Two Layers SAS: Damping of Torsion Mode

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F2F Meeting

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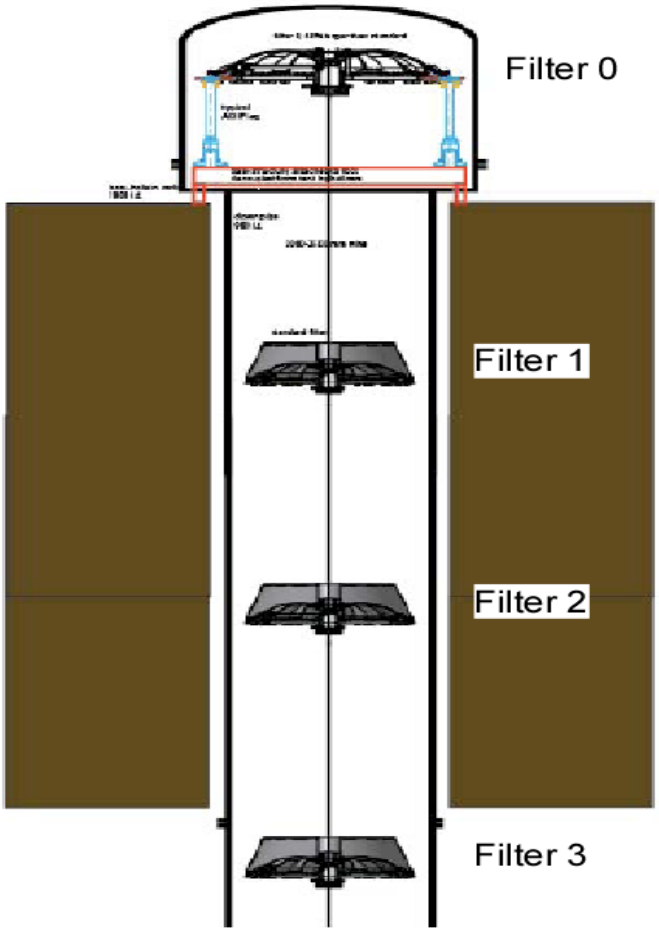
Torsion Mode of Filters

- Each GAS filter is suspended by a single wire.
- Single wire is flexible in torsion mode
  → good attenuation in yaw mode
  (rotation about vertical axis)

- This mode has quite low resonant frequency & high Q
- Once this mode is excited, filters keep oscillating for a long time.(During this time, we cannot lock interferometer.)

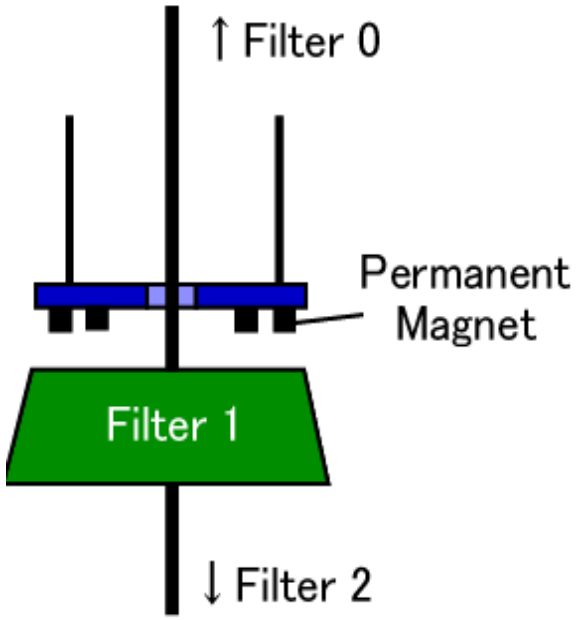


How to Damp This Mode?

- A disc is suspended from Filter 0.
- Permanent magnets attached to the disc damp the motion of Filter 1 by eddy current.

- The motion of Filter 2 & 3 is also damped, if the torsional stiffness of each wire is optimal.
- We need to optimize the damping strength & torsional stiffness of every wires.

