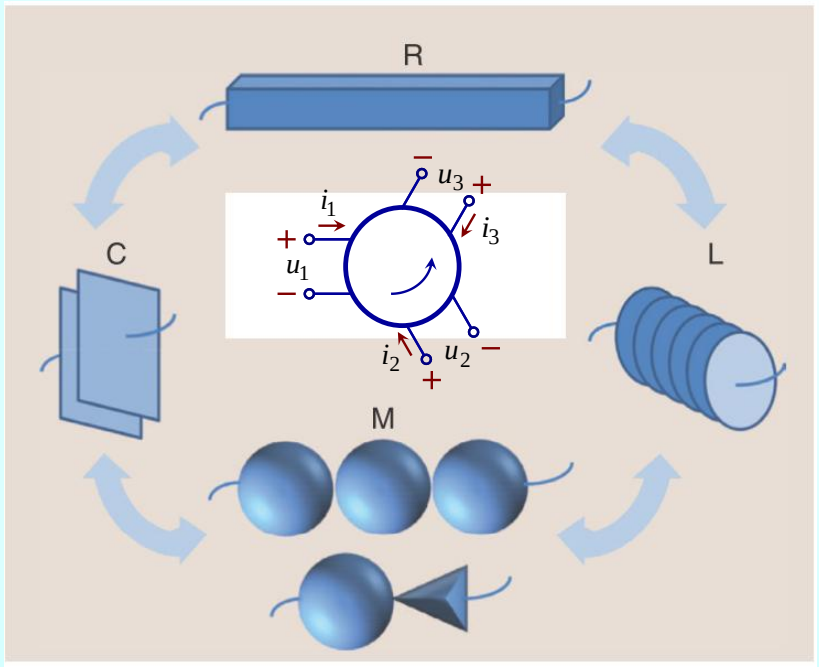
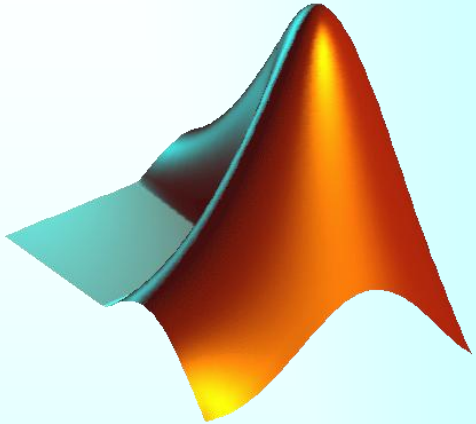
др Милка Потребић, ванредни професор, *Практикум из рачунарске анализе кола*, Универзитет у Београду – Електротехнички факултет, 2017.

Практикум из рачунрске анализе кола





Милка Потребић

MATLAB: Simscape
SimPowerSystems

ОДРЕЂИВАЊЕ АМПЛИТУДСКЕ & ФАЗНЕ КАРАКТЕРИСТИКЕ

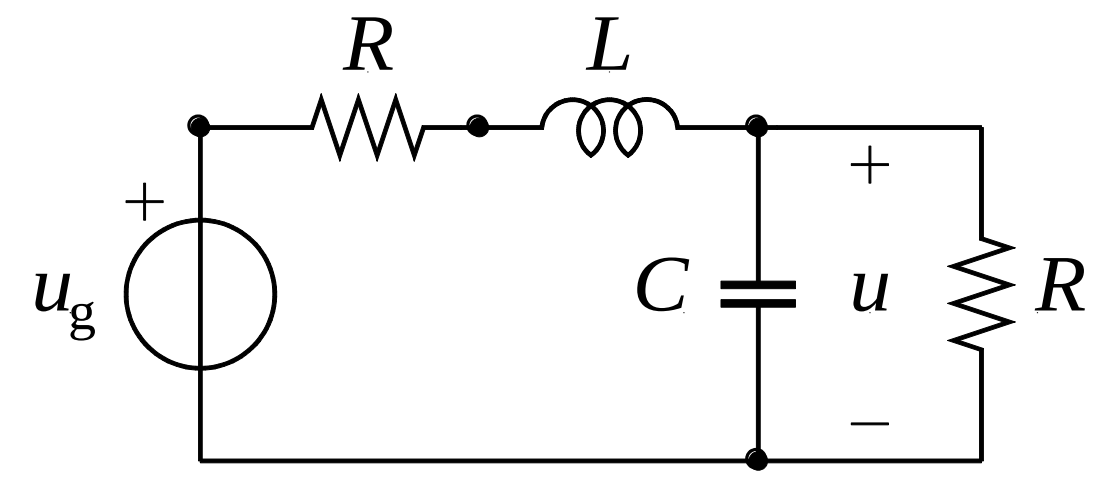
Филтар пропусник ниских учестаности

Вредности елемената електричног кола са слике су познате и постоји веза $L = R^2 C$.

(а) Одредити трансфер функцију (уопштену комплексну преносну функцију електричног кола, трансмитансу напона) $\underline{H}(\underline{s}) = \frac{\underline{U}(\underline{s})}{\underline{U}_g(\underline{s})}$.

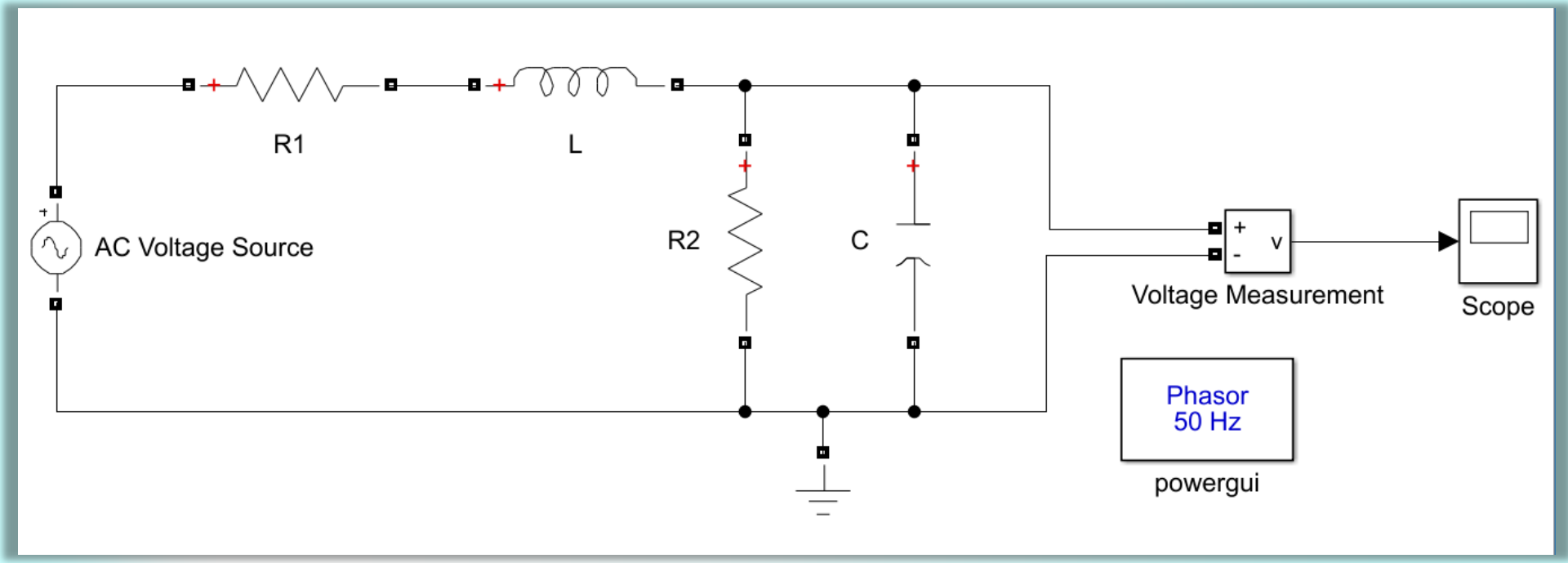
(б) Нацртати амплитудску карактеристику.

(в) Одредити пропусни опсег 3 dB.



$$u_g = \sqrt{2} U_g \cos(\omega t + \theta_g)$$

MATLAB: Simscape
SimPowerSystems



AC Voltage Source

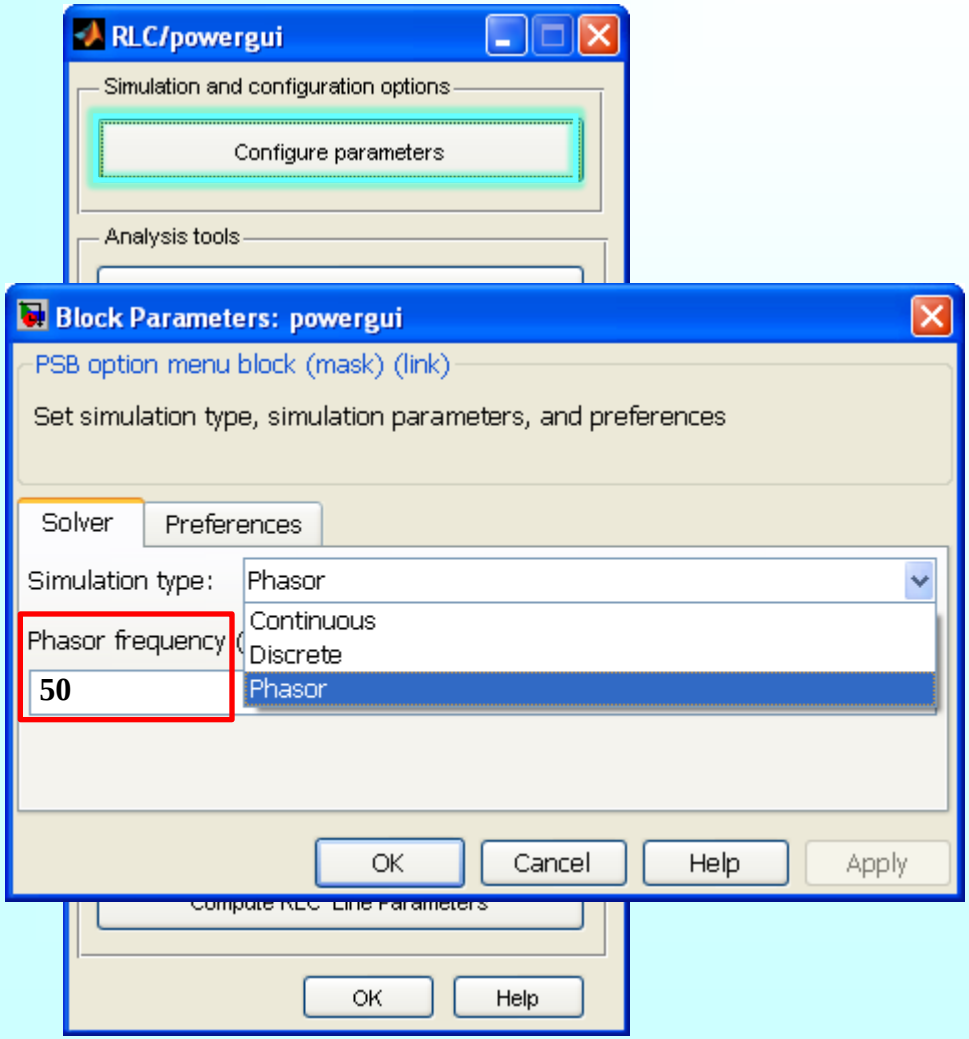
$$u_g = \sqrt{2}\underbrace{U_g}_{230\,\mathrm{V}} \sin\left(\underbrace{\omega}_{2\pi\underbrace{f}_{50\,\mathrm{Hz}}} t + \underbrace{\theta_g}_{\pi/2}\right)$$

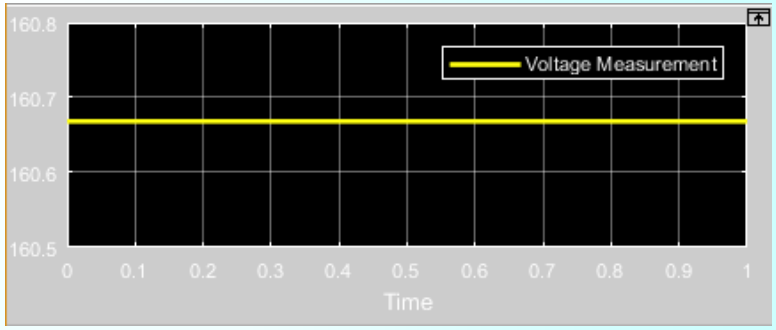
$$R_1 = R_2 = 1\,\mathrm{k\Omega}$$

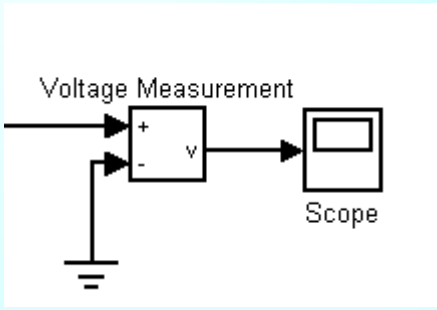
$$L = 1\,\mathrm{mH}$$

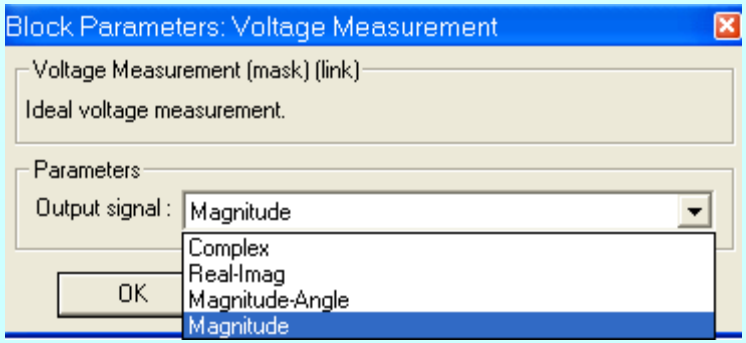
$$C = 1\,\mu\mathrm{F}$$

ФАЗОРСКА ТРАНСФОРМАЦИЈА

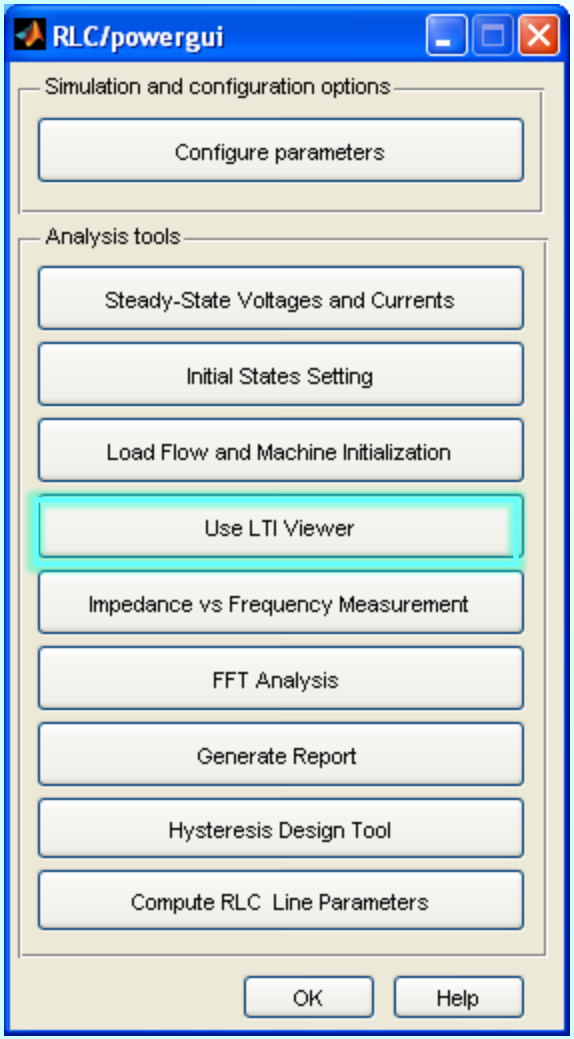


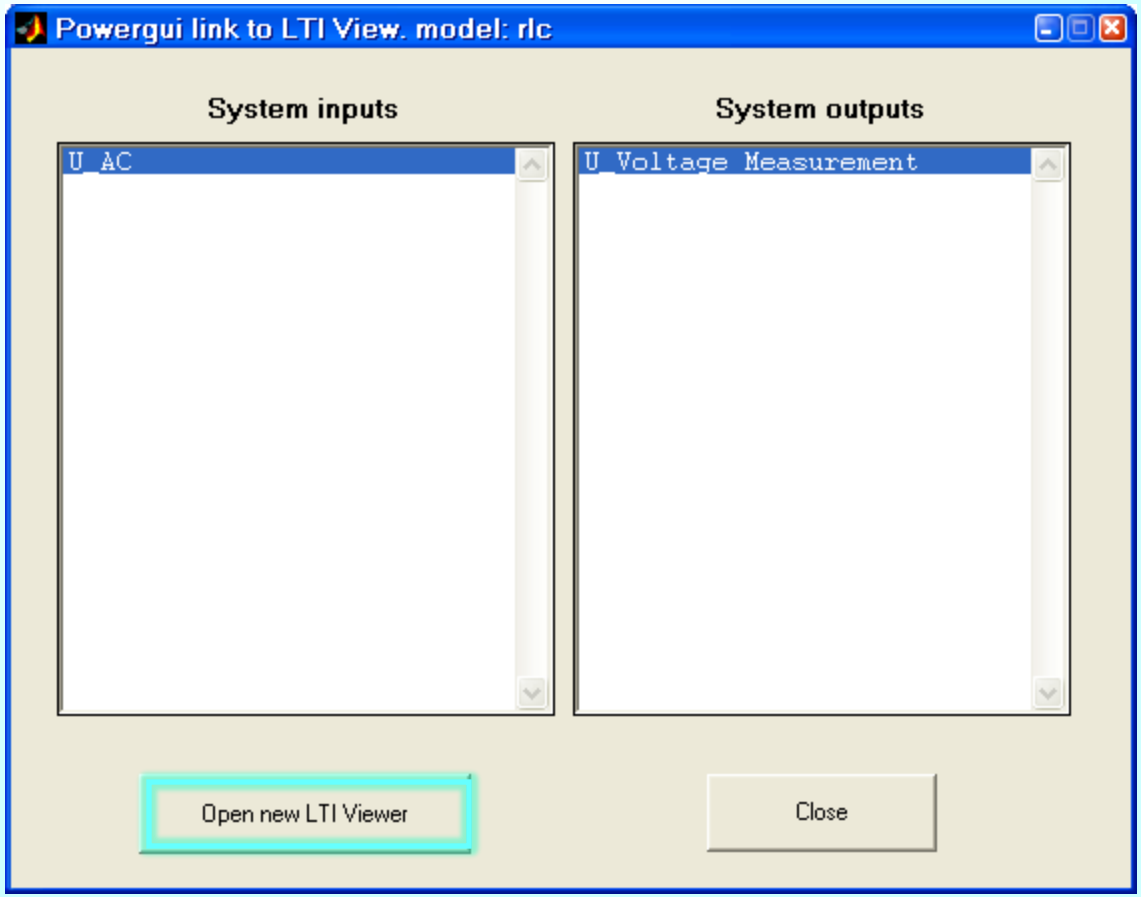




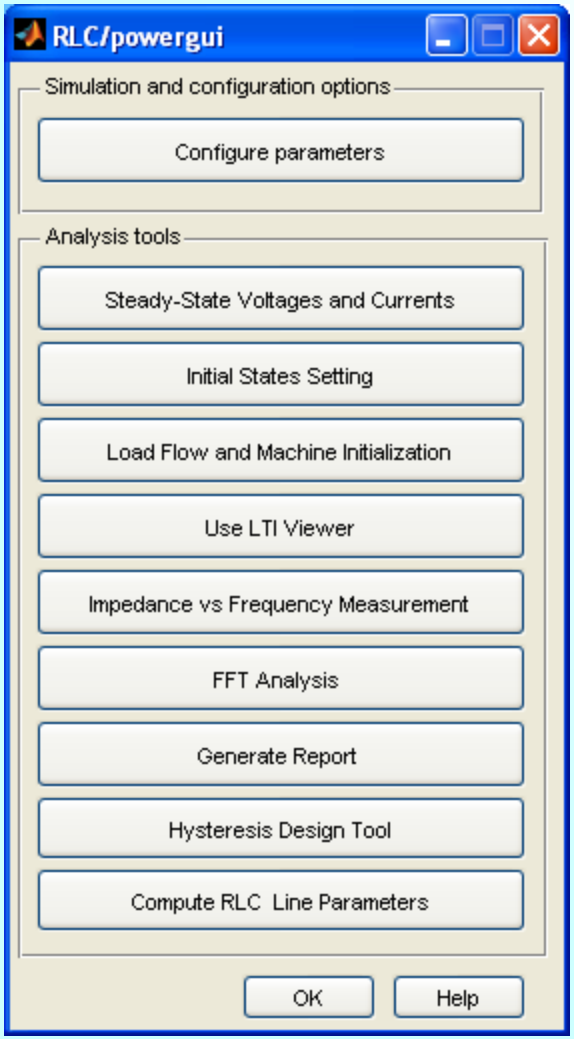


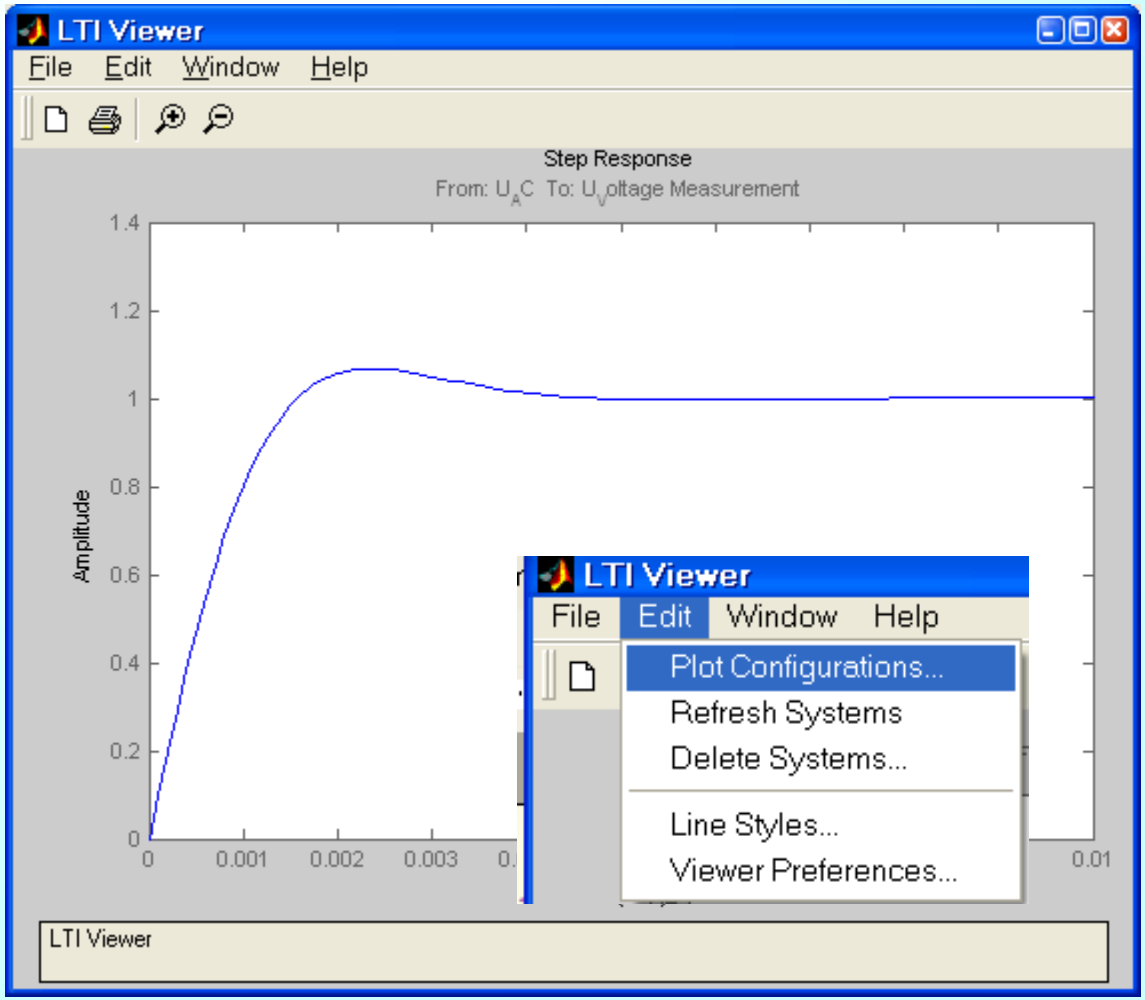
ОДСКОЧНИ, ИМПУЛСНИ ОДЗИВ, ...

