_4_1', 'A_5_1',-1);
    end
    if nrGL==6

plot(w/2/pi,tetamagA(1,:),w/2/pi,tetamagA(2,:),w/2/pi,tetamagA(3,:),w/2/pi,tetamagA
(4,:),w/2/pi,tetamagA(5,:),w/2/pi,tetamagA(6,:));
        legend('1° DOF', '2° DOF', '3° DOF', '4° DOF', '5° DOF','6° DOF',-1);
    end
end
if sobrep~=1
    index=([num2str(iGL),'1']);
    axes(handles.axes1);
    plot(w/2/pi,tetamagA(iGL,:));
    set(gca, 'XTickLabel',' ');
    ylabel('Mag. [dB]');
    title(['FRFs (acelerancia) \theta_{',index,'}']);
    axes(handles.axes3);
    plot(w/2/pi,tetafA(iGL,:));
    set(gca, 'YLim', [-180 180]);
    set(gca, 'YTick', [-180 0 180]);
    xlabel('f [Hz]'); ylabel('fase [°]');
    set(handles.pushbutton3,'Visible','on');
    set(handles.pushbutton4,'Visible','on');
    set(handles.togglebutton1,'Visible','on');
    set(handles.togglebutton2,'Visible','on');
end
% --- Executes on button press in togglebutton1.
function togglebutton1_Callback(hObject, eventdata, handles)
% hObject    handle to togglebutton1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
% Hint: get(hObject,'Value') returns toggle state of togglebutton1

button_state = get(hObject,'Value');
if button_state == get(hObject,'Max')
    set(handles.axes3,'Visible','off');
    set(handles.text3,'Visible','on')    % toggle button is pressed
elseif button_state == get(hObject,'Min')
    set(handles.text3,'Visible','off');  % toggle button is not pressed
    set(handles.axes3,'Visible','on');
end
% --- Executes on button press in togglebutton2.
```

```
function togglebutton2_Callback(hObject, eventdata, handles)
% hObject    handle to togglebutton2 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hint: get(hObject,'Value') returns toggle state of togglebutton2

button_state = get(hObject,'Value');
if button_state == get(hObject,'Max')
    set(handles.axes1,'Visible','off');
    set(handles.text2,'Visible','on')   % toggle button is pressed
elseif button_state == get(hObject,'Min')
    set(handles.text2,'Visible','off');  % toggle button is not pressed
    set(handles.axes1,'Visible','on');
end
% --- Executes on button press in pushbutton5.
function pushbutton5_Callback(hObject, eventdata, handles)
% hObject    handle to pushbutton5 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
```

M_Resp_Freq_Bode_Receptancia.m

```
function varargout = respostatemp(varargin)
% Begin initialization code - DO NOT EDIT
gui_Singleton = 1;
gui_State = struct('gui_Name',       mfilename, ...
    'gui_Singleton',  gui_Singleton, ...
    'gui_OpeningFcn', @M_Resposta_Freq_Bode_Receptancia_OpeningFcn, ...
    'gui_OutputFcn',  @M_Resposta_Freq_Bode_Receptancia_OutputFcn, ...
    'gui_LayoutFcn',  [] , ...
    'gui_Callback',   []);
if nargin & isstr(varargin{1})
    gui_State.gui_Callback = str2func(varargin{1});
end

if nargout
    [varargout{1:nargout}] = gui_mainfcn(gui_State, varargin{:});
else
    gui_mainfcn(gui_State, varargin{:});
end
% End initialization code - DO NOT EDIT


% --- Executes just before M_Resposta_Freq_Bode_Receptancia is made visible.
function M_Resposta_Freq_Bode_Receptancia_OpeningFcn(hObject, eventdata, handles,
varargin)
% This function has no output args, see OutputFcn.
% hObject    handle to figure
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
% varargin   command line arguments to M_Resposta_Freq_Bode_Receptancia (see
VARARGIN)

% Choose default command line output for M_Resposta_Freq_Bode_Receptancia
handles.output = hObject;

% Update handles structure
guidata(hObject, handles);

% UIWAIT makes M_Resposta_Freq_Bode_Receptancia wait for user response (see
UIRESUME)
% uiwait(handles.figure1);



% --- Outputs from this function are returned to the command line.
function varargout = M_Resposta_Freq_Bode_Receptancia_OutputFcn(hObject, eventdata,
handles)
```

```
% varargout  cell array for returning output args (see VARARGOUT);
% hObject    handle to figure
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Get default command line output from handles structure
varargout{1} = handles.output;


scnsize = get(0,'ScreenSize');
pos1  = [scnsize(3)/12,5,scnsize(3)/8.7,scnsize(4)/15];
set(hObject, 'Position',pos1, 'Visible','on');


refresh
set(hObject, 'Units', 'pixels');
handles.banner = imread('fundo.jpg'); % Read the image file banner.jpg
info = imfinfo('fundo.jpg'); % Determine the size of the image file
position = get(hObject, 'Position');
% set(hObject, 'Position', [position(1:2) info.Width+100 info.Height+100]);
axes(handles.background);
image(handles.banner)
set(handles.background, ...
    'Visible', 'off', ...
    'Units', 'pixels',...
    'Position', [0 0 15*info.Width 15*info.Height]);

% --- Executes during object creation, after setting all properties.
function popupmenu1_CreateFcn(hObject, eventdata, handles)
% hObject    handle to popupmenu1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    empty - handles not created until after all CreateFcns called

% Hint: popupmenu controls usually have a white background on Windows.
%       See ISPC and COMPUTER.
run('Dados');
if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end
if nrGL==5
    set(hObject, 'String', {'Grau de Liberdade 1', 'Grau de Liberdade 2', 'Grau de
Liberdade 3', 'Grau de Liberdade 4', 'Grau de Liberdade 5'});
end
if nrGL==6
    set(hObject, 'String', {'Grau de Liberdade 1', 'Grau de Liberdade 2', 'Grau de
Liberdade 3', 'Grau de Liberdade 4', 'Grau de Liberdade 5', 'Grau de Liberdade
6'});
end

% --- Executes on selection change in popupmenu1.
function popupmenu1_Callback(hObject, eventdata, handles)
% hObject    handle to popupmenu1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hints: contents = get(hObject,'String') returns popupmenu1 contents as cell array
%        contents{get(hObject,'Value')} returns selected item from popupmenu1


% --- Executes on button press in pushbutton1.
function pushbutton1_Callback(hObject, eventdata, handles)
% hObject    handle to pushbutton1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

cla;
run('Dados');
run('FRFDreceptancia');
```

```
popup_sel_index = get(handles.popupmenu1, 'Value');
switch popup_sel_index
    case 1
        iGL=1;
        set(handles.text1,'String','.........');
        set(handles.text2,'String','.........');
    case 2
        iGL=2;
        set(handles.text1,'String','.........');
        set(handles.text2,'String','.........');
    case 3
        iGL=3;
        set(handles.text1,'String','.........');
        set(handles.text2,'String','.........');
    case 4
        iGL=4;
        set(handles.text1,'String','.........');
        set(handles.text2,'String','.........');
    case 5
        iGL=5;
        set(handles.text1,'String','.........');
        set(handles.text2,'String','.........');
    case 6
        iGL=6;
        set(handles.text1,'String','.........');
        set(handles.text2,'String','.........');
end

index=([num2str(iGL),'1']);
axes(handles.axes1);
plot(w/2/pi,tetamag(iGL,:));
set(gca, 'XTickLabel',' ');
ylabel('Mag. [dB]');
title(['Resposta em Frequencia (receptancia) \theta_{',index,'}']);
axes(handles.axes3);
plot(w/2/pi,tetaf(iGL,:));
set(gca, 'YLim', [-180 180]);
set(gca, 'YTick', [-180 0 180]);
xlabel('f [Hz]'); ylabel('fase [°]');

set(handles.pushbutton3,'Visible','on');
set(handles.pushbutton4,'Visible','on');
set(handles.togglebutton1,'Visible','on');
set(handles.togglebutton2,'Visible','on');


% --- Executes on button press in togglebutton1.
function togglebutton1_Callback(hObject, eventdata, handles)
% hObject    handle to togglebutton1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hint: get(hObject,'Value') returns toggle state of togglebutton1

button_state = get(hObject,'Value');
if button_state == get(hObject,'Max')
    set(handles.axes3,'Visible','off');
    set(handles.text1,'Visible','on');  % toggle button is pressed
elseif button_state == get(hObject,'Min')
    set(handles.text1,'Visible','off');  % toggle button is not pressed
    set(handles.axes3,'Visible','on');
end



% --- Executes on button press in togglebutton2.
function togglebutton2_Callback(hObject, eventdata, handles)
% hObject    handle to togglebutton2 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
```

```
% Hint: get(hObject,'Value') returns toggle state of togglebutton2

button_state = get(hObject,'Value');
if button_state == get(hObject,'Max')
    set(handles.axes1,'Visible','off');
    set(handles.text2,'Visible','on');   % toggle button is pressed
elseif button_state == get(hObject,'Min')
    set(handles.text2,'Visible','off');  % toggle button is not pressed
    set(handles.axes1,'Visible','on');
end
```

M_Resp_Freq_Cont_Modal_Acelerancia.m

```
function varargout = respostatemp(varargin)
% Begin initialization code - DO NOT EDIT
gui_Singleton = 1;
gui_State = struct('gui_Name',       mfilename, ...
    'gui_Singleton',  gui_Singleton, ...
    'gui_OpeningFcn', @M_Resposta_Freq_Cont_Modal_Aceleranc_OpeningFcn, ...
    'gui_OutputFcn',  @M_Resposta_Freq_Cont_Modal_Aceleranc_OutputFcn, ...
    'gui_LayoutFcn',  [] , ...
    'gui_Callback',   []);
if nargin & isstr(varargin{1})
    gui_State.gui_Callback = str2func(varargin{1});
end

if nargout
    [varargout{1:nargout}] = gui_mainfcn(gui_State, varargin{:});
else
    gui_mainfcn(gui_State, varargin{:});
end
% End initialization code - DO NOT EDIT



% --- Executes just before M_Resposta_Freq_Cont_Modal_Aceleranc is made visible.
function M_Resposta_Freq_Cont_Modal_Aceleranc_OpeningFcn(hObject, eventdata,
handles, varargin)
% This function has no output args, see OutputFcn.
% hObject    handle to figure
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
% varargin   command line arguments to M_Resposta_Freq_Cont_Modal_Aceleranc (see
VARARGIN)

% Choose default command line output for M_Resposta_Freq_Cont_Modal_Aceleranc
handles.output = hObject;

% Update handles structure
guidata(hObject, handles);

% UIWAIT makes M_Resposta_Freq_Cont_Modal_Aceleranc wait for user response (see
UIRESUME)
% uiwait(handles.figure1);



% --- Outputs from this function are returned to the command line.
function varargout = M_Resposta_Freq_Cont_Modal_Aceleranc_OutputFcn(hObject,
eventdata, handles)
% varargout  cell array for returning output args (see VARARGOUT);
% hObject    handle to figure
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Get default command line output from handles structure
varargout{1} = handles.output;
```

```
scnsize = get(0,'ScreenSize');
pos1  = [scnsize(3)/12,5,scnsize(3)/8.7,scnsize(4)/15];
set(hObject, 'Position',pos1, 'Visible','on');

refresh
set(hObject, 'Units', 'pixels');
handles.banner = imread('fundo.jpg'); % Read the image file banner.jpg
info = imfinfo('fundo.jpg'); % Determine the size of the image file
position = get(hObject, 'Position');
% set(hObject, 'Position', [position(1:2) info.Width+100 info.Height+100]);
axes(handles.background);
image(handles.banner)
set(handles.background, ...
    'Visible', 'off', ...
    'Units', 'pixels',...
    'Position', [0 0 15*info.Width 15*info.Height]);

% --- Executes during object creation, after setting all properties.
function popupmenu1_CreateFcn(hObject, eventdata, handles)
% hObject    handle to popupmenu1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    empty - handles not created until after all CreateFcns called

% Hint: popupmenu controls usually have a white background on Windows.
%       See ISPC and COMPUTER.
run('Dados');
if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end
if nrGL==5
    set(hObject, 'String', {'1° Grau de Liberdade', '2° Grau de Liberdade', '3°
Grau de Liberdade', '4° Grau de Liberdade', '5° Grau de Liberdade'});
end
if nrGL==6
    set(hObject, 'String', {'1° Grau de Liberdade', '2° Grau de Liberdade', '3°
Grau de Liberdade', '4° Grau de Liberdade', '5° Grau de Liberdade','6° Grau de
Liberdade'});
end



% --- Executes on selection change in popupmenu1.
function popupmenu1_Callback(hObject, eventdata, handles)
% hObject    handle to popupmenu1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hints: contents = get(hObject,'String') returns popupmenu1 contents as cell array
%        contents{get(hObject,'Value')} returns selected item from popupmenu1


% --- Executes on button press in pushbutton1.
function pushbutton1_Callback(hObject, eventdata, handles)
% hObject    handle to pushbutton1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

run('RespostaFreq2');
axes(handles.axes1);
cla;
popup_sel_index = get(handles.popupmenu1, 'Value');
switch popup_sel_index
    case 1
        iGL=1;
        set(handles.text1,'String','..........');
    case 2
```

```
        iGL=2;
        set(handles.text1,'String','.........');
    case 3
        iGL=3;
        set(handles.text1,'String','.........');
    case 4
        iGL=4;
        set(handles.text1,'String','.........');
    case 5
        iGL=5;
        set(handles.text1,'String','.........');
    case 6
        iGL=6;
        set(handles.text1,'String','.........');
end
index=([num2str(iGL),'1']);
if nrGL==5

plot(w/2/pi,alfamA(iGL,:),w/2/pi,alfasmmA(iGL,:,1),w/2/pi,alfasmmA(iGL,:,2),w/2/pi,
alfasmmA(iGL,:,3),w/2/pi,alfasmmA(iGL,:,4),w/2/pi,alfasmmA(iGL,:,5));
    legend(['A_{',index,'}'],'c1°','c2°','c3°','c4°','c5°',-1);
end
if nrGL==6

plot(w/2/pi,alfamA(iGL,:),w/2/pi,alfasmmA(iGL,:,1),w/2/pi,alfasmmA(iGL,:,2),w/2/pi,
alfasmmA(iGL,:,3),w/2/pi,alfasmmA(iGL,:,4),w/2/pi,alfasmmA(iGL,:,5),w/2/pi,alfasmmA
(iGL,:,6));
    legend(['A_{',index,'}'],'c1°','c2°','c3°','c4°','c5°','c6',-1);
end
title(['Resposta em Frequencia/Contribuiçao Modal (Acelerancia)
\theta_{',index,'}']);
xlabel('f [Hz]'); ylabel('Mag. [dB]');
set(handles.pushbutton4,'Visible','on');
set(handles.pushbutton5,'Visible','on');
set(handles.togglebutton1,'Visible','on');


% --- Executes on button press in togglebutton1.
function togglebutton1_Callback(hObject, eventdata, handles)
% hObject    handle to togglebutton1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hint: get(hObject,'Value') returns toggle state of togglebutton1

button_state = get(hObject,'Value');
if button_state == get(hObject,'Max')
    set(handles.text1,'Visible','on');  % toggle button is pressed
elseif button_state == get(hObject,'Min')
    set(handles.text1,'Visible','off');  % toggle button is not pressed
end
```

M_Resp_Freq_Cont_Modal_Receptancia.m

```
function varargout = respostatemp(varargin)
% Begin initialization code - DO NOT EDIT
gui_Singleton = 1;
gui_State = struct('gui_Name',       mfilename, ...
    'gui_Singleton',  gui_Singleton, ...
    'gui_OpeningFcn', @M_Resposta_Freq_Cont_Modal_Recept_OpeningFcn, ...
    'gui_OutputFcn',  @M_Resposta_Freq_Cont_Modal_Recept_OutputFcn, ...
    'gui_LayoutFcn',  [] , ...
    'gui_Callback',   []);
if nargin & isstr(varargin{1})
    gui_State.gui_Callback = str2func(varargin{1});
end

if nargout
    [varargout{1:nargout}] = gui_mainfcn(gui_State, varargin{:});
else
```

```
    gui_mainfcn(gui_State, varargin{:});
end
% End initialization code - DO NOT EDIT

clc;


% --- Executes just before M_Resposta_Freq_Cont_Modal_Recept is made visible.
function M_Resposta_Freq_Cont_Modal_Recept_OpeningFcn(hObject, eventdata, handles,
varargin)
% This function has no output args, see OutputFcn.
% hObject    handle to figure
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
% varargin   command line arguments to M_Resposta_Freq_Cont_Modal_Recept (see
VARARGIN)

% Choose default command line output for M_Resposta_Freq_Cont_Modal_Recept
handles.output = hObject;

% Update handles structure
guidata(hObject, handles);

% UIWAIT makes M_Resposta_Freq_Cont_Modal_Recept wait for user response (see
UIRESUME)
% uiwait(handles.figure1);



% --- Outputs from this function are returned to the command line.
function varargout = M_Resposta_Freq_Cont_Modal_Recept_OutputFcn(hObject,
eventdata, handles)
% varargout  cell array for returning output args (see VARARGOUT);
% hObject    handle to figure
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Get default command line output from handles structure
varargout{1} = handles.output;


scnsize = get(0,'ScreenSize');
pos1  = [scnsize(3)/12,5,scnsize(3)/8.7,scnsize(4)/15];
set(hObject, 'Position',pos1, 'Visible','on');

refresh
set(hObject, 'Units', 'pixels');
handles.banner = imread('fundo.jpg'); % Read the image file banner.jpg
info = imfinfo('fundo.jpg'); % Determine the size of the image file
position = get(hObject, 'Position');
% set(hObject, 'Position', [position(1:2) info.Width+100 info.Height+100]);
axes(handles.background);
image(handles.banner)
set(handles.background, ...
    'Visible', 'off', ...
    'Units', 'pixels',...
    'Position', [0 0 15*info.Width 15*info.Height]);

% --- Executes during object creation, after setting all properties.
function popupmenu1_CreateFcn(hObject, eventdata, handles)
% hObject    handle to popupmenu1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    empty - handles not created until after all CreateFcns called

% Hint: popupmenu controls usually have a white background on Windows.
%       See ISPC and COMPUTER.
run('Dados');
if ispc
    set(hObject,'BackgroundColor','white');
else
```

```
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end
if nrGL==5
    set(hObject, 'String', {'1° Grau de Liberdade', '2° Grau de Liberdade', '3°
Grau de Liberdade', '4° Grau de Liberdade', '5° Grau de Liberdade'});
end
if nrGL==6
    set(hObject, 'String', {'1° Grau de Liberdade', '2° Grau de Liberdade', '3°
Grau de Liberdade', '4° Grau de Liberdade', '5° Grau de Liberdade','6° Grau de
Liberdade'});
end


% --- Executes on selection change in popupmenu1.
function popupmenu1_Callback(hObject, eventdata, handles)
% hObject    handle to popupmenu1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hints: contents = get(hObject,'String') returns popupmenu1 contents as cell array
%        contents{get(hObject,'Value')} returns selected item from popupmenu1


% --- Executes on button press in pushbutton1.
function pushbutton1_Callback(hObject, eventdata, handles)
% hObject    handle to pushbutton1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

run('RespostaFreq2');
axes(handles.axes1);
cla;
popup_sel_index = get(handles.popupmenu1, 'Value');
switch popup_sel_index
    case 1
        iGL=1;
        set(handles.text1,'String','.......');
    case 2
        iGL=2;
        set(handles.text1,'String','.......');
    case 3
        iGL=3;
        set(handles.text1,'String','.......');
    case 4
        iGL=4;
        set(handles.text1,'String','.......');
    case 5
        iGL=5;
        set(handles.text1,'String','.......');
    case 6
        iGL=6;
        set(handles.text1,'String','.......');
end

index=([num2str(iGL),'1']);
if nrGL==5

plot(w/2/pi,alfam(iGL,:),w/2/pi,alfasmm(iGL,:,1),w/2/pi,alfasmm(iGL,:,2),w/2/pi,alf
asmm(iGL,:,3),w/2/pi,alfasmm(iGL,:,4),w/2/pi,alfasmm(iGL,:,5));
    legend(['R_{',index,'}'],'c1°','c2°','c3°','c4°','c5°',-1);
end
if nrGL==6

plot(w/2/pi,alfam(iGL,:),w/2/pi,alfasmm(iGL,:,1),w/2/pi,alfasmm(iGL,:,2),w/2/pi,alf
asmm(iGL,:,3),w/2/pi,alfasmm(iGL,:,4),w/2/pi,alfasmm(iGL,:,5),w/2/pi,alfasmm(iGL,:,
6));
    legend(['R_{',index,'}'],'c1°','c2°','c3°','c4°','c5°','c6°',-1);
end
title(['Resposta em Frequencia/Contribuiçao Modal (Receptancia)
\theta_{',index,'}']);
```

