# Nonlinear Vibrations of Aerospace Structures

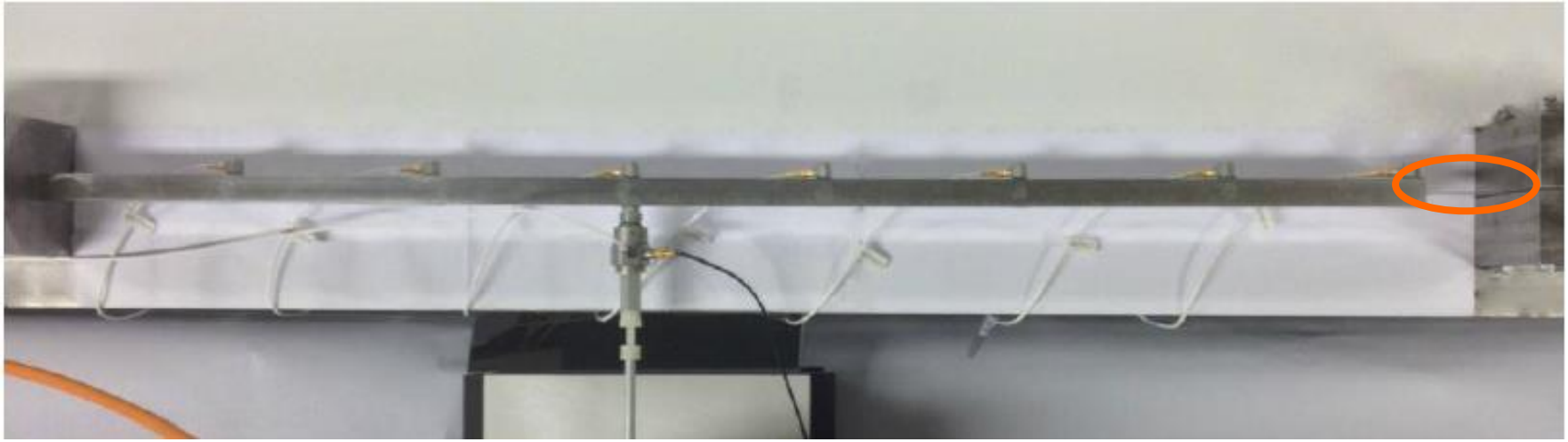
University of Liège, Belgium

**T02** **Nonlinear FRFs**

Nonlinear symptoms

Nonlinear Identification to Design
Software

# Nonlinear Model of the 1st Beam Mode

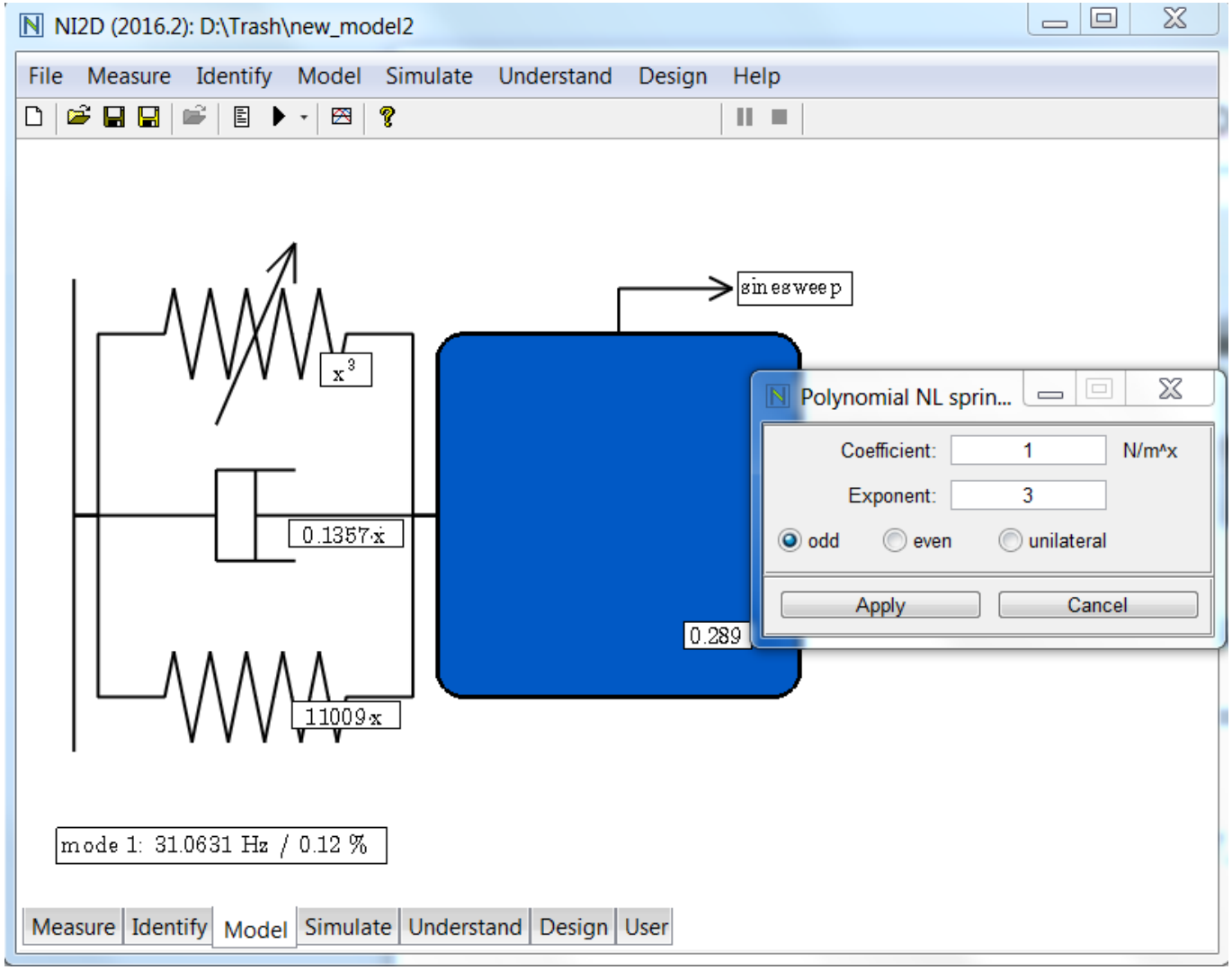


Linear model identified at low level (31 Hz, 0.12%):

$$0.289\ddot{x} + 0.1357\dot{x} + 11009x = Fsin\omega t$$

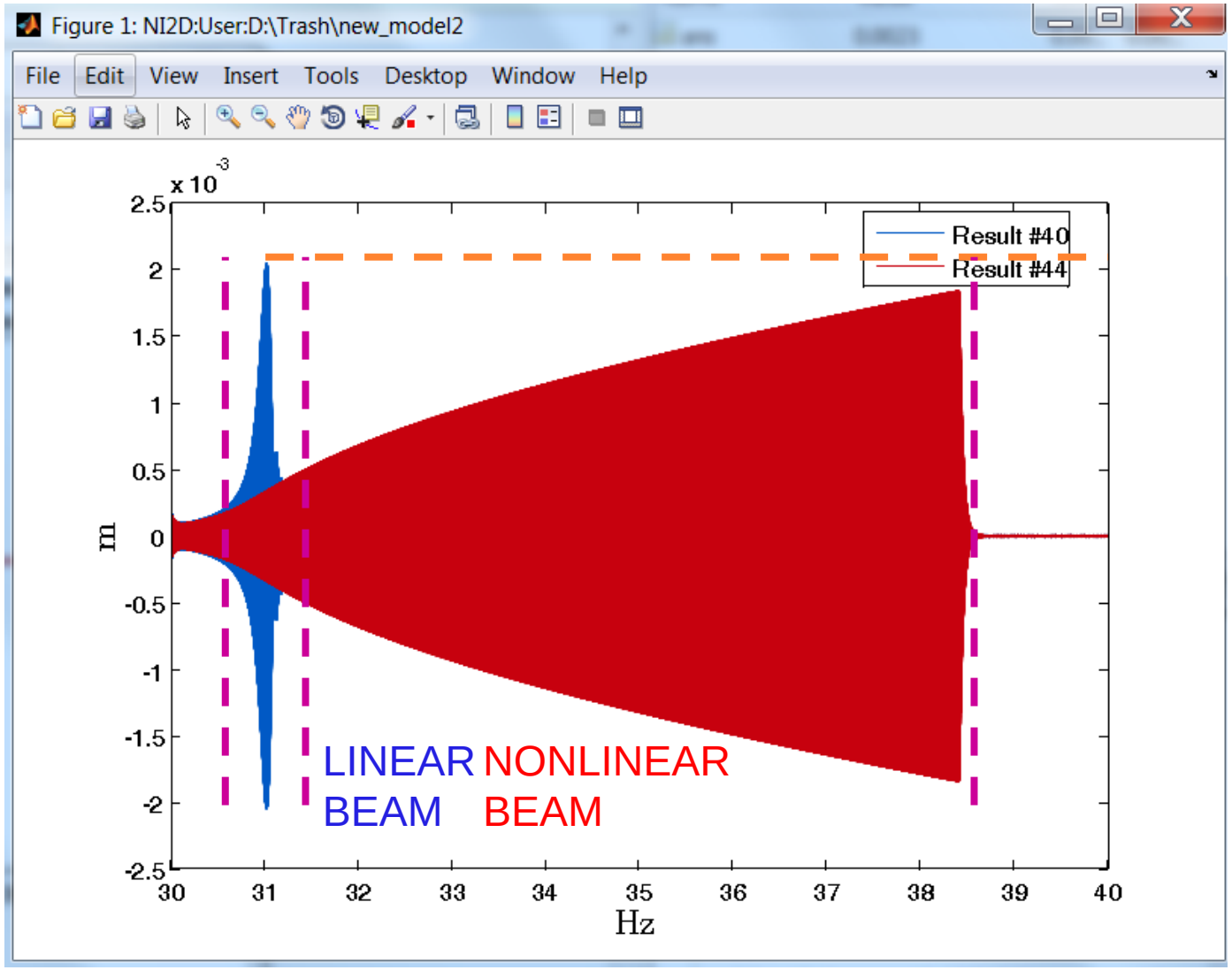
Nonlinearity identified at high level: $2.37.10^9\, x^3$