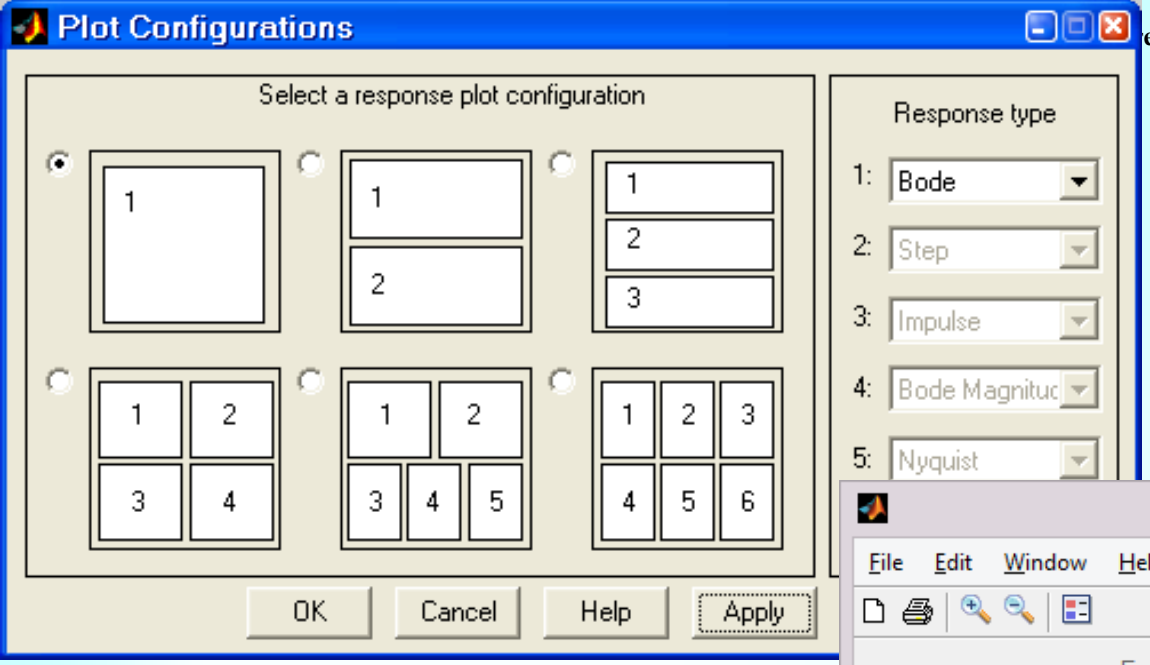


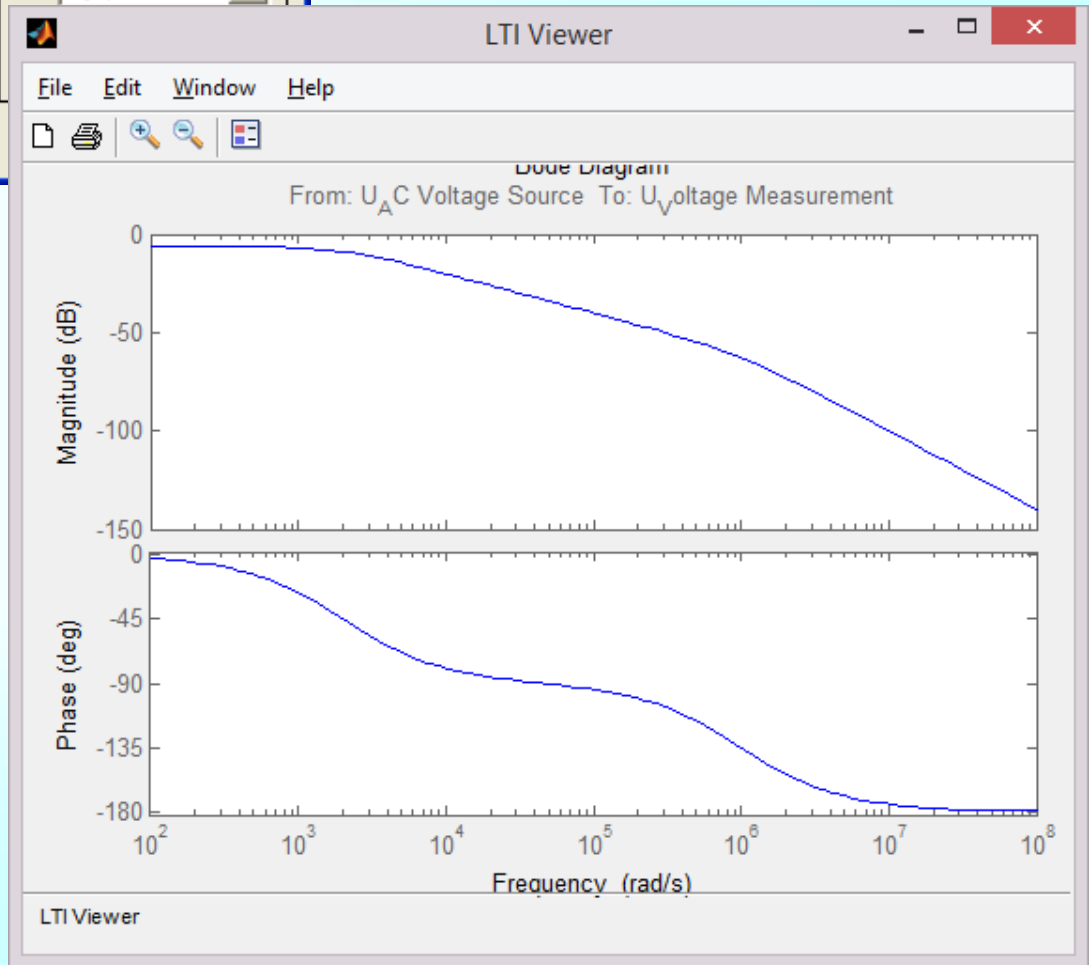


ОДСКОЧНИ, ИМПУЛСНИ ОДЗИВ, ...









АМПЛИТУДСКА КАРАКТЕРИСТИКА

ФАЗНА КАРАКТЕРИСТИКА

```
w:=`&omega;`
```
$$\omega$$

```
assume(R>0 and C>0 and L>0 and w>0)
zamena:={L=C*R^2}
```
$$\{L = C\,R^2\}$$

```
vrednosti:={C=1, R=1}
```
$$\{C = 1,\ R = 1\}$$

```
Z1:=R+s*L
```
$$R + L\,s$$

```
Z2:=1/(s*C+1/R)
```
$$\frac{1}{C\,s + \frac{1}{R}}$$

```
H(s):=Z2/(Z1+Z2) | zamena
```
$$\frac{1}{(C\,s + \frac{1}{R})\left(R + \frac{1}{C\,s + \frac{1}{R}} + C\,R^2\,s\right)}$$

```
simplify(H(s))
```
ТРАНСФЕР ФУНКЦИЈА
$$\frac{1}{C^2\,R^2\,s^2 + 2\,C\,R\,s + 2}$$

ФРЕКВЕНЦИЈСКИ ОДЗИВ

```
Hjw(w):=simplify(H(s)|{s=I*w})
```
$$-\frac{\omega^2\,C^2\,R^2 + 2\,\omega\,C\,R\,i - 2}{\omega^4\,C^4\,R^4 + 4}$$

```
Aw(w):=Simplify(abs(Hjw(w)))
```
$$\frac{1}{\sqrt{\omega^4\,C^4\,R^4 + 4}}$$

```
plot(Aw(w)|vrednosti, w=0..5,
     AxesTitles =["ω", "A(ω)"],
     AxesTitleFont =["Times New Roman", 16, Bold],
     GridVisible = TRUE,
     XTicksNumber = None,
     XTicksAt = [1 = "1/(RC)", 2 = "2/(RC)", 3 = "3/(RC)", 4 = "4/(RC)"],
     TicksLabelFont = ["Times New Roman", 16])
```

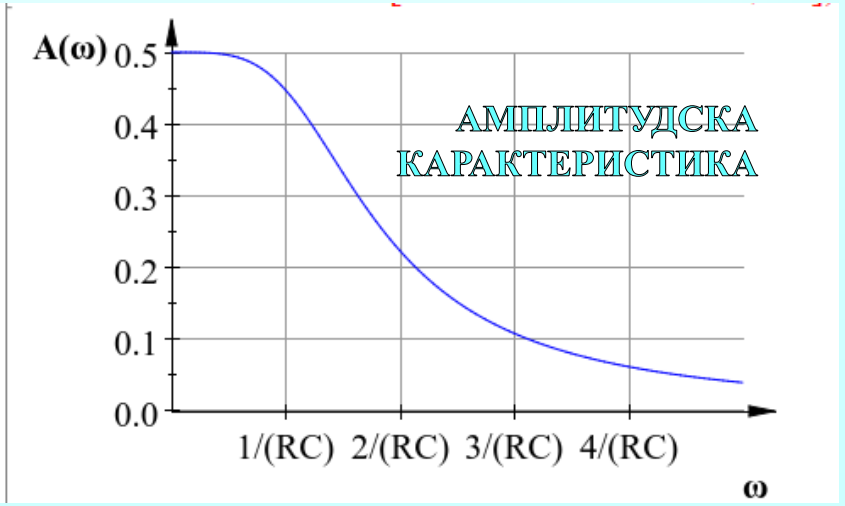
3 dB ПРОПУСНИ ОПСЕГ

```
Aref:=Aw(w) | {w=0}
```
$$\frac{1}{2}$$

```
w3dB:=simplify(solve(Aw(w)=Aref/sqrt(2), w))
```
$$\left\{\frac{\sqrt{2}}{C\,R}\right\}$$

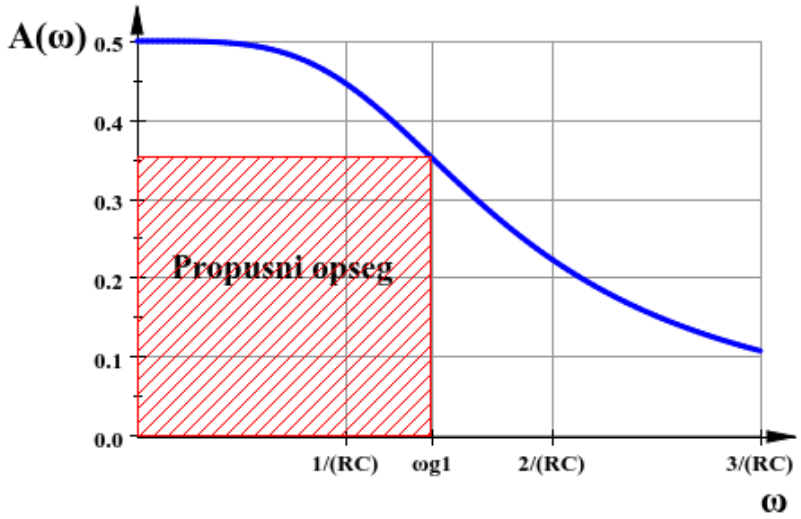
```
BandPass3dB:= {0, op(w3dB)}
```
$$\left\{0,\ \frac{\sqrt{2}}{C\,R}\right\}$$

```
wg1:=w3dB[1] | vrednosti
```
$$\sqrt{2}$$



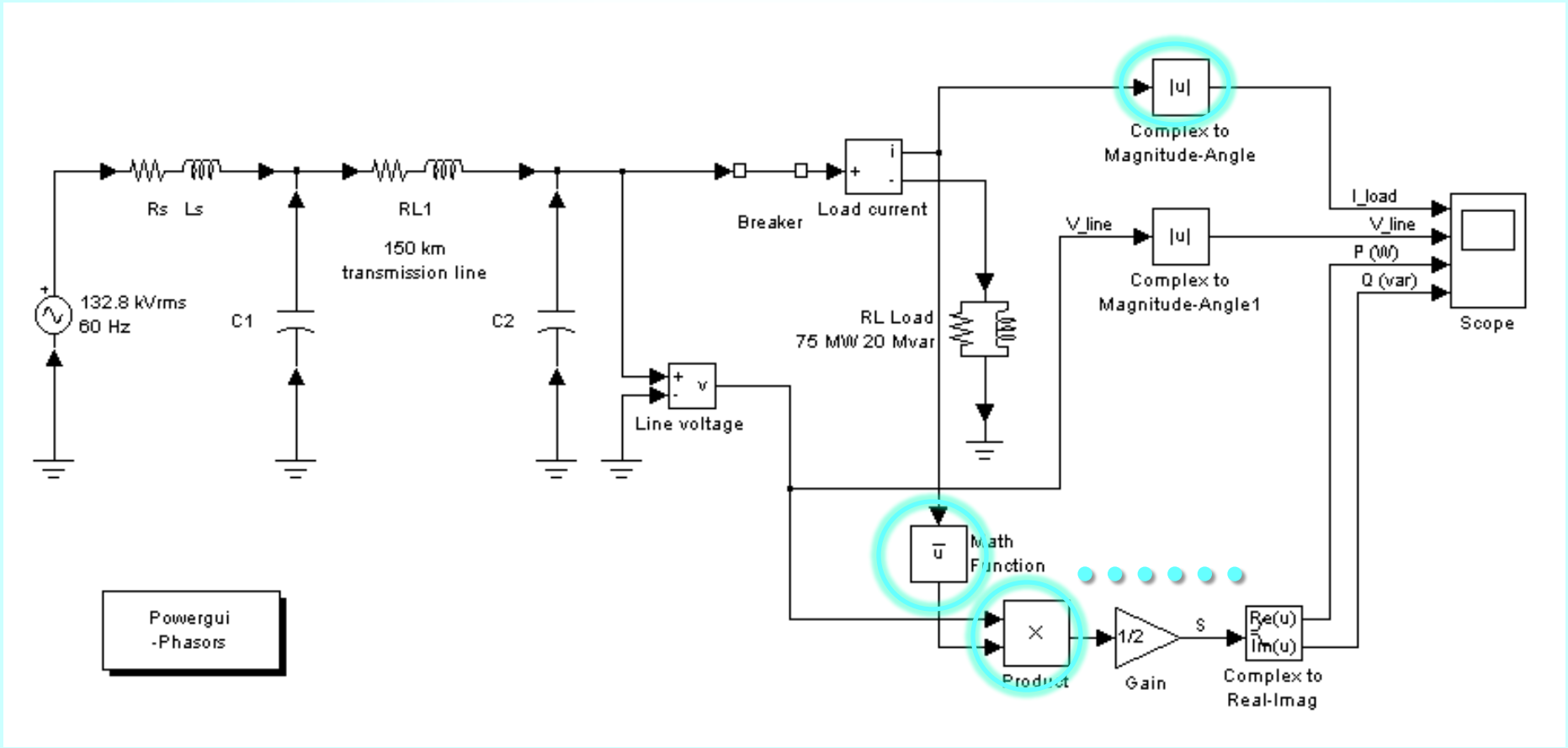
MATLAB: MuPAD

```
f1 := Aw(w)|vrednosti, w = 0..4, LineWidth = 0.7*unit::mm, Color = RGB::Blue:
f2:= plot::Rectangle(0..wg1, 0..Aref/sqrt(2), Filled = TRUE, FillColor = RGB::Red, LineColor= RGB::Red):
plotfunc2d(f1, f2, YRange= 0 .. Aref,

Scaling=Automatic,
Title= "Propusni opseg", TitleFont = ["Times New Roman", 14, Bold],  TitlePosition=[0.7,0.2],

AxesTitles = ["ω", "A(ω)"],
AxesTitleFont =["Times New Roman", 16, Bold],

GridVisible = TRUE,

XTicksNumber = None,
XTicksAt = [1 = "1/(RC)", 2 = "2/(RC)", 3 = "3/(RC)", 4 = "4/(RC)", wg1 = "ωg1"],
TicksLabelFont = ["Times New Roman", 10, Bold], ViewingBoxXRange = Automatic..3)
```



MATLAB: MuPAD

А КАКО МЕРИТИ
МОДУО НАПОНА/СТРУЈЕ, СНАГУ, ...



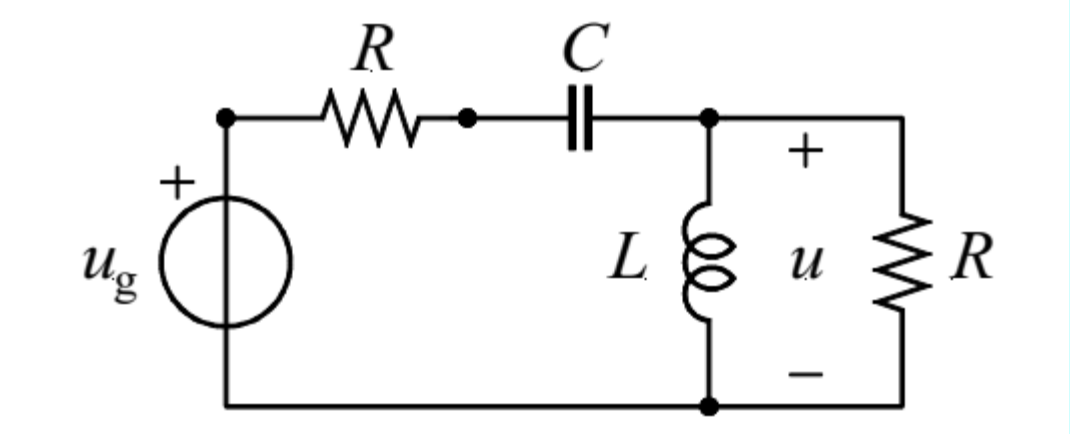
Филтар пропусник високих учестаности

Вредности елемената електричног кола са слике су познате и постоји веза $L = R^2 C$.

(а) Одредити трансфер функцију (уопштену комплексну преносну функцију електричног кола, трансмитансу напона) $\underline{H}(\underline{s}) = \frac{\underline{U}(\underline{s})}{\underline{U}_g(\underline{s})}$.

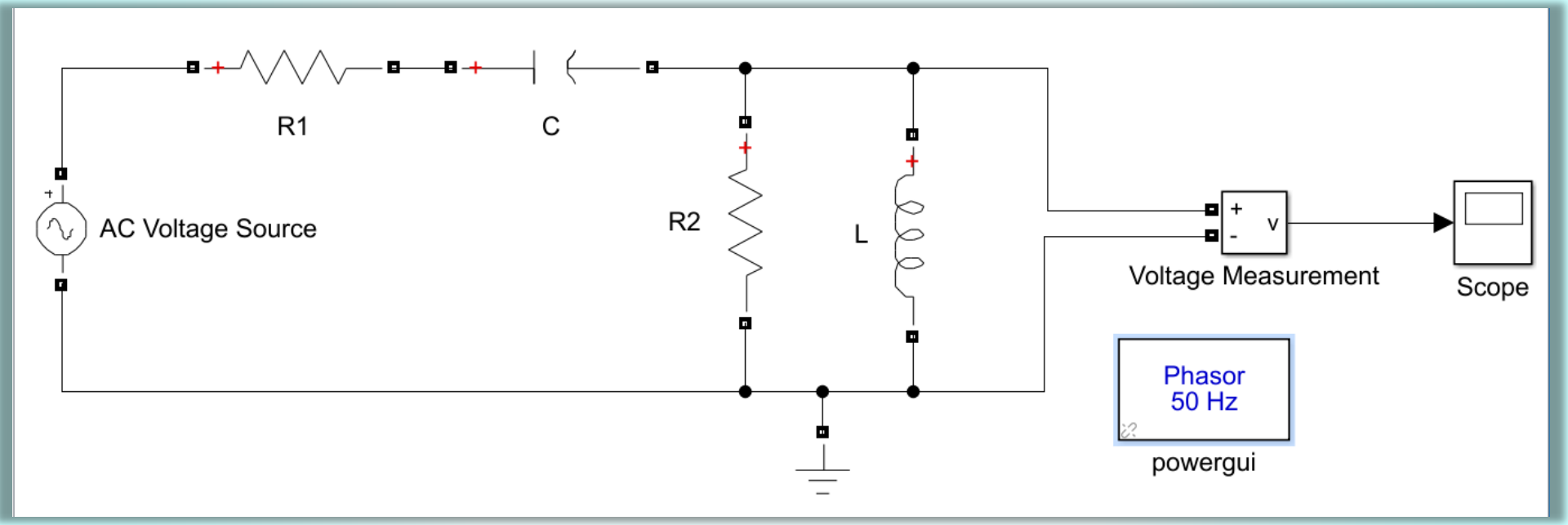
(б) Нацртати амплитудску карактеристику.

(в) Одредити пропусни опсег 3 dB.



$$u_g = \sqrt{2} U_g \cos(\omega t + \theta_g)$$

MATLAB: Simscape
SimPowerSystems



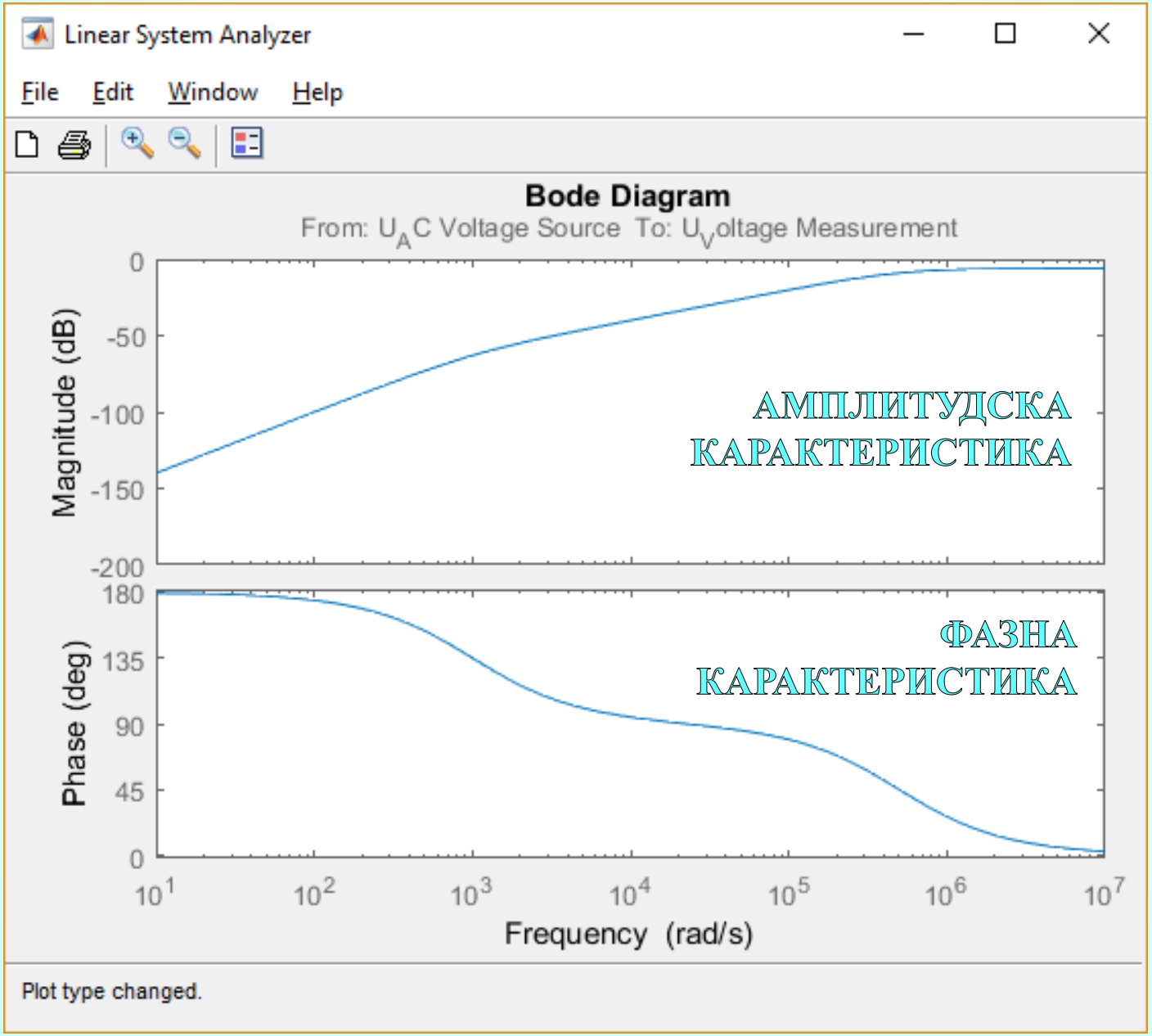
AC Voltage Source

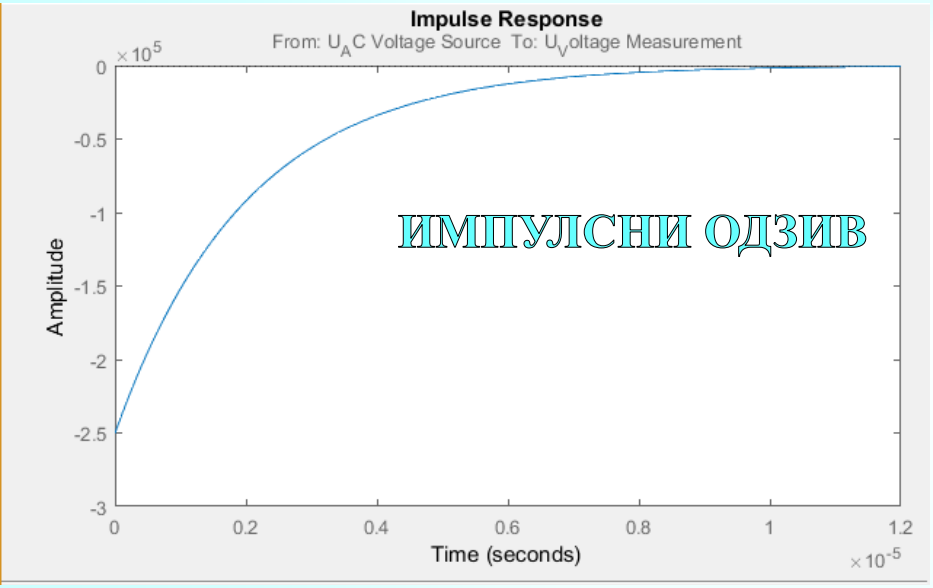
$$u_g = \sqrt{2}\underbrace{U_g}_{230\,\mathrm{V}} \sin(\underbrace{\omega}_{2\pi\,\underbrace{f}_{50\,\mathrm{Hz}}} t + \underbrace{\theta_g}_{\pi/2})$$

