INTELLIGENT CONTROL BASED ON NEURAL CONTROLLER FOR APPLICATION IN THE ETE SPHERICAL TOKAMAK

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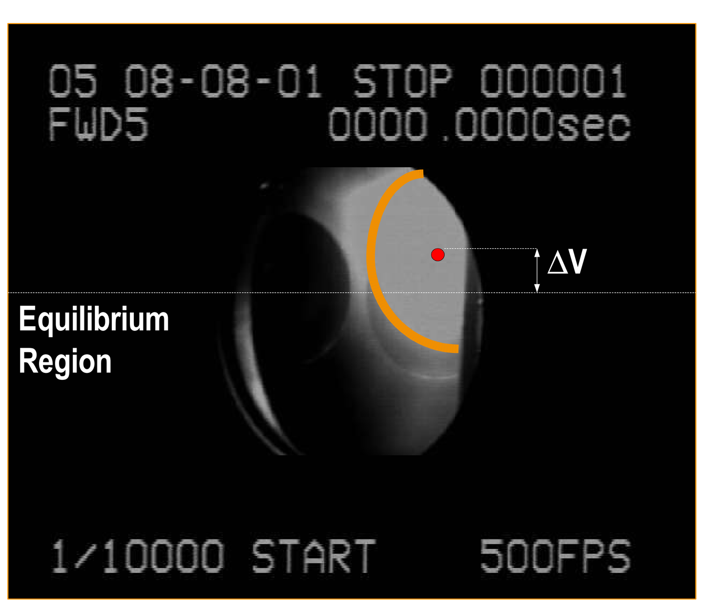
Abstract

This poster presents an approach to the problem of controlling the vertical displacement of the plasma in the *ETE* tokamak based on Artificial Neural Networks (*ANN*). *ETE* is a low aspect ratio tokamak that should operate with highly elongated plasmas, which are unstable to vertical displacements. To control the vertical position of the plasma, an intelligent controller is under development based on an *ANN* of the feed-forward type that uses multiple layer perceptrons trained with an error back-propagation algorithm. There are several ways available to implement a neural controller. The *ETE* tokamak controller will use hybrid architecture of the feedback-error-learning type (*FEL*), composed of the neural part and a classic part. The classic part (Proportional Integral Derivative – *PID*) of the controller supplies the initial solution (starting point) so that the neural part can identify the problem and gradually substitute the classic one in the dynamic nonlinear control of the plasma equilibrium. To test this hybrid controller, a simple magnetic levitation (MagLev) system was constructed that in certain aspects is analogous to the tokamak plasma vertical equilibrium system. In the MagLev it is possible to implement the nonlinear control of the vertical position of a metallic sphere, both using a classic controller (*PID*) and a hybrid controller (*PID+FEL*). The controller to be installed in *ETE* will be implemented on a neural hardware. This intelligent controller running on neural hardware should be capable to act in a few microseconds time interval, allowing real time control of the vertical displacement of the plasma.

