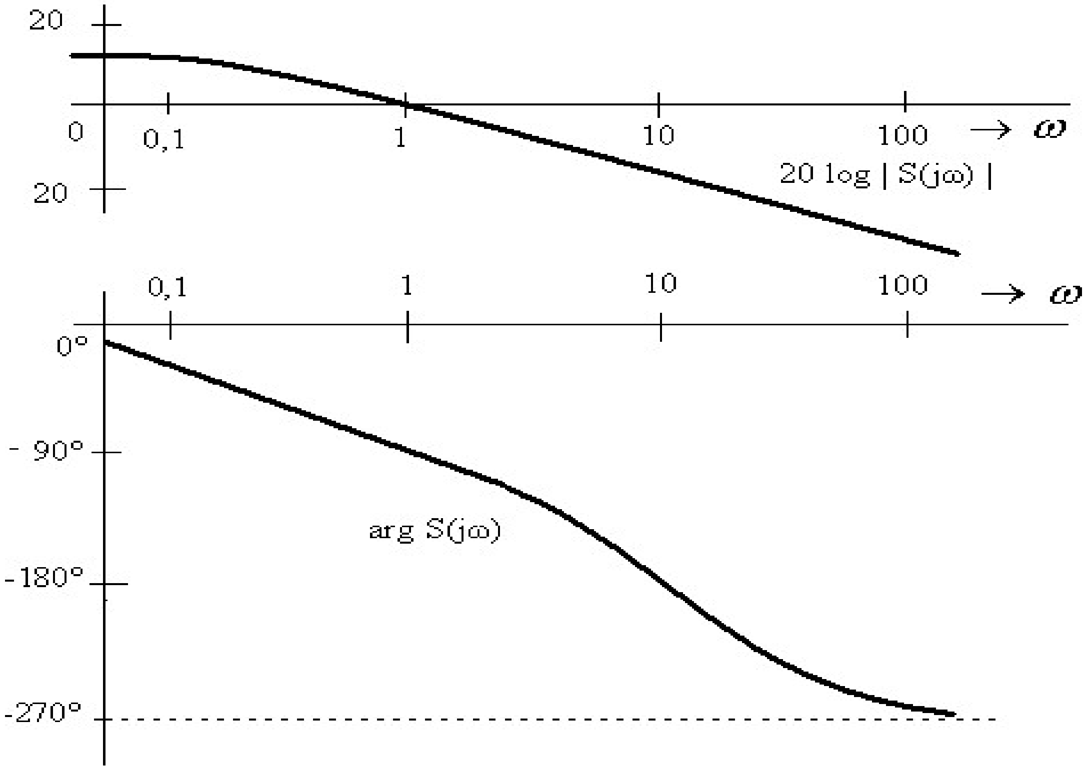
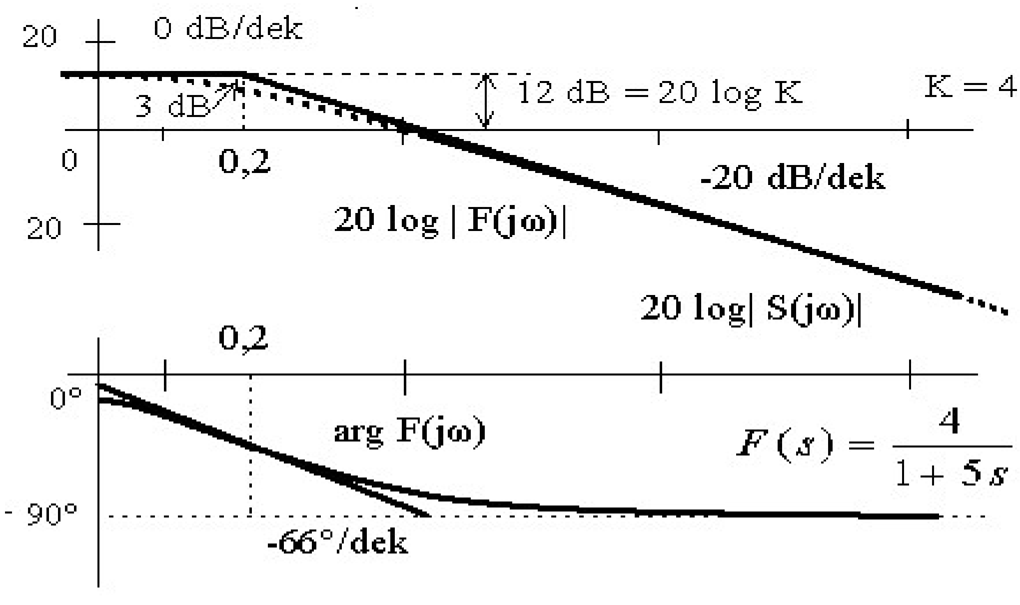
Identifikácia z frekvenčných charakteristík

