O`ZBEKISTON RESPUBLIKASI
OLIY VA O'RTA MAXSUS TA'LIM VAZIRLIGI

TOSHKET TO`QIMACHILIK VA YENGIL SANOAT
INSTITUTI

«Texnologik jarayonlarni avtomatlashtirish va
kompyuterlashtirish» kafedrasi

«AVTOMATIK BOSHQARISH NAZARIYASI» FANIDAN

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Kirish

Texnika va texnologiyalarning rivojlanishi natijasida texnologik jarayonlarni avtomatlashtirishga talab kuchaydi. Bunda boshkaruvchi va boshkariluvchi ob`ektlarni uz ichiga olgan sistemalar yaratilmokda. Bunda sistemaga yukori aniklik, ishonchlilik va boshka talablarga javob berishi zarur. Shu sababdan Avtomatik boshkarish nazariyasi fanini urganish muxim va universal axamiyatga ega.

Kurs loyxasida berilgan sistemaning dinamik sintezi, diskret sistemaning turgunligi va nochizikli elementga ega bulgan sistemada avtotebranishni aniklash ishlarini Matlab programmasidagi xisoblash ishlari keltirilgan.

VARIANT 6.
VAZIFA 3.
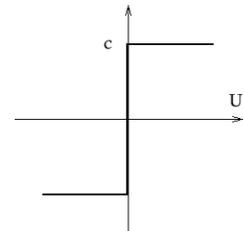
Berilgan:

1. Chiziqli qism parametrlari

K$_2$	K$_3$	K$_4$	T$_1$	T$_2$	T$_3$	ν
16	5	0,07	0,2	0,17	0,15	27

2. Sistemaga talablar

ε$_{ст}$	δ	T$_у$
0,17	20	0,4

3. Nochiziqli qism parametrlari

Тип	b	m	c
IV	3	0.4	4

4. Impulsli element parametrlari

T	γ
0,5	0,1
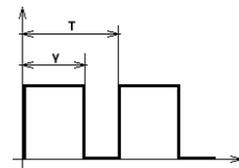
Berilgan sistemaning modeli
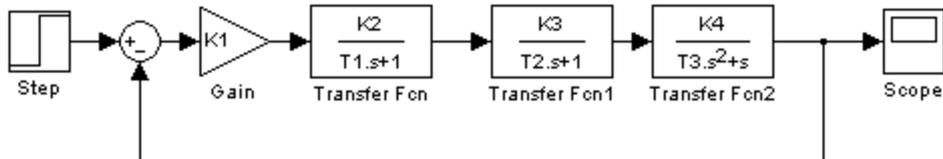
I – Qism.

Berilgan sistemada noaniq K_1 mavjud. Uning kiymatini topish uchun zaruriy bulgan sistemaning umumiy uzatish koeffisienti aniqlanadi:

$$K_{зар} = K_1 \cdot K_2 \cdot K_3 \cdot K_4$$

Xamda zaruriy sistemaning umumiy uzatish koeffisienti berilgan qiymatlar nisbatidan katta yoki teng bo`lishi zarur

$$K_{зар} \geq \frac{\nu}{\varepsilon_{\text{T}}} = \frac{27}{0,17} = 159$$

Zaruriy sistemaning umumiy uzatish koeffisienti aniqlangandan sung K_1 topiladi.

$$K_1 = \frac{159}{16 \cdot 5 \cdot 0,07} = 5,6$$

Sistema elementlari qiymatlarini kiritamiz:

>>a1 = 5.6000

>> a2=tf([16],[0.2 1])

Transfer function:
```
   16
---------
0.2 s + 1
```

>> a3=tf([5],[0.17 1])

Transfer function:
```
    5
----------
0.17 s + 1
```

>> a4=tf([0.07],[0.15 1 0])

Transfer function:
```
    0.07
------------
0.15 s^2 + s
```

Ochiq sistemaning uzatish funksiyasi:

>> W=a1*a2*a3*a4

Transfer function:
```
              31.36
-----------------------------------------
0.0051 s^4 + 0.0895 s^3 + 0.52 s^2 + s
```

Yopiq sistemaning uzatish funksiyasi:

$$W_{berk} = \cfrac{k1*k2*k3*k4}{p(T1p+1)(T2p+1)(T3p+1)+\ k1*k2*k3*k4} = \cfrac{31.36}{p(0.2p+1)(0.17p+1)(0.15p+1)+\ 31.36} =$$

$$= \cfrac{31.36}{0.0051p^4+0.0895p^3+0.52p^2+p+31.36};$$

Ochiq sistemadagi "p"ni "jw" bilan almashtiramiz:

$$W_{ochiq}(jw) = \cfrac{31.36}{0.0051(jw)^4+0.0895(jw)^3+0.52(jw)^2+jw} = \cfrac{31.36}{0.051w^2-0.0895jw^3-0.52w^2+jw} =$$

$$= \cfrac{31.36}{(jw-0.0895jw^3)+(0.0051w^4-0.52w^2)} =$$

$$= \cfrac{31.36}{(jw-0.0895jw^3)+(0.0051w^4-0.52w^2)} \cdot \cfrac{(jw-0.0895jw^3)-(0.0051w^4-0.52w^4)}{(jw-0.0895jw^3)-(0.0051w^4-0.52w^2)} =$$

$$= \cfrac{31.36\,jw-2.8\,jw^3-0.16\,w^4-16.3\,w^2}{-0.003w^8-0.003w^6-0.091w^4-w^2};$$

Ochiq sistema uzatish funksiyasining xaqiqiy va mavhum qismini ajratib olamiz:

$$U(w) = \cfrac{0.16\,w^4+16.3\,w^2}{0.003w^8+0.003w^6+0.091w^4+w^2};$$

$$V(w) = \cfrac{2.8\,jw^3-31.36\,jw}{0.003w^8+0.003w^6+0.091w^4+w^2}$$

**Bundan sistemaning Amplitida Faza Xarakteristikasini quramiz:**

|		
0	#ДЕЛ/0!	#ДЕЛ/0!
0,1	16,28677	-313,035
0,5	15,97287	-59,9423
1	15,00456	-26,0346
1,5	13,28433	-13,3215
2	10,5611	-6,28429
2,5	7,15361	-2,29246
3	4,1751	-0,48325
3,5	2,259975	0,103964
4	1,215833	0,216606
4,5	0,67416	0,194282
5	0,390197	0,148544
5,5	0,236096	0,108311
6	0,148921	0,078129
6,5	0,097523	0,056566
7	0,066027	0,041356
7,5	0,046038	0,030605
8	0,032947	0,022941
8,5	0,024128	0,017417
9	0,018035	0,013385
9,5	0,01373	0,010406
10	0,010625	0,008179
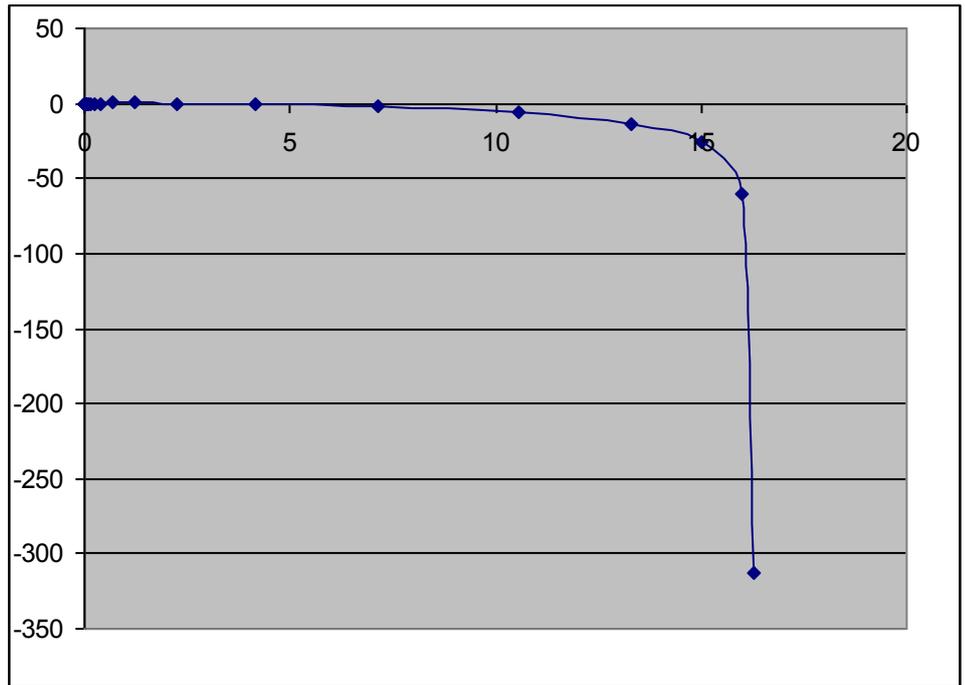
Berilgan sistemani analiz qilish uchun uning modelini Matlab da kuramiz, va u quyidagi ko`rinishga ega bo`ladi.
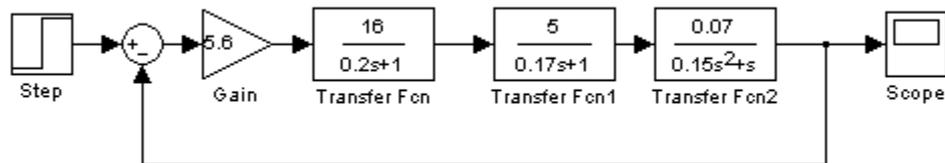
Sistemaning asosiy xarakteristikasi bo`lgan turg`unligini aniqlash uchun uning o`tkinchi jarayon grafigini olamiz, va quyidagi ko`rinishga ega bo`ladi.
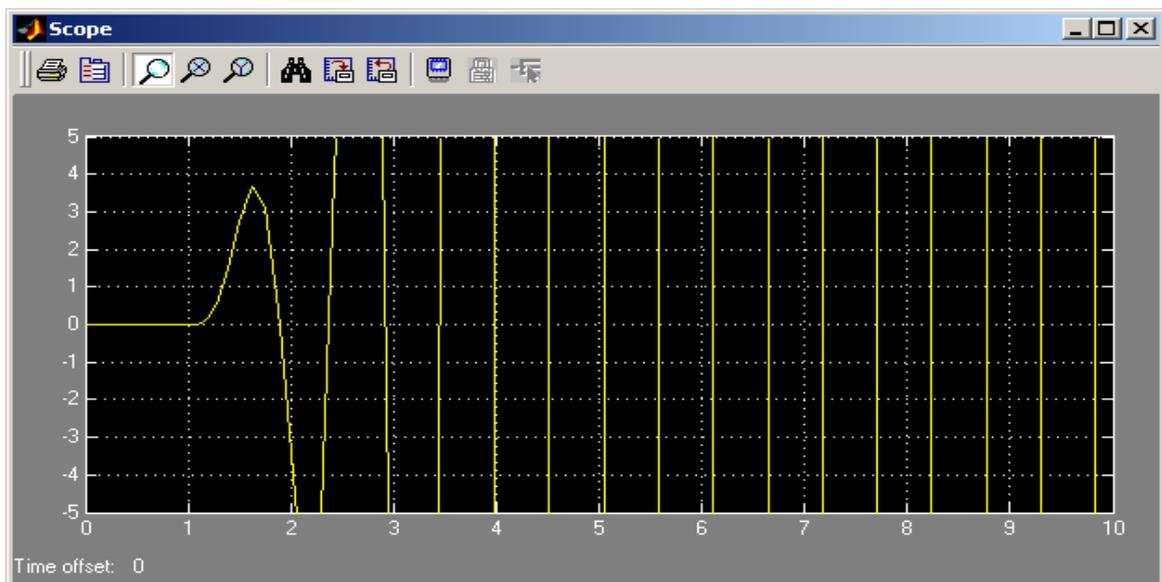
Grafikdan ko`rinib turibdiki sistemamiz Noturgun. Negaki vaqt o`tishi bilan ma`lum bir qiymatga erishmayapti.
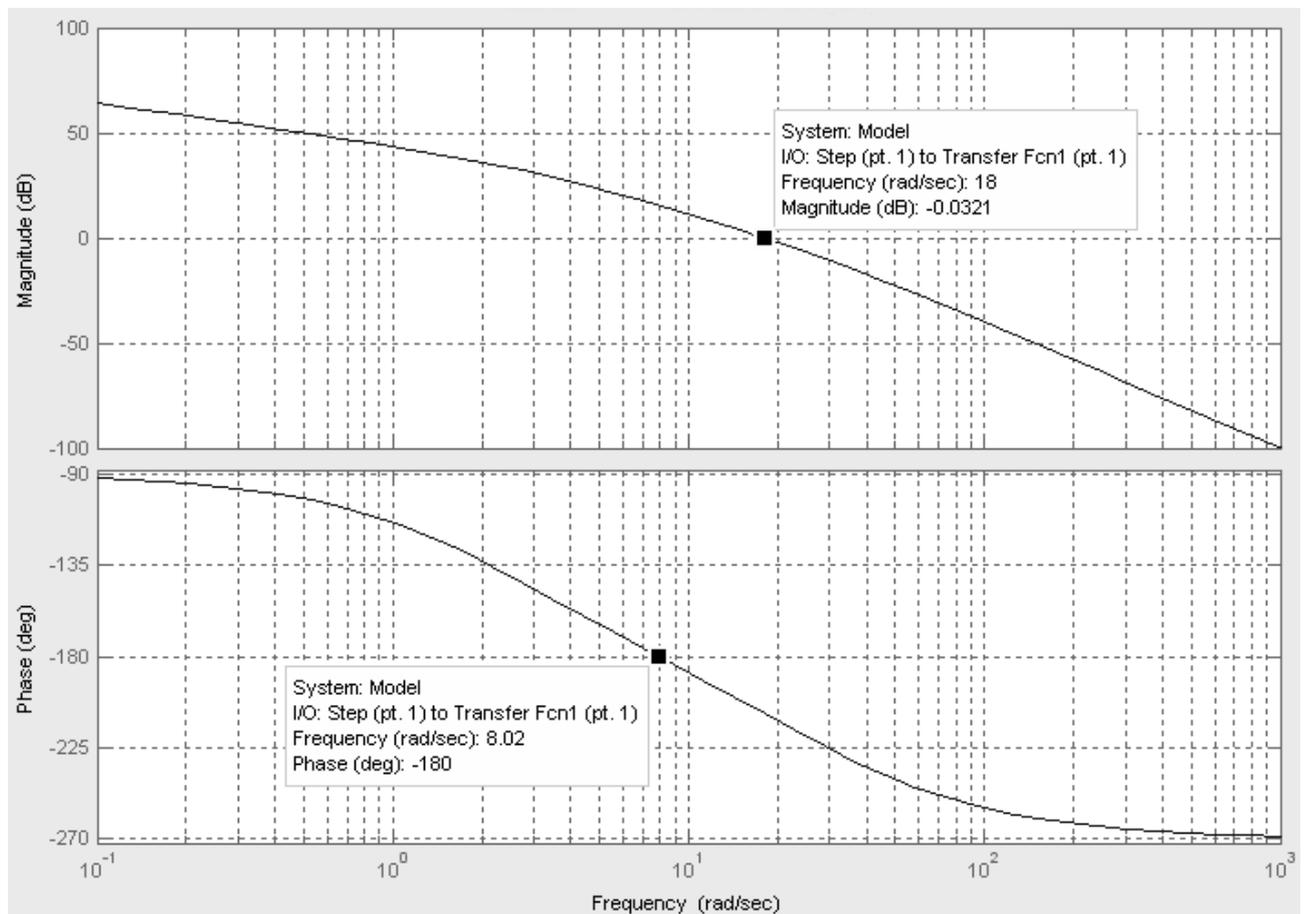
LAChX dan ma`lumki, kuchuytirish koeffisienti chastota $\omega_{sr}=18$ *rad/sek* da 0 chizig`i bilan kesishadi, fazani -180^0 da kesib o`tishining chastotasi esa $\omega_p=8,02$ *rad/sek*, ya`ni

$$\omega_{sr} > \omega_p$$

bo`lgani uchun sistema noturg`un.

