Experiment No. 05

5.1 Experiment Name

s1= Low frequency signal (like 0Hz to 1Hz)

s2= High frequency signal (like 100Hz to 500Hz)

s3= Midrange frequency signal (like 5Hz to 30Hz)

s4=s1+s2+s3;

Design a digital filter (high pass/ low pass/ band pass/ band reject) using python code.

5.2 Objectives

- To get a better understanding of digital filter design using python
- To become acquainted with filter and it's working criteria.

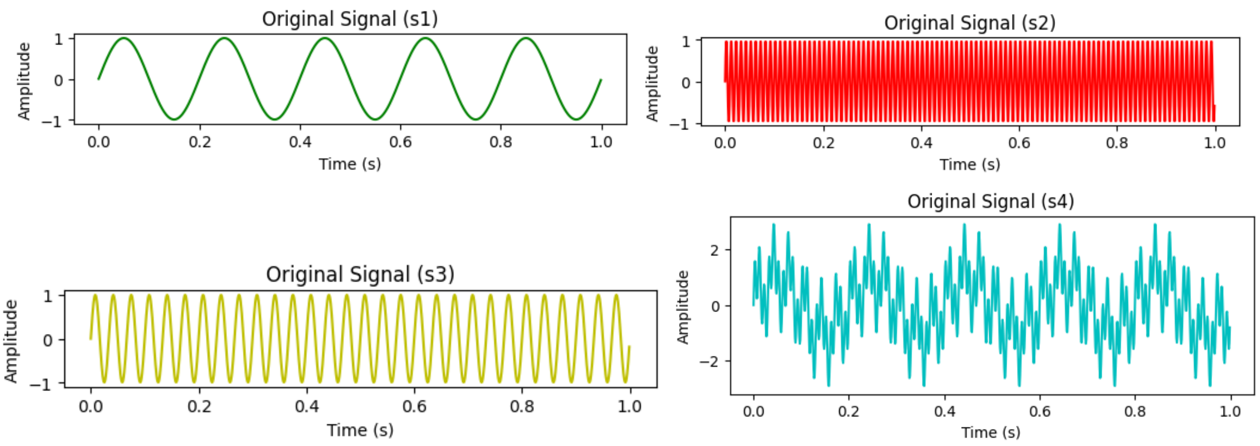
5.3 Apparatus

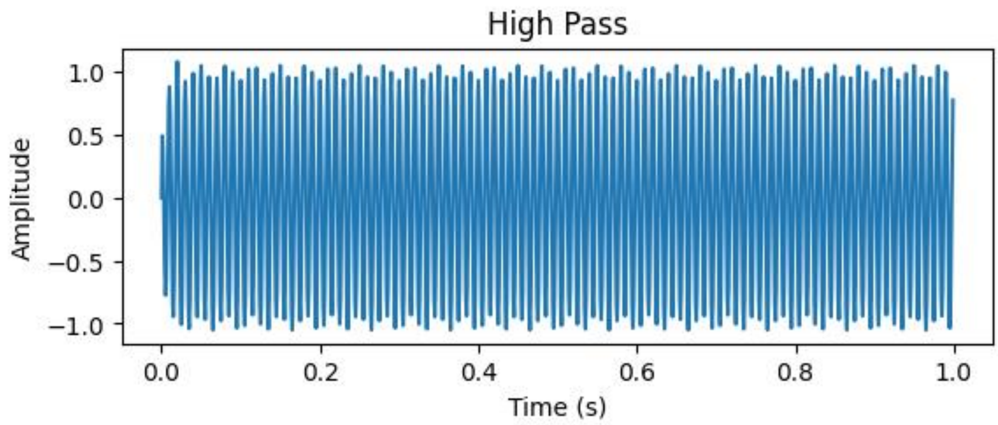
- Jupyter Notebook

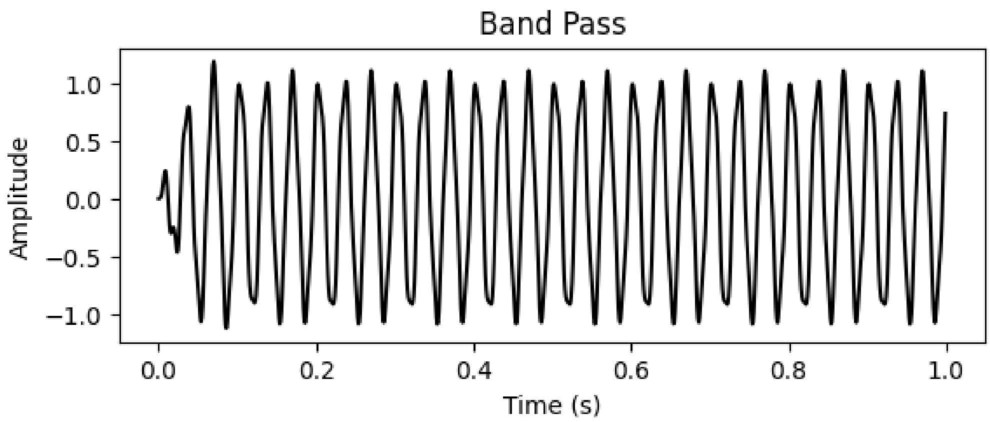
5.4 Python code & graph

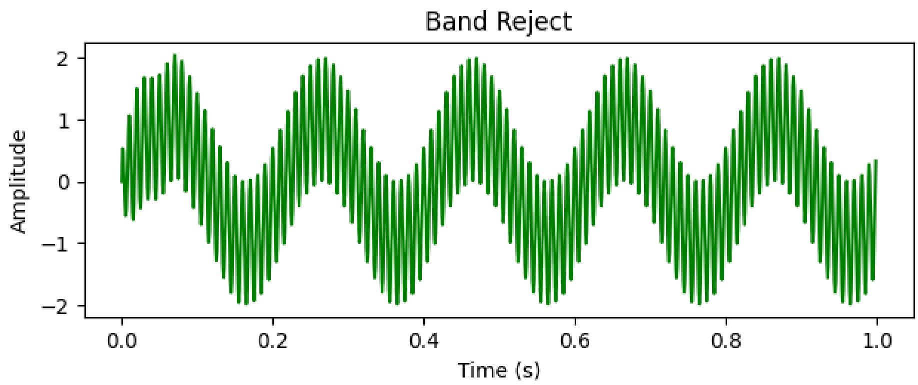
```
import numpy as np
from scipy import signal
import matplotlib.pyplot as plt

# Define the sampling frequency and duration
fs = 1000 # Sampling frequency (Hz)
duration = 1 # Duration of the signal (seconds)
t = np.linspace(0, duration, int(fs * duration), endpoint=False) # Time vector

# Generate the signals
s1 = np.sin(2 * np.pi * 5 * t) # Low-frequency signal (5 Hz sine wave)
s2 = np.sin(2 * np.pi * 100 * t) # High-frequency signal (100 Hz sine wave)
s3 = np.sin(2 * np.pi * 30 * t) # Mid-range frequency signal (30 Hz sine wave)

# Add the signals together
s4 = s1 + s2 + s3

# Plot the original and filtered signals
plt.figure()
plt.subplot(4, 1, 1)
plt.plot(t, s1,'g')
plt.title('Original Signal (s1)')
plt.xlabel('Time (s)')
plt.ylabel('Amplitude')

plt.figure()
plt.subplot(4, 1, 2)
plt.plot(t, s2,'r')
plt.title('Original Signal (s2)')
plt.xlabel('Time (s)')
plt.ylabel('Amplitude')

plt.figure()
plt.subplot(4, 1, 3)
plt.plot(t, s3,'y')
plt.title('Original Signal (s3)')
plt.xlabel('Time (s)')
plt.ylabel('Amplitude')

plt.figure()
plt.subplot(2, 1, 1)
plt.plot(t, s4,'c')
plt.title('Original Signal (s4)')
plt.xlabel('Time (s)')
plt.ylabel('Amplitude')

# Design the low-pass filter
fc = 20 # Cutoff frequency (Hz)
order = 4 # Filter order
b, a = signal.butter(order, fc, btype='low', fs=fs)
```

```python