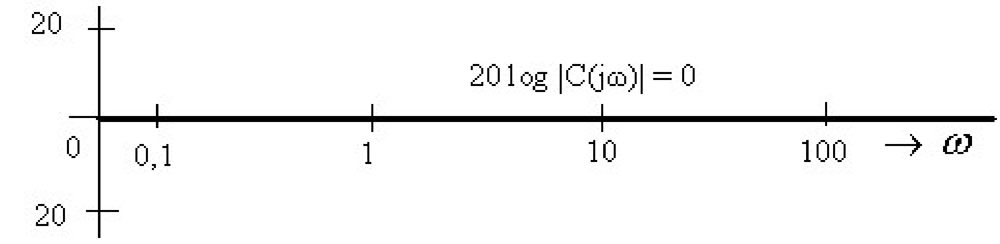
Bodeho metóda

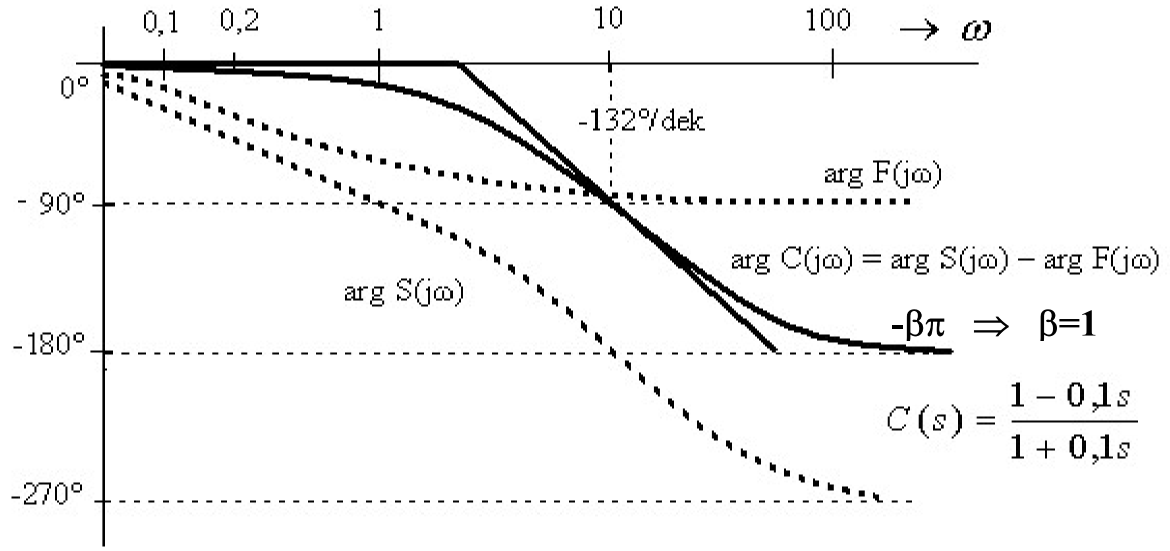




Zosilnenie určíme z asymptoty v oblasti najnižších frekvencií – priamka rovnobežná s x-osou y=20logK=12 dB $\Rightarrow$ K=4

Bod zlomu $\omega_1 = \frac{1}{T_1} = 0{,}2$ $\Rightarrow$ T=5





Porovnáme fázovú logaritmickú frekvenčnú charakteristiku frekvenčného prenosu zodpovedajúceho prenosu $F(s) = \frac{K}{1+T_1 s} = \frac{4}{1+5s}$ s nameranou fázovou charakteristikou skutočného systému.