Korrektlovchi kurilmani esa eng sodda, xam integrallovchi, xam differensiallovchi xarakterga ega bulgan inersial zvenoni tanlaymiz.

$$W_k(p) = \frac{T_1 p + 1}{T_2 p + 1}$$

Zaruriy (turgun) sistemani sintez kilish uchun uning tarkibiga korrektlovchi qurilma kiritamiz. Bunda korrektlovchi kurilmani sistema tarkibida eng katta kuchaytirish koeffisientiga ega bulgan buginiga teskari parallel ulaymiz. Sababi sistemani turgunligiga kuchaytirish koeffisienti bevosita ta`sir etadi.
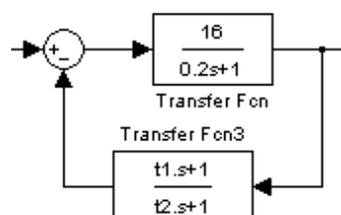
Qidirilayotgan vaqt doimiylarining boshlang`ich qiymatlarini ixtiyoriy kiritamiz.

```
>> t1=0.01;
>> t2=0.01;
```

Matlab dagi "NCD Blockset" qismidan "NCD Outport" blokini sistema chiqishiga ulaymiz. Bu blok yordamida bizga kerakli bulgan o`tkinchi jarayon grafigining parametrlarini berishimiz mumkin.
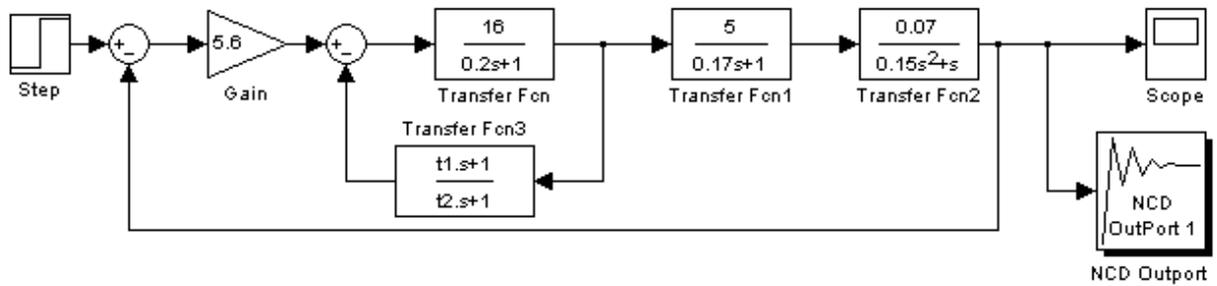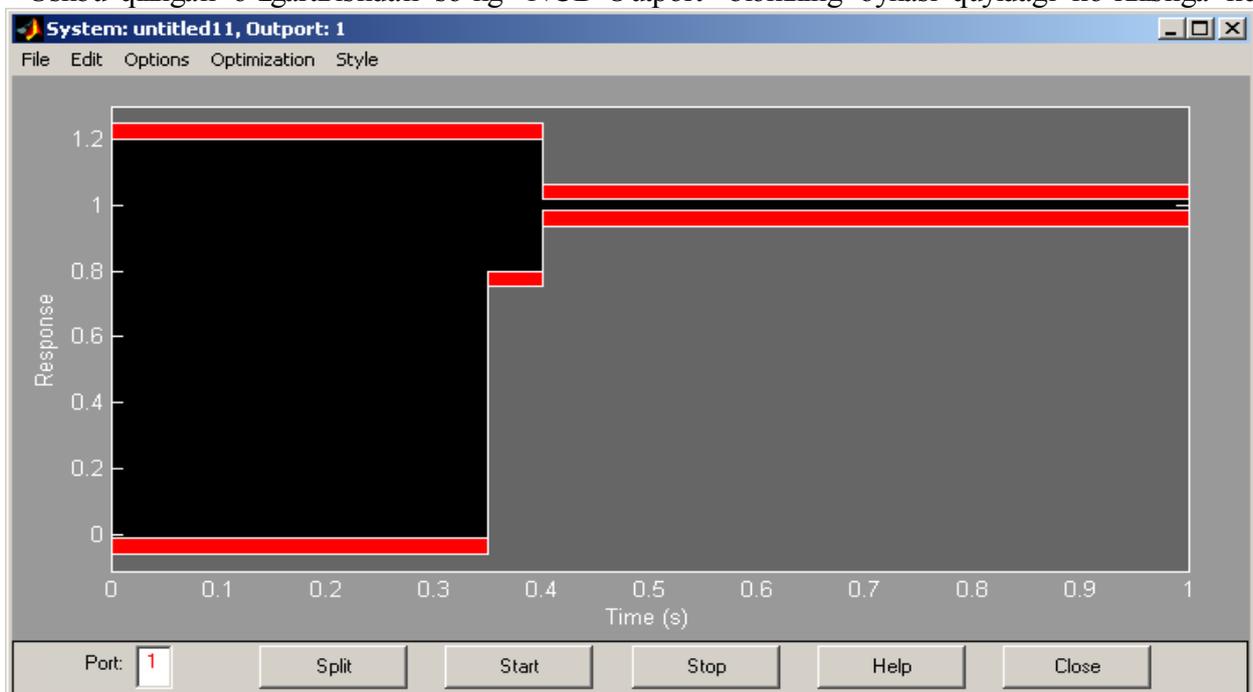

Talab etilgan parametrlarni sozlash uchun ushbu blokning oynasidan "Options" qismidan "Step Response" punktini tanlaymiz va kerakli qiymatlarni kiritamiz.

Bizning sistema uchun u quyidagicha.

Ushbu qilingan o`zgartirishdan so`ng "NCD Outport" blokining oynasi quyidagi ko`rinishga keladi.

Korrektlovchi qurilmaning boshlangich parametrlarini va ularning chegaraviy qimatlarini "Optimization/Parameters" oynasida kiritamiz

Bizning sistema uchun u quyidagicha:
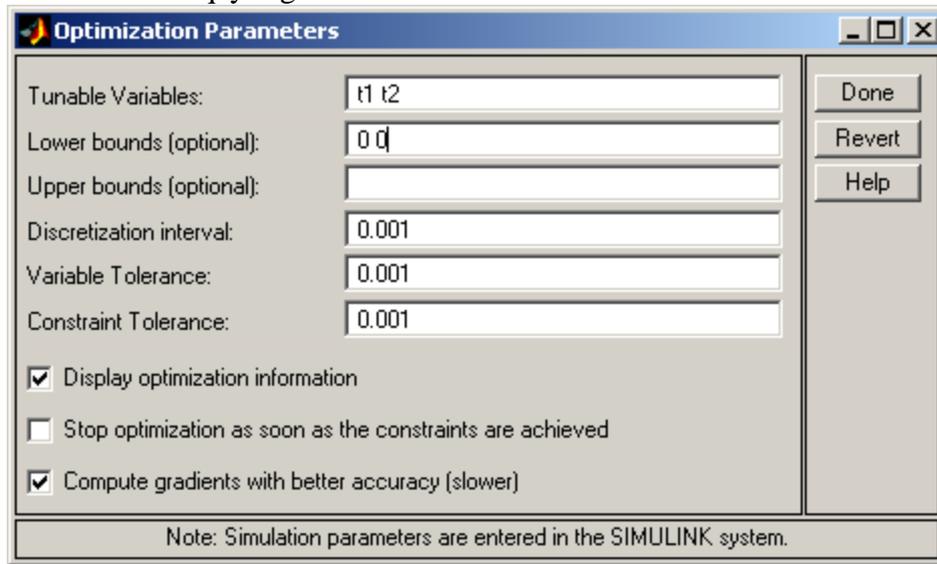
So`ngra Start tugmasini bosish orqali korrektlovchi qurilmaning qidirilayotgan qiymatlarini aniqlaymiz.