```
xlabel('f [Hz]'); ylabel('Mag. [dB]');
set(handles.pushbutton3,'Visible','on');
set(handles.pushbutton4,'Visible','on');
set(handles.togglebutton1,'Visible','on');
% --- Executes on button press in togglebutton1.
function togglebutton1_Callback(hObject, eventdata, handles)
% hObject    handle to togglebutton1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hint: get(hObject,'Value') returns toggle state of togglebutton1

button_state = get(hObject,'Value');
if button_state == get(hObject,'Max')
    set(handles.text1,'Visible','on');  % toggle button is pressed
elseif button_state == get(hObject,'Min')
    set(handles.text1,'Visible','off');  % toggle button is not pressed
end
```

M_Resposta_Impulsos.m

```
function varargout = M_Resposta_Impulsos(varargin)
% M_RESPOSTA_IMPULSOS M-file for M_Resposta_Impulsos.fig
%      M_RESPOSTA_IMPULSOS, by itself, creates a new M_RESPOSTA_IMPULSOS or raises
the existing
%      singleton*.
%
%      H = M_RESPOSTA_IMPULSOS returns the handle to a new M_RESPOSTA_IMPULSOS or
the handle to
%      the existing singleton*.
%
%      M_RESPOSTA_IMPULSOS('CALLBACK',hObject,eventData,handles,...) calls the
local
%      function named CALLBACK in M_RESPOSTA_IMPULSOS.M with the given input
arguments.
%
%      M_RESPOSTA_IMPULSOS('Property','Value',...) creates a new
M_RESPOSTA_IMPULSOS or raises the
%      existing singleton*.  Starting from the left, property value pairs are
%      applied to the GUI before M_Resposta_Impulsos_OpeningFunction gets called.
An
%      unrecognized property name or invalid value makes property application
%      stop.  All inputs are passed to M_Resposta_Impulsos_OpeningFcn via varargin.
%
%      *See GUI Options on GUIDE's Tools menu.  Choose "GUI allows only one
%      instance to run (singleton)".
%
% See also: GUIDE, GUIDATA, GUIHANDLES

% Edit the above text to modify the response to help M_Resposta_Impulsos

% Last Modified by GUIDE v2.5 25-May-2004 14:33:42

% Begin initialization code - DO NOT EDIT
gui_Singleton = 1;
gui_State = struct('gui_Name',       mfilename, ...
    'gui_Singleton',  gui_Singleton, ...
    'gui_OpeningFcn', @M_Resposta_Impulsos_OpeningFcn, ...
    'gui_OutputFcn',  @M_Resposta_Impulsos_OutputFcn, ...
    'gui_LayoutFcn',  [] , ...
    'gui_Callback',   []);
if nargin & isstr(varargin{1})
    gui_State.gui_Callback = str2func(varargin{1});
end

if nargout
    [varargout{1:nargout}] = gui_mainfcn(gui_State, varargin{:});
else
    gui_mainfcn(gui_State, varargin{:});
end
```

```
% End initialization code - DO NOT EDIT


% --- Executes just before M_Resposta_Impulsos is made visible.
function M_Resposta_Impulsos_OpeningFcn(hObject, eventdata, handles, varargin)
% This function has no output args, see OutputFcn.
% hObject    handle to figure
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
% varargin   command line arguments to M_Resposta_Impulsos (see VARARGIN)

% Choose default command line output for M_Resposta_Impulsos
handles.output = hObject;

% Update handles structure
guidata(hObject, handles);

% UIWAIT makes M_Resposta_Impulsos wait for user response (see UIRESUME)
% uiwait(handles.figure1);


% --- Outputs from this function are returned to the command line.
function varargout = M_Resposta_Impulsos_OutputFcn(hObject, eventdata, handles)
% varargout  cell array for returning output args (see VARARGOUT);
% hObject    handle to figure
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Get default command line output from handles structure
varargout{1} = handles.output;

scnsize = get(0,'ScreenSize');
pos1  = [scnsize(3)/12,5,scnsize(3)/8.7,scnsize(4)/15];
set(hObject, 'Position',pos1, 'Visible','on');

refresh
set(hObject, 'Units', 'pixels');
handles.banner = imread('fundo.jpg'); % Read the image file banner.jpg
info = imfinfo('fundo.jpg'); % Determine the size of the image file
position = get(hObject, 'Position');
axes(handles.background);
image(handles.banner)
set(handles.background, ...
    'Visible', 'off', ...
    'Units', 'pixels',...
    'Position', [0 0 10*info.Width 10*info.Height]);

% --- Executes during object creation, after setting all properties.
function velocidade_CreateFcn(hObject, eventdata, handles)
% hObject    handle to velocidade (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    empty - handles not created until after all CreateFcns called

% Hint: edit controls usually have a white background on Windows.
%       See ISPC and COMPUTER.
if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end

function velocidade_Callback(hObject, eventdata, handles)
% hObject    handle to velocidade (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hints: get(hObject,'String') returns contents of velocidade as text
%        str2double(get(hObject,'String')) returns contents of velocidade as a
double
```

```
velocidade=str2double(get(hObject,'String'));
if isnan(velocidade)
    set(hObject, 'String', 0);
    errordlg('Input must be a number','Error');
end

data = getappdata(gcbf, 'metricdata');
data.velocidade = velocidade;
setappdata(gcbf, 'metricdata', data);

% --- Executes on button press in pushbutton1.
function pushbutton1_Callback(hObject, eventdata, handles)
% hObject    handle to pushbutton1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

data = getappdata(gcbf, 'metricdata');

set(handles.velocidade,'Style','text','FontWeight','demi','FontSize',12,'Background
Color',[0.8 0.8 0.8]);
set(handles.pushbutton1,'Visible','off');
set(handles.popupmenu1, 'Visible', 'on');
set(handles.pushbutton4, 'Visible', 'on');


% --- Executes during object creation, after setting all properties.
function popupmenu1_CreateFcn(hObject, eventdata, handles)
% hObject    handle to popupmenu1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    empty - handles not created until after all CreateFcns called

% Hint: popupmenu controls usually have a white background on Windows.
%       See ISPC and COMPUTER.
if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end
set(hObject, 'String', {'Resposta Temporal', 'Contribuiçao dos
Harmonicos','Representaçao da Solicitaçao','Espectro'});


% --- Executes on selection change in popupmenu1.
function popupmenu1_Callback(hObject, eventdata, handles)
% hObject    handle to popupmenu1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hints: contents = get(hObject,'String') returns popupmenu1 contents as cell array
%        contents{get(hObject,'Value')} returns selected item from popupmenu1


% --- Executes on button press in pushbutton4.
function pushbutton4_Callback(hObject, eventdata, handles)
% hObject    handle to pushbutton4 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)


popup_sel_index = get(handles.popupmenu1, 'Value');
switch popup_sel_index
    case 1
        set(handles.popupmenu1, 'Visible', 'off');
        set(handles.pushbutton4, 'Visible', 'off');
        set(handles.text5, 'String', 'Resposta
Temporal','FontWeight','demi','FontSize',10,'Visible','on');
        TipoGraf=1;
        data = getappdata(gcbf, 'metricdata');
        data.TipoGraf = TipoGraf;
```

```
        setappdata(gcbf, 'metricdata', data);
        set(handles.popupmenu3, 'Visible', 'on');
        set(handles.pushbutton5, 'Visible', 'on');

    case 2
        set(handles.text5, 'String', 'Contribuiçao do
Harmonico','FontWeight','demi','FontSize',10,'Visible','on');
        TipoGraf=2;
        data = getappdata(gcbf, 'metricdata');
        data.TipoGraf = TipoGraf;
        setappdata(gcbf, 'metricdata', data);
        set(handles.popupmenu1, 'Visible', 'off');
        set(handles.pushbutton4, 'Visible', 'off');
        set(handles.popupmenu3, 'Visible', 'on');
        set(handles.pushbutton5, 'Visible', 'on');
    case 3
        set(handles.text5, 'String', 'Representaçao da
Solicitaçao','FontWeight','demi','FontSize',10,'Visible','on');
        TipoGraf=3;
        data = getappdata(gcbf, 'metricdata');
        data.TipoGraf = TipoGraf;
        setappdata(gcbf, 'metricdata', data);
        set(handles.popupmenu1, 'Visible', 'off');
        set(handles.pushbutton4, 'Visible', 'off');
        wrot=2*data.velocidade;
        run('RespostaImpulsoPeriodico');
        axes(handles.axes1);
        set(handles.axes1,'Visible','on');
        plot(t,TIP);
        xlabel('t [seg]');
        ylabel('f(t)');
        set(handles.pushbutton6, 'Visible', 'on');
        set(handles.togglebutton1,'Visible','on');
        set(handles.text7,'String','Representaçao do trem de impulsos');
    case 4
        set(handles.text5, 'String',
'Espectro','FontWeight','demi','FontSize',10,'Visible','on');
        TipoGraf=4;
        data = getappdata(gcbf, 'metricdata');
        data.TipoGraf = TipoGraf;
        setappdata(gcbf, 'metricdata', data);
        set(handles.pushbutton9,'Visible','on');
        set(handles.popupmenu1, 'Visible', 'off');
        set(handles.pushbutton4, 'Visible', 'off');
        set(handles.popupmenu3, 'Visible', 'on');
        set(handles.pushbutton5, 'Visible', 'on');
end


% --- Executes during object creation, after setting all properties.
function popupmenu3_CreateFcn(hObject, eventdata, handles)
% hObject    handle to popupmenu3 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    empty - handles not created until after all CreateFcns called

% Hint: popupmenu controls usually have a white background on Windows.
%       See ISPC and COMPUTER.
run('Dados');
if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end
if nrGL==5
    set(hObject, 'String', {'Grau de Liberdade 1', 'Grau de Liberdade 2','Grau de
Liberdade 3','Grau de Liberdade 4','Grau de Liberdade 5'});
end
if nrGL==6
    set(hObject, 'String', {'Grau de Liberdade 1', 'Grau de Liberdade 2','Grau de
Liberdade 3','Grau de Liberdade 4','Grau de Liberdade 5','Grau de Liberdade 6'});
```

```
end


% --- Executes on selection change in popupmenu3.
function popupmenu3_Callback(hObject, eventdata, handles)
% hObject    handle to popupmenu3 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hints: contents = get(hObject,'String') returns popupmenu3 contents as cell array
%        contents{get(hObject,'Value')} returns selected item from popupmenu3


% --- Executes on button press in pushbutton5.
function pushbutton5_Callback(hObject, eventdata, handles)
% hObject    handle to pushbutton5 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
data = getappdata(gcbf, 'metricdata');

wrot=2*data.velocidade;
run('RespostaImpulsoPeriodico2');
popup_sel_index = get(handles.popupmenu3, 'Value');
set(handles.togglebutton4,'Visible','on');
switch popup_sel_index

    case 1
        iGL=1;
        set(handles.pushbutton7,'Visible','on');
        set(handles.axes1,'Visible','on');
        if data.TipoGraf==1
            axes(handles.axes1);
            plot(t,teta(1,:));
            xlabel('t [seg]');
            ylabel('\theta (t)');
            set(handles.pushbutton6, 'Visible', 'on');
            set(handles.text7,'String','........');
        end
        if data.TipoGraf==2
            for k=1:ntsf
                axes(handles.axes1);
                plot(t,tetah(1,:,k+1));
                xlabel('t [seg]');
            end
            set(handles.pushbutton6, 'Visible', 'on');
        end
%         if data.TipoGraf==4
%             axes(handles.axes6);
%             set(handles.axes1,'Visible','off');
%             set(handles.axes6,'Visible','on');
%             stem(Swh/2/pi,Spf);   %Representaçao da magnitude do impulso em
funçao da frequencia
%             axes(handles.axes8);
%             set(handles.axes8,'Visible','on');
%             stem(Swh/2/pi,abs(Spr(1,:)))
%             xlabel('Freq [Hz]');
%             set(handles.pushbutton6, 'Visible', 'on');
%         end


    case 2
        iGL=2;

        if data.TipoGraf==1
            axes(handles.axes1);
            plot(t,teta(2,:));
            xlabel('t [seg]');
            set(handles.pushbutton6, 'Visible', 'on');
        end
```

```
        if data.TipoGraf==2
            for k=1:ntsf
                axes(handles.axes1);
                plot(t,tetah(2,:,k+1));
                xlabel('t [seg]');
            end
            set(handles.pushbutton6, 'Visible', 'on');
        end
%         if data.TipoGraf==4
%             set(handles.axes1,'Visible','off');
%             axes(handles.axes6);
%             set(handles.axes6,'Visible','on');
%             stem(Swh/2/pi,Spf);   %Representaçao da magnitude do impulso em
funçao da frequencia
%             axes(handles.axes8);
%             set(handles.axes8,'Visible','on');
%             stem(Swh/2/pi,abs(Spr(2,:)))
%             xlabel('Freq [Hz]');
%             set(handles.pushbutton6, 'Visible', 'on');
%         end

    case 3
        iGL=3;

        if data.TipoGraf==1
            axes(handles.axes1);
            plot(t,teta(3,:));
            xlabel('t [seg]');
            set(handles.pushbutton6, 'Visible', 'on');
        end
        if data.TipoGraf==2
            for k=1:ntsf
                axes(handles.axes1);
                plot(t,tetah(3,:,k+1));
                xlabel('t [seg]');
            end
            set(handles.pushbutton6, 'Visible', 'on');
        end
        if data.TipoGraf==4
            set(handles.axes1,'Visible','off');
            set(handles.axes6,'Visible','on');
            axes(handles.axes6);
            stem(Swh/2/pi,Spf);   %Representaçao da magnitude do impulso em funçao
da frequencia
            axes(handles.axes8);
            set(handles.axes8,'Visible','on');
            stem(Swh/2/pi,abs(Spr(3,:)))
            xlabel('Freq [Hz]');
            set(handles.pushbutton6, 'Visible', 'on');
        end

    case 4
        iGL=4;

        if data.TipoGraf==1
            axes(handles.axes1);
            plot(t,teta(4,:));
            xlabel('t [seg]');
            set(handles.pushbutton6, 'Visible', 'on');
        end
        if data.TipoGraf==2
            for k=1:ntsf
                axes(handles.axes1);
                plot(t,tetah(4,:,k+1));
                xlabel('t [seg]');
            end
            set(handles.pushbutton6, 'Visible', 'on');
        end
        if data.TipoGraf==4
            set(handles.axes1,'Visible','off');
```

```
            set(handles.axes6,'Visible','on');
            axes(handles.axes6);
            stem(Swh/2/pi,Spf);   %Representaçao da magnitude do impulso em funçao
da frequencia
            axes(handles.axes8);
            set(handles.axes8,'Visible','on');
            stem(Swh/2/pi,abs(Spr(4,:)))
            xlabel('Freq [Hz]');
            set(handles.pushbutton6, 'Visible', 'on');
        end

    case 5
        iGL=5;

        if data.TipoGraf==1
            axes(handles.axes1);
            plot(t,teta(5,:));
            xlabel('t [seg]');
            set(handles.pushbutton6, 'Visible', 'on');
        end
        if data.TipoGraf==2
            for k=1:ntsf
                axes(handles.axes1);
                plot(t,tetah(5,:,k+1));
                xlabel('t [seg]');
            end
            set(handles.pushbutton6, 'Visible', 'on');
        end
        if data.TipoGraf==4
            set(handles.axes1,'Visible','off');
            axes(handles.axes6);
            set(handles.axes6,'Visible','on');
            stem(Swh/2/pi,Spf);   %Representaçao da magnitude do impulso em funçao
da frequencia
            axes(handles.axes8);
            set(handles.axes8,'Visible','on');
            stem(Swh/2/pi,abs(Spr(5,:)))
            xlabel('Freq [Hz]');
            set(handles.pushbutton6, 'Visible', 'on');
        end


    case 6
        iGL=6;

end

if data.TipoGraf==1
    axes(handles.axes1);
    plot(t,teta(iGL,:));
    xlabel('t [seg]');
    set(handles.pushbutton6, 'Visible', 'on');
end

if data.TipoGraf==2
    for k=1:ntsf
        axes(handles.axes1);
        plot(t,tetah(iGL,:,k+1));
        xlabel('t [seg]');
    end
    set(handles.pushbutton6, 'Visible', 'on');
end
axes(handles.axes6);
cla;
if data.TipoGraf==4
    set(handles.axes1,'Visible','off');
    if iGL==1
        axes(handles.axes6);
        set(handles.axes6,'Visible','on');
```

```
        stem(Swh/2/pi,Spf);    %Representaçao da magnitude do impulso em funçao da
frequencia
    end
    axes(handles.axes8);
    if iGL~=1
        set(handles.axes6,'Visible','off');
    end
    set(handles.axes8,'Visible','on');
    stem(Swh/2/pi,abs(Spr(iGL,:)))
    xlabel('Freq [Hz]');
    set(handles.pushbutton6, 'Visible', 'on');
end
if data.TipoGraf==4
    set(handles.togglebutton1,'Visible','off');
    set(handles.togglebutton2,'Visible','on');
    set(handles.togglebutton3,'Visible','on');
else
    set(handles.togglebutton1,'Visible','on');
end


% --- Executes on button press in pushbutton7.
function pushbutton7_Callback(hObject, eventdata, handles)
% hObject    handle to pushbutton7 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)



% --- Executes on button press in pushbutton9.
function pushbutton9_Callback(hObject, eventdata, handles)
% hObject    handle to pushbutton9 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)


% --- Executes on button press in togglebutton1.
function togglebutton1_Callback(hObject, eventdata, handles)
% hObject    handle to togglebutton1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hint: get(hObject,'Value') returns toggle state of togglebutton1

button_state = get(hObject,'Value');
if button_state == get(hObject,'Max')
    set(handles.text7,'Visible','on');  % toggle button is pressed
elseif button_state == get(hObject,'Min')
    set(handles.text7,'Visible','off');  % toggle button is not pressed
end

% --- Executes on button press in togglebutton2.
function togglebutton2_Callback(hObject, eventdata, handles)
% hObject    handle to togglebutton2 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
% Hint: get(hObject,'Value') returns toggle state of togglebutton2
button_state = get(hObject,'Value');
if button_state == get(hObject,'Max')
    set(handles.text9,'Visible','on');  % toggle button is pressed
    set(handles.axes8,'Visible','off');
elseif button_state == get(hObject,'Min')
    set(handles.text9,'Visible','off');  % toggle button is not pressed
    set(handles.axes8,'Visible','on');
end
% --- Executes on button press in togglebutton3.
function togglebutton3_Callback(hObject, eventdata, handles)
% hObject    handle to togglebutton3 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
```

```
% Hint: get(hObject,'Value') returns toggle state of togglebutton3

button_state = get(hObject,'Value');
if button_state == get(hObject,'Max')
    set(handles.text8,'Visible','on');  % toggle button is pressed
    set(handles.axes6,'Visible','off');
elseif button_state == get(hObject,'Min')
    set(handles.text8,'Visible','off');  % toggle button is not pressed
    set(handles.axes6,'Visible','on');
end
```

M_Resposta_Aciclismo.m

```
function varargout = M_Resposta_Impulsos_Aciclismo(varargin)
% M_RESPOSTA_IMPULSOS_ACICLISMO M-file for M_Resposta_Impulsos_Aciclismo.fig
%      M_RESPOSTA_IMPULSOS_ACICLISMO, by itself, creates a new
M_RESPOSTA_IMPULSOS_ACICLISMO or raises the existing
%      singleton*.
%
%      H = M_RESPOSTA_IMPULSOS_ACICLISMO returns the handle to a new
M_RESPOSTA_IMPULSOS_ACICLISMO or the handle to
%      the existing singleton*.
%
%      M_RESPOSTA_IMPULSOS_ACICLISMO('CALLBACK',hObject,eventData,handles,...)
calls the local
%      function named CALLBACK in M_RESPOSTA_IMPULSOS_ACICLISMO.M with the given
input arguments.
%
%      M_RESPOSTA_IMPULSOS_ACICLISMO('Property','Value',...) creates a new
M_RESPOSTA_IMPULSOS_ACICLISMO or raises the
%      existing singleton*.  Starting from the left, property value pairs are
%      applied to the GUI before M_Resposta_Impulsos_Aciclismo_OpeningFunction gets
called.  An
%      unrecognized property name or invalid value makes property application
%      stop.  All inputs are passed to M_Resposta_Impulsos_Aciclismo_OpeningFcn via
varargin.
%
%      *See GUI Options on GUIDE's Tools menu.  Choose "GUI allows only one
%      instance to run (singleton)".
%
% See also: GUIDE, GUIDATA, GUIHANDLES

% Edit the above text to modify the response to help M_Resposta_Impulsos_Aciclismo

% Last Modified by GUIDE v2.5 08-Jun-2004 15:20:22

% Begin initialization code - DO NOT EDIT
gui_Singleton = 1;
gui_State = struct('gui_Name',       mfilename, ...
    'gui_Singleton',  gui_Singleton, ...
    'gui_OpeningFcn', @M_Resposta_Impulsos_Aciclismo_OpeningFcn, ...
    'gui_OutputFcn',  @M_Resposta_Impulsos_Aciclismo_OutputFcn, ...
    'gui_LayoutFcn',  [] , ...
    'gui_Callback',   []);
if nargin & isstr(varargin{1})
    gui_State.gui_Callback = str2func(varargin{1});
end

if nargout
    [varargout{1:nargout}] = gui_mainfcn(gui_State, varargin{:});
else
    gui_mainfcn(gui_State, varargin{:});
end
% End initialization code - DO NOT EDIT


