Development of the inertial sensor for DECIGO Pathfinder

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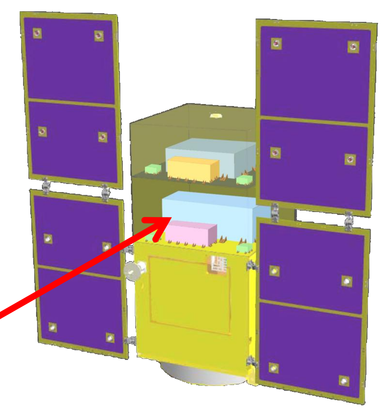
1. Abstract

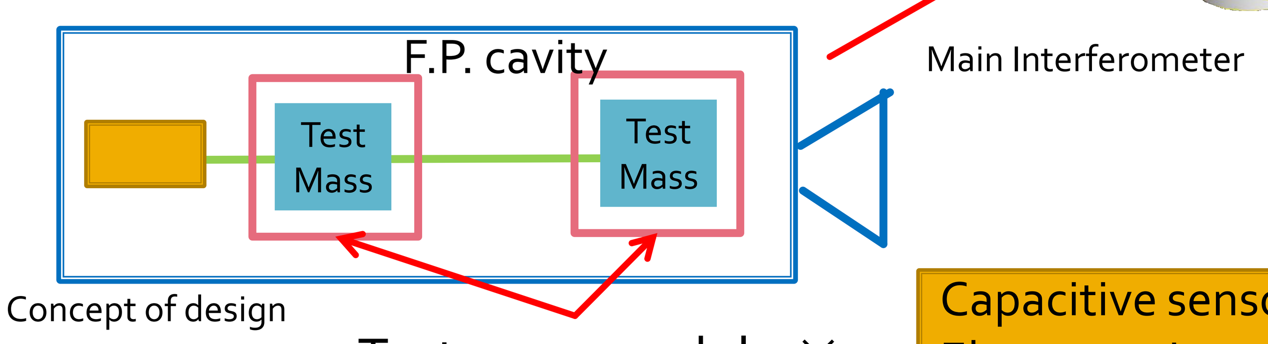
This article reports on the development of inertial sensors for DECIGO Pathfinder (DPF), which is the precursor of DECIGO, spaceborne gravitational-wave (GW) antenna of Japan in future.
To achieve drag-free control, DPF will have micro thrusters and inertial sensors which sense external force on the satellite structure.
The inertial sensor comprises a proof mass (test mass : T.M.) and position controllers which consist of capacitive sensors and electrostatic actuators. The position controller will sense the relative position between the proof mass and its housing, and control the proof mass motion with the actuator. We achieved the control of translational motion and yaw motion. We will report on the feedback system of the capacitive sensors and the electrostatic actuators.

2. DECIGO Pathfinder (DPF)

Purpose

- Technology demonstration for DECIGO
- Gravitational-wave detection (0.1-1Hz)
- Earth gravity monitoring

