## Contents

```
close all
```

## Generating the BPSK Sequence

```
bits=randi([0 1],4176,1)';
bpsk = zeros(1,size(bits,2));
neg = find(bits==0);
bpsk(neg) = complex(-1,0);
pos = find(bits==1);
bpsk(pos) = complex(1,0);
bpskMat = zeros(size(bpsk,2)/48, 64);
row = 1;
for i = 1:48:size(bpsk,2)
    bpskMat(row,[2:6,8:20, 22:27, 39:43, 45:57, 59:64]) = bpsk(i:i+47);
    row = row+1;
end
```

## Data, null and pilot carriers

1 - Null, 2-27 - data, 28 - 38 - Null, 39 - 64 - data 7, 21, (-21, -7) -> 44, 58 (7, 21, 44, 58) -> pilot (all 1s)

```
nulls = [1 28:38];
pilot = [7 21 44 58];

bpskMat(:,nulls) = 0;
bpskMat(:,pilot) = 1;

bpskIFFT = zeros(size(bpskMat,1), size(bpskMat,2));
for i = 1:size(bpskIFFT,1)
    bpskIFFT(i,:) = ifft(bpskMat(i,:));
end

% Cyclic prefix
bpskIFFT = [bpskIFFT(:,end-15:end) bpskIFFT];

% We now have 87 OFDM symbols (each row of bpskIFFT is an OFDM symbol)
```
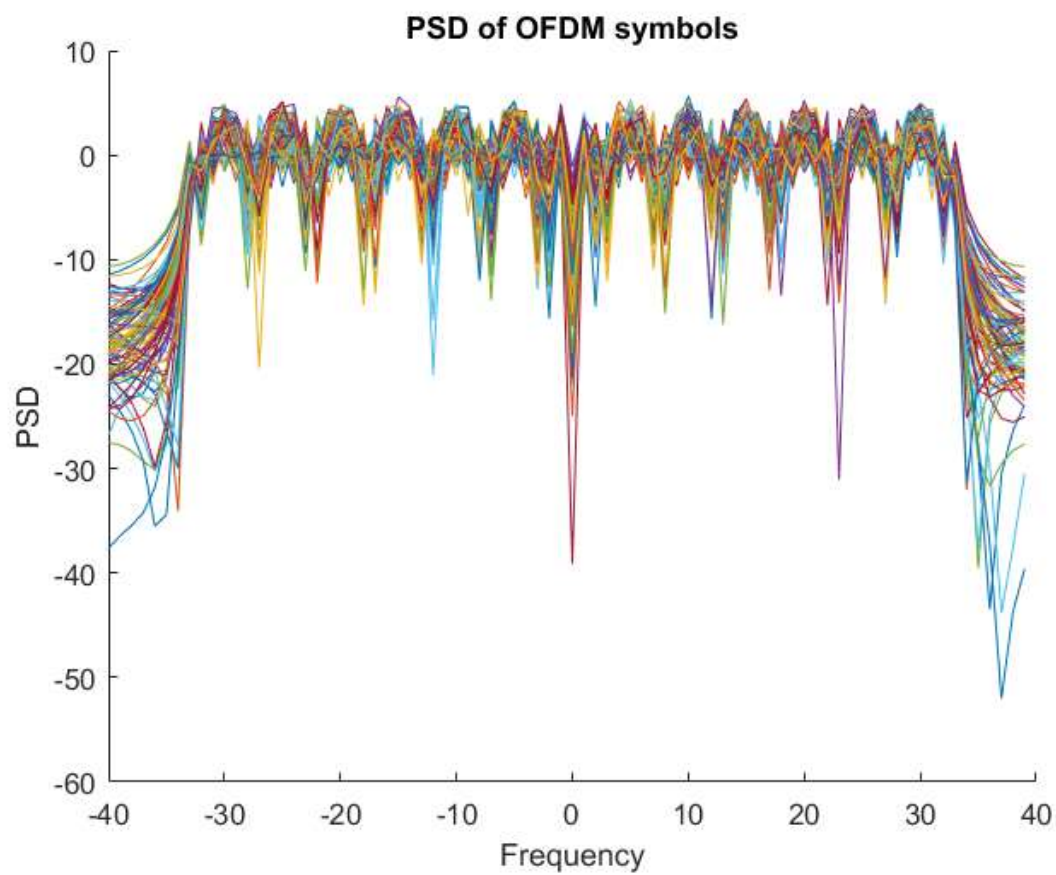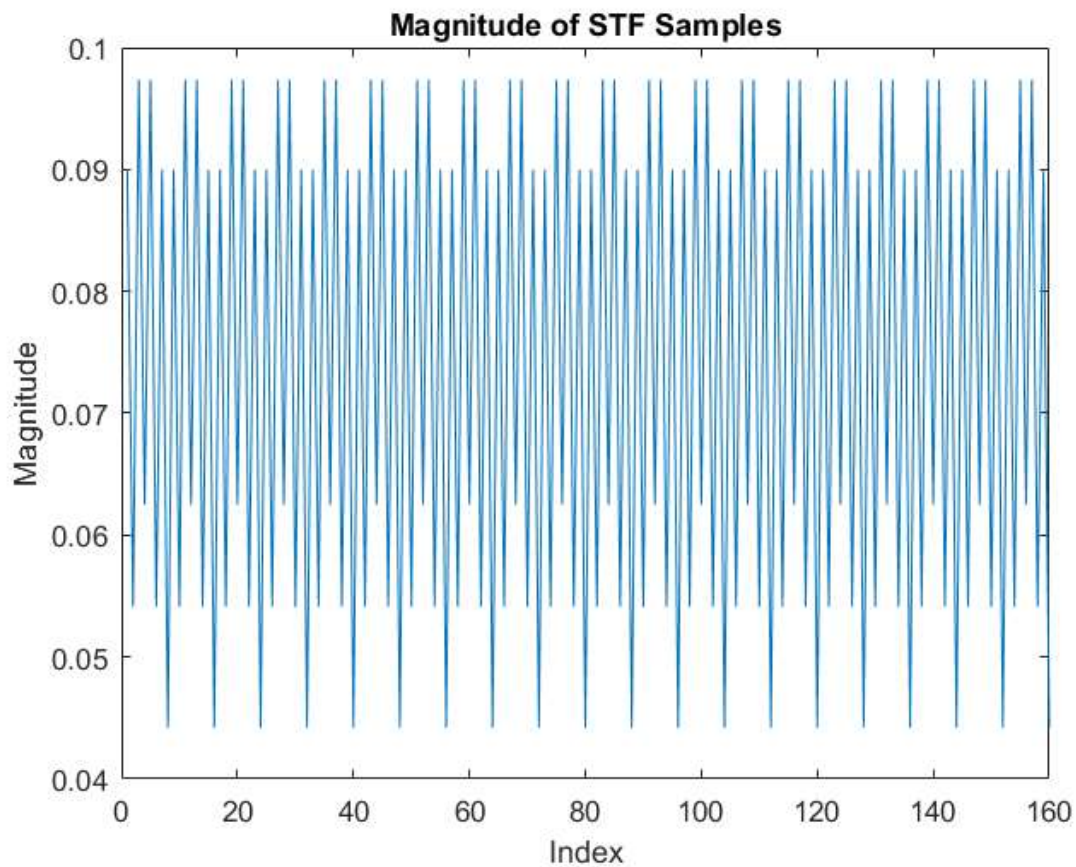
## Generating STF

```matlab
Sk = [0 0 0 0 0 0 0 0 1+1i 0 0 0 -1+1i 0 0 0 -1-1i 0 0 0 1-1i 0 0 0 ...
     -1-1i 0 0 0 1-1i 0 0 0 0 0 0 0 1-1i 0 0 0 -1-1i 0 0 0 1-1i 0 0 0 ...
     -1-1i 0 0 0 -1+1i 0 0 0 1+1i 0 0 0 0 0 0 0];

STF=ifft(fftshift(Sk));
STF = STF(6:21);
STFSeq = [];
for i = 1:10
    STFSeq = [STFSeq STF];
end

% Magnitude of samples of STF
figure(1);
plot(abs(STFSeq));
title('Magnitude of STF Samples');
xlabel('Index');
ylabel('Magnitude');

% PSD of OFDM Data Symbols
figure(2);
hold on;
for i = 1:size(bpskIFFT,1)
    rowVec = bpskIFFT(i,:);
    plot(-length(rowVec)/2:length(rowVec)/2 -1, fftshift(20*log10(abs(fft(rowVec)))));
end
title('PSD of OFDM symbols');
xlabel('Frequency');
ylabel('PSD');
```

