Duffing Oscillator
Group Project

AC Course Naples 2017 - Analysis & Control of Complex Systems

Group 3 – Team Members

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Duffing Oscillator – Characteristics & Description

- mathematical model

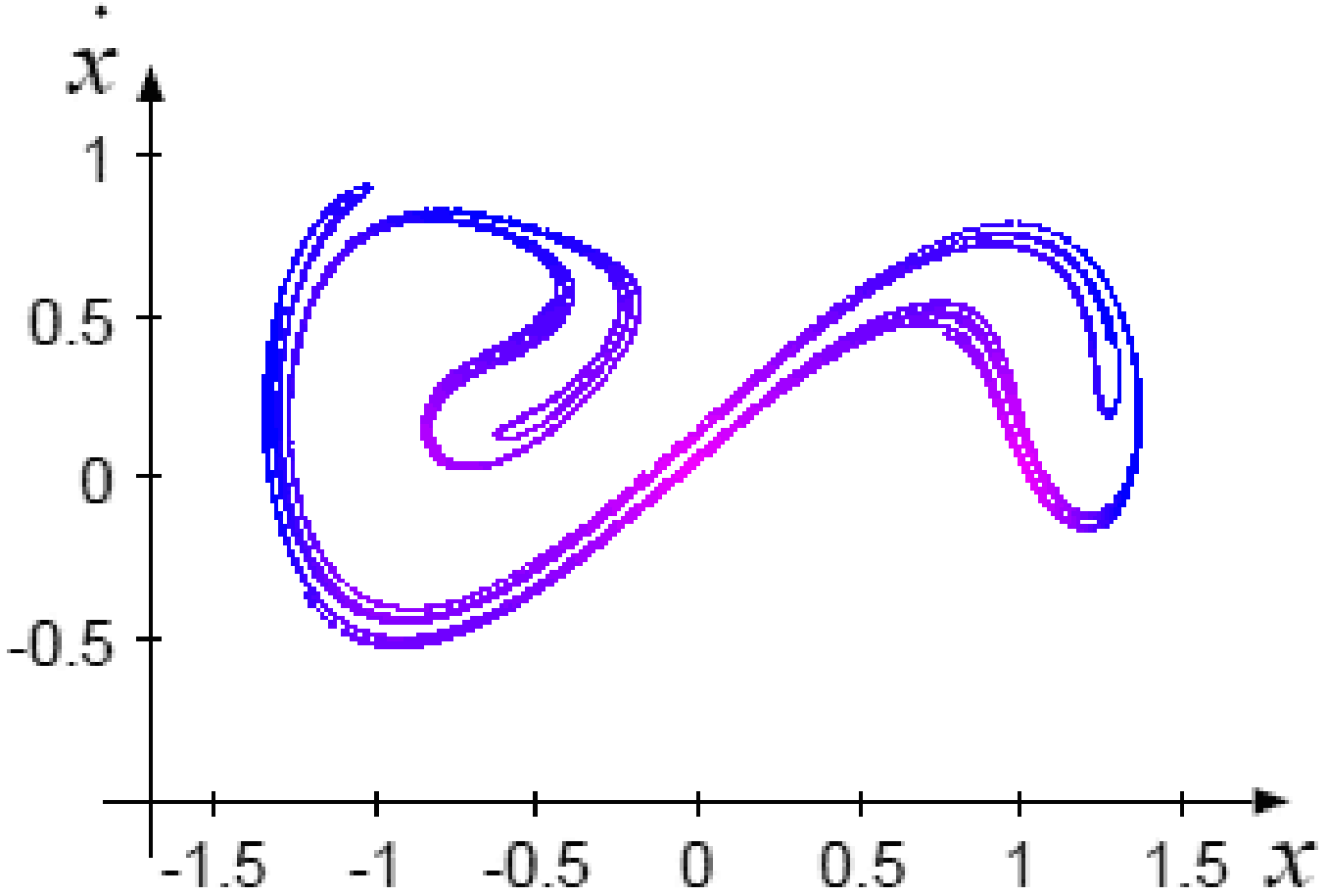
$$\begin{cases} \dot{x}_1 = x_2 \\ \dot{x}_2 = -\delta x_2 - \beta x_1 - \alpha x_1^3 + \gamma \cos(\omega t) \end{cases}.$$

