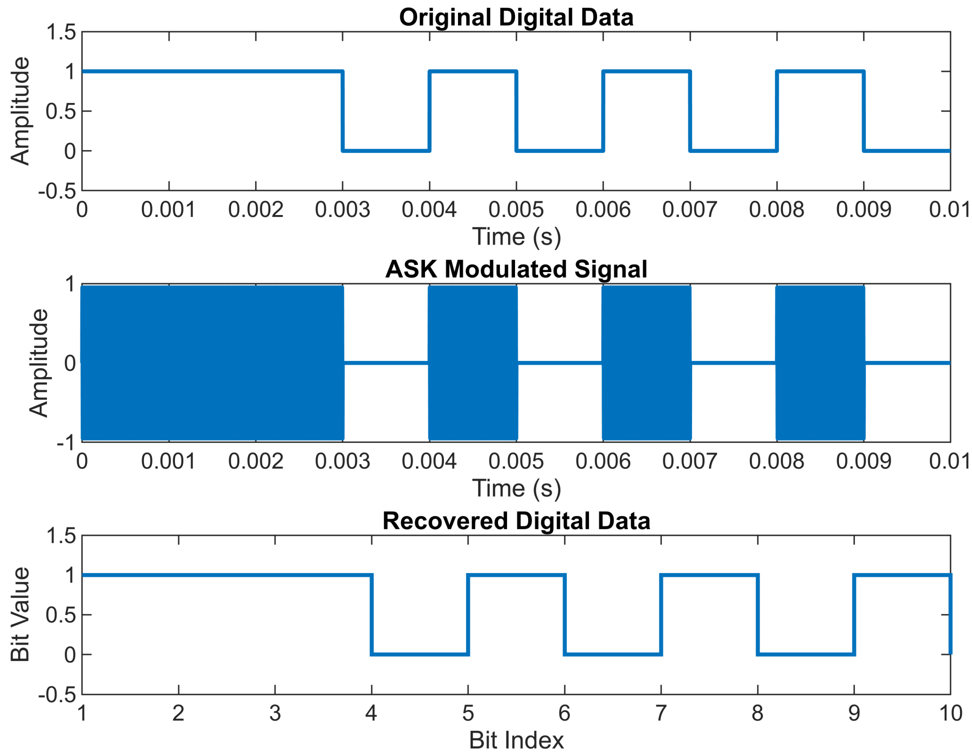
Codes for ASK and FSK modulation and demodulation: –

ASK Modulation and Demodulation -

```
fs = 1e6;
bit_rate = 1e3;
fc = 100e3;
Tb = 1 / bit_rate;
N = 10;
t = 0:1/fs:N*Tb - 1/fs;
data = randi([0 1], 1, N);
data_stream = repelem(data, fs * Tb);
carrier = sin(2 * pi * fc * t);
ask_signal = data_stream .* carrier;
rectified = abs(ask_signal);

[b, a] = butter(5, (bit_rate * 2) / fs);
filtered = filtfilt(b, a, rectified); % Zero-phase

threshold = 0.5 * (max(filtered) + min(filtered)); % Adaptive threshold
samples_per_bit = fs * Tb;

recovered_bits = zeros(1, N);
for i = 1:N
    center = round((i-1)*samples_per_bit + samples_per_bit/2);
    if center > length(filtered)
        center = length(filtered);
    end
    recovered_bits(i) = filtered(center) > threshold;
end

figure;
subplot(3,1,1);
plot(t, data_stream, 'LineWidth', 1.5);
title('Original Digital Data');
xlabel('Time (s)');
ylabel('Amplitude');
ylim([-0.5 1.5]);

subplot(3,1,2);
plot(t, ask_signal, 'LineWidth', 1.5);
title('ASK Modulated Signal');
xlabel('Time (s)');
ylabel('Amplitude');

subplot(3,1,3);
stairs(recovered_bits, 'LineWidth', 1.5);
title('Recovered Digital Data');
xlabel('Bit Index');
ylabel('Bit Value');
```

```
ylim([-0.5 1.5]);
```



In Amplitude Shift Keying (ASK), a digital signal is transmitted by controlling whether a carrier wave is present or absent. When the bit is 1, the carrier is sent at full amplitude; when the bit is 0, the carrier is turned off (or suppressed).