→Need Simulation

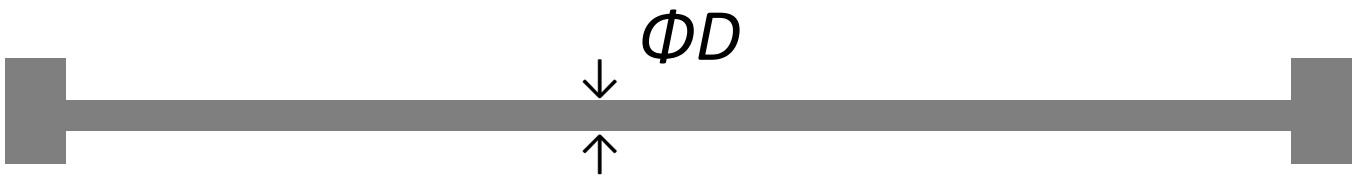


Torsional Stiffness of Wire

- Torsional stiffness depends on the thickness of the wire.

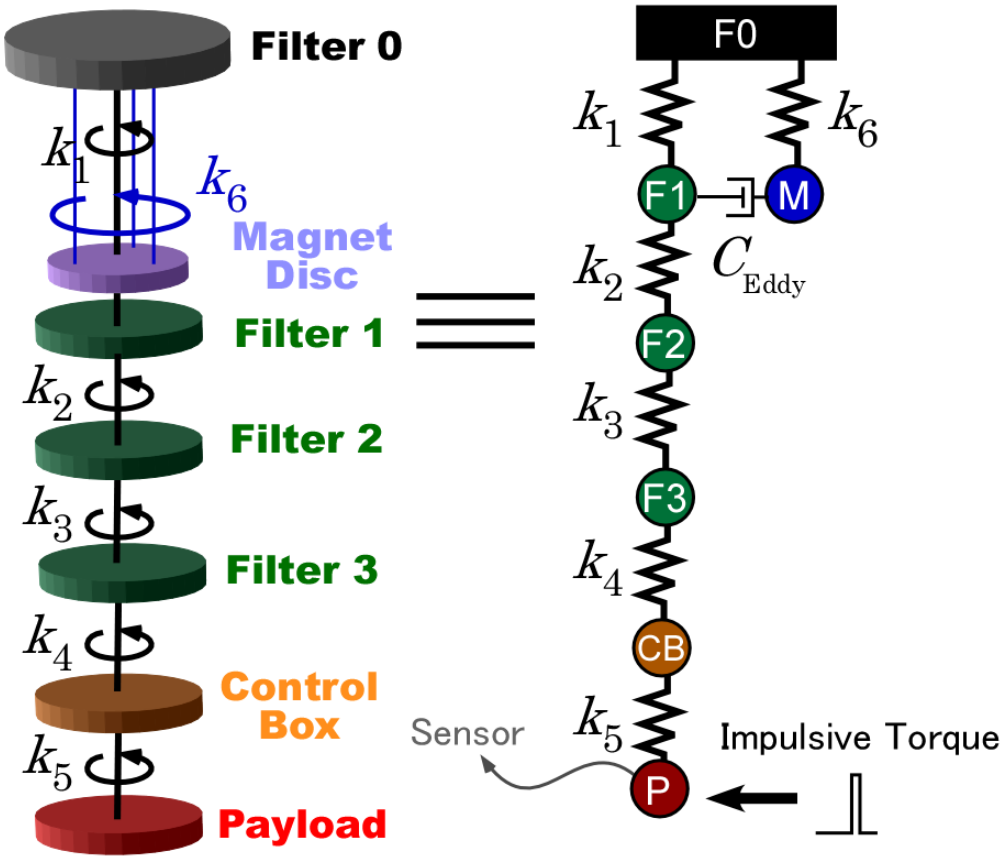
$$k_\phi \propto D^4$$ *D*: Wire Diameter

- Find optimal torsional stiffness of each wire
  = Find optimal thickness of each wire