% --- Executes just before M_Resposta_Impulsos_Aciclismo is made visible.
function M_Resposta_Impulsos_Aciclismo_OpeningFcn(hObject, eventdata, handles,
varargin)
```

```
% This function has no output args, see OutputFcn.
% hObject    handle to figure
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
% varargin   command line arguments to M_Resposta_Impulsos_Aciclismo (see VARARGIN)

% Choose default command line output for M_Resposta_Impulsos_Aciclismo
handles.output = hObject;

% Update handles structure
guidata(hObject, handles);

% UIWAIT makes M_Resposta_Impulsos_Aciclismo wait for user response (see UIRESUME)
% uiwait(handles.figure1);


% --- Outputs from this function are returned to the command line.
function varargout = M_Resposta_Impulsos_Aciclismo_OutputFcn(hObject, eventdata,
handles)
% varargout  cell array for returning output args (see VARARGOUT);
% hObject    handle to figure
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Get default command line output from handles structure
varargout{1} = handles.output;

scnsize = get(0,'ScreenSize');
pos1  = [scnsize(3)/12,5,scnsize(3)/8.7,scnsize(4)/15];
set(hObject, 'Position',pos1, 'Visible','on');



refresh
set(hObject, 'Units', 'pixels');
handles.banner = imread('fundo.jpg'); % Read the image file banner.jpg
info = imfinfo('fundo.jpg'); % Determine the size of the image file
position = get(hObject, 'Position');
axes(handles.background);
image(handles.banner)
set(handles.background, ...
    'Visible', 'off', ...
    'Units', 'pixels',...
    'Position', [0 0 10*info.Width 10*info.Height]);

% --- Executes during object creation, after setting all properties.
function velocidade_CreateFcn(hObject, eventdata, handles)
% hObject    handle to velocidade (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    empty - handles not created until after all CreateFcns called

% Hint: edit controls usually have a white background on Windows.
%       See ISPC and COMPUTER.
if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end

function velocidade_Callback(hObject, eventdata, handles)
% hObject    handle to velocidade (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hints: get(hObject,'String') returns contents of velocidade as text
%        str2double(get(hObject,'String')) returns contents of velocidade as a
double


velocidade=str2double(get(hObject,'String'));
if isnan(velocidade)
```

```
    set(hObject, 'String', 0);
    errordlg('Input must be a number','Error');
end

data = getappdata(gcbf, 'metricdata');
data.velocidade = velocidade;
setappdata(gcbf, 'metricdata', data);

% --- Executes on button press in pushbutton1.
function pushbutton1_Callback(hObject, eventdata, handles)
% hObject    handle to pushbutton1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

data = getappdata(gcbf, 'metricdata');

set(handles.velocidade,'Style','text','FontWeight','demi','FontSize',12,'Background
Color',[0.8 0.8 0.8]);
set(handles.pushbutton1,'Visible','off');
set(handles.popupmenu1, 'Visible', 'on');
set(handles.pushbutton4, 'Visible', 'on');


% --- Executes during object creation, after setting all properties.
function popupmenu1_CreateFcn(hObject, eventdata, handles)
% hObject    handle to popupmenu1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    empty - handles not created until after all CreateFcns called

% Hint: popupmenu controls usually have a white background on Windows.
%       See ISPC and COMPUTER.
if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end
set(hObject, 'String', {'Resposta Temporal', 'Contribuiçao dos
Harmonicos','Representaçao da Solicitaçao','Espectro'});


% --- Executes on selection change in popupmenu1.
function popupmenu1_Callback(hObject, eventdata, handles)
% hObject    handle to popupmenu1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hints: contents = get(hObject,'String') returns popupmenu1 contents as cell array
%        contents{get(hObject,'Value')} returns selected item from popupmenu1


% --- Executes on button press in pushbutton4.
function pushbutton4_Callback(hObject, eventdata, handles)
% hObject    handle to pushbutton4 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)


popup_sel_index = get(handles.popupmenu1, 'Value');
switch popup_sel_index
    case 1
        set(handles.popupmenu1, 'Visible', 'off');
        set(handles.pushbutton4, 'Visible', 'off');
        set(handles.text5, 'String', 'Resposta
Temporal','FontWeight','demi','FontSize',10,'Visible','on');
        TipoGraf=1;
        data = getappdata(gcbf, 'metricdata');
        data.TipoGraf = TipoGraf;
        setappdata(gcbf, 'metricdata', data);
        set(handles.popupmenu3, 'Visible', 'on');
        set(handles.pushbutton5, 'Visible', 'on');
```

```
    case 2
        set(handles.text5, 'String', 'Contribuiçao do
Harmonico','FontWeight','demi','FontSize',10,'Visible','on');
        TipoGraf=2;
        data = getappdata(gcbf, 'metricdata');
        data.TipoGraf = TipoGraf;
        setappdata(gcbf, 'metricdata', data);
        set(handles.popupmenu1, 'Visible', 'off');
        set(handles.pushbutton4, 'Visible', 'off');
        set(handles.popupmenu3, 'Visible', 'on');
        set(handles.pushbutton5, 'Visible', 'on');
    case 3
        set(handles.text5, 'String', 'Representaçao da
Solicitaçao','FontWeight','demi','FontSize',10,'Visible','on');
        TipoGraf=3;
        data = getappdata(gcbf, 'metricdata');
        data.TipoGraf = TipoGraf;
        setappdata(gcbf, 'metricdata', data);
        set(handles.popupmenu1, 'Visible', 'off');
        set(handles.pushbutton4, 'Visible', 'off');
        wrot=2*data.velocidade;
        run('RespostaImpulsoPeriodicoAciclismo');
        axes(handles.axes1);
        set(handles.axes1,'Visible','on');
        plot(t,TIP);
        xlabel('t [seg]');
        set(handles.pushbutton6, 'Visible', 'on');
        set(handles.togglebutton1,'Visible','on');
        set(handles.text7,'String','Representaçao do trem de impulsos');
    case 4
        set(handles.text5, 'String',
'Espectro','FontWeight','demi','FontSize',10,'Visible','on');
        TipoGraf=4;
        data = getappdata(gcbf, 'metricdata');
        data.TipoGraf = TipoGraf;
        setappdata(gcbf, 'metricdata', data);
        set(handles.pushbutton9,'Visible','on');
        set(handles.popupmenu1, 'Visible', 'off');
        set(handles.pushbutton4, 'Visible', 'off');
        set(handles.popupmenu3, 'Visible', 'on');
        set(handles.pushbutton5, 'Visible', 'on');
end


% --- Executes during object creation, after setting all properties.
function popupmenu3_CreateFcn(hObject, eventdata, handles)
% hObject    handle to popupmenu3 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    empty - handles not created until after all CreateFcns called

% Hint: popupmenu controls usually have a white background on Windows.
%       See ISPC and COMPUTER.
run('Dados');
if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end
if nrGL==5
    set(hObject, 'String', {'Grau de Liberdade 1', 'Grau de Liberdade 2','Grau de
Liberdade 3','Grau de Liberdade 4','Grau de Liberdade 5'});
end
if nrGL==6
    set(hObject, 'String', {'Grau de Liberdade 1', 'Grau de Liberdade 2','Grau de
Liberdade 3','Grau de Liberdade 4','Grau de Liberdade 5','Grau de Liberdade 6'});
end
```

```
% --- Executes on selection change in popupmenu3.
function popupmenu3_Callback(hObject, eventdata, handles)
% hObject    handle to popupmenu3 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hints: contents = get(hObject,'String') returns popupmenu3 contents as cell array
%        contents{get(hObject,'Value')} returns selected item from popupmenu3


% --- Executes on button press in pushbutton5.
function pushbutton5_Callback(hObject, eventdata, handles)
% hObject    handle to pushbutton5 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
data = getappdata(gcbf, 'metricdata');

wrot=2*data.velocidade;
run('RespostaImpulsoPeriodicoAciclismo');
popup_sel_index = get(handles.popupmenu3, 'Value');
switch popup_sel_index

    case 1
        iGL=1;
        set(handles.pushbutton7,'Visible','on');
        set(handles.axes1,'Visible','on');
        if data.TipoGraf==1
            axes(handles.axes1);
            plot(t,teta(1,:));
            xlabel('t [seg]');
            set(handles.pushbutton6, 'Visible', 'on');
            set(handles.text7,'String','........');
        end
        if data.TipoGraf==2
            for k=1:ntsf
                axes(handles.axes1);
                plot(t,tetah(1,:,k+1));
                xlabel('t [seg]');
            end
            set(handles.pushbutton6, 'Visible', 'on');
        end


    case 2
        iGL=2;

        if data.TipoGraf==1
            axes(handles.axes1);
            plot(t,teta(2,:));
            xlabel('t [seg]');
            set(handles.pushbutton6, 'Visible', 'on');
        end
        if data.TipoGraf==2
            for k=1:ntsf
                axes(handles.axes1);
                plot(t,tetah(2,:,k+1));
                xlabel('t [seg]');
            end
            set(handles.pushbutton6, 'Visible', 'on');
        end

    case 3
        iGL=3;

        if data.TipoGraf==1
            axes(handles.axes1);
            plot(t,teta(3,:));
            xlabel('t [seg]');
            set(handles.pushbutton6, 'Visible', 'on');
        end
```

```
        if data.TipoGraf==2
            for k=1:ntsf
                axes(handles.axes1);
                plot(t,tetah(3,:,k+1));
                xlabel('t [seg]');
            end
            set(handles.pushbutton6, 'Visible', 'on');
        end
        if data.TipoGraf==4
            set(handles.axes1,'Visible','off');
            set(handles.axes6,'Visible','on');
            axes(handles.axes6);
            stem(Swh/2/pi,Spf);  %Representaçao da magnitude do impulso em funçao
da frequencia
            axes(handles.axes8);
            set(handles.axes8,'Visible','on');
            stem(Swh/2/pi,abs(Spr(3,:)))
            xlabel('Freq [Hz]');
            set(handles.pushbutton6, 'Visible', 'on');
        end

    case 4
        iGL=4;

        if data.TipoGraf==1
            axes(handles.axes1);
            plot(t,teta(4,:));
            xlabel('t [seg]');
            set(handles.pushbutton6, 'Visible', 'on');
        end
        if data.TipoGraf==2
            for k=1:ntsf
                axes(handles.axes1);
                plot(t,tetah(4,:,k+1));
                xlabel('t [seg]');
            end
            set(handles.pushbutton6, 'Visible', 'on');
        end
        if data.TipoGraf==4
            set(handles.axes1,'Visible','off');
            set(handles.axes6,'Visible','on');
            axes(handles.axes6);
            stem(Swh/2/pi,Spf);  %Representaçao da magnitude do impulso em funçao
da frequencia
            axes(handles.axes8);
            set(handles.axes8,'Visible','on');
            stem(Swh/2/pi,abs(Spr(4,:)))
            xlabel('Freq [Hz]');
            set(handles.pushbutton6, 'Visible', 'on');
        end

    case 5
        iGL=5;

        if data.TipoGraf==1
            axes(handles.axes1);
            plot(t,teta(5,:));
            xlabel('t [seg]');
            set(handles.pushbutton6, 'Visible', 'on');
        end
        if data.TipoGraf==2
            for k=1:ntsf
                axes(handles.axes1);
                plot(t,tetah(5,:,k+1));
                xlabel('t [seg]');
            end
            set(handles.pushbutton6, 'Visible', 'on');
        end
        if data.TipoGraf==4
            set(handles.axes1,'Visible','off');
```

```
            axes(handles.axes6);
            set(handles.axes6,'Visible','on');
            stem(Swh/2/pi,Spf);   %Representaçao da magnitude do impulso em funçao
da frequencia
            axes(handles.axes8);
            set(handles.axes8,'Visible','on');
            stem(Swh/2/pi,abs(Spr(5,:)))
            xlabel('Freq [Hz]');
            set(handles.pushbutton6, 'Visible', 'on');
        end


    case 6
        iGL=6;

end

if data.TipoGraf==1
    axes(handles.axes1);
    plot(t,teta(iGL,:));
    xlabel('t [seg]');
    set(handles.pushbutton6, 'Visible', 'on');
end

if data.TipoGraf==2
    for k=1:ntsf
        axes(handles.axes1);
        plot(t,tetah(iGL,:,k+1));
        xlabel('t [seg]');
    end
    set(handles.pushbutton6, 'Visible', 'on');
end
axes(handles.axes6);
cla;
if data.TipoGraf==4
    set(handles.axes1,'Visible','off');
    if iGL==1
        axes(handles.axes6);
        set(handles.axes6,'Visible','on');
        stem(Swh/2/pi,Spf);   %Representaçao da magnitude do impulso em funçao da
frequencia
    end
    axes(handles.axes8);
    if iGL~=1
        set(handles.axes6,'Visible','off');
    end
    set(handles.axes8,'Visible','on');
    stem(Swh/2/pi,abs(Spr(iGL,:)))
    xlabel('Freq [Hz]');
    set(handles.pushbutton6, 'Visible', 'on');
end
if data.TipoGraf==4
    set(handles.togglebutton1,'Visible','off');
    set(handles.togglebutton2,'Visible','on');
    set(handles.togglebutton3,'Visible','on');
else
    set(handles.togglebutton1,'Visible','on');
end


% --- Executes on button press in pushbutton7.
function pushbutton7_Callback(hObject, eventdata, handles)
% hObject    handle to pushbutton7 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)



% --- Executes on button press in pushbutton9.
function pushbutton9_Callback(hObject, eventdata, handles)
```

```
% hObject    handle to pushbutton9 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)


% --- Executes on button press in togglebutton1.
function togglebutton1_Callback(hObject, eventdata, handles)
% hObject    handle to togglebutton1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hint: get(hObject,'Value') returns toggle state of togglebutton1

button_state = get(hObject,'Value');
if button_state == get(hObject,'Max')
    set(handles.text7,'Visible','on');  % toggle button is pressed
elseif button_state == get(hObject,'Min')
    set(handles.text7,'Visible','off');  % toggle button is not pressed
end


% --- Executes on button press in togglebutton2.
function togglebutton2_Callback(hObject, eventdata, handles)
% hObject    handle to togglebutton2 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hint: get(hObject,'Value') returns toggle state of togglebutton2

button_state = get(hObject,'Value');
if button_state == get(hObject,'Max')
    set(handles.text9,'Visible','on');  % toggle button is pressed
    set(handles.axes8,'Visible','off');
elseif button_state == get(hObject,'Min')
    set(handles.text9,'Visible','off');  % toggle button is not pressed
    set(handles.axes8,'Visible','on');
end


% --- Executes on button press in togglebutton3.
function togglebutton3_Callback(hObject, eventdata, handles)
% hObject    handle to togglebutton3 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hint: get(hObject,'Value') returns toggle state of togglebutton3

button_state = get(hObject,'Value');
if button_state == get(hObject,'Max')
    set(handles.text8,'Visible','on');  % toggle button is pressed
    set(handles.axes6,'Visible','off');
elseif button_state == get(hObject,'Min')
    set(handles.text8,'Visible','off');  % toggle button is not pressed
    set(handles.axes6,'Visible','on');
end



% --- Executes on button press in togglebutton5.
function togglebutton5_Callback(hObject, eventdata, handles)
% hObject    handle to togglebutton5 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hint: get(hObject,'Value') returns toggle state of togglebutton5
```

M_Resposta_Impulsos_Seno.m

```
function varargout = M_Resposta_Impulsos_Seno(varargin)
```

```
% M_RESPOSTA_IMPULSOS_SENO M-file for M_Resposta_Impulsos_Seno.fig
%      M_RESPOSTA_IMPULSOS_SENO, by itself, creates a new M_RESPOSTA_IMPULSOS_SENO
or raises the existing
%      singleton*.
%
%      H = M_RESPOSTA_IMPULSOS_SENO returns the handle to a new
M_RESPOSTA_IMPULSOS_SENO or the handle to
%      the existing singleton*.
%
%      M_RESPOSTA_IMPULSOS_SENO('CALLBACK',hObject,eventData,handles,...) calls the
local
%      function named CALLBACK in M_RESPOSTA_IMPULSOS_SENO.M with the given input
arguments.
%
%      M_RESPOSTA_IMPULSOS_SENO('Property','Value',...) creates a new
M_RESPOSTA_IMPULSOS_SENO or raises the
%      existing singleton*.  Starting from the left, property value pairs are
%      applied to the GUI before M_Resposta_Impulsos_Seno_OpeningFunction gets
called.  An
%      unrecognized property name or invalid value makes property application
%      stop.  All inputs are passed to M_Resposta_Impulsos_Seno_OpeningFcn via
varargin.
%
%      *See GUI Options on GUIDE's Tools menu.  Choose "GUI allows only one
%      instance to run (singleton)".
%
% See also: GUIDE, GUIDATA, GUIHANDLES

% Edit the above text to modify the response to help M_Resposta_Impulsos_Seno

% Last Modified by GUIDE v2.5 08-Jun-2004 15:20:22

% Begin initialization code - DO NOT EDIT
gui_Singleton = 1;
gui_State = struct('gui_Name',       mfilename, ...
    'gui_Singleton',  gui_Singleton, ...
    'gui_OpeningFcn', @M_Resposta_Impulsos_Seno_OpeningFcn, ...
    'gui_OutputFcn',  @M_Resposta_Impulsos_Seno_OutputFcn, ...
    'gui_LayoutFcn',  [] , ...
    'gui_Callback',   []);
if nargin & isstr(varargin{1})
    gui_State.gui_Callback = str2func(varargin{1});
end

if nargout
    [varargout{1:nargout}] = gui_mainfcn(gui_State, varargin{:});
else
    gui_mainfcn(gui_State, varargin{:});
end
% End initialization code - DO NOT EDIT


% --- Executes just before M_Resposta_Impulsos_Seno is made visible.
function M_Resposta_Impulsos_Seno_OpeningFcn(hObject, eventdata, handles, varargin)
% This function has no output args, see OutputFcn.
% hObject    handle to figure
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
% varargin   command line arguments to M_Resposta_Impulsos_Seno (see VARARGIN)

% Choose default command line output for M_Resposta_Impulsos_Seno
handles.output = hObject;

% Update handles structure
guidata(hObject, handles);

% UIWAIT makes M_Resposta_Impulsos_Seno wait for user response (see UIRESUME)
% uiwait(handles.figure1);
```

```
% --- Outputs from this function are returned to the command line.
function varargout = M_Resposta_Impulsos_Seno_OutputFcn(hObject, eventdata,
handles)
% varargout  cell array for returning output args (see VARARGOUT);
% hObject    handle to figure
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Get default command line output from handles structure
varargout{1} = handles.output;

scnsize = get(0,'ScreenSize');
pos1  = [scnsize(3)/12,5,scnsize(3)/8.7,scnsize(4)/15];
set(hObject, 'Position',pos1, 'Visible','on');


refresh
set(hObject, 'Units', 'pixels');
handles.banner = imread('fundo.jpg'); % Read the image file banner.jpg
info = imfinfo('fundo.jpg'); % Determine the size of the image file
position = get(hObject, 'Position');
axes(handles.background);
image(handles.banner)
set(handles.background, ...
    'Visible', 'off', ...
    'Units', 'pixels',...
    'Position', [0 0 10*info.Width 10*info.Height]);

% --- Executes during object creation, after setting all properties.
function velocidade_CreateFcn(hObject, eventdata, handles)
% hObject    handle to velocidade (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    empty - handles not created until after all CreateFcns called

% Hint: edit controls usually have a white background on Windows.
%       See ISPC and COMPUTER.
if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end

function velocidade_Callback(hObject, eventdata, handles)
% hObject    handle to velocidade (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hints: get(hObject,'String') returns contents of velocidade as text
%        str2double(get(hObject,'String')) returns contents of velocidade as a
double


velocidade=str2double(get(hObject,'String'));
if isnan(velocidade)
    set(hObject, 'String', 0);
    errordlg('Input must be a number','Error');
end

data = getappdata(gcbf, 'metricdata');
data.velocidade = velocidade;
setappdata(gcbf, 'metricdata', data);

% --- Executes on button press in pushbutton1.
function pushbutton1_Callback(hObject, eventdata, handles)
% hObject    handle to pushbutton1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

data = getappdata(gcbf, 'metricdata');
```

```
set(handles.velocidade,'Style','text','FontWeight','demi','FontSize',12,'Background
Color',[0.8 0.8 0.8]);
set(handles.pushbutton1,'Visible','off');
set(handles.popupmenu1, 'Visible', 'on');
set(handles.pushbutton4, 'Visible', 'on');


% --- Executes during object creation, after setting all properties.
function popupmenu1_CreateFcn(hObject, eventdata, handles)
% hObject    handle to popupmenu1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    empty - handles not created until after all CreateFcns called

% Hint: popupmenu controls usually have a white background on Windows.
%       See ISPC and COMPUTER.
if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end
set(hObject, 'String', {'Resposta Temporal', 'Contribuiçao dos
Harmonicos','Representaçao da Solicitaçao','Espectro'});