Natijada o`tkinchi jarayon grafigi quyidagi ko`rinishga ega bo`ladi:
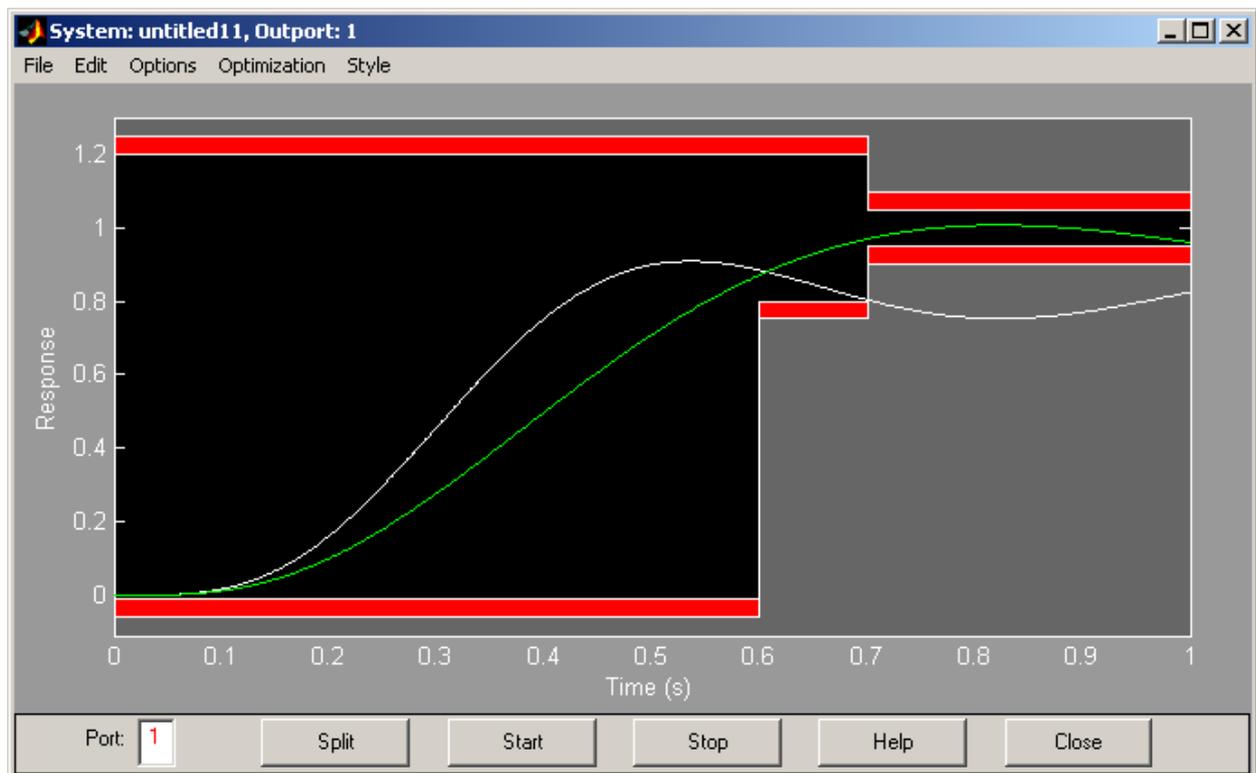
Optimallash natijasida talabga javob beradigan sistemaning korrektlovchi qurilmasining T_1 va T_2 parametrlari aniqlanadi:

t1 = 0.1818
t2 = 0.6547

Sistemaning turg`inligini LACHX orqali aniqlaymiz. Buning uchun berk sistemaning umumiy uzatish funksiyasi topilib, **bode** komandasi orqali uning LACHX sini quramiz:
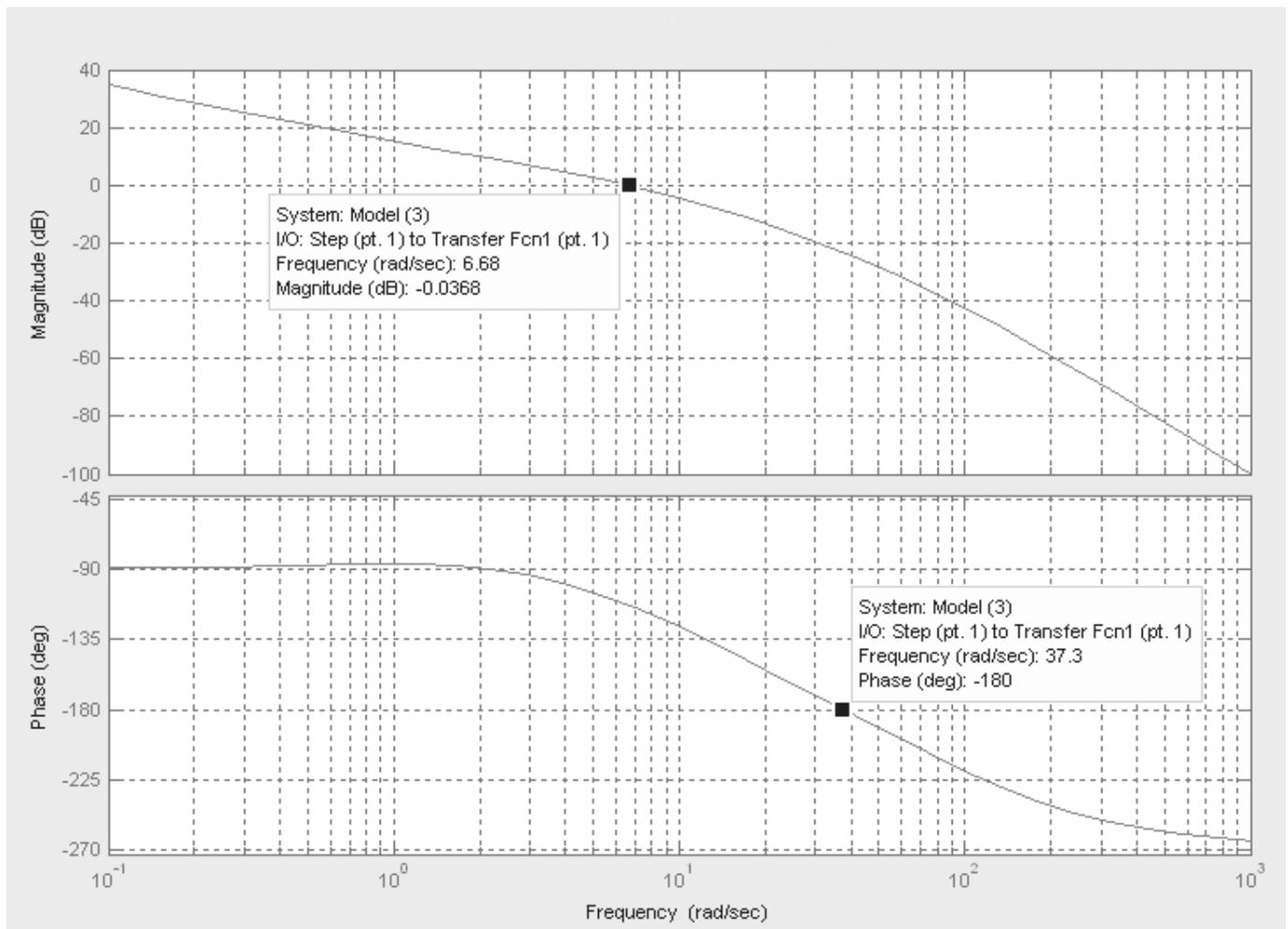
Ko`rinib turibdiki sistemamiz turgunlikka erishgan va talab etilgan sifat ko`rsatgichlarga ega. Sistemaning LAChXsini kurib chikamiz

