Inteligentni ventil

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Odsek za sisteme in vodenje
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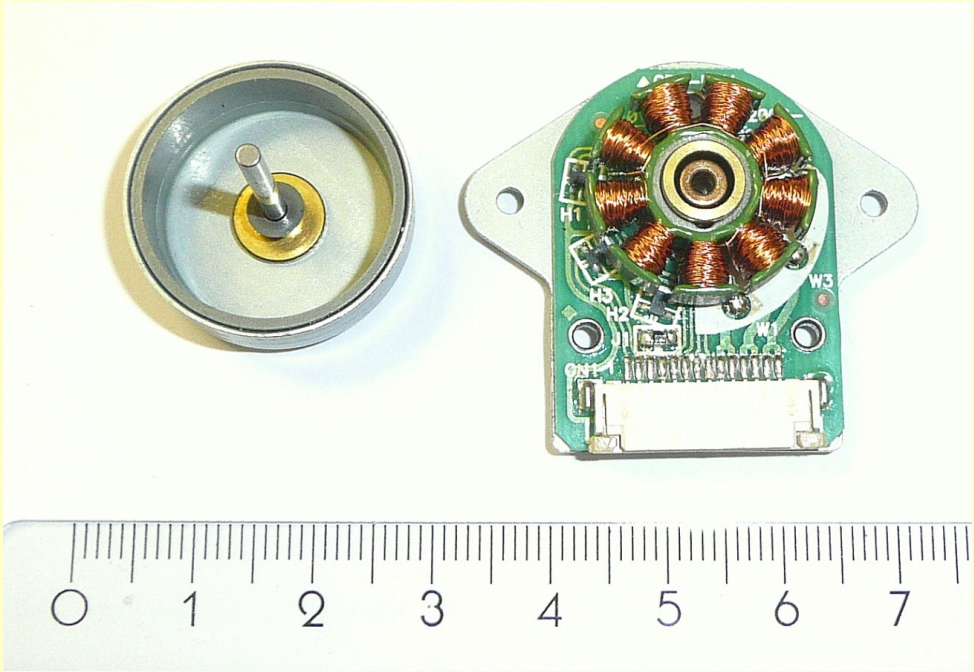
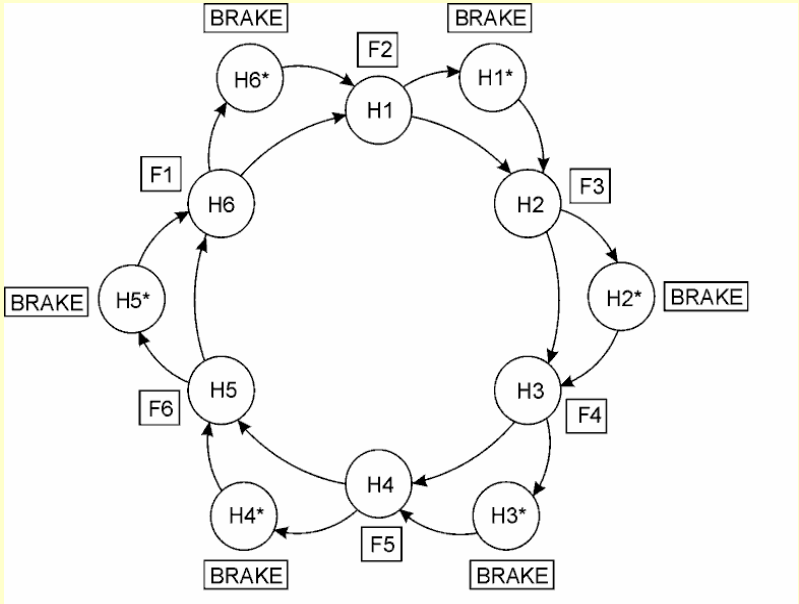
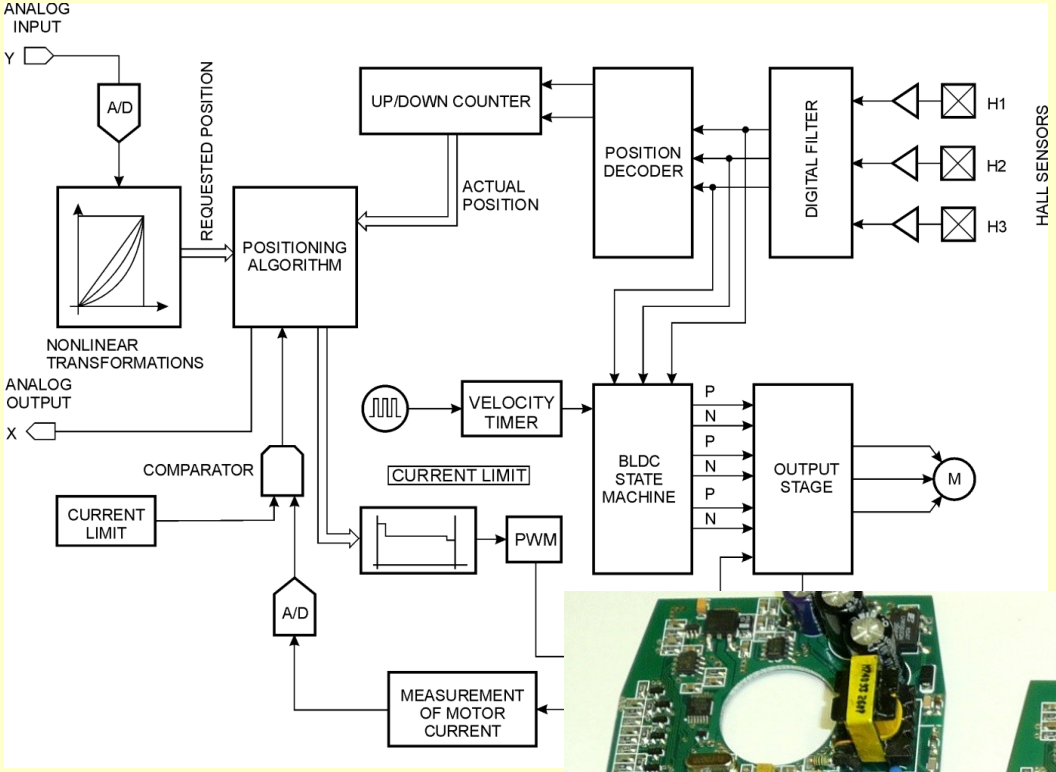
- Danfoss Trata, d.o.o.: Razvoj nove serije ventilov (zvezni in tropoložajni ventili)
- Razvoj **elektronike pogona** ventilov
- Razvoj "inteligentnega" **adaptivnega sistema** za zmanjševanje oscilacij

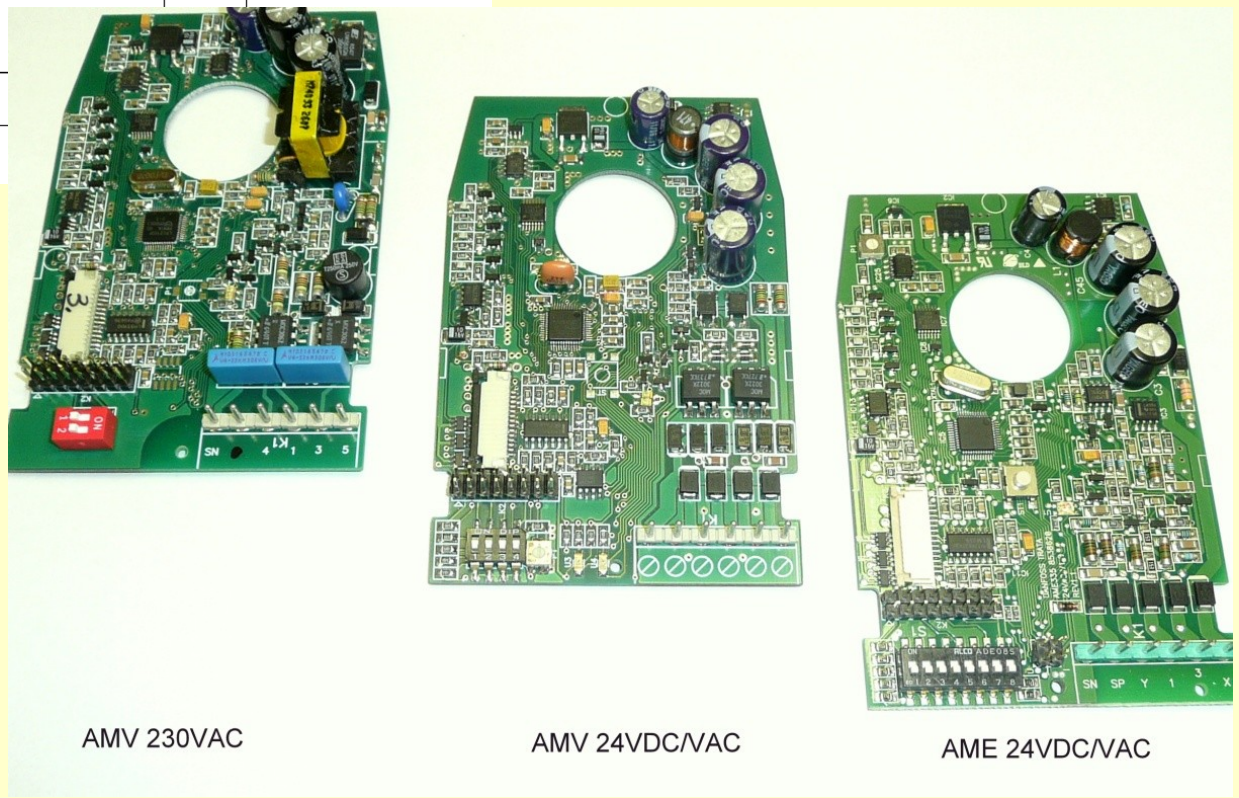
Razvoj elektronike pogona

- Temelji na **BLDC** motorjih
- Ponovljiva končna sila
- Konstantna hitrost odpiranja/zapiranja
- Dimenzije, cena, ... in ostale omejitve



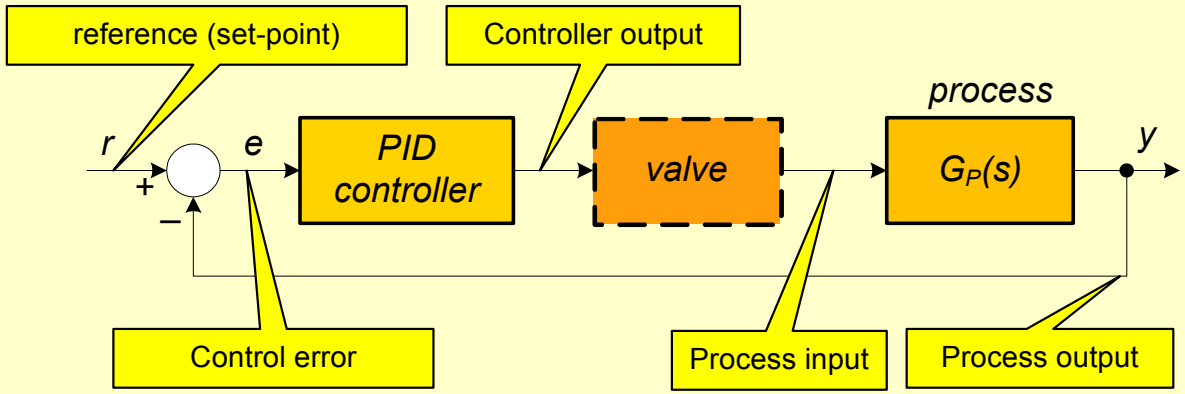



ANALOG INPUT
Y
A/D
REQUESTED POSITION
NONLINEAR TRANSFORMATIONS
POSITIONING ALGORITHM
UP/DOWN COUNTER
ACTUAL POSITION
POSITION DECODER
DIGITAL FILTER
H1
H2
H3
HALL SENSORS
ANALOG OUTPUT
X
VELOCITY TIMER
BLDC STATE MACHINE
P
N
P
N
P
N
OUTPUT STAGE
M
COMPARATOR
CURRENT LIMIT
CURRENT LIMIT
PWM
A/D
MEASUREMENT OF MOTOR CURRENT


