

27th International Conference "Mechanika-2023"

Acceleration Control of a Servomotor Driven Ball Screw Feed System under Earthquake Effects

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SUMMARY

Goal of the Study

Physical Model

Mathematical Modelling

Earthquake Record

Simulations & Results

Conclusions

Goal of the Study

- Critical buildings, vibration-sensitive equipments
- Vibration isolation

MRI devices



<https://vetmr.com.tr/index.php/2020/11/22/mr-manyetik-rezonans-goruntuleme/>

Robotic surgical devices



<https://healthintechno.com/2020/12/07/da-vinci-robotik-cerrahi/>

Data banks



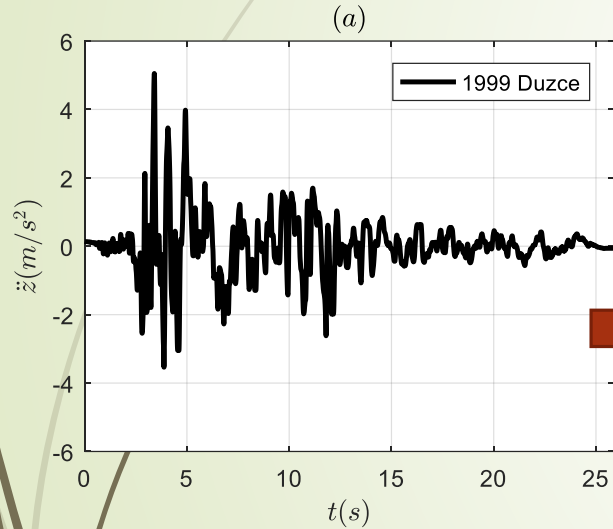
<http://www.ucab.com.tr/blog/detay/veri-merkezi-data-center-ve-standartlari-nedir>

Historical monuments

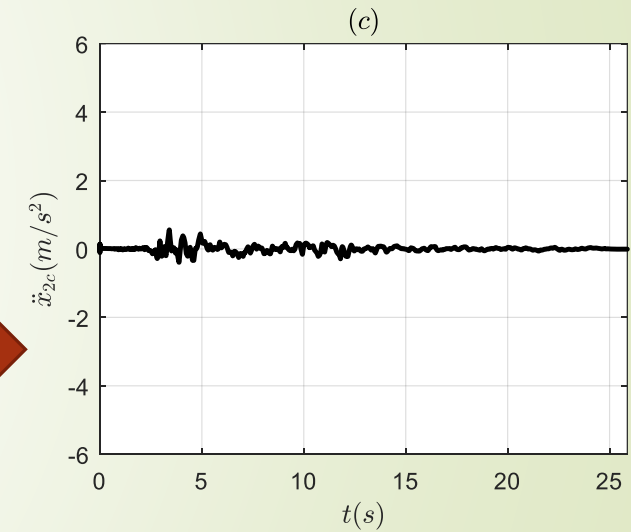
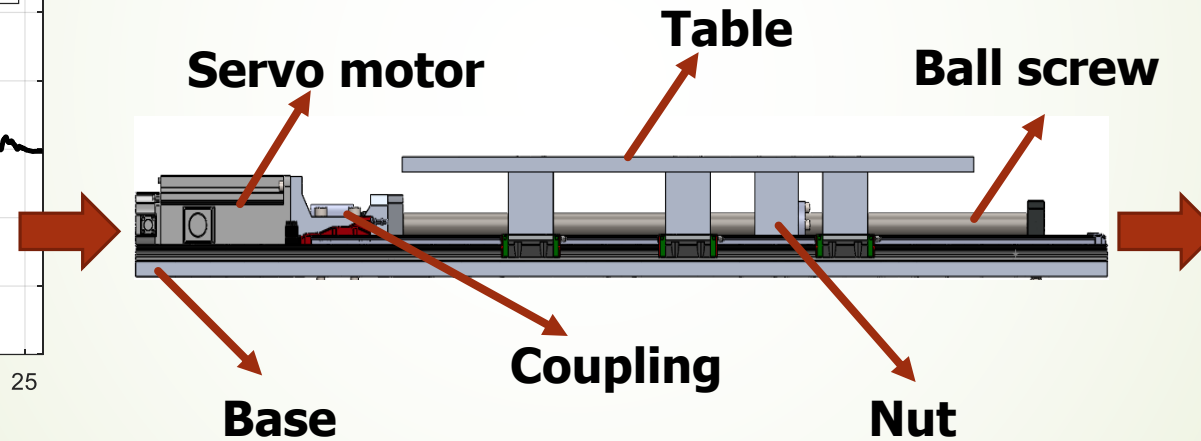


