6.3.18 $N=41$, $SL=-30\,dB$, $\bar{n}=6$

- note: Beampattern and sensitivity affected by $\bar{w}_{dq}$ normalization. Beampattern is not 0 dB at $u_s=0$.

- array gain not affected by normalization

- Villeneuve MVDR beamformer maintains low sidelobes and nulls interferers outside the main beam

- MVDR does not protect desired signal as well as MVDR, but has less sensitivity

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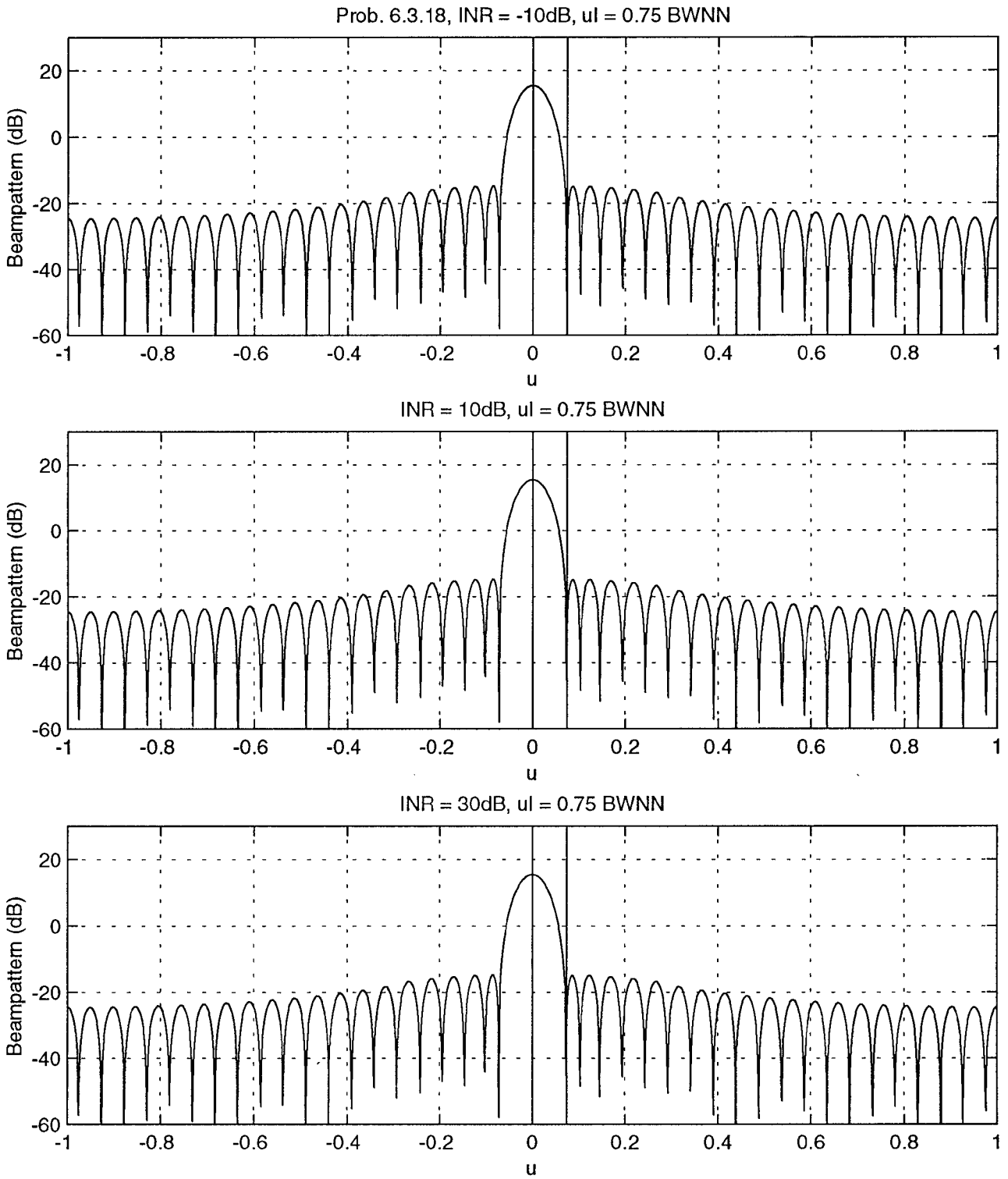
Prob. 6.3.18, INR = -10dB, ul = 0.75 BWNN
Beampattern (dB)
20
0
-20
-40
-60
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
u
INR = 10dB, ul = 0.75 BWNN
Beampattern (dB)
20
0
-20
-40
-60
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
u
INR = 30dB, ul = 0.75 BWNN
Beampattern (dB)
20
0
-20
-40
-60
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
u

