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ON NON-LINEAR DYNAMICS BEHAVIOUR OF A FIXED OFFSHORE PLATFORM FOR ENERGY HARVESTING

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Abstract. In this work we analyze the dynamic behavior of an offshore platform system using piezoelectric material in its structure for a possible energy harvesting. We analyzed the behavior of the average power produced, together with the Maximum Lyapunov Exponent and Bifurcation diagram. Another analysis performed was for a given set of parameters the basins of attraction in which we detected the presence of two attractors for the initial conditions in range of [-5.5], we also analyzed the behavior of the amplitude dynamics (*A*) of the sea wave applied to the system with parameter (*p*) related to the damping coefficient of the structure and thus we determine the regions in which the system is chaotic or periodic. With this we calculate the average power for p in [0,5] and for values of $p \rightarrow 5$ there is an increase in the average power of the system with a value of $A = 2.5$.

Keywords: offshore platform, nonlinear dynamics, piezoceramic

1. Introduction

In the last decades, the demand for energy consumption has been growing and several ways to obtain a clean and sustainable energy have been researched. Some examples for obtaining clean and sustainable energy are wind energy, solar energy, etc [1]. However, an energy that is being exploited is obtained by the waves of the sea waves [2]. Thus, we analyzed the behavior of a mathematical model of an oil platform under the action of an external force of the type $F_{ext}(\mathrm{t}) = A\sin(\omega_1 \mathrm{t}) + \mathrm{B}\sin(\omega_2 \mathrm{t})$, where *A* and *B* is amplitude of wave sea and $\boldsymbol{\omega_1}$ and $\boldsymbol{\omega_2}$ are the frequencies of wave and applying piezoceramic patches to its structure for possible power generation. The analyzed model is proposed by [2] and described by:

$$
\begin{aligned}
&I\ddot{\varphi} + \mu\dot{\varphi} + c(\varphi+\theta) - \mathrm{p}\sin(\varphi+\theta) = \mathrm{c}\,\theta_0 + F_{ext}(\mathrm{t}) + \mathrm{X}v \\
&\dot{v} + \lambda v + \kappa\varphi = 0
\end{aligned} \tag{1}
$$

where θ_0 is an initial imperfection (for a perfect model $\theta_0 = 0$); φ, $\dot{\varphi}$ and $\ddot{\varphi}$ represent the perturbed displacement, velocity and acceleration, respectively, *I* is the generalized inertia, μ is the damping coefficient *p* is the load parameter and *g* is the acceleration of gravity. , χ is the coupling term of the piezoelectric, *κ* is the reciprocal temporal constant in electrical circuit, $\lambda \approx 1/RC$ is the reciprocal of the dimensionless time constant of electrical circuit, *R* is load resistance, *C* capacitance and ν is the dimensionless voltage in load resistor [2, 3]. Figure (1) represents a scheme of platform structure with a piezoelectric material for energy harvesting.

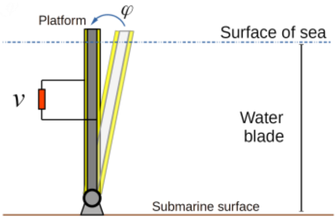

Fig. 1: Scheme of offshore platform structure, adapted to [2].

2. Numerical Results and Discussion

For the numerical analysis of the simplified model, we used the following parameters μ=0.1, c=0.5, θ=0.95, θ_0=0.009485, χ=0.5, $\omega_1=2\pi f_1$, $\omega_2=2\pi f_1+0.2$, $f_1=0.2$, κ=0.05, B=2.5 and γ=0.01. Figure 2. (a) show the basin of attraction for the initial conditions between and with p = 0.5, 2 (b) represents the parameter space of the Lyapunov Maximum Exponent for px A in [0.2.5] x [0, 5] and initial condition [0, 0, 0], 2 (c) show Maximum Lyapunov exponent for A = 2.5 and p in [0.5] and initial condiction [0, 0, 0] , 2 (d) the bifurcation diagram for A = 2.5 and p in [0.5] and initial condiction [0, 0, 0]and 2 (e) the average power of the systems $P_{avg} = \frac{\lambda}{T}\int^{\tau_2} v^2(t)dt$ same initial con

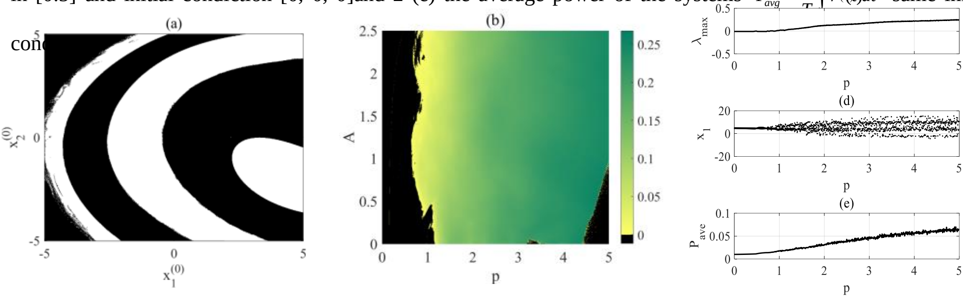

Fig. 2: (a) Basins of attraction of eqs. (1), (b) Maximum Lyapunov Exponent p x A in [0, 2.5]x[0,5], (c) Maximum Lyapunov Exponent for A=2.5 and p in [0,5] ,(d) Diagram Bifurcation for A=2.5 and p in [0,5] and (e) Average Power for A=2.5 and p in [0,5]

3. Concluding Remarks

We analyzed basins of attraction for p = 0.5, which revealed the emergence of two attractors. In this way, we establish the initial condition [0,0,0] and analyze the Maximum Lyapunov exponent for parameters A (amplitude of the sea wave) and p (the damping coefficient of the structure) and determine the chaotic and periodic regions. with this we calculate the average power for p at [0.5] and for values of p → 5 there is an increase in the average power of the system with a value of A = 2.5. Future works will be related to erosion of the basis of attractions.

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