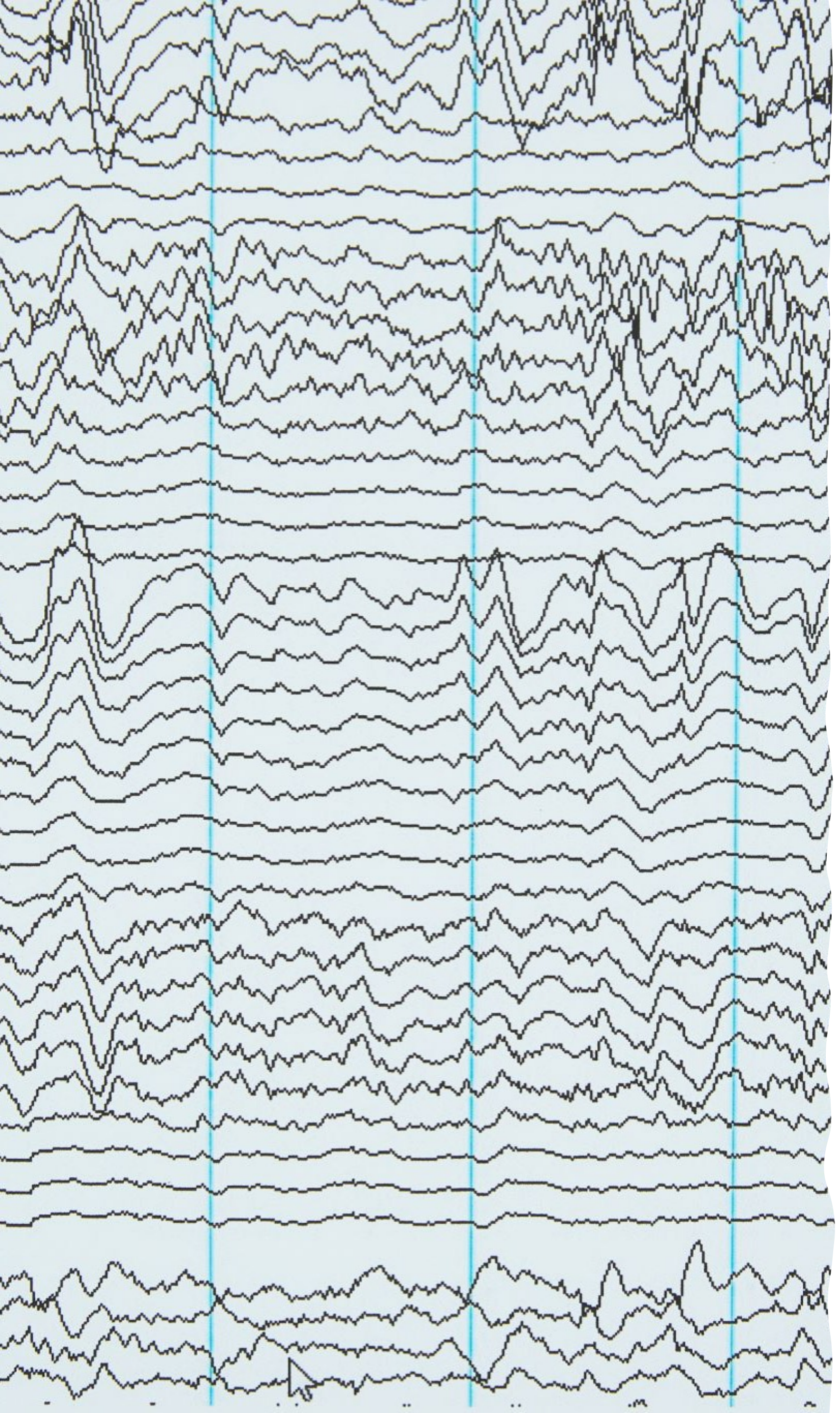
Computational Physics Laboratory - I

Feedback



Feedback

- We find that most of the students did not understand amplitude modulation, properly.
- Therefore, we provide the basic information of the amplitude modulation in this document.
- Moreover, we added an example to show how to programmatically finding the Fourier Spectrum of a signal.
- Read this document and solve the problems related to amplitude modulation sections of CPL106 lab sheet.
- You have one week to submit the answers.
- *Remember that when you plot the Fourier spectrum (Results of FFT), you need to plot only for positive frequencies (This is valid for all the FFT related questions).*

