EXPERIMENT CM11: MODULATION AND DEMODULATION FOR ASK AND FSK

Related course: KIE2008 (Communication System)

OBJECTIVES:
To investigate the modulation and demodulation for ASK and FSK implemented in MATLAB

EQUIPMENT:
PC and MATLAB

REFERENCE(S):
J.G. Proakis, M. Salehi, “Fundamental of Communication Systems”, 2nd Ed., Pearson, 2014

TEST:
TEST 1: Amplitude Shift Keying (ASK) modulation and demodulation
TEST 2: Frequency Shift Keying (FSK) modulation and demodulation

TEST 1: Amplitude Shift Keying (ASK)

Amplitude-shift keying (ASK) is a form of modulation that represents digital data as variations in the amplitude of a carrier wave. The process involved in ASK modulation is similar to the type of modulation done in the Amplitude Modulation (analog) case except that the message signal is a digital signal.

PRINCIPLE OF OPERATION

i. ASK Modulation
The generated analog message signal is first converted to a digital signal. The digital signal generated is then multiplied by a carrier to generate the amplitude modulated signal (Double-sideband suppressed-carrier (DSB-SC) signal).

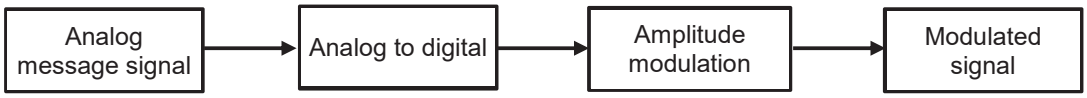


Figure 1: Block Diagram of ASK Modulator

ii. ASK Demodulation
Synchronous Detection is used to demodulate the signal. For this, the carrier needs to be generated in the receiver side. The process is similar to Amplitude Modulation.

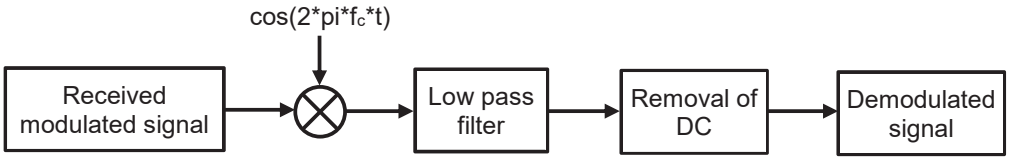


Figure 2: Block diagram of an ASK demodulator

PROCEDURES:

1. Using the code given, generate digital data in MATLAB.
2. Implement ASK modulation using carrier multiplication.
3. Add optional noise (e.g., awgn(signal,SNR,measured')).
4. Apply synchronous demodulation.
5. Low-pass filter and recover binary data.
6. Plot: Digital signal, Modulated signal, Spectrum (fft) and Demodulated signal

QUESTIONS:

1. Describe all the output figures obtained from the experiment.
2. What are the advantages and disadvantages of FSK?

```
% Parameters
Fs = 10000;              % Sampling frequency
Fc = 500;                % Carrier frequency
Tb = 0.01;               % Bit duration
t = 0:1/Fs:Tb-1/Fs;

% Generate random binary data
N = 20;
data = randi([0 1], 1, N);

% ASK modulation
ask_signal = [];
for n = 1:N
    carrier = cos(2*pi*Fc*t);
    ask_bit = data(n) * carrier;     % ASK = binary * carrier
    ask_signal = [ask_signal ask_bit];
end

% ASK demodulation
received = ask_signal;               % No noise for basic experiment
demod = received .* cos(2*pi*Fc*(0:length(received)-1)/Fs);

% Low-pass filtering
[b,a] = butter(5, (Fc/Fs));
filtered = filtfilt(b,a,demod);

% Bit decision
samples_per_bit = length(t);
decoded = zeros(1,N);
for k = 1:N
    segment = filtered((k-1)*samples_per_bit + 1 : k*samples_per_bit);
    decoded(k) = mean(segment) > 0.2;    % Threshold
end

% Plotting
figure;
subplot(3,1,1); stem(data); title('Original Digital Data');
subplot(3,1,2); plot(ask_signal); title('ASK Modulated Signal');
subplot(3,1,3); plot(filtered); title('Demodulated Signal (Filtered)');
```

TEST 2: Frequency Shift Keying (FSK) Modulation

The digital signals generated by PAM, PPM, etc. are called baseband signals as their bandwidth is concentrated around the zero frequency. These signals can be transmitted via a wired medium. However, to transmit these signals via a band pass channel, a mechanism to shift the signal to that band is required. For this purpose, Frequency Modulation is one of the choices and this frequency modulation is called Frequency Shift Keying (FSK).

