地面振動の能動防振
Active vibration isolation of ground vibration

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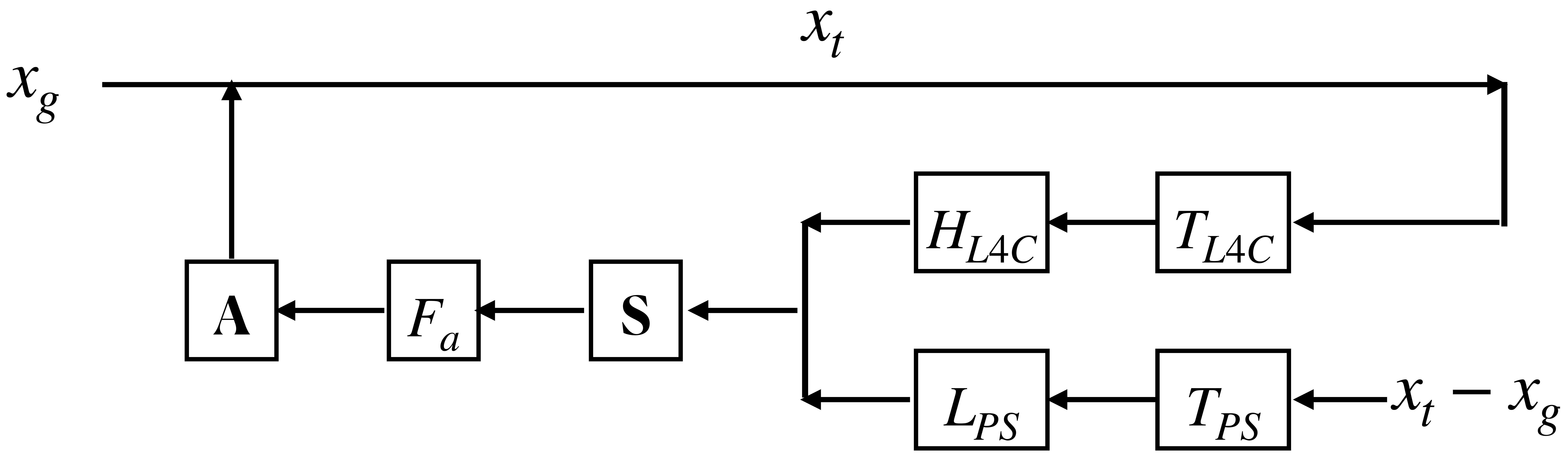
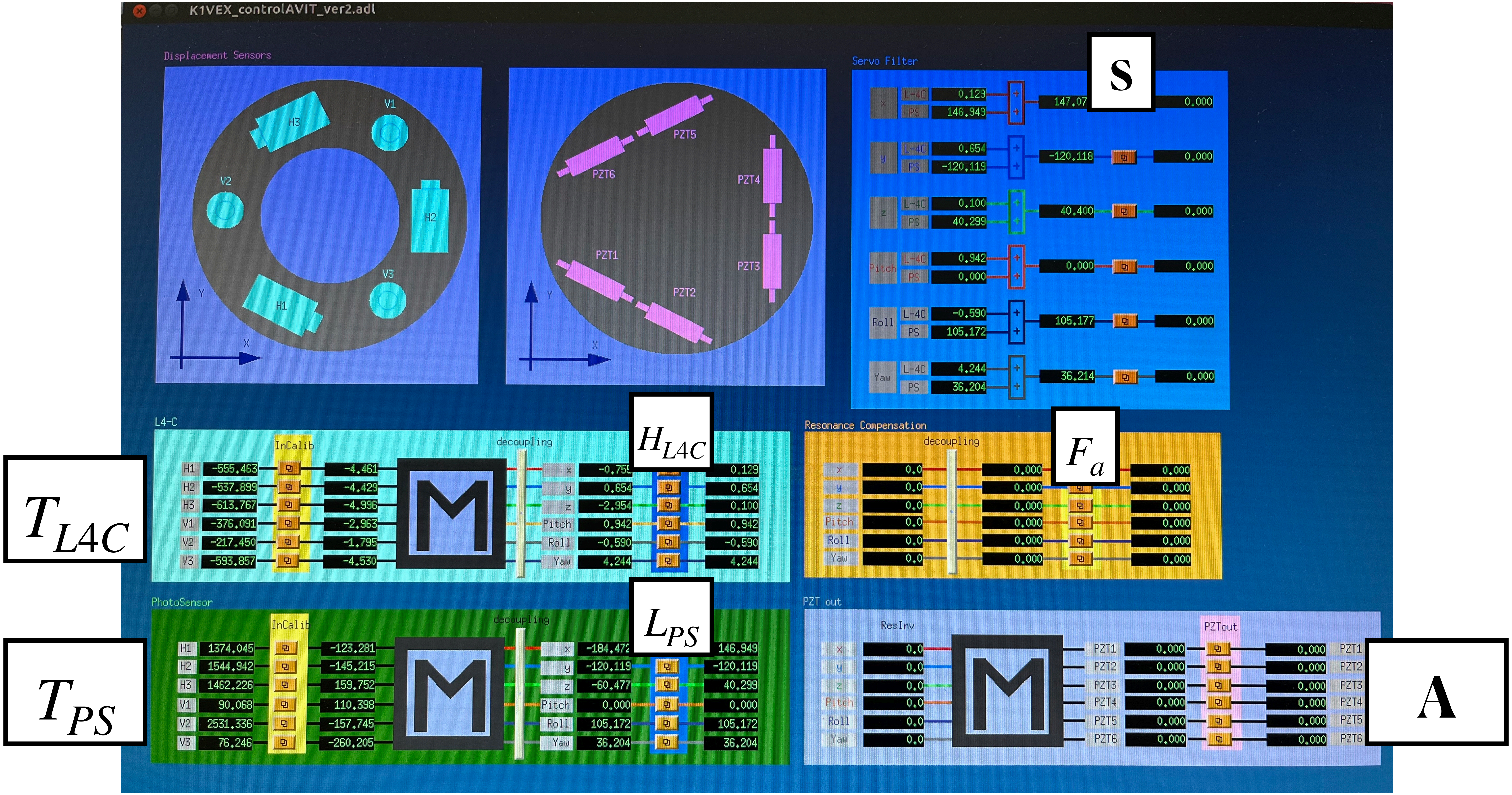
October 1st, 2021 @Ando Lab Seminar