<https://www.arkeolojikhaber.com/haber-kybeleheykeli-istanbul-arkeoloji-muzelerinde-ziyarete-acildi-28313>

Physical Model



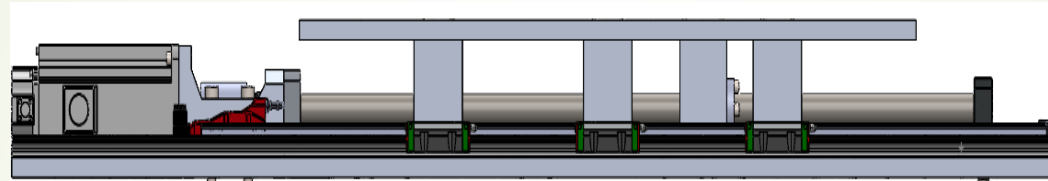
Earthquake record



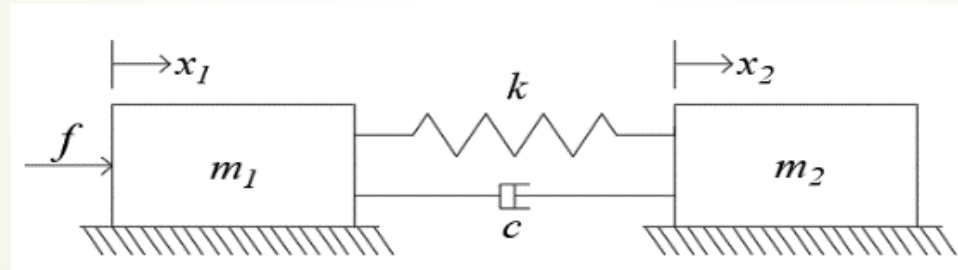
Controlled time history
plot of table

Mathematical Modelling

Physical model of system



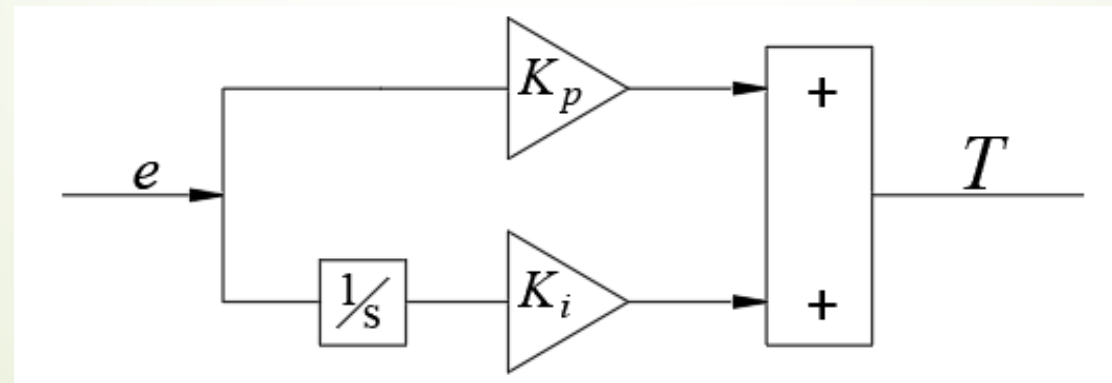
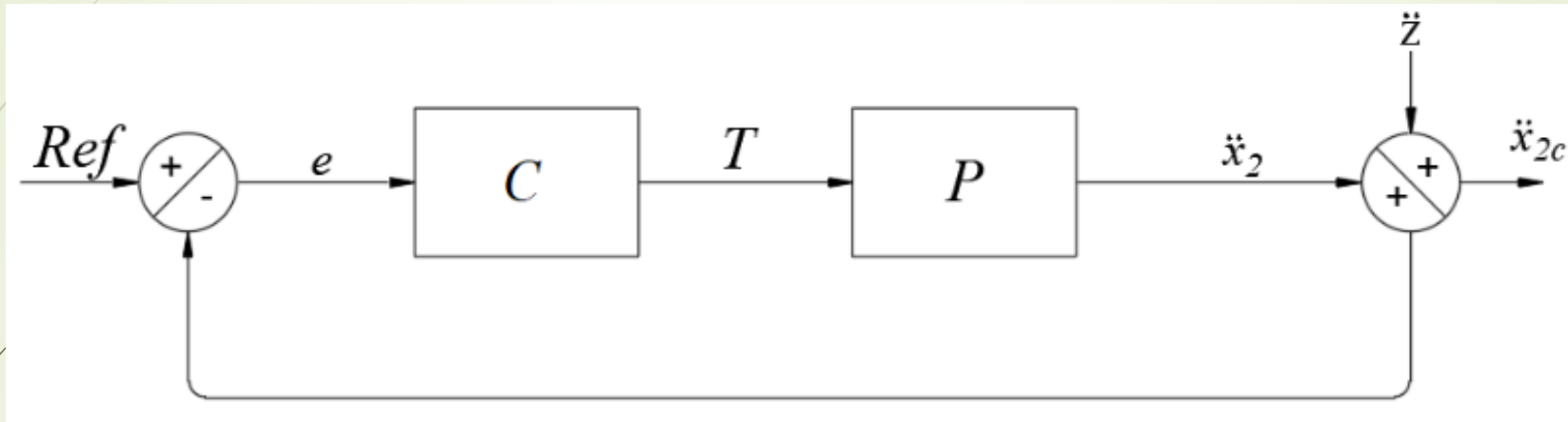
Equivalent physical system