AMV 230VAC
AMV 24VDC/VAC
AME 24VDC/VAC

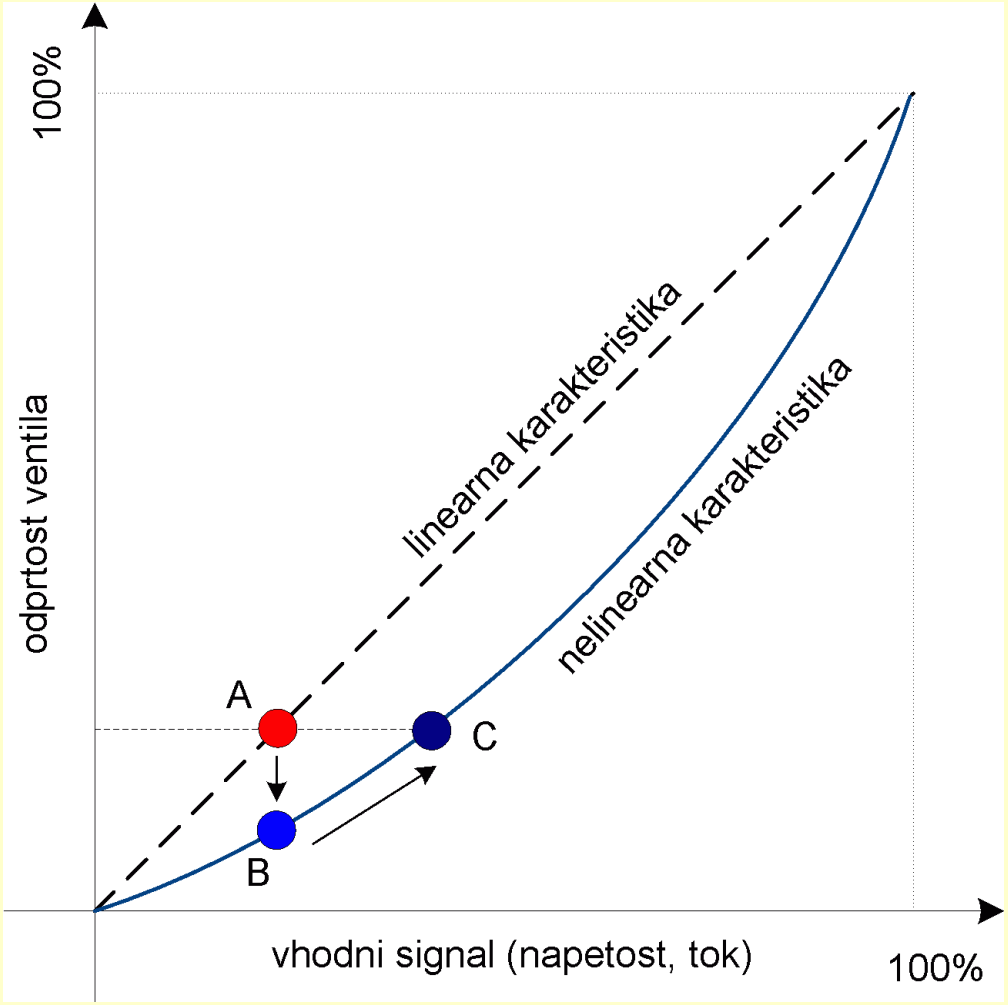
Razvoj adaptivnega sistema

- **Oscilacije** v zaprtozančnem sistemu
  - Slabo nastavljeni regulatorji
  - Nelinearnost sistema
  - Letno-zimski režim delovanja
  - Periodične motnje
  - Histereza ventila

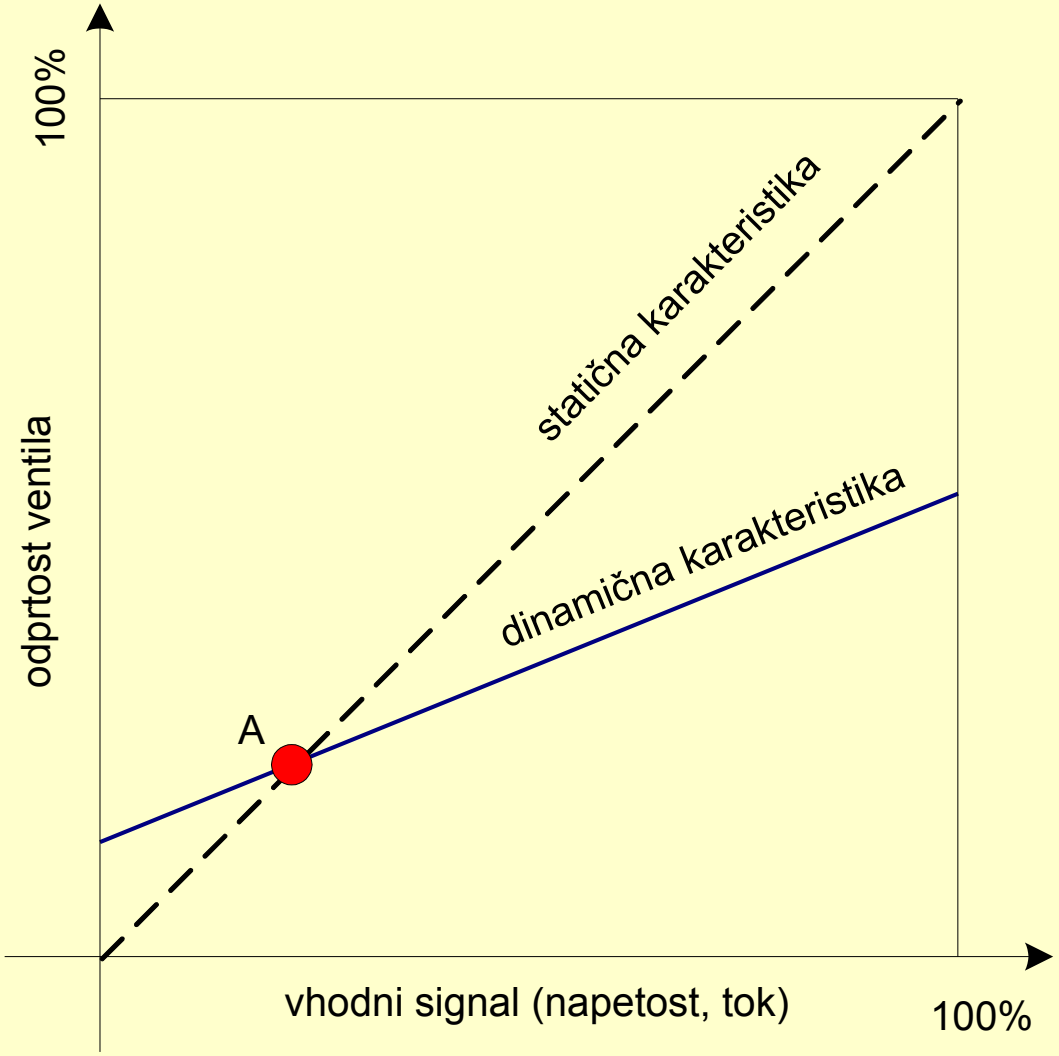


- Posledice: **izraba ventila**, neoptimalno delovanje zaprtozančnega sistema.

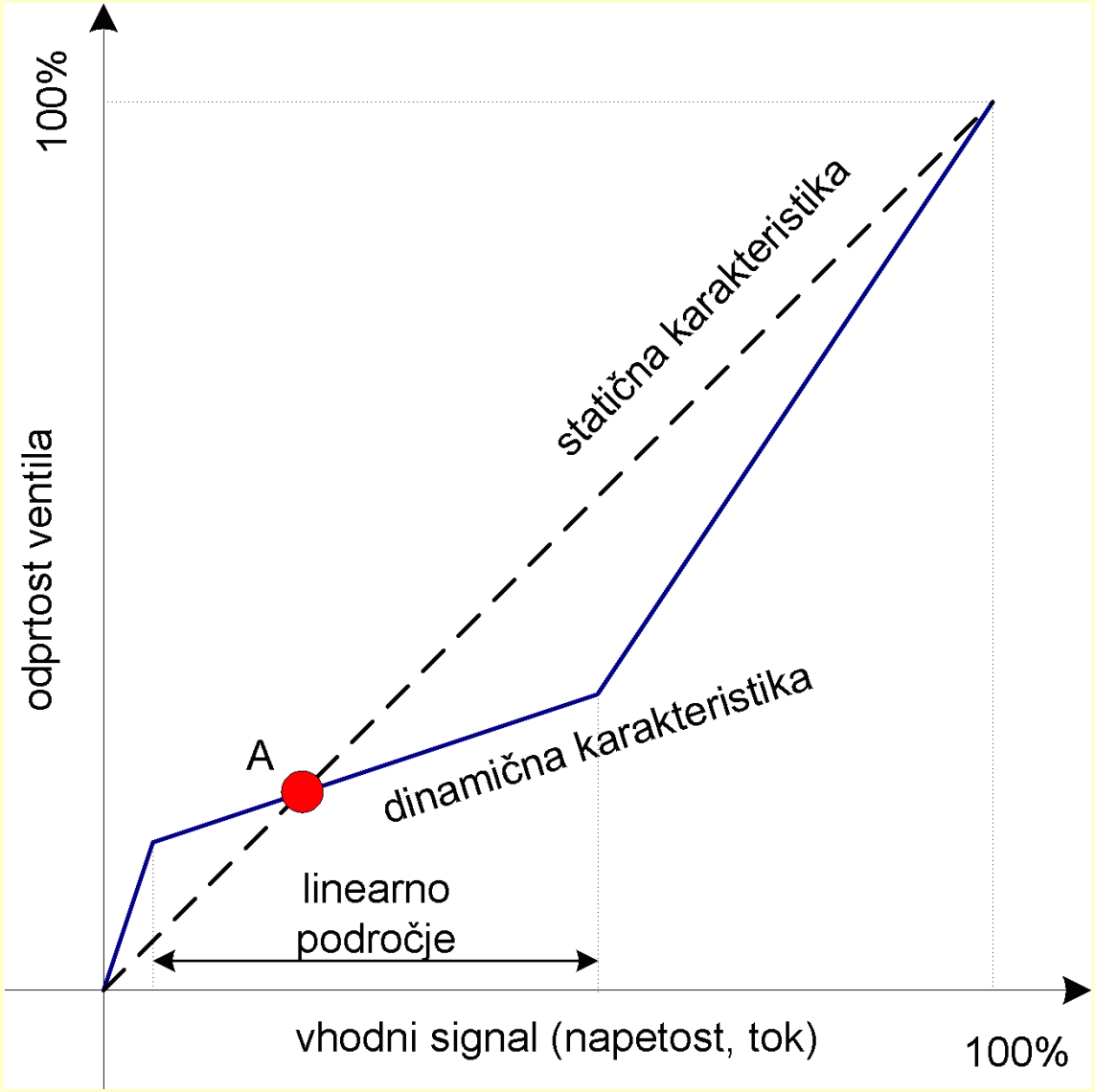
- Zahteve: Samodejno zmanjševanje oscilacij, ki potrebuje minimalno število podanih parametrov s strani operaterja
- Kako zmanjšati oscilacije? **Zmanjšati ojačenje ventila**.