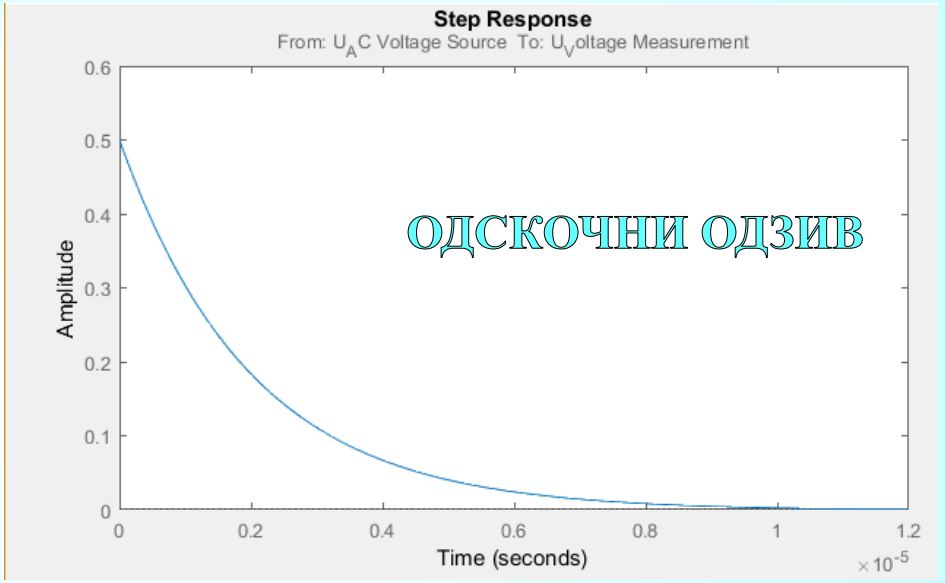
$$R_1 = R_2 = 1\,\mathrm{k\Omega}$$

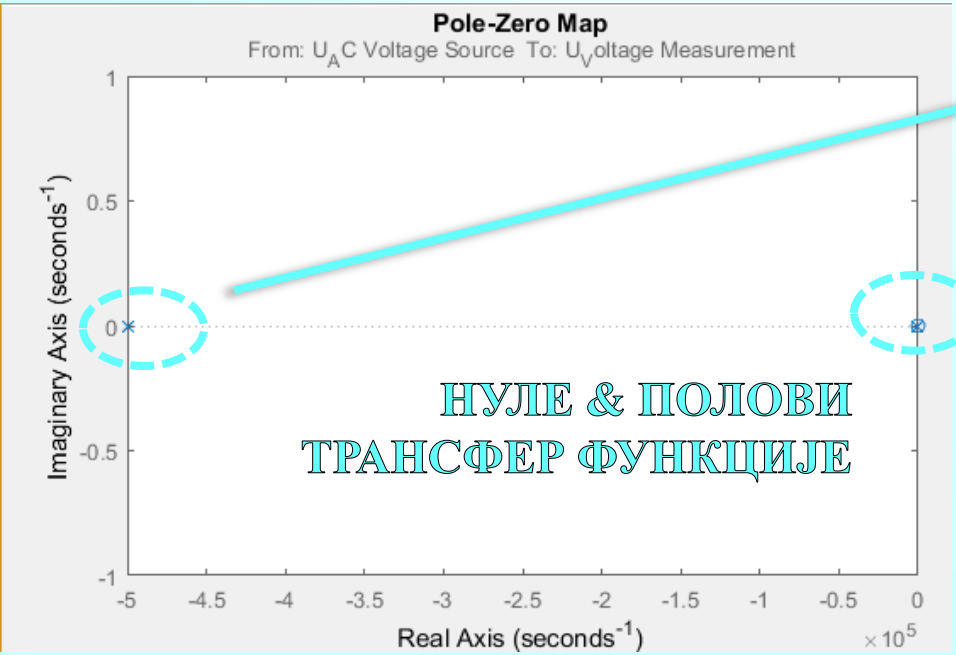
$$L = 1\,\mathrm{mH}$$

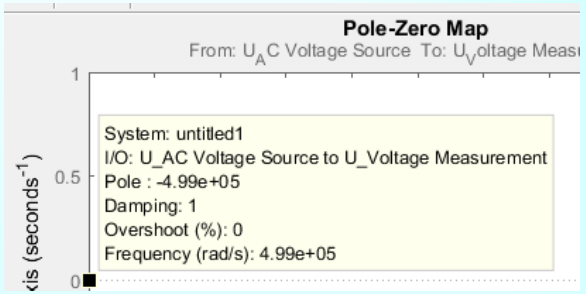
$$C = 1\,\mu\mathrm{F}$$

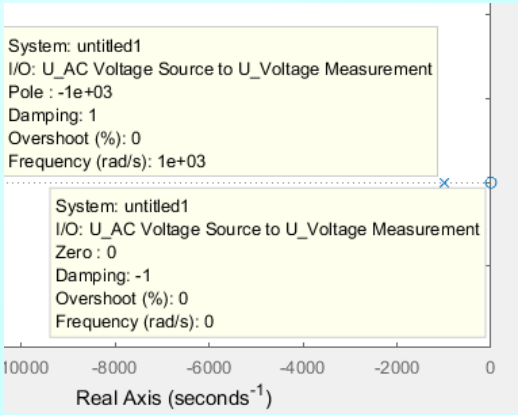

Linear System Analyzer
File Edit Window Help
Bode Diagram
From: U_AC Voltage Source To: U_Voltage Measurement
Magnitude (dB)
0
-50
-100
-150
-200
АМПЛИТУДСКА КАРАКТЕРИСТИКА
Phase (deg)
180
135
90
45
0
ФАЗНА КАРАКТЕРИСТИКА
10^1 10^2 10^3 10^4 10^5 10^6 10^7
Frequency (rad/s)
Plot type changed.


Impulse Response
From: U_AC Voltage Source To: U_Voltage Measurement
×10^5
0
-0.5
-1
-1.5
-2
-2.5
-3
Amplitude
0
0.2
0.4
0.6
0.8
1
1.2
Time (seconds)
×10^-5
ИМПУЛСНИ ОДЗИВ


Step Response
From: U_AC Voltage Source To: U_Voltage Measurement
0.6
0.5
0.4
0.3
0.2
0.1
0
Amplitude
0
0.2
0.4
0.6
0.8
1
1.2
Time (seconds)
×10^-5
ОДСКОЧНИ ОДЗИВ


Pole-Zero Map
From: U_AC Voltage Source To: U_Voltage Measurement
1
0.5
0
-0.5
-1
Imaginary Axis (seconds^-1)
-5
-4.5
-4
-3.5
-3
-2.5
-2
-1.5
-1
-0.5
0
Real Axis (seconds^-1)
×10^5
НУЛЕ & ПОЛОВИ
ТРАНСФЕР ФУНКЦИЈЕ


Pole-Zero Map
From: U_AC Voltage Source To: U_Voltage Meas
1
0.5
0
System: untitled1
I/O: U_AC Voltage Source to U_Voltage Measurement
Pole : -4.99e+05
Damping: 1
Overshoot (%): 0
Frequency (rad/s): 4.99e+05


System: untitled1
I/O: U_AC Voltage Source to U_Voltage Measurement
Pole : -1e+03
Damping: 1
Overshoot (%): 0
Frequency (rad/s): 1e+03
System: untitled1
I/O: U_AC Voltage Source to U_Voltage Measurement
Zero : 0
Damping: -1
Overshoot (%): 0
Frequency (rad/s): 0
10000
-8000
-6000
-4000
-2000
0
Real Axis (seconds^-1)

```
w:=`&omega;`
```
$$\omega$$

```
assume(R>0 and C>0 and L>0 and w>0)
zamena:={L=C*R^2}
```
$$\{L = C\,R^2\}$$

```
vrednosti:={C=1, R=1}
```
$$\{C = 1,\ R = 1\}$$

```
Z1:=R+1/(s*C)
```
$$R + \frac{1}{C\,s}$$

```
Z2:=1/(1/(s*L)+1/R)
```
$$\frac{1}{\frac{1}{R}+\frac{1}{L\,s}}$$

```
H(s):=Z2/(Z1+Z2) | zamena
```
$$\frac{1}{\left(\frac{1}{R}+\frac{1}{C\,R^2\,s}\right)\left(R+\frac{1}{C\,s}+\frac{1}{\frac{1}{R}+\frac{1}{C\,R^2\,s}}\right)}$$

```
simplify(H(s))
```
ТРАНСФЕР ФУНКЦИЈА

$$\frac{C^2\,R^2\,s^2}{2\,C^2\,R^2\,s^2+2\,C\,R\,s+1}$$

ФРЕКВЕНЦИЈСКИ ОДЗИВ

```
Hjw(w):=simplify(H(s)|{s=I*w})
```
$$\frac{\omega^2\,C^2\,R^2\left(2\,\omega^2\,C^2\,R^2+2\,\omega\,C\,R\,\mathrm{i}-1\right)}{4\,\omega^4\,C^4\,R^4+1}$$

```
Aw(w):=Simplify(abs(Hjw(w)))
```
$$\frac{\omega^2\,C^2\,R^2}{\sqrt{4\,\omega^4\,C^4\,R^4+1}}$$

```
Aref:=Simplify(limit(Aw(w), w=infinity))
```
$$\frac{1}{2}$$

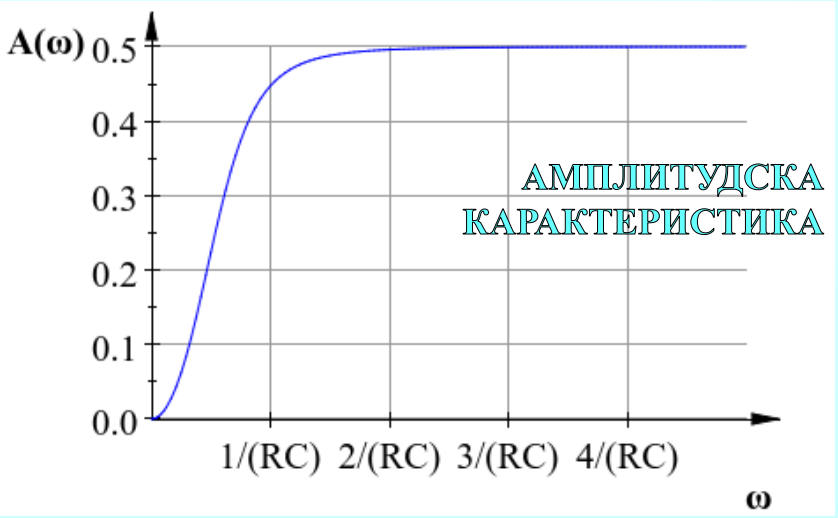
3 dB ПРОПУСНИ ОПСЕГ

```
w3dB:=simplify(solve(Aw(w)=Aref/sqrt(2), w))
```
$$\left\{\frac{\sqrt{2}}{2\,C\,R}\right\}$$

```
BandPass3dB:= {w3dB, infinity}
```
$$\left\{\left\{\frac{\sqrt{2}}{2\,C\,R}\right\}, \infty\right\}$$

```
wg1:=w3dB[1] | vrednosti
```
$$\frac{\sqrt{2}}{2}$$

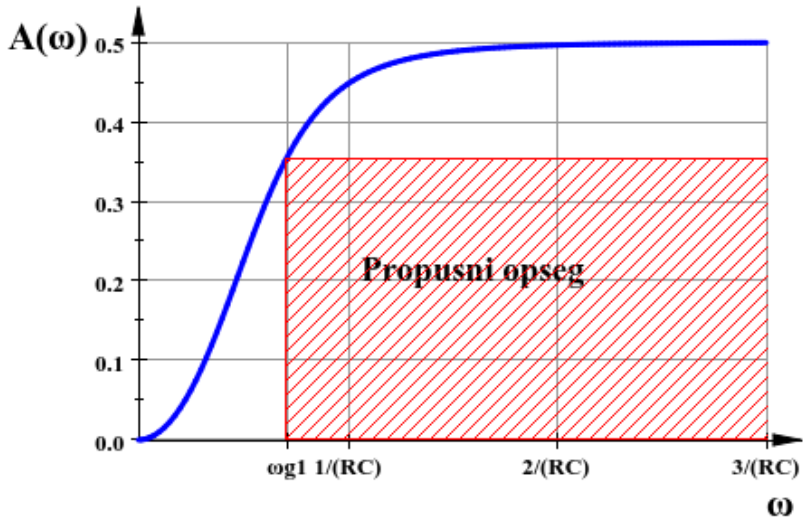
```
plot(Aw(w)|vrednosti, w=0..5,
     AxesTitles =["ω", "A(ω)"],
     AxesTitleFont =["Times New Roman", 16, Bold],
     GridVisible = TRUE,
     XTicksNumber = None,
     XTicksAt = [1 = "1/(RC)", 2 = "2/(RC)", 3 = "3/(RC)", 4 = "4/(RC)"],
     TicksLabelFont = ["Times New Roman", 16])
```



АМПЛИТУДСКА КАРАКТЕРИСТИКА

MATLAB: MuPAD

```
f1 := Aw(w)|vrednosti, w = 0..4, LineWidth = 0.7*unit::mm, Color = RGB::Blue:
f2:= plot::Rectangle(wg1..4, 0..Aref/sqrt(2), Filled = TRUE, FillColor = RGB::Red, LineColor= RGB::Red):
plotfunc2d(f1, f2, YRange= 0 .. Aref,

Scaling=Automatic,
Title= "Propusni opseg", TitleFont = ["Times New Roman", 14, Bold],  TitlePosition=[1.6,0.2],

AxesTitles = ["ω", "A(ω)"],
AxesTitleFont =["Times New Roman", 16, Bold],

GridVisible = TRUE,

XTicksNumber = None,
XTicksAt = [1 = "1/(RC)", 2 = "2/(RC)", 3 = "3/(RC)", 4 = "4/(RC)", wg1 = "ωg1"],
TicksLabelFont = ["Times New Roman", 10, Bold], ViewingBoxXRange = Automatic..3)
```



MATLAB: MuPAD

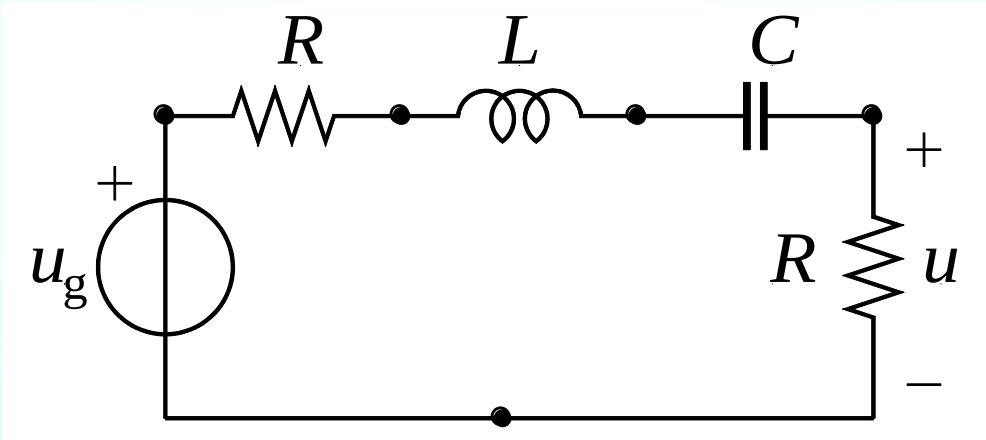
Филтар пропусник опсега учестаности

Вредности елемената електричног кола са слике су познате и постоји веза $L = R^2 C$.

(а) Одредити трансфер функцију (уопштену комплексну преносну функцију електричног кола, трансмитансу напона) $\underline{H}(\underline{s}) = \frac{\underline{U}(\underline{s})}{\underline{U}_g(\underline{s})}$.

(б) Нацртати амплитудску карактеристику.

(в) Одредити пропусни опсег 3 dB.



$$u_g = \sqrt{2} U_g \cos(\omega t + \theta_g)$$

```
w:=`&omega;`
```
ω

```
assume(R>0 and C>0 and L>0 and w>0)
zamena:={L=C*R^2}
```
$\{L = C\,R^2\}$

```
vrednosti:={C=1, R=1}
```
$\{C = 1,\ R = 1\}$

```
H(s):=R/(R+s*L+1/(s*C)+R) | zamena
```
$$\frac{R}{2\,R + \frac{1}{C\,s} + C\,R^2\,s}$$

```
simplify(H(s))
```
ТРАНСФЕР ФУНКЦИЈА

$$\frac{C\,R\,s}{(C\,R\,s+1)^2}$$

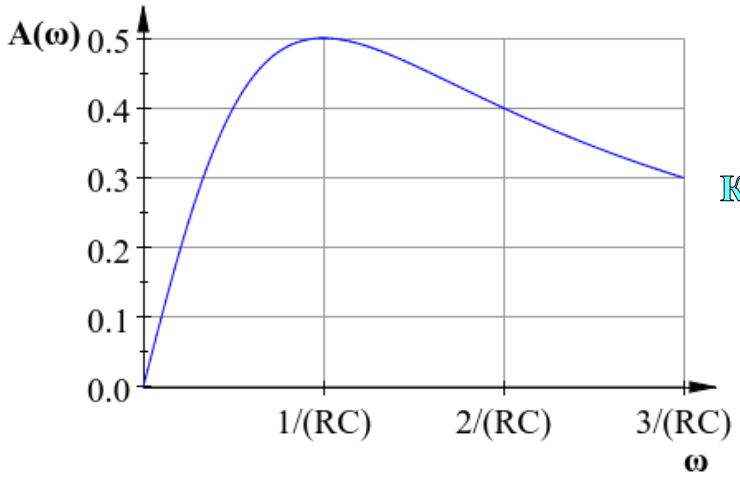
```
Hjw(w):=Simplify(H(s)|{s=I*w})
```
$$\frac{\omega\,C\,R\,i}{(1+\omega\,C\,R\,i)^2}$$

ФРЕКВЕНЦИЈСКИ ОДЗИВ

MATLAB: MuPAD

```
Aw(w):=Simplify(abs(Hjw(w)))
```
$$\frac{\omega\,C\,R}{\omega^2\,C^2\,R^2+1}$$

```
plot(Aw(w)|vrednosti, w=0..3,
     AxesTitles =["ω", "A(ω)"],
     AxesTitleFont =["Times New Roman", 16, Bold],
     GridVisible = TRUE,
     XTicksNumber = None,
     XTicksAt = [1 = "1/(RC)", 2 = "2/(RC)", 3 = "3/(RC)"],
     TicksLabelFont = ["Times New Roman", 16])
```



АМПЛИТУДСКА КАРАКТЕРИСТИКА

```
Aref:=Aw(w)|{w=1/(R*C)}
```
$$\frac{1}{2}$$

3 dB ПРОПУСНИ ОПСЕГ

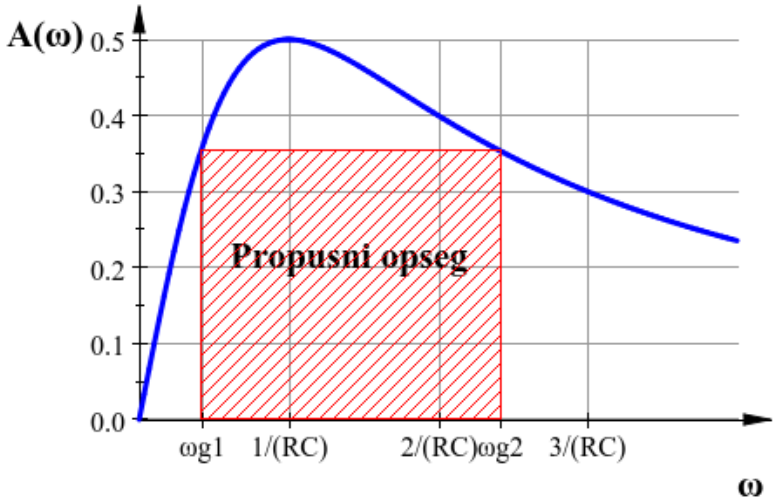
```
w3dB:=simplify(solve(Aw(w)=Aref/sqrt(2), w))
```
$$\left\{\frac{\sqrt{2}-1}{C\,R},\ \frac{\sqrt{2}+1}{C\,R}\right\}$$

```
BandPass3dB:= w3dB
```
$$\left\{\frac{\sqrt{2}-1}{C\,R},\ \frac{\sqrt{2}+1}{C\,R}\right\}$$

```
wg1:=w3dB[1] | vrednosti
```
$\sqrt{2}-1$

```
wg2:=w3dB[2] | vrednosti
```
$\sqrt{2}+1$

```
f1 := Aw(w)|vrednosti, w = 0..4, LineWidth = 0.7*unit::mm, Color = RGB::Blue:
f2:= plot::Rectangle(wg1..wg2, 0..Aref/sqrt(2), Filled = TRUE, FillColor = RGB::Red, LineColor= RGB::Red):
plotfunc2d(f1, f2,  YRange= 0 .. Aref,

Scaling=Automatic,
Title= "Propusni opseg", TitleFont = ["Times New Roman", 16, Bold],  TitlePosition=[1.4,0.2],

AxesTitles = ["ω", "A(ω)"],
AxesTitleFont =["Times New Roman", 16, Bold],

GridVisible = TRUE,

XTicksNumber = None,
XTicksAt = [1 = "1/(RC)", 2 = "2/(RC)", 3 = "3/(RC)", wg1 = "ωg1",  wg2 = "ωg2"],
TicksLabelFont = ["Times New Roman", 12])
```



MATLAB: MuPAD

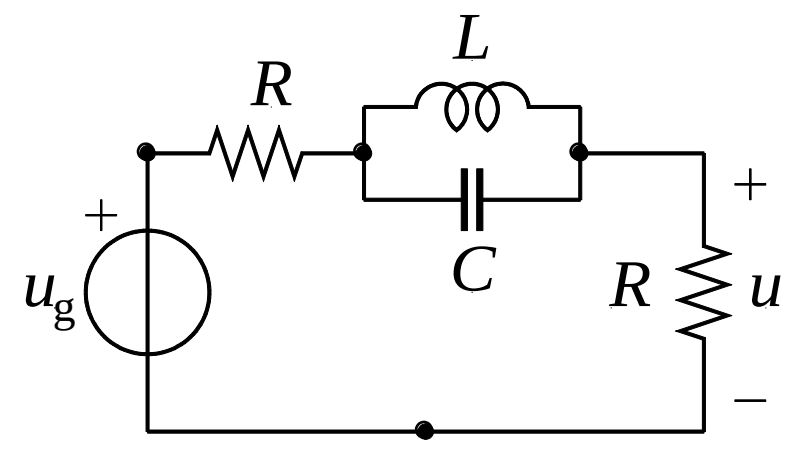
Филтар непропусник опсега учестаности

Вредности елемената електричног кола са слике су познате и постоји веза $L = R^2 C$.

(а) Одредити трансфер функцију (уопштену комплексну преносну функцију електричног кола, трансмитансу напона) $\underline{H}(\underline{s}) = \frac{\underline{U}(\underline{s})}{\underline{U}_g(\underline{s})}$.

(б) Нацртати амплитудску карактеристику.