- an example of a dynamical system that exhibits chaotic behavior

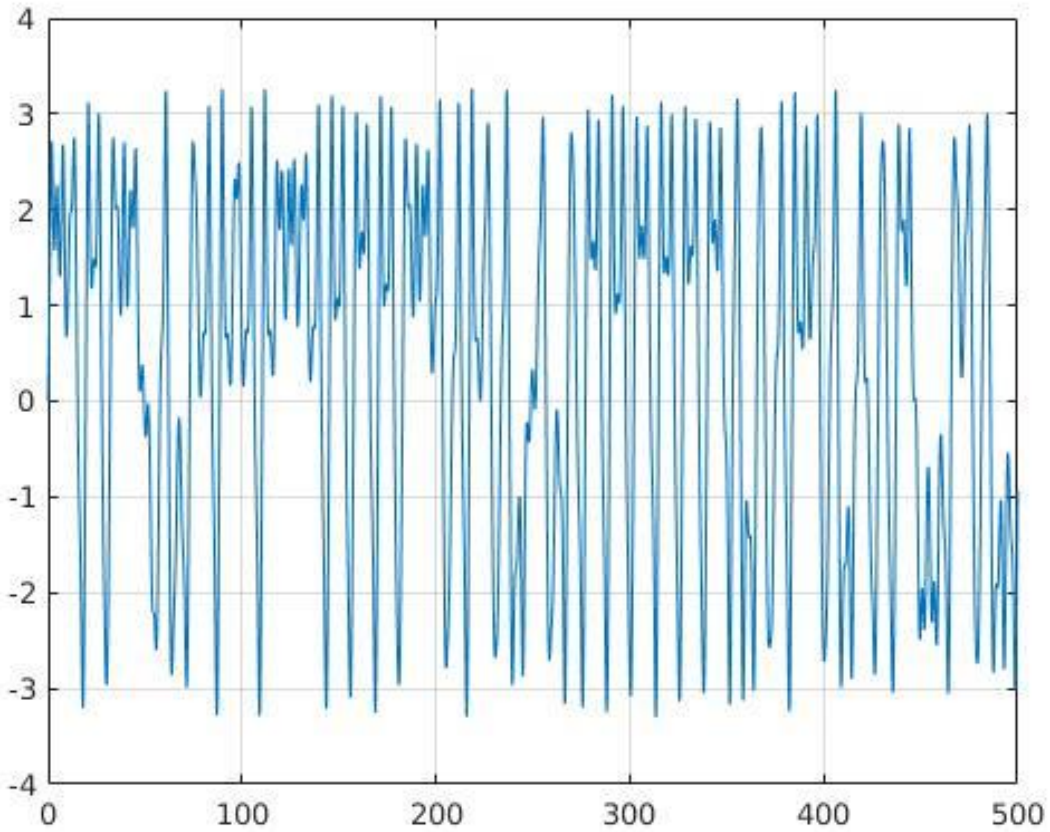
History & Interpretation

- introduced by Georg Duffing (1861–1944)
- describe the oscillations of a mass attached to a nonlinear spring and a linear damper

