Tehnika frekvencijskog masikranja

Tehnika frekvencijksog maskiranja koristi se pri projektovanja veoma selektivnih filtara

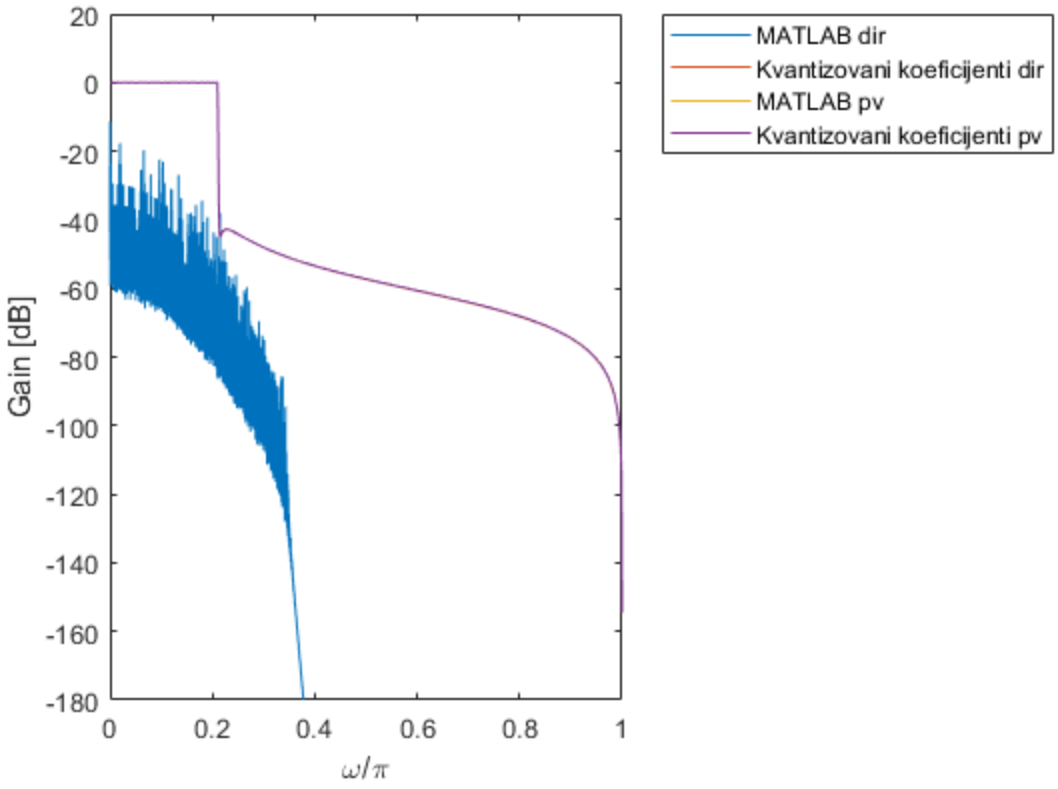
Parametri filtra

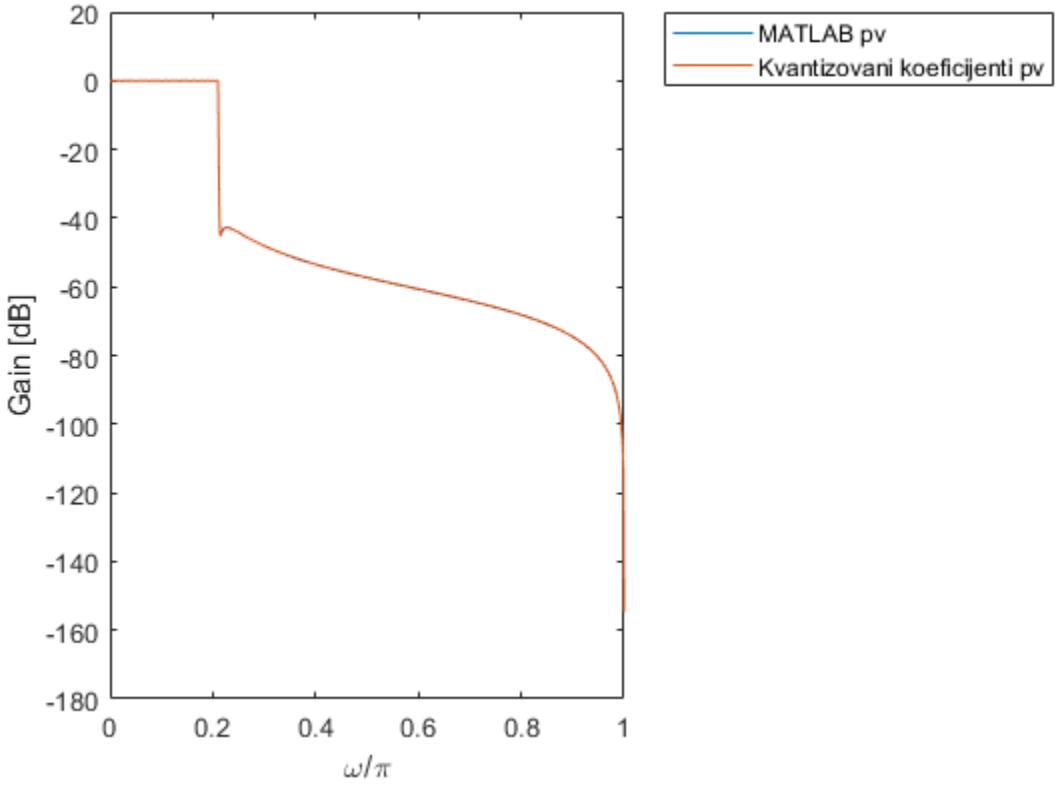
```
close all
clear
rs=60;
deltas=10^-(rs/20);
deltap=1-sqrt(1-deltas^2);
rp=-20*log10(1-deltap);
rpdd=0.01;
wp=0.21*pi; % granicna frekvencija propusnog opsega rezultujuceg filtra
ws=0.215*pi; % granicna frekvencija nepropusnog opsega rezultujuceg filtra
broj_tacaka_f_kk=100000;
pogresni_parametri=0;
bb=15;
```