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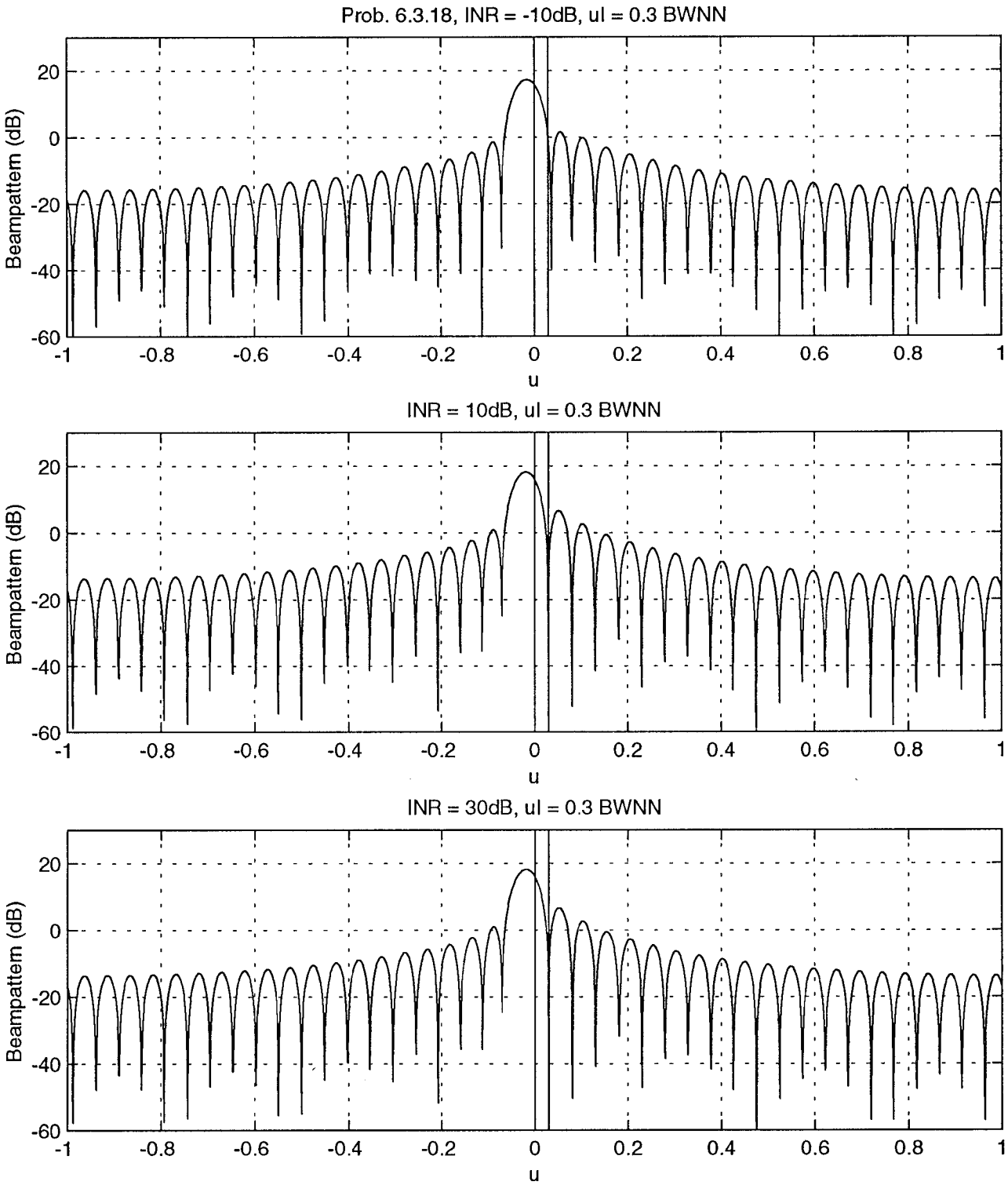
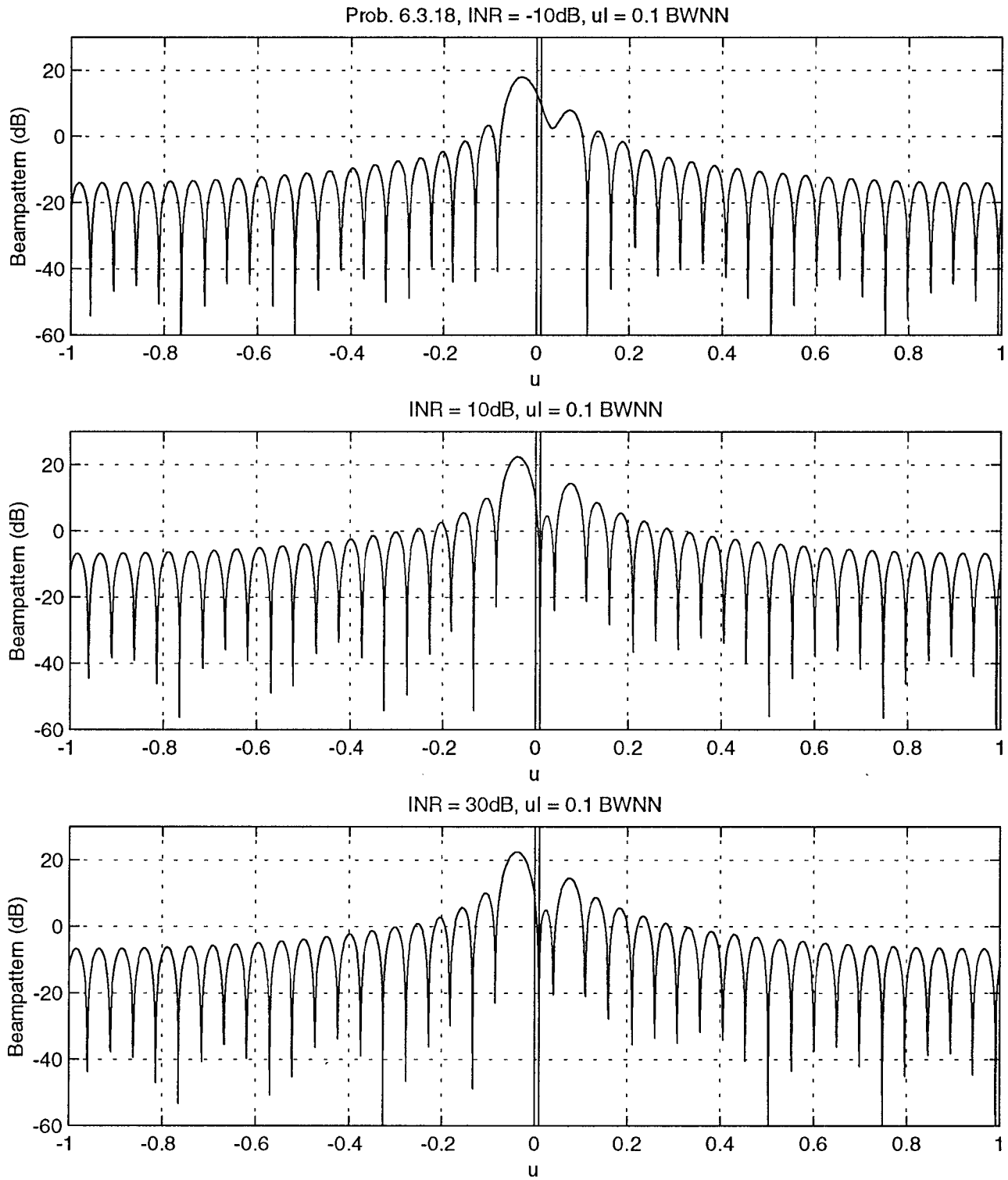
