Identifikacija Modela Linearnog Dinamičkog Sustava

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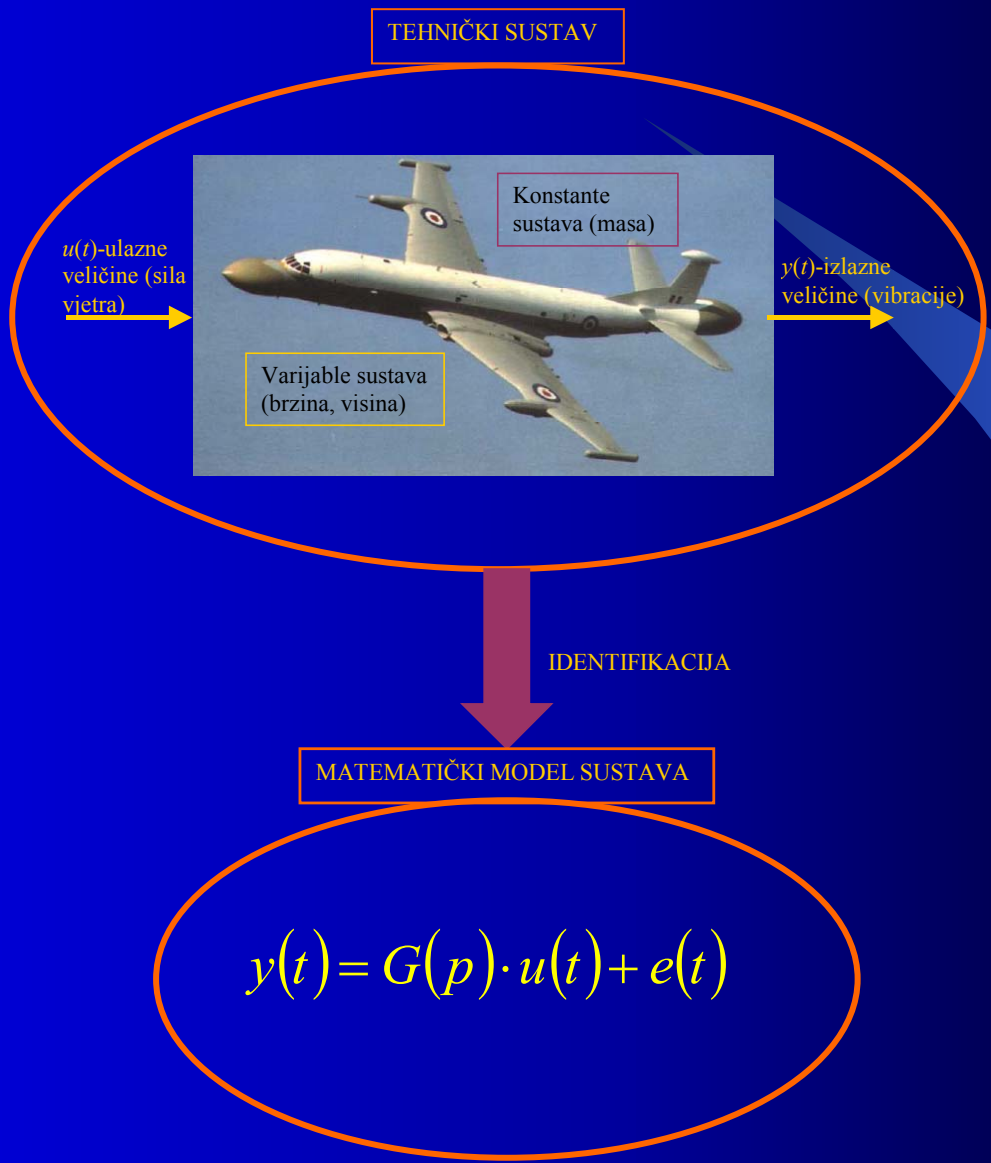
Uvod


TEHNIČKI SUSTAV
Konstante sustava (masa)
u(t)-ulazne veličine (sila vjetra)
y(t)-izlazne veličine (vibracije)
Varijable sustava (brzina, visina)
IDENTIFIKACIJA
MATEMATIČKI MODEL SUSTAVA
$y(t) = G(p) \cdot u(t) + e(t)$