% --- Executes on selection change in popupmenu1.
function popupmenu1_Callback(hObject, eventdata, handles)
% hObject    handle to popupmenu1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hints: contents = get(hObject,'String') returns popupmenu1 contents as cell array
%        contents{get(hObject,'Value')} returns selected item from popupmenu1


% --- Executes on button press in pushbutton4.
function pushbutton4_Callback(hObject, eventdata, handles)
% hObject    handle to pushbutton4 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)


popup_sel_index = get(handles.popupmenu1, 'Value');
switch popup_sel_index
    case 1
        set(handles.popupmenu1, 'Visible', 'off');
        set(handles.pushbutton4, 'Visible', 'off');
        set(handles.text5, 'String', 'Resposta
Temporal','FontWeight','demi','FontSize',10,'Visible','on');
        TipoGraf=1;
        data = getappdata(gcbf, 'metricdata');
        data.TipoGraf = TipoGraf;
        setappdata(gcbf, 'metricdata', data);
        set(handles.popupmenu3, 'Visible', 'on');
        set(handles.pushbutton5, 'Visible', 'on');

    case 2
        set(handles.text5, 'String', 'Contribuiçao do
Harmonico','FontWeight','demi','FontSize',10,'Visible','on');
        TipoGraf=2;
        data = getappdata(gcbf, 'metricdata');
        data.TipoGraf = TipoGraf;
        setappdata(gcbf, 'metricdata', data);
        set(handles.popupmenu1, 'Visible', 'off');
        set(handles.pushbutton4, 'Visible', 'off');
        set(handles.popupmenu3, 'Visible', 'on');
        set(handles.pushbutton5, 'Visible', 'on');
    case 3
        set(handles.text5, 'String', 'Representaçao da
Solicitaçao','FontWeight','demi','FontSize',10,'Visible','on');
        TipoGraf=3;
```

```
        data = getappdata(gcbf, 'metricdata');
        data.TipoGraf = TipoGraf;
        setappdata(gcbf, 'metricdata', data);
        set(handles.popupmenu1, 'Visible', 'off');
        set(handles.pushbutton4, 'Visible', 'off');
        wrot=2*data.velocidade;
        run('RespostaImpulsoPeriodicoSeno2');
        axes(handles.axes1);
        set(handles.axes1,'Visible','on');
        plot(t,TIP);
        xlabel('t [seg]');
        set(handles.pushbutton6, 'Visible', 'on');
        set(handles.togglebutton1,'Visible','on');
        set(handles.text7,'String','Representaçao do trem de impulsos');
    case 4
        set(handles.text5, 'String',
'Espectro','FontWeight','demi','FontSize',10,'Visible','on');
        TipoGraf=4;
        data = getappdata(gcbf, 'metricdata');
        data.TipoGraf = TipoGraf;
        setappdata(gcbf, 'metricdata', data);
        set(handles.pushbutton9,'Visible','on');
        set(handles.popupmenu1, 'Visible', 'off');
        set(handles.pushbutton4, 'Visible', 'off');
        set(handles.popupmenu3, 'Visible', 'on');
        set(handles.pushbutton5, 'Visible', 'on');
end


% --- Executes during object creation, after setting all properties.
function popupmenu3_CreateFcn(hObject, eventdata, handles)
% hObject    handle to popupmenu3 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    empty - handles not created until after all CreateFcns called

% Hint: popupmenu controls usually have a white background on Windows.
%       See ISPC and COMPUTER.
run('Dados');
if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end
if nrGL==5
    set(hObject, 'String', {'Grau de Liberdade 1', 'Grau de Liberdade 2','Grau de
Liberdade 3','Grau de Liberdade 4','Grau de Liberdade 5'});
end
if nrGL==6
    set(hObject, 'String', {'Grau de Liberdade 1', 'Grau de Liberdade 2','Grau de
Liberdade 3','Grau de Liberdade 4','Grau de Liberdade 5','Grau de Liberdade 6'});
end



% --- Executes on selection change in popupmenu3.
function popupmenu3_Callback(hObject, eventdata, handles)
% hObject    handle to popupmenu3 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hints: contents = get(hObject,'String') returns popupmenu3 contents as cell array
%        contents{get(hObject,'Value')} returns selected item from popupmenu3


% --- Executes on button press in pushbutton5.
function pushbutton5_Callback(hObject, eventdata, handles)
% hObject    handle to pushbutton5 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
data = getappdata(gcbf, 'metricdata');
```

```
wrot=2*data.velocidade;
run('RespostaImpulsoPeriodicoSeno2');
popup_sel_index = get(handles.popupmenu3, 'Value');
switch popup_sel_index

    case 1
        iGL=1;
        set(handles.pushbutton7,'Visible','on');
        set(handles.axes1,'Visible','on');
        if data.TipoGraf==1
            axes(handles.axes1);
            plot(t,teta(1,:));
            xlabel('t [seg]');
            set(handles.pushbutton6, 'Visible', 'on');
            set(handles.text7,'String','........');
        end
        if data.TipoGraf==2
            for k=1:ntsf
                axes(handles.axes1);
                plot(t,tetah(1,:,k+1));
                xlabel('t [seg]');
            end
            set(handles.pushbutton6, 'Visible', 'on');
        end


    case 2
        iGL=2;

        if data.TipoGraf==1
            axes(handles.axes1);
            plot(t,teta(2,:));
            xlabel('t [seg]');
            set(handles.pushbutton6, 'Visible', 'on');
        end
        if data.TipoGraf==2
            for k=1:ntsf
                axes(handles.axes1);
                plot(t,tetah(2,:,k+1));
                xlabel('t [seg]');
            end
            set(handles.pushbutton6, 'Visible', 'on');
        end

    case 3
        iGL=3;

        if data.TipoGraf==1
            axes(handles.axes1);
            plot(t,teta(3,:));
            xlabel('t [seg]');
            set(handles.pushbutton6, 'Visible', 'on');
        end
        if data.TipoGraf==2
            for k=1:ntsf
                axes(handles.axes1);
                plot(t,tetah(3,:,k+1));
                xlabel('t [seg]');
            end
            set(handles.pushbutton6, 'Visible', 'on');
        end
        if data.TipoGraf==4
            set(handles.axes1,'Visible','off');
            set(handles.axes6,'Visible','on');
            axes(handles.axes6);
            stem(Swh/2/pi,Spf);   %Representaçao da magnitude do impulso em funçao
da frequencia
            axes(handles.axes8);
            set(handles.axes8,'Visible','on');
```

```
            stem(Swh/2/pi,abs(Spr(3,:)))
            xlabel('Freq [Hz]');
            set(handles.pushbutton6, 'Visible', 'on');
        end

    case 4
        iGL=4;

        if data.TipoGraf==1
            axes(handles.axes1);
            plot(t,teta(4,:));
            xlabel('t [seg]');
            set(handles.pushbutton6, 'Visible', 'on');
        end
        if data.TipoGraf==2
            for k=1:ntsf
                axes(handles.axes1);
                plot(t,tetah(4,:,k+1));
                xlabel('t [seg]');
            end
            set(handles.pushbutton6, 'Visible', 'on');
        end
        if data.TipoGraf==4
            set(handles.axes1,'Visible','off');
            set(handles.axes6,'Visible','on');
            axes(handles.axes6);
            stem(Swh/2/pi,Spf);   %Representaçao da magnitude do impulso em funçao
da frequencia
            axes(handles.axes8);
            set(handles.axes8,'Visible','on');
            stem(Swh/2/pi,abs(Spr(4,:)))
            xlabel('Freq [Hz]');
            set(handles.pushbutton6, 'Visible', 'on');
        end

    case 5
        iGL=5;

        if data.TipoGraf==1
            axes(handles.axes1);
            plot(t,teta(5,:));
            xlabel('t [seg]');
            set(handles.pushbutton6, 'Visible', 'on');
        end
        if data.TipoGraf==2
            for k=1:ntsf
                axes(handles.axes1);
                plot(t,tetah(5,:,k+1));
                xlabel('t [seg]');
            end
            set(handles.pushbutton6, 'Visible', 'on');
        end
        if data.TipoGraf==4
            set(handles.axes1,'Visible','off');
            axes(handles.axes6);
            set(handles.axes6,'Visible','on');
            stem(Swh/2/pi,Spf);   %Representaçao da magnitude do impulso em funçao
da frequencia
            axes(handles.axes8);
            set(handles.axes8,'Visible','on');
            stem(Swh/2/pi,abs(Spr(5,:)))
            xlabel('Freq [Hz]');
            set(handles.pushbutton6, 'Visible', 'on');
        end


    case 6
        iGL=6;

end
```

```
if data.TipoGraf==1
    axes(handles.axes1);
    plot(t,teta(iGL,:));
    xlabel('t [seg]');
    set(handles.pushbutton6, 'Visible', 'on');
end

if data.TipoGraf==2
    for k=1:ntsf
        axes(handles.axes1);
        plot(t,tetah(iGL,:,k+1));
        xlabel('t [seg]');
    end
    set(handles.pushbutton6, 'Visible', 'on');
end
axes(handles.axes6);
cla;
if data.TipoGraf==4
    set(handles.axes1,'Visible','off');
    if iGL==1
        axes(handles.axes6);
        set(handles.axes6,'Visible','on');
        stem(Swh/2/pi,Spf);    %Representaçao da magnitude do impulso em funçao da
frequencia
    end
    axes(handles.axes8);
    if iGL~=1
        set(handles.axes6,'Visible','off');
    end
    set(handles.axes8,'Visible','on');
    stem(Swh/2/pi,abs(Spr(iGL,:)))
    xlabel('Freq [Hz]');
    set(handles.pushbutton6, 'Visible', 'on');
end
if data.TipoGraf==4
    set(handles.togglebutton1,'Visible','off');
    set(handles.togglebutton2,'Visible','on');
    set(handles.togglebutton3,'Visible','on');
else
    set(handles.togglebutton1,'Visible','on');
end


% --- Executes on button press in pushbutton7.
function pushbutton7_Callback(hObject, eventdata, handles)
% hObject    handle to pushbutton7 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)



% --- Executes on button press in pushbutton9.
function pushbutton9_Callback(hObject, eventdata, handles)
% hObject    handle to pushbutton9 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)


% --- Executes on button press in togglebutton1.
function togglebutton1_Callback(hObject, eventdata, handles)
% hObject    handle to togglebutton1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hint: get(hObject,'Value') returns toggle state of togglebutton1

button_state = get(hObject,'Value');
if button_state == get(hObject,'Max')
    set(handles.text7,'Visible','on');  % toggle button is pressed
```

```
elseif button_state == get(hObject,'Min')
    set(handles.text7,'Visible','off');  % toggle button is not pressed
end


% --- Executes on button press in togglebutton2.
function togglebutton2_Callback(hObject, eventdata, handles)
% hObject    handle to togglebutton2 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hint: get(hObject,'Value') returns toggle state of togglebutton2

button_state = get(hObject,'Value');
if button_state == get(hObject,'Max')
    set(handles.text9,'Visible','on');  % toggle button is pressed
    set(handles.axes8,'Visible','off');
elseif button_state == get(hObject,'Min')
    set(handles.text9,'Visible','off');  % toggle button is not pressed
    set(handles.axes8,'Visible','on');
end


% --- Executes on button press in togglebutton3.
function togglebutton3_Callback(hObject, eventdata, handles)
% hObject    handle to togglebutton3 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hint: get(hObject,'Value') returns toggle state of togglebutton3

button_state = get(hObject,'Value');
if button_state == get(hObject,'Max')
    set(handles.text8,'Visible','on');  % toggle button is pressed
    set(handles.axes6,'Visible','off');
elseif button_state == get(hObject,'Min')
    set(handles.text8,'Visible','off');  % toggle button is not pressed
    set(handles.axes6,'Visible','on');
end



% --- Executes on button press in togglebutton5.
function togglebutton5_Callback(hObject, eventdata, handles)
% hObject    handle to togglebutton5 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hint: get(hObject,'Value') returns toggle state of togglebutton5
```

M_Resposta_impulsos_seno_e_impulso.m

```
function varargout = M_Resposta_Impulsos_Seno_e_Impulso(varargin)
% M_RESPOSTA_IMPULSOS_SENO_E_IMPULSO M-file for
M_Resposta_Impulsos_Seno_e_Impulso.fig
%      M_RESPOSTA_IMPULSOS_SENO_E_IMPULSO, by itself, creates a new
M_RESPOSTA_IMPULSOS_SENO_E_IMPULSO or raises the existing
%      singleton*.
%
%      H = M_RESPOSTA_IMPULSOS_SENO_E_IMPULSO returns the handle to a new
M_RESPOSTA_IMPULSOS_SENO_E_IMPULSO or the handle to
%      the existing singleton*.
%
%      M_RESPOSTA_IMPULSOS_SENO_E_IMPULSO('CALLBACK',hObject,eventData,handles,...)
calls the local
%      function named CALLBACK in M_RESPOSTA_IMPULSOS_SENO_E_IMPULSO.M with the
given input arguments.
%
```

```
%      M_RESPOSTA_IMPULSOS_SENO_E_IMPULSO('Property','Value',...) creates a new
M_RESPOSTA_IMPULSOS_SENO_E_IMPULSO or raises the
%      existing singleton*.  Starting from the left, property value pairs are
%      applied to the GUI before M_Resposta_Impulsos_Seno_e_Impulso_OpeningFunction
gets called.  An
%      unrecognized property name or invalid value makes property application
%      stop.  All inputs are passed to
M_Resposta_Impulsos_Seno_e_Impulso_OpeningFcn via varargin.
%
%      *See GUI Options on GUIDE's Tools menu.  Choose "GUI allows only one
%      instance to run (singleton)".
%
% See also: GUIDE, GUIDATA, GUIHANDLES

% Edit the above text to modify the response to help
M_Resposta_Impulsos_Seno_e_Impulso

% Last Modified by GUIDE v2.5 25-May-2004 14:33:42

% Begin initialization code - DO NOT EDIT
gui_Singleton = 1;
gui_State = struct('gui_Name',       mfilename, ...
    'gui_Singleton',  gui_Singleton, ...
    'gui_OpeningFcn', @M_Resposta_Impulsos_Seno_e_Impulso_OpeningFcn, ...
    'gui_OutputFcn',  @M_Resposta_Impulsos_Seno_e_Impulso_OutputFcn, ...
    'gui_LayoutFcn',  [] , ...
    'gui_Callback',   []);
if nargin & isstr(varargin{1})
    gui_State.gui_Callback = str2func(varargin{1});
end

if nargout
    [varargout{1:nargout}] = gui_mainfcn(gui_State, varargin{:});
else
    gui_mainfcn(gui_State, varargin{:});
end
% End initialization code - DO NOT EDIT


% --- Executes just before M_Resposta_Impulsos_Seno_e_Impulso is made visible.
function M_Resposta_Impulsos_Seno_e_Impulso_OpeningFcn(hObject, eventdata, handles,
varargin)
% This function has no output args, see OutputFcn.
% hObject    handle to figure
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
% varargin   command line arguments to M_Resposta_Impulsos_Seno_e_Impulso (see
VARARGIN)

% Choose default command line output for M_Resposta_Impulsos_Seno_e_Impulso
handles.output = hObject;

% Update handles structure
guidata(hObject, handles);

% UIWAIT makes M_Resposta_Impulsos_Seno_e_Impulso wait for user response (see
UIRESUME)
% uiwait(handles.figure1);


% --- Outputs from this function are returned to the command line.
function varargout = M_Resposta_Impulsos_Seno_e_Impulso_OutputFcn(hObject,
eventdata, handles)
% varargout  cell array for returning output args (see VARARGOUT);
% hObject    handle to figure
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Get default command line output from handles structure
varargout{1} = handles.output;
```

```
scnsize = get(0,'ScreenSize');
pos1  = [scnsize(3)/12,5,scnsize(3)/8.7,scnsize(4)/15];
set(hObject, 'Position',pos1, 'Visible','on');

refresh
set(hObject, 'Units', 'pixels');
handles.banner = imread('fundo.jpg'); % Read the image file banner.jpg
info = imfinfo('fundo.jpg'); % Determine the size of the image file
position = get(hObject, 'Position');
axes(handles.background);
image(handles.banner)
set(handles.background, ...
    'Visible', 'off', ...
    'Units', 'pixels',...
    'Position', [0 0 10*info.Width 10*info.Height]);

% --- Executes during object creation, after setting all properties.
function velocidade_CreateFcn(hObject, eventdata, handles)
% hObject    handle to velocidade (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    empty - handles not created until after all CreateFcns called

% Hint: edit controls usually have a white background on Windows.
%       See ISPC and COMPUTER.
if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end

function velocidade_Callback(hObject, eventdata, handles)
% hObject    handle to velocidade (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hints: get(hObject,'String') returns contents of velocidade as text
%        str2double(get(hObject,'String')) returns contents of velocidade as a
double


velocidade=str2double(get(hObject,'String'));
if isnan(velocidade)
    set(hObject, 'String', 0);
    errordlg('Input must be a number','Error');
end

data = getappdata(gcbf, 'metricdata');
data.velocidade = velocidade;
setappdata(gcbf, 'metricdata', data);

% --- Executes on button press in pushbutton1.
function pushbutton1_Callback(hObject, eventdata, handles)
% hObject    handle to pushbutton1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

data = getappdata(gcbf, 'metricdata');

set(handles.velocidade,'Style','text','FontWeight','demi','FontSize',12,'Background
Color',[0.8 0.8 0.8]);
set(handles.pushbutton1,'Visible','off');
set(handles.popupmenu1, 'Visible', 'on');
set(handles.pushbutton4, 'Visible', 'on');


% --- Executes during object creation, after setting all properties.
function popupmenu1_CreateFcn(hObject, eventdata, handles)
% hObject    handle to popupmenu1 (see GCBO)
```

```
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    empty - handles not created until after all CreateFcns called

% Hint: popupmenu controls usually have a white background on Windows.
%       See ISPC and COMPUTER.
if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end
set(hObject, 'String', {'Resposta Temporal', 'Contribuiçao dos
Harmonicos','Representaçao da Solicitaçao','Espectro'});


% --- Executes on selection change in popupmenu1.
function popupmenu1_Callback(hObject, eventdata, handles)
% hObject    handle to popupmenu1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hints: contents = get(hObject,'String') returns popupmenu1 contents as cell array
%        contents{get(hObject,'Value')} returns selected item from popupmenu1


% --- Executes on button press in pushbutton4.
function pushbutton4_Callback(hObject, eventdata, handles)
% hObject    handle to pushbutton4 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)


popup_sel_index = get(handles.popupmenu1, 'Value');
switch popup_sel_index
    case 1
        set(handles.popupmenu1, 'Visible', 'off');
        set(handles.pushbutton4, 'Visible', 'off');
        set(handles.text5, 'String', 'Resposta
Temporal','FontWeight','demi','FontSize',10,'Visible','on');
        TipoGraf=1;
        data = getappdata(gcbf, 'metricdata');
        data.TipoGraf = TipoGraf;
        setappdata(gcbf, 'metricdata', data);
        set(handles.popupmenu3, 'Visible', 'on');
        set(handles.pushbutton5, 'Visible', 'on');

    case 2
        set(handles.text5, 'String', 'Contribuiçao do
Harmonico','FontWeight','demi','FontSize',10,'Visible','on');
        TipoGraf=2;
        data = getappdata(gcbf, 'metricdata');
        data.TipoGraf = TipoGraf;
        setappdata(gcbf, 'metricdata', data);
        set(handles.popupmenu1, 'Visible', 'off');
        set(handles.pushbutton4, 'Visible', 'off');
        set(handles.popupmenu3, 'Visible', 'on');
        set(handles.pushbutton5, 'Visible', 'on');
    case 3
        set(handles.text5, 'String', 'Representaçao da
Solicitaçao','FontWeight','demi','FontSize',10,'Visible','on');
        TipoGraf=3;
        data = getappdata(gcbf, 'metricdata');
        data.TipoGraf = TipoGraf;
        setappdata(gcbf, 'metricdata', data);
        set(handles.popupmenu1, 'Visible', 'off');
        set(handles.pushbutton4, 'Visible', 'off');
        wrot=2*data.velocidade;
        run('RespostaImpulsoPeriodicoSenoEImpulso2');
        axes(handles.axes1);
        set(handles.axes1,'Visible','on');
        plot(t,TIP);
```

```
        xlabel('t [seg]');
        set(handles.pushbutton6, 'Visible', 'on');
        set(handles.togglebutton1,'Visible','on');
        set(handles.text7,'String','Representaçao do trem de impulsos');
    case 4
        set(handles.text5, 'String',
'Espectro','FontWeight','demi','FontSize',10,'Visible','on');
        TipoGraf=4;
        data = getappdata(gcbf, 'metricdata');
        data.TipoGraf = TipoGraf;
        setappdata(gcbf, 'metricdata', data);
        set(handles.pushbutton9,'Visible','on');
        set(handles.popupmenu1, 'Visible', 'off');
        set(handles.pushbutton4, 'Visible', 'off');
        set(handles.popupmenu3, 'Visible', 'on');
        set(handles.pushbutton5, 'Visible', 'on');
end