The equations of motion for the open loop controlled system

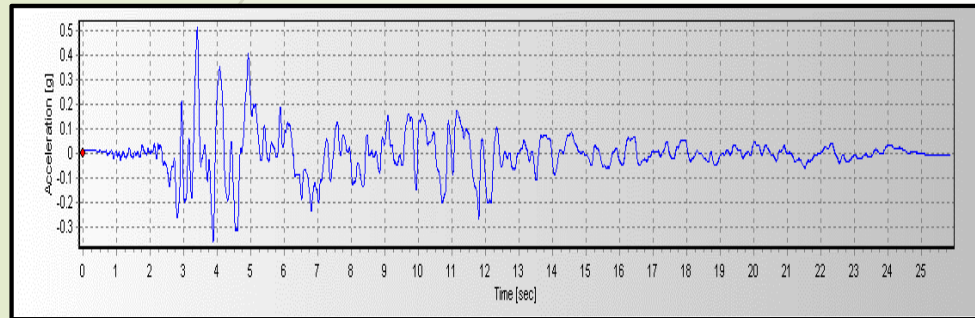
$$\begin{bmatrix} m_1 & 0 \\ 0 & m_2 \end{bmatrix} \begin{Bmatrix} \ddot{x}_1 \\ \ddot{x}_2 \end{Bmatrix} + \begin{bmatrix} c & -c \\ -c & c \end{bmatrix} \begin{Bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{Bmatrix} + \begin{bmatrix} k & -k \\ -k & k \end{bmatrix} \begin{Bmatrix} x_1 \\ x_2 \end{Bmatrix} = \begin{Bmatrix} f \\ 0 \end{Bmatrix}$$