(в) Одредити пропусни опсег 3 dB.



$$u_g = \sqrt{2} U_g \cos(\omega t + \theta_g)$$

MATLAB: MuPAD

```
w:=`&omega;`
```

$$\omega$$

```
assume(R>0 and C>0 and L>0 and w>0)
zamena:={L=C*R^2}
```

$$\{L = C\,R^2\}$$

```
vrednosti:={C=1, R=1}
```

$$\{C = 1,\ R = 1\}$$

```
H(s):=R/(R+1/(1/(s*L)+s*C)+R) | zamena
```

$$\frac{R}{2\,R + \frac{1}{C\,s + \frac{1}{C\,R^2\,s}}}$$

```
simplify(H(s))
```

ТРАНСФЕР ФУНКЦИЈА

$$\frac{C^2\,R^2\,s^2 + 1}{2\,C^2\,R^2\,s^2 + C\,R\,s + 2}$$

```
Hjw(w):=Simplify(H(s)|{s=I*w})
```

$$-\frac{\omega^2\,C^2\,R^2 - 1}{-2\,\omega^2\,C^2\,R^2 + \omega\,C\,R\,\mathrm{i} + 2}$$

ФРЕКВЕНЦИЈСКИ ОДЗИВ

АМПЛИТУДСКА КАРАКТЕРИСТИКА

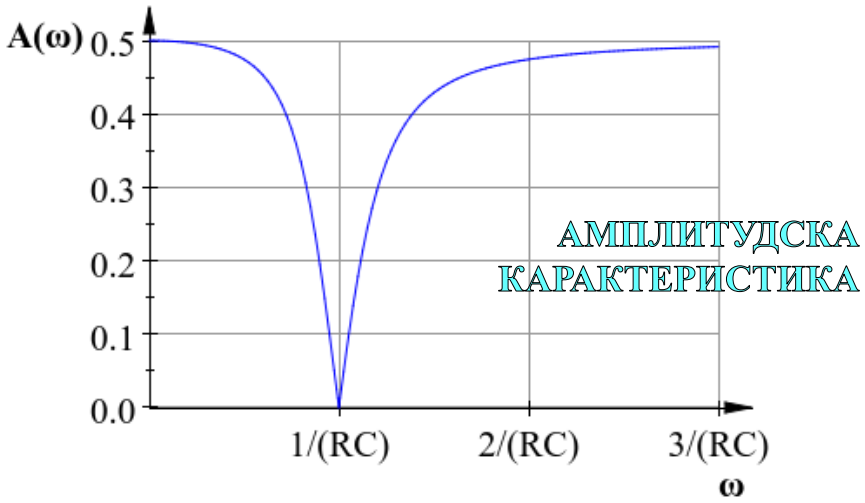
```
Aw(w):=Simplify(abs(Hjw(w)))
```

$$\frac{\left|\omega\,C\,R - 1\right|\,(\omega\,C\,R + 1)}{\sqrt{(2\,\omega^2\,C^2\,R^2 - 2)^2 + \omega^2\,C^2\,R^2}}$$

```
Aw(w):=Simplify(abs(Hjw(w)))
```

$$\frac{|\omega C R - 1|\,(\omega C R + 1)}{\sqrt{(2\omega^2 C^2 R^2 - 2)^2 + \omega^2 C^2 R^2}}$$

```
plot(Aw(w)|vrednosti, w=0..3,
     AxesTitles =["ω", "A(ω)"],
     AxesTitleFont =["Times New Roman", 16, Bold],
     GridVisible = TRUE,
     XTicksNumber = None,
     XTicksAt = [1 = "1/(RC)", 2 = "2/(RC)", 3 = "3/(RC)"],
     TicksLabelFont = ["Times New Roman", 16])
```



АМПЛИТУДСКА КАРАКТЕРИСТИКА

```
Aref:=Aw(w)|{w=0}
```

$$\frac{1}{2}$$

```
Simplify(limit(Aw(w), w=infinity))
```

$$\frac{1}{2}$$

3 dB ПРОПУСНИ ОПСЕГ

```
w3dB:=simplify(solve(Aw(w)=Aref/sqrt(2), w))
```

$$\left\{\frac{\sqrt{17}-1}{4CR}, \frac{\sqrt{17}+1}{4CR}\right\}$$

```
BandStop3dB:= w3dB
```

$$\left\{\frac{\sqrt{17}-1}{4CR}, \frac{\sqrt{17}+1}{4CR}\right\}$$

```
wg1:=w3dB[1] | vrednosti
```

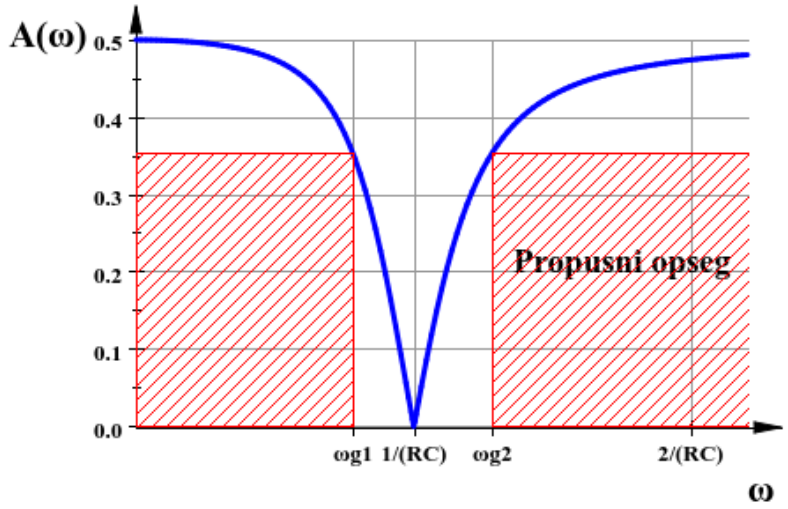
$$\frac{\sqrt{17}}{4} - \frac{1}{4}$$

```
wg2:=w3dB[2] | vrednosti
```

$$\frac{\sqrt{17}}{4} + \frac{1}{4}$$

MATLAB: MuPAD

```
f1 := Aw(w)|vrednosti, w = 0..3, LineWidth = 0.7*unit::mm, Color = RGB::Blue:
f2:= plot::Rectangle(0..wg1, 0..Aref/sqrt(2), Filled = TRUE, FillColor = RGB::Red, LineColor= RGB::Red):
f3:= plot::Rectangle(wg2..3, 0..Aref/sqrt(2), Filled = TRUE, FillColor = RGB::Red, LineColor= RGB::Red):
plotfunc2d(f1, f2, f3, YRange= 0 .. Aref,

Scaling=Automatic,
Title= "Propusni opseg", TitleFont = ["Times New Roman", 14, Bold],  TitlePosition=[1.75,0.2],

AxesTitles = ["ω", "A(ω)"],
AxesTitleFont =["Times New Roman", 16, Bold],

GridVisible = TRUE,

XTicksNumber = None,
XTicksAt = [1 = "1/(RC)", 2 = "2/(RC)", 3 = "3/(RC)", wg1 = "ωg1",  wg2 = "ωg2"],
TicksLabelFont = ["Times New Roman", 10, Bold], ViewingBoxXRange = Automatic..2.2)
```



MATLAB: MuPAD

Устаљен сложеноперіодичан одзив

Електрично коло са слике има познате вредности елемената:

$L_1 = L$, $L_2 = 2L$,

$C_1 = C$, $C_2 = 2C$,

$R_1 = R_2 = R$.

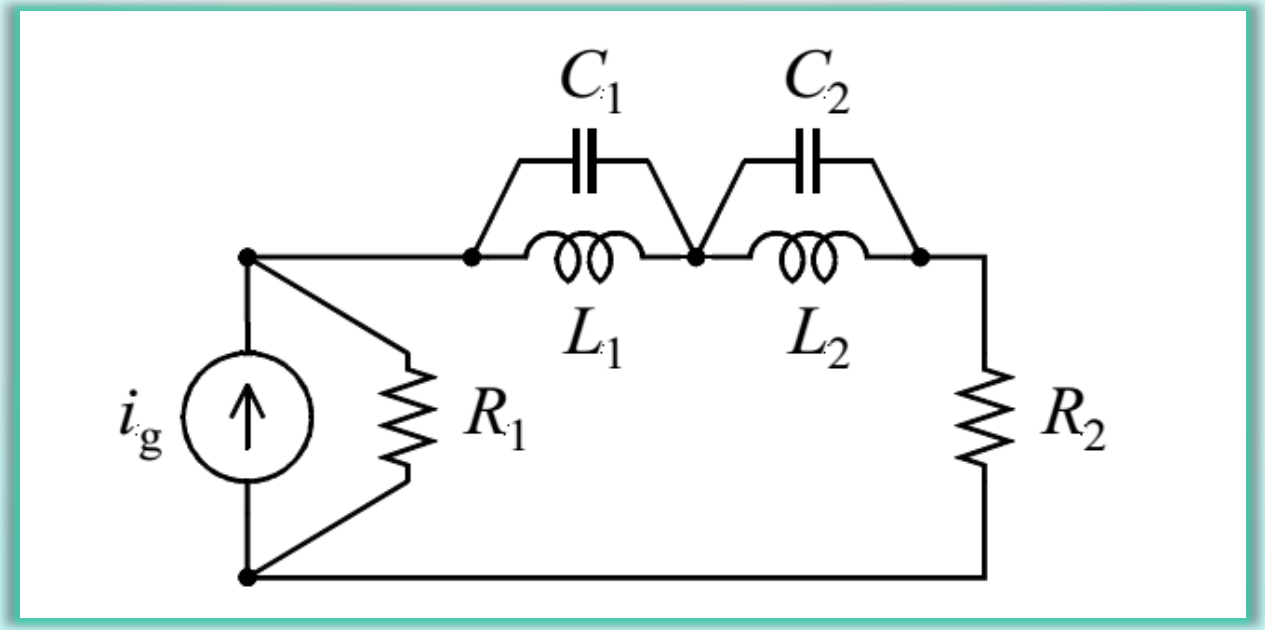
Побуда (екситација) је $i_g(t) = I_m + I_m \cos(\frac{1}{2\sqrt{CL}}t) + I_m \sin(\frac{1}{\sqrt{CL}}t)$

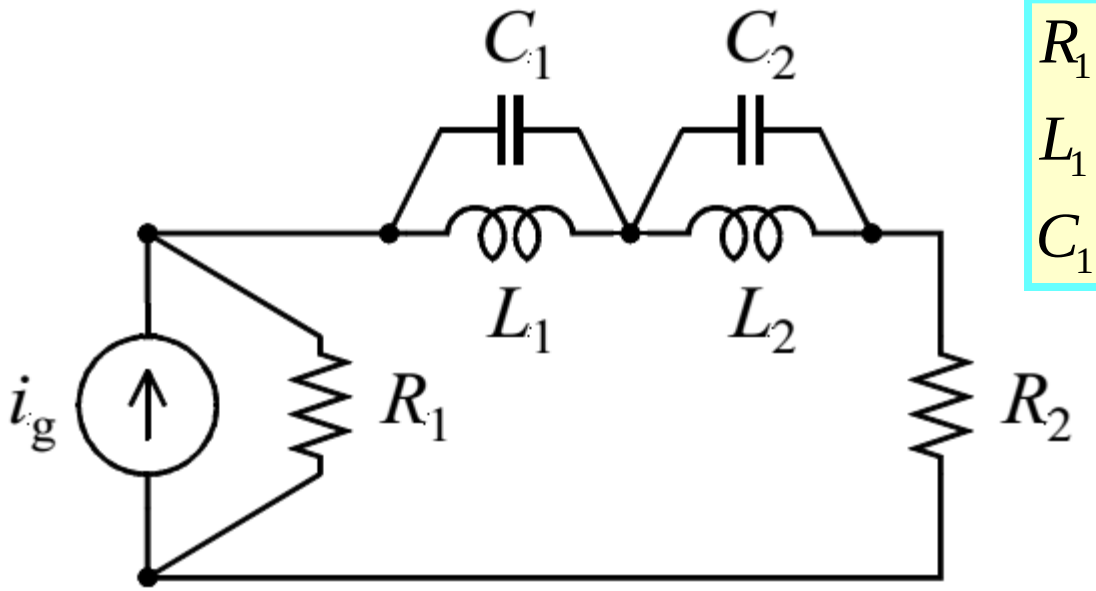
Одзив је устаљен.

(а) Одредити напон отпорника R_2.

(б) Одредити напон струјног извора (струјног генератора).

(б) Ког реда је ово коло?





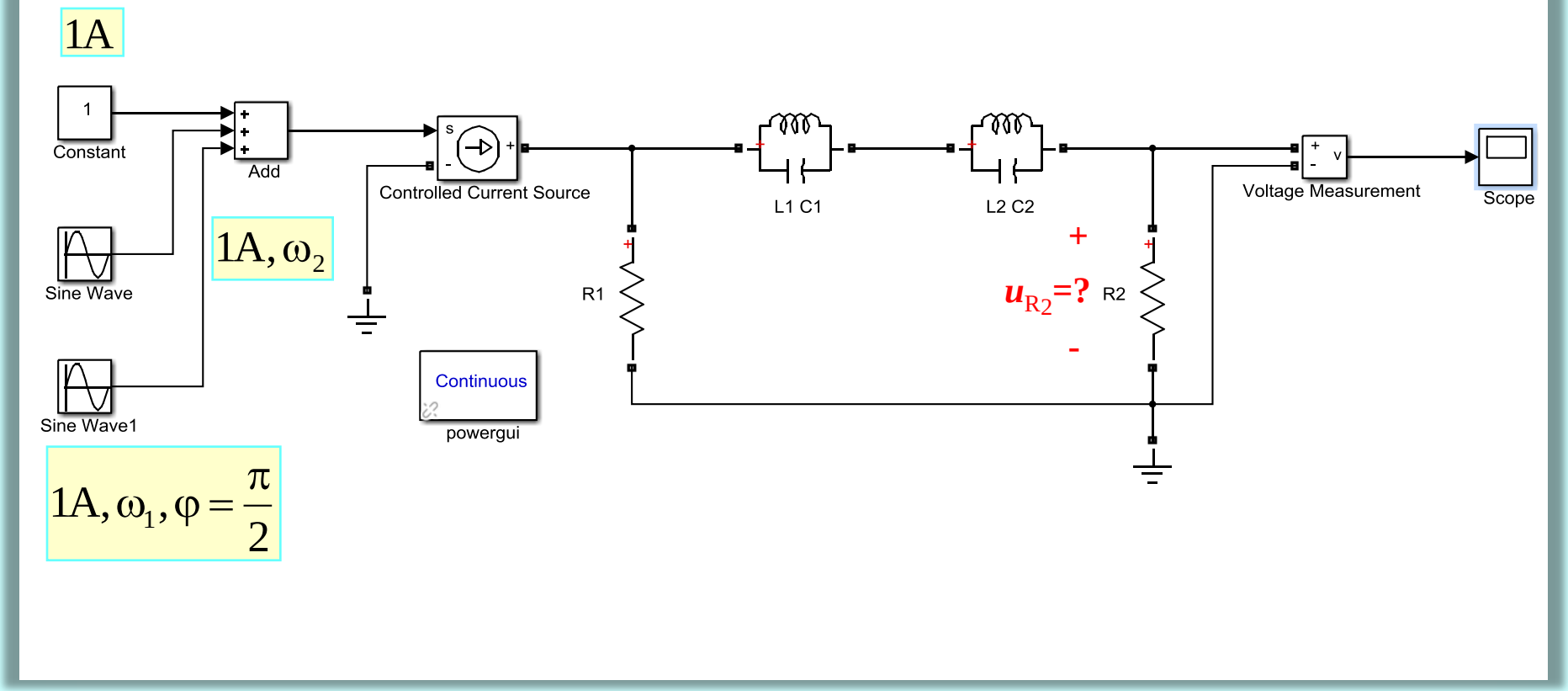
$$R_1 = R_2 = 1\,\mathrm{k\Omega}$$
$$L_1 = L,\ L_2 = 2L,\ L = 0.5\,\mathrm{mH}$$
$$C_1 = C,\ C_2 = 2C,\ C = 5\,\mu\mathrm{F}$$

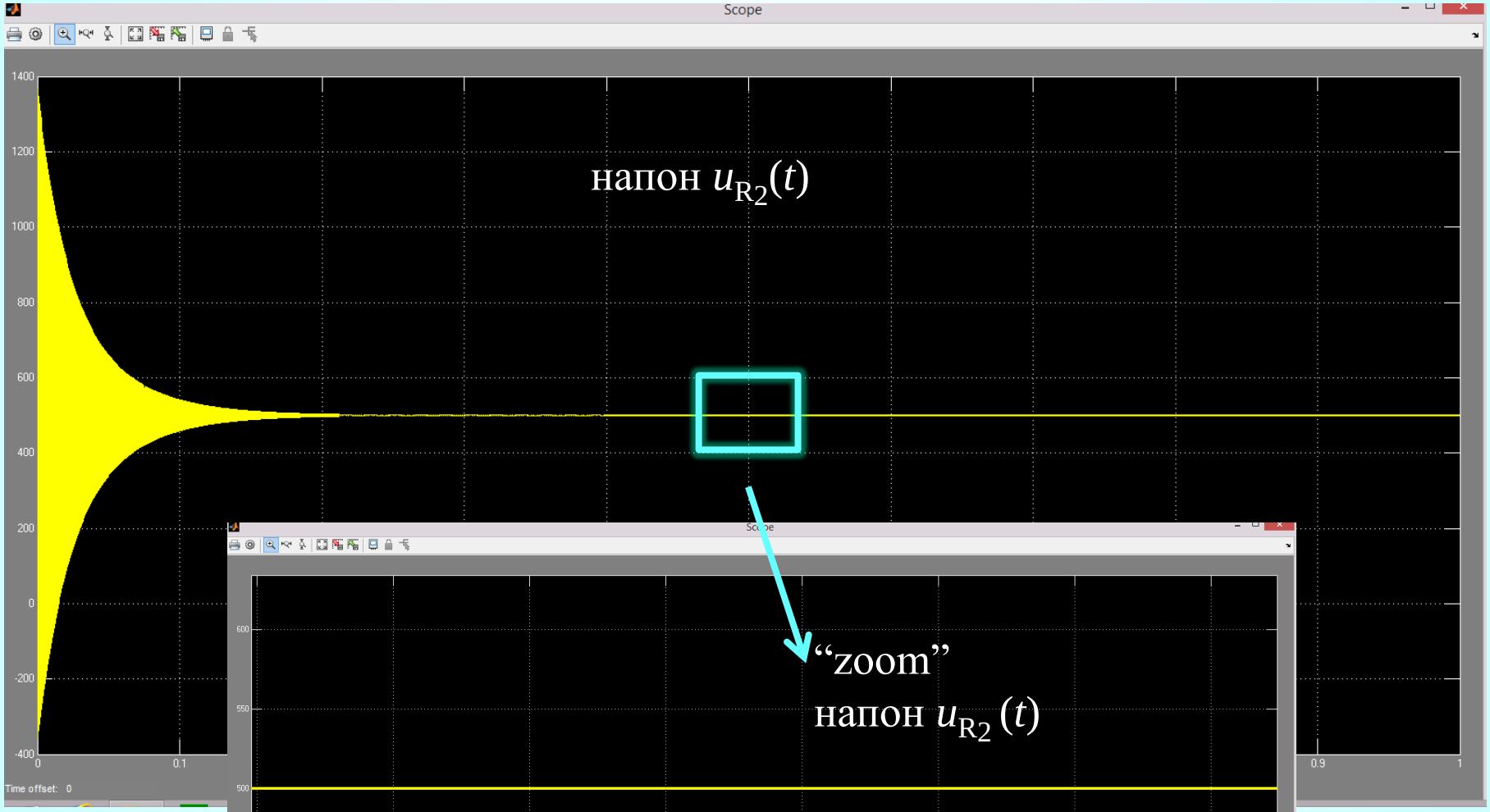
$$i_g(t) = \underbrace{I_\mathrm{m}}_{1\mathrm{A}} + I_\mathrm{m}\cos(\omega_1 t) + I_\mathrm{m}\sin(\omega_2 t)$$

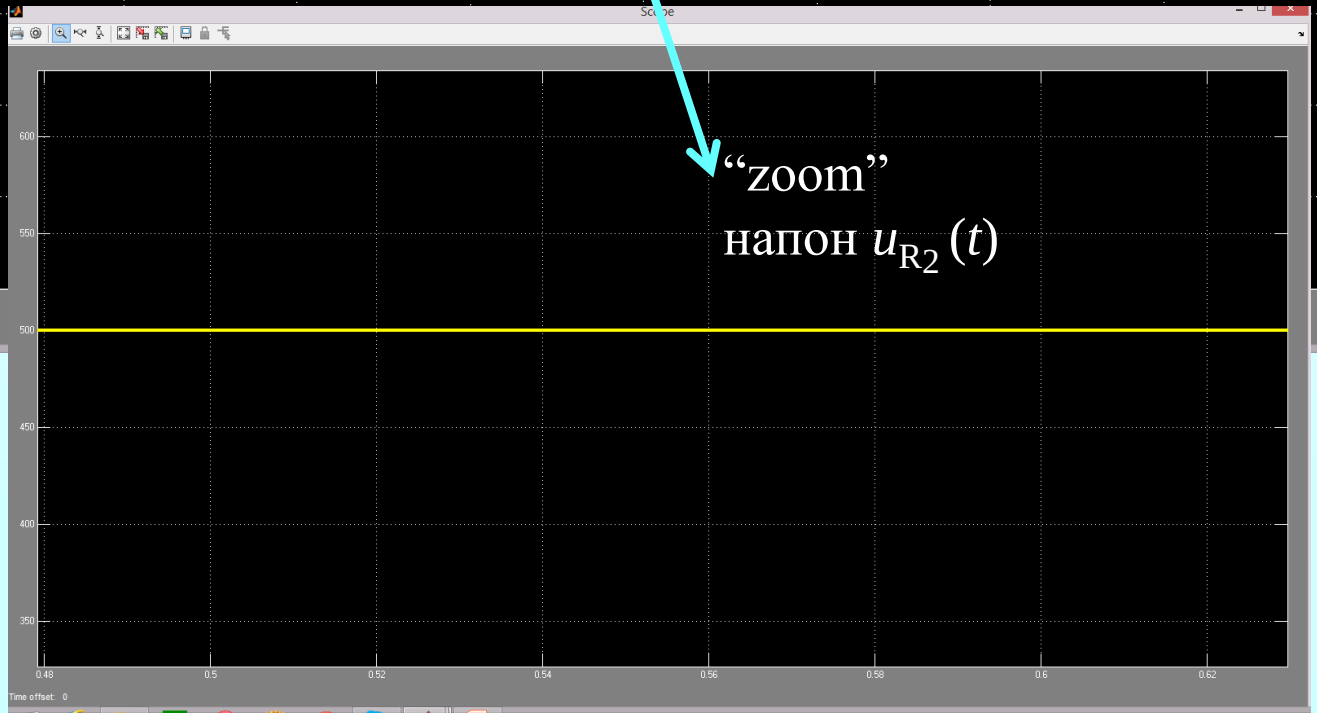
$$\omega_1 = \frac{1}{\sqrt{L_2 C_2}} = \frac{1}{2\sqrt{LC}} = 10^4\ \mathrm{rad/s}$$

$$\omega_2 = \frac{1}{\sqrt{L_1 C_1}} = \frac{1}{\sqrt{LC}} = 2\cdot 10^4\ \mathrm{rad/s}$$

MATLAB: Simscape
SimPowerSystems




Scope
напон $u_{R_2}(t)$
1400
1200
1000
800
600
400
200
0
-200
-400
0
0.1
0.9
1
Time offset: 0


Scope
“zoom”
напон $u_{R_2}(t)$
600
550
500
450
400
350
0.48
0.5
0.52
0.54
0.56
0.58
0.6
0.62
Time offset: 0

```
assume(L1>0 and L2>0 and C1>0 and C2>0 and R1>0 and R2>0 and L>0 and C>0 and R>0 and I_m>0)
```

```
zamene:={L1=L, C1=C, L2=2*L, C2=2*C, R1=R, R2=R}
```

$$\{R1 = R,\ R2 = R,\ C2 = 2\,C,\ L2 = 2\,L,\ C1 = C,\ L1 = L\}$$

```
pobuda:={ I_g(I*0)=I_m,  I_g(I*w1)=I_m/sqrt(2),  I_g(I*w2)=(I_m/sqrt(2))*exp(-I*PI/2)}
```

$$\left\{I_g(\mathrm{w1\ i}) = \frac{\sqrt{2}\,I_m}{2},\ I_g(\mathrm{w2\ i}) = -\frac{\sqrt{2}\,I_m\,\mathrm{i}}{2},\ I_g(0) = I_m\right\}$$

```
frekvencije:={w0=0, w1=1/(2*sqrt(L*C)), w2=1/sqrt(L*C)}
```

$$\left\{\mathrm{w2} = \frac{1}{\sqrt{C}\,\sqrt{L}},\ \mathrm{w1} = \frac{1}{2\,\sqrt{C}\,\sqrt{L}},\ \mathrm{w0} = 0\right\}$$

```
UR2(s):=R1*I_g(s)*R2/(R1+1/(s*C1+1/(s*L1))+1/(s*C2+1/(s*L2))+R2)
```

$$\frac{\mathrm{R1\ R2}\ I_g(s)}{\mathrm{R1} + \mathrm{R2} + \frac{1}{\mathrm{C1}\ s + \frac{1}{\mathrm{L1}\ s}} + \frac{1}{\mathrm{C2}\ s + \frac{1}{\mathrm{L2}\ s}}}$$

```
UR2_jw(w):=Simplify(U(s) | {zamene, s=I*w})
```

$$\frac{R^2\ I_g(w\,\mathrm{i})\ \left(C\,L\,w^2 - 1\right)\ \left(4\,C\,L\,w^2 - 1\right)\ \mathrm{i}}{8\,\mathrm{i}\,R\,C^2\,L^2\,w^4 + 6\,C\,L^2\,w^3 - 10\,\mathrm{i}\,R\,C\,L\,w^2 - 3\,L\,w + 2\,R\,\mathrm{i}}$$