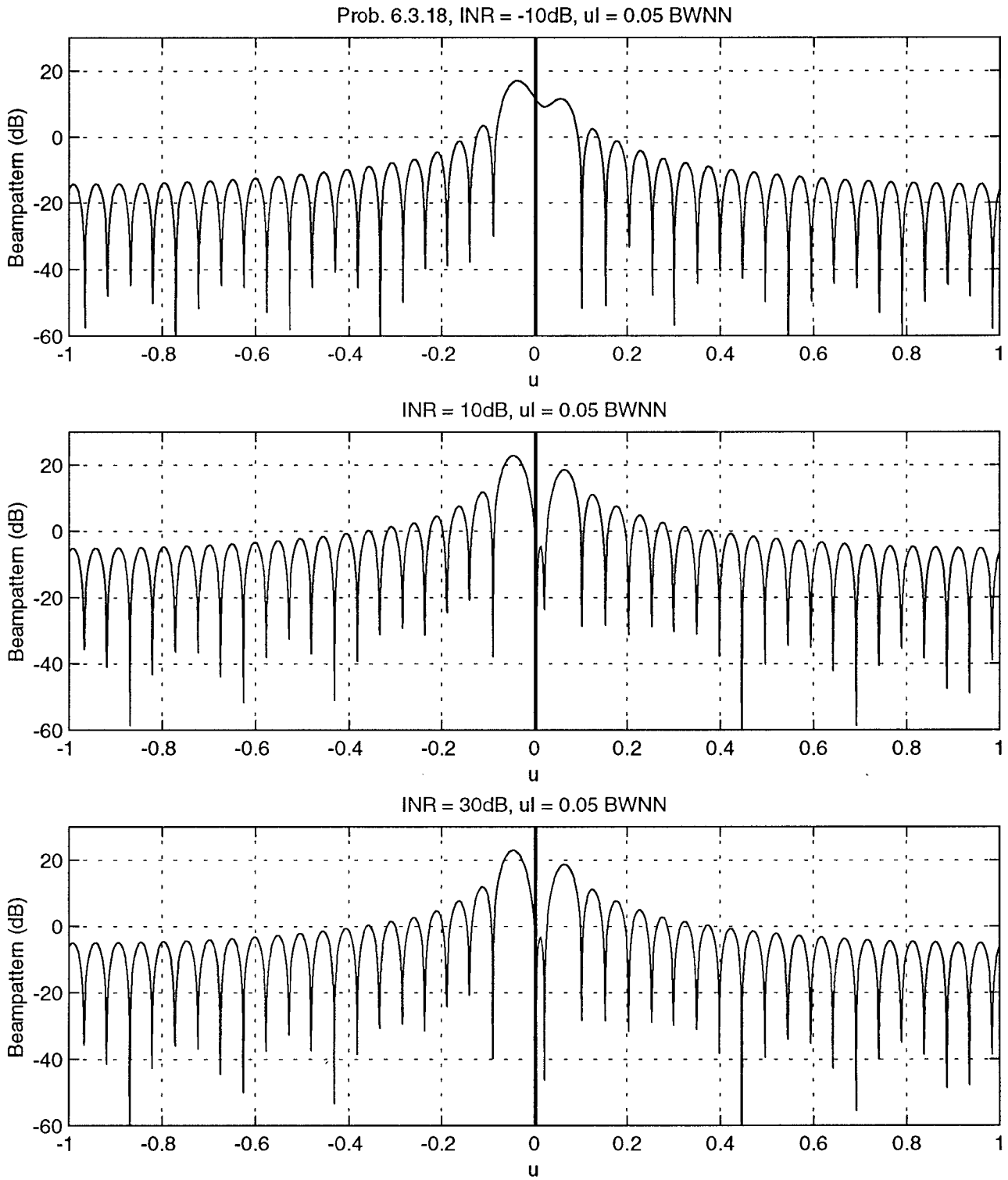