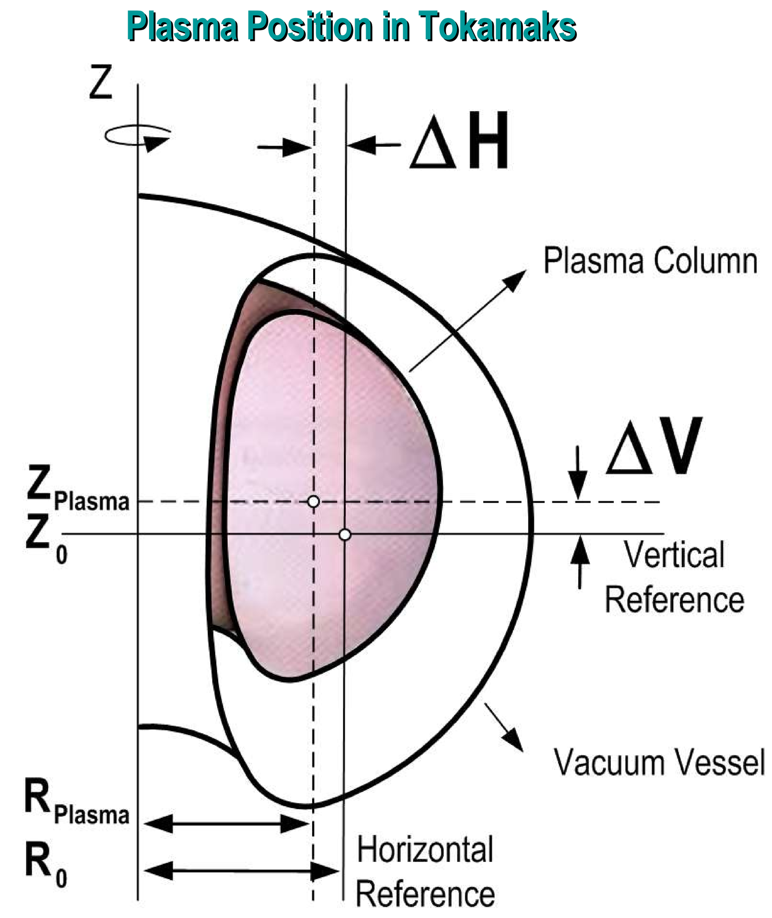
ETE Tokamak Plasmas

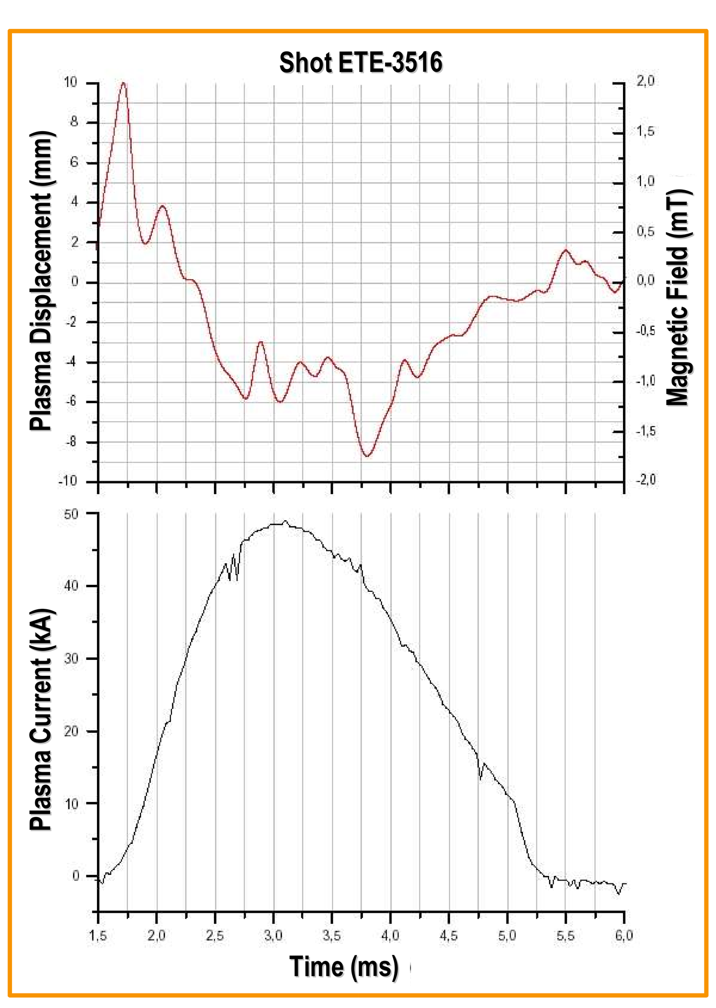
Complexity of this control system in this type of experiment it must characteristics of non-linear dynamic of plasma column, that it becomes necessary the use of a non-linear control system that is capable to act in fast events, as of vertical displacement (250us), and still adapt the variation of plasma parameters in tokamak ETE