MATLAB: MuPAD

```
UR2_jw(w):=Simplify(U(s) | {zamene, s=I*w})
```

$$\frac{R^2\, I_g(w\,\mathrm{i})\,\left(C\,L\,w^2-1\right)\,\left(4\,C\,L\,w^2-1\right)\,\mathrm{i}}{8\,\mathrm{i}\,R\,C^2\,L^2\,w^4+6\,C\,L^2\,w^3-10\,\mathrm{i}\,R\,C\,L\,w^2-3\,L\,w+2\,R\,\mathrm{i}}$$

```
UR2_0:=simplify(Ujw(w) | {w=w0} | frekvencije |  pobuda)
```

$$\frac{I_m\,R}{2}$$

```
UR2_wg1:=simplify(Ujw(w)| {w=w1}| frekvencije |  pobuda)
```

$$0$$

```
UR2_wg2:=simplify(Ujw(w)| {w=w2}| frekvencije |  pobuda )
```

$$0$$

```
uR2(t):=(U0 + sqrt(2)*abs(Uwg1)*cos(w1*t+arg(Uwg1)) + sqrt(2)*abs(Uwg2)*cos(w2*t+arg(Uwg2)) | frekvencije)
```

$$\frac{I_m\,R}{2}$$

MATLAB: MuPAD

MATLAB: MuPAD

```
Z(s):=Simplify(1/(s*C1+1/(s*L1))+1/(s*C2+1/(s*L2))+R2)
```

$$R2 + \frac{1}{C2\,s + \frac{1}{L2\,s}} + \frac{L1\,s}{C1\,L1\,s^2 + 1}$$

```
UR1(s):=Simplify(I_g(s)*R1*Z(s)/(R1+Z(s)))
```

$$R1\,I_g(s) - \frac{R1^2\,I_g(s)}{R1 + R2 + \frac{1}{C2\,s + \frac{1}{L2\,s}} + \frac{L1\,s}{C1\,L1\,s^2 + 1}}$$

```
UR1_jw(w):=Simplify(UR1(s) | {zamene, s=I*w})
```

$$\frac{R\,I_g(w\,\mathrm{i})}{2} + \frac{3\,L\,R\,w\,I_g(w\,\mathrm{i})\,\left(2\,C\,L\,w^2 - 1\right)}{2\,\left(2\,R\,\mathrm{i} - 3\,L\,w + C\,\left(6\,L^2\,w^3 - 10\,L\,R\,w^2\,\mathrm{i}\right) + 8\,C^2\,L^2\,R\,w^4\,\mathrm{i}\right)}$$

```
UR1_0:=simplify(UR1_jw(w) | {w=w0} | frekvencije | pobuda)
```

$$\frac{I_m\,R}{2}$$

```
UR1_wg1:=simplify(UR1_jw(w) | {w=w1} | pobuda | frekvencije)
```

$$\frac{\sqrt{2}\,I_m\,R}{2}$$

```
UR1_wg2:=simplify(UR1_jw(w) | {w=w2} | pobuda | frekvencije)
```

$$-\frac{\sqrt{2}\,I_m\,R\,\mathrm{i}}{2}$$

```
uR1(t):=(UR1_0 + sqrt(2)*abs(UR1_wg1)*cos(w1*t+arg(UR1_wg1)) +
sqrt(2)*abs(UR1_wg2)*cos(w2*t+arg(UR1_wg2)) | frekvencije)
```

$$\frac{I_m\,R}{2} + I_m\,R\,\cos\left(\frac{t}{2\,\sqrt{C}\,\sqrt{L}}\right) + I_m\,R\,\cos\left(\frac{\pi}{2} - \frac{t}{\sqrt{C}\,\sqrt{L}}\right)$$

```
Simplify(uR1(t))
```

$$\frac{I_m\,R\,\left(2\,\cos\left(\frac{t}{2\,\sqrt{C}\,\sqrt{L}}\right) + 2\,\sin\left(\frac{t}{\sqrt{C}\,\sqrt{L}}\right) + 1\right)}{2}$$

MATLAB: Simscape

Foundation Library

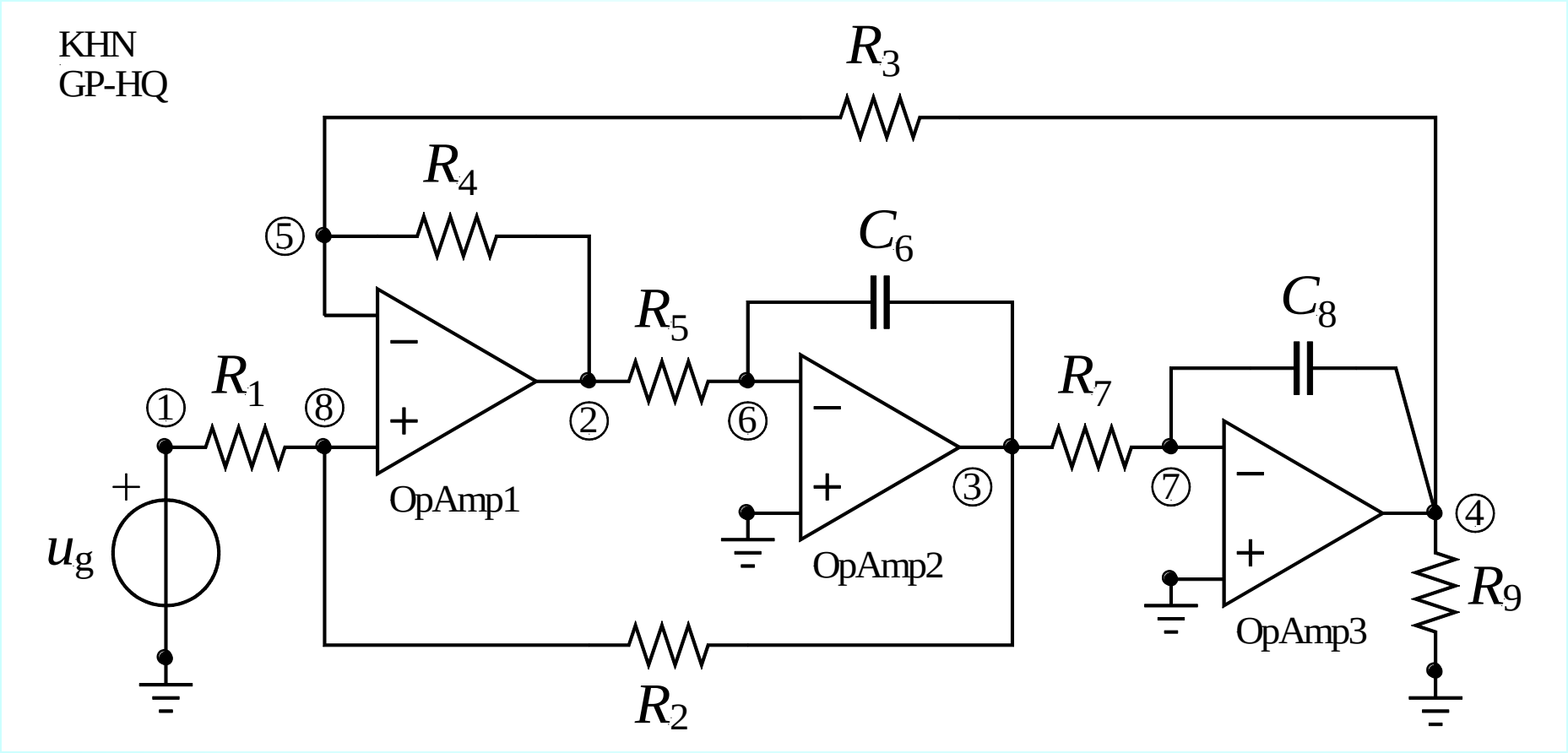
Utilities

Simulink

ОДРЕЂИВАЊЕ АМПЛИТУДСКЕ & ФАЗНЕ КАРАКТЕРИСТИКЕ

KHN active filter

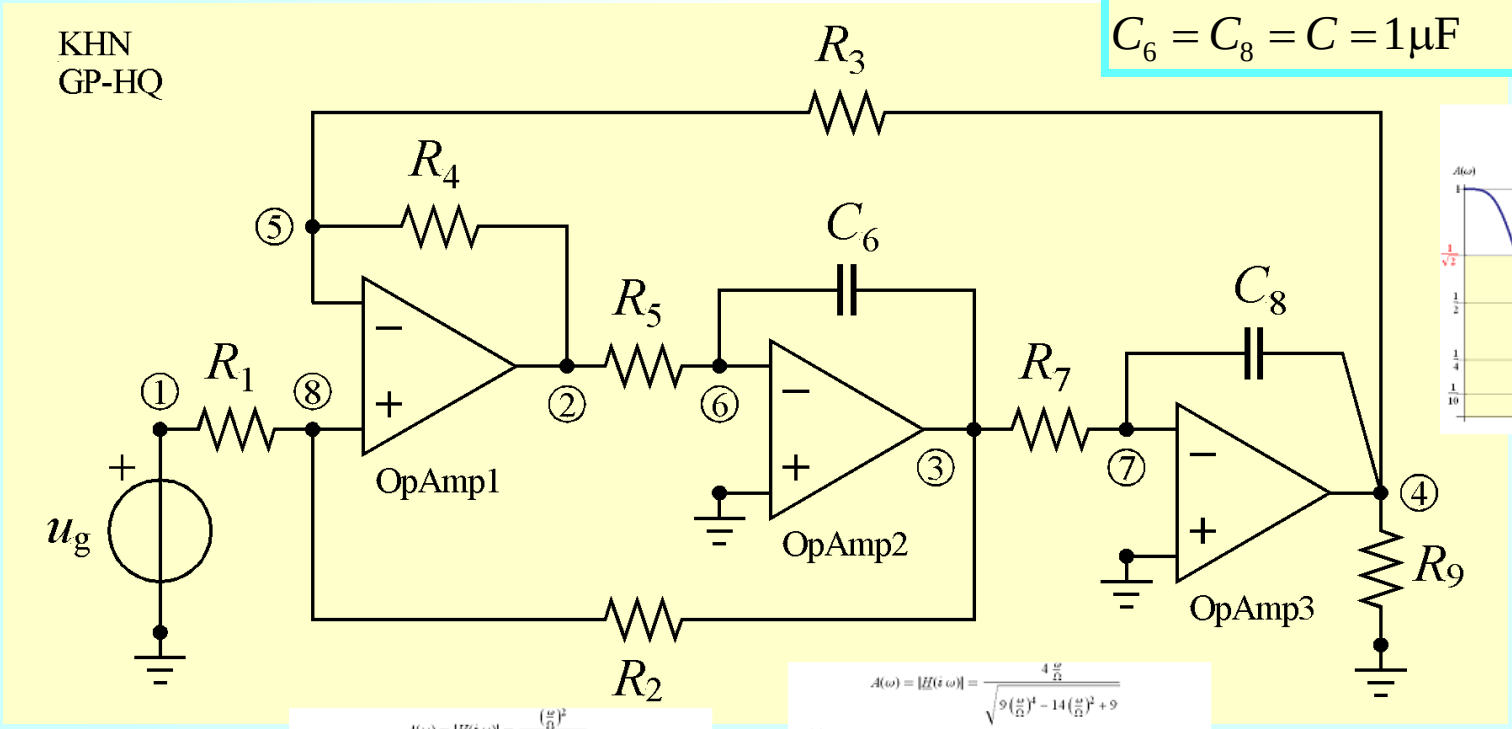
Kerwin-Huelsman-Newcomb, state-variable biquad, UAF42

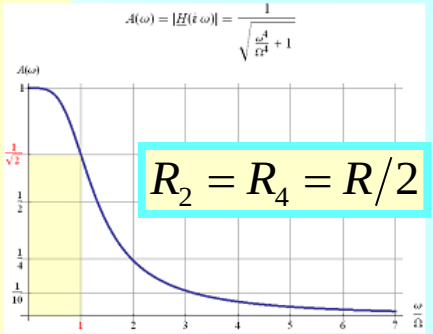


Kerwin-Huelsman-Newcomb, state-variable biquad, UAF42

KHN active filter

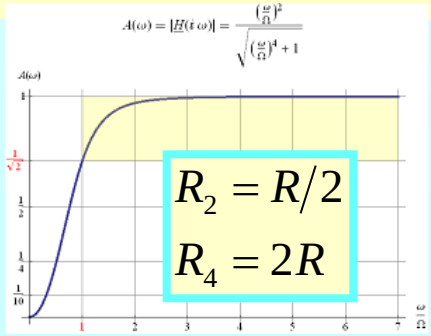
$$R_1 = R_3 = R_5 = R_7 = R_9 = R = 1\text{k}\Omega$$
$$C_6 = C_8 = C = 1\mu\text{F}$$





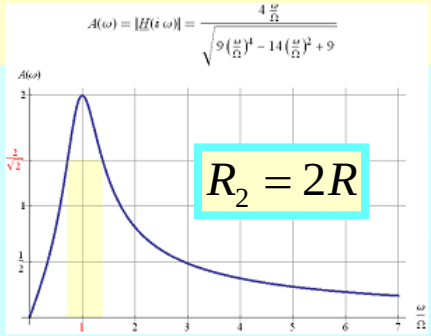
$$\underline{H}(\underline{s}) = \frac{\underline{V}_4(\underline{s})}{\underline{U}_g(\underline{s})}$$

LowPass, LP



HighPass, HP

$$\underline{H}(\underline{s}) = \frac{\underline{V}_2(\underline{s})}{\underline{U}_g(\underline{s})}$$



$$\underline{H}(\underline{s}) = \frac{\underline{V}_3(\underline{s})}{\underline{U}_g(\underline{s})}$$

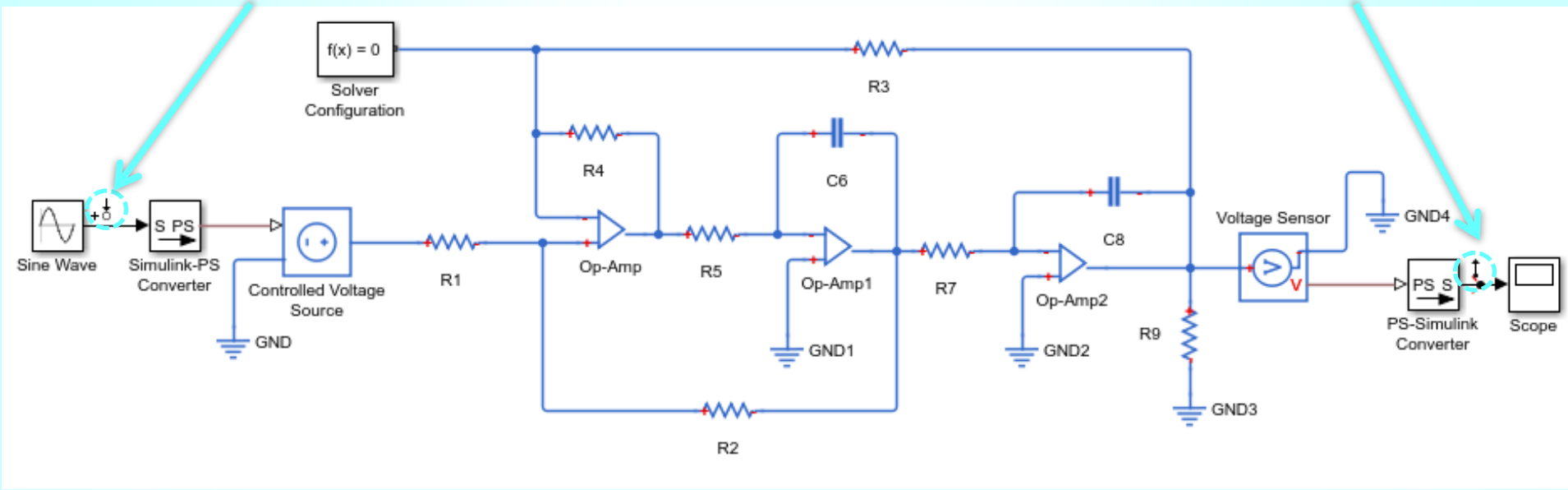
BandPass, BP

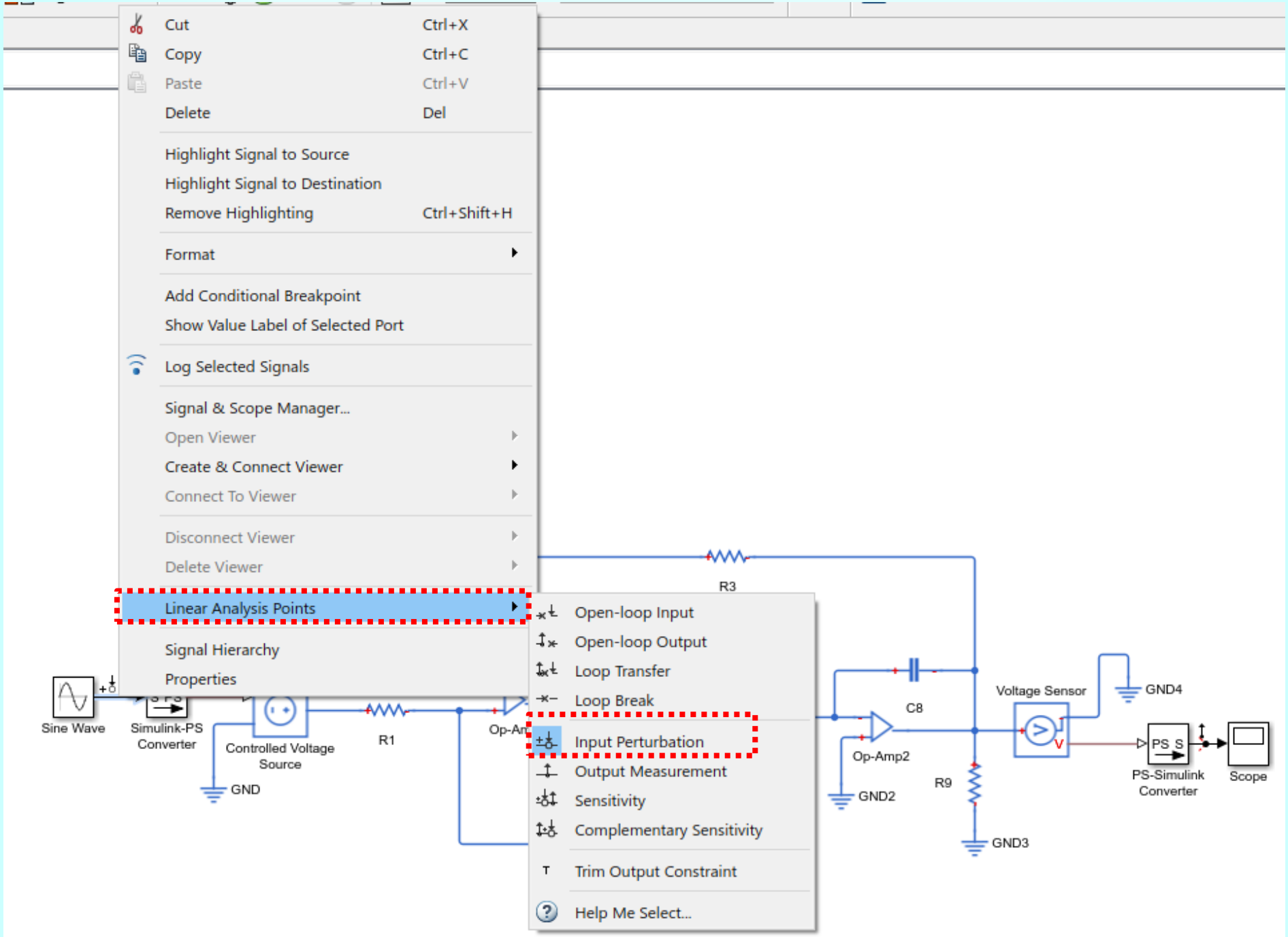
УЛАЗ – ИЗЛАЗ КОЛА (СИСТЕМА)

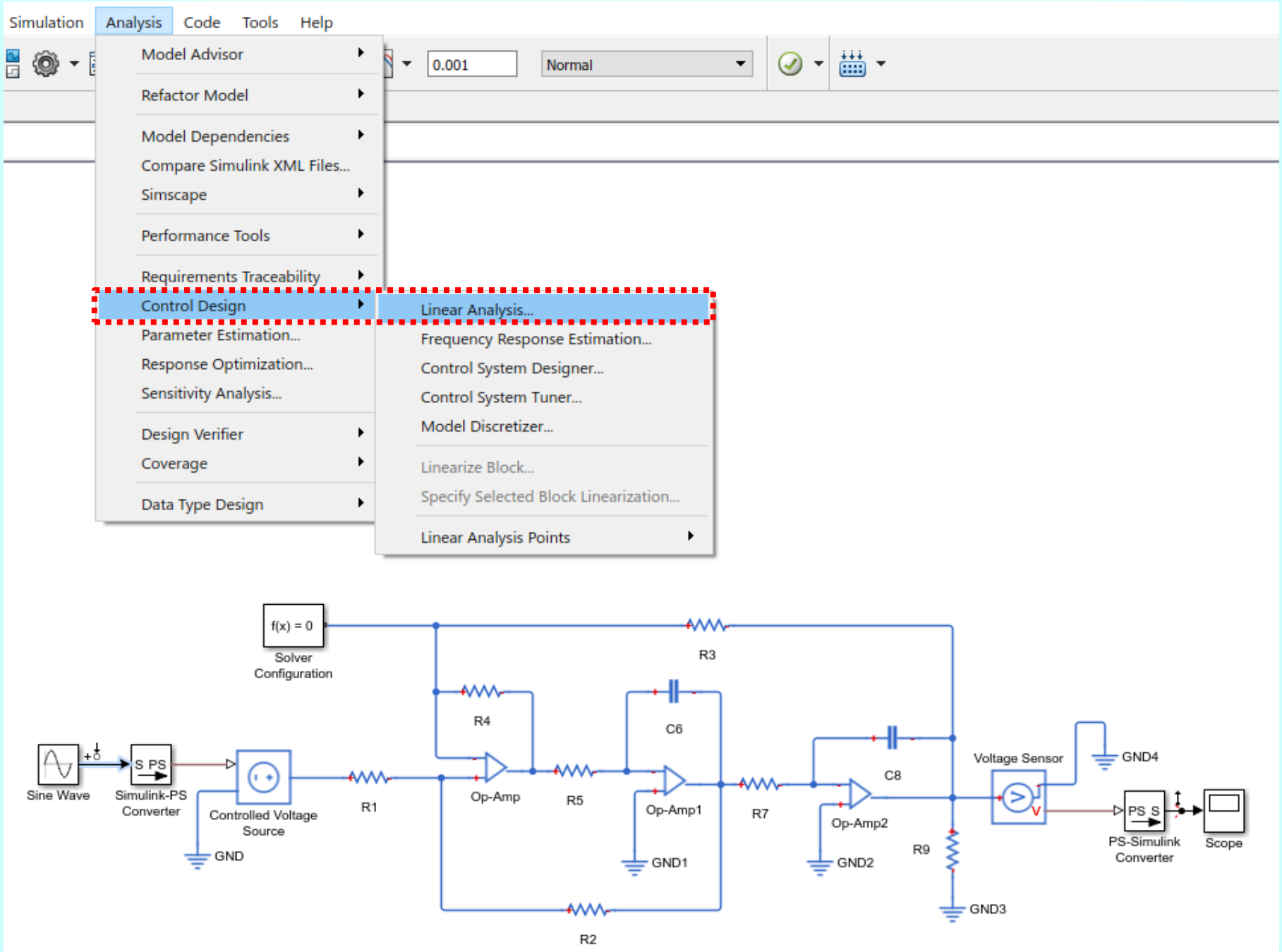
Филтар пропусник ниских учестаности

Input Perturbation

Output Measurement




Cut Ctrl+X
Copy Ctrl+C
Paste Ctrl+V
Delete Del
Highlight Signal to Source
Highlight Signal to Destination
Remove Highlighting Ctrl+Shift+H
Format
Add Conditional Breakpoint
Show Value Label of Selected Port
Log Selected Signals
Signal & Scope Manager...
Open Viewer
Create & Connect Viewer
Connect To Viewer
Disconnect Viewer
Delete Viewer
Linear Analysis Points
Signal Hierarchy
Properties
Open-loop Input
Open-loop Output
Loop Transfer
Loop Break
Input Perturbation
Output Measurement
Sensitivity
Complementary Sensitivity
Trim Output Constraint
Help Me Select...
R3
Sine Wave
Simulink-PS Converter
Controlled Voltage Source
GND
R1
C8
Op-Amp2
GND2
R9
GND3
Voltage Sensor
GND4
PS-Simulink Converter
Scope