Direktan dizajn filtra

```
[Ndd,wndd]=cheb1ord(wp/pi,ws/pi,rpdd,rs);
if rem(Ndd,2)==0 % iir filtar mora biti neparnog reda
        Ndd=Ndd+1;
end
[bdd,add]=cheby1(Ndd,rpdd,wndd);
[zdd,pdd,kdd]=cheby1(Ndd,rpdd,wndd);
[psort,ind]=sort(abs(pdd));
pOdd=[];
NOdd=0;
AOdduk=ones(broj_tacaka_f_kk,1);
AOddukqq=ones(broj_tacaka_f_kk,1);
p1dd(1)=pdd(ind(1));
N1dd=1;
a1dd(N1dd,1:2)=poly(pdd(ind(1)));
a1ddqq(N1dd,1:2)=round(a1dd(N1dd,1:2)*(2^bb))/2^bb;
[A1dd(:,N1dd),w]=freqz(fliplr(a1dd(N1dd,1:2)),a1dd(N1dd,1:2),broj_tacaka_f_kk);
[A1ddqq(:,N1dd),w]=freqz(fliplr(a1ddqq(N1dd,1:2)),a1ddqq(N1dd,1:2),broj_tacaka_f_kk);
A1dduk=A1dd(:,N1dd);
A1ddukqq=A1ddqq(:,N1dd);
for br=1:(Ndd-1)/2
    if br/2~=round(br/2)
        pOdd=[pOdd;pdd(ind(2*(br-1)+2:2*(br-1)+3))];
```

```
        N0dd=N0dd+1;
        a0dd(N0dd,1:3)=poly(pdd(ind(2*(br-1)+2:2*(br-1)+3)));
        a0ddqq(N0dd,1:3)=round(a0dd(N0dd,1:3)*(2^bb))/2^bb;
        [A0dd(:,N0dd),w]=freqz(fliplr(a0dd(N0dd,1:3)),a0dd(N0dd,1:3),broj_tacaka_f_kk);
        [A0ddqq(:,N0dd),w]=freqz(fliplr(a0ddqq(N0dd,1:3)),a0ddqq(N0dd,1:3),broj_tacaka_f_kk);
        A0dduk=A0dduk.*A0dd(:,N0dd);
        A0ddukqq=A0ddukqq.*A0ddqq(:,N0dd);
    else
        p1dd=[p1dd;pdd(ind(2*(br-1)+2:2*(br-1)+3))];
        N1dd=N1dd+1;
        a1dd(N1dd,1:3)=poly(pdd(ind(2*(br-1)+2:2*(br-1)+3)));
        a1ddqq(N1dd,1:3)=round(a1dd(N1dd,1:3)*(2^bb))/2^bb;
        [A1dd(:,N1dd),w]=freqz(fliplr(a1dd(N1dd,1:3)),a1dd(N1dd,1:3),broj_tacaka_f_kk);
        [A1ddqq(:,N1dd),w]=freqz(fliplr(a1ddqq(N1dd,1:3)),a1ddqq(N1dd,1:3),broj_tacaka_f_kk);
        A1dduk=A1dduk.*A1dd(:,N1dd);
        A1ddukqq=A1ddukqq.*A1ddqq(:,N1dd);
    end
end
[Gd,w]=freqz(bdd,add,broj_tacaka_f_kk);
[Gdqq,w]=freqz(round(bdd*2^bb)/(2^bb),round(add*2^bb)/(2^bb),broj_tacaka_f_kk);
Gpv=(A0dduk+A1dduk)/2;
Gpvqq=(A0ddukqq+A1ddukqq)/2;

figure,plot(w/pi,20*log10(abs(Gd)),w/pi,20*log10(abs(Gdqq)),w/pi,20*log10(abs(Gpv)),w/pi,20*log10
(abs(Gpvqq)));
xlabel('\omega/\pi'); ylabel('Gain [dB]');
ylim([-180 20]);
legend('MATLAB dir','Kvantizovani koeficijenti dir','MATLAB pv','Kvantizovani koeficijenti
pv','location','NEO');
figure,plot(w/pi,20*log10(abs(Gpv)),w/pi,20*log10(abs(Gpvqq)));
xlabel('\omega/\pi'); ylabel('Gain [dB]');
ylim([-180 20]);
legend('MATLAB pv','Kvantizovani koeficijenti pv','location','NEO');
```


MATLAB dir
Kvantizovani koeficijenti dir
MATLAB pv
Kvantizovani koeficijenti pv
Gain [dB]
20
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
0
0.2
0.4
0.6
0.8
1
ω/π