Control System



Control System

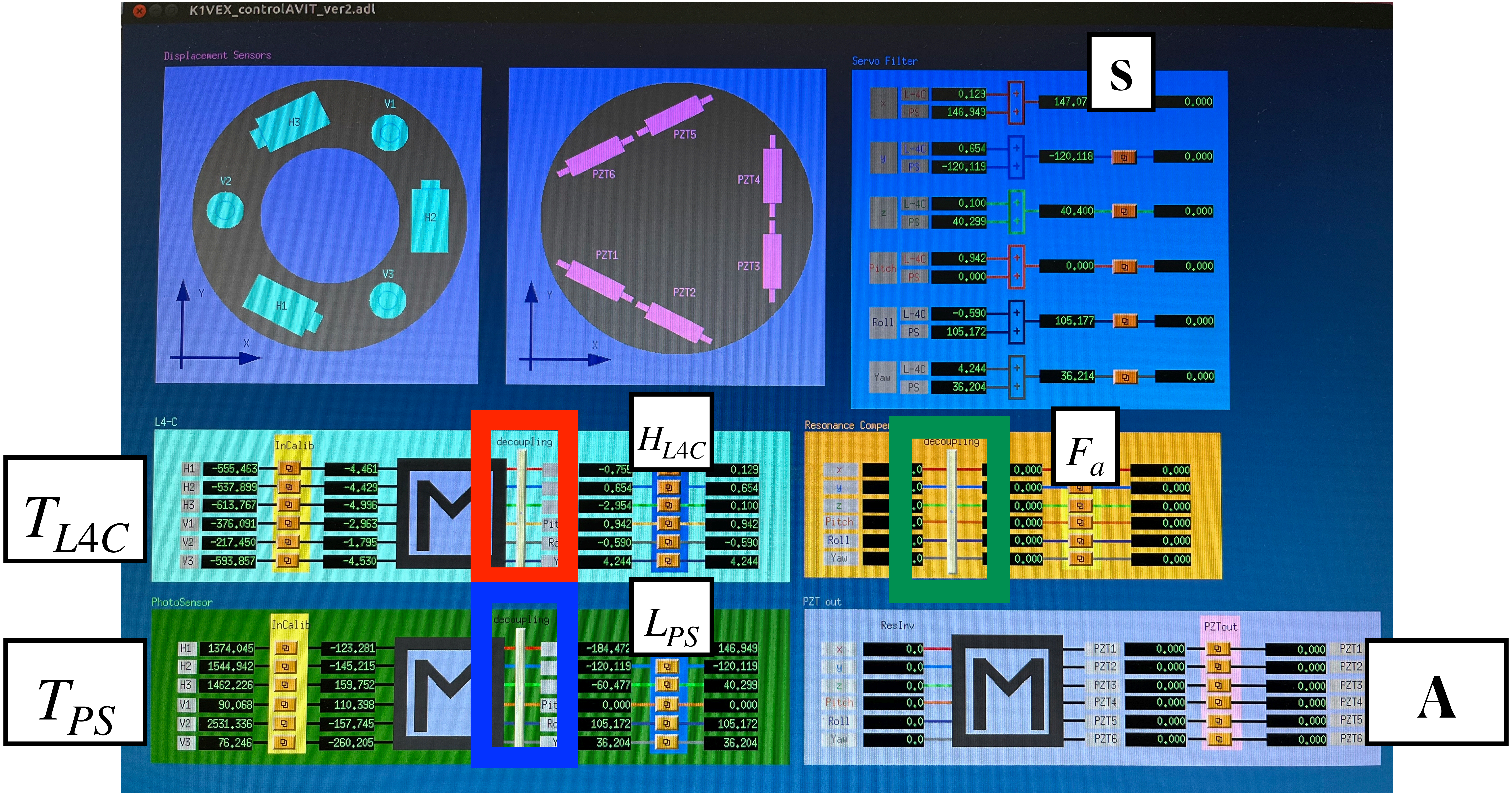


Active vibration isolation of ground vibration (x-direction)

x方向の地面振動の能動防振

- To do the active vibration isolation of the ground vibration(x-direction)
  1. decoupling of L4C(x, y, z), decoupling of PS(x,y)
  2. decoupling of actuator(x,y,z,pitch, roll)
  3. Making the Resonance Compensation filter to cancel the transfer function of the actuator
  4. Setting the gain of PS to mix the signal of L4C and PS properly
  5. Setting the gain of the Servo filter

