CONTENTS

DIRECT SEQUENCE SPREAD SPECTRUM

Introduction

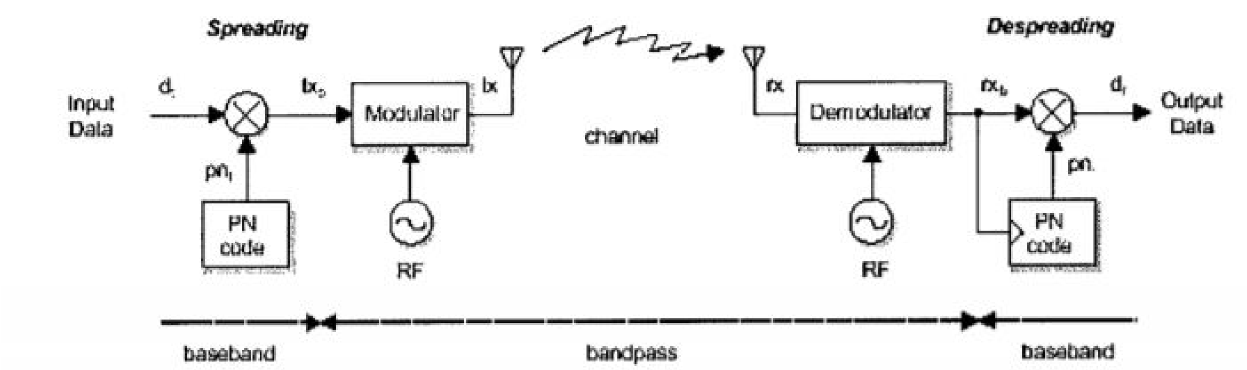
Of the various spread spectrum modulation techniques available today, the best-known and most widely used method remains direct sequence spread spectrum (DSSS). Direct sequence signals meet these requirements by employing a pseudo-noise sequence that is independent of the information data. These sequences are used to spread the spectrum over a bandwidth that is much greater than that of the information being transmitted. In the following sections, we will examine direct sequence spread spectrum in great detail. We will first look at the basic concepts of DSSS signals, including baseband modulation and demodulation. The following section builds upon the knowledge of the characteristics of spread spectrum signals gained previously by going into greater detail on three of them: code division multiplexing, low power density, and interference rejection. After addressing the performance specifications of DSSS (processing gain and jamming margin), we will delve into pseudo-noise sequences. These sequences are responsible for all of the desirable characteristics of DSSS signals.

Basic Concepts of DSSS

The purpose of this section is to familiarize the reader with the basic concepts of DSSS systems. The various components and functionality of a DSSS system are presented and discussed, leading to a simplified description of the modulation and demodulation of these types of signals. The figures presented in these sections are particularly useful for understanding the principles of frequency spreading because they show both the time and frequency domains.

Block Diagram

Throughout this report we have made references to DSSS systems and the components that create the spread spectrum signals. This diagram also points out that all of the spreading and dispreading is performed baseband the bandpass region is only used to modulate the coded signal onto useable frequencies. As a matter of fact, we will be concerned solely with baseband when we examine the modulation and demodulation of DSSS signals.



Code-Division Multiple Access (CDMA)

Code-division multiple access (CDMA) was conceived several decades ago. Recent advances in electronic technology have finally made its implementation possible. CDMA differs from FDMA because only one channel occupies the entire bandwidth of the link. It differs from TDMA because all stations can send data simultaneously; there is no timesharing.

Analogy

Let us first give an analogy. CDMA simply means communication with different codes. For example, in a large room with many people, two people can talk in English if nobody else understands English. Another two people can talk in Chinese if they are the only ones who understand Chinese, and so on. In other words, the common channel, the space of the room in this case, can easily allow communication between several couples, but in different languages (codes).