Neparametarske metode identifikacije

- Fourier-ova analiza

  -Određivanje prijenosne funkcije:

$$\hat{G}(i\omega) = \frac{Y(\omega)}{U(\omega)}$$

$$Y(\omega) = T \cdot \sum_{k=1}^{N} y(kT) \cdot e^{-i\omega kT}$$

$$U(\omega) = T \cdot \sum_{k=1}^{N} u(kT) \cdot e^{-i\omega kT}$$

- Analiza spektra

-Prijenosna funkcija:

$$\hat{G}^N(i\omega) = \frac{\hat{\Phi}_{yu}^N(\omega)}{\hat{\Phi}_u^N(\omega)}$$

$$\hat{\Phi}_u^N(\omega) = \sum_{k=-\gamma}^{\gamma} w_\gamma(k) \cdot \hat{R}_u^N(k) \cdot e^{-i\cdot\omega\cdot k}$$

$$w_\gamma(k) = \int_{-\pi}^{\pi} W_\gamma(\xi) e^{i\cdot\xi\cdot k} d\xi$$

$$\hat{\Phi}_{yu}^N(\omega) = \sum_{l=-\gamma}^{\gamma} \hat{R}_{yu}^N(l) \cdot w_\gamma(l) \cdot e^{-i\cdot\omega\cdot l}$$

$$\hat{R}_u^N(k) = \frac{1}{N} \sum_{t=1}^{N} u(t+k) \cdot u(t)$$

$$\hat{R}_{yu}^N(\tau) = \frac{1}{N} \sum_{k=1}^{N} y(k) \cdot u(k-\tau)$$

Parametarske Metode Identifikacije

- Gotovi modeli su dani općim izrazom:

$$y(t) = G(q,\theta)\cdot u(t) + H(q,\theta)\cdot e(t)$$

- Racionalna funkcija $G(q, \theta)$:

$$G(q,\theta) = \frac{B(q)}{F(q)} = \frac{b_1\cdot q^{-n\cdot k} + b_2\cdot q^{-n\cdot k-1} + \ldots + b_{nb}\cdot q^{-n\cdot k-n\cdot b+1}}{1 + f_1\cdot q^{-1} + \ldots + f_{nf}\cdot q^{-n\cdot f}}$$

- Racionalna funkcija $H(q,\ \theta)$:

$$H(q,\theta)=\frac{C(q)}{D(q)}=\frac{1+c_1\cdot q^{-1}+\ldots+c_{ne}\cdot q^{-n\cdot c}}{1+d_1\cdot q^{-1}+\ldots+d_{nd}\cdot q^{-n\cdot d}}$$

- Parametri *nb*, *nc*, *nd*, *nf* i *nk* se odabiru, a zatim se koeficijenti $\theta=\{b_1, b_2,\ldots b_{nk}, f_1, f_2,\ldots f_{nf}, c_1, c_2,\ldots c_{nb}, d_1, d_2,\ldots d_{nf}\}$ modela moraju prilagoditi rezultatima mjerenja.

Pregled gotovih modela

- Box-Jenkins (BJ)

$$y(t) = \frac{B(q)}{F(q)} \cdot u(t) + \frac{C(q)}{D(q)} \cdot e(t)$$

- Output-error (OE)

$$y(t) = \frac{B(q)}{F(q)} \cdot u(t) + e(t)$$

- AutoRegressiveMovingAverageeXogenous (Armax)

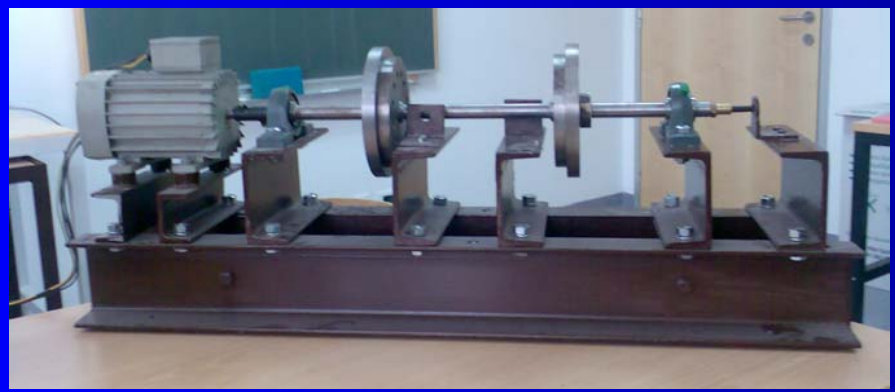
$$A(q) \cdot y(t) = B(q) \cdot u(t) + C(q) \cdot e(t)$$