Amplitude Modulation (AM)

- Signals are modulated to transmit and receive the information from one location to another.
- Original signal or the information we need to transmit is known as modulating signal.

$$S_m(t) = A_m \sin(2\pi F_m t)$$

- The high frequency signal which carry the signal is known as carrier signal.

$$S_c(t) = A_c \sin(2\pi F_c t)$$

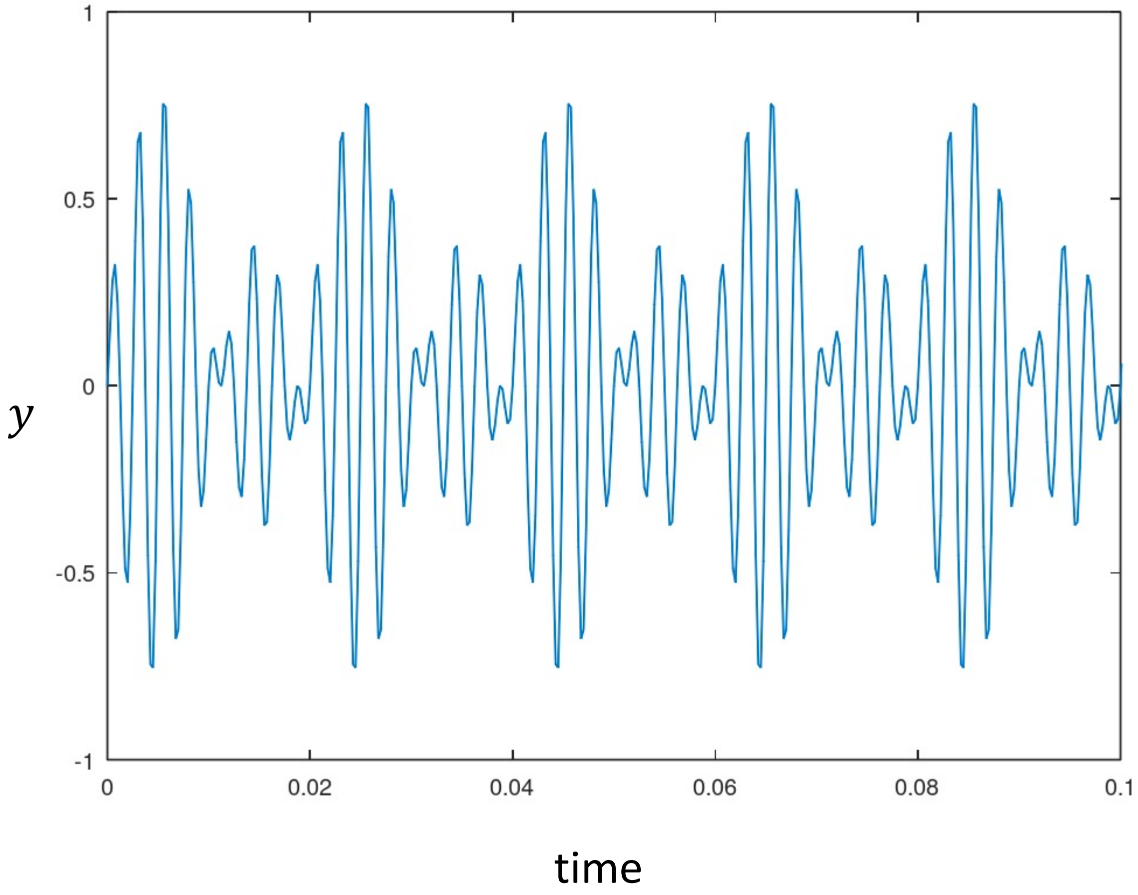
- In amplitude modulation, amplitude of the carrier wave is varying according to the modulating signal.
- Thus, the modulated signal becomes

$$S(t) = \underbrace{(A_c + A_m \sin(2\pi F_m t))}_{\text{New Amplitude}} \sin(2\pi F_c t)$$

