

# **Upravljanje brzinom motora jednosmerne struje primenom analogne negativne povratne sprege**

**Diplomski rad**

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28. septembar, 2022

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# **Teorijski uvod**

# Sistemi automatskog upravljanja

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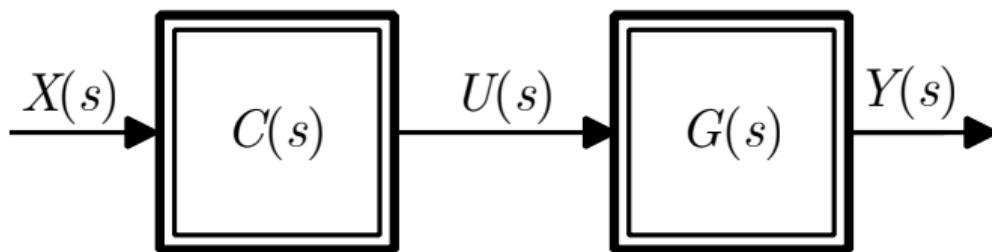


Figure: Opšta blok šema sistema automatskog upravljanja.

# Motor stalne struje

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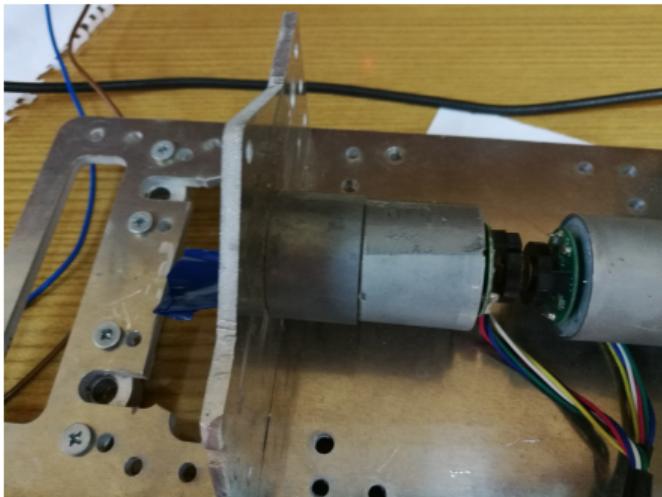


Figure: Motor stalne struje.

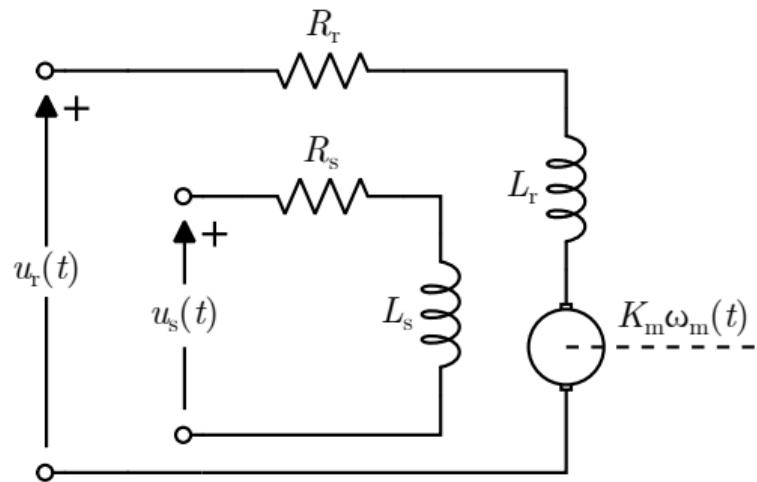
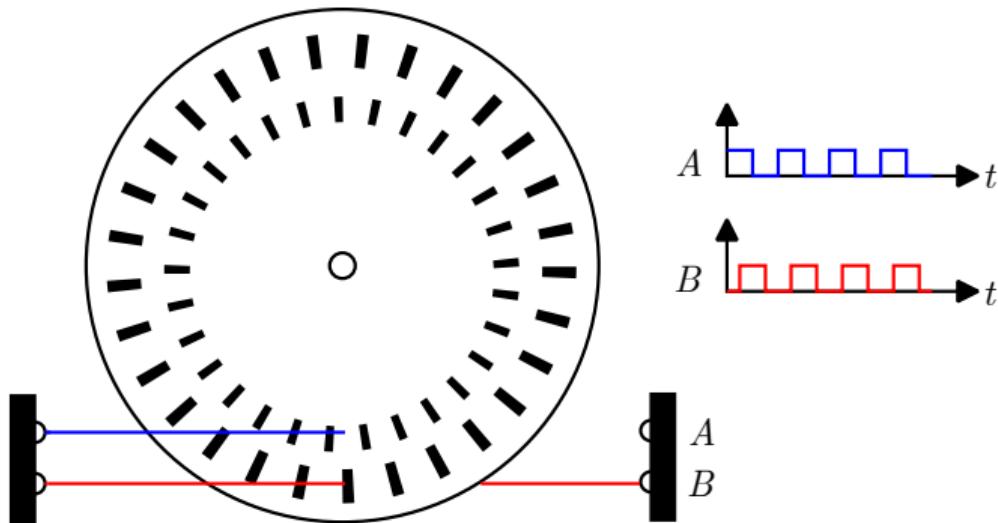


Figure: Model motora stalne struje.

