Experiment 5

Adaptive Line Enhancer

5.1 Aim: To design an adaptive line enhancer

5.2 Theory:

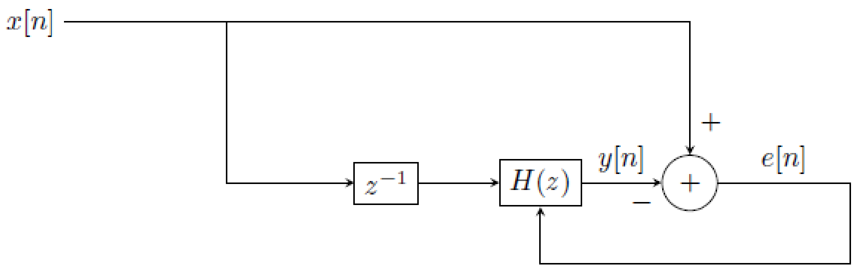


Figure 1: The system used for implementing the Adaptive Line Enhancer

In adaptive line enhancement, a measured signal x[n] contains two signals, a nearly-periodic signal m[n] and an unknown signal n[n]. It is based on the straightforward concept of linear prediction. A nearly-periodic signal can be perfectly predicted using linear combinations of its past samples, whereas a non-periodic signal cannot.

An adaptive filter is similar to linear predictor whose coefficients are varied based on the error signal. Its most common representation is as follows:

$$y[n] = \hat{x}[n] = \sum_{i=1}^{N} w[i]x[n-i]$$

Thus, the output of the filter (y[n]) is the predicted value (x[n]), which in turn is based on the N previous values of the signal, where N is the order of the filter. The filter coefficients are given by w[n]. In a linear predictor, they are chosen so as to minimise the expected value of the square of error, which is given by

$$\begin{aligned} e[n] &= y[n] - x[n] \\ &= \hat{x}[n] - x[n] \end{aligned}$$

Once we obtain the error of the k^{th} iteration, the values of the filter coefficients for the $(k + 1)^{th}$ iteration are updated according to the formula

$$\mathbf{w_{k+1}[n]} = \mathbf{w_k[n]} + \mu \mathbf{x[n]} e[n]$$

Where **μ** is a constant controlling the convergence rate. This procedure is repeated until the relative change in the filter coefficients is less than some predefined limit **ε**. This condition is given by

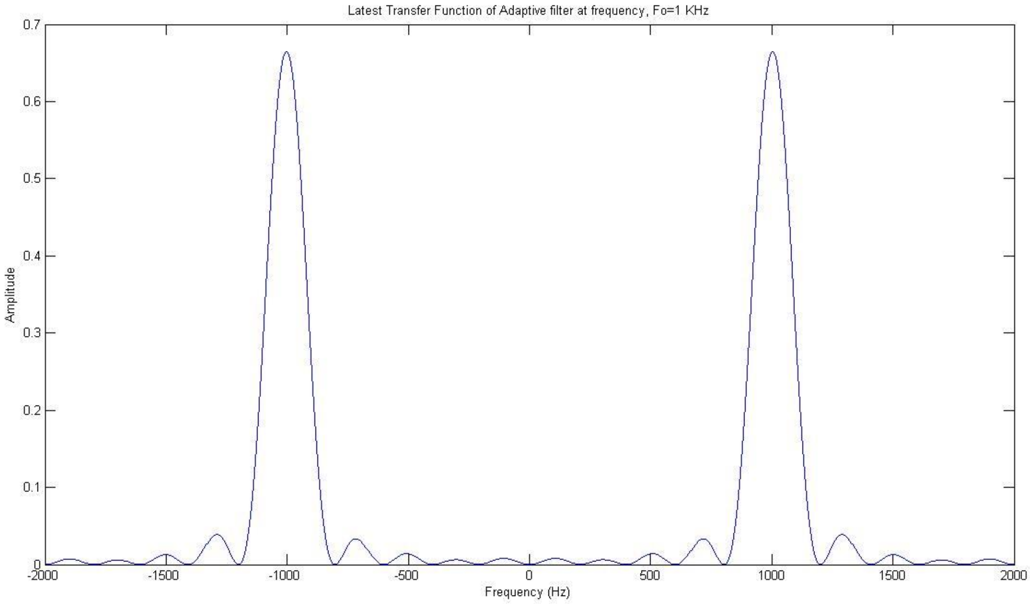
$$\frac{\|\mathbf{w}_{\mathbf{k+1}}[\mathbf{n}] - \mathbf{w}_{\mathbf{k}}[\mathbf{n}]\|^2}{\|\mathbf{w}_{\mathbf{k}}[\mathbf{n}]\|^2} \leq \epsilon$$