Control System



Decoupling

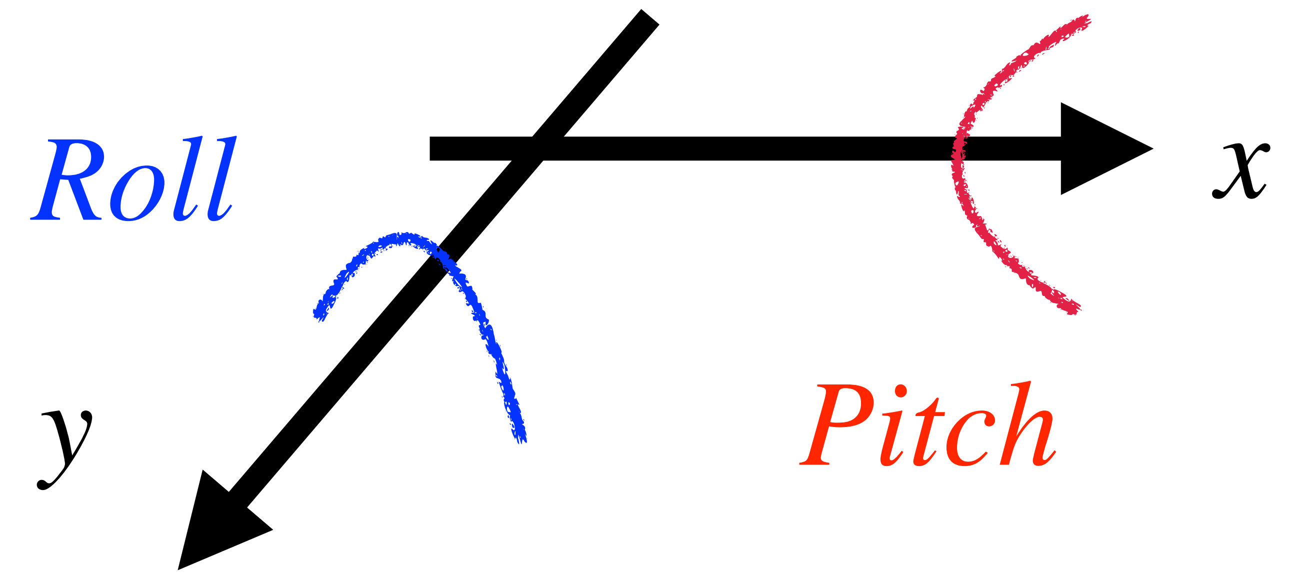
decoupling of L4C(x, y, z), decoupling of PS(x,y), decoupling of Actuator(x,y,z)

- For L4C, check the peaks of the transfer functions for x, y, and z directions
  - Those peaks are the resonance of the device
  - Then calculate the matrix
- For PS and Actuator, put test signals of different frequencies in the x, y, and z directions
  - Then calculate the matrix

$$
\begin{array}{c} \\ x \\ y \\ z \\ Pitch \\ Roll \\ Yaw \end{array}
\begin{array}{c}
\begin{array}{cccccc} x & y & z & Pitch & Roll & Yaw \end{array} \\
\begin{pmatrix}
s_{xx} & s_{xy} & s_{xz} & s_{xP} & s_{xR} & s_{xY} \\
s_{yx} & s_{yy} & s_{yz} & s_{yP} & s_{yR} & s_{yY} \\
s_{zx} & s_{zy} & s_{zz} & s_{zP} & s_{zR} & s_{zY} \\
s_{Px} & s_{Py} & s_{Pz} & s_{PP} & s_{PR} & s_{PY} \\
s_{Rx} & s_{Ry} & s_{Rz} & s_{RP} & s_{RR} & s_{RY} \\
s_{Yx} & s_{Yy} & s_{Yz} & s_{YP} & s_{YR} & s_{YY}
\end{pmatrix}
\end{array}
$$

Decoupling

decoupling of actuator(x, y, Pitch, Roll)



- Even if you put in a signal to move only in the x direction, the actuators could be actually turning to Pitch and Roll as well.
- Determine components of $\square$ by varying the value of the components of $\square$ so that C is zero.

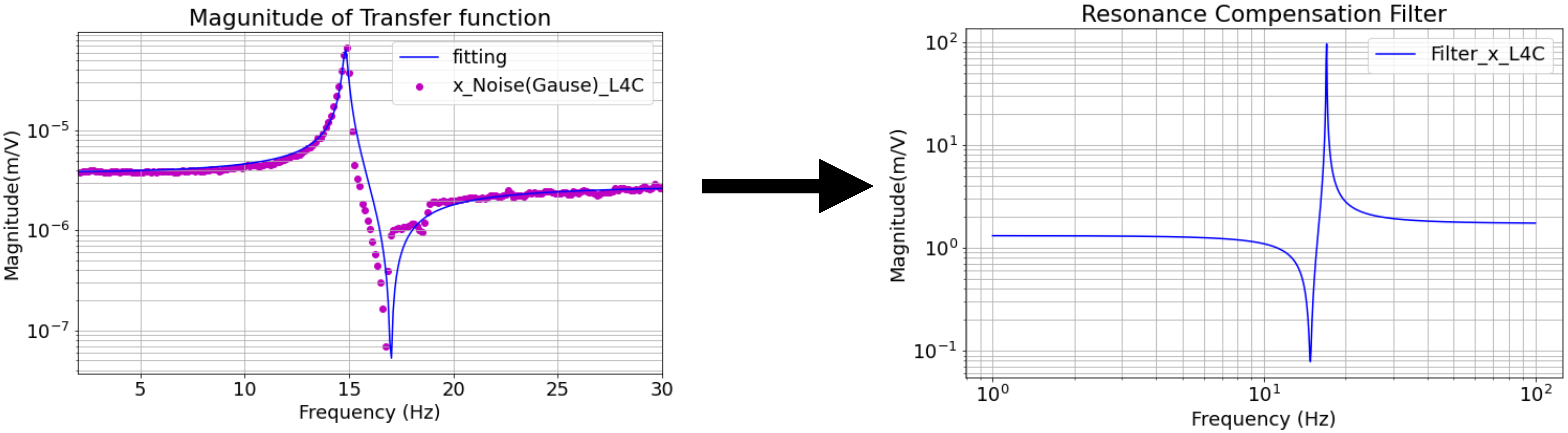
$$H_{x \to L4C}(\omega) = \frac{i\omega^3}{\omega_0^2 - \omega^2}[1 - C\frac{g}{\omega^2}]$$