Rozdiel medzi fázovými frek. charakteristikami sa ustáli na hodnote -$\beta\pi = \pi \;\Rightarrow\; \beta = 1$, pričom cez hodnotu -$\beta$.90°=90° prechádza pri frekvencii $\omega = \frac{1}{T} = 10 \qquad \Rightarrow \qquad$ T=0,1

Výsledný prenos: $S(s) = F(s)\left(\frac{1-Ts}{1+Ts}\right)^{\beta} = \frac{4}{1+5s}\frac{1-0{,}1s}{1+0{,}1s}$

Vrbanova metóda

Uvažujeme systém v tvare $S(s) = \dfrac{12}{s(1+s)}$

Nameraná frekvenčná charakteristika (ovplyvnená šumom merania)

k	ω	$U(\omega)$	$V(\omega)$
1	0,5	-10,08	-18,24
2	1	-6,3	-6,3
3	2	-2,28	-1,26
4	3	-1,26	-0,38

$$\mathbf{H}\hat{\boldsymbol{\theta}} = \mathbf{y}$$

$$\mathbf{H} = \begin{pmatrix} \mathbf{h}^T(\omega_1) \\ \mathbf{h}^T(\omega_2) \\ \vdots \\ \mathbf{h}^T(\omega_N) \end{pmatrix} \qquad \hat{\boldsymbol{\theta}} = (b_0, b_1, \ldots, b_m, a_0, a_1, \ldots, a_{n-1})^T$$

$$\mathbf{h}(\omega)^T = \left(1, -\omega, -\omega^2, \omega^3, \ldots, (-1)^{\mathrm{int}\frac{m+1}{2}}\omega^m, -x_0(\omega), x_1(\omega), x_2(\omega), -x_3(\omega), \ldots, (-1)^{\mathrm{int}\frac{n-2}{2}} x_{n-1}(\omega)\right)$$

$$\mathbf{y} = -\left((-1)^{\mathrm{int}\frac{n-1}{2}} x_n(\omega_1), \ldots, (-1)^{\mathrm{int}\frac{n-1}{2}} x_n(\omega_N)\right)^T$$

$$x_q(\omega) = \omega^q\left[U(\omega) + (-1)^{q+1}V(\omega)\right] \qquad q = 0, \ldots, n$$

Predpokladáme prenos modelu v tvare: $\dfrac{b_0}{s^2 + a_1 s}$

$\hat{\boldsymbol{\theta}} = (b_0, a_1)^T$ $\quad m = 0,\ \ n = 2,\ \ a_0 = 0$ (astatizmus)

$\mathbf{h}(\omega_k)^T = (1, x_1(\omega_k))$ $\quad k = 1, \ldots, N = 4$

$$x_1(\omega_k) = \omega_k\left[U(\omega_k) + V(\omega_k)\right] \qquad x_2(\omega_k) = \omega_k^2\left[U(\omega_k) - V(\omega_k)\right]$$

$$\mathbf{H} = \begin{pmatrix} \mathbf{h}^T(\omega_1) \\ \mathbf{h}^T(\omega_2) \\ \mathbf{h}^T(\omega_3) \\ \mathbf{h}^T(\omega_4) \end{pmatrix} = \begin{pmatrix} 1 & -14.16 \\ 1 & -12.6 \\ 1 & -7.08 \\ 1 & -4.92 \end{pmatrix} \qquad \mathbf{y} = -\begin{pmatrix} x_2(\omega_1) \\ x_2(\omega_2) \\ x_2(\omega_3) \\ x_2(\omega_4) \end{pmatrix} = \begin{pmatrix} -2.04 \\ 0 \\ 4.08 \\ 7.92 \end{pmatrix}$$

$$\hat{\boldsymbol{\theta}} = (12.1018,\ 0.9919)$$

Levyho metóda

Uvažujeme systém v tvare $S(s) = \dfrac{1}{s^2 + 4s + 1}$

Nameraná frekvenčná charakteristika (ovplyvnená šumom merania)

k	ω	$U(\omega)$	$V(\omega)$
1	0,001	1.0019	0.0019
2	0,1	0.8703	-0.3459
3	0,2	0.6216	-0.5033
4	0,4	0.2603	-0.4817
5	0,5	0.1698	-0.4319
6	0,8	0.0362	-0.3004
7	1	0.0070	-0.2434
8	1,25	-0.0184	-0.1941
9	1,5	-0.0247	-0.1568
10	5	-0.0161	-0.0171