# We Built the Model in NI2D

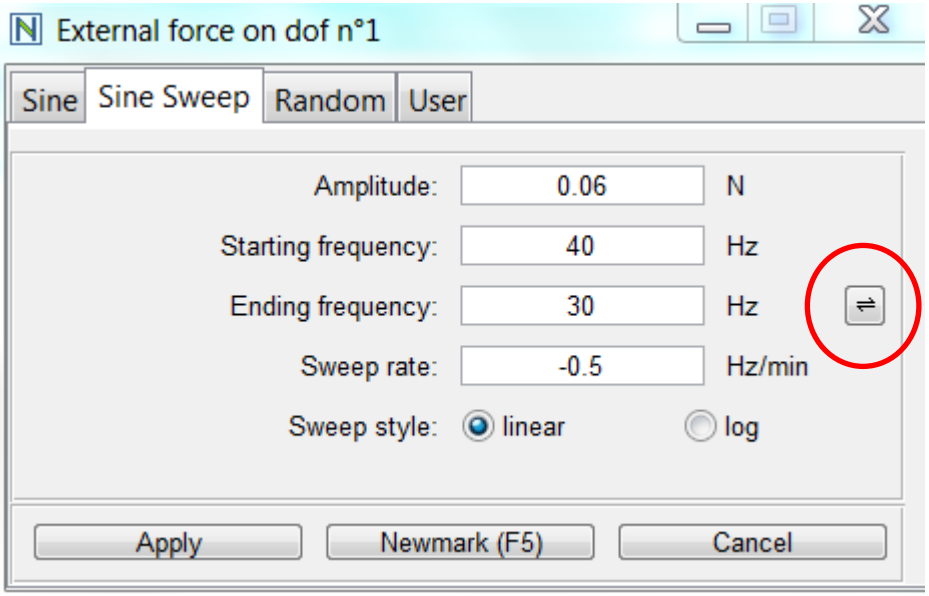


# 2.1: let’s revisit what we observed last week

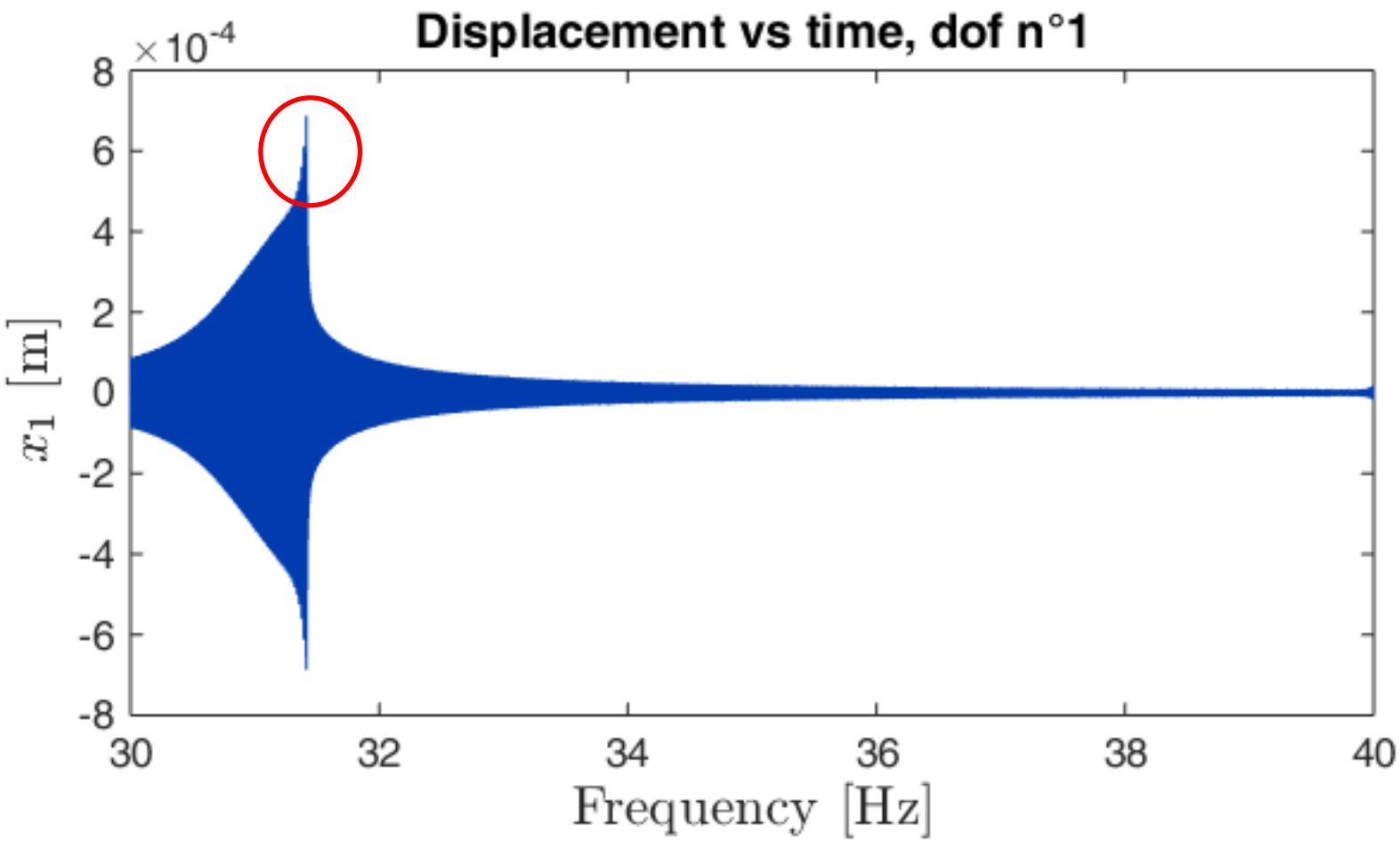
# Nonlinearity Introduces a Fundamental Change



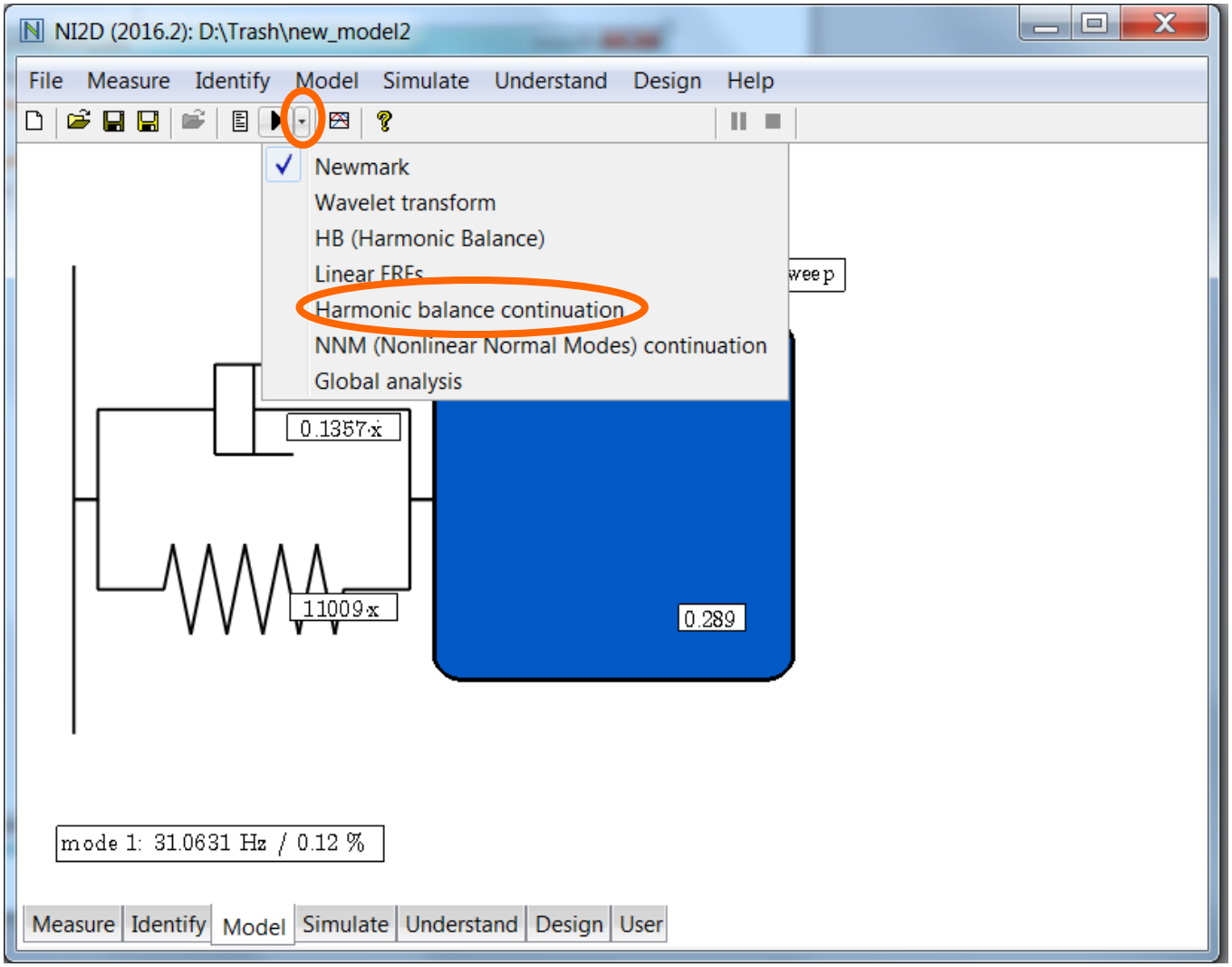
# Let’s Reverse the Sweep.



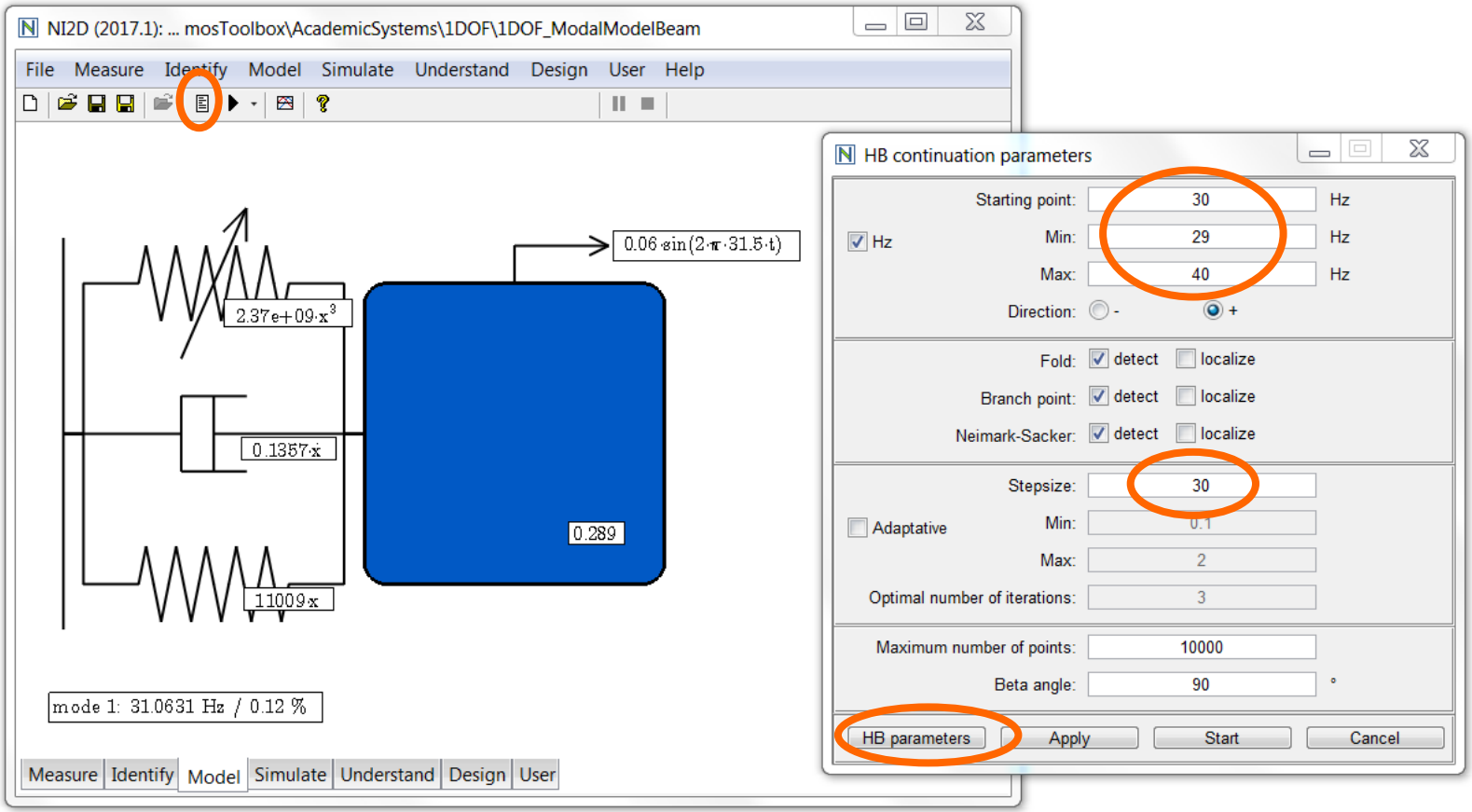
# We Can Jump Up Too !