$$\begin{array}{c} \\ x \\ y \\ z \\ Pitch \\ Roll \\ Yaw \end{array} \begin{array}{c} \begin{array}{cccccc} x & y & z & Pitch & Roll & Yaw \end{array} \\ \begin{pmatrix} s_{xx} & s_{xy} & s_{xz} & s_{xP} & s_{xR} & s_{xY} \\ s_{yx} & s_{yy} & s_{yz} & s_{yP} & s_{yR} & s_{yY} \\ s_{zx} & s_{zy} & s_{zz} & s_{zP} & s_{zR} & s_{zY} \\ s_{Px} & s_{Py} & s_{Pz} & s_{PP} & s_{PR} & s_{PY} \\ s_{Rx} & s_{Ry} & s_{Rz} & s_{RP} & s_{RR} & s_{RY} \\ s_{Yx} & s_{Yy} & s_{Yz} & s_{YP} & s_{YR} & s_{YY} \end{pmatrix} \end{array}$$

Making the Resonance Compensation filter

To cancel the peak from the transfer function of the actuator

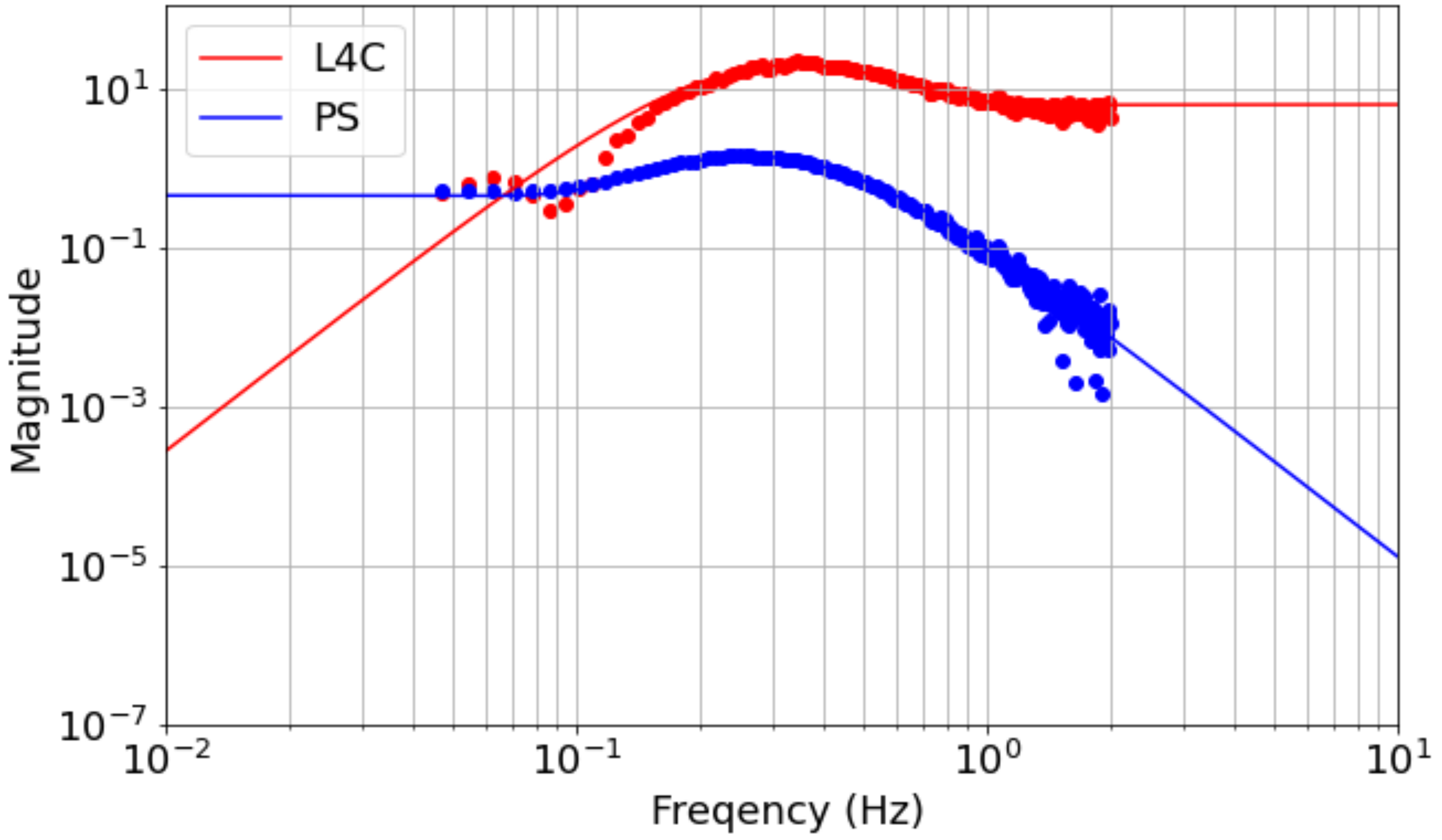
1. Put the test signal in the actuator, and get the outcome of the actuator
2. Calculate the transfer function of the actuator (by fitting the data)
3. Make the Resonance Compensation filter as the inverse function of the transfer function