# Rotacioni enkoder

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# Pretvarač učestanosti u napon

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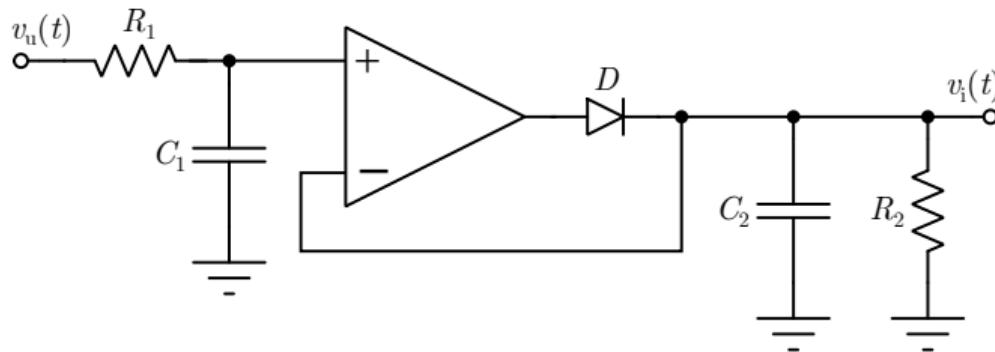


Figure: Električna šema pretvarača učestanosti u napon.

# Pretvarač učestanosti u napon

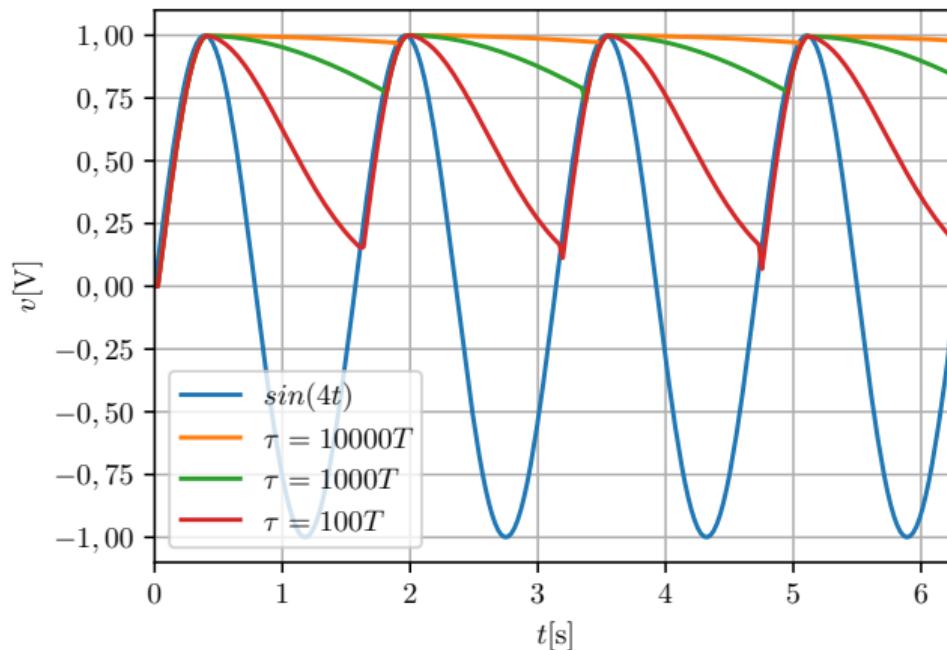


Figure: Primer ulaznog signala i nekoliko izlaznih signala pretvarača učestanosti u napon.

# Negativna povratna sprega

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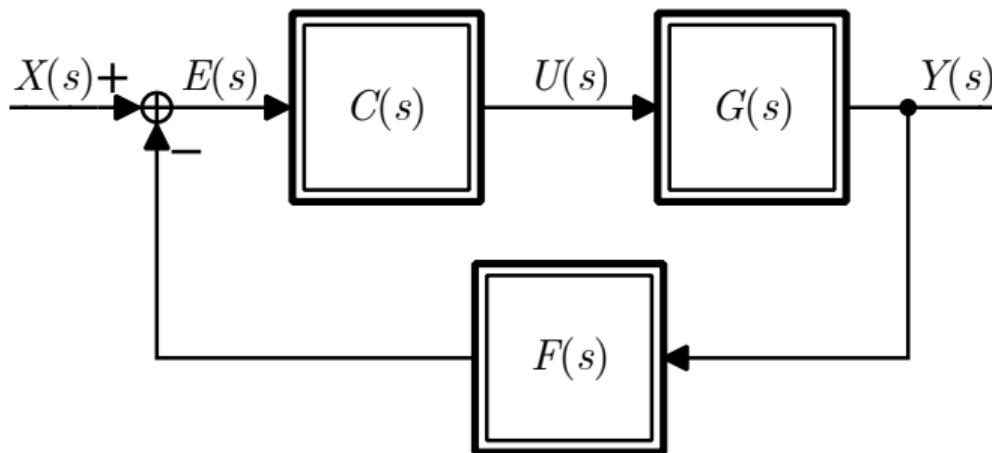


Figure: Opšta blok šema sistema sa negativnom povratnom spregom.

# P regulator

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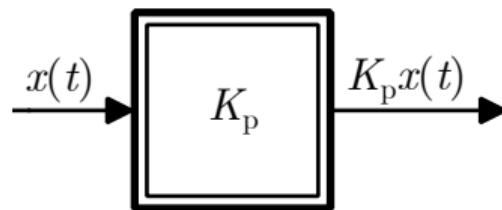


Figure: Opšta blok šema P regulatora.