$$\hat{\boldsymbol{\theta}} = (a_1, a_2, \ldots, a_n, b_0, b_1, \ldots, b_m)^T$$

$$F_k = F(j\omega_k) = U(\omega_k) + jV(\omega_k), \qquad k = 1, \ldots, N$$

$$H = \begin{pmatrix} -j\omega_1 F_1 & \ldots & -(j\omega_1)^n F_1 & 1 & j\omega_1 & \ldots & (j\omega_1)^m \\ \vdots & \ddots & \vdots & \vdots & \vdots & \ddots & \vdots \\ -j\omega_N F_N & \ldots & -(j\omega_N)^n F_N & 1 & j\omega_N & \ldots & (j\omega_N)^m \end{pmatrix} \qquad y = \begin{pmatrix} F_1 \\ \vdots \\ F_N \end{pmatrix}$$

$$\hat{\theta} = [\mathrm{Re}(H^* H)]^{-1} \mathrm{Re}(H^* y)$$

*** označuje transpozíciu komplexne združeného čísla**

Predpokladáme prenos modelu v tvare: $\dfrac{b_0}{a_2 s^2 + a_1 s + 1}$

$$\hat{\boldsymbol{\theta}} = (a_1, a_2, b_0)^T \qquad m = 0, \quad n = 2$$

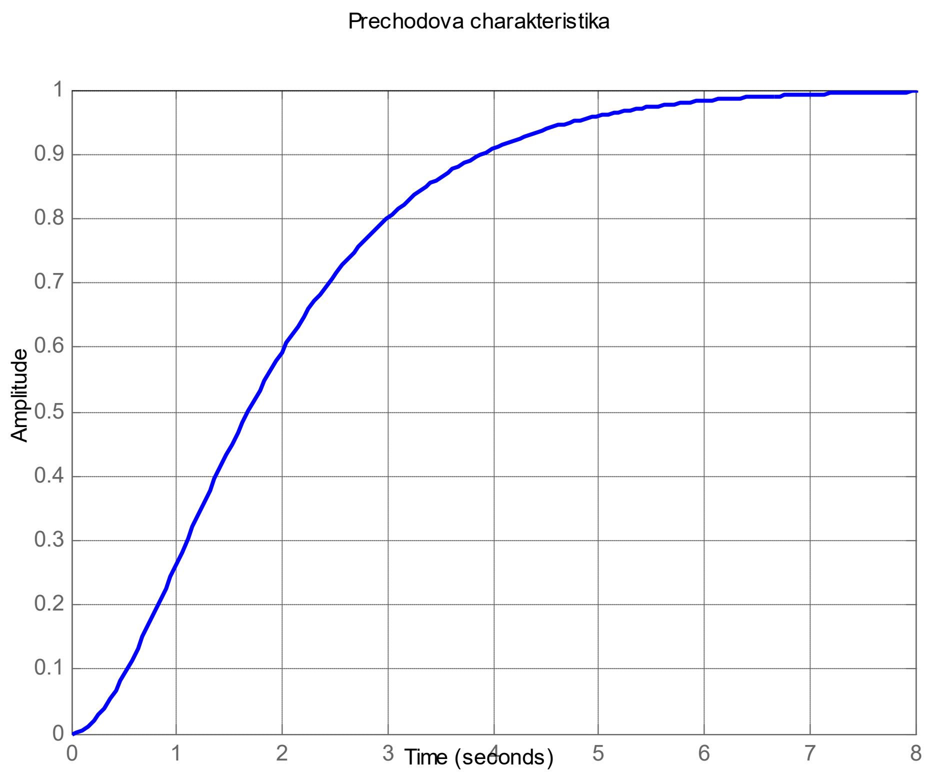
$$H = \begin{pmatrix} -j\omega_1 F_1 & -(j\omega_1)^2 F_1 & 1 \\ \vdots & \vdots & \vdots \\ -j\omega_{10} F_{10} & -(j\omega_{10})^2 F_{10} & 1 \end{pmatrix} = \begin{pmatrix} 0.0000 - 0.0010i & 0.0000 + 0.0000i & 1.0000 \\ -0.0346 - 0.0870i & 0.0087 - 0.0035i & 1.0000 \\ -0.1007 - 0.1243i & 0.0249 - 0.0201i & 1.0000 \\ -0.1927 - 0.1041i & 0.0416 - 0.0771i & 1.0000 \\ -0.2160 - 0.0849i & 0.0425 - 0.1080i & 1.0000 \\ -0.2403 - 0.0290i & 0.0232 - 0.1923i & 1.0000 \\ -0.2434 - 0.0070i & 0.0070 - 0.2434i & 1.0000 \\ -0.2426 + 0.0230i & -0.0288 - 0.3033i & 1.0000 \\ -0.2353 + 0.0370i & -0.0555 - 0.3529i & 1.0000 \\ -0.0854 + 0.0803i & -0.4013 - 0.4270i & 1.0000 \end{pmatrix}$$