Magnitude of STF Samples



PSD of OFDM symbols

## Generating LTF

```
Lk = [0 0 0 0 0 0 1, 1, -1, -1, 1, 1, -1, 1, -1, 1, 1, 1, 1, 1, 1, -1, -1, 1, 1, -1, 1, -1
, 1, 1, 1, 1, 1, 0,...
1, -1, -1, 1, 1, -1, 1, -1, 1, -1, -1, -1, -1, -1, 1, 1, -1, -1, 1, -1, 1, -1, 1, 1, 1 0 0
```

```
  0 0 0];

rLongIFFT = ifft(fftshift(Lk));
rLTF = [rLongIFFT rLongIFFT];
rLTF = [rLongIFFT(33:64) rLTF];
```

## Generating two OFDM packets

```
rows = floor(4096/size(bpskIFFT,2));
packet1 = [];
packet2 = [];
for k = 1:rows
    packet1 = [packet1 bpskIFFT(k,:)];
end
for k = rows+1:size(bpskIFFT,1)
    packet2 = [packet2 bpskIFFT(k,:)];
end
packet1 = [STFSeq rLTF packet1];
packet2 = [STFSeq rLTF packet2];
idle = zeros(1,100);
tx_packet = [idle packet1 packet2];
% <End of Step 1>
```

## Distortion

```
% magnitude distortion
tx_packet = tx_packet*10^(-5);

% phase shift by -3pi/4
tx_packet = tx_packet*exp(-1i*3*pi/4);

% frequency offset
for k=1:length(tx_packet)
    tx_packet(k) = tx_packet(k) * exp(-1i*2*pi*0.00017*k);
end

% channel noise
tx_packet = tx_packet + (10^(-7)*randn(size(tx_packet)));
```

## Plot of distorted STF frame

```
figure(3);
subplot(2,1,1);
plot(1:length(tx_packet(101:260)),abs(tx_packet(101:260)));
title('Packet 1 STF');
subplot(2,1,2);
plot(1:length(tx_packet(4501:4660)),abs(tx_packet(4501:4660)));
title('Packet 2 STF');
```