# Bang-bang regulator

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$$K_p \rightarrow \infty$$

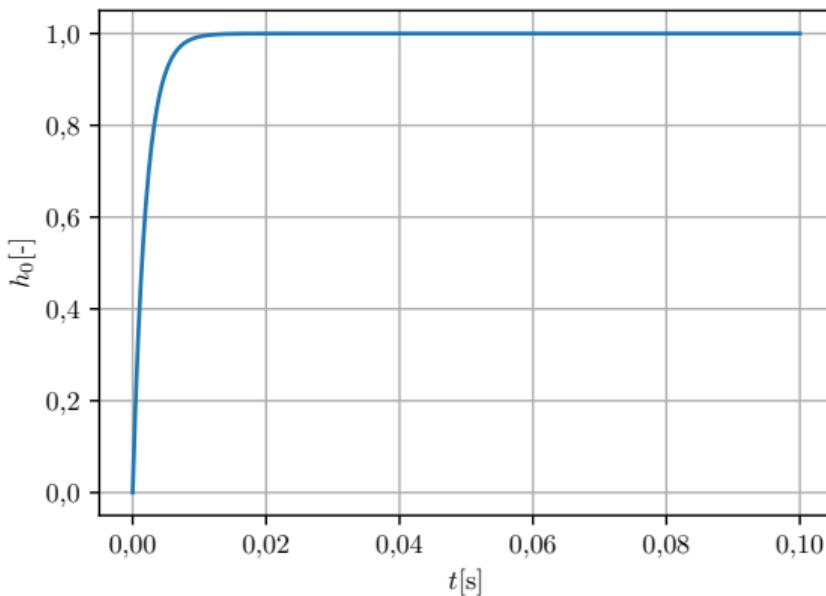


Figure: Očekivani napon na izlazu bang-bang regulatora.

# PI regulator

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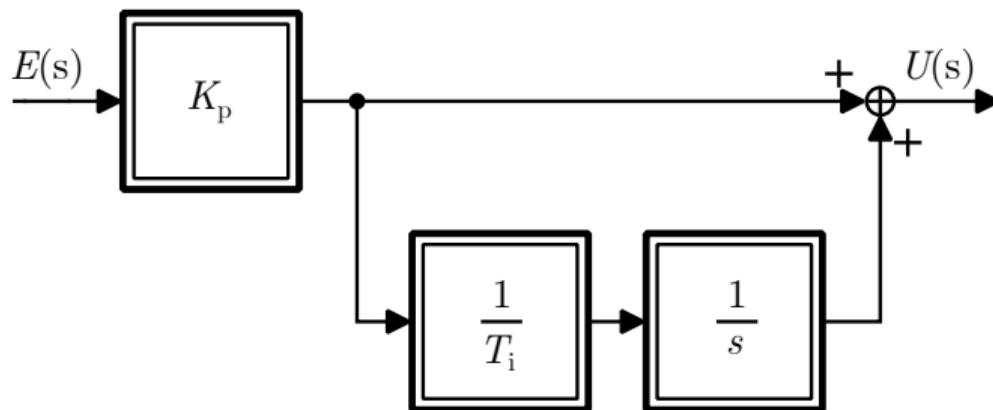


Figure: Opšta blok šema sistema sa PI regulatorom.

# Pojačavač snage

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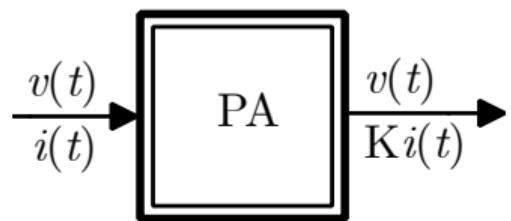


Figure: Opšta blok šema sistema sa negativnom povratnom spregom.

# Pojačavač snage u klasi B

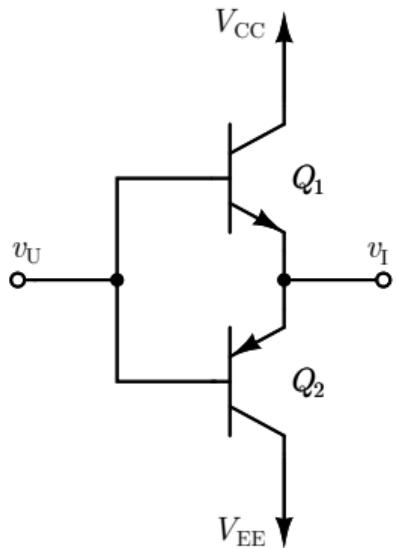


Figure: Pojačavač snage u klasi B.

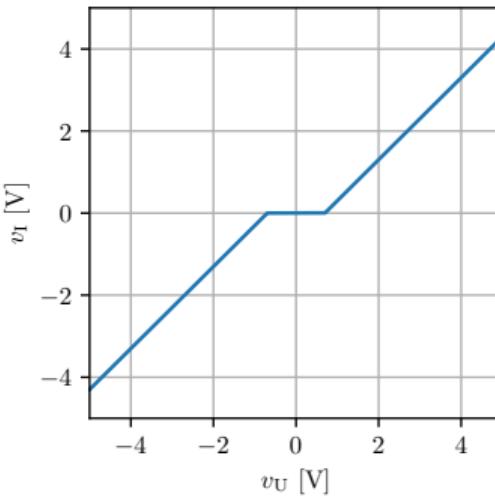


Figure: Jednosmerna prenosna karakteristika.