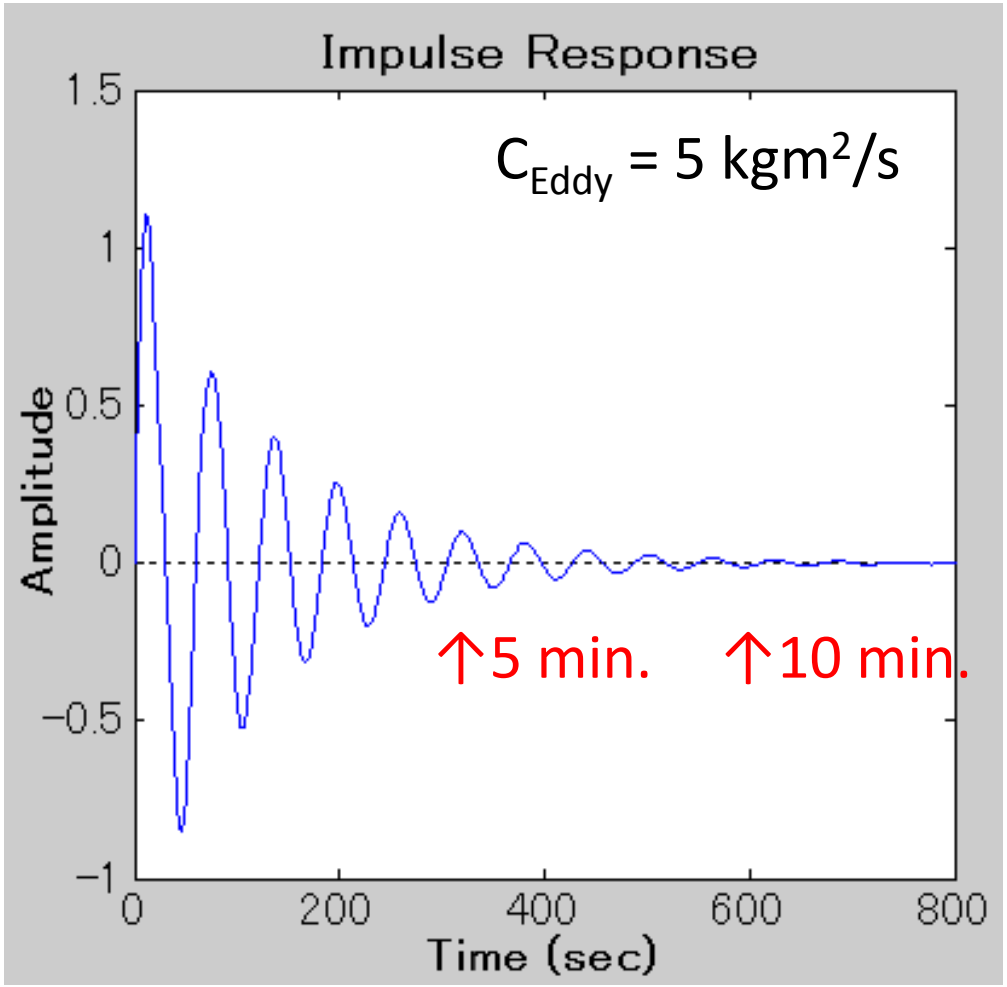


Simulation Model

- 1-D “point-mass” model
- Impulsive torque is exerted to the payload, and angular displacement of the payload is sensed.
- Calculate impulsive response → Estimate damping time
- Find best parameters that shorten the damping time most



Simulation Result & Optimized Parameters



	Value [Nm/rad]
k_1	0.70
k_2	0.70
k_3	0.70
k_4	0.27
k_5	0.27
k_6	>10

Torsional modes are damped in < 10 min.