In MATLAB, this can be implemented by multiplying the binary data stream with a sinusoidal carrier. This produces an ASK waveform where the amplitude directly mirrors the data pattern.

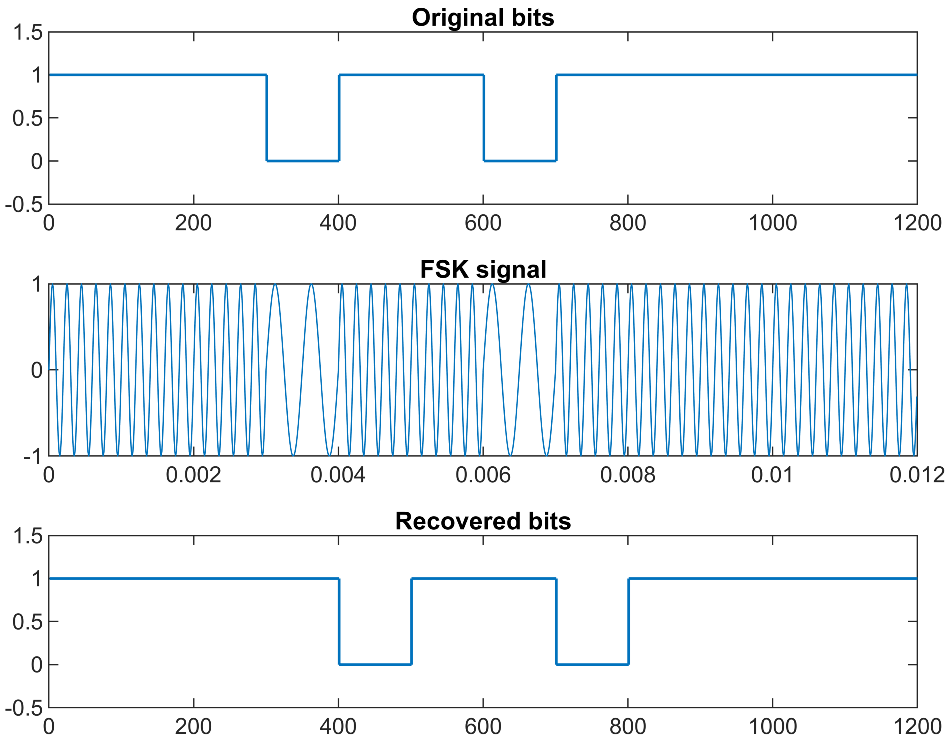
For demodulation, the process usually involves:

1. Rectifying the signal to extract its envelope.
2. Passing it through a low-pass filter to remove high-frequency ripples.
3. Using a comparator with a threshold to decide whether each bit is a 1 or 0, thereby reconstructing the original data.

FSK Modulation and Demodulation -

```
fs       = 100e3;        % sample rate
Rb       = 1e3;          % bit rate
Tb       = 1/Rb;         % bit time
Nb       = 12;           % number of bits
Npb      = round(fs*Tb); % samples per bit (100)
```

```
t_bit    = (0:Npb-1)/fs;
f0 = 2e3;  % bit-0 -> 2 cycles per bit
f1 = 5e3;  % bit-1 -> 5 cycles per bit
data = randi([0 1],1,Nb);
fsk = zeros(1,Npb*Nb);
w0  = sin(2*pi*f0*t_bit);
w1  = sin(2*pi*f1*t_bit);
for k = 1:Nb
    idx = (k-1)*Npb + (1:Npb);
    if data(k)==0
        fsk(idx) = w0;
    else
        fsk(idx) = w1;
    end
end
BW  = 800; % passband width
bp0 = designfilt('bandpassiir','FilterOrder',6, ...
      'HalfPowerFrequency1',f0-BW/2,'HalfPowerFrequency2',f0+BW/2, ...
      'SampleRate',fs);
bp1 = designfilt('bandpassiir','FilterOrder',6, ...
      'HalfPowerFrequency1',f1-BW/2,'HalfPowerFrequency2',f1+BW/2, ...
      'SampleRate',fs);
y0  = filter(bp0,fsk);
y1  = filter(bp1,fsk);
e0  = abs(hilbert(y0));
e1  = abs(hilbert(y1));
diff_env   = e1 - e0;
diff_mat   = reshape(diff_env, Npb, Nb);       % columns = bits
metric     = mean(diff_mat,1);                 % energy per bit
rx_bits    = metric > 0;
t = (0:numel(fsk)-1)/fs;
figure;
subplot(3,1,1);
stairs(repelem(data,Npb),'LineWidth',1); ylim([-0.5 1.5]);
title('Original bits');
subplot(3,1,2);
plot(t,fsk); xlim([0, Nb*Tb]); title('FSK signal');
subplot(3,1,3);
stairs(repelem(rx_bits,Npb),'LineWidth',1); ylim([-0.5 1.5]);
title('Recovered bits');
```




```
num_err = sum(rx_bits ~= data);
disp(['Bit errors: ' num2str(num_err) ' of ' num2str(Nb)]);
```

```
Bit errors: 4 of 12
```