% --- Executes during object creation, after setting all properties.
function popupmenu3_CreateFcn(hObject, eventdata, handles)
% hObject    handle to popupmenu3 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    empty - handles not created until after all CreateFcns called

% Hint: popupmenu controls usually have a white background on Windows.
%       See ISPC and COMPUTER.
run('Dados');
if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end
if nrGL==5
    set(hObject, 'String', {'Grau de Liberdade 1', 'Grau de Liberdade 2','Grau de
Liberdade 3','Grau de Liberdade 4','Grau de Liberdade 5'});
end
if nrGL==6
    set(hObject, 'String', {'Grau de Liberdade 1', 'Grau de Liberdade 2','Grau de
Liberdade 3','Grau de Liberdade 4','Grau de Liberdade 5','Grau de Liberdade 6'});
end



% --- Executes on selection change in popupmenu3.
function popupmenu3_Callback(hObject, eventdata, handles)
% hObject    handle to popupmenu3 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hints: contents = get(hObject,'String') returns popupmenu3 contents as cell array
%        contents{get(hObject,'Value')} returns selected item from popupmenu3


% --- Executes on button press in pushbutton5.
function pushbutton5_Callback(hObject, eventdata, handles)
% hObject    handle to pushbutton5 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
data = getappdata(gcbf, 'metricdata');

wrot=2*data.velocidade;
run('RespostaImpulsoPeriodicoSenoEImpulso2');
popup_sel_index = get(handles.popupmenu3, 'Value');
set(handles.togglebutton4,'Visible','on');
switch popup_sel_index

    case 1
        iGL=1;
        set(handles.pushbutton7,'Visible','on');
```

```
        set(handles.axes1,'Visible','on');
        if data.TipoGraf==1
            axes(handles.axes1);
            plot(t,teta(1,:));
            xlabel('t [seg]');
            set(handles.pushbutton6, 'Visible', 'on');
            set(handles.text7,'String','........');
        end
        if data.TipoGraf==2
            for k=1:ntsf
                axes(handles.axes1);
                plot(t,tetah(1,:,k+1));
                xlabel('t [seg]');
            end
            set(handles.pushbutton6, 'Visible', 'on');
        end

    case 2
        iGL=2;

        if data.TipoGraf==1
            axes(handles.axes1);
            plot(t,teta(2,:));
            xlabel('t [seg]');
            set(handles.pushbutton6, 'Visible', 'on');
        end
        if data.TipoGraf==2
            for k=1:ntsf
                axes(handles.axes1);
                plot(t,tetah(2,:,k+1));
                xlabel('t [seg]');
            end
            set(handles.pushbutton6, 'Visible', 'on');
        end

    case 3
        iGL=3;

        if data.TipoGraf==1
            axes(handles.axes1);
            plot(t,teta(3,:));
            xlabel('t [seg]');
            set(handles.pushbutton6, 'Visible', 'on');
        end
        if data.TipoGraf==2
            for k=1:ntsf
                axes(handles.axes1);
                plot(t,tetah(3,:,k+1));
                xlabel('t [seg]');
            end
            set(handles.pushbutton6, 'Visible', 'on');
        end
        if data.TipoGraf==4
            set(handles.axes1,'Visible','off');
            set(handles.axes6,'Visible','on');
            axes(handles.axes6);
            stem(Swh/2/pi,Spf);   %Representaçao da magnitude do impulso em funçao
da frequencia
            axes(handles.axes8);
            set(handles.axes8,'Visible','on');
            stem(Swh/2/pi,abs(Spr(3,:)))
            xlabel('Freq [Hz]');
            set(handles.pushbutton6, 'Visible', 'on');
        end

    case 4
        iGL=4;

        if data.TipoGraf==1
            axes(handles.axes1);
```

```
            plot(t,teta(4,:));
            xlabel('t [seg]');
            set(handles.pushbutton6, 'Visible', 'on');
        end
        if data.TipoGraf==2
            for k=1:ntsf
                axes(handles.axes1);
                plot(t,tetah(4,:,k+1));
                xlabel('t [seg]');
            end
            set(handles.pushbutton6, 'Visible', 'on');
        end
        if data.TipoGraf==4
            set(handles.axes1,'Visible','off');
            set(handles.axes6,'Visible','on');
            axes(handles.axes6);
            stem(Swh/2/pi,Spf);   %Representaçao da magnitude do impulso em funçao
da frequencia
            axes(handles.axes8);
            set(handles.axes8,'Visible','on');
            stem(Swh/2/pi,abs(Spr(4,:)))
            xlabel('Freq [Hz]');
            set(handles.pushbutton6, 'Visible', 'on');
        end

    case 5
        iGL=5;

        if data.TipoGraf==1
            axes(handles.axes1);
            plot(t,teta(5,:));
            xlabel('t [seg]');
            set(handles.pushbutton6, 'Visible', 'on');
        end
        if data.TipoGraf==2
            for k=1:ntsf
                axes(handles.axes1);
                plot(t,tetah(5,:,k+1));
                xlabel('t [seg]');
            end
            set(handles.pushbutton6, 'Visible', 'on');
        end
        if data.TipoGraf==4
            set(handles.axes1,'Visible','off');
            axes(handles.axes6);
            set(handles.axes6,'Visible','on');
            stem(Swh/2/pi,Spf);   %Representaçao da magnitude do impulso em funçao
da frequencia
            axes(handles.axes8);
            set(handles.axes8,'Visible','on');
            stem(Swh/2/pi,abs(Spr(5,:)))
            xlabel('Freq [Hz]');
            set(handles.pushbutton6, 'Visible', 'on');
        end


    case 6
        iGL=6;

end

if data.TipoGraf==1
    axes(handles.axes1);
    plot(t,teta(iGL,:));
    xlabel('t [seg]');
    set(handles.pushbutton6, 'Visible', 'on');
end

if data.TipoGraf==2
    for k=1:ntsf
```

```
        axes(handles.axes1);
        plot(t,tetah(iGL,:,k+1));
        xlabel('t [seg]');
    end
    set(handles.pushbutton6, 'Visible', 'on');
end
axes(handles.axes6);
cla;
if data.TipoGraf==4
    set(handles.axes1,'Visible','off');
    if iGL==1
        axes(handles.axes6);
        set(handles.axes6,'Visible','on');
        stem(Swh/2/pi,Spf);   %Representaçao da magnitude do impulso em funçao da
frequencia
    end
    axes(handles.axes8);
    if iGL~=1
        set(handles.axes6,'Visible','off');
    end
    set(handles.axes8,'Visible','on');
    stem(Swh/2/pi,abs(Spr(iGL,:)))
    xlabel('Freq [Hz]');
    set(handles.pushbutton6, 'Visible', 'on');
end
if data.TipoGraf==4
    set(handles.togglebutton1,'Visible','off');
    set(handles.togglebutton2,'Visible','on');
    set(handles.togglebutton3,'Visible','on');
else
    set(handles.togglebutton1,'Visible','on');
end


% --- Executes on button press in pushbutton7.
function pushbutton7_Callback(hObject, eventdata, handles)
% hObject    handle to pushbutton7 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)



% --- Executes on button press in pushbutton9.
function pushbutton9_Callback(hObject, eventdata, handles)
% hObject    handle to pushbutton9 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)


% --- Executes on button press in togglebutton1.
function togglebutton1_Callback(hObject, eventdata, handles)
% hObject    handle to togglebutton1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hint: get(hObject,'Value') returns toggle state of togglebutton1

button_state = get(hObject,'Value');
if button_state == get(hObject,'Max')
    set(handles.text7,'Visible','on');  % toggle button is pressed
elseif button_state == get(hObject,'Min')
    set(handles.text7,'Visible','off');  % toggle button is not pressed
end


% --- Executes on button press in togglebutton2.
function togglebutton2_Callback(hObject, eventdata, handles)
% hObject    handle to togglebutton2 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
```

```
% Hint: get(hObject,'Value') returns toggle state of togglebutton2

button_state = get(hObject,'Value');
if button_state == get(hObject,'Max')
    set(handles.text9,'Visible','on');  % toggle button is pressed
    set(handles.axes8,'Visible','off');
elseif button_state == get(hObject,'Min')
    set(handles.text9,'Visible','off');  % toggle button is not pressed
    set(handles.axes8,'Visible','on');
end


% --- Executes on button press in togglebutton3.
function togglebutton3_Callback(hObject, eventdata, handles)
% hObject    handle to togglebutton3 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hint: get(hObject,'Value') returns toggle state of togglebutton3

button_state = get(hObject,'Value');
if button_state == get(hObject,'Max')
    set(handles.text8,'Visible','on');  % toggle button is pressed
    set(handles.axes6,'Visible','off');
elseif button_state == get(hObject,'Min')
    set(handles.text8,'Visible','off');  % toggle button is not pressed
    set(handles.axes6,'Visible','on');
end
```

M_Resposta_Temporal_Cont_Modal.m

```
function varargout = respostatemp(varargin)
% Begin initialization code - DO NOT EDIT
gui_Singleton = 1;
gui_State = struct('gui_Name',       mfilename, ...
                   'gui_Singleton',  gui_Singleton, ...
                   'gui_OpeningFcn', @M_Resposta_Temporal_Cont_Modal_OpeningFcn,
...
                   'gui_OutputFcn',  @M_Resposta_Temporal_Cont_Modal_OutputFcn, ...
                   'gui_LayoutFcn',  [] , ...
                   'gui_Callback',   []);
if nargin & isstr(varargin{1})
    gui_State.gui_Callback = str2func(varargin{1});
end

if nargout
    [varargout{1:nargout}] = gui_mainfcn(gui_State, varargin{:});
else
    gui_mainfcn(gui_State, varargin{:});
end
% End initialization code - DO NOT EDIT

clc;


% --- Executes just before M_Resposta_Temporal_Cont_Modal is made visible.
function M_Resposta_Temporal_Cont_Modal_OpeningFcn(hObject, eventdata, handles,
varargin)
% This function has no output args, see OutputFcn.
% hObject    handle to figure
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
% varargin   command line arguments to M_Resposta_Temporal_Cont_Modal (see
VARARGIN)

% Choose default command line output for M_Resposta_Temporal_Cont_Modal
handles.output = hObject;

% Update handles structure
```

```
guidata(hObject, handles);

% UIWAIT makes M_Resposta_Temporal_Cont_Modal wait for user response (see UIRESUME)
% uiwait(handles.figure1);



% --- Outputs from this function are returned to the command line.
function varargout = M_Resposta_Temporal_Cont_Modal_OutputFcn(hObject, eventdata,
handles)
% varargout  cell array for returning output args (see VARARGOUT);
% hObject    handle to figure
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Get default command line output from handles structure
varargout{1} = handles.output;


scnsize = get(0,'ScreenSize');
pos1  = [scnsize(3)/12,5,scnsize(3)/8.7,scnsize(4)/15];
set(hObject, 'Position',pos1, 'Visible','on');

refresh
set(hObject, 'Units', 'pixels');
handles.banner = imread('fundo.jpg'); % Read the image file banner.jpg
info = imfinfo('fundo.jpg'); % Determine the size of the image file
position = get(hObject, 'Position');
% set(hObject, 'Position', [position(1:2) info.Width+100 info.Height+100]);
axes(handles.background);
image(handles.banner)
set(handles.background, ...
    'Visible', 'off', ...
    'Units', 'pixels',...
    'Position', [0 0 10*info.Width 10*info.Height]);


% --- Executes during object creation, after setting all properties.
function popupmenu1_CreateFcn(hObject, eventdata, handles)
% hObject    handle to popupmenu1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    empty - handles not created until after all CreateFcns called

% Hint: popupmenu controls usually have a white background on Windows.
%       See ISPC and COMPUTER.

run('Dados');
if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end
if nrGL==5
    set(hObject, 'String', {'Grau de Liberdade 1', 'Grau de Liberdade 2', 'Grau de
Liberdade 3', 'Grau de Liberdade 4', 'Grau de Liberdade 5'});
end
if nrGL==6
    set(hObject, 'String', {'Grau de Liberdade 1', 'Grau de Liberdade 2', 'Grau de
Liberdade 3', 'Grau de Liberdade 4', 'Grau de Liberdade 5', 'Grau de Liberdade
6'});
end


% --- Executes on selection change in popupmenu1.
function popupmenu1_Callback(hObject, eventdata, handles)
% hObject    handle to popupmenu1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hints: contents = get(hObject,'String') returns popupmenu1 contents as cell array
```

```
%        contents{get(hObject,'Value')} returns selected item from popupmenu1


% --- Executes on button press in pushbutton1.
function pushbutton1_Callback(hObject, eventdata, handles)
% hObject    handle to pushbutton1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

axes(handles.axes1);
cla;
run('RespostaTemp');
popup_sel_index = get(handles.popupmenu1, 'Value');
switch popup_sel_index
    case 1
        Gliberd=1;
        set(handles.text1,'String','Grau de Liberdade 1','Visible','on');

    case 2
        Gliberd=2;
        set(handles.text1,'String','Grau de Liberdade 2','Visible','on');

    case 3
        Gliberd=3;
        set(handles.text1,'String','Grau de Liberdade 3','Visible','on');

    case 4
        Gliberd=4;
        set(handles.text1,'String','Grau de Liberdade 4','Visible','on');

    case 5
        Gliberd=5;
        set(handles.text1,'String','Grau de Liberdade 5','Visible','on');

    case 6
        Gliberd=6;
        set(handles.text1,'String','Grau de Liberdade 6','Visible','on');
end

data = getappdata(gcbf, 'metricdata');
data.Gliberd = Gliberd;
setappdata(gcbf, 'metricdata', data);
set(handles.popupmenu1, 'Visible', 'off');
set(handles.pushbutton1, 'Visible', 'off');
set(handles.popupmenu2, 'Visible', 'on');
set(handles.pushbutton3, 'Visible', 'on');



% --- Executes during object creation, after setting all properties.
function popupmenu2_CreateFcn(hObject, eventdata, handles)
% hObject    handle to popupmenu2 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    empty - handles not created until after all CreateFcns called

% Hint: popupmenu controls usually have a white background on Windows.
%       See ISPC and COMPUTER.

run('Dados');
if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end
if nrGL==5
    set(hObject, 'String', {'Resposta Total', 'Contribuiçao 2°modo natural',
'Contribuçao 3°modo natural', 'Contribuiçao 4°modo natural', 'Contribuiçao 5°modo
natural'});
end
if nrGL==6
```

```
    set(hObject, 'String', {'Resposta Total', 'Contribuiçao 2°modo natural',
'Contribuçao 3°modo natural', 'Contribuiçao 4°modo natural', 'Contribuiçao 5°modo
natural','Contribuiçao 6°modo natural'});
end



% --- Executes on selection change in popupmenu2.
function popupmenu2_Callback(hObject, eventdata, handles)
% hObject    handle to popupmenu2 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hints: contents = get(hObject,'String') returns popupmenu2 contents as cell array
%        contents{get(hObject,'Value')} returns selected item from popupmenu2


% --- Executes on button press in pushbutton3.
function pushbutton3_Callback(hObject, eventdata, handles)
% hObject    handle to pushbutton3 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
data = getappdata(gcbf, 'metricdata');

set(handles.pushbutton4,'Visible','on');
set(handles.pushbutton5,'Visible','off');
set(handles.pushbutton6,'Visible','off');
set(handles.text2,'Visible','off');
set(handles.text3,'Visible','off');
set(handles.togglebutton1,'Visible','off');
axes(handles.axes1);
cla;
run('Dados');
run('RespostaTemp');
popup_sel_index = get(handles.popupmenu2, 'Value');
switch popup_sel_index
    case 1
        if nrGL==5

plot(t,teta(data.Gliberd,:),t,tetasm(data.Gliberd,:,1),t,tetasm(data.Gliberd,:,2),t
,tetasm(data.Gliberd,:,3),t,tetasm(data.Gliberd,:,4));
            legend('Resposta do Sistema','2°Modo Natural','3°Modo Natural','4°Modo
Natural','5°Modo Natural',-1);
            if data.Gliberd==1
                set(handles.text4,'String','................');
            end
            if data.Gliberd==2
                set(handles.text4,'String','................');
            end
            if data.Gliberd==3
                set(handles.text4,'String','................');
            end
            if data.Gliberd==4
                set(handles.text4,'String','................');
            end
            if data.Gliberd==5
                set(handles.text4,'String','................');
            end

        end
        if nrGL==6

plot(t,teta(data.Gliberd,:),t,tetasm(data.Gliberd,:,1),t,tetasm(data.Gliberd,:,2),t
,tetasm(data.Gliberd,:,3),t,tetasm(data.Gliberd,:,4),t,tetasm(data.Gliberd,:,5));
            legend('Resposta do Sistema','2°Modo Natural','3°Modo Natural','4°Modo
Natural','5°Modo Natural','6°Modo Natural',-1);
            if data.Gliberd==1
                set(handles.text4,'String','................');
            end
            if data.Gliberd==2
```

```
                set(handles.text4,'String','................');
            end
            if data.Gliberd==3
                set(handles.text4,'String','................');
            end
            if data.Gliberd==4
                set(handles.text4,'String','................');
            end
            if data.Gliberd==5
                set(handles.text4,'String','................');
            end
            if data.Gliberd==6
                set(handles.text4,'String','................');
            end

           set(handles.togglebutton1,'Visible','on');

        end


    case 2
        plot(t,teta(data.Gliberd,:),t,tetasm(data.Gliberd,:,1));
        legend('Resposta do Sistema','2°Modo Natural',-1);

    case 3
        plot(t,teta(data.Gliberd,:),t,tetasm(data.Gliberd,:,2));
        legend('Resposta do Sistema','3°Modo Natural',-1);

    case 4
        plot(t,teta(data.Gliberd,:),t,tetasm(data.Gliberd,:,3));
        legend('Resposta do Sistema','4°Modo Natural',-1);

    case 5
        plot(t,teta(data.Gliberd,:),t,tetasm(data.Gliberd,:,4));
        legend('Resposta do Sistema','5°Modo Natural',-1);

    case 6
        plot(t,teta(data.Gliberd,:),t,tetasm(data.Gliberd,:,5));
        legend('Resposta do Sistema','6°Modo Natural',-1);

end

xlabel('t [seg]');
ylabel('\theta(t)');
set(handles.pushbutton5,'Visible','on');
set(handles.pushbutton6,'Visible','on');
set(handles.text2,'Visible','on');
set(handles.text3,'Visible','on');


% --- Executes on button press in pushbutton4.
function pushbutton4_Callback(hObject, eventdata, handles)
% hObject    handle to pushbutton4 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)


% --- Executes on button press in togglebutton1.
function togglebutton1_Callback(hObject, eventdata, handles)
% hObject    handle to togglebutton1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hint: get(hObject,'Value') returns toggle state of togglebutton1

end


button_state = get(hObject,'Value');
if button_state == get(hObject,'Max')
    set(handles.text4,'Visible','on')   % toggle button is pressed
elseif button_state == get(hObject,'Min')
```

```
    set(handles.text4,'Visible','off');  % toggle button is not pressed
end
```

M_Resposta_Temporal_Total.m

```
function varargout = respostatemp(varargin)
% Begin initialization code - DO NOT EDIT
gui_Singleton = 1;
gui_State = struct('gui_Name',       mfilename, ...
    'gui_Singleton',  gui_Singleton, ...
    'gui_OpeningFcn', @M_Resposta_Temporal_Cont_Modal_OpeningFcn, ...
    'gui_OutputFcn',  @M_Resposta_Temporal_Cont_Modal_OutputFcn, ...
    'gui_LayoutFcn',  [] , ...
    'gui_Callback',   []);
if nargin & isstr(varargin{1})
    gui_State.gui_Callback = str2func(varargin{1});
end

if nargout
    [varargout{1:nargout}] = gui_mainfcn(gui_State, varargin{:});
else
    gui_mainfcn(gui_State, varargin{:});
end
% End initialization code - DO NOT EDIT

clc;


% --- Executes just before M_Resposta_Temporal_Cont_Modal is made visible.
function M_Resposta_Temporal_Cont_Modal_OpeningFcn(hObject, eventdata, handles,
varargin)
% This function has no output args, see OutputFcn.
% hObject    handle to figure
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
% varargin   command line arguments to M_Resposta_Temporal_Cont_Modal (see
VARARGIN)

% Choose default command line output for M_Resposta_Temporal_Cont_Modal
handles.output = hObject;

% Update handles structure
guidata(hObject, handles);

% UIWAIT makes M_Resposta_Temporal_Cont_Modal wait for user response (see UIRESUME)
% uiwait(handles.figure1);



% --- Outputs from this function are returned to the command line.
function varargout = M_Resposta_Temporal_Cont_Modal_OutputFcn(hObject, eventdata,
handles)
% varargout  cell array for returning output args (see VARARGOUT);
% hObject    handle to figure
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Get default command line output from handles structure
varargout{1} = handles.output;


scnsize = get(0,'ScreenSize');
pos1  = [scnsize(3)/12,5,scnsize(3)/8.7,scnsize(4)/15];
set(hObject, 'Position',pos1, 'Visible','on');

refresh
set(hObject, 'Units', 'pixels');
handles.banner = imread('fundo.jpg'); % Read the image file banner.jpg
info = imfinfo('fundo.jpg'); % Determine the size of the image file
position = get(hObject, 'Position');
```