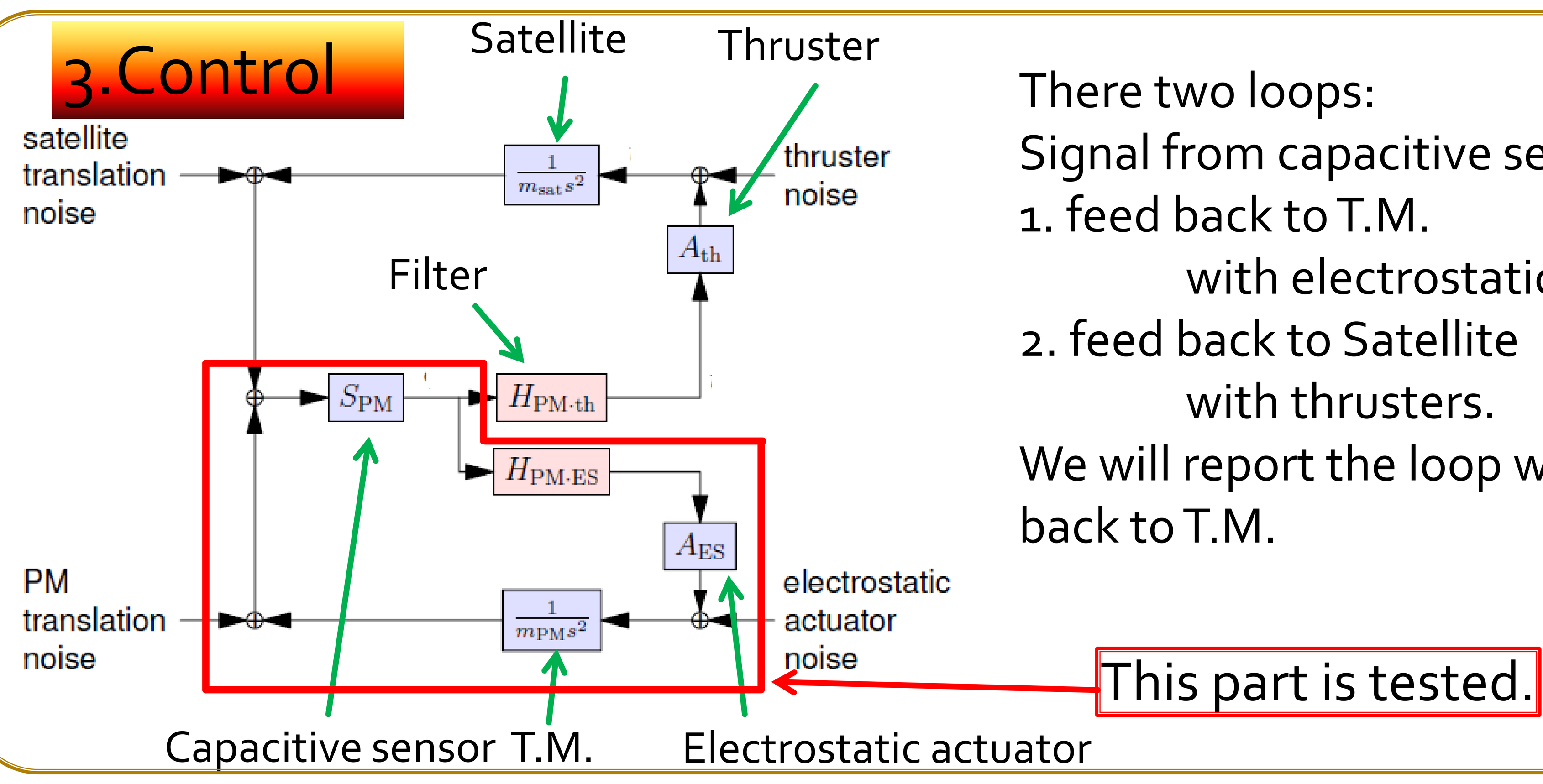




Test mass module ×2

Capacitive sensors
Electrostatic actuators

3. Control



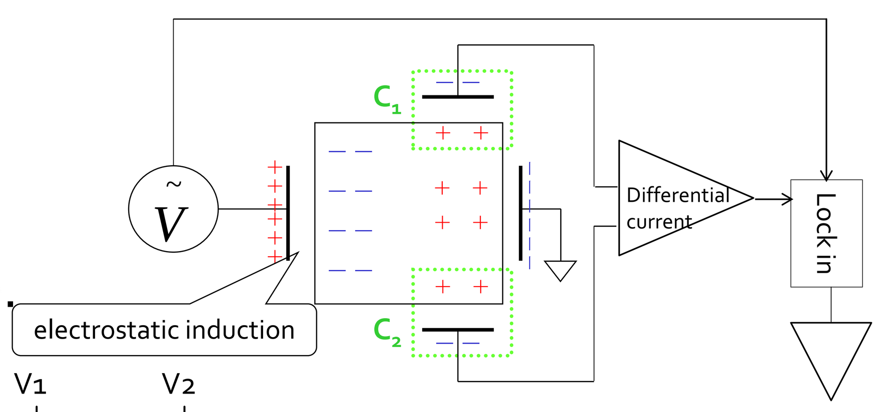
There two loops:
Signal from capacitive sensors will
1. feed back to T.M. with electrostatic actuators.
2. feed back to Satellite with thrusters.
We will report the loop which feed back to T.M.