Duffing Oscillator – Phase Diagram

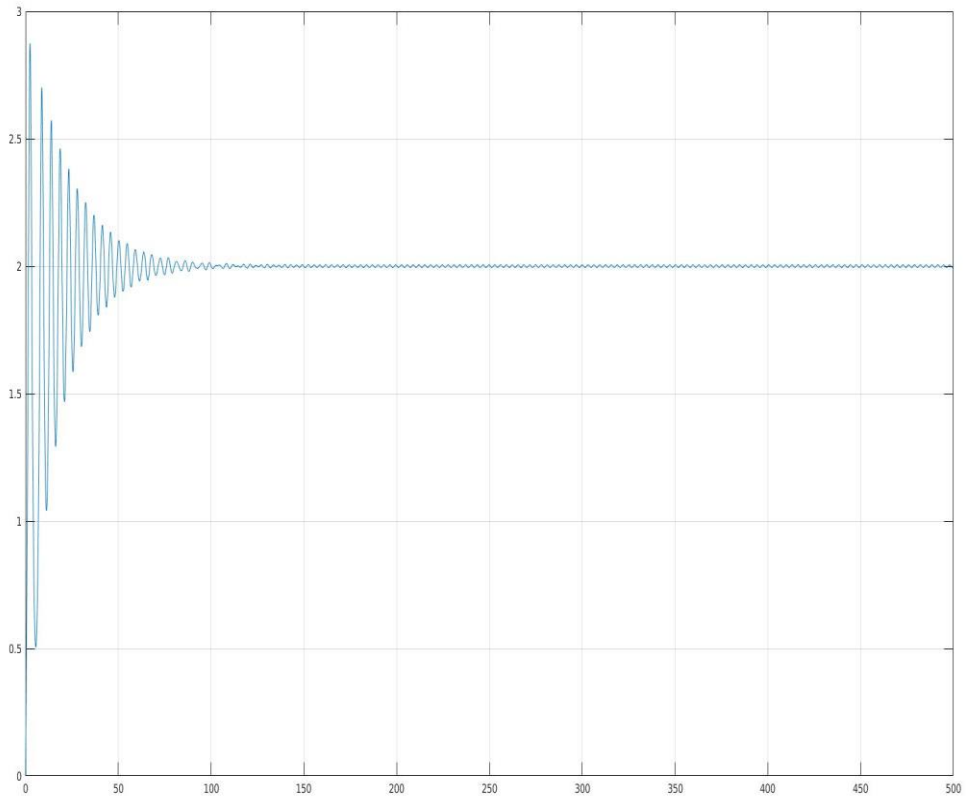


Duffing Oscillator – System Simulation



Chaotic Behaviour

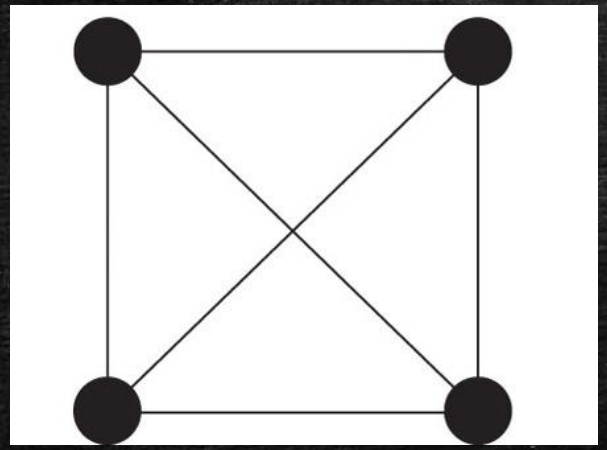
alpha = 0.25 , beta = - 1, **gamma = 1.5**, delta = 0.1, omega = 2