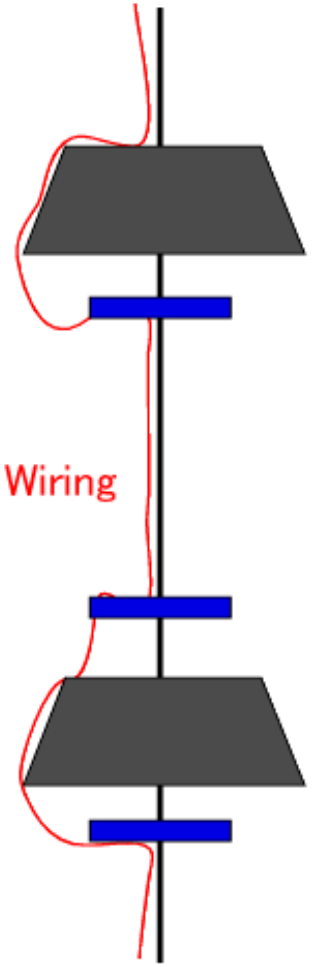
Proposed Wire Design

- From the torsional stiffness, wire diameters are calculated.

#	Diameter [mm]	Length [m]
1	3.74	2.1
2	3.74	2.1
3	3.74	2.1
4	2.94	2.1
5	2.45	1.0

Note: Wiring Problem

- In real case, wiring (for sensors and actuators) also introduces distributed damping.
- This damping is less welcome because it may introduce creak noise.
- We will study wiring configuration experimentally with prototype.



End

Appendix

Parameters Used in the Simulation

- Moment of inertia of each filter

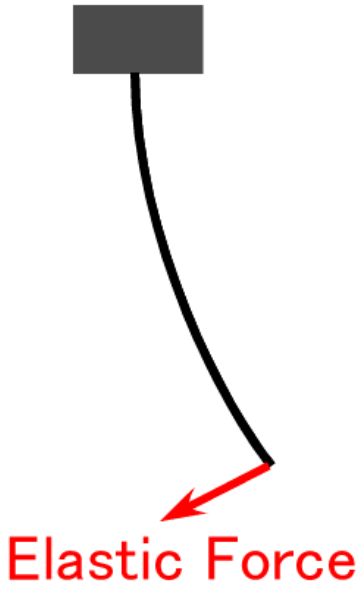
Filter Name	Detail	Moment of Inertia [kgm^2]
Standard Filter	Filter 1~3	6.24
Payload	Platform	1.95
	Magnet Box	2.35
	Intermediate Mass	0.69
	Recoil Mass	0.45
	Test Mass	0.17
	Total	5.61
Control Box		2.0
Magnet Disc		1.84

- As the design of the control box is not fixed, its moment of inertia may change.

Proposed Wire Design (Detail)

- From the torsional stiffness, wire diameters are calculated.

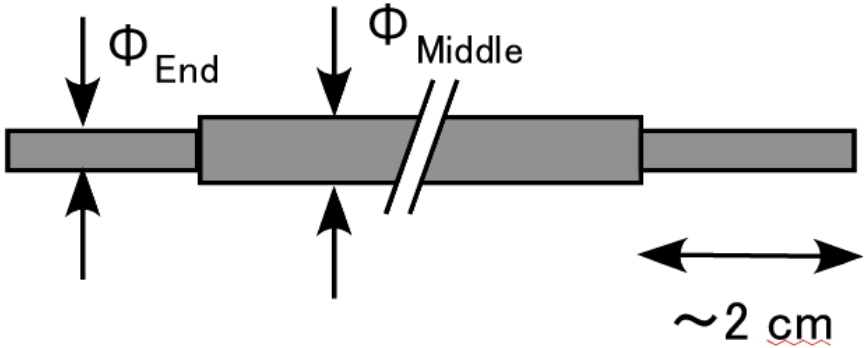
#	Diameter [mm]	Length [m]
1	3.74	2.1
2	3.74	2.1
3	3.74	2.1
4	2.94	2.1
5	2.45	1.0



- Relatively thick wires (almost rods)
- Thick wires are not good for horizontal attenuation.
  (Elasticity of wires may worsen the performance of SAS.)

Proposed Wire Design (Detail)

- This elastic stiffness only depends on the thickness of first few cm from the head of the wire.
- We can make wires thick in the middle & thin at the ends.



#	Diameter (End) [mm]	Diameter (Middle) [mm]	Length [m]
1	3.74	3.74	2.1
2	3.44	3.74	2.1
3	3.11	3.74	2.1
4	2.74	2.94	2.1
5	2.45	2.45	1.0