Simulation
Analysis
Code
Tools
Help
Model Advisor
Refactor Model
Model Dependencies
Compare Simulink XML Files...
Simscape
Performance Tools
Requirements Traceability
Control Design
Parameter Estimation...
Response Optimization...
Sensitivity Analysis...
Design Verifier
Coverage
Data Type Design
Linear Analysis...
Frequency Response Estimation...
Control System Designer...
Control System Tuner...
Model Discretizer...
Linearize Block...
Specify Selected Block Linearization...
Linear Analysis Points
0.001
Normal
f(x) = 0
Solver Configuration
R3
R4
C6
C8
Sine Wave
Simulink-PS Converter
Controlled Voltage Source
GND
R1
Op-Amp
R5
Op-Amp1
R7
Op-Amp2
R9
Voltage Sensor
GND4
PS-Simulink Converter
Scope
GND1
GND2
GND3
R2

Linear Analysis Tool - khn_LP - Bode Plot 1

LINEAR ANALYSIS | ESTIMATION | PLOTS AND RESULTS | VIEW

Load Session | Save Session | Preferences

Analysis I/Os: Model I/Os | Operating Point: Model Initial Condition | Parameter Variations: None

Result Viewer | Diagnostic Viewer | More Options

Bode Plot 1 | Step | Bode | Impulse | Nyquist

FILE | SETUP | OPTIONS | LINEARIZE

Data Browser

Search workspace variables

MATLAB Workspace

Name	Value
ans	1x1 mupad

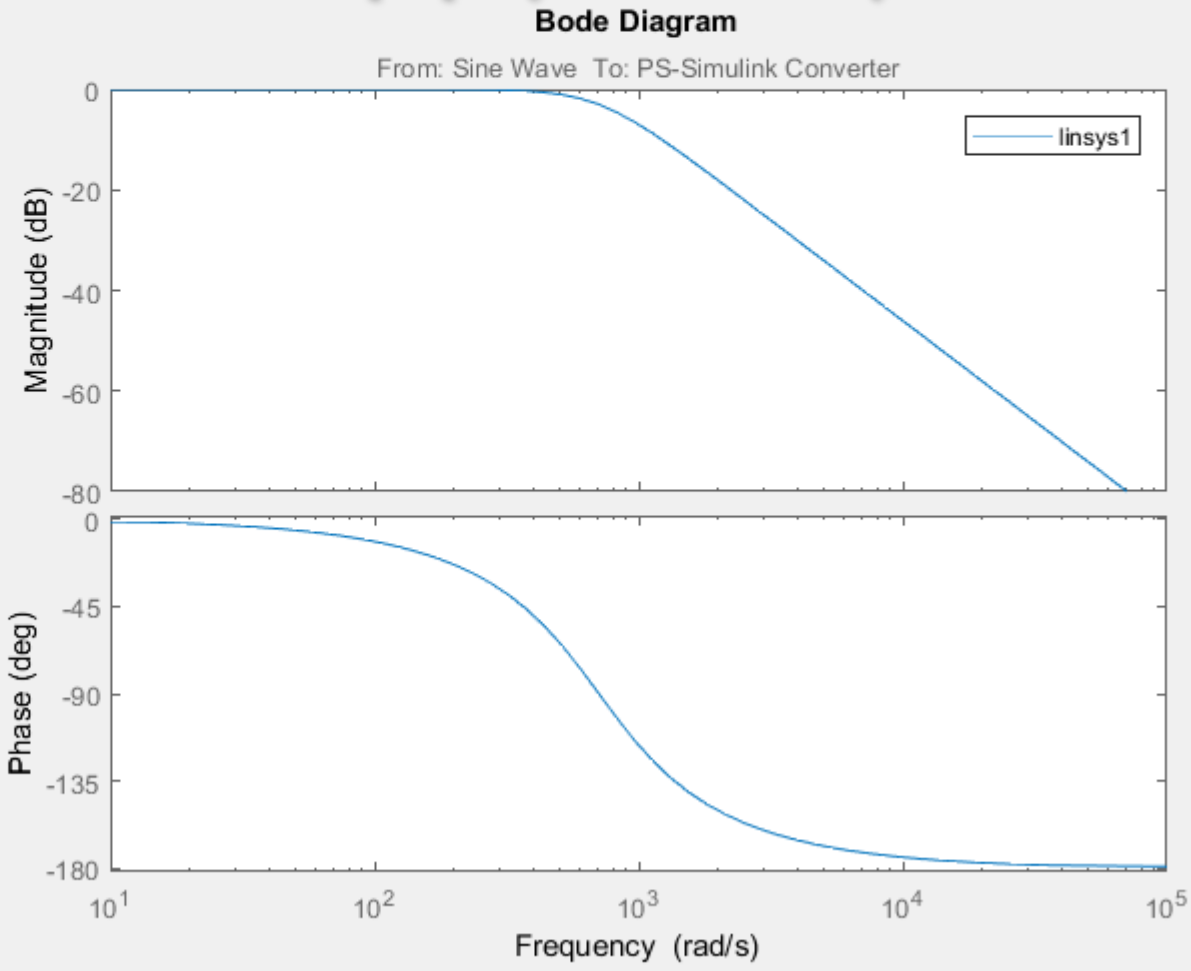
Linear Analysis Workspace

Name	Value
linsys1	1x1 ss

Variable Preview

Bode Plot 1

Филтар пропусник ниских учестаности



The linearization result "linsys2" is created in the Linear Analysis Workspace.

Linear Analysis Tool - khn_LP - Bode Plot 1

LINEAR ANALYSIS | ESTIMATION | PLOTS AND RESULTS | BODE PLOT 1 | VIEW

Input Signal: Create New | Result Viewer

Analysis I/Os:

Operating Point:

NEW INPUT

Sinestream...

Fixed Sample Time Sinestream...

Chirp...

Random...

Bode Plot 1 | Bode | Nichols | Nyquist | Singular ...

ESTIMATE

Data Browser

Search workspa

MATLAB Wo

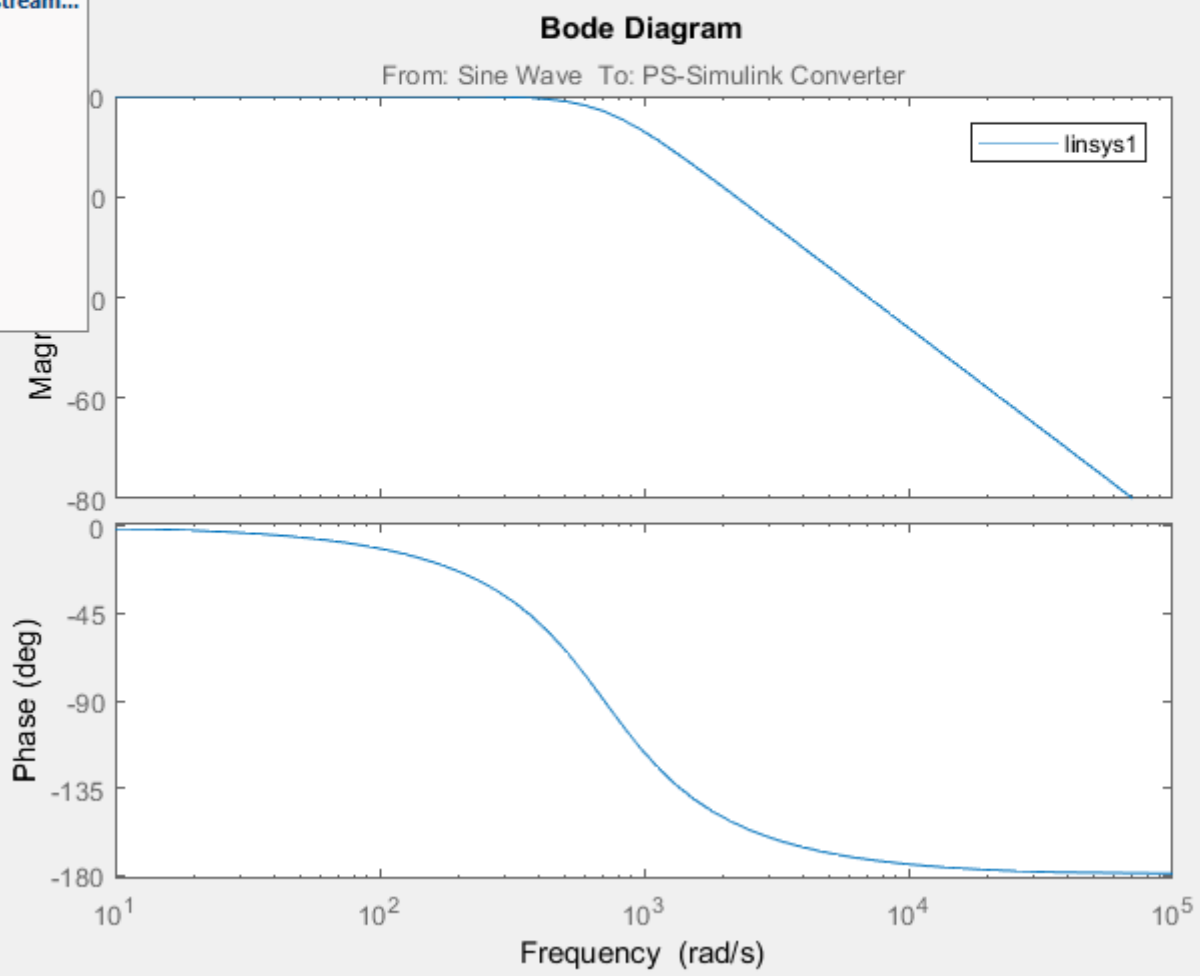
Name

ans

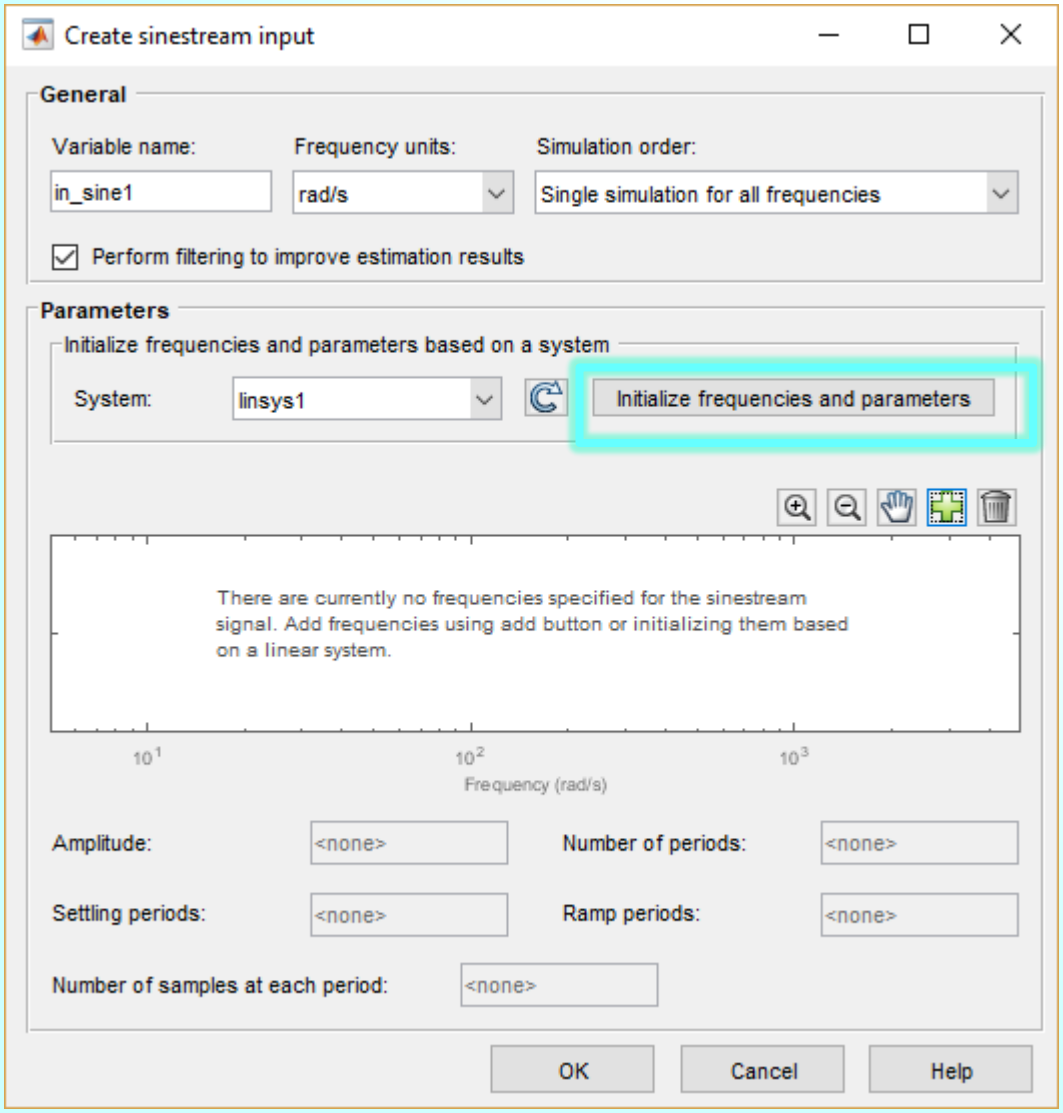
Linear Analysis Workspace

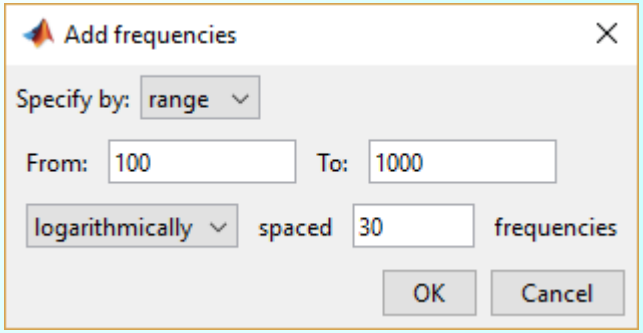
Name	Value
linsys1	1x1 ss

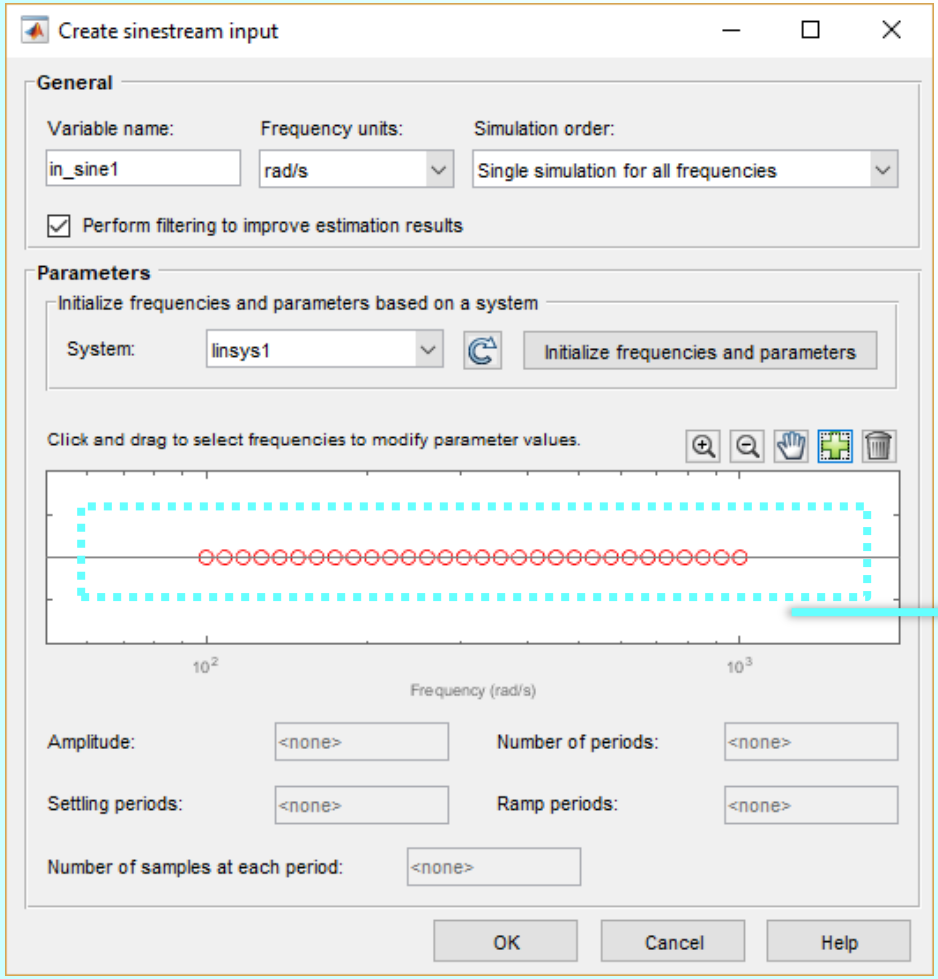
Variable Preview

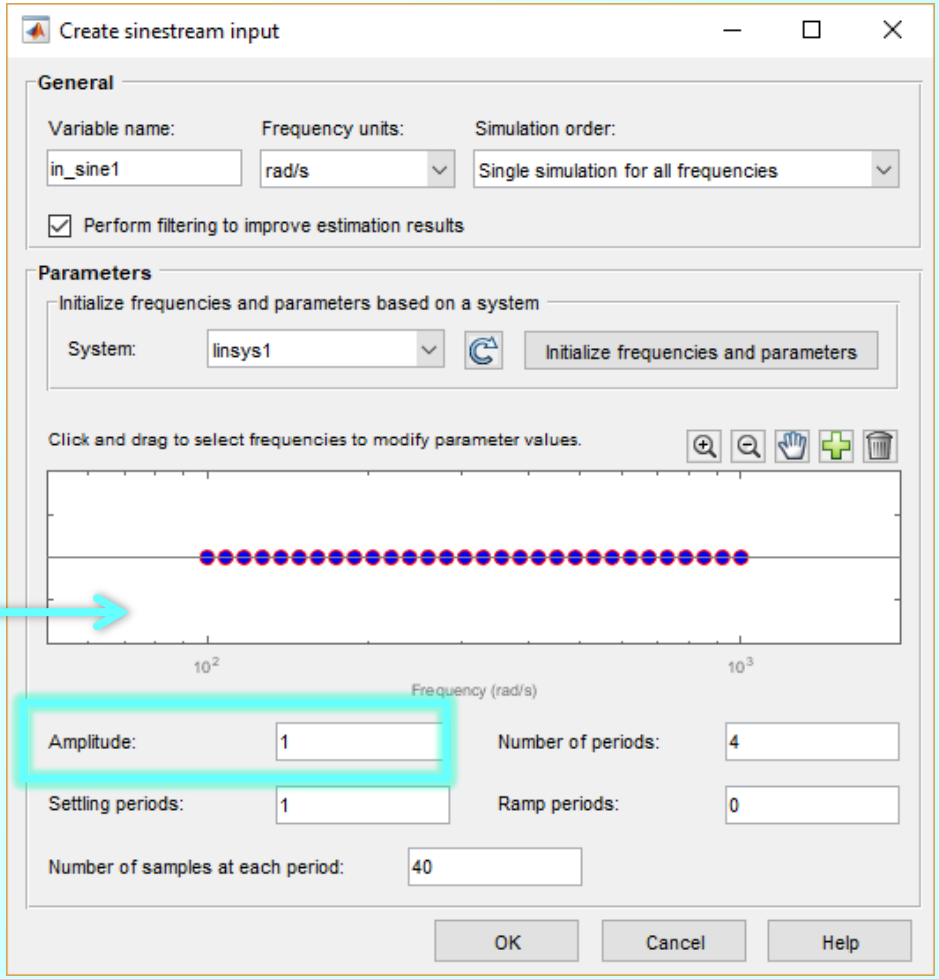


The linearization result "linsys2" is created in the Linear Analysis Workspace.


Create sinestream input
General
Variable name:
in_sine1
Frequency units:
rad/s
Simulation order:
Single simulation for all frequencies
Perform filtering to improve estimation results
Parameters
Initialize frequencies and parameters based on a system
System:
linsys1
Initialize frequencies and parameters
There are currently no frequencies specified for the sinestream signal. Add frequencies using add button or initializing them based on a linear system.
10^1
10^2
10^3
Frequency (rad/s)
Amplitude:
<none>
Number of periods:
<none>
Settling periods:
<none>
Ramp periods:
<none>
Number of samples at each period:
<none>
OK
Cancel
Help


Add frequencies
Specify by:
range
From:
100
To:
1000
logarithmically
spaced
30
frequencies
OK
Cancel


Create sinestream input
General
Variable name:
in_sine1
Frequency units:
rad/s
Simulation order:
Single simulation for all frequencies
Perform filtering to improve estimation results
Parameters
Initialize frequencies and parameters based on a system
System:
linsys1
Initialize frequencies and parameters
Click and drag to select frequencies to modify parameter values.
10^2
10^3
Frequency (rad/s)
Amplitude:
<none>
Number of periods:
<none>
Settling periods:
<none>
Ramp periods:
<none>
Number of samples at each period:
<none>
OK
Cancel
Help


Create sinestream input
General
Variable name:
in_sine1
Frequency units:
rad/s
Simulation order:
Single simulation for all frequencies
Perform filtering to improve estimation results
Parameters
Initialize frequencies and parameters based on a system
System:
linsys1
Initialize frequencies and parameters
Click and drag to select frequencies to modify parameter values.
10^2
10^3
Frequency (rad/s)
Amplitude:
1
Number of periods:
4
Settling periods:
1
Ramp periods:
0
Number of samples at each period:
40
OK
Cancel
Help

Linear Analysis Tool - khn_LP - Bode Plot 2

LINEAR ANALYSIS | ESTIMATION | PLOTS AND RESULTS | BODE PLOT 2 | VIEW

Input Signal: in_sine1
Analysis I/Os: Model I/Os
Operating Point: Model Initial Condition