PRINCIPLE OF OPERATION

i. Modulation
Frequency shift keying (FSK) is a form of modulation that represents digital data as variations in the frequency of a carrier wave. The process involved in this type of modulation is similar to the type of modulation done in the Frequency Modulation (analog) case, except that the message signal is a digital Signal.

1. The generated analog message signal is first converted to a digital signal.
2. The digital signal generated is modulated using the narrow band frequency modulation technique to generate the FSK signal.

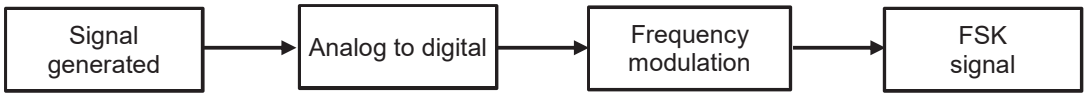


Figure 9: Block diagram of FSK modulator

ii. Demodulation
Improved zero crossing detection is used to demodulate the signal. The process is similar to the one done in Frequency Modulation.

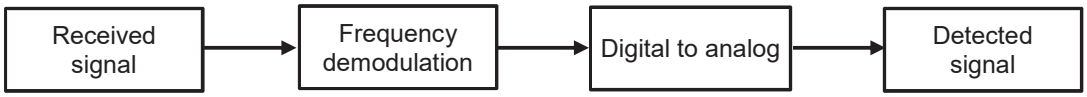


Figure 10: Block diagram of FSK demodulator

PROCEDURES:

1. Using the code given, generate digital data in MATLAB.
2. Assign two frequency f0 and f1.
3. Construct the FSK signal based on bit values.
4. Perform demodulation using correlators or zero-crossing method.
5. Low-pass filter and recover binary data.
6. Plot: Digital signal, Modulated signal, Spectrum (fft) and Demodulated signal

QUESTIONS:

1. Describe all the output figures obtained from the experiment.
2. What are the advantages and disadvantages of FSK?

```
% Parameters
Fs = 10000;
Fc0 = 300;      % Frequency for bit 0
Fc1 = 600;      % Frequency for bit 1
Tb = 0.01;
t = 0:1/Fs:Tb-1/Fs;

N = 20;
data = randi([0 1],1,N);

% FSK modulation
fsk_signal = [];
for n = 1:N
    if data(n)==0
        fsk_bit = cos(2*pi*Fc0*t);
    else
        fsk_bit = cos(2*pi*Fc1*t);
    end
    fsk_signal = [fsk_signal fsk_bit];
end

% FSK demodulation using correlators
samples = length(t);
decoded = zeros(1,N);

for k = 1:N
    segment = fsk_signal((k-1)*samples+1:k*samples);
    c0 = sum(segment .* cos(2*pi*Fc0*t));
    c1 = sum(segment .* cos(2*pi*Fc1*t));
    decoded(k) = c1 > c0;
end

% Plotting
figure;
subplot(3,1,1); stem(data); title('Original Data');
subplot(3,1,2); plot(fsk_signal); title('FSK Modulated Signal');
subplot(3,1,3); stem(decoded); title('Demodulated Data');
```

OPEN ENDED TASK:

1. Modify the provided MATLAB code to create a hybrid modulation scheme where:
   Bit 0 → transmitted using ASK
   Bit 1 → transmitted using FSK (choose your own Fc0 and Fc1).
2. You may choose:
   How to combine the signals
   How long each segment is
   How to structure the frame (e.g., ASK then FSK, or alternating)
3. Plot of the hybrid modulated signal
4. Explanation of how you structured the hybrid modulation
5. Discussion of when such a hybrid system might be useful in real communication systemsLow-pass filter and recover binary data.
6. Plot: Digital signal, Modulated signal, Spectrum (fft) and Demodulated signal

END OF EXPERIMENT