LAChX dan ma`lumki, kuchuytirish koeffisienti chastota $\omega_{sr}$=6,68 rad/sek da 0 chizigi bilan kesishadi, fazani -180$^0$ da kesib utishining chastotasi esa $\omega_p$=37,3 rad/sek, ya`ni

$$\omega_{sr} < \omega_p$$

bulgani uchun sistema **TURG`UN.**

Korrektlangan sistemaning modeli quyidagi ko`rinishga ega:
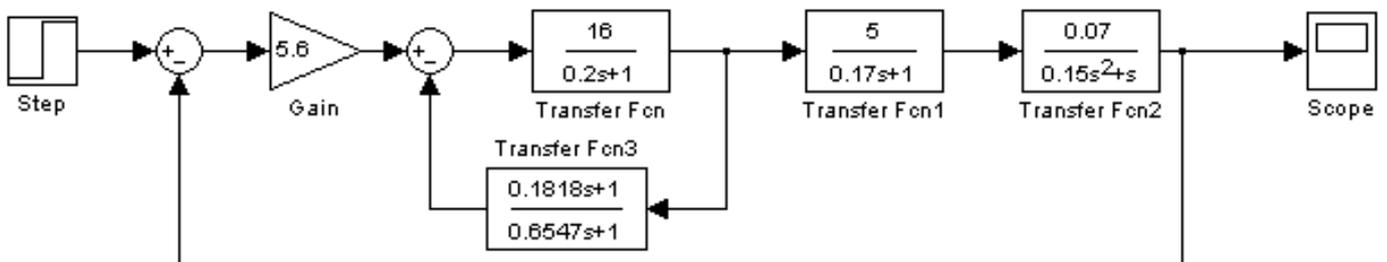
Korrektlangan sistemaning umumiy uzatish funksiyasini topamiz:

>> a=5.6;
>> b=tf([16],[0.2 1])
Transfer function:

```
    16
---------
0.2 s + 1
```

>> c=tf([5],[0.17 1])

Transfer function:

```
     5
----------
0.17 s + 1
```

>> d=tf([0.07],[0.15 1 0])

Transfer function:

```
    0.07
------------
0.15 s^2 + s
```

>> T=tf([0.1818 1],[0.6547 1])

Transfer function:

```
0.1818 s + 1
------------
0.6547 s + 1
```

>> w2=b/(1+b*T)

Transfer function:

```
    2.095 s^2 + 13.68 s + 16
----------------------------------------------
0.02619 s^3 + 0.8836 s^2 + 7.164 s + 17
```

>> h=a*w2*c*d

Transfer function:

```
                4.106 s^2 + 26.8 s + 31.36
--------------------------------------------------------------------------------------
0.0006678 s^6 + 0.03091 s^5 + 0.4916 s^4 + 3.609 s^3 + 12.6 s^2 + 17 s
```

>> v=h/(1+h)

Transfer function:

```
               0.002742 s^8 + 0.1448 s^7 + 2.868 s^6 + 28.97 s^5 + 163.9 s^4 + 520.8 s^3 + 850.9 s^2 + 533.1 s
-------------------------------------------------------------------------------------------------------------------------------------------
4.459e-007 s^12 + 4.129e-005 s^11 + 0.001612 s^10 + 0.03522 s^9 + 0.4844 s^8 + 4.496 s^7 + 29.34s^6 + 136.7 s^5 + 445.5 s^4 + 949.3 s^3 + 1140 s^2 + 533.1 s
```

Ochik sistemaning umumiy uzatish fuknsiyasi:

$$W_{oym}(p) = \frac{4.106 p^2 + 26.8 p + 31.36}{0.0006678 p^6 + 0.03091 p^5 + 0.4916 p^4 + 3.609 p^3 + 12.6 p^2 + 17 p}$$

Yopiq sistemaning umumiy uzatish funksiyasi:

$$\frac{0.002742s^8 + 0.1448s^7 + 2.868s^6 + 28.97s^5 + 163.9s^4 + 520.8s^3 + 850.9s^2 + 533.1s}{4.459e\text{-}007s^{12} + 4.129e\text{-}005s^{11} + 0.001612s^{10} + 0.03522s^9 + 0.4844s^8 + 4.496s^7 + 29.34s^6 + 136.7s^5 + 445.5s^4 + 949.3s^3 + 1140s^2 + 533.1s}$$

$$W_{\ddot{e}ym}(p) = \frac{0.002742p^8 + 0.1448p^7 + 2.868p^6 + 28.97p^5 + 163.9p^4 + 520.8p^3 + 850.9p^2 + 533.1p}{4.46e - 007p^{12} + 4.13e - 005p^{11} + 0.002p^{10} + 0.04p^9 + 0.48p^8 + 4.5p^7 + 29.3p^6 + 136.7p^5 + 445.5p^4 + 494.3p^3 + 1140p^2 + 533.1p}$$