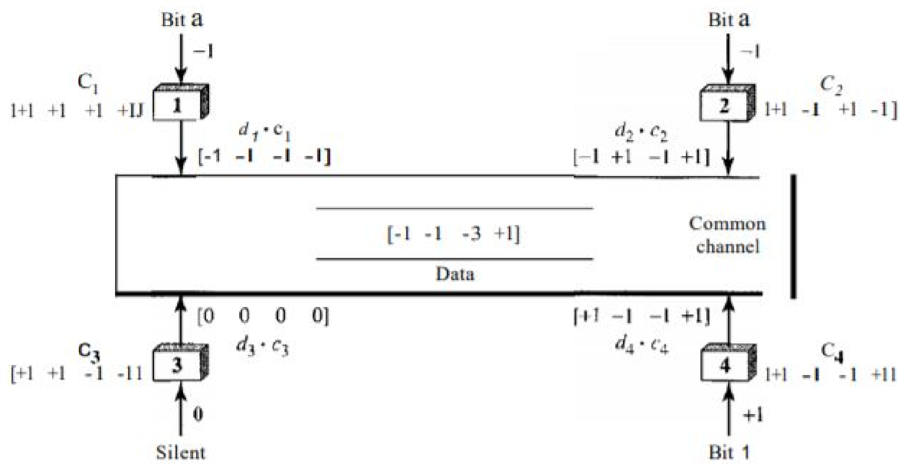
Idea

Let us assume we have four stations 1, 2, 3, and 4 connected to the same channel. The data from station 1 are d l , from station 2 are d2, and so on. The code assigned to the first station is cI, to the second is c2, and so on. We assume that the assigned codes have two properties. 1. If we multiply each code by another, we get O. 2. If we multiply each code by itself, we get 4 (the number of stations). With these two properties in mind, let us see how the above four stations can send data using the same common channel.

Implementing CDMA Using DSSS Technology

Code-division multiple access (CDMA) is commonly implemented using direct sequence spread spectrum (DSSS) technology in actual applications. In a DSSS system, the information signal (data) to be transmitted is mixed with a pseudo random code sequence to spread the bandwidth of the transmitted signal At reception the exact same code sequence is used to reduce the bandwidth of the received spread spectrum signal back to that of the information signal transmitted The information (data) transmitted is then recovered Any other signal that does not have the signature applied to the transmitted spread spectrum signal by the pseudo random code sequence used is rejected at reception. Therefore, the pseudo-random code sequence used in the bandwidth spreading and reduction is a means of identifying a transmitted signal A set of spread spectrum signals having recognizable signatures can be produced by using different pseudo-random code sequences Assigning a code sequence to a user provides an efficient means of identifying the spread spectrum signal related to each user user signal)and thus allows discrimination of the various use signals, This is exactly what is required to implement a CDMA system.

Working



Encoding and Decoding

As a simple example, we show how four stations share the link during a I-bit interval. The procedure can easily be repeated for additional intervals. We assume that stations 1 and 2 are sending a 0 bit and channel 4 is sending a 1 bit. Station 3 is silent. The data at the sender site are translated to -1, -1, 0, and +1. The result is a new sequence which is sent to the channel. For simplicity, we assume that all stations send the resulting sequences at the same time. The sequence on the channel is the sum of all four sequences as defined before. Now imagine station 3, which we said is silent, is listening to station 2. Station 3 multiplies the total data

on the channel by the code for station 2, which is [+1 -1 +1-1], to get [-1-1-3 +1]·[+1-1 +1-1] =-4/4 =-1 = bit 1.

Sequence Generation

To generate chip sequences, we use a Walsh table, which is a two-dimensional table with an equal number of rows and columns.

$$W_1 = \begin{bmatrix} +1 \end{bmatrix} \qquad W_{2N} = \begin{bmatrix} W_N & W_N \\ W_N & \overline{W_N} \end{bmatrix}$$

a. Two basic rules

$$W_1 = \begin{bmatrix} +1 \end{bmatrix} \qquad W_2 = \begin{bmatrix} +1 & +1 \\ +1 & -1 \end{bmatrix} \qquad W_4 = \begin{vmatrix} +1 & +1 & +1 & +1 \\ +1 & -1 & +1 & -1 \\ +1 & +1 & -1 & -1 \\ +1 & -1 & -1 & +1 \end{vmatrix}$$

Advantages of DSSS

There are some advantages of direct sequence spread spectrum which are given below

- It has best discrimination against multipath signals.
- It avoids intentional interference such as jamming effectively.
- Performance of DSSS system in presence of noise is better than FHSS system.
- Low probability of interception The transmitted energy remains the same, but the wideband DSSS signal looks like noise to any receiver that does not know the signal’s code sequence. So there is extremely low possibility of intercepting this signal.
- Increased tolerance to interference DSSS modulators process a narrowband information signal to spread it over a much wider bandwidth. Spreading the information signal desensitizes the original narrowband signal to same potential difference to the channel.

- Increasing Ranging capability Timing error is directly proportional to range error and inversely proportional to the signal bandwidth. This property enables DSSS signal to measure distance or equipment location, through a method known as triangulation.

