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A
SIMULATION REPORT ON

FSK MODULATION & NON-COHERENT DEMODULATION

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ABSTRACT

This report is on FSK non-coherent demodulation using MATLAB to contribute to the understanding of the non-coherently-detected frequency-shift keying (FSK) modulation from a practical standpoint. Specifically, the performances of a non-coherent correlator receiver and detect signals of unknown carrier phase and are compared with theoretical results. It is shown that the complexity and cost of the circuit on receiver side is minimized. This result is credited to absence of phase lock between transmitter and receiver which in case of coherent as to detected and corrected accordingly.

INTRODUCTION

Binary FSK (usually referred to simply as FSK) is a modulation scheme typically used to send digital information between digital equipment such as teleprinters and computers. The data are transmitted by shifting the frequency of a continuous carrier in a binary manner to one or the other of two discrete frequencies. One frequency is designated as the “mark” frequency and the other as the “space” frequency. The mark and space correspond to binary one and zero, respectively. Synchronous transmissions have mark-to-space and space-to-mark transitions in synchronism with a reference clock. The minimum duration of a mark or space condition is called the element length. Typical values for element length are between 5 and 22 milliseconds, but element lengths of less than 1 microsecond and greater than 1 second have been used. Bandwidth constraints in telephone channels and signal propagation considerations in HF channels generally require the element length to be greater than 0.5 millisecond. An alternate way of specifying element length is in terms of the keying speed. The keying speed in “bauds” is equal to the inverse of the element length in seconds. For example, an element length of 20 milliseconds (.02 seconds) is equivalent to a 50-baud keying speed. Frequency measurements of the FSK signal are usually stated in terms of “shift” and center frequency. The shift is the frequency difference between the mark and space frequencies. Shifts are usually in the range of 50 to 1000 Hertz. The nominal center frequency is halfway between the mark and space frequencies. Occasionally the FM term “deviation” is used. The deviation is equal to the absolute value of the difference between the center frequency and the mark or space frequencies. The deviation is also equal, numerically, to one-half of the shift. FSK can be transmitted coherently or noncoherently. Coherency implies that the phase of each mark or space tone has a fixed phase relationship with respect to a reference. This is similar to generating an FSK signal by switching between two fixed-frequency oscillators to produce the mark and space frequencies. While this method is sometimes used, the constraint that transitions from mark to space and vice versa must be phase continuous (“glitch” free) requires that the shift and keying rate be interrelated. A synchronous FSK signal which has a shift in Hertz equal to an exact integral multiple (n = 1, 2...) of the keying rate in bauds, is the most common form of coherent FSK. Coherent FSK is capable of superior error performance but noncoherent FSK is simpler to generate and is used for the majority of FSK transmissions. Noncoherent FSK has no special phase relationship between consecutive elements, and, in general, the phase varies randomly. Coherent and non-coherent are processes happen on the transmitter side; it means that there is coherent and non-coherent detection not modulation. Coherent detection is the process happened when the receiver exploits knowledge of the carrier’s phase to detect the signals. Non-coherent detection when the receiver doesn't utilize such phase reference information and the advantages of non-coherent over coherent is to reduce of complexity. So far, we have only considered the case of coherent receivers, i.e. receivers that use knowledge of the phase of the carrier frequency. In a communications system using the modulation of a carrier frequency, the oscillators used at the transmitter and receiver are not phase locked. As a consequence, there is a phase difference between the reference signal transmitted and the reference signal used in the demodulator. In order to perform a coherent demodulation in the receiver, this phase difference must be estimated and corrected. [1]