Tekshirish:
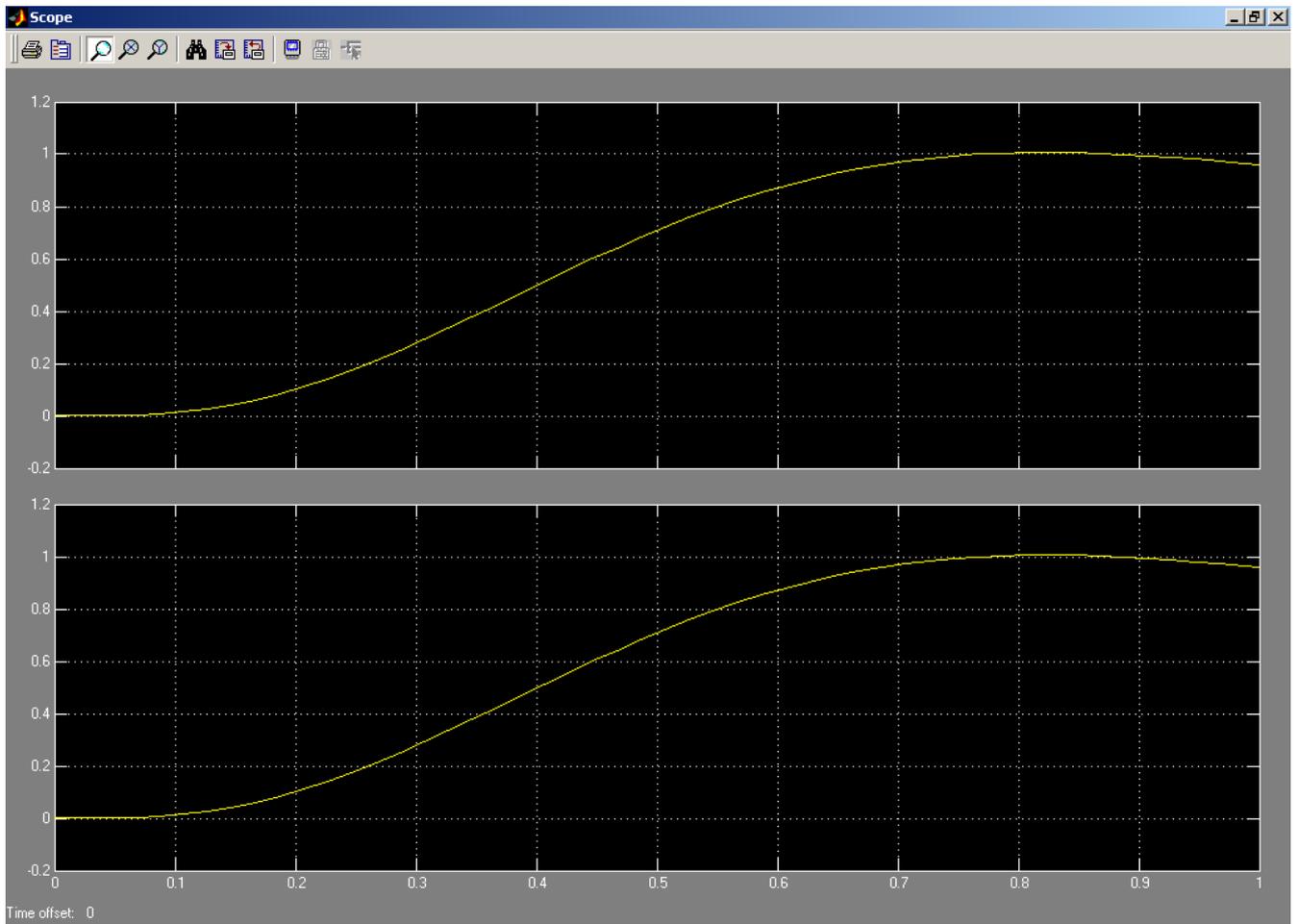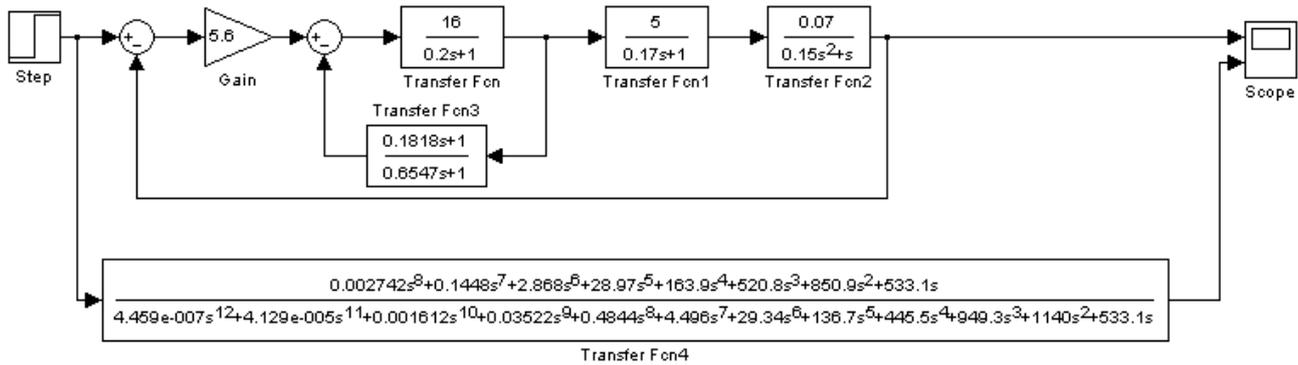
BERK SISTEMANING MUVOZANAT REJIMIDAGI XATOLIGINI XISOBLASH.

Ochiq sistmaning umumiy uzatish funksiyasidan foydalanamiz:

$$\mathbf{W_{ochiq}} = \frac{31.36}{0.0051p^4 + 0.0895p^3 + 0.52p^2 + p}$$

$$\Phi_\Delta(p) = \frac{1}{1+W_{ochiq}} = \frac{1}{1+\dfrac{31.36}{0.051p^4 + 0.0895p^3 + 0.52p^2 + p}} = \frac{0.0051p^4 + 0.0895p^3 + 0.52p^2 + p}{0.0051p^4 + 0.0895p^3 + 0.52p^2 + p + 31.36}$$

$\Delta x(t)$ - berk sistemaning muvozanat rejimidagi xatoligi

$$C_0 = \lim_{p \to 0} \Phi_\Delta(p) = \lim_{p \to 0}(\Phi_\Delta) = \frac{0}{31.36} = 0$$

$$C_1 = \lim_{p \to 0} \frac{1}{p}[\Phi_\Delta(p) - C_0] = \lim_{p \to 0} \frac{1}{p}\left[\frac{0.0051p^4 + 0.0895p^3 + 0.52p^2 + p}{0.0051p^4 + 0.0895p^3 + 0.52p^2 + p + 31.36} - 0\right] = \frac{1}{31.36}$$

$$C_2 = \lim_{p \to 0} \frac{1}{p^2}[\Phi_\Delta(p) - C_0 - C_1 \cdot p] = \lim_{p \to 0} \frac{1}{p^2}\left[\frac{0.0051p^4 + 0.0895p^3 + 0.52p^2 + p}{0.0051p^4 + 0.0895p^3 + 0.52p^2 + p + 31.36} - 0 - \frac{1}{31.36} \cdot p\right] =$$

$$= \lim_{p \to 0} \frac{1}{p^2}\left[\frac{(0.0051p^4 + 0.0895p^3 + 0.52p^2 + p) \cdot 31.36 - 0.0051p^5 + 0.0895p^4 + 0.52p^3 + p^2 + 31.36}{(0.0051p^4 + 0.0895p^3 + 0.52p^2 + p + 31.36) \cdot 31.36}\right] =$$

$$= \lim_{p \to 0}\left[\frac{0.0051p^4 + 0.0895p^3 + 0.052p^2 + p}{0.0051p^4 + 0.0895p^3 + 0.052p^2 + p + 31.36} - \frac{p}{31.36}\right] =$$

$$= \lim_{p \to 0}\left[\frac{0.16p^4 - 0.0051p^5 - 0.0895p^4 + 2.8p^3 - 0.052p^3 - p^2 + 1.63p^2}{0.16p^4 + 2.8p^3 + 1.63p^2 + 31.36p + (31.36)^2}\right] =$$

$$= \lim_{p \to 0} \frac{1}{p^2}\left[\frac{-0.051p^5 + 0.07p^4 + 2.75p^3 + 0.63p^2}{0.16p^4 + 2.8p^3 + 1.63p^2 + 31.36p + 31.36^2}\right] = \lim_{p \to 0}\left[\frac{-0.051p^3 + 0.07p^2 + 2.75p + 0.63}{0.16p^4 + 2.8p^3 + 1.63p^2 + 31.36p + 983.5}\right] =$$

$$= \frac{0.63}{983.5} = 0.00064$$

a) x(t)=1(t) x`(t)=0 x``(t)=0 $\varepsilon = C_0 x(t) + C_1 x`(t) + C_2/21*x^4(t) = 0$
b) x(t)=t x`(t)=1 x``(t)=0 $\varepsilon = 0*t + 0.03*1 + (0.00064/2)*0 = 0.03$
c) x(t)=t^2 x`(t)=2t x``(t)=2 $\varepsilon = 0*t^2 + 0.03*2*t + (0.00064/2)*2 = 0.06t + 0.00064$

II-QISM. IMPULSLI QISM

K1 kuchayirgich o`rniga davri 0.5 sek ga teng va impuls uzunligi 0.1sek ga teng bo`lgan impulsli element ulaymiz.