MATLAB pv
Kvantizovani koeficijenti pv
Gain [dB]
20
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
0
0.2
0.4
0.6
0.8
1
ω/π

Frekvencijsko maskiranje - parametri

```
M=16;
m=floor(wp*M/2/pi);
if ws*M-2*m*pi<pi && m>0  % dizajn tipa 1
    wppt=wp*M-2*m*pi; % granicna frekvencija propusnog opsega prototip filtra
    wspt=ws*M-2*m*pi; % granicna frekvencija nepropusnog opsega prototip filtra
    wpf1=(2*m*pi+wppt)/M; % granicna frekvencija propusnog opsega maskirajuceg filtra F1
    wsf1=(2*(m+1)*pi-wspt)/M; % granicna frekvencija nepropusnog opsega maskirajuceg filtra F1
    wpf2=(2*m*pi-wppt)/M; % granicna frekvencija propusnog opsega maskirajuceg filtra F2
    wsf2=(2*m*pi+wspt)/M; % granicna frekvencija nepropusnog opsega maskirajuceg filtra F2
else
    m=ceil(ws*M/2/pi);  % dizajn tipa 2
    if 2*m*pi-wp*M<pi
        wppt=2*m*pi-ws*M; % granicna frekvencija propusnog opsega prototip filtra
        wspt=2*m*pi-wp*M; % granicna frekvencija nepropusnog opsega prototip filtra
        wpf1=(2*(m-1)*pi+wspt)/M; % granicna frekvencija propusnog opsega maskirajuceg filtra F1
        wsf1=(2*m*pi-wppt)/M; % granicna frekvencija nepropusnog opsega maskirajuceg filtra F1
        wpf2=(2*m*pi-wspt)/M; % granicna frekvencija propusnog opsega maskirajuceg filtra F2
        wsf2=(2*m*pi+wppt)/M; % granicna frekvencija nepropusnog opsega maskirajuceg filtra F2
    else
        pogresni_parametri=1;
    end
end
if pogresni_parametri==0
```

Frekvencijsko maskiranje - prototip filtar

```
    [Npt,wnpt]=cheb1ord(wppt/pi,wspt/pi,rp,rs);
    if rem(Npt,2)==0 % iir filtar mora biti neparnog reda
        Npt=Npt+1;
    end
    [bpt,apt]=cheby1(Npt,rp,wnpt);
    [zpt,ppt,kpt]=cheby1(Npt,rp,wnpt);
    [psort,ind]=sort(abs(ppt));
    pOpt=[];
    NOpt=0;
    AOptMuk=ones(broj_tacaka_f_kk,1);
    AOptMukqq=ones(broj_tacaka_f_kk,1);
    p1pt(1)=ppt(ind(1));
    N1pt=1;
    a1pt(N1pt,1:2)=poly(ppt(ind(1)));
    a1ptqq(N1pt,1:2)=round(a1pt(N1pt,1:2)*(2^bb))/2^bb;

[A1ptM(:,N1pt),w]=freqz(upsample(fliplr(a1pt(N1pt,1:2)),M),upsample(a1pt(N1pt,1:2),M),broj_tacaka
_f_kk);

[A1ptMqq(:,N1pt),w]=freqz(upsample(fliplr(a1ptqq(N1pt,1:2)),M),upsample(a1ptqq(N1pt,1:2),M),broj_
tacaka_f_kk);
    A1ptMuk=A1ptM(:,N1pt);
    A1ptMukqq=A1ptMqq(:,N1pt);
    for br=1:(Npt-1)/2
```

```
        if br/2~=round(br/2)
            pOpt=[pOpt;ppt(ind(2*(br-1)+2:2*(br-1)+3))];
            NOpt=NOpt+1;
            aOpt(NOpt,1:3)=poly(ppt(ind(2*(br-1)+2:2*(br-1)+3)));
            aOptqq(NOpt,1:3)=round(aOpt(NOpt,1:3)*(2^bb))/2^bb;

[AOptM(:,NOpt),w]=freqz(upsample(fliplr(aOpt(NOpt,1:3)),M),upsample(aOpt(NOpt,1:3),M),broj_tacaka
_f_kk);

[AOptMqq(:,NOpt),w]=freqz(upsample(fliplr(aOptqq(NOpt,1:3)),M),upsample(aOptqq(NOpt,1:3),M),broj_
tacaka_f_kk);
            AOptMuk=AOptMuk.*AOptM(:,NOpt);
            AOptMukqq=AOptMukqq.*AOptMqq(:,NOpt);
        else
            p1pt=[p1pt;ppt(ind(2*(br-1)+2:2*(br-1)+3))];
            N1pt=N1pt+1;
            a1pt(N1pt,1:3)=poly(ppt(ind(2*(br-1)+2:2*(br-1)+3)));
            a1ptqq(N1pt,1:3)=round(a1pt(N1pt,1:3)*(2^bb))/2^bb;

[A1ptM(:,N1pt),w]=freqz(upsample(fliplr(a1pt(N1pt,1:3)),M),upsample(a1pt(N1pt,1:3),M),broj_tacaka
_f_kk);

[A1ptMqq(:,N1pt),w]=freqz(upsample(fliplr(a1ptqq(N1pt,1:3)),M),upsample(a1ptqq(N1pt,1:3),M),broj_
tacaka_f_kk);
            A1ptMuk=A1ptMuk.*A1ptM(:,N1pt);
            A1ptMukqq=A1ptMukqq.*A1ptMqq(:,N1pt);
        end
    end
```