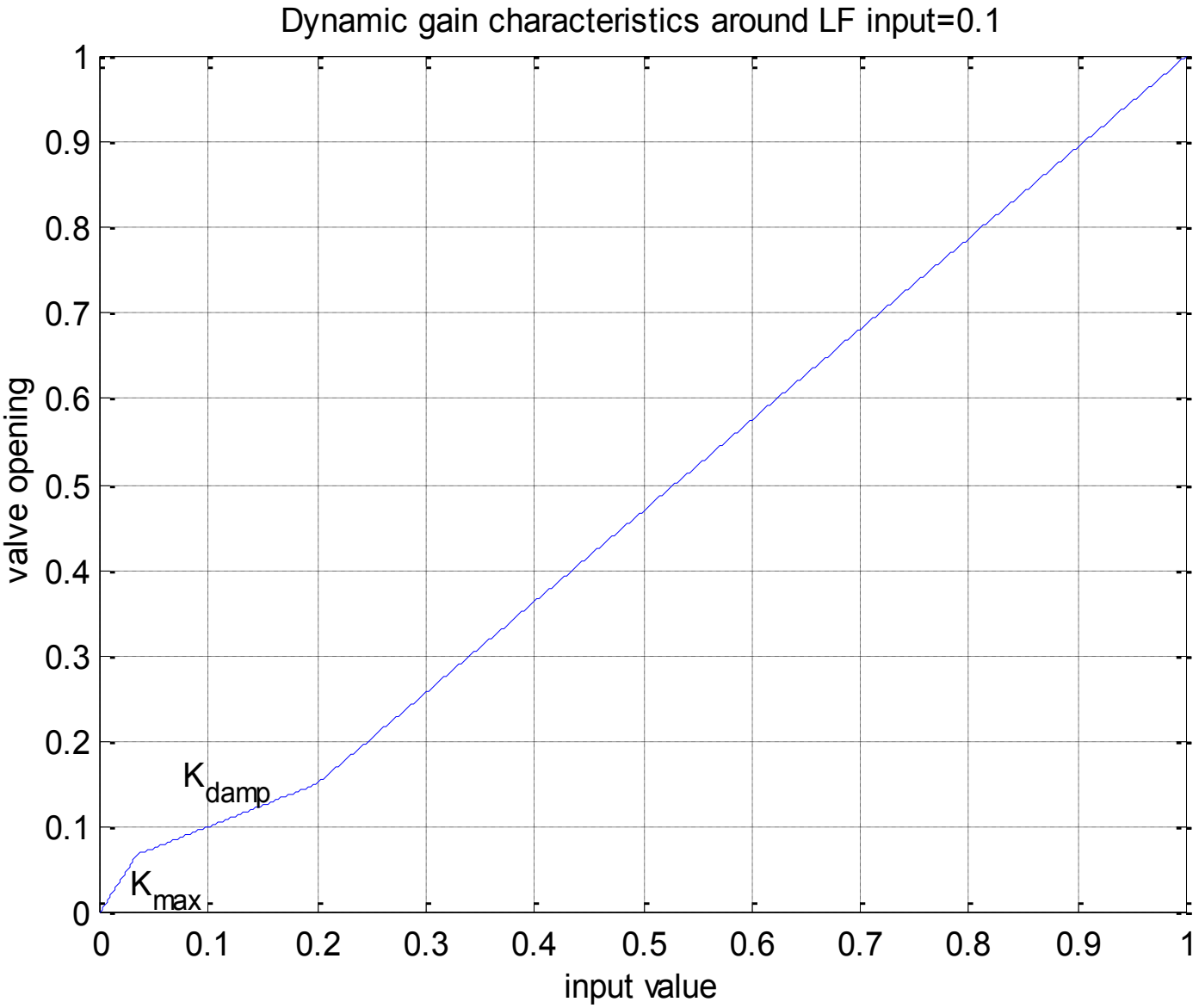


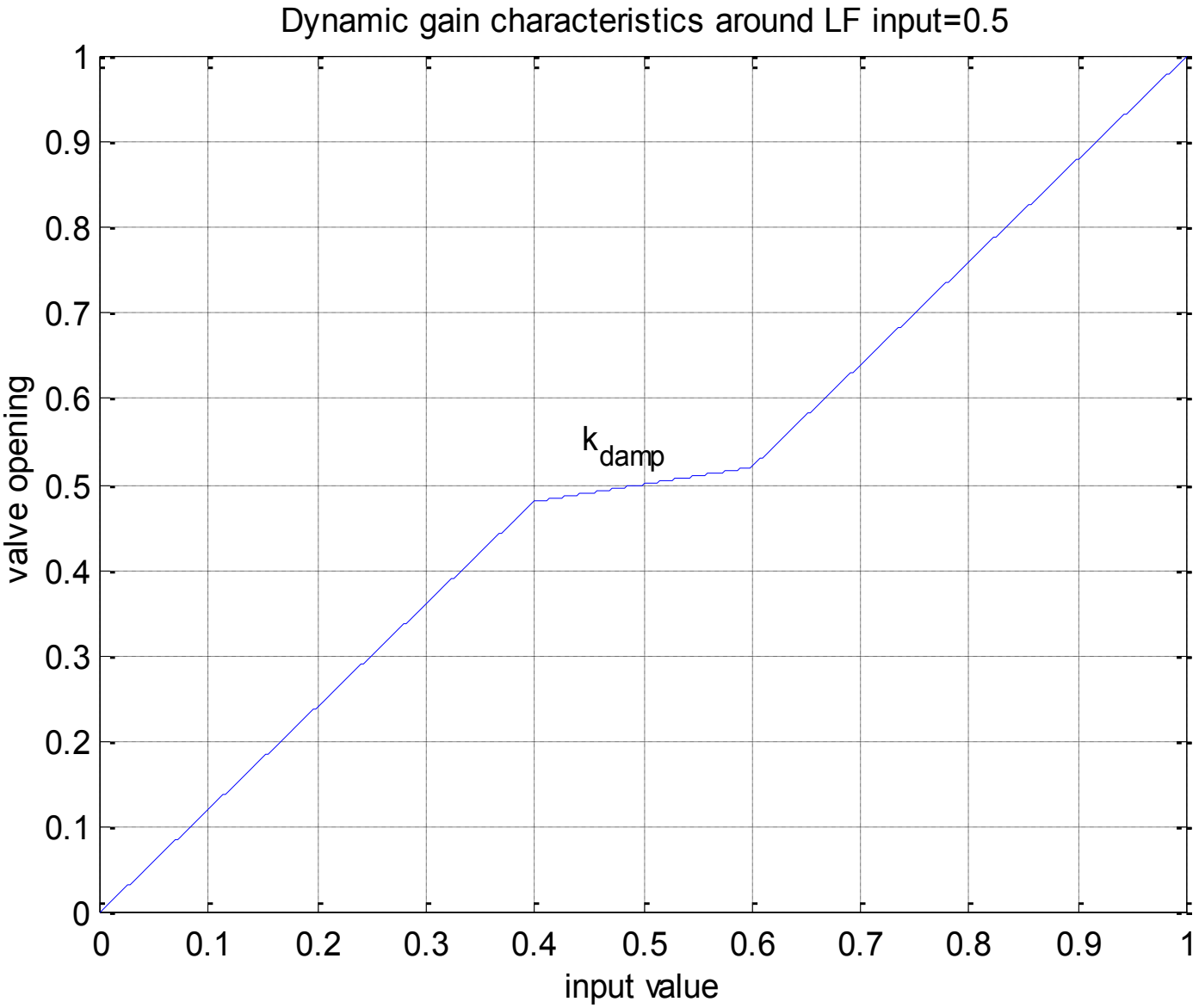
- **Zmanjšati dinamično ojačenje.**

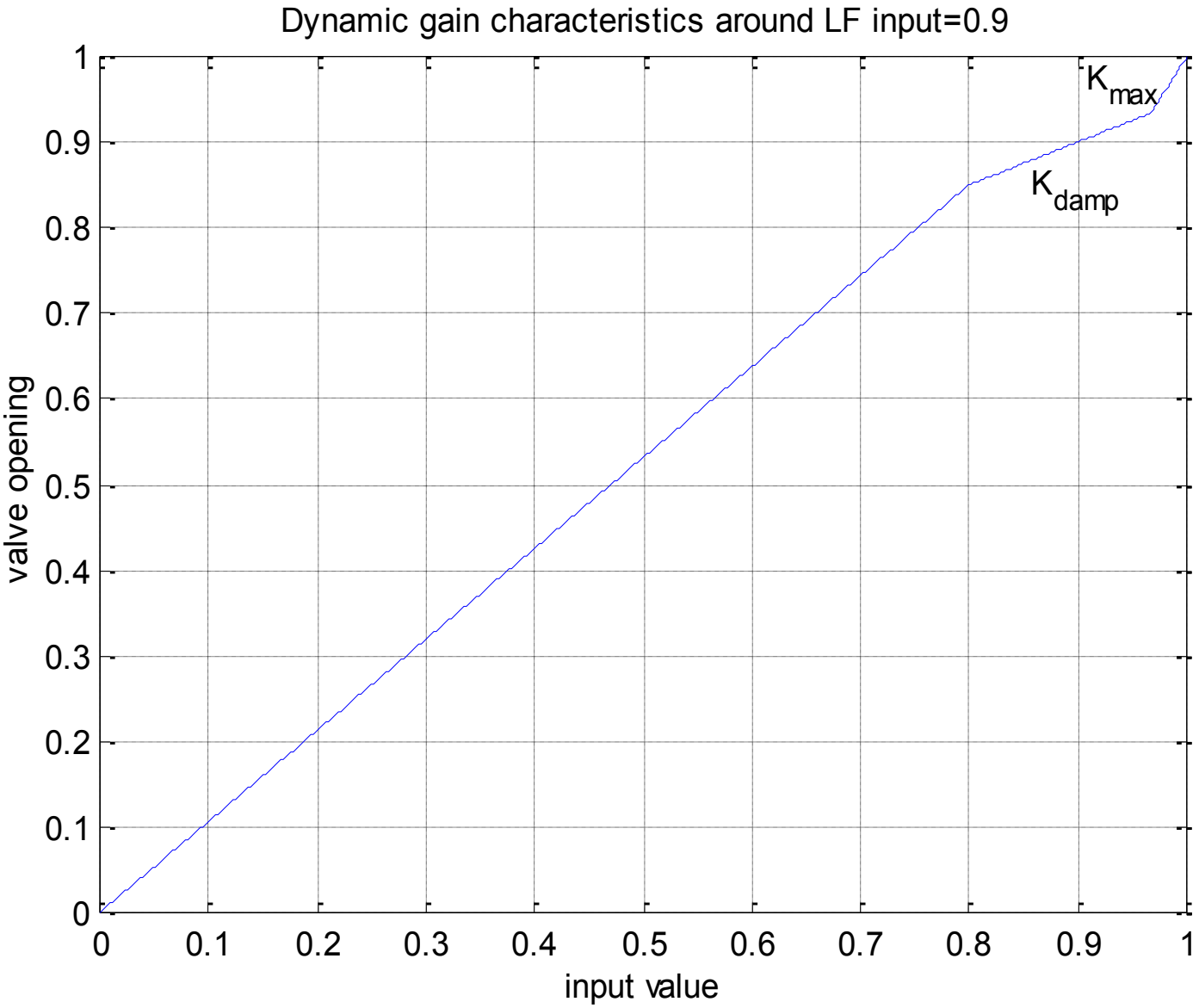


- **Nelinearno dinamično ojačenje.**

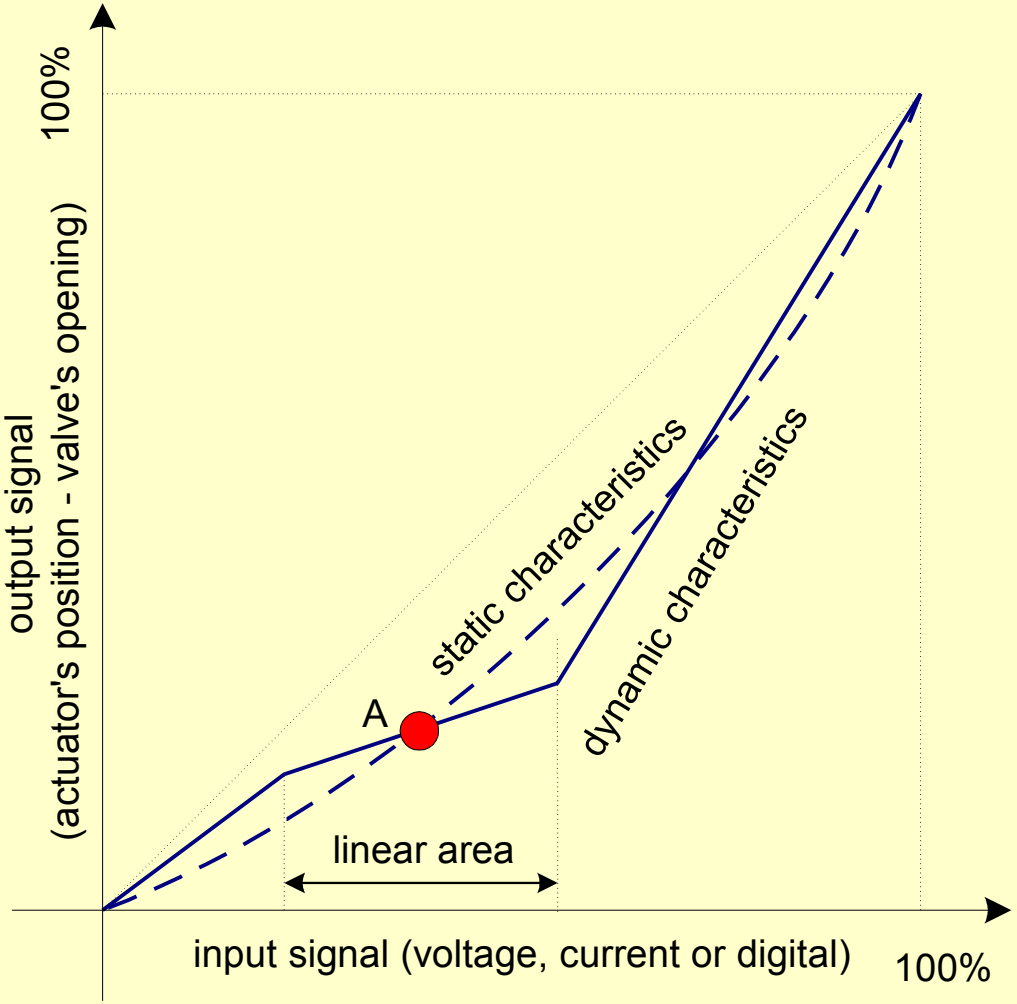


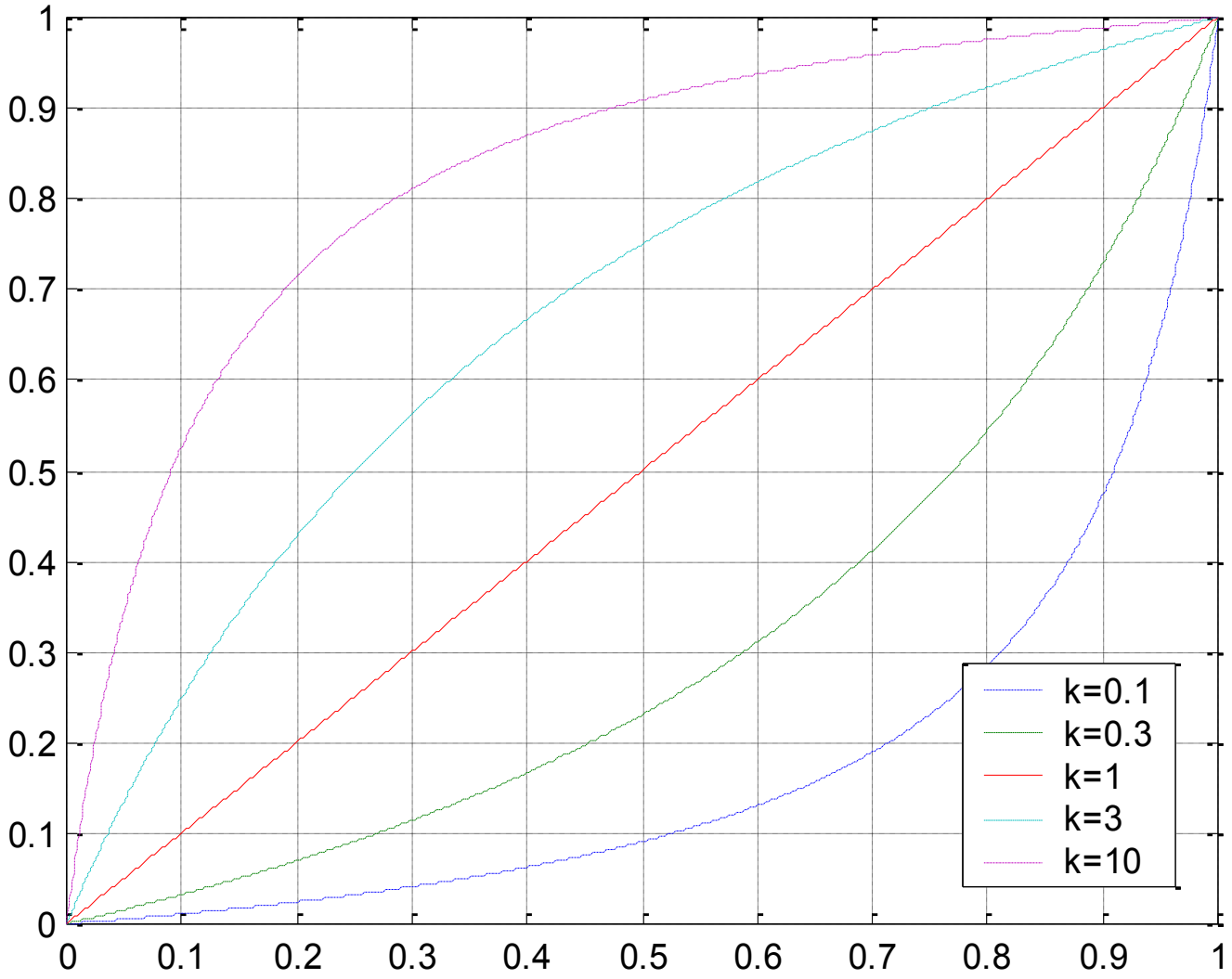

Dynamic gain characteristics around LF input=0.1
valve opening
input value
K damp
K max
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1