5.3 Source Code:

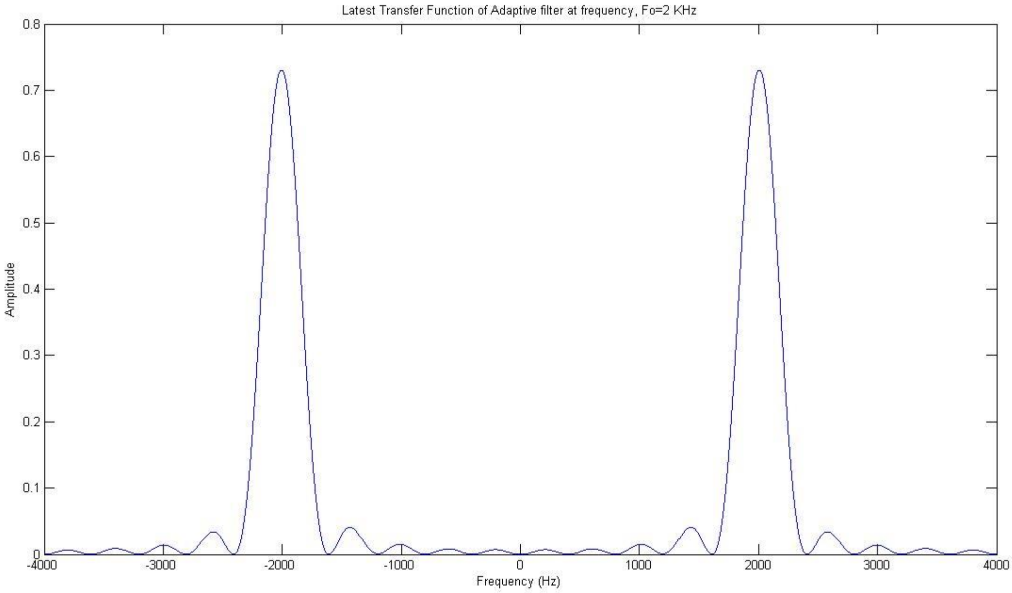
```
clc;clear all;close all;

A=2;
fo=20e3;
sampling_rate=80e3;
t=1:1/sampling_rate:2;

m=A*sin(2*pi*fo*t);
n=0.5*normrnd(0,1,1,length(t));
x=m+n;

figure;plot(n);title('Noise');
figure;
subplot(2,1,1); plot(t,m);title('Signal');
subplot(2,1,2); plot(t,x);title('Signal+Noise');

N=20;
w=zeros(1,N);%suppose N order filters

epsilon=1;%for the loop to iterate once
threshold=10e-8;i=0;mu=10e-4;
while  epsilon>threshold

    display(i);
    w_old=w;
    error(i+1,1)= x(1,i+N+1)-w*(x(N+i:-1:1+i))';
    w=w+mu*x(N+i:-1:1+i)*error(i+1,1);
    epsilon=(norm(w-w_old)/norm(w_old))^2;
    i=i+1;
end

[h, omega] = freqz(fliplr(w), 1, linspace(-pi,pi,1000));
figure;
plot (omega , abs (h) .^ 2) ;xlim ([ omega(1) , omega(length(omega))]);
```