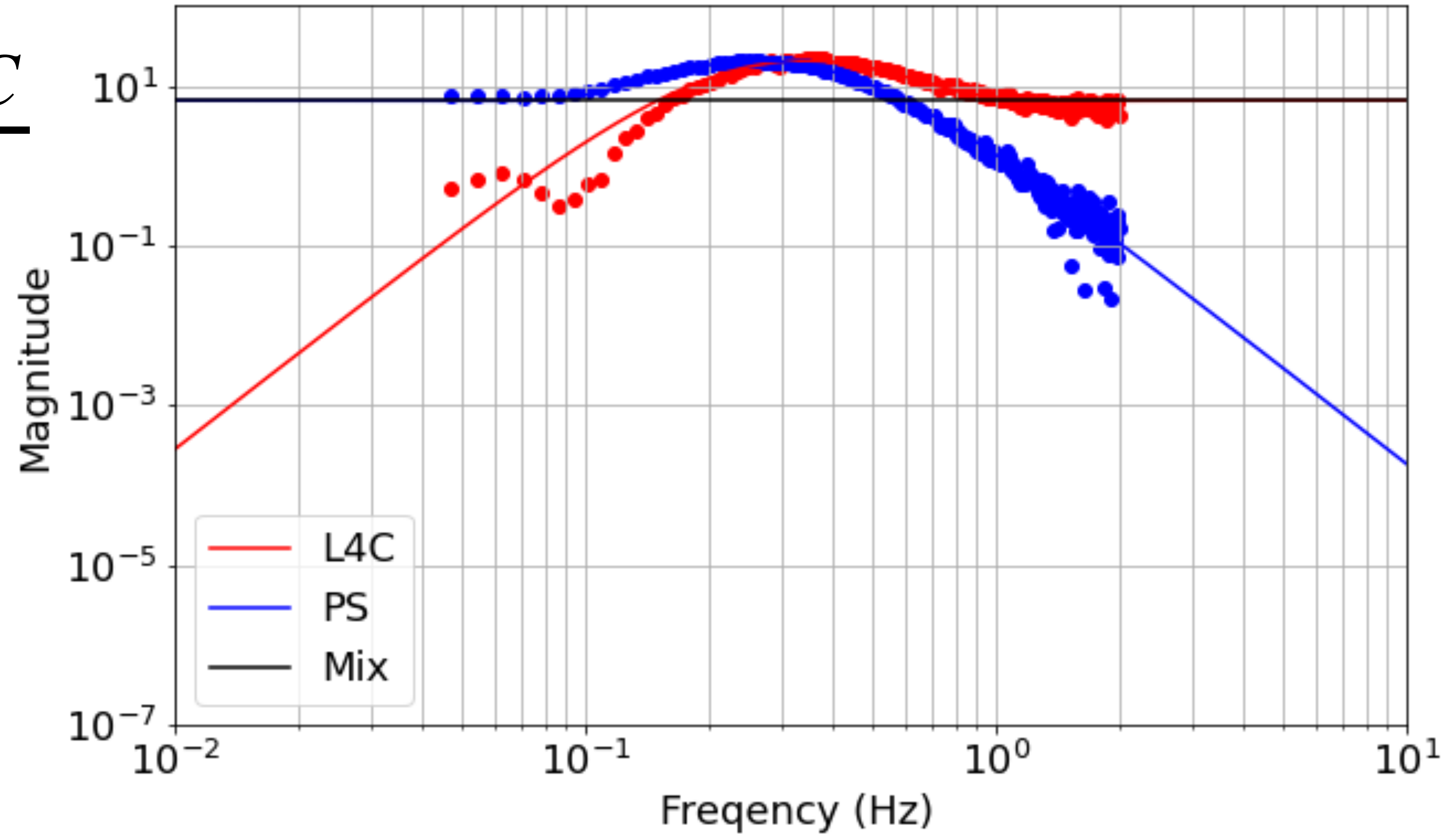
Setting the gain of Photo Sensor

To mix the signal of L4C and PS properly

1. Fitting the outcome of L4C and PS respectively
2. Fix the gain of PS to equate the gain of PS with that of L4C



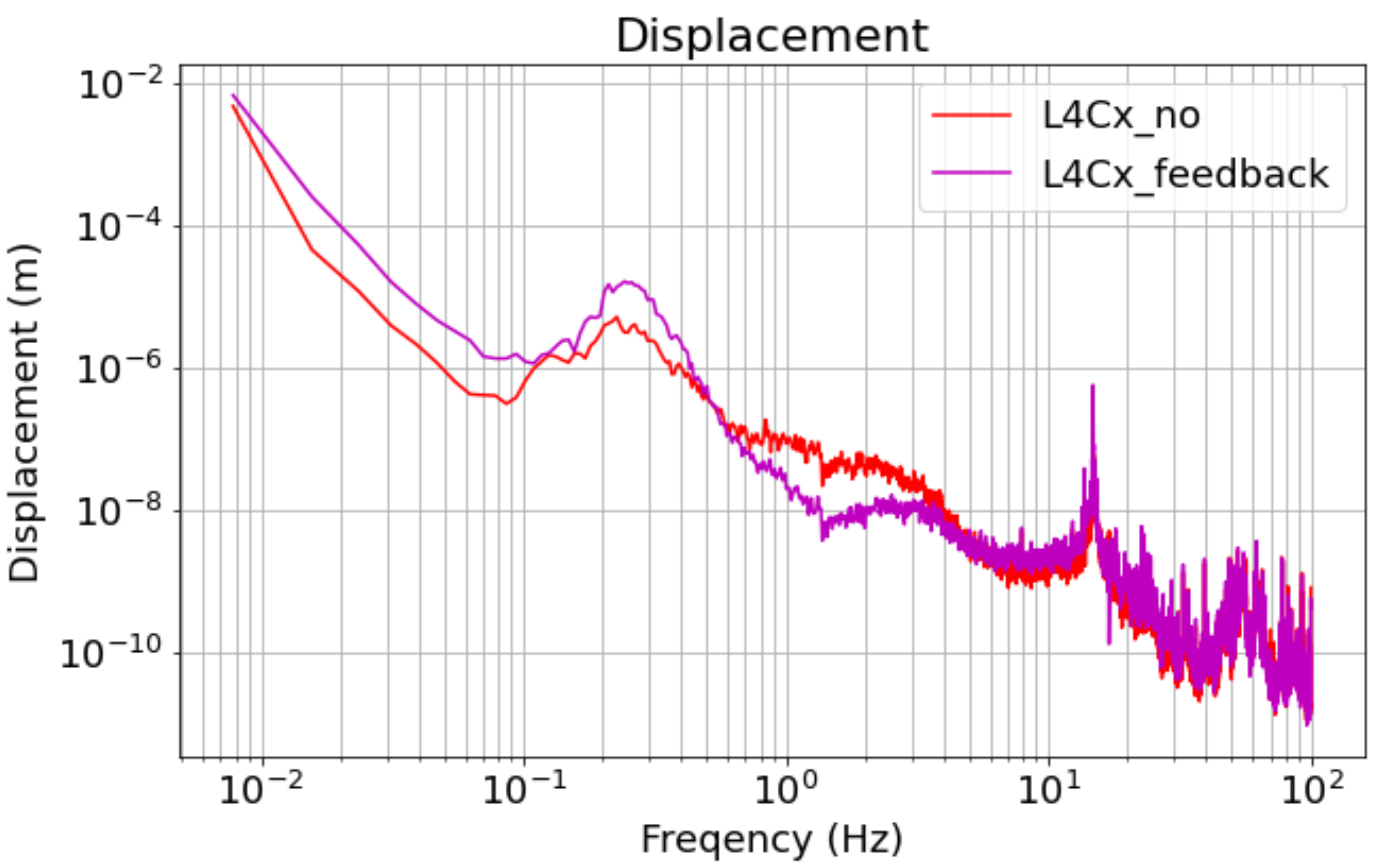
$$PS \times \frac{Gain_{L4C}}{Gain_{PS}}$$