Closed Loop Control System

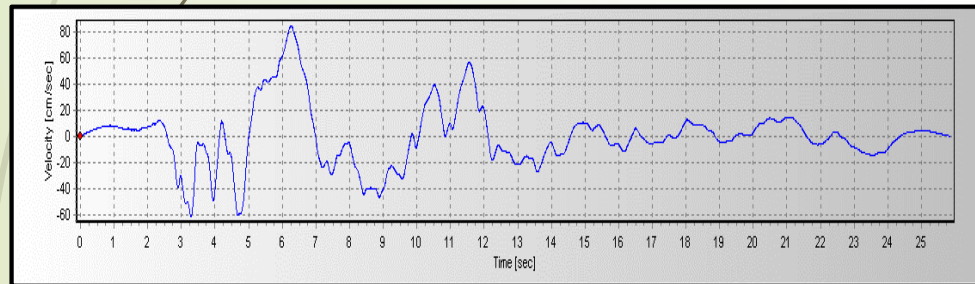


Earthquake Record

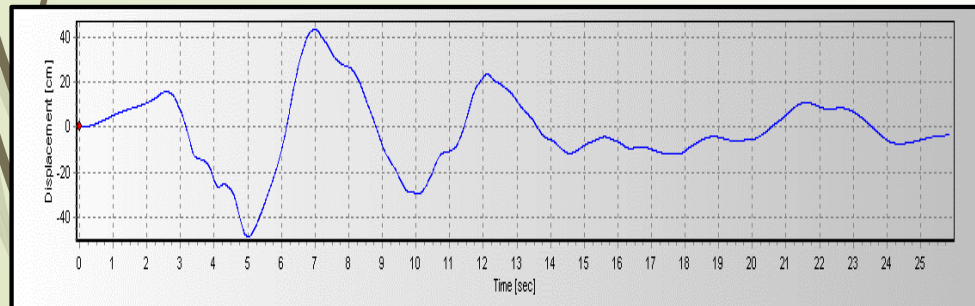
Component	Earthquake	Date	Station	PGA (g)	PGV (cm/sn)	PGD (cm)
RSN1605	Duzce	11/17/1999	Duzce	0.515	84.094	48.743



Acceleration



Velocity



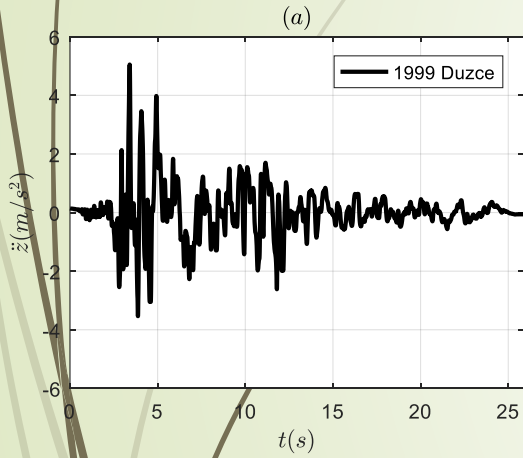
Displacement

- Peer Ground Motion Database record (1999 Duzce earthquake)

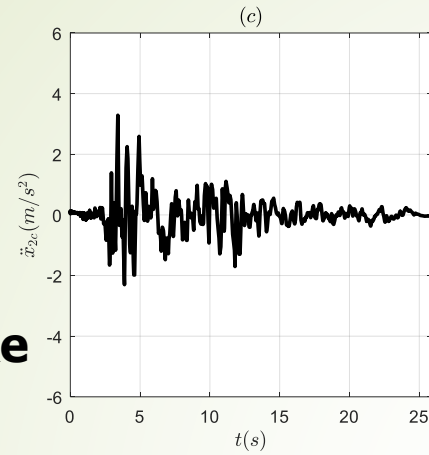
[PEER Ground Motion Database - PEER Center \(berkeley.edu\)](http://peer.berkeley.edu)