Packet 1 STF



Packet 2 STF
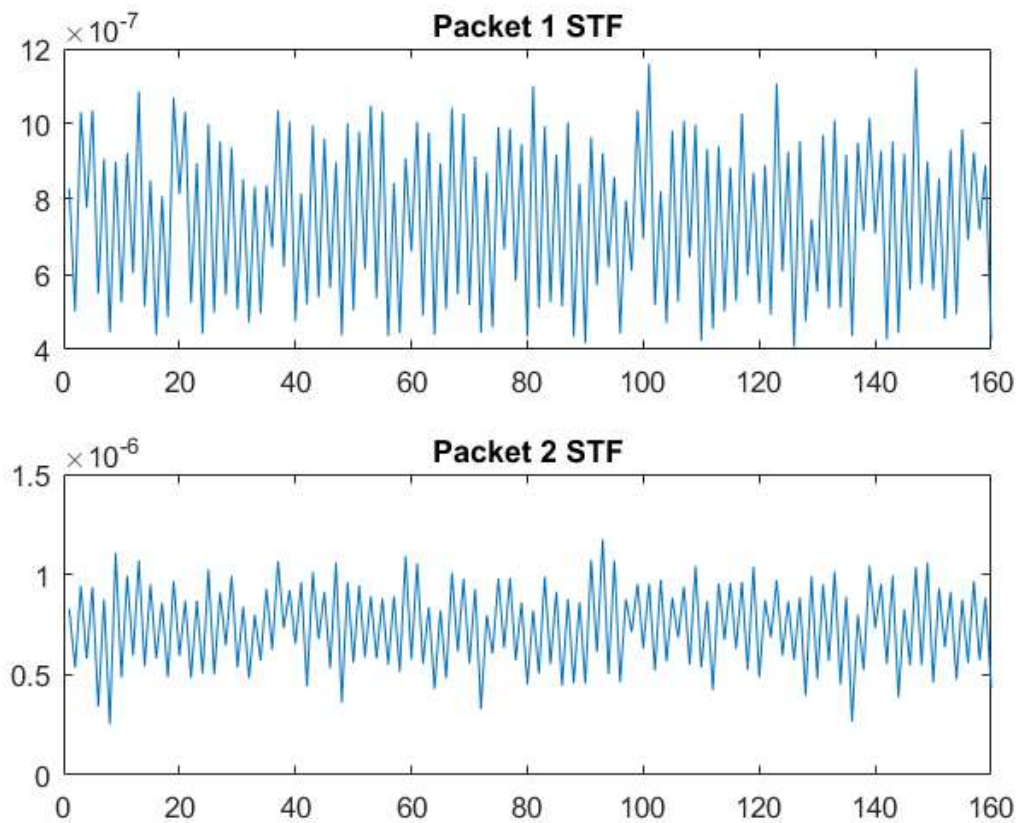
## Packet Detection

```matlab
rx_packet = tx_packet;

% Perform self correlation on the samples with a window size of 16.

autoCorr = zeros(2,length(rx_packet)-16);
i = 1;

for k = 1:length(rx_packet)-31
    for influence = 0:15
        autoCorr(1,i) = k;
        autoCorr(2,i) = autoCorr(2,i) + (rx_packet(k+influence).*conj((rx_packet(k+influen
ce+16))));
    end
    i = i+1;
end

figure(4);
plot(autoCorr(1,:),abs(autoCorr(2,:)));
title('Auto Correlation');
```

**Auto Correlation**
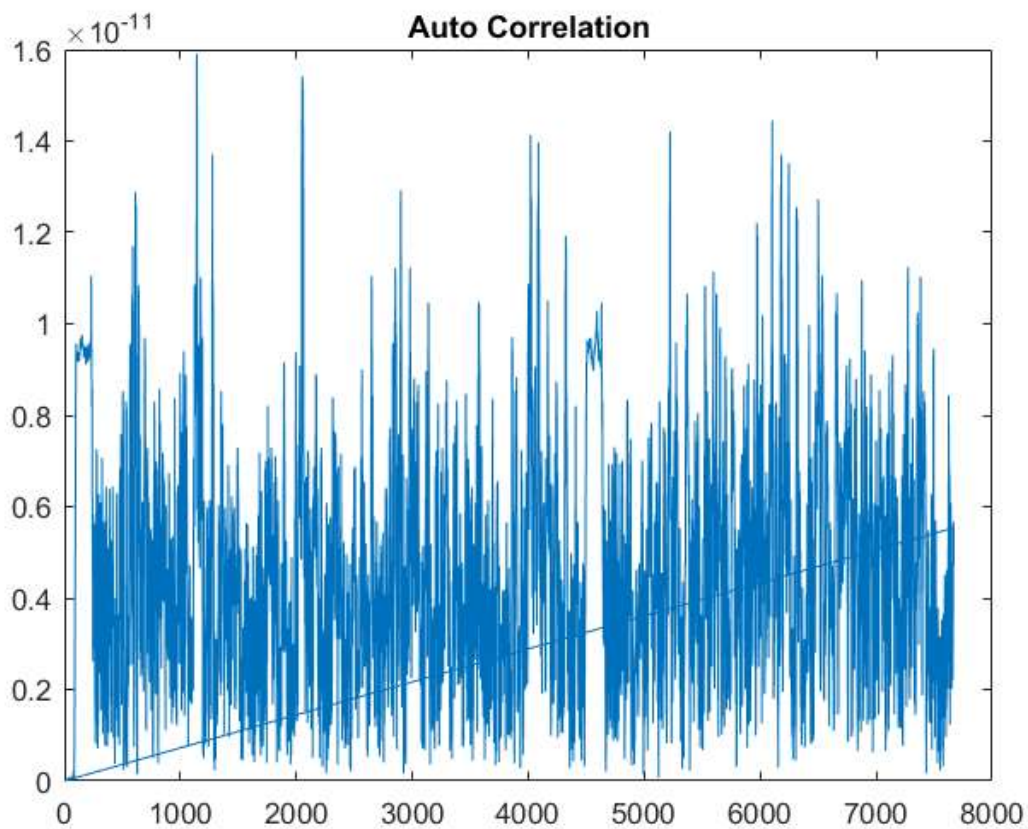
## Packet Synchronization

```matlab
crossCorr = zeros(2,length(rx_packet));
i = 1;
for index = 0:length(rx_packet)-1
    for i = index:index+15-1
        crossCorr(1,index+1) = index+1;
        crossCorr(2,index+1) = crossCorr(2,index+1) + (rx_packet(index+1).*conj((STF(i-ind
ex+1))));
    end
    i = i+1;
end


figure(5);
plot(crossCorr(1,:),abs(crossCorr(2,:)));
title('Cross Correlation');
```