Dynamic gain characteristics around LF input=0.5
valve opening
input value
k damp
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

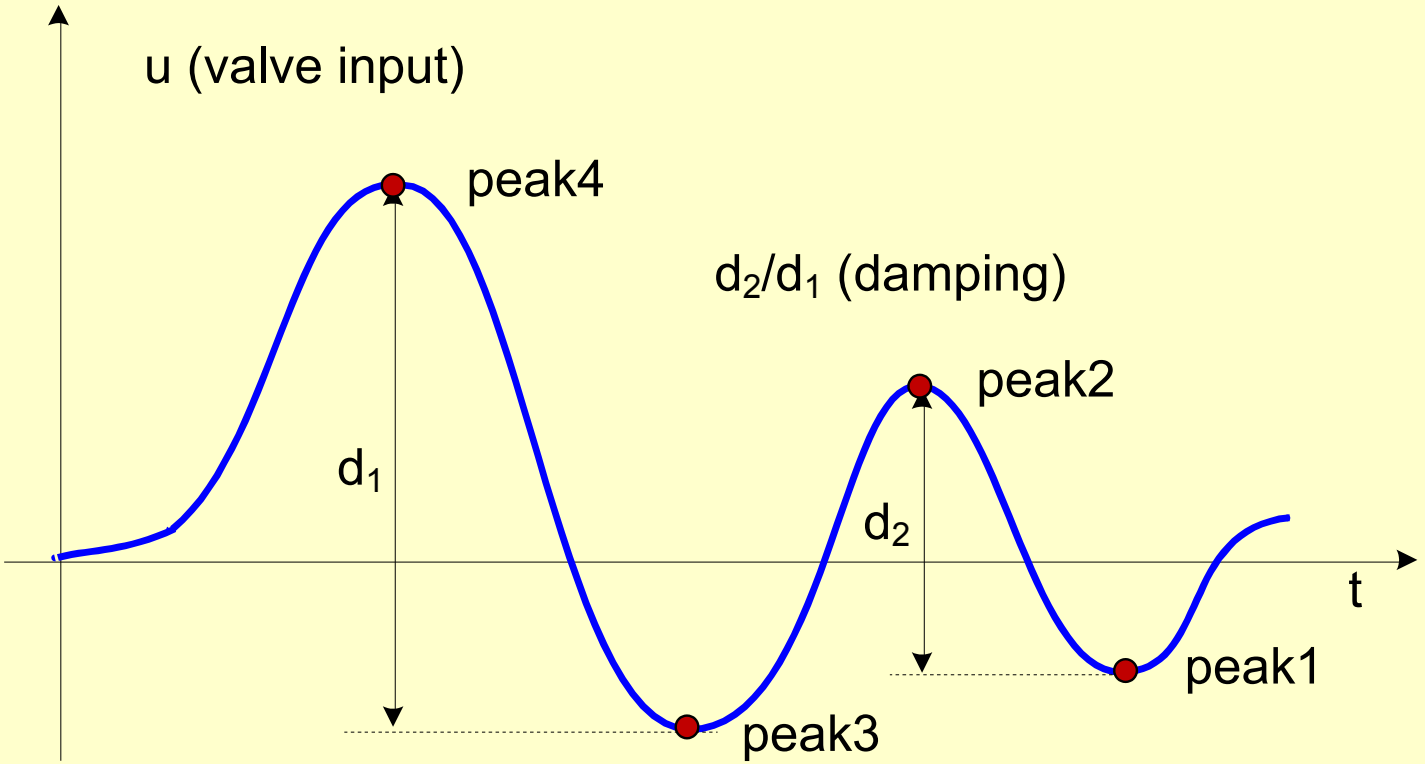

Dynamic gain characteristics around LF input=0.9
valve opening
input value
K max
K damp
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

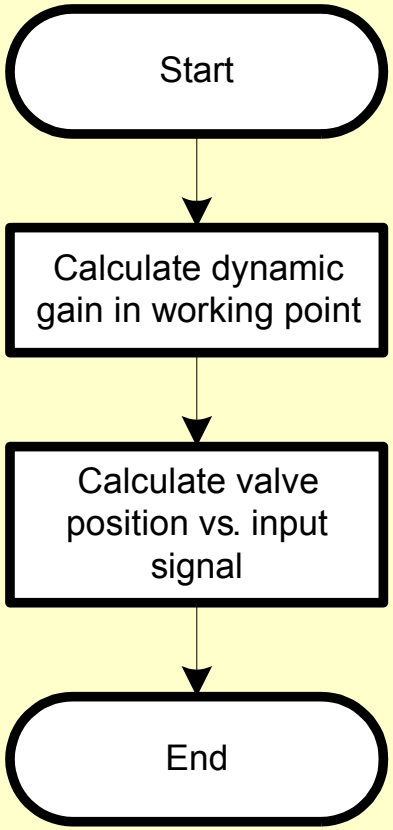
- **Kombinirano nelinearno statično in dinamično ojačenje.**