Simulations & Results

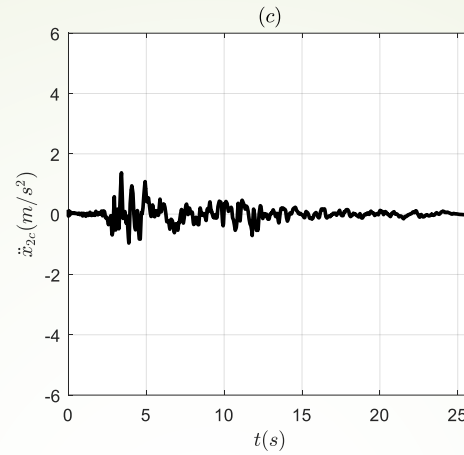
1999 Duzce earthquake



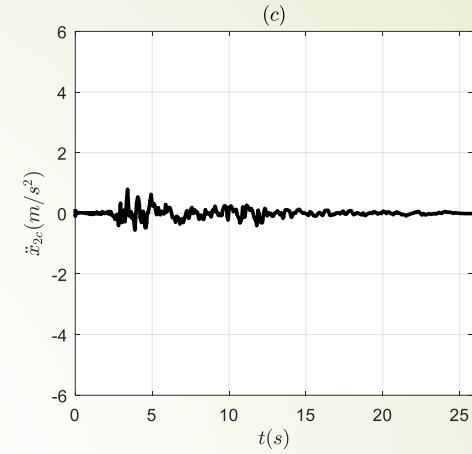
➤ $K_p = 1; K_i = 0;$



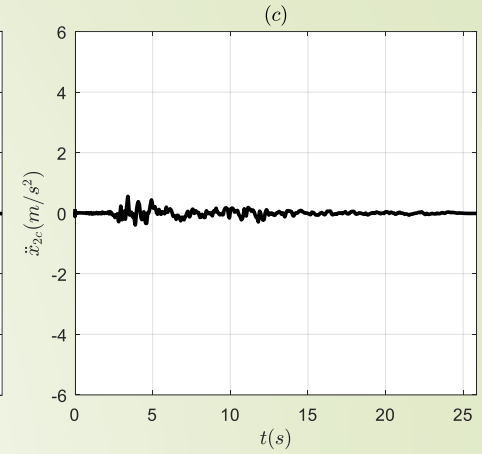
➤ $K_p = 5; K_i = 0;$



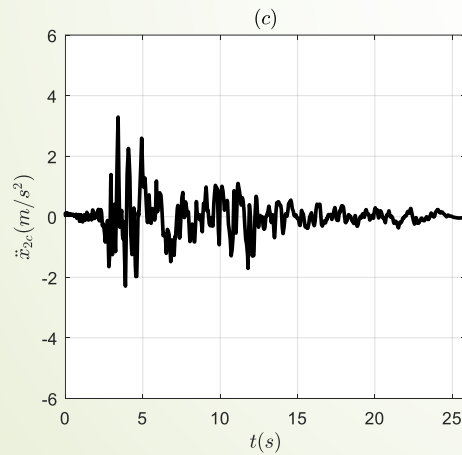
➤ $K_p = 10; K_i = 0;$



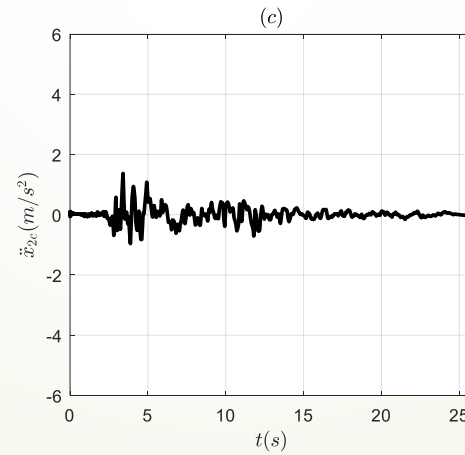
➤ $K_p = 15; K_i = 0;$



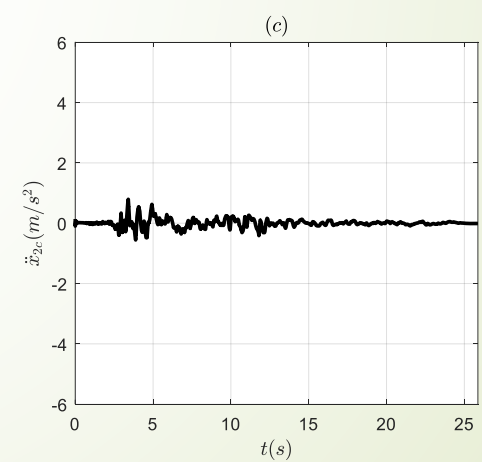