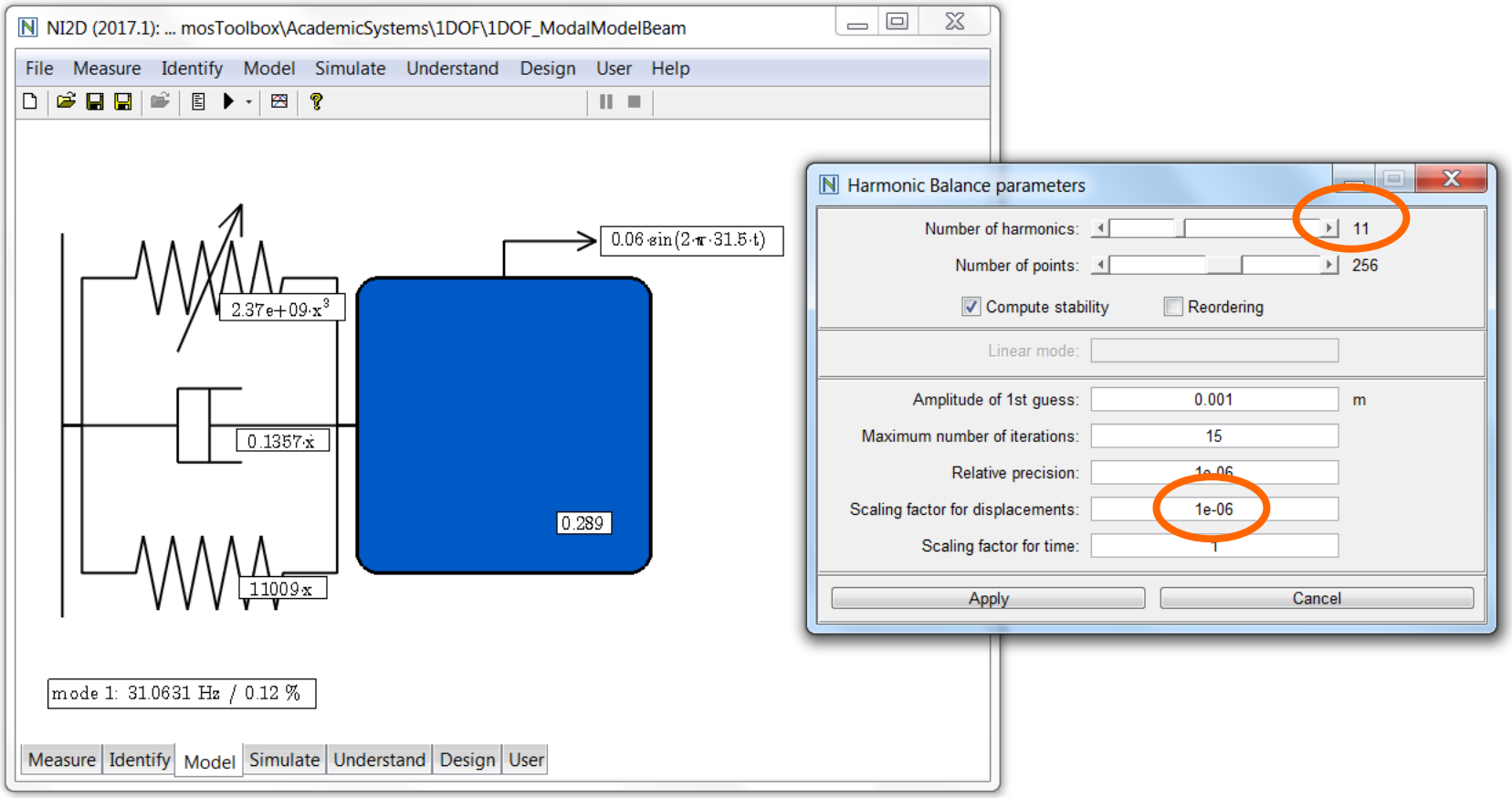
# Calculate the Nonlinear FRF



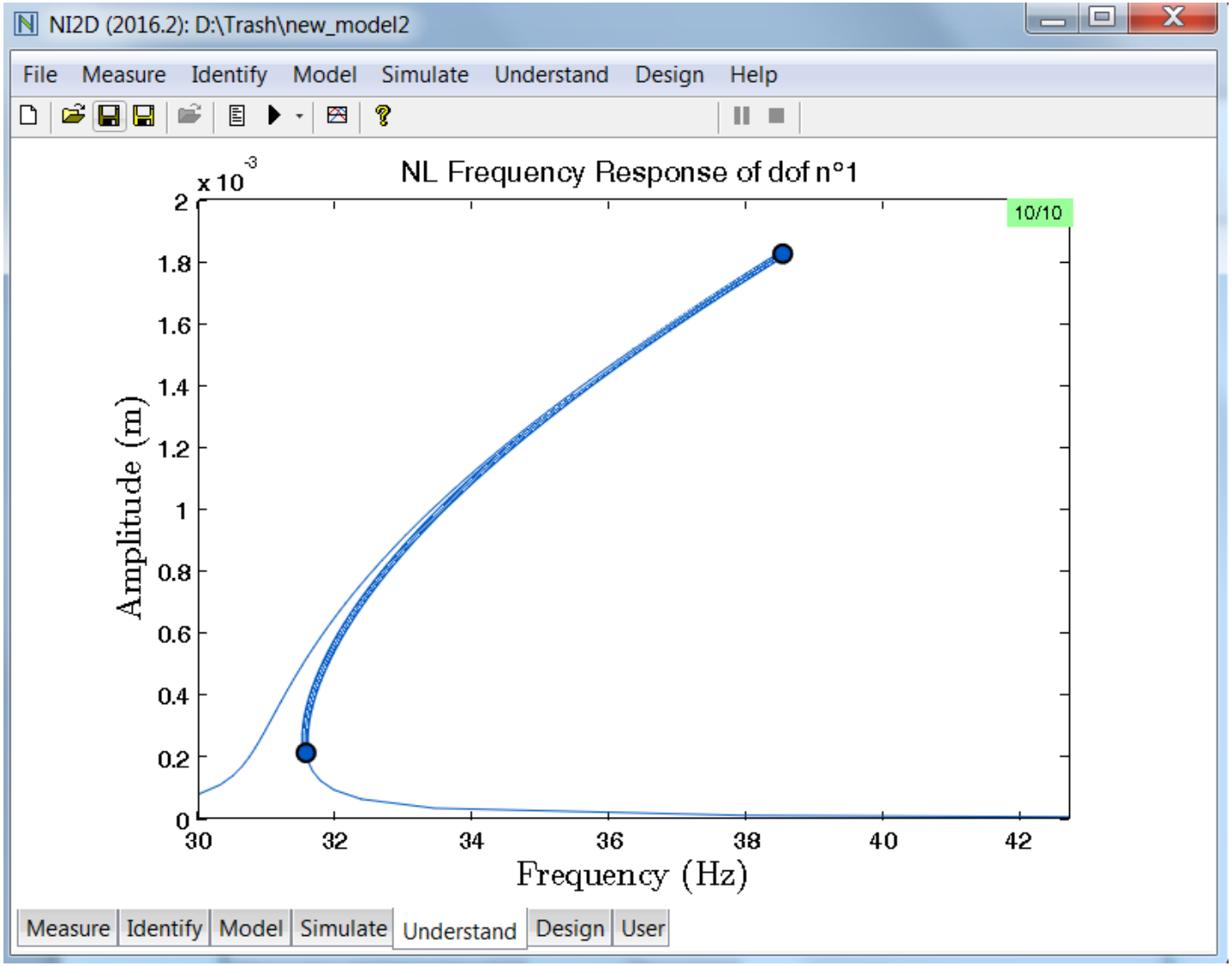
# Set Appropriate Numerical Parameters



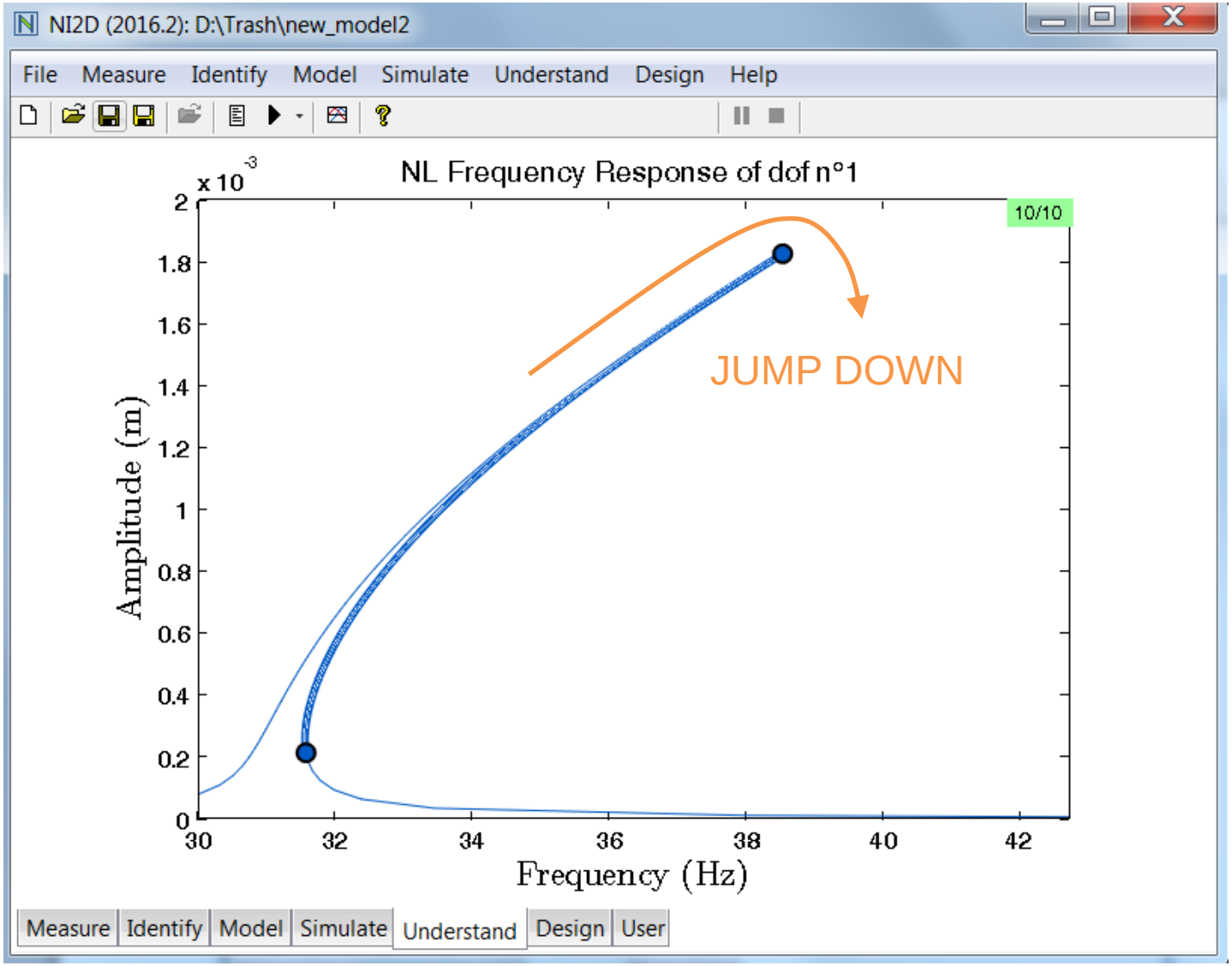
# Set Appropriate Numerical Parameters



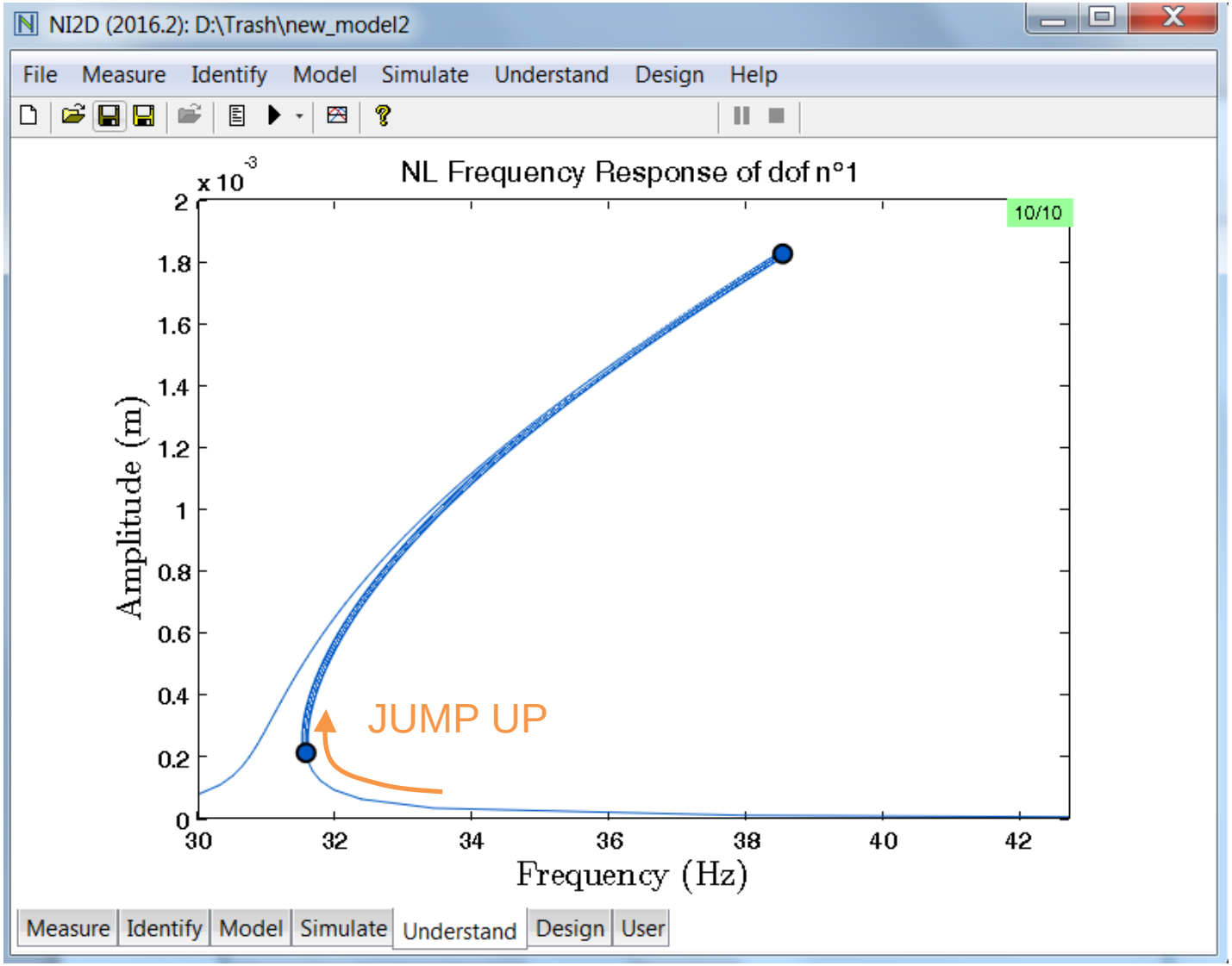