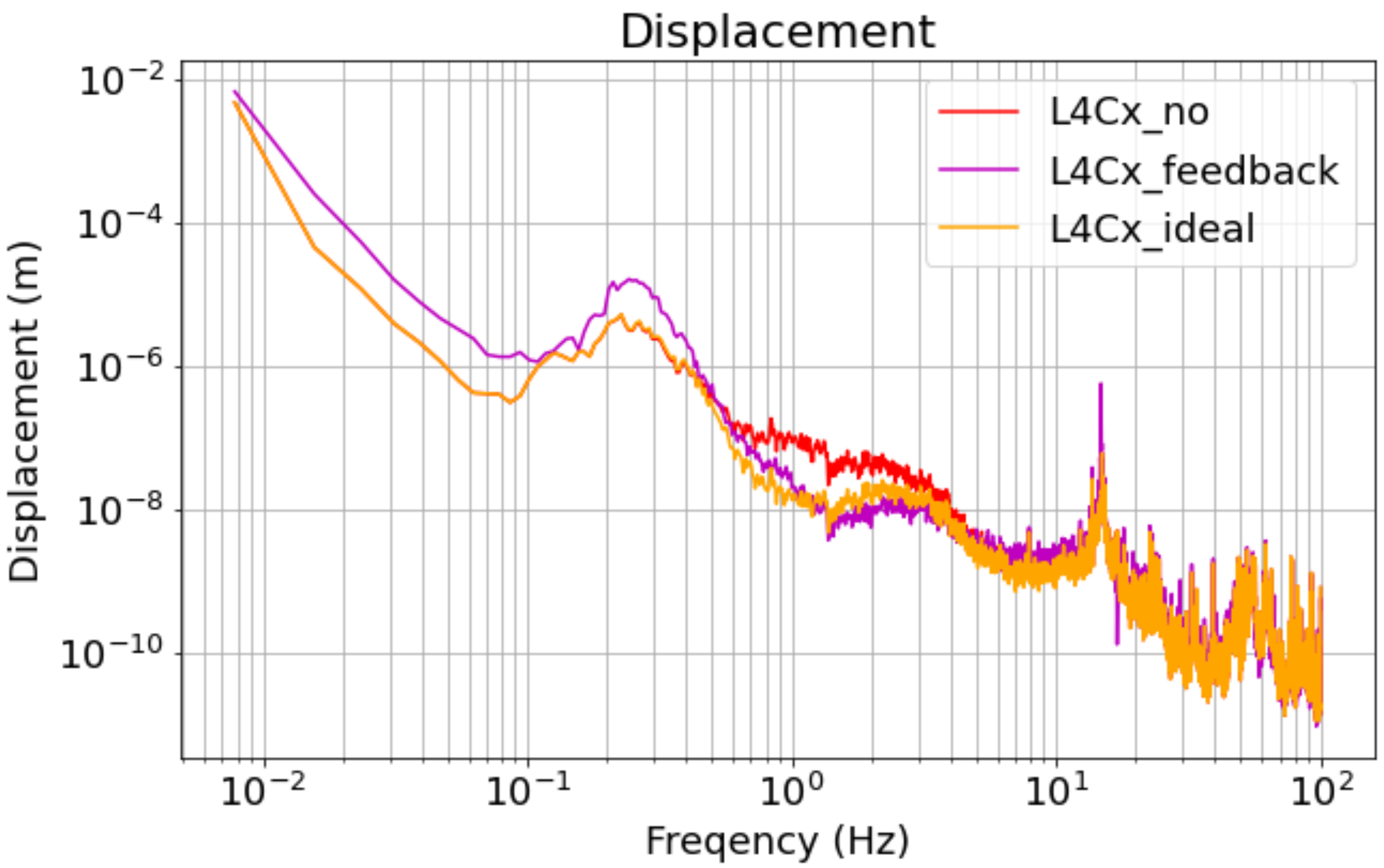


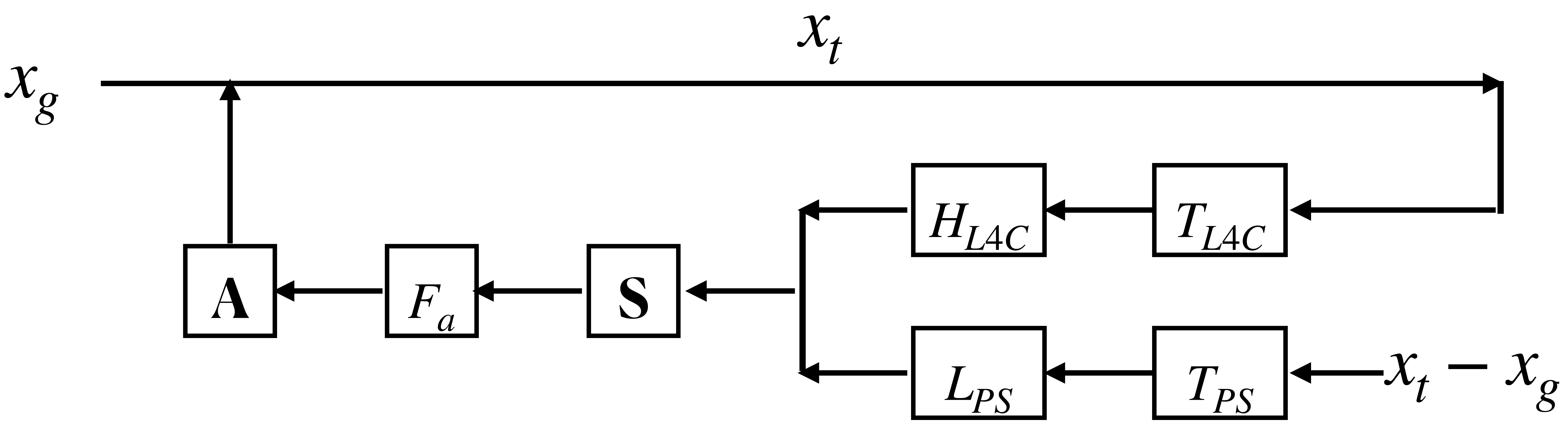
Final Result

The result of my active vibration isolation

- Then, set the gain of the Servo filter (as high as possible without oscillating)