Disadvantages of DSSS

There are some disadvantages of direct sequence spread spectrum which are given below

- This system becomes slow due to large acquisition time.
- It requires wideband channel with small phase distortion.
- The pseudo noise generator should generate sequence at high rates.
- Code acquisition may be difficult.
- Affected by Jamming.
- Suspectable to near-far problem

Applications of DSSS

There are some applications of direct sequence spread spectrum which are given below

- It is used in military and many commercial applications.
- It is very simpler to implement.
- It is used in the low probability of intercept signal.
- Code division multiple access with direct sequence spread spectrum.
- It can withstand multi-access interference.

DSSS vs FHSS

DSSS

- Channel
  - – 2.4 GHz
  - –Amount 14 channels
  - –Width of 22MHz.

– Spaced with 5MHz.

- Narrow band interference
  - Narrowband interference in the same channel is reduced by the processing pain.
- Main parameters
  - Modulated by DBPSK and DQPSK are very power efficient.
  - Data rates are 5.5 Mbps and 11 Mbps.
- Co-location
  - Maximum of 3 co-located networks.
  - Maximum data rates 33 Mbps.
- Security
  - Low Secure.

FHSS

- Channel

  – 2.4 GHz

  –Amount 79channels

  –Width of 1MHz.

  – Spaced with 1MHz.
- Narrow band interference
  - Narrowband interference in the same channel is not reduced by the processing pain.
  - Narrow band interference in a different channel has no influence.
- Main parameters
  - Modulated by GFSK is less power efficient in narrowband operation.
  - Data rates are 1 Mbps and 2 Mbps.
- Co-location
  - Maximum of 12 co-located networks.
  - Maximum data rates 24 Mbps.
- Security
  - High Secure.