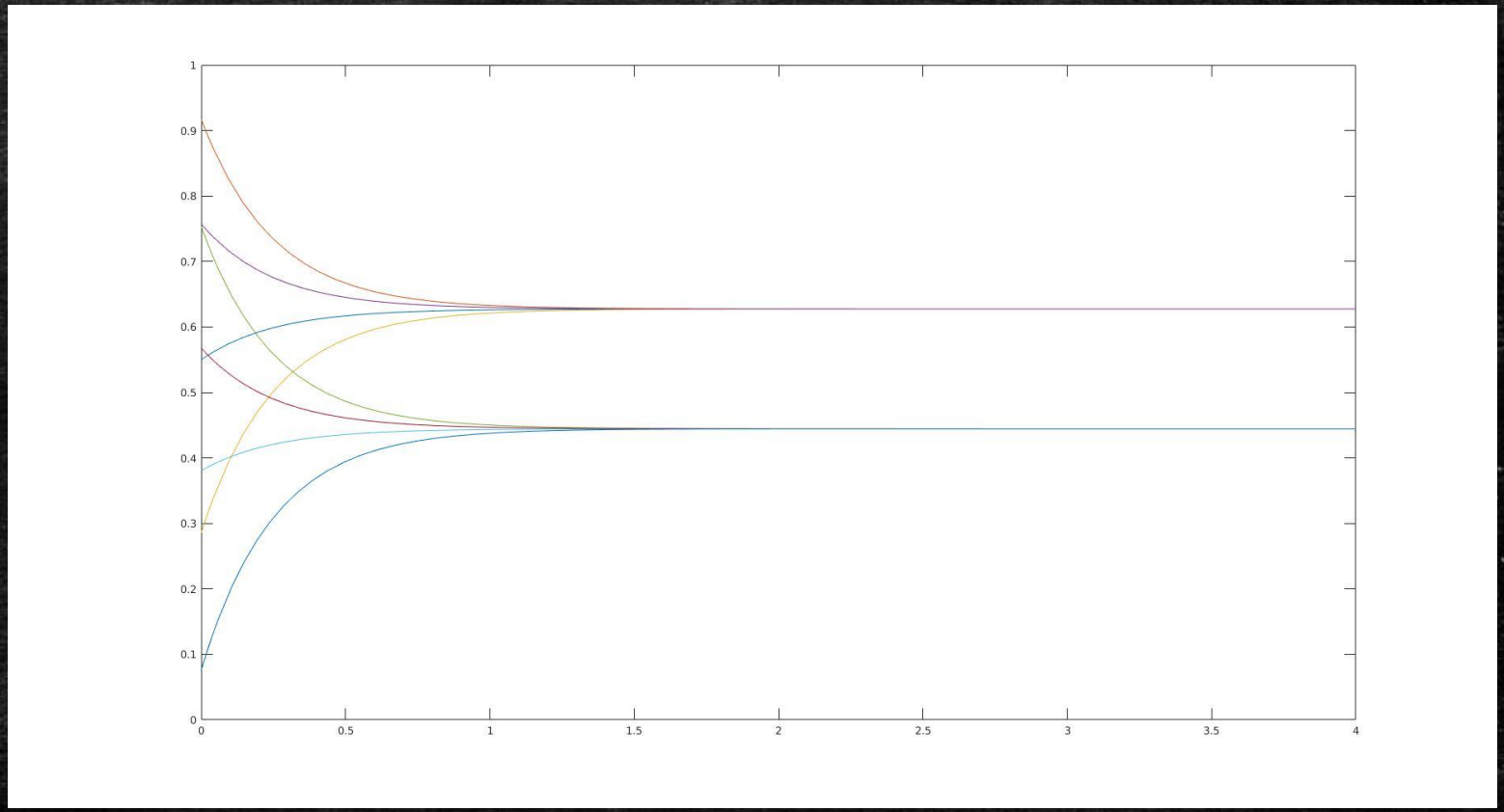
Stabilized Harmonic Behaviour

alpha = 0.25 , beta = - 1, **gamma = 0.01**, delta = 0.1, omega = 2

Duffing Oscillator – All-to-all Network

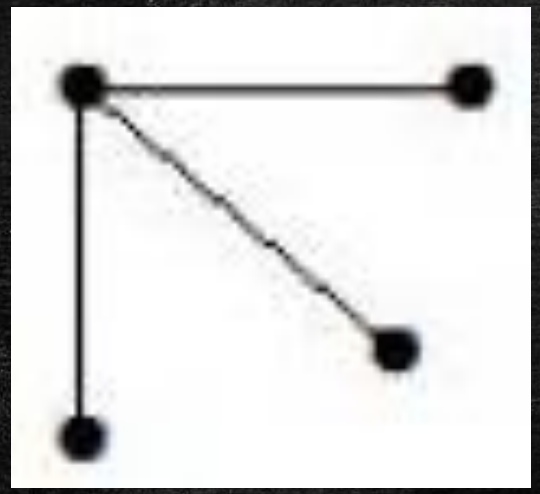


All-to-all Network Topology
with four nodes

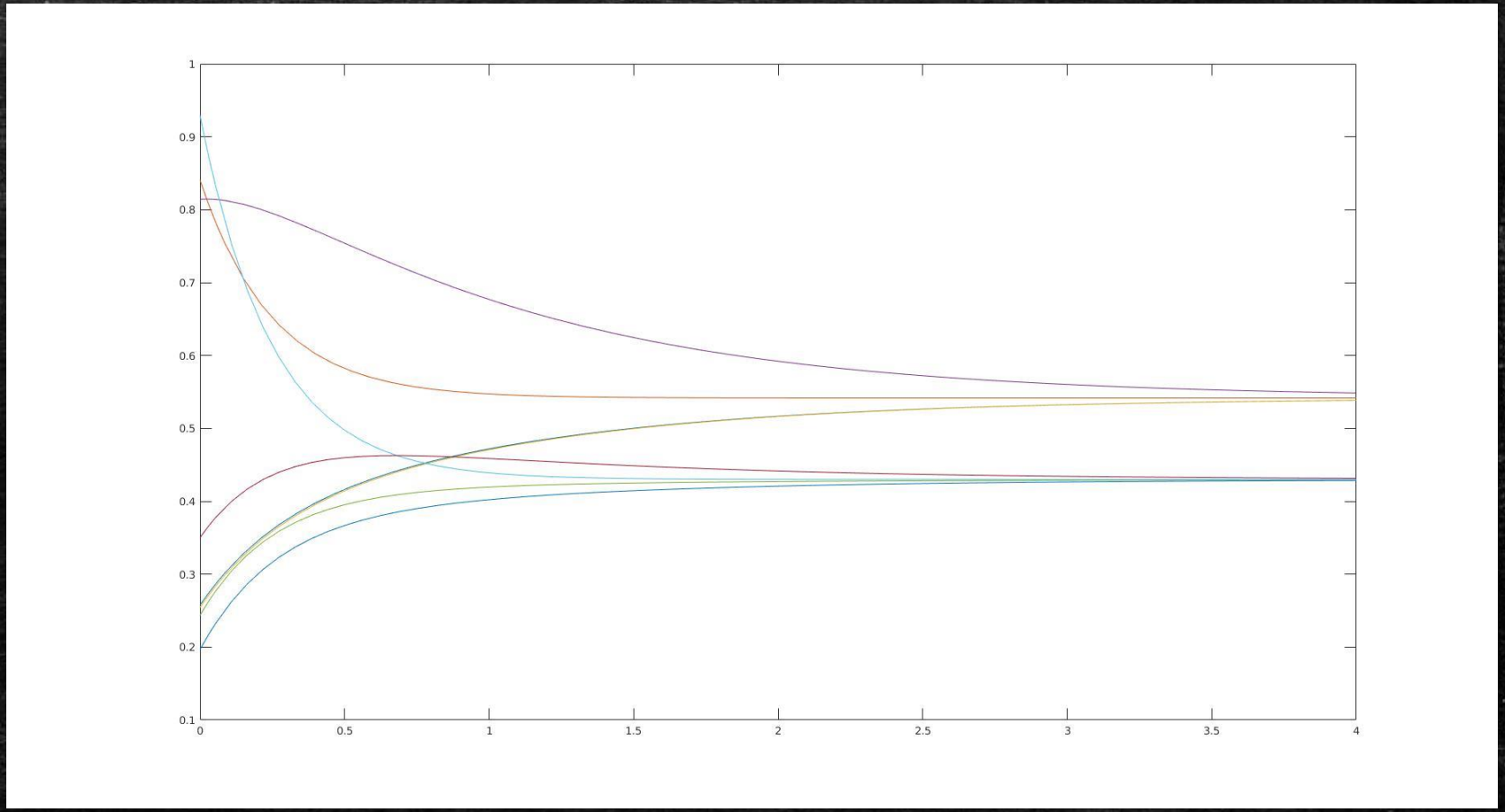


Simulink Model Output

Duffing Oscillator – Star Network