Result Viewer
Diagnostic Viewer
More Options

Bode Plot 2 | Bode Plot 1 | Bode | Nichols | Nyquist

SETUP | OPTIONS | ESTIMATE

Data Browser

Search workspace variables

MATLAB Workspace

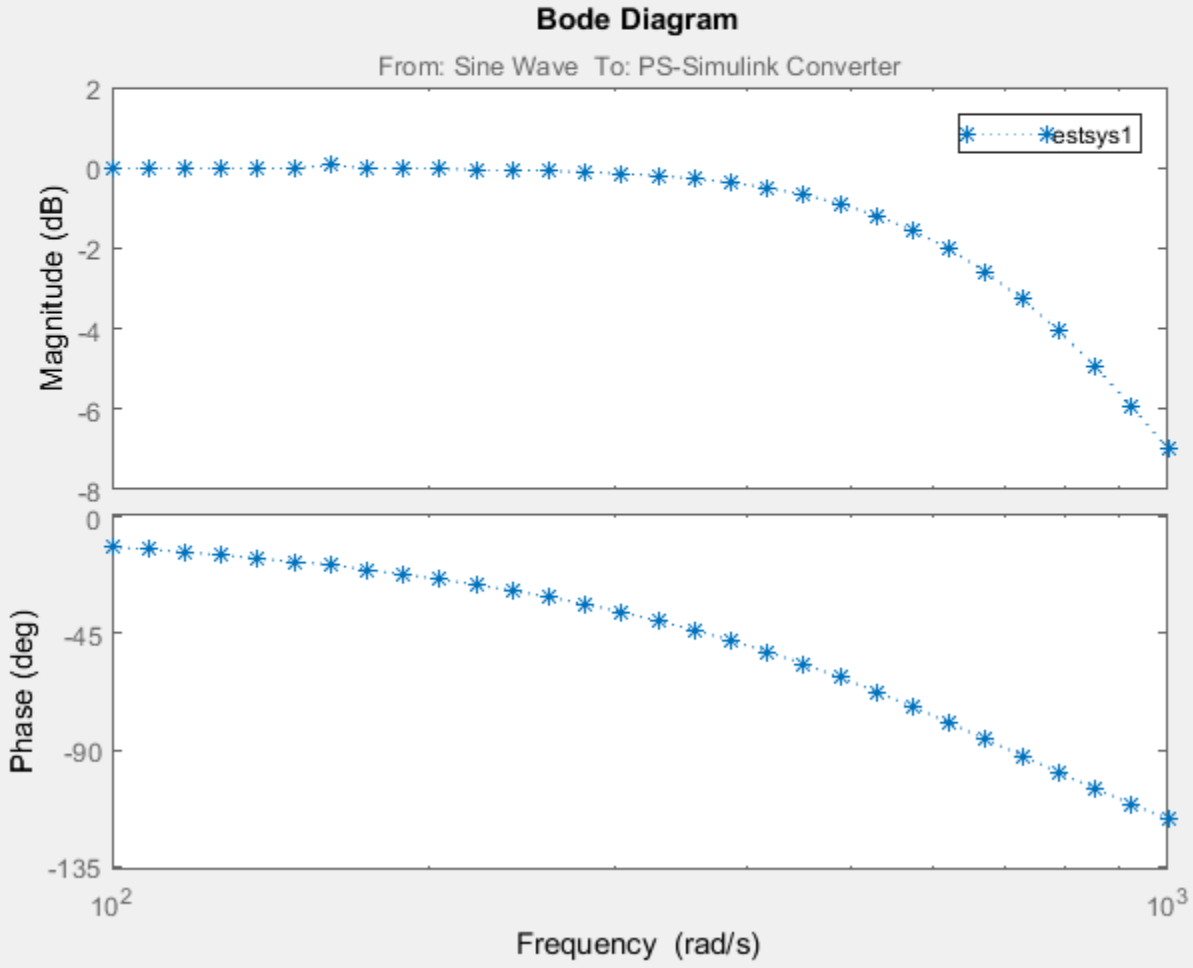
Name	Value
ans	1x1 mupad

Linear Analysis Workspace

Name	Value
estsys1	1x1 frd
in_sine1	1x1 Sinestr...
linsys1	1x1 ss

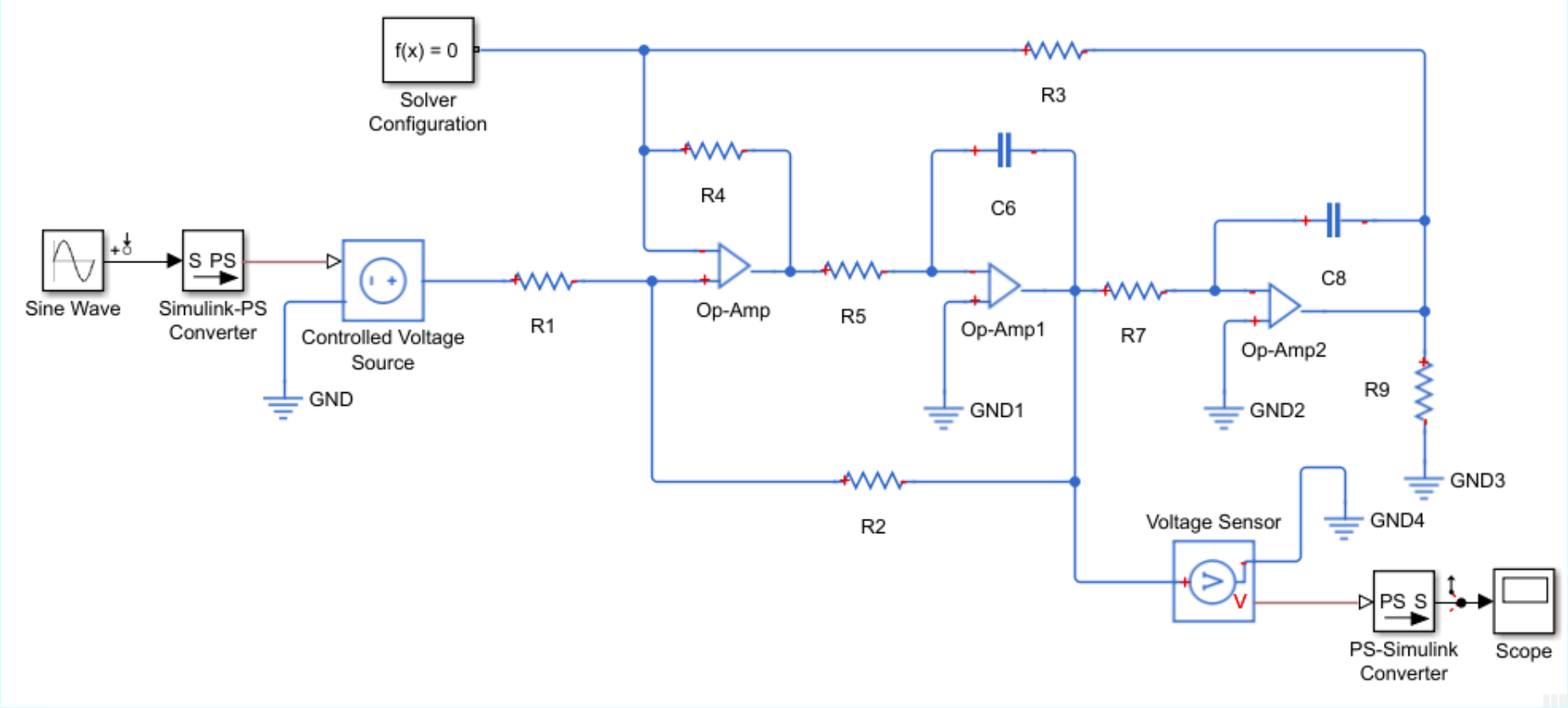
Variable Preview

Bode Plot 1 | Bode Plot 2



The estimation result "estsys1" is created in the Linear Analysis Workspace.

Филтар пропусник опсега учестаности



Linear Analysis Tool - khn_BP - Bode Plot 1

LINEAR ANALYSIS | ESTIMATION | PLOTS AND RESULTS | BODE PLOT 1 | VIEW

Load Session | Save Session | Preferences

Analysis I/Os: Model I/Os

Operating Point: Model Initial Condition

Parameter Variations: None

Result Viewer | Diagnostic Viewer | More Options

Bode Plot 1 | Step | Bode | Impulse | Nyquist

FILE | SETUP | OPTIONS | LINEARIZE

Data Browser

Search workspace variables

MATLAB Workspace

Name	Value
ans	1x1 mupad

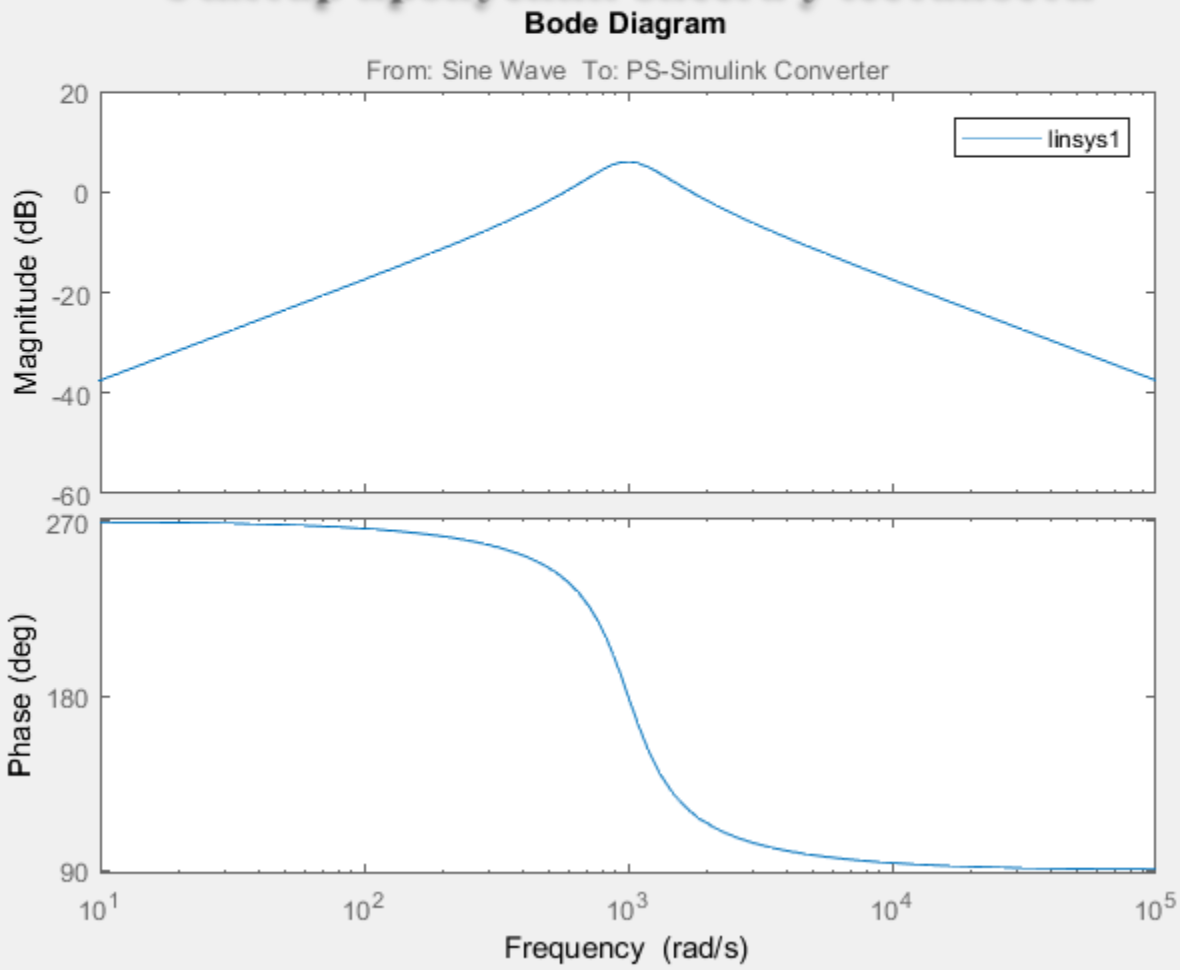
Linear Analysis Workspace

Name	Value
linsys1	1x1 ss

Variable Preview

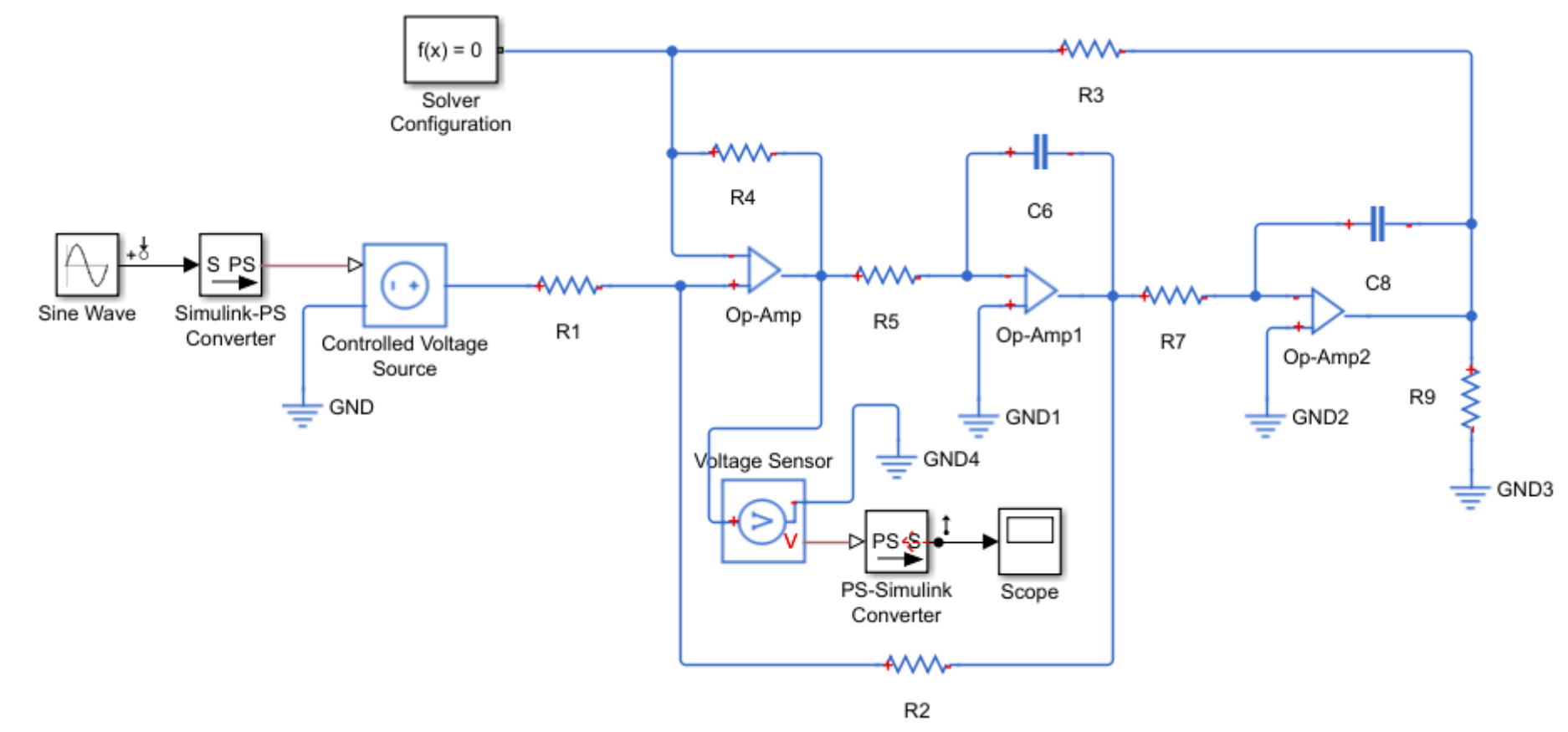
Bode Plot 1

Филтар пропусник опсега учестаности



The linearization result "linsys1" is created in the Linear Analysis Workspace.

Филтар пропусник високих учестаности



Linear Analysis Tool - khn_HP - Bode Plot 1

LINEAR ANALYSIS | ESTIMATION | PLOTS AND RESULTS | BODE PLOT 1 | VIEW

Load Session | Save Session | Preferences

Analysis I/Os: Model I/Os

Operating Point: Model Initial Condition

Parameter Variations: None

Result Viewer | Diagnostic Viewer | More Options

Bode Plot 1 | Step | Bode | Impulse | Nyquist

FILE | SETUP | OPTIONS | LINEARIZE

Data Browser

Search workspace variables

MATLAB Workspace

Name	Value
ans	1x1 mupad

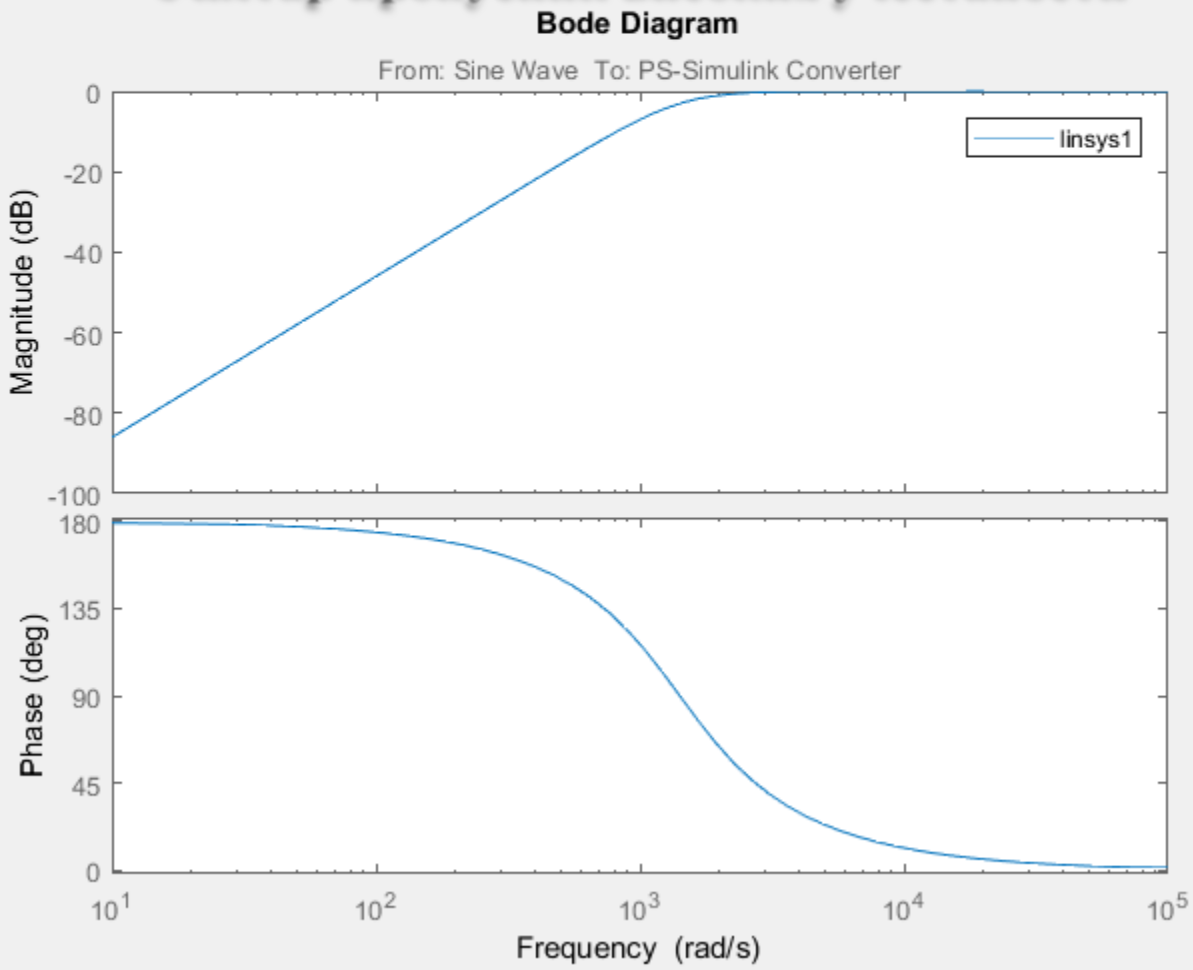
Linear Analysis Workspace

Name	Value
linsys1	1x1 ss

Variable Preview

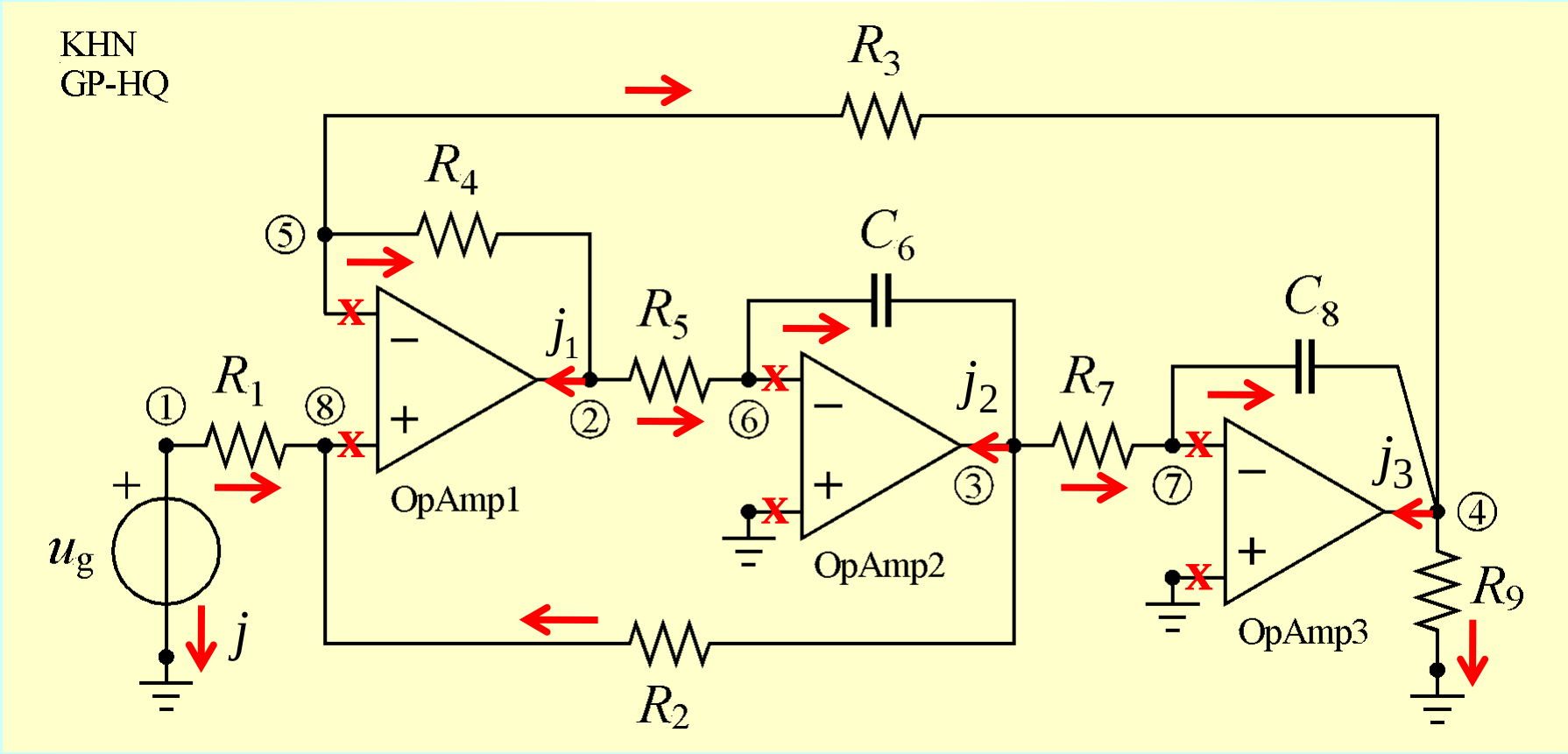
Bode Plot 1

Филтар пропусник високих учестаности



The linearization result "linsys1" is created in the Linear Analysis Workspace.

