DSP LAB

Experiment – 6

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AIM – To analyse the Discrete-Time Fourier Transform of a given signal x(t), sampled appropriately to obtain x[n], and to plot the magnitude spectrum X(f) vs f.

Theory:

The Discrete Time Fourier transform is a continuous function of frequency f that represents the frequency domain representation of a discrete, infinite length sequence x[n].

It is defined as:

$$\mathrm{X(f)} = \sum_{\mathrm{n}=-\infty}^{\infty} \mathrm{x[n]} \times (\mathrm{e}^{-\mathrm{j}2\pi \mathrm{fn}})$$

The X(f) shows the frequency content of the sequence x[n] and as the sequence gets decomposed in frequency component, we say X(f) as signal spectrum.

The Fourier transform of a discrete-time sequence x[n] exists if and only if the sequence x[n] is absolutely summable i.e.

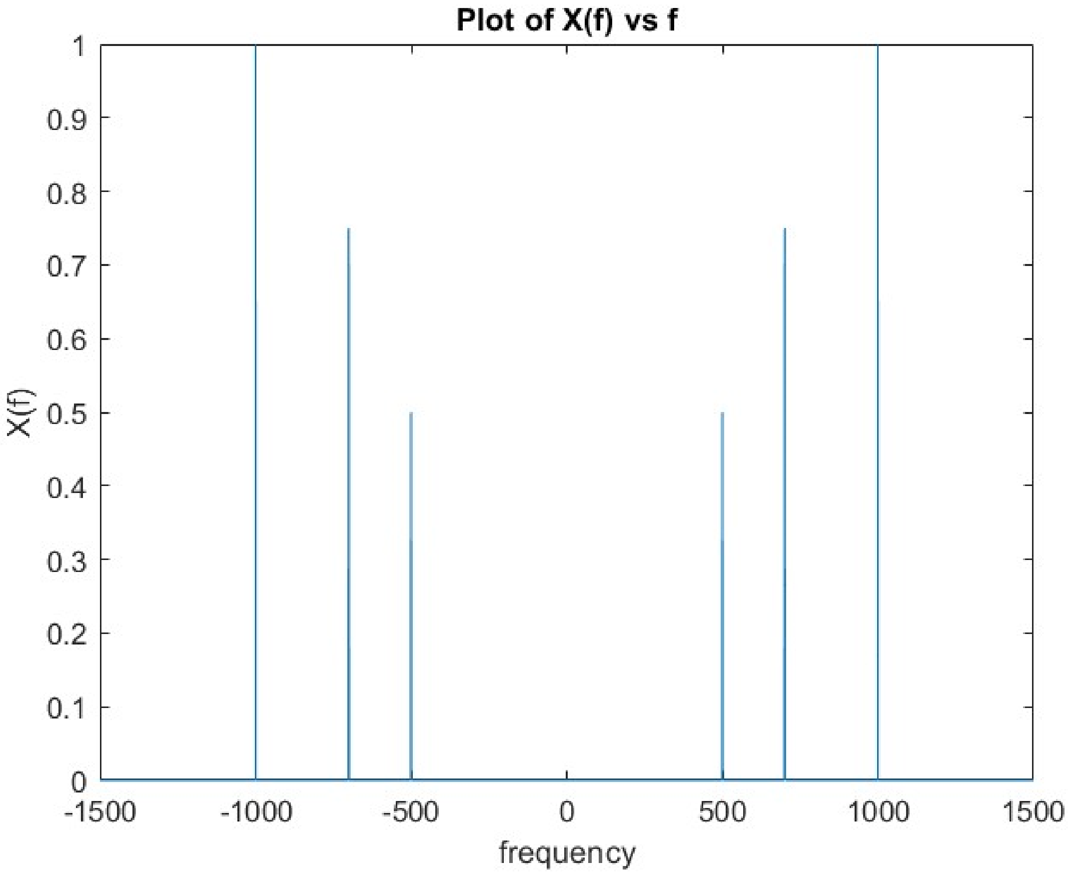
$$\sum_{\mathrm{n}=-\infty}^{\infty} |x[n]| < \infty$$

And thus, it can only apply to stable systems, which means their poles of transfer function should be inside the unit circle.

MATLAB CODE:

```
f1 = 500;
f2 = 1000;
f3 = 700;
fs =3000;
t = 0:1/fs:1;
w= -pi:2*pi/fs:pi;
x_t = sin(2*pi*f1*t)+2*sin(2*pi*f2*t)+1.5*sin(2*pi*f3*t);
X = find_dtft(x_t,w);
figure;
plot(w*fs/(2*pi),abs(X));
function X = find_dtft(x_t,w)
    N=length(x_t);
    X= zeros(size(w));
    for k=1:length(w)
            X(k) =sum(x_t.*exp(-1j*w(k)*(0:N-1))) / N;
    end
end
```

PLOT:



Observation:

- We appropriately chose the sampling frequency so that Nyquist Theorem is not violated, and we can easily show them without aliasing.
- Then we calculated the DTFT of the discrete signal given to us by iterating over the range of frequencies.
- And the plot provides us the insights into the frequency content of the signal by showing the relative strength of the signal at different frequency.

Conclusion:

- We accurately represent the continuous time signal in the discrete domain.
- The peaks in the magnitude spectrum correspond to the dominant frequency components present in the signal.