LITERATURE SURVEY RELATED TO THE TOPIC

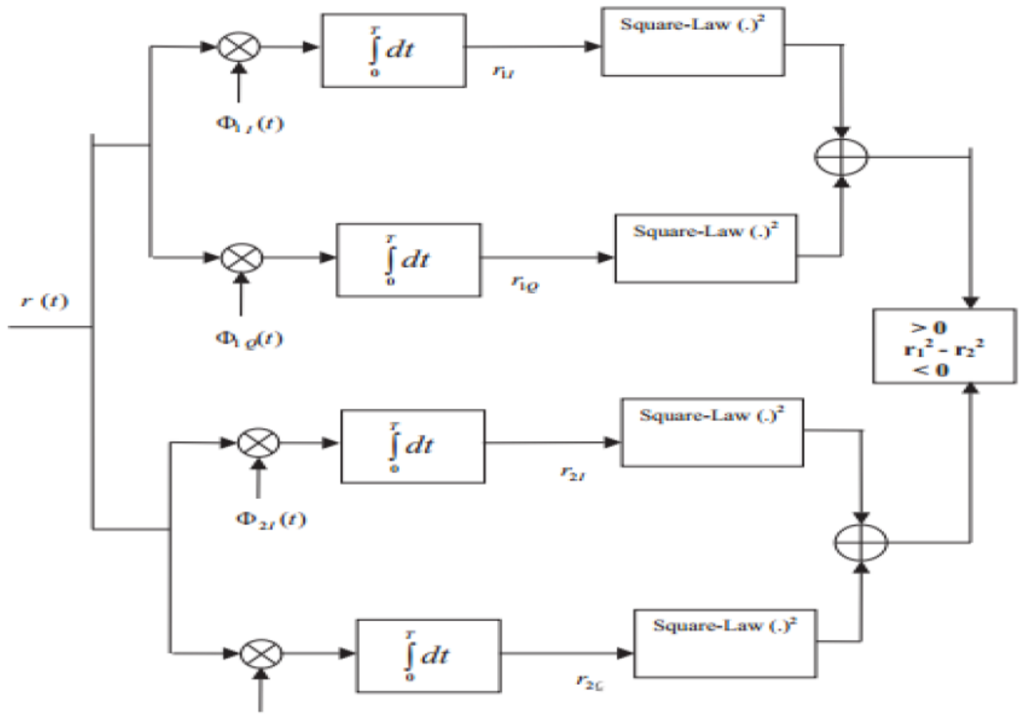
For non–coherent detection phase measurement cannot be exploited. The coherent receiver is modified as follows: For a frequency f1, 2 correlators are implemented, one to correlate with an in–phase reference signal:

$$\Phi_{1I} = \sqrt{\frac{2}{T}} \cos\left(2\pi f_1 t\right)$$

and the other to correlate with a quadrature (90◦ out of phase) reference signal:

$$\Phi_{1Q} = \sqrt{\frac{2}{T}}\sin(2\pi f_1 t)$$

For this reason, a non–coherent detector therefore requires twice as many channel branches as a coherent detector. The diagram below illustrates a non–coherent receiver for the detection of binary FSK (BFSK):



Non coherent Binary FSK demodulator and square-law detector

The upper two branches are configured to detect f1, and the lower two branches are configured to detect f2. If the received signal is of the form cos(2πf1)+n(t), where the phase is 0 and the frequency is f1, the top branch of the receiver would yield the maximum output. The second branch would yield a near 0 output since the reference signal q 2T sin (2πf1t) is orthogonal to the signal component. The third and fourth branches would also yield near zero outputs since their f2 reference signals are also orthogonal to the signal component.

If the received signal is of the form cos (2πf1t + φ), the received signal will partially correlate with the cos(2πf1t) reference signal and partially correlate with the sin(2πf1t) reference signal. The third and fourth reference signals will still return a near zero value due to orthogonality. • The receiver is therefore able to decide whether the received signal was an f1 signal or an f2 signal by squaring and summing the outputs from the upper two branches and comparing them with the sum of the squares of the outputs from the lower two branches.

r_1 is given by: $r^2_1 = r^2_{1I} + r^2_{1Q}$

r_2 is given by: $r^2_2 = r^2_{2I} + r^2_{2Q}$

The decision criterion is given by:

$r^2_1 > r^2_2$, $r^2_1 - r^2_2 > 0$, choose s1

$r^2_2 > r^2_1$, $r^2_2 - r^2_1 > 0$, choose s2

A receiver based on this decision criterion is known as a quadrature receiver. [4]

MATLAB CODE:

```
%FSK Non-coherent Demodulation
clc;
clear all;
close all;
x=input('Enter the binary info(entered as row vector): ');
bp=input('Enter the value of Tb(seconds): ');
%Plotting the graph
bit=[];
for n=1:1:length(x)
    if x(n)==1;
       se=ones(1,100);
    else x(n)==0;
        se=zeros(1,100);
    end
     bit=[bit se];

end
t1=bp/100:bp/100:100*length(x)*(bp/100);
subplot(3,1,1);
plot(t1,bit,'lineWidth',2.5);grid on;
axis([ 0 bp*length(x) -.5 1.5]);
ylabel('amplitude(volt)');
```