- We got the following result (The gain of Servo filter was 300):







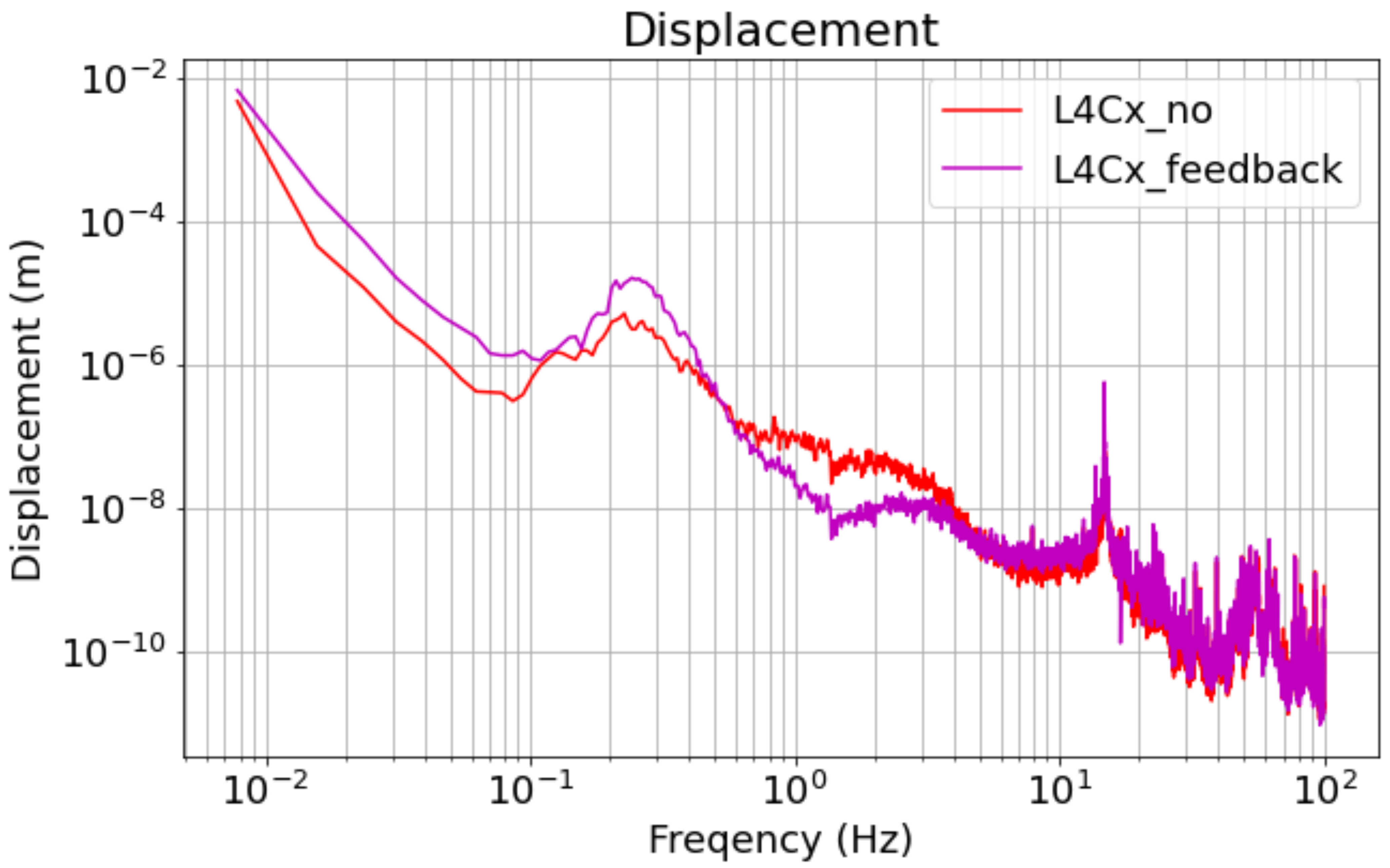
$$x_t = x_g - AF_aS(H_{L4C}T_{L4C} + L_{PS}T_{PS}(x_t - x_g))$$

