Experiment 10
Impulse Invariant Method

Aim

To design IIR filter using impulse invariant method and study its response.

Theory

Impulse invariant technique is based on keeping the impulse response of the analog filter invariant. The design starts with analog impulse response $h(n)$ designed using analog design method and then directly samples the analog impulse response to get the impulse response of the digital filter $h(nT)$. For detailed theory the reader is requested to refer Chapter 8 on IIR filter design.

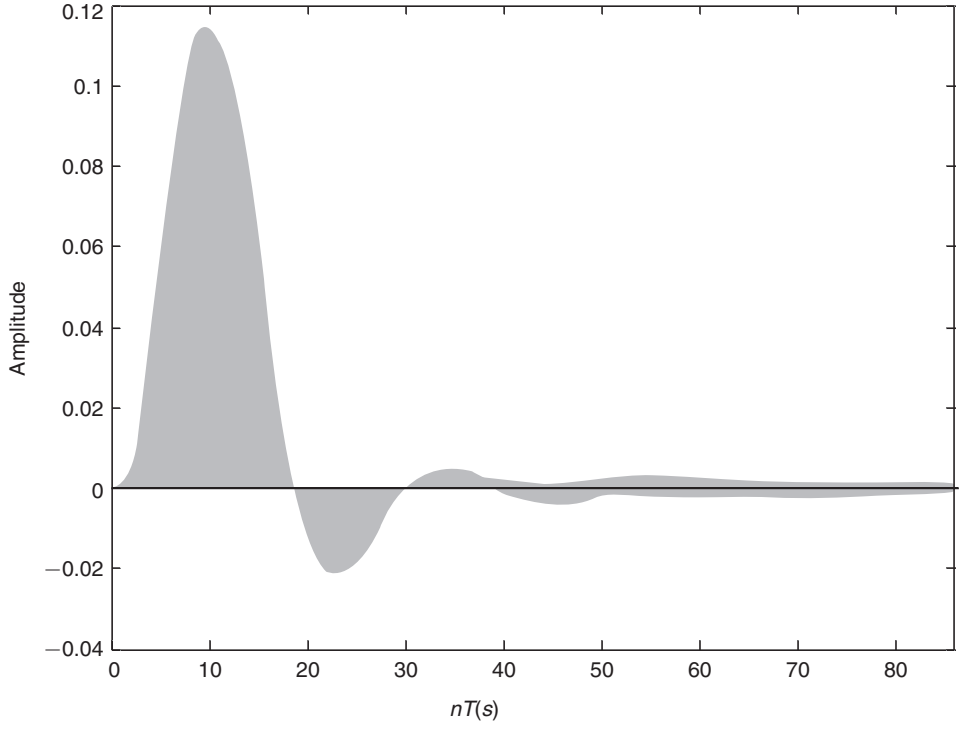

Figure 1 Impulse response of the filter using impulse invariant method.

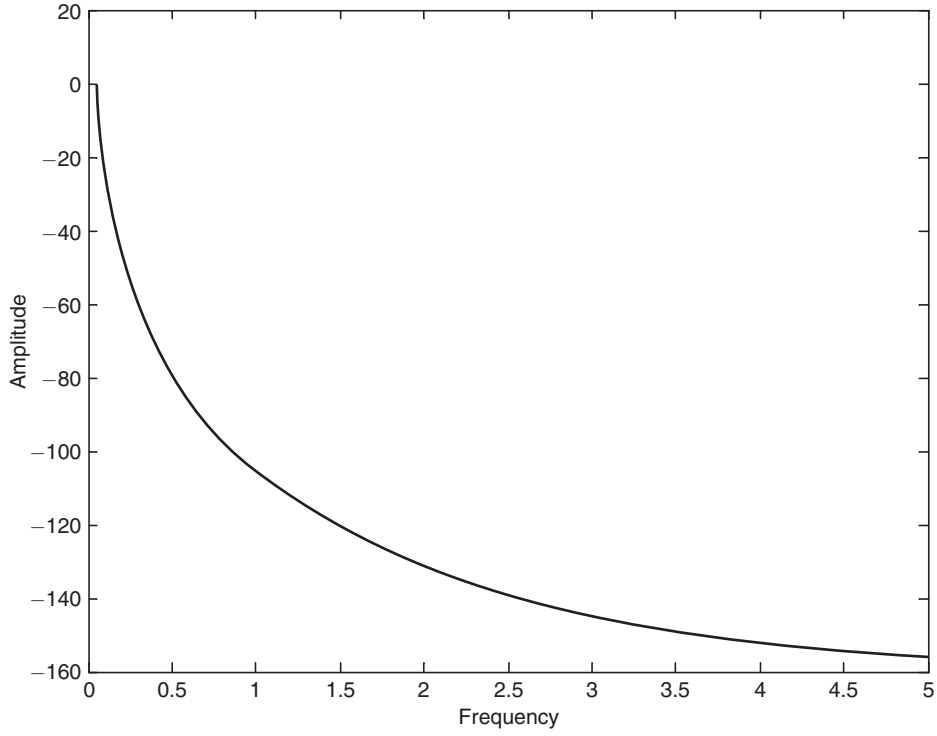

Figure 2 The magnitude plot of the filter using impulse invariant method.

Experiment

We will use "impinvar" command in MATLAB to design the IIR filter using impulse invariant method. First we will use "butter" command to design analog Butterworth filter as per our specifications like cut-off frequency and type of filter (low pass, high pass, etc.). Let us design an analog low-pass filter of order 4 with cut-off frequency of 0.3. We will then use "impinvar" command to convert the transfer function in analog domain to a DT domain using impulse invariant method. We will now plot the impulse response of the system using impulse function. The impulse response is plotted in Figure 1. We have used sampling frequency of 10. The MATLAB program is as follows.

```
%impulse invariant method
clear all;
for i=1:60,
    s(i)=i;
end
for i=1:60,
    z(i)=(1+s(i))/(1-s(i));
end
```

```
for i=1:60,
    s(i)=-i;
end
for i=1:60,
  z(i)=-(1+s(i))/(1-s(i));
end
plot(z);
[b,a]=butter(4,0.3,'s');
    [bz,az]=impinvar(b,a,10);
    [Ha,Wa]=freqs(b,a,512);
    [Hz,Wz]=freqz(bz,az,512,10);
    plot(Wa/(2*pi),20*log10(abs(Ha))); hold on;
    plot(Wz,20*log10(abs(Hz)))
```

Teaser *The reader is encouraged to verify the impulse response for the high pass filter and confirm that it will result in unstable filter.*