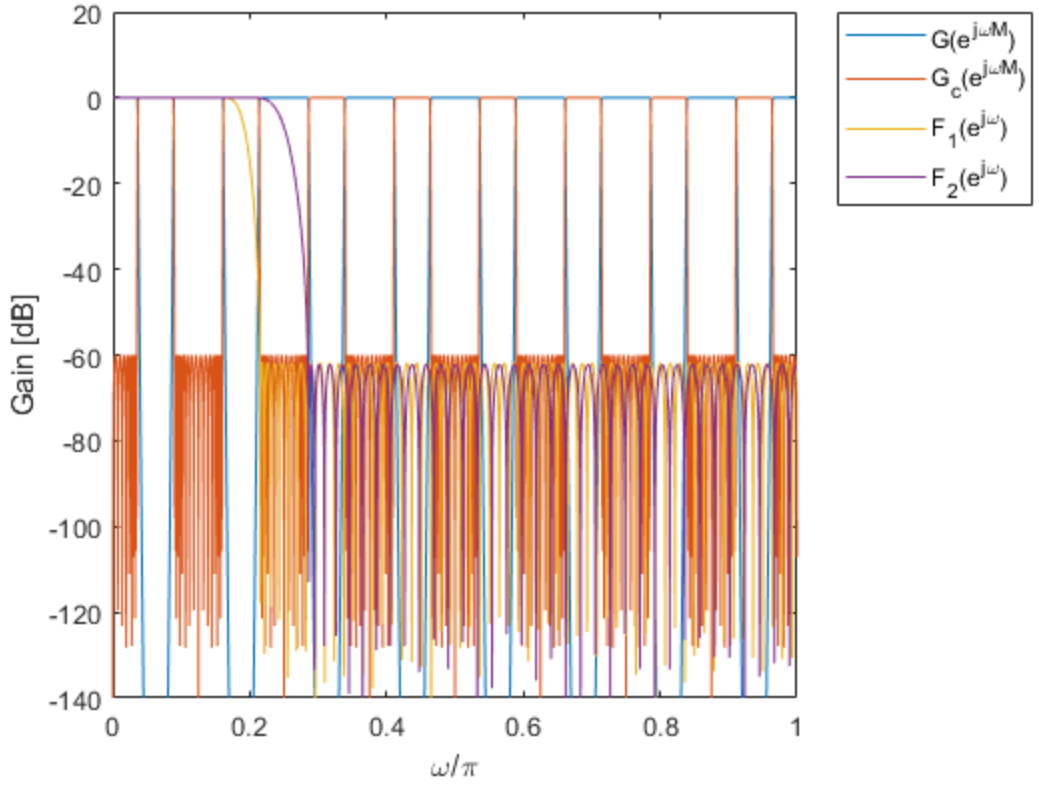
Frekvencijsko maskiranje - maskirajući filtri

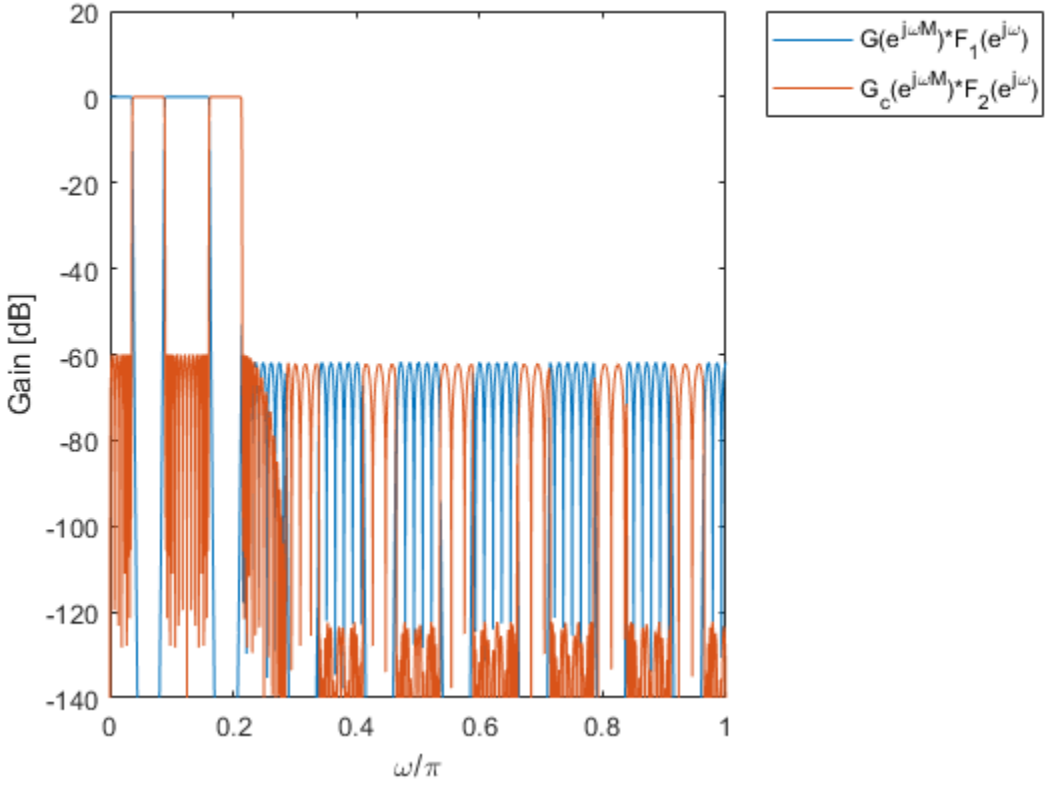
```
    [N1,ff1,aa1,tf1]=firpmord([wpf1 wsf1]/pi,[1 0],[0.5*(1-10^(-rpdd/20)) 0.8*deltas]);
    [N2,ff2,aa2,tf2]=firpmord([wpf2 wsf2]/pi,[1 0],[0.5*(1-10^(-rpdd/20)) 0.8*deltas]);
    if rem(N1,2)~=0
        N1=N1+1;
    end
    if rem(N2,2)~=0
        N2=N2+1;
    end
    f1p=firpm(N1,ff1,aa1,tf1);
    faktor=sum(f1p);
    if faktor>1
        f1p=f1p/faktor;
    else
        f1p=f1p/(2-faktor);
    end
    f2p=firpm(N2,ff2,aa2,tf2);
    faktor=sum(f2p);
    if faktor>1
        f2p=f2p/faktor;
    else
        f2p=f2p/(2-faktor);
```