Matlab da impulsli elementni "Pulse Generator" va "Product" bloklari yordamida xosil qilinadi. Bunda "Pulse Generator" bloki parametrlari berilganlar bilan sozlanadi. Natijada quyidagi modelni hosil qilamiz.
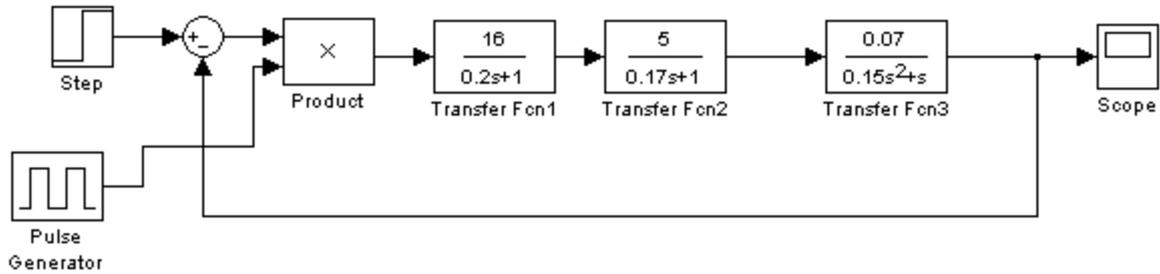
Sistemaning o`tkinchi jarayon grafigi quyidagi ko`rinishga ega bo`ladi
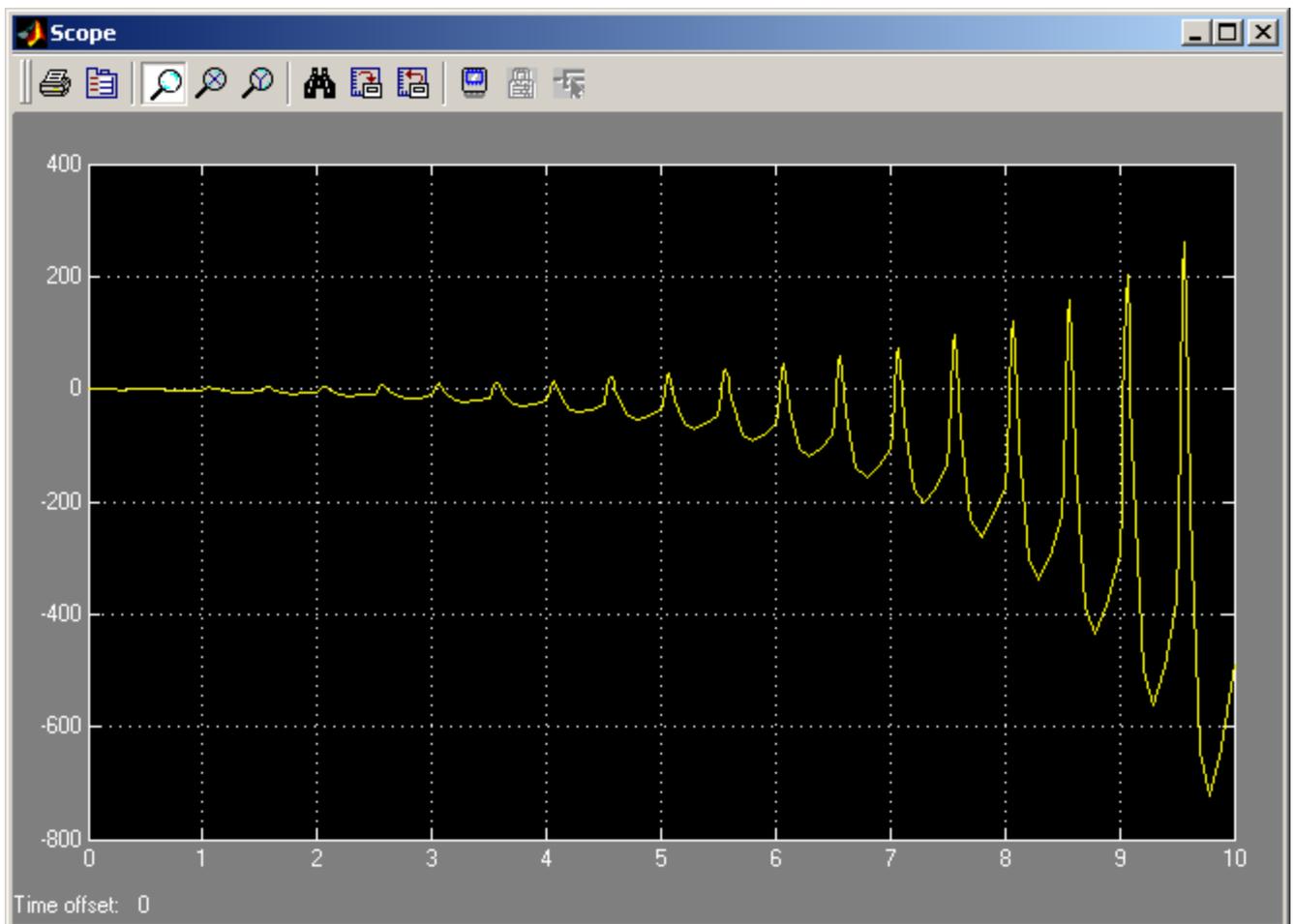
ko`rinib turibtiki sistema NOTURG`UN

Block Parameters: Pulse Generator ⊠

─ Pulse Generator ─────────────────────────────────

Generate pulses at regular intervals where the pulse type determines the computational technique used.

Time-based is recommended for use with a variable step solver, while Sample-based is recommended for use with a fixed step solver or within a discrete portion of a model using a variable step solver.

─ Parameters ─────────────────────────────────────

Pulse type: | Time based ▾ |

Amplitude:

| 1 |

Period (secs):

| 0.5 |

Pulse Width (% of period):

| 20 |

Phase delay (secs):

| 0 |

☑ Interpret vector parameters as 1-D

| OK | Cancel | Help | Apply |

Block Parameters: Step ⊠

─ Step ───

Output a step.

─ Parameters ─────────────────────────────────────

Step time:

| 0 |

Initial value:

| 0 |

Final value:

| 1 |

Sample time:

| 0 |

☑ Interpret vector parameters as 1-D

☑ Enable zero crossing detection

| OK | Cancel | Help | Apply |

Ochiq sistemaning uzatish funksiyasi

>> w1=tf([16],[0.2 1])*tf([5],[0.17 1])*tf([0.07],[0.15 1 0])

Transfer function:
             5.6

0.0051 s^4 + 0.0895 s^3 + 0.52 s^2 + s

Yopiq sistemaning umumiy uzatish funksiyasining diskret ko`rinishi

>> z=c2d(w1/(1+w1),0.5)

Transfer function:

0.5742 z^6 + 1.433 z^5 + 0.04021 z^4 - 0.0337 z^3 + 0.001979 z^2 - 1.941e-005 z - 4.456e-007
----
z^7 + 0.1465 z^6 + 1.033 z^5 - 0.1728 z^4 + 0.008543 z^3 - 0.0001167 z^2 + 1.231e-007 z - 2.391e-008

Sampling time: 0.5

Xarakteristik tenglama ildizlarini aniqlaymiz

>> g=roots([1 0.1465 1.033 -0.1728 0.008543 -0.0001167 1.231e-007 -2.391e-008])

g =

 -0.1547 + 1.0254i
 -0.1547 - 1.0254i
  0.0821
  0.0528
  0.0357
 -0.0039 + 0.0114i
 -0.0039 - 0.0114i

>> a=sqrt(real(g).^2+imag(g).^2)

a =

  1.0370
  1.0370
 0.0821
  0.0528
  0.0357
  0.0120
  0.0120

Xosil bo`lgan  7ta yechimdan  2tasi 1san katta bo`lgani uchun sistema NOTURG'UN

III – Qism. NOCHIZIQLI QISM

K1 kuchaytirgich urniga kirish signali 0 ga teng bulganda chikish signalning kattaligi -9 dan 9 gacha uzgaradigan nochizikli element ulaymiz.