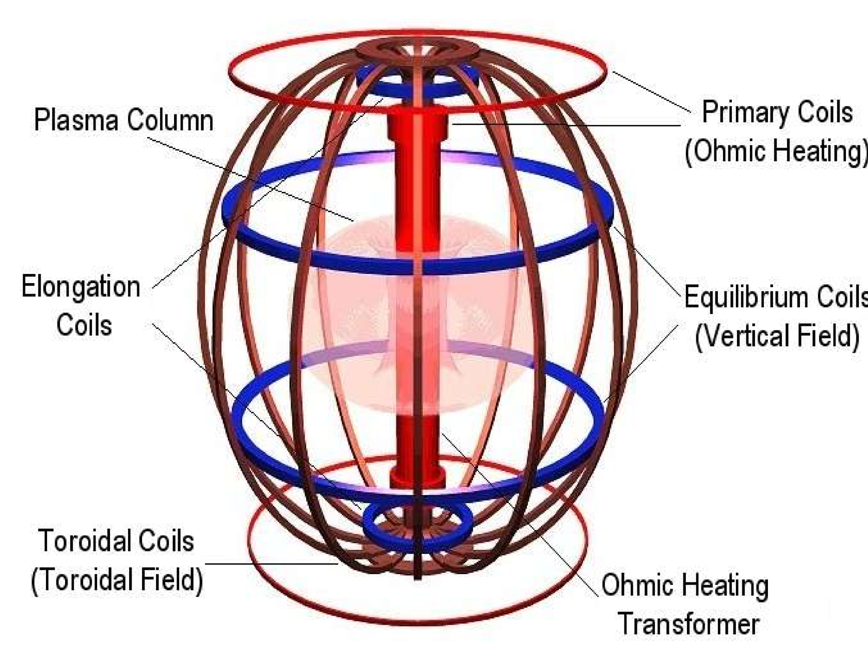
SHOT ETE- 1481

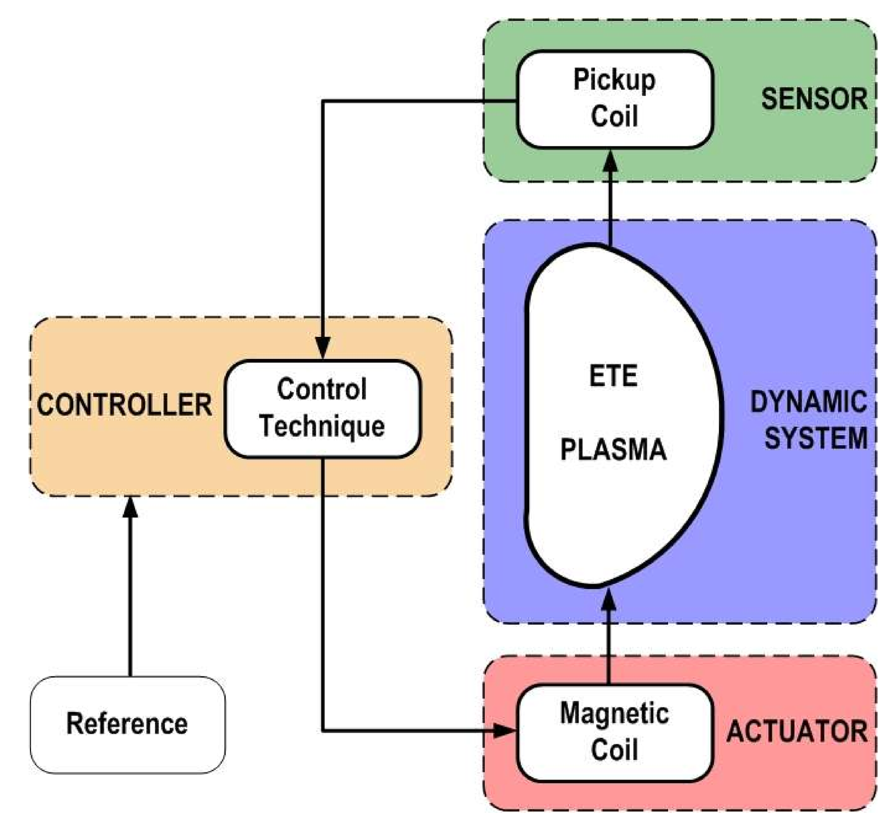
Plasma Position in Tokamaks





Magnetic Configuration in ETE Tokamak





Control Requirements in ETE

To act in the vertical plasma displacement, to prevent the *premature end* of discharge in ETE

