EXP-1.1

Flat-Top Sampling

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```python
#Flat-top Sampling
#NAME: AHAMED HARIZ A
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import numpy as np
import matplotlib.pyplot as plt
from scipy.signal import butter, lfilter
fs = 1000  # Sampling frequency (samples per second)
T = 1      # Duration in seconds
t = np.arange(0, T, 1/fs)  # Time vector
fm = 5     # Frequency of message signal (Hz)
message_signal = np.sin(2 * np.pi * fm * t)
pulse_rate = 50  # pulses per second
pulse_train_indices = np.arange(0, len(t), int(fs / pulse_rate))
pulse_train = np.zeros_like(t)
pulse_train[pulse_train_indices] = 1
flat_top_signal = np.zeros_like(t)
sample_times = t[pulse_train_indices]
pulse_width_samples = int(fs / (2 * pulse_rate)) # Adjust pulse width as needed
for i, sample_time in enumerate(sample_times):
    index = np.argmin(np.abs(t - sample_time))
    if index < len(message_signal):
        sample_value = message_signal[index]
        start_index = index
        end_index = min(index + pulse_width_samples, len(t))
        flat_top_signal[start_index:end_index] = sample_value

def lowpass_filter(signal, cutoff, fs, order=5):
    nyquist = 0.5 * fs
    normal_cutoff = cutoff / nyquist
    b, a = butter(order, normal_cutoff, btype='low', analog=False)
    return lfilter(b, a, signal)

cutoff_freq = 2 * fm  # Nyquist rate or slightly higher
reconstructed_signal = lowpass_filter(flat_top_signal, cutoff_freq, fs)

plt.figure(figsize=(14, 10))

plt.subplot(4, 1, 1)
plt.plot(t, message_signal, label='Original Message Signal')
plt.title('Name: AHAMED HARIZ A\nReg no: 212224060009\n\nOriginal Message Signal')
plt.xlabel('Time (s)')
```
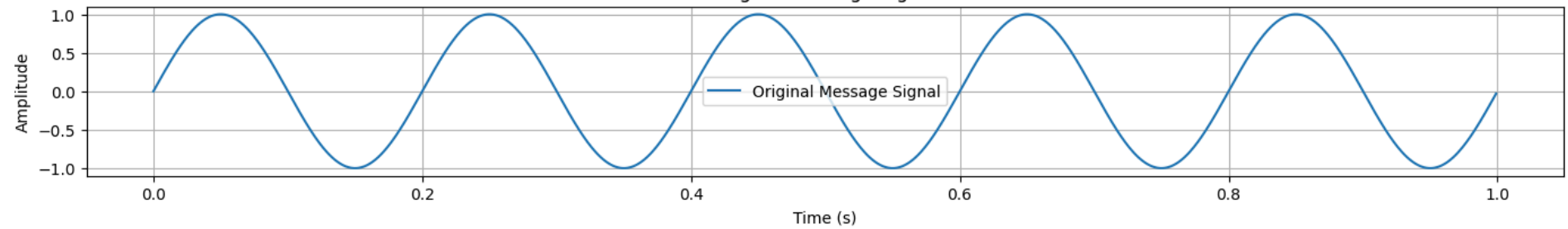
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plt.xlabel('Time (s)')
plt.ylabel('Amplitude')
plt.legend()
plt.grid(True)

plt.subplot(4, 1, 2)
plt.stem(t[pulse_train_indices], pulse_train[pulse_train_indices], basefmt=" ",
label='Ideal Sampling Instances')
plt.title('Ideal Sampling Instances')
plt.xlabel('Time (s)')
plt.ylabel('Amplitude')
plt.legend()
plt.grid(True)
plt.subplot(4, 1, 3)
plt.plot(t, flat_top_signal, label='Flat-Top Sampled Signal')
plt.title('Flat-Top Sampled Signal')
plt.xlabel('Time (s)')
plt.ylabel('Amplitude')
plt.grid(True)
plt.legend()
plt.subplot(4, 1, 4)
plt.plot(t, reconstructed_signal, label=f'Reconstructed Signal (Low-pass Filter, Cutoff={cutoff_freq} Hz)', color='green')
plt.title('Reconstructed Signal')
plt.xlabel('Time (s)')
plt.ylabel('Amplitude')
plt.legend()
plt.grid(True)
plt.tight_layout()
plt.show()
```
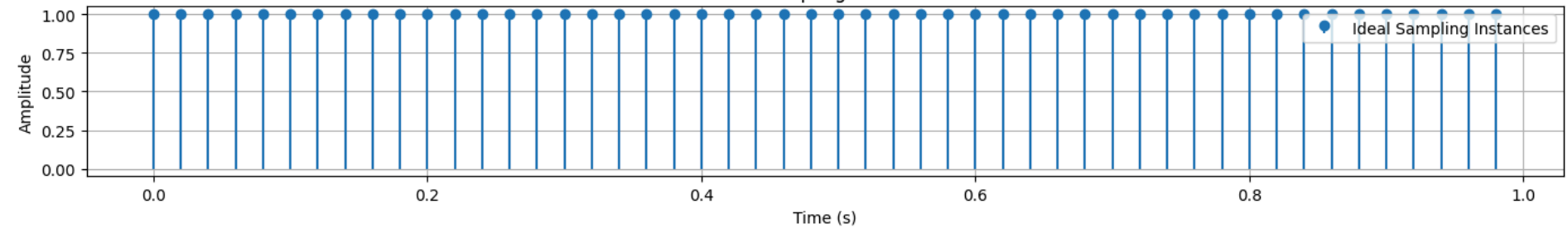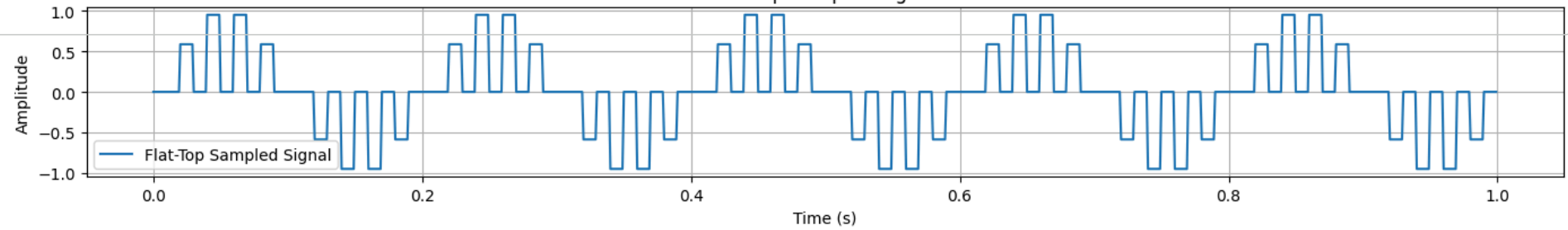
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Original Message Signal

Ideal Sampling Instances

Flat-Top Sampled Signal

Reconstructed Signal