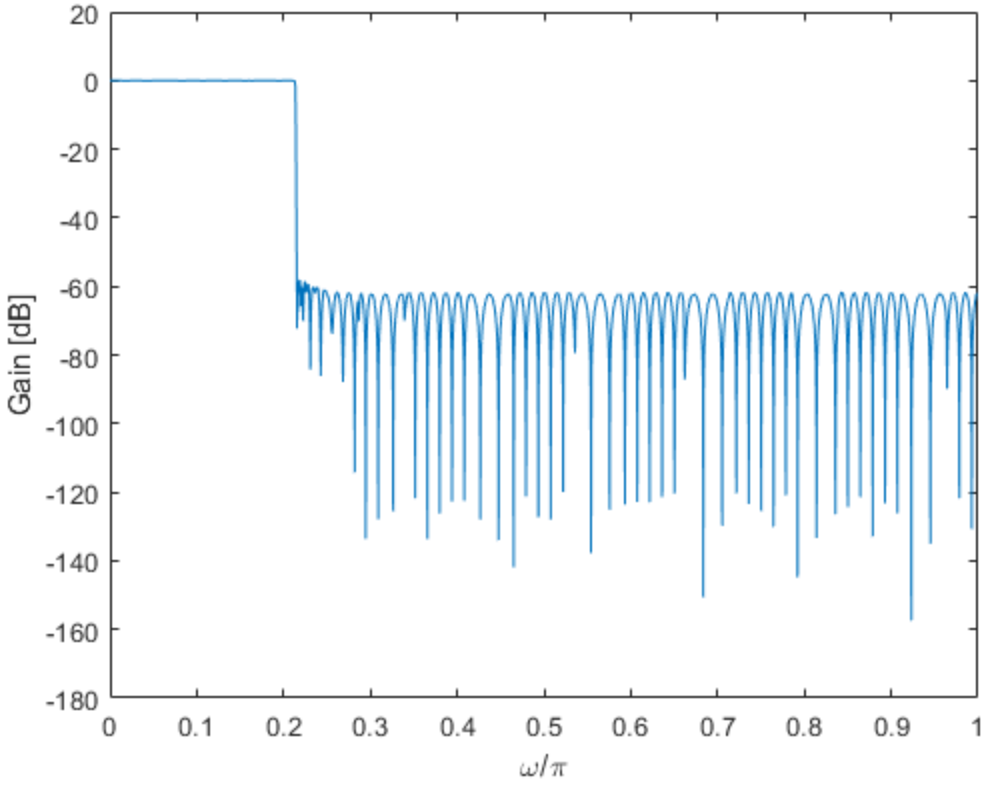
```
    end
    if N1>N2
        f1=f1p;
        f2=zeros(size(f1));
        f2((N1-N2)/2+1:(N1-N2)/2+length(f2p))=f2p;
    else
        f2=f2p;
        f1=zeros(size(f2));
        f1((N2-N1)/2+1:(N2-N1)/2+length(f1p))=f1p;
    end

    G_M=(A0ptMuk+A1ptMuk)/2;
    Gc_M=(A0ptMuk-A1ptMuk)/2;
    [F1,w]=freqz(f1,1,broj_tacaka_f_kk);
    [F2,w]=freqz(f2,1,broj_tacaka_f_kk);
    G_Mqq=(A0ptMukqq+A1ptMukqq)/2;
    Gc_Mqq=(A0ptMukqq-A1ptMukqq)/2;
    [F1qq,w]=freqz(round(f1*2^bb)/(2^bb),1,broj_tacaka_f_kk);
    [F2qq,w]=freqz(round(f2*2^bb)/(2^bb),1,broj_tacaka_f_kk);

figure,plot(w/pi,20*log10((abs(G_M))),w/pi,20*log10((abs(Gc_M))),w/pi,20*log10((abs(F1))),w/pi,20
*log10((abs(F2))));
    xlabel('\omega/\pi'); ylabel('Gain [dB]');

legend('G(e^{j\omegaM})','G_c(e^{j\omegaM})','F_1(e^{j\omega})','F_2(e^{j\omega})','location','NE
O');
    ylim([-140 20]);
    figure,plot(w/pi,20*log10((abs(G_M)).*(abs(F1))),w/pi,20*log10((abs(Gc_M)).*(abs(F2))));
    xlabel('\omega/\pi'); ylabel('Gain [dB]');

legend('G(e^{j\omegaM})*F_1(e^{j\omega})','G_c(e^{j\omegaM})*F_2(e^{j\omega})','location','NEO');
    ylim([-140 20]);
    figure,plot(w/pi,20*log10(abs(G_M.*F1+Gc_M.*F2)));
    xlabel('\omega/\pi'); ylabel('Gain [dB]');
    ylim([-180 20]);

figure,plot(w/pi,20*log10(abs(G_M.*F1+Gc_M.*F2)),w/pi,20*log10(abs(G_Mqq.*F1qq+Gc_Mqq.*F2qq)));
    xlabel('\omega/\pi'); ylabel('Gain [dB]');
    ylim([-140 20]);
    legend('MATLAB','Kvantizovani koeficijenti','location','NEO');


figure,plot(w/pi,20*log10((abs(G_M))),w/pi,20*log10((abs(Gc_M))),w/pi,20*log10((abs(F1))),w/pi,20
*log10((abs(F2))),w/pi,20*log10(abs(G_M.*F1+Gc_M.*F2)),'k');
    xlabel('\omega/\pi'); ylabel('Gain [dB]');

legend('G(e^{j\omegaM})','G_c(e^{j\omegaM})','F_1(e^{j\omegaw})','F_2(e^{j\omega})','H(e^{j\omega
})','location','NEO');
    ylim([-140 20]);
    figure,plot(w/pi,((abs(G_M))),w/pi,((abs(Gc_M))),w/pi,((abs(F1))),w/pi,((abs(F2)))); hold on
    plot(w/pi,(abs(G_M.*F1+Gc_M.*F2)),'k','linewidth',2);
    xlabel('\omega/\pi'); ylabel('{\fontname{Monotype Corsiva}M} (\omega)');
```

