7 DIGITAL FILTER REALIZATION

Example 7 Compare direct FIR filter realization with overlap-add computation in the frequency domain

Transfer function of FIR filter is

$$H(z)=\sum_{k=0}^{9} h(k)\,z^{-k}\text{ , where } h(k)\in\langle 0,1)\text{ is random vector}$$

and input vector is random signal $\{x(n),\,0\le n<1000\}$

Solution

```
h=rand(1,10);                  % generate random transfer function (N2=10)
x=rand(1,1000)                 % generate random input function
yr=filter(h,1,x);              % reference computation by filter function
N=32;                          % FFT size used in overlap-add method
y=ola(x,h,N)                   % computation by overlap-add method
subplot(2,1,1), plot(yr)       % compare results
subplot(2,1,2),
plot(real(y(1:1000))-yr);      % note that output y is (in general) complex so real part is taken
                               % also note that only the first 1000 samples is compared, convolution
                               % provides (1000+10-1=1009 samples)
```

Questions

What size of FFT is optimal? Try to use different sizes of N.
Is it possible to use this approach for IIR filtration?
Try to approximate IIR filtration by FIR filtration in the frequency domain.

Example 8 Compute state-space representation of IIR filter from Example 1

Solution

```
[b,a,v,u,C]=iirdes('ell','p',[0.1 0.2 0.25 0.3]*pi,0.1,0.001);
[A,B,C,D]= tf2ss(b,a)                 % compute state space representation
```

Example 9 Show that transformation of the state-space representation by random nonsingular matrix P does not change filter transfer function

Solution

```
[b,a,v,u,C]=iirdes('ell','p',[0.1 0.2 0.25 0.3]*pi,0.1,0.001);
[A,B,C,D]= tf2ss(b,a)            % compute state space representation
P=rand(size(A))                  % take random matrix P with the same size as A
det(P)                           % check that inverse matrix exists – MUST have nonzero determinant!
invP=inv(P)                      % compute inverse matrix
AA=invP*A*P                      % find new state-space representation
BB=invP*B
CC=C*P
DD=D
[bb,aa]=ss2tf(AA,BB,CC,DD)       % find coefficients of direct form
aa-a                             % compare differences
bb-b
```