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Section : A-(02)

Department :EEE

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Course Title : Communication Engineering I Lab

Experiment No : 3 and 4

Experiment Name : Amplitude Shift-Keying (ASK) Modulation and Demodulation and Frequency Shift-Keying (FSK) Modulation and Demodulation

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Introduction: -

Amplitude Shift Keying (ASK) –

Amplitude Shift Keying (ASK) is a type of amplitude modulation where digital data is sent by turning a carrier wave on or off. In this method, a binary 1 is transmitted as a carrier wave at full amplitude, while a binary 0 is sent by either switching the carrier off completely or reducing its amplitude significantly.This technique is also called on-off keying (OOK) or interrupted continuous wave. ASK is easy to design and can be decoded using a simple envelope detector.However, its main drawback is high sensitivity to noise—any unwanted changes in amplitude caused by interference can make the receiver misinterpret the signal, confusing ones and zeros.

Frequency Shift Keying (FSK) –

Frequency Shift Keying (FSK) is a digital modulation method where binary data is transmitted by changing the carrier wave's frequency between two set values.

Mark frequency (higher frequency) represents binary 1

Space frequency (lower frequency) represents binary 0

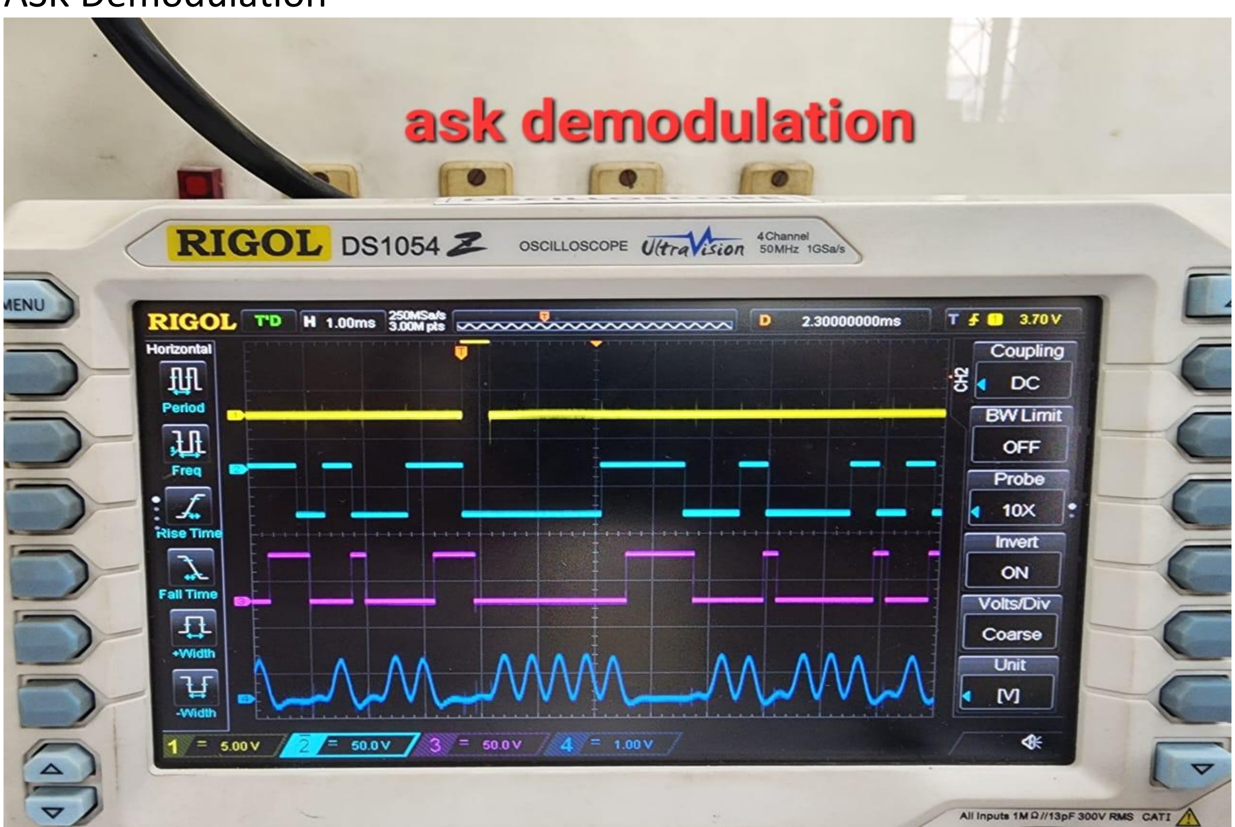
You can think of it as the digital counterpart of frequency modulation (FM), which gives it better resistance to noise. Since most noise affects amplitude rather than frequency, FSK signals can be cleaned using limiters without degrading the information.