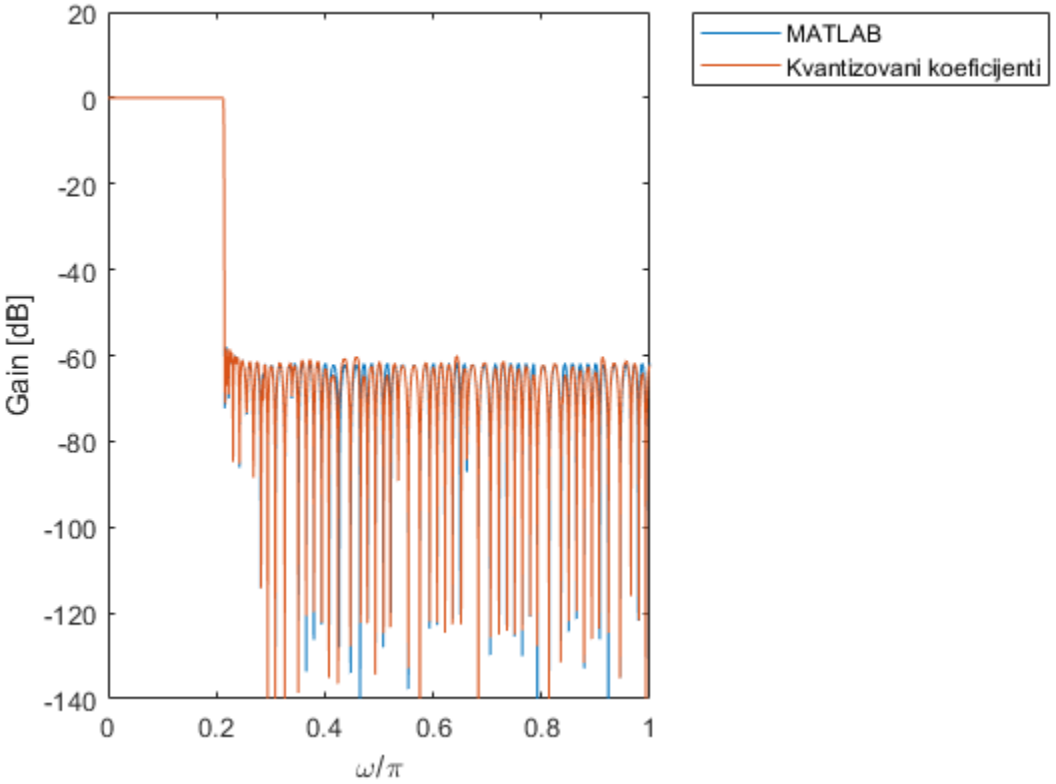
```
legend('G(e^{j\omegaM})','G_c(e^{j\omegaM})','F_1(e^{j\omega})','F_2(e^{j\omega})','H(e^{j\omega}
)','location','NEO');
    ylim([0 1.1]);

figure,plot(w/pi,20*log10(abs(Gpv)),w/pi,20*log10(abs(Gpvqq)),w/pi,20*log10(abs(G_M.*F1+Gc_M.*F2)
),w/pi,20*log10(abs(G_Mqq.*F1qq+Gc_Mqq.*F2qq)));
    xlabel('\omega/\pi'); ylabel('Gain [dB]');
    ylim([-140 20]);
    legend('MATLAB pv','Kvantizovani koeficijenti pv','MATLAB','Kvantizovani
koeficijenti','location','NEO');
    Filtar={'Direktan IIR';'Direktan IIR - All Pass A_0';'Direktan IIR - All Pass A_1';'Prototip
IIR';'Prototip IIR - All Pass A_0';'Prototip IIR - All Pass A_1';'Maskirajuci F_1';'Maskirajuci
F_2'};
    Red_filtra={num2str(Ndd);num2str(2*NOdd);num2str(2*N1dd-
1);num2str(Npt);num2str(2*NOpt);num2str(2*N1pt-1);num2str(N1);num2str(N2)};
    T=table(Filtar,Red_filtra)
```