# Pojačavač snage u klasi AB

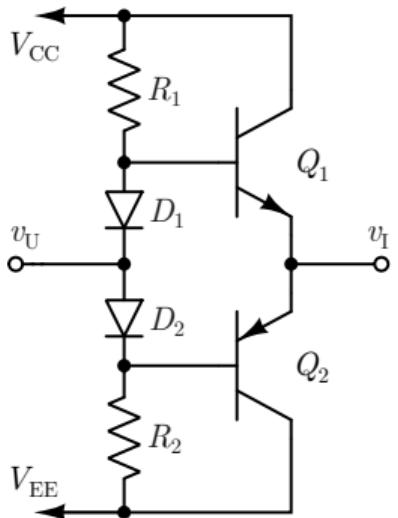


Figure: Pojačavač snage u klasi B.

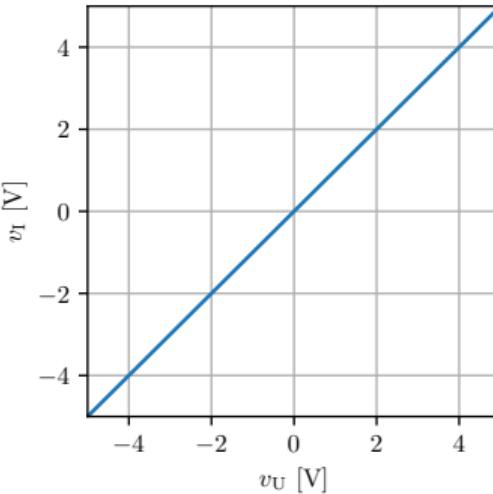


Figure: Jednosmerna prenosna karakteristika.

# Karakteristike korišćenih komponenti

# Merenje karakteristike motora

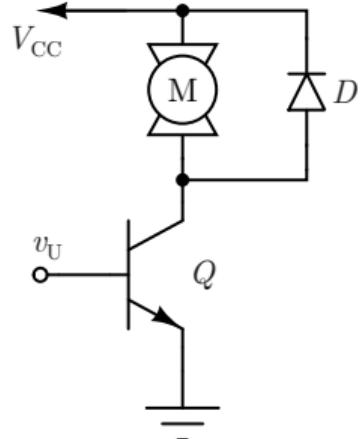


Figure: Električna šema za testiranje motora.

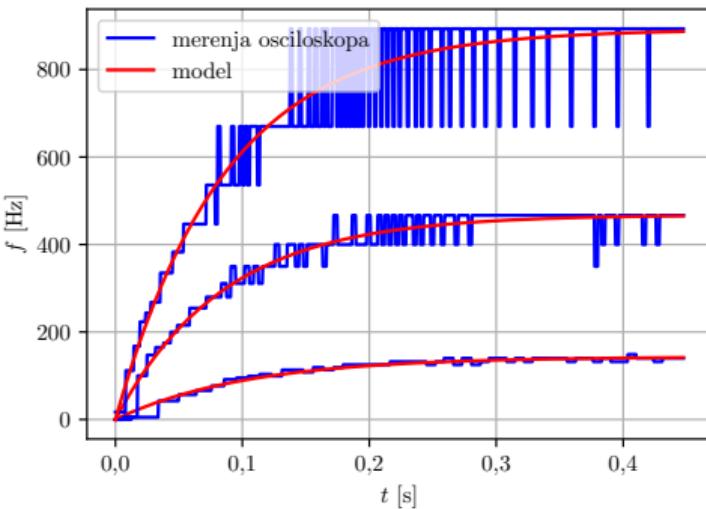


Figure: Grafik preklopljenih izmerenih i modela karakteristike motora.

# Greška merenja

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$$\frac{\Delta f}{f} = \frac{f\Delta f}{1-(f\Delta f)^2}$$

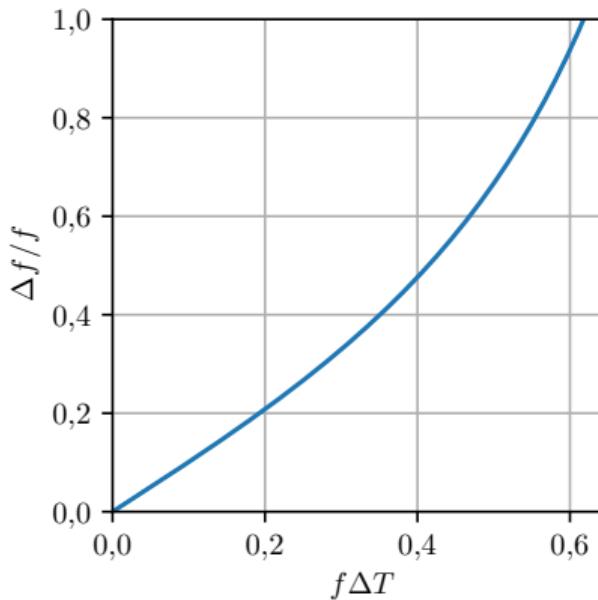


Figure: Odnos normalizovane relativne greške u odnosu na normalizovanu frekvenciju.

# Pretvarač učestanosti u napon

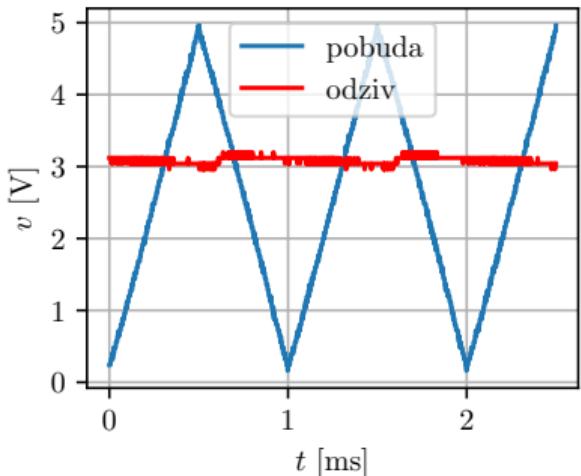


Figure: Odziv pretvarača na pobudu konstante frekvencije.