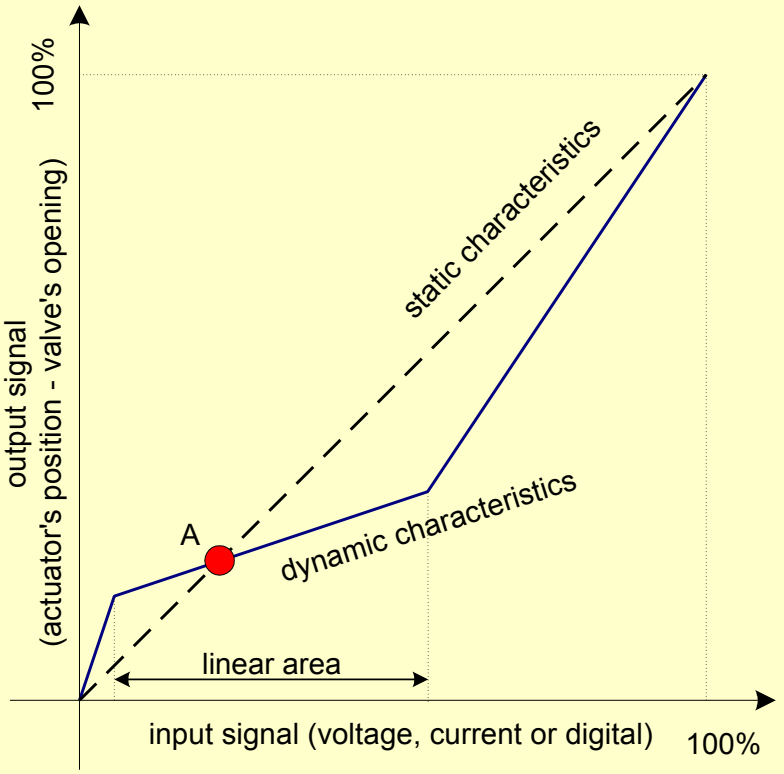


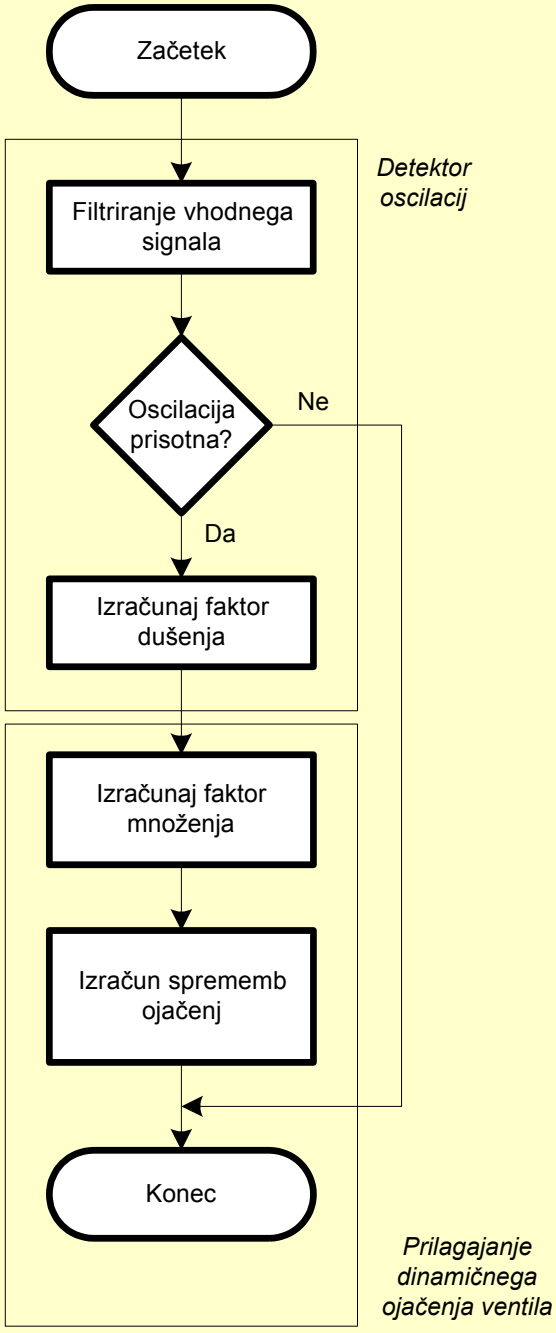

1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
k=0.1
k=0.3
k=1
k=3
k=10

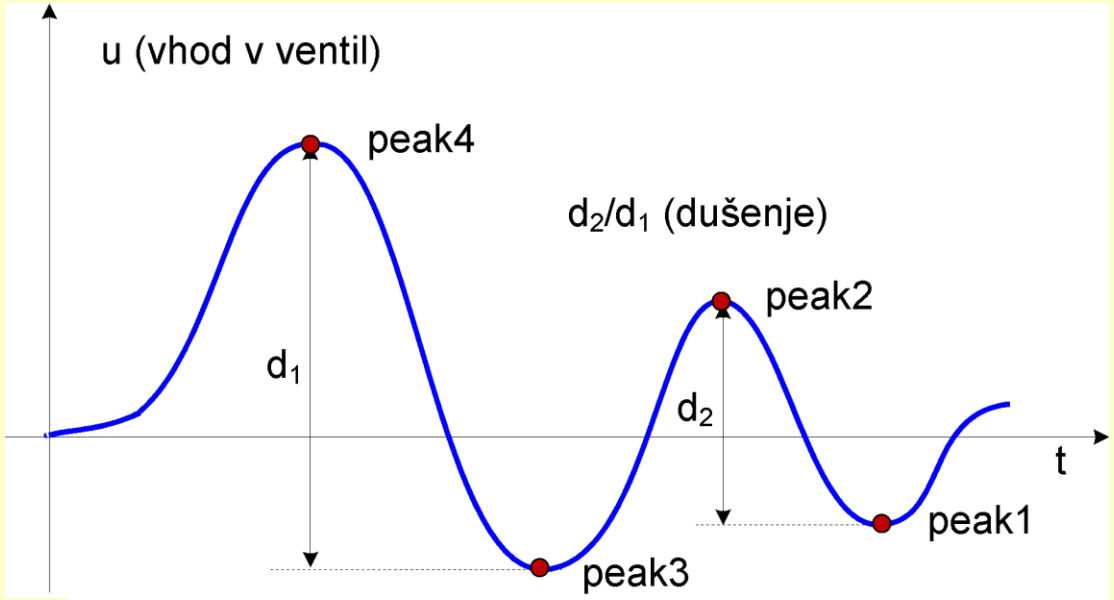
- Kako vemo, da je prisotna **oscilacija**?
- Merimo vhodni signal v ventil:

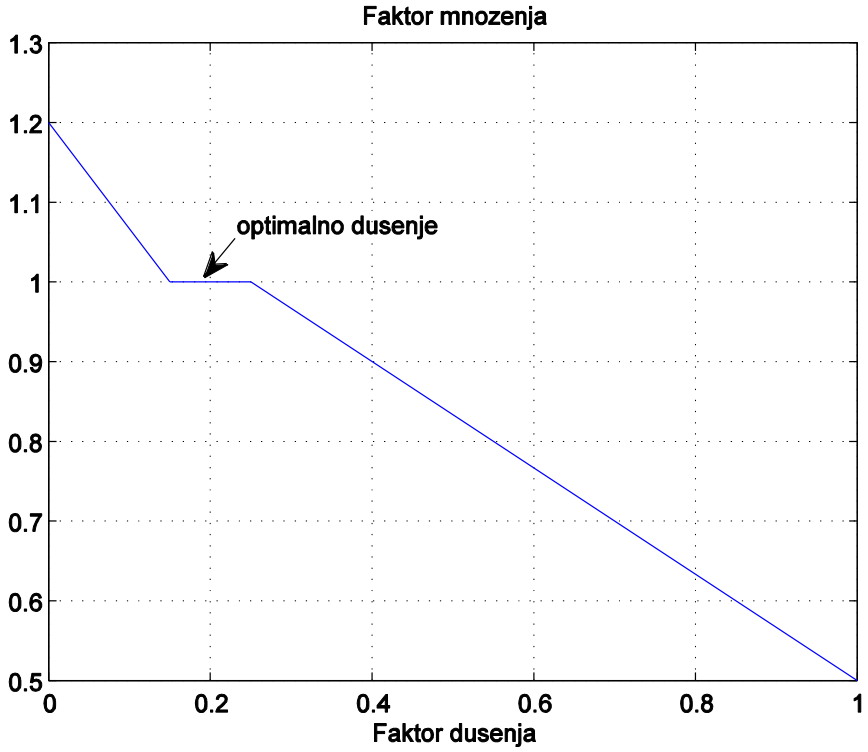


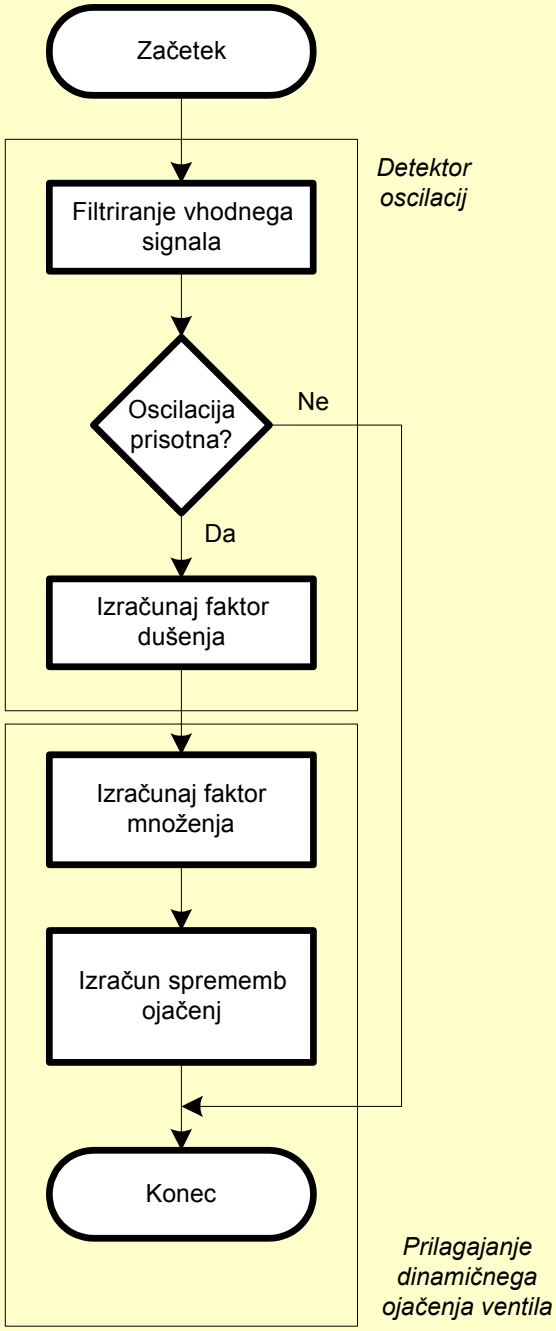

Start
Calculate dynamic gain in working point
Calculate valve position vs. input signal
End