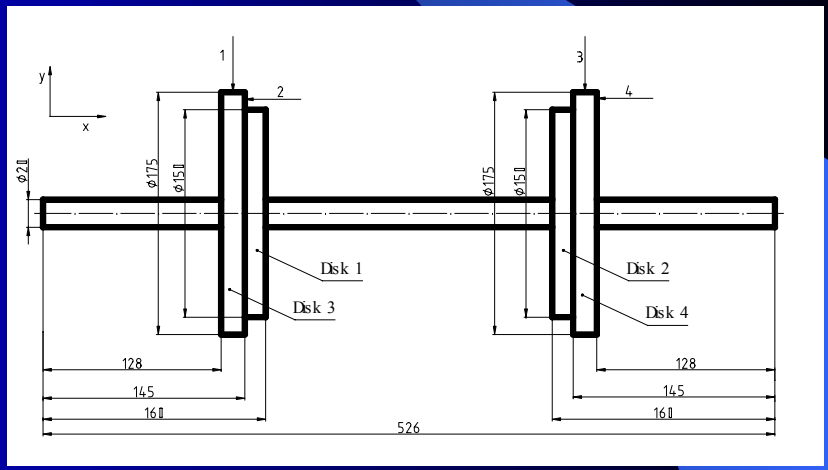
- AutoRegressiveeXogenous (Arx)