In Frequency Shift Keying (FSK), digital data is transmitted by switching the carrier wave between two distinct frequencies—one assigned to logic 0 and the other to logic 1.

In MATLAB, this can be implemented by:

- Generating a sine wave at frequency f_1 whenever the bit is 0
- Generating a sine wave at frequency f_2 whenever the bit is 1
- Concatenating these segments to form the complete FSK signal

For demodulation, the received signal is processed through two bandpass filters, one tuned to f_1 and the other to f_2, to isolate the respective frequency components. Envelope detection is then applied to each output, and during each bit period, the filter output with the stronger envelope indicates the transmitted bit.

<u>Report Questions: -</u>

1) FM vs. FSK Modulation

- **FM (Frequency Modulation)** changes the carrier's frequency **continuously** in response to an **analog signal** such as voice or music.
- **FSK (Frequency Shift Keying)** changes (or "shifts") the carrier between **two fixed frequencies** to represent binary **0** and **1**.
- FM is an **analog** modulation method; FSK is a **digital** one.
- FM uses a **wide range** of frequencies, while FSK only switches between **two specific tones**.

2) AM vs. ASK Modulation

- **AM (Amplitude Modulation)** changes the carrier's amplitude **smoothly and continuously** based on an **analog input** (like audio).
- **ASK (Amplitude Shift Keying)** switches the carrier's amplitude between **two levels** (high/low or on/off) to represent digital **0** and **1**.
- AM is **analog** and is widely used for broadcasting voice/music, while ASK is a **digital modulation** technique used for binary data transmission.

3) Why FSK is often better than ASK

- **Noise Immunity:** FSK is more resistant to **amplitude noise**, since it encodes data in frequency changes, while ASK is highly vulnerable to interference that alters amplitude.
- **Bandwidth:** ASK typically uses less bandwidth than FSK, but this comes **at the cost of reliability**.
- **Applications:** FSK is a popular choice for **modems, RFID systems, and low-power wireless devices** due to its robustness. ASK is simpler and cheaper to implement but is less dependable in noisy environments.

4) Similarities between ASK and FSK Demodulators

1. Both use **envelope detection**, which involves **rectifying** the signal and then using a **low-pass filter** to smooth it.
2. Both require a **comparator circuit** to convert the smoothed analog envelope into clean digital "0" and "1" outputs.
3. In both methods, demodulation works by **isolating the relevant signal feature** (amplitude for ASK, frequency for FSK) and then converting it back into binary data.

Conclusion:

This lab provided valuable hands-on experience with two key digital modulation techniques — **Amplitude Shift Keying (ASK)** and **Frequency Shift Keying (FSK)**. We observed how **ASK** transmits binary data by turning a carrier signal on or off, while **FSK** encodes data by switching between two different frequencies.

Through experimentation, we saw that **ASK** is simpler but more prone to errors in the presence of noise, as amplitude disturbances can easily corrupt the signal. **FSK**, in contrast, showed better performance in noisy conditions due to its frequency-based encoding method, making it more reliable.

Beyond just reinforcing theoretical knowledge, this experiment deepened our understanding of the practical trade-offs between **simplicity, bandwidth usage, and noise immunity.** These insights are essential as we progress toward designing and analyzing more advanced communication systems.