```
% set(hObject, 'Position', [position(1:2) info.Width+100 info.Height+100]);
axes(handles.background);
image(handles.banner)
set(handles.background, ...
    'Visible', 'off', ...
    'Units', 'pixels',...
    'Position', [0 0 10*info.Width 10*info.Height]);


% --- Executes during object creation, after setting all properties.
function popupmenu1_CreateFcn(hObject, eventdata, handles)
% hObject    handle to popupmenu1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    empty - handles not created until after all CreateFcns called

% Hint: popupmenu controls usually have a white background on Windows.
%       See ISPC and COMPUTER.
run('Dados');
if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end
if nrGL==5
    set(hObject, 'String', {'Resposta do Sistema','Resposta do 1°GL','Resposta do
2°GL','Resposta do 3°GL','Resposta do 4°GL','Resposta do 5°GL'});
end
if nrGL==6
    set(hObject, 'String', {'Resposta do Sistema','Resposta do 1°GL','Resposta do
2°GL','Resposta do 3°GL','Resposta do 4°GL','Resposta do 5°GL','Resposta do
6°GL'});
end


% --- Executes on selection change in popupmenu1.
function popupmenu1_Callback(hObject, eventdata, handles)
% hObject    handle to popupmenu1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hints: contents = get(hObject,'String') returns popupmenu1 contents as cell array
%        contents{get(hObject,'Value')} returns selected item from popupmenu1


% --- Executes on button press in pushbutton1.
function pushbutton1_Callback(hObject, eventdata, handles)
% hObject    handle to pushbutton1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

run('Dados');
run('RespostaTemp');
axes(handles.axes1);
cla;
popup_sel_index = get(handles.popupmenu1, 'Value');
switch popup_sel_index
    case 1
        if nrGL==5
            plot(t,teta(1,:),t,teta(2,:),t,teta(3,:),t,teta(4,:),t,teta(5,:));
            legend('Resposta GL 1','Resposta GL 2','Resposta GL 3','Resposta GL
4','Resposta GL 5',-1);
            set(handles.text3,'String','.............');
        end
        if nrGL==6

plot(t,teta(1,:),t,teta(2,:),t,teta(3,:),t,teta(4,:),t,teta(5,:),t,teta(6,:));
            legend('Resposta GL 1','Resposta GL 2','Resposta GL 3','Resposta GL
4','Resposta GL 5','Resposta GL 6',-1);
            set(handles.text3,'String','.............');
```

```
        end
        axis([0 max(t) 1.2*ymintotal 1.2*ymaxtotal]);

    case 2
        plot(t,teta(1,:));
        axis([0 max(t) 1.2*ymin(1) 1.2*ymax(1)]);
        set(handles.text3,'String','..............');

    case 3
        plot(t,teta(2,:));
        axis([0 max(t) 1.2*ymin(2) 1.2*ymax(2)]);
        set(handles.text3,'String','..............');


    case 4
        plot(t,teta(3,:));
        axis([0 max(t) 1.2*ymin(3) 1.2*ymax(3)]);
        set(handles.text3,'String','..............');

    case 5
        plot(t,teta(4,:));
        axis([0 max(t) 1.2*ymin(4) 1.2*ymax(4)]);
        set(handles.text3,'String','..............');


    case 6
        plot(t,teta(5,:));
        axis([0 max(t) 1.2*ymin(5) 1.2*ymax(5)]);
        set(handles.text3,'String','..............');

    case 7
        plot(t,teta(6,:));
        axis([0 max(t) 1.2*ymin(6) 1.2*ymax(6)]);
        set(handles.text3,'String','..............');

end

xlabel('t [seg]');
ylabel('\theta (t)');
set(handles.pushbutton3, 'Visible','on');
set(handles.togglebutton1, 'Visible','on');
set(handles.pushbutton4, 'Visible','on');
set(handles.text1, 'Visible','on');
set(handles.text2, 'Visible','on');

% --- Executes on button press in pushbutton3.
function pushbutton3_Callback(hObject, eventdata, handles)
% hObject    handle to pushbutton3 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)


% --- Executes on button press in pushbutton4.
function pushbutton4_Callback(hObject, eventdata, handles)
% hObject    handle to pushbutton4 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)


% --- Executes on button press in togglebutton1.
function togglebutton1_Callback(hObject, eventdata, handles)
% hObject    handle to togglebutton1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hint: get(hObject,'Value') returns toggle state of togglebutton1


button_state = get(hObject,'Value');
if button_state == get(hObject,'Max')
```

```
    set(handles.text3,'Visible','on')   % toggle button is pressed
elseif button_state == get(hObject,'Min')
    set(handles.text3,'Visible','off');  % toggle button is not pressed
end
```

M_Resposta_Transiente.m

```
function varargout = respostatemp(varargin)
% Begin initialization code - DO NOT EDIT
gui_Singleton = 1;
gui_State = struct('gui_Name',       mfilename, ...
                   'gui_Singleton',  gui_Singleton, ...
                   'gui_OpeningFcn', @M_Resposta_Transiente_OpeningFcn, ...
                   'gui_OutputFcn',  @M_Resposta_Transiente_OutputFcn, ...
                   'gui_LayoutFcn',  [] , ...
                   'gui_Callback',   []);
if nargin & isstr(varargin{1})
    gui_State.gui_Callback = str2func(varargin{1});
end

if nargout
    [varargout{1:nargout}] = gui_mainfcn(gui_State, varargin{:});
else
    gui_mainfcn(gui_State, varargin{:});
end
% End initialization code - DO NOT EDIT
clc;
% --- Executes just before M_Resposta_Transiente is made visible.
function M_Resposta_Transiente_OpeningFcn(hObject, eventdata, handles, varargin)
% This function has no output args, see OutputFcn.
% hObject    handle to figure
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
% varargin   command line arguments to M_Resposta_Transiente (see VARARGIN)

% Choose default command line output for M_Resposta_Transiente
handles.output = hObject;

% Update handles structure
guidata(hObject, handles);

% UIWAIT makes M_Resposta_Transiente wait for user response (see UIRESUME)
% uiwait(handles.figure1);



% --- Outputs from this function are returned to the command line.
function varargout = M_Resposta_Transiente_OutputFcn(hObject, eventdata, handles)
% varargout  cell array for returning output args (see VARARGOUT);
% hObject    handle to figure
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Get default command line output from handles structure
varargout{1} = handles.output;

scnsize = get(0,'ScreenSize');
pos1  = [scnsize(3)/12,5,scnsize(3)/8.7,scnsize(4)/15];
set(hObject, 'Position',pos1, 'Visible','on');


refresh
set(hObject, 'Units', 'pixels');
handles.banner = imread('fundo.jpg'); % Read the image file banner.jpg
info = imfinfo('fundo.jpg'); % Determine the size of the image file
position = get(hObject, 'Position');
% set(hObject, 'Position', [position(1:2) info.Width+100 info.Height+100]);
axes(handles.background);
image(handles.banner)
set(handles.background, ...
```

```
    'Visible', 'off', ...
    'Units', 'pixels',...
    'Position', [0 0 10*info.Width 10*info.Height]);


% --- Executes during object creation, after setting all properties.
function popupmenu1_CreateFcn(hObject, eventdata, handles)
% hObject    handle to popupmenu1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    empty - handles not created until after all CreateFcns called

% Hint: popupmenu controls usually have a white background on Windows.
%       See ISPC and COMPUTER.
run('Dados');
if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end
if nrGL==5
    set(hObject, 'String', {'Grau de Liberdade 2', 'Grau de Liberdade 3', 'Grau de
Liberdade 4', 'Grau de Liberdade 5'});
end
if nrGL==6
    set(hObject, 'String', {'Grau de Liberdade 2', 'Grau de Liberdade 3', 'Grau de
Liberdade 4', 'Grau de Liberdade 5','Grau de Liberdade 6'});
end



% --- Executes on selection change in popupmenu1.
function popupmenu1_Callback(hObject, eventdata, handles)
% hObject    handle to popupmenu1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hints: contents = get(hObject,'String') returns popupmenu1 contents as cell array
%        contents{get(hObject,'Value')} returns selected item from popupmenu1



% --- Executes on button press in pushbutton1.
function pushbutton1_Callback(hObject, eventdata, handles)
% hObject    handle to pushbutton1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

axes(handles.axes1);
clc;
cla;
run('RespostaTransiente');
popup_sel_index = get(handles.popupmenu1, 'Value');
switch popup_sel_index
    case 1
        plot(t,teta(1,:));grid on; hold on;
        set(handles.text1,'String','.......................');
    case 2
        plot(t,teta(2,:));grid on; hold on;
        set(handles.text1,'String','.......................');
    case 3
        plot(t,teta(3,:));grid on; hold on;
        set(handles.text1,'String','.......................');
    case 4
        plot(t,teta(4,:));grid on; hold on;
        set(handles.text1,'String','.......................');
    case 5
        plot(t,teta(5,:));grid on; hold on;
        set(handles.text1,'String','.......................');
end
xlabel('t [seg]');
ylabel('\theta (t)');
title('Resposta no Tempo a um transiente');
```

```
set(handles.pushbutton3,'Visible','on');
set(handles.togglebutton1,'Visible','on');



% --- Executes on button press in togglebutton1.
function togglebutton1_Callback(hObject, eventdata, handles)
% hObject    handle to togglebutton1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hint: get(hObject,'Value') returns toggle state of togglebutton1

button_state = get(hObject,'Value');
if button_state == get(hObject,'Max')
    set(handles.text1,'Visible','on')   % toggle button is pressed
elseif button_state == get(hObject,'Min')
    set(handles.text1,'Visible','off');  % toggle button is not pressed
end
```

M_Velocidades_Criticas.m

```
function varargout = M_Velocidades_Criticas(varargin)
% M_VELOCIDADES_CRITICAS M-file for M_Velocidades_Criticas.fig
%      M_VELOCIDADES_CRITICAS, by itself, creates a new M_VELOCIDADES_CRITICAS or
raises the existing
%      singleton*.
%
%      H = M_VELOCIDADES_CRITICAS returns the handle to a new
M_VELOCIDADES_CRITICAS or the handle to
%      the existing singleton*.
%
%      M_VELOCIDADES_CRITICAS('CALLBACK',hObject,eventData,handles,...) calls the
local
%      function named CALLBACK in M_VELOCIDADES_CRITICAS.M with the given input
arguments.
%
%      M_VELOCIDADES_CRITICAS('Property','Value',...) creates a new
M_VELOCIDADES_CRITICAS or raises the
%      existing singleton*.  Starting from the left, property value pairs are
%      applied to the GUI before M_Velocidades_Criticas_OpeningFunction gets
called.  An
%      unrecognized property name or invalid value makes property application
%      stop.  All inputs are passed to M_Velocidades_Criticas_OpeningFcn via
varargin.
%
%      *See GUI Options on GUIDE's Tools menu.  Choose "GUI allows only one
%      instance to run (singleton)".
%
% See also: GUIDE, GUIDATA, GUIHANDLES

% Edit the above text to modify the response to help M_Velocidades_Criticas

% Last Modified by GUIDE v2.5 07-May-2004 12:16:45

% Begin initialization code - DO NOT EDIT
gui_Singleton = 1;
gui_State = struct('gui_Name',       mfilename, ...
                   'gui_Singleton',  gui_Singleton, ...
                   'gui_OpeningFcn', @M_Velocidades_Criticas_OpeningFcn, ...
                   'gui_OutputFcn',  @M_Velocidades_Criticas_OutputFcn, ...
                   'gui_LayoutFcn',  [] , ...
                   'gui_Callback',   []);
if nargin & isstr(varargin{1})
    gui_State.gui_Callback = str2func(varargin{1});
end

if nargout
    [varargout{1:nargout}] = gui_mainfcn(gui_State, varargin{:});
else
```

```
    gui_mainfcn(gui_State, varargin{:});
end
% End initialization code - DO NOT EDIT


% --- Executes just before M_Velocidades_Criticas is made visible.
function M_Velocidades_Criticas_OpeningFcn(hObject, eventdata, handles, varargin)
% This function has no output args, see OutputFcn.
% hObject    handle to figure
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
% varargin   command line arguments to M_Velocidades_Criticas (see VARARGIN)

% Choose default command line output for M_Velocidades_Criticas
handles.output = hObject;

% Update handles structure
guidata(hObject, handles);

% UIWAIT makes M_Velocidades_Criticas wait for user response (see UIRESUME)
% uiwait(handles.figure1);


% --- Outputs from this function are returned to the command line.
function varargout = M_Velocidades_Criticas_OutputFcn(hObject, eventdata, handles)
% varargout  cell array for returning output args (see VARARGOUT);
% hObject    handle to figure
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Get default command line output from handles structure
varargout{1} = handles.output;


scnsize = get(0,'ScreenSize');
pos1  = [scnsize(3)/12,6,scnsize(3)/9,scnsize(4)/20];
set(hObject, 'Position',pos1, 'Visible','on');

set(hObject, 'Units', 'pixels');
handles.banner = imread('fundo.jpg'); % Read the image file banner.jpg
info = imfinfo('fundo.jpg'); % Determine the size of the image file
position = get(hObject, 'Position');
% set(hObject, 'Position', [position(1:2) info.Width+100 info.Height+100]);
axes(handles.background);
image(handles.banner)
set(handles.background, ...
    'Visible', 'off', ...
    'Units', 'pixels',...
    'Position', [0 0 10*info.Width 10*info.Height]);

axes(handles.axes1);
run('Dados');
wnrpm=wn*60/(2*pi);
linew1=line([0 16000],[wnrpm(2) wnrpm(2)],'Color','b');
linew2=line([0 16000],[wnrpm(3) wnrpm(3)],'Color','m');
linew3=line([0 16000],[wnrpm(4) wnrpm(4)],'Color','g');
linew4=line([0 16000],[wnrpm(5) wnrpm(5)],'Color','k');
% if nrGL==6
%     linew5=line([0 16000],[wnrpm(6) wnrpm(6)],'Color','c');
% end
linew=line([0 16000],[0 16000]);
set(linew,'color','r','linewidth',2);
xlabel('\Omega arvore [rpm] ');
ylabel('\omega_n [rpm]');
title('Velocidades Criticas');
legend('2ª vel critica','3ª vel critica','4ª vel critica','5ª vel critica','Vel da
Arvore',-1);
% if nrGL==5
%     legend('2ª vel critica','3ª vel critica','4ª vel critica','5ª vel
critica','Vel da Arvore',-1);
```

```
% end
% if nrGL==6
%     legend('2ª vel critica','3ª vel critica','4ª vel critica','5ª vel
critica','6ª vel critica','Vel da Arvore',-1);
% end
% --- Executes on button press in togglebutton1.
function togglebutton1_Callback(hObject, eventdata, handles)
% hObject    handle to togglebutton1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hint: get(hObject,'Value') returns toggle state of togglebutton1
button_state = get(hObject,'Value');
if button_state == get(hObject,'Max')
    set(handles.text1,'String','   ','Visible','on');
elseif button_state == get(hObject,'Min')
    set(handles.text1,'Visible','off');  % toggle button is not pressed
end
```

Menu_Calculos_Freq_Naturais.m

```
function varargout = Menu_Calculos_Freq_Naturais(varargin)
% MENU_CALCULOS_FREQ_NATURAIS M-file for Menu_Calculos_Freq_Naturais.fig
%      MENU_CALCULOS_FREQ_NATURAIS, by itself, creates a new
MENU_CALCULOS_FREQ_NATURAIS or raises the existing
%      singleton*.
%
%      H = MENU_CALCULOS_FREQ_NATURAIS returns the handle to a new
MENU_CALCULOS_FREQ_NATURAIS or the handle to
%      the existing singleton*.
%
%      MENU_CALCULOS_FREQ_NATURAIS('CALLBACK',hObject,eventData,handles,...) calls
the local
%      function named CALLBACK in MENU_CALCULOS_FREQ_NATURAIS.M with the given
input arguments.
%
%      MENU_CALCULOS_FREQ_NATURAIS('Property','Value',...) creates a new
MENU_CALCULOS_FREQ_NATURAIS or raises the
%      existing singleton*.  Starting from the left, property value pairs are
%      applied to the GUI before Menu_Calculos_Freq_Naturais_OpeningFunction gets
called.  An
%      unrecognized property name or invalid value makes property application
%      stop.  All inputs are passed to Menu_Calculos_Freq_Naturais_OpeningFcn via
varargin.
%
%      *See GUI Options on GUIDE's Tools menu.  Choose "GUI allows only one
%      instance to run (singleton)".
%
% See also: GUIDE, GUIDATA, GUIHANDLES

% Edit the above text to modify the response to help Menu_Calculos_Freq_Naturais

% Last Modified by GUIDE v2.5 12-May-2004 16:28:40

% Begin initialization code - DO NOT EDIT
gui_Singleton = 1;
gui_State = struct('gui_Name',       mfilename, ...
                   'gui_Singleton',  gui_Singleton, ...
                   'gui_OpeningFcn', @Menu_Calculos_Freq_Naturais_OpeningFcn, ...
                   'gui_OutputFcn',  @Menu_Calculos_Freq_Naturais_OutputFcn, ...
                   'gui_LayoutFcn',  [] , ...
                   'gui_Callback',   []);
if nargin & isstr(varargin{1})
    gui_State.gui_Callback = str2func(varargin{1});
end

if nargout
    [varargout{1:nargout}] = gui_mainfcn(gui_State, varargin{:});
else
    gui_mainfcn(gui_State, varargin{:});
```

```
end
% End initialization code - DO NOT EDIT


% --- Executes just before Menu_Calculos_Freq_Naturais is made visible.
function Menu_Calculos_Freq_Naturais_OpeningFcn(hObject, eventdata, handles,
varargin)
% This function has no output args, see OutputFcn.
% hObject    handle to figure
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
% varargin   command line arguments to Menu_Calculos_Freq_Naturais (see VARARGIN)

% Choose default command line output for Menu_Calculos_Freq_Naturais
handles.output = hObject;

% Update handles structure
guidata(hObject, handles);

% UIWAIT makes Menu_Calculos_Freq_Naturais wait for user response (see UIRESUME)
% uiwait(handles.figure1);


% --- Outputs from this function are returned to the command line.
function varargout = Menu_Calculos_Freq_Naturais_OutputFcn(hObject, eventdata,
handles)
% varargout  cell array for returning output args (see VARARGOUT);
% hObject    handle to figure
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)


% Get default command line output from handles structure
varargout{1} = handles.output;


scnsize = get(0,'ScreenSize');
pos1  = [scnsize(3)/12,5,scnsize(3)/9,scnsize(4)/15];
set(hObject, 'Position',pos1, 'Visible','on');


handles.banner = imread('fundo.jpg'); % Read the image file banner.jpg
info = imfinfo('fundo.jpg'); % Determine the size of the image file
position = get(hObject, 'Position');
axes(handles.background);
image(handles.banner);
set(handles.background, ...
    'Visible', 'off', ...
    'Units', 'pixels',...
    'Position', [0 0 10*info.Width 10*info.Height]);

set(hObject, 'Units', 'pixels');
handles.banner = imread('logo_demegi.jpg'); % Read the image file banner.jpg
info = imfinfo('logo_demegi.jpg'); % Determine the size of the image file
position = get(hObject, 'Position');
axes(handles.axes3);
image(handles.banner);
set(handles.axes3, ...
    'Visible', 'off', ...
    'Units', 'pixels');


% --- Executes during object creation, after setting all properties.
function popupmenu1_CreateFcn(hObject, eventdata, handles)
% hObject    handle to popupmenu1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    empty - handles not created until after all CreateFcns called

% Hint: popupmenu controls usually have a white background on Windows.
%       See ISPC and COMPUTER.
```

```
run('Dados');

if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end

if nrGL==5
    set(hObject, 'String', {'Frequencia Fundamental', '2ª Frequencia Natural', '3ª
Frequencia Natural', '4ª Frequencia Natural', '5ª Frequencia Natural'});
end
if nrGL==6
    set(hObject, 'String', {'Frequencia Fundamental', '2ª Frequencia Natural', '3ª
Frequencia Natural', '4ª Frequencia Natural', '5ª Frequencia Natural','6ª
Frequencia Natural'});
end


% --- Executes on selection change in popupmenu1.
function popupmenu1_Callback(hObject, eventdata, handles)
% hObject    handle to popupmenu1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hints: contents = get(hObject,'String') returns popupmenu1 contents as cell array
%        contents{get(hObject,'Value')} returns selected item from popupmenu1