4. Control of Test Mass with Capacitive sensors and Electrostatic actuators

4.1 Principle

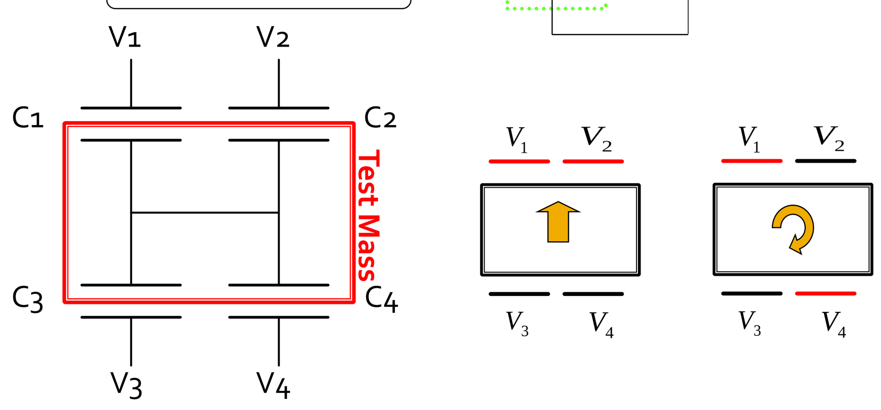
Capacitive sensor

We can sense the displacement of the T.M. as the difference of the capacitance.