Prob. 6.3.18, INR = -10dB, ul = 0.3 BWNN
Beampattern (dB)
20
0
-20
-40
-60
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
u
INR = 10dB, ul = 0.3 BWNN
Beampattern (dB)
20
0
-20
-40
-60
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
u
INR = 30dB, ul = 0.3 BWNN
Beampattern (dB)
20
0
-20
-40
-60
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
u

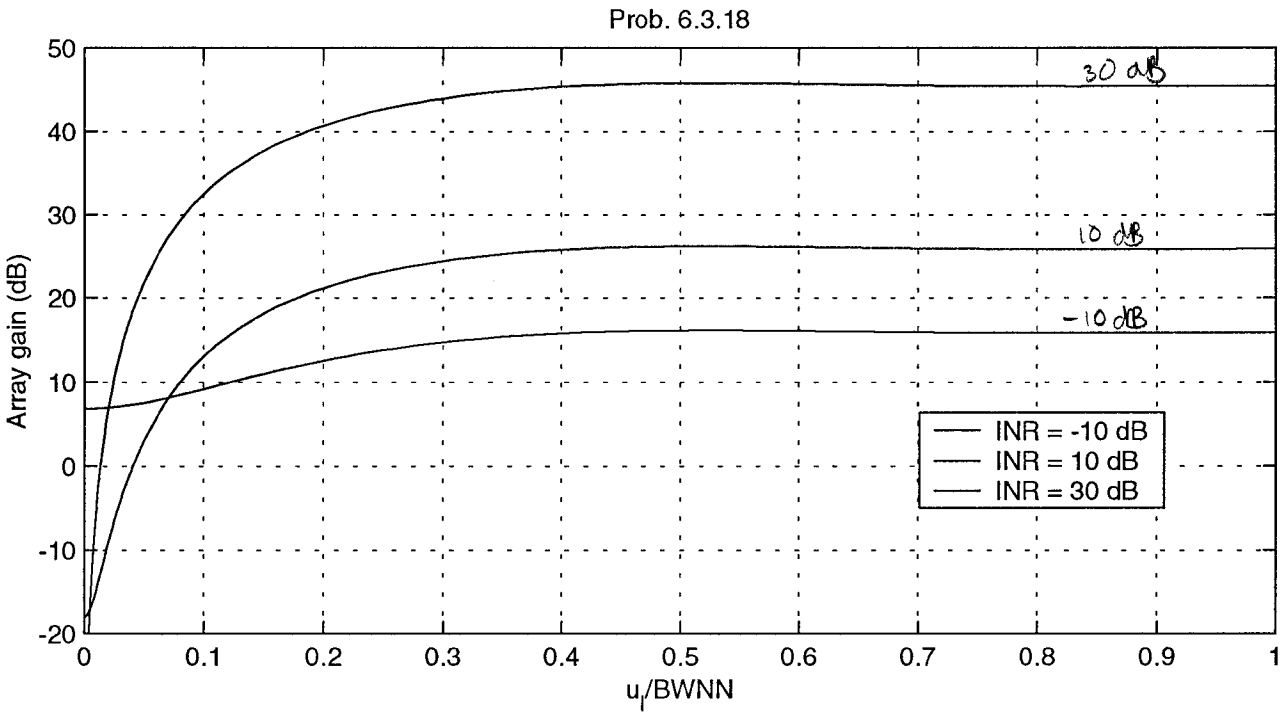
6.3.18 4/8

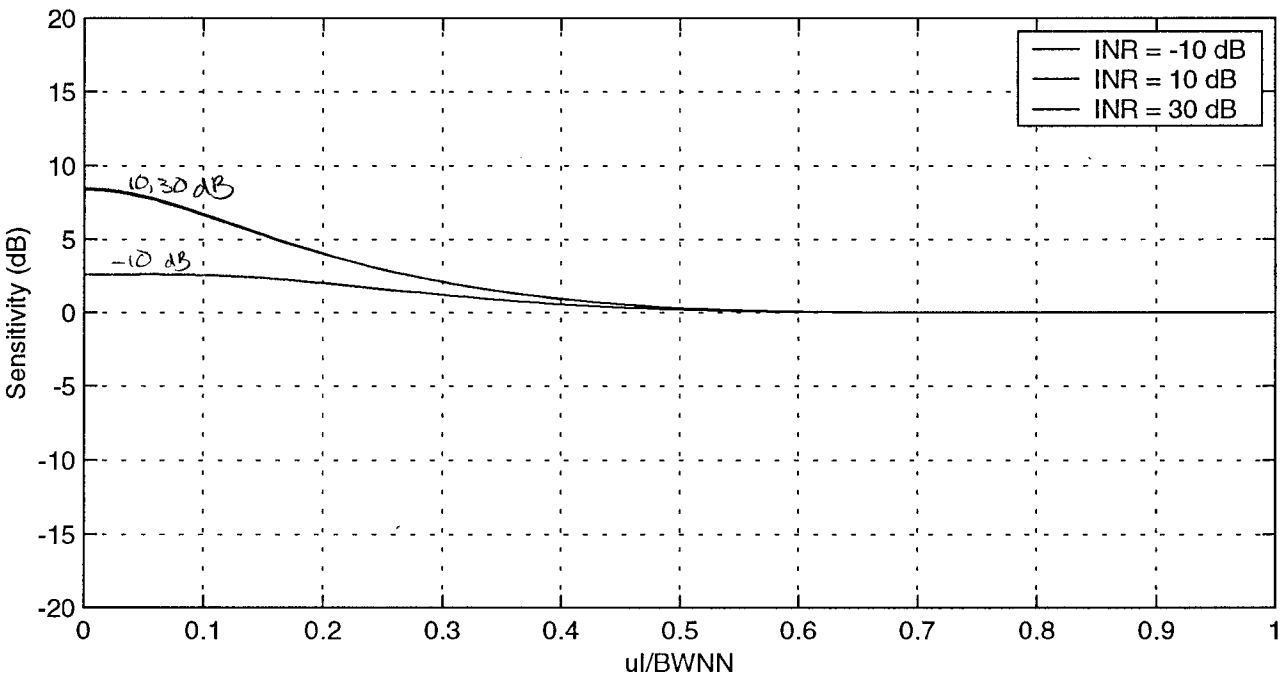

Prob. 6.3.18, INR = -10dB, ul = 0.1 BWNN
Beampattern (dB)
20
0
-20
-40
-60
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
u
INR = 10dB, ul = 0.1 BWNN
Beampattern (dB)
20
0
-20
-40
-60
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
u
INR = 30dB, ul = 0.1 BWNN
Beampattern (dB)
20
0
-20
-40
-60
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
u

6.3.18 5/8


Prob. 6.3.18, INR = -10dB, ul = 0.05 BWNN
Beampattern (dB)
20
0
-20
-40
-60
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
u
INR = 10dB, ul = 0.05 BWNN
Beampattern (dB)
20
0
-20
-40
-60
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
u
INR = 30dB, ul = 0.05 BWNN
Beampattern (dB)
20
0
-20
-40
-60
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
u

6.3.18 6/8


Prob. 6.3.18
Array gain (dB)
u/BWNN
30 dB
10 dB
-10 dB
INR = -10 dB
INR = 10 dB
INR = 30 dB