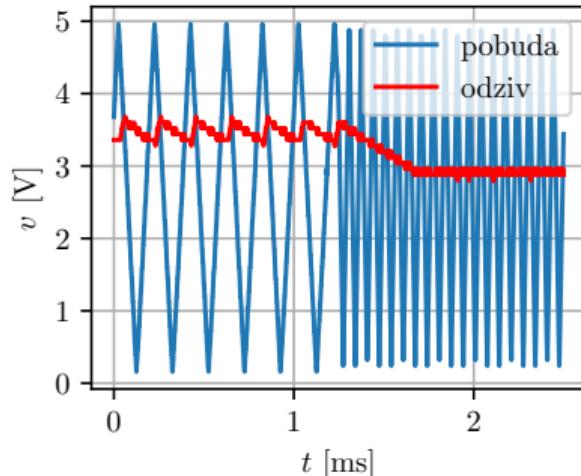


Figure: Odziv pretvarača na skokovitu promenu frekvencije pobudnog napona.

# Pretvarač učestanosti u napon sa filtrom

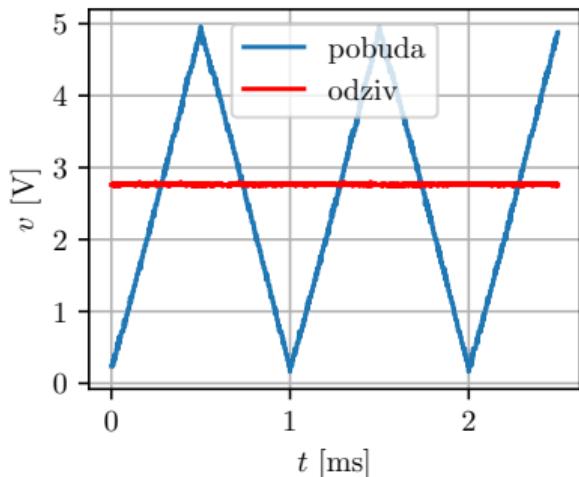


Figure: Odziv pretvarača na pobudu konstante frekvencije.

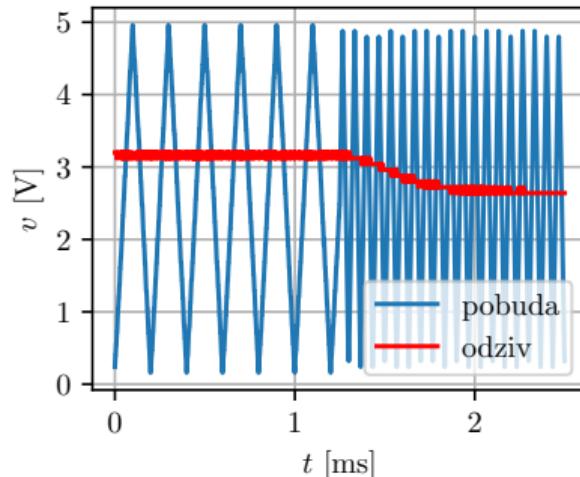


Figure: Odziv pretvarača na skokovitu promenu frekvencije pobudnog napona.

# Karakteristika pretvarača frekvencije u napon

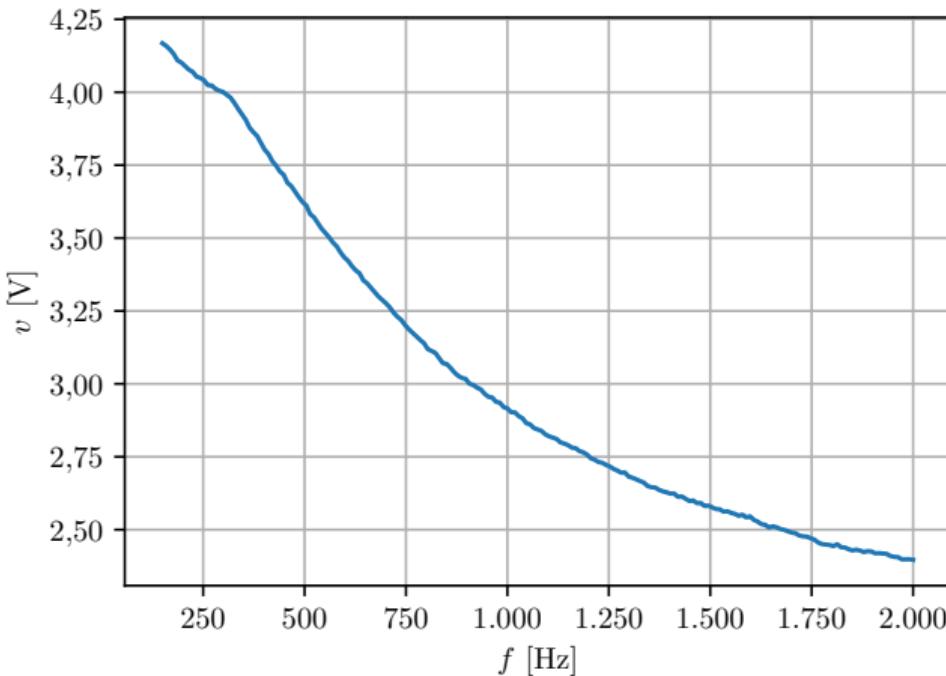


Figure: Prenosna karakteristika pretvarača učestanosti.