Cross Correlation
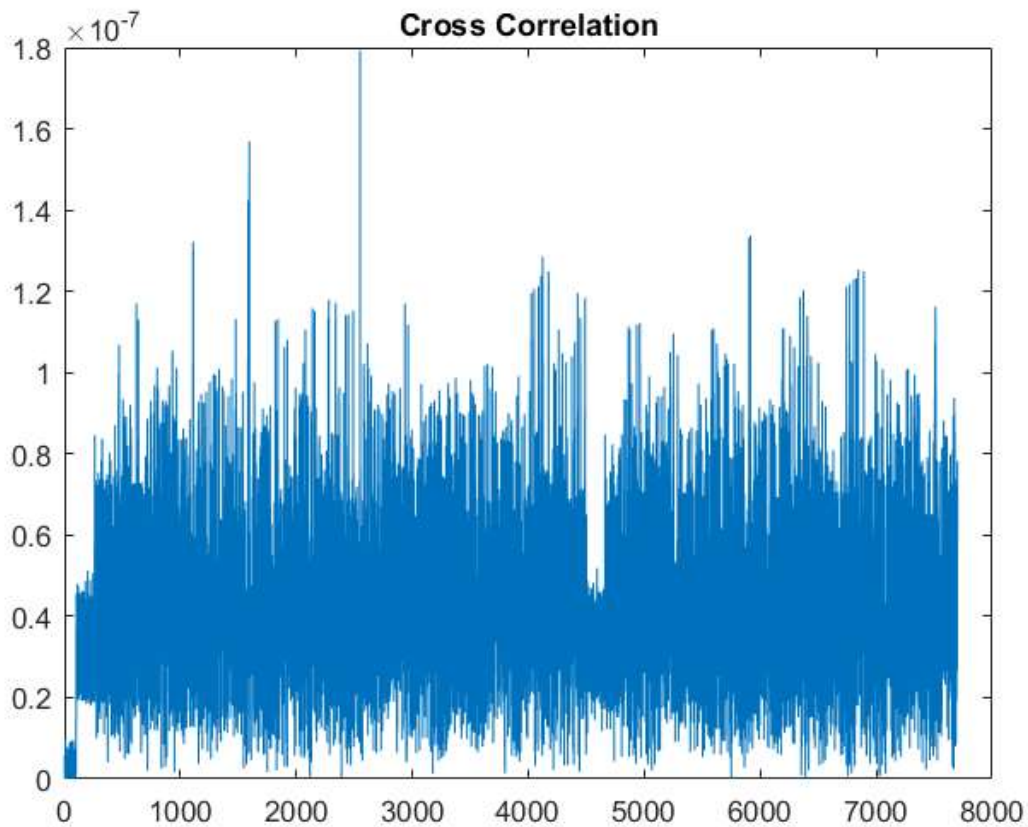
## Storing sample index for start of STF

```
[vals,indices] = find(abs(crossCorr(2,:))>(1.35*10^(-8))));
STF_Start(1) = indices(1);
for i = 1:length(indices)
    if(indices(i)>=STF_Start(1)+length(packet1))
        STF_Start(2) = indices(i);
        break;
    end
end
    display('STF start indices for the two packets: ');
    STF_Start

% End of Step 4
```

```
STF start indices for the two packets:

STF_Start =

        101        4501
```

## Frequency Compensation

```
LTF_Start = STF_Start+160;


N = 64;
for n = 0:N-1
    deltaF1(n+1) = angle(rx_packet(LTF_Start(1)+32+n+N)/rx_packet(LTF_Start(1)+n+32));
    deltaF1(n+1) = deltaF1(n+1)/(2*pi*N);
```

```matlab
        delF = mean(deltaF1);
end

% rx_packet_1 = rx_packet(LTF_Start(1)+32:STF_Start(2)-1);
% rx_packet_2 = rx_packet(LTF_Start(2)+32:end);

rx_compensated = rx_packet;
for k = 1:length(rx_compensated)
    rx_compensated(k) = rx_compensated(k)*exp(-1i*2*pi*delF*k);
end

LTFCompensated1 = rx_compensated(LTF_Start(1)+32:LTF_Start(1)+95);
XtoDecode = [ rx_compensated(LTF_Start(1)+160:STF_Start(2)-1)  rx_compensated(LTF_Start(2)+
160:end)];
```