% --- Executes on button press in pushbutton1.
function pushbutton1_Callback(hObject, eventdata, handles)
% hObject    handle to pushbutton1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

clc;cla;
run('Dados');
popup_sel_index = get(handles.popupmenu1, 'Value');
switch popup_sel_index
    case 1
        iGL=1;
    case 2
        iGL=2;
    case 3
        iGL=3;
    case 4
        iGL=4;
    case 5
        iGL=5;
    case 6
        iGL=6;
end
set(handles.text2, 'Visible', 'on','String', wn(iGL));
set(handles.text4, 'Visible', 'on','String', u(:,iGL));
set(handles.text6, 'Visible', 'on','String', wn(iGL)/2/pi);
set(handles.text8, 'Visible', 'on','String', (wn(iGL)/2/pi)*60);
set(handles.text1, 'Visible', 'on');
set(handles.text3, 'Visible', 'on');
set(handles.text5, 'Visible', 'on');
set(handles.text7, 'Visible', 'on');
set(handles.text9, 'Visible', 'on');
set(handles.text10,'String','Frequencia de oscilaçao do movimento natural de
resposta a uma perturbaçao inicial');
set(handles.text11,'String','Vector modal (soluçao do sistema homogeneo associado a
cada uma das frequencias naturais)');
set(handles.togglebutton1, 'Visible', 'on');
set(handles.togglebutton2, 'Visible', 'on');
x=1:1:GL;
eixo=zeros(GL,GL);
```

```
eixo(:,iGL)=0;
valormax=abs(max(fi(:,iGL)));
valormin=min(fi(:,iGL));
axes(handles.axes5);
plot(x,fi(:,iGL),x,eixo(:,iGL),'k','LineWidth',1.5);hold on;grid off;
title('Forma Natural de Vibraçao');
xlabel('Degree of Freedom');
set(gca,'xtick',1:1:GL);

% --- Executes on button press in togglebutton1.
function togglebutton1_Callback(hObject, eventdata, handles)
% hObject    handle to togglebutton1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hint: get(hObject,'Value') returns toggle state of togglebutton1

button_state = get(hObject,'Value');
if button_state == get(hObject,'Max')
    set(handles.text10,'Visible','on');   % toggle button is pressed
elseif button_state == get(hObject,'Min')
    set(handles.text10,'Visible','off');  % toggle button is not pressed
end

% --- Executes on button press in togglebutton2.
function togglebutton2_Callback(hObject, eventdata, handles)
% hObject    handle to togglebutton2 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hint: get(hObject,'Value') returns toggle state of togglebutton2

button_state = get(hObject,'Value');
if button_state == get(hObject,'Max')
    set(handles.text11,'Visible','on');  % toggle button is pressed
elseif button_state == get(hObject,'Min')
    set(handles.text11,'Visible','off');  % toggle button is not pressed
end
```

Menu_Calculos_matriz_Massa.m

```
function varargout = Menu_Calculos_Matriz_Massa(varargin)
% MENU_CALCULOS_MATRIZ_MASSA M-file for Menu_Calculos_Matriz_Massa.fig
%      MENU_CALCULOS_MATRIZ_MASSA, by itself, creates a new
MENU_CALCULOS_MATRIZ_MASSA or raises the existing
%      singleton*.
%
%      H = MENU_CALCULOS_MATRIZ_MASSA returns the handle to a new
MENU_CALCULOS_MATRIZ_MASSA or the handle to
%      the existing singleton*.
%
%      MENU_CALCULOS_MATRIZ_MASSA('CALLBACK',hObject,eventData,handles,...) calls
the local
%      function named CALLBACK in MENU_CALCULOS_MATRIZ_MASSA.M with the given input
arguments.
%
%      MENU_CALCULOS_MATRIZ_MASSA('Property','Value',...) creates a new
MENU_CALCULOS_MATRIZ_MASSA or raises the
%      existing singleton*.  Starting from the left, property value pairs are
%      applied to the GUI before Menu_Calculos_Matriz_Massa_OpeningFunction gets
called.  An
%      unrecognized property name or invalid value makes property application
%      stop.  All inputs are passed to Menu_Calculos_Matriz_Massa_OpeningFcn via
varargin.
%
%      *See GUI Options on GUIDE's Tools menu.  Choose "GUI allows only one
%      instance to run (singleton)".
%
% See also: GUIDE, GUIDATA, GUIHANDLES
```

```
% Edit the above text to modify the response to help Menu_Calculos_Matriz_Massa

% Last Modified by GUIDE v2.5 12-May-2004 18:44:49

% Begin initialization code - DO NOT EDIT
gui_Singleton = 1;
gui_State = struct('gui_Name',       mfilename, ...
                   'gui_Singleton',  gui_Singleton, ...
                   'gui_OpeningFcn', @Menu_Calculos_Matriz_Massa_OpeningFcn, ...
                   'gui_OutputFcn',  @Menu_Calculos_Matriz_Massa_OutputFcn, ...
                   'gui_LayoutFcn',  [] , ...
                   'gui_Callback',   []);
if nargin & isstr(varargin{1})
    gui_State.gui_Callback = str2func(varargin{1});
end

if nargout
    [varargout{1:nargout}] = gui_mainfcn(gui_State, varargin{:});
else
    gui_mainfcn(gui_State, varargin{:});
end
% End initialization code - DO NOT EDIT


% --- Executes just before Menu_Calculos_Matriz_Massa is made visible.
function Menu_Calculos_Matriz_Massa_OpeningFcn(hObject, eventdata, handles,
varargin)
% This function has no output args, see OutputFcn.
% hObject    handle to figure
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
% varargin   command line arguments to Menu_Calculos_Matriz_Massa (see VARARGIN)

% Choose default command line output for Menu_Calculos_Matriz_Massa
handles.output = hObject;

% Update handles structure
guidata(hObject, handles);

% UIWAIT makes Menu_Calculos_Matriz_Massa wait for user response (see UIRESUME)
% uiwait(handles.figure1);


% --- Outputs from this function are returned to the command line.
function varargout = Menu_Calculos_Matriz_Massa_OutputFcn(hObject, eventdata,
handles)
% varargout  cell array for returning output args (see VARARGOUT);
% hObject    handle to figure
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Get default command line output from handles structure
varargout{1} = handles.output;


scnsize = get(0,'ScreenSize');
pos1  = [scnsize(3)/12.4,scnsize(4)/25,scnsize(3)/8.5,scnsize(4)/30];

set(hObject, 'Position',pos1, 'Visible','on');

refresh
set(hObject, 'Units', 'pixels');
handles.banner = imread('fundo.jpg'); % Read the image file banner.jpg
info = imfinfo('fundo.jpg'); % Determine the size of the image file
position = get(hObject, 'Position');
axes(handles.background);
image(handles.banner)
set(handles.background, ...
    'Visible', 'off', ...
    'Units', 'pixels',...
```

```
    'Position', [0 0 10*info.Width 10*info.Height]);

set(handles.text10,'String','Matriz que agrupa a inercia existente em cada um dos
graus de liberdade');



% --- Executes on button press in pushbutton1.
function pushbutton1_Callback(hObject, eventdata, handles)
% hObject    handle to pushbutton1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

run('Dados');
set(handles.text2, 'Visible', 'on','String', MM(:,1));
set(handles.text3, 'Visible', 'on','String', MM(:,2));
set(handles.text4, 'Visible', 'on','String', MM(:,3));
set(handles.text5, 'Visible', 'on','String', MM(:,4));
set(handles.text6, 'Visible', 'on','String', MM(:,5));
if nrGL==5
    set(handles.frame1, 'Visible', 'on');
end
if nrGL==6
    set(handles.text9, 'Visible', 'on','String', MM(:,6));
    set(handles.frame2, 'Visible', 'on');
end
set(handles.text7, 'Visible', 'on');
set(handles.text8, 'Visible', 'on');




% --- Executes on button press in pushbutton2.
function pushbutton2_Callback(hObject, eventdata, handles)
% hObject    handle to pushbutton2 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)


% --- Executes on button press in togglebutton1.
function togglebutton1_Callback(hObject, eventdata, handles)
% hObject    handle to togglebutton1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hint: get(hObject,'Value') returns toggle state of togglebutton1

button_state = get(hObject,'Value');
if button_state == get(hObject,'Max')
    set(handles.text10,'Visible','on')   % toggle button is pressed
elseif button_state == get(hObject,'Min')
    set(handles.text10,'Visible','off');  % toggle button is not pressed
end
```

Menu_Calculos_Matriz_Modal.m

```
function varargout = Menu_Calculos_Matriz_Modal(varargin)
% MENU_CALCULOS_MATRIZ_MODAL M-file for Menu_Calculos_Matriz_Modal.fig
%      MENU_CALCULOS_MATRIZ_MODAL, by itself, creates a new
MENU_CALCULOS_MATRIZ_MODAL or raises the existing
%      singleton*.
%
%      H = MENU_CALCULOS_MATRIZ_MODAL returns the handle to a new
MENU_CALCULOS_MATRIZ_MODAL or the handle to
%      the existing singleton*.
%
%      MENU_CALCULOS_MATRIZ_MODAL('CALLBACK',hObject,eventData,handles,...) calls
the local
%      function named CALLBACK in MENU_CALCULOS_MATRIZ_MODAL.M with the given input
arguments.
```

```
%
%      MENU_CALCULOS_MATRIZ_MODAL('Property','Value',...) creates a new
MENU_CALCULOS_MATRIZ_MODAL or raises the
%      existing singleton*.  Starting from the left, property value pairs are
%      applied to the GUI before Menu_Calculos_Matriz_Modal_OpeningFunction gets
called.  An
%      unrecognized property name or invalid value makes property application
%      stop.  All inputs are passed to Menu_Calculos_Matriz_Modal_OpeningFcn via
varargin.
%
%      *See GUI Options on GUIDE's Tools menu.  Choose "GUI allows only one
%      instance to run (singleton)".
%
% See also: GUIDE, GUIDATA, GUIHANDLES

% Edit the above text to modify the response to help Menu_Calculos_Matriz_Modal

% Last Modified by GUIDE v2.5 12-May-2004 16:52:28

% Begin initialization code - DO NOT EDIT
gui_Singleton = 1;
gui_State = struct('gui_Name',       mfilename, ...
                   'gui_Singleton',  gui_Singleton, ...
                   'gui_OpeningFcn', @Menu_Calculos_Matriz_Modal_OpeningFcn, ...
                   'gui_OutputFcn',  @Menu_Calculos_Matriz_Modal_OutputFcn, ...
                   'gui_LayoutFcn',  [] , ...
                   'gui_Callback',   []);
if nargin & isstr(varargin{1})
    gui_State.gui_Callback = str2func(varargin{1});
end

if nargout
    [varargout{1:nargout}] = gui_mainfcn(gui_State, varargin{:});
else
    gui_mainfcn(gui_State, varargin{:});
end
% End initialization code - DO NOT EDIT


% --- Executes just before Menu_Calculos_Matriz_Modal is made visible.
function Menu_Calculos_Matriz_Modal_OpeningFcn(hObject, eventdata, handles,
varargin)
% This function has no output args, see OutputFcn.
% hObject    handle to figure
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
% varargin   command line arguments to Menu_Calculos_Matriz_Modal (see VARARGIN)

% Choose default command line output for Menu_Calculos_Matriz_Modal
handles.output = hObject;

% Update handles structure
guidata(hObject, handles);

% UIWAIT makes Menu_Calculos_Matriz_Modal wait for user response (see UIRESUME)
% uiwait(handles.figure1);


% --- Outputs from this function are returned to the command line.
function varargout = Menu_Calculos_Matriz_Modal_OutputFcn(hObject, eventdata,
handles)
% varargout  cell array for returning output args (see VARARGOUT);
% hObject    handle to figure
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Get default command line output from handles structure
varargout{1} = handles.output;
```

```
scnsize = get(0,'ScreenSize');
pos1  = [scnsize(3)/12.4,scnsize(4)/25,scnsize(3)/8.5,scnsize(4)/30];

set(hObject, 'Position',pos1, 'Visible','on');

refresh
set(hObject, 'Units', 'pixels');
handles.banner = imread('fundo.jpg'); % Read the image file banner.jpg
info = imfinfo('fundo.jpg'); % Determine the size of the image file
position = get(hObject, 'Position');
axes(handles.background);
image(handles.banner)
set(handles.background, ...
    'Visible', 'off', ...
    'Units', 'pixels',...
    'Position', [0 0 10*info.Width 10*info.Height]);
set(handles.text8,'String','Matriz que agrupa os vectores modais ocupando cada um
desses vectores uma coluna da matriz');

% --- Executes on button press in pushbutton1.
function pushbutton1_Callback(hObject, eventdata, handles)
% hObject    handle to pushbutton1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

run('Dados');
set(handles.text2, 'Visible', 'on','String', fi(:,1));
set(handles.text3, 'Visible', 'on','String', fi(:,2));
set(handles.text4, 'Visible', 'on','String', fi(:,3));
set(handles.text5, 'Visible', 'on','String', fi(:,4));
set(handles.text6, 'Visible', 'on','String', fi(:,5));
if nrGL==5
    set(handles.frame2, 'Visible', 'on');
end
if nrGL==6
    set(handles.text7, 'Visible', 'on','String', fi(:,6));
    set(handles.frame3, 'Visible', 'on');
end

% --- Executes on button press in togglebutton1.
function togglebutton1_Callback(hObject, eventdata, handles)
% hObject    handle to togglebutton1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
% Hint: get(hObject,'Value') returns toggle state of togglebutton1

button_state = get(hObject,'Value');
if button_state == get(hObject,'Max')
    set(handles.text8,'Visible','on')   % toggle button is pressed
elseif button_state == get(hObject,'Min')
    set(handles.text8,'Visible','off');  % toggle button is not pressed
end
```

Menu_Calculos_Matriz_Rigidez.m

```
function varargout = Menu_Calculos_Matriz_Rigidez(varargin)
% MENU_CALCULOS_MATRIZ_RIGIDEZ M-file for Menu_Calculos_Matriz_Rigidez.fig
%      MENU_CALCULOS_MATRIZ_RIGIDEZ, by itself, creates a new
MENU_CALCULOS_MATRIZ_RIGIDEZ or raises the existing
%      singleton*.
%
%      H = MENU_CALCULOS_MATRIZ_RIGIDEZ returns the handle to a new
MENU_CALCULOS_MATRIZ_RIGIDEZ or the handle to
%      the existing singleton*.
%
%      MENU_CALCULOS_MATRIZ_RIGIDEZ('CALLBACK',hObject,eventData,handles,...) calls
the local
%      function named CALLBACK in MENU_CALCULOS_MATRIZ_RIGIDEZ.M with the given
input arguments.
%
```

```
%      MENU_CALCULOS_MATRIZ_RIGIDEZ('Property','Value',...) creates a new
MENU_CALCULOS_MATRIZ_RIGIDEZ or raises the
%      existing singleton*.  Starting from the left, property value pairs are
%      applied to the GUI before Menu_Calculos_Matriz_Rigidez_OpeningFunction gets
called.  An
%      unrecognized property name or invalid value makes property application
%      stop.  All inputs are passed to Menu_Calculos_Matriz_Rigidez_OpeningFcn via
varargin.
%
%      *See GUI Options on GUIDE's Tools menu.  Choose "GUI allows only one
%      instance to run (singleton)".
%
% See also: GUIDE, GUIDATA, GUIHANDLES

% Edit the above text to modify the response to help Menu_Calculos_Matriz_Rigidez

% Last Modified by GUIDE v2.5 13-May-2004 12:16:04

% Begin initialization code - DO NOT EDIT
gui_Singleton = 1;
gui_State = struct('gui_Name',       mfilename, ...
                   'gui_Singleton',  gui_Singleton, ...
                   'gui_OpeningFcn', @Menu_Calculos_Matriz_Rigidez_OpeningFcn, ...
                   'gui_OutputFcn',  @Menu_Calculos_Matriz_Rigidez_OutputFcn, ...
                   'gui_LayoutFcn',  [] , ...
                   'gui_Callback',   []);
if nargin & isstr(varargin{1})
    gui_State.gui_Callback = str2func(varargin{1});
end

if nargout
    [varargout{1:nargout}] = gui_mainfcn(gui_State, varargin{:});
else
    gui_mainfcn(gui_State, varargin{:});
end
% End initialization code - DO NOT EDIT


% --- Executes just before Menu_Calculos_Matriz_Rigidez is made visible.
function Menu_Calculos_Matriz_Rigidez_OpeningFcn(hObject, eventdata, handles,
varargin)
% This function has no output args, see OutputFcn.
% hObject    handle to figure
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
% varargin   command line arguments to Menu_Calculos_Matriz_Rigidez (see VARARGIN)

% Choose default command line output for Menu_Calculos_Matriz_Rigidez
handles.output = hObject;

% Update handles structure
guidata(hObject, handles);

% UIWAIT makes Menu_Calculos_Matriz_Rigidez wait for user response (see UIRESUME)
% uiwait(handles.figure1);


% --- Outputs from this function are returned to the command line.
function varargout = Menu_Calculos_Matriz_Rigidez_OutputFcn(hObject, eventdata,
handles)
% varargout  cell array for returning output args (see VARARGOUT);
% hObject    handle to figure
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Get default command line output from handles structure
varargout{1} = handles.output;

%Color: [0.9255 0.9137 0.8471]
```

```
scnsize = get(0,'ScreenSize');
pos1  = [scnsize(3)/12.4,scnsize(4)/25,scnsize(3)/8.5,scnsize(4)/30];

set(hObject, 'Position',pos1, 'Visible','on');


handles.banner = imread('fundo.jpg') % Read the image file banner.jpg
info = imfinfo('fundo.jpg') % Determine the size of the image file
position = get(hObject);
axes(handles.background);
image(handles.banner)
set(handles.background, ...
    'Visible', 'off', ...
    'Units', 'pixels',...
    'Position', [0 0 15*info.Width 15*info.Height]);

set(handles.text10, 'String','..................');



% --- Executes on button press in pushbutton1.
function pushbutton1_Callback(hObject, eventdata, handles)
% hObject    handle to pushbutton1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
% data = getappdata(0, 'metricdata');
%
run('Dados');
set(handles.text2, 'Visible', 'on','String', k(:,1));
set(handles.text3, 'Visible', 'on','String', k(:,2));
set(handles.text4, 'Visible', 'on','String', k(:,3));
set(handles.text5, 'Visible', 'on','String', k(:,4));
set(handles.text6, 'Visible', 'on','String', k(:,5));
set(handles.text7, 'Visible', 'on');
set(handles.text8, 'Visible', 'on');

if nrGL==5
    set(handles.frame1, 'Visible', 'on');
end
if nrGL==6
    set(handles.text9, 'Visible', 'on','String', k(:,6));
    set(handles.frame2, 'Visible', 'on');
end



% --- Executes on button press in pushbutton2.
function pushbutton2_Callback(hObject, eventdata, handles)
% hObject    handle to pushbutton2 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)


% --- Executes on button press in togglebutton1.
function togglebutton1_Callback(hObject, eventdata, handles)
% hObject    handle to togglebutton1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hint: get(hObject,'Value') returns toggle state of togglebutton1


button_state = get(hObject,'Value');
if button_state == get(hObject,'Max')
    set(handles.text10,'Visible','on')   % toggle button is pressed
elseif button_state == get(hObject,'Min')
    set(handles.text10,'Visible','off');  % toggle button is not pressed
end
```

RespostaFreq2.m

```
%PROJECTO DE FIM DE CURSO
%CARACTERIZAÇAO DA VIBRAÇAO E RUIDO DE UMA ARVORE DE EQUILIBRAGEM DE MOTOR

run('Dados');
mk=k*(1+j*0.005);
mc=0.05*10E-4*k;
% Mt=M0*cos(w*t);


%Resposta do sistema(regime harmonico)
% Mt=M0*cos(w*t);

%Resposta em frequencia
w=linspace(0,wn(GL)*1.2,2048);
alfa=zeros(GL,length(w));
alfasm=zeros(GL,length(w),GL);
for i=1:GL
    etas(i)=0.005;
end
for i=1:GL
    for iw=1:length(w)
        alfasm(:,iw,i)=fi(:,i)*fi(1,i)/(wn(i)^2-w(iw)^2+j*wn(i)^2*etas(i));
    end
    alfa=alfa+alfasm(:,:,i);
end

for i=1:GL
    alfaA(i,:)=-alfa(i,:).*w.^2;
    for l=1:GL
        alfasmA(i,:,l)=-alfasm(i,:,l).*w.^2;
    end
end

alfam=20*log10(abs(alfa));
alfasmm=20*log10(abs(alfasm));

alfamA=20*log10(abs(alfaA));
alfasmmA=20*log10(abs(alfasmA));

% for i=1:GL
%       index=([num2str(i),'1']);
%     figure(i)
%
plot(w/2/pi,alfamA(i,:),w/2/pi,alfasmmA(i,:,1),w/2/pi,alfasmmA(i,:,2),w/2/pi,alfasm
mA(i,:,3),w/2/pi,alfasmmA(i,:,4),w/2/pi,alfasmmA(i,:,5));
% %     axis([0 0 1.2*min(alfam(i,:)) 1.2*max(alfam(i,:))]);
%     legend(['A_{',index,'}'],'c1°','c2°','c3°','c4°','c5°',-1);
%     back=uicontrol('style','pushbutton','units','normal','position',[0.91 0.5
0.090 0.095],...
%        'string','Menu','callback','close all,Graficos');
% %    pause;
%  title(['Resposta em Frequencia (acelerancia) \theta_{',index,'}']);
% xlabel('f [Hz]'); ylabel('Mag. [dB]');
% end
```

RespostaImpulsoPeriodico2.m