Controlled time history plots of table



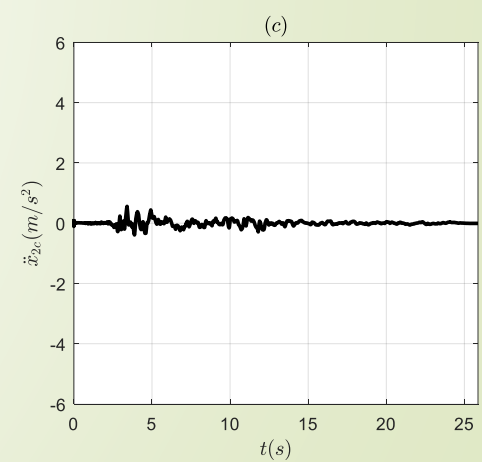
➤ $K_p = 1; K_i = 0.1;$



➤ $K_p = 5; K_i = 0.1;$



➤ $K_p = 10; K_i = 0.1;$

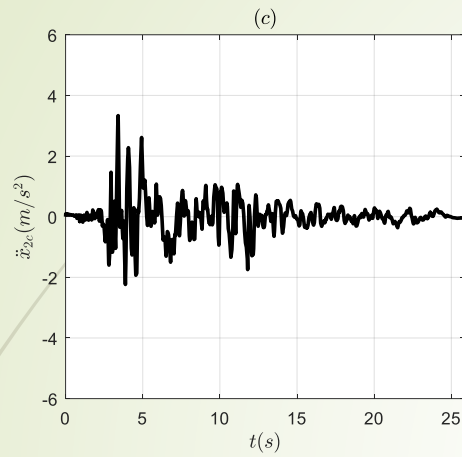


➤ $K_p = 15; K_i = 0.1;$

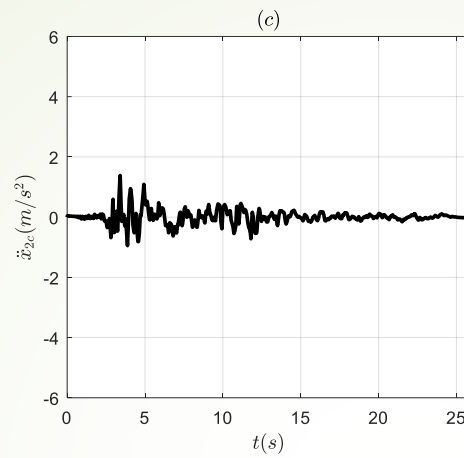
Kp (Prportional Constant)	Ki (Integral constant)	%TR
1	0	68.017
5	0	27.111
10	0	15.684
15	0	11.033
1	0.1	65.013
5	0.1	27.113
10	0.1	65.684
15	0.1	11.033

