Appendix F: A general-purpose program for designing the linear-phase FIR filters in the minimax sense

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**********************************************************************************************
% Matlab m-file (firgen.m)
% for designing a multiband  FIR filter using the
% the Remez algorithm
%
% Tapio Saramaki  16.10.95

clear all
disp('I am a program for designing a multiband FIR')
disp('filter with the aid of the Remez routine.')
disp('I assume that the desired function as well')
disp('as the permissible error in each band are')
disp('constants')
nbands=input('Number of bands: ');
for k=1:nbands
  disp(' ')
  fprintf('Band number %g.\',k)
  disp(' ')
  wc(2*k-1)=input('Lower edge as a fraction of pi: ');
  wc(2*k)=input('Upper edge as a fraction of pi: ');
  m(k)=input('Desired constant in the band: ');
  d(k)=input('Permissible deviation in the band: ');
  wwc(4*(k-1)+1)=wc(2*k-1);
  wwc(4*(k-1)+2)=wc(2*k);
  m2(2*k-1)=m(k);
  d2(2*k-1)=d(k);
  mm(2*k-1)=m(k);
  dd(2*k-1)=d(k);
  mmm(2*k-1)=m(k);
  ddd(2*k-1)=d(k);
end
%order estimation
  for k=1:2*nbands-2
  f(k)=wc(k+1);end
  dev=d;
  ma=m;
  end
[N,fo,mo,w] = remezord(f,ma,dev);
for k=1:nbands-1
  a=(wwc(4*k+1)-wwc(4*k-2))/500;
  wwc(4*k-1)=wwc(4*k-2)+a;
  wwc(4*k)=wwc(4*k+1)-a;
  amax=max(m2(2*k-1)+d2(2*k-1),m2(2*k+1)+d2(2*k+1));
  amin=min(m2(2*k-1)-d2(2*k-1),m2(2*k+1)-d2(2*k+1));
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  dd(2*k)=(amax-amin)/2
  mm(2*k)=(amax+amin)/2
  amax=max(m2(2*k-1)+d2(2*k-1),m2(2*k+1)+d2(2*k+1));
  amin=-amax;
  ddd(2*k)=amax
  mmm(2*k)=0.
end
disp('Type 0 for not taking, 1 for taking care')
disp('of the transition band ripples such that')
disp('the limits are 1+delta_p and -delta_s, and')
disp('2 for the limits 1+delta_p and -(1-delta_p)')
itype=input('your selection: ');
if itype==0
  for k=1:2*nbands-2
  f(k)=wc(k+1);end
  dev=d;
  ma=m;
end
if itype==1
  nbands=2*nbands-1;
  for k=1:2*nbands-2
  f(k)=wwc(k+1);end
  dev=dd;
  ma=mm;
end
if itype==2
  nbands=2*nbands-1;
  for k=1:2*nbands-2
  f(k)=wwc(k+1);end
  dev=ddd;
  ma=mmm;
end
[N1,fo,mo,w] = remezord(f,ma,dev);
fo(1)=wc(1);
%error in remezord !!!!!
for k=1:length(dev)
w(k)=1/dev(k);end
if itype==0 fo(2*nbands)=wc(2*nbands);end
if itype > 0 fo(2*nbands)=wwc(2*nbands);end
fprintf('Estimated order is %g.\',N)
N=input('Your initial selection for N:  ')
h = remez(N,fo,mo,w);
%test for meeting the criteria
isu=0
for k=1:nbands
  [a1,z]=zeroam(h,fo(2*k-1),fo(2*k-1),1);
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  [a2,z]=zeroam(h,fo(2*k),fo(2*k),1);
  if abs(a1-ma(k)) > dev(k) isu=1;end
  if abs(a2-ma(k)) > dev(k) isu=1;end
end
increase=1;
if isu==0 increase=0;end
if isu==0 hs=h;NS=N;end
%increase the order by 2 until the
%criteria are met
if increase==1
  ll=0
    while ll < 1
    N=N+2;
N
    h = remez(N,fo,mo,w);
%test for meeting the criteria
    isu=0
    for k=1:nbands
      [a1,z]=zeroam(h,fo(2*k-1),fo(2*k-1),1);
      [a2,z]=zeroam(h,fo(2*k),fo(2*k),1);
      if abs(a1-ma(k)) > dev(k) isu=1;end
      if abs(a2-ma(k)) > dev(k) isu=1;end
    end
    if isu==0 ll=1;
    hs=h;NS=N;end
    end
end
%decrease the order by 2 until the
%criteria are just met
if increase==0
  ll=0
    while ll < 1
    N=N-2;
    h = remez(N,fo,mo,w);
%test for meeting the criteria
    isu=0
    for k=1:nbands
      [a1,z]=zeroam(h,fo(2*k-1),fo(2*k-1),1);
      [a2,z]=zeroam(h,fo(2*k),fo(2*k),1);
      if abs(a1-ma(k)) > dev(k) isu=1;end
      if abs(a2-ma(k)) > dev(k) isu=1;end
    end
    ll=1
    if isu==0 ll=0;
    hs=h;NS=N;end
    end
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end
%test whether the criteria are met by
%N=NS-1
%If yes, increase the order by 2 until the
%criteria are just met
N=NS+1
  ll=0
    while ll < 1
    N=N-2;
    h = remez(N,fo,mo,w);
%test for meeting the criteria
    isu=0
    for k=1:nbands
      [a1,z]=zeroam(h,fo(2*k-1),fo(2*k-1),1);
      [a2,z]=zeroam(h,fo(2*k),fo(2*k),1);
      if abs(a1-ma(k)) > dev(k) isu=1;end
      if abs(a2-ma(k)) > dev(k) isu=1;end
    end
    ll=1
    if isu==0 ll=0;
    hs=h;NS=N;end
    end
end
fprintf('Minimum order is %g.\',NS)
figure(1)
[H,W]=freqz(hs,1,1024);
plot(W/pi,20*log10(abs(H)));grid;
ylabel('Amplitude in dB'); xlabel('Angular frequency omega/pi');
figure(2)
impz(hs); grid;
xlabel('n in samples');
ylabel('Impulse response');
figure(3)
zplane(hs);title('Zero plot')
```