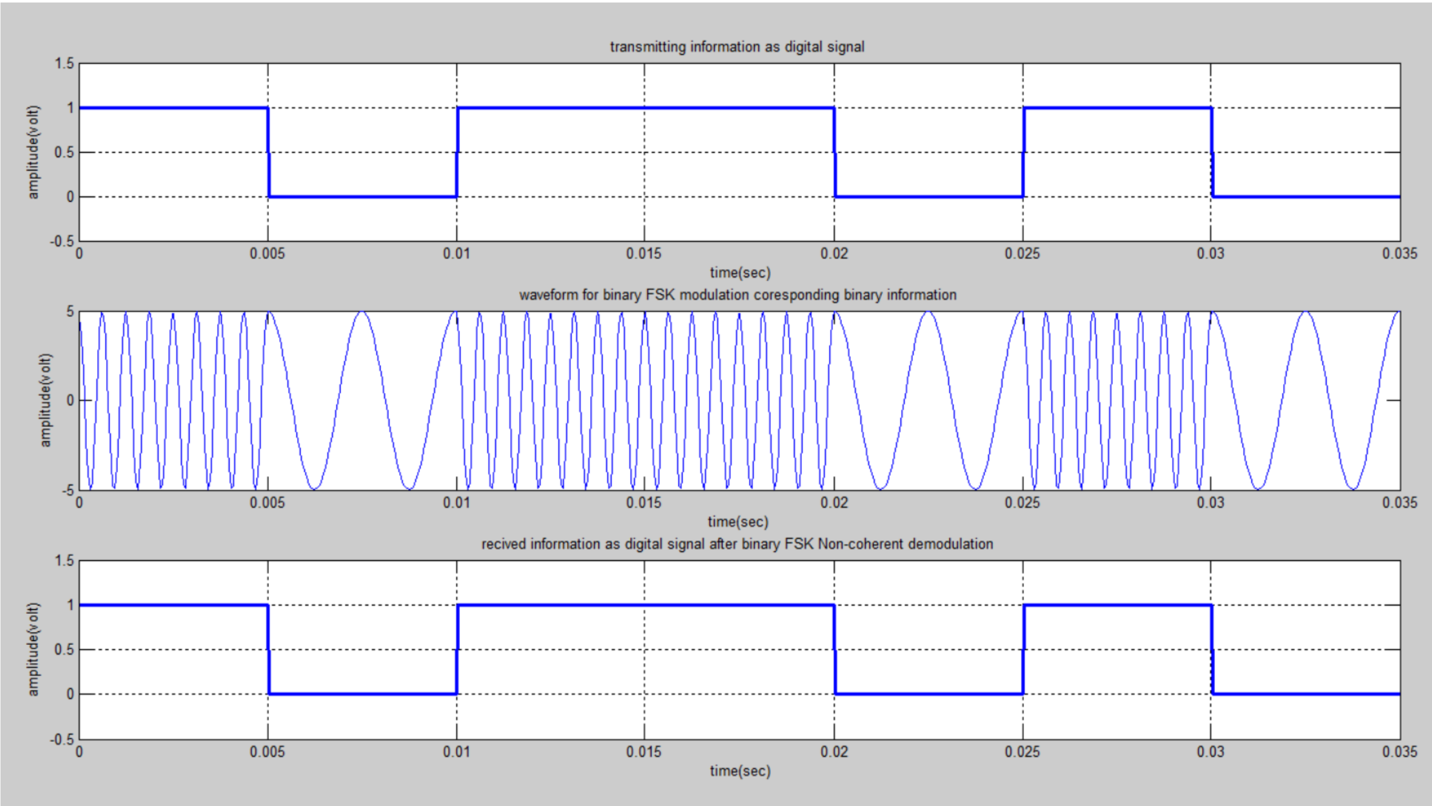
```
xlabel(' time(sec)');
title('transmitting information as digital signal');
%Signal Geneartion
A=5;
br=1/bp;
f1=br*8;
f2=br*2;
t2=bp/99:bp/99:bp;
ss=length(t2);
m=[];
for (i=1:1:length(x))
    if (x(i)==1)
        y=A*cos(2*pi*f1*t2);
    else
        y=A*cos(2*pi*f2*t2);
    end
    m=[m y];
end
t3=bp/99:bp/99:bp*length(x);
subplot(3,1,2);
plot(t3,m);
xlabel('time(sec)');
ylabel('amplitude(volt)');
title('waveform for binary FSK modulation coresponding binary information');
%Non coherent Demodulation
mn=[];
for n=ss:ss:length(m)
  t=bp/99:bp/99:bp;
  y1=cos(2*pi*f1*t);
  y2=cos(2*pi*f2*t);


  y11=sin(2*pi*f1*t);
  y22=sin(2*pi*f2*t);
  mm=y1.*m((n-(ss-1)):n);
  mmm=y2.*m((n-(ss-1)):n);
  mm1=y11.*m((n-(ss-1)):n);
  mmm1=y22.*m((n-(ss-1)):n);
  t4=bp/99:bp/99:bp;
  z1=trapz(t4,mm);
```

```
        z11=trapz(t4,mm1);
        z2=trapz(t4,mmm);
        z22=trapz(t4,mmm1);
        zz1=round(2*z1/bp);
        zz11=round(2*z11/bp);
        zz2= round(2*z2/bp);
        zz22= round(2*z22/bp);
        %square law detection
        R1=zz1^2+zz11^2;
        R2=zz2^2+zz22^2;
        if((R1>R2))
          a=1;
        else(R2>R1)
          a=0;
        end
        mn=[mn a];
      end
      disp(' Binary information at Reciver :');
      disp(mn);
      bit=[];
      for n=1:length(mn);
          if mn(n)==1;
             se=ones(1,100);
          else mn(n)==0;
              se=zeros(1,100);
          end
           bit=[bit se];

      end
      t4=bp/100:bp/100:100*length(mn)*(bp/100);
      subplot(3,1,3)
      plot(t4,bit,'LineWidth',2.5);grid on;
      axis([ 0 bp*length(mn) -.5 1.5]);
      ylabel('amplitude(volt)');
      xlabel(' time(sec)');
      title('recived information as digital signal after binary FSK Non-coherent demodulation');
```
[5]