To easily adapt the new parameters of plasma, to allow the ETE to more investigate *plasmas with elongated formats*

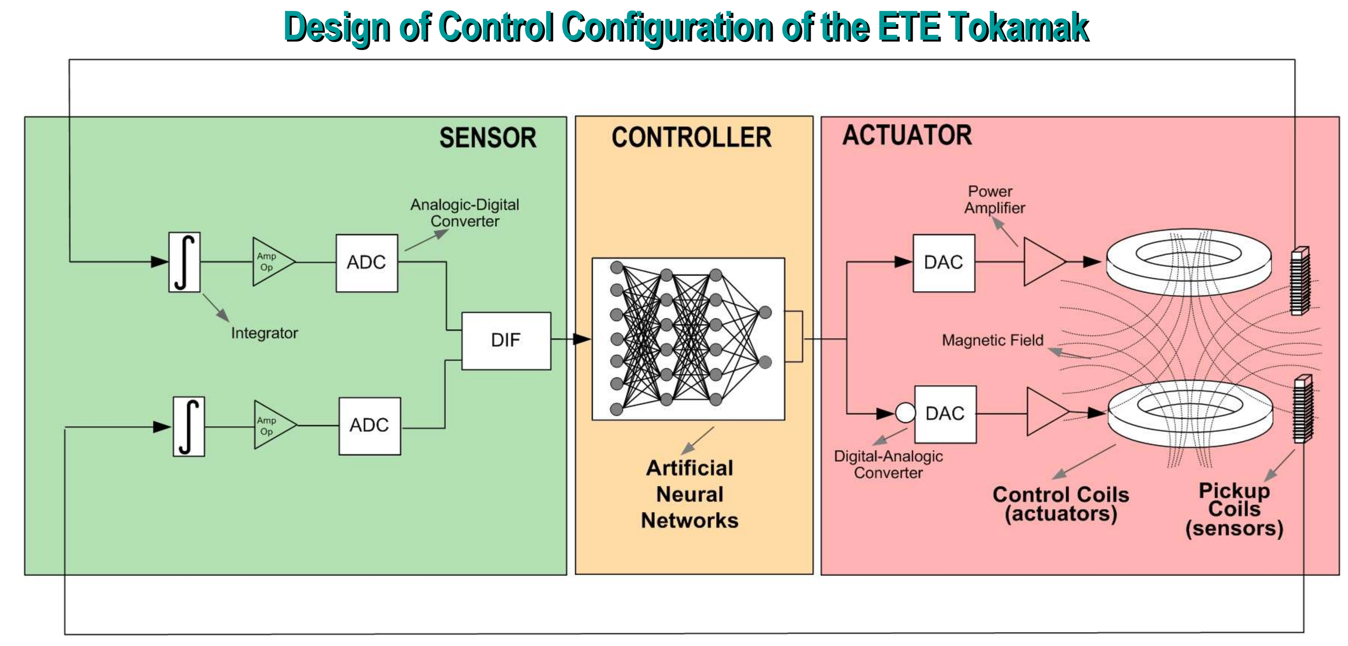
To be enough fast, to *act some times in the vertical instability* of plasma in ETE

The main parameters of control for equilibrium of plasma in ETE are:

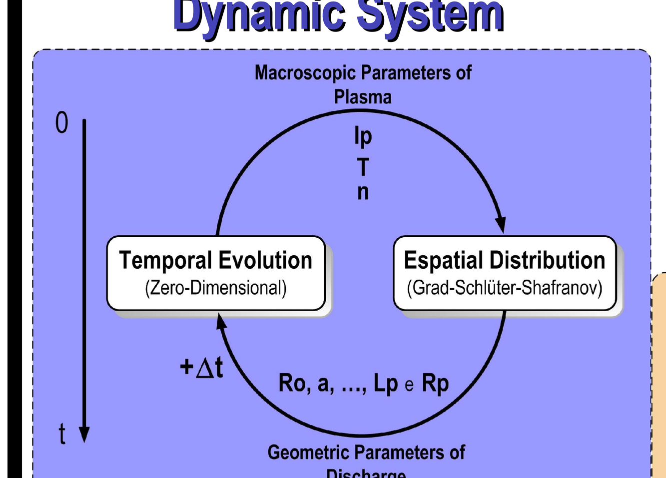
Period of esteem controller lesser 60μs

Maximum vertical displacement ±5mm

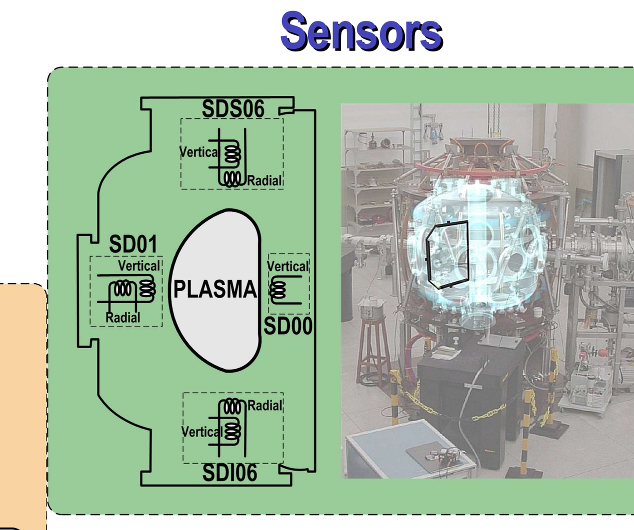
Design of Control Configuration of the ETE Tokamak