Sensitivity (dB)
ul/BWNN
10,30 dB
-10 dB
INR = -10 dB
INR = 10 dB
INR = 30 dB

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```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% problem 6.3.18
% K. Bell 11/29/98
% updated by K. Bell 11/17/00
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

clear all
close all

%************************
% Array
%************************
N = 41;                                  % Elements in array
d = 0.5;                                 % sensor spacing half wavelength wrt wc
D = [-(N-1)/2:1:(N-1)/2].';
BWNN = 2/(N*d);
u=[-1:0.001:1];
uI = [[1:-0.01:0.05] [0.04:-0.001:0]]*BWNN;
nI = length(uI);
nu=length(u);
vv = exp(j*pi*D*u);
vI = exp(j*pi*D*uI);

sigma_i = 10.^([-10 10 30]/10);

%************************
% Source
%************************
us = 0.0;
AS = exp(j*pi*D*us);
sigma_n = 1;
sigma_s = 1;
SINRin = sigma_s./(sigma_i+sigma_n);

SL = -30;
nbar = 6;
x0 = cosh(acosh(10^(-SL/20))/(N-1));
cc=cos((2*[1:1:floor((N-1)/2)]-1)*0.5*pi/(N-1)).';
udc = acos(cc/x0)/(pi*d);
uu = [1:1:(N-1)/2].'/(N*d);
u_nbar = udc(nbar) ;       % u_nbar Chebychev
sigma = nbar/(N*d*u_nbar);
udcmod = udc*sigma;              % modified Chebychev
uz = [udcmod(1:nbar-1);uu(nbar:(N-1)/2)];
ut = [uz;-uz];
w = poly(exp(j*2*pi*d*ut)).';
wq=w/sum(w);
wdq = wq/norm(wq);

Rs = sigma_s*AS*AS';

Tq = zeros(2,nI);
Aq = zeros(2,nI);

for n=1:nI
   for k=1:3
      Sn = sigma_i(k)*vI(:,n)*vI(:,n)'+sigma_n*eye(N);
      Sninv = inv(Sn);
      wq = Sninv*wdq/real(wdq'*Sninv*wdq);
      Tq(k,n) = 10*log10(real(wq'*wq));
      Aq(k,n) = 10*log10(real((wq'*Rs*wq)/(wq'*Sn*wq))/SINRin(k));
      Bq(k,:) = 10*log10(abs(wq'*vv).^2);

      if uI(n)==0.75*BWNN | uI(n)==0.3*BWNN |uI(n)==0.1*BWNN|uI(n)==0.05*BWNN
         if k==1
            figure
```

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```
            set(gcf,'Paperposition',[0.25 1 8 9])
         end

         subplot(3,1,k)
         plot(u,Bq(k,:),'-g');
         hold on
         plot(us*[1 1],[-60 30],'c')
         plot(uI(n)*[1 1],[-60 30],'r')
         xlabel('u')
         ylabel('Beampattern (dB)')
         grid on
         hold off
         if k==1
            title(['Prob. 6.3.18, INR = ' num2str(10*log10(sigma_i(k))) 'dB, uI = '
num2str(uI(n)/BWNN) ' BWNN'])
         else
            title(['INR = ' num2str(10*log10(sigma_i(k))) 'dB, uI = ' num2str(uI(n)/BWNN)
' BWNN'])
         end
         axis([-1 1 -60 30])
         set(gca,'Ytick',[-60 -40 -20 0 20])
      end
   end
end

figure
subplot(2,1,1)
plot(uI/BWNN,Aq);
title('Prob. 6.3.18')
legend('INR = -10 dB','INR = 10 dB','INR = 30 dB')
axis([0 1 -20 50])
grid on
xlabel('u_I/BWNN')
ylabel('Array gain (dB)')

subplot(2,1,2)
plot(uI/BWNN,Tq);
legend('INR = -10 dB','INR = 10 dB','INR = 30 dB')
axis([0 1 -20 20])
grid on
xlabel('uI/BWNN')
ylabel('Sensitivity (dB)')
set(gcf,'Paperposition',[0.25 1 8 9])
```