# Apply the filter to the combined signal
filtered_signal = signal.lfilter(b, a, s4)
plt.figure()
plt.subplot(2, 1, 1)
plt.plot(t, filtered_signal,'m')
plt.title('Low Pass')
plt.xlabel('Time (s)')
plt.ylabel('Amplitude')
# Design the high-pass filter
fc = 60 # Cutoff frequency (Hz)
order = 4 # Filter order
b, a = signal.butter(order, fc, btype='high', fs=fs)

# Apply the filter to the combined signal
filtered_signal = signal.lfilter(b, a, s4)
plt.figure()
plt.subplot(2, 1, 1)
plt.plot(t, filtered_signal)
plt.title('High Pass')
plt.xlabel('Time (s)')
plt.ylabel('Amplitude')

# Design the band-pass filter
fc_low = 20 # Lower cutoff frequency (Hz)
fc_high = 70 # Upper cutoff frequency (Hz)
order = 4 # Filter order
b, a = signal.butter(order, [fc_low, fc_high], btype='bandpass', fs=fs)

# Apply the filter to the combined signal
filtered_signal = signal.lfilter(b, a, s4)
plt.figure()
plt.subplot(2, 1, 1)
plt.plot(t, filtered_signal,'k')
plt.title('Band Pass')
plt.xlabel('Time (s)')
plt.ylabel('Amplitude')

# Design the band-reject filter
fc_low = 20 # Lower cutoff frequency (Hz)
fc_high = 70 # Upper cutoff frequency (Hz)
order = 4 # Filter order
b, a = signal.butter(order, [fc_low, fc_high], btype='bandstop', fs=fs)
# Apply the filter to the combined signal
filtered_signal = signal.lfilter(b, a, s4)
plt.figure()
plt.subplot(2, 1, 1)
plt.plot(t, filtered_signal,'g')
plt.title('Band Reject')
plt.xlabel('Time (s)')
plt.ylabel('Amplitude')
plt.tight_layout()
plt.show()
```









5.5 Discussion & Conclusion

In this experiment, we used the python to analyze different given signals and design digital filter with necessary requirements. Through this experiment, we got a better understanding of the designing process and its' practical use and understood the scope of improvements in the regarding field. Here, we designed 4th order for all the filter i.e., band pass, band reject, high pass, low pass filters. We set the frequency range according to our study requirement and used butter function for designing.