KHN active filter

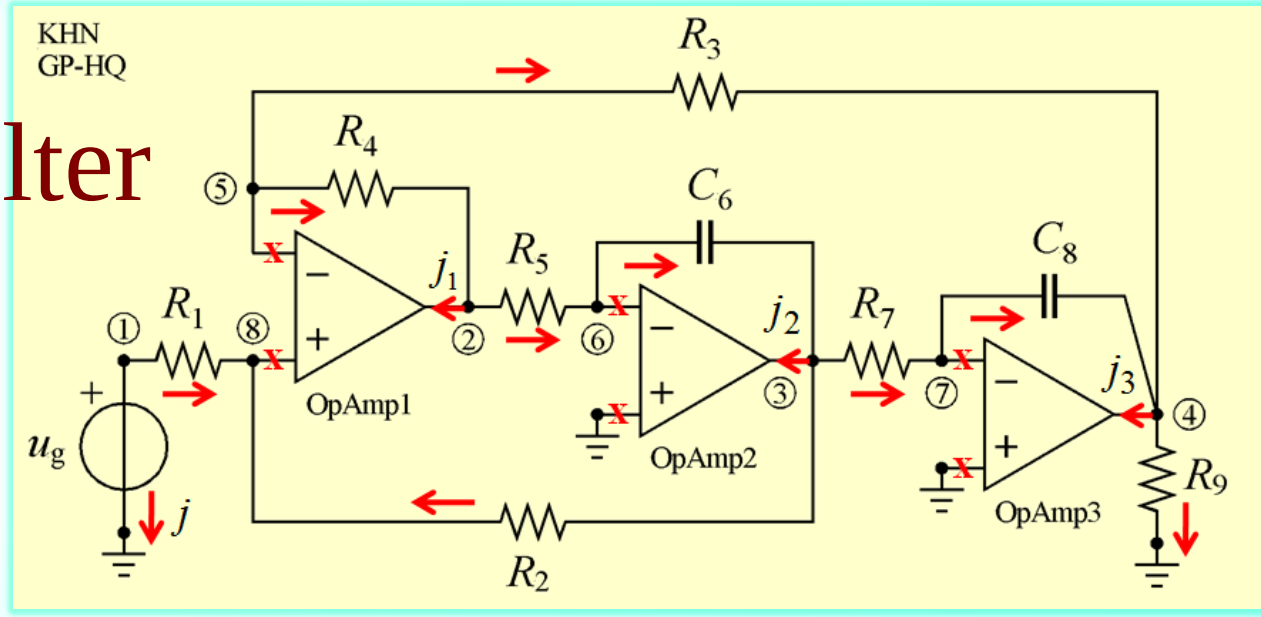


$$\underline{H}_{\text{LowPass}}(\underline{s}) = \frac{\underline{V}_4(\underline{s})}{\underline{V}_1(\underline{s})} = ?$$

$$\underline{H}_{\text{BandPass}}(\underline{s}) = \frac{\underline{V}_3(\underline{s})}{\underline{V}_1(\underline{s})} = ?$$

$$\underline{H}_{\text{HighPass}}(\underline{s}) = \frac{\underline{V}_2(\underline{s})}{\underline{V}_1(\underline{s})} = ?$$

KHN active filter



$$(1)\ \underline{J}+\left(\underline{V}_1-\underline{V}_8\right)/R_1=0$$

$$(2)\ \underline{J}_1+\left(\underline{V}_2-\underline{V}_6\right)/R_5-\left(\underline{V}_5-\underline{V}_2\right)/R_4=0$$

$$(3)\ \underline{J}_2+\left(\underline{V}_3-\underline{V}_8\right)/R_2+\left(\underline{V}_3-\underline{V}_7\right)/R_7-sC_6\left(\underline{V}_6-\underline{V}_3\right)=0$$

$$(4)\ \underline{J}_3-\left(\underline{V}_5-\underline{V}_4\right)/R_3+\underline{V}_4/R_9-sC_8\left(\underline{V}_7-\underline{V}_4\right)=0$$

$$(5)\left(\underline{V}_5-\underline{V}_2\right)/R_4+\left(\underline{V}_5-\underline{V}_4\right)/R_3=0$$

$$(6)-\left(\underline{V}_2-\underline{V}_6\right)/R_5+sC_6\left(\underline{V}_6-\underline{V}_3\right)=0$$

$$(7)-\left(\underline{V}_3-\underline{V}_7\right)/R_7+sC_8\left(\underline{V}_7-\underline{V}_4\right)=0$$

$$(8)-\left(\underline{V}_1-\underline{V}_8\right)/R_1-\left(\underline{V}_3-\underline{V}_8\right)/R_2=0$$

$$\underline{V}_5=\underline{V}_8$$

$$\underline{V}_6=0$$

$$\underline{V}_7=0$$

$$\underline{V}_1=\underline{U}_g$$

MATLAB: MuPAD

```
assume(R1>0 and R2>0 and R3>0 and R4>0 and R5>0 and C6>0 and R7>0 and C8>0
and R>0 and C>0 and Ug>0 and s<>0 and w>0)
```

```
zamena_LowPass:={R1=R, R2=R/2, R3=R, R4=R/2, R5=R, C6=C, R7=R, C8=C}
```

$$\left\{R1 = R,\ R3 = R,\ R5 = R,\ R7 = R,\ R2 = \frac{R}{2},\ R4 = \frac{R}{2},\ C6 = C,\ C8 = C\right\}$$

```
zamena_BandPass:={R1=R, R2=2*R, R3=R, R4=R, R5=R, C6=C, R7=R, C8=C}
```

$$\{R1 = R,\ R3 = R,\ R4 = R,\ R5 = R,\ R7 = R,\ R2 = 2\,R,\ C6 = C,\ C8 = C\}$$

```
zamena_HighPass:={R1=R, R2=R/2, R3=R, R4=2*R, R5=R, C6=C, R7=R, C8=C}
```

$$\left\{R1 = R,\ R3 = R,\ R5 = R,\ R7 = R,\ R2 = \frac{R}{2},\ R4 = 2\,R,\ C6 = C,\ C8 = C\right\}$$

```
vrednosti:={R=1, C=1}
```

$$\{C = 1,\ R = 1\}$$

```
w0:=1/(R*C)
```

$$\frac{1}{C\,R}$$

MATLAB: MuPAD

```
jednacine:={J+(V1-V8)/R1=0,
J1+(V2-V6)/R5-(V5-V2)/R4=0,
J2+(V3-V8)/R2+(V3-V7)/R7-s*C6*(V6-V3)=0,
J3-(V5-V4)/R3+v4/R9-s*C8*(V7-V4)=0,
(V5-V2)/R4+(V5-V4)/R3=0,
-(V2-V6)/R5+s*C6*(V6-V3)=0,
-(V3-V7)/R7+s*C8*(V7-V4)=0,
-(V1-V8)/R1-(V3-V8)/R2=0,
V5=V8,
V6=0,
V7=0,
V1=Ug}
```

$$\left\{J1 + \frac{V2 - V5}{R4} + \frac{V2 - V6}{R5} = 0,\ V1 = Ug,\ V5 = V8,\ J2 + \frac{V3 - V8}{R2} + \frac{V3 - V7}{R7} + \sigma_2 = 0,\ J + \frac{V1 - V8}{R1} = 0,\ J3 + \frac{V4 - V5}{R3} + \frac{v4}{R9} + \sigma_1 = 0,\ V6 = 0,\right.$$

$$\left.V7 = 0,\ -\frac{V1 - V8}{R1} - \frac{V3 - V8}{R2} = 0,\ -\frac{V2 - V5}{R4} - \frac{V4 - V5}{R3} = 0,\ -\frac{V2 - V6}{R5} - \sigma_2 = 0,\ -\frac{V3 - V7}{R7} - \sigma_1 = 0\right\}$$

where

$$\sigma_1 = C8\ s\ (V4 - V7)$$

$$\sigma_2 = C6\ s\ (V3 - V6)$$

```
promenljive:={V1, V2, V3, V4, V5, V6, V7, V8, J, J1, J1, J2, J3}
```

$$\{J,\ J1,\ J2,\ J3,\ V1,\ V2,\ V3,\ V4,\ V5,\ V6,\ V7,\ V8\}$$

odziv:=solve(jednacine, promenljive)

$$\begin{cases} \left\{\left[J = -\frac{Ug\,(R4 + C8\,R3\,R7\,s + C8\,R4\,R7\,s + \sigma_5)}{\sigma_4},\ J1 = -\frac{\sigma_2 - R2\,Ug + \sigma_1 + C6\,C8\,R2\,R5\,R7\,Ug\,s^2}{\sigma_4},\right.\right. & \text{if } \sigma_4 \neq 0 \\ J2 = \frac{R4\,Ug + C8\,R2\,R3\,Ug\,s + C8\,R2\,R4\,Ug\,s + C8\,R3\,R7\,Ug\,s + C8\,R4\,R7\,Ug\,s + \sigma_2 + \sigma_1 + C6\,C8\,R3\,R5\,R7\,Ug\,s^2}{\sigma_4}, \\ J3 = -\big(R2\,R9\,Ug + R1\,R4\,v4 + R2\,R4\,v4 + C8\,R2\,R3\,R9\,Ug\,s + C8\,R2\,R4\,R9\,Ug\,s + C8\,R1\,R3\,R7\,s\,v4 \\ + C8\,R1\,R4\,R7\,s\,v4 - C6\,C8\,R2\,R5\,R7\,R9\,Ug\,s^2 + C6\,C8\,R1\,R3\,R5\,R7\,s^2\,v4 \\ \left.\left. + C6\,C8\,R2\,R3\,R5\,R7\,s^2\,v4\big)\big/(R9\,\sigma_4),\ V1 = Ug,\ V2 = \frac{C6\,C8\,R2\,R5\,R7\,Ug\,s^2\,(R3 + R4)}{\sigma_4},\right.\right. \\ \left.\left. V3 = -\frac{C8\,R2\,R3\,R7\,Ug\,s + C8\,R2\,R4\,R7\,Ug\,s}{\sigma_4},\ V4 = \frac{R2\,Ug\,(R3 + R4)}{\sigma_4},\ V5 = \sigma_3,\ V6 = 0,\ V7 = 0,\ V8 = \sigma_3\right]\right\} \\ \varnothing & \text{if } \sigma_5 + R4 \neq 0 \wedge \sigma_4 = 0 \end{cases}$$

where

$$\sigma_1 = C6\,C8\,R2\,R4\,R7\,Ug\,s^2$$

$$\sigma_2 = C6\,C8\,R2\,R3\,R7\,Ug\,s^2$$

$$\sigma_3 = \frac{R2\,Ug\,(\sigma_5 + R4)}{\sigma_4}$$

$$\sigma_4 = R1\,R4 + R2\,R4 + C8\,R1\,R3\,R7\,s + C8\,R1\,R4\,R7\,s + C6\,C8\,R1\,R3\,R5\,R7\,s^2 + C6\,C8\,R2\,R3\,R5\,R7\,s^2$$

$$\sigma_5 = C6\,C8\,R3\,R5\,R7\,s^2$$

MATLAB: MuPAD

V4(s):=V4 | odziv[1] | zamena_LowPass

$$\frac{3\,R^2\,Ug}{4\left(\frac{3\,C^2\,R^4\,s^2}{2}+\frac{3\,C\,R^3\,s}{2}+\frac{3\,R^2}{4}\right)}$$

H_LowPass(s):=Simplify(V4(s)/Ug)

$$\frac{1}{2\,C^2\,R^2\,s^2+2\,C\,R\,s+1}$$

V3(s):=V3 | odziv[1] | zamena_BandPass

$$-\frac{4\,C\,R^3\,Ug\,s}{3\,C^2\,R^4\,s^2+2\,C\,R^3\,s+3\,R^2}$$

H_BandPass(s):=Simplify(V3(s)/Ug)

$$-\frac{4\,C\,R\,s}{3\,C^2\,R^2\,s^2+2\,C\,R\,s+3}$$

V2(s):=V2 | odziv[1] | zamena_HighPass

$$\frac{3\,C^2\,R^4\,Ug\,s^2}{2\left(\frac{3\,C^2\,R^4\,s^2}{2}+3\,C\,R^3\,s+3\,R^2\right)}$$

H_HighPass(s):=Simplify(V2(s)/Ug)

$$\frac{C^2\,R^2\,s^2}{C^2\,R^2\,s^2+2\,C\,R\,s+2}$$

Hjw_LowPass(w):=(H_LowPass(s)|{s=I*w})

$$\frac{1}{-2\,C^2\,R^2\,w^2+2\,C\,R\,w\,\mathrm{i}+1}$$

Hjw_BandPass(w):=(H_BandPass(s)|{s=I*w})

$$-\frac{4\,C\,R\,w\,\mathrm{i}}{-3\,C^2\,R^2\,w^2+2\,C\,R\,w\,\mathrm{i}+3}$$

Hjw_HighPass(w):=(H_HighPass(s)|{s=I*w})

$$-\frac{C^2\,R^2\,w^2}{-C^2\,R^2\,w^2+2\,C\,R\,w\,\mathrm{i}+2}$$

Aw_LowPass(w):=Simplify(abs(Hjw_LowPass(w)))

$$\frac{1}{\sqrt{4\,C^4\,R^4\,w^4+1}}$$

Aw_BandPass(w):=Simplify(abs(Hjw_BandPass(w)))

$$\frac{4\,C\,R\,w}{\sqrt{\left(3\,C^2\,R^2\,w^2-3\right)^2+4\,C^2\,R^2\,w^2}}$$

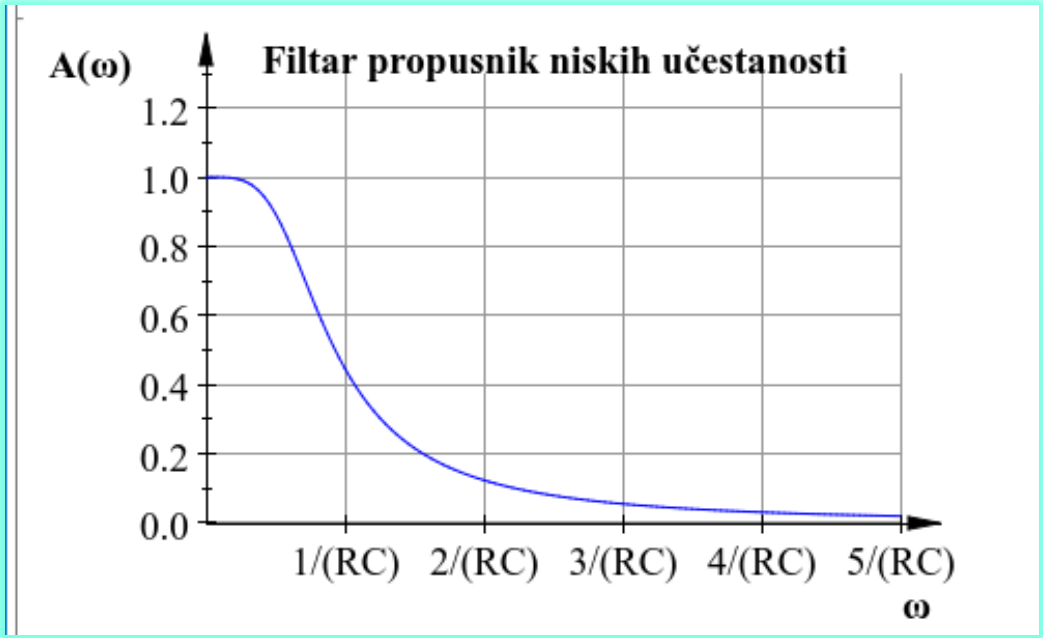
Aw_HighPass(w):=Simplify(abs(Hjw_HighPass(w)))

$$\frac{C^2\,R^2\,w^2}{\sqrt{C^4\,R^4\,w^4+4}}$$

MATLAB: MuPAD

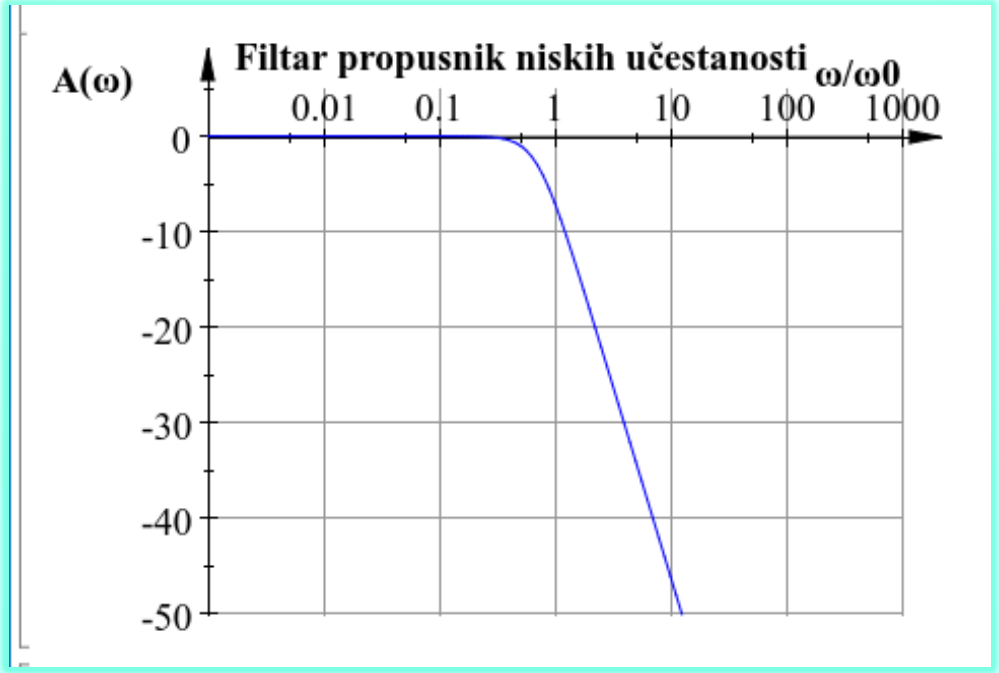
MATLAB: MuPAD

```
plotfunc2d(Aw_LowPass(w) | vrednosti, w=0..5,
      Scaling=Automatic,
      Title= "Filtar propusnik niskih učestanosti", TitleFont = ["Times New Roman", 14, Bold],  TitlePosition=[2.5,1.3],

     AxesTitles =["ω", "A(ω)"],
     AxesTitleFont =["Times New Roman", 14, Bold],

     GridVisible = TRUE,

     XTicksNumber = None,
     XTicksAt = [1 = "1/(RC)", 2 = "2/(RC)", 3 = "3/(RC)", 4 = "4/(RC)", 5 = "5/(RC)"],
     TicksLabelFont = ["Times New Roman", 14])
```



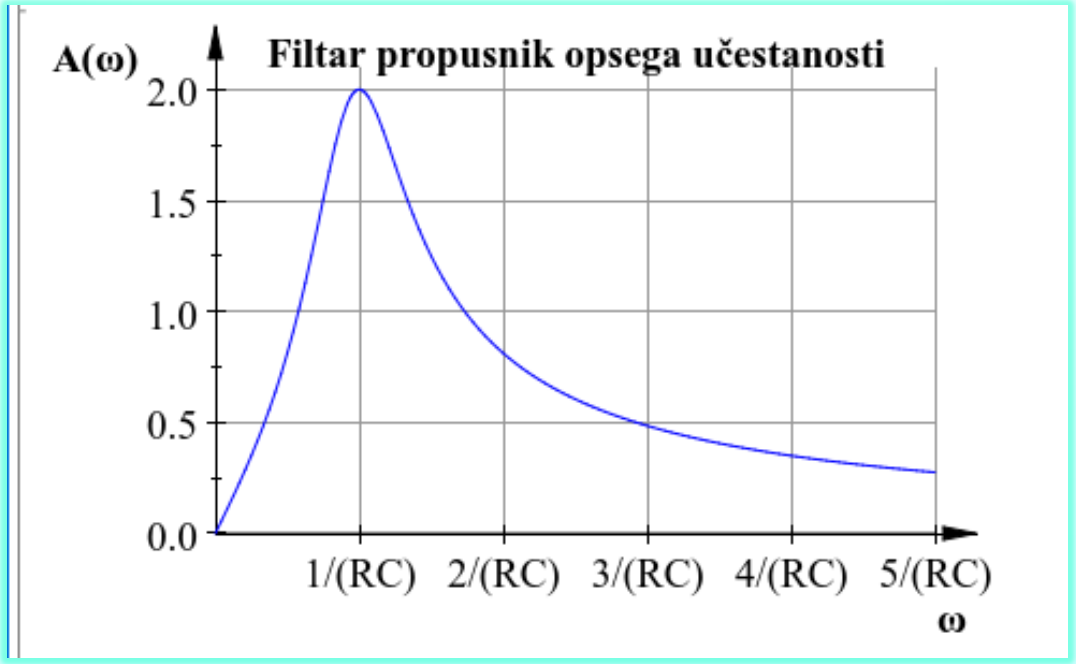
MATLAB: MuPAD

```
plotfunc2d(20*log10(Aw_LowPass(w)) | vrednosti, w=1e-3..1000,
      ViewingBoxYRange = -50 .. 5, CoordinateType = LogLin,
      Scaling=Automatic,
      Title= "Filtar propusnik niskih učestanosti", TitleFont = ["Times New Roman", 14, Bold],  TitlePosition=[0.5,7],

      AxesTitles =["ω/ω0", "A(ω)"],
      AxesTitleFont =["Times New Roman", 14, Bold],

     GridVisible = TRUE,

     TicksLabelFont = ["Times New Roman", 14])
```



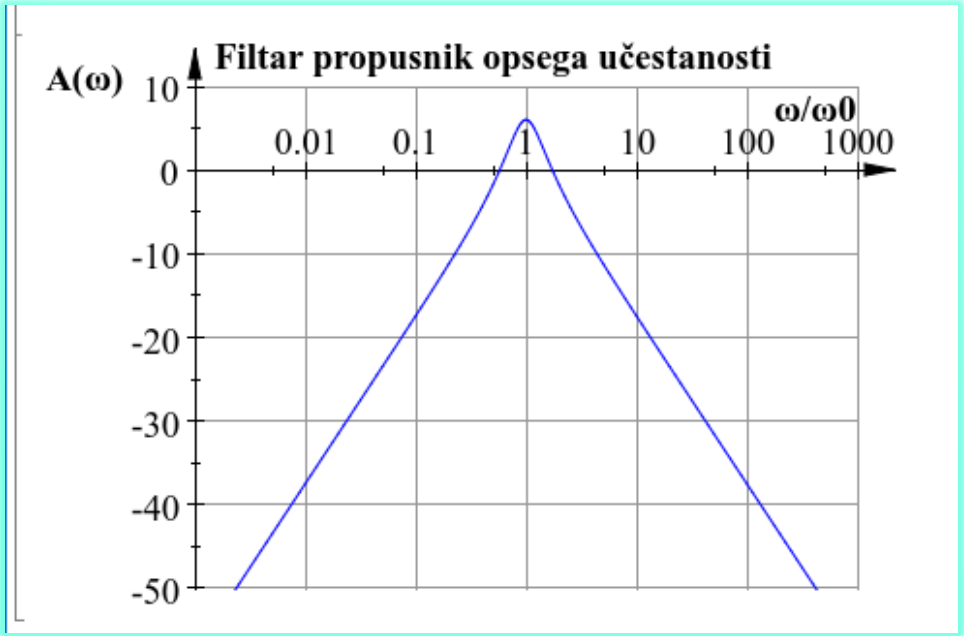
MATLAB: MuPAD

```
plotfunc2d(Aw_BandPass(w) | vrednosti, w=0..5,
      Scaling=Automatic,
      Title= "Filtar propusnik opsega učestanosti", TitleFont = ["Times New Roman", 14, Bold],  TitlePosition=[2.5,2.1],

      AxesTitles =["ω", "A(ω)"],
      AxesTitleFont =["Times New Roman", 14, Bold],

     GridVisible = TRUE,

     XTicksNumber = None,
     XTicksAt = [1 = "1/(RC)", 2 = "2/(RC)", 3 = "3/(RC)", 4 = "4/(RC)", 5 = "5/(RC)"],
     TicksLabelFont = ["Times New Roman", 14])
```



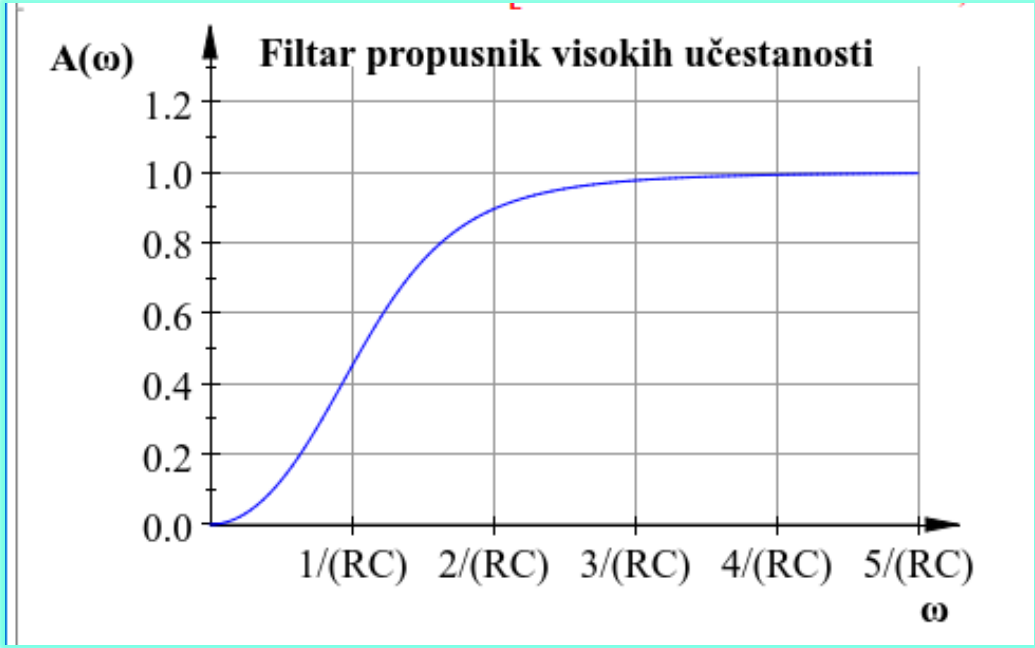
MATLAB: MuPAD

```
plotfunc2d(20*log10(Aw_BandPass(w)) | vrednosti, w=1e-3..1000,
      ViewingBoxYRange = -50 .. 10, CoordinateType = LogLin,
      Scaling=Automatic,
      Title= "Filtar propusnik opsega učestanosti", TitleFont = ["Times New Roman", 14, Bold],  TitlePosition=[0.5,12],

      AxesTitles =["ω/ω0", "A(ω)"],
      AxesTitleFont =["Times New Roman", 14, Bold],

      GridVisible = TRUE,

      TicksLabelFont = ["Times New Roman", 14])
```



MATLAB: MuPAD

```
plotfunc2d(Aw_HighPass(w)|vrednosti, w=0..5,
      Scaling=Automatic,
      Title= "Filtar propusnik visokih učestanosti", TitleFont = ["Times New Roman", 14, Bold],  TitlePosition=[2.5,1.3],

      AxesTitles =["ω", "A(ω)"],
      AxesTitleFont =["Times New Roman", 14, Bold],

      GridVisible = TRUE,

      XTicksNumber = None,
      XTicksAt = [1 = "1/(RC)", 2 = "2/(RC)", 3 = "3/(RC)", 4 = "4/(RC)", 5 = "5/(RC)"],
      TicksLabelFont = ["Times New Roman", 14])
```



MATLAB: MuPAD

```
plotfunc2d(20*log10(Aw_HighPass(w)) | vrednosti, w=1e-3..1000,
      ViewingBoxYRange = -50 .. 10, CoordinateType = LogLin,
      Scaling=Automatic,
      Title= "Filtar propusnik visokih učestanosti", TitleFont = ["Times New Roman", 14, Bold],  TitlePosition=[0.5,12],

      AxesTitles =["ω/ω0", "A(ω)"],
      AxesTitleFont =["Times New Roman", 14, Bold],

      GridVisible = TRUE,

      TicksLabelFont = ["Times New Roman", 14])
```