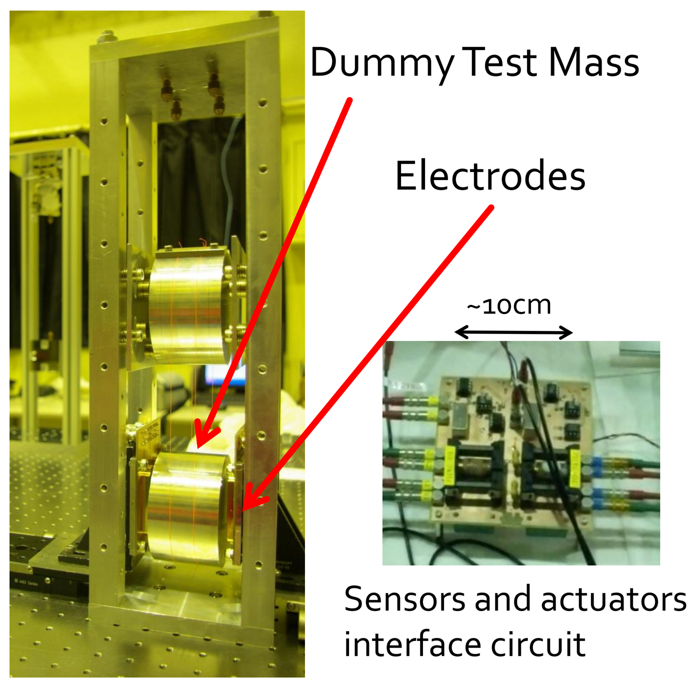


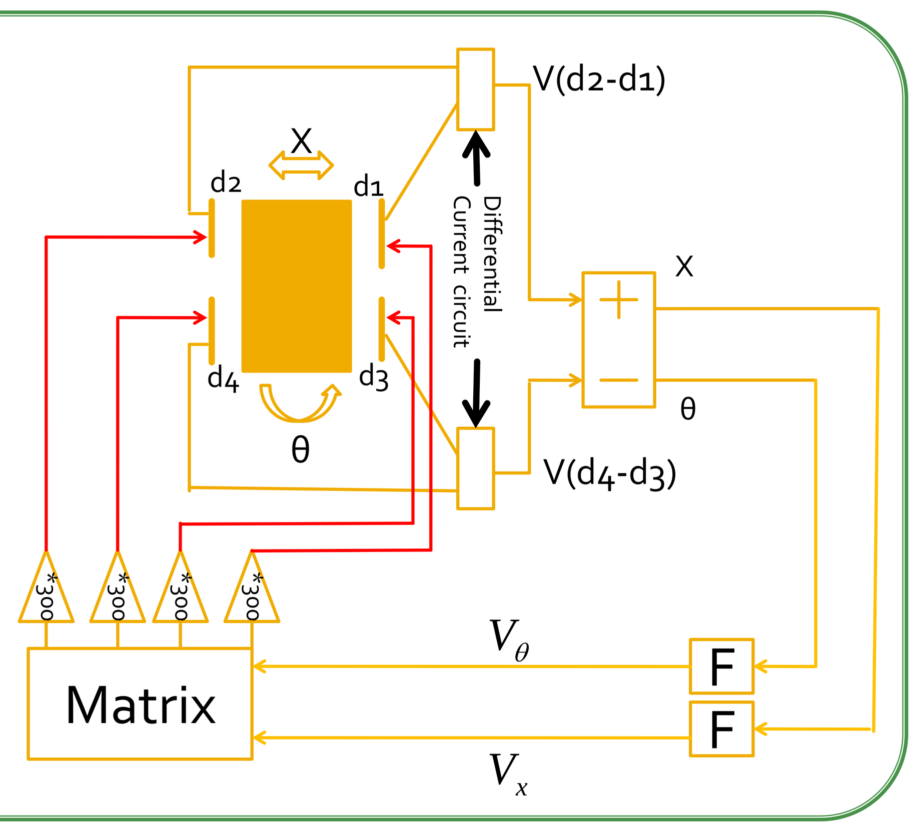
Electrostatic actuator

We can actuate the T.M.'s DOFs by charging the electric filed around the T.M.