$$y = \begin{pmatrix} F_1 \\ \vdots \\ F_{10} \end{pmatrix} = \begin{pmatrix} 1.0019 + 0.0019i \\ 0.8703 - 0.3459i \\ 0.6216 - 0.5033i \\ 0.2603 - 0.4817i \\ 0.1698 - 0.4319i \\ 0.0362 - 0.3004i \\ 0.0070 - 0.2434i \\ -0.0184 - 0.1941i \\ -0.0247 - 0.1568i \\ -0.0161 - 0.0171i \end{pmatrix} \qquad \hat{\boldsymbol{\theta}} = (a_1, a_2, b_0)^T = (3.9618 \;\; 1.035 \;\;\; 0.9560)$$

Vyhodnotenie bodov frekvenčnej charakteristiky z prechodovej

Uvažujeme systém v tvare $\qquad S(s) = \dfrac{1}{s^2 + 2s + 1}$

Nameraná prechodová charakteristika

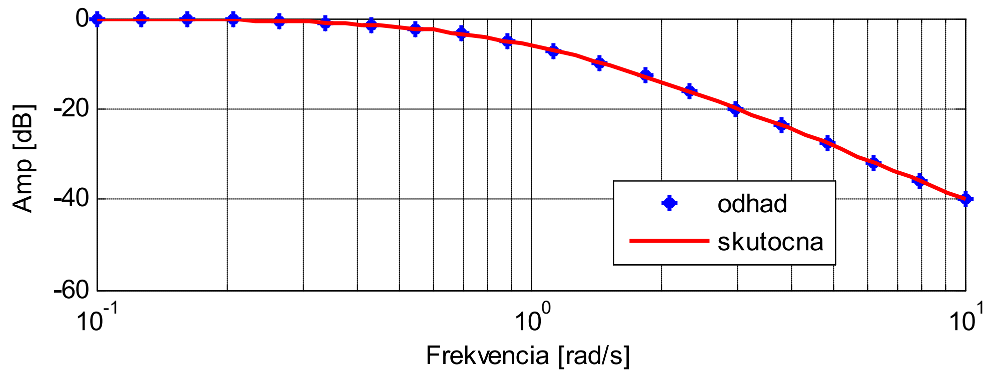


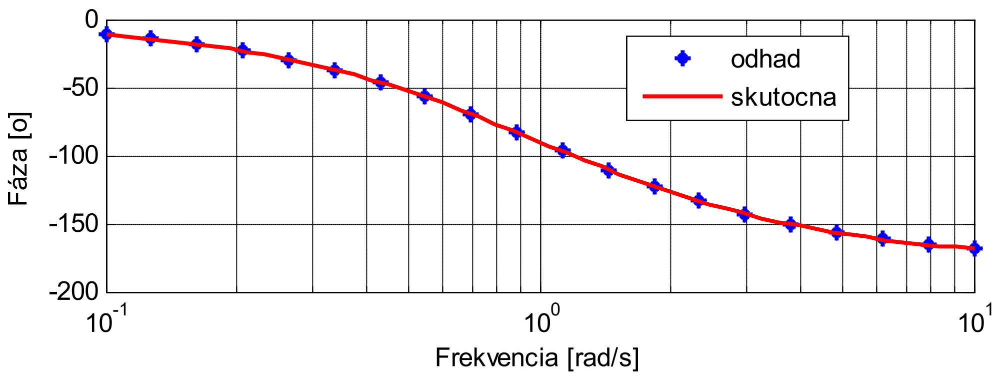
N=1001 $\qquad$ počet diskrétnych hodnôt prechodovej charakteristiky
Δt=0,01 $\qquad$ perióda vzorkovania.
m=20 $\qquad$ počet bodov frekvenčnej charakteristiky
w=logspace(-1,1,m)

Výpočet:

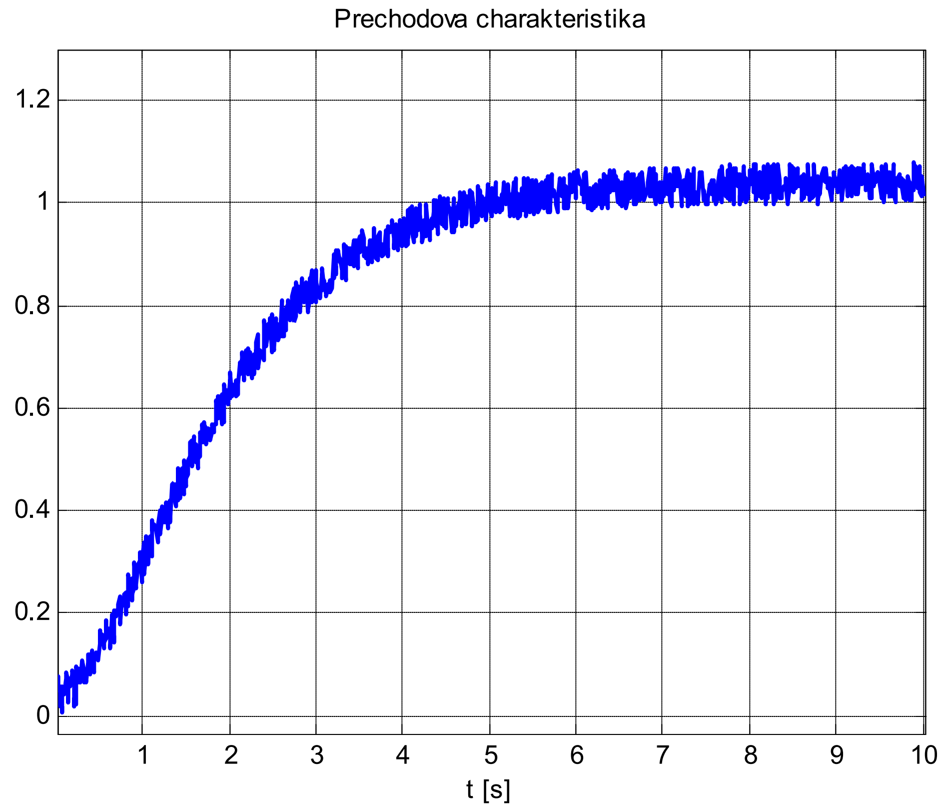
$$\boxed{F(j\omega_i)=\sum_{k=0}^{N}\left\{\cos\left[\omega_i\left(k+\frac{1}{2}\right)\Delta t\right]-j\sin\left[\omega_i\left(k+\frac{1}{2}\right)\Delta t\right]\right\}(g_{k+1}-g_k)}\qquad i=1,2,\ldots,m$$

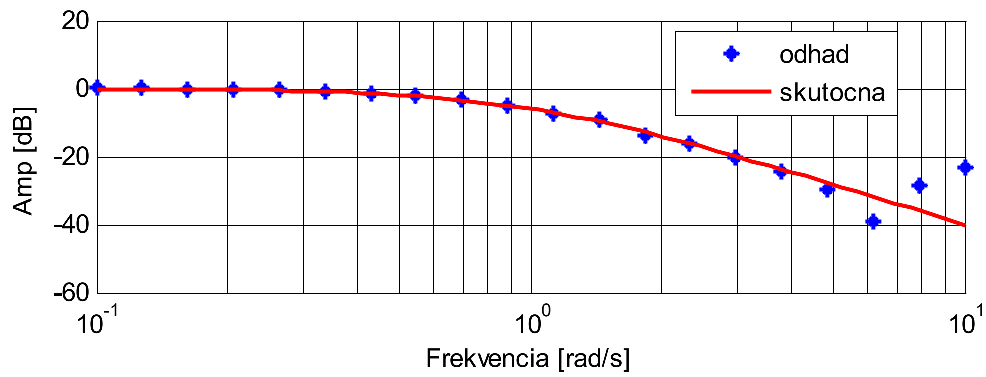
```
for i=1:m
    ReS=0;
    ImS=0;
    for k=1:(N-1)
        ReS=ReS+cos(w(i)*(k-0.5)*dt)*(h(k+1)-h(k));
        ImS=ImS-sin(w(i)*(k-0.5)*dt)*(h(k+1)-h(k));
    end
    A(i)=sqrt(ReS^2+ImS^2);         %Výpočet amplitudy
    fi(i)=180*atan2(ImS,ReS)/pi;   %Výpočet fáze ve stupních
```