## Magnitude Distortion estimation

```matlab
LTFfft1 = fft((LTFCompensated1));
magDist1 = (LTFfft1./fftshift(Lk));
display('Channel distortion to each subcarrier:');
magDist1

XtoDecodeMat = zeros(size(XtoDecode,2)/80, 80);
in = 1;
for i = 1:size(XtoDecodeMat,1)
    for j = 1:size(XtoDecodeMat,2)
        XtoDecodeMat(i,j) = XtoDecode(in);
        in = in+1;
    end
end

XtoDecodeMat = XtoDecodeMat(:,17:end);
XDecoded = zeros(size(XtoDecodeMat,1), size(XtoDecodeMat,2));
for i = 1:size(XtoDecodeMat,1)
    XDecodeMatFFT(i,:) = fft(XtoDecodeMat(i,:));
    XDecoded(i,:) = XDecodeMatFFT(i,:)./magDist1;
end


XDecoded = XDecoded(:,[2:6,8:20, 22:27, 39:43, 45:57, 59:64]);
XBpsk = zeros(size(XDecoded,1), size(XDecoded,2));
for i = 1:size(XBpsk,1)
    for j = 1:size(XBpsk,2)
        dist1 = sqrt(real(XDecoded(i,j)-1)^2 + imag(XDecoded(i,j)-0)^2);
        dist0 = sqrt(real(XDecoded(i,j)+1)^2 + imag(XDecoded(i,j)-0)^2);
        if(dist1<dist0)
            XBpsk(i,j) = 1;
        else
            XBpsk(i,j)=-1;
        end
    end
end


XDataVector = [];
XDataDecoded = XBpsk;
for i = 1:size(XDataDecoded,1)
    XDataVector = [XDataVector XDataDecoded(i,:)];
end
```

```matlab
display('Received data bits');
XDataVector

clear sum;
error = find(bpsk~=XDataVector);
error = 100*length(error)/length(bpsk);
display('Error percentage:');
error
```

Channel distortion to each subcarrier:

magDist1 =

   1.0e-05 *

  Columns 1 through 4

  -0.6974 - 0.7149i      Inf -     Infi  -0.6769 - 0.7255i  -0.7196 - 0.7848i

  Columns 5 through 8

  -0.6370 - 0.6650i  -0.6333 - 0.8265i  -0.8015 - 0.6773i  -0.6711 - 0.6793i

  Columns 9 through 12

  -0.7015 - 0.6407i  -0.7347 - 0.6889i  -0.7743 - 0.7599i  -0.7002 - 0.7213i

  Columns 13 through 16

  -0.6684 - 0.8088i  -0.5985 - 0.6908i  -0.6541 - 0.6788i  -0.7001 - 0.7051i

  Columns 17 through 20

  -0.7096 - 0.7731i  -0.7233 - 0.7531i  -0.6139 - 0.7441i  -0.6726 - 0.6497i

  Columns 21 through 24

  -0.6981 - 0.7371i  -0.6844 - 0.7838i  -0.6928 - 0.7829i  -0.7120 - 0.6777i

  Columns 25 through 28

  -0.6568 - 0.6901i  -0.6687 - 0.7778i  -0.7691 - 0.6942i     -Inf -     Infi

  Columns 29 through 32

     -Inf -     Infi      Inf +     Infi      Inf +     Infi     -Inf -     Infi

  Columns 33 through 36

      Inf +     Infi     -Inf -     Infi      Inf -     Infi      Inf -     Infi

  Columns 37 through 40

     -Inf +     Infi     -Inf +     Infi  -0.7385 - 0.7750i  -0.7156 - 0.6451i

  Columns 41 through 44

  -0.7472 - 0.7256i  -0.6811 - 0.7534i  -0.7399 - 0.6627i  -0.6656 - 0.7765i

Columns 45 through 48

-0.6814 - 0.7335i  -0.7638 - 0.6841i  -0.6516 - 0.6384i  -0.7438 - 0.7013i

Columns 49 through 52

-0.7443 - 0.6789i  -0.7041 - 0.7076i  -0.7571 - 0.7184i  -0.7881 - 0.7635i

Columns 53 through 56

-0.6578 - 0.8028i  -0.7017 - 0.7163i  -0.6118 - 0.7018i  -0.6878 - 0.6710i

Columns 57 through 60

-0.6529 - 0.7723i  -0.6514 - 0.7264i  -0.7521 - 0.8074i  -0.6752 - 0.8453i

Columns 61 through 64

-0.7760 - 0.7195i  -0.6361 - 0.7525i  -0.6904 - 0.6912i  -0.7081 - 0.6835i

Received data bits

XDataVector =

  Columns 1 through 13

    -1    -1     1    -1     1    -1    -1     1     1    -1     1    -1     1

  Columns 14 through 26

    -1     1     1     1    -1     1    -1     1    -1     1    -1     1     1

  Columns 27 through 39

     1    -1     1     1     1     1     1     1    -1     1    -1     1     1

  Columns 40 through 52

     1    -1    -1    -1     1     1     1    -1    -1    -1    -1    -1     1

  Columns 53 through 65

    -1    -1     1    -1     1     1    -1     1    -1     1     1     1    -1

  Columns 66 through 78

    -1    -1     1    -1     1     1     1    -1    -1     1     1    -1     1

  Columns 79 through 91

     1    -1    -1    -1     1     1     1    -1    -1    -1    -1    -1     1

  Columns 92 through 104

     1     1    -1    -1    -1    -1    -1    -1     1    -1     1    -1     1

  Columns 105 through 117

     1     1     1    -1    -1     1     1     1     1    -1    -1     1    -1

  Columns 118 through 130

1    -1     1    -1    -1    -1     1     1     1    -1     1    -1    -1

Columns 131 through 143

     1    -1    -1     1    -1    -1    -1    -1    -1    -1     1    -1    -1

Columns 144 through 156

    -1    -1     1    -1    -1    -1    -1    -1     1    -1     1     1     1

Columns 157 through 169

    -1    -1    -1    -1     1    -1     1     1     1     1    -1     1     1

Columns 170 through 182

    -1    -1     1    -1    -1     1     1     1    -1    -1     1     1    -1

Columns 183 through 195

     1    -1    -1     1     1     1     1    -1     1    -1    -1    -1    -1

Columns 196 through 208

     1    -1     1    -1     1     1     1    -1    -1    -1    -1    -1     1

Columns 209 through 221

    -1    -1    -1     1    -1    -1    -1     1     1    -1    -1    -1    -1

Columns 222 through 234

     1    -1    -1     1     1    -1     1    -1     1    -1    -1    -1     1

Columns 235 through 247

    -1     1     1    -1    -1    -1    -1     1    -1     1    -1     1     1

Columns 248 through 260

    -1     1    -1     1    -1     1     1    -1    -1    -1     1     1     1

Columns 261 through 273

    -1    -1    -1    -1    -1     1     1     1    -1     1    -1    -1    -1

Columns 274 through 286

    -1    -1    -1     1     1    -1    -1     1     1    -1     1    -1     1

Columns 287 through 299

    -1     1    -1     1     1    -1    -1    -1     1    -1    -1    -1    -1

Columns 300 through 312

    -1    -1     1    -1    -1     1    -1    -1    -1    -1    -1     1    -1

Columns 313 through 325

1    -1    -1     1     1    -1    -1    -1     1     1    -1    -1     1

Columns 326 through 338

        1    -1    -1    -1    -1    -1     1    -1     1     1    -1    -1     1

Columns 339 through 351

        1    -1    -1     1     1     1     1     1    -1    -1    -1     1    -1

Columns 352 through 364

        1    -1     1    -1    -1     1     1     1     1     1     1    -1    -1

Columns 365 through 377

       -1    -1     1    -1    -1     1    -1     1    -1    -1    -1    -1     1

Columns 378 through 390

       -1    -1     1     1     1    -1    -1    -1    -1    -1     1     1     1

Columns 391 through 403

        1     1     1     1    -1    -1     1    -1     1    -1     1     1    -1

Columns 404 through 416

        1     1     1     1     1    -1     1    -1     1    -1     1     1    -1

Columns 417 through 429

        1    -1     1    -1     1    -1    -1    -1     1     1    -1    -1    -1

Columns 430 through 442

        1    -1    -1    -1    -1     1     1     1    -1    -1     1     1    -1

Columns 443 through 455

       -1    -1     1    -1    -1    -1    -1    -1    -1    -1     1     1     1

Columns 456 through 468

        1    -1     1    -1    -1    -1    -1     1    -1    -1     1    -1    -1

Columns 469 through 481

        1    -1     1     1     1     1     1    -1     1     1     1    -1    -1

Columns 482 through 494

       -1    -1     1    -1    -1     1     1    -1    -1    -1    -1     1     1

Columns 495 through 507

       -1     1     1    -1    -1     1    -1    -1     1    -1     1     1     1

Columns 508 through 520

       -1    -1     1    -1    -1    -1     1    -1    -1     1     1     1     1

Columns 521 through 533

  -1    -1     1    -1    -1     1    -1    -1    -1     1     1    -1    -1

Columns 534 through 546

   1    -1    -1     1     1     1    -1    -1     1     1     1     1    -1

Columns 547 through 559

   1     1     1     1    -1    -1     1    -1    -1    -1     1     1    -1

Columns 560 through 572

  -1     1    -1     1     1     1    -1    -1    -1     1     1    -1     1

Columns 573 through 585

  -1    -1    -1     1    -1    -1    -1     1    -1    -1     1     1     1

Columns 586 through 598

   1    -1     1    -1    -1    -1     1    -1    -1     1    -1    -1     1

Columns 599 through 611

  -1    -1    -1     1     1    -1    -1    -1     1     1    -1    -1     1

Columns 612 through 624

   1     1     1     1     1    -1    -1     1    -1     1     1     1    -1

Columns 625 through 637

  -1     1     1     1     1    -1    -1    -1    -1     1    -1    -1     1

Columns 638 through 650

  -1     1     1     1     1     1     1     1     1     1     1    -1     1

Columns 651 through 663

   1     1    -1    -1     1    -1     1     1     1     1     1     1    -1

Columns 664 through 676

   1     1    -1    -1    -1    -1     1    -1     1    -1    -1     1    -1

Columns 677 through 689

  -1    -1     1    -1     1    -1    -1    -1    -1     1    -1     1     1

Columns 690 through 702

  -1    -1     1     1    -1    -1     1    -1    -1    -1     1    -1    -1

Columns 703 through 715

   1    -1    -1     1    -1     1     1    -1     1    -1     1    -1     1

Columns 716 through 728

   -1    1    1    1    1   -1   -1   -1   -1    1   -1    1   -1

Columns 729 through 741

    1   -1   -1    1    1   -1   -1   -1    1    1    1    1   -1

Columns 742 through 754

   -1    1   -1   -1    1   -1   -1   -1    1   -1   -1   -1   -1

Columns 755 through 767

   -1   -1   -1   -1   -1   -1   -1    1    1   -1   -1   -1    1

Columns 768 through 780

   -1   -1    1   -1   -1    1    1   -1    1   -1    1   -1   -1

Columns 781 through 793

    1   -1    1    1    1    1   -1   -1    1   -1    1    1    1

Columns 794 through 806

   -1   -1   -1    1    1   -1    1    1    1    1   -1   -1    1

Columns 807 through 819

    1    1   -1   -1   -1    1   -1   -1    1    1   -1    1    1

Columns 820 through 832

   -1   -1    1   -1    1   -1   -1   -1    1   -1    1   -1   -1

Columns 833 through 845

    1   -1   -1    1   -1    1   -1   -1   -1    1   -1   -1    1

Columns 846 through 858

    1   -1    1    1    1    1   -1    1   -1   -1    1   -1   -1

Columns 859 through 871

    1   -1   -1    1   -1   -1   -1   -1    1    1    1    1   -1

Columns 872 through 884

   -1    1    1   -1   -1    1   -1   -1    1   -1    1   -1   -1

Columns 885 through 897

   -1   -1   -1    1   -1    1   -1   -1   -1    1   -1    1   -1

Columns 898 through 910

    1    1   -1    1    1   -1   -1    1   -1   -1    1   -1    1

Columns 911 through 923

1       1      -1       1       1      -1      -1       1      -1       1      -1      -1      -1