# Karakteristike pojačavača snage

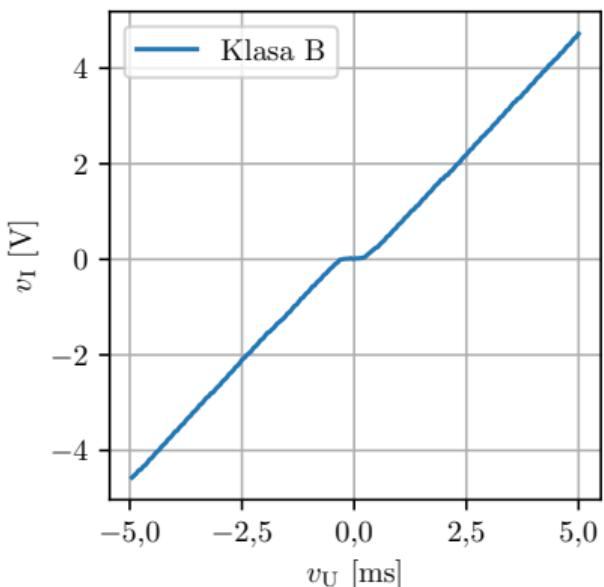


Figure: Izmerena statička karakteristika pojačavača snage u klasi B.

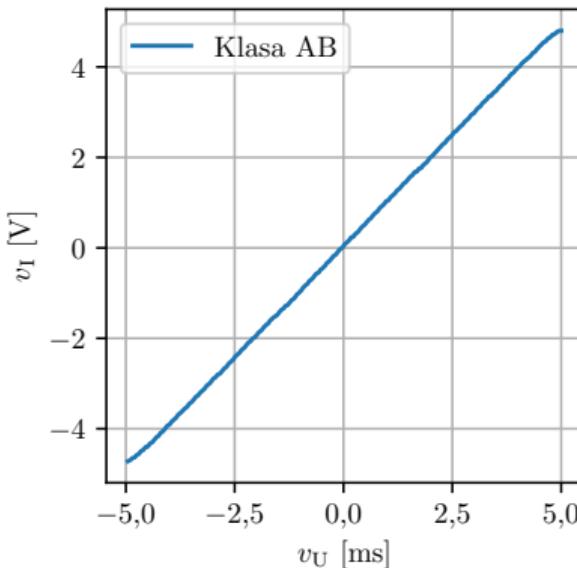


Figure: Izmerena statička karakteristika pojačavača snage u klasi AB.

# Karakteristike pojačavača snage

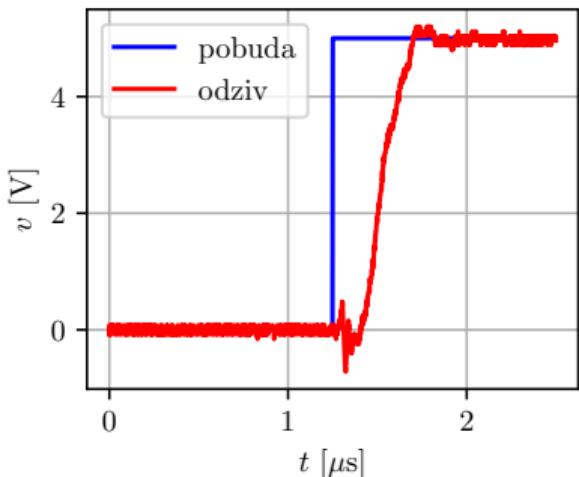


Figure: Izmeren odziv pojačavača u klasi AB na odskočnu pobudu.

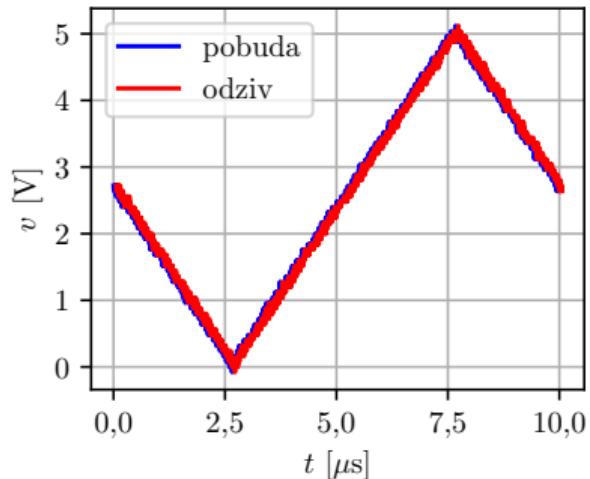


Figure: Izmeren odziv pojačavača u klasi AB na rampu.