Amplitude Modulation (AM)

$$S(t) = (A_c + A_m \sin(2\pi F_m t)) \sin(2\pi F_c t)$$

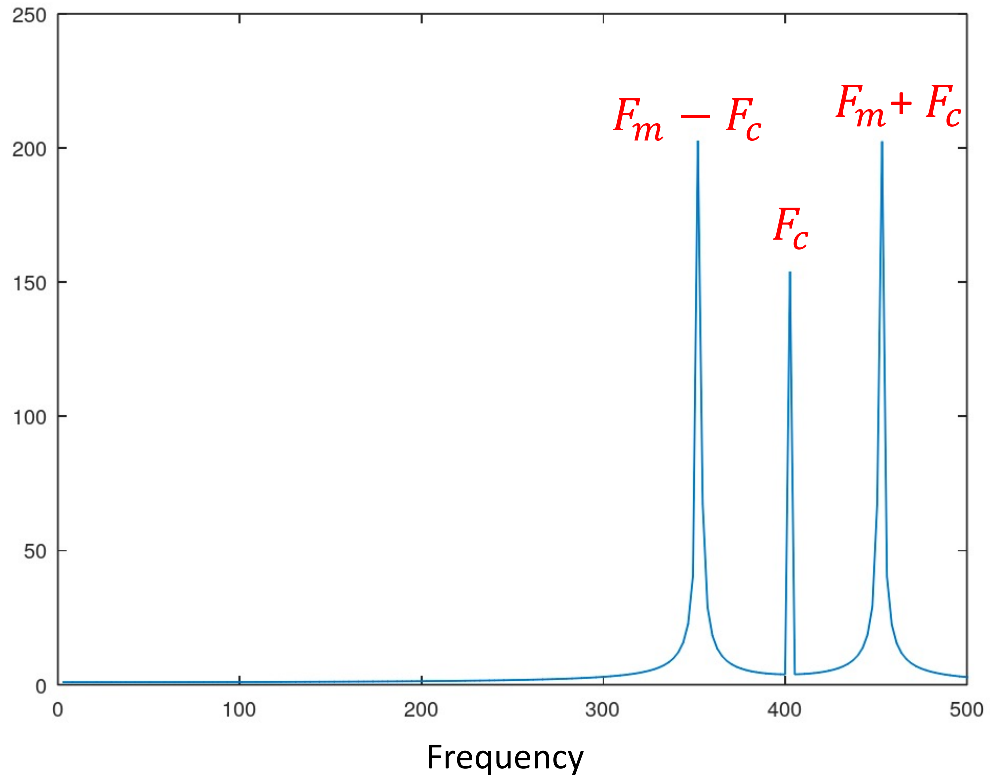
$$F_c > F_m$$



If you plot the modulated signal $s(t)$, you will obtain a graph like above.

Fourier Transform of AM Signal

- Three frequencies are appearing in the Fourier spectrum.
- Those frequencies are
  - $F_c - F_m$
  - F_c
  - $F_m + F_c$
- Bandwidth = $F_{\max} - F_{\min} = 2\ F_m$



Fourier Transform of AM signal

The following modulating signal, $S_m(t)$, is an addition of two signals with different frequencies (F_{m1} and F_{m2}).