$$A(q) \cdot y(t) = B(q) \cdot u(t) + e(t)$$

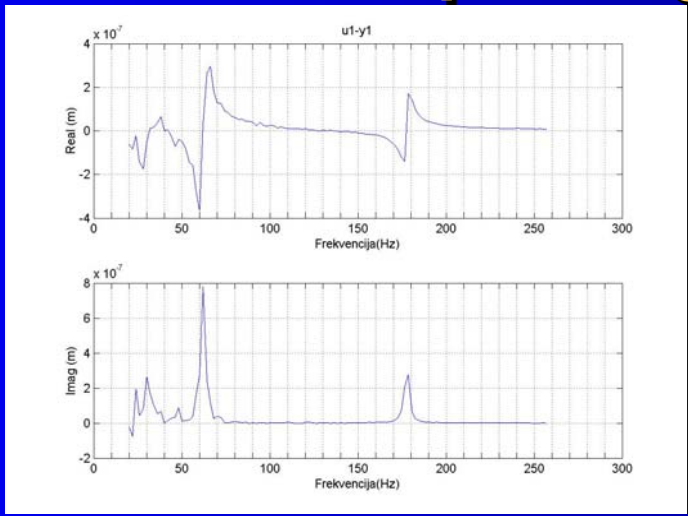
Mjerenje

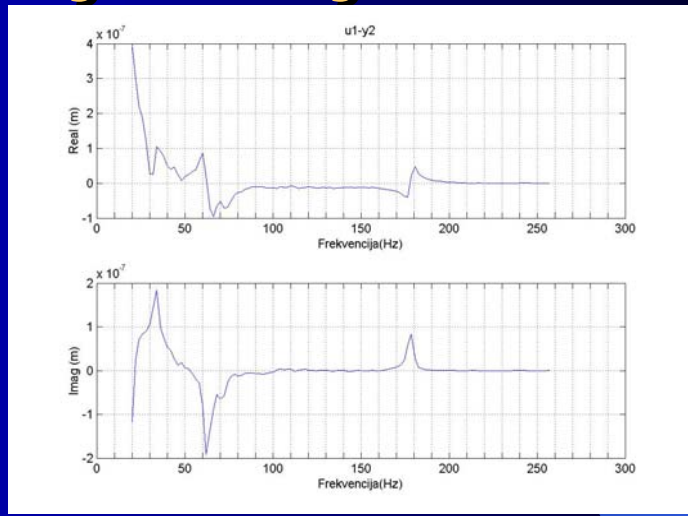
- Mjereni sustav

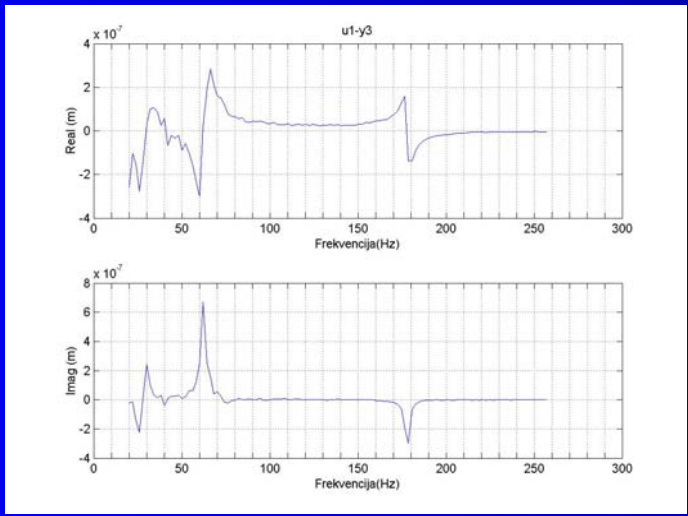


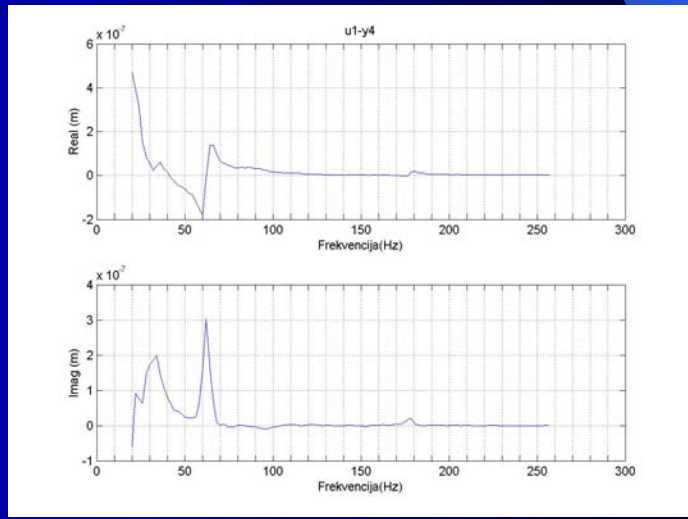


Rezultati prvog mjerenja

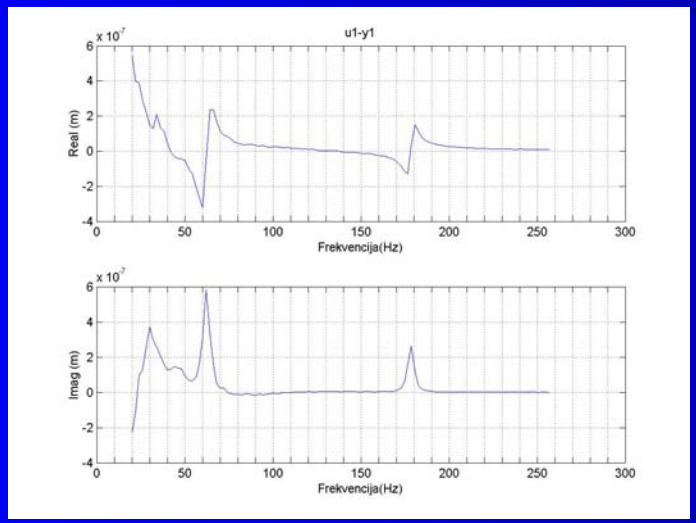


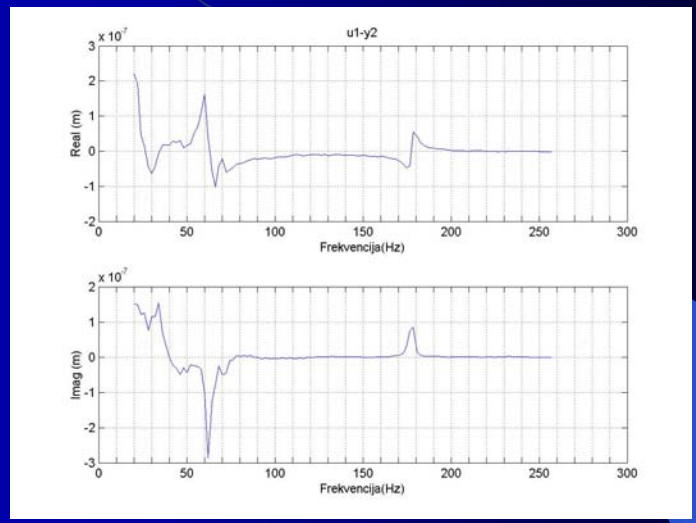


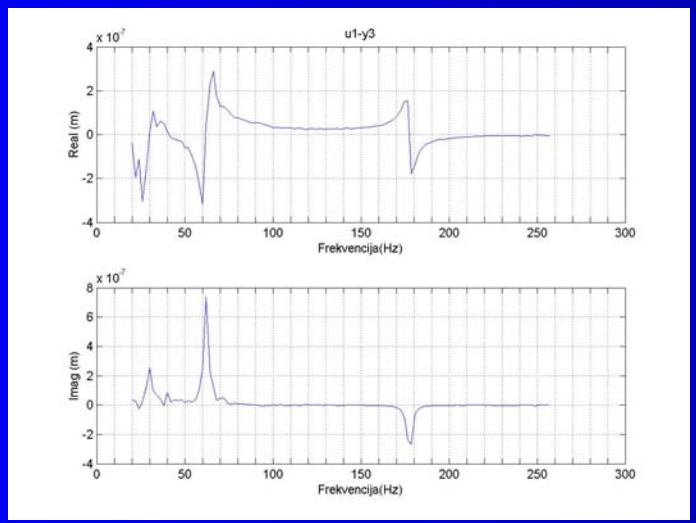


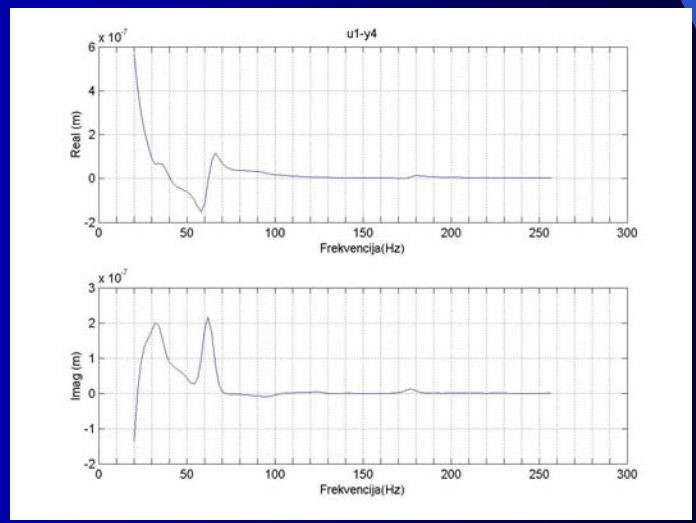


Rezultati drugog mjerenja

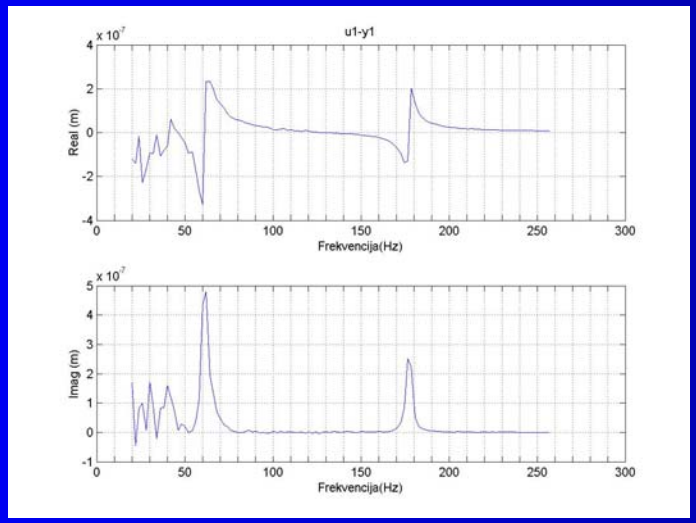


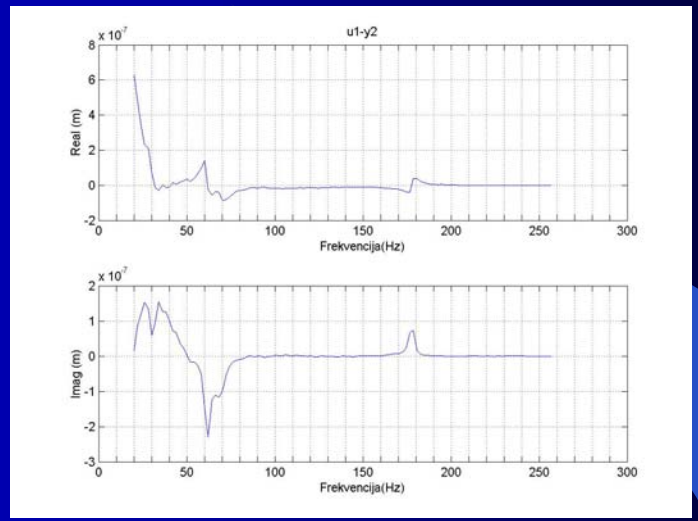


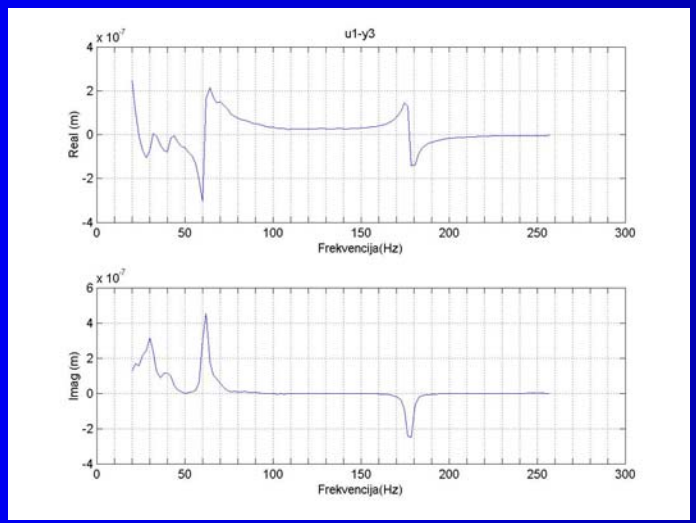


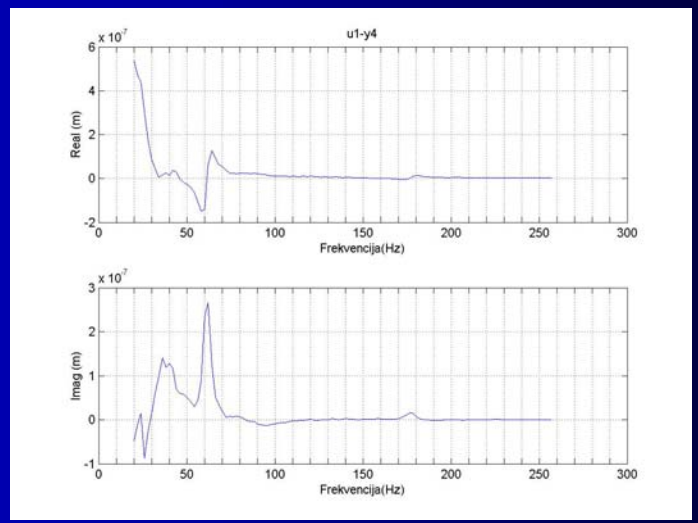


Rezultati trećeg mjerenja

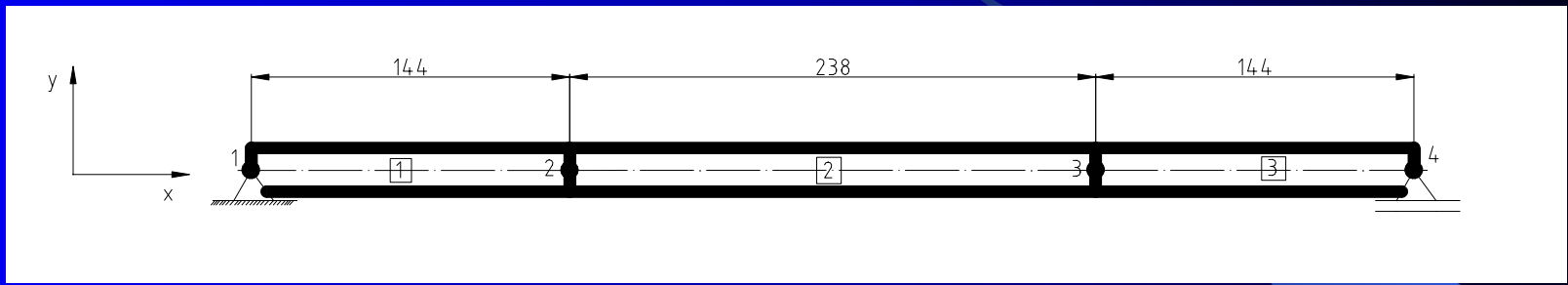




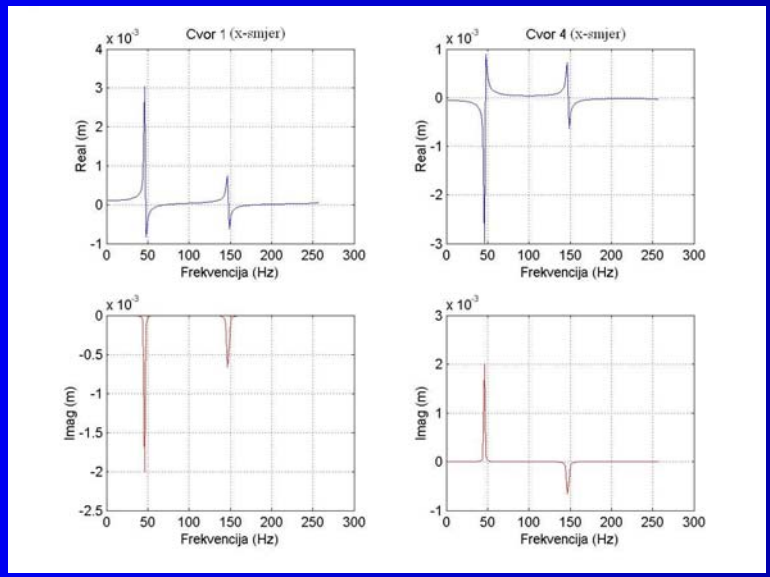


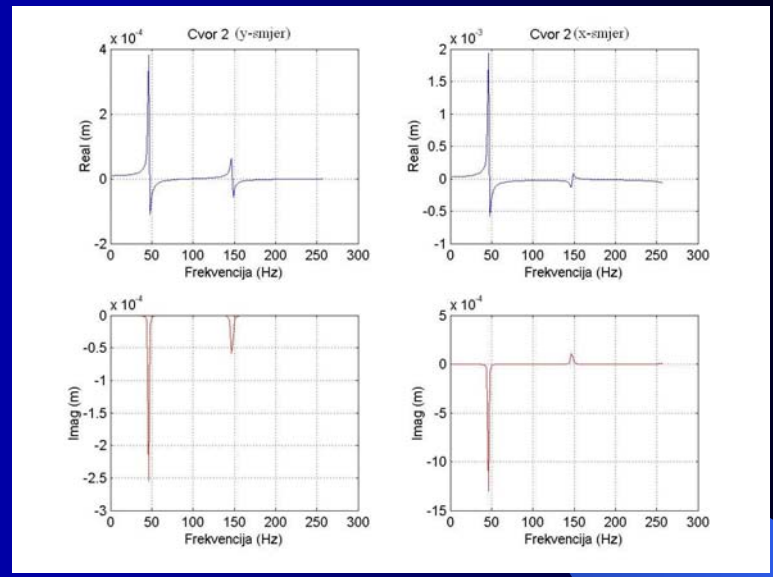


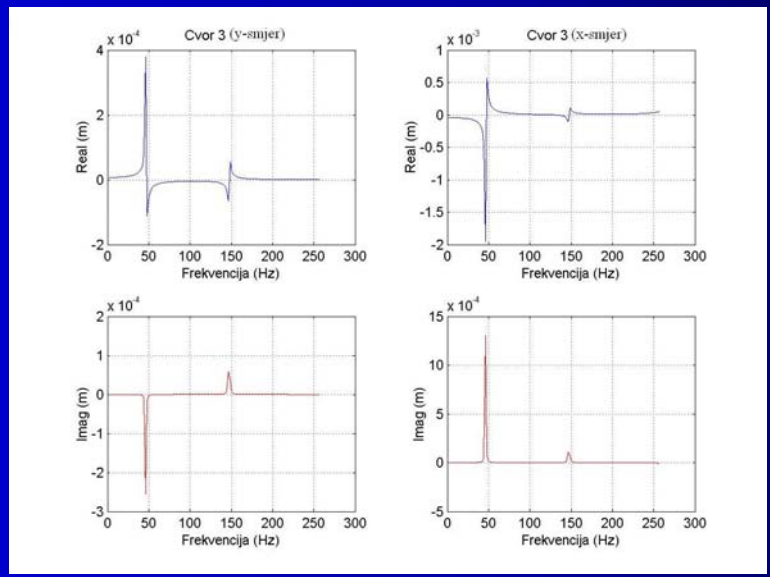
Analitičko rješenje sustava



ČVOR	w	β	F_y	M
1	0 (7)	? (1)	?	0
2	? (2)	? (3)	0	0
3	? (4)	? (5)	0	0
4	0 (8)	? (6)	?	0

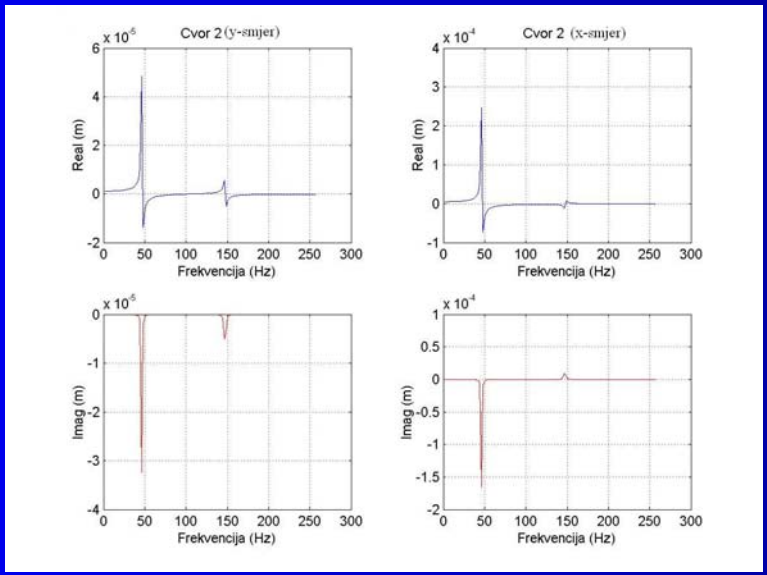

Cvor 1 (x-smjer)
Cvor 4 (x-smjer)
Real (m)
Imag (m)
Frekvencija (Hz)

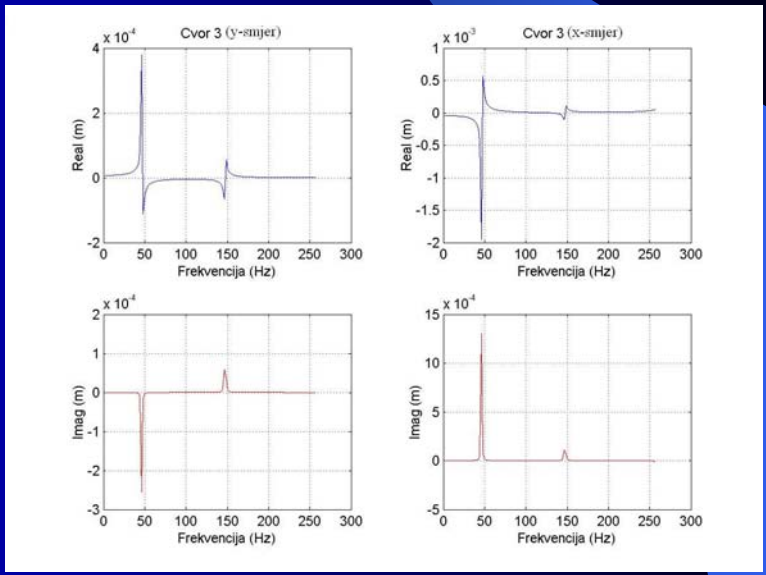

Cvor 2 (y-smjer)
Cvor 2 (x-smjer)
Real (m)
Imag (m)
Frekvencija (Hz)


Cvor 3 (y-smjer)
Cvor 3 (x-smjer)
Real (m)
Imag (m)
Frekvencija (Hz)

Redukcija sustava

- Dobivene prijenosne funkcije nakon Guyan-ove redukcije





Zaključak

- Mjerenjem vlastitih vibracija na sustavu vratila potvrđeno je poklapanje sa analitičkim rješenjem.
- Kod udarne uzbude bolje su se pokazale neparametarske metode.
- Kod uzbude “shaker-om” bolje rezultate su dale parametarske metode.
- Identificirana prijenosna funkcija se može koristiti u aktivnoj kontroli vibracija.