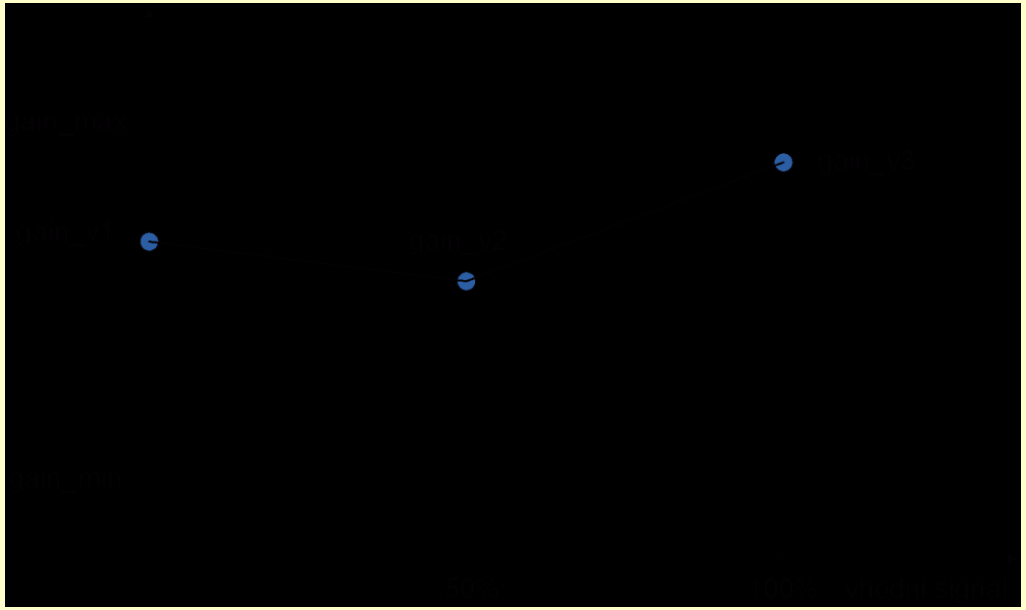

100%
output signal
(actuator's position - valve's opening)
static characteristics
A
dynamic characteristics
linear area
input signal (voltage, current or digital)
100%

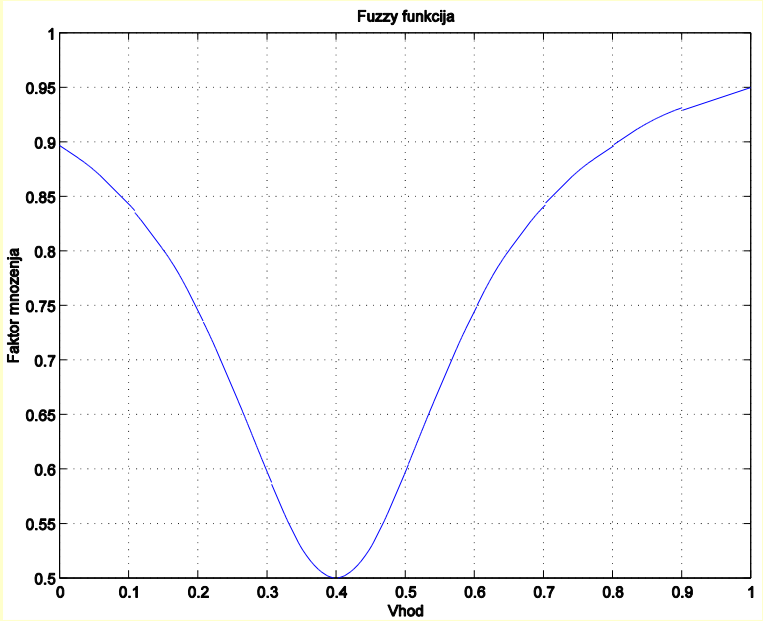

Začetek
Filtriranje vhodnega signala
Oscilacija prisotna?
Ne
Da
Izračunaj faktor dušenja
Izračunaj faktor množenja
Izračun sprememb ojačenj
Konec
Detektor oscilacij
Prilagajanje dinamičnega ojačenja ventila

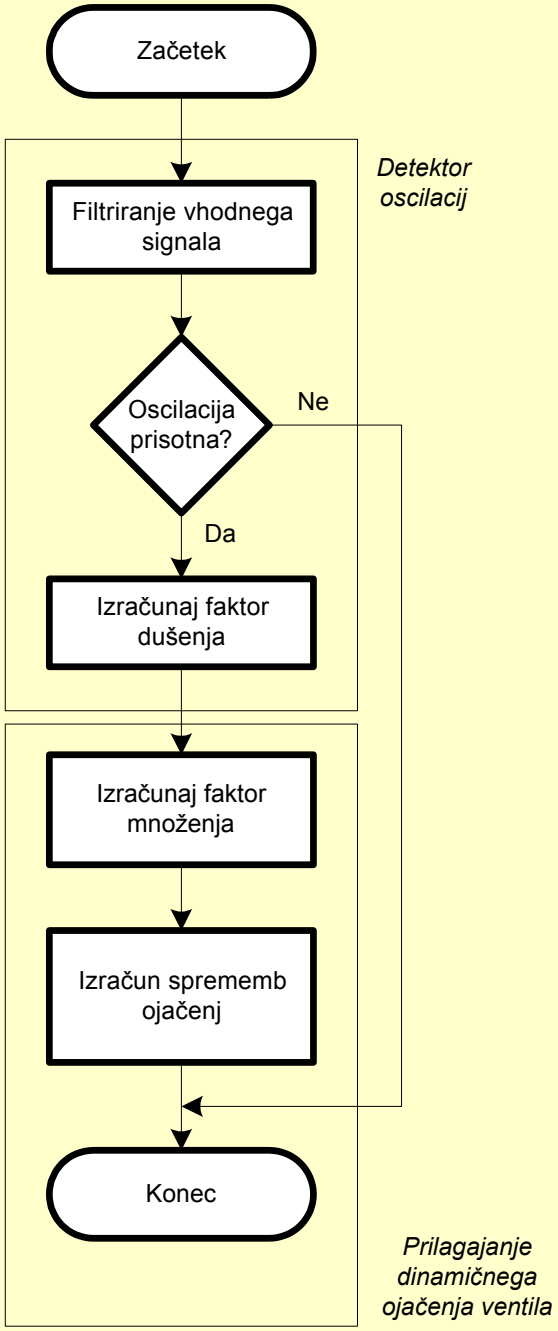

u (vhod v ventil)
peak4
d2/d1 (dušenje)
peak2
d1
d2
t
peak1
peak3

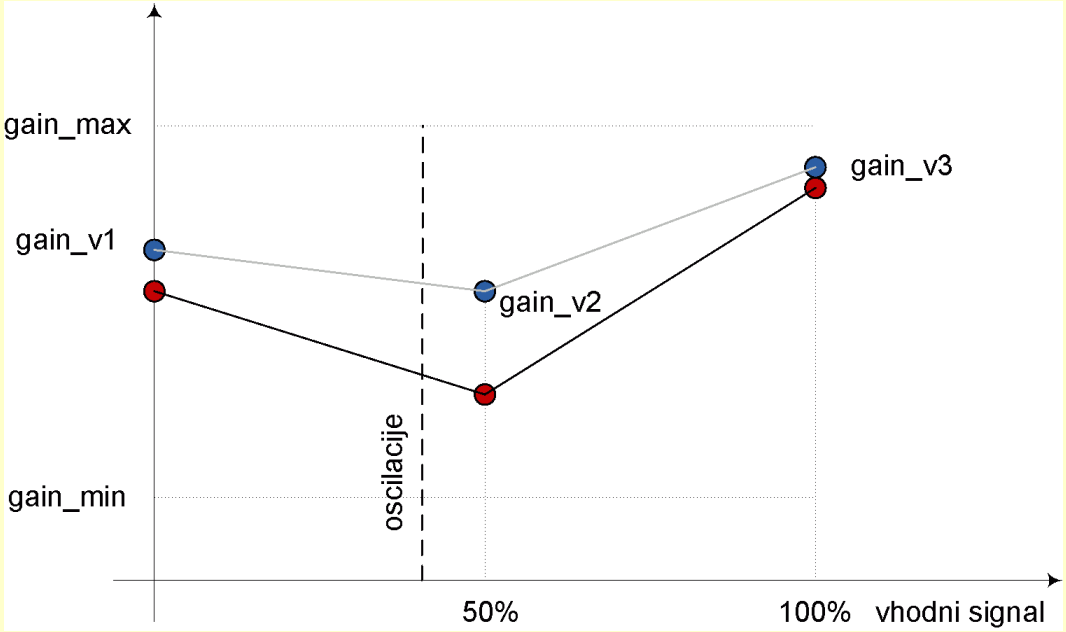

Faktor mnozenja
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
optimalno dusenje
0
0.2
0.4
0.6
0.8
1
Faktor dusenja

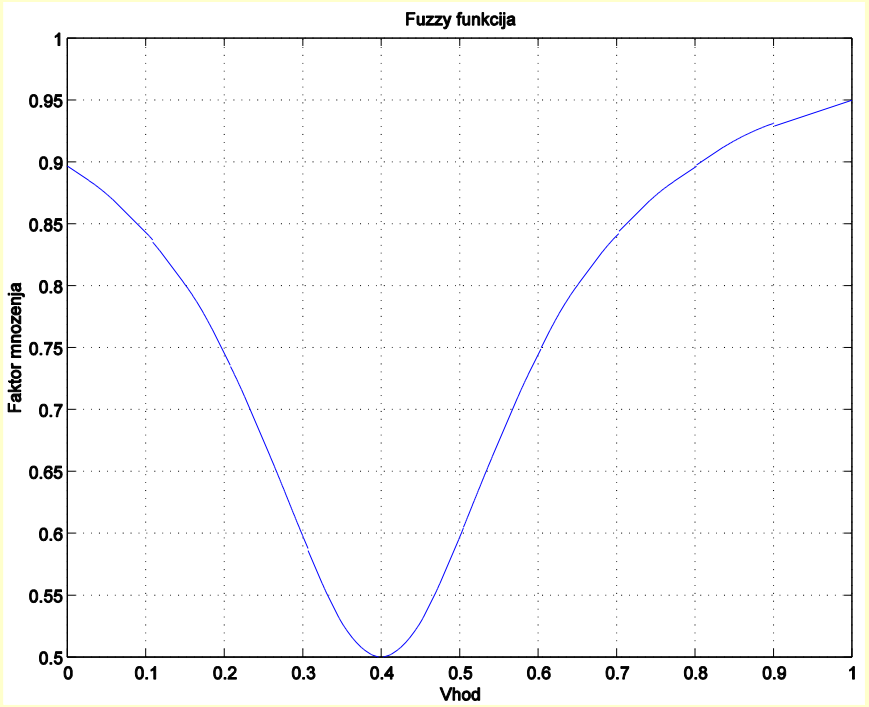

Začetek
Filtriranje vhodnega signala
Oscilacija prisotna?
Ne
Da
Izračunaj faktor dušenja
Izračunaj faktor množenja
Izračun sprememb ojačenj
Konec
Detektor oscilacij
Prilagajanje dinamičnega ojačenja ventila