$$S_m(t) = A_{m1}\sin(2\pi F_{m1}t) + A_{m2}\sin(2\pi F_{m2}t)$$

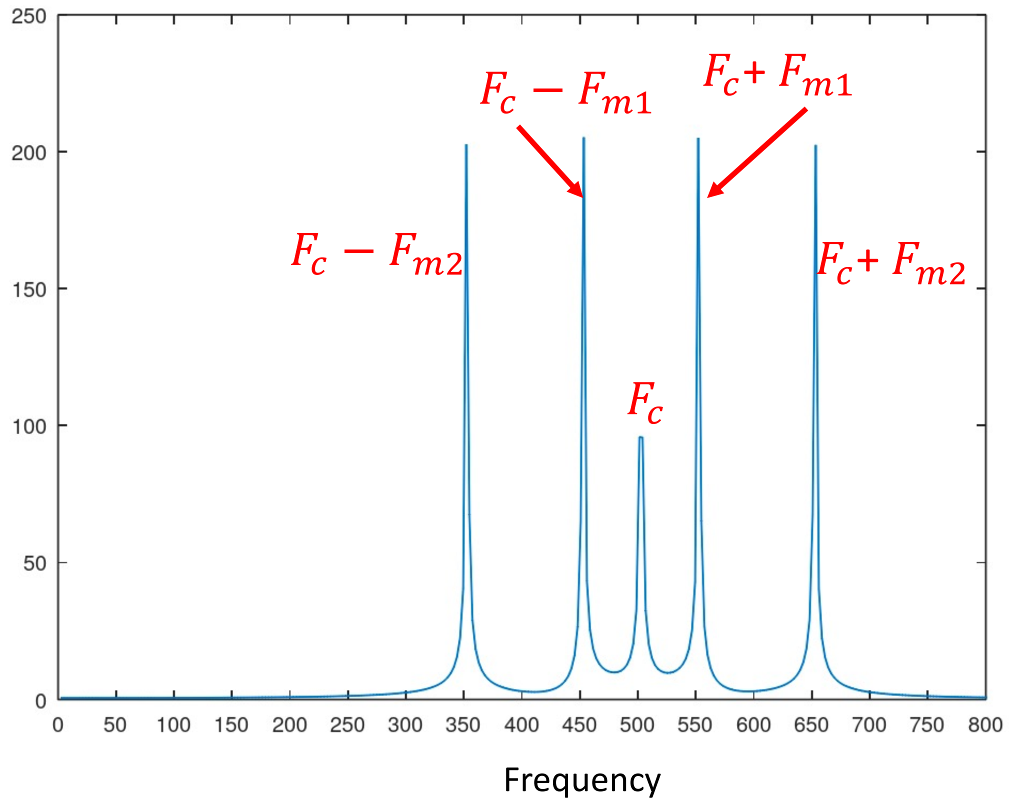
The carrier signal, $S_c(t)$, is given by

$$S_c(t) = A_c\sin(2\pi F_c t)$$

So, the modulated signal, $S(t)$, is given by

$$S(t) = (A_c + A_{m1}\sin(2\pi F_{m1}t) + A_{m2}\sin(2\pi F_{m2}t))\sin(2\pi F_c t)$$

$$F_{m2} > F_{m1}$$



Example

You are given an amplitude modulated (AM) signal $x(t)$ defined as follows:

$$x(t) = (1 + 0.5\sin(2\pi.10t) + 0.2\sin(2\pi.40t))\cos(2\pi.100t)$$

```
#The function for generating the signal
def xm(t):
    return (1+0.5* np.sin(2*np.pi*10*t)+0.2* np.sin(2*np.pi*40*t))*np.cos(2*np.pi*100*t)
```

We need to obtain the Fourier Transform of the above modulated signal.