# The Nonlinear FRFs



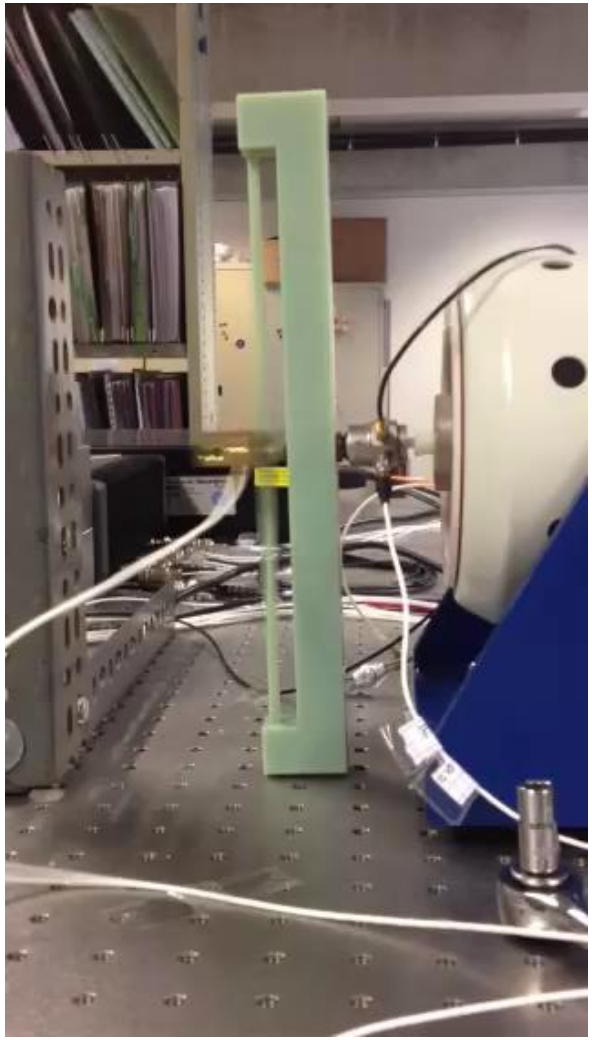
# The Jump Phenomenon Can Be Understood

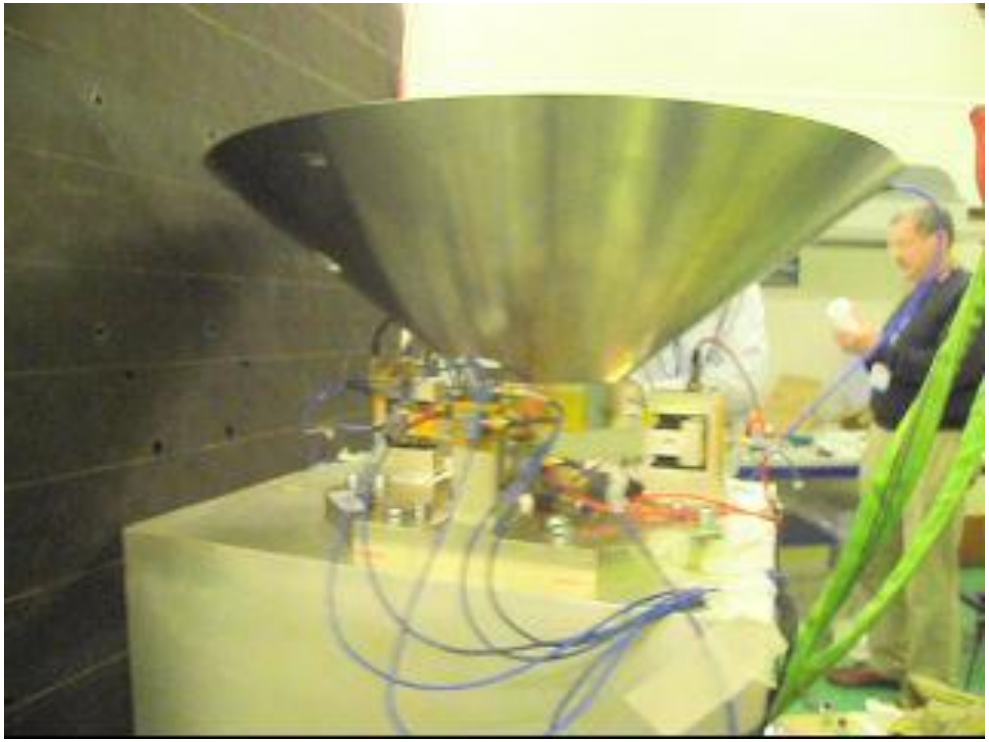


# The Jump Phenomenon Can Be Understood



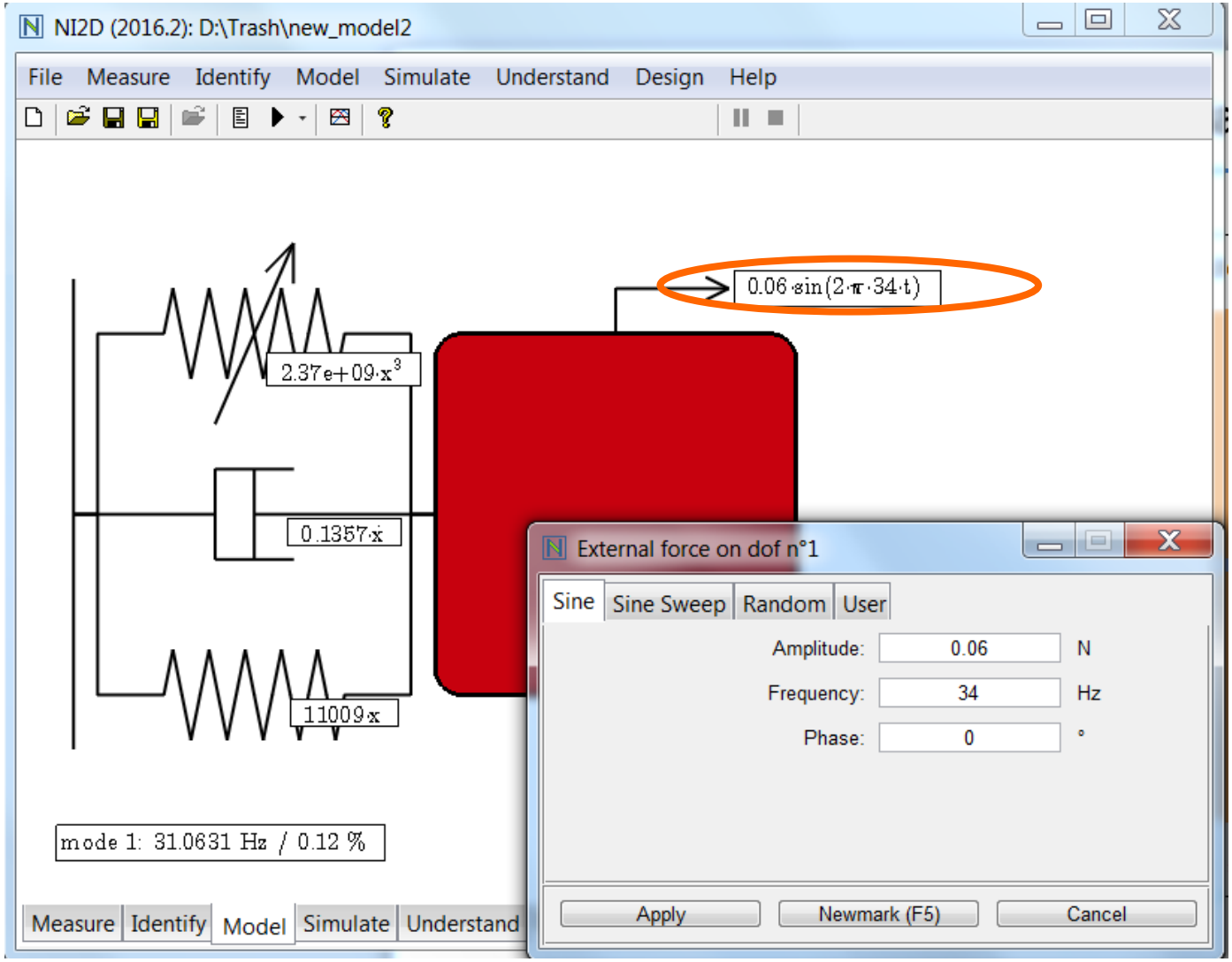