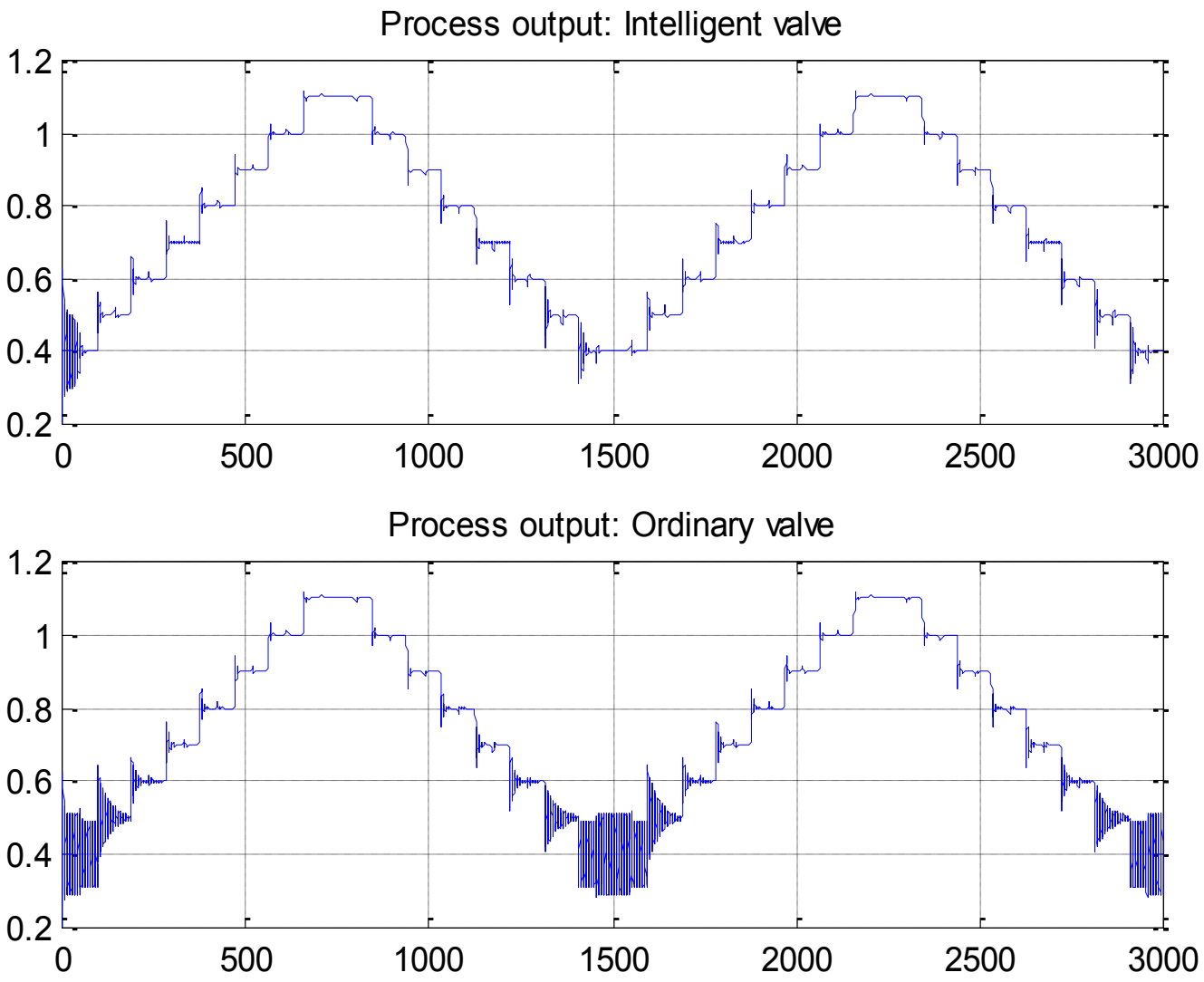

Fuzzy funkcija
Faktor mnozenja
Vhod
1
0.95
0.9
0.85
0.8
0.75
0.7
0.65
0.6
0.55
0.5
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

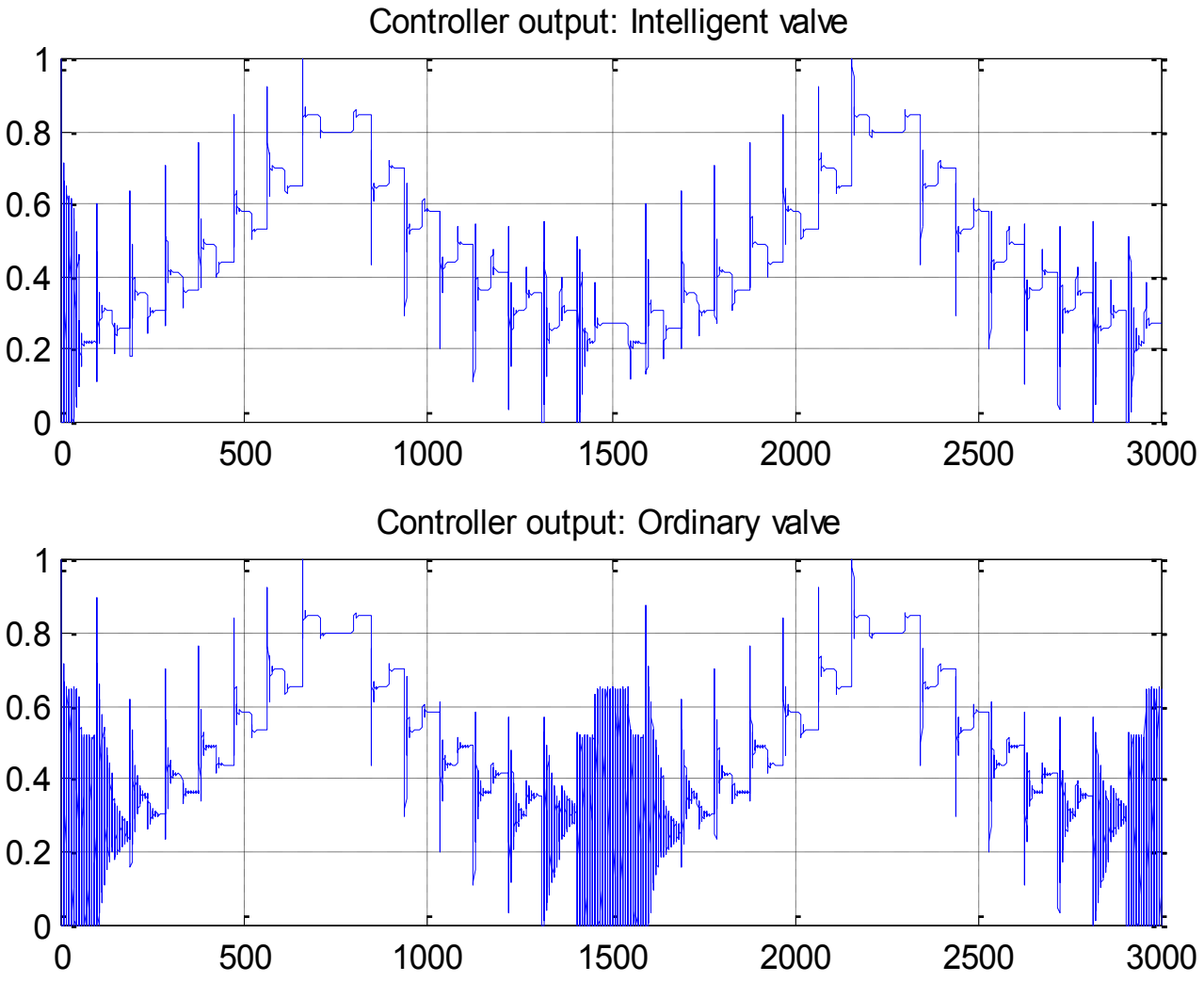

Začetek
Filtriranje vhodnega signala
Oscilacija prisotna?
Ne
Da
Izračunaj faktor dušenja
Izračunaj faktor množenja
Izračun sprememb ojačenj
Konec
Detektor oscilacij
Prilagajanje dinamičnega ojačenja ventila