Matlab da nochizikli elementni "Sign" va "Gain" bloklari yordamida xosil kilinadi. Bunda "Gain" bloki parametrlari berliganlar bilan sozlanadi.

Natijada kuyidagi modelni xosil kilamiz.
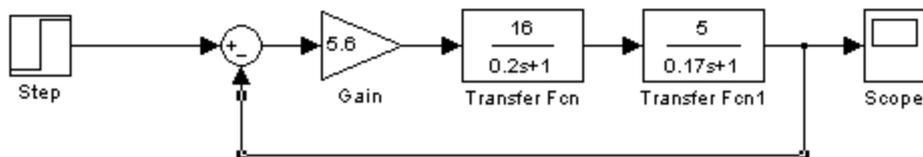
$$W_{ochik}(p) = \frac{K_1 \cdot K_2 \cdot K_3}{(T_1 p + 1)(T_2 p + 1)} = \frac{5.6 \cdot 16 \cdot 5}{(0.2 p + 1)(0.17 p + 1)} =$$

$$= \frac{4.48}{0.034 p^2 + 0.37 p + 1}$$

$$W(jw) = \frac{4.48}{-0.034w^2 + 0.37 jw + 1} = \frac{4.48}{((1 - 0.034w^2) + 0.37 jw)} = \frac{((1 - 0.034w^2) - 0.37 jw)}{((1 - 0.034w^2) - 0.37 jw)} =$$

$$= \frac{4.48 \cdot ((1 - 0.034w^2) - 0.37 jw)}{(1 - 0.34w^2)^2 - (0.37 jw)^2} = \frac{4.48 - 0.15w^2 - 1.65 jw}{0.001w^4 + 0.04w^2 + 1}.$$

$$U(w) = \frac{4.48 - 0.15w^2}{0.001w^4 + 0.04w^2 + 1}$$

$$V(w) = \frac{1.65w}{0.001w^4 + 0.04w^2 + 1}$$

$$K_H = q(a) - jq(a).$$

$$q(a) = \frac{8}{\pi a} \left(\sqrt{1 - \frac{9}{a^2}} + \sqrt{1 - \frac{1.44}{a^2}} \right.$$

$$q'(a) = -\frac{24}{\pi a^2} \cdot 0.6$$

$$a = 3 \div \infty$$

w	u	v	a	q	q`
0	4,48	0	3	0,778357	-0,50955414
3	2,1721027	-3,43511	5	0,902305	-0,18343949
6	-0,246253	-2,64989	6	0,783788	-0,12738854
8	-0,668757	-1,72414	8	0,610099	-0,07165605
10	-0,701333	-1,1	10	0,495978	-0,04585987
15	-0,482804	-0,40825	15	0,335727	-0,02038217
20	-0,313672	-0,18644	20	0,253106	-0,01146497
30	-0,154097	-0,05844	30	0,169358	-0,00509554
40	-0,089722	-0,02514	40	0,12718	-0,00286624
50	-0,05834	-0,01299	50	0,101804	-0,00183439
60	-0,040864	-0,00755	60	0,084864	-0,00127389
70	-0,030178	-0,00477	70	0,072755	-0,00093592
80	-0,023183	-0,0032	80	0,063668	-0,00071656
90	-0,018359	-0,00225	90	0,056599	-0,00056617
100	-0,014895	-0,00164	1000	0,005096	-4,586E-06
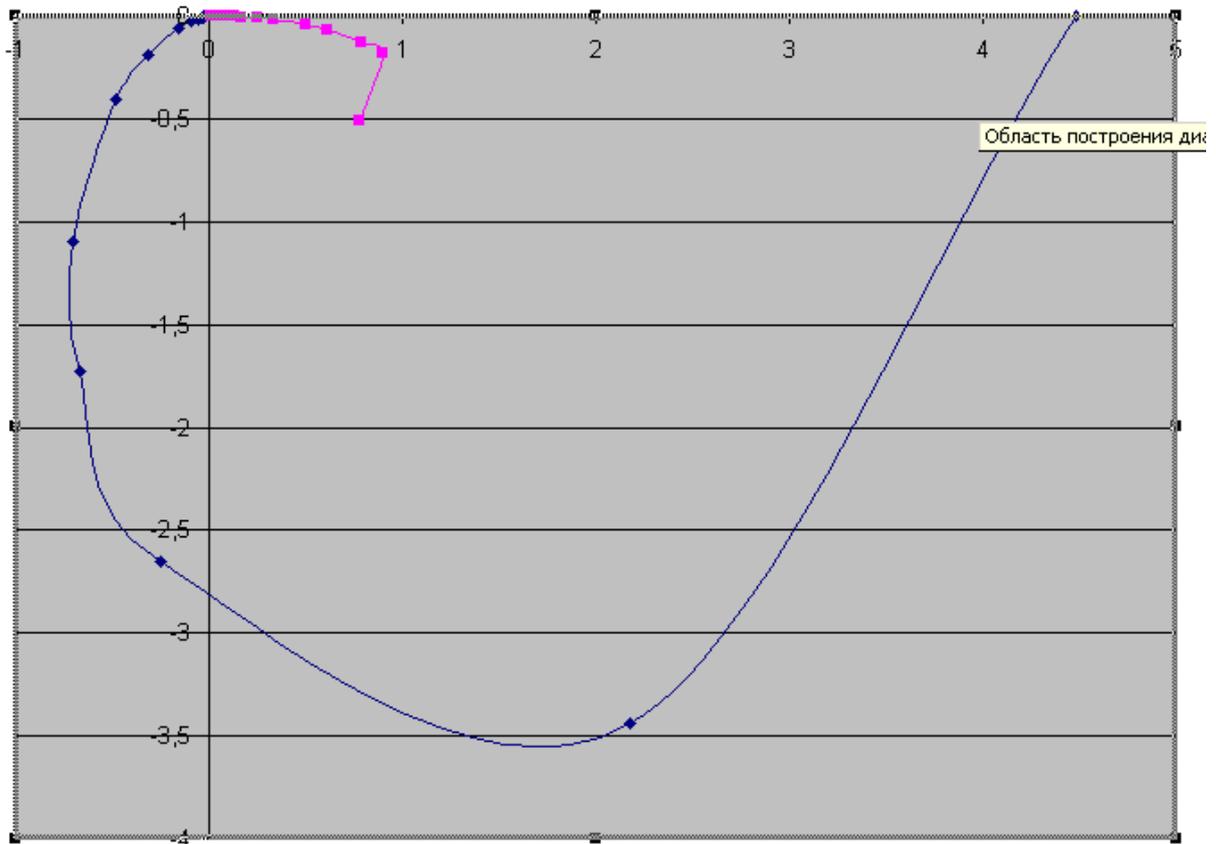
Bizning sistemada avtotebranish mavjud emas.

Xulosa

Kurs loyxasini bajarish natijasida berilgan sistemaning talab etilgan parametr va sifat kursatgichlariga mos sintezi amalga oshirildi. Talab etilgan sistemada korrektlovchi kurilma parallel teskari aloka usuli bilan ulandi, sababi bu usul universal va anik.

Sistema turgunligini aniklashda berilgan sistema va talab etilgan sistema LAChXlari kurildi.

Sistemani analizi va sintezi Matlab 7 matematik paketi yordamida amalga oshirildi.

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