Code

```
clc
close all
clear all
Source1=0
subplot(4,4,1)
stem(Source1);
title('Station 1')
for i=1
    if Source1(i)==0
        Source1(i)=-1;
    End
End
Source2=0
subplot(4,4,2)

stem(Source2);
title('Station 2')
for i=1
    if Source2(i)==0
        Source2(i)=-1;
    end
end
Source3=0
subplot(4,4,3)

stem(Source3);
title('Station 3')
for i=1
    if Source3(i)==0
        Source3(i)=-1;
    end
end
Source4=1
subplot(4,4,4)
stem(Source4);
title('Station 4')
for i=1
    if Source4(i)==0
        Source4(i)=-1;
    end
end
b=[1 1 1 1];
for i=1:4
    if b(i)==0
        b(i)=-1;
    end
end
subplot(4,4,5)
stairs(b);
title('Pseudo 1')
axis([0 5 -2 2])
s=1;
```

```
for i=1:4
    c(s)=Source1*b(i);
    s=s+1;
end
subplot(4,4,6)
stairs(c);
title('DSSS 1')
axis([0 5 -2 2])
d=[1 -1 1 -1];
for i=1:4
    if d(i)==0
        d(i)=-1;
    end
end
subplot(4,4,7)
stairs(d);
title('Pseudo 2')
axis([0 5 -2 2])
s=1;
for i=1:4
    e(s)=Source2*d(i);
    s=s+1;
end
subplot(4,4,8)
stairs(e);
title('DSSS 2')
axis([0 5 -2 2])

f=[1 1 -1 -1];
for i=1:4
    if f(i)==0
        f(i)=-1;
    end
end
subplot(4,4,9)
stairs(f);
title('Pseudo 3')
axis([0 5 -2 2])
s=1;
for i=1:4
    g(s)=Source3*f(i);
    s=s+1;
end
subplot(4,4,10)
stairs(g);
title('DSSS 3')
axis([0 5 -2 2])
h=[1 -1 -1 1];
for i=1:4
    if h(i)==0
        h(i)=-1;
    end
end
subplot(4,4,11)
```

```
stairs(h);
title('Pseudo 4')
axis([0 5 -2 2])
s=1;
for i=1:4
    n(s)=Source4*h(i);
    s=s+1;
end
subplot(4,4,12)
stairs(n);
title('DSSS 4')
axis([0 5 -2 2])
for i=1:4
o(i)=c(i)+e(i)+g(i)+n(i);
end
disp('Data present in the Channel')
disp(o)
subplot(4,4,14.5)
stairs(o);
title('Channel')
axis([0 5 -2 2])
for i=1:4
    if o(i)==0
        o(i)=-1;
    end
end
Receiver = input('Enter the receiver station : ')
if Receiver == 1
    select = input('Enter the transmitter station : ');
switch select
    case 2
        for i=1:4
            p(i)=d(i)*o(i);
        end
        op1=p(1)+p(2)+p(3)+p(4);
        Databit=(op1)/4;
        for i=1
         if Databit(i)==-1
            Databit(i)=0;
         end

        end
        disp('Data = ')
        disp(Databit)
    case 3
        for i=1:4
            p(i)=f(i)*o(i);
        end
        op1=p(1)+p(2)+p(3)+p(4);
        Databit=(op1)/4;
         for i=1
         if Databit(i)==-1
            Databit(i)=0;
         end
         end
```

```
        disp('Data = ')
        disp(Databit)
    case 4
        for i=1:4
            p(i)=h(i)*o(i);
        end
        op1=p(1)+p(2)+p(3)+p(4);
        Databit=(op1)/4;
         for i=1
         if Databit(i)==-1
            Databit(i)=0;
         end

         end
        disp('Data = ')
        disp(Databit)
end
end
if Receiver == 2
    select = input('Enter the transmitter station : ');
switch select
    case 1
        for i=1:4
            p(i)=b(i)*o(i);
        end
        op1=p(1)+p(2)+p(3)+p(4);
        Databit=(op1)/4;
         for i=1
         if Databit(i)==-1
            Databit(i)=0;
         end

         end
        disp('Data = ')
        disp(Databit)
    case 3
        for i=1:4
            p(i)=f(i)*o(i);
        end
        op1=p(1)+p(2)+p(3)+p(4);
        Databit=(op1)/4;
         for i=1
         if Databit(i)==-1
            Databit(i)=0;
         end
         end
        disp('Data = ')
        disp(Databit)
    case 4
        for i=1:4
            p(i)=h(i)*o(i);
        end
        op1=p(1)+p(2)+p(3)+p(4);
        Databit=(op1)/4;
         for i=1
         if Databit(i)==-1
```

```
            Databit(i)=0;
         end

         end
        disp('Data = ')
        disp(Databit)

end
end
if Receiver == 3
    select = input('Enter the transmitter station : ');
switch select
    case 1
        for i=1:4
            p(i)=b(i)*o(i);
        end
        op1=p(1)+p(2)+p(3)+p(4);
        Databit=(op1)/4;
         for i=1
         if Databit(i)==-1
            Databit(i)=0;
         end
         end
        disp('Data = ')
        disp(Databit)
    case 2
        for i=1:4
            p(i)=d(i)*o(i);
        end
        op1=p(1)+p(2)+p(3)+p(4);
        Databit=(op1)/4;
         for i=1
         if Databit(i)==-1
            Databit(i)=0;
         end
         end
        disp('Data = ')
        disp(Databit)
    case 4
        for i=1:4
            p(i)=h(i)*o(i);
        end
        op1=p(1)+p(2)+p(3)+p(4);
        Databit=(op1)/4;
         for i=1
         if Databit(i)==-1
            Databit(i)=0;
         end
         end
        disp('Data = ')
        disp(Databit)

end
end
if Receiver == 4
```

```
    select = input('Enter the transmitter station : ');
switch select
    case 1
        for i=1:4
            p(i)=b(i)*o(i);
        end
        op1=p(1)+p(2)+p(3)+p(4);
        Databit=(op1)/4;
         for i=1
         if Databit(i)==-1
            Databit(i)=0;
         end
         end
        disp('Data = ')
        disp(Databit)
    case 2
        for i=1:4
            p(i)=d(i)*o(i);
        end
        op1=p(1)+p(2)+p(3)+p(4);
        Databit=(op1)/4;
         for i=1
         if Databit(i)==-1
            Databit(i)=0;
         end
         end
        disp('Data = ')
        disp(Databit)
    case 3
        for i=1:4
            p(i)=f(i)*o(i);
        end
        op1=p(1)+p(2)+p(3)+p(4);
        Databit=(op1)/4;
         for i=1
         if Databit(i)==-1
            Databit(i)=0;
         end
         end
        disp('Data = ')
        disp(Databit)

end
end
```