COMMAND WINDOW

```
Enter the binary info[1 0 1 1 0 1 0]
Enter the value of Tb1/200

ans =

     1


ans =

     1


ans =

     1

 Binary information at Reciver :
     1     0     1     1     0     1     0

fx >>
```

OUTPUT WINDOW



RESULT's EXPLAINATION:

The above command window and output window shows the Fsk non-coherent demodulation of message signal in binary form [1 0 1 1 0 1 0]. The information and bit rate details are entered corresponding Fsk signal is generated and the demodulated output is displayed. The Fsk signal consists of summation of sinusoidal wave of two frequency depending on the value transmitted i.e., if logic 1 is transmitted then sinusoidal wave of frequency f1 is transmitted and if logic 0 is transmitted then sinusoidal signal of frequency f2 is transmitted. The demodulated signal is produced after non-coherent demodulation and matched the input signal therefore Fsk non-coherent demodulation is performed.

APPLICATION:

1) The most common application which everyone is aware of that is FM Radio broadcasting.
2) Bluetooth or BLE (Bluetooth Low Energy) which normally used everywhere like in mobile phone, wireless speakers, Laptops, etc. uses GFSK (Gaussian Frequency Shift Keying) modulation technique for data transmission. Difference between GFSK and FSK is nothing but GFSK has an additional Gaussian Filter to reduce the side band power. [3]

ADVANTAGES:

1) It has lower probability of error (P_e).
2) It provides high SNR (Signal to Noise Ratio).
3) It has higher immunity to noise due to constant envelope. Hence it is robust against variation in attenuation through channel.
4) FSK transmitter and FSK receiver implementations are simple for low data rate application. [2]

DISADVANTAGES:

1) It uses larger bandwidth compare to other modulation techniques such as ASK and PSK. Hence it is not bandwidth efficient.
2) The BER (Bit Error Rate) performance in AWGN channel is worse compare to PSK modulation. [2]

CONCLUSION:

The Fsk non-coherent demodulation was implemented using MATLAB and the Fsk signal and the demodulated signal based on the given input signal was generated. The outputs are clearly shown as graph in the output window.

REFERENCE:

1) WJ Communications, Inc. • 401 River Oaks Parkway • San Jose, CA 95134-1918 • Phone: 1-800-WJ1-4401 • Fax: 408-577-6620 • e-mail: sales@wj.com • Web site: www.wj.com.
2) http://www.rfwireless-world.com
3) http://techiesms.blogspot.in/2016/04/practical-application-modulation.html
4) Coherent and non-coherent from www.notesandbook.com
5) www.mathworks.com