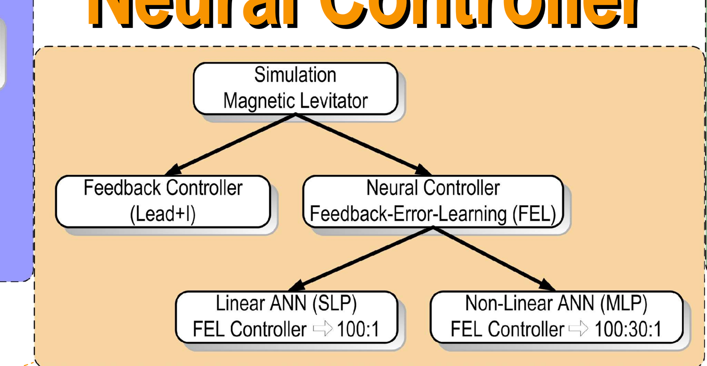
Dynamic System



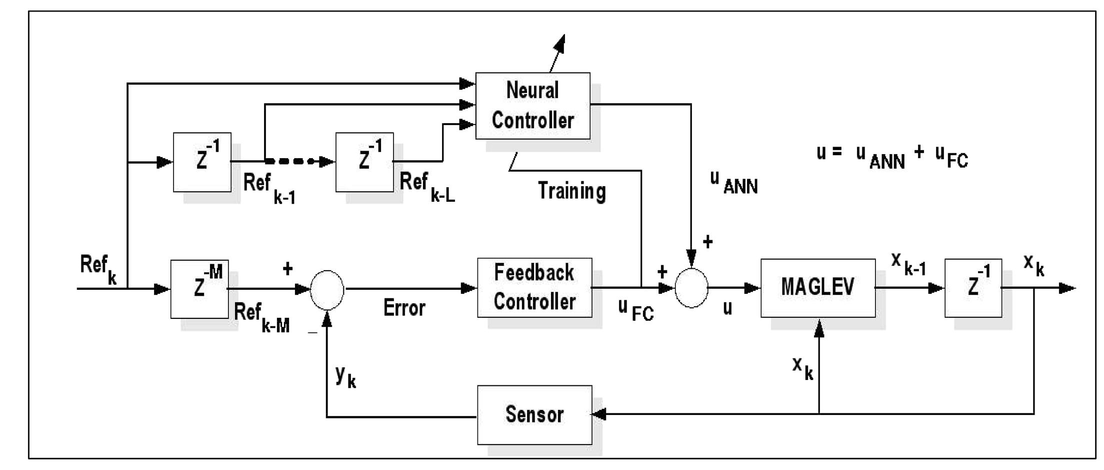
Sensors



Neural Controller

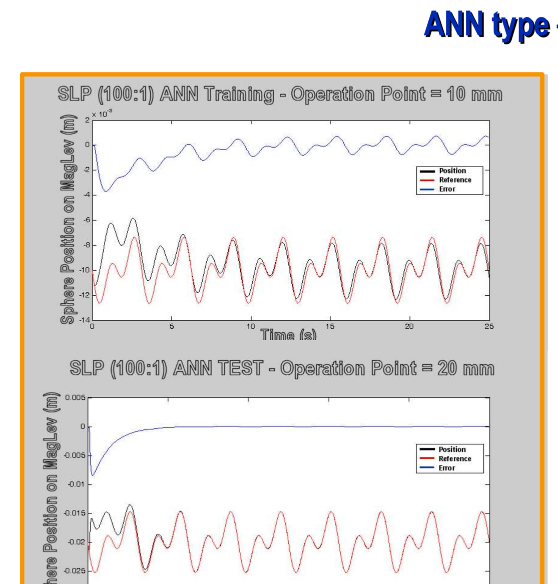


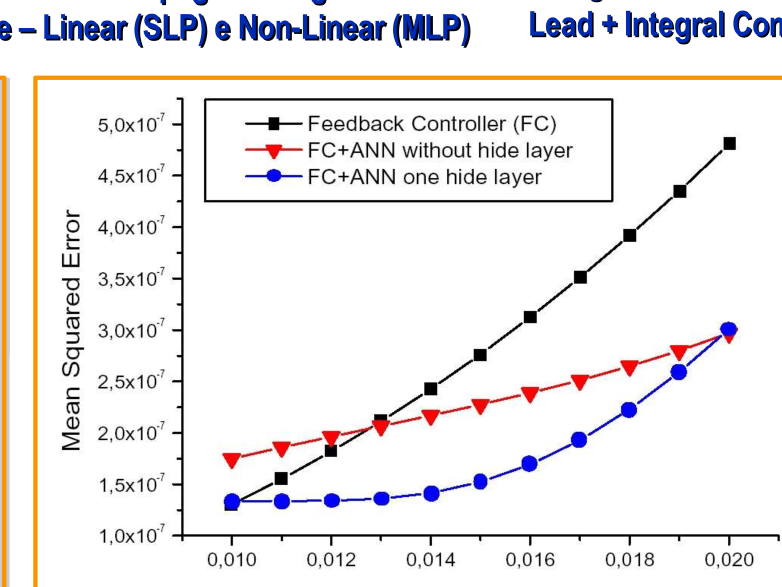
Feedback-Error-Learning (FEL) Controller