For decoding (demodulation), common approaches include FM-based methods like zero-crossing detection and phase-locked loops, or techniques using filters followed by envelope detection.

Oscilloscope Graphs: -

ASK Modulation –

ASK Demodulation –

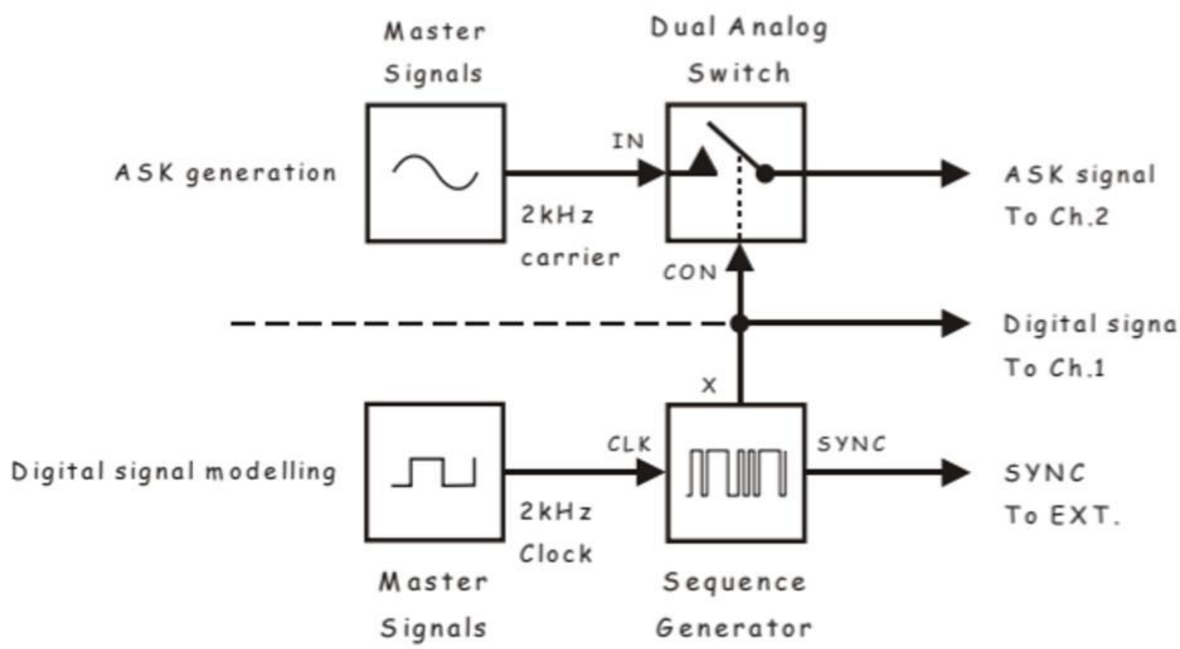


FSK Modulation –

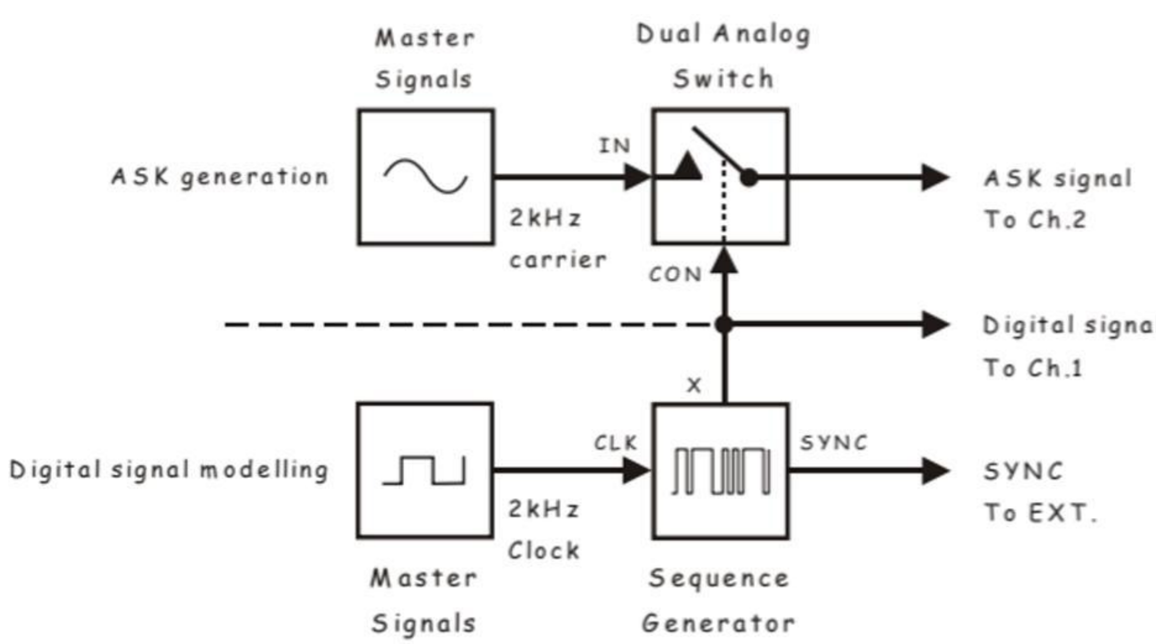