$$\%TR = \left| \frac{\ddot{x}_{2cRMS}}{\ddot{z}_{RMS}} \right| \times 100$$

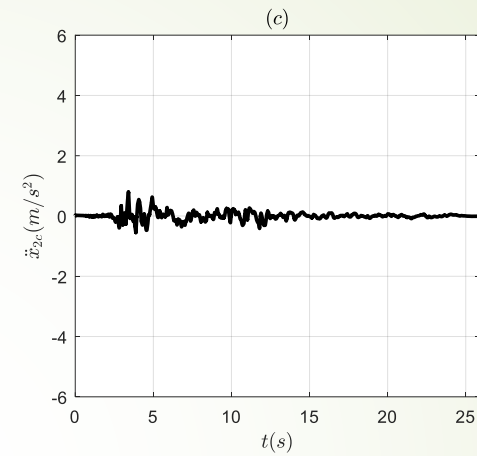
➤ $K_p = 1; K_i = 1;$



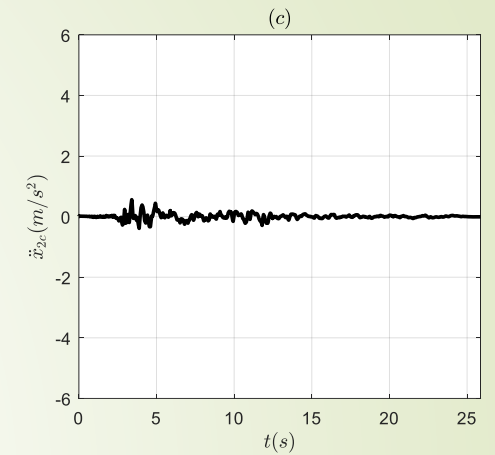
➤ $K_p = 5; K_i = 1;$



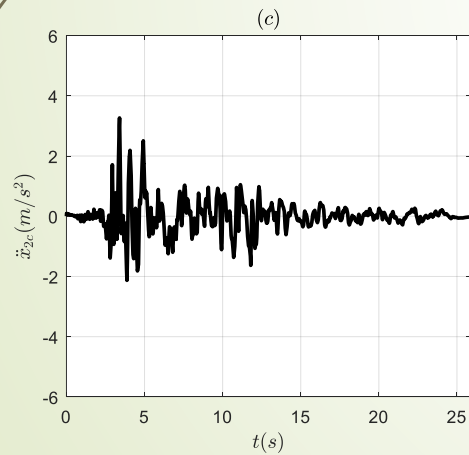
➤ $K_p = 10; K_i = 1;$



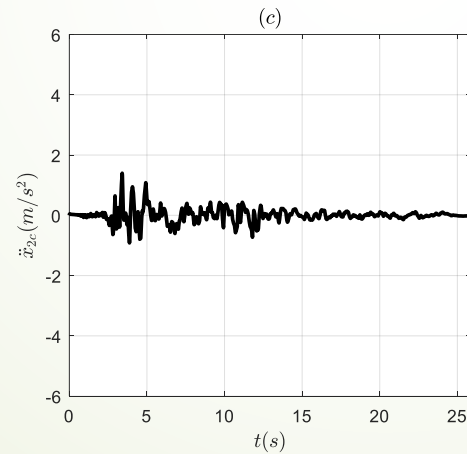
➤ $K_p = 15; K_i = 1;$



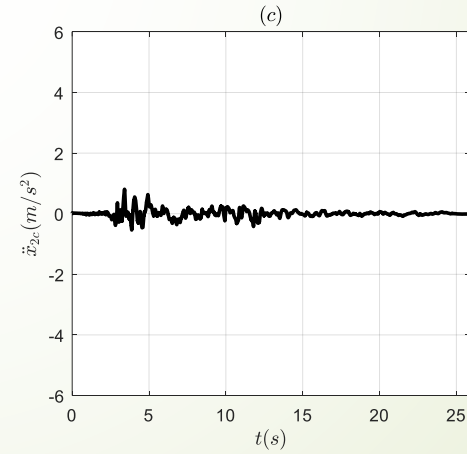
➤ $K_p = 1; K_i = 5;$



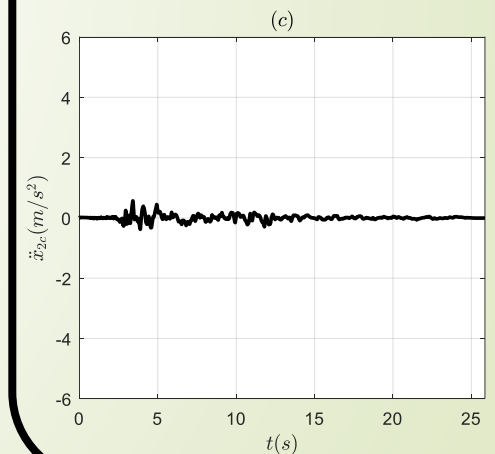
➤ $K_p = 5; K_i = 5;$



➤ $K_p = 10; K_i = 5;$



➤ $K_p = 15; K_i = 5;$



Controlled time history plots of table

Kp (Prportional Constant)	Ki (Integral constant)	%TR
1	1	64.741
5	1	27.09
10	1	15.678
15	1	11.030
1	5	61.381
5	5	26.683
10	5	15.589
15	5	10.997

Conclusion

- ▶ While compensating the permanent errors with the value of K_i at the points where the K_p value is low, these permanent values disappear when we increase the K_p value.
- ▶ Servo motor driven ball screw feed system can be a promising candidate as an active vibration control platform for suppressing earthquake induced accelerations.
- ▶ Future works; PI control approach will be tested under different earthquakes.

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THANK YOU FOR YOUR ATTENTION