Command Window and Workspace

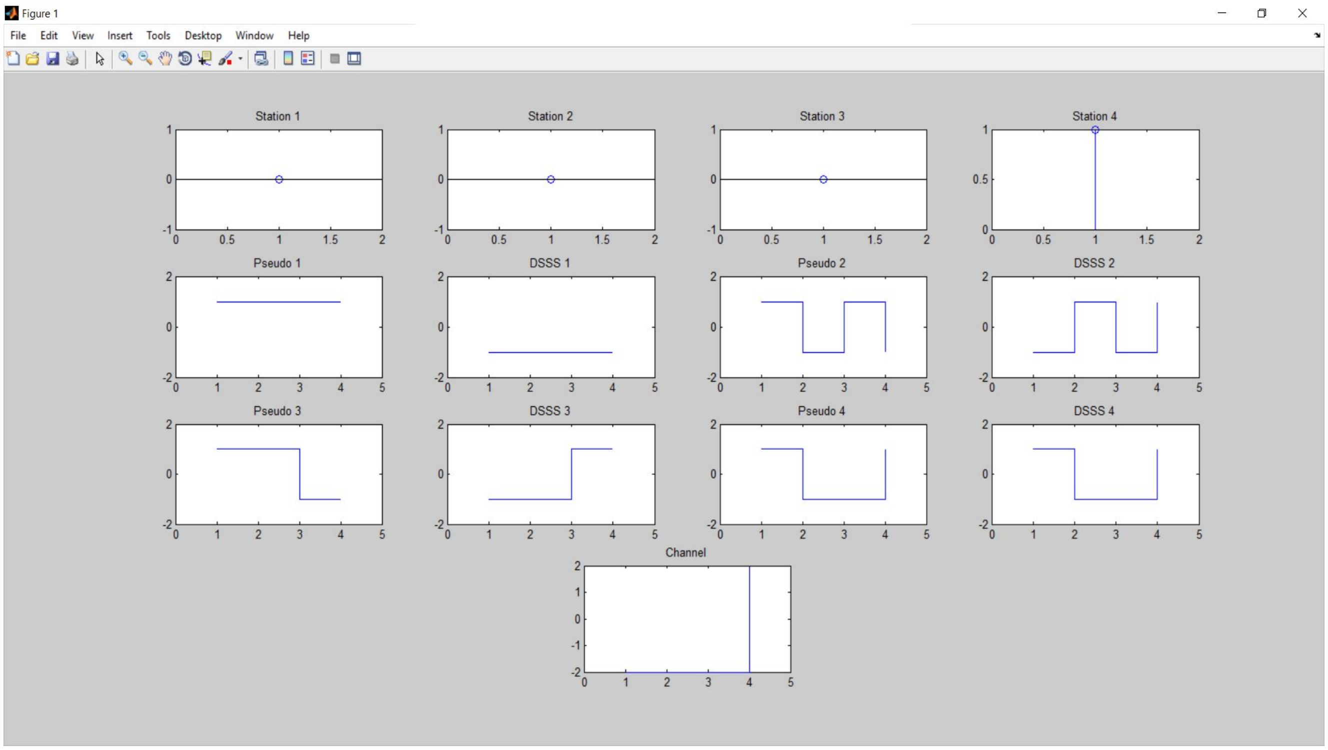
Command Window

```
Source1 =

     0


Source2 =

     0


Source3 =

     0


Source4 =

     1

Data present in the Channel
    -2    -2    -2     2

Enter the receiver station : 3

Receiver =

     3

Enter the transmitter station : 1
Data =
     0

fx >>
```

Workspace

Name	Value	Min	Max
b	[1,1,1,1]	1	1
c	[-1,-1,-1,-1]	-1	-1
d	[1,-1,1,-1]	-1	1
Databit	0	0	0
e	[-1,1,-1,1]	-1	1
f	[1,1,-1,-1]	-1	1
g	[-1,-1,1,1]	-1	1
h	[1,-1,-1,1]	-1	1
i	1	1	1
n	[1,-1,-1,1]	-1	1
o	[-2,-2,-2,2]	-2	2
op1	-4	-4	-4
p	[-2,-2,-2,2]	-2	2
Receiver	3	3	3
s	5	5	5
select	1	1	1
Source1	-1	-1	-1
Source2	-1	-1	-1
Source3	-1	-1	-1
Source4	1	1	1

Graph



Conclusion

Spread Spectrum promises several benefits such as higher capacity and resist multipath propagation. Spread spectrum signals are difficult to intercept for an unauthorized person, they are easily hidden. For an unauthorized person, it is difficult to even detect their presence in many cases. They are resistant to jamming. They provide a measure of immunity to distortion due to multipath propagation. They have multiple access capability.

Spread spectrum is now finding widespread civilian and commercial applications such as cellular telephones, personal communications and position location. For example DSSS is used in electronic industries association’s interim standard IS-95 for cellular telephones, as well as wide range of position location systems such as the global position location and other vehicle location and messaging systems.

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