Columns 924 through 936

      -1       1      -1      -1       1       1      -1      -1      -1      -1       1       1      -1

Columns 937 through 949

      -1       1      -1       1      -1       1       1      -1      -1       1       1       1      -1

Columns 950 through 962

       1      -1      -1      -1      -1      -1      -1      -1      -1       1      -1      -1      -1

Columns 963 through 975

       1       1      -1      -1      -1      -1      -1       1       1      -1       1      -1      -1

Columns 976 through 988

       1      -1       1       1       1       1      -1      -1      -1      -1       1      -1      -1

Columns 989 through 1001

      -1       1       1      -1      -1       1       1      -1       1      -1      -1       1      -1

Columns 1002 through 1014

      -1      -1       1       1       1      -1      -1      -1      -1       1      -1      -1       1

Columns 1015 through 1027

       1       1      -1       1      -1      -1       1       1      -1       1      -1      -1       1

Columns 1028 through 1040

      -1       1      -1      -1       1       1      -1      -1       1       1      -1       1       1

Columns 1041 through 1053

       1      -1      -1      -1      -1       1      -1      -1      -1      -1       1      -1      -1

Columns 1054 through 1066

       1       1      -1      -1      -1       1       1       1       1      -1      -1       1      -1

Columns 1067 through 1079

       1      -1      -1      -1      -1      -1      -1      -1       1      -1      -1       1      -1

Columns 1080 through 1092

       1      -1       1      -1       1       1       1       1      -1      -1       1       1      -1

Columns 1093 through 1105

       1       1      -1       1      -1       1       1      -1       1       1       1      -1      -1

Columns 1106 through 1118

-1   1   1   -1   -1   1   -1   -1   -1   -1   1   -1   1

Columns 1119 through 1131

  1   1   1   1   1   -1   1   -1   -1   -1   1   1   1

Columns 1132 through 1144

-1   1   1   1   -1   -1   1   1   -1   1   -1   1   1

Columns 1145 through 1157

-1   1   1   1   1   1   1   1   -1   1   1   1   -1

Columns 1158 through 1170

  1   1   -1   1   1   1   -1   -1   1   -1   1   -1   -1

Columns 1171 through 1183

  1   -1   1   1   -1   -1   -1   1   -1   -1   1   1   1

Columns 1184 through 1196

-1   1   1   1   -1   -1   1   1   1   1   -1   1   1

Columns 1197 through 1209

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Columns 1210 through 1222

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Columns 1223 through 1235

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Columns 1236 through 1248

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Columns 1249 through 1261

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Columns 1262 through 1274

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Columns 1275 through 1287

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Columns 1288 through 1300

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Columns 1301 through 1313

  1   -1   -1   1   -1   -1   1   -1   1   -1   -1   -1   -1

Columns 1314 through 1326

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Columns 1327 through 1339

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Columns 1340 through 1352

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Columns 1353 through 1365

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Columns 1366 through 1378

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Columns 1379 through 1391

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Columns 1392 through 1404

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Columns 1405 through 1417

  -1   -1    1   -1    1    1    1   -1    1    1   -1    1   -1

Columns 1418 through 1430

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Columns 1431 through 1443

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Columns 1444 through 1456

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Columns 1457 through 1469

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Columns 1470 through 1482

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Columns 1483 through 1495

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Columns 1496 through 1508

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Columns 1509 through 1521

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Columns 1522 through 1534

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Columns 1535 through 1547

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Columns 1548 through 1560

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Columns 1561 through 1573

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Columns 1574 through 1586

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Columns 1587 through 1599

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Columns 1600 through 1612

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Columns 1613 through 1625

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Columns 1626 through 1638

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Columns 1639 through 1651

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Columns 1652 through 1664

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Columns 1665 through 1677

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Columns 1678 through 1690

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Columns 1691 through 1703

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Columns 1704 through 1716

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Columns 1717 through 1729

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Columns 1730 through 1742

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Columns 1743 through 1755

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Columns 1756 through 1768

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Columns 1769 through 1781

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Columns 1782 through 1794

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Columns 1795 through 1807

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Columns 1808 through 1820

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Columns 1821 through 1833

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Columns 1834 through 1846

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Columns 1847 through 1859

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Columns 1860 through 1872

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Columns 1873 through 1885

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Columns 1886 through 1898

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Columns 1899 through 1911
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Columns 1912 through 1924