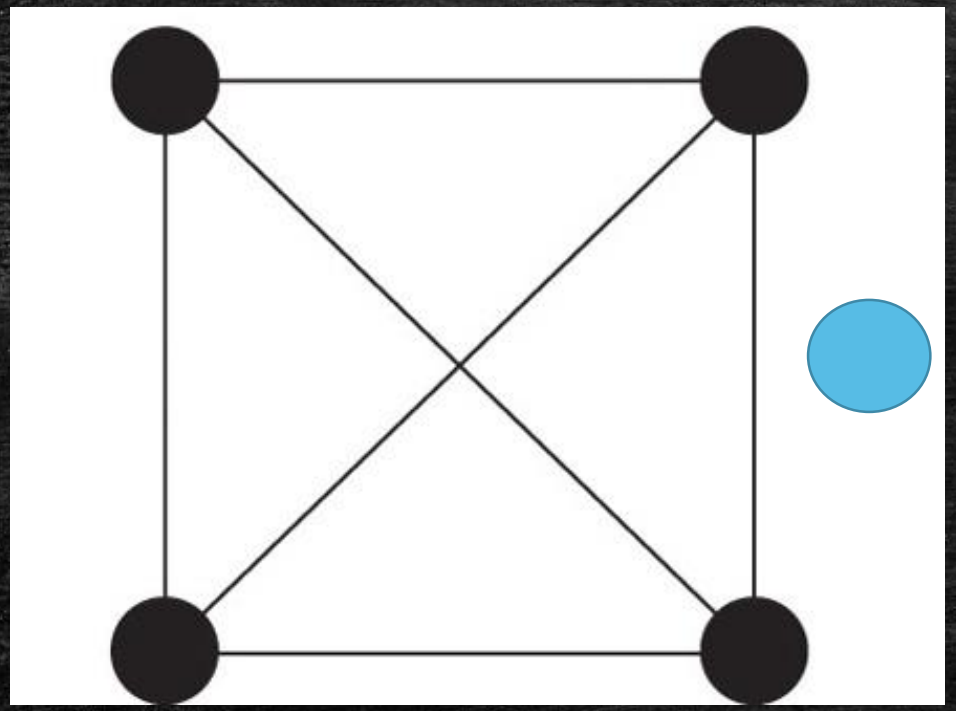


Star Network Topology
with four nodes



Simulink Model Output

Duffing Oscillator – All-to-all Network + Pinner



All-to-all Network Topology
with four nodes

+ Pinner

$$C = (B, AB, A^2B, \ldots, A^{N-1}B) \quad (2)$$

$$\text{rank}(C) = N \quad (3)$$

Controlability Condition

Thank you for attention!