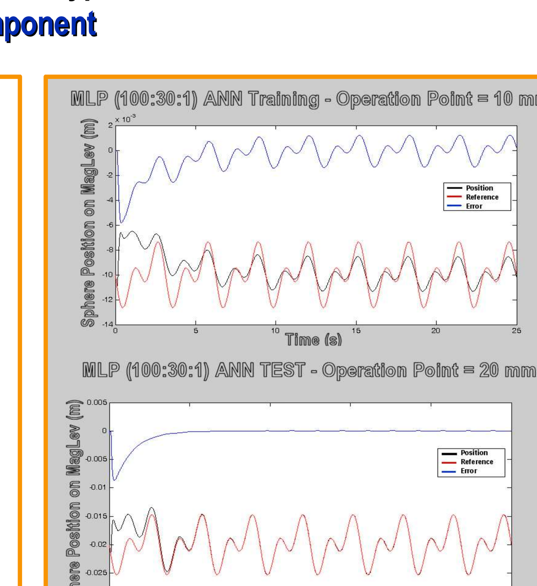


Neural Controller
Error Back-Propagation Algoritm
ANN type – Linear (SLP) e Non-Linear (MLP)

Feedback Controller
Analogic Controller Lead type
Lead + Integral Component





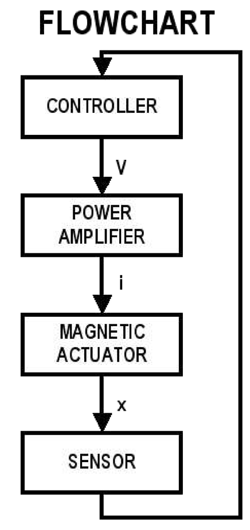


Magnetic Levitator (MagLev)

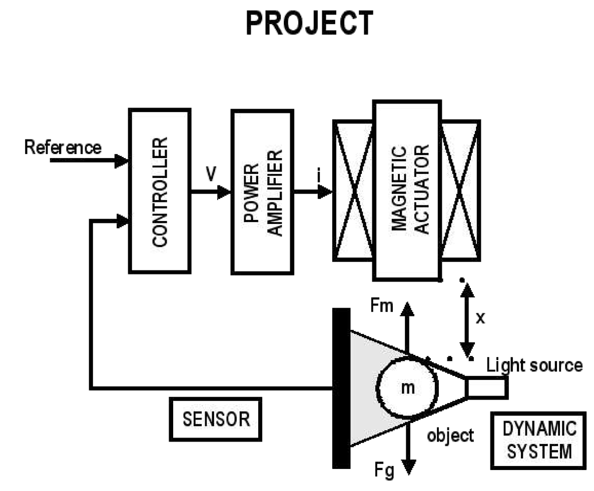
Electromagnet

Parameters	Value
R	~9,16 Ω
L (até 10 kHz)	~122,5 mH
Wire	24 AWG
Turns	~1800
L/R	~13,5 ms
Ferrit	100 mm x 10 mm
Solenoid	80 mm x 25 mm
Distance X_0	~0,005 m – 0,025 m
Current i_0	~0,3 - 1 A

FLOWCHART



PROJECT

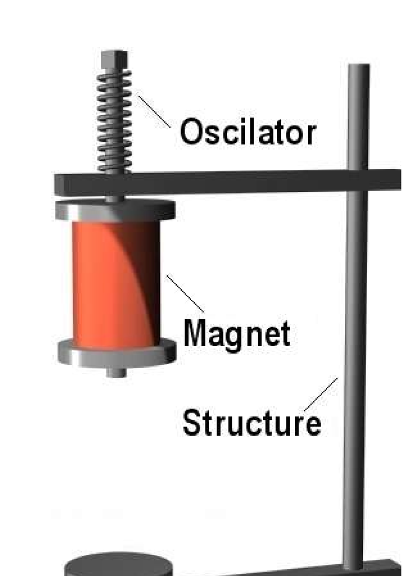


Matallic Spheres

Weight	Diameter
0,98 – 1,02 g	15 mm

Control dynamic of MagLev, in this case a metallic sphere that approximately floats the distances of 20mm of electromagnet, is necessary to act on the electric current in the electromagnet making with that the electromagnetic force compensates the mass and the acceleration of the gravity, in order to keep the sphere in equilibrium

Metallic Sphere in MagLev



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