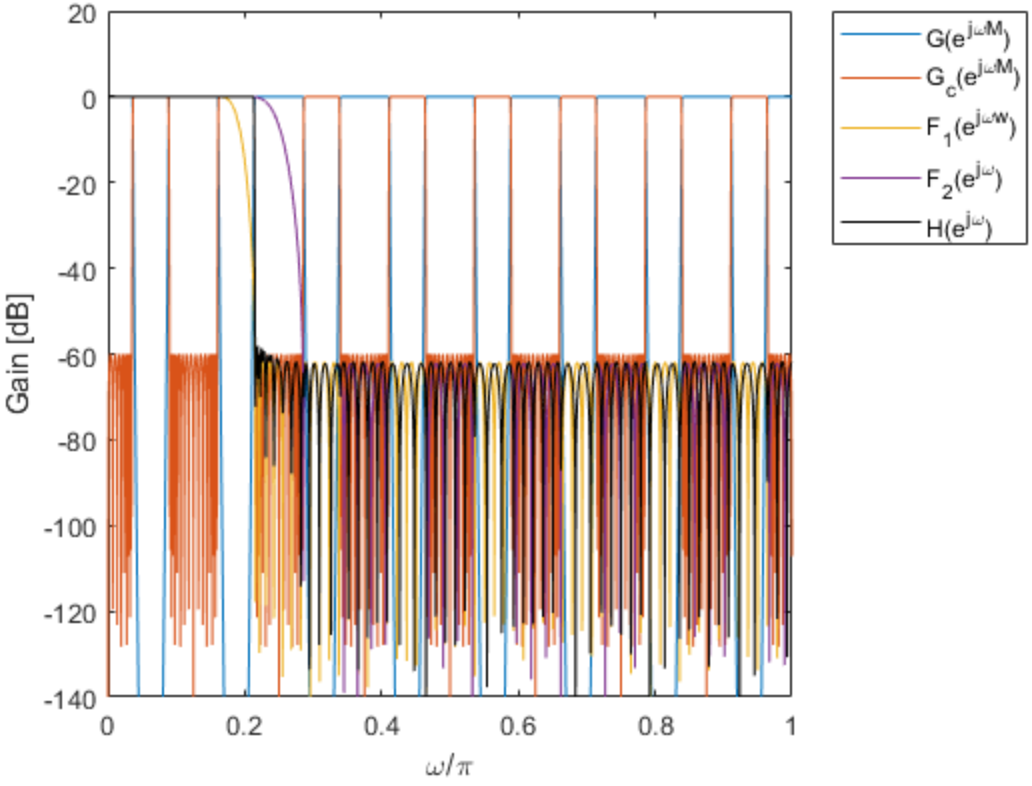
```
T =

  8×2 table

               Filtar                 Red_filtra
    ____________________________    __________

    {'Direktan IIR'               }     {'49' }
    {'Direktan IIR - All Pass A_0'}     {'24' }
    {'Direktan IIR - All Pass A_1'}     {'25' }
    {'Prototip IIR'               }     {'21' }
    {'Prototip IIR - All Pass A_0'}     {'10' }
    {'Prototip IIR - All Pass A_1'}     {'11' }
    {'Maskirajuci F_1'            }     {'140'}
    {'Maskirajuci F_2'            }     {'94' }
```