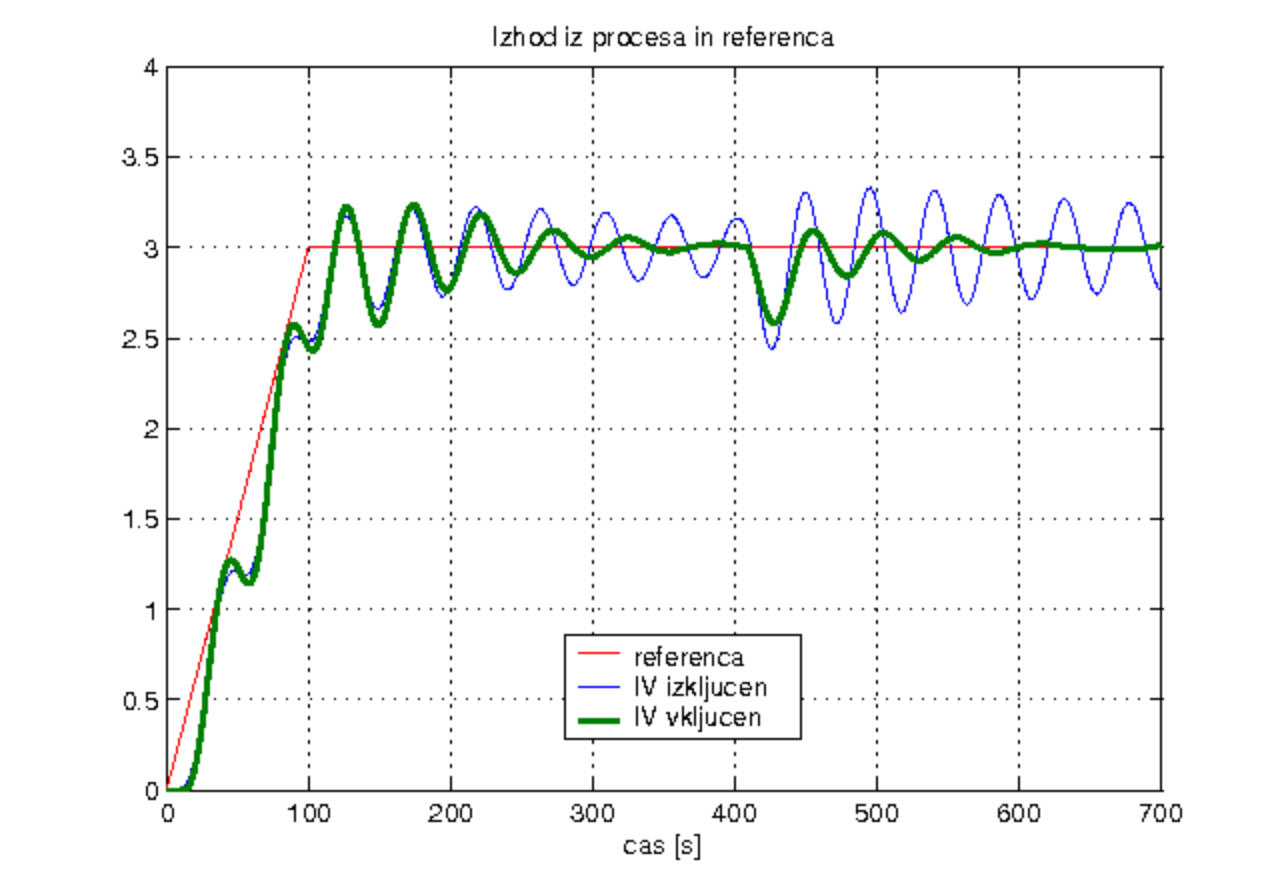

gain_max
gain_v1
gain_v2
gain_v3
gain_min
oscilacije
50%
100%
vhodni signal

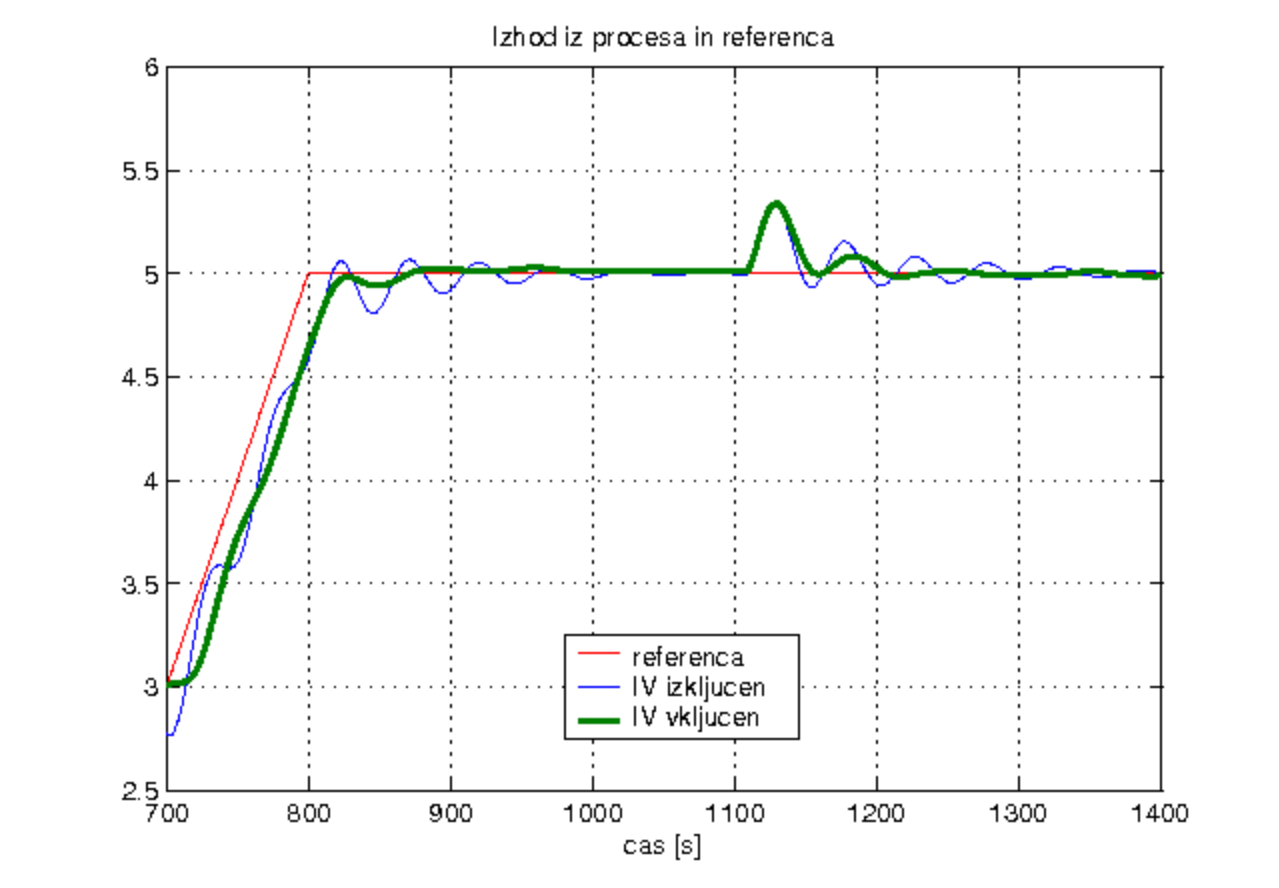

Fuzzy funkcija
Faktor mnozenja
Vhod
1
0.95
0.9
0.85
0.8
0.75
0.7
0.65
0.6
0.55
0.5
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

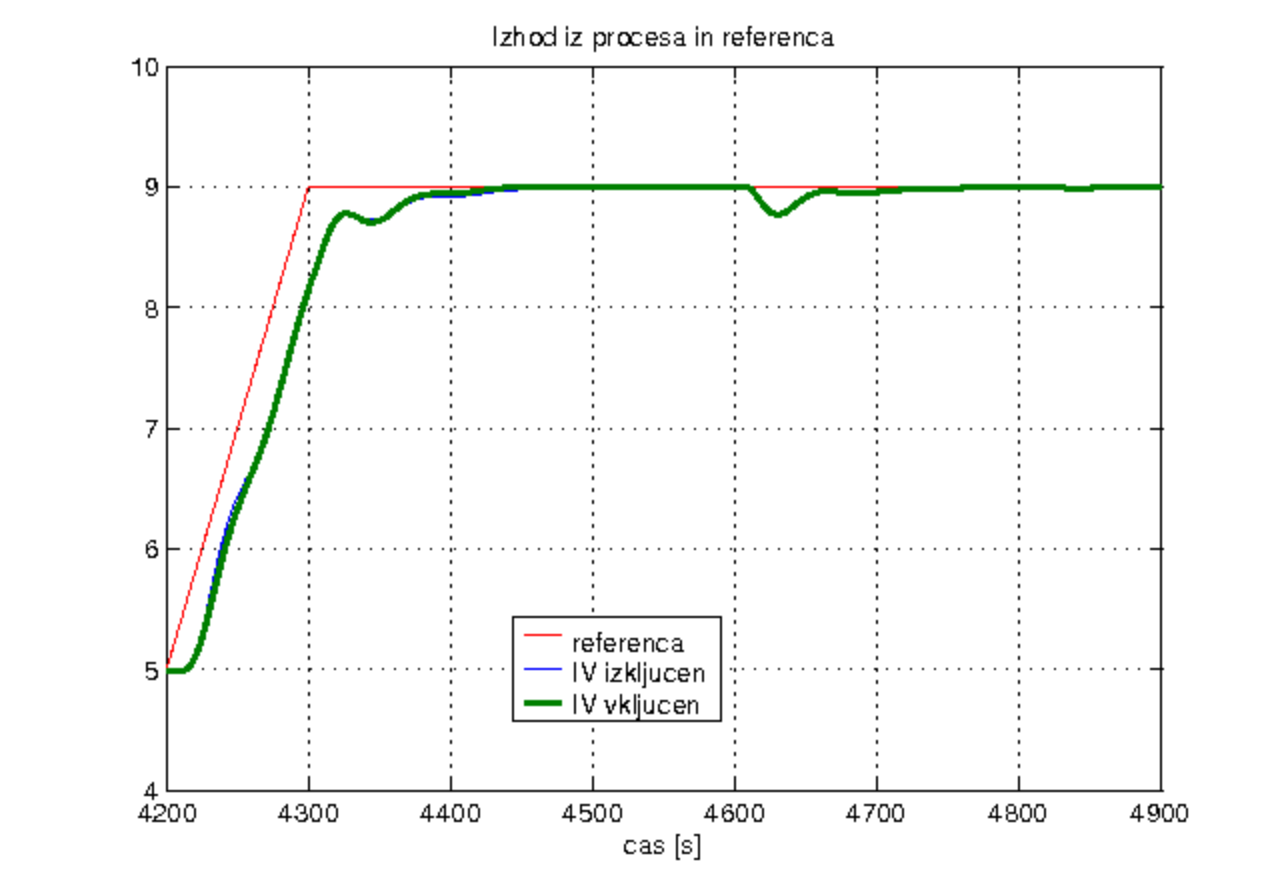
Preizkus sistema




Controller output: Intelligent valve
1
0.8
0.6
0.4
0.2
0
0
500
1000
1500
2000
2500
3000
Controller output: Ordinary valve
1
0.8
0.6
0.4
0.2
0
0
500
1000
1500
2000
2500
3000

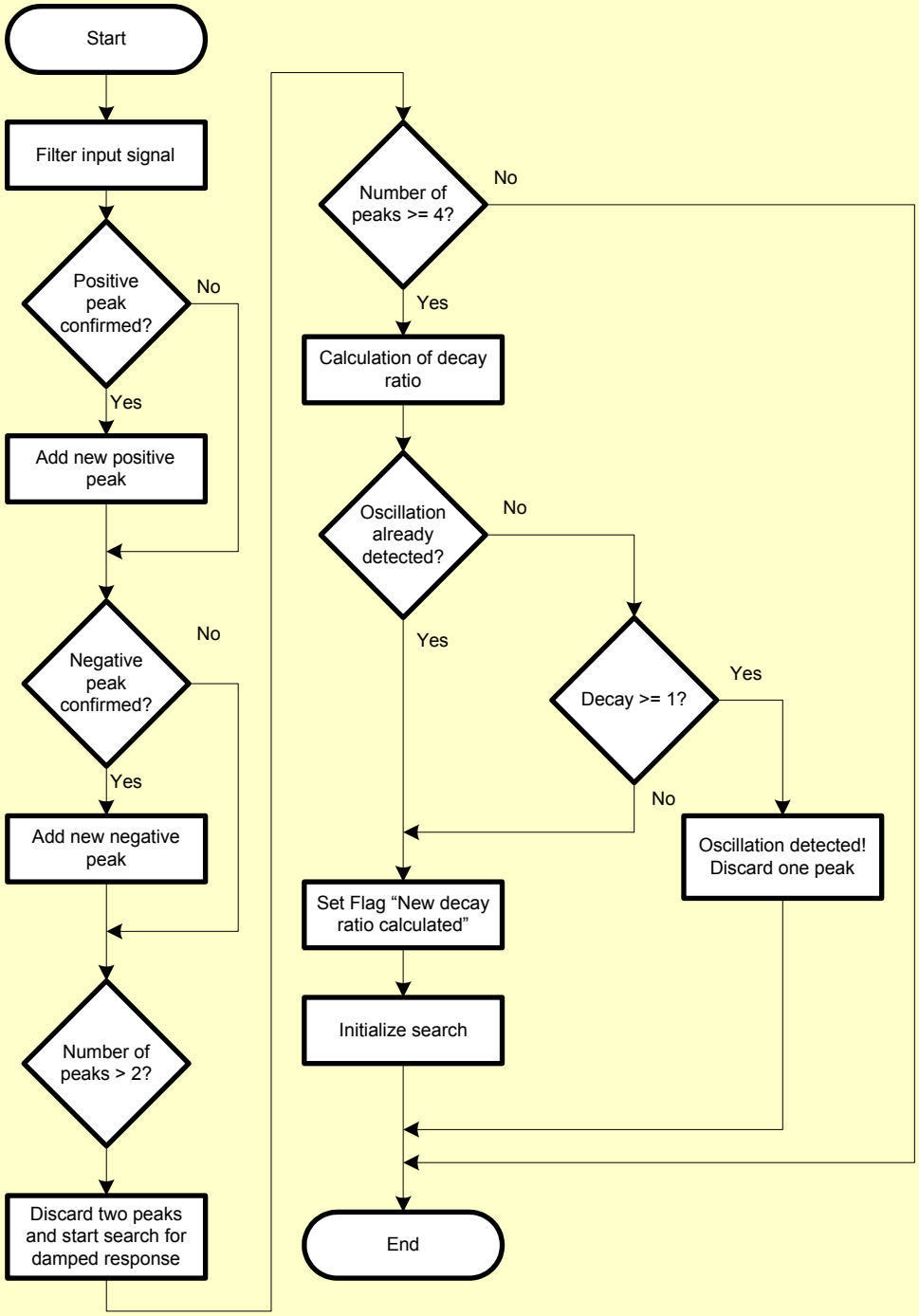

Izhod iz procesa in referenca
4
3.5
3
2.5
2
1.5
1
0.5
0
0
100
200
300
400
500
600
700
cas [s]
referenca
IV izkljucen
IV vkljucen


Izhod iz procesa in referenca
6
5.5
5
4.5
4
3.5
3
2.5
700
800
900
1000
1100
1200
1300
1400
cas [s]
referenca
IV izkljucen
IV vkljucen


Izhod iz procesa in referenca
10
9
8
7
6
5
4
4200
4300
4400
4500
4600
4700
4800
4900
cas [s]
referenca
IV izkljucen
IV vkljucen

Zaključek

- Razvoj elektronike
- Razvoj adaptivne funkcije
- Učinkovitost testirana na testni progi v Danfossu
- Ventil v proizvodnji – okoli 10.000 kosov
- Uspešno sodelovanje: raziskovalna ustanova - podjetje


Start
Filter input signal
Positive peak confirmed?
No
Yes
Add new positive peak
Negative peak confirmed?
No
Yes
Add new negative peak
Number of peaks > 2?
Discard two peaks and start search for damped response
Number of peaks >= 4?
No
Yes
Calculation of decay ratio
Oscillation already detected?
No
Yes
Decay >= 1?
Yes
No
Oscillation detected! Discard one peak
Set Flag “New decay ratio calculated”
Initialize search
End

- Parametri?
- Minimalno: hystd in Tlp
  - **Hystd**: odvisno od šuma/motenj signala. Deltau = 3*hystd
  - **Tlp**: pričakovana perioda oscilacij (v sekundah). Dejanska perioda mora biti < 4*Tlp za prvo detektirano oscilacijo.
  - **Delta**: Območje zmanjšanega ojačenja (10%). Odvisno od velikosti oscilacij.