```
%PROJECTO DE FIM DE CURSO
%CARACTERIZAÇAO DA VIBRAÇAO E RUIDO DE UMA ARVORE DE EQUILIBRAGEM DE MOTOR

run('Dados');

%Resposta do sistema(sobreposiçao modal)
% Mt=M0*cos(w*t);
csi=zeros(GL-1,1);%amortecimentos modais
% close all;
```

```
F=zeros(GL,1);
A=1;               %Amplitude do impulso
% wrot=10000;          %velocidade de rotaçao
T=1/(wrot/60);     %periodo
t0=T/10;           %duraçao do impulso
ntsf=30;
t=linspace(0,5*T,2048);

%Resposta no tempo a uma solicitaçao harmonica
tetah=zeros(GL,length(t),ntsf+1); %resposta temporal para uma sequencia de impulsos
teta=zeros(GL,length(t));
TIP=zeros(1,length(t));

A0=2*A*t0/T;
TIP=TIP+A0/2;
Spf=zeros(1,ntsf+1);Spf(1)=A0/2; %espectro de força
Spr=zeros(GL,ntsf+1);
Swh=zeros(1,ntsf+1);
Fh0=A*t0/T;
F(1)=Fh0;
N0=transpose(fi2)*F;

%RESPOSTA NO TEMPO
eta=zeros(GL-1,length(t));
for i=1:GL-1
    eta(i,:)=N0(i)/(wn2(i)^2);            %Coordenadas generalizadas
end

tetasm=zeros(GL,length(t),GL-1);
for i=1:GL-1
    tetasm(:,:,i)=fi2(:,i)*eta(i,:);
    tetah(:,:,1)=tetah(:,:,1)+tetasm(:,:,i);
end


teta=teta+tetah(:,:,1);
Spr(:,1)=transpose(max(transpose(tetah(:,:,1)))); %espectro de resposta

for k=1:ntsf

    Fh=(2*A/(k*pi))*sin(k*pi*t0/T); %Força provocada pelo impulso
    wh(k)=k*2*pi/T;                     %Frequencia
    Spf(k+1)=abs(Fh);                 %Magnitude
    Swh(k+1)=wh(k);
    F(1)=Fh;

    N=transpose(fi2)*F;

    %RESPOSTA NO TEMPO
    eta=zeros(GL-1,length(t));
    for i=1:GL-1
        mz(i,i)=1/((wn2(i)^2-wh(k)^2)+j*2*csi(i)*wn2(i)*wh(k)); %com amortecimento
    end

    amp=mz*N;
    Spr(:,k+1)=fi2*amp;

    %Sobreposiçao modal
    for i=1:GL
        tetah(i,:,k+1)=real(Spr(i,k+1)*exp(j*wh(k)*t));
    end
    teta=teta+tetah(:,:,k+1);

end
% for i=1:GL
%     figure(5+i)              %Representaçao Resposta no grau de liberdade i
%     plot(t,teta(i,:));
% end
%
% for i=1:GL
```

```
%     figure(5000+i);
%     subplot(2,1,1);
%     stem(Swh/2/pi,Spf);    %Representaçao da magnitude do impulso em funçao da
frequencia
%
%     subplot(2,1,2);
%     stem(Swh/2/pi,abs(Spr(i,:)));    %Representaçao da magnitude da resposta em
funçao da frequencia
% end
```

RespostaImpulsoPeriodicoAciclismo.m

```
%PROJECTO DE FIM DE CURSO
%CARACTERIZAÇAO DA VIBRAÇAO E RUIDO DE UMA ARVORE DE EQUILIBRAGEM DE MOTOR
run('Dados');

%Resposta do sistema(sobreposiçao modal)
% Mt=M0*cos(w*t);

csi=zeros(GL-1,1);%amortecimentos modais
% close all;

F=zeros(GL,1);
A=0.75;                 %Amplitude do impulso

% wrot=1000;            %velocidade de rotaçao
wacic=wrot;
T=1/(wacic/60);    %periodo
% T=1;
% wseno=pi/tc;

% t0=T/10;              %duraçao do impulso
ntsf=150;
t=transpose(linspace(0,5*T,1024));
An=zeros(ntsf,1); Bn=zeros(ntsf,1);



%Resposta no tempo a uma solicitaçao harmonica
tetah=zeros(GL,length(t),ntsf+1); %resposta temporal para uma sequencia de impulsos
teta=zeros(GL,length(t));
TIP=zeros(length(t),1);

A0=4*A/pi;
TIP=1/2*A0;

for n=1:ntsf
    An(n)=-4/pi/(1+2*n)/(-1+2*n)*A*cos(n*pi)^2;
    Bn(n)=-4/pi/(1+2*n)/(-1+2*n)*A*sin(n*pi)*cos(n*pi);
end


Spf=zeros(1,ntsf+1);Spf(1)=A0/2; %espectro de força
Spr=zeros(GL,ntsf+1);
Swh=zeros(1,ntsf+1);


Fh0=A0/2;
F(1)=Fh0;
N0=transpose(fi2)*F;

%RESPOSTA NO TEMPO
eta=zeros(GL-1,length(t));
for i=1:GL-1
    eta(i,:)=N0(i)/(wn2(i)^2);           %Coordenadas generalizadas
end

tetasm=zeros(GL,length(t),GL-1);
for i=1:GL-1
```

```
    tetasm(:,:,i)=fi2(:,i)*eta(i,:);
    tetah(:,:,1)=tetah(:,:,1)+tetasm(:,:,i);
end

teta=teta+tetah(:,:,1);

Spr(:,1)=transpose(max(transpose(tetah(:,:,1)))); %espectro de resposta(VER)


for k=1:ntsf
    TIP=TIP+An(k)*cos(k*2*pi/T*t)+Bn(k)*sin(k*2*pi/T*t);
    wh=k*2*pi/T;                                %Frequencia
    Spf(k+1)=abs(TIP(k));                          %Magnitude
    Swh(k+1)=wh;
    F(1)=TIP(k);

    N=transpose(fi2)*F;

%       figure(30)
%       plot(t,TIP,'b'); hold on;
%

    %RESPOSTA NO TEMPO
    eta=zeros(GL-1,length(t));
    for i=1:GL-1
        mz(i,i)=1/((wn2(i)^2-wh^2)+j*2*csi(i)*wn2(i)*wh); %com amortecimento
    end

    amp=mz*N;
    Spr(:,k+1)=fi2*amp;



    %Sobreposiçao modal
    for i=1:GL
        tetah(i,:,k+1)=real(Spr(i,k+1)*exp(j*wh*t));
    end
    teta=teta+tetah(:,:,k+1);

end
% figure(10)
% stem(abs(An))
% figure(20)
% stem(abs(Bn))
% figure(40)
% plot(t,TIP,'r','LineWidth',2)

%%%%%%%FUNÇAO SENO + IMPULSO %%%%%%%%%%%%%%%%%%%%
Ab=2;
ftb=Ab*sin(2*pi/T*transpose(t));
ftt=transpose(TIP)+ftb;
% figure(80)
% plot(t,ftt)

% for i=1:GL
%       figure(15+i);
%       plot(t,teta(i,:));    %Representaçao Resposta no grau de liberdade 1
% end
% for i=1:GL
%       figure(10+i);
%       subplot(2,1,1);
%       stem(Swh/2/pi,Spf);    %Representaçao da magnitude do impulso em funçao da
frequencia
%       subplot(2,1,2);
%       stem(Swh/2/pi,Spr(i,:));    %Representaçao da magnitude da resposta em funçao
da frequencia
% end
```

RespostaImpulsoPeriodicoSeno2.m

```
%PROJECTO DE FIM DE CURSO
%CARACTERIZAÇAO DA VIBRAÇAO E RUIDO DE UMA ARVORE DE EQUILIBRAGEM DE MOTOR

run('Dados');

%Resposta do sistema(sobreposiçao modal)
% Mt=M0*cos(w*t);

csi=zeros(GL-1,1);%amortecimentos modais
% close all;

F=zeros(GL,1);
A=0.75;                %Amplitude do impulso

% wrot=6305.6;         %velocidade de rotaçao

T=1/(wrot/60);   %periodo
% T=1;
tc=1/11*T;    %duraçao do impulso
wseno=pi/tc;

% t0=T/10;         %duraçao do impulso
ntsf=100;
t=transpose(linspace(0,5*T,1024));
An=zeros(ntsf,1); Bn=zeros(ntsf,1);

%Resposta no tempo a uma solicitaçao harmonica
tetah=zeros(GL,length(t),ntsf+1); %resposta temporal para uma sequencia de impulsos
teta=zeros(GL,length(t));
TIP=zeros(length(t),1);

A0=4/T*A/pi*tc;
TIP=1/2*A0;

for n=1:ntsf
    An(n)=-4*T*tc/pi/(T+2*n*tc)/(-T+2*n*tc)*A*cos(pi/T*n*tc)^2;
    Bn(n)=-4*T*tc/pi/(T+2*n*tc)/(-T+2*n*tc)*A*sin(pi/T*n*tc)*cos(pi/T*n*tc);
end

Spf=zeros(1,ntsf+1);Spf(1)=A0/2; %espectro de força
Spr=zeros(GL,ntsf+1);
Swh=zeros(1,ntsf+1);


Fh0=A*tc/T;
F(1)=Fh0;
N0=transpose(fi2)*F;

%RESPOSTA NO TEMPO
eta=zeros(GL-1,length(t));
for i=1:GL-1
    eta(i,:)=N0(i)/(wn2(i)^2);            %Coordenadas generalizadas
end

tetasm=zeros(GL,length(t),GL-1);
for i=1:GL-1
    tetasm(:,:,i)=fi2(:,i)*eta(i,:);
    tetah(:,:,1)=tetah(:,:,1)+tetasm(:,:,i);
end

teta=teta+tetah(:,:,1);

Spr(:,1)=transpose(max(transpose(tetah(:,:,1)))); %espectro de resposta(VER)


for k=1:ntsf
    TIP=TIP+An(k)*cos(k*2*pi/T*t)+Bn(k)*sin(k*2*pi/T*t);
```

```
    wh=k*2*pi/T;                                %Frequencia
    Spf(k+1)=abs(TIP(k));                           %Magnitude
    Swh(k+1)=wh;
    F(1)=TIP(k);

    N=transpose(fi2)*F;

%       figure(30)
%       plot(t,TIP,'b'); hold on;
%

    %RESPOSTA NO TEMPO
    eta=zeros(GL-1,length(t));
    for i=1:GL-1
        mz(i,i)=1/((wn2(i)^2-wh^2)+j*2*csi(i)*wn2(i)*wh); %com amortecimento
    end

    amp=mz*N;
    Spr(:,k+1)=fi2*amp;
    %Sobreposiçao modal
    for i=1:GL
        tetah(i,:,k+1)=real(Spr(i,k+1)*exp(j*wh*t));
    end
    teta=teta+tetah(:,:,k+1);

end

% figure(10)
% stem(abs(An))
% figure(20)
% stem(abs(Bn))
%
% figure(40)
% plot(t,TIP,'r','LineWidth',2)
%%%%%%FUNÇAO SENO + IMPULSO %%%%%%%%%%%%%%%%%%%
Ab=2;
ftb=Ab*sin(2*pi/T*transpose(t));

ftt=transpose(TIP)+ftb;
% figure(80)
% plot(t,ftt)
% for i=1:GL
%       figure(15+i);
%       plot(t,teta(i,:));     %Representaçao Resposta no grau de liberdade 1
% end
% for i=1:GL
%
%       figure(10+i);
%       subplot(2,1,1);
%       stem(Swh/2/pi,Spf);     %Representaçao da magnitude do impulso em funçao da
frequencia
%
%       subplot(2,1,2);
%       stem(Swh/2/pi,Spr(i,:));     %Representaçao da magnitude da resposta em funçao
da frequencia
% end
```

RespostaImpulsoPeriodicoSenoEImpulso2.m

```
%PROJECTO DE FIM DE CURSO
%CARACTERIZAÇAO DA VIBRAÇAO E RUIDO DE UMA ARVORE DE EQUILIBRAGEM DE MOTOR

run('Dados');

%Resposta do sistema(sobreposiçao modal)
% Mt=M0*cos(w*t);

csi=zeros(GL-1,1);%amortecimentos modais
% close all;
```

```
F=zeros(GL,1);
A=0.75;                 %Amplitude do impulso

% wrot=6305.6;          %velocidade de rotaçao

T=1/(wrot/60);    %periodo
% T=1;
tc=1/11*T;     %duraçao do impulso
wseno=pi/tc;

% t0=T/10;              %duraçao do impulso
ntsf=100;
t=transpose(linspace(0,5*T,1024));
An=zeros(ntsf,1); Bn=zeros(ntsf,1);


%Resposta no tempo a uma solicitaçao harmonica
tetah=zeros(GL,length(t),ntsf+1); %resposta temporal para uma sequencia de impulsos
teta=zeros(GL,length(t));
TIP=zeros(length(t),1);
Fh=zeros(length(t),1);

A0=4/T*A/pi*tc;
TIP=1/2*A0;

for n=1:ntsf
    An(n)=-4*T*tc/pi/(T+2*n*tc)/(-T+2*n*tc)*A*cos(pi/T*n*tc)^2;
    Bn(n)=-4*T*tc/pi/(T+2*n*tc)/(-T+2*n*tc)*A*sin(pi/T*n*tc)*cos(pi/T*n*tc);
end


Spf=zeros(1,ntsf+1);Spf(1)=A0/2; %espectro de força
Spr=zeros(GL,ntsf+1);
Swh=zeros(1,ntsf+1);

Fh0=A*tc/T;
F(1)=Fh0;
N0=transpose(fi2)*F;
%RESPOSTA NO TEMPO
eta=zeros(GL-1,length(t));
for i=1:GL-1
    eta(i,:)=N0(i)/(wn2(i)^2);           %Coordenadas generalizadas
end
tetasm=zeros(GL,length(t),GL-1);
for i=1:GL-1
    tetasm(:,:,i)=fi2(:,i)*eta(i,:);
    tetah(:,:,1)=tetah(:,:,1)+tetasm(:,:,i);
end
teta=teta+tetah(:,:,1);
Spr(:,1)=transpose(max(transpose(tetah(:,:,1)))); %espectro de resposta(VER)
for k=1:ntsf
    Fh=Fh+An(k)*cos(k*2*pi/T*t)+Bn(k)*sin(k*2*pi/T*t);
    wh=k*2*pi/T;                      %Frequencia
    Spf(k+1)=abs(Fh(k));                  %Magnitude
    Swh(k+1)=wh;
    F(1)=Fh(k);
    N=transpose(fi2)*F;

%     figure(30)
%     plot(t,TIP,'b'); hold on;
end

%%%%%%%FUNÇAO SENO + IMPULSO %%%%%%%%%%%%%%%%%%%
Ab=2;
ftb=Ab*sin(2*pi/T*transpose(t));

TIP=transpose(Fh)+ftb;
% figure(80)
% plot(t,TIP)
```

```
for k=1:ntsf
    wh=k*2*pi/T;                        %Frequencia
    F(1)=TIP(k);
    N=transpose(fi2)*F;
%     figure(30)
%     plot(t,TIP,'b'); hold on;
%
    %RESPOSTA NO TEMPO
    eta=zeros(GL-1,length(t));
    for i=1:GL-1
        mz(i,i)=1/((wn2(i)^2-wh^2)+j*2*csi(i)*wn2(i)*wh); %com amortecimento
    end
    amp=mz*N;
    Spr(:,k+1)=fi2*amp;

    %Sobreposiçao modal
    for i=1:GL
        tetah(i,:,k+1)=real(Spr(i,k+1)*exp(j*wh*t));
    end
    teta=teta+tetah(:,:,k+1);
end
% figure(10)
% stem(abs(An))
% figure(20)
% stem(abs(Bn))
% figure(40)
% plot(t,TIP,'r','LineWidth',2)
% for i=1:GL
%     figure(15+i);
%     plot(t,teta(i,:));    %Representaçao Resposta no grau de liberdade 1
% end
% for i=1:GL
%     figure(10+i);
%     subplot(2,1,1);
%     stem(Swh/2/pi,Spf);    %Representaçao da magnitude do impulso em funçao da
frequencia
%
%     subplot(2,1,2);
%     stem(Swh/2/pi,Spr(i,:));    %Representaçao da magnitude da resposta em funçao
da frequencia
% end
```

RespostaTemp.m

```
%PROJECTO DE FIM DE CURSO
%CARACTERIZAÇAO DA VIBRAÇAO E RUIDO DE UMA ARVORE DE EQUILIBRAGEM DE MOTOR

run('Dados');

%Resposta do sistema(sobreposiçao modal)
% Mt=M0*cos(w*t);

teta0=zeros(GL,1);
tetapt0=zeros(GL,1);
eta0=fi2'*MM*teta0;
etapt0=fi2'*MM*tetapt0;
csi=zeros(GL-1,1);%amortecimentos modais
N=transpose(fi2)*F;

%Resposta no tempo a uma solicitaçao harmonica
% t=0:0.0001:3.5E-3;
t=linspace(0,3.5E-3,1024);
teta=zeros(GL,length(t));

wexcf=0.75*wn(2);

%RESPOSTA NO TEMPO
eta=zeros(GL-1,length(t));
```

```
for i=1:GL-1
    beta=wexcf/wn2(i);
    amplit=(N(i)/wn2(i)^2)*(1/sqrt((1-beta^2)^2+(2*csi(i)*beta)^2));
    desf=atan2(2*csi(i)*beta,(1-beta^2));
    eta(i,:)=amplit*cos(wexcf*t-desf);
end

%Sobreposiçao modal

tetasm=zeros(GL,length(t),GL-1);
ymax=zeros(GL,1);
ymin=zeros(GL,1);
for i=1:GL-1
    tetasm(:,:,i)=fi2(:,i)*eta(i,:);
    teta=teta+tetasm(:,:,i);
    for j=1:GL
        ymax(j)=max(teta(j,:));
        ymin(j)=min(teta(j,:));
    end
end
ymaxim=max(teta(:,:));
yminim=min(teta(:,:));
ymaxtotal=max(ymaxim);
ymintotal=min(yminim);


% figure(1)
% plot(t,teta(1,:),t,teta(2,:),t,teta(3,:),t,teta(4,:),t,teta(5,:));
% legend('Resposta GL 1','Resposta GL 2','Resposta GL 3','Resposta GL 4','Resposta
GL 5');
% back=uicontrol('style','pushbutton','units','normal','position',[0.91 0.5 0.090
0.095],...
%         'string','Menu','callback','close all,Graficos');
%    pause;
% for i=1:GL-1
%     plot(t,tetasm(1,:,i));hold on;
% end
% for i=1:GL
%     figure(i+1)
%
plot(t,teta(i,:),t,tetasm(i,:,1),t,tetasm(i,:,2),t,tetasm(i,:,3),t,tetasm(i,:,4));
%     ymax=max(teta(i,:));
%     ymin=min(teta(i,:));
%     xmax=max(t);
%     axis([0 xmax 1.2*ymin 1.2*ymax]);
%     legend('Resposta do Sistema','2°Modo Natural','3°Modo Natural','4°Modo
Natural','5°Modo Natural',-1);
%     xlabel('tempo [seg]');
%     ylabel('\theta(t)');
%     title('Contribuiçao Modal para a Resposta do Sistema');
%     back=uicontrol('style','pushbutton','units','normal','position',[0.91 0.5
0.090 0.095],...
%         'string','Menu','callback','close all,Graficos');
%    pause;
% end
```

RespostaTransiente.m

```
%PROJECTO DE FIM DE CURSO
%CARACTERIZAÇAO DA VIBRAÇAO E RUIDO DE UMA ARVORE DE EQUILIBRAGEM DE MOTOR

run('Dados');


%Resposta Transiente
F0=1;
% t=0:0.0001:3.5E-3;
t=linspace(0,3.5E-3,1024);
tc=8E-4;
```

```
wi=0.75*wn(2);
teta=zeros(GL-1,length(t));
for i=2:GL
    wni=wn(i);
    ki(i-1)=MM(i,i)*(wni^2);
    ks=ki(i-1);
    for j=1:length(t)
        tj=t(j);
        if tj <= tc
            teta(i-1,j)=(F0/ks)*(1/(1-(wi/wni)^2))*(sin(wi*tj)-
(wi/wni)*sin(wni*tj));% Solicitaçao seno
%           teta(i-1,j)=(1-cos(wni*tj))*(F0/(wni^2)); % Solicitaçao rectangular
        else
            teta(i-1,j)=(F0/ks)*((wni/wi)/(1-(wi/wni)^2))*(sin(wni*tj)+sin(wni*(tj-
tc)));% Solicitaçao seno
%               teta(i-1,j)=(cos(wni*(tj-tc))-cos(wni*tj))*F0/(wni^2);% Solicitaçao
rectangular
        end
    end
end
% for i=1:GL-1
%     figure(i)
%     plot(t,teta(i,:));grid on; hold on;
%     back=uicontrol('style','pushbutton','units','normal','position',[0.91 0.5
0.090 0.095],...
%         'string','Menu','callback','close all,Graficos');
% end
```