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Columns 1925 through 1937

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Columns 1938 through 1950

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Columns 1951 through 1963

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Columns 1964 through 1976

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Columns 1977 through 1989

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Columns 1990 through 2002

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Columns 2003 through 2015

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Columns 2016 through 2028

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Columns 2029 through 2041

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Columns 2042 through 2054

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Columns 2055 through 2067

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Columns 2068 through 2080

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Columns 2081 through 2093

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Columns 2094 through 2106

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Columns 2107 through 2119

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Columns 2120 through 2132

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Columns 2133 through 2145

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Columns 2146 through 2158

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Columns 2159 through 2171

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Columns 2172 through 2184

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Columns 2185 through 2197

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Columns 2198 through 2210

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Columns 2211 through 2223

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Columns 2224 through 2236

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Columns 2250 through 2262

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Columns 2289 through 2301

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Columns 2341 through 2353

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Columns 2354 through 2366

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Columns 2419 through 2431

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Columns 2458 through 2470

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Columns 2510 through 2522

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Columns 2523 through 2535

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Columns 2536 through 2548

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Columns 2549 through 2561

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Columns 2562 through 2574

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Columns 2614 through 2626

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Columns 2679 through 2691

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Columns 2692 through 2704

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Columns 2705 through 2717

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Columns 2718 through 2730

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Columns 2731 through 2743

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Columns 2744 through 2756

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Columns 2783 through 2795

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Columns 2796 through 2808

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Columns 2809 through 2821

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Columns 2822 through 2834

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Columns 2835 through 2847

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Columns 2848 through 2860

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Columns 2861 through 2873

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Columns 2874 through 2886

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Columns 2887 through 2899

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Columns 2900 through 2912

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Columns 2913 through 2925

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Columns 2926 through 2938

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Columns 3095 through 3107

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Columns 3277 through 3289

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Columns 3290 through 3302

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Columns 3303 through 3315

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Columns 3394 through 3406

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Columns 3420 through 3432

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Columns 3433 through 3445

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Columns 3446 through 3458

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Columns 3459 through 3471

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Columns 3472 through 3484

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Columns 3485 through 3497
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Columns 3498 through 3510

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Columns 3524 through 3536

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Columns 3537 through 3549

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Columns 3589 through 3601

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Columns 3732 through 3744

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Columns 3745 through 3757

  -1   -1    1    1   -1    1   -1    1   -1   -1   -1   -1   -1

Columns 3758 through 3770

   1    1    1    1    1    1   -1   -1    1    1    1    1    1

Columns 3771 through 3783

   1    1    1   -1    1   -1   -1   -1    1   -1   -1    1    1

Columns 3784 through 3796

  -1    1    1    1    1   -1   -1   -1    1   -1   -1    1   -1

Columns 3797 through 3809

   1   -1   -1    1    1   -1    1   -1   -1   -1    1    1    1

Columns 3810 through 3822

  -1   -1   -1    1   -1    1   -1   -1    1    1   -1    1    1

Columns 3823 through 3835

   1    1   -1   -1    1    1    1   -1    1    1   -1   -1    1

Columns 3836 through 3848

  -1   -1    1   -1    1   -1   -1    1    1   -1    1    1    1

Columns 3849 through 3861

   1   -1    1   -1    1   -1    1   -1   -1    1   -1   -1   -1

Columns 3862 through 3874

  -1    1   -1   -1    1   -1    1    1   -1    1    1    1   -1

Columns 3875 through 3887

   1    1    1    1   -1   -1   -1    1   -1    1    1   -1    1

Columns 3888 through 3900

   1   -1   -1    1   -1   -1    1    1   -1   -1    1   -1    1

Columns 3901 through 3913

   1   -1    1    1   -1   -1    1   -1   -1    1    1    1    1

Columns 3914 through 3926

   1    1    1   -1   -1    1   -1    1   -1   -1    1    1    1

Columns 3927 through 3939

   1   -1    1    1   -1   -1    1   -1   -1   -1   -1    1   -1

Columns 3940 through 3952

  -1   -1    1   -1    1   -1    1   -1   -1    1    1   -1   -1

Columns 3953 through 3965

   1    1   -1   -1   -1   -1   -1    1   -1    1   -1   -1   -1

Columns 3966 through 3978

  -1    1   -1    1    1    1   -1   -1   -1   -1    1    1   -1

Columns 3979 through 3991

   1   -1    1    1    1   -1   -1    1   -1   -1    1   -1   -1

Columns 3992 through 4004

   1    1   -1    1    1    1    1    1   -1   -1    1    1   -1

Columns 4005 through 4017

   1    1   -1    1    1   -1   -1   -1    1    1    1   -1   -1

Columns 4018 through 4030

  -1    1   -1   -1   -1    1   -1   -1   -1   -1   -1    1    1

Columns 4031 through 4043

  -1   -1   -1   -1    1   -1   -1   -1   -1   -1    1   -1    1

Columns 4044 through 4056

   1   -1   -1    1    1    1   -1   -1   -1   -1    1   -1    1

Columns 4057 through 4069

   1    1   -1    1   -1   -1    1    1   -1    1   -1    1   -1

Columns 4070 through 4082

   1   -1    1    1    1    1   -1    1   -1   -1    1   -1   -1

Columns 4083 through 4095

```
  -1     1    -1     1    -1     1    -1     1    -1     1     1    -1     1

  Columns 4096 through 4108

   1    -1     1    -1    -1    -1     1     1    -1     1    -1    -1    -1

  Columns 4109 through 4121

   1     1    -1    -1     1     1     1    -1    -1    -1    -1    -1     1

  Columns 4122 through 4134

  -1    -1     1     1    -1    -1     1    -1    -1    -1     1    -1     1

  Columns 4135 through 4147

  -1     1     1     1    -1     1    -1     1     1    -1     1     1     1

  Columns 4148 through 4160

  -1    -1     1     1     1     1    -1     1     1     1    -1     1     1

  Columns 4161 through 4173

  -1    -1     1     1    -1     1     1     1    -1    -1    -1     1    -1

  Columns 4174 through 4176

  -1    -1    -1
```

Error percentage:

error =

    1.0536