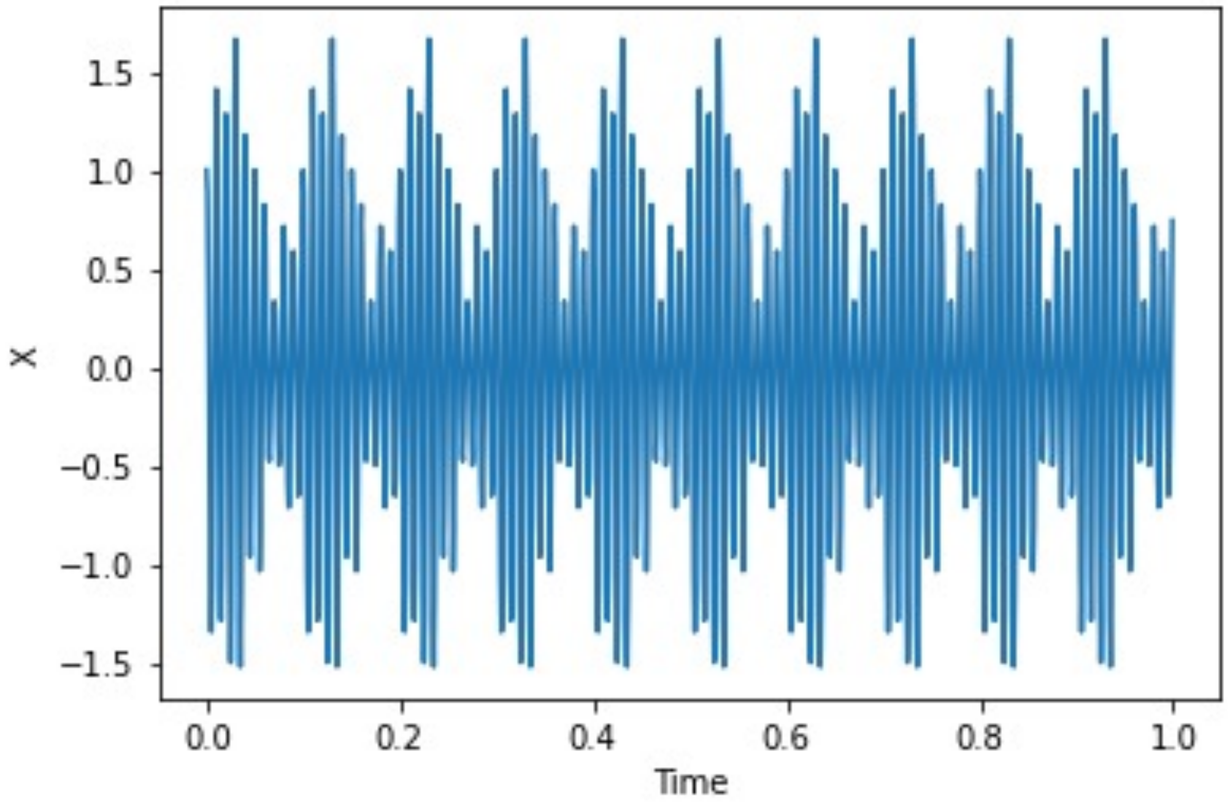
We need to sample the signal first. The sampling frequency 1000 Hz. The duration of the signal is 1s.

```
#Total number of samples is 1000
#Signal duration is 1 seconds
#Sampling frequency is 1000 Hz
tmax=1
Fs=1000
ts=1/Fs
t=np.arange(0,tmax,ts)

#The signal
x_sig = xm(t)
```

```
plt.plot(t,x_sig)
plt.xlabel("Time")
plt.ylabel("X")
```

```
Text(0, 0.5, 'X')
```



- Let’s plot the sampled modulated signal.

- You need to plot the Fourier transformed signal only for the positive frequencies

```python
#Fourier transforming the signal
ft=fft(x_sig)

#Finding the frequencies
F_sig= fftfreq(len(x_sig),d=ts)
```

```python
#Need to find the magnitudes of the Fourier transformed signal
magnitude = np.abs(ft)

# Select only the positive frequencies
positive_mask = F_sig >= 0
positive_F_sig = F_sig[positive_mask]

# Select only the magnitudes corresponding to the positive frequencies
positive_magnitude = magnitude[positive_mask]

plt.plot(positive_F_sig,positive_magnitude)
plt.xlim(0,200)
plt.xlabel("Frequencies")
plt.ylabel("Ft")
```

```
Text(0, 0.5, 'Ft')
```