# Kompletan sistem

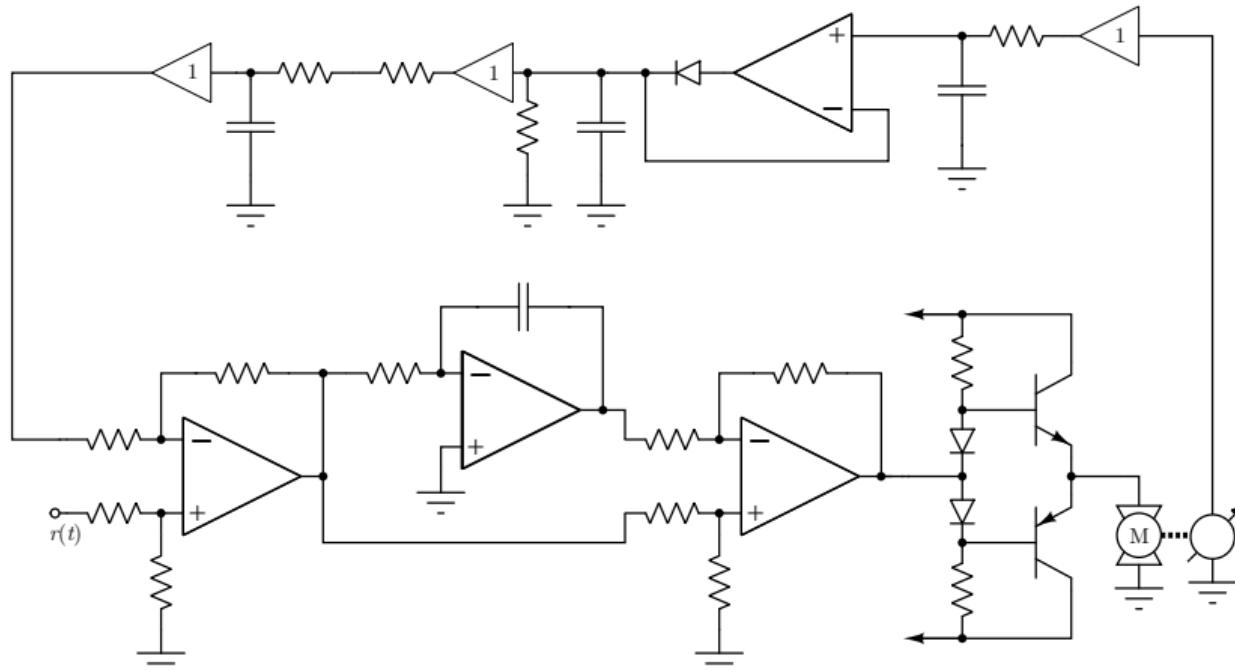


Figure: Blok šema celog sistema.

# Radno merno okruženje

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Figure: Radno okruženje sa projektovanim sistemom i aparaturom za merenje.

# Rezultati i diskusija

# Rezultati merenja karakteristike motora

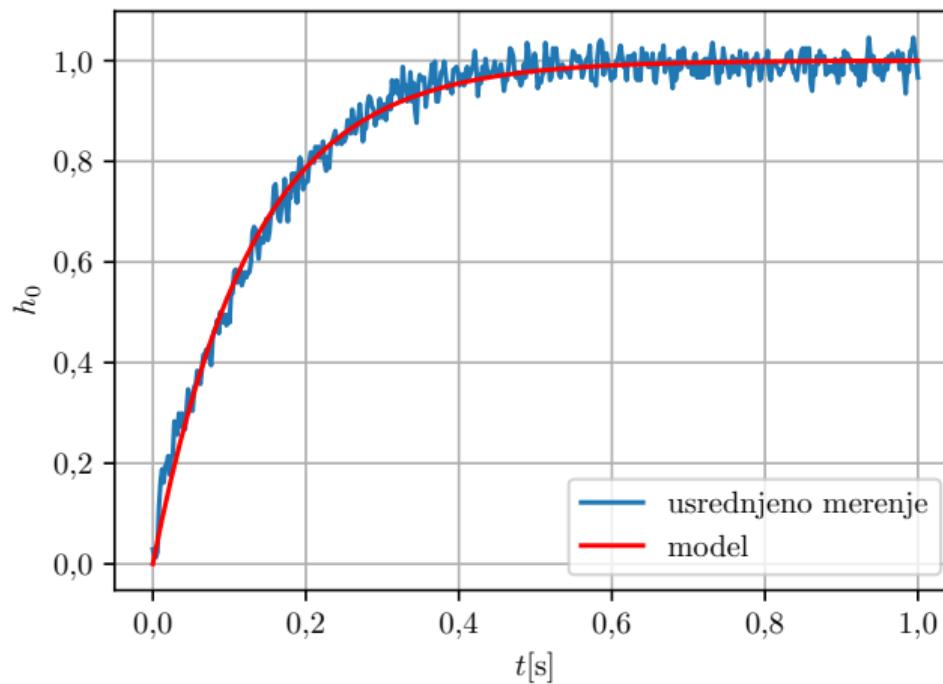


Figure: Usrednjeni relativni odziv sistema i njegov model sa parametrima  $K_m = 0.314$  i  $T_m = 132$  ms.