5.5 RESULT:

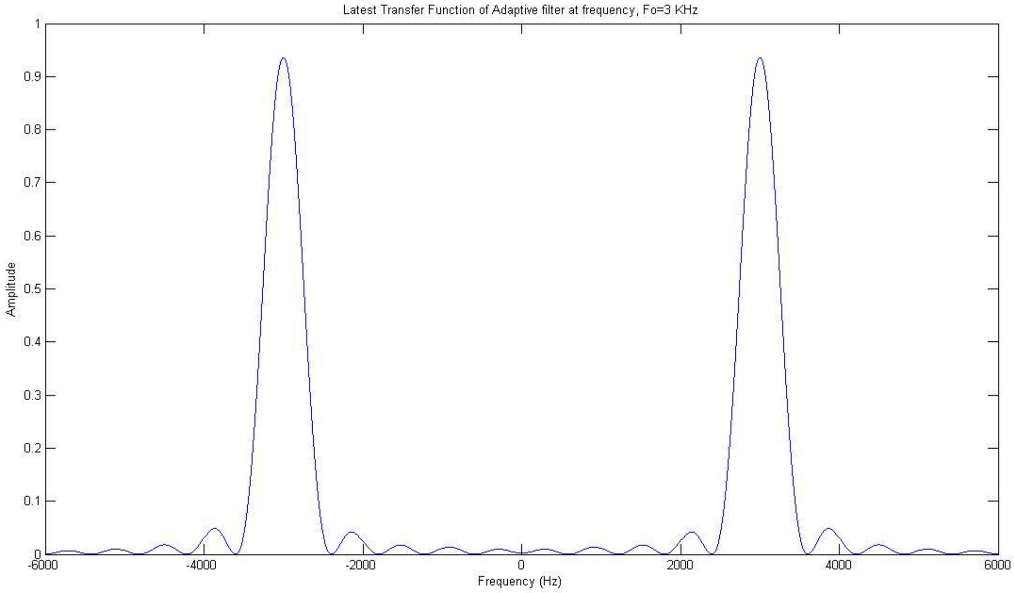
FREQUENCY= 1 KHZ



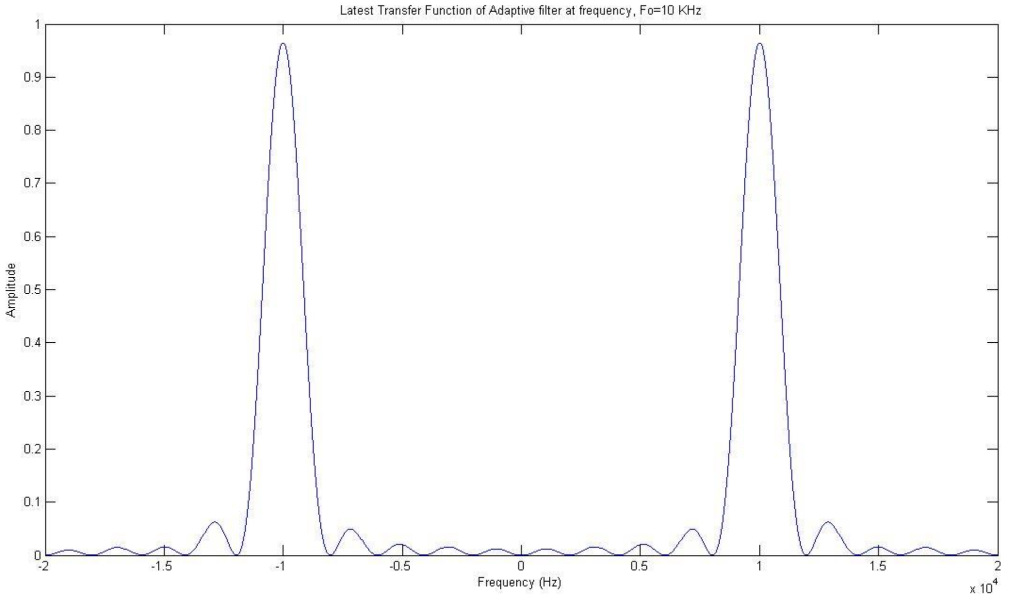
FREQUENCY= 2 KHZ



FREQUENCY= 3 KHZ



FREQUENCY FREQUENCY= 10 KHZ



5.5 Discussion: Deep Kiran Shroti

- Adaptive line enhancer is based on the concept of Linear Predictor.
- In linear predictor we predict future values from N-1 samples and filter coefficients whereas in Adaptive line enhancer we predict filter coefficients from the given signal.
- The values of mu and epsilon must be chosen carefully so that the coefficients converge.
- The adaptive line enhancer has significant applications in the enhancement of narrowband spectral lines in a broadband noise field when there is a poor signal-to-noise ratio at the input where there is insufficient a priori information on which to design appropriate filters. The device automatically filters out the components of the signal which are uncorrelated in time and passes the correlated portions. Since the properties of the device are determined solely by the input signal statistics, the properties of the filter automatically adjust to variations in the input signal statistics to obtain the least mean square (LMS) approximation to a Wiener-Hopf filter.

Discussion: Ved Prakash Tiwari

- The working of the scheme depends upon the signal to noise ratio of the being processed signal.
- With multiple components present in the signal we transfer it into multi-band filter with sharp cut-off values.
- The signal is compared against the estimated value and the obtained error is used as feedback to the adaptation of new filter coefficients.
- The increment of the filter coefficients is such that it grows in negative direction of gradient of error resulting reduction in error at each next iteration.