FSK Demodulation –

ASK block diagram: -

ASK Modulation –

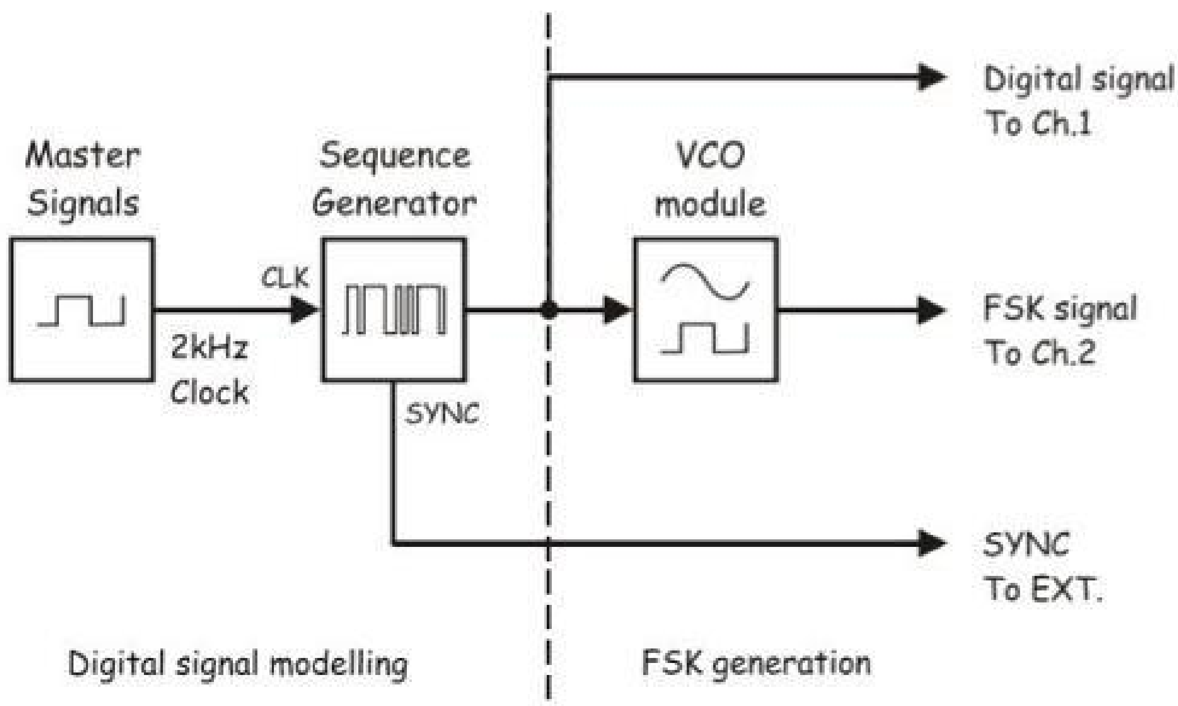


Demodulation –

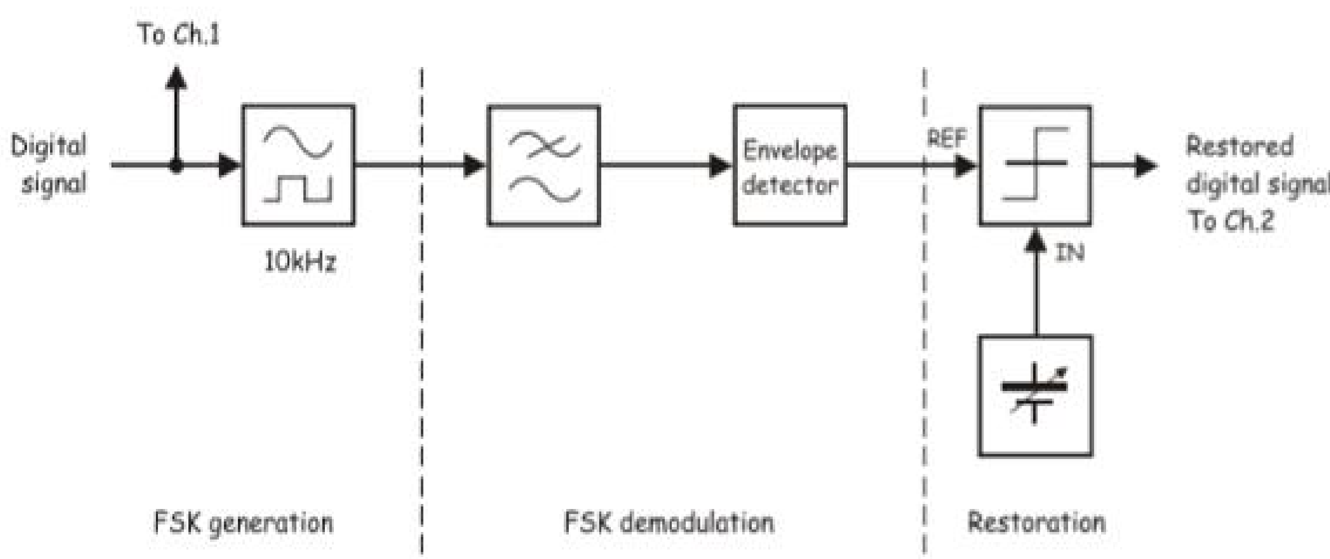


FSK block diagram:

Modulation –



Demodulation –

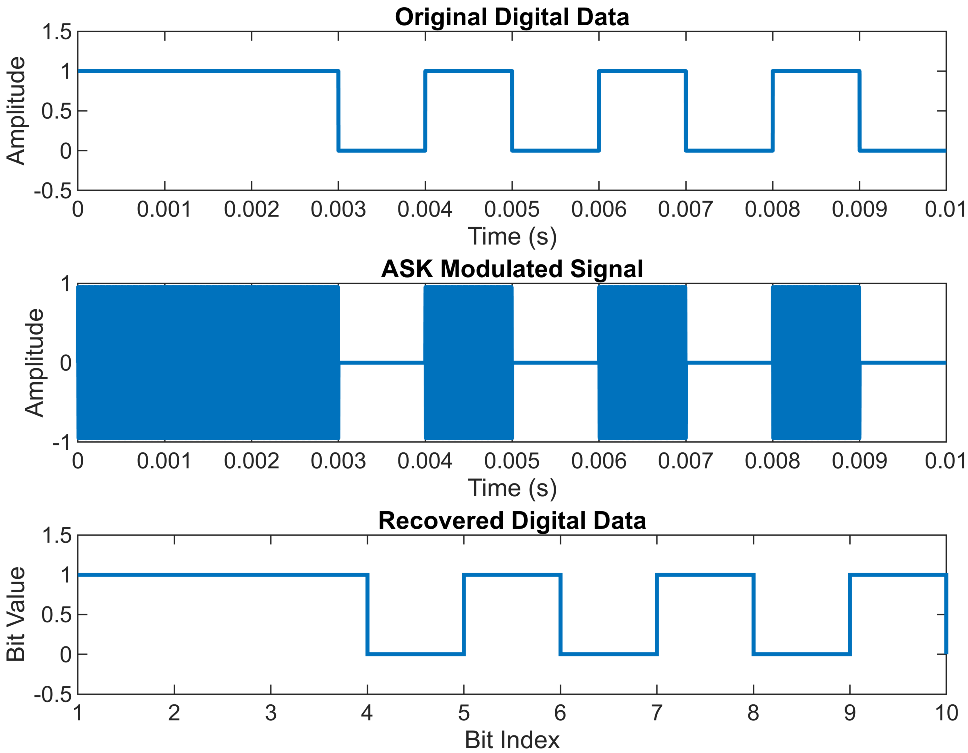


Codes for ASK and FSK modulation and demodulation: –

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.

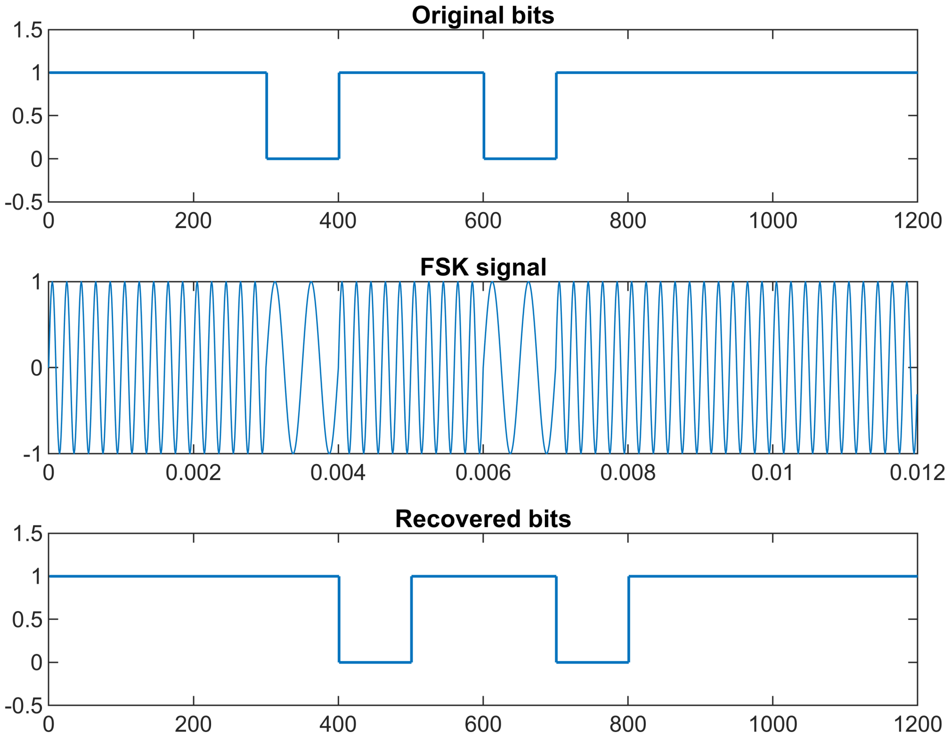
For demodulation, the process usually involves:

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.