# The Jump Phenomenon in Practice



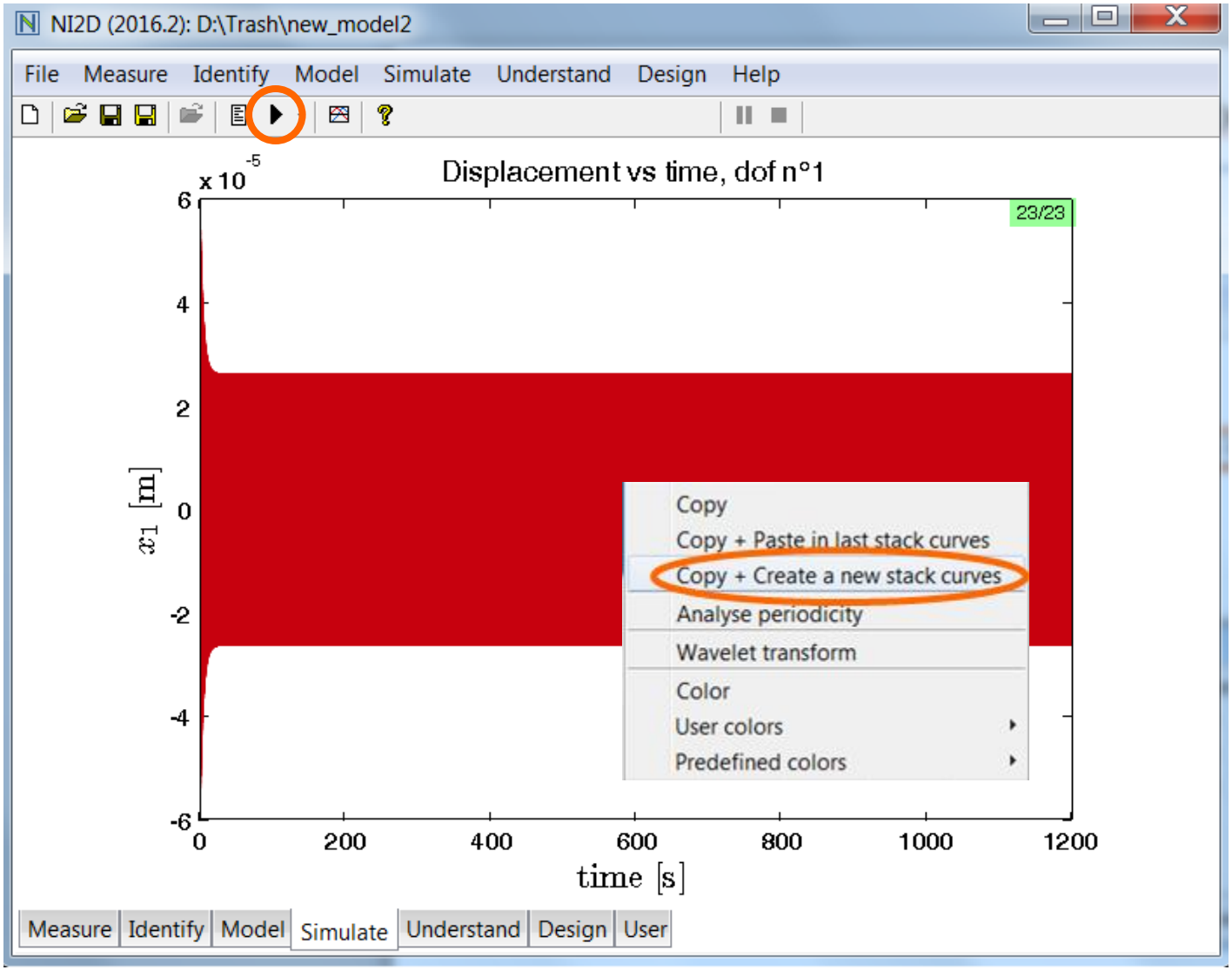


# 2.2: sine with a fixed frequency in the multi-valued region

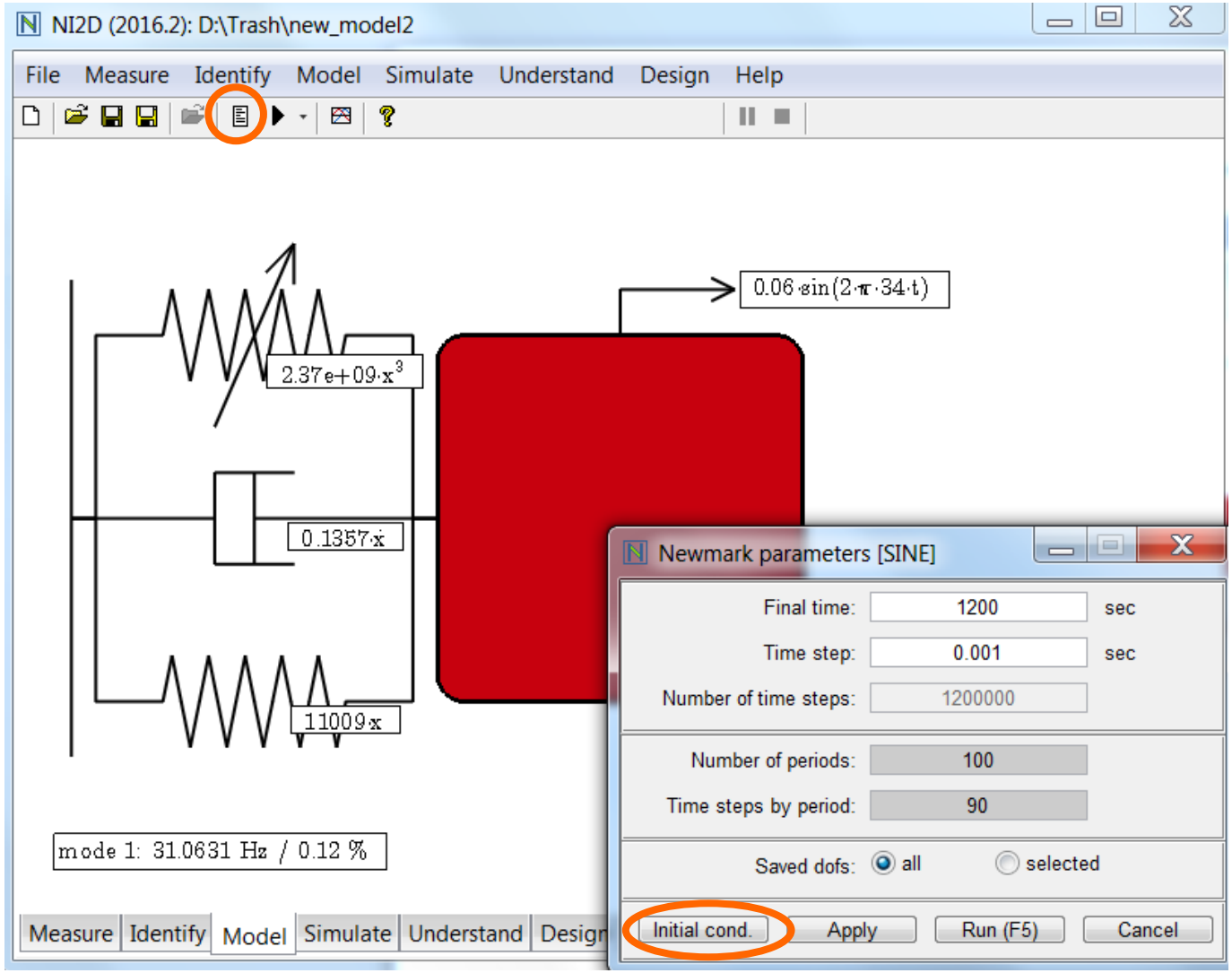
# Consider an Excitation with a Fixed Frequency



