UNC CHARLOTTE
The WILLIAM STATES LEE COLLEGE *of* ENGINEERING

UNC Charlotte – Lee College of Engineering - Senior Design Program

Senior Design Project Description

Company Name	*ASML US*	**Date Submitted**	*6/17/2019*
Project Title	*Active Inertial Damping of Robot Vibrations* **ASML_DAMP**	**Planned Starting Semester**	*Fall 2019*

Personnel

Typical teams will have 4-6 students, with engineering disciplines assigned based on the anticipated Scope of the Project. 250 hours are expected per person. Complete the following table if this information is known, otherwise the Senior Design Committee will develop based on the project scope:

Discipline	Number	Discipline	Number
Mechanical	3	Electrical	1
Computer	1	Systems	
Other (any, incl. Mechanical)			

Company and Project Overview:

ASML is the leading photolithography tool supplier to the semiconductor industry, and consistently one of the two largest semiconductor equipment suppliers in the world. We engineer, design, build, market, install and maintain the machines that print the majority of the semiconductor chips used in computers, cellphones and elsewhere.

ASML's headquarters are in The Netherlands, where the main engineering and integration site is located. The company also has two large engineering and production sites in the US: Wilton CT (ASML US), and San Diego CA (Cymer). Cymer produces the light sources that power the lithography process. This includes Deep Ultraviolet Lasers (193nm wavelength - light path in air and water) and the Extreme Ultraviolet Light Source (13nm wavelength – light path in very low pressure hydrogen ~vacuum). ASML US in Wilton produces all variants (including DUV and EUV versions) of several major modules of the TWINSCAN® Lithography machine: The Reticle Stage, the Reticle Handler, and several optical modules, including Wafer Alignment, Wafer Level Sensing (topology mapping), and Actinic Light Uniformity Compensation. All EUV modules are designed to operate in ultra-clean vacuum environment. In addition, Wilton also produces the optical module of the YIELDSTAR® in-line wafer inspection tool.

This Student Project will be sponsored by the Mechanical Development Group of ASML US (Wilton), and will target a mechanical issue that compromises our capability to keep up with an aggressive roadmap, where our machines have to perform at ever decreasing error levels to enable printing ever smaller features on chips. The issue is the ability of a robot operating inside a vacuum chamber, at considerable speed and acceleration, to be able to pick, move and place sensitive payloads that are only held on the end effector by gravity and friction, without causing the payload to move relative to the end effector. This is important to ASML, because a robot operating in a vacuum chamber cannot be outfitted with a vacuum-grip end effector. Mechanical and electrostatic grippers are also excluded, because they create unacceptable levels of particulate contamination and mechanical/other damage of the payload. Thus, we are only left with gravity and friction to constrain the payload on the end-effector. Amplification of ground vibrations through the robot structure causes accelerations that momentarily exceed the gravity/friction hold, causing motion of the payload relative to the end effector and loss of positional accuracy in the transfer of the payload from a pre-alignment station to the final point of use.

In this project, students will develop:

1) A simple structure which is representative of the changing dynamics of a moving robot. For example, the structure may be a cantilever beam with a mass that can slide up and down the length of the beam, being powered open-loop by a motor. As the mass moves, the resonant frequency of the beam changes. Ideally, the beam can also be excited into vibrating at natural frequencies by pumping energy via small amplitude motions of the mass.
2) An active inertial damper, comprising an inertial mass, an actuator, a sensor and a controller.
3) A proof of concept, comprising the active damper attached to the simple structure, and means of measuring vibration amplitude with the active damper turned off and turned on. Ideally, the proof of concept shall demonstrate 5x attenuation of the vibration amplitude at several resonances of the beam.

Project Requirements:

The students, in consultation with advisors at UNCC and ASML, shall:

Engineer, design and build a simple motorized structure that captures the essential vibration behaviors of a hypothetical robot. Ideally, a continuum of resonant frequencies between 25 and 50 Hz shall be achievable by the structure.

Engineer, design and build an active inertial damper comprising an inertial mass, an actuator, a sensor and a controller. Ideally the inertial mass shall not exceed $1/10^{th}$ of the effective mass of the vibrating structure.

A proof of concept experiment, comprising the structure, the damper, and means to excite the structure (ideally, the structure would be self-exciting, but this is not a hard requirement). In the experiment, the natural frequency of the structure will be continuously varied in different patterns (by manual control input), and the active damper will automatically adjust its behavior to cancel out most of the vibrations (5x attenuation goal, compared to no damper).

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Expected Deliverables/Results:

- A design of a structure with continuously variable natural frequency (25 to 50 Hz)
- A design of an active inertial damper and controller
- A design of a set of experiments to measure the damper performance
- Working continuously variable frequency structure
- Working active inertial damper
- Proof of concept experiment
- A report with the design, analysis, conclusions, recommendations, and way forward

Disposition of Deliverables at the End of the Project:

Apparatus, results, etc. may be presented at the EXPO.
Apparatus may remain at UNCC after completion of the project, for the purpose of re-use in subsequent ASML projects.

List here any specific skills, requirements, knowledge needed or suggested (If none please state none):

Periodic progress reviews with ASML (suggested weekly ~ 1 hour) on Skype, Design review meetings at UNCC and/or Skype.

Skill/knowledge/interest:

- Mechanical Engineering with a strong interest in vibrations or mechatronics.
- Mechanical, Electrical (or other) Engineering with a strong interest in controls.
- Mechanical Engineering with a strong interest in design.
- Mechanical, Computer (or other) Engineering with interest in mechatronics programming.
- Mechanical, Electrical (or other) Engineering with a strong interest in testing.

At the outset of the project, ASML requires no specific knowledge beyond acceptable academics in Engineering. However, the individual(s) must be willing to dedicate substantial effort towards "on the job" learning in the areas outlined above.