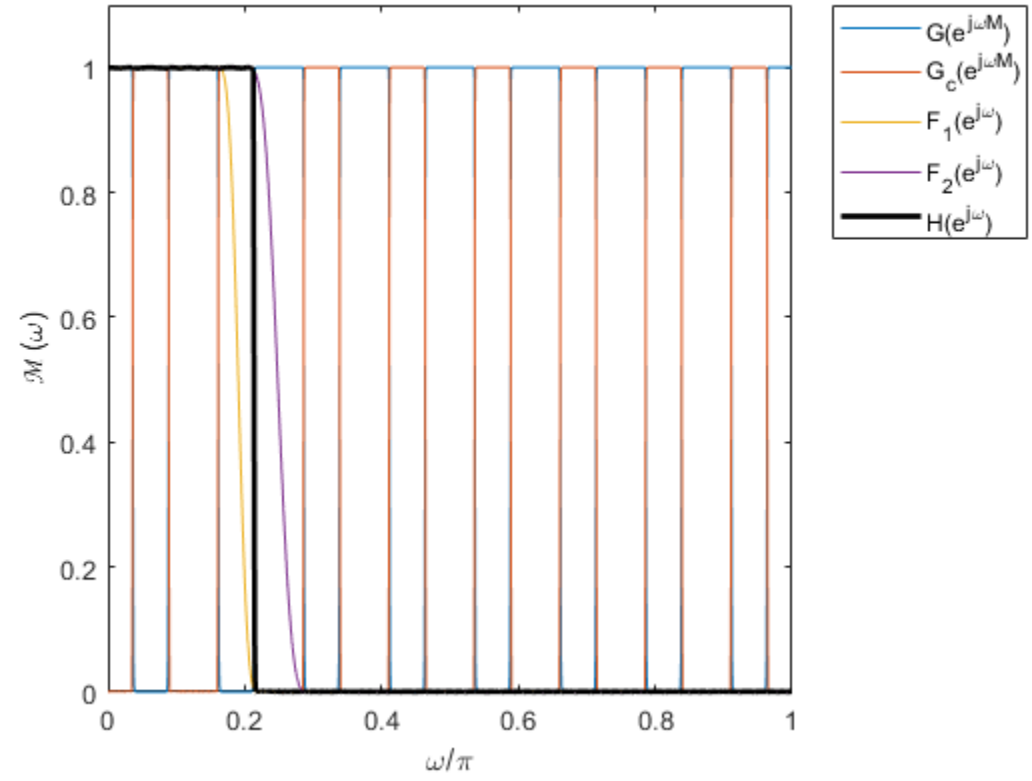

20
0
-20
-40
-60
-80
-100
-120
-140
Gain [dB]
0
0.2
0.4
0.6
0.8
1
ω/π
G(e^jω/M)
G_c(e^jω/M)
F_1(e^jω)
F_2(e^jω)

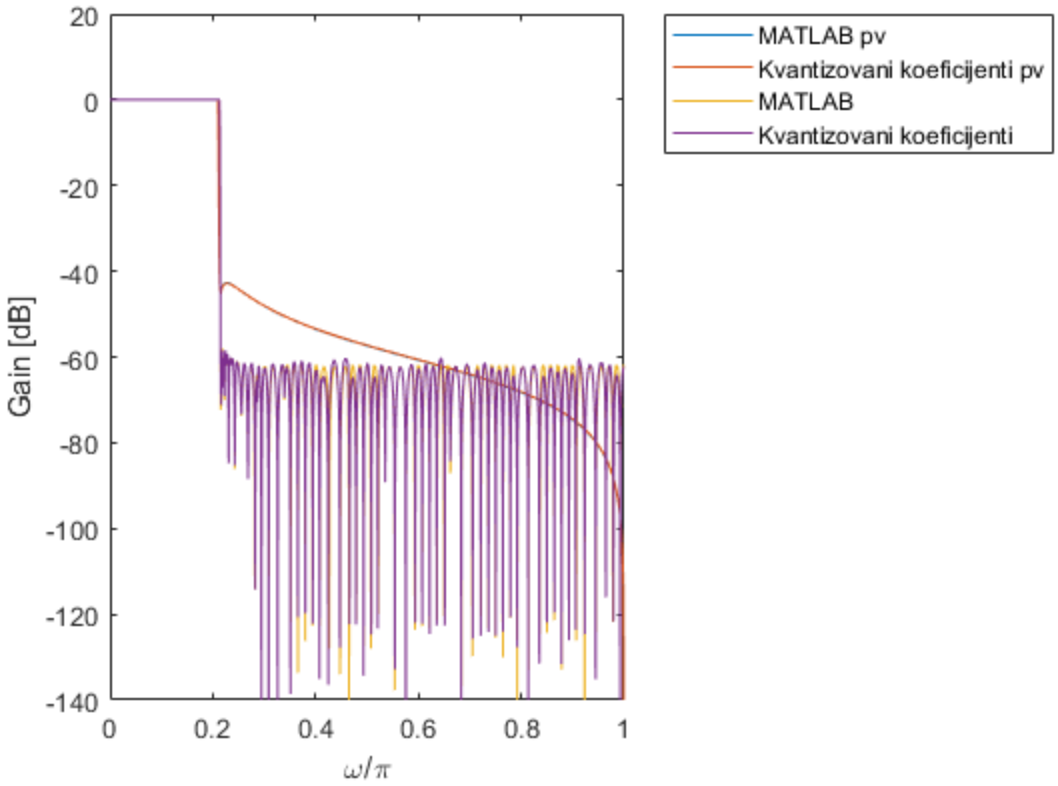

20
0
-20
-40
-60
-80
-100
-120
-140
Gain [dB]
0
0.2
0.4
0.6
0.8
1
ω/π
G(e^jω/M)*F_1(e^jω)
G_c(e^jω/M)*F_2(e^jω)


20
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
Gain [dB]
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
ω/π


MATLAB
Kvantizovani koeficijenti
20
0
-20
-40
-60
-80
-100
-120
-140
Gain [dB]
0
0.2
0.4
0.6
0.8
1
ω/π


20
0
-20
-40
-60
-80
-100
-120
-140
Gain [dB]
0
0.2
0.4
0.6
0.8
1
ω/π
G(e^jωM)
G_c(e^jωM)
F_1(e^jωW)
F_2(e^jω)
H(e^jω)


1
0.8
0.6
0.4
0.2
0
M(ω)
0
0.2
0.4
0.6
0.8
1
ω/π
G(e^jωM)
G_c(e^jωM)
F_1(e^jω)
F_2(e^jω)
H(e^jω)




```
end
```

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