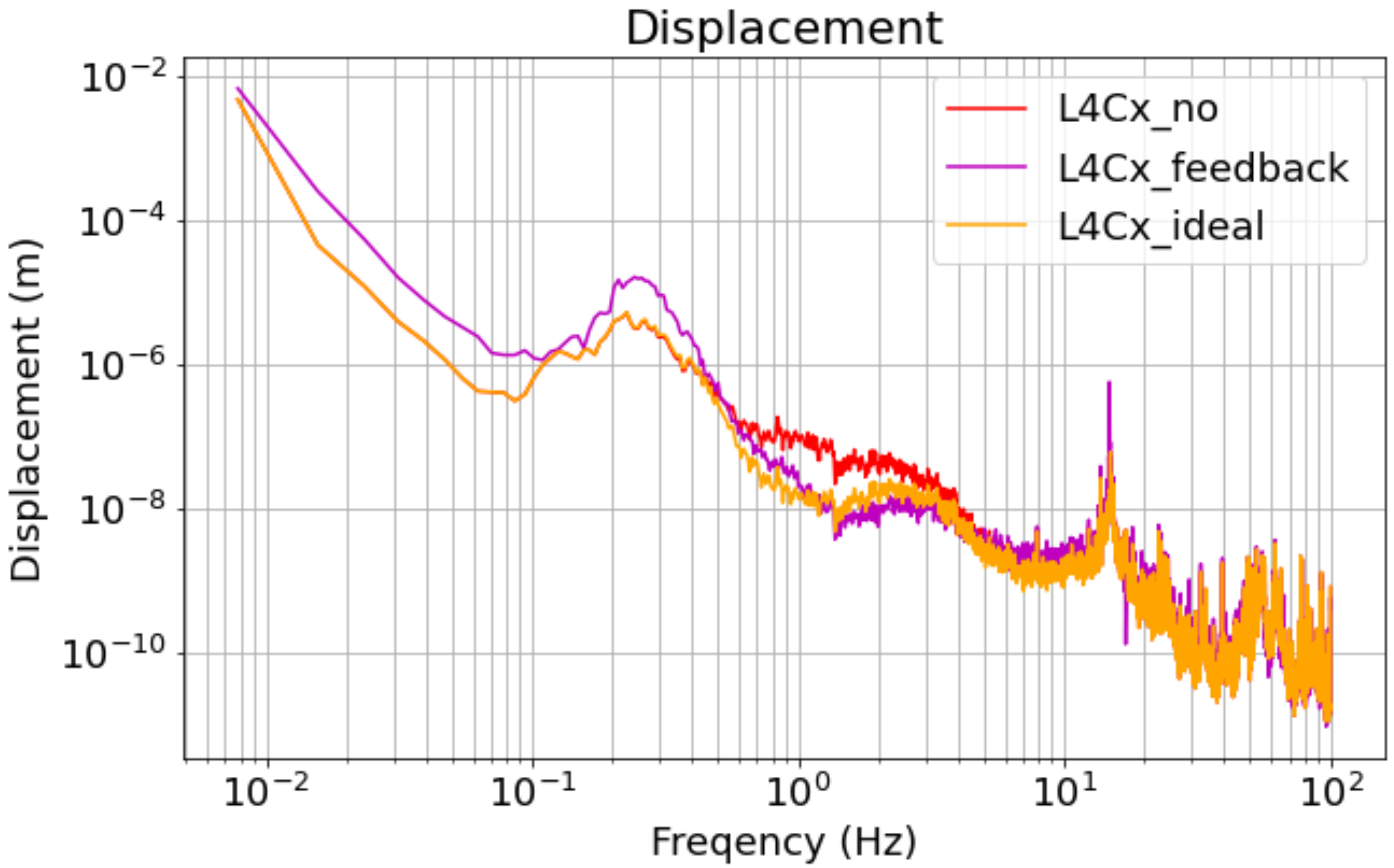
$$x_t = \frac{1 + AF_aSL_{PS}T_{PS}}{1 + AF_aS(H_{L4C}T_{L4C} + L_{PS}T_{PS})}x_g$$

Final Result and Discussion

The result of my active vibration isolation

- Then, set the gain of the Servo filter (as high as possible without oscillating)
- We got the following result (The gain of Servo filter was 300):





Thank you for listening!