



ABCDE



## Scientific Report

First name / Family name

Marialena Vagia

Nationality

Greek

Name of the *Host Organisation*

Norwegian University of Science and  
Technology /Department of  
Engineering Cybernetics

First Name / family name  
of the *Scientific Coordinator*

Jan Tommy Gravdahl

Period of the fellowship

10/10/2011 to 09/10/2012



## I – SCIENTIFIC ACTIVITY DURING YOUR FELLOWSHIP

During the scholarship period I worked in the area of control of nanopositioning devices. Nanotechnology science involving imaging, measuring, modeling and manipulation of devices and materials at nanoscale, demand great requirements for properties like high resolution, accuracy, stability and fast response. In that sense implementation of control techniques for such structures is fundamental. To that sense, two different control approaches have been examined and proposed as an outcome of the fellowship period for a nanopositioning device that already existed in the Nano – Lab of Department of Engineering Cybernetics NTNU.

The performance and accuracy of nanopositioning applications can be inhibited by the presence of non-ideal characteristics such as creep, hysteresis and mechanical resonance. Taking into account the previous stated facts, in the beginning a force feedback controller was designed and applied to a nanopositioning device in order to achieve both tracking and damping. The actuator's load force is used as a feedback variable to the system whose transfer function from the applied actuator load to the measured load force, exhibits zero-pole ordering allowing an integral controller to provide good tracking and damping performance with guaranteed stability. For a more in-depth investigation of the stability margin and closed loop bandwidth of the system, an antialiasing filter, a reconstruction filter, an amplifier and a displacement sensor were added to the model. In that case, the anti-aliasing and reconstruction filters' cutoff frequencies need to be chosen in an optimal way, with the help of the system's root locus methodology. After the choice of these cutoff frequencies, new optimal integral controller gains are inserted, achieving greater stability margins.

In the sequel, a nonlinear damping controller for a nanopositioning system was also proposed during the fellowship period. The scope of the nonlinear applied control technique is to improve the system's performance without destroying the stability properties



which may be proved using the theory of passivity. The controller gain which precedes the integrator in the integral force feedback scheme is exchanged with a constant term added to a varying term which is a function of the absolute value of the measurement in the nonlinear approach. The measurement noise defines an upper bound on the constant nonlinear controller gain.

## II – PUBLICATION(S) DURING YOUR FELLOWSHIP

**Arnfinn Aas Eielsen, Marialena Vagia, Jan Tommy Gravdahl**  
*“Damping and Tracking Control Schemes for Nanopositioning”*,  
submitted to IEEE Transactions on Mechatronics.

**Arnfinn Aas Eielsen, Marialena Vagia, Jan Tommy Gravdahl  
and Kristin Y. Pettersen**  
*“Fixed-Structure, Low-Order Damping and Tracking Control  
Schemes for Nanopositioning”* submitted to The 6th IFAC  
Symposium on Mechatronic Systems Mechatronics '13)  
Zhejiang University, Hangzhou, China, April 10-12, 2013

**Marialena Vagia, Arnfinn A. Eielsen, and J. Tommy Gravdahl**  
*“Design of a nonlinear damping control scheme for a  
nanopositioning device”* (to be submitted)

## III – ATTENDED SEMINARS, WORKHOPS, CONFERENCES

1st ABCDE Seminar, Berlin, Germany, 10.11.-11.11.2011

## IV – RESEARCH EXCHANGE PROGRAMME (REP)

Due to my pregnancy it was not possible for me to make the REP visits (doctor advised that I should not travel).