# Rezultati merenja karakteristike motora

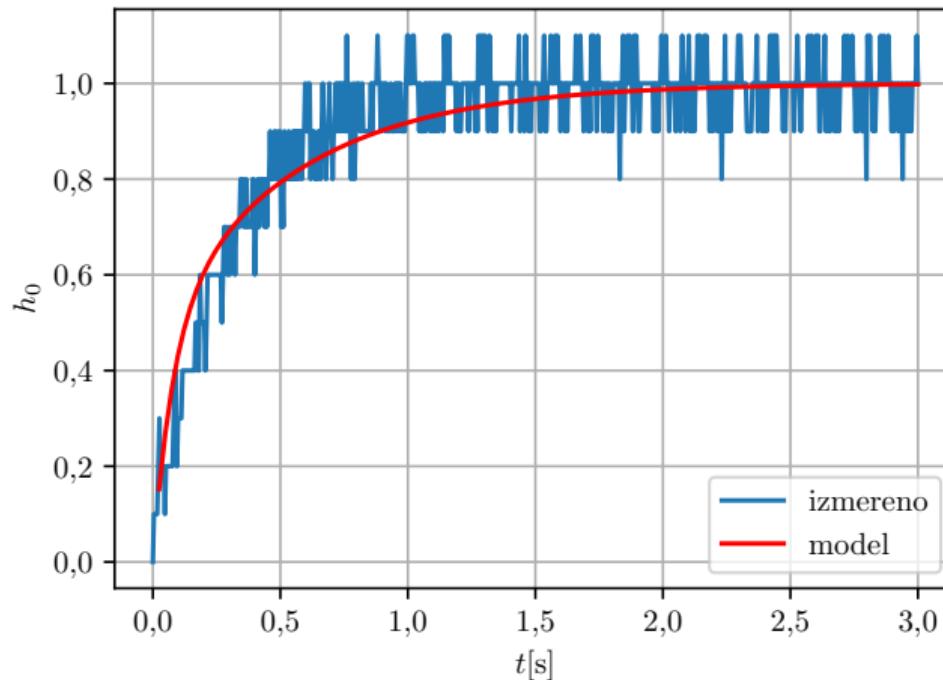


Figure: Odskočni odziv sistema sa parametrima PI regulatora  $K_p = 3$  i  $T_i = 100$  ms.

# Rezultati merenja karakteristike motora

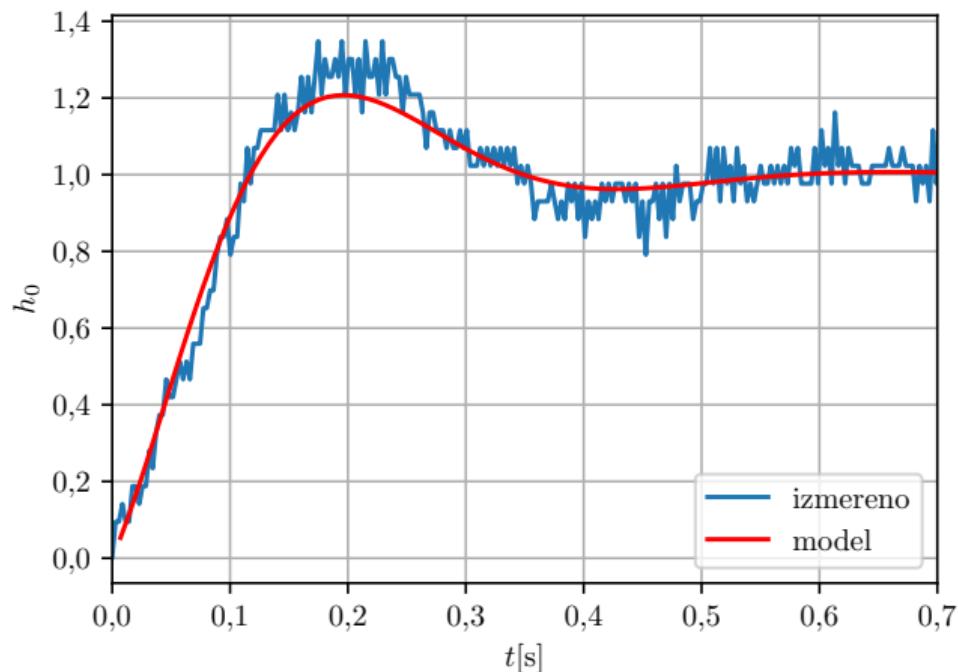


Figure: Odskočni odziv sistema sa parametrima PI regulatora  $K_p = 3$  i  $T_i = 10 \text{ ms}$ .

# Pozicije nule i polova PI regulatora

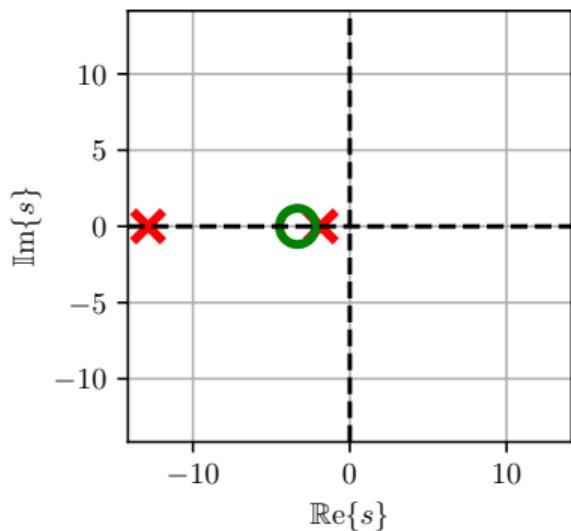


Figure: Pozicija nula i polova prenosne funkcije za sistem bez preskoka.

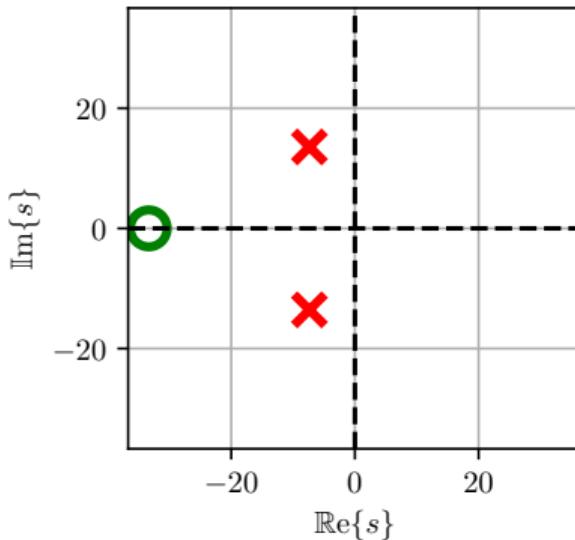


Figure: Pozicija nula i polova prenosne funkcije za sistem sa preskokom.

**Hvala na pažnji!**

# Zahvalnost