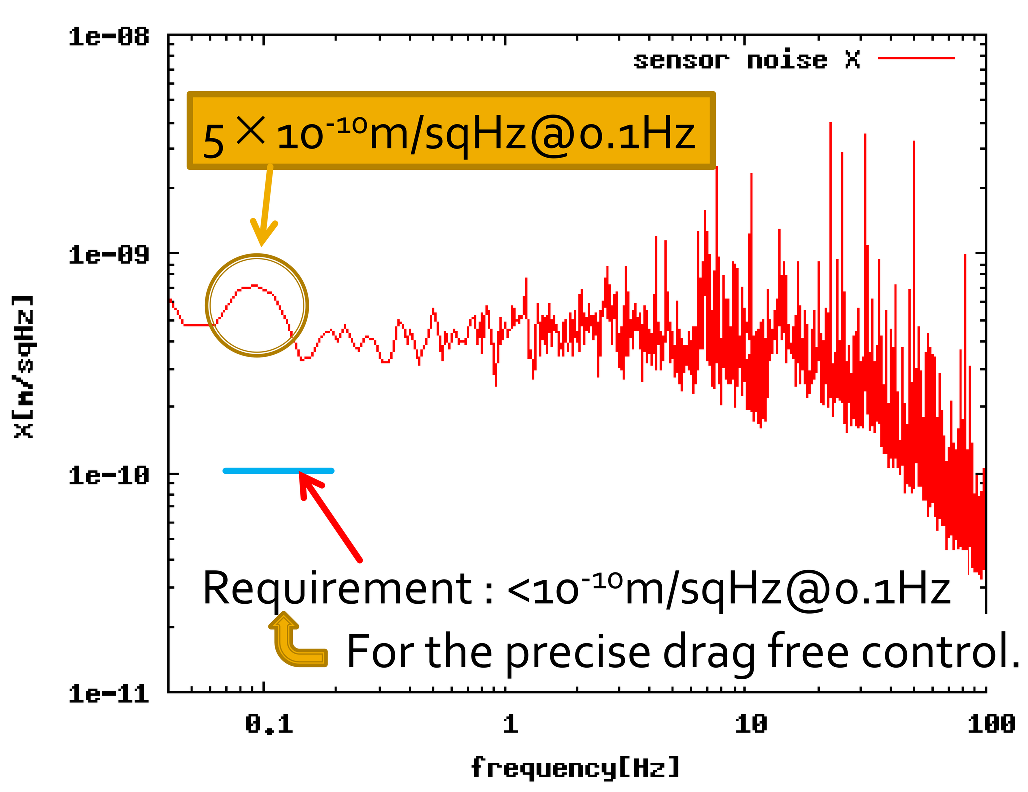
4.2 Experiment system





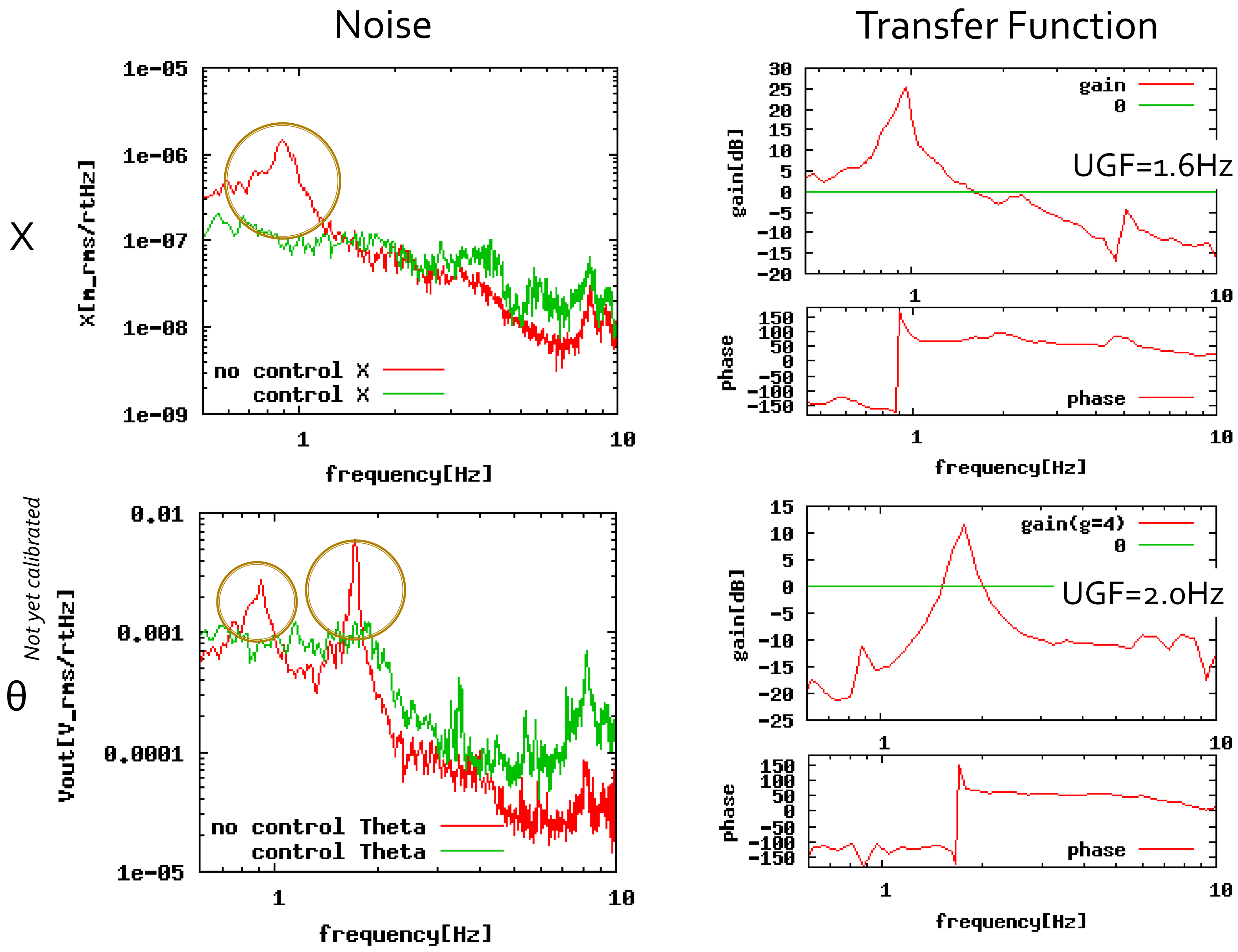
4.3 Sensor noise

The capacitive sensor noise



We almost achieved the requirement 10^{-10}m/sqHz@0.1Hz

4.4 Two DOFs control



As a result of the feed back control, the resonance peeks are suppressed

5. Conclusion and future work

Conclusion:
- We almost achieved the sensor noise requirement, 10^{-10}m/sqHz@0.1Hz.
- We have controlled the translational and yaw motions of a dummy test mass suspended by the double pendulum.

Future work:
- We are going to make a Free-fall drop experiment to control all DOFs.