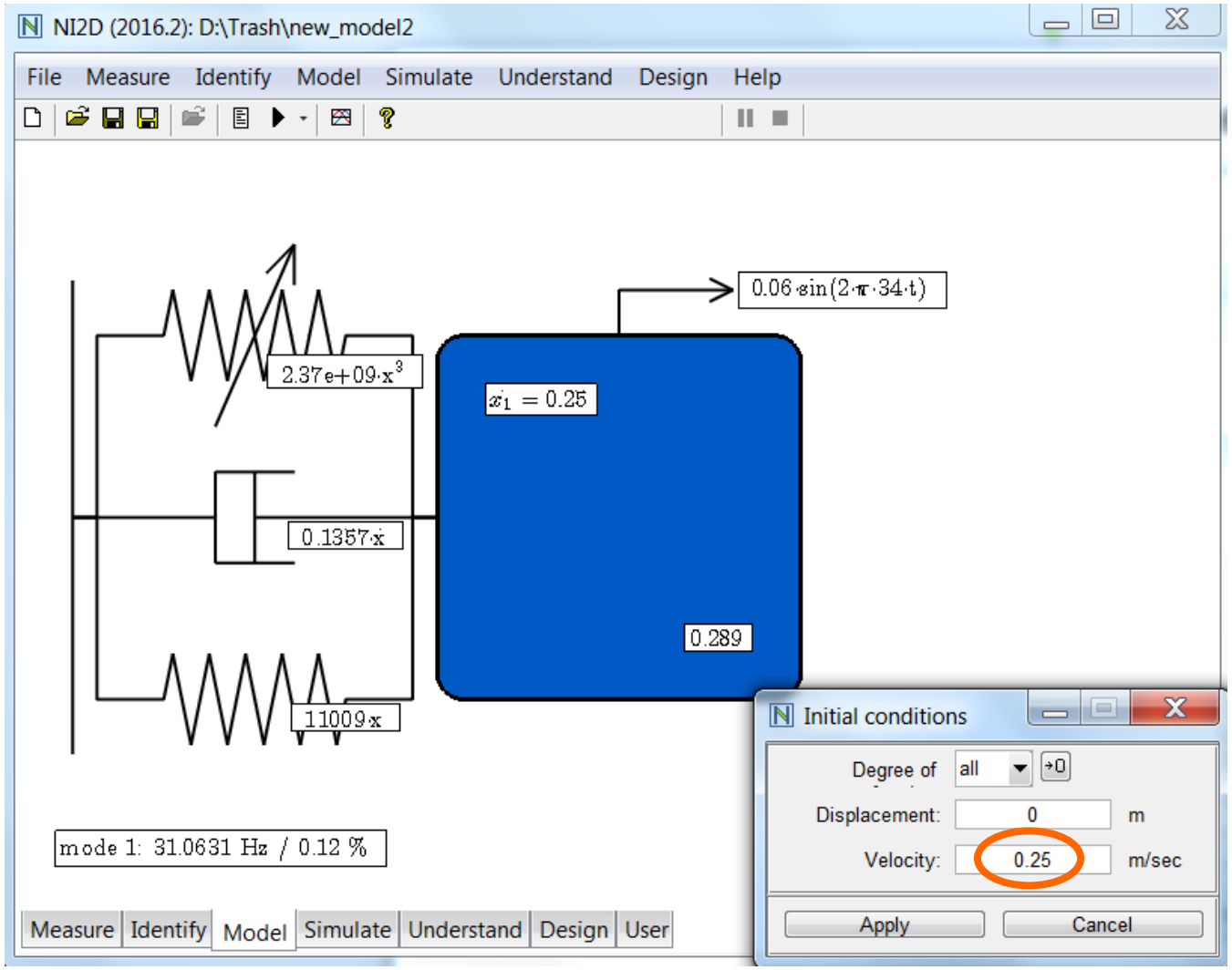
# Run and Save


NI2D (2016.2): D:\Trash\new_model2
File
Measure
Identify
Model
Simulate
Understand
Design
Help
Displacement vs time, dof n°1
x 10^-5
23/23
x1 [m]
time [s]
Copy
Copy + Paste in last stack curves
Copy + Create a new stack curves
Analyse periodicity
Wavelet transform
Color
User colors
Predefined colors
Measure
Identify
Model
Simulate
Understand
Design
User

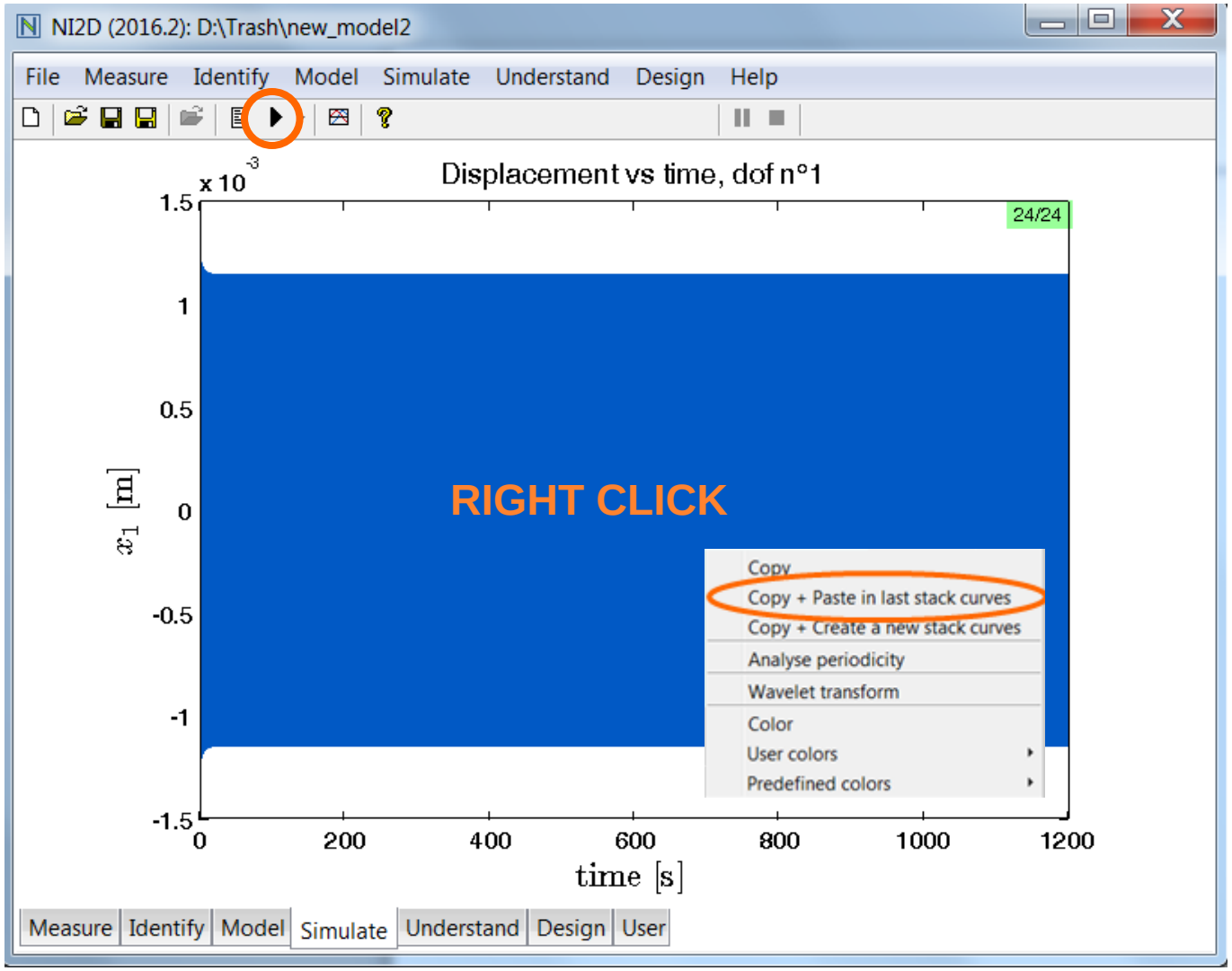
# Change Initial Conditions



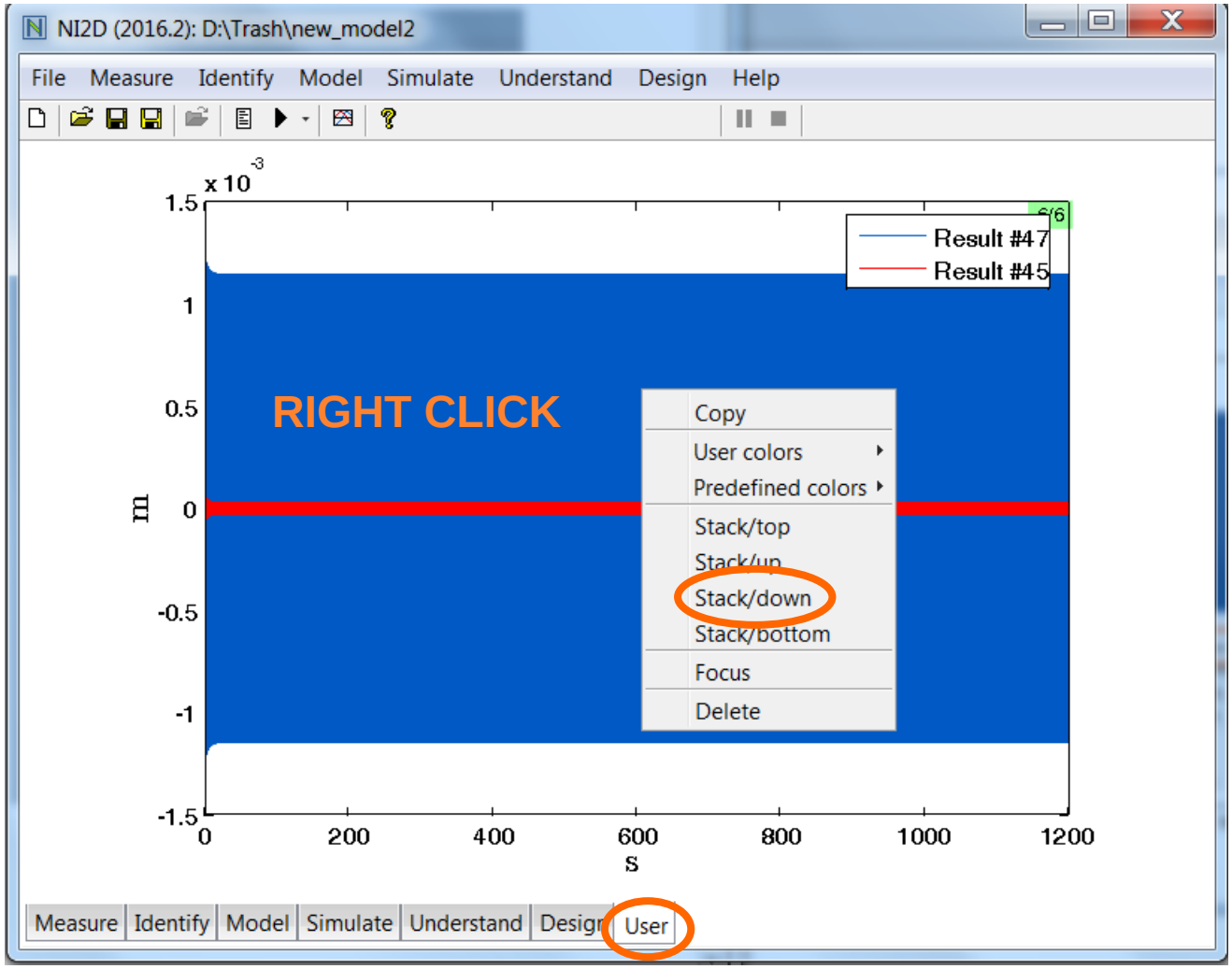
# Apply Initial Impulse and Change Colors



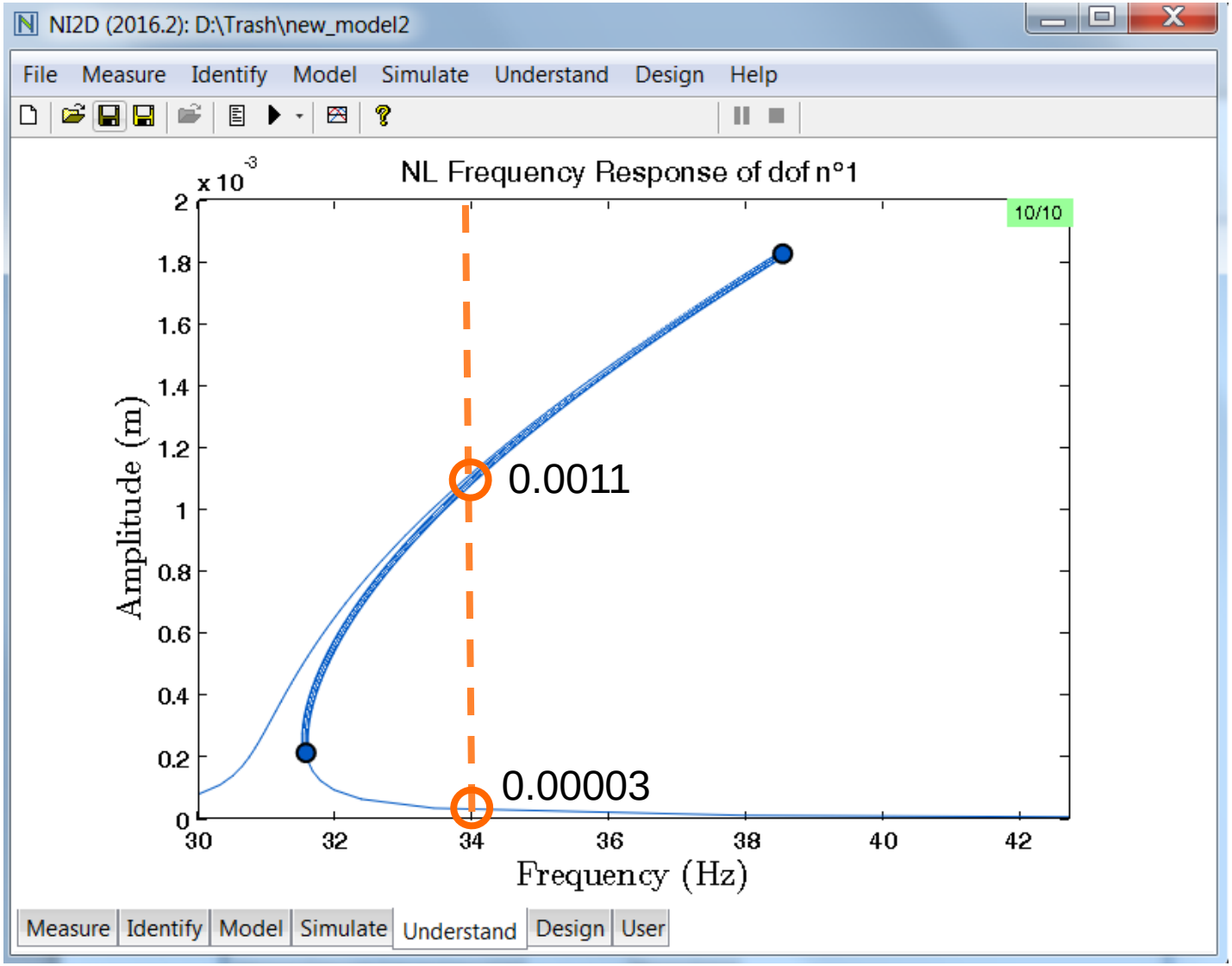
# Run and Compare



# What Do You Think ?

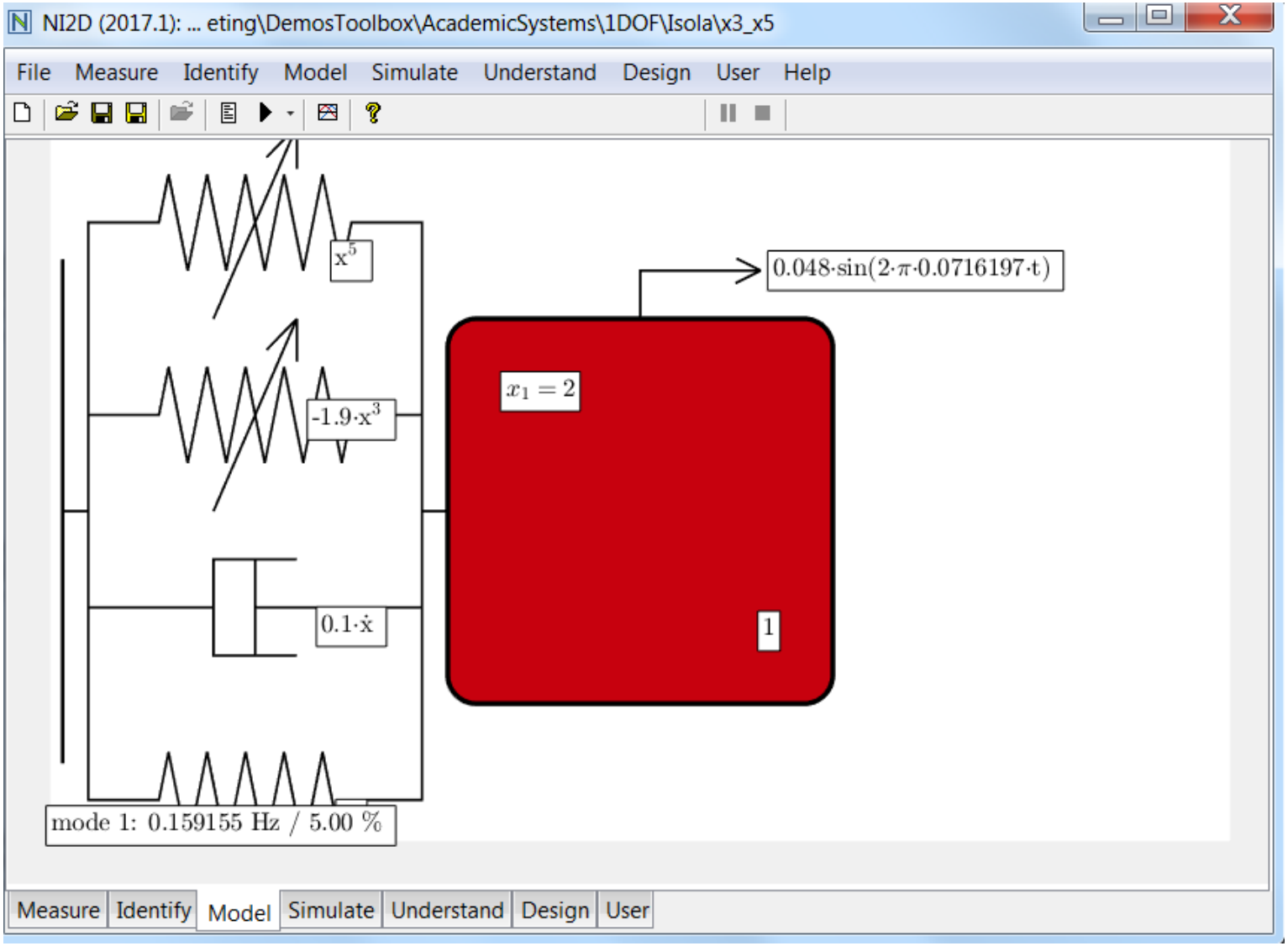


# Usefulness of Nonlinear FRFs

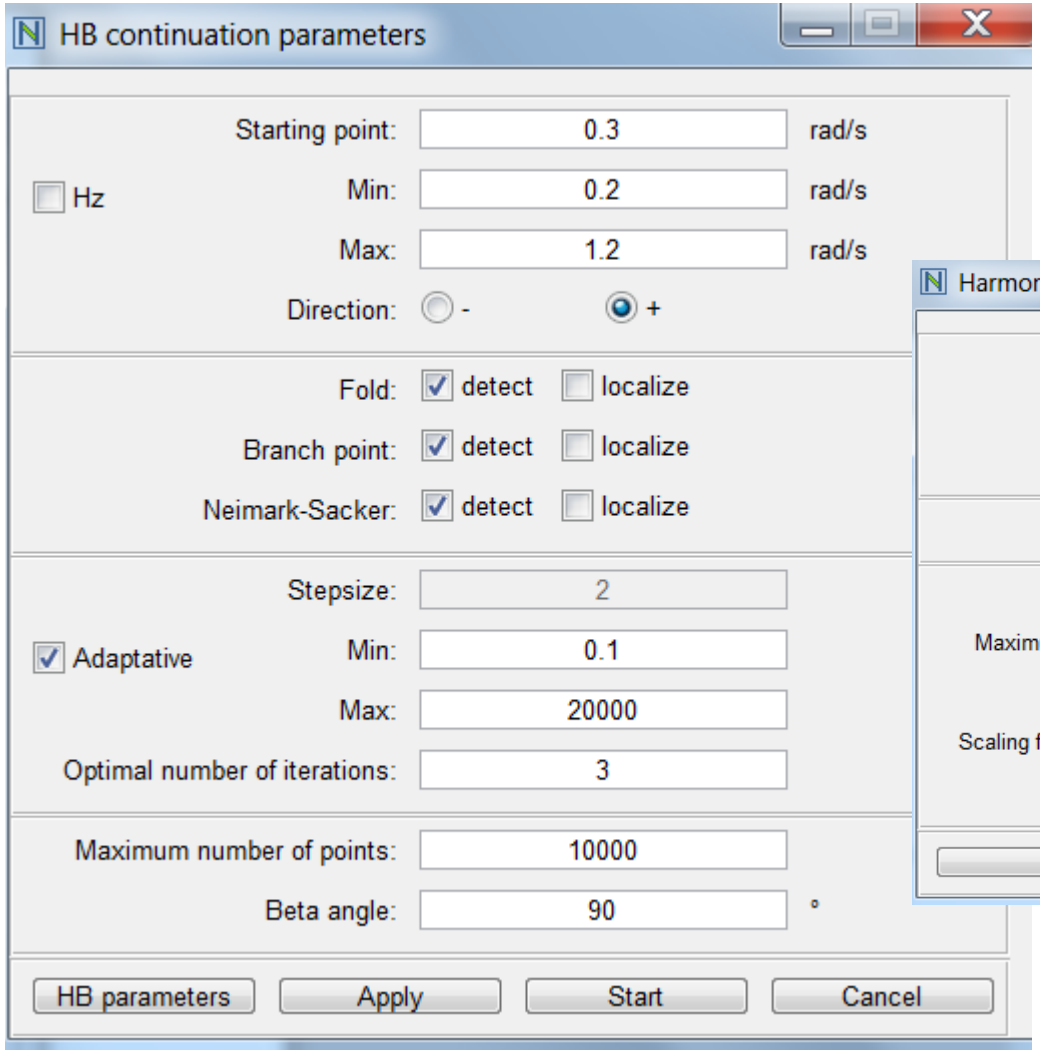


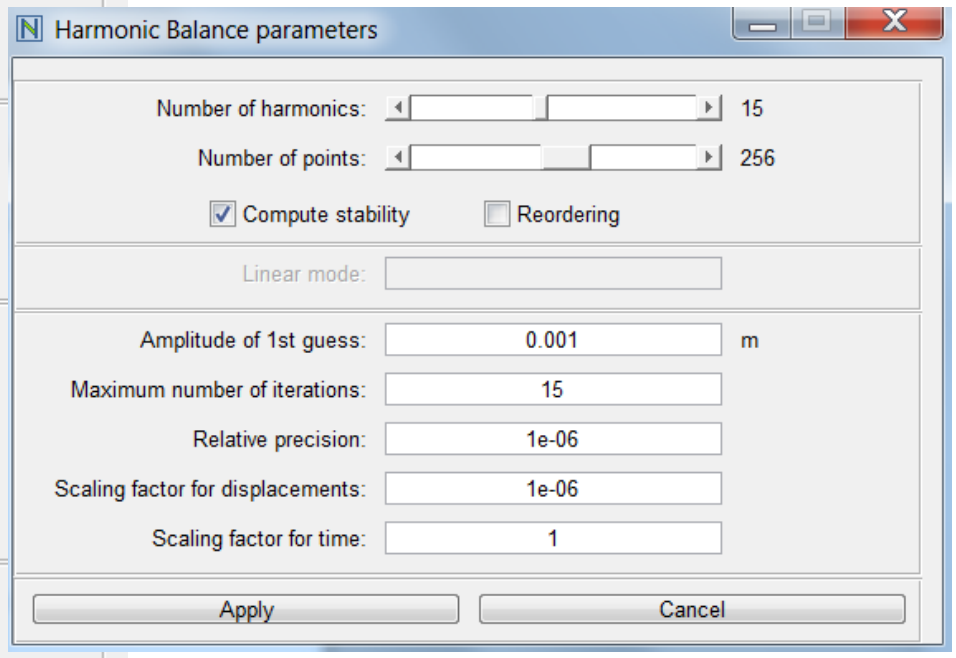
# 2.3: a new puzzling result

# Create a New System in NI2D

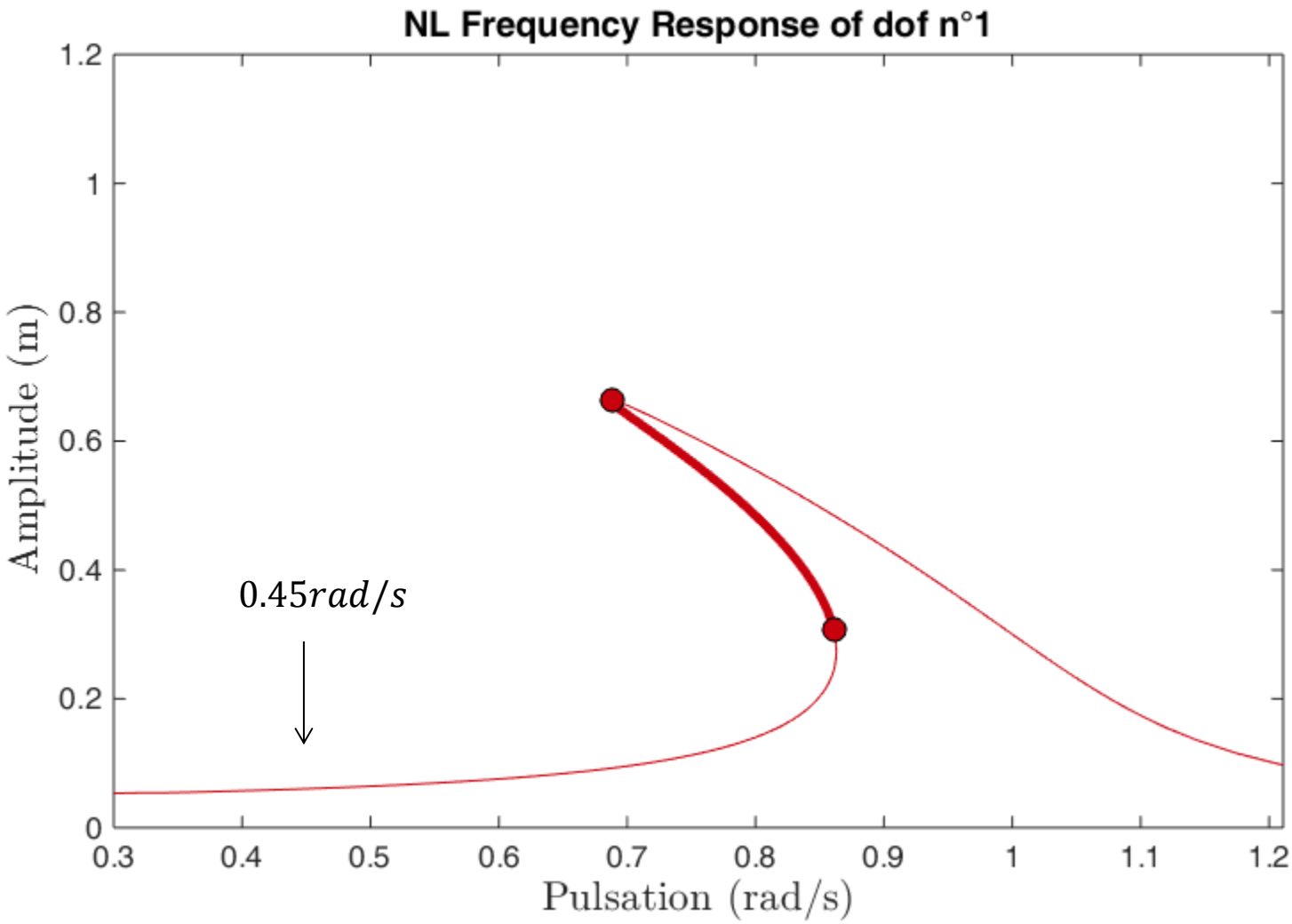


# Parameters for Nonlinear FRF Calculation

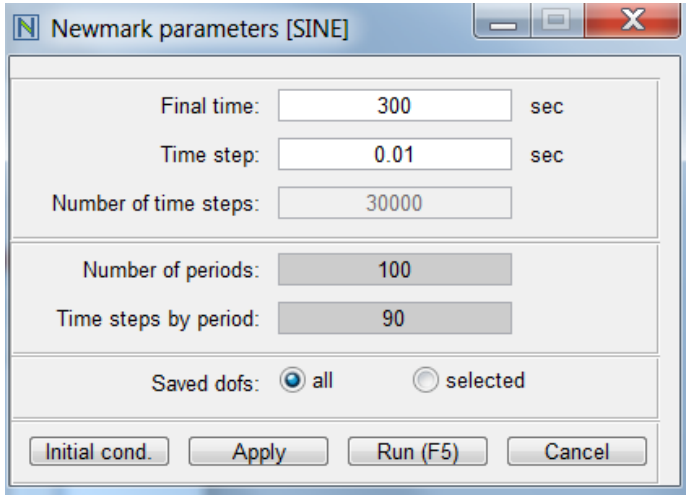


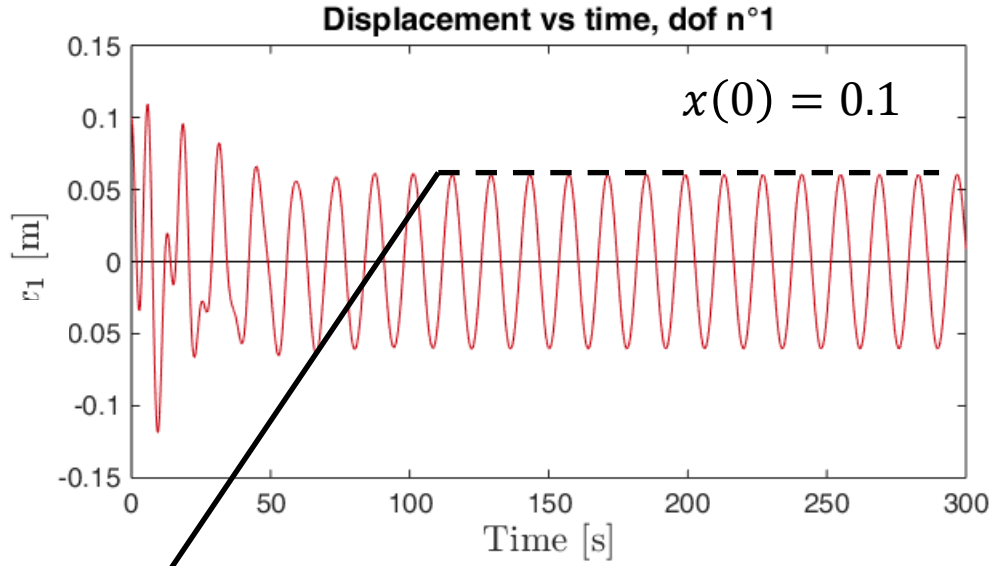



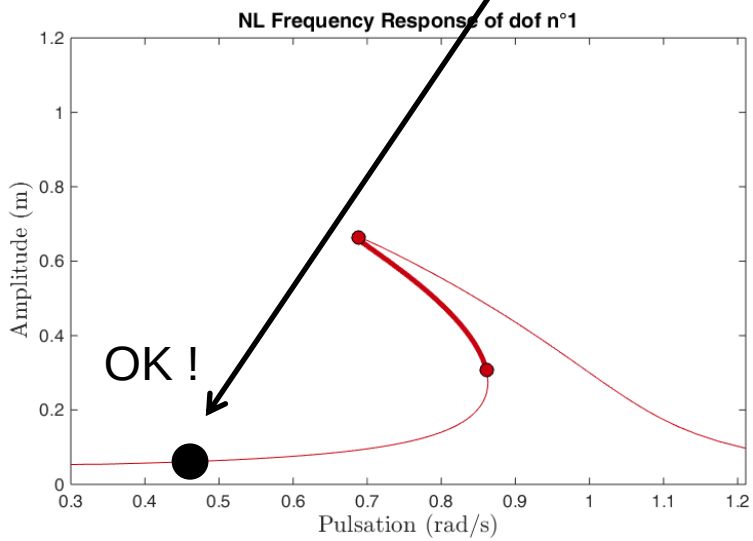
# The Nonlinear FRF



# First Nonlinear Time Integration



# Second Nonlinear Time Integration