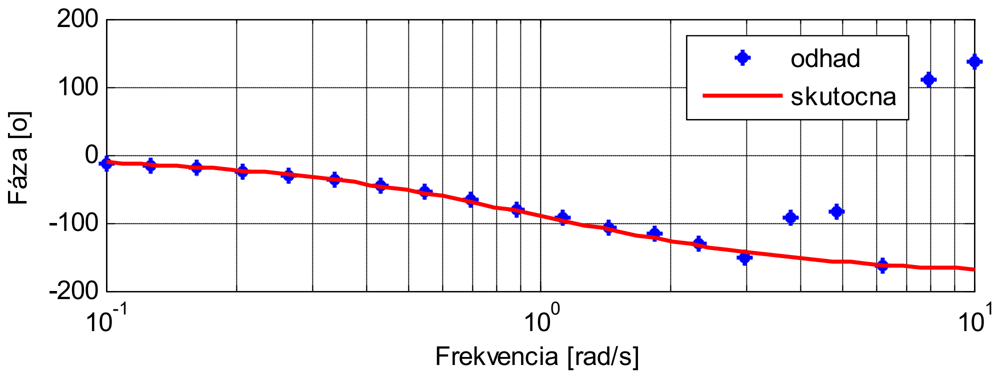




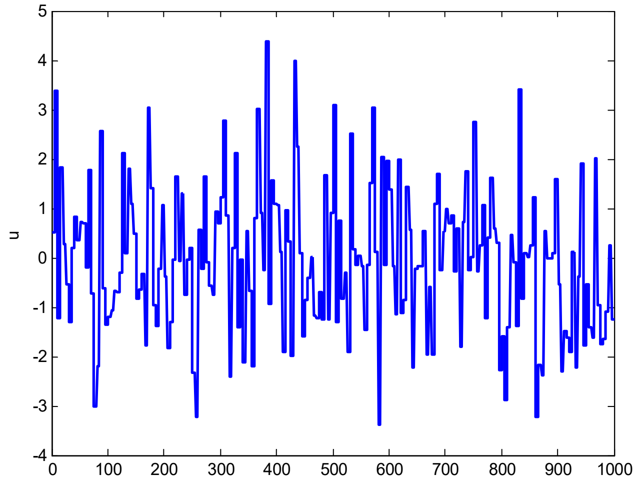
Ak je nameraná prechodová charakteristika ovplyvnená šumom

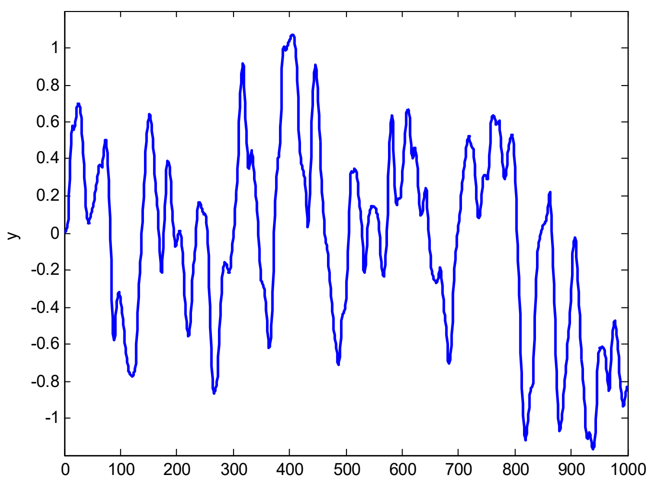




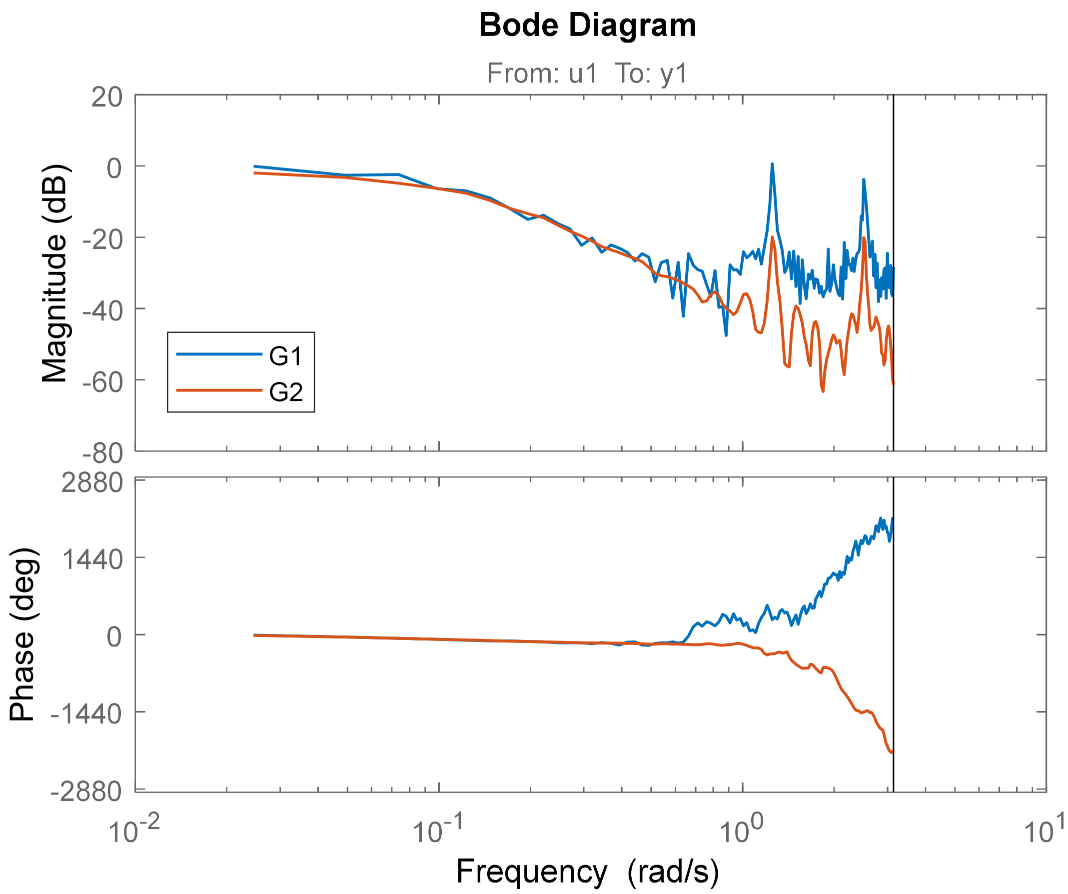


Vyhodnotenie bodov frekvenčnej charakteristiky z odozvy na všeobecný vstupný signál



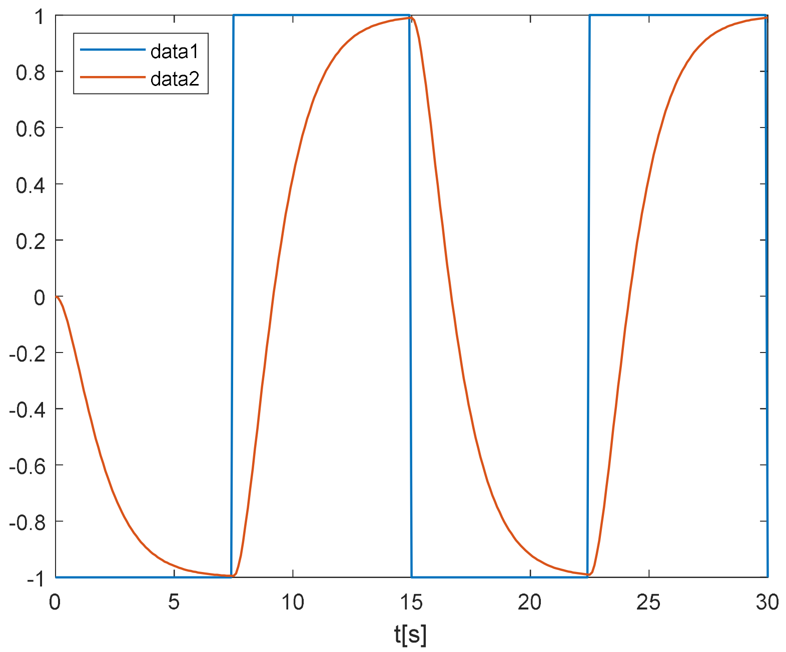



```
dat=iddata(y,u,1);
G1 = etfe(dat)
G2 = etfe(dat,100)        %pouzitie Hammingovho okna na "vyhladenie"
bodeplot(G1);
bodeplot(G2)
```



Uvažujeme systém v tvare $$S(s)=\frac{1}{s^2+2s+1}$$

Namerané vstupno-výstupné údaje – perióda vzorkovania T_s=0.1 s




```
num=[1];
den=[1 2 1];
G=tf(num,den)
load udaje
dat=iddata(ys,us,0.1);
G1 = etfe(dat)
G2 = etfe(dat